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Abstract

Dietary composition and presentation impacts on the behaviour of animals, and failure to provide a suitable diet can lead to reduced welfare through the development of poor health, the inability to express normal behaviours and the development of abnormal behaviours. This study assessed the effects of two commonly fed pet rabbit diets (extruded nuggets with hay (EH) and muesli with hay (MH)) alongside hay only (HO) and muesli only (MO) on the behaviour of 32 Dutch rabbits observed over 17 months. Increased time spent feeding was observed in the groups fed ad libitum hay (HO, EH, MH) compared to the MO group ($P<0.05$). A corresponding high level of inactivity was observed in the MO group compared to rabbits receiving hay ($P<0.05$). In the groups provided with hay a preference to consume hay in a natural grazing posture was observed. The higher activity levels and absence of abnormal behaviours when hay was fed support recommendations that forage should form a significant portion of the diet for domestic rabbits.

Introduction

As herbivores, wild rabbits consume relatively large amounts of a high fibre diet of low nutritional quality (Williams and Wells, 1974). This requires them to apportion a large amount of their time budget to grazing. Rabbits spend 30-70% of time outside the burrow grazing, pausing occasionally to groom (Mykytowycz, 1958; Myers and Poole ,1961; Myers and Mykytowycz, 1958; Lockley, 1961). Time spent eating varies with age, sex and social status within the group and has also been shown to increase when food availability falls during drought (Myers and Mykytowycz, 1958; Mykytowycz, 1958). Grazing occurs mainly during late afternoon and throughout the night and daylight hours are spent underground in warrens (Myers and Mykytowycz, 1958; Mykytowycz, 1958; Lockley, 1961; Lockley, 1962). Caecotrophy is performed while underground (Southern, 1942). Domestic rabbits kept in free range conditions exhibit a similar feeding pattern to their wild counterparts (Vastrade, 1987; Lehmann, 1991). In contrast, many pet rabbits are housed in small hutches with limited exercise opportunities (Mullan and Main, 2006; PDSA, 2011) and a diet consisting largely of concentrates (mono-component nugget or muesli mixes) (PDSA 2011) which can be consumed rapidly (Lidfors, 1997), with limited or no access to hay or grass (Mullan and Main, 2006; PDSA, 2011).

Stereotypic behaviours are described as behaviours that are relatively invariant, regularly repeated and without an obvious function (Mason, 1991). Stereotypic behaviours reported to occur in laboratory rabbits include excessive grooming, sham chewing (chewing with nothing in mouth), bar biting, licking parts of cage, digging against cage, biting water nipple, sliding nose against bars, head pressing and running repeatedly in a defined pattern (Gunn and Morton, 1995; Lidfors, 1997). An apathetic state of inactivity and boredom has also been reported by Gunn and Morton (1995). Stereotypic behaviours occur most frequently during the night (Gunn and Morton, 1995) when rabbits are naturally at their most active (Mykytowycz 1958).

53 Whilst not studied in pet rabbits, the beneficial impact of providing hay to laboratory rabbits has
54 been demonstrated (Lidfors, 1997; Berthelsen and Hansen, 1999) . The provision of hay to
55 individually housed laboratory rabbits has proved effective at reducing the expression of abnormal
56 behaviours (Lidfors, 1997; Berthelsen and Hansen, 1999).

57 Rabbits can consume pelleted feeds rapidly (Lidfors, 1997) and, whilst they may provide adequate
58 nutrition for the maintenance of the rabbit, foraging behaviour is limited. If fed in limited amounts
59 the rapid consumption of the daily ration may leave the rabbit in a state of hunger for a considerable
60 portion of the day (Lidfors, 1997). It has been suggested that stereotypies in pigs and broiler
61 breeder chickens develop through hunger and frustration at an inability to forage (Lawrence and
62 Terlouw, 1993; de Jong et al., 2003; de Jong et al., 2005) when a restricted diet is fed. Rabbits
63 provided with hay spend considerably more time interacting with it than with other forms of
64 environmental enrichment, suggesting its importance to this species (Lidfors, 1997).

65 Despite recommendations that the ideal diet for pet rabbits is one of grasses, herbs, and leaves
66 mimicking that of their wild counterparts (Clauss, 2012), the benefits of hay for meeting behavioural
67 needs of rabbits , and that rabbits are able to maintain weight gain on forage only diets (Lebas,
68 2004; Leiber et al., 2008), studies suggest that at least 15-17% of pet rabbits do not have access to
69 hay (Mullan and Main 2006; Schepers et al. 2009) and 36-42% are not fed recommended amounts
70 (PDSA 2011; 2012). Veterinary surgeons frequently recommend feeding rabbits concentrates in
71 limited amounts, as it is recognised that owners may often feed what may be considered excessive
72 amounts of concentrate diets (Harcourt-Brown, 2002a; Meredith, 2006; PDSA, 2011) but it is unclear
73 as to whether ad libitum (*ad lib*) access to hay is routinely recommended.

74 This study aimed to assess the effect of two commonly fed/recommended diet regimes (extruded
75 nugget with *ad lib* hay and a mixed muesli type diet with *ad lib* hay), alongside a forage based diet
76 and a muesli only diet, on the feeding behaviour and time budget of pet rabbits.

Materials and methods

Study animals

This study was conducted as part of a long term study to assess the effect of diet on the health and welfare of pet rabbits, as previously described by Prebble and Meredith (2014). Thirty two Dutch rabbits from five mixed litters (20 male and 12 female) were purchased at 8-9 weeks old from a single breeder. They were weighed on arrival (mean weight 0.84 kg±0.084). The rabbits were housed in 12 male-female neutered pairs and four male-male neutered pairs in wooden floor pens (0.96m^2) with 12mm thick rubber matting, with shavings provided as bedding. The pens were split between two rooms with a 12hr light (0600-1800): 12 hour dark cycle, a temperature of 18^{o}C (±2^{o}C) and relative humidity between 40 and 70%. Rabbits were randomly allocated in pairs to four diet treatment groups and day 0 was designated as the day when the rabbits had been transitioned completely onto the treatment diet after an acclimatisation period. Detailed consideration of the experimental setup of the study with regard to the design and housing was undertaken and approved by the Ethical Review Committees of the Royal (Dick) School of Veterinary Studies and the Food and Environment Research Agency (FERA). The rabbits were housed in a facility licensed by the Home Office, however a project licence under the Animals (Scientific Procedures) Act 1986 (ASPA) was not required for this study. The study was continually monitored by the FERA Ethics Committee and Home Office inspector throughout its duration.

In the week following arrival six rabbits displayed signs of digestive disease, subsequently diagnosed as an outbreak of coccidiosis and clostridial enterotoxaemia. Supportive treatment was provided. Despite this, three rabbits died, but three recovered over the following 2 weeks. All remaining rabbits then received prophylactic treatment with a two day course of toltrazuril (Baycox 50 mg/ml Oral Suspension for Piglets, Calves and Lambs, Bayer plc, Newbury, Berkshire, UK) at a dose rate of 2.5mg/kg (Redrobe et al., 2010) on day -43 and -42 and repeated five days later on day -37 and -36 and metronidazole (Flagyl S 200mg/5ml Oral Suspension, Winthrop Pharmaceuticals UK Limited,

Guildford, Surrey, UK) at a dose rate of 20mg/kg twice daily for five days. Three 8 week old Dutch rabbits arrived on day -23 to replace those that died.

Diets

On arrival, rabbits were acclimatised over a period of 40 days (days -54 to -14) by maintaining their weaning diet and were fed 50g per rabbit of an extruded diet (Burgess® Excel-Junior and Dwarf Rabbit; Burgess Pet Care, Thornton Le Dale, North Yorkshire, UK) once a day plus *ad lib* Timothy Hay. Hay was provided in wall mounted hayracks to enable intake to be monitored and to prevent faecal and urinary contamination which may reduce intake of hay. Water was provided *ad lib* in 700ml bottles. At day-14 the paired rabbits were allocated to one of four diet treatment groups:

1 - Hay Only (HO) - *ad lib* supply of Timothy Hay (n=8);

2 – Extruded diet and Hay (EH) - 50g per rabbit Burgess Excel- Adult Rabbit (Burgess Pet Care, Thornton Le Dale, North Yorkshire, UK) with *ad lib* supply of day (n=8);

3 - Muesli and Hay (MH) - 60g per rabbit Russell Rabbit Complete Muesli (Supreme Petfoods Limited, Ipswich, Suffolk, UK) with *ad lib* hay (n=8);

4 - Muesli Only (MO) - *ad lib* supply (125g per rabbit) of Russell Rabbit Complete Muesli (Supreme Petfoods Limited, Ipswich, Suffolk, UK) (n=8).

Rabbits were gradually transitioned on to their respective new diets over a two week period (day -14 to day 0) to prevent digestive conditions associated with sudden dietary changes (Tzika et al. 2004). From day 0 to the end of the study, (day 510; 17 months), rabbits were only fed the diet of that group.

The nutritional compositions of diets are shown in Table 1. The EH and MH diets represent two commonly fed diets fed according to the manufacturer's guidelines. The muesli consisted of 11

components: extrudates (4 types), pellets (2 types), grains (3 types), rolled peas and alfalfa stalks. Quantities of concentrates offered in the EH and MH groups were based on the lower end of the range of the manufacturer's stated guidelines to replicate dietary advice given by veterinary surgeons (Harcourt-Brown 2002a; Meredith 2006). The inclusion of the HO group was to provide a forage only diet similar to that of wild rabbits. The MO group was included because many commercially available muesli based diets are labelled as complete or 'nutritionally complete', leading owners to feed them alone. Muesli was provided to the MO group in sufficient quantities to ensure an ad libitum supply of food. All concentrates were weighed out and replaced daily to ensure accurate and consistent weights were offered. No measures were taken to prevent selective sorting or feeding of the different components of the muesli.

In the month following transition all rabbits were neutered and vaccinated against myxomatosis (Nobivac Myxo, MSD Animal Health, Milton Keynes, UK) and Viral Haemorrhagic Disease (Cylap, Pfizer Limited, Sandwich, UK) as recommended for pet rabbits at that age.

The rabbits continued on the four trial diets for 17 months (72 weeks). One pair of rabbits in the MO group had to be separated in week 3 following the development of aggressive behaviour and are not included in the analysis.

Data collection

Behavioural observations were performed over two 24 hour periods in week 8 (timepoint 1: T1) and week 18 (timepoint 2: T2) of the trial diet period. A video recording using closed circuit television (CCTV was made for 24 hours from 0900h. Daily food rations (concentrates and/or hay) and water were provided prior to the start of recording, following which no one entered the room for the 24 hour period. Red light was used during the 12h dark period which was present for 28 days prior to data collection to allow habituation. Recordings were carried out with WebCCTV NVR (Quadrox, Herent, Belgium).

149

150 Instantaneous scans of the CCTV recordings were performed every 15 minutes and the behaviour
151 performed by each of the rabbits in the pen recorded. Data was collected by pen and
152 measurements relating to bout duration were not recorded as rabbits were housed in pairs and
153 could not be distinguished from each other on recordings. At both timepoints (T1 and T2) the first
154 observations were in sequence from the lowest to the highest pen numbers. Individual behaviours
155 were categorised into five groups (Feeding, Maintenance, Active, Inactive and Investigative) for
156 analysis.
157 An ethogram based on Gunn and Morton (1993) was developed following prior observation of the
158 rabbits and is detailed in Table 2. In addition, assessment of proximity was made during each
159 instantaneous scan. Proximity was described as rabbits either separated by more than a third of the
160 pen (apart), in the same third of the pen without touching (near to each other) , or in direct physical
161 contact (together).
162

163 Statistical Analysis

164 Analysis of the data by behaviour group (Table 2) was performed on the total data set and also
165 separately on data from light and dark periods. Behaviours in the feeding category were also
166 analysed individually. The effects of sex on behavioural expression could not be assessed as it was
167 not possible to distinguish between individual rabbits. Statistical analysis was performed using R
168 software (v3.1.2 © 2014 The R Foundation for Statistical Computing and the R package *lme4* v 1.1-7).
169 Overall percentages of time spent performing each behaviour when both time points were
170 considered together were analysed using generalised linear mixed-effect models with binomial
171 errors (*glmeb*) with Pen as the random effect. *Glmeb* models were also used to compare how hay
172 was consumed, and whether rabbits differed in how much they stayed physically closer together
173 between the 2 timepoints. When considering differences in behaviour between diet treatment

groups at specific time points, general linear models with binomial errors (*glmb*) were utilised. Tukey's post-hoc tests were carried out for both sets of models to assess pair-wise differences between groups where overall differences were found. Pearson's correlation was used to examine relationships between behaviours. P<0.05 was taken to indicate statistical significance and mean ± standard errors are quoted throughout.

Results

Figure 1 shows the percentage of time spent performing different behaviours at the two timepoints by diet treatment group. Overall, *feeding* was negatively correlated with *inactivity* at both time points (T1: ρ=-0.892, T2: ρ=-0.918, P<0.001) and *maintenance* behaviours at timepoint 2 (ρ=-0.547, P=0.035).

Effect of dark/ light period on behaviour

Differences in percentage of time spent performing different behaviours were affected by the light dark cycle (Figure 2). *Feeding* (Dark: mean=32.44% ±2.84, Light:28.54% ±4.68), *maintenance* (Dark:9.76% ±1.34, Light:5.93% ±1.06) and investigative (Dark:3.15% ±0.69, Light:1.5% ±0.29) behaviours occurred more frequently in the dark period (Overall: P<0.001, T1: P<0.019, T2: P<0.013) whilst *inactive* (Dark:52.31% ±2.29, Light:63.20% ±3.90) behaviours occurred more frequently in the light period (P<0.001 for overall, T1 and T2).

In the light period, the HO group spent more time *feeding* (overall 49.7% ±2.4) in comparison to 9.3% (±3.5) of time by the MO group (P<0.001 for overall, T1 and T2), and the HO group spent less time *inactive* (overall 45.8% ±3.3) than the MO group (overall 83% ±6.2, P<0.001 for overall, T1 and T2). No differences between the 4 groups in percentage of time spent performing *maintenance* and *investigative* behaviours were present in the light period (P>0.085 for overall, T1 and T2). In contrast, *maintenance* behaviours were performed more frequently in the MO group than all other

groups in the dark period overall (P<0.029) and T1 (P<0.037), but only the HO group spent less in *maintenance* than MO at timepoint 2 (P<0.001, P>0.120 other groups) (Figure 2).

Effect of diet group on behaviour

Over the total twenty four hour period (combining light and dark periods) at each timepoint, the MO group spent significantly less percentage time *feeding* (T1:11.33% ±4.33, T2:9.33% ±4.68) and more time *inactive* (T1:71% ±4.02, T2:74.67% ±3.35) than all other groups (P<0.006, Figure 1). The HO group also spent significantly more percentage time *feeding* (T1:44.25% ±1.60, T2:40.75% ±1.31) than the MH (T1:26% ±1.68, T2:23.5% ±1.44) group at both timepoints (P<0.001). The EH group spent significantly less percentage time *feeding* (T1:26% ±1.68, T2:23.5% ±1.44) than the HO group (P<0.001), however there was no significant difference in levels of *inactivity* between these two groups (53% ±2.42) at time point 1 (P=0.846). At time point 2 the EH group spent significantly more percentage time *inactive* (59.25% ±1.70, than the HO group (P<0.002). Compared to the EH group, the MH group spent significantly less percentage time *feeding* and more time *inactive* at timepoint 1 (P<0.001), but there was no significant difference spent *inactive* at timepoint 2 (P>0.09).

Consumption of hay from between the bars, with the front paws placed on the hayrack (T1:16.38% ±5.75, T2:26.45% ±14.9) occurred significantly less than consumption of hay whilst in a natural grazing posture from either the floor or whilst sat in the hay rack (T1:83.62% ±5.75, T2:73.55% ±14.9, P<0.001, Figure 3).

Observations of *maintenance* behaviours were significantly higher in the MO group (T1:11.67% ±1.47, T2:12.67% ±1.89) than in the HO group (T1:5% ±0.41, T2:6% ±1.35) at both timepoints (P<0.001) and the EH group (T1:7% ±1.37, T2:9.75% ±2.14) at timepoint 1 (P=0.027). *Maintenance* behaviours occurred significantly more frequently in the MH group (T1:9% ±2.86, T2:8.25% ±1.7)

than the HO group at timepoint 1 (P<0.02) but not timepoint 2 (P=0.391). While at timepoint 2 *maintenance* behaviours were significantly greater in the MO group than the MH group (P=0.038).

Active behaviours were observed significantly more frequently in the MH group (T1:2.5% ±0.65, T2:2% ±0.58) than the HO group (T1:0.5% ±0.29, T2:1.75% ±0.85) only at timepoint 1 (P=0.018). *Investigative* behaviour occurred more frequently in the MO group (T1:4.67% ±0.63, T2:2% ±0.48) than the HO group again only at timepoint 1 (T1:1.25% ±0.25, T2:2% ±0.41, P=0.001).

In all groups, time spent in direct physical contact (together) was greater at T2 (38.73% ±2.37) than at T1 (10.13% ±1.58, Figure 4, P<0.001). The HO group spent less time together (T1:4% ±1.08, T2: 27.75% ±3.09) than the MH (T1:14.25% ±8.76, T2:46.5% ±7.44) and MO (T1:15.33% ±6.22, T2:58% ±6.08) groups at both timepoints (P<0.015). The MH and MO groups spent a greater proportion of time together than the EH (T1:8.25% ±2.78, T2:27.5% ±4.17) group only at the second timepoint (P<0.001). In addition the MO group spent more time together than the MH group only at timepoint 2 (P=0.019)

Other observations

Throughout the study, rabbits from MH, HO and EH groups were observed pulling hay from the hay rack using a digging motion with their front paws and subsequently consuming hay from the floor. In addition, rabbits in the majority of pens also jumped into the hay rack to consume hay.

Over the whole study period (17 months), hair chewing was recorded in one rabbit within the MO group and occurred in the period following the removal of its pen mate from the trial. Chewing of objects in the pen was seen infrequently on the videos (0.14% of observations), however damage to wooden fixtures within the pen as a result of chewing occurred in all groups over the whole study

period. Chewing of the rubber matting used as flooring was observed only in the MO group. In addition to chewing the rubber matting, rabbits in the MO group were also often observed eating the shavings provided as bedding over the duration of the entire 17 month trial.

Discussion

This study has provided preliminary information on the effect of diet on the time budgets of pet rabbits. Diet affects time budgets of many herbivorous mammals including horses, sheep and pigs (Ruckebusch and Gaujoux, 1976; Robert et al., 1993; Thorne et al., 2005). Previous studies in rabbits have been limited to laboratory rabbits which focus on environmental enrichment including the use of hay and food based enrichments rather than their use as a diet (Lidfors, 1997; Berthelsen and Hansen, 1999; Harris et al., 2001), whereas this study assessed the effect of different feeding regimes on the time budgets of pet rabbits.

Time spent feeding was highest in the HO group which had the diet of lowest nutritional value. Wild rabbits spend between 30-70% of their time above ground eating (Myers and Mykytowycz, 1958; Mykytowycz, 1958) but this can rise to 90% when diet quality is poor (Myers and Poole, 1961). As wild rabbits are above ground between 11 and 13 hours per day (Mykytowycz, 1958) this equates to a range of approximately 14 - 38% of total time spent eating. The time spent feeding in the groups provided with hay (HO, EH and MH) groups falls within this range at both timepoints, however the average time spent feeding by the HO group was at the top end of this range and is similar to figures reported by Myers and Poole (1961) in rabbits during summer when diet quality is of low nutritional value. Conversely the MO group spent less time feeding (9-11%) than wild rabbits. Reduced opportunity for foraging in herbivores, including rabbits, has been associated with the development of abnormal and stereotypical behaviours (Robert et al., 1993; Lidfors, 1997; Berthelsen and Hansen, 1999; Thorne et al., 2005). These may occur as a result of boredom, hunger or frustrated attempts to display foraging behaviours which they are motivated to perform(Newberry, 1995; D'Eath et al., 2009).

The reduction in time spent feeding was matched with corresponding increases in time spent inactive; a similar pattern of behaviour is also reported in sheep (Ruckebusch and Gaujoux, 1976). The increase in inactivity and reduction in active feeding behaviours may have contributed to both the development of abnormal behaviours (see below) and high weight gain and increased body condition observed in the MO group (Prebble and Meredith, 2014).

Stereotypy has been reported to occur at a mean frequency of 11% over a 24 hr period in laboratory rabbits (Gunn and Morton, 1995). Stereotypical behaviours include hair chewing, chewing objects, nose sliding and licking objects (Gunn and Morton, 1995). Hair chewing along with other abnormal behaviours are suggested as indicators of stress (Podberscek et al., 1991; Gunn and Morton, 1995) and therefore in the one rabbit in which hair chewing was observed, this could have been triggered by the loss of the companion, as rabbits are highly motivated to have social contact (Seaman et al., 2008). The lack of access to hay may also have contributed to the hair chewing in this rabbit, as provision of hay has been demonstrated to prevent hair chewing in laboratory rabbits (Mulder et al., 1992). Although chewing of wood occurred in all diet groups in this study, the chewing of rubber matting and ingesting of shavings in the MO group could be indicative of abnormal behaviour. The chewing of rubber matting may be misdirected chewing as a consequence of reduced time feeding. Increased levels of abnormal behaviours have been found in pigs that do not have a suitable substrate for foraging (Spoolder et al. 1995). This would indicate that the rabbits needed or craved a higher fibre food source and is a behaviour also reported in horses fed on a low forage diet (Houpt et al. 1988).

The level of potential stereotypy and abnormal behaviour is lower in this study than that reported by Gunn and Morton (1995) and this may reflect differences in the rabbit's husbandry. Rabbits in this study were housed in pairs whereas rabbits studied previously were housed in social isolation which increases expression of abnormal behaviours (Chu et al. 2004). The observations of Gunn and

294 Morton (1995) were also performed in laboratory cages which limited behaviours such as rearing,
295 hoping and lying outstretched. Increasing the amount of space available reduces inactivity and
296 allows expression of a fuller behavioural repertoire in rabbits (Dixon et al. 2010) and reduces
297 abnormal behaviour (Chu et al. 2004). Therefore the social contact and increased space (allowing
298 expression of most behaviours) provided in this study may have contributed to the low overall levels
299 of abnormal behaviours seen. In addition, the use of instantaneous scans rather than continuous
300 monitoring may have reduced detection of misdirected chewing behaviour as it occurs as an event
301 rather than a state.

302

303 The higher proportion of time spent consuming hay from the floor or whilst sitting in the hayrack
304 suggests that rabbits prefer to consume hay in a natural grazing posture with the head down rather
305 than from a hay rack which requires elevation of the head. Similar findings have been observed in
306 horses which have been observed actively pull hay onto the floor and spending a higher proportion
307 of time consuming it from the floor than from troughs (Sweeting et al., 1985).

308

309 The findings of this study highlight the effect of forage on behaviour in pet rabbits. The increased
310 inactivity and reduction in time spent eating in rabbits on the muesli only diet indicates an impact on
311 welfare through the inability to express normal foraging behaviour (evidenced by misdirected
312 chewing of rubber matting and consumption of bedding), in addition to the development of obesity,
313 also reported elsewhere in the MO rabbits (Prebble et al., 2014) through reduced activity levels.
314 Provision of forage is essential to promote welfare of rabbits and should form a significant portion of
315 the rabbit's diet.

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Table 1. Nutritional composition of diets offered, with values expressed as % Dry Matter (DM)

Table 2. Rabbit Ethogram used in this study (based on Gunn and Morton (1993))

Figure 1. Time budgets of Dutch rabbits fed on four diets, hay only (HO), Extruded nugget and hay (EH), Muesli and hay (MH) and Muesli only (MO). Percentage of observations consisting of feeding, inactive, maintenance and other (made up of active and investigative behaviours) behaviours for a 24 hour period at timepoint 1 (week 8) and timepoint 2 (week 18) after the start of the dietary treatments.

Figure 2. Time budgets of Dutch rabbits fed on four diets, hay only (HO), Extruded nugget and hay (EH), Muesli and hay (MH) and Muesli only (MO. Percentage of observations consisting of feeding, inactive, maintenance and other (made up of active and investigative behaviours) behaviours for the light and dark periods (12 hour light dark cycle) at timepoint 2 (week 18) after the start of the dietary treatments.

Figure 3. Feeding behaviour of Dutch rabbits fed on four diets, hay only (HO), Extruded nugget and hay (EH), Muesli and hay (MH) and Muesli only (MO). Breakdown of the feeding behaviours observed at timepoint 1 (week 8) and timepoint 2 (week 18) after the start of the dietary treatments.

Figure 4. Proximity of paired Dutch rabbits to each other. Rabbits fed on one of four diets, hay only (HO), Extruded nugget and hay (EH), Muesli and hay (MH) and muesli only (MO). Percentage of time spent separated by more than a third of the pen, in the same third of the pen without touching, or in direct physical contact over a 24hour period at timepoint 1 (week 8) and timepoint 2 (week 18) after the start of the dietary treatments.