Catering for lean cats: effects of feeding method on physical activity, prandial behaviour, health and body condition of domestic cats

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Abstract

Today, more than fifty percent of the cats kept as pets are considered to have overweight or to be obese, with the number of cats with overweight still increasing. As overweight increases the risk of several health problems, it can bring the owner financial problems and affects the welfare of the animal. Several risk factors are known that cause overweight, such as low physical activity, genetics and eating energy dense food. The natural feeding behaviour of cats exists of a large number of small meals, with on average about ten to twenty meals per day. Cats housed as pets with ad libitum access to food generally use a similar feeding strategy as their feral conspecifics and consume a large amount of small meals throughout the day. Owners use several feeding methods to feed their cats, with restricted meal feeding most often applied. This study aims to test the effects of the feeding schedule on the behaviour, physical activity, health, and body condition of domestic cats. In current behavioural study the behavioural response of twelve domestic shorthair cats with four meal schedules was observed. Cats received two meals a day (*N*=2), ad libitum access (*N*=2), six meals a day at fixed times (*N*=4), or six meals a day at random times (*N*=4) during five days. On the fifth day the behaviour of each cat was video recorded and analysed. It was expected on forehand that more pre-prandial behaviours (e.g. high activity, food searching behaviours) would show in cats on schedules of low meal frequencies. Also more prominent postprandial satiety behaviour was expected to be seen in these cats. The ad libitum fed cats were expected to have a high feeding frequency with low food intake per meal. However, no clear behavioural differences were found between cats receiving the four meal schedules. Sitting and facial grooming occurred more ($P \leq 0.001$, Mixed Model analyses) during the postprandial phase compared to the pre-prandial phase and seems indicators of satiety in cats. With the help of Actical accelerometers the general activity was observed in all cats during a control week and week of experimental meal schedule. The cats' day time dependent activity differed among the meal schedules ($P<0.001$), but not between the control and test week. The ad libitum fed cats showed a lower activity at the standard procedure feeding times (8:00 hour and 15:00 hour). Overeating was observed in the ad libitum fed cats, possibly as they were not used to ad libitum access to food. The ad litibum fed cats had low feeding frequency and ate large amounts of food per meal. In addition to the controlled animal experiment a survey among cat owners was conducted. The questionnaire was carried out to test for direct relationships between the applied feeding method and activity, health, food motivation and body condition in cats housed as pets. A total of 1008 cat owners filled in the survey. Only adult cats which did not receive special diet feedings were included for further analyses (*N*=750). More cats with overweight were seen in cats fed meals, i.e. relative to those fed ad libitum ($P<0.001$, Chi-square test). In cats fed on variable times underweight cats were overrepresented ($P<0.01$). Thus, ad libitum feeding seems to prevent overweight in cats housed as pets, though in the present survey only a small proportion (16.4 percent) of the cats were fed ad libitum, possibly, reflecting that only a small number of cats are resistant to overeating. In the survey, cats which expressed strong food motivated behaviours had more overweight and they more often received meal feedings, instead of ad libitum food, as compared to cats with apparent lower food motivation ($P<0.001$). Possibly, owners base their feeding method on the food motivation and intake of their cat. Meal feeding, i.e. feed restriction, may in it turn stimulate food motivated behaviours in cats, together resulting in the found relationship. To conclude, lower activity of experimental cats fed ad libitum was seen during certain clock hours but overall activity was unaffected by meal schedules. In pet cats, the feeding method used by owners had a strong relationship with the cats' body condition. Meal feeding, as opposed to ad libitum feeding, was associated with overweight. The causal relationship remains to be determined and could be that owners adopt meal feeding in response to their cats over-eating of cats expressing increased food motivation and intake in response to restricted food availability. The present findings suggest that food motivation and energy intake are more determining in whether or not cats develop overweight than energy expenditure by behavioural activity.

1. Introduction

In recent decades the prevalence of cats with overweight has increased dramatically, especially in Western Europe and the United States. In the United States approximately 58 percent of the cats, around 43 million, are considered to have overweight or to be obese according to the National Pet Obesity Survey 2012 (Calabash, 2013). This survey was conducted by veterinarians who examined the body condition of 450 cats from 121 animal hospitals around the United States. In canine research, numerous studies found a relation between canine obesity and diabetes mellitus (Krook et al., 1960), hypertension (Rocchini et al., 1987), cardiovascular problems, and muscular or skeletal disorders (Edney and Smith, 1986). In humans there is good evidence that obesity is linked to similar diseases such as diabetes mellitus, cancers, hypertension and cardiovascular diseases (Ogden et al., 2003). A cohort study in overweight and obese cats revealed associations with diabetes mellitus, lameness and skin problems (Scarlett and Donoghue, 1998). It is speculated that cardiovascular diseases and hypertension are diseases linked to obesity in cats although reliable feline studies are rare. Appelton et al. (2001) studied the effects of weight gain on insulin sensitivity in sixteen cats. During ten months the cats in the study had unlimited access to high energy feed which resulted in a mean bodyweight increase of 1.9 kilograms (44.2 percent). While the cats gained weight the insulin sensitivity was reduced by more than half. Results of this study suggest that some cats are more likely to develop glucose intolerance, of which the risk is increased by obesity. According to a life history study in cats and dogs of Laflamme (2012) the risk of diabetes mellitus increases about 2-fold in overweight cats and about 4-fold in obese cats. According to Veterinary Pet Insurance Co. (VPI) their clients paid out $25 million in vet bills for obesity related diseases in 2010. Petplan USA, another pet health insurer, considers obesity related diseases as the most common insurance claims they receive. Pets with health problems can be a financial disaster for the owner and can corrode the joy of having a pet. Besides the related health problems of the cat and financial problems for owners, overweight and obesity also affect the welfare of pets negatively. This study is about identifying factors that may regulate overweight in cats, and focusses on how feeding methods may affect prandial behaviour, physical activity, body condition and health of domestic cats. Energy intake by means of eating and energy expenditure by behavioural activity are both important factors for weight control in cats. Identifying which meal schedules or energy balance influencing behaviours (i.e. food intake or activity) are most strongly related to overweight (and/or leanness) in cats may be useful for designing optimal feeding methods. Eventually, more information on what makes cats obese will help cat owners to manage their cat's weight effectively.

Overweight results mainly from an imbalance between energy intake and energy expenditure. A higher energy intake than expenditure will lead to an excess amount of body fat. Too much body fat impairs body functions and shortens longevity in animals (Laflamme, 2006). Main causes for the growing obesity problem in domestic cats are the changed diet and lifestyle of cats over the last two to three decades (Farrow et al., 2013). Decreased physical activity and increased availableness of highly palatable, energy-dense food are the main causes of overweight and obesity, as reviewed by De Godoy and Swanson (2013). As in humans, inactivity and feeding high-fat diets contributes to an increase in body fat (Butterwick and Hawthorne, 1998) in animals. Research of Sloth (1992) and Scarlett et al. (1994) found a positive correlation between overweight cats and cats being confined indoors. It can be assumed that most cats kept indoors are generally less active compared with cats that can freely roam outside. Not only physical activity and the type of food are known risk factors, also genetics (De Godoy and Swanson (2013), gender, neutering, mid-age, and feeding regimen (Russell et al., 2000; Lund et al., 2005) are associated with overweight and obesity. The owner's opinion about body condition is also known to be an important risk factor for obesity in pets confirmed by several studies (Scarlett et al., 1994; Russel et al., 2000; Robertson, 1999; Calabash, 2013). Many of these risk factors are found by using questionnaires which were sent to cat owners and by assessing the body condition of the cats in these questionnaires. A study of Calabash (2013) revealed that 45.3 percent of the cat owners in their study (N=450) incorrectly identified their overweight or obese cats as "normal weight". These cat owners were asked to score their pet's current body condition score as: too thin,

normal, overweight and obese. Afterwards veterinarians scored the body condition of the same cats by use of the same categories. It seems that cat owners do not have an accurate view of the real and/or optimal weight of their cat. Kienzle and Bergler (2006) found the relationship between owner and cat to be more intense in owners with obese cats, the human-animal relationship is therefore seen as another important factor. The misinterpretation of cat behaviour by owners is mentioned as another risk leading to overweight (Heath, 2005). Owners often misread the behaviour of their cat when it comes to food. Cats have not evolved an elaborate social feeding behaviour repertoire like humans and dogs, therefore cats may not communicate extensively with each other about food. When a cat initiates contact with its owner, owners often mistakenly assume that the cat is begging for food. If food is given at those times, the cat soon learns that initiating contact will result in food, which could explain the begging behaviour of many cats. To conclude from this part, the cat owner, e.g. by means of the home environment, feeding strategy, and human response towards cat behaviour, has a strong influence on the body condition of the cat.

The domestic cat (*Felis sylvestris catus*) is descended from the African wildcat (*Felis sylvestris lybica*) and is still very close related and very similar to this species in size, shape, behaviour and physiology. The domestic cat is an obligate carnivore and its hepatic function is specialized to metabolize animal tissue, existing mainly of proteins. Therefore, cats require a high level of proteins in their diet and some essential specific amino acids like taurine, niacin, thiamin and arginine. Feeding is a primary biological need and in nature an animal has to compose its own diet in order to meet its nutritional requirements. Feral cats completely depend on the presence of prey and because there is no constant availability of prey, there is no constant food availability. Good hunting skills and physical condition of the feral cat are crucial to make a hunt successful (Surguss and Hurley, 2005). Feral cats hunt small prey like mice, birds and voles and sometimes hunt for larger mammals like young rabbits and hares. The average mouse provides about 30kcal (126kJ) or eight percent of the daily energy requirement of the cat (Mugford, 1977). In this way feral cats have to hunt repeatedly at day and night to obtain enough food. Based on wild observations, the natural feeding behaviour of cats exists of a large number of small meals per day, on average about ten to twenty meals per 24 hours (Kane et al., 1981; MacDonald et al., 1984).

The eating behaviour of animals can be divided into pre-prandial, prandial and postprandial phases, which together make up the eating pattern. The duration of each phase depends on the individual and is influenced by many factors like the individual preference, food type, and the feeding regimen. The pre-prandial phase, also known as the anticipatory phase, is linked with feeding motivation and hunger. The purpose of the pre-prandial phase is to obtain food (Barbano and Cador, 2005). Motivation is a process that arouses an animal to act towards a desired direction and elicits, controls, and sustains goal-directed behaviours. For example, hunger is a motivation that evokes the desire to eat (Blundell et al., 2010). Feeding motivation may rise for example by specific stimuli such as the smell and sight of food (Orsini, 2003). Behaviours that can be seen during the pre-prandial phase are approach, exploration and a higher activity (Barbano and Cador, 2005). Increased periods of activity are seen during the pre-prandial phase in several animal species (Van der Harst et al., 2003, Peters et al., 2012, Shepherdson et al., 1993).
The start of the prandial phase, also known as the consummatory phase, is influenced by the interaction between external and internal factors that modify the food intake. Food motivation behaviour is still important in this phase. Examples of external factors that influence feeding behaviour are season and the quality of the food. Internal factors that are linked to food intake are for example circulating levels of glucose, leptin, and insulin in the blood (Barbano and Cador, 2005). The decision to begin a meal depends, for example, on the emotional state of the individual, the palatability of the available food and the effort that is needed to obtain the food (Kringelbach, 2004). Research of Yeomans (1996) has shown that the food intake is enhanced when the palatability of food increases. This study was performed with 54 human volunteers eating pasta with three different palatability levels. Between the eating episodes the subjects had to rate aspects of palatability. Results of this study show that a higher rate on palatability led to a higher food intake and more appetite. To observe prandial behaviours in animals and humans, the eating rate, food intake, and the daily feeding patterns

are often examined (Berridge, 1996). The study of Ohkuma et al. (2013) suggests a link between eating rate and obesity. In this study 7275 human individuals from forty years and older categorized themselves in four groups for eating rate: slow, medium, relatively fast and very fast. Results of this study showed that the proportions of subjects that were obese or had elevated waist levels had a significant faster eating rate. A study of Andrade et al. (2008) compared slow and quick eating rates in thirty healthy women. With use of visual analogue scales subjects rated hunger and satiety levels, desire to eat, meal palatability and thirst. Two test visits were used to compare the slow and quick eating rates. Slow eating rate led to a significant decrease in energy intake and significant increases in drinking behaviour. This study is in line with the findings in the study of Ohkuma et al. (2013) and suggests that a slow eating rate results in an earlier satiation, leading to a lower energy intake. Research about the relationship between eating rate and obesity in cats is limited. Bradshaw and Thorne state in their book (1992) that cats often overeat or under eat when presented with a novel food source. It can be speculated that cats have to habituate to taste, structure and contents of the food in order to establish normal eating habits.

Behaviour during both the pre-prandial and prandial phase is regulated by the central nervous system and is linked to the 'wanting' and 'liking' systems in the brain (as discussed by Berridge, 1996). Wanting is referred as the disposition to eat or as appetite and is linked to the motivation to obtain food. Dopamine fosters the wanting system in the brain and the release of dopamine is provoked by palatable foods and other pleasant rewards (Berridge, 2009). The liking system is linked to the eating behaviour and if fostered by opioids (Berridge, 1996). Opioids are important for the sensory pleasure or palatability of food and for the regulation of food intake (Davis, 2009). Although liking and wanting are processes that go often hand in hand these mechanisms are distinguishable in particular brain regions and both are necessary for a normal rewarding feeling during and after eating. In short, liking is an affective consequence of consummatory behaviour and wanting the affective state linked with motivation and appetitive behaviour (Berridge, 2009).

When the liking and wanting system becomes less active the postprandial phase starts. During this phase, also known as the satisfaction phase, the food motivation is low and satiety dominates (Berridge, 2009). Satiation, which precedes satiety, is a central state occurring when sufficient food has been taken into the stomach. Signals of stomach fullness are generated by stretch receptors in the stomach and hormones such as ghrelin, cholecystokinin, GLP-1 and PYY. The build-up of satiation depends on several factors such as the energy density, palatability, and texture of the foods, the feeding motivation of the subject, cognitive factors, and environmental cues (Blundell et al., 2010). Behaviours that are often seen during the postprandial satiety phase are grooming and resting, although this is only confirmed in literature in rats (Bindra and Blond, 1958)

The applied feeding regimen may have a relationship with the body condition in cats. Russell et al. (2000) studied the influence of feeding regimen on body condition in the cat. In this study they collected data by interviewing cat owners (n=136) and by assessing the body condition of their cats. Although neutering and middle age are important factors influencing body condition found by Russell and co-workers, feeding regimen (ad libitum feeding) was identified as a risk factor for obesity. Besides the study of Russell et al. (2000) only little research has been done to elucidate the mechanisms by which feeding methods affects the bodyweight in cats. It can be assumed that the most effective feeding method to keep cats lean is the method that corresponds well with the natural feeding behaviour of feral cats. In wild situations cats have to be physical in optimal condition to be able to catch prey and in this way to obtain food. Designing a natural feeding method for household cats is often quite difficult because of its practical implications (e.g. a cat owner that lives in an apartment cannot provide the cat with living mice). In this way, cat owners have to find a compromise between practical feeding methods and the natural feeding behaviour of the cat. Two feeding methods used in practice are free choice feeding (further referred as ad libitum feeding) and meal feeding. During ad libitum feeding food is continuously available and the cat can eat as much as it wants whenever it wants. With meal feeding a specific amount of food is offered at certain times each day. Part of the cat owners use a combination of ad libitum feeding and meal feeding methods, often kibbles are given continuously and additionally some moist food is provided in one or more meals (Hand et al., 2000). In comparison with ad libitum feeding, meal feeding leads often to periods of hunger in animals which

has some welfare implications. According to the 'Five Freedoms' of the Farm Animal Welfare Council (Brambell, 1965) animals kept by man should be free from hunger. Still, laboratory, companion and farm animals are often kept on a restricted diet to prevent overweight and to promote fertility. These animals are feed restricted and could experience hunger, but generally have fewer health problems compared to their overweight conspecifics. Although the physical health of feed restricted animals is better, those animals show more redirected feeding behaviours towards non-food objects. These redirected behaviours develop sometimes into stereotypies which are often indicators of a decline in animal welfare (Mason and Latham, 2004). Choosing the appropriate feeding method, which keeps the animal satisfied and healthy but is also practical for the pet owner can be difficult. There is no optimal feeding method for all cats. The preferred method of feeding an individual cat depends on several non-nutritional factors like food type, owners schedule and preference, and the feeding environment. Nutritional considerations for selecting an appropriate feeding method include the cat's body condition, health status, and type of food (Hand et al., 2000).

Meal distribution, feeding frequency and food type all make up the feeding method. All three aspects play important roles and have varied effects on the behaviour of cats. Deng and her colleagues (2011) did research about the effect of feeding frequency on physical activity in adult cats. The difference in activity of six cats receiving two meals a day and six cats receiving four daily meals was observed. The voluntary activity levels were monitored by Actical activity monitors for seven days. Deng and co-workers found no significant difference in activity levels in cats fed two or four meals a day, although they suggested different daily activity patterns in cats fed one meal a day compared to those in cats fed multiple meals (not tested statistically). In humans there is an association found between an increased eating frequency and lower body weight status. A study of Drummond et al. (1998), found an association between increased eating frequency and lower body weight in men, but not in women. In this study, 48 men and 47 women between 20 and 55 years old and with a Body Mass Index between 18 and 30 were recruited. Male subjects with a high eating frequency appeared to compensate their food intake by reducing the mean energy consumed per eating episode and by this way did not increase their total energy intake. Female subjects were less capable to compensate for energy intake and had an increase in total energy intake when eating frequency increased.
Next to the feeding frequency also the food predictability is an important factor that affects prandial behaviours in animals and humans. In feral cats food predictability is important for current hunting behaviours (Surguss and Hurley, 2005). In cats housed as pets, food predictability effect pre-prandial and prandial behaviours. The knowledge about the time the next meal will be present is important for the moment of termination of the present meal. In a study of De Graaf et al. (1999) human subjects eat more when these subjects knew they had no access to food for the next two hours compared with a situation where the following meal was twenty minutes ahead. Future availability of food is therefore an important factor when deciding on the current consumption. It is also shown that dopamine neurons are more active when pleasant foods are suddenly and unexpectedly received (Roitman et al., 2004). Roitman studied this by using rats in an operant conditioning test. The rats had learned to press a lever in order to obtain a sucrose reward. During the test the dopamine release in the brain of the rats was observed. In half of the rats a light cue was given to signal for an upcoming sucrose reward. The naive rats had the same training but were never signalled with a light cue before being rewarded with sucrose. During the test, different dopamine responses were observed in the naive and trained rats. The peak of the dopamine surges were found when the lever presses occur. When the sucrose was consumed no further increase in dopamine was found. These results implicate that dopamine signalling is linked with the pre-prandial phase (wanting) and also reveal that unexpected meals lead to a higher dopamine response. To conclude from this part, meal frequency and food predictability apparently have important effects on prandial behaviours (especially pre-prandial behaviour), including in cats.

The domestication of cats has led to a restriction in the level to which cats can choose their own food source and eating times but also made it easier for the cat to obtain food. Cat owners offer foods that are nutritionally complete, safe, and with high caloric contents. This changed the prandial behaviours of cats. Instead of consuming multiple small preys a day, cats that are housed as pets consume only a

few meals a day and do not have to be very active and motivated to obtain those meals. Some cats adapt well to these feeding methods but the number of overweight cats is high and still increasing. Only limited research is available about the extent to which feeding methods determine the body condition in cats. Therefore, this study aims to find associations between feeding method and risk factors of overweight and obesity in the domestic cat (*Felis sylvestris catus*). Type of food (e.g. (caloric) content and palatability) is an important risk factor for overweight in pets but is not included in this research. This study aims to find out in what degree feeding method (e.g. meal schedule) effects the prandial behaviour and physical activity and in this way the body condition and health in domestic cats. During a behavioural research, prandial behaviour and physical activity of cats are observed and potential risk behaviours for overweight are determined. Additional to the behavioural research an owner's questionnaire is used to gain insight in the effects of feeding method on physical activity, prandial behaviour, body condition, and health of domestic cats in household environments. Fig. 1 presents schematically the different aspects of the research.

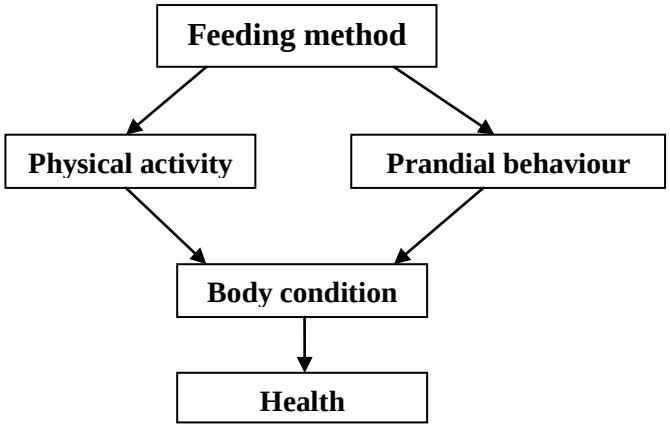

Fig. 1: Structural equation model testing relationships among feeding method, physical activity, body condition, health, prandial behaviour and their link with overweight and obesity in cats.

We hypothesized that an increase in feeding frequency will lead to more natural feeding patterns and will influence physical activity, body condition, and health in cats positively. Having a better insight in the physiological and behavioural responses in cats derived from a specific feeding method, will reveal which feeding regimens can be best applied to lower the risk of overweight and obesity in domestic cats.

2. Methodology

This research on the effects of different meal schedules on general activity and feeding patterns in domestic cats consist of two parts; an experiment focussing on prandial behaviours and physical activity of laboratory cats at Wageningen University, and an online survey amongst cat owners.

2.1 Experimental behaviour study

Subjects
Fourteen domestic shorthair cats from the Wageningen University were used for behavioural observations during the time that cats were on one of different meal schedules. Two of the cats got health problems during the test and therefore the data of these animals were not used for further analyses. More information about the subjects can be found in Table 1 and Appendix 1.

Table 1: Characteristics of the 12 study subjects (Mean ± SE)

Parameters	♂	♀
Number of animals	6	6
Age (months)	22.8 ± 1.8	23 ± 2.4
Bodyweight (grams)	3075 ± 63.8	2605 ± 45.6

The cats were housed in two groups, a male group of eight males and a female group of eight females. The cat facility was equipped with an indoor and outdoor area where the cats could climb, jump and there were several resting areas. The cats were used to being fed two restricted meals a day, as provided outside the cat rooms in the morning (08:00 hour) and afternoon (15:00 hour). Water was available ad libitum. There was a light-dark cycle of 13 hours of light (lights off at 20:00 hour). The temperature in the cat room fluctuated between 20°C and 23°C.

Study design
The prandial behaviour and general activity was compared between cats receiving different meal schedules. Table 2 shows the four different meal schedules and the number of cats per treatment.

Table 2: Feeding methods

Treatment	**Meal schedules**	**# cats**	**# ♂**
Treatment 1	2 meals with fixed intervals	2	1
Treatment 2	6 meals with fixed intervals	4	2
Treatment 3	6 meals with random intervals	4	2
Treatment 4	Ad libitum	2	1

The meal schedules existed of two meals per day, six meals per day at fixed and random intervals, and ad libitum feeding. Each individual cat received one specific meal schedule during the study period. Cats from treatment one (two meal feeding) received their food at 10:00 hour and 18:00 hour. The cats in treatment two received their six meals at fixed intervals of two hours, with the first meal starting at 9:00 hour. The cats with treatment three received their food at unpredictable random times with at least one hour interval between two meals. These cats received their meals randomly between 9:00 hour and 19:00 hour each day. All cats with random feeding times experienced a different daily feeding schedule. The ad libitum fed cats could eat during day and night and had access to 300 grams of food which was provided in the morning once a day.

During the study period cats received the food in a special feeding station which was installed in their home room. The feeding station was made of Perspex on top of a wooden platform and was 90x40x60 (lxbxh) centrimetres in size. The test-cat could enter and leave the feeding station at any times during the test week. In this week only one specific cat could enter the station by use of the Microchip ID System (Sure-Flap®) in the cat flap which was installed in the front of the transparent box. To prevent other cats entering, the passage of the cat flap was extended ten centimetres and narrowed. Also a Perspex wall was installed inside the box in order to force the cats to curve their way towards the food.

In this way, the cat flap system closed faster, preventing other cats to sneak into the feeding station. Before the start of the research the cats were trained how to use the cat flap system and were habituated with eating out of a pet feeder inside the feeding station. The training of the cats was done by luring the cats towards the cat flap by use of a food reward. The feeding area in the box could be accessed by the researchers through a special door which was located at the top of the box and on the side of the box. An automatic six day pet feeder from the producer Andrew James was used to keep the feeding times fixed. The pet feeder could be programmed for a maximum of six different feeding times a day with a minimum interval of one hour between two meals. The feeder consisted of a horizontal, motor driven disk on which six food cups were positioned side by side. The disk was enclosed by a plastic cover with one opening which permitted access to only a single food cup at any given time. The ad libitum fed cats received their food in one food bowl placed in the feeding station. A digital weighing scale with data logger was installed underneath the pet feeder and food bowl. This registered changes in the weight of the pet feeder and food bowl. The weighing scale that was used was the A&D EK-2000i and was combined with the portable data logger: AD-1688. The time interval for registration weight loss varied per treatment, with treatments 1, 2, and 3 having an interval of ten seconds and treatment 4 having an interval of twenty seconds. A schematic overview of the research set-up can be seen in Fig. 2.

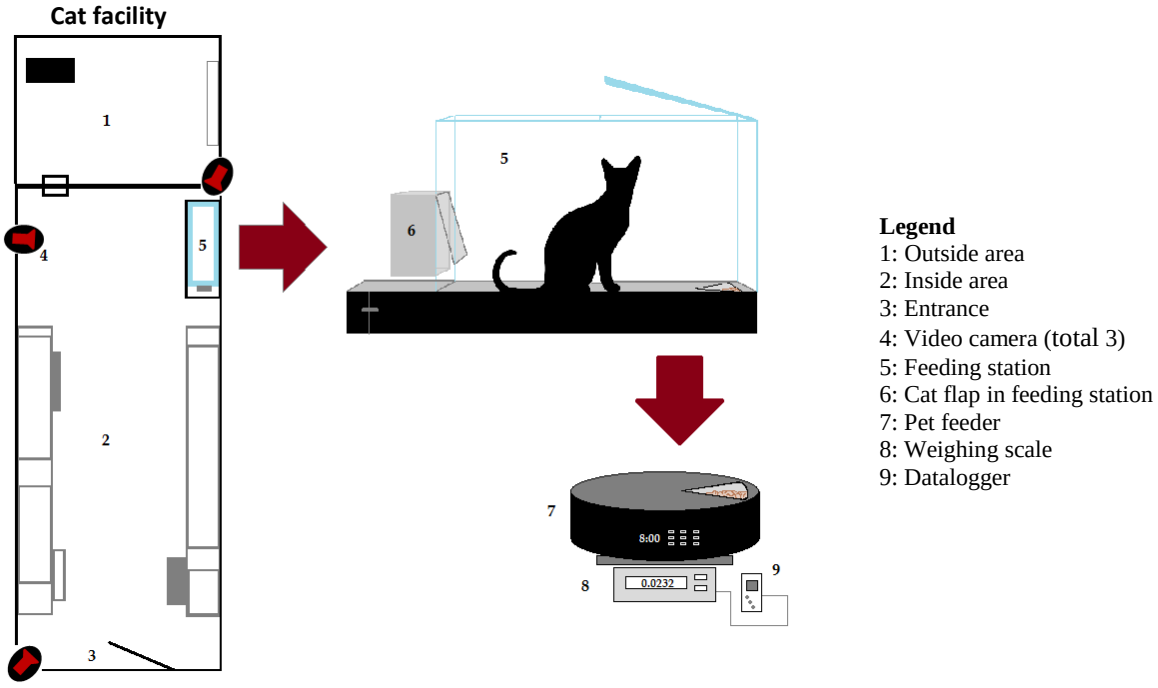

Fig. 2: Schematic overview of the research set-up

Throughout the study the cats consumed a commercial premium dry cat food (Perfect Fit –In Home – Chicken®). The ad libitum fed cats (treatment 4) ate a variable food amount per day and the fixed meal fed cats (other treatments) received a same amount of food every day. This daily amount of food was based on the age and weight of the cat and the type of food served. The daily food consumption of the test cat was noted during the whole test period.

The habituation period to an experimental meal schedule, as provided automatically in the feeding station, was from Monday till Thursday (4 days). On Mondays and Tuesdays cats were aided in becoming aware that food was available to them inside the feeding station. This by putting the cat in front of the entrance of the feeding station. On Friday, following a 4-day habituation period, the pre-prandial, prandial and postprandial behaviour of each cat was observed. On this day, disturbances by humans were kept to a minimum. The cat rooms were video recorded on Tuesday, Thursday and Friday from 05:00 hour till 20:00 hour, the location of the video cameras can be seen in Fig.2. Three cameras were used per room and approximately eighty percent of the room could be observed, the

outside area could not be observed. The weight of each cat was noted on Monday and on Friday. In this way the weight differences before and after the introduction of the new feeding method was examined (see Appendix 1).

Activity monitoring
To observe a possible change in general activity with a change in meal schedule, each cat was fitted with an Actical Activity Monitor® (Mini Mitter, Bend, OR, USA) to a neck collar. The Actical was 28×27×10 mm in size and weighs 17 grams. An Actical monitor, also known as accelerometer, contains omnidirectional sensors that are capable to register the intensity and duration of movements (Deng et al., 2011). The use of this monitor in research with cats has been validated by the study of Lascelles et al. (2008). In the present study, each cat wore the Actical for two periods of six full days, from Tuesday 09:00 hour till Monday 09:00 hour. The first week of wearing the Actical, the 'normal' activity of the cat was observed (= control week), i.e. when cats received their regular meal schedule consisting of two restricted meals a day. The second week of wearing the Actical, the experimental meal schedule was applied. Actical data was collected with the Actical 3.0 program. The Actical software presented each interval count (each number) as activity counts and the activity levels were expressed as activity counts per epoch (epoch length is 15 seconds). To control the variability, each cat wore the same Actical in the first and second week.

Behavioural observations
Scoring of the behaviours was done with The Observer XT 10.0 (Noldus Information Technology B.V., Wageningen, The Netherlands). Behaviours were scored with Focal Sampling Continues Recording and the observed behaviours can be found in the ethograms of Appendix 2. The observations were done for all cats on Friday (test day). Pre-prandial behaviour was observed during the five minutes before entering the feeding station and postprandial behaviour was observed during five minutes directly after leaving the feeding station. Prandial behaviour was observed for the total time the cat was inside the feeding station. The observations of the prandial behaviour started when the cat had their front paws inside the feeding station and stopped when the cat had two (front) paws outside the feeding station These observations were done for six visits per individual cat on the test day, where three times concluded a visit when a meal was present and three times a visit when no meals were present. The observed visits were randomly chosen. Some cats did not visit the feeding station six times on the test day, therefore all visits (<6) were observed for these cats. The scored behaviours were displayed as percentages of the observation time when the cats were visible.

Data processing and statistical analyses
The data of the weighing scale (data logger) was put in Microsoft Access were it was converted to calculate eating time, eating rate, and the number of meals consumed. The eating time was found by first calculating when a meal episode starts and stops. In some occasions the cats pressed on the weighing scale with their paws or snout, causing erroneous recordings, and therefore the data had to be filtered. To correct for erroneous recordings, a new meal was assumed to start when the weight decreased at least 0.5 grams and with a maximum weight loss of 15 grams. Weight losses of more than 15 grams were considered as incorrect. When there was no weight loss between the records for two minutes, the following weight loss was noted as the next meal. Each meal received a meal number in a chronological order with first meal started after 08:00 hour. Finally, only meals with two records, thus lasting at least 15 seconds, were considered to be correct meals. Single records of weight loss were removed from the data. The formula used to calculate the eating rate per meal was: Eating rate per meal number = Food intake * (60/ Eating duration). Only the data of Friday (test day) was used for the statistical analyses.

The Actical data of all cats was transferred to Microsoft Access were it was converted to calculate activity per hour. This was done by summing up the Actical counts per epoch (15 seconds) for each clock hour. Only the activity counts from Tuesday until Friday were used for further analyses. Also weekday and treatment were added to the data. For further analyses the activity data on the test day

and during the control/test week (4 days) were used. The total activity counts per cat from the test day were used to have a total activity score of each cat.
A linear regression model was carried out with Microsoft Excel 2010. The activity counts (per animal) and the number of visits to the feeding station (per animal) on the test day were fitted in a regression model, with the activity counts as dependent variable and the number of visits as independent variable. The R-squared was used as criterion for how well the model fitted the data. R-squared ranges between 0 and 1, where 0 indicate that the model explains none of the variability of the response data around its mean. A scatterplot was made for providing an overview of the data (activity counts x visits) with the linear line fitted.

The adjusted data of the weighing scale, Actical activity monitors and scored behaviour were analysed with Restricted Maximum Likelihood (REML) by use of a Linear Mixed Model (LMM) in the computer program GENSTAT (GenStat 2000). REML assumes data to have a normal distribution, which is not strictly the case for binary or count data, but LMM takes the actual distribution into account and implements REML-type analyses. REML was used to test for a significant difference between the four meal schedules. The response variates (Y) included the observed behaviours as can be seen in Appendix 2. The fixed part of the model contained the meal schedule and the individual cats were fitted as random effect to account for covariance between multiple measurements in the same individual. The general model fitted was: $Y_{ij} = \mu + \text{Meal schedule}_i + \text{Cat}_j + e_{ij}$. With the behaviour as response variate (Y), overall mean (μ), fixed effect of the four meal schedules (Meal schedule), random effect of the twelve cats (Cat), and a random error term (e). The basic model was extended in order to account for the meal phase; pre-prandial and postprandial. An interaction term was included to test if meal schedule effects manifested only in the pre-prandial or postprandial phase. This resulted in the following model: $Y_{ijk} = \mu + \text{Phase}_i + \text{Meal schedule}_j + \text{Phase}_i \bullet \text{Meal schedule}_j + \text{Cat}_k + e_{ijk}$. Only this extended model was used for further analyses.

The cats activity levels, represented in the Actical counts, were analysed for effects of meal schedule as well as those of day of the week and clock hour. The statistical model fitted was as follows: $Y_{ijkl} = \mu + \text{Weekday}_i + \text{Clock hour}_j + \text{Meal schedule}_k + \text{Weekday}_i \bullet \text{Meal schedule}_k + \text{Clock hour}_j \bullet \text{Meal schedule}_k + \text{Cat}_l + e_{ijkl}$, with activity counts (Y), overall mean (μ), fixed effect of the four meal schedules, fixed effect of Weekday, fixed effect of Clock hour, interaction effect of Weekday and Meal schedule, interaction effect of Clock hour and Meal schedule, random effect of cat (Cat), and a random error term (e). Additionally, the difference in activity of cats fed two meals (N=2) was examined to test if there was a difference in activity between the control week and test week. In both weeks these cats received two similar sized meals. A statistical model was used to test mainly for an effect of type of week (control versus test) on activity counts; $Y_{ijkl} = \mu + \text{Weekday}_i + \text{Clock hour}_j + \text{Week}_k + \text{Weekday}_i \bullet \text{Week}_k + \text{Clock hour}_j \bullet \text{Week}_k + \text{Cat}_l + e_{ijkl}$.

From the models ran by GenStat we retrieved the probability levels, predicted means and standard errors. A probability of $P< 0.05$ was considered significant and a trend considered $P< 0.10$. Significant contrasts between fixed effect levels were identified when differences between two predicted means were greater than twice the standard error of the difference.

2.2 Survey

Next to the behavioural study, the feeding methods, behaviour, and health of privately owned cats was examined by use of an owners questionnaire. Survey Project 2.1.0.0 was used to make the survey online accessible. A total of 1008 participants filled in the survey. Candidate participants were recruited via advertisements in national media and on the website of the Wageningen University and Research Centre. The questions in the survey were partly based on the questions already used in the surveys of Russell et al. (2000), Colliard et al. (2009), and Robertson (1999). The used survey questions are presented in Appendix 3 (survey questions are in Dutch). The survey contained questions about the general characteristics of the cat (age, breed, gender, neuter status, and home environment) and questions regarding the applied feeding methods the owners use. Questions about

the type of food, a health score (1-100), food motivation, and body condition were included to find a possible link with feeding method. The body condition was scored by use of the Body Condition Score (BCS) which consisted out of nine levels ranging from 1 (emaciated) to 5 (ideal) to 9 (obese). The BCS was scored by the owner, aided by pictures of cats with given BCS scores, as available in Appendix 3.

Cats that were too young (<1 year old) or too old (>15 years old) were excluded for further study as the BCS in kittens and senior cats is mainly influenced by the age of the cat (Lund et al., 2005). Additionally, the health score is possibly also not reliable in senior cats and therefore only adult cats were included. Also, cats that received a special diet feeding were not taken in the research. After filtering, a total of 750 cats were included in the research. The survey answers were digitally processed in Microsoft Access and descriptive analyses were done to associate feeding methods used among the participants with for example cat Body Condition Scores. To make the data (the answers) more suitable for analyses, part of the data was categorized. The BCS score of cats was assigned by the owner with use of the 9-point scale. These scores were classified for analyses as underweight (score 1, 2 and 3), ideal weight (score 4 and 5) and overweight (score 6, 7, 8 and 9). The answers about how often the cats were fed were classified as meal feeding (1-4 meals per day) and not meal feeding (0 meals). Data of the health score was categorized as healthy (score 0-49) and unhealthy (score 50-100). Cat owners were asked about the behaviour of their cat when provided with food. Four options were given, with two answers indicating high food motivation (the cat is often begging for food) and the other two answers indicating low food motivation (low response towards food and few begging behaviours). In this way the cats were classified as high (food) motivated cats and low motivated cats. The data of how often owners gave treats to their cats were easily grouped as: not given treats, sometimes given treats and often given treats. Regarding food quality, owners were asked about the brand of the food given to their cat. Based on the answers cats were sorted for receiving A-class or B-class food. A-class food consisted of premium cat food and (raw) meat and B-class food comprised of lower quality food. Owners rated the activity of their cat for the morning, afternoon and evening with a 0-100 scale for each part of the day. The physical activity scored by the owners was converted into three classes with scores between 0-50 as not classified, scores between 51-150 as ‘low activity’ and scores between 151-300 as ‘high activity’. Cats with scores between 0-50 were not used for further analyses because we suspect that in these cases owners did not answer the questions correctly and the default 0 was left unchanged.

Chi-square calculations were done to examine associations in the data. Linear regression analyses were carried out with Microsoft Excel 2010. In the model, the original activity scores filled in by cat-owners were used as the dependent variable and the BCS (1-9) was used as the independent variable.

3. Results

Twelve cats were examined for their behaviour when they were fed according to predetermined meal schedules. Information about the cat characteristics (i.e. gender, age, BCS, weight, etc.) can be found in Appendix 1. The behaviour of the cats was observed inside and around the individual feeding station and feed intakes were calculated from weighing scale datalogger records. Voluntary physical activity of the cats was monitored by Actical activity monitors.

3.1 Experimental behaviour study

The cats' visits to the individual feeding stations, eating patterns and general physical activity patterns were recorded continuously; data is summarized in Table 3. The duration (time in seconds) of the cats inside the feeding station was calculated for all visits on the test day. The weighing scale below the feeder in the feeding station registered the decline in weight when the cats were eating. The weighing scale registered the eating rate, food intake per eating bout and the eating duration. The physical activity of the cats was registered by the Actical activity monitors that the cats wore during the control week and the week of treatment. Results can be found in Table 3.

Cats which receive two meals a day, and the ad libitum fed cats, spent significantly longer time in the feeding station per visit compared with the cats fed six meals a day (P=0.001, see Table 3). No significant differences in visiting times were found between cats fed six times at fixed times and at random times. Daily times spent inside the feeding station, and the number of times inside the station per day did not differ between the meal schedules. No significant effects were seen between the meal schedules for eating rate, food intake and eating duration.
The physical activity of the cats, expressed as mean activity counts per hour, was tested for differences between the control week (when cats received the normal two meal feedings), and the treatment week (representing meal schedules). No significant effects of meal schedules were found on activity counts. Also, no significant difference was seen between the activity in the control and treatment week.
The correlations between the number of times the feeding station was visited and the activity of the cats are presented in Fig. 3.

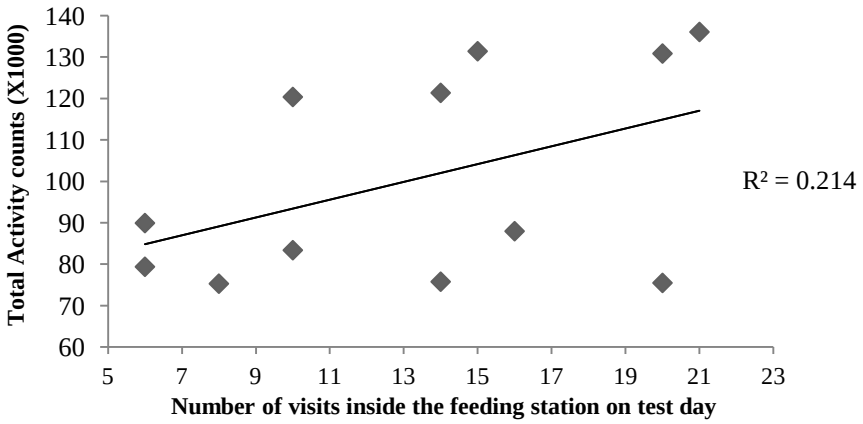

Fig. 3: The correlation between daily physical activity (total activity counts for 24h) and total number of feeding station visits per cat (*N*=12) on the test day when cats were on an experimental meal schedule. The number of visits per cat is shown on the x-axis and the total activity per cat on the test day is presented on the y-axis. A linear trend line indicates the (non-significant) change in activity counts with the increase in number of visits.

No correlation was found between the activity of the cats and the number of visits to the feeding station on the test day (R^2=0.214; *P*=0.130, see Fig. 3). The relationship between y (activity) and x (number of visits) was displayed in the formula: y = 2152.1x + 71872. The mean (±SE) of activity counts was 100566.5 (± 24960.0) and mean (±SE) number of visits per day was 13.3 (± 5.4).

Table 3: Predicted mean scores (±SE) for cats (*N*=12) in general and on different meal schedules. Cats had access to two meals a day, six meals a day (at fixed intervals or random times) or ad libitum access to food. Food was available through an automated feeder placed in an individual feeding station. Response variates (column 1) were tested for effects of meal schedule using a mixed model. Records of the individual parameters are shown in column six. Records of the mean time per visit, total duration and number of times in station are based on the total number of visits on the test day. Within a row, predicted means for meal schedules differ significantly when not sharing any letter in their superscripts.

Parameter	**General**	**Meal schedule**				**Records**
		Two meals	**Six meals fixed**	**Six meals random**	**Ad libitum**	
Duration time in feeding station						
Mean time per visit (s)	172.2 ± 14.3	238.7 ± 34.1[b]	106.6 ± 18.8[a]	106.1 ± 21.2[a]	237.4 ± 36.0[b]	78
Total duration per day (s)	1659.0 ± 191.8	2053.0 ± 442.9	1697.0 ± 313.2	1342.0 ± 313.2	1545.0 ± 442.9	12
# times in station	12.6 ± 1.5	14.5 ± 3.4	15.0 ± 2.4	14.8 ± 2.4	6.0 ± 3.4	12
Eating behaviour						
Eating rate (grams per minute)	5.7 ± 0.8	5.7 ± 1.7	5.0 ± 1.3	4.1 ± 1.4	7.9 ± 1.8	58
Intake (grams per eating bout)	18.0 ± 7.5	19.1 ± 17.4	28.0 ± 12.3	8.5 ± 12.2	16.4 ± 17.3	58
Eating duration (s)	208.9 ± 25.0	284.8 ± 59.5	184.0 ± 42.1	145.6 ± 41.3	221.2 ± 56.6	58
Activity counts						
Activity counts test day (h)	4134.0 ± 356.9	4402.0 ± 824.3	4321.0 ± 582.9	4286.0 ± 582.9	3526.0 ± 824.3	288
Activity counts control week (h)	5293.0 ± 400.8	5437 ± 925.5	5429 ± 654.4	4916 ± 654.4	5391 ± 925.5	1152
Activity count treatment week (h)	4509.0 ± 238.1	5045.0 ± 550.0	4980.0 ± 388.9	4830.0 ± 388.9	3181.0 ± 550.0	1152

Prandial behaviour was also observed during the time the cats were inside the feeding station when a meal was present. The results of the behavioural scores for prandial behaviour of cats on different meal schedules are presented in Table 4.

Table 4: Predicted means of prandial behavioural scores (±SE) for cats (N=12) on different meal schedules. Food was available through an automated feeder placed in an individual feeding station. Response variates (column 1) were tested for effects of meal schedule using a mixed model. Observations within a row are based on 40 records and based on the mean observation time of 205.7 seconds (83.2-593.0) when the cat was inside the box and a meal was served. Differences between meal schedules were never significant.

Parameter	General	Meal schedule			
		Two meals	Six meals fixed	Six meals random	Ad libitum
Eating	56.4 ± 4.5	43.8 ± 11.0	56.8 ± 7.3	52.4 ± 7.3	71.9 ± 10.2
Food oriented	21.2 ± 2.3	24.0 ± 5.8	23.6 ± 3.6	24.5± 3.6	12.6 ± 4.9
Attempting to access food	6.9 ± 2.5	10.5 ± 6.5	6.4 ± 3.9	10.7 ± 4.0	0.0 ± 5.4

No significant effect was found between the observed time spent eating between the four meal schedules. Descriptively, the cats fed two daily meals spent the least amount of time eating per visit. No differences between the meal schedule were found for behaviours as being food oriented (e.g. sniffing and chewing) and attempting to access food (e.g. scratching feeder). Albeit not significant, cats fed ad libitum showed these food searching behaviours almost never.

The cats' location, activity movements and grooming behaviour outside the feeding station was recorded around the time of consuming a meal (i.e. five minutes before and five minutes after) and the results of the observations are shown in Table 5.

Table 5: Predicted mean behavioural scores (±SE) for cats (*N*=12, 136 records) in general and for when they were on one of the different meal schedules: cats had access to two meals a day, six meals (at fixed intervals or random times) a day or ad libitum access to food. Food was available through an automated feeder placed in an individual feeding station. All behaviour scores are expressed as percentages of the total observation time when the cat was in sight (fixed observation bouts of ten minutes). Response variates (column one) were tested for effects of meal schedule using a mixed model. Effects of meal schedule were never significant.

Parameter	General	Meal schedule			
		Two meals	Six meals fixed	Six meals random	Ad libitum
Location					
Near the station	3.7 ± 1.2	2.6 ± 2.9	7.6 ± 1.9	3.0 ± 1.9	1.5 ± 3.0
On station	5.1 ± 2.5	2.0 ± 5.8	5.0 ± 4.0	7.9 ± 3.9	5.5 ± 5.9
In front of station entrance	12.9 ± 1.8	16.0 ± 4.3	10.5 ± 2.8	11.6 ± 2.8	13.5 ± 4.5
Activity					
Walking	20.3 ± 2.1	17.2 ± 5.0	22.4 ± 3.3	15.6 ± 3.2	26.0 ± 5.2
Running	1.1 ± 0.3	1.3 ± 0.7	1.5 ± 0.5	1.2 ± 0.5	0.4 ± 0.8
Standing	13.5 ± 1.7	14.6 ± 4.1	11.4 ± 2.7	12.8 ± 2.7	15.2 ± 4.2
Sitting	35.9 ± 2.7	36.1 ± 6.3	32.4 ± 4.1	32.5 ± 4.0	42.6 ± 6.6
Grooming behaviour					
Grooming face	2.5 ± 0.6	3.7 ± 1.5	1.8 ±1.0	2.3 ± 1.0	2.3 ± 1.6
Grooming body	4.0 ± 1.0	5.4 ± 2.3	3.3 ± 1.5	2.6 ± 1.5	4.7 ± 2.5

The cats in all treatment groups spent little time near the feeding station, as presented in Table 5. No differences between the meal schedule groups were found in the activity behaviours (walking and running) or sitting and standing. Facial grooming and body grooming was observed in all meal schedule groups although the cats spent limited time on grooming behaviours (~6.5%). We found no effects of meal schedule on the grooming behaviour of the cats.

Additionally, the cats' location, movements and grooming behaviour was analysed whilst discriminating the pre-prandial phase from the postprandial phase. The location, movements and grooming behaviour of the cats was scored five minutes before entering the feeding station (pre-prandial phase) and five minutes after leaving the feeding station (postprandial phase). Results from a statistical analysis on the fixed effects Meal schedule, Phase (pre-prandial, postprandial) and interactions between these are presented in Table 6. Interaction effects were never significant, though

for sitting there was a trend (P = 0.094), and the same applied to effects of Meal schedule. Phase effects were found for sitting (P < 0.001) and grooming (P = 0.001).

When comparing the behaviour before and after a meal no difference occurred for the location of the cats, the activity movements (walking and running) or grooming, but across meal schedules (P ≤ 0.001 for Phase effect) cats sat more after a meal than before and similarly engaged more in facial grooming after meal consumption.

The general activity of the cats was analysed for effects of meal schedule using a Mixed Model that accounted for time of day (Clock hour) and day of the week (Week day). The used Mixed model contained the activity counts as the response variate, the fixed effects: Clock hour, Weekday, and Meal schedule, and two-way interactions (Clockhour*Meal schedule and Weekday*Meal schedule). Table 7 shows the P-values for the fixed effects.

Table 7: P-values (column 2) for the fixed effects (column 1) of a Mixed Model analyses on activity scores in cats (*N*=12, 1152 records) kept on one of four meal schedules. Meal schedules consists of two meals a day, six meals (at fixed intervals or random times) a day and ad libitum access to food. Weekday includes Tuesday till Friday and Clock hour included 24-hours (08:00, 09:00,...07:00).

Fixed effects	***P*-value**
Weekday • Meal schedule	0.725
Clock hour • Meal schedule	<0.001
Meal schedule	0.104
Clock hour	<0.001
Weekday	0.016

The interaction between the day of the week and meal schedule had no effect on the cats activity (*P*=0.725), but a significant interaction effect occurred between meal schedule and clock hour (*P*<0.001). Also, in general the time of the day affected the activity of the cats significantly (P<0.001). Day of the week alone affected the activity of the cats (*P*=0.016) in that on Friday the observed cats were significant less active compared with Tuesday. For the week days Tuesday to Friday the respective means were: 4937^{b},4622^{ab},4343^{ab}, and 4134^{a}. A closer view on the daily activity patterns of the cats receiving different meal schedules (different lines), is presented graphically with activity counts on the y-axis and Clock hour on the x-axis (see Fig. 4).

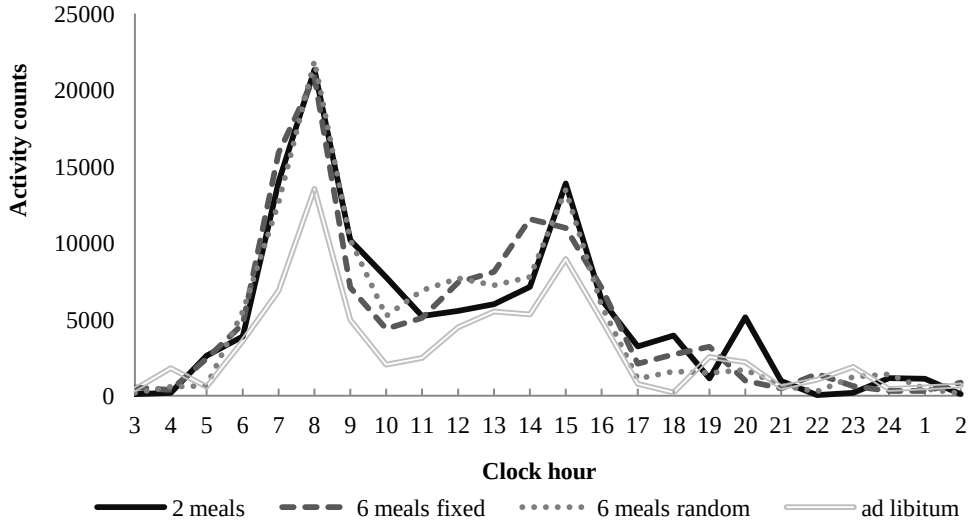

Fig. 4: Predicted means of daily physical activity (activity counts/epoch) of cats with four different meal schedules per clock hour. Two meals *N*=2, 6 meals fixed *N*=4, 6 meals random *N*=4, ad libitum *N*=2.

Table 6: Predicted mean behavioural scores (± SE) for cats (*N*=12, 68 records) in general and on different meal schedules. Cats had access to two meals a day, six meals a day (at fixed intervals or random times) or ad libitum access to food. Food was available through an automated feeder placed in an individual feeding station. All behaviour scores are expressed as percentages of the observation time when the cat was in sight. Observations bouts are presented in pre-prandial and post-prandial phase (fixed observation bouts of five minutes per phase). Response variates (column one) are tested for effects of meal schedule and phase using a Mixed Model with interaction effects. For each parameter, predicted means differ between the pre-prandial phase and the postprandial phase when not sharing any letter in their superscripts.

Parameter	Phase	General	Meal schedule			
			Two meals	Six meals fixed	Six meals random	Ad libitum
Location						
Near the station	pre-prandial	4.1 ± 1.6	4.9 ± 3.8	6.5 ± 2.6	2.8 ± 2.6	2.1 ± 3.9
	postprandial	3.3 ± 2.1	0.4 ± 4.8	8.8 ± 3.3	3.3 ± 3.3	0.9 ± 4.9
On station	pre-prandial	6.6 ± 3.4	0.5 ± 7.8	4.8 ± 5.3	10.3 ± 5.2	10.8 ± 8.0
	postprandial	3.6 ± 2.1	3.6 ± 4.8	5.1± 3.1	5.3 ± 3.1	0.2 ± 5.0
In front of entrance	pre-prandial	12.0 ± 2.1	7.6 ± 4.9	7.5 ± 3.2	10.6 ± 3.1	22.3 ± 5.2
	postprandial	13.9 ± 3.0	24.4 ± 6.9	13.5 ± 4.5	12.7 ± 4.5	4.8 ± 7.2
Activity						
Walking	pre-prandial	19.0 ± 3.3	19.6 ± 7.7	19.8 ± 5.1	11.8 ± 5.0	24.8 ± 8.1
	postprandial	21.7 ± 2.4	14.8 ± 5.7	25.1 ± 3.7	19.4 ± 3.6	27.2 ± 6.0
Running	pre-prandial	1.0 ± 0.3	0.5 ± 0.7	1.9 ± 0.4	1.4 ± 0.4	0.2 ± 0.7
	postprandial	1.2 ± 0.5	2.0 ± 1.1	1.2 ± 0.7	1.1 ± 0.7	0.6 ± 1.2
Standing	pre-prandial	11.6 ± 2.1	9.5 ± 5.0	8.8 ± 3.2	12.3 ± 3.2	15.9 ± 5.3
	postprandial	15.4 ± 2.7	19.7 ± 6.3	14.1 ± 4.2	13.4 ± 4.2	14.3 ± 6.4
Sitting	pre-prandial	25.8 ± 4.3^{a}	17.3 ± 9.9^{a}	23.8 ± 6.6^{a}	27.4 ± 6.5^{a}	34.9 ± 10.3^{a}
	postprandial	45.8 ± 3.5^{b}	54.9 ± 8.1^{b}	41.1 ± 5.2^{b}	37.5 ± 5.1^{b}	49.9 ± 8.5^{b}
Grooming behaviour						
Grooming face	pre-prandial	0.5 ± 0.4^{a}	0.0 ±1.0^{a}	0.6 ± 0.6^{a}	1.2 ± 0.6^{a}	0.0 ± 1.0^{a}
	postprandial	4.6 ± 1.3^{b}	7.3 ± 2.9^{b}	3.0 ± 2.0^{b}	3.3 ± 1.9^{b}	4.7 ± 3.1^{b}
Grooming body	pre-prandial	2.9 ± 1.7	3.7 ± 3.9	4.0 ± 2.5	3.2 ± 2.5	0.6 ± 4.1
	postprandial	5.2 ± 1.4	7.1 ± 3.2	2.6 ± 2.1	2.1 ± 2.1	9.1 ± 3.3

The cats receiving different meal schedules had similar daily activity patterns with high activity around 08:00 hour and 15:00 hour. All cats showed a drop in activity after 8:00 hour, with this drop being less steep in cats fed two meals and in cats fed six meals at random times. The ad libitum fed cats showed significant lower activity around 08:00 hour compared to the cats with other meal schedules. These interpretations were based on when the difference between two predicted means were greater than twice the maximum standard error of the difference (P<0.05). Ad libitum fed cats showed also significant lower activity at 15:00 hour, though this was not significant compared to cats on six meals feedings at fixed times. At 14:00 hour, cats that received six meals at fixed times showed higher activity compared with cats in other treatments. Cats fed two meals received their first meal at 10:00 hour and their second meal at 18:00 hour, during both feeding times the cats showed the highest activity of all other cats (but not significantly higher). The cats with this meal schedule showed also a small (not-significant) peak in activity at 20:00 hour. Cats receiving six meals at fixed times got their first meal at 9:00 hour with an interval between the meals of two hours. In these cats, higher activity was not shown at the six scheduled feeding times.

The activity of the cats (*N*=2) fed two meals a day in the control week and in the test week was examined to find a possible effect of feeding inside the feeding station on the activity of the cats. In both weeks these two cats received two similar sized meals with seven to eight hours interval between the two meals. A Mixed Model was used to test the fixed effects of Week (control week and test week), Clock hour and Weekday with two-way interactions between the fixed effects. Results are presented in Table 8.

Table 8: P-values (column 2) for the fixed effects (column 1) of a Mixed Model analysis on activity score in cats (*N*=2, 384 records) fed two similar meals in the control week and during the test week. Weekday includes Tuesday till Friday and Clock hour included 24-hours (08:00, 09:00,...07:00).

Fixed effects	***P*-value**
Weekday • Week (control/test)	0.353
Clock hour • Week (control/test)	0.091
Week (control/test)	0.302
Clock hour	<0.001
Weekday	0.783

No significant interaction effect was found between the day of the week and type of the week (control or test) that affected the activity of the cats. During all days of the control- and the test week the activity of the cats was not significantly different. A tendency was seen in the interaction model for Clock hour and type of week (*P*=0.091). Week (control/test) and weekday had no effect on the activity of the cats. As also previously mentioned (Table 7, Fig. 4), Clock hour affected the activity of the cats (*P*<0.001).
Fig. 5 shows a graph of the predicted means of the activity counts of the cats in the control week and test week. During the control week the cats received meals at 8:00 and 15:00 hour and during the test week the meals were provided at 10:00 and 18:00 hour.

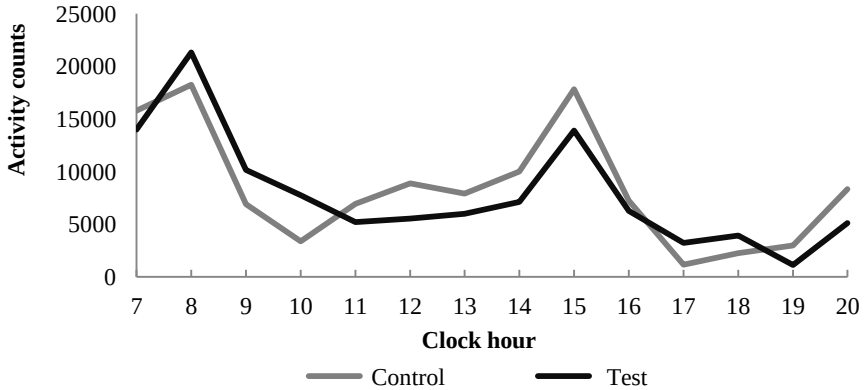

Fig. 5: Predicted means for activity in cats (*N*=2) fed two meals a day during control and test week. Feeding times in control week were at 08:00 hour and 15:00 hour and during the test week the meals were provided at 10:00 and 18:00 hour.

The general activity patterns of the cats during the control week and test week did not differ with changing feeding times, as can be seen in Fig. 5. No significant interaction was found between activity counts and clock hour and week.

3.2 Survey

The survey amongst cat owners included several questions about feeding methods and behavioural characteristics of the cat. Analyses were targeted to the questions of feeding methods and there associations with body condition, health, activity and food motivated behaviours. For a total of 1008 cat questionnaires were received of which a total of 995 different households participated. After filtering (see Methodology), 750 records were retained for further analysis. More information about the selected group of cats can be found in Appendix 4. The survey contained several questions about the applied feeding methods and the eating behaviour, health, and Body Condition Score (BCS) of the cats. Fig. 6 shows the results of the feeding method and feeding time the cat owners used and the BCS of the cats in the research population.

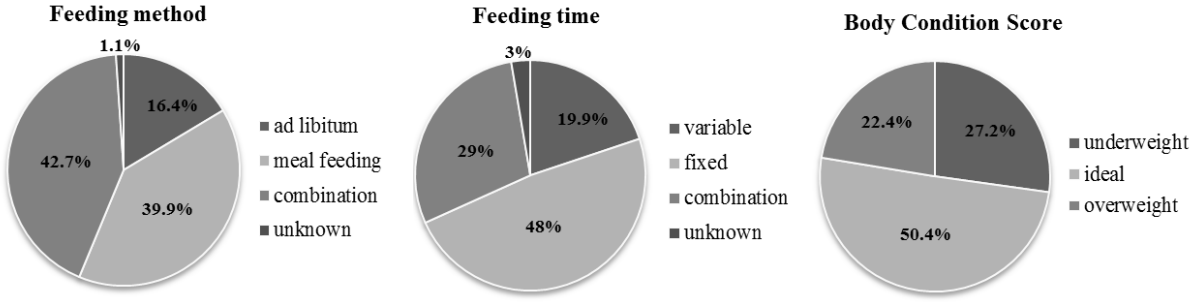

Fig. 6: Distribution of cats per feeding method, feeding times, and BCS in this research population

Feeding methods used by cat owners were ad libitum feeding, meal feeding and a combination of these, with ad libitum feeding being applied the least. From all cat owners that filled in the survey, 48 percent gave their cat food at fixed moments on the day. Providing food at variable day times was reported less. The BCS score of cats was assigned by the owner on the 9-point scale. These scores were classified for analyses as underweight (score 1, 2 and 3), ideal weight (score 4 and 5) and overweight (score 6, 7, 8 and 9), and most of the cats had an ideal BCS score according to the cat owner.
To examine possible interaction effects between two factors a Chi-square tests were carried out. The distribution of cats across different BCS categories and the three feeding methods is presented in Table 9.

Table 9: Number of subjects and standardised residuals (between brackets) as calculated with a Chi-square test for feeding method and Body Condition Score in adult cats. $\chi^2(df=4, N=742) = 30.14, P<0.001$.

	Feeding method			
Body Condition Score	**Meal feeding**	**Ad libitum**	**Combination**	Total
Underweight	58 (**-2.56**)	42 (1.50)	101 (1.54)	201
Ideal weight	152 (0.11)	70 (1.02)	152 (-0.73)	374
Overweight	89 (**2.65**)	11 (**-3.17**)	67 (-0.59)	167
Total	299	123	320	742

There were clear significant associations between feeding method and body condition score ($\chi^2_{(df=4, N=742)} = 30.14$, $P<0.001$), with more cats than expected being classified overweight in the meal feeding group. In the same meal feeding group relative few cats were scored as having underweight. Additionally, there were fewer cats with overweight than expected in the group that received ad libitum access to food. Combination feeding, which often involved a combination with ad libitum pellet feeding and meal feeding of moist food, had no relationship with body condition score.

When performing the same test for cats which received premium quality food, comparable results were found($\chi^2_{(df=4,\ N=280)} = 14.82$, $P<0.01$).
Another question in the survey addressed the number of times the owner provided meals, with owners that provided ad libitum food being recorded as '0 meals'. To correctly analyse the data of this question the data was classified as meal feeding (1-4 meals per day) and not meal feeding (0 meals) and related to body condition scores. The results of this test are presented in Table 10.

Table 10: Number of subjects and standardised residuals (between brackets) as calculated with a Chi-square test for meal feeding and Body Condition Score in adult cats. $\chi^2(df=2, N=732) = 17.42$, $P < 0.001$.

	Type of feeding		
Body Condition Score	**Meal feeding**	**No meal feeding**	Total
Underweight	151 (-0.82)	51 (1.64)	202
Ideal weight	287 (-0.46)	82 (0.92)	369
Overweight	147 (1.62)	14 (**-3.22**)	161
Total	585	147	732

A significant lower number of cats than expected had overweight when fed ad libitum; $\chi^2_{(df=2,\ N=732)} = 17.42$, $P<0.001$. Therefore Table 10 shows similar results compared with Table 9. Although the residuals are not greater than two, a tendency is seen of more cats with overweight in the group of meal feeding, and of many cats with underweight in the group of ad libitum feeding.

Next investigated was the moment the cat received fresh new food (further referred as the feeding times). Owners could answer this question by choosing three options: fixed feeding times, variable feeding times and a combination. Often the combination was chosen when cats received fixed feeding times but also received some food (or treats) at variable times. The feeding times and its effect on the BCS are shown in Table 11.

Table 11: Number of subjects and standardised residuals (between brackets) as calculated with a Chi-square test for feeding times and Body Condition Score in adult cats. $\chi^2(df=4, N=730) = 11.74$, $P < 0.01$.

	Feeding times			
Body Condition Score	**Fixed times**	**Variable times**	**Combination**	Total
Underweight	85 (-1.45)	56 (**2.38**)	59 (-0.09)	200
Ideal weight	193 (0.78)	68 (-0.80)	106 (-0.34)	367
Overweight	85 (0.44)	25 (-1.43)	53 (0.62)	163
Total	363	149	218	730

Significant more underweight cats than expected were seen in the group for which the feeding times were variable; $\chi^2_{(df=4,\ N=730)} = 11.74$, $P<0.01$. The number of cats with underweight tended to be lower when feeding at variable times a day. When only examining the cats which receive premium quality food no significant effects were found, although a comparable tendency was seen between variable feeding times and underweight; $\chi^2_{(df=4,\ N=276)} = 8.04$, $P < 0.1$.

Food motivation may affect the BCS of the cat and cat owners were asked about the behaviour of their cat when provided with food. They could choose from four answers, with two answers indicating high food motivation (the cat is often begging for food) and two others indicating low motivation (low response towards food and only few begging behaviours). In this way the cats were classified as high motivated cats and low motivated cats for further analyses. Table 12 shows the relationship of food motivation with the BCS of the cat ($\chi^2_{(df=2,\ N=744)} = 34.34$, $P<0.001$).

Table 12: Number of subjects and standardised residuals (between brackets) as calculated with a Chi-square test for feeding motivation and Body Condition Score in adult cats (n= 744). Outcome of Chi-square test: χ^2(df=2, N=744) =34.34, P<0.001

		Food motivation		
Body Condition Score		**High motivation**	**Low motivation**	Total
Underweight		74 (-1.85)	128 (1.69)	202
Ideal weight		155 (-1.14)	219 (1.04)	374
Overweight		109 (**3.74**)	59 (**-3.41**)	168
	Total	338	406	744

Table 12 shows a clear significant effect in the observed number of cats with overweight, with significantly high numbers in the group of high food motivated cats and low numbers in the low food motivated cats. When only examining the cats which receive premium quality food comparable significant results were found between motivation and overweight; $\chi^2_{(df=2,\ N=284)}$ =13.77, P<0.001.
Other possible factors that influence the body condition of the cat were examined, like daily activity, food quality, outdoor access and daily time (hours) spending alone, but no association was found with the BCS of the cats.
Food motivation of the cat is assumed to have a relationship with the feeding method applied by the owner. Table 13 shows the relationships between food motivation of the cat and the applied feeding method ($\chi^2_{(df=2,\ N=736)}$ =58.22, P<0.001).

Table 13: Number of subjects and standardised residuals (between brackets) as calculated with a Chi-square test for feeding motivation and applied feeding method. χ^2(df=2, N=736) =58.22, P<0.001.

		Food motivation		
Feeding method		**High motivation**	**Low motivation**	Total
Meal feeding		178 (**3.72**)	120 (**-3.38**)	298
Ad libitum		24 (**-4.11**)	96 (**3.74**)	120
Combination		131 (-1.07)	187 (0.98)	318
	Total	333	403	736

Significant more cats which received meal feedings were classified as highly food motivated. In the ad libitum fed cats significantly less cats were seen with high food motivation and more cats were seen with lower food motivation.

Regarding the health score of the cats, owners gave their cat a health score between zero and hundred. For analyses all cats with a score between zero and 49 were considered healthy. No significant relationships were found between the health scores and feeding methods, feeding times, daily activity, BCS and food motivation. A tendency was seen in given treats and the health score of the cat. Cat owners were asked how often food treats were given and options that could be chosen from were: not given treats, sometimes given treats and often given treats. Results of this test can be seen in Table 14 ($\chi^2_{(df=2,\ N=742)}$ =4.49, P<0.1).

Table 14: Number of subjects and standardised residuals (between brackets) as calculated with a Chi-square test for feeding treats and health score in adult cats. χ^2(df=2, N=742) =4.49, P <0.1.

		Feeding treats			
Health score		**Often**	**Sometimes**	**Not**	Total
High - healthy		138 (-0.73)	229 (0.19)	259 (0.37)	626
Low - unhealthy		36 (1.69)	39 (-0.45)	41 (-0.86)	116
	Total	174	268	300	742

There was a tendency for a high number of cats with a low health score in the group that received treats often. Given treats to the cat was not associated with BCS and dental health.

Owners had to rate the activity of their cat for the morning, afternoon and evening with a 0-100 scale for each part of the day. The physical activity scored by the owners was converted into three classes with scores between 0-50 as ‘not classified’, scores between 51-150 as ‘low activity’, and scores

between 150-300 as ‘high activity’. Cats with scores between 0-50 were not used for further analyses because of a strong suspicion of incorrect data. The Chi-square test revealed no relationship between the activity of cats (low activity group versus high activity group) and BCS, health score, food motivation and the applied feeding method.
To examine if there was correlation between the original data of the activity score (scores 50-300) and the BCS (1-9) a linear regression analyses was carried out. Fig. 7 shows the scatterplot of this regression model.

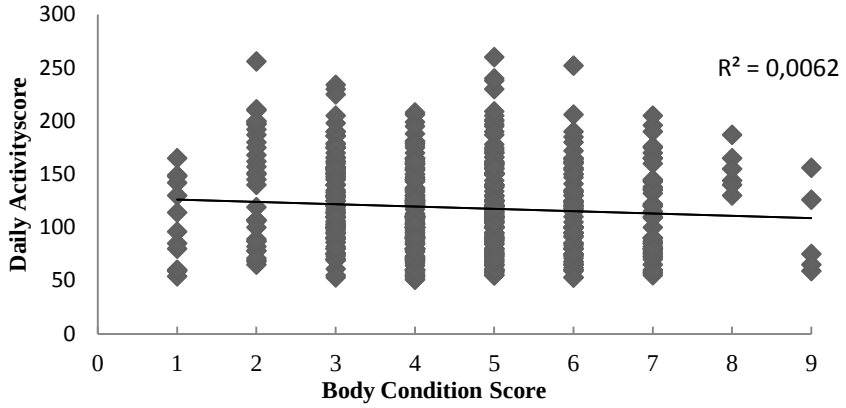

Fig. 7: Linear regression model with Body Condition Score (1-9) and Activity score (50-300) for each cat scored by their owner (*N*=627)

As can be seen from Fig.7, the linear model explains a minimal amount of the variance in the data (R^2=0.0062). A significant (direct) relationship was found though between the BCS and the activity score ($F_{1,626}$=3.9; *P*=0.049): y = -2.1864x + 128.35.

4. Discussion

Cats in first world countries are at serious risk of developing overweight, with recent estimates of over half of the cat population suffering from overweight or obesity (Calabash, 2013). This overweight makes cats vulnerable to a range of health disorders (Laflamme, 2012). Different factors regulate a cat's body condition and more insight in these could help to prevent unwanted fattening of privately owned cats. Feeding methods may both affect energy expenditure, via behavioural activity, as well as energy intake (food consumption), therefore in the current study the effects of feeding method on behavioural activity, food intake and body condition are assessed. To this aim, a survey was conducted among cat owners and the effects of meal schedules on behaviour were recorded in a controlled animal experiment. In this experiment, the prandial behaviours and physical activity of twelve laboratory cats which received four different meal schedules was observed.

4.1 Experimental behaviour study

The behavioural study allowed to investigate if the prandial behaviour, i.e. before, during and after a meal, changed according to the meal schedule the cats received. In theory, the availability of food could affect the motivation before the meal, the liking during the meal and the satisfaction after the meal, as expressed in general activity and grooming.

Meal schedule and its effect on wanting

Where the behaviour during a meal may be more indicative of the degree to which cats like the food, the number of visits to the feeding station may mirror wanting. The wanting system in the brain is fostered by dopamine and is linked to food motivation (Berridge, 2009). The presence of high levels of dopamine in the blood could prove the occurrence of wanting, but this study focuses on the behavioural indicators of food motivation. When looking at the results of the number of visits to the feeding station no significant differences between the cats receiving different meal schedules were found. The cats fed two meals were one average 14.5 times inside the feeding station on the test day, which means the cats were at least twelve times inside the station when no food was present. The cats which received six meals visited the feeding station for around 15 times on the test day and were nine times inside the box when no meal was present. The cats which were fed ad libitum were only few times of the day inside the feeding station (mean of six times). It was expected on forehand that cats fed with a higher feeding frequency would have fewer moments of hunger, reducing the signs of strong food motivation (wanting) like being inside the feeding station. The aforementioned results support that cats receiving two meals showed relatively many food motivated behaviours and cats fed ad libitum showed few. Looking at the number of times inside the box when no meals were served, the six meals fed cats where indeed less often (albeit not significant) inside the feeding station compared with the cats fed two meals. No difference was found between the number of feed station visits of cats receiving six meals at fixed and random times. This is somewhat surprising as the study of Roitman et al. (2004) reveals that a higher dopamine response is seen in rats that receive food rewards at unpredictable times, and on forehand is was expected to see differences in the number of visits in cats fed with regular intervals or randomly.

During the current behavioural study the cats were observed five minutes before entering the feeding station (pre-prandial phase) and five minutes after leaving the feeding station (postprandial phase). It was expected that all cats would be near the feeding station especially prior to meal delivery. During this pre-prandial phase cats are food motivated and food searching behaviours are typically seen (Barbano and Cador, 2005). Contrary to expectations, during the pre-prandial phase the cats in this research were not often near the feeding station at least not more than during the postprandial phase. In general, cats were only a small percentage of the observation time seen near the feeding station and no significant differences occurred in time spent near the station among the cats receiving different meal schedules. Cats on two meals a day were expected to experience realtively strong hunger (Blundell et al., 2010), but were not present near the feeding station more often than the frequently fed cats. It

seems that the presence near the feeding station, in the present study design, was not a good predictor for food motivation (low construct validity).
A possible explanation for not finding strong behavioural differences among cats fed on different meal schedules during the pre-prandial phase is that the cats trained themselves to focus on the sound of the feeder. When the feeder turned it made a little noise, which was a trigger for the cats to enter the feeding station. During most pre-prandial observations the cats were not near the feeding station but ran with a high speed (latency times typically below fifteen seconds) towards the station when the feeder turned. This will have affected the normal anticipation behaviour prior to meals and it is recommended in future studies to use a silent feeder that does not trigger the cats. But registrating the latency times will possible also give insight in the food motivation of the cats and can therefore be used as tool for measuring wanting. The ad libitum fed cats were more present near the entrance of the feeding station during the pre-prandial phase, as these cats were not triggered by the sound of the feeder.

Meal schedule and its effect on liking
Specific behavioural parameters which were recorded on cats inside the feeding station and the duration time inside the feeding station, assumingly provided information on the liking of food. The liking system is linked to the eating behaviour and if fostered by opioids (Berridge, 1996), which are important for the sensory pleasure or palatability of food and for the regulation of food intake (Davis, 2009). Cats fed two meals a day or those that had ad libitum access to food were significant longer inside the feeding station per visit compared with the cats fed six meals (P=0.001). This can be explained by the fact that more food was available for these cats per meal; the cats eating duration was longer, leading to a longer time inside the feeding station. When looking at the total duration inside the feeding station per day, no differences among the meal schedules were found. The cats which were fed ad libitum were only few times of the day inside the feeding station and ate very large amounts (circa 8 grams per minute) of food during almost every visit. After consuming these large meals, it looked like (subjective observation) the cats were more lethargic and were less social towards the other cats and people. Assumingly, these cats overate and may have been nauseous after large meal consumption. Also, the two ad libitum fed cats gained a lot of weight during the test week (see Appendix 1). The results of the ad libitum fed cats are unexpected when considering the natural eating behaviour in cats. In nature, cats consume small amounts of food, spread over several meals during day and night (Kane et al., 1981; MacDonald et al., 1984). When domestic cats receive only a small number of meals, so larger amounts of food per meal, most cats do not consume all the food immediately and increase the number of meals taken throughout the day (Surgess and Hurley, 2005). It was expected that most cats fed ad libitum would show similar eating frequencies as their feral conspecifics. The surprising amount of food consumed by the present cats fed ad libitum may be caused by the novelty of the feeding schedule. The cats were used to have only two restricted meals a day with relative low amounts of food per meal. The BCS of the cats, presented in Appendix 1, is quiet low and most of the cats were lean. Possibly, the cats in the study experience a minor degree of hunger due to the food restriction and when feeding these cats ad libitum they may find it difficult to control food intake and overeat. A pilot study for measuring the optimal (mean) habituation time for cats to get used to the ad libitum access to food is recommended and by our knowledge not been done before.
The prandial behaviour of the cats was observed at the time the cat was inside the feeding station during feeding times. The prandial behaviours observed were eating, food oriented behaviours (sniffing, licking, etc.) and attempting to access food (such as scratching at the pet feeder). Cats spent most of their time inside the feeding station on eating and food oriented behaviours. No differences were found in time spent eating among all meal schedules. Also, the data of the weighing scale and datalogger, used for observing the food-intake behaviour of the cats revealed no differences in eating rate among the cats with different meal schedules. Several studies in humans (Ohkuma et al., 2013; Otsuka et al., 2006) indicate that humans with a faster eating rate are more at risk for overeating. When having a fast eating rate, the satiation response of the brain is delayed and generally more food will be consumed. It is expected that an increase in food motivation leads to a faster eating rate and

higher risk for overeating. The eating rates in the present cats on different meal shedules were not significantly different, although ad libitum fed cats showed the fastest eating rate (7.9 grams per minute). Possibly, the earlier mentioned overeating in these cats was due to their relatively fast eating rate. The a priori assumption was that cats fed two meals (instead of six meals or more) are more food motivated prior to meal delivery and that these cats have a fast eating rate. Indeed these cats had a relative fast eating rate (5.7 grams per minute), but this was not significantly different from eating rates of the cats fed on the other meal schedules. An explanation for not finding any significant differences in eating rate may be that all cats showed strong food motivated behaviours and relative fast eating rates. By our knowledge no research is available about the normal eating rate in cats and factors that lead to increased eating rate in cats.

Regarding the intake per eating bout (meal size) cats fed two meals ate on average 19 grams per meal. This means the cats ate the whole meal available in one eating bout; each meal in the automatic pet feeder was approximately 21 grams. The mean food intake per eating bout of cats receiving six meals at fixed times a day was 28 gram and is unexpected because these cats received around seven grams of food per meal. Possible explanations for erroneous recordings can be that cats receiving this meal schedule were pressing with their snout of paws on the feeder and in this way disrupted the weighing scale recordings.

Meal schedule and its effect on (postprandial) activity and behaviour

The activity of cats is an important factor when considering prandial behaviours and has a direct link with overweight in cats (Slingerland et al., 2009). In several animal species, food motivation is associated with increased activity and more food searching behaviours (Van der Harst et al., 2003, Peters et al., 2012, Shepherdson et al., 1993). Assuming that the two meals fed cats had the highest food motivation, higher activity was expected in these cats. Deng et al. (2011) studied the effects of feeding frequency on the activity of cats. In their study no differences in activity levels in cats fed two or four meals a day were observed. Different daily activity patterns in cats fed one meal a day and cat fed multiple meals were seen, but these differences were not statistically proven. In current study, differences in physical activity in cats receiving different meal schedules were found. The ad libitum fed cats showed lower daily activity at certain clock hours in the current study, but no statistical difference in activity among the cats receiving different meal schedules was found between the control week and during the test week. It can therefore be assumed that the changing feeding method had no effect on the overall daily activity of the cats. To examine if cats with a high activity score (Actical data) were also more times inside the feeding station a scatter plot was made. Only a low correlation was found between number of visits and total activity on the test day (R^2=0.214,*P*=0.130) and it can therefore be concluded that high active cats do not visit the feeding station more often.

At the start of present study, a difference in around feeding activity (e.g. walking, running, and standing) among the cats receiving different meal schedules was expected. Higher general activity, for example, was assumed to occur during the pre-prandial phase especially in the food motivated cats, i.e. those that received only two meals. Actually, little difference in activity around feeding was found among the four different meal schedules. During the observation time of five minutes before entering the feeding station the cats showed no difference in time spent on walking and running. Also, no differences between the pre-prandial and postprandial phase were found for walking, running and standing. Sitting was seen more during the postprandial phase (*P*<0.001), possibly indicating a satiety response. Grooming behaviours were rare and no differences occurred because of the different meal schedules. Grooming, which takes place in a sitting position, occurred most in the postprandial phase (*P*=0.001), at least in the from of facial grooming. Grooming in cats serves as cleaning the hair coat and removing excessive oil and ectoparasites (Eckstein and Hart, 2000a,b). Observations in domestic cats indicate that cats spend eight percent of their active time in self grooming (e.g. licking) (Eckstein and Hart, 2000b). Several studies in rats confirm grooming to be part of the Behavioral Satiety Sequence (BSS) (Antin et al., 1975), as grooming is most seen after eating and before resting (Bindra and Blond, 1958). It is likely that this behaviour is not species specific and that the BSS is also

applicable to cats. Cats fed two meals a day showed the most grooming behaviour which possibly indicates these cats were more satiated compared with the cats which received six meals (not significant). The lower percentage of observed facial grooming in the ad libitum fed cats can be due to the fact that these cats overeat themselves more and therefore were not comfortable enough to engage in grooming behaviours in the postprandial phase. The cats fed six meals a day showed the least postprandial grooming behaviour compared with cats fed two meals and cats fed ad libitum (not significant). This could reflect reduced satiety in these cats as these cats receive smaller amounts of food per meal. Additionally, time spent on attempting to access food (scratching feeder) and being food oriented (e.g. sniffing) is the highest in the cats fed six meals a day. These results possibly indicate the lower after meal satiety levels in the cats fed six meals.

On Fridays all cats were significantly less active compared with Tuesdays. This lower activity on Friday can be explained by the near absence of the humans in the cat facility on this day. Possible the activity of the cats is controlled by the presence of people in the cat facility. Hour of the day had a significant effect on the activity of the cats, with a significant difference among the meal schedules ($P<0.001$). The cats' activity patterns included high activity around the normal feeding times (08:00 hour and 15:00 hour) and relative low activity in between the two feeding times and at night. A difference between the activity patterns in cats receiving different meal schedules was found in cats fed ad libitum. These cats showed significant lower activity peaks at 08:00 hour and 15:00 hour ($P<0.05$). Possible explanation for this result may be the lower food motivation in ad libitum fed cats especially when these cats consumed a meal moments before these feeding times; less activity is seen during satiety (Blundell et al., 2010). When not making assumptions about the satiety effects, maybe the ad libitum fed cats were more used to the new feeding method and habituated to their own meal schedule. Because food motivation (as shown in higher activity) is less seen in ad libitum fed cats it is expected that cats fed ad libitum have a more constant spread of activity during the day instead of showing extreme peaks of activity. Interesting to know, and not studied in present study, is when/if the ad libitum fed cats stop showing these high activity peaks. A long term observation study is recommended for studying this habituation period.
The cats receiving six meals at fixed hours a day showed significant higher activity at 14:00 hour compared with the cats in the other treatments ($P<0.05$). At this time no food was served and the previous feeding time was at 13:00 hour and the next meal was planned at 15:00 hour. It is unclear why these cats showed higher activity in between these two meals. One possible explanation can be that these cats were habituated to the feeding times and were already anticipated for the following meal. The higher activity in these cats can also be explained by the fact that these cats already show the highest activity in early afternoon in general.
To test if providing food inside the feeding station had effect on the activity of the cats. The activity of the cats fed two meals was observed in the control and test week. In both weeks the cats received similar sized meals with an interval of seven to eight hours between the meals. The activity patterns of the two meal fed cats in the control week and in the test week were not different ($P=0.302$). Thus, it seems unlikely that providing food in the feeding station influences the activity of the cats and it did not influence activity monitoring. The activity patterns in both weeks was characterized by high activity peaks at 08:00 hour and 15:00 hour, even though the cats in the test week received no food at those times. The fact that activity patterns did not change with changing meal schedules can be explained by three hypotheses. Firstly, the activity in the treatment cats was strongly influenced by the higher activity of the other cats which were not in the test. All other cats show anticipation prior to the meal deliveries at 08:00 hour and 15:00 hour. The test cats possibly imitated the behaviour (higher activity) of the other cats. Secondly, the test cats may still have been used to being active at those two moments of the day. Higher activity is shown in the time before a meal is consumed (Van der Harst et al., 2003, Peters et al., 2012, Shepherdson et al., 1993) and it is interesting to know when these activity patterns change towards the new feeding times. This change in activity pattern was only observed in current study with the ad libitum fed cats. Finding only minimal changes in activity patterns is possibly due to fact that the cats need more habituation time (at least more than four days). Thirdly, the presence of humans in the cat facility may have played a role. Around 07:30 hour the animal

keepers enter the cat facility and in this way trigger the cat's attention. At 9:30 most tasks are finished in the cat facility and the animal keepers leave the cat facility and return around 14:00 hour. The interaction with humans will have affected the activity in the test cats. These uncontrolled influences on the activity of the cats possible contributed to finding only minimal effects of meal schedule on the activity of the cats.

4.2 Survey

The survey was used to find direct relationships between the applied feeding methods and body condition and health in pet cats. A total of 1008 cat owners participated in the survey. After filtering the information of 750 cat owners was used for further analyses.

Feeding method and its effect on body condition
Several studies in humans and animals found a relationship between feeding method (i.e. food type, eating frequency) on body condition and/or body weight. In a recent study of Allirot et al. (2013) men (N=20) with a normal weight received breakfast in four episodes or in one episode. In comparison with the test-persons receiving a single breakfast, the subjects which received breakfast in four episodes experienced a decrease in hunger and had a decrease in energy intake at lunch. This study confirms that having a higher eating frequency (eating more frequent small meals) leads to less energy intake and eventually to a decrease in the risk of obesity. This is possibly also applicable in cats, as cats are in general used to eat frequently small meals. Allirot and co-workers studied also the effects of breakfast spread over four meals in obese humans in a follow-up study with similar research design (Allirot et al., 2014). This latest study revealed that obese subjects did not adjust the energy intake when receiving breakfast in four episodes. Obese individuals seem to be able to adjust the volume but not the energy content of their food intake. In this way, advising obese people to have frequent small meals may cause the intake of more energy dense food, leading to a higher energy intake. Further insight could come from future studies in (obese) humans and animals which investigate the effects of eating frequency on the biomarkers (i.e. GLP-1, PYY, ghrelin) that influence appetite and satiation (Allirot et al., 2014).
The current study revealed a significant (P<0.001) relationship between the feeding method used by cat owners and the cat's body condition; in the meal feeding group, more cats than expected were classified by their owner as being overweight and fewer cats than expected were indicated as having underweight. In the group of cats that had ad libitum access to food, fewer cats than expected had overweight. These results indicate a higher risk for overweight in the meal fed cats and a lower risk of overweight in cats fed ad libitum. Possibly, ad libitum fed cats experience less intense hunger and motivation to eat, and as a result eat smaller meals, more frequently. As described by Surgess and Hurley (2005), feeding patterns in ad libitum fed cats are characterized by small amounts of food eaten frequently, which corresponds with the feeding patterns of feral cats (Kane et al., 1981; MacDonald et al., 1984). Meal feeding, especially at low meal frequency, increases food motivated behaviours. Intermittent food-deprivation facilitated hunger is likely to increase the eating rate (i.e. speed of consumption), which results in a higher risk for overeating (Ohkuma et al., 2013). Together this suggests that meal fed cats are at a higher risk for overeating. In part this may result from bouts of hunger increasing the sensitivity to stress-induced over-eating, as discussed before and in line with the finding that restricted eating (eating specific meals, not snacking) is a strong predictor of stress-induced overeating in humans (Greeno and Wing, 1994).

The relation between the applied feeding method and the BCS of the cats was also tested separately for cats that receive premium quality food and raw meat (N=280). After filtering for these food type effects, similar results were found with a significant effect between meal feeding and overweight (P<0.01). An alternative analysis strategy in which number of meals was categorized by no meal feeding (ad libitum access) and meal feeding (>1 meals per day), again revealed less overweight cats in the group that had ad libitum access to food. All these results confirm that feeding method used by cat owners has a relationship with the body condition of the cat. The results of present study contradict

findings of the study of Russell et al. (2000) were ad libitum feeding was seen as important risk factor for overweight in pets. A study by Robertson (1999) found no relation between ad libitum feeding and overweight and based on the confounding results in several studies, it seems a lot remains unknown regarding the body condition effects of feeding frequency in cats.

Cat owners reported more often underweight in their cat when they applied variable feeding times ($P<0.01$). In nature, feral cats completely depend on the presence of prey and because there is no constant availability of prey, there is no constant food availability. It can be assumed that providing meals at unpredictable, variable times is a more or less natural feeding method, and prevents stress-induced over-eating. Animals fed according to unpredictable feeding times may have higher (food searching related) activity, which could contribute to optimal weight in cats (De Godoy and Swanson, 2013)

Feeding method and its effect on food motivation (wanting)
As described, food restriction leads to hunger in animals which increases food motivated behaviours (Blundell et al., 2010). Here, cat owners were asked about the food motivation of their cat in the survey. The answers were expressed as high (food) motivated cats and low motivated cats. More highly motivated cats than expected had overweight, and in the group of cats that were scored low on food motivation, fewer than expected overweight ($P<0.001$). Furthermore, cats with low food motivation were over-represented in the groups of cats fed ad libitum, and those with high food motivation typically received restricted diets. These resulst may be explained in two ways. Firstly, cat owners likely choose the feeding method depending on the food motivation of their cat. When cats show strong food motivated behaviours the cat owners may decide to provide the food in restricted meals in order to control the cat's bodyweight. Secondly, cat owners possibly base the feeding method on the actual body condition of their cat. When the body condition increases and the cat gets fat owners may decide to put it on a restricted diet. The cause and effect relationship between feeding method applied by owners and the cats' food motivation and body condition, unfortunately, cannot be determined on the basis of the present findings,
Strikingly, many ad libitum fed cats seem to be able to control other eating behaviour and body conditon. In humans there is evidence of a significant genetic and familial association of obesity (Stunkard et al., 1990) and in dogs some breeds are relatively prone to obesity (Markwell and Butterwick, 1994). In humans (Roberts and Greenberg, 1996) and presumably more mammalian species, it has been concluded that obesity is a multifactorial, multigene condition resulting from a complex interaction of genetics and environmental effects. Probably, genetics plays an important role in normal prandial behaviours in cats also. In the study of Serisier et al. (2013) eighty cats that were fed ad libitum were observed for the duration of eight years. This study state the existence of two phenotypes in cats. Cats that regulate their food intake (when having ad libitum access to food) during their life and cats that are heavier at twelve months of age, and gain more weight thereafter. These findings are somewhat equivalent with those reported in human studies, indicating that rapid growth at childhood is a major risk factor for overweight in adulthood (Stettler et al., 2005; Druet et al., 2012). Serisier and colleagues state that the important candidate factors associated with overweight in cats are physical activity levels, in utero factors, epigenetic differences and food digestibility differences. This would imply that actually the minority of cats maintain a healthy bodycondition when food is always available; the survey revealed a low number of cats fed ad libitum ($N=123$) compared with the number of cats fed meals ($N=299$) and a combination diet ($N=320$). The findings that cats with lower food motivation being the ad libitum fed cats can also be reasonably explained by the fact that ad libitum fed cats do not have to be very food motivated to obtain food. In this case, the food motivated behaviour of the cat is a response originating from the applied feeding method. To conclude from this part, food motivation in cats can be a behavioural response from the provided feeding method but food motivation can also be a characteristic of the cat that leads to a specific feeding method applied by the owner.

Feeding method and its effect on health

It was expected on forehand that there was no direct relationship between the applied feeding method and the health score of the cats. Health of the animal is not primarily influenced by the feeding method but is influenced by several environmental and internal factors. Nevertheless, overweight and obesity increases the risk of several health problems (Laflamme, 2012). The health score of the cats was assessed by the cat owners (score 1-100). No relationships were found between the health scores of the cats (classified as healthy or not healthy) and the applied feeding method, the daily activity of the cat, and food motivation of the cat. A tendency was seen in given treats and the health score of the cats. Cats that received treats often tended to have a reduced health. This can be partly explained by the high sugar contents in a lot of pet treats (Calabash, 2010). Cats are obligate carnivores that are adapted to diets with high protein and low carbohydrate contents. When compared with the omnivorous dog, cats have less digestive enzymes in the gastrointestinal tract that can metabolize glucose. Feeding treats with high sugar contents more often leads to higher insulin responses which results in overstimulation of the pancreatic β cells and the exhaustion of these cells (Farrow et al., 2013). The carnivore connection theory, mentioned by Brand Miller and Colagiuri (1994), state that unnaturally high carbohydrate intake in carnivores may contribute to the development of diabetes mellitus. Only five cats in present survey had diabetes mellitus and these cats had a mean BCS of five (normal weight). Only one cat with diabetes received treats often and had overweight (BCS of seven). Possibly various health problems led to a lower health score in the cats that received treats often. In fact, not only sugar content of the treats are important but also other ingredients, such as protein, lipid, vitamins and fibre contents, affect the health in the cats in several ways. Russell et al. (2000) found a relation between frequent treat feeding and body condition. Cats fed treats two to three times per week had a higher body mass than cats receiving treats less than twice a week or more than four times a week. In current study, no relationship was found between feeding treats and overweight (BCS) in cats.

Different studies show that physical activity is very important to prevent and control a healthy weight in cats (Russell et al., 2000; Slingerland et al., 2009; Colliard et al., 2009). The chi-square test did not find significant results between the activity score and the applied feeding method, health score, BCS, and food motivation of the cat. It seems that the feeding method applied by the owner does not influenced the activity of the cats. In addition to the chi-square test, a regression model was applied with use of the original data of the activity score and the BCS, revealing a significant inverse relationship between the BCS and the activity score (P=0.049). The activity of the cats decreases with an increase in BCS, though the linear model explained minimal variance in the data (R^2=0.0062). Such findings would be in agreement with studies in humans, indicating that low activity levels may be a significant factor underlying the development of obesity (Prentice and Jebb, 1995) and studies in cats that reveal that inactive cats have a higher bodyweight (Russell et al., 2000; Slingerland et al., 2009; Colliard et al., 2009). Alternatively, a higher bodyweight can result in a lower activity levels in animals.

General comments about the survey

In present study meal feeding and combination feeding was mostly used by cat owners. When looking at the times the meals were served, most of the cats in the survey received their meals at fixed times a day. It can be assumed that restricted feeding and feeding at fixed times a day is the most common feeding method used by Dutch cat owners. The cats in present study varied in body condition score with most cats scoring the ideal body condition. The BCS was scored by the owner with use of a picture (9-point scale) shown in the survey in Appendix 3. Existing body condition scoring charts for cats require some training, which make them less useful for pet owners to use (Laflamme 1997). Several studies state that cat owners have difficulties in interpreting the right body condition of their cat (Scarlett et al., 1994). A study of Calabash (2013) revealed that 45.3 percent of the cat owners in their study (N=450) incorrectly identified their overweight or obese cats as “normal weight”. These cat owners were asked to score their pet’s current body condition score as: too thin, normal, overweight and obese. Afterwards veterinarians scored the body condition of the same cats with the same scoring

system. As can be concluded from these studies, cat owners often award their cats a too low BCS. Taken this in account for the current study, 45 percent of the cats had likely a higher BCS than was scored by the owner. Nevertheless, a total of 173 overweight and obese animals were scored. To control the reliability of the body condition in future studies, it is recommended to assess the body condition by experienced people like veterinarians. Using more than one assessment tool is also advised, and the S.H.A.P.E™ system (German et al., 2006) and Feline Body Mass Index™ (Hawthorne and Butterwick, 2000) are reliable tools for the assessment of body condition in cats.

4.3 Comparison results behaviour study and survey

Results of the behavioural study revealed minimal effects of the meal schedule on the behaviour in the studied cats, this is conflicting with the results of the survey. No pre-prandial behavioural differences among the cats receiving different meal schedules were observed, mainly due to fact that the sound of the feeder influenced the anticipation behaviour. It was expected on forehand that the cats fed two meals showed more food motivation compared with the cats fed six meals, but no such results were found. Highly motivated cats in the survey (as reported by the owners) were most of the time cats which received a restricted diet. This result confirms that food motivation is more seen in cats receiving food at a low frequency. The two meal fed cats in the behavioural study were expected to showed this higher food motivated behaviour, compared with the six meals fed cats, but this was not observed. Longer pre-prandial observation time (>5 minutes) may help to sensitively find differences in pre-prandial behaviours.
In the behavioural experiment no differences in overall daily activity were found between the cats fed different meal schedules, though the cats' activity patterns were different. The ad libitum fed cats showed lower activity peaks in the morning and afternoon and gained much weight during the test. These cats showed minimal control over their eating behaviour and overeating was seen during the whole week. Thus, in the experimental study, the ad libitum fed cats showed to be at risk of overweight. In contrast, in the survey a strong relationship was found between the feeding method and the body condition of the cats, in that ad libitum feeding was found to be the optimal feeding method for the prevention of overweight and obesity. These opposing results between the behavioural experiment and survey can be explained by the fact the cats in the behavioural study were used to have two restricted meals a day and feeding these cats ad libitum is an extreme difference in feeding method. Possibly, when these cats are more used to the ad libitum feeding, the feeding frequency will increase and the amount of food per meal will decrease (less chance for overeating). Longer habituation time is therefore recommended in the laboratory cats. Next, a more stable, predictable but challenging environment will improve the chance of observing more natural behaviours in these cats. Under conditions that less aberrant behaviours in the laboratory cats is observed the results of the behavioural study and survey may become more similar.

5. Conclusion

The main biological question of this research was if the feeding method effects prandial behaviour, physical activity, body condition and health in cats. From literature it was evident that feral cats, still very similar in morphology and behaviour to domestic cats, have relative high eating frequencies with relatively small meals sizes. Overweight and obesity is rare in feral cats, and a more natural approach in feeding method could potentially lower the chance of overweight in domestic cats. From the results of the behavioural study it cannot be said that feeding two times a day, six times a day or ad libitum influences prandial behaviours in cats. Meal schedule related general activity differences were seen during certain hours of the day; around the standard two feeding times of the day the ad libitum fed cats showed lower activity. A possible explanation for not finding strong differences in behaviour and overall activity among the different meal schedules is the relative short habituation time of the cats to the experimental meal schedules. A longer habituation time for the cats to get used to their new meal schedule, especially with ad libitum feeding, will increase the validity of the research. Also, offering the test cats a more predictable and challenging living environment, may prevent the cats from engaging in abnormal prandial behaviours and show more natural behaviour. Cat owner reports revealed how the ad libitum fed pet cats were most likely to have underweight and express low food motivation. This in contrast to meal restricted cats. The applied feeding method had a significant relationship with the a cat's body condition, with ad libitum feeding being associated with appropriate control of body weight in cats. Feeding method used by cat owners had no effects on the cats' physical activity. Cats on a restricted diet showed stronger food motivation (pre-prandial motivation), which can be explained by more intens hunger levels in between meals. No relation existed between the cats' health and the applied feeding method, or between health and overweight. In conclusion, the feeding frequency influences the activity and behaviour in cats, but the extent to which the observed changes in activity promote weight control remains unsure. Cats fed ad libitum consume several small meals per day and results of the survey showed that ad libitum fed pet cats, contrary to those at the experimental research facility, are less prone to overweight. Likely, cats fed ad libitum have to habituate to this feeding method to prevent overeating. Low stress levels and "good genes" may be important to control healthy prandial behaviours in cats fed ad libitum.

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Appendix 1 Information of the subjects

Cat name	Gender	Birth date	Initial Mother	Initial Father	Bodyweight at start of test week	Bodyweight at end of test week	BCS*	Treatment
Panter	♂	6-5-2012	a	a	2880	3206	B	4
Lord	♂	20-2-2012	?	?	2840	2820	B	3
Jacob	♂	1-4-2012	b	b	3327	3320	B	1
Jack	♂	21-4-2012	c	b	3010	2965	C	2
Edward	♂	4-12-2011	d	b	3360	3320	C	3
Absint	♂	1-4-2012	b	b	3030	3030	A	2
Jill	♀	7-5-2012	e	c	2810	3020	C	4
Carolien	♀	1-4-2012	b	b	2750	2727	C	3
Bone	♀	26-12-2011	f	c	2415	2373	B	1
Bella	♀	26-12-2011	f	c	2645	2610	B	3
Anouk	♀	6-5-2012	g	b	2548	2520	B	2
Aal	♀	1-4-2012	b	b	2460	2480	B	2

*Body Condition Score; Waltham S.H.A.P.E. (7-point scale (A to G)) scored on: 12/11/2013
Treatment: 1= 2 meals per day; 2= 6 meals per day at fixed times; 3= 6 meals a day at random times; 4= ad libitum

Appendix 2 Ethogram

Ethogram 1: Outside the feeding station (5 minutes before entrance and 5 minutes after leaving)
Focal Sampling Continuous.

Behaviour	Description
Locomotion	
Resting	Lying in a relaxed, or asleep, posture, ears lowered, eyes may be closed
Sitting	Hind paws underneath the body, no movements of the hind paws and cat stays at the same spot
Standing	Paws in straight position without movements, cat stays at the same spot
Walking	Slowest gait of locomotion from one location towards another with use of paw movements
Running	Fastest gait of locomotion from one location towards another with use of paw movements.
Location	
Near the station on the floor	Cat is standing, sitting, lying, walking, running on the floor near the feeding station (within 1 metre)
In front of the station entrance	Cat is standing, sitting, lying or walking in front of the feeding station entrance (within 50 centimetres)
On the feeding station	Cat is standing, sitting, lying, walking, running on the feeding station
Not near the station on the floor	Cat is standing, sitting, lying, walking, running on the floor but not near the feeding station
On shelf or balcony	Cat is standing, sitting, lying, walking, running on a shelf or on the balcony
Out of sight	Animal cannot be observed because is not visible on the video recordings
Disturbance	Animal is disturbed by human contact or loud noises outside the cat facility
Grooming	
Grooming facial area	Biting, licking, nibbling at facial area with use of the paws
Grooming other body parts	Biting, licking, nibbling at own body parts except facial area
Grooming other cat	Biting, licking or nibbling at the body parts of other cat
Not grooming	Cats is not licking the paws or nibbling, and biting its own fur of that of other cats
Events	
Playing	Fast movements towards an object or other cat, tail may be hold at a high position
Jumping	Cat has is all his paws in the air and the cat body moved from one point to another point
Agonistic behaviour	All unpleasant contacts with other cats such as fighting, submission, fleeing, dominance and other forms of aggression
Scratching	Using claws to clean hairs of the own body with fast movements
Stretching	Elongating limbs sometimes with a bout of yawning
Drinking	Taking in water while not recently have consumed a meal
After meal drinking	Taking in water through the mouth within 2 minutes after consuming a meal
Defecating	Discharge faeces or urine from body

Ethogram 2: Cat is inside the feeding station. Focal Sampling Continuous starts when two paws are inside the station and stops when two paws are outside the station. Behaviours with a * are behavioural events.

Behaviour	Description
Eating behaviour	
Eating	Taking in food through the mouth while being in the feeding station
Food oriented	In close contact with food bowl, chewing on food and other behaviours except eating and attempting to get access to food.
Attempting to access food	Trying to reach (other) food by using the paws (for digging) and mouth (for pushing), not eating food
Locomotion	
Walking	Slowest gait of locomotion from one location towards another with use of paw movements
Standing	Paws in straight position without movements, cat stays at the same spot
Sitting	Hind paws underneath the body, no movements of the hind paws and cat stays at the same spot
Resting	Lying in a relaxed, or asleep, posture, ears lowered, eyes may be closed
Grooming behaviour	
Grooming facial area	Biting, licking, nibbling at facial area with use of the paws
Grooming other body parts	Biting, licking, nibbling at own body parts except facial area
Other	
Playing	Fast movements towards an object (cat-flap), tail may be hold at a high position
Scratching*	Using claws to clean hairs of the own body with fast movements
Stretching*	Elongating limbs sometimes with a bout of yawning
Head up*	Suddenly elongating head in response to disturbance of other cats or sounds inside the cat facility
Disturbance	Animal is disturbed by human contact or loud noises outside the cat facility
Entering feeding box	Head and two paws of the animal are inside the feeding station, two hind paws move towards the cat flap system
Leaving feeding box	Head and two paws of the animal are outside the feeding station, two hind paws move towards the cat flap system
Other	Cat shows other (not-prandial) behaviour not included in this ethogram

Appendix 3 Survey questions

Welkom bij het onderzoek naar eetgedrag van katten
Katten in Nederland hebben regelmatig overgewicht of zijn zelfs zwaarlijvig, met nadelige gevolgen voor de diergezondheid. Wageningen Universiteit doet onderzoek naar het eetgedrag van katten, om een bijdrage te leveren aan de preventie van overgewicht.

Met deze enquête inventariseren we hoe katteneigenaren hun kat voeren, de activiteit en persoonlijkheid van de kat en hoe dit relateert met gewicht en gezondheid. Uitkomsten worden gecombineerd met experimentele voerstudies, om verbanden te vinden tussen maaltijdpatronen, activiteit, voermotivatie & persoonlijkheid en gewicht. De enquête stelt vragen over [1] herkomst en leefsituatie, [2] eetgedrag en de manier van voerverstrekking, [3] gezondheid, en [4] karaktereigenschappen.

Wij vragen u vriendelijk de vragenlijst in te vullen voor één specifieke kat in uw huishouden. Heeft u meerdere katten dan kunt u de vragenlijst meerdere keren invullen.

Wilt u op de hoogte blijven van de onderzoeksresultaten? De resultaten worden weergegeven op de website: dierenwetenschap.com.

Deel 1: Algemene vragen

Wat is uw (roep)naam en woonplaats? ***Uw persoonsgegevens blijven geheim, indien u toch anoniem wilt blijven kunt u deze vraag open houden.***

(roep)naam	woonplaats

Wat beschrijft het beste uw woonsituatie?
- Stads, huis met tuin
- Stads, huis (flat) zonder tuin
- Buitenwijk, huis met tuin
- Buitenwijk, huis (flat) zonder tuin
- Landelijk, huis met tuin
- Landelijk, huis (flat) zonder tuin

Wat is de naam van uw kat?

Heeft uw kat een stamboom?
- Ja
- Nee

Van welk ras of van welke kruising is uw kat?
- Onbekend
- Huis-tuin-keukenkat (Europees korthaar)
- Ras:…….
- Kruising: ……..

Leeftijd: hoeveel jaren of maanden (indien jonger dan een jaar) is uw kat?

jaren	maanden

Wat is het geslacht van uw kat en is uw kat geholpen (gecastreerd/gesteriliseerd)?

- Poes (niet geholpen)
- Poes (geholpen)
- Kater (niet geholpen)
- Kater (geholpen)

Bent u de eerste eigenaar van deze kat?

- Ja
- Nee

Hoelang bent u al de eigenaar van deze kat?

- Korten dan een half jaar
- Een half jaar tot jaar
- Een jaar tot 2 jaar
- Meer dan 2 jaar

Waar komt de kat vandaan?

- Winkel
- Bekende, kennis (privé persoon)
- Fokker (kleinschalig – max. 3 nesten per jaar)
- Fokker (meer dan 3 nesten per jaar)
- Asiel (dierenopvang)
- Aangelopen
- Anders, namelijk:……..

Hoeveel huisdieren (katten & honden) heeft u?

	1	2	3	4 of meer
Katten	◯	◯	◯	◯
Honden	◯	◯	◯	◯

Uit hoeveel gezinsleden bestaat uw huishouden? Noteer het totale aantal personen(inclusief uzelf).

Wat beschrijft het beste hoeveel tijd uw kat buiten is (per gemiddelde dag).

- Altijd binnen
- Minder dan een uur per dag buiten
- Een uur tot 2 uren buiten
- Twee uren tot 4 uren buiten
- Vier uren tot 8 uren buiten
- Acht uren tot 16 uren buiten
- Vrijwel altijd buiten

Uitgaande van een gemiddelde doordeweekse dag, hoeveel uren per dagdeel is uw kat <u>alleen in huis</u>?

	1 uur alleen	2 uur alleen	3 uur alleen	4 uur alleen	5 uur alleen	6 uur alleen
In de ochtend:	◯	◯	◯	◯	◯	◯
In de middag:	◯	◯	◯	◯	◯	◯
In de avond:	◯	◯	◯	◯	◯	◯

Kunt u op de 3 verschillende schuifbalken een schatting geven welke deel van de tijd uw kat actief is, tijdens een dagdeel (0% alleen maar rusten en 100% alleen maar bezig en actief)?

Deel van de tijd actief in de ochtend:

Deel van de tijd actief in de middag:

Deel van de tijd actief in de avond:

Waar bevindt uw kat zich over het algemeen tijdens een gemiddelde dag?

	Altijd	Meestal	Soms	Zelden	Nooit
-Binnenshuis	◯	◯	◯	◯	◯
-In een afgesloten buitenruimte (zoals bijvoorbeeld een balkon of kattenren)	◯	◯	◯	◯	◯
-Buitenshuis (vrij buiten)	◯	◯	◯	◯	◯

Deel 2: Voerverstrekking en eetgedrag

Komt uw kat wel eens met een prooi thuis en hoe vaak is dit?

- Ja, dit gebeurt vaak (meerdere keren per week)
- Ja, dit gebeurt regelmatig (enkele keren per maand)
- Ja, dit gebeurt soms (hooguit eenmaal per maand)
- Nee, dit gebeurt praktisch nooit (kat komt bv niet buiten)

Volgt uw kat een bepaald dieet (denk aan nierdieet, hypoallergeen dieet, enz.), zo ja welk dieet?

- Mijn kat volgt geen dieet
- Mijn kat volgt een dieet, namelijk: ……..

Waaruit bestaat het dagelijkse menu van uw kat? Als u verschillende voeren geeft, wat is grofweg het aandeel (in procenten, samen 100%) van elk voedingstype? Geef eventueel de producent of merknaam van het voer.

Droogvoer (brokken).

Aandeel per dag (%):

Merk(en):

Natvoer (blikvoer)

Aandeel per dag (%):

Merk(en):

Vleesvoeding (hoog % vers vlees)

Aandeel per dag (%):

Merk(en):

Ik voer anders, namelijk; (type + procenten invoeren)

Op welke manier voert u uw kat meestal?

- Ik geef het voer in maaltijden (voer is niet altijd aanwezig)
- Ik geef onbeperkt voer (voer is zo goed als altijd aanwezig)
- Ik geef een combinatie, brokken zijn altijd aanwezig en zachtvoer geef ik in maaltijden
- Anders, namelijk:……..

Hoe vaak per dag voert u uw kat (buiten de snacks en overige extraatjes) om? Noteer het aantal

keren dat u voer geeft (per dag) hieronder:

Als u het aantal maaltijden zou moeten onderverdelen in hoofdmaaltijden en kleine maaltijden. Waarbij de hoofdmaaltijden minimaal 1,5 keer meer voer bevatten dan de kleinere maaltijden. Hoeveel van deze hoofdmaaltijden geeft u per dag?
Let op: Indien u het voer niet in maaltijden aanbiedt of als u alleen maaltijden van ongeveer gelijke hoeveelheid aanbiedt, dan kunt u hieronder '0' (nul) invullen.

Op welke momenten geeft u uw kat voer (buiten de snacks en overige extraatjes om)?

- Ik geef alleen op vaste momenten voer
- Ik geef vooral op vaste momenten voer maar soms geef ik ook tussendoor voer
- Ik geef op vaste momenten voer maar geef ook regelmatig tussendoor voer
- Ik geef op variabele momenten voer

Wanneer besluit u uw kat te voeren (buiten de snacks en overige extraatjes om)?

- Wanneer het tijd is om te voeren
- Wanneer ik merk dat mijn kat hongerig is en/of gaat bedelen
- Wanneer ik zie dat de voerbak leeg is
- Anders, namelijk wanneer:……

Hoe vaak komt de situatie voor dat uw vers voer wilt geven terwijl er nog ''oud'' voer aanwezig is?

- Altijd
- Meestal
- Soms
- Zelden
- Nooit

Hoe bepaalt u de dagelijkse hoeveelheid voer voor uw kat?

- Ik voer een vaste dagelijkse hoeveelheid die door de dierenarts of specialist is vastgesteld
- Ik voer een vaste dagelijkse hoeveelheid die vastgesteld is aan de hand van het lichaamsgewicht en leeftijd van mijn kat zoals op de verpakking van mijn voer staat en/of ik zelf berekend heb
- Ik geef een vaste hoeveelheid voer op basis van wat mijn kat normaliter opeet
- Wanneer mijn kat vermagert geef ik voer bij en wanneer hij/zij aankomt geef ik minder voer
- Ik geef zoveel voer als mijn kat eet en dit varieert
- De hoeveelheid voer varieert, los van eerder genoemde redenen
- De hoeveelheid voer is redelijk constant, los van eerder genoemde redenen

Wat doet de kat nadat hij/zij nieuw voer heeft gekregen?

- De kat eet het voer meestal direct op (binnen 15 minuten is de bak leeg)
- De kat eet vaak alles direct op, soms blijft er nog een kleine hoeveelheid voer liggen (binnen één uur is de voerbak wel leeg)
- De kat eet een gedeelte van het voer, vaak blijft er nog voer liggen
- De kat reageert niet/weinig als voer wordt gegeven
- Anders, namelijk:……

Wat beschrijft het best de voermotivatie (trek) van uw kat voor het <u>normale (hoofd) voer</u>? De onderstaande antwoorden staan op volgorde van weinig interesse tot sterk voer gemotiveerd.

- Mijn kat is weinig gemotiveerd voor voer
- Mijn kat is gemotiveerd voor voer, dit toont hij/zij door direct te reageren als ik hem/haar wil gaan voeren maar hij/zij bedelt niet tot nauwelijks om voer
- Mijn kat is erg gemotiveerd voor voer, dit toont hij/zij door direct te reageren als ik hem/haar wil gaan voeren en regelmatig te bedelen om voer
- Mijn kat is erg gemotiveerd voor voer, dit toont hij/zij door direct te reageren als ik richting de voeropslag loop, hij/zij veel bedelt en regelmatig op zoek gaat naar ander eten (ook niet kattenvoer)

Welk soort kattensnoepjes/extraatjes geeft u aan uw kat? Noteer hieronder het merknaam/de merkennamen van de door u veelgebruikte kattensnoepjes en/of beschrijf het product (bijvoorbeeld kaasblokje, vleeswaren, enz.).

Hoe vaak geeft u uw kat kattensnoepjes? (kies een antwoord dat het meeste past bij uw situatie)

- Meerdere snoepjes per dag
- Enkele snoepjes per dag
- Meerdere snoepjes per week, soms zijn er dagen dat ik geen snoepjes geef
- Enkele snoepjes per week, er zijn veel dagen dat ik geen snoepjes geef
- Ik geef zelden kattensnoepjes
- Ik geef nooit kattensnoepjes

Deel 3: Gezondheid

Kunt u op de schuifbalk op een schaal van 0 tot 100 aangeven hoe u de algemene gezondheid van uw kat inschat (0 = mijn kat heeft nooit ziekteverschijnselen, 100 = mijn kat vertoond altijd wel ziekteverschijnselen)?
Dus 100% = erg ziek!

Hoe vaak bent u in het <u>afgelopen jaar</u> met gezondheidsproblemen van uw kat naar de dierenarts of specialist geweest (uitgezonderd preventieve zorg, vaccinaties en fokgerelateerde behandelingen)? Noteer hieronder het aantal bezoeken bij de dierenarts of specialist.

Van welke aandoeningen heeft uw kat last of heeft hij/zij het afgelopen jaar last gehad?
Meerdere antwoorden mogelijk.

- Mijn kat heeft geen van deze ziektes
- Infectieziektes
- Hart & vaat ziektes
- Huidaandoeningen (bijvoorbeeld vlooien, mijten, abcessen)
- Aandoeningen aan urinair stelsel (bijvoorbeeld blaasproblemen)
- Immuunziektes (bijvoorbeeld allergie)
- Zenuw & hersen ziektes (bijvoorbeeld epilepsie)
- Ademhalingsziektes
- Aandoeningen aan gewrichten, banden en botten
- Aandoeningen in de bek (bijvoorbeeld tandsteen)
- Spijsvertering problemen
- Hormoonziektes
- Aandoeningen aan oog, oor of neus
- Suikerziekte
- Anders, namelijk:

Hoe ziet u de algemene gezondheidstoestand van uw kat, op een schaal van 1 (super gezond) tot 5 (ongezond)?

	Ongezond 1	2	3	4	5 gezond
De vacht van mijn kat glanst					
Het gebit van mijn kat is in orde (niet/nauwelijks tandsteen/tandplak)					
Mijn kat beweegt zich goed					
De ontlasting van mijn kat is goed					
Mijn kat zit lekker in zijn vel					

Hoeveel weegt u kat? (in kilogram)

Als u naar uw kat kijkt en de ribben bevoelt, in welke categorie (zie figuur) past uw kat? U kunt dit aangeven door middel van het nummer op de schuifbalk.

Deel 4. Karaktereigenschappen

Om een beeld te krijgen van de persoonlijkheid van uw kat vragen we u om (meerdere malen) met 1 woord een specifieke karaktereigenschap van de kat te beschrijven. Voor deze eigenschap kunt u de kat dan een score geven van 0 (= deze eigenschap is niet aanwezig) tot 100 (= deze eigenschap is maximaal sterk aanwezig). Op deze manier kunt u zelf de best passende woorden gebruiken om uw kat te karakteriseren. Het is mogelijk hier zowel positieve als negatieve karaktereigenschappen te noemen!
Door op de knop 'Toevoegen' te klikken slaat u de informatie over de bepaalde karaktereigenschap op en kunt u een nieuwe eigenschap invullen door nogmaals op 'toevoegen' te drukken in de tabel (het programma maakt dan een nieuw invulvak aan). Het is van belang om met slechts 1 woord de eigenschap te beschrijven.

Geef hieronder een (karakter/gedrags-)eigenschap van 1 woord en geef uw kat hiervoor een score tussen 0 (eigenschap is afwezig) en 100 (eigenschap is maximaal aanwezig).
De schuif in de onderstaande balk staat standaard op 50 en is te veranderen door de verdikking op de balk met de linkermuisknop te selecteren (ingedrukt houden) en naar links of rechts te slepen.

Dit is het einde van de vragenlijst, klik nu op 'Verzenden' om de antwoorden op te slaan (1x klikken, en na een korte wachttijd ontvangt u een bevestiging van ontvangst).
Heel erg bedankt voor uw medewerking!

Appendix 4 Respondents information

Respondents information (*N*=750)

General information	Number of cats
European Shorthair	543
Mix-breed	54
Breed	131
Breed with pedigree	99
Unknown	22
Female intact	32
Female neutered	323
Male intact	11
Male neutered	346
Unknown	38
Age 1-5 year	405
Age 6-10 year	225
Age 11-15 year	115
Unknown	5
BCS 1	28
BCS 2	39
BCS 3	149
BCS 4	173
BCS 5	188
BCS 6	84
BCS 7	69
BCS 8	11
BCS 9	9