Plant-based diets for dogs and cats – an investigation of pet feeding practices, motivations and concerns

by

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ABSTRACT

PLANT-BASED DIETS FOR DOGS AND CATS – AN INVESTIGATION OF PET FEEDING PRACTICES, MOTIVATIONS AND CONCERNS

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This thesis is an investigation of the prevalence of meat-avoidance amongst pet keepers, the prevalence of plant-based feeding practices, and the motivations and concerns of pet keepers regarding animal- and plant-based pet foods. A questionnaire was disseminated online to English-speaking pet keepers (n = 3,673), and descriptive statistics were utilised. Few pets were fed strictly plant-based diets (1.6%; 59/3,673). One dog was kept by a vegetarian, otherwise vegans were the only pet keepers who fed plant-based diets to their pets, with 27% (58/212) doing so. Consideration of animal rights and lack of concern regarding plant-based diets being unnatural were most significantly associated with vegan pet keepers feeding plant-based diets to their pets (OR 9.12 and 14.27 respectively, p < 0.05). A large proportion (45%; 269/599) of pet keepers reported desire for evidence regarding nutritional adequacy of plant-based diets for pets; more research in this area is clearly warranted.
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# TABLE OF CONTENTS

Abstract ............................................................................................................................... ii

Acknowledgements ........................................................................................................... iii

Table of Contents .............................................................................................................. v

List of Tables ................................................................................................................... viii

List of Figures .................................................................................................................. ix

List of Symbols, Abbreviations or Nomenclature .............................................................. x

List of Appendices ......................................................................................................... xi

1. CHAPTER 1: LITERATURE REVIEW ............................................................................ 1
   1.1 INTRODUCTION ...................................................................................................... 2
   1.2 FEEDING PRACTICES ........................................................................................... 3
   1.3 VEGANISM ............................................................................................................ 3
       1.3.1 Vegan Motives ................................................................................................. 5
           1.3.1.1 Health ....................................................................................................... 5
           1.3.1.2 The Environment .................................................................................... 8
           1.3.1.3 Ethics and Morality ................................................................................. 10
       1.3.2 Speciesism and the Vegan Dilemma .............................................................. 11
   1.4 PLANT-BASED PET FOOD ..................................................................................... 12
       1.4.1 Particular Concerns ....................................................................................... 13
           1.4.1.1 Nutritional Adequacy ............................................................................. 13
               1.4.1.1.1 Total Protein ..................................................................................... 13
               1.4.1.1.2 The Sulfur Amino Acids: Methionine, Cysteine and Taurine ........ 15
               1.4.1.1.3 Omega Fatty Acids ......................................................................... 16
LIST OF TABLES

Table 1. Demographic data of pet keepers participating in the "Pet Feeding Practices" Survey (n = 3,673) ........................................................................................................45

Table 2. Dog feeding practices by country. Feeding practices data represented as percentage and frequency of respondents indicating they fed a diet including or exclusively consisting of particular diets. ........................................................................46

Table 3. Cat feeding practices by country. Feeding practices data represented as percentage and frequency of respondents indicating they fed a diet including or exclusively consisting of particular diets. ........................................................................47

Table 4. Summary of nine peer-reviewed publications published between 2008 and 2017, documenting pet feeding practices in Australia, Canada, New Zealand, the UK and the USA from data spanning 2004 to 2016. ........................................................................48

Table 5. Demographic data of pet keepers participating in the "Pet Feeding Practices" survey (n = 3,673) ........................................................................................................69

Table 6. Prevalence of veganism and vegetarianism in pet keepers participating in the "Pet Feeding Practices" survey (n = 3,673) compared to the general population of their respective countries. ........................................................................70

Table 7. Concerns regarding pet foods and financial motivation to buy plant-based pet food, reported by pet keepers participating in the "Pet Feeding Practices" survey. Survey respondents are grouped according to respondent diet, and concerns are shown as percentage and number in parentheses. ........................................................................71

Table 8. Odds of vegan pet keepers feeding a plant-based diet to their pet based on responses of pet owners to the "Pet Feeding Practices" survey. R2 = 0.524 ................72
LIST OF FIGURES

Figure 1. Proportion of pet keepers following a given diet, by age group. ....................73

Figure 2. Current composition of pet diets (dog top, cat bottom), according to their keepers’ diet, based on responses of pet keepers to the “Pet Feeding Practices”. Y axis represents percentage of pet keepers within a given diet group. ........................................74

Figure 3. Percentage of pet keepers (dog top, cat bottom) who would consider feeding a plant-based diet if one were available that fit their criteria, according to pet keeper diet, based on responses of pet keepers to the “Pet Feeding Practices”. Y axis represents percentage of pet keepers within a given diet group. ..............................................................75
**LIST OF SYMBOLS, ABBREVIATIONS OR NOMENCLATURE**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>Amino acids</td>
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<tr>
<td>AAFCO</td>
<td>Association of American Feed Control Officials</td>
</tr>
<tr>
<td>DHA</td>
<td>Docosahexaenoic acid</td>
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<tr>
<td>EPA</td>
<td>Eicosapentaenoic acid</td>
</tr>
<tr>
<td>FEDIAF</td>
<td>European Pet Food Industry Federation</td>
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<tr>
<td>NRC</td>
<td>National Research Council</td>
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<tr>
<td>PUFA</td>
<td>Polyunsaturated fatty acids</td>
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<td>Ω-3</td>
<td>Omega 3</td>
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<tr>
<td>Ω-6</td>
<td>Omega 6</td>
</tr>
<tr>
<td>ALA</td>
<td>α-linolenic acid</td>
</tr>
<tr>
<td>RAP</td>
<td>Raw animal products</td>
</tr>
</tbody>
</table>
LIST OF APPENDICES

APPENDIX 1:  Survey Instrument
CHAPTER 1: LITERATURE REVIEW

PET FEEDING PRACTICES, VEGANISM, AND PLANT-BASE PET FOODS

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1.1 INTRODUCTION

Human diets have developed distinct trends, some based on religion, culture, preventing or managing disease, minimising negative impacts, or personal taste preferences (Santeramo et al., 2018; Sloan, 2017, 2018). The role of companion animals has evolved over the years of their domestication to our current relationship, which closely resembles that of a family member in most cases (Case, 2008). Considering this, it is unsurprising that trends in companion animal nutrition closely shadow trends in human nutrition (Agri-Food, 2012; PFI, 2015). Currently prominent examples include natural, ‘ancestral’, ‘grain-free’, homemade or raw diets (Buff, Carter, Bauer, & Kersey, 2014; Laflamme et al., 2008; Lummis, 2014; Michel, 2006; Michel et al., 2008).

Recently, diets minimising [ovo-lacto vegetarian, vegetarian] or else completely eschewing [plant-based, strict vegetarian, vegan] animal products have been a growing dietary trend in many developed countries worldwide (Bates, Lennox, Bates, & Swan, 2009; Crawford, 2015; Santeramo et al., 2018). Reported reasons for this dietary shift have included: the negative health effects associated with consumption of animal products, the environmental impact of animal agriculture and the ethical implications of animal use and slaughter (Janssen, Busch, Rödiger, & Hamm, 2016b; Kersche-Risch, 2015; Radnitz, Beezhold, & DiMatteo, 2015). Plant-based diets formulated for companion dogs and cats have also been introduced to the market in recent years as an option for pet keepers [syn. owner, parent, guardian] who wish to avoid purchasing or preparing animal-derived products (Knight & Leitsberger, 2016b). It is the purpose of this introduction to present the concept of veganism, review the relationship between veganism
and companion animals, and discuss the motivations and concerns regarding the feeding of plant-based diets to cats and dogs.

1.2 FEEDING PRACTICES

The majority of pets, over 90% of cats and 80-90% of dogs, are reportedly fed commercial diets (Laflamme et al., 2008). Trends in companion animal nutrition often shadow trends in human nutrition, as pets are now generally viewed as family members, and many pet keepers refer to themselves as pet ‘guardians’ or pet ‘parents’, reflecting this close relationship (Boya, Dotson, & Hyatt, 2015; Case, 2008). As human dietary practices change, there may too be a growing prevalence of homemade and/or raw diet feeding, at least among some demographics of pet keepers (Connolly, Hienze, & Freeman, 2014; Dinallo, Poplarski, Van Deventer, Eirmann, & Wakshlag, 2017; Morgan, Willis, & Shepherd, 2017). There have been few studies published comprehensively investigating pet feeding practices within the past 10 years, and no previously published studies have included plant-based diet feeding practices amongst the general pet-keeping population.

1.3 VEGANISM

According to The Vegan Society, the group that first coined the term ‘vegan’ in 1944, the definition of veganism is:

“A philosophy and way of living which seeks to exclude - as far as is possible and practicable – all forms of exploitation of, and cruelty to, animals for food, clothing or any other
purpose; and by extension, promotes the development and use of animal-free alternatives for the benefit of humans, animals and the environment.” (Boo, 2014)

It is thus evident that, while it encompasses diet, veganism is truly a philosophy and lifestyle. Though the term is often used to describe companion animals or their diet, such as “a vegan dog” or “vegan dog food”, it is inappropriate to apply that term as the animal in question has made no conscious decision to adopt the philosophy and is simply eating the food that is provided for them. Thus, throughout this paper, when non-human animals are referred to, they will be described as plant-based, not vegan, where appropriate.

In many studies of human nutrition or psychology, vegans are frequently grouped in with vegetarians, and thus there is no differentiation between those who consume eggs, milk, and/or honey and those who avoid animal products entirely. Sometimes veganism may be incorporated into a sort of diet scale with strict vegetarian [vegan] on one end and fully omnivorous on the other end (Allen, Wilson, Ng, & Dunne, 2000; Beardsworth & Keil, 1991). This may confound some findings and can make discussion of veganism and its associations or effects on other outcomes or variables challenging. Nevertheless, the vegan diet has become widely researched, particularly the associated risks and benefits to human health, and newer publications clearly differentiate between vegans and other less stringent meat-avoiders such as vegetarians or pescetarians (Craig, 2009; Dinu, Abbate, Gensini, Casini, & Sofi, 2017; Glick-Bauer & Yeh, 2014; Le & Sabaté, 2014).
1.3.1 Vegan Motives

Worldwide, meat consumption has been reportedly declining in affluent countries, with public interest in plant-based foods concurrently growing (GlobalData, 2017; Santeramo et al., 2018; Sloan, 2017). In the past few years there has been great development in meat, egg and dairy alternatives, with new products being introduced to the market at a rapid rate (Doris, 2018; Nunes, 2016; Watrous, 2016). Approximately 1-3% of the population of the United States identify as vegan (GlobalData, 2017; Newport, 2012), with similar numbers reported in other affluent countries (Bates, Lennox, Bates, et al., 2009; DEFRA, 2007; FSA, 2006; HealthNavigator, 2017; Henderson, Gregory, & Swan, 2002; RoyMorgan, 2016; VVSQ, 2013). Even amongst omnivores, the practice of meat consumption is reportedly decreasing in some demographics (Muchenje, 2018; Santeramo et al., 2018). The motives most commonly reported for reduction or elimination of dietary animal products will be discussed here.

1.3.1.1 Health

Risks to human health associated with the consumption of animal products, particularly meats, are quite widely researched, including: coronary heart disease, stroke, type 2 diabetes, obesity, and a variety of cancers (Bella, Justyna, Ippolito, Di Prima, & Sciacca, 2017; Fardet & Boirie, 2014; Yip, Crane, & Karnon, 2013)). Moreover, consumption of a plant-based diet has also been reported to result in health benefits, such as: decreased evidence of inflammation and lower body mass index, blood cholesterol, blood glucose and blood pressure, when compared to vegetarian and/or meat-containing diets (Craig, 2009; Dinu et al., 2017; Glick-Bauer & Yeh, 2014; Le & Sabaté, 2014).
Data also exist to support therapeutic use of vegan diets in the treatment of common chronic health conditions - hypertension, hypercholesterolemia, fibromyalgia, rheumatoid arthritis, and type 2 diabetes may all be improved through consumption of plant-based diets (Hafström et al., 2001; Kaartinen et al., 2009; McDougall, 1999; Trap & Barnard, 2010). As such, there is a growing health movement promoting a whole-foods plant-based diet, and many are adopting a vegan diet at least in part for their own health (Janssen et al., 2016b; Kersche-Risch, 2015; Radnitz et al., 2015). For example, in humans, a balanced vegan diet has been associated with improvement of painful inflammatory conditions such as rheumatoid arthritis and fibromyalgia (Hafström et al., 2001; Kaartinen et al., 2009), as well as decreased risk of cancers (Dinu et al., 2017; Frentzel-Beyme & Chang-Claude, 1994) and cardiovascular disease (Craig, 2009; Frentzel-Beyme & Chang-Claude, 1994) when compared with people eating a diet inclusive of animal products. People consuming a vegan diet have also been found to have different gut microbiota than people consuming animal products, with a lower burden of opportunistic pathogens and greater abundance of protective species (Ferrocino et al., 2015; Glick-Bauer & Yeh, 2014). The changes in microbial communities may be associated with decreased inflammation and contribute to the lower risk of chronic diseases and gastrointestinal neoplasia in vegans, though the health outcomes of these changes in microbiota are yet to be described (Glick-Bauer & Yeh, 2014).

However, there are also nutrients of concern for vegans, with dietary intakes found to be lower in vegans than in people who regularly consume animal products. In
one study, nutrients found to be below the UK Reference Nutrient Intakes in vegans included: vitamin B12 and zinc, though the increasing practice of fortifying foods with essential nutrients may mitigate this risk (Davey et al., 2002). Vitamin D levels are also lowest in vegans, and may be associated with inadequate intakes in people living at high latitudes without adequate sun exposure (Craig, 2009; Davey et al., 2002).

Caution must thus be employed when extrapolating to companion animal health and nutrition. It is unlikely that a plant-based diet would confer the same health benefits to dogs and cats as it may do for their human keepers. The diseases in humans for which vegan diets confer the most protection against, including rheumatoid arthritis, cardiovascular disease and primary gastrointestinal neoplasia, are not commonly diagnosed in companion animals. The potential effects of plant-based diets on the gut microbiome of companion animals are unknown.

Just as with humans, diets devoid of animal products are also at risk of insufficiency for dogs and cats. Unlike humans, however, the practice of feeding ‘complete and balanced’ diets to pets is commonplace, and if a complete and balanced plant-based diet is fed, the risk of nutritional insufficiency should not be a concern in companion animals, as by definition the ‘complete and balanced’ diet must contain all the known essential nutrients required for the species and the life stage for which the diet is formulated (AAFCO, 2018; FEDIAF, 2017b). However, formulation of a plant-based diet that is indeed ‘complete and balanced’ for dogs or cats may be more challenging than formulation of conventional diets, due to the requirements for nutrients that are not readily available in plant-derived ingredients (FEDIAF, 2017a).
1.3.1.2 The Environment

The health of the environment is also known to be impacted by dietary choices, as it is likely that food production is the human activity with the most diverse and adverse environmental impacts (González, Frostell, & Carlsson-Kanyama, 2011; Steinfeld, Gerber, Wassenaar, & de Haan, 2006). Diets including animal-derived products have been implicated as having a much higher impact on the environment than plant-based ones (de Boer & Aiking, 2011; Hedenus, Wirsenius, & Johansson, 2014; Scarborough et al., 2014). Indeed, animal agriculture has been implicated as being one of the largest global contributors to greenhouse gas emissions and climate change, biodiversity loss, deforestation and desertification, freshwater consumption, water pollution, and oceanic dead zones (Aiking, 2014; González et al., 2011; Steinfeld et al., 2006).

Greenhouse gas emission from the animal agricultural sector has been estimated to lie between 18 and 30% of total global emissions (Audsley et al., 2009; Steinfeld et al., 2006). Animal agriculture is also the largest anthropogenic user and degrader of land across the globe, accounting for nearly half of global land area (Asner, Elmore, Olander, Martin, & Harris, 2004; FAO, 2003; Goldewijk & Battjes, 1997; Steinfeld et al., 2006). Loss of forest and natural habitat, due to conversion to pasture and cropland to support animal agriculture, has proven catastrophic for biodiversity (Wassenaar et al., 2007; WRI, 2000), while agricultural invasion of traditional territories has sparked conflict between people, particularly evident on the African continent (FAO, 2006; Nori, Switzer, & Crawford, 2005). Over 20 years ago, nearly three quarters of total land and
vegetation was already considered degraded, largely due to expansion and intensification of animal agriculture (Dregne & Chou, 1994). This has not since been mitigated, and increasing emigration, particularly from African countries, has occurred as a result of degraded land and the conflict which ensues (Requier-Desjardins & Bied-Charreton, 2006). Freshwater use for animal production exceeds that used for plant production by 1.5 – 20 times per unit of nutritional value, resulting in dry rivers and increasingly scarce freshwater resources (Mekonnen & Hoekstra, 2012; UNESCO, 2009). In the USA, replacement of meat by equivalent high protein crop products has been proposed to result in at least a 30% reduction in the food-related water footprint (Mekonnen & Hoekstra, 2012).

The environmental impact of pet foods, too, has recently been brought into question (Okin, 2017; Swanson, Carter, Yount, Aretz, & Buff, 2013). Since their advent in the late 1800s, commercial pet foods have used animal by-products from the slaughter of animals for human consumption (Aldrich, 2006; Swanson et al., 2013). However, with increasing prevalence of feeding ultra-high protein, meat-rich, human-grade, raw and homemade foods, there is increasing competition with the human food system and pressure on animal production systems (Dodd, Cave, Adolphe, & Verbrugghe, 2018; Okin, 2017; Swanson et al., 2013). It has been estimated that dogs and cats in the United States alone consume nearly a quarter of the dietary energy that humans do, and considering the high reliance on animal protein, contribute a third of the environ-
mental impacts from animal production (Okin, 2017). While these figures were estimated based on gross assumptions and no similar studies have been performed, consideration of the environmental impact of pet food is clearly warranted.

1.3.1.3 Ethics and Morality

The most commonly reported reason for abstinence from animal product consumption is based on moral disfavour of the use of non-human animals (Janssen et al., 2016b; Kersche-Risch, 2015; Radnitz et al., 2015). While most of the general public will profess care for animals and their wellbeing, many still consume animal-based products, thus supporting the “meat paradox” – the cognitive dissonance resulting from the desire to avoid harm to animals while adhering to a diet that requires them to suffer and be killed (Graça, Calhieros, & Oliviera, 2015; Lund, McKeegan, Cribbin, & Sandøe, 2016; Prunty & Apple, 2013). The vegan lifestyle has been proposed as a solution to this paradox, marrying the desire to minimise harm to other creatures with a diet containing none of the products associated with perceived cruelty to animals. Unsurprisingly, people who have chosen to abstain from eating animals have been found to possess stronger moral objection towards animal use and empathy for them, when compared with people who do consume animal products (Allen et al., 2000; Filippi et al., 2010; Rothgerber, 2015b). Indeed, individuals avoiding meat consumption were demonstrated to have higher levels of empathy and altruism than omnivores, not only towards non-human animals, but also to other humans as well (Beardsworth & Keil, 1991; Dietz, Frisch, Kalof, Stern, & Guagnano, 1995; Filippi et al., 2010). Individuals who had adopted a fully vegan lifestyle consistently outperformed those who identified as [ovo-
lacto-] vegetarian in assessments of morality and empathy (Bilewicz, Imhoff, & Drogosz, 2010; Povey, Wellens, & Conner, 2001; Rothgerber, 2013).

Given this documented greater affinity for animals amongst meat-abstainers compared to omnivores, it is no surprise that they have been found to have more positive attitudes towards pets and be more likely to live with them (Preylo & Arikawa, 2008; Rothgerber, 2013, 2014). Even vegans with otherwise abolitionist perspectives on animal use often approve of adopting companion animals from shelters and rescues (Lund et al., 2016; Rothgerber, 2013). It may thus be the case that vegans are over-represented in the pet-owning population when compared with the general population.

1.3.2 Speciesism and the Vegan Dilemma

The practice of feeding products derived from some species of animals to other species of animals represents part of a wider moral issue termed ‘speciesism’ (Fjellstrom, 2002; Horta, 2010). Speciesism has been defined as discrimination, or unjustified disadvantageous treatment and consideration, of particular species (Horta, 2010). In 2013, Rothgerber coined the term ‘the vegetarian dilemma’ in reference to the moral conflict between vegetarians and vegans applying speciesist values to feed animal products to their pets (Rothgerber, 2013). The moral conundrum arises as an animal-based diet may be considered best for the pet’s well-being, but elicits concern for the same reasons that the pet keeper is avoiding animal products in their own diet. Considering their stronger ethical objections to the use of animals, this dilemma was even more prevalent in vegans than in vegetarians (Rothgerber, 2013). It was reported that these pet keepers felt guilt and internal conflict when considering the implications of
feeding animal products to their companion animals. It is likely that this moral trade-off may even act as a barrier to adoption of pets by some vegans. Recently plant-based diets have been introduced to the pet food market and provide a potential resolution to this moral dilemma for vegetarians and vegans sharing their homes with cats and/or dogs (Brown, 2009; Brown, Vanselow, Redman, & Pluske, 2009; Knight & Leitsberger, 2016b; Wakefield, Shofer, & Michel, 2006a). If nutritionally adequate, these may prove to be a suitable option for vegan pet keepers to provide appropriate nutrition for their pets without compromising their personal morals.

1.4 PLANT-BASED PET FOOD

Up until recently, there were very few plant-based pet foods commercially available for companion animals. However, the demand for plant-based pet food products has resulted in growth of this niche within the industry (Knight & Leitsberger, 2016b). In Canada alone, at least 13 products marketed as complete diets for dogs, and 6 products marketed as complete diets for cats were available at time of print. One report has been published, which found that ethical vegetarians or vegans who kept pets were significantly less likely to feed their pets diets high in animal products than non-vegans (Rothgerber, 2013). In that study, 21% of vegan respondents and 5.4% of vegetarian respondents reporting feeding a diet composed of less than 25% animal products, though quantification of animal-derived content in the pets’ diets was not described, and would likely be challenging for pet keepers to determine. Nevertheless, this suggests a requirement for plant-based diets to meet the needs of both these pets and their keepers. However, little research has been published regarding plant-based diets in companion
animal nutrition, and it is currently unknown how many cats or dogs are fed plant-based diets. Though previous surveys have examined feeding practices and attitudes amongst vegetarian and vegan pet keepers (Rothgerber, 2013, 2014; Wakefield et al., 2006a), there is as of yet no indication as to the scope of the topic amongst the pet population in general.

1.4.1 Particular Concerns

Neither the nutritional adequacy of plant-based pet foods nor the health effects on the pets eating those foods have been well defined. Feeding plant-based diets to dogs and cats is thus considered to be a risk factor for malnutrition by many veterinarians and veterinary nutritionists (M. Fox, 2005; Freeman, 2018; Gray, Sellon, & Freeman, 2004; Kanakubo, Fascetti, & Larsen, 2015). There are some nutrients of particular concern, based on their low concentration in plant ingredients, and/or their requirements in dogs and cats (FEDIAF, 2017a). These include: total protein, sulfur amino acids, vitamins A, B12 and D. Though essential minerals such as calcium, selenium and zinc are also not typically found in high concentrations in plant materials, they are easily provided from non-animal-derived sources in conventional supplements and are thus of little concern and will be discussed no further.

1.4.1.1 Nutritional Adequacy

1.4.1.1.1 Total Protein

Though protein can be readily found in plant ingredients, dogs and cats have a relatively higher protein requirement when compared to humans. Furthermore, when considering protein in a diet, not only is the total quantity of the protein important, but
also the quality as determined by the protein digestibility and constituent amino acids [AA] (Semp, 2014; Yamka, Jamikorn, True, & Harmon, 2003). Dietary protein provides both non-essential and essential AA. Amino acids are primarily used to synthesize proteins within the body, though they may also be utilized in processes such as creation of functional metabolites, bile acid conjugation, or catabolized as energy. Essential AA are termed such as they cannot be synthesized within the body and must be obtained from the diet in adequate amounts to maintain life, growth, or support gestation and lactation. The ten AA essential for dogs are: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine, while cats also require the β-aminoisosulfonic acid taurine (NRC, 2006).

Animal tissues tend to contain high-quality proteins, as often all ten essential AA are provided in sufficient quantities in a highly digestible source, such as chicken muscle and organs. In contrast, the quality of plant proteins is considered poorer, as their AA profiles may be incomplete, particularly with respect to lysine; the sulfur amino acids: methionine and cysteine; and taurine (FEDIAF, 2017a; Gray et al., 2004; Kanakubo et al., 2015; Semp, 2014). While single plant-derived ingredients do not provide complete proteins to meet all essential AA requirements for dogs, complementary proteins may be utilized to meet these requirements. By combining proteins with complementary amino acid profiles, a complete amino acid profile can be created (Bressani, 2010). For cats, addition of taurine is also required, as taurine is not found in non-animal sources (Gray et al., 2004).
1.4.1.1.2 The Sulfur Amino Acids: Methionine, Cysteine and Taurine

While taurine, a β-aminosulfonic acid, is not always considered essential for dogs as it can be synthesized when adequate amounts of sulfur-AA are present in the diet, it is always essential in cats and may be considered conditionally essential for some dogs (AAFCO, 2018; FEDIAF, 2017b; NRC, 2006). In the body, taurine is not incorporated into protein, but instead is critically involved in fetal development, growth, neuromodulation, sight, heart function, osmotic balance, and antioxidation reactions (NRC, 2006).

Both dogs and cats have obligatory bile acid conjugation with taurine, leading to higher losses through fecal excretion in contrast to other species (Backus et al., 2006; Fascetti, Reed, Rogers, & Backus, 2003; Kanakubo et al., 2015). Dogs and cats eating plant-based diets may be at increased risk of taurine deficiency, as taurine is absent in plants other than algae, and plant-based diets replete with protein may be marginal in taurine’s precursor sulfur AA (NRC, 2006). This deficiency may manifest clinically with signs ranging from lethargy and anorexia, to blindness from retinal degeneration, reproductive dysfunction, and cardiac disease (Fascetti et al., 2003; NRC, 2006).

It is crucial, therefore, that plant-based diets formulated for cats have added taurine, and those for dogs, if taurine is not added, have sufficient quantities of methionine and cysteine, to support normal sulfur AA metabolism as well as taurine synthesis (FEDIAF, 2017b; NRC, 2006). Non-animal sources of synthetic methionine and taurine are readily available, their bioavailability is well known, and they are widely used already throughout the animal feed industries (Han & Lee, 2000; Pion, Kittleson, Rogers, & Morris, 1987; Zangeronimo, Fialho, de Freitas, Rodrigues, & Murgas, 2006).
1.4.1.1.3 Omega Fatty Acids

The omega-3 [Ω-3] polyunsaturated fatty acids [PUFA], docosahexaenoic acid [DHA] and eicosapentaenoic acid [EPA], are essential fatty acids required by the body not for energy, as with many other dietary lipids, but for critical cellular structure and physiological functions (Chandler, 2015; NRC, 2006). For adult, non-reproductive cats and dogs, α-linolenic [ALA] is the only essential Ω-3 PUFA required to maintain health, from which the longer-chain EPA and DHA can be synthesized in small amounts sufficient for adult maintenance (NRC, 2006). During growth, however, kittens and puppies require direct provision of dietary EPA and DHA, as these essential PUFA selectively accumulate within the developing nervous tissues (Heinemann & Bauer, 2006). Both EPA and DHA must thus be provided in diets formulated to support canine and feline gestation, lactation and growth. While terrestrial plants can be rich sources of ALA, they are not a significant source of EPA or DHA. Until recently, fish oil was the only concentrated dietary source of EPA and DHA widely used (Sarter, Kelsey, Schwartz, & Harris, 2015). Many species of algae containing high levels of EPA and DHA can be included in food formulation and are beginning to be accepted for use in pet food (AAFCO, 2018; Garcia-Vaquero & Hayes, 2016).

While dogs can adequately synthesize the omega-6 [Ω-6] PUFA arachidonic acid from its precursor linoleic acid, cats have much lower enzyme activities required for this metabolic pathway (Bauer, 1997). Thus, arachidonic acid is also considered an essential nutrient in feline diets (NRC, 2006). Like EPA and DHA, arachidonic acid is not
found in terrestrial plants, but can be sourced from algae (Garcia-Vaquero & Hayes, 2016).

1.4.1.1.4 Vitamins

Vitamin A is found exclusively in animal tissues. Plants do contain precursor pro-vitamin A carotenoids, which most mammals, including dogs, can metabolise to active vitamin A (Deming & Erdman Jr, 1999). Cats, however, have a unique evolutionary adaptation resulting in the inability to convert precursor nutrients into active vitamin A and thus have an essential dietary requirement for the preformed vitamin (Schweigert, Raila, Wichert, & Kienzle, 2002). Diets for dogs may provide adequate carotenoids if dark orange vegetables are included, though synthetic vitamin A analogues (Lee et al., 2004), essential for felines, are often added to plant-based diets regardless of the species for which the diet is intended for.

The B vitamin complex includes a number of essential nutrients: thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine (B6), biotin (B7), folate (B9), and cobalamin (B12). In general, the B vitamins are enzymatic cofactors and precursors required for many metabolic processes throughout the body. Of the B vitamins, only cobalamin cannot be found in any plant materials. Cobalamin is made only by microbes in soil, fermented organic substances, and in specific parts of the gastrointestinal tract of animals (Maugh II, 1973). While the canine and feline gastrointestinal tracts do contain the necessary flora for cobalamin synthesis, production occurs caudal to the site of absorption and thus the vitamin cannot be taken up by the animal (NRC, 2006). Thus,
dietary inclusion of cobalamin is required for both species. The dietary source of cobalamin in most pet foods is synthetically-derived, produced from microbial fermentation (Maugh II, 1973; NRC, 2006).

Vitamin D is the precursor to the hormone calcitriol, which critically influences calcium homeostasis and bone metabolism in the body (Hazewinkel & Tryfonidou, 2002; Tam, Heersche, Jones, & Rasmussen, 1986). There are three potential sources of vitamin D: dietary vitamin D as ergocalciferol \([D_2]\) from fungi or cholecalciferol \([D_3]\) traditionally from animal tissues or excretions, and endogenous synthesis in the skin when exposed to ultraviolet light (How, Hazewinkel, & Mol, 1994). Whereas most animals, given adequate sunlight or UV radiation, are capable of synthesizing vitamin D in their skin, cats and dogs exhibit high enzymatic catabolism of vitamin precursors resulting in negligible conversion to \(D_3\), thus requiring dietary provision of the vitamin (Hazewinkel & Tryfonidou, 2002; How et al., 1994). Differences in physiological activity between \(D_2\) and \(D_3\) have been documented, in carnivorous cats and omnivorous humans (Morris, 2002a; Shieh et al., 2016; Wilson et al., 2016). Small studies have indicated that dogs may indeed be capable of utilizing ergocalciferol with equal efficiency as cholecalciferol as a dietary source of vitamin D (Arnold & Elvehjem, 1939; Delaney, 2015), though these findings have yet to be repeated and no recommendations for the inclusion of \(D_2\) in canine or feline diets exist as of yet. However, while \(D_3\) has traditionally been derived from animal tissues or secretions, it has also been isolated from some terrestrial and aquatic plants, which have been demonstrated to be biologically active in animals (Boland, Skliar, Curino, & Milanesi, 2003; Wang, Bengtsson, Kärnfelt, & Björn, 2001).
Though commercial preparations of plant-sourced vitamin D$_3$ exist in the human nutritional supplement market this does not appear to have yet been adopted by the pet food industry. It would thus appear that vitamin D may be the nutrient of most concern in a plant-based diet for companion animals.

1.4.1.2 Veterinary Approval

Despite reports of increasing reliance on non-veterinary resources, veterinarians are likely still the most trusted source of nutritional information for many animal caretakers (Connolly et al., 2014; Morgan et al., 2017; Rajagopaul et al., 2016). Considering the relative novelty, low prevalence, and unconventional formulation, the topic of plant-based pet foods is controversial within the veterinary community. While there have been opinion pieces and reviews written by veterinarians who do express their support for the practice, or at least do not condemn it, (Hienze, 2016; Knight, 2005a, 2005b; Knight & Leitsberger, 2016b), others caution against the practice or openly discourage it (M. Fox, 2005; Larsen, 2015; Nancarrow, 2012). It has been reported that feeders of unconventional diets may not always be forthright with their veterinarian when discussing the diet of their pet (Morgan et al., 2017; Rothgerber, 2013).

1.4.2 Suitability for Dogs

The domesticated dog, *Canis lupus familiaris*, is a descendant from wolf species that has co-existed with humans for 10,000-30,000 years (Freedman et al., 2014; Skoglund, Götherström, & Jakobsson, 2011). Dogs and wolves are canids, a family of the zoological order carnivora, though this taxonomic nomenclature is misleading, as the order carnivora also contains obligate carnivores such as the felidae family (e.g. cat,
cheetah, lion etc.) and herbivores like the ailuropodidae family (e.g. panda) (Wozencraft, 2005). The diet of the dog’s ancestor, the wolf (Canis lupus), can vary drastically, ranging from a diet almost completely based on prey animals to one containing up to 50% plant-matter, making them true omnivores or facultative carnivores, and certainly not true carnivores (Bosch, Hagen-Plantinga, & Hendriks, 2015; Watts & Newsome, 2017; Zlatanova, Ahmed, Valasseva, & Genov, 2014).

Not only are wolves naturally omnivorous in their wild state, but the domestication of the dog in co-evolution with humans has resulted in further evolutionary adaptation to diets with higher plant content (Axelsson et al., 2013). The predecessor of the domesticated dog began to live in close association with humans during the early agricultural revolution, scavenging from refuse and waste near human settlements. As humans adopted a more sedentary lifestyle and began cultivating plants as a ready nutritional resource, their early dump sites would have included food waste and feces rich in starches upon which the domesticated dog’s predecessor could feed (Perry et al., 2007). Indeed, differences in the genome of the domesticated dog and wolves indicate that the predecessor of the dog adapted to a diet richer in starch as they began to rely on human settlements as sources of nutrition (Axelsson et al., 2013; Bosch et al., 2015). The domesticated dog may also be considered a type of carnivorous omnivore – an animal capable of eating both animal- and plant-based diets (Buff et al., 2014; D. Hill, 2004).

Two studies examining the nutrient content of plant-based dog food found that by-and-large, the nutrients examined met published requirements (Kanakubo et al., 2013).
2015; Semp, 2014). Semp (2014) measured total protein, fat, calcium, phosphorus, potassium, sodium, copper, iron, zinc, manganese and magnesium in five plant-based dog diets. Though two diets failed to meet recommended levels of potassium, when fed according to the manufacturer's guidelines, the dog's potassium requirements were met (Semp, 2014). Kanakubo (et al., 2015) analysed 19 vegetarian dog diets - one including dried egg and the others completely plant-based – for total protein and amino acids; all were above minimum AAFCO recommendations, or else had passed AAFCO feeding trials or clinical trials (Kanakubo et al., 2015).

Studies investigating the health status of dogs fed plant-based diets have also had favourable results, with no adverse health outcomes attributable to diet detected in any dog (Brown et al., 2009; Semp, 2014). In one study, serum folic acid, cobalamin, iron, and total protein were measured in 20 dogs who had been maintained on a plant-based diet for at least 6 months prior to enrollment in the study (Semp, 2014). Folic acid and cobalamin were below the reference range in five dogs, while iron was low in one dog, though mean levels of all serum nutrients measured were higher or the same in dogs fed a plant-based diet as dogs fed a conventional diet (Semp, 2014). None of the dogs exhibited any signs related to their low nutrient levels, making interpretation of the findings challenging. Given that folic acid has not been considered to be a nutrient at particular risk of deficiency in plant-based diets, being found ubiquitously in plant-derived ingredients, this was an unexpected and yet unexplained finding. Another study compared the haematological characteristics of sprint-racing sled dogs fed an experimental meat-free diet with a cohort fed a conventional diet recommended for active dogs.
(Brown et al., 2009). The dogs were enrolled in trial and fed their respective diets for 4 months whilst continuing their routine exercise and competition schedule. Veterinary health checks revealed no abnormalities, haematology results were within the normal reference range in all dogs and no differences were detected between diet groups (Brown et al., 2009). A limitation of both studies, however, is that each examined only a handful of parameters and neither evaluated markers of health and nutritional status comprehensively - findings must be interpreted with caution.

1.4.3 Suitability for Cats

Unlike dogs, cats are genuine obligate carnivores in that they evolved with a diet exclusively consisting of prey animals (Morris, 2002b; Verbrugghe, Hesta, Daminet, & Janssens, 2012; Zoran, 2002). Unique evolutionary adaptations have resulted in cats acquiring strict dietary requirements – they need a high intake of nitrogen and amino acids for protein synthesis, pre-fabricated taurine, arginine, vitamins A, B12 and D, and high levels of essential fatty acids (Morris, 2002b; Zoran, 2002). These nutrients are all found in higher concentration in animal tissues than in plants, and so legitimate concerns have been raised regarding the ability of plant-based diets to meet these requirements in strict carnivores (M. Fox, 2005; Kanakubo et al., 2015; Parr & Remillard, 2014).

As with dogs, studies that have evaluated the nutrient content of plant-based cat foods have been few. Unlike dogs, however, the results have been less favourable. In one study that analysed total protein, fat, calcium, phosphorus, potassium, sodium, copper, iron, zinc, manganese and magnesium in four plant-based cat diets, one diet was
found to have insufficient protein as well as potassium below the recommended inclusion level (Semp, 2014). Another study analysed total protein and amino acids in seven vegetarian diets for cats, with one diet containing dried egg and the rest completely plant-based (Kanakubo et al., 2015). Of the seven diets, six were found to be deficient in 1 or more amino acid (Kanakubo et al., 2015). A third study has been performed with two plant-based cat diets only, in which crude protein, crude fat, essential amino acids, linoleic acid, arachidonic acid, calcium, phosphorus, selenium, vitamin A, niacin, pyridoxine, and vitamin B12 were measured. One extruded diet was found to be deficient in lysine, methionine, total sulfur amino acids, taurine, arachidonic acid and pyridoxine, while the other canned diet contained insufficient methionine, total sulfur amino acids, taurine, arachidonic acid, calcium, phosphorus, vitamin A, niacin, pyridoxine and vitamin B12 (Gray et al., 2004). This does not necessarily indicate that feline-appropriate diets cannot be formulated using non-animal-derived ingredients, just that of those independently tested in the published studies, many diets were found to have insufficiencies in essential nutrients.

Despite these findings, the only two published studies in which the health status of cats fed plant-based diets have been investigated found no clinical nutrient deficiencies or adverse health effects attributable to the unconventional feeding practice (Semp, 2014; Wakefield et al., 2006a). In one study, serum folic acid, cobalamin, iron and total protein were measured in 15 cats who had been maintained on a plant-based diet for at least 6 months prior to enrollment in the study (Semp, 2014). Folic acid was found to be below the reference range in eight cats. Similar to the dogs, all serum nutrients were
higher or the same in cats fed a plant-based diet as in cats fed conventional diets, with the exception of folic acid. Again, significance of the low folic acid was not discussed. In the other study, 17 cats were enrolled who had been maintained for at least one year on either or both of the two diets found previously by Gray and colleagues (2004) to have multiple nutrient deficiencies (Wakefield et al., 2006a). Only one cat had a plasma taurine level below the reference range, though this was above what the author’s termed the critical threshold. Three cats had whole blood taurine below the reference range, though again, all were above the author’s reported critical concentration (Wakefield et al., 2006a). No adverse health conditions were associated with the borderline taurine status in the affected cats. Serum cobalamin of all cats was within the normal reference range, and all cats were considered to be clinically healthy. (Wakefield et al., 2006a). As with the canine studies, neither study evaluated comprehensive markers of health status, and findings should be interpreted with caution.

1.5 CONCLUSION

Associations exist between people’s affinity for animals, avoiding their consumption, and living with companion animals (Allen et al., 2000; Preylo & Arikawa, 2008; Rothgerber & Mican, 2014). Previous studies have documented that people who avoid animal products in their own diets feel moral conflict when feeding animal products to their pets (Rothgerber, 2013, 2014). A potential resolution for this dilemma is the practice of feeding plant-based diets to companion animals, though this practice may be considered controversial, as neither cats nor dogs are herbivores. Only a handful of studies have been published investigating the nutritional adequacy of plant-based diets
or the health of cats and dogs fed those diets, and results have been conflicting (Brown et al., 2009; Gray et al., 2004; Kanakubo et al., 2015; Semp, 2014; Wakefield et al., 2006a). As there is currently little data published with regards to diet amongst pet keepers and how this affects pet diet, there is a need for research to estimate the magnitude and scope of this issue.

1.6 OBJECTIVES AND HYPOTHESES

Objectives

1. Describe the overall trends in current pet feeding practices.

2. Estimate the proportion of pet keepers who are completely omnivorous, avoid some meat (pescetarian), avoid all meat (vegetarian) or avoid all animal products (vegan).

3. Estimate the proportion of pets fed plant-based diets.

   a. Quantify feeding of commercial vs. homemade plant-based diets

4. Identify motivations and concerns of pet keepers regarding plant- and animal-based pet foods

5. Describe the characteristics of pet keepers who are the most likely to be feeding their pets a plant-based diet.

Objective 1 is investigated in Chapter 2, objectives 2 through 5 are investigated in Chapter 3.

Hypotheses
1. Most pet keepers feed commercial diets, while a minority feed raw or homemade and few feed plant-based diets.

2. The prevalence of meat-avoidance is higher in the population of pet keepers than reported in the general population.

3. Very few pets are fed plant-based diets.
   a. Of those fed plant-based, almost all are fed commercial plant-based diets.

4. Pet keepers will be motivated to feed their pets plant-based diets for the same reasons they themselves avoid animal products in their own diet. Concerns will exist regarding the nutritional sufficiency or health effects of plant-based diets, particularly amongst pet keepers who do not feed them to their pets.

5. Vegans with concern for animal rights and no concern regarding the health effects of plant-based diets will be the group most likely to feed a plant-based diet to their pets.

Hypothesis 1 is tested in Chapter 2, hypotheses 2 through 5 are tested in Chapter 3.
CHAPTER 2: CURRENT DOG AND CAT FEEDING PRACTICES

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2.1 INTRODUCTION

Conventional pet foods have been marketed to pet owners for over 150 years. However, the concept of a diet being “complete and balanced” was only introduced 50 years ago (AAFCO, 1969) and empirical estimates of nutrient requirements are lacking in the literature. The National Research Council [NRC] first published collections of pet nutrition research as the Nutrient Requirements for Dogs in 1953 (NRC, 1953) and Nutrient Requirements of Laboratory Animals, which included cats, in 1962 (NRC, 1962). Since then, these publications have provided the basis of the nutritional guidelines for the pet food industry through the Association of American Feed Control Officials [AAFCO] and the European Pet Food Industry Federation [FEDIAF].

Trends in companion animal nutrition often shadow trends in human nutrition, as pets are now commonly viewed as family members, and many pet keepers refer to themselves as “pet parents” or “pet guardians”, reflecting this close relationship (Boya et al., 2015; Case, 2008; Oliviera, 2005). Research from the pet food industry and veterinarians suggest that many of these “pet parents” now prefer “natural” and “holistic” homemade [HM] diets and raw animal products [RAP] over conventional processed kibble and wet pet foods (Freeman, Chandler, Hamper, & Weeth, 2013; Morgan et al., 2017; Remillard, 2008; Simonsen, Fasenko, & Lillywhite, 2014; Sprinkle, 2018a).

Between 2000-2010, the majority of pets were fed conventional (commercial heat-processed, animal-based) diets (Laflamme et al., 2008). Over 95% of cats and nearly 90% of dogs were reported to be eating conventional diets, with only about a
quarter of pets being offered HM diets or RAP and less than 5% fed HM diets exclusively (Courcier, RM, Mellor, & Yam, 2010; Laflamme et al., 2008). In more recent years these numbers may have been changing. Data suggests that increasingly fewer pets are being fed conventional diets, especially as the sole diet, with increasing incidence of HM and/or RAP feeding (Connolly et al., 2014; Dinallo et al., 2017; Morgan et al., 2017; Thompson et al., 2015). Trust in the pet food industry has been decreasing, though veterinarians are still considered a reliable resource for food recommendations by 60-70% of pet keepers (Morgan et al., 2017; Sprinkle, 2018b). It is clear that a growing number of pet keepers are turning to other sources of guidance regarding their pet's health and nutrition (Connolly et al., 2014; Gerstner & Liesegang, 2017; Morgan et al., 2017).

The risks associated with feeding unconventional diets, such as HM diets and RAP, have been well reported, including: infectious pathogen exposure (Bojanić et al., 2017; Nemser et al., 2014; van Bree et al., 2018; Weese, Rousseau, & Arroyo, 2005) and dietary insufficiency and imbalances (Dillitzer, Becker, & Kienzle, 2011; Lauten, Smith, Kirk, Bartges, & Adams, 2005; Stockman, Fascetti, Kass, & Larsen, 2013). Nutritionally-associated diseases reported secondary to feeding unbalanced HM diets include: pansteatitis, dysregulation of bone metabolism, myelopathy and seizures (Hutchinson et al., 2012; Niza, Vilela, & Ferreira, 2003; Tal, MacKenzi, Parr, & Verbrugghe, 2018; M. Taylor, Geiger, Saker, & Larson, 2009; Verbrugghe et al., 2011). Infectious diseases and antibiotic resistance have also been reported in association with feeding RAP diets (Baede et al., 2017; Giacometti, Magarotto, Serraino, & Piva, 2017; Kent et al., 2017). Thus, it is necessary to document feeding practices of pet keepers
and identify trends, not only to keep practitioners aware of current practices, but also to identify associations between feeding practices and pet health status.

The objective of this study was to describe current pet feeding practices and compare with reported data over the previous 15 years. It was hypothesized that more pet keepers would include HM and RAP in their pet’s diet, while less would feed conventional pet foods exclusively.

2.2 METHODOLOGY

2.2.1 Survey

A multiple choice and short answer survey titled “Pet Feeding Practices” was developed and administered online, via SurveyMonkey, from September 2016 to January 2017. Data collected for this study was part of a larger project investigating pet keeper concerns about animal- and plant-based pet foods (Dodd, Cave, Shoveller, Adolphe, & Verbrugghe, submitted May 2018). The full questionnaire is available in Appendix I. Questions pertaining to the present study were six multiple-choice questions collecting demographic data (age, gender, country), pet type (cat, dog or both), location of pet food purchasing (supermarket, pet store, veterinary clinic, direct from manufacturer, online, HM, ‘other’), and pet diet. Pet diet was categorized as conventional or HM; meat-based, vegetarian, or vegan; raw or cooked; and, in the case of cooked conventional diets, kibble or canned. Treats, both conventional and HM, and food scraps/leftovers were also included as options, though no definitions for the terms were given. Frequency of feeding options were ‘never’, ‘occasionally’, ‘frequently’, or ‘daily’. For respondents with both cats and dogs, questions were first answered regarding their dog(s), then their
cat(s). The questionnaire was piloted on 15 volunteers, their responses did not contribute to the data collection but served as feedback to improve survey design during the development phase. The aim of the survey was to collect data from a sample representative of the general pet keeping population. The survey was distributed online through social media, initially to 20 English language pet-centric groups, including dog and cat breeders, keepers, and general enthusiasts. Wider sharing of the survey through social media was encouraged in order to reach a broad audience. Direct sharing of the questionnaire to veterinary hospitals/clinics, other pet professional and para-professional groups, as well as pet nutrition-related groups was avoided in order to minimize selection bias. The survey was available online for a total of 135 days from September 2016 to January 2017. This study was approved by the research ethics board of the University of Guelph (REB #17-08-092).

**2.2.2 Literature Search**

In order to compare feeding practices reported by the sample population with previous accounts, a literature search was performed using Web of Science and PubMed databases. The following keywords were used, in combinations: American, Australia, British, Canada, cat, dog, diet, feeding, Finland, food, New Zealand, nutrition, pet, practices, UK, United Kingdom, USA. Studies were included if published after the year 2000 and based in Australia, Canada, Finland, New Zealand, the UK or the USA, in order to be comparable to the present data. Eligible studies included those with a primary objective including description of pet feeding practices and comparable data regarding
two or more of commercial, HM, RAP, scrap and treat feeding practices, published between 2000 and 2018. Data regarding pet feeding practices, study design characteristics, sample population and demographics, were extracted from each study by the main author.

2.2.3 Statistical Analyses

Survey responses were analyzed and descriptive statistics used to assess categorical data. All data were reported as frequency (n) and percentage (%). Qualitative comparison was made between the present survey data for independent geographical regions and previously published studies. All analyses were performed with conventional software (IBM® SPSS® Statistics Version 24, IBM Corp, North Castle, New York, USA).

2.3 RESULTS

A total of 3,673 questionnaires were complete enough for statistical analysis out of a total of 3,718 undertaken (45 excluded). The 45 surveys not included were due to attrition prior to identifying type of pet. Half of respondents kept only dogs (1,871/3,673), while 16% had only cats (602/3,673), and 33% had both dogs and cats (1,200/3,673). Respondent demographics are presented in Table 1. The survey questions were considered independently, so the number of responses for each question differed, thus proportions are representative only for the number of people answering each question. For example, respondents who had only cats were not included in data analysis regarding dogs.
2.3.1 Global Data

Survey responses were collected from the English-speaking pet keeping population, including responses from 57 different countries. The countries most represented included: Australia, Canada, Finland, New Zealand, the UK and the USA (Table 1).

Dietary information was acquired for 2,940 dogs and 1,542 cats. Feeding practices are shown in Tables 2 and 3. Exclusive feeding was determined as the feeding of one type of food (conventional, HM or RAP) without any inclusion of any other type of diet, other than treats and scraps. Inclusive feeding was determined as multiple types of food fed. Though less than a quarter of dogs (11%, 318/2,940) and a quarter of cats (25%, 391/1,542) were fed a conventional diet exclusively, the majority of pets (79% of dogs 2,327/2,940, 90% of cats 1,390/1,542) were fed diets that included conventional food. Of those animals being fed conventional diets, more cats (86%, 1,196/1,390) than dogs (79%, 1,839/2,327) were fed this way on a daily basis. Although 8% of dogs (243/2,940) and 18% of cats (282/1,542), were fed veterinary therapeutic diets, less than 5% of them (5% of dogs 11/243, 4% of cats 11/282) were fed the veterinary therapeutic diet exclusively.

Three quarters of respondents (82% of dogs 2,411/2,940, 62% of cats 955/1,542) reported feeding a diet that included HM foods, though only 7% of dogs (215/2,940) and 4% of cats (57/1,542) were fed HM diets exclusively. Raw animal products were fed to 66% of dogs (1,948/2,940) and 53% of cats (812/1,542) in this survey. Of the pets receiving RAP, more pets were fed a HM RAP (89%, of dogs 1,724/1,948, 87% of cats 709/812) than were fed a commercial RAP (67% of dogs 1,296/1,948, 64%
of cats 516/812). Few pets (10% of dogs 290/2,940, 6% of cats 96/1,542) were fed RAP exclusively. A smaller number of pets were fed vegetarian foods, with these foods included in the diet of 22% of dogs (650/2,940) and 5% of cats (73/1,542). Of these pets, approximately half (46% of dogs 302/650, 70% of cats 51/73) were fed completely plant-based (vegan) foods, with a 15% (44/302 dogs, 11/73 cats) fed plant-based diets exclusively.

Aside from their main diet, pets were also regularly fed treats and scraps. Almost all dogs (89%, 2,625/2,940) and three quarters of cats (67%, 1,040/1,542) were given treats, though only a quarter of those dogs (28%, 723/2,625) and less than a quarter of those cats (13%, 138/1,040) received treats daily. Similarly, the feeding of scraps was prevalent, as they were fed to 83% of dogs (2,438/2,940) and 61% of cats (934/1,542). As with treats, few animals who received scraps (12% of dogs 291/2,438, 6% of cats 55/934) did so on a daily basis. Cooked meats were the most common scraps, fed to 86% of dogs (2,088/2,438) and 81% of cats (754/934) who received scraps. Raw meat scraps were also fed to 64% of dogs (1,564/2,438) and 65% of cats (604/934) who were offered scraps.

In total, 3,664 survey respondents answered the question relating to location of pet food purchases. Regardless of the number of pets the participant provided data for, they only answered the location of pet food purchase question once. Pet stores were the most popularly reported location of pet food purchasing, accounting for 51% of respondents (1,867/3664). Supermarkets (30%, 1,095/3,664), online distributors (29%, 1,064/3,664), and purchasing direct from manufacturers (14%, 508/3,664) were the next
most popular. Ten percent of respondents reported purchasing pet food from their veterinarian (351/3,664). Farm or animal feed stores (4%, 145/3,664), butchers (3%, 101/3,664), and big-box stores (2%, 66/3,664) were other reported locations.

2.3.2 Regional Data

In order to compare results to previously published studies, which focused typically on a handful of geographical locations, the present data were also analyzed independently for each country for which a previous study had been published. Table 2 and 3 depicts the pet feeding data per country.

2.3.2.1 Dogs

Conventional diets were included in the diet of Australian dogs the least (70%, 132/189), though exclusive feeding of conventional diets was lowest in Finland (0.6%, 1/176). Exclusive feeding of both conventional diets in general and kibble specifically was reported by New Zealand dog keepers (17%, 22/130 conventional, 10%, 13/130 kibble), while Finnish dog keepers reported the lowest exclusive feeding of kibble (0% 0/176). Homemade diets were fed most frequently by Australian dog keepers (94%, 177/189 inclusive; 17%, 32/189 exclusive), and least frequently by dog keepers in New Zealand (72%, 93/130 inclusive). Both Australian and Finnish dog keepers reported the highest inclusion of RAP (88%, 167/189 Australia; 90%, 158/176 Finland), with Australian dog keepers feeding RAP exclusively the most (17%, 32/189). Treats and scraps varied little between country, with the exception of high scrap feeding in New Zealand (90%, 117/130).
2.3.2.2 Cats

Respondents from Australia and Finland reported the lowest practices of feeding conventional diets both inclusive (81%, 101/124 Australia, 82%, 99/121 Finland) and exclusively (9%, 11/124 Australia, 7% 8/121 Finland), as well as the lowest feeding of kibble exclusively (2%, 3/124 Australia, 0%, 0/121 Finland). Correspondingly, diets including HM and RAP were highest in Australia (78%, 97/124, 84%, 104/124) and Finland (66% 81/121 HM, 79%, 95/121 RAP). Exclusive feeding of HM and RAP were similar in Finland as with other countries, but higher in Australia (10%, 12/124 HM; 14%, 17/124 RAP). Conventional feeding was highest in New Zealand (94%, 97/103 inclusive, 35%, 36/103 exclusive), also with the highest exclusive kibble feeding (13%, 13/103). New Zealand similarly had the lowest prevalence of homemade diet feeding, included in only 46% (47/103) of cat’s diets. Diets including RAP were lowest in Canada (38%, 55/144). Treats were least commonly fed to cats in Australia (45%, 56/124) and New Zealand (47%, 48/103).

2.3.3 Comparison with Previously Published Studies

The literature search resulted in nine peer-reviewed papers published between 2008 and 2017, documenting pet feeding practices from data spanning 2004 to 2016. A summary of these publications is provided in table 4. The following publications were available per independent geographical regions: Australia (Laflamme et al., 2008; Rohlf, Toukhsati, Coleman, & Bennett, 2010; Toribio et al., 2009), Canada (Connolly et al., 2014; Rajagopaul et al., 2016), New Zealand (Singh et al., 2011), the UK (German, Holden, Gernon, Morris, & Biourge, 2011), and the USA (Connolly et al., 2014; Dinallo
et al., 2017; Laflamme et al., 2008; Morgan et al., 2017). No studies investigating pet feeding practices in Finland were found, and no other country was strongly represented in this study, thus comparison to previously published data was not performed and the current data can now act as the baseline for Finland pet feeding practices.

The feeding practices reported by the study respondents differed in many cases from those previously documented. Prevalence of conventional feeding, especially as the exclusive diet, was generally lower for individual countries, while inclusion of non-conventional foods such as HM foods and RAP in the diet was greater.

2.3.3.1 Australia

Previous publications investigating dog feeding practices reported relatively consistent findings regarding commercial, HM and RAP feeding practices (Laflamme et al., 2008; Rohlf et al., 2010), which differ greatly from the present data. For dogs, a decrease in the exclusive feeding of conventional diets, with increased feeding of HM and RAP, as well as increase in exclusive feeding of HM and RAP is suggested. For cat feeding practices, a similar decrease in exclusive feeding of conventional diets and an increase in feeding of HM and RAP, including exclusive HM and RAP feeding, are evident when compared with prior reports (Laflamme et al., 2008; Toribio et al., 2009).

2.3.3.2 Canada

For dogs, exclusive feeding of commercial diets was lower, with inclusion of HM and RAP being markedly higher in the present study than previous accounts which focused
on dog breeders and dogs diagnosed with cancer (Connolly et al., 2014; Rajagopaul et al., 2016).

2.3.3.3 New Zealand

When compared to working dog feeding practices in New Zealand, the only difference found in dog feeding practices was a higher prevalence of exclusive kibble feeding and a slightly lower prevalence of exclusive HM (Singh et al., 2011). Inclusion of commercial and HM were similar to previous estimates.

2.3.3.4 United Kingdom

Conventional feeding practices of obese dogs in the UK were similar, though feeding of HM was much lower (German et al., 2011) than reported in the current study. No previous studies reported the prevalence of RAP feeding.

2.3.3.5 United States of America

Compared to Laflamme et al. (2008) and Dinallo et al. (2017), inclusion of conventional pet food did not differ greatly for either dogs or cats, though exclusive feeding of kibble is decreased. Inclusion of HM diets does not differ much for cats, though is higher in dogs, and exclusive HM feeding is the same. Previous studies showed a great variation in prevalence of RAP feeding in dogs, i.e. between 9-40% (Dinallo et al., 2017; Laflamme et al., 2008; Morgan et al., 2017) and in cats, i.e. from 9-34% (Laflamme et al., 2008; Morgan et al., 2017). In the present study, even greater numbers of dog keepers and cat keepers reported feeding their pet RAP.
2.4 DISCUSSION

Results indicated that, in the countries represented in the survey, conventional diets are still the most popular choice for pet keepers. These diets were introduced to provide a convenient, reliable source of nutrition for dogs and cats. For decades, pet keepers around the world have trusted pet food companies to provide for every nutritional requirement of their animal, yet within the past ten years, data suggests that feeding practices may have been changing (Connolly et al., 2014; Dinallo et al., 2017; Laflamme et al., 2008; Morgan et al., 2017; Sprinkle, 2018a, 2018b). While the present study shows that the majority of pets are still being fed conventional pet food, a large proportion of survey respondents reported feeding HM diets and RAP, with a small proportion feeding vegetarian or vegan diets. Though around 10% of pets were fed veterinary therapeutic diets, few pets were fed these diets solely. Successful dietary management of many diseases requires adherence to a strict nutrient profile, and the practice of feeding other food sources along with a veterinary therapeutic diet may decrease efficacy of the nutritional management of disease.

The differences detected may partially be explained by lack of trust in the pet food industry (Connolly et al., 2014; Sprinkle, 2018a). In 2007, a large and highly publicized global pet food crisis occurred, where diets from many of the largest and most popular pet food brands were found to be contaminated with inorganic toxins (Hansen, 2008; Puschner & Reimschuessel, 2011). A second possible contributing factor is the humanization of pets, with trends in pet feeding practices shadowing trends in human nutrition; with increasing consumer interest in ‘natural’ and ‘holistic’ foods (Buff et al., 2014; PFI,
Promoters of HM diets and RAP claim that these foods will improve health, increase energy and even reverse chronic diseases such as cancer, yet these claims are generally made without peer-reviewed evidence by individuals with little to no background in veterinary science or nutrition (Benitez, 2017; Taylor-Laino, 2013; Woodford, 2012).

Still, differences within the literature in study population (eg: dog breeders, dogs presenting at a weight loss clinic, dogs presenting to a tertiary oncology service), recruitment strategy, and survey method (eg: in person interview, paper survey, telephone survey, electronic or web-based survey) likely account for some of the variation. Most studies had relatively similar age and gender demographics, though the present study consistently had a greater number of female respondents, and occasionally had a younger sample population. It is also likely that the definition of exclusive utilized in the present study was inconsistent with previous studies. In this study, exclusivity of feeding was not asked of the respondents, but determined if respondents indicated that they fed a certain type of diet and never fed any other foods, other than treats or scraps. This may have been more discriminant than other studies if exclusivity of diet feeding was self-reported by respondents.

Avoidance of conventional pet foods in favour of HM diets and RAP may put the health of pets at risk. Published analyses of HM diets or recipes intended for dogs and cats indicate that most have one or more nutrient insufficiencies and imbalances when compared to NRC nutrient density (Stockman et al., 2013; Streiff et al., 2002). These analyses showed the most common and significant nutrient insufficiencies in HM diets
to be calcium, phosphorus, vitamin D and essential amino acids. Additional published reports have shown many cases of adverse health conditions directly resulting from the feeding of an inadequate HM diet (Hutchinson et al., 2012; Kienzle & Dobenecker, 2012; Niza et al., 2003; Polizopoulou, Kazakos, Patsikas, & Roubies, 2005). Skeletal abnormalities caused by insufficient or excess calcium, phosphorus and/or vitamin D appear to be the most commonly reported physiological effect of an imbalanced HM diet (de Fornel-Thibaud et al., 2007; Kienzle & Dobenecker, 2012; Tal et al., 2018; Verbrugghe et al., 2011).

The results from this study suggest that more pet keepers who are feeding RAP are choosing to use HM rather than commercial RAP. Raw HM diets are associated with the same potential for nutritional deficiencies and adverse health effects as cooked HM diets (de Fornel-Thibaud et al., 2007; Dillitzer et al., 2011; Polizopoulou et al., 2005; M. Taylor et al., 2009). In addition, raw feeding has been shown to pose the extra risk of contamination with microbial pathogens (Nemser et al., 2014; van Bree et al., 2018; Weese et al., 2005). Pets fed diets containing RAP are at risk of infection from pathogenic bacteria as no cooking step is undertaken to kill potential bacterial contaminants. While conventional raw diets may undergo some sort of processing, such as dehydration, freeze-drying or high-pressure pasteurization, it has been shown that these processing methods may be insufficient to destroy bacteria such as Salmonella (Mehlenbacher, Churchill, Olsen, & Bender, 2012). Not only have pet foods containing raw animal products been implicated in clinical infections in pets (Fauth et al., 2015;
Giacometti et al., 2017; Kent et al., 2017), but they have also been implicated in potential transmission to the pets' human companions (Lefebvre, Reid-Smith, Boerlin, & Weese, 2008; Leonard et al., 2011; Nash, Chissel, Jones, Warburton, & Verlander, 2005). Of great concern is the possibility for transmission of antibiotic-resistant organisms from pets fed RAP to their keepers (Baede et al., 2017; Leonard et al., 2015).

In stark contrast to feeding RAP, some participants chose instead to avoid animal products altogether in the diets of their pets. Around a quarter of dogs and less than 5% of cats were offered vegetarian or strictly plant-based [vegan] foods as part of their diet, though few were fed these diets exclusively. Considering that the prevalence of vegetarian or strictly plant-based diets has not previously been documented, the results of this study cannot be compared to any previously published data. Vegetarian and strictly plant-based diets are generally accepted as suitable for dogs, though veterinary supervision is encouraged, but they are not considered suitable for cats (FEDIAF, 2017a). Homemade plant-based diets pose the same risks for nutritional insufficiency as HM diets containing animal products, and likely pose additional risks with relation to some essential nutrients such as sulfur amino acids, long-chain polyunsaturated fatty acids, and vitamins B12 and D (FEDIAF, 2017a; Kanakubo et al., 2015; Michel, 2006). Few studies have been published that have investigated the health status of dogs or cats fed plant-based diets. Though no adverse health effects attributable to consumption of a vegetarian or plant-based diet have been reported, these studies investigated only a handful of health parameters or markers of nutrient status (Brown et al., 2009; Semp, 2014;
Wakefield et al., 2006a). Comprehensive investigation of the impact of feeding these diets long-term has yet to be published for either dogs or cats and given the increased prevalence of feeding these diets, further research is warranted.

In addition to their main diet, most pets were fed treats and scraps of ‘human’ food. There does not appear to be any great differences in the prevalence of feeding treats or scraps in this study compared with previously published studies. Considering the high proportion of pets reportedly fed treats or snacks, the risks of these foods must be considered. Feeding excessive treats or scraps can contribute to obesity and unbalancing of otherwise appropriate diets (Freeman et al., 2011; German et al., 2011). The proportion of an animal’s dietary calories provided by treats or snacks was quantified neither by the present study, nor by any of the previously published studies. Thus, the risk of excessive treating or scrap feeding cannot be quantified.

Limitations to the present study must be considered when interpreting the current results. To minimize selection bias, no reference was made to any particular type of diet or feeding practice in the title or introduction of the survey. However, given that the survey was available for sharing, it is possible that specialty focus groups or specific types of pet keepers were recruited into the study, biasing the results. The magnitude in the differences detected between some feeding practices reported in this study when compared with previously published studies, particularly studies performed recently and with similar demographics, indicate that there was likely some difference in the questionnaire or statistical methods resulting in altered reporting of feeding practices. In the present study, exclusivity of feeding practices was not asked of the respondents but determined
if they selected that they fed only one type (conventional, HM or RAP) of diet and never fed any other foods, with the exception of treats and snacks. This may have been more discriminant than other methodologies which may have relied on self-reporting of exclusivity of feeding, which may be less accurate.

2.5 CONCLUSION

Pet feeding practices have most likely changed over the past decade. While most pet keepers still report feeding their dog or cat a conventional food, at least as part of their pet’s diet, there appears to be a growing prevalence of alternative feeding practices. Few pets were reportedly consuming a conventional food exclusively, with many now being additionally or alternatively fed HM diets and RAP. In addition to their main diet, most pets are also fed treats and scraps. Few HM diets are nutritionally sufficient to meet the requirements of dogs or cats, and RAP additionally pose the risk of bacterial contamination. With a possible increase in the prevalence of alternative feeding practices, clinicians in both general and specialty veterinary practice must be aware of the diseases associated with malnutrition and ensure a thorough dietary history is collected from their clients in order to facilitate rapid and efficient diagnosis, management and treatment.
2.6 TABLES

Table 1. Demographic data of pet keepers participating in the "Pet Feeding Practices" Survey (n = 3,673)

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>%</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
<td>6%</td>
<td>215</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>92%</td>
<td>3381</td>
</tr>
<tr>
<td></td>
<td>Prefer not to disclose</td>
<td>2%</td>
<td>77</td>
</tr>
<tr>
<td>Age (years)</td>
<td>&lt; 20</td>
<td>4%</td>
<td>129</td>
</tr>
<tr>
<td></td>
<td>21 – 30</td>
<td>26%</td>
<td>946</td>
</tr>
<tr>
<td></td>
<td>31 – 40</td>
<td>19%</td>
<td>680</td>
</tr>
<tr>
<td></td>
<td>41 – 50</td>
<td>20%</td>
<td>734</td>
</tr>
<tr>
<td></td>
<td>51 – 60</td>
<td>20%</td>
<td>725</td>
</tr>
<tr>
<td></td>
<td>61 – 70</td>
<td>10%</td>
<td>378</td>
</tr>
<tr>
<td></td>
<td>&gt; 70</td>
<td>2%</td>
<td>81</td>
</tr>
<tr>
<td>Country</td>
<td>Australia</td>
<td>7%</td>
<td>258</td>
</tr>
<tr>
<td></td>
<td>Canada</td>
<td>11%</td>
<td>405</td>
</tr>
<tr>
<td></td>
<td>Finland</td>
<td>7%</td>
<td>247</td>
</tr>
<tr>
<td></td>
<td>New Zealand</td>
<td>5%</td>
<td>177</td>
</tr>
<tr>
<td></td>
<td>United Kingdom</td>
<td>23%</td>
<td>836</td>
</tr>
<tr>
<td></td>
<td>United States</td>
<td>41%</td>
<td>1485</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>7%</td>
<td>265</td>
</tr>
</tbody>
</table>
Table 2. Dog feeding practices by country. Feeding practices data represented as percentage and frequency of respondents indicating they fed a diet including or exclusively consisting of particular diets.

<table>
<thead>
<tr>
<th>Country</th>
<th>n</th>
<th>Conventional Inclusive</th>
<th>Conventional Exclusive</th>
<th>Kibble Exclusive</th>
<th>Wet Exclu-HM Inclusive</th>
<th>HM Exclusive</th>
<th>RAP Inclusive</th>
<th>RAP Exclusive</th>
<th>Treats</th>
<th>Scraps</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global</strong></td>
<td>2940</td>
<td>79% (2327)</td>
<td>11% (318)</td>
<td>6% (188)</td>
<td>0.1% (4)</td>
<td>82% (2411)</td>
<td>7% (215)</td>
<td>66% (1948)</td>
<td>10% (290)</td>
<td>89% (2625)</td>
</tr>
<tr>
<td><strong>Regional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>189</td>
<td>70% (132)</td>
<td>3% (6)</td>
<td>2% (3)</td>
<td>0% (0)</td>
<td>94% (177)</td>
<td>17% (32)</td>
<td>88% (167)</td>
<td>17% (32)</td>
<td>86% (162)</td>
</tr>
<tr>
<td>Canada</td>
<td>355</td>
<td>75% (267)</td>
<td>13% (45)</td>
<td>7% (26)</td>
<td>0.3% (1)</td>
<td>75% (268)</td>
<td>6% (22)</td>
<td>52% (185)</td>
<td>8% (27 )</td>
<td>89% (317)</td>
</tr>
<tr>
<td>Finland</td>
<td>176</td>
<td>78% (138)</td>
<td>0.6% (1)</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>85% (149)</td>
<td>1.7% (3)</td>
<td>90% (158)</td>
<td>6% (11 )</td>
<td>88% (155)</td>
</tr>
<tr>
<td>New Zealand</td>
<td>130</td>
<td>78% (102)</td>
<td>17% (22)</td>
<td>10% (13)</td>
<td>0% (0)</td>
<td>72% (93)</td>
<td>2% (3)</td>
<td>70% (91)</td>
<td>12% (16 )</td>
<td>88% (114)</td>
</tr>
<tr>
<td>UK</td>
<td>609</td>
<td>75% (458)</td>
<td>11% (68)</td>
<td>5% (29)</td>
<td>0.3% (2)</td>
<td>82% (502)</td>
<td>5% (29)</td>
<td>66% (402)</td>
<td>11% (67)</td>
<td>88% (533)</td>
</tr>
<tr>
<td>USA</td>
<td>1295</td>
<td>81% (1077)</td>
<td>13% (163)</td>
<td>8% (107)</td>
<td>0.1% (1)</td>
<td>81% (1049)</td>
<td>7% (97)</td>
<td>62% (808)</td>
<td>7% (93 )</td>
<td>88% (1151)</td>
</tr>
</tbody>
</table>

Inclusive was defined including the diet of interest, with or without other foods. Exclusive was defined as including the diet of interest without any other foods, with the exception of treats or scraps. HM = homemade, RAP = raw animal products.
Table 3. Cat feeding practices by country. Feeding practices data represented as percentage and frequency of respondents indicating they fed a diet including or exclusively consisting of particular diets.

<table>
<thead>
<tr>
<th>Country</th>
<th>n</th>
<th>Conventional Inclusive</th>
<th>Conventional Exclusive</th>
<th>Kibble Exclusive</th>
<th>Wet Exclusive</th>
<th>HM Inclusive</th>
<th>HM Exclusive</th>
<th>RAP Inclusive</th>
<th>RAP Exclusive</th>
<th>Treats</th>
<th>Scraps</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global</strong></td>
<td>1542</td>
<td>90% (1,390)</td>
<td>25% (391)</td>
<td>6% (86)</td>
<td>0.8% (12)</td>
<td>62% (955)</td>
<td>4% (57)</td>
<td>53% (812)</td>
<td>6% (96)</td>
<td>67% (1040)</td>
<td>61% (934)</td>
</tr>
<tr>
<td><strong>Regional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>124</td>
<td>81% (101)</td>
<td>9% (11)</td>
<td>2% (3)</td>
<td>0% (0)</td>
<td>78% (97)</td>
<td>10% (12)</td>
<td>84% (104)</td>
<td>14% (17)</td>
<td>45% (56)</td>
<td>67% (83)</td>
</tr>
<tr>
<td>Canada</td>
<td>144</td>
<td>87% (125)</td>
<td>28% (41)</td>
<td>5% (7)</td>
<td>2% (3)</td>
<td>51% (73)</td>
<td>3% (5)</td>
<td>38% (55)</td>
<td>6% (9)</td>
<td>64% (92)</td>
<td>53% (77)</td>
</tr>
<tr>
<td>Finland</td>
<td>121</td>
<td>82% (99)</td>
<td>7% (8)</td>
<td>0% (0)</td>
<td>0% (0)</td>
<td>66% (81)</td>
<td>0.8% (1)</td>
<td>79% (95)</td>
<td>3% (4)</td>
<td>76% (92)</td>
<td>48% (58)</td>
</tr>
<tr>
<td>New Zea-</td>
<td>103</td>
<td>94% (97)</td>
<td>35% (36)</td>
<td>13% (13)</td>
<td>0% (0)</td>
<td>46% (47)</td>
<td>1% (1)</td>
<td>49% (50)</td>
<td>5% (5)</td>
<td>47% (48)</td>
<td>65% (67)</td>
</tr>
<tr>
<td>land</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>335</td>
<td>86% (305)</td>
<td>28% (95)</td>
<td>5% (16)</td>
<td>1% (4)</td>
<td>65% (217)</td>
<td>3% (10)</td>
<td>41% (137)</td>
<td>5% (18)</td>
<td>73% (245)</td>
<td>76% (255)</td>
</tr>
<tr>
<td>USA</td>
<td>633</td>
<td>92% (580)</td>
<td>29% (185)</td>
<td>7% (44)</td>
<td>0.8% (5)</td>
<td>58% (366)</td>
<td>3% (20)</td>
<td>49% (311)</td>
<td>4% (28)</td>
<td>68% (432)</td>
<td>58% (367)</td>
</tr>
</tbody>
</table>

Inclusive was defined including the diet of interest, with or without other foods. Exclusive was defined as including the diet of interest without any other foods, with the exception of treats or scraps. HM = homemade, RAP = raw animal products.
Table 4. Summary of nine peer-reviewed publications published between 2008 and 2017, documenting pet feeding practices in Australia, Canada, New Zealand, the UK and the USA from data spanning 2004 to 2016.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Year data collected</th>
<th>Country</th>
<th>Survey methodology</th>
<th>Study population</th>
<th>Demographics</th>
<th>Sample size</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connolly et al. 2014</td>
<td>2012</td>
<td>Canada, USA</td>
<td>eSurvey</td>
<td>Breeders</td>
<td>83% female; 7.5% 18-29, 14.7% 30-39, 21.7% 40-49, 33.4% 50-59, 18.3% 60-69, 4.5% &gt; 70 years old</td>
<td>1,913</td>
<td>Dogs</td>
</tr>
<tr>
<td>Dinallo et al. 2017</td>
<td>2015</td>
<td>USA</td>
<td>In-person administration of eSurvey</td>
<td>Agility trial participants</td>
<td></td>
<td>494</td>
<td>Dogs</td>
</tr>
<tr>
<td>German et al. 2011</td>
<td>2005-2010</td>
<td>UK</td>
<td>Paper questionnaire sent prior to consultation</td>
<td>Patients of weight-loss clinic</td>
<td></td>
<td>95</td>
<td>Dogs</td>
</tr>
<tr>
<td>Laflamme et al. 2008</td>
<td>2004</td>
<td>Australia, USA</td>
<td>Telephone survey</td>
<td>Randomized Australian and USA citizens from local phonebook</td>
<td></td>
<td>1,104</td>
<td>Cats</td>
</tr>
<tr>
<td>Morgan et al. 2017</td>
<td>2016</td>
<td>USA</td>
<td>eSurvey</td>
<td>American pet keepers with online activity</td>
<td>82% female; 15.3% 18-30, 17% 31-40, 18.7% 41-50, 31.3% 51-60, 17.7% &gt;61 years old</td>
<td>2,171</td>
<td>Cats</td>
</tr>
<tr>
<td>Rajagopaul et al. 2016</td>
<td>2014</td>
<td>Canada</td>
<td>Paper survey + in-person interview</td>
<td>Dogs with definitive cancer diagnosis attending cancer center</td>
<td>63% female; 5% 18-29, 71% 30-59, 24% 60+ years old</td>
<td>75</td>
<td>Dogs</td>
</tr>
<tr>
<td>Rohlf et al. 2010</td>
<td></td>
<td>Australia</td>
<td>Paper questionnaire given out in-person</td>
<td>Melbourne residents attending vet clinics and dog-related community events</td>
<td>81% female, mean age 41.9 years (SD 13.8)</td>
<td>182</td>
<td>Dogs</td>
</tr>
<tr>
<td>Singh et al. 2011</td>
<td>2007</td>
<td>New Zealand</td>
<td>Paper questionnaire</td>
<td>Members of New Zealand Sheep Dog Trial Association</td>
<td></td>
<td>542</td>
<td>Dogs</td>
</tr>
<tr>
<td>Toribio et al. 2008</td>
<td>2006</td>
<td>Australia</td>
<td>Paper questionnaire</td>
<td>Randomized residents from Sydney phonebook</td>
<td></td>
<td>194</td>
<td>Cats</td>
</tr>
</tbody>
</table>
CHAPTER 3: PLANT-BASED DIETS FOR PETS: A SURVEY OF PET KEEPER ATTITUDES AND FEEDING PRACTICES

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3.1 INTRODUCTION

Human diets minimising (‘ovo-lacto vegetarian’, ‘vegetarian’) or eschewing animal products completely (‘strict vegetarian’, ‘vegan’) have been increasing in prevalence worldwide in the past decade (Bates, Lennox, Bates, et al., 2009; Kosonen et al., 2005; RoyMorgan, 2016). Motivations reported for this shift away from animal products include health concerns, sustainability/environmental preservation and empathy for non-human animals (de Boer & Aiking, 2011; N. Fox & Ward, 2008; Kersche-Risch, 2015). These motivations are certainly not unfounded: the many health risks associated with human consumption of animal products are becoming widely appreciated by the scientific and general public (Bella et al., 2017; Organization, 2015; PCRM, 2015), environmental impacts known to be associated with our dietary choices are similarly well documented, (Hedenus et al., 2014; Mekonnen & Hoekstra, 2012; Scarborough et al., 2014), and now even the environmental impact of pet foods, traditionally derived mostly from animal by-products, have recently been brought to light (Deng & Swanson, 2015; Okin, 2017; Swanson et al., 2013). With many pet keepers now seeking by-product-free, human-grade, and meat-centric foods, there is even direct competition with animal products otherwise destined for the human food chain (Deng & Swanson, 2015; Swanson et al., 2013). With regards to empathy for animals, people who have chosen to abstain from eating animals have been found to possess stronger empathy for both other humans and for non-human species than people who consume meat (Filippi et al., 2010; Preylo & Arikawa, 2008).
Pet keepers have also been found to have higher levels of empathy for animals than people who do not live with pets (Paul, 2000; N. Taylor & Signal, 2005). Considering their high regard for animals, pet keepers clearly want to feed diets that they consider healthy and beneficial for their companions’ wellbeing (Berschneider, 2002; Case, 2008; Remillard, 2008). For some, however, this may conflict with ideologies to minimize or avoid use of products derived from other animals. Termed “the vegetarian’s dilemma”, a moral conflict has been documented amongst pet keepers who avoid animal products in their own diets and report feelings of guilt and internal conflict regarding feeding animal products to their pets (Rothgerber, 2013). Recently plant-based diets have been introduced to the pet food market and provide a potential resolution to this moral dilemma for vegetarians and vegans that share their homes with omnivorous and carnivorous pets (Brown, 2009; Brown et al., 2009; Knight & Leitsberger, 2016a; Wakefield, Shofer, & Michel, 2006b).

Considering the facultative and obligatory carnivorous physiology of dogs and cats respectively, the suitability of these plant-based diets in meeting the nutritional needs of these animals has been questioned (Brown, 2009; Gray et al., 2004; Kanakubo et al., 2015). Few studies have evaluated the nutritional content of plant-based pet foods or health parameters and nutrient status of pets fed plant-based diets. It is clear that neither the nutritional adequacy of commercially available plant-based pet foods nor the health effects on the pets eating those foods are well defined. Despite concerns of nutritional adequacy, it has been found that pet keepers abstaining from eating meat for ethi-
cal reasons are significantly less likely to feed their pets diets containing animal products than non-vegans, with 21% of vegan pet keepers and 5% of vegetarian pet keepers reporting feeding a diet composed of less than 25% animal products (Rothgerber, 2013). Little research has been published regarding the prevalence of plant-based diets in companion animal nutrition, and it is unknown how many pet keepers currently feed plant-based diets to their dogs or cats.

Previous surveys have examined feeding practices and attitudes amongst vegetarian and vegan pet keepers (Rothgerber, 2013, 2014; Wakefield et al., 2006b), but these were specifically directed at vegetarians and vegan groups and thus gave no indication as to the scope of the issue amongst the pet population in general. It was therefore the purpose of this study to estimate the number of pet keepers who feed plant-based diets to their dogs and/or cats, identify their concerns regarding animal products and ascertain their motivations for feeding plant-based diets. Estimation of the prevalence of this type of feeding provides a baseline from which growth of the trend could be measured, as well as to inform veterinarians, nutritionists and pet professionals as to the scope of this controversial practice at present. Understanding the attitudes, concerns and motivations of pet keepers feeding their pets plant-based diets is necessary for effective communication between veterinarians and their clients in order to serve both their clients’ and patients’ best interests. It was hypothesized that there would be a higher prevalence of vegetarianism and veganism amongst pet keepers than has been reported in the general population, and that there would be more concern regarding animal-derived ingredients in pet foods amongst vegetarians and vegans than other diet groups. It was
also hypothesized that vegetarian and vegan pet keepers would have fewer concerns regarding plant-based pet foods and would be more likely to feed these diets to their dogs and/or cats as compared to omnivorous pet keepers.

3.2 METHODOLOGY

A multiple choice and short answer survey titled “Pet Feeding Practices” was administered online (www.surveymonkey.net), a copy of the questionnaire is available in Appendix I. To minimize selection bias, no reference was made to any particular type of diet or feeding practice in the title or introduction of the survey. The study was supported by the research ethics board of the University of Guelph (REB #17-08-029). The questionnaire started with multiple-choice questions [MCQ] collecting demographic data (age, gender, country), pet keeper diet (omnivore, pescetarian, vegetarian or vegan, with descriptions of each diet) and pet type (cat, dog or both). An omnivorous diet was defined as one that included meat; pescetarian was defined as including fish but no other meats; vegetarian was defined as avoiding all meat but including eggs, dairy and/or honey; and vegan was defined as being devoid of all animal products. The next series of MCQs also included an open-text option of ‘other’ where the pet keeper could input their response. These included locations where pet food was sourced (supermarket, pet store, veterinary clinic, direct from manufacturer, online, homemade, ‘other’) type of pet diet, and concerns regarding pet foods. Type of pet diet was categorized as commercial or homemade; meat-based, vegetarian, or vegan; raw or cooked; and, in the case of cooked commercial diets, extruded or canned. While the term ‘meat-based’ is not entirely accurate, as many pet foods utilise animal by-products not conventionally
considered ‘meat’, such as offal, blood or bone meal and also typically contain a large amount of plant ingredients, this was utilised within the survey text for simplicity. Similarly, the term ‘vegan’ was utilised within the text of the survey in order to be easily identifiable. The true meaning, however, of the term ‘vegan’ is defined as a lifestyle/philosophy, and not simply a diet (Boo, 2014). Thus, the phrase ‘plant-based’ is used within this paper for the purpose of describing food devoid of animal products, as it is recognized that neither dogs nor cats are free to choose their lifestyle nor express their philosophical ideologies to their caregivers. Feeding frequency of each type of diet was also determined, with pet keepers reporting feeding any type of diet either ‘daily’, ‘often’, ‘infrequently’ or ‘never’. Respondents could choose from a list of possible concerns regarding meat-based pet foods: farm animal welfare, farm animal rights, health concerns, environmental concerns, social concerns, and ‘other’; and plant-based pet foods: unnatural, unhealthy, not nutritionally complete and balanced, cost, moral acceptability, and ‘other’. For pet keepers who indicated that they did not feed a plant-based diet, an extra MCQ was included to ascertain whether they would feed a plant-based diet if one were available that met their standards or desired attributes. For those who indicated they would not feed a plant-based diet even if it met their specific stipulations, a follow-up open-text option question was then asked to differentiate between individuals harbouring further concerns regarding plant-based diets and rejection of the diet based purely on non-cognitive negative affective response (Lawton, Conner, & McEachan, 2009). The questionnaire ended with a set of questions to assess financial motivation of pet keepers to feed a commercial plant-based diet, if one were available to them. For pet keepers with both
cats and dogs, questions were first answered regarding their dog, then their cat, and then finished with the generic questions regarding purchasing of plant-based diets. The questionnaire was piloted on 15 volunteers and questions adjusted as required to improve the survey experience.

The survey was distributed online through social media to a number of English language pet-centric groups, including dog and cat breeders, keepers, and general enthusiasts. Sharing of the survey was encouraged in order to reach a broad audience. Veterinary hospitals/clinics, other pet professional and para-professional groups, and nutrition-related groups were avoided in order to minimize selection bias, as the aim of the survey was to collect data from a sample representational of the general pet-keeper population. The survey was available online for a total of 135 days, although it was only actively promoted for the first 65 days.

Survey responses were analysed and descriptive statistics used to assess categorical data. Quantitative and qualitative data were reported as frequency (n) and percentage (%). When comparing responses by country, only those countries from which more than 100 responses were received were considered large enough for comparison, based on sample size calculations using published estimates of prevalence of meat-avoidance in the population. Sample size was calculated from the formula \( n = \frac{Z^2 \times P(1-P)}{e^2} \), where \( Z \) = value from standard normal distribution corresponding to confidence level 95%, \( P \) = expected true proportion (based on estimates of meat-avoidance in the human population previously published), and \( e \) = desired precision. Comparison of proportions between the current study and previous studies was performed by calculating
95% confidence intervals. Univariate analysis was conducted using Chi-square to select variable to include in a binary logistic regression model to assess relationships between variables of interest and feeding practice outcomes. Variables evaluated were: age, gender, country, and concerns regarding animal- and plant-based diets. Statistical significance was set at $P < 0.05$, trends were recognized if $P$ was $> 0.05$ but $< 0.1$. All analyses were performed and all figures created with commercial software (IBM® SPSS® Statistics Version 24, IBM Corp, North Castle, New York, USA).

### 3.3 RESULTS

A total of 3,718 questionnaires were commenced, of which 3,673 were complete enough to include for statistical analysis. Those not included were due to attrition prior to identifying type of pet. Survey participants comprised 1,871/3,673 (51%) dog keepers, 602/3,673 (16%) cat keepers, and 1,200/3,673 (33%) keepers of both dogs and cats. Pet keeper demographics are presented in Table 1. The survey questions were considered independently, so the number of responses for each question differed, thus proportions are representative only for the number of people answering each question. For example, pet keepers who had only cats were not included in data analysis regarding dogs.

The majority of pet keepers (84%, 3082/3,673) reported eating an omnivorous diet, with 5.8% (212/3,673) identifying as vegan, 6.2% (229/3,673) as vegetarian, and the remaining 4% (150/3,673) as pescetarian. Differences in meat-avoidance were detected between age groups ($P = 0.001$) and are depicted in Figure 1. Vegetarianism tended to be reported twice as frequently in females as compared to males (3%; 6/215
males vs 6%; 218/3,381 females, \( P = 0.099 \)). A higher prevalence of veganism was reported in males (8.3%, 18/215) than females (5.8% 186/3,381), \( P = 0.046 \). The prevalence of meat avoidance was different between countries (Table 2).

In total, 51% (1,659/3,231) of survey respondents reported at least one concern regarding meat-based pet foods, resulting in a total of 5,115 concerns reported regarding meat-based pet foods. Pet keepers over 60 years of age reported less concerns (42%; 164/392) than younger age groups (\( P = 0.003 \)). Concerns were more frequently expressed by respondents in the UK (55%; 403/737) and least frequently in the USA (42%; 562/1,326, \( P = 0.001 \)). There were no differences in the frequency of concern expressed between different pet categories (dog, cat or both). The most commonly reported concern overall was for the welfare of farmed animals, reported by 39% (1,275/3,231) of pet keepers. Significant differences in the number of concerns expressed about animal products in pet foods were detected between pet keepers when categorised according to their dietary status. Omnivores reported fewer concerns, and vegans more concerns; vegans also differed from other diet groups in all concern categories except for ‘other’ (Table 3). In comparison, 91% of pet keepers (3,044/3,318) reported at least one concern regarding strictly plant-based (‘vegan’) pet foods, for a total of 11,399 concerns reported regarding plant-based pet foods, roughly double that reported for meat-based pet foods. Whereas just over half of pet keepers reported concern regarding meat-based pet foods, almost all pet keepers indicated concern regarding plant-based pet foods. Differences were detected between age groups, with concerns being most frequently reported in the youngest two age groups (95%; 921/971),
decreasing with age to be lowest in the oldest two age groups (89%; 939/1,059), \( P = 0.001 \). Pet keepers who had dogs only reported the lowest number of concerns (88%; 1,498/1,693) while those who had cats only reported the highest number of concerns (95%; 508/537), \( P = 0.001 \). As with concerns regarding animal products, the greatest differences between concerns regarding plant-based pet foods were detected among pet keeper diet groups (Table 3).

Dietary information was provided for 1,542 cats and 2,940 dogs. Most pets (cats 99% 1,530/1,545; dogs 97% 2,848/2940) were fed food that contained meat. Daily feeding of conventional extruded was reported for 61% (1,796/2,940) of dogs and 69% (1,064/1,545) of cats, with daily feeding of conventional canned food to 15% (427/2,940) of dogs and 44% (684/1,545) of cats. Many pets were fed diets inclusive of vegetarian or plant-based foods (3.3% 51/1,545 cats; 10.4% 305/2,940 dogs), but exclusive feeding of plant-based diets was reported only by vegans and one vegetarian. In total, 0.7% (11/1,545) of cats and 1.6% (48/2,940) of dogs were fed a strictly plant-based diet. Of the pets being fed strictly plant-based diets, the majority (dogs 91%; 40/44; cats 73%; 8/11) were fed a diet that included some homemade foods, while 18% (2/11) of cats and 2% (1/44) of dogs fed plant-based diets were fed a homemade plant-based diet exclusively.

Only 27% (58/212) of vegans reported feeding their pets a plant-based diet, yet 78% (131/168) of vegan pet keepers indicated they would feed a plant-based diet to their pet if one were available that met the pet keepers’ required criteria (Figures 2 and 3). In total, 35% (1,083/3,130) of pet keepers who did not already feed a plant-based
diet to their pet indicated interest in doing so, with 55% of those pet keepers (599/1,083) stating further stipulations needed to be met before they would do so. Of these pet keepers who indicated further stipulations, 45% (269/599) reported a need for further evidence of nutritional sufficiency. Veterinary approval (20%; 122/599) and greater availability (20%; 117/599) were also commonly reported. Motivation to feed a plant-based diet was measured in terms of cost compared to what the pet keeper currently paid for their pets’ food. Significant differences in motivation to feed a plant-based diet were detected based on pet keeper diets (Table 3). The remainder of pet keepers (65%; 1,936/3,130) simply would not feed a plant-based diet, regardless of whether one existed that would meet all of their criteria.

With the exception of a single vegetarian, only vegan respondents reported feeding a plant-based diet to their pet. Pet keeper diet was thus excluded from predictive models, and binary logistic regression was employed to determine what factors were associated with vegans feeding their pets a plant-based diet. After elimination of insignificant variables, only concern for “animal rights”, lack of concern for plant-based diets being “unnatural” or providing “incomplete nutrition” were significant predictors of vegans feeding their pets a plant-based diet based on binary logistic regression modelling (Table 4). Concern for the “unhealthiness” of meat-based diets neared significance.
3.4 DISCUSSION

At this point in time, the diet of most pets included animal products to some degree. However, of those pets fed diets that included animal products, some were regularly fed vegetarian and plant-based foods with occasional animal-derived foods added. Twice as many dogs as cats were fed exclusively plant-based diets. This higher prevalence of plant-based feeding to dogs was not unexpected, considering the more flexible omnivorous physiology of dogs, and the relative lack of commercial plant-based diets for cats. Perhaps counter-intuitively, in this study meat-avoiding pet keepers appeared to keep cats in preference to dogs, though this only reached significance in vegetarians and not vegans. Considering the obligatory carnivorous physiology of cats, one may expect pet keepers who themselves avoid meat to also avoid having pets who eat meat, but this was not supported by the findings of this study. Furthermore, pescetarians with cats were found to be more interested in feeding a plant-based diet to their pet than were pescetarians with dogs (Figure 3). It may simply be that the relative dearth of plant-based options for cats leaves more cat keepers waiting for a suitable alternative, thus inflating the number of those who do not currently feed a plant-based diet but would do so if one were available. Alternatively, this may be a reflection of some intrinsic preference meat-avoiding pet keepers have for cats, particularly since it was found that vegetarians were more likely to keep cats, and less likely to keep dogs.

Regarding the relative lack of commercial plant-based options for cats, comparatively more cats were fed a homemade plant-based diet than reported in dogs, though the sample size was very small. Despite the small number, this finding is particularly
concerning, as complete and balanced homemade diets are challenging for pet keepers to make even with the inclusion of animal products (de Fornel-Thibaud et al., 2007; Dillitzer et al., 2011; Hutchinson et al., 2012; Lauten et al., 2005; Michel, 2006; Rahaman & Yathiraj, 2000; Remillard, 2008; Roudebush & Cowell, 1992; Stockman et al., 2013; Verbrugghe et al., 2011), while homemade vegetarian and vegan diets have been considered contraindicated in cats (Parr & Remillard, 2014).

The findings of this study suggest that more pet keepers have interest in feeding a plant-based diet than currently do so, especially those avoiding meat in their own diet. An association between meat avoidance and guilt associated with pet food has been previously documented (Rothgerber, 2013, 2014), which would reinforce these results. That being said, the majority of pet keepers indicated that they would not feed a plant-based diet, even if one were hypothetically available that met the needs of their pet. This indicated a strong non-cognitive response based on emotion, rather than logic (Lawton et al., 2009). This was certainly anticipated, considering the general acceptance of carnism as social normality, and is in agreement with previous studies demonstrating the reluctance of many people to consider the implications of their animal consumption or change their eating behaviours (Graça, Calhieros, et al., 2015; Graça, Oliveira, & Manuela, 2015; Macdiarmid, Douglas, & Campbell, 2016; Prunty & Apple, 2013). Additionally, the perceived paucity of evidence supporting plant-based diets for pets, concern of veterinary disapproval, and challenges with availability reported in this survey all likely contribute to an effective case against plant-based pet foods too strong to be overcome by logical questioning or reason. For those pet keepers who indicated
that they would consider feeding a plant-based diet if further stipulations were met, the most frequently cited desire was for evidence of nutritional sufficiency. This strongly suggests that future research in this area is warranted.

As hypothesized, there were differences in the concerns reported by pet keepers who avoided meat in their diet and those who did not. This appears to support the findings of psychology studies that suggested that those who consume animal products have a lower consideration for the wellbeing of those animals (Allen et al., 2000; Lund et al., 2016; McDonald, 2000; Prunty & Apple, 2013). It may also be the case that, considering the social normality of carnism, many people who eat animal products have simply not considered the ethical implications of their actions. These concerns, however, were not consistent throughout the spectrum of meat-avoidance. Significant differences in the number of concerns reported were detected not only between the extreme ends of the diet spectrum (omnivores vs vegans), but also between more similar diets like vegans and vegetarians (Table 3). This is likely attributable to the more ideological lifestyle adopted by most vegans, as opposed to the vegetarian diet (Lund et al., 2016; McDonald, 2000). These results are supported by the differences in animal ethics and empathy towards humans and animals previously documented between vegetarians, vegans and omnivores (Allen et al., 2000; Filippi et al., 2010; Lund et al., 2016). As such, the findings of this survey fit with our understanding of the differences between these groups of people in the general population and the described psychology of animal consumption (Graça, Oliviera, et al., 2015; Macdiarmid et al., 2016; Prunty & Apple, 2013). In comparison with meat-avoiders, people who report consumption of meat have
been found to have less empathy for animals, less concern for animal rights and do not believe the killing of animals is wrong, even amongst those considering themselves ‘conscientious omnivores’ (Rothgerber, 2015a, 2015b). It should be noted that in this survey no definitions were provided for the concern categories listed [ie: animal welfare vs animal rights], and thus the distinction between these would have been open to the interpretation of the individual respondent. That being said, the number and type of concerns regarding animal products reported by the vegan and vegetarian groups agrees with past studies examining the ethics and beliefs of vegetarians and vegans (Janssen et al., 2016b; Kersche-Risch, 2015; Lund et al., 2016). The present data suggests that those choosing to abstain from meat consumption have more concern for the animal from which that meat came from, regardless of whether they are consuming those products themselves or feeding them to their pet. While improvements in animal welfare have been heavily promoted in recent years in response to the demand for ‘humane’ food, it is unlikely that many vegans could be persuaded by these claims due to their moral objection of animal use and not just overt abuse (Janssen et al., 2016b). As such, it is predicted that as the prevalence of veganism increases, the demand for plant-based pet foods will also increase, regardless of the expansion of ‘ethically-raised’ meat in the pet food market (Lummis; PFI, 2015).

Almost all survey respondents reported concerns regarding plant-based diets for pets. As with concerns regarding animal-based diets, pet keeper diet was the most significant factor associated with concern regarding plant-based pet foods (Table 3). Concern regarding the nutritional adequacy of plant-based pet foods was the most common
concern, and was consistently the most reported concern by all pet keepers, though this was lower in vegans. This concern is certainly warranted, considering the challenges of formulating a plant-based diet that is nutritionally complete and balanced according to the nutrient profiles published by the Association of American Feed Control Officials and the European Pet Food Federation, based on nutrient requirements established by the National Research Council (AAFCO, 2018; FEDIAF, 2017b; NRC, 2006). This is particularly true for carnivorous cats. Obligate carnivores are defined as such due to their unique evolutionary dietary idiosyncrasies resulting in requirements for nutrients not found in plants, such as vitamins A and B12, and taurine (Kanakubo et al., 2015; Morris, 2002b; Verbrugghe et al., 2012).

Few studies have evaluated the nutritional content of plant-based pet foods (Gray et al., 2004; Kanakubo et al., 2015; Kienzle & Engelhard, 2001; Semp, 2014). Within these studies, the adequacy of the diets varied widely. Furthermore, labelling compliance was determined to be poor (Kanakubo et al., 2015). Unfortunately, these phenomena appear to be common within the pet food industry, with multiple accounts of commercial pet foods failing to meet labelling standards, guaranteed analysis, industry recommended nutrient profiles, or containing ingredients other than those listed on the packaging (Gosper, Raubenheimer, Machovsky-Capuska, & Chaves, 2016; R. Hill, Choate, Scott, & Molenberghs, 2009; Maine, Atterbury, & Change, 2015). Thus, this does not appear to be an issue exclusive to plant-based diets. Studies evaluating health parameters and nutrient status of dogs or cats fed plant-based diets are also few in number (Gray et al., 2004; Semp, 2014; Wakefield et al., 2006b). Clearly, neither the
nutritional adequacy of commercially available plant-based pet foods nor the short- or long-term effects on the physiology and health of pets eating those foods are well defined, contributing to the skepticism reported by pet keepers in this current study.

For those pet keepers who reported concern regarding the unhealthiness of meat-based pet foods, it is likely that there is a degree of confounding associated with the distrust of pet food companies and manufacturing process as opposed to the ingredients alone. Due to the survey design, these two ideas were not able to be fully separated, and thus this finding must be interpreted with some caution. Some pet keeper comments regarding concerns for animal products reported in the ‘other’ section were regarding the possibility of contamination, the quality of the animal ingredients, or the suspected origin of the product or its ingredients, with China being particularly referenced by American pet keepers. It would thus appear that at least some of the reported concern regarding the unhealthiness of meat-based pet food was not simply the fact that the food contained animal ingredients per se, but the sourcing or processing of those ingredients. This finding, while unquantified in this study, supports other recent reports of distrust in the pet food industry and motivations for feeding non-commercial or alternative diets (Michel et al., 2008; Morgan et al., 2017).

While data from previous studies suggested the prevalence of pet keepership amongst vegetarians and vegans may be higher than the generally reported rate of pet keepership, no previous study had reported prevalence of vegetarianism or veganism among pet keepers (AVMA, 2002; Rothgerber, 2013). The results of this study appear to support our expectation that vegetarianism and veganism were higher in pet keepers
than reported rates in the general public (Table 2) (ADA, 2003; Bates, Lennox, Bates, et al., 2009; DEFRA, 2007; FSA, 2006; GlobalData, 2017; HealthNavigator, 2017; Kivimäki, 2013; Newport, 2012; Radnitz et al., 2015; RoyMorgan, 2016; Vinnari, Montonen, Härkänen, & Männistö, 2007; VVSQ, 2013). Also in agreement with previous studies of the general public, avoidance of meat consumption was more common in younger age groups than in older (Figure 1), (Allès et al., 2017; Davey et al., 2002; Vinnari, Montonen, Härkänen, & Männistö, 2008). It warrants consideration, however, that the results of this current study were compared to a number of previous studies reporting results from surveys with variable sampling methodologies spanning multiple years. To confirm these findings, this study should be repeated with the samples of pet keepers and non-pet keepers in order to directly compare the two populations.

Due to the limitation of language, the sample was mostly representative of pet keepers in English-speaking countries (Great Britain, the United States of America, Canada, Australia and New Zealand), though there was also a large sample size from Finland. The sample of pet keepers responding to the survey was based on self-selection into the study; as such there was risk of sampling bias, which probably accounts for the gender bias detected. Though this was not unexpected, considering the gender-skewed responses to previous studies regarding pet nutrition (Connolly et al., 2014; Morgan et al., 2017; Rajagopaul et al., 2016), the strong bias towards female pet keepers was even greater than predicted. Considering that females have been reported to have higher empathy towards animals than males and are more likely to avoid eating
animals and animal products, this may have increased the proportion of meat-avoidance and concerns for animal welfare and/or animal rights reported by survey pet keepers when compared with the overall pet keeper population (Herzog Jr, Betchard, & Pittman, 1991; Lund et al., 2016; N. Taylor & Signal, 2005). That being said, females are reportedly more likely to keep pets, so the results may yet be indicative of the general pet keeper population (Rothgerber, 2013). Considering the nature of internet-based surveys, there is also the possibility that the sample acquired in this study was not truly representative of the pet-owning population at large and may have included vegetarian- and vegan-biased respondents and/or pet keepers with particular interest in pet foods. Furthermore, it may be that keepers following an alternative or unconventional diet themselves are more likely to have an interest in discussing pet nutrition.

3.5 CONCLUSION

This study represents the first investigation into the prevalence of meat-avoidance in the pet keeper population. The prevalence of vegetarianism and veganism was higher in the pet keeper population than in the general population and accounted for approximately 12% of pet keepers in the sample population. To put that into perspective, in the USA alone, with its population of 325 million and a national pet-owning rate estimated at 56%, there may be around 20 million vegetarian and vegan pet keepers (AVMA, 2002; U.S. and World Population Clock., 2017). The concerns that have been reported to motivate people to avoid meat in their own diets appear to be the same concerns that pet keepers feel regarding animal-based pet foods, particularly so for vegans. Nearly one-quarter of vegan pet keepers reported feeding their pets a plant-based diet,
while almost half of those who indicated they did not currently do so reported that they would if there were a plant-based diet available that met their standards. For the majority of pet keepers interested in feeding a plant-based diet to their pet, the major obstacle currently hindering them was a lack of evidence of nutritional sufficiency. It is clear that an association exists between the diet a pet keeper has chosen to follow and the diet they choose to feed their pet. Considering these findings and the implications these could have on pet health, nutrition, and the pet food market, more research is clearly warranted regarding plant-based pet foods.

3.6 ACKNOWLEDGEMENTS

The MSc student stipend for Dr. Dodd was partially funded by a Mitacs Accelerate award in partnership with Petcurean Pet Nutrition.
### Table 5. Demographic data of pet keepers participating in the "Pet Feeding Practices" survey (n = 3,673)

<table>
<thead>
<tr>
<th>Category</th>
<th>Variable</th>
<th>%</th>
<th>n</th>
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</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male</td>
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<tr>
<td></td>
<td>Female</td>
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<td>3381</td>
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<tr>
<td></td>
<td>Prefer not to dis-</td>
<td>2%</td>
<td>77</td>
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<td></td>
<td>close</td>
<td></td>
<td></td>
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<tr>
<td>Age (years)</td>
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<td></td>
<td>21 – 30</td>
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<td>31 – 40</td>
<td>19%</td>
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<td></td>
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<td></td>
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<td>1485</td>
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<tr>
<td></td>
<td>Other</td>
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<td>265</td>
</tr>
</tbody>
</table>
Table 6. Prevalence of veganism and vegetarianism in pet keepers participating in the “Pet Feeding Practices” survey (n = 3,673) compared to the general population of their respective countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>General population*</th>
<th>Study respondents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% Vegetarian 95% CI SE</td>
<td>% Vegan 95% CI SE</td>
<td>% Vegetarian 95% CI SE</td>
</tr>
<tr>
<td>Australia</td>
<td>1.2-2.7 0.004 0.0008</td>
<td>5.5-12.5a 0.017</td>
<td>3.9-10.1a,b 0.016</td>
</tr>
<tr>
<td>Canada</td>
<td>4** - - 0.011</td>
<td>2.8-7.1a,b 0.019</td>
<td>8.8-15.2a 0.016</td>
</tr>
<tr>
<td>Finland</td>
<td>0.35-0.51 0.0004 0.003</td>
<td>6.3-13.7a 0.019</td>
<td>4.6-11.4a,b 0.017</td>
</tr>
<tr>
<td>New Zealand</td>
<td>2.3** - - -</td>
<td>3.2-10.8a,b 0.019</td>
<td>0-4.1b 0.011</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>2.4-3.6 0.003 0.002</td>
<td>5.3-8.7a 0.009</td>
<td>3.5-6.5b 0.008</td>
</tr>
<tr>
<td>United States</td>
<td>3.7-6.3 0.007 0.004</td>
<td>3.0-5.0b 0.005</td>
<td>3.0-5.0b 0.005</td>
</tr>
</tbody>
</table>

Significant (Chi Square, \( P < 0.05 \)) differences in vegetarianism and veganism between countries detected in this study are indicated by superscript letter. For data regarding the general population, the symbol "-" indicates a lack of reliable data.

*According to other publications (ADA, 2003; Bates, Lennox, & Swan, 2009; DEFRA, 2007; FSA, 2006; GlobalData, 2017; Henderson et al., 2002; Kivimäki, 2013; Newport, 2012; Radnitz et al., 2015; "The slow but steady rise of vegetarianism in Australia,;" 2016; "Vegetarianism & veganism," 2017; Vinnari et al., 2007; VVSQ, 2013)

**Sample size not recorded, 95% CI cannot be determined
Table 7. Concerns regarding pet foods and financial motivation to buy plant-based pet food, reported by pet keepers participating in the “Pet Feeding Practices” survey. Survey respondents are grouped according to respondent diet, and concerns are shown as percentage and number in parentheses.

<table>
<thead>
<tr>
<th>Concern regarding meat-based diets</th>
<th>Omnivore</th>
<th>Pescetarian</th>
<th>Vegetarian</th>
<th>Vegan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 2,717</td>
<td>n = 121</td>
<td>n = 203</td>
<td>n = 190</td>
</tr>
<tr>
<td>Farm animal welfare</td>
<td>33.8 (916)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>73.2 (88)&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>63.5 (129)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>74.7 (142)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Farm animal rights</td>
<td>17.7 (480)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>44.6 (54)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>48.2 (98)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>76.8 (146)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>27.2 (740)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>41.3 (50)&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td>34.0 (69)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>47.9 (91)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Environment</td>
<td>18.1 (493)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>47.9 (58)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>36.9 (75)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>65.3 (124)&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Social</td>
<td>4.5 (121)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.4 (15)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.4 (15)&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>31.0 (59)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Other</td>
<td>3.8 (102)</td>
<td>4.1 (5)</td>
<td>5.4 (11)</td>
<td>4.2 (8)</td>
</tr>
<tr>
<td>None</td>
<td>56.9 (1,547)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>18.2 (22)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>32.0 (65)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>13.2 (25)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concern regarding plant-based diets</th>
<th>Omnivore</th>
<th>Pescetarian</th>
<th>Vegetarian</th>
<th>Vegan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 2,782</td>
<td>n = 134</td>
<td>n = 210</td>
<td>n = 192</td>
</tr>
<tr>
<td>Unnatural</td>
<td>69.2 (1,925)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>62.7 (84)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>71.4 (150)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37.5 (72)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Unhealthy</td>
<td>51.2 (1,439)</td>
<td>61.2 (82)</td>
<td>61.9 (130)</td>
<td>40.1 (77)</td>
</tr>
<tr>
<td>Incomplete</td>
<td>74.0 (2,059)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>76.1 (102)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>79.0 (166)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>58.3 (112)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cost</td>
<td>13.1 (364)</td>
<td>13.4 (18)</td>
<td>9.5 (20)</td>
<td>16.1 (31)</td>
</tr>
<tr>
<td>Immoral</td>
<td>50.4 (1,402)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>45.5 (61)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>56.2 (118)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.6 (51)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Other</td>
<td>9.5 (265)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>9.7 (13)&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>17.6 (37)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>14.1 (27)&lt;sup&gt;b,c&lt;/sup&gt;</td>
</tr>
<tr>
<td>None</td>
<td>7.8 (216)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11.1 (15)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.1 (15)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>30.0 (58)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Financial motivation to buy a plant-based diet</th>
<th>Omnivore</th>
<th>Pescetarian</th>
<th>Vegetarian</th>
<th>Vegan</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I would not feed my pet a plant-based diet”</td>
<td>75 (1,735)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>51 (59)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>58 (105)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22 (37)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>“I would only feed it if it cost less than what I currently feed”</td>
<td>4.9 (112)</td>
<td>4.3 (5)</td>
<td>5.5 (10)</td>
<td>1.8 (3)</td>
</tr>
<tr>
<td>“I would feed it if it cost the same as what I currently feed”</td>
<td>17 (403)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>34 (39)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>25 (46)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>30 (50)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>“I would feed it even if it cost more than what I currently feed”</td>
<td>2.3 (53)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>11 (13)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>12 (21)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>46 (78)&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Significant (Chi Square, $P < 0.05$) differences within rows (between diet groups) are indicated by superscript letters.
Table 8. Odds of vegan pet keepers feeding a plant-based diet to their pet based on responses of pet owners to the “Pet Feeding Practices” survey. R² = 0.524

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE</th>
<th>P value</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (compared to female)</td>
<td>0.670</td>
<td>0.782</td>
<td>0.391</td>
<td>1.96</td>
</tr>
<tr>
<td>Dog (compared to both dog and cat)</td>
<td>0.562</td>
<td>0.574</td>
<td>0.328</td>
<td>1.75</td>
</tr>
<tr>
<td>Cat (compared to both dog and cat)</td>
<td>-0.493</td>
<td>0.747</td>
<td>0.509</td>
<td>0.610</td>
</tr>
<tr>
<td>Animal rights concerns</td>
<td>2.211</td>
<td>0.926</td>
<td>0.017</td>
<td>9.12</td>
</tr>
<tr>
<td>Concern for unhealthiness of meat-based diet for pets</td>
<td>0.982</td>
<td>0.516</td>
<td>0.057</td>
<td>2.67</td>
</tr>
<tr>
<td>Concern for environmental impacts of meat-based diets</td>
<td>-0.186</td>
<td>0.643</td>
<td>0.772</td>
<td>0.83</td>
</tr>
<tr>
<td>Concern for social impacts of meat-based diets</td>
<td>-0.830</td>
<td>0.542</td>
<td>0.126</td>
<td>0.44</td>
</tr>
<tr>
<td>No concern for unnaturalness of plant-based diet for pets</td>
<td>2.658</td>
<td>1.115</td>
<td>0.017</td>
<td>14.27</td>
</tr>
<tr>
<td>No concern for unhealthiness of plant-based diet for pets</td>
<td>1.030</td>
<td>0.753</td>
<td>0.171</td>
<td>2.80</td>
</tr>
<tr>
<td>No concern for incompleteness of plant-based diet for pets</td>
<td>1.010</td>
<td>0.508</td>
<td>0.047</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Data shows results of binary logistic regression.
Figure 1. Proportion of pet keepers following a given diet, by age group.
Figure 2. Current composition of pet diets (dog top, cat bottom), according to their keepers’ diet, based on responses of pet keepers to the “Pet Feeding Practices”. Y axis represents percentage of pet keepers within a given diet group.
Figure 3. Percentage of pet keepers (dog top, cat bottom) who would consider feeding a plant-based diet if one were available that fit their criteria, according to pet keeper diet, based on responses of pet keepers to the “Pet Feeding Practices”. Y axis represents percentage of pet keepers within a given diet group.
CHAPTER 4: GENERAL DISCUSSION AND CONCLUSION

PET FEEDING PRACTICES, VEGANISM, AND PLANT-BASE PET FOODS

SAS Dodd

Department of Clinical Studies, Ontario Veterinary College, University of Guelph, 50 Stone Road, Guelph, Ontario, N1G 2W1, Canada
4.1 GENERAL DISCUSSION

The purpose of this thesis was to describe pet feeding practices, particularly in association with plant-based diets. Specifically, it aimed to estimate the proportion of pet keepers who avoided animal products in their own diets, the proportion of pets fed plant-based diets, and to identify the motivations and concerns of pet keepers regarding plant- and animal-based diets. Estimation of the proportion of pets fed plant-based diets would serve to quantify this niche of the market. Moreover, determining the concerns and motivations of pet keepers regarding the presence or absence of animal-derived products in pet food could guide veterinarians in their education of pet keepers regarding the nutritional needs of their companions, as well as suggest areas for further investigation of plant-based pet foods.

The findings of this research have improved knowledge of current pet feeding practices, particularly with respect to plant-based diets. Previously, studies of plant-based feeding practices only investigated vegetarian and vegan pet keepers, with no estimate made of the prevalence of the practice in the general pet keeping population. This research not only reinforces the findings of those previous studies, with regard to the concerns and motivations of vegetarian and vegan pet keepers, but also puts this into perspective by estimating the proportion of vegetarian and vegan pet keepers, as well as the proportion of pets fed plant-based diets.
4.1.1 Pet Feeding Practices

Based on the data collected from an online survey, Chapter 2 reports that most dogs and almost all cats are currently fed conventional dry and/or wet diets, at least as a component of their main diet. However, over half of pet keepers were also feeding homemade and/or raw foods to their pets. Around a quarter of dogs (of 2,940) were fed diets that included vegetarian or plant-based [vegan] foods; few (1.5%, 44/2,940) were fed exclusively plant-based diets.

The high prevalence of homemade and raw food feeding may contribute to nutritionally-associated health conditions, as these diets are at high risk of nutritional insufficiency and imbalance, with the extra risk of pathogen exposure for diets containing raw animal products (Stockman et al., 2013; Weese et al., 2005). Among veterinarians and nutritionists, commercial diets are generally considered to be less at risk of nutritional insufficiency than homemade diets (Parr & Remillard, 2014; Remillard, 2008). This study thus highlights the need for vigilance among veterinarians and reinforces the practice of collecting dietary information from every pet at every visit in order to identify dietary risk factors, discuss appropriate nutritional management of dogs and cats, and aid in diagnosis of nutritionally-associated conditions.
4.1.2 ‘Veganism’ in Pets and their People

In Chapter 3, as predicted, meat avoidance was reported to be higher in the pet keeping population sampled than has previously been reported for the general population, where data were available for comparison. In particular, veganism appeared to be greater in magnitude among the survey respondents, however some confidence intervals overlapped so the significance of this was indeterminable. Further research directly comparing pet keepers with non-pet keepers would be required to definitively determine statistically significant differences between the two populations.

This thesis was the first to estimate the avoidance of animal products in pet diets. Around a quarter of dogs and less than 5% of cats were reported to be fed vegetarian or plant-based foods as a component of their diet. Less than 5% of pets were fed a strictly plant-based [vegan] diet. With the exception of one dog kept by a vegetarian, all pets fed strictly plant-based diets were kept by vegans. Interestingly, this only accounted nearly a third of vegan pet keepers, though over three quarters reported interest in doing so. Of the vegans who reported an interest in feeding their pet a plant-based diet, yet did not currently do so, a large proportion cited a requirement for more evidence of nutritional sufficiency. While many of the commercial plant-based diets have nutritional adequacy statements invoking either AAFCO or FEDIAF nutrient profiles (Dodd, Adolphe, & Verbrugghe, submitted May 2018), it has previously been demonstrated that only some products met the recommended nutrient profiles when third party analyses were performed (Gray et al., 2004; Kanakubo et al., 2015; Semp, 2014). This indicates further research in the area is required, and if the findings of this study accurately
represent the general pet-keeping population, a large enough proportion demand this research to justify it’s the time and money required.

4.1.3 Concern Regarding Animal-Based Pet Food

The concerns regarding animal-based pet food, reported in Chapter 3, were in close alignment with concerns previously reported by vegans regarding their own diets (Janssen, Busch, Rödiger, & Hamm, 2016a; Kersche-Risch, 2015). As hypothesized, vegans reported far more concerns, particularly with regards the rights of farmed animals. This was particularly true for vegans who fed their pet a strictly plant-based diet, as concern for farm animals’ rights was a positive predictor of feeding a plant-based diet to pets. This clearly reflects the motivation for feeding a plant-based diet being the same as the motivations reported for humans adopting a plant-based diet or vegan lifestyle (N. Fox & Ward, 2008; Kersche-Risch, 2015).

As predicted, concern regarding the rights, not welfare, of farmed animals was a strong predictor in the model of plant-based feeding amongst vegan respondents. Distinction between animal rights and animal welfare may not have been clear, with no definition given for the terminology in the survey, yet a significant association was found with concern for animal rights being a risk factor for feeding a plant-based diet, but concern for animal welfare was not. If taken at face value, this would suggest that there is a need for nutritionally replete plant-based pet diets in the market, as an individual concerned for animal rights is unlikely to feed an animal-based diet, even if the welfare of the animals used were improved, making plant-based diets the only ethically consistent option for them.
4.1.4 Concern Regarding Plant-Based Pet Food

The results in Chapter 3 suggest that pet keepers were concerned regarding the nutritional sufficiency of plant-based pet foods. Vegans reported markedly fewer concerns with plant-based pet food than did non-vegans. In particular, vegans who reported feeding strictly plant-based diets to their pets had the least concern of all. Unexpectedly, a lack of concern regarding plant-based diets being unhealthy was not strongly associated with the feeding practice, though a lack of concern regarding plant-based diets being unnatural or incomplete was associated with feeding a plant-based diet. Of note here is that there was a dissociation between diets being perceived as incomplete and unhealthy. This may suggest that pet keepers do not recognize the health risks of improper nutrition, though this was not a topic addressed in the survey instrument. Aside from vegan philosophy and pet diet ingredient source, this warrants further investigation into pet keeper perception of nutrition and its effects on health status of pets.

There is little data published regarding the effects that plant-based diets may have on dog or cat health. Previous studies have identified some mild nutrient deficiencies, while others detected no abnormalities (Brown et al., 2009; Semp, 2014; Wakefield et al., 2006a). However, no studies have examined health and nutrient status comprehensively, and focused only on selected parameters such as haemogram (Brown et al., 2009), blood taurine and cobalamin levels (Wakefield et al., 2006a), or haemogram, markers of liver, kidney and pancreatic health and function, magnesium, calcium, iron,
folic acid, cobalamin and carnitine (the latter not being an essential nutrient). Considering the extensive gaps in knowledge, as well as the concerns of vegan pet keepers, need for further research in this area is clearly indicated.

4.1.5 Limitations

One of the largest limitations of the study had to do with recruitment and the sample population. The survey was only available online and was shared and promoted on social media, which would only have been brought to the attention of a sub-set of the pet keeping population that were active on social media during the data collection period and who were members of pet-related groups. Sampling bias was then introduced by participant self-recruitment into the study. Pet keepers with particular interest in pet feeding practices were more likely to undertake the survey than pet keepers without much interest in pet feeding practices. As the title of the survey purposefully did not reflect any particular type of feeding practice, this bias was minimized as much as possible, but it is likely that the higher prevalence of alternative or unconventional feeding practices detected in this study may have been influenced at least in part by this non-random sampling process. For a potentially more accurate description of general pet feeding practices, a randomized sampling methodology, as has been previously described (Laflamme et al., 2008; Toribio et al., 2009), would introduce less bias, though participation in the study would still be based on cooperation of pet keepers, with those particularly interested in pet nutrition still more likely to enroll than those without any particular interest. Another possible methodology to reduce bias due to participant inter-
est could include collection of dietary history data from veterinary patients attending annual wellness examinations, though findings would only be applicable to the pet keeping demographic routinely taking their pet to the veterinarian for health checks. Indeed, a comparison of findings from studies using similar questionnaires and performed in the same time period and geographical location, but utilizing different sampling and recruitment methods, would be of benefit to compare results and determine the magnitude of effects of potential sampling biases.

4.2 CONCLUSION

The purpose of this research was to generate new knowledge regarding pet feeding practices with regard to plant-based diets, and to investigate the concerns of pet keepers regarding animal- and plant-based diets. The results of this thesis indicate an interest in plant-based diets from the pet-keeping population, particularly suggesting a need to better examine plant-based diets for dogs and cats. While at present only a small proportion of pet keepers are currently feeding plant-based diets to their pets, it is possible that the number doing so will continue to increase. Further studies are needed in order to quantify the nutrient content of plant-based pet foods, identify health concerns amongst plant-based pets, and investigate the health effects of plant-based diets on pets.
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APPENDICES

7.1 APPENDIX 1: Survey Instrument

Welcome to the Pet Feeding Practices Survey
This survey is for the purpose of university postgraduate research, there is no affiliation
with any pet food company or industry. Your participation is important and valued, thank
you.

This information is completely confidential, and no individual can be identified. The pur-
pose of collecting this information is to look at possible trends associated with feeding
practices.

1. What is your age?
   a. Less than 20 years old
   b. 21 to 30 years old
   c. 31 to 40 years old
   d. 41 to 50 years old
   e. 51 to 60 years old
   f. 61 to 70 years old
   g. Over 70 years old

2. What is your gender?
   a. Female
   b. Male
   c. Prefer not to disclose

3. In what Country do you live?

4. What is your Zip or postal code?
5. How would you describe the diet you eat?
   a. Omnivore – I eat both plant and animal products
   b. Pescetarian – I eat fish/shellfish and plant products, I may or may not eat dairy, egg or honey products
   c. Ovo-Lacto Vegetarian – I eat plant-products, dairy and/or egg and/or honey products
   d. Vegan – I eat no animal products

6. Where do you buy your pet food?
   a. Supermarket
   b. Pet Store
   c. Veterinary Clinic
   d. Direct from Manufacturer
   e. Online
   f. I make the food myself
   g. Other

7. Which of these pet(s) do you have?
   a. Dog
   b. Cat
   c. Both

8. How often do you feed these types of food to your dog(s)?
a. Conventional (meat based) commercial dry food (biscuits or kibbles)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

b. Conventional (meat based) commercial wet food (cans, pouches or rolls)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

c. Conventional (meat based) commercial raw food
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

d. Vegetarian commercial dry food (biscuits or kibbles)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

e. Vegan commercial dry food (biscuits or kibbles)
   i. Every day
   ii. Often
   iii. Occasionally
iv. Never

f. Vegetarian commercial wet food (cans, pouches or rolls)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

g. Vegan commercial wet food (cans, pouches or rolls)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

h. Home-prepared food including cooked meat
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

i. Home-prepared food including raw meat
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

j. Home-prepared vegetarian food
   i. Every day
   ii. Often
iii. Occasionally
iv. Never

k. Home-prepared vegan food
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

l. A diet prescribed by my veterinarian
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

m. Conventional (meat based) commercial treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

n. Vegetarian commercial treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

o. Vegan commercial treats
   i. Every day
ii. Often

iii. Occasionally

iv. Never

p. Conventional (meat based) homemade treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

q. Vegetarian homemade treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

r. Vegan homemade treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

s. Food scraps/left overs (including cooked meat)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

t. Food scraps/left overs (including raw meat)
i. Every day
ii. Often
iii. Occasionally
iv. Never
u. Vegetarian food scraps/left overs (including dairy, eggs or honey)
i. Every day
ii. Often
iii. Occasionally
iv. Never
v. Vegan food scraps/left overs
i. Every day
ii. Often
iii. Occasionally
iv. Never
9. In the previous questions, did you indicate that you feed any commercial or home-prepared vegan diet to your dog(s)?
   a. Yes
   b. No
10. What motivates you to feed your dog(s) a vegan diet? (Check all that apply)
   a. Farm animal welfare
   b. Farm animal rights
   c. Health concerns
d. Environmental concerns

e. Social concerns

f. No concerns

g. Other

11. What concerns do you have regarding feeding your dog(s) a vegan diet? (Check all that apply)

   a. Not natural
   b. Health concerns
   c. May not be nutritionally complete
   d. Cost concerns
   e. Not morally justifiable
   f. No concerns
   g. Other

12. What concerns do you have regarding feeding your dog(s) a diet that includes animal products? (Check all that apply)

   a. Farm animal welfare
   b. Farm animal rights
   c. Health concerns
   d. Environmental concerns
   e. Social concerns
   f. No concerns
   g. Other
13. What concerns do you have which prevent you from feeding your dog(s) a vegan diet? (Check all that apply)
   a. Not natural
   b. Health concerns
   c. May not be nutritionally complete
   d. Cost concerns
   e. Not morally justifiable
   f. No concerns
   g. Other

14. If there were a vegan diet that satisfied all your concerns, as identified in the last question, would you feed it to your dog(s)?
   a. Yes
   b. No

15. What further requirements might you have before considering feeding a vegan diet to your dog(s)?

16. How often do you feed these types of food to your cat(s)?
   a. Conventional (meat based) commercial dry food (biscuits or kibbles)
      i. Every day
      ii. Often
      iii. Occasionally
      iv. Never
   b. Conventional (meat based) commercial wet food (cans, pouches or rolls)
i. Every day
ii. Often
iii. Occasionally
iv. Never

c. Conventional (meat based) commercial raw food
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

d. Vegetarian commercial dry food (biscuits or kibbles)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

e. Vegan commercial dry food (biscuits or kibbles)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

f. Vegetarian commercial wet food (cans, pouches or rolls)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

108
g. Vegan commercial wet food (cans, pouches or rolls)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

h. Home-prepared food including cooked meat
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

i. Home-prepared food including raw meat
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

j. Home-prepared vegetarian food
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

k. Home-prepared vegan food
   i. Every day
   ii. Often
   iii. Occasionally
iv. Never

l. A diet prescribed by my veterinarian
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

m. Conventional (meat based) commercial treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

n. Vegetarian commercial treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

o. Vegan commercial treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

p. Conventional (meat based) homemade treats
   i. Every day
   ii. Often
iii. Occasionally
iv. Never

q. Vegetarian homemade treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

r. Vegan homemade treats
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

s. Food scraps/left overs (including cooked meat)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

t. Food scraps/left overs (including raw meat)
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

u. Vegetarian food scraps/left overs (including dairy, eggs or honey)
   i. Every day
ii. Often

iii. Occasionally

iv. Never

v. Vegan food scraps/left overs
   i. Every day
   ii. Often
   iii. Occasionally
   iv. Never

17. In the previous questions, did you indicate that you feed any commercial or home-prepared vegan diet to your cat(s)?
   a. Yes
   b. No

18. What motivates you to feed your cat(s) a vegan diet? (Check all that apply)
   a. Farm animal welfare
   b. Farm animal rights
   c. Health concerns
   d. Environmental concerns
   e. Social concerns
   f. No concerns
   g. Other

19. What concerns do you have regarding feeding your cat(s) a vegan diet? (Check all that apply)
a. Not natural
b. Health concerns
c. May not be nutritionally complete
d. Cost concerns
e. Not morally justifiable
f. No concerns
g. Other

20. What concerns do you have regarding feeding your cat(s) a diet that includes animal products? (Check all that apply)
   a. Farm animal welfare
   b. Farm animal rights
   c. Health concerns
d. Environmental concerns
e. Social concerns
f. No concerns
g. Other

21. What concerns do you have which prevent you from feeding your cat(s) a vegan diet? (Check all that apply)
   a. Not natural
   b. Health concerns
c. May not be nutritionally complete
d. Cost concerns
e. Not morally justifiable
f. No concerns

g. Other

22. If there were a vegan diet that satisfied all your concerns, as identified in the last question, would you feed it to your cat(s)?
   
a. Yes
   
b. No

23. What further requirements might you have before considering feeding a vegan diet to your cat(s)?

24. Relative to how much you currently spend on pet food, how much would you be willing to spend for a vegan diet, if it were suitable for your pet?
   
a. I would only buy it if it cost less than what I currently pay
   
b. I would buy it if it cost the same as what I currently pay
   
c. I would buy it even if it cost more than what I currently pay
   
d. I would not buy vegan food for my pet

25. How likely would you be to buy vegan pet food from a large pet food manufacturer, provided the diet was suitable for your pet’s needs?
   
a. Visual scale from “I would never buy it” to “I would definitely buy it”

26. How likely would you be to buy vegan pet food from a company that only produces vegan products provided the diet was suitable for your pet’s needs?
   
a. Visual scale from “I would never buy it” to “I would definitely buy it”
Thank you very much for taking the time to participate in this survey which will help us understand more about people’s attitudes towards pet food. We intend to publish the results of this survey in a peer-reviewed journal. If you have any questions or concerns regarding this questionnaire, please email this address: petfoodsurvey@gmail.com