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Challenges in Formulating Diets for Senior Dogs and Cats

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Introduction

In pets, as in humans, there is increasing interest in interventions that promote 'health and wellbeing' into later life, and extend these beyond their current limits. The purpose of this review is to assess the relevance of current knowledge in ageing in humans, as well as reviewing recent research on ageing in pet populations. The role of diet and other factors that influence the ageing process, and ultimately life-span in pets are highlighted; in addition future opportunities and challenges to furthering our understanding of the ageing process in pets are identified. Advancing knowledge on the fundamental biology of ageing will be key for the development, and evaluation of strategies that extend both the quality and quantity of life in human and pet populations.

In human populations lifespan has consistently increased over recent years and this phenomenon shows no signs of abating, advancing on average 2 years per decade (Mathers 2013) In principle this is very good news, however, there are some down sides. Ageing in humans is accompanied by a progressive loss of physical capability and function, characterised as 'frailty', and this can lead to a loss of mobility, independence, and an increased need for support, creating challenges for public health policy, and increased demand for health and welfare systems.
The concept of ageing in pets is well established and recognised by owners and veterinarians. Terms like senior and geriatric are widely used to describe the ageing pet, however these life stages are not well defined, and are usually assigned based on the chronological age of the pet. This approach is somewhat arbitrary, and may not reflect the real 'biological' age of the pet, or reflect some of the subtle changes that may be recognised by the owner such as activity, food intake, bodyweight , body composition, time spent sleeping, or other changes in behaviour.

Changes in life-span

Reports of long-lived pets in the popular media and press, indicate that some achieve remarkable longevity, with the oldest reported cat reaching an astonishing 38 years. There is some evidence that lifespan is higher in pet or domesticated dogs and cats compared with feral or 'wild' dog and cat populations. The average life expectancy in pet cats (12 to 14 years) (Banfield 2013, Taylor 1995), is considerably higher than the reported median lifespan in feral cats (4.7), (Levy et al 2003). It is not known what factors contribute to the striking difference in lifespan between feral and pet cat populations, although accidents, diseases, parasites, availability of food, and the stresses of multiple and frequent pregnancies may all contribute.

Biology of ageing

Ageing is a biological process common to all living organisms. It is a complex biological process and is defined as the progressive reduction of an organism's ability to face the demands of its environment. Thus, ageing causes progressive incapacity to maintain homeostasis and to respond to illnesses and environmental

factors. The specific manifestations of ageing are insidious, often progress slowly, and lead to a functional decline.
In humans it is thought that the accumulation of random molecular damage in the macromolecules of all cells is the major determinant of lifespan, and this results in age dependent defects in cellular function, and reduced function at a tissue level which manifest as age related frailty, disability and disease (Mathers 2013). Many factors, both endogenous and exogenous, are thought to contribute to the cellular and tissue damage that contribute to the ageing process. The development of interventions to prolong lifespan and /or halt the onset of age related diseases is dependent on advancing knowledge and understanding of the fundamental biology of ageing

Ageing in companion animals

Definitions of Ageing

The concept of ageing in pets is well established and recognised by owners and veterinarians. Terms like senior and geriatric are widely used to describe the ageing pet, however these life stages are not well defined, and are usually assigned based on the chronological age of the pet. It is generally considered that an animal becomes a "senior" when it enters the last third of its presumed lifespan; however this definition is very subjective. This approach is somewhat arbitrary, and may not reflect the real 'biological' age of the pet, or reflect some of the subtle changes that may be recognised by the owner such as activity, food intake, bodyweight, body composition, time spent sleeping, or other changes in behaviour. Over the past couple of decades, there has been an attempt to make clear distinctions between the process of ageing and age-related disease. However the dichotomy between the two is blurred. The terms 'old', 'senior' and 'geriatric' are often used interchangeably and are not clearly defined. The term senior refers to functionality and an animal is senior when it shows signs of age-related physical changes. The term geriatric refers to the chronological age of the animal. The Senior Care Guidelines of The American Animal Hospital Association (AAHA) suggest that pets are considered senior in the last 25% of their life span as expected by their species, breed and size.

Phenotypes of Ageing

Cats generally appear to display fewer signs of ageing until near the end of the lifespan, whereas dogs are more like humans in that they show a steady decline in condition from mid-age onwards. Numerous studies have shown a negative correlation between the size (height) and weight of a dog and its life expectancy (Greer, Canterberry, and Murphy, 2007). Due to the large variation in sizes between the breeds, dogs show large differences in longevity despite the similarities in physiology, diet and environment.

Factors affecting Ageing

Gender has impact on longevity, similar to human beings; female dogs have longer life expectancy providing they remain intact, and if spayed then the difference in lifespan between male and females becomes no longer significantly different (Waters et al. 2009). The advantage was not observed in spayed females; however the nature of benefit of ovarian tissue to longevity is unknown.
In dogs, there is a known association between lifespan and breed size, where large breed dogs have a shorter lifespan than smaller dog breeds. While the cause for this difference in lifespan is unknown, computer modelling of data from over 56,000 dogs

from 74 different breeds has demonstrated that large sized breeds age sooner than small breeds as measured by a risk of mortality (Kraus et al. 2013).
Polymorphisms in insulin-like growth hormone have been found to be associated with longevity in several dog species (Piper et al. 2008). A single nucleotide polymorphism in this gene has been found to be common to small breed dogs but uncommon in large and giant breeds (Sutter et al. 2007). Further research is needed to investigate whether this polymorphism could be related to differences in longevity according to breed size.

There is a growing body of evidence on the influence of diet on longevity and lifespan. Dietary energy restriction has been extensively studied in rodent models, and has been shown to have a generally positive impact on lifespan. However, there is limited evidence that this effect translates to humans (Mathers, 2013). One study has looked at the effect of energy restriction in dogs (Lawler et al., 2008). A total of 48 Labrador retrievers from 7 different litters were pair matched (sex and weight) and assigned into one of 2 groups. One group (over fed) was initially fed ad libitum, although this was later restricted to avoid excessive weight gain, the other group was restricted to 75% intake of their litter mates (restricted). The study followed dogs over two decades, and reported a significant increase in median lifespan (13.2 Vs 11 years) in the 'restricted' group. This was associated with a delay in the development of orthopaedic diseases, which is a common age related issue in the breed studied. Body weight was also lower in the diet 'restricted' group, however, this difference did not appear to be due to differences in physical size, but as a result of increased adiposity in the 'over fed' group, suggesting that being overweight may be a negative risk factor for life-span. Energy restriction is unlikely to be a practical solution for most pets, or humans, and in reality the consequences of excess energy intake i.e. obesity, has far greater potential relevance to lifespan.
In humans the relationship between obesity and lifespan is well established, and in countries where obesity is now at 'epidemic' levels, such as the USA, there is the worrying phenomenon that the trend of increased life span over past decades will plateau, and potentially reverse (Olshansky et al., 2005). In dogs and cats the impact of obesity is also known to be associated with various diseases (German 2006), and there is also evidence that obesity shortens lifespan in dogs (Salt and Morris, 2013). However there is no straightforward or simple solution for tackling the obesity issue in pets (or humans)

Physiological Ageing in Companion Animals

1. Cognitive function

It has been shown that the cognitive abilities of dogs, like those of humans, change with age. In addition, dogs are often used as a model of human ageing. Cognitive function describes how the brain influences our perception of the world around us. This most commonly manifests as behavioural changes such as increased or decreased activity, vocalization, and altered interaction with the owners (Laflamme & Gunn-Moore 2014). For example, overall sleep time is increased throughout the day in middle-aged to senior dogs, this is a result of increased number of sleep bouts while each individual sleep interval may be similar or even decreased compared with younger dogs (Zanghi et al. 2013). Cognitive dysfunction has been found in 28-68% of dogs older than 9 (Landsberg et al. 2012).

There is some literature pertaining to the pathophysiology of cognitive decline in dogs and has been more extensively studied in dog than cat. Studies have shown changes such as decreased glucose metabolism (Pan 2011), less neurogenesis (Siwak-Tapp et al. 2007), reduced efficacy of the ubiquitin-proteasome system and accumulation of defective proteins (Ghi et al. 1999) and beta-amyloid plaque formation associated with certain pathologies. There may also be a gradual decline in the function of the pineal gland and a decrease in melatonin (Rozencwaig et al. 1987). A decrease in melatonin could explain some of the changes associated with ageing such as changes in sleep patterns and decreased cognitive function. Oxidative changes also play an important role in brain ageing as the brain has a high metabolic rate which results in a high load of reactive oxygen species (ROS). With age, the brain's ability to efficiently utilize glucose is decreased and the production of ROS increases (Studzinski et al. 2008). Neural tissue has high lipid content due to the presence myelin which increases the susceptibility to oxidative damage. The hypothesized involvement of oxidative damage in the pathogenesis of brain ageing and canine cognitive dysfunction is the reason that nutrients with anti-oxidant properties have been suggested to have protective and therapeutic effects in management and prevention of this condition.

The effects of age on canine cognition and associated neuropathology have been more extensively studied than cats because dogs provide a good model for human ageing. For example, dogs develop extensive senile plaques and accumulation of lipofuscin. The prevalence of cognitive dysfunction is around 67% in dogs aged 15-16 years (Neilson et al 2001). The canine cognitive dysfunction syndrome is characterised by behavioural signs unattributed to other medical conditions. Studies of canine dysfunction have often relied on questionnaires from owners around activities such as disorientation and sleep. Open field tests might therefore be more quantifiable, such as discrimination learning and spacial recognition tests. Far less is known in cats, apart from owner described problems such as altered sleep patterns and difficulties with navigation. Cats are generally believed to have less cognitive impairment compared to dogs, but this may be due to lack of evidence based studies or due to evolutionary capacity.

2. Body composition and energy expenditure

There is considerable evidence to support the fact that maintenance energy requirements (MER) decrease with age in dogs, although the evidence is less substantiated in cats. Energy requirements decline with age, due to reduction of basal metabolic rate and decreased levels of activity. The number of studies definitively showing this in aged dogs and cats is comparatively very few.

Typically, lean body mass decreases with age and fat mass often increases with age. However, this appears to be in the middle portion of life because in super-senior years, fat mass may also decline. While obesity (increased fat mass) is a common clinical condition in middle aged animals, underweight is more commonly reported in senior dogs and cats (Davies 2011) and the prevalence of obesity appears to decrease with age (Harper 1998; Scarlett et al. 1994. The lower proportion of obesity appears to be a combination of weight loss which occurs in cats after the age of 8, combined with lower survival of obese cats (Harper 1998). Reasons for weight loss in older animals are complex and may be interrelated. These may include higher incidence of pathology and disease associated with ageing,

age-related sarcopenia, and non-specific decreased intake in older pets. Despite reduction in acuity of senses and overall caloric intake, feeding patterns of cats do not appear to be altered with age (Peachy and Harper 2002). Sarcopenia is often heralded as impeding mortality in dogs and cats and there many theories on mechanisms, impact, prevention and treatment. Like many of the physiological consequences of ageing, sarcopenia develops slowly over many years making short-term studies very difficult. Preservation of body weight and in particular lean body mass has been associated with a longer and healthier life.

3. Musculoskeletal system

Both loss of muscle and bone mass are typical of ageing in cats and dogs. In dogs the most common form of joint disease is osteoarthritis which is a disease of the synovial joints characterized by degeneration of articular cartilage and the formation of new bone at the joint margins resulting in joint pain and restriction in mobility. Ageing in the joint cartilage is characterised by the cartilage becoming thinner and more fragile. Mild changes may be present at an early age and have mild effect on joint stability and cause mild inflammation which will not cause clinical signs until later in life as inflammation progresses and additional pathology accumulates. There are several biomarkers that are associated with bone turnover and may be used as markers to osteoarthritis in ageing cats such as bone-specific alkaline phosphatase and carboxy terminal collagen crosslink (Yamka et al. 2006).

4. Skin and Coat

Morphological changes to the skin and coat occur with age, namely thinning and lightning (greying) of the coat, a reduction in gloss, seborrhoea, and thinning or hardening of the skin. These integumentary changes are probably one of the most obvious to the owner. The skin undergoes dermal epidermal atrophy and hyperkeratosis may develop on the nose and foot pads. Senior animals may also groom themselves less often leading to matting, odour and dermatitis. Also, aged skin can be a less efficient barrier to pathogens therefore increasing the likelihood of infections. While 'greying' occurs with chronological ageing, it is not directly associated with biological ageing and has no known impact on longevity or morbidity (Glaser 1991; Schnoor et al. 1998).

5. Digestive system

Age related changes may affect digestion and absorption of nutrients. Also, gut physiology and function are altered in ageing and can be accompanied by increased incidence of gastrointestinal (GI) infections. GI alterations in age include slower transit time, altered enzymatic activity, impaired circulation and reduced bile secretions. A large number of studies have been carried out in people examining the effect of age on the GI tract. Decreased nutrient absorption is a common finding in elderly people (Woudstra and Thomson 2002). In the human literature the results suggest some aspects of gut function decline with age but there is no age-related decline in digestive efficiency. Older dogs have been shown to have smaller duodenal villi surface area, lower jejunal villus height and greater colonic crypt depth (Kuzmuk et al. 2005). Age-related functional changes of nutrient absorption have also been suggested; however there is no conclusive evidence of their existence. To date, no decrease due to age on digestive function in dogs of macro- and micronutrients has been documented (Sheffy et al. 1985; Larsen and Farcas

2014) and in fact, there may be an increase or no difference in fat and protein digestion in dogs in ages 8-15 years (Lloyd 1954). Therefore, although structural anatomic and histologic changes may exist, there is little or no impact on nutrient digestibility in dogs. Therefore, senior dogs may require less energy (to match the decreasing energy requirements as detailed above). Fermentable carbohydrates may be beneficial to older animals including resistant start and non-starch polysaccharides. In cats above the age of 7 fat and protein digestibility is reported to become progressively reduced which may contribute to an increase in energy requirements in super-senior cats (Laflamme and Gunn-Moore 2014). It has been suggested cats require more digestible diets with as much energy as adult diets. More work is required in this area and for a more comprehensive review of studies to date see Harper (1998).

Ageing may also affect the intestinal microbiome as older dogs have been reported to have lower colonic concentrations of Bacteriodes, Eubacteria, Peptostreptococci, Bifidobacteria, lactobacilli, and higher concentrations of clostridium species compared with younger dogs on the same diet (Kearns 1998), although other studies did not find such changes (Gomes et al. 2011). Differences in bacterial products (butyric acid, histamine, agmatine, and spermine) between young and senior beagles have been described, supporting the possibility of age related differences in function or composition of bacteria in the canine gastric tract (Gomes 2011). The effect of age on the microbiota in cats and dogs is relatively unknown. Gut health and age in companion animals is an under-studied area and can be considered as effects of diet, the mucosa and microbiota. The use of prebiotics in companion animal nutrition has been reviewed by Swanson and Fahey 2007. In comparison to other species, little is known in the area of prebiotics and companion animals and studies specifically on senior animals are scarce. Studies addressing the diet to favourably manipulate gut microbiota in old animals may allow dietary tools to be developed to promote health.

6. Urinary system

There may be reductions in kidney mass, parenchymal cells and histological changes to the kidney with age. This may result in a decline in kidney function and relates to the age related increased prevalence of renal disease. Ageing may also cause reduced sphincter function in the bladder leading to urinary incontinence. There are many publications on renal disease (please see section below regarding nutritional management of renal disease), however the aetiology of the disease is largely unknown.

7. Cardio-respiratory system

The cardio-vascular system of the ageing dog may also have a reduced function and become more susceptible to disease. There is myocardial fibrosis and wall thickening in the heart which may reduce efficiency, ventricular filling and cardiac output. Chronic valvular disease may also develop and there may be decreased blood flow to the brain and other internal organs. There may also be similar functional declines in the respiratory system such as bronchial constriction and diminished cough reflex. Also, there may be atrophy of the diaphragm and a loss of alveolar elasticity. Differences in expression and function of myocardial calcium channels have been found in ageing dogs (Gan et al. 2013), and these and other age related changes may provide some insight towards the pathogenesis of age related myocardial disease.

8. Senses

In senior animals, the sense of taste, smell, sight, and hearing tend to diminish with age. These changes may have an impact on the food choices of the ageing animal. It has been proposed that senior dogs have decreased ability to sense their environment and to respond to environmental changes such as temperature or humidity changes; however this has not yet been proven in pets (Larsen and Farcas 2014). Loss of olfactory neurons and taste buds may also decrease palatability and a lack of saliva can also decrease appetite in older pets.
Anatomical age-related changes have been documented to impact corneal cellularity and thickness in ageing dogs (Gwin et al. 1982) which may increase risk of corneal opacities and decreased vision. Age related lenticular opacities may develop in several mechanisms including diabetes, oxidative damage, dehydration, and UV light radiation (Williams 2006). The peroxidation of lenticular lipids and oxidation of proteins may be the end result of several cataractogenic pathways including glucose energy metabolism which takes place in the lens itself (Williams 2006).

9. Metabolism

The metabolic response to feeding is altered in ageing dogs with respect to insulin base, peak, and rate of response to a meal (Stesser et al. 1993; Larson et al. 2003; Hayek et al. 2000). Decreased response to ghrelin, a hormone that promotes hunger has also been documented and may contribute to the decreased appetite commonly seen in aged animals (Fahey et al. 2008).
Geriatric cats have been shown to have higher risk for insulin resistance and diabetes mellitus, especially in combination with excessive fat mass (Hoenig et al. 2011). Adiponectin is also high in lean geriatric cats when compared with younger lean cats (Hoenig et al. 2011).

Diabetes mellitus in dogs is the result of absolute insulin deficiency due to reduction in pancreatic beta cells whereas this disease in cats is characterised as insulin resistance and glucose intolerance. The implications are that insulin therapy is life-long in dogs whereas cats may show remission (for example- with weight loss). For both dogs and cats, this disease prevalence increases with age and is commonly diagnosed in middle aged to senior adults. A high protein, low carbohydrate diet has been suggested to assist with nutritional management of diabetes mellitus primarily in cats (Bennett et al. 2006; Frank et al. 2001). Healthy body weight, primarily in obese dogs and cats is another important consideration in the management of this disease.

Effective thermoregulation decreases with age, as shown by decreased ability to pant and ineffective vasodilation makes dogs more prone to heat stroke. Decreased BMR and cardiac output may make pets more susceptible to the cold.

10. Immunity

Ageing is closely associated with a reduced ability to resist infection. Immuno-senescence may be defined as the multifactorial complex of changes that occur in the immune system with age, which may predispose the animal to increase morbidity and mortality due to infections. The effect of the ageing process on immune systems of companion animals has been reviewed by Day (2012). An ageing immune system may be characterised by atrophy of the thymus and

lowered resistance to oxidative stress, as well as changes in haematological parameters.
In dogs and cats there is a relative abundance of literature detailing changes in the immune function with age. This includes a decrease in numbers of immature neutrophils and lymphocytes and increased numbers of mature neutrophils with age (Strauss 1993; Gomes 2011). In vitro tests have shown reduced response to stimulus in mononuclear cells from older dogs; however in vivo there was no correlation of age to cellular response to lipopolysaccharide (Kearns et al. 1999). The faecal concentration of immunoglobulin A has been shown to increase when Beagle puppies mature to adult dogs; however this was shown to decrease in ageing dogs suggesting a decrease in gut-associated immune response with ageing (Zaine et al 2010). Gene expression alterations may also occur with age. Age related alteration in gene expression have been found in dogs with relation to the diet, where dogs fed an animal based diet had higher degree of gene alterations compared with dogs fed a plant based diet (Kil et al. 2010). Differences in gene expression were also demonstrated in adipose tissue; however these were less pronounced (Swanson et al. 2009). DNA damage may also increase in senior animals. This may contribute to morbidity and mortality in several ways including oncogenic cell transformation.
Inflammatory markers appear to increase in ageing dogs (Swanson et al. 2009) similar to other species such as rodents. The contribution of pro-inflammatory conditions such as obesity or other causes of chronic low grade inflammation to the ageing processes warrants further investigation.

11. Oral Health

Ageing animals often have dental problems such as tartar (mineralisation of dental plaque), periodontal disease, gum inflammation and infection and therefore difficulty eating. There may also be reduced saliva production from glands with age. Periodontal disease is a common condition in dogs and increasing age may be associated with increasing prevalence and severity of the disease.
There is very limited research performed in the area of oral care in dogs and cats with age. There are published guidelines for vets to follow when treating animals with age-related decline (Holmstrom 2012). There is also limited published information on size, shape, texture of kibbles for senior animals that may prevent age related decline in oral health which this may provide us with an opportunity to determine if the beneficial effects of tooth-brushing observed in younger dogs may have prolonged effects into senior years, or may even benefit senior dogs before diseases like PD take hold.

12. Other

Ageing is clearly a multi-factorial disease and affects many other aspects of physiology not covered by this review. Some aspects not touched on in detail here are:
Benign and malignant neoplasms are more common with increasing age; however the causes can be multi-factorial. Effective treatment or prevention of cancers by dietary means is likely to be many research-years in the future.
Geriatric animals can also have a decrease in liver mass, leading to decreases in liver function and hepatic enzyme production. Indeed, all internal organs show some degree (and some better characterized than others) with age.

Nutritional Requirements of Ageing Cats and Dogs

The unique nutritional and welfare requirements of senior animals are similar to those of elderly people, in that there is very little research defining actual nutritional requirements. In people, the recommended allowances tend to be based on younger populations adjusted for age related decline such as metabolic rate and physical activity (Chandra et al 1991). Similarly, nutritional information for senior animals is extrapolated from adults, other species and in general is based on very limited experimental evidence. There are currently no distinct nutritional guidelines for senior dogs or cats from any of the regulatory councils (AAFCO, FEDIAF, or NRC). However, nutritional management may assist in delaying or preventing development of many age-related associated pathological changes.
There is actually very little evidence that the requirements of nutrients changes with age. Animals with sub-clinical disease may benefit from increased levels of nutrients such as water-soluble vitamins, but in general there is no direct evidence to support a difference in nutrient requirements compared with adult animals. However there have been plenty of suggestions that added levels of certain nutrients may have functional effects although the evidence for this is, more often than not, scarce. There have been a limited number of reviews written specifically on nutrient requirements for senior animals (e.g. Laflamme 2012, Taylor et al 1995,Markham and Hodgkins 1989) and most conclude that studies and recommendations for nutrient requirements in old animals are lacking.

Energy requirements
It has been suggested that energy requirements of senior dogs are around 20-25% less than young adults (Kienzle and Rainbird 1991; Taylor and Neville 1995), however more recent meta-analysis of energy requirements in dogs (Bermingham et al., 2014) and cats (Bermingham et al., 2010) did not report a difference between senior and younger adults. In theory a decrease in energy requirements might be expected in older animals as a result of a decline in lean body mass, and perhaps activity levels, however these as yet are not proven changes in older pets.
Paradoxically a relatively high proportion of geriatric dogs are below ideal body weight and body condition, which suggests that some pets may not be getting adequate nutrition, rather than too much.

Protein requirements
There is controversy over whether protein should be restricted in senior animals to protect kidney function, and on the contrary protein requirements increase in older animals primarily to support lean body mass. The source, bioavailability, rate of absorption and amino acid profile will also have an impact on health however very little has been researched in this area in companion animals (or indeed in humans). It has been suggested that a decrease in protein with age to prevent degenerative changes in kidney structure and function (Frantz et al. 2007). However, the general consensus is that as muscle loss occurs with age, the protein content should be increased to minimize age-related tissue loss. More digestible or higher quality protein may also be preferred. The altered protein requirement is likely related to increased protein turnover rather than a decrease in digestibility as there is little evidence to suggest protein digestibility decreases with age. Rather, increased protein excretion in ageing dogs has been documented (Wannemacher 1966). Decreased protein synthesis in aged pets combined with increased protein catabolism suggests that protein restriction may be more detrimental in senior pets

compared with young animals (Laflamme 2005). Protein and fat digestibility are decreased in senior cats (Perez-Camargo et al. 2004) and similarly fat soluble nutrients such as vitamin A, E as well as potassium may have decreased absorption too (Laflamme & Gunn-Moore 2014). Individual amino acid requirements may also need to be different for senior animals, again with very little scientific research performed in this area. Although protein tends to incur the most focus, fat and carbohydrate digestion may also be impaired in older animals. One study suggested that loss of lean body mass due to decreased protein intake may be prevented by supplementation of lysine in the diet (Frantz et al. 2007).

Digestion

At the digestive level, senior diets may use high quality, highly digestible ingredients, such as increases in total alimentary fibre intake to stimulate bowel movement. FOS (fructo-oligo-saccharides) may be added as a pre-biotic to positively impact on the gut microbiota. It may also benefit to increase meal frequency to prevent distention and discomfort of the stomach, reduce incidence of hunger and reduce stress on the ageing GI tract. This may also enhance optimal nutrient utilization. Prebiotics and probiotics may also benefit gut health in senior animals. While digestibility of protein is not altered in older dogs and cats, fat digestibility appears lower in ageing cats and may lead to increased energy requirement to maintain an ideal body condition (Taylor and Neville 1995).

Essential nutrients

Ageing animals may be predisposed to kidney disease, therefore phosphorus levels are often decreased in senior diets (with an appropriate decrease in calcium to support maintenance of the Ca:P ratio). While healthy adult dogs may tolerate a wide range of sodium intake as long as they have free access to water, sodium in excess is not recommended in dogs with primary or secondary hypertension or in dogs with fluid retention such as edema or fluid effusion. Sodium restriction has not been shown to be of benefit for hypertension control in dogs with either primary or secondary hypertension (Gresco et al. 1994; Littman 1988). There is some literature on sodium and bone health in healthy young dogs (Brunell 1971), but very little is known about senior pets. However primary osteoporosis has not been reported in dogs and cats.

Antioxidants

Oxidative stress has been associated with higher risk for many age related diseases and primarily neoplastic disease. A nutritional aim of many senior diets is to reduce oxidative damage by the addition of antioxidants. These include vitamin C, vitamin E, lutein, taurine, carotenoids (such as beta carotene and lycopene), polyphenols and micronutrients such as selenium, zinc and copper (as cofactors of superoxide dismutase- SOD). Diets supplemented with vitamin E, beta carotene, and essential fatty acids supported increased longevity compared with cats on a basal diet or on a diet supplemented with vitamin E alone (Cupp et al. 2008). A cocktail of supplements which includes antioxidants (vitamin E, Ginko biloba, phosphatidyil serine, and pyridoxine) was shown to improve short term memory performance in a single study (Araujo et al. 2008).

Other

The taste and olfactory preferences will likely change with age and more is needed to be found on characterizing exactly what these may be. Food format is likely to be

one. Wet food may be preferred in senior animals and may also increase urine volume, dilute crystalloids and increase the frequency of urination to reduce the risk of urinary tract problems. There may also be decreases in taste sensitivity with age, so they may require a more palatable diet or flavour enhancers added to the diet.

In addition to nutritional considerations, ageing animals may need specific adjustments made to their habitat to help them function in their environment. For example dogs and cats with osteoarthritis may benefit from easier access to an elevated food or water bowl, and steps for easier reach to bed or sofa. Animals with reduced senses such as reduced vision as a result of lenticular nuclear sclerosis or cataracts will benefit from maintaining an unchanging landscape and avoiding placing obstacles in their path.
Also, the impact of physical activity in the ageing pet must also be considered. Activity tends to decrease with age, as it does in humans and the reasons are multi-factorial such as joint pain, lack of energy (low metabolic rate) and muscle loss (Harper 1998). Maintenance of low-level physical activity may benefit older animals.

Conclusions
Just as humans tend to be living longer, improved living conditions and veterinary care, combined with more involved, quality-conscious pet owners have contributed significantly to increased life expectancy among domestic animals. These improvements in life expectancy have resulted in increased numbers of older pets, however it has not been accompanied by an increased understanding on their specific nutritional needs. More research is needed to better define the nutritional needs of our ageing pet population

References available on request