



Characterisation of plant eating in dogs

Karen Lynn Chieko Sueda ^{a,*}, Benjamin Leslie Hart ^b, Kelly Davis Cliff ^b

^a Behavior Service, VCA West Los Angeles Animal Hospital, c/o Animal Imaging,
1827 Pontius Avenue, Los Angeles, CA 90025, USA

^b Department of Anatomy, Physiology and Cell Biology, School of Veterinary Medicine,
University of California, Davis, CA 95616, USA

Accepted 24 May 2007

Available online 12 July 2007

Abstract

Grass or plant eating is a widely recognized behaviour amongst domestic dogs. We first estimated the prevalence of plant eating by administering a written survey to owners of healthy dogs visiting the outpatient service of a veterinary medical teaching hospital for routine health maintenance procedures. Of 47 owners systematically surveyed whose dogs had daily exposure to plants, 79% reported that their dog had eaten grass or other plants. Using an internet survey targeting owners of plant-eating dogs, we then acquired information regarding the frequency and type of plants eaten, frequency with which dogs appeared ill before eating plants and frequency with which vomiting was seen afterwards. Of 3340 surveys returned, 1571 met enrollment criteria. Overall, 68% of dogs were reported to eat plants on a daily or weekly basis with the remainder eating plants once a month or less. Grass was the most frequently eaten plant by 79% of dogs. Only 9% were reported to frequently appear ill before eating plants and only 22% were reported to frequently vomit afterwards. While no relationship was found between sex, gonadal status, breed group or diet type with regard to frequency or type of plants eaten, a younger age was significantly associated with: (1) an increase in frequency of plant eating; (2) an increase in consuming non-grass plants; (3) a decrease in regularly showing signs of illness before eating plants and (4) a decrease in regularly vomiting after consuming plants. The findings support the perspective that plant eating is a normal behaviour of domestic dogs.

© 2007 Elsevier B.V. All rights reserved.

Keywords: Dogs; Canids; Feeding behaviour; Plant eating; Grass eating

1. Introduction

One area of domestic dog (*Canis familiaris*) behaviour that has received little attention in the scientific literature is the regular or periodic consumption of plant material of little apparent

* Corresponding author. Tel.: +1 310 478 5035; fax: +1 310 478 5135.

E-mail address: Karen.Sueda@vcamail.com (K.L.C. Sueda).

nutritive value. Judging by how frequently animal behaviourists are asked about plant eating, this behaviour appears to be quite common, though no studies have documented its prevalence among domestic dogs. Amongst the most commonly asked questions are whether plant eating is a sign of illness, if dogs eat plants to induce vomiting and whether plant eating is a sign of a dietary deficiency (Beaver, 1981; Houpt, 2005; Lindsay, 2001; Overall, 1997).

Evaluation of scats and stomach contents of wild canids indicate that they regularly ingest plant material, especially grass. Such studies report the appearance of plant matter in about 11% of samples of Latvian wolves (Andersone and Ozolins, 2004) and approximately 74% of samples collected in the summer from grey wolves reintroduced to Yellowstone National Park (Wyoming, USA) (Stahler et al., 2006). In studies where specific plant types were identified, grass was found in 2–3% of the samples of timber wolves (Mech, 1966), 10% of samples in Latvian wolves (Andersone, 1998) and 14% of samples from Greek wolves (Papageorgiou et al., 1994).

Some blades of grass undoubtedly appear in scats as a result of adherence to carcasses being eaten, or from ingestion of the intestinal contents of herbivorous prey. However, intentional consumption of grass by wolves has also been documented (Murie, 1944; Stahler et al., 2006). After observing blades of grass wrapped around intestinal worms in wolf scats, Murie (1944) suggested that grass might have a scouring effect in removing worms.

Based on the studies and the commonly asked questions mentioned above, four hypotheses were developed regarding plant eating in domestic dogs: (1) most plant eating occurs in dogs exhibiting signs of illness; (2) most bouts of plant eating are followed within a few minutes by vomiting; (3) plant eating occurs primarily due to a dietary deficiency of some type and (4) plant eating is a normal, relatively innate behaviour, possibly reflecting a behavioural predisposition of their wild canid ancestors and relatives. The hypotheses are not necessarily mutually exclusive. For example, while most periodic plant eating could be normal, gastrointestinal distress or illness may also trigger the behaviour.

Following a pilot survey to gather preliminary information about the occurrence of illness prior to and vomiting after eating plants, two studies were conducted to characterize plant-eating behaviour amongst domestic dogs and to test the above hypotheses. The purpose of Study 1 was to estimate the prevalence of plant eating in a sample of healthy, well-cared-for dogs. In Study 2 we sought to acquire extensive data about plant eating with regard to types of plants eaten, frequency of plant eating and influences of age, breed group, sex and gonadal status in a large sample of domestic dogs that ate plants. Of particular interest was the acquisition of information relevant to predictions related to the above hypotheses.

2. Materials and methods

2.1. Pilot study

Veterinary students at the University of California, Davis (CA, USA) were asked to fill out a survey on plant eating in their dogs. This pilot survey was intended to aid in the design of the questionnaires used in Studies 1 and 2 and to provide preliminary data on the proportion of dogs that show illness prior to eating plants and the proportion that vomit afterwards.

2.2. Study 1

2.2.1. Study design

The primary purpose of Study 1 was to estimate the prevalence of plant-eating behaviour from a convenience sample of at least 40 healthy dogs presented to the outpatient service of a veterinary teaching

hospital. Data were collected on sex, age, gonadal status and diet. Also, for plant-eating dogs, data were collected on the regular occurrence of signs of illness prior to eating plants and the occurrence of vomiting regularly within 1 h after eating plants.

2.2.2. Survey design

A written survey, previously tested in the pilot study, was given to owners of dogs brought to the outpatient clinic of the University of California, Davis, Veterinary Medical Teaching Hospital (CA, USA). An attempt was made to personally hand the survey to all clients, so as to guard against the bias inherent in allowing clients to voluntarily pick up a survey form. The owners were told that the survey was designed to study eating behaviour of pet dogs in general and not specifically plant eating. The survey contained questions regarding the general description of the dog and its environment; information about the consumption of non-food items, such as stones, clothing, paper, toys, faeces and plants; current diet and medical history (Table 1). Owners bringing more than one dog to the hospital were asked to complete one survey for the dog with the earlier appointment time. Questions were presented in multiple-choice and short-answer format. For multiple-choice questions, owners were specifically instructed to select either the most accurate response or for some questions, all the responses that pertained to their dog. The survey took approximately 10 min to complete. Owners of dogs that consumed plants were asked additional questions that specifically addressed plant-eating behaviour, including whether their dog frequently exhibited signs of illness, described as depression, loss of appetite and inactivity (Hart, 1988) before eating plants, and whether their dog regularly vomited within 1 h after eating plants. Owners were asked to describe how their dog behaved most of the time and not how the dog behaved on one or a few occasions.

A medical history was obtained and a physical examination was performed on each dog by a veterinarian to rule out medical conditions that could cause vomiting not associated with plant eating and diseases that might increase or decrease ingestive behaviour in general. Medications and medical problems that warranted exclusion of subjects included gastrointestinal disease, hyperadrenocorticism, diabetes mellitus and administration of medications such as corticosteroids or anticonvulsants that may increase appetite (Plumb, 2002).

Surveys were included in the study only if the individual completing the survey was the dog's primary caregiver, the dog had access to plants for at least 1 h per day, the dog had been in the household for at least 1 month and owners were able to observe their dog's behaviour for at least 3 h per day. These restrictions were

Table 1

Study 1, summary of survey questions presented to owners of both plant-eating and non-plant-eating dogs brought to the University of California, Davis Veterinary Medical Teaching Hospital outpatient clinic (not inclusive of all questions)

Section	
Description of dog	Sex, gonadal status, major breed group, age Duration in household Time spent with dog daily and able to observe behaviour Hours per day dog has access to plants
Diet fed	Type and percentage of diet consisting of commercial kibble/canned or raw, "people food", treats
Information on non-food items consumed	Types of non-food items consumed Information on plant eating behaviour (if owner had observed their dog eating plants or seen plants in vomit or feces) - Type of plants eaten - Type of plant most frequently eaten Signs of illness and vomiting before and after plant eating
Medical history	Current medical history Current medications

imposed to ensure that the dog had sufficient opportunity to engage in plant-eating behaviour and be observed by their owner.

2.2.3. Data analysis

The proportion of respondents who indicated that they had witnessed their dog eating plants and/or observed plants in their dog's faeces or vomit at least once was determined. Dogs were evaluated as to whether they were fed predominantly (at least 51% of the time) a commercial, nutritionally balanced diet of kibble or canned food certified by the Association of American Feed Control Officials (AAFCO), or primarily raw or home-cooked diets which are more likely to be nutritionally inadequate than commercial diets (Alenza et al., 1998; Freeman and Michel, 2001; Berschneider, 2002). Raw and home-cooked diets were considered nutritionally deficient for the purposes of this study. In addition, the percentages of plant-eating and non-plant-eating dogs whose owners supplemented their diet with vegetables or fruits were determined. For plant-eating dogs, the proportion of owners who stated that their the dogs frequently appeared ill before eating plants and the proportion of owners who stated that their dogs frequently vomited within 1 h after eating plants were also determined. Because of the relatively small number of subjects, no statistical evaluation of the data was planned.

2.3. Study 2

2.3.1. Study design

Study 2 was designed to collect descriptive information on dogs that eat plants and to acquire data that would either support or allow rejection of the hypotheses given in the Introduction. The hypothesis that most plant eating is associated with signs of illness (Hypothesis 1) would be confirmed if the majority (i.e. greater than 50%) of owners reported that their dogs commonly appeared ill prior to eating plants. This hypothesis could be rejected if a large proportion of dog owners reported that their dogs rarely seemed ill before eating plants. We arbitrarily set the "large proportion" cut-off at 75%.

The hypothesis that most plant eating is followed within a few minutes by vomiting (Hypothesis 2) would be confirmed if the majority (i.e. greater than 50%) of owners reported that their dogs commonly vomited after eating plants. This hypothesis could be rejected if a large proportion of dog owners reported that their dogs rarely vomited after eating plants. Again, we arbitrarily set this cut-off point at 75%.

The hypothesis that plant eating reflects a dietary deficiency (Hypothesis 3) would be supported if owners feeding their dogs a nutritionally deficient diet reported that their dogs consumed plants more frequently than dogs fed a nutritionally balanced diet. The hypothesis would not be supported by data revealing no relationship between dietary quality and plant-eating frequency.

The hypothesis that plant eating is a normal behaviour (Hypothesis 4) was not tested directly but would be supported by the process of exclusion, i.e. if Hypotheses 1–3 were rejected.

2.3.2. Survey design

To obtain the large sample necessary to collect general information on the frequency of plant eating, type of plants eaten and the effects of age, sex, gonadal status and breed group on plant eating, we turned to an internet survey where thousands of responses can be expected. Similar surveys have been used in a variety of data-based behavioural and medical investigations (e.g. Janson and Wist, 2004; McCobb et al., 2001; Kim et al., 2001; Gobar and Kass, 2002) and have been shown to provide data of a quality comparable to traditional survey methods (Gosling et al., 2004; Reips, 2002; Rhodes et al., 2003). Since it was not used to determine the prevalence of plant-eating behaviour, the internet survey utilised in Study 2 was specifically targeted toward owners of plant-eating dogs.

Using an established web-based program (Survey Suite, University of VA, USA), a survey was designed for internet distribution that would take approximately 20 min to complete. The survey included questions dealing with the description of the dog and its environment, information on plant eating and the dog's diet and medical history (Table 2). For households possessing more than one dog that ate plants, respondents were asked to answer the questions for the dog that ate plants most frequently. Questions were presented in

Table 2

Study 2, summary of questions presented to owners of plant-eating dogs in an internet survey (not inclusive of all questions)

Section	
Description of dog	Sex, gonadal status, major breed group, age Duration in household Time spend with dog daily
Information on plant eating	Number times observed eating plants Frequency of plant eating Age when plant eating first noticed Typically only chews or eats plants Where dog has access to plants Type of plants eaten Type of plant most frequently eaten Sign of illness before and after plant eating Vomiting within 1 h after eating plants
Diet fed	Home cooked Raw Commercial kibble or canned
Medical history	Current medical history Current medications

either multiple-choice or short-answer format. With regard to frequency of plant eating, respondents were asked to choose from the following: (1) daily; (2) weekly, defined as at least once a week but less than daily; (3) monthly, defined as at least once a month but less than weekly; (4) less than once a month. Respondents were also asked whether their dog frequently appeared ill before, or vomited after, eating plants. The survey focused only on the presence or absence of illness or vomiting and did not ask owners to describe their nature or severity.

We used an internet search engine to find websites most likely to be visited by dog owners interested in plant-eating behaviour and managers of these websites were asked to post a link to the survey. Moderators of internet “chat groups” related to dogs and dog behaviour were also contacted and asked to inform their group members of the survey. The survey was posted for 3 weeks before being closed.

Survey responses were screened and assessed for the inclusion criteria; only those surveys in which dog owners stated they spent at least 6 h per day in the company of their dogs and had observed plant eating on at least 10 occasions during the time they owned their dogs were included. These restrictions ensured that the owners had an adequate opportunity to observe their dogs’ plant-eating behaviour on several occasions and could accurately determine how their dogs most commonly behaved before and after eating plants. Exclusion criteria included medical problems or current medications that might induce plant eating or vomiting (see Section 2.2). Because we were also trying to determine whether dogs consumed plants due to a dietary deficiency, dogs that were reported to only chew or mouth plants, without appearing to ingest plants, were excluded from the study. Duplicate or incomplete surveys were not utilized. The respondents were not aware that these criteria were used for exclusion.

2.3.3. Data analysis

Analyses for the dependent variables, which were considered on a dichotomous basis, involved the following: frequency of plant eating (once a week or more versus less than once a week); eating primarily grass versus non-grass; frequently appearing ill versus rarely appearing ill before eating plants and frequently vomiting versus rarely vomiting after eating plants. The analysis involved an initial screening with a stepwise logistic regression to select those independent variables that appeared to act as predictors of differences ($P < 0.05$) in the dependent variables (Hosmer and Lemeshow, 1989; SAS, V.9.1, logistic

procedure). The independent variables were: age, categorized as <1 year, 1–2 years, 3–9 years or >9 years; sex and gonadal status, categorized as male-neutered, male-intact, female-spayed or female-intact; breed group, categorized as mixed, sporting, herding, hound, terrier, working, non-sporting or toy and diet, categorized as complete by virtue of being at least 51% commercial, AAFCO-certified dog food or incomplete by virtue of being 51% or greater home-cooked or raw food. After the initial screening, an explicit model was fitted (without any model selection) with multiple comparisons to determine which independent variables significantly predicted dependent variables (SAS, V.9.1, genmod procedure). Significance was set at the $\alpha = 0.05$ level. When a level of significance is reported, that level was derived from the multiple comparisons based on the explicit model and when a non-significant level is reported, the value was taken from the initial screening analysis.

3. Results

3.1. Pilot study

Twenty-five pilot surveys were returned from respondents, all of whom stated that their dogs ate grass. None of the dogs exhibited signs of illness prior to eating grass. Two dogs (8%) were reported to regularly vomit after eating grass, 13 (52%) to occasionally vomit and 10 (40%) had never been observed vomiting afterwards.

3.2. Study 1

Of 98 surveys given to dog owners in Study 1, 78 (80%) were completed and returned. Of these, 47 (60%) met the criteria for inclusion. Ten of the 47 owners (21%) reported that they had never seen their dogs eat plants and had not noticed grass or other plant material in their faeces or vomit. The remaining 79% reported that they had seen their dogs eat grass at least once or noticed grass in their dogs' faeces or vomit.

With regard to the 37 dogs reported to eat plants, the number of plant-eating episodes observed throughout the duration of ownership was fewer than 10 for 12 dogs (32%), over 10 but less than 100 for 18 dogs (49%) and over 100 for 7 dogs (19%). Grass was the plant primarily eaten by 35 dogs (95%).

Thirty-three owners answered the questions regarding their dogs' behaviour before and after eating plants. Of these, four dogs (12%) were reported to regularly appear ill before eating plants and six (18%) were reported to regularly vomit afterwards. Three (50%) of the regularly vomiting dogs were reported to also appear ill before eating plants. None of the non-plant-eating dogs consumed a diet supplemented with vegetables or fruits, while diets of 10 of 37 plant-eating dogs (27%) were supplemented with some vegetables or fruits by their owner.

3.3. Study 2

Of 3340 surveys returned, 1571 (47%) met the inclusion criteria. The survey data contained 197 intact males, 560 castrated males, 219 intact females and 595 spayed females. Data on the estimated time spent with the dog, total number of plant-eating occasions observed, frequency of plant eating, age of the dog, duration of the dog in the household and where the dog had access to plants are presented in Table 3. The estimated total of number of plant-eating occasions observed by the respondents over the duration of ownership was evenly split between 10 and 100 times and over 100 times; the reported frequency of plant eating was daily

Table 3

Study 2, percentage of owners reporting: the length of time spent with their dog per day; the total number of times they observed their dog eating plants; the frequency of plant eating by their dog; their dog's age; their duration of ownership; where their dog had access to plants ($N = 1571$ surveys)

Estimated time spent with dog per day (h)			
6–9	10–12	13–15	>15
25	18	16	41
Estimated total plant-eating occasions observed			
10–20	21–50	51–100	>100
11	21	18	50
Estimated frequency of plant eating by dogs			
Daily	Weekly	Monthly	<Monthly
24	44	22	10
Age of dog covered by survey (years)			
<1	1–2	3–9	>9
4	23	55	18
Duration of dog in household (years)			
<1	1–3	4–6	>6
8	35	19	38
Access to plants by dog			
Yard			Walks
95			62

or weekly for 68% of respondents and monthly or less by 32%; almost all dogs (95%) had access to plants in the yard with the remaining dogs having access to plants on walks or in other locations.

The distribution of plant type reported eaten most often is shown in Fig. 1. Grass (long, short or clippings) was listed by 79% of respondents as the plant they observed their dog consume most frequently; non-grass plants eaten included mainly berries, sticks and leaves. Almost all respondents (98%) mentioned that grass was consumed on at least some occasions. Several respondents commented that their dogs appeared very “selective” in regard to the type or portion of grass eaten.

Data relating to frequency of plant eating and plant type eaten as a function of sex and gonadal status, breed group and dietary quality, are presented in Table 4. Most owners (1439/1571; 92%) said that their dogs rarely showed signs of illness before or after eating plants. Vomiting regularly within 1 h after eating plants was also infrequent; 78% (1225/1571) of respondents stated that their dogs rarely vomited after eating plants.

The only significant predictor of frequency of plant eating was age of the dog. In the follow-up multiple comparisons, frequency of plant eating was significantly inversely related to age group ($P < 0.001$; Fig. 2A). In the initial analysis, sex/gonadal status, breed group and diet were not related to frequency of plant eating ($P = 0.194, 0.130$ and 0.067 , respectively).

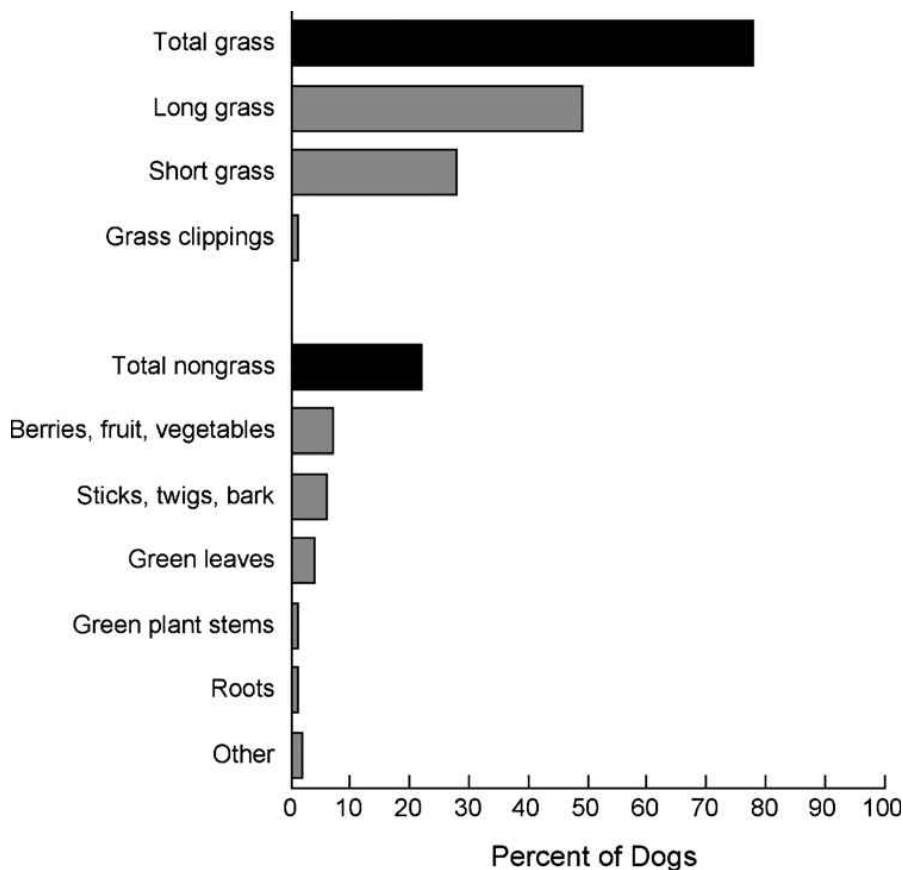


Fig. 1. Percentages of dogs that primarily consumed grass or non-grass plant types as reported by their owners in an internet survey (Study 2) ($N = 1571$). Plant types mentioned by fewer than 15 (1%) respondents are represented as other.

Table 4

Study 2, plant-eating frequency, expressed as daily or weekly (≥ 1 week) or monthly (< 1 /week) and type of plant eaten as a function of sex/gonadal status, breed group and diet ($N = 1571$)

	<i>N</i>	Frequency of plant eating		Type of plant eaten	
		≥ 1 per week; <i>N</i> (%)	< 1 per week; <i>N</i> (%)	Grass; <i>N</i> (%)	Non-grass; <i>N</i> (%)
Sex/gonadal status					
Male-intact	197	127 (64)	70 (36)	143 (73)	54 (27)
Male-neutered	560	317 (66)	189 (34)	438 (78)	122 (22)
Female-intact	219	155 (71)	64 (29)	163 (74)	56 (26)
Female-spayed	595	411 (69)	184 (31)	483 (81)	112 (19)
Breed					
Mixed breed	172	113 (66)	59 (34)	143 (84)	29 (16)
Sporting group	309	222 (72)	87 (28)	238 (77)	71 (23)
Herding group	296	194 (66)	102 (34)	231 (78)	65 (22)
Hound group	131	79 (60)	52 (40)	106 (81)	25 (19)
Terrier group	153	94 (61)	59 (39)	113 (74)	40 (26)
Working group	320	229 (72)	91 (28)	252 (79)	68 (21)
Non-sporting group	100	72 (72)	28 (28)	78 (78)	22 (22)
Toy group	90	61 (68)	29 (32)	66 (73)	24 (27)
Diet					
Commercial	1245	831 (67)	414 (33)	976 (78)	269 (22)
Home/raw	326	233 (71)	93 (29)	251 (77)	72 (23)

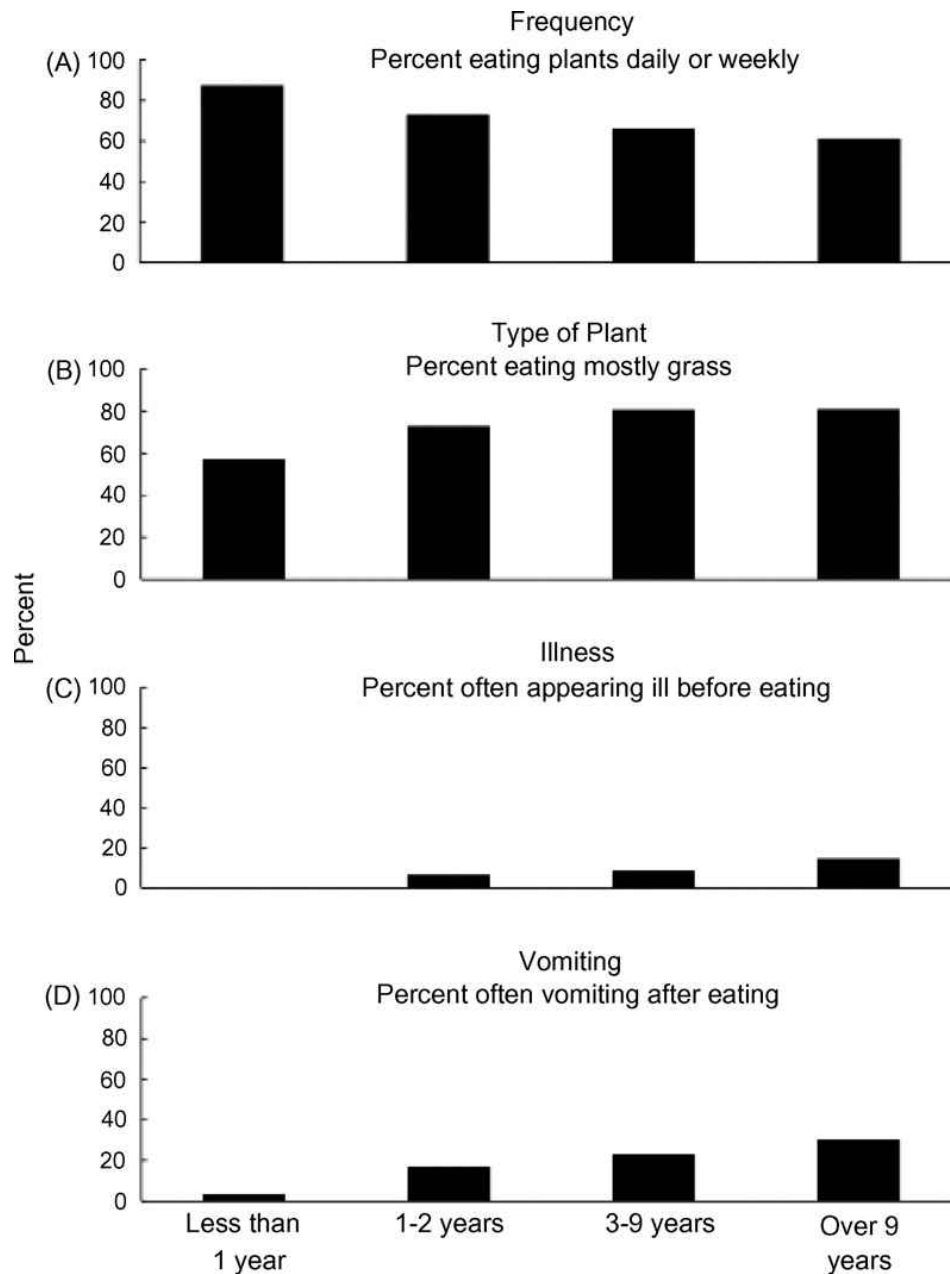


Fig. 2. Comparison of different age groups of dogs in an internet survey (Study 2) with regard to: (A) percent exhibiting daily or weekly plant consumption; (B) percent observed to consume primarily grass; (C) percent regularly showing signs of illness before eating plants and (D) percent vomiting after eating plants.

A significant predictor with regard to type of plant eaten (grass versus non-grass) was age. In multiple comparisons there was a significant increasing tendency for older dogs to primarily eat grass ($P = 0.003$; Fig. 2B). Interestingly, gonadally intact dogs were more likely to eat grass than neutered dogs, even after controlling for age ($P = 0.005$). However, among both intact and neutered females there was an increased tendency to eat non-grass plants in the oldest age group ($P = 0.024$). Breed group and diet were not significant in the initial analysis with regard to the type of plant eaten ($P = 0.704$ and 0.271 , respectively).

Although frequently showing signs of illness before eating plants was seen in only 8% of dogs overall, the initial analysis revealed an effect of age, with an increasing tendency to show illness

with increasing age ($P < 0.001$; Fig. 2C). No effect of diet, sex/gonadal status or breed group was apparent ($P = 0.796$, 0.527 and 0.114 , respectively).

While vomiting frequently after eating plants was seen in only 22% of dogs, the initial screening analysis revealed that age, breed group and diet were significant predictors of vomiting. The multiple comparisons revealed that the older the dog the more likely it was to regularly vomit ($P < 0.001$; Fig. 2D). Dogs in the hound and toy breed groups were more likely to regularly vomit than dogs in the other breed groups ($P = 0.0031$). Additionally, dogs fed a complete, balanced diet were more likely to regularly vomit than those fed a home-made diet ($P < 0.001$). Sex/gonadal status was not a significant predictor ($P = 0.13$). This analysis also revealed that if dogs showed signs of illness before eating plants they were more likely to vomit afterwards than dogs rarely showing signs of illness beforehand ($P < 0.001$).

4. Discussion

Based on the finding in Study 1, that approximately 79% of healthy, well-cared-for dogs eat plants, particularly grass, plant eating appears to be a common behaviour of domestic dogs. In Study 2, involving only plant-eating dogs, almost all of the dogs were reported to eat grass on at least some occasions. The fact that this behaviour is widespread and occurs in all domesticated breed groups indicates that it likely serves some biological function.

Three hypotheses regarding the causes or consequences of plant eating by dogs were tested directly. One hypothesis was that dogs eat plants when they feel ill; a second hypothesis was that dogs frequently vomit after ingesting plant material. Neither hypothesis was supported by the data obtained from these studies. Data from three diverse populations of dog owners, 25 veterinary students (Pilot Survey), 47 screened clients of the outpatient clinic with apparently healthy dogs (Study 1) and 1571 screened respondents to an internet survey (Study 2), revealed that most dogs appear normal before eating plants and do not regularly vomit afterwards. The magnitude of the data was convincing, with 100, 88 and 92% of owners from the Pilot Survey, Study 1 and Study 2, respectively, reporting that their dogs appeared normal before eating plants, and 87, 82 and 78%, respectively, reporting no regular vomiting afterwards.

Given that a few dogs do appear to be ill prior to eating plants and that vomiting does sometimes follow plant eating, it is possible that gastric and/or intestinal discomfort sometimes evokes plant eating and that plant consumption may cause enough gastric irritation to lead to vomiting. This assumption is consistent with the finding from Study 2 that if dogs showed signs of illness before eating plants they were more likely to vomit afterwards than dogs that did not show signs of illness beforehand. While we attempted to exclude dogs with known medical problems, it is reasonable to assume that some dogs included in the study had gastrointestinal distress or illness without their owners being aware of the problem.

A third hypothesis was that plant eating reflected a dietary deficiency of some type. No relationship was found between type of diet and frequency of plant eating, or type of plant eaten in Study 2. In Study 1, no dogs in the non-plant-eating group were supplemented with vegetables or fruit, whereas 10 of 37 (27%) plant-eating dogs' diets were supplemented with some type of vegetable or fruit, suggesting that plant eating is not evoked by absence of plant material in the diet and that offering plant material in the diet does not prevent plant eating from occurring. While a detailed study investigating deficiencies in specific elements such as fibre, vitamins or minerals is needed, a provisional conclusion is that the type of diet does not affect the tendency to engage in plant eating. At this time, we cannot discern a reason for dogs fed a commercial diet to be more likely to vomit after eating plants than dogs on home-cooked or raw food diets. However,

the findings that most dogs eat plants to some degree and plant eating is not associated with dietary deficiency, signs of illness or vomiting, lends support to Hypothesis 4, that plant eating is mostly a normal behaviour.

Study 2 found that the majority of plant-eating dogs of all breeds consume grass most often and at roughly the same frequency, despite the fact that dog breeds tend to exhibit different food preferences and feeding patterns (Thorne, 1995). Grass eating is also widespread amongst wolves; grass was the primary plant type found in timber wolf scat (2–%; Mech, 1966) and the second most common plant type found in the scat of Latvian wolves, with conifer needles being the most frequent (Anderson, 1998). This points to an evolutionary background where plant eating was maintained in wild canids through natural selection and was conserved in dogs during domestication.

Natural selection would have favoured periodic plant eating if it conferred a selective advantage on canids displaying the behaviour. One possibility is that ingestion of non-nutritive plant material provides a mechanical means of expelling intestinal parasites. As mentioned in the introduction, intestinal worms have been observed wrapped around blades of grass in wolf scats (Murie, 1944).

Non-nutritional plant eating has been studied in detail in wild chimpanzees (*Pan troglodytes*), which consume whole leaves from a variety of plant species, particularly during the time of year when intestinal parasitism risk is high (Wrangham, 1995). The observation that whole leaves pass through the intestinal tract intact, sometimes along with intestinal nematodes (Huffman et al., 1996), together with evidence of increased intestinal motility from the swallowing of whole leaves, has led investigators to propose that whole leaves have a purging effect on intestinal nematodes (Huffman and Canton, 2001). Controlled, laboratory studies could be performed with domestic dogs to determine whether or not plant eating reduces intestinal parasites in this species.

Another perspective on this issue comes from observations of parasite loads in young canids compared with older canids. Coyotes less than 1 year of age (Franson et al., 1978) and young dogs, especially those without close medical oversight (Fontanarrosa et al., 2006; Ramirez-Barrios et al., 2004; Kirkpatrick, 1988), have a higher prevalence of intestinal parasites than adults. If the predisposition towards plant eating in domestic dogs stems from an innate behaviour in ancestral canids for periodic expulsion of intestinal parasites, one would expect younger canids, including dogs, to engage in the behaviour more frequently than older dogs. This perspective is supported by the finding in Study 2 of an inverse relationship between age and frequency of plant eating. The data also reveal that younger dogs are less likely to appear ill before, or vomit after, eating plants, a finding consistent with the concept of ongoing control of parasites. The finding that some dogs do not eat plants at all (Study 1) could be explained on the basis of relaxation of selection for plant-eating behaviour, reflecting dog-owner use of prophylactic treatment for intestinal parasites.

5. Conclusions

Plant eating, especially grass eating, commonly occurs among all breed groups of domestic dogs and appears to be a normal behaviour unassociated with illness, vomiting or dietary deficiency. Although this study only investigated plant-eating behaviour in domestic dogs, plant eating has also been observed in wolves and other wild canids. Since the behaviour appears to have been conserved through domestication and artificial selection, it seems likely that it serves some biological purpose. Further studies are needed to determine what, if any, selective advantage plant eating may offer, such as an increase in gastrointestinal motility and/or the

expulsion of intestinal parasites. Because non-nutritional plant eating with a health-related function is a type of herbal medication (Hart, 2005), if a health maintenance function is eventually demonstrated for plant eating by canids, the behaviour would represent the first documented example of herbal medicine in carnivores.

Acknowledgements

Supported by the University of California, Davis, Center for Companion Animal Health (allocation #03-65-F). The authors thank Stanley L. Marks, specialist in clinical nutrition, for providing assistance in formulating survey questions and Neil Willits of the Department of Statistics for statistical advice and data processing.

References

- Alenza, D.P., Rutteman, G.R., Pena, L., Beynen, A.C., Cuesta, P., 1998. Relation between habitual diet and canine mammary tumors in a case-control study. *J. Vet. Intern. Med.* 12, 132–139.
- Anderson, Z., 1998. Summer nutrition of wolf (*Canis lupus*) in the Slitere Nature Reserve, Latvia. *Proc. Latvian Acad. Sci.* 52, 79–80.
- Anderson, Z., Ozolins, J., 2004. Food habits of wolves *Canis lupus* in Latvia. *Acta Theriologica* 49, 357–367.
- Beaver, B.L., 1981. Grass eating by carnivores. *Vet. Med. Small Anim. Clin.* 76, 968–969.
- Berschneider, H.M., 2002. Alternative diets. *Clin. Tech. Small Anim. Pract.* 17, 1–5.
- Fontanarrosa, M.F., Vezzani, D., Basabe, J., Eiras, D.F., 2006. An epidemiological study of gastrointestinal parasites of dogs from Southern Greater Buenos Aires (Argentina): age, gender, breed, mixed infections, and seasonal and spatial patterns. *Vet. Parasitol.* 136, 283–295.
- Franson, J.C., Jorgenson, R.D., Boggess, E.K., Greve, J.H., 1978. Gastrointestinal parasitism of Iowa coyotes in relation to age. *J. Parasitol.* 64, 303–305.
- Freeman, L.M., Michel, K.E., 2001. Evaluation of raw food diets for dogs. *J. Am. Vet. Med. Assoc.* 218, 705–709.
- Gobar, G.M., Kass, P.H., 2002. World wide web-based survey of vaccination practices, postvaccinational reactions, and vaccine site-associated sarcomas in cats. *J. Am. Vet. Med. Assoc.* 220, 1425–1576.
- Gosling, S.D., Vazire, S., Srivastava, S., John, O.P., 2004. Should we trust web-based studies? A comparative analysis of six preconceptions about internet questionnaires. *Am. Psychol.* 59, 93–104.
- Hart, B.L., 1988. Biological basis of the behaviour of sick animals. *Neurosci. Biobehav. Rev.* 12, 123–137.
- Hart, B.L., 2005. The evolution of herbal medicine: behavioural perspectives. *Anim. Behav.* 70, 975–989.
- Hosmer, D.W., Lemeshow, S., 1989. *Applied Logistic Regression*. Wiley, New York, pp. 106–112.
- Houpt, K.A., 2005. Ingestive behavior: food and water intake. In: *Domestic Animal Behavior for Veterinarians and Animal Scientists*, fourth ed. Blackwell Publishing, Ames, IA, pp. 309–359.
- Huffman, M.A., Canton, J.M., 2001. Self-induced increase of gut motility and the control of parasitic infections in wild chimpanzees. *Int. J. Primatol.* 22, 329–346.
- Huffman, M.A., Page, J.E., Sukhdeo, M.V.K., Gotoh, S., Kalunde, M.S., Chandrasiri, T., Towers, G.H.N., 1996. Leaf-swallowing by chimpanzees: a behavioural adaptation for the control of strongyle nematode infections. *Int. J. Primatol.* 17, 475–503.
- Janson, C., Wist, M., 2004. An internet survey of asthma treatment. *J. Asthma* 41, 49–55.
- Kim, H.L., Gerber, G.S., Patel, R.V., Hollowell, C.M., Bales, G.T., 2001. Practice patterns in the treatment of female urinary incontinence: a postal and internet survey. *Urology* 57, 45–48.
- Kirkpatrick, C.E., 1988. Epizootiology of endoparasitic infections in pet dogs and cats presented to a veterinary teaching hospital. *Vet. Parasitol.* 30, 113–124.
- Lindsay, S.R., 2001. Appetitive and elimination problems. *Handbook of Applied Dog Behavior and Training. Etiology and Assessment of Behavior Problems*, vol. 2. Iowa State University Press, Ames, IA, pp. 273–299.
- Mech, L.D., 1966. Results—the Timber wolf and its ecology. *Fauna of the National Park of the United States: The Wolves of Isle Royale*. National Park Service. 3 September 2004. <http://www.cr.nps.gov/history/online_books/fauna7/fauna5g.htm>.
- McCobb, E.C., Brown, E.A., Damiani, K., Dodman, N.H., 2001. Thunderstorm phobia in dogs: an internet survey of 69 cases. *J. Am. Anim. Hosp. Assoc.* 37, 319–324.

- Murie, A., 1944. Food habits of wolves. Fauna of the National Parks of the United States: The Wolves of Mount McKinley. National Park Service. 29 November 2004. <http://www.cr.nps.gov/history/online_books/fauna5/fauna.htm>.
- Overall, K.L., 1997. Miscellaneous behavioral problems: emphasis on management. In: *Clinical Behavioral Medicine for Small Animals*, Mosby-Year Book Inc., St. Louis, MO, pp. 251–273.
- Papageorgiou, N., Vlachos, C., Sfougaris, A., Tsachalidis, E., 1994. Status and diet of wolves in Greece. *Acta Theriologica* 39, 411–416.
- Plumb, D.C., 2002. *Veterinary Drug Handbook*, fourth ed. Pharma Vet Publishing, White Bear Lake, MN, pp. 108, 680, 715.
- Ramirez-Barrios, R.A., Barboza-Mena, G., Munoz, J., Angulo-Cubillan, F., Hernandez, E., Gonzalez, F., Escalona, F., 2004. Prevalence of intestinal parasites in dogs under veterinary care in Maracaibo, Venezuela. *Vet. Parasitol.* 121, 11–20.
- Reips, U., 2002. Standards for internet-based experimenting. *Exp. Psychol.* 49, 243–256.
- Rhodes, S.D., Bowie, D.A., Hergenrather, K.C., 2003. Collecting behavioural data using the world wide web: considerations for researchers. *J. Epidemiol. Community Health* 57, 68–73.
- Stahler, D.R., Smith, D.W., Guernsey, D.S., 2006. Foraging and feeding ecology of the grey wolf (*Canis lupus*): lessons from Yellowstone National Park, Wyoming, USA. *J. Nutr.* 136, 1923S–1926S.
- Thorne, C., 1995. Feeding behaviour of domestic dogs and the role of experience. In: Serpell, J. (Ed.), *The Domestic Dog: Its Evolution, Behaviour and Interactions with People*. Cambridge University Press, Cambridge, UK, pp. 103–114.
- Wrangham, R., 1995. Relationship of chimpanzee leaf-swallowing to a tapeworm infection. *Am. J. Primatol.* 37, 297–303.