

## **Feeding cats for health and longevity – an idiosyncratic perspective<sup>#</sup>**

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### **Overview**

While most of what I am going to write is based more on common sense and anecdote than hard evidence (Stogdale, 2004), many of the contentions herein are supported by recent scientific papers and clinical review articles (see bibliography). In any event I think it is timely that more common sense was brought to bear on this issue.

I will draw together historical information about how cats have been fed in Australia since the 1960s and how and why changes in feeding practices have occurred. I will provide some comments concerning how cats are currently fed in America, and why this has changed over the last few years. Finally, I will touch on how “big cats” are fed in captivity, and provide some recommendations for feeding cats at different life stages, in an Australian setting. Interestingly, feeding practices appear to have been shifted more as a result of marketing forces, rather than by the recommendations of veterinarians or independent feline nutritionists.

My opinion has been formulated on the basis of being a veterinarian for over 25 years, taking into account the things I have seen and read over that time, and also anecdotal experience with *my cats* (n=4) and my friends’ and relations’ cats. They are supported also by the impressions of my senior colleague Dr Victor Menrath.

### **How cats have been fed in Australia since the 1960’s**

During the 1960s and 1970s cats were fed mostly a mixture of table scraps, cheap raw beef and offal (mainly raw beef heart and liver). Tinned food was all fish and not commonly fed. Kittens were recommended to be fed strips of raw beef supplemented by calcium carbonate powder (“1 teaspoon per pound of beef”) plus liver and vitamin A weekly. Special recipes were recommended for pregnant and lactating queens (Victor Menrath, personal communication).

Commercial cat food was introduced before I graduated from vet school in 1981. Commercial canned cat foods (based on meat, meat by-products, offal and/or fish) and extruded commercial dry food (kibble) were widely available at supermarkets, pet stores and other outlets. Indeed, the feeding of these alleged “nutritionally complete” foods was recommended by my lecturers at *The University of Sydney*. As well, “pet meat and pet mince” were available through pet stores and supermarkets. It was inexpensive as it was typically based on kangaroo meat (preserved with sulphites), or other meat or meat

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<sup>#</sup> The views expressed in this paper are my own and not necessarily those of any of the organisations with which I am affiliated. I have no financial interest in any pet food manufacturer. Address for correspondence: R.Malik@vetc.usyd.edu.au

by-products unsuitable for human consumption, and this is still the case. It should be emphasised that then and even now, in NSW at least, there is no legislation as to how pet food should be constituted, or about its safety or hygiene, there is no requirement to list all the ingredients, or to state whether or not preservatives have been added (Malik and Sibraa, 2005). This last statement is remarkable, and surely deserves the attention of the *Australian Veterinary Association* and the *Australian College of Veterinary Scientists*.

Nutritional diseases referable to feeding diets that were not nutritionally “complete” are still seen today, but less commonly than they apparently were in the 1960s and 1970s. These include **nutritional secondary hyperparathyroidism** (from feeding diets high in phosphate and low in calcium to skeletally immature kittens) (Watson, 1983) **hypervitaminosis A** (when cats are fed a diet rich in liver) (Seawright *et al*, 1967), **pansteatitis** (from a diet high in polyunsaturated fats without sufficient antioxidants e.g. certain types of fish) (Watson *et al*, 1973), **thiamine deficiency** (from sulphur dioxide in fresh meat treated with sulphite preservatives, fresh fish containing thiaminases or meat that had been cooked without addition of supplementary thiamine) (Malik & Sibraa, 2005). Experimentally, it was known that when cats were fed certain commercial diets, commercial dog food, or vegetarian diets, they would develop **retinal degeneration due to taurine deficiency** (Markwell *et al*, 1995), but this was on the whole rare because of the large amount of fresh meat typically fed to cats in Australia.

Commercial foods had well known disease associations, although their documentation took time to be widely accepted. Historically, and drawing from epidemiologic data from the USA, there seemed to be an association between feeding commercial cat food and the development of hyperthyroidism. Anecdotally, Vic Menrath’s experience with hyperthyroidism in Australia prior to the early 1980s was a single cat with a thyroid adenoma in 1977; in contrast, a substantial percentage of cats 12 to 15 years-of-age currently have thyroid nodules and often go on to develop hyperthyroidism. Feeding dry food was strongly associated with the development of feline idiopathic cystitis (known also as FUS, FLUTD, interstitial cystitis) and urethral obstruction, especially if the ash content was poorly constituted (Bartges & Kirt, 2006). As an aside, it has been concerning for me hear from colleagues at Kasetsart University about the huge increase in idiopathic cystitis and urinary obstruction in Thailand since the introduction there of commercial dry cat food in place of table scraps and other rations based on meat by-products. In the USA, there is currently a marked increase in the number of oxalate uroliths being diagnosed in cats, not only in the bladder and urethra, but also in the ureter(s), and there is a consensus that the prevalence of this type of stone has increased directly as a result of the widespread use of acidifying dry food diets fed in supermarkets and veterinary clinics across North America, Ironically, these had been introduced to “promote lower urinary tract health” (Bartges & Kirt, 2006). Odontoclastic resorptive lesions on teeth were rarely, if ever, seen in the 1960s and 1970s, but this entity became increasingly prevalent in the mid to late 1980s (Reiter & Mendoza 2002; Victor Menrath, personal communication). Food allergies manifest as “miliary dermatitis”, eosinophilic granuloma complex and inflammatory bowel disease were rarely seen in the 1960s and 1970s except when cats were fed fresh or canned fish; these entities became much more prevalent when commercial canned and dry food were introduced (Victor Menrath, personal communication).

In Australia, until recently, three manufacturers have dominated the supermarket cat food market – Walthams/Uncle Bens (owned by the Mars Corporation), Friskies (Nestle/Purina) and Snappy Tom, the latter using predominantly fish by-products. Also available is fresh meat from a variety of small manufacturers from at pet stores, “pet barns” and supermarkets; it is inexpensive, accounting for an important portion of the market, especially in urban areas.

**Few papers from academic veterinarians have provided insightful information about what cats are fed in Australia since 1980 and the implications of these feeding practices.** Although the market is regularly surveyed by organisations such as the *Pet Information and Advisory Service*, this information remains “hard to get” as it used for marketing purposes and coveted by the organisations that paid for its collection.

In the late 1980s and 1990s, “Premium” pet food (predominantly dry food) and “Prescription diets” became increasingly available in Australia, and were widely endorsed and sold by veterinarians. Indeed, initially they were generally only available through veterinary outlets. Hills (owned by Colgate Palmolive), Iams/Eukanuba and Walthams/Royal Canin are currently the three main players. Nestle Purina had a transient presence in the 1990s but failed to gain a significant veterinary market share, although it has remained successful in the premium supermarket division. These dry foods generally use high quality animal protein, typically in larger proportions than in less expensive supermarket brands, and contain also a high fat content. They are exceedingly palatable, produce a small volume stool and are “addictive” for cats. **I believe that these diets have contributed to obesity in cats in North America and Australia, as people generally fail to follow the feeding recommendations provided by manufacturers, or even worse, feed them *ad libitum* throughout the day.** Cats require only small amounts of these diets for maintenance energy requirements – less than people are accustomed to feeding based on their experience with supermarket brands. The ration is consumed so quickly and with so much relish that cats do not seem satiated. Accordingly, they often “complain” vocally, and through their body language, that they have not received enough food (the Oliver Twist syndrome). Not surprisingly, cats become conspicuously obese when fed in this manner, with prominent deposition of adipose tissue in the inguinal region, about the falciform ligament and in the perirenal region. Ironically, cats are then “prescribed” a “light” ration that is less calorically dense.

The explosion of knowledge in feline medicine of the 1980s and 1990s resulted in the discovery of important new disease associations. Dilated cardiomyopathy was shown largely attributable to feeding diets marginally deficient in taurine (Markwell *et al*, 1995). **Upon reflection, it seems to me that the uncommonness of this type of feline DCM in Australian cats was likely to be attributable to easy access to fresh meat, fish and animal by-products (all rich in taurine).** More recently, the importance of the protein content of the diet and its glycaemic index has been shown to be of great importance in relation to obesity, fat metabolism and the predisposition towards diabetes mellitus. Professor Jacqueline Rand’s group at the University of Queensland is at the forefront of this research. Cats that become fat, especially when they are fed a high carbohydrate ration (with a high glycaemic index), are at risk for developing

insulin resistance, glucose toxicity (a.k.a. Islet exhaustion), “transient” and eventually permanent diabetes mellitus (Zoran, 2002; Hoenig, 2006; Kirk 2006).

Many authorities believe that the feeding of highly palatable, “addictive”, high fat “premium” cat foods *ad libitum* to cats in North America accounts for the high incidence of feline diabetes there. Likewise, many experts believe that there may be an association between the feeding of these diets and the sporadic development of hepatic lipidosis should such cats develop intercurrent disease associated with anorexia, for example pancreatitis. The increasing prevalence of hepatic lipidosis in Australia (Musca *et al.*, 2006) seems to parallel, perhaps coincidentally, the penetration of the Australian cat food market with these US-style diets. In my view, obesity contributes also to degenerative joint disease, because an athletic animal like the cat which jumps and lands (often onto hard ground, taking most of the weight into the forelimbs) is at much greater risk for developing osteoarthritis when overweight. As an aside, apart from feeding cats less food, the best way to avoid obesity is by giving cats an enriched environment, including lots of “vertical space” (ladders, stairs, climbing poles, “cat castles”) and by providing them with a feline companion (which is helpful also for our veterinary business!). Feeding a “light” commercial diet is in no shape or form the answer to a cat with obesity!

**“It just goes to show that when you try to fly against the face of nature, especially with a creature that has been resistant to selective change for tens of thousands of years, you can expect trouble.” - Vic Menrath, the first Australian-trained feline specialist**

### **Re-emergence of the view that ‘natural’ foods are necessary for cats in Australia**

In the 1990s, Tom Lonsdale, Breck Muir and a variety of like-minded Australian colleagues helped remind our profession and the general public that cats were obligate carnivores, and that they did very well when fed more “natural” food such as chicken wings, chicken drumsticks, lamb shanks, chunks of uncut red meat, and the like (Lonsdale 2001). Although there was a strong emphasis on “texture” in relation to periodontal health, the raw meaty bones fraternity provided cogent arguments that fresh meat by-products “on the bone”, and containing skin and connective tissues, were also an important source of varied micronutrients. Food was eaten slowly and with effort, rather than being gulped down in a short time. Presumably this would result in a less extreme post-prandial alkaline tide. There is also much more tenacity about possession of food when natural diets are provided, and there is no doubt that cats seem more satisfied at the completion of a “natural meal”. Effort extended in chewing, gnawing and consuming the ration provides exercise for the gums (and indeed for the whole cat). Importantly, the natural self-cleaning action of stripping the flesh off the bone reduces tartar accumulation and promotes good gingival and oral cavity hygiene. Even tearing apart long strips or chunks of meat can achieve this end. This contention was largely supported by an independent review of the literature commissioned by the *Australian Veterinary Association* (Watson, 1994).

It seems that the influence of this clade of veterinarians had an important impact on pet food manufacturers, worldwide, - some responded with diets designed to require more chewing (such as Hills T/D™) or with additional products designed to achieve the same

end (e.g. “Greenies”). Interestingly, there has been a recent trend on the North American feline literature to re-assert the importance of feeding cats as obligate carnivores – with a requirement for high protein in the ration. Articles like Debra Zoran’s excellent reviews in *JAVMA* and the pink pages of *Journal of Feline Medicine and Surgery* on “the carnivore connection” testify to a paradigm shift in our thinking in relation to feline nutrition. It behoves us to remember Niels Pedersen’s notion that cats are almost subclinically dehydrated even when fed natural diets; feeding a dry ration to such a species is in my view looking for trouble, as cats are almost insipidly dehydrated as a matter of course.

“A senior veterinary representative from a multinational pet food corporation looked at me like I’d gone insane when I told her I fed my cats a 50% raw meat diet and that I didn’t agree with feeding dry food to cats. On a canned/raw diet my cats can be fed ad libitum, still retain a trim figure and barely touch the water bowl - as soon as I give them dry they become insatiated, obese little monsters that are also desperate to drink out of the toilet.” - *Dr Carolyn O’Brien, a registered feline specialist from the University of Melbourne*

“Experience of 40 years of practice and tens of thousands of cats tells me that cats on a basically raw meat diet live longest. Do I have proof? Of course not.” - *Assoc Prof Vic Menrath*

### **The increasing role of multinational pet food manufacturers in nutritional research**

A little spoken of trend in relation to feline nutrition is the influence of multinational food corporations on the direction of feline nutritional research. The vast majority of nutritional studies in cats - and dogs for that matter - are conducted by or funded by corporations such as Walthams, Nestle Purina, Iams and Hills. Although these studies are often of the highest standard, and conducted by independent researchers of the first order, concern must arise as to bias entering the scientific literature when as manufacturers are setting research agendas. These multinational companies expend considerable effort in providing nutritional information to veterinary students, the veterinary profession and new cat owners. In my view the information they present is often commercially driven but cloaked as scientific dogma. Finally, these companies employ some of the most qualified veterinary internists in the country to espouse the virtues of their products. Indeed they are subsidizing this meeting, the proceedings these notes are printed on, and no doubt the current session!

Thus there is an unfortunate entwining of competing interests – commercial and academic – which has muddied the evolution of knowledge in relation to feline nutrition. Most veterinary researchers in academia interested in small animal nutrition or gastroenterology receive substantial grant support from these manufacturers. Unfortunately, little money is available to support independent nutritional research, as this is not a priority area for the *Australian Research Council*, and such research is inherently expensive because it requires animals to be housed, fed and maintained for substantial periods of time. For these reasons, little is being done to compare the nutritional impact of commercial versus natural diets. **Consequently, I challenge a multinational pet food manufacturer to act as an industry partner for a funded ARC linkage grant to ascertain the health and longevity benefits of feeding a hybrid commercial/natural diet in comparison to normal commercial cat food!**

While the valuable contribution made by pet food manufacturers to our knowledge of feline nutrition is acknowledged, it behoves us as professionals to ensure that our expertise is not compromised by too close an association with bodies with commercial interests in the outcome of our research. Rigorous independent research is the only way to ensure this.

### Teleology and “big cats”

Finally, we need to think a little about the likely natural diet of cats. Without doubt, through evolution, cats would have eaten predominantly small mammalian prey, such as mice, rats, field mice, rabbits and the like. Birds and insects would in some situations be important food sources also, and they certainly are reported to be present in the stomach contents of feral cats that are killed by commercial shooters. Fish would *not* be a natural food item for small cats (except for the specially adapted fishing cat), and neither would they likely scavenge larger prey such as the ruminant species. Rabbits would provide for a large meal, followed by a period of rest for digestion. On the other hand, rodents and small birds would likely be devoured quickly, with the cat moving soon onto the next “victim”. Small prey would be almost totally consumed – flesh bones, gut and ingest. Rabbit would be nearly totally consumed, except for part of the pelt and the head. In contrast, large cats (lions, tigers, leopard, cheetah etc) generally eat intermittently, feasting on a large carcass that would provide foods requiring digestion for a substantial period. They would eat meat, bones, guts and their contents, according to hierarchal considerations.

In zoological gardens and game parks, attempts to feed large cats artificial man-made diets have resulted in a variety of disease issues, especially in relation to poor periodontal health resulting in periodontal disease and palatine erosions. Fitch & Fagan (1982) conducted a survey which revealed that of 20 cheetahs in a wildlife park fed a formulated diet, 15 (75%) had perforation of the palate by the penetrating action of the lower molars. In contradistinction, 39 individuals fed animal carcasses lacked the disease condition. Similar observations have been made by others (Shepherdson *et al*, 1993; Phillips 1993). These various authors also commented that cheetahs fed “natural diets” also seemed behaviourally more content, with less stereotypic behaviours such as pacing. Or stated another way, feeding of natural food would appear to represent a form of environmental enrichment. Vosburgh *et al* (1982) made similar observations in relation to timber wolves. As a result, it is recommended that “big cats” be fed predominantly “natural food” (Lindburg, 1988). There is no Science Diet for lions and tigers, and they don’t seem to need a hairball control diet either!

### My recommendations for feeding cats

Having provided all this background, the logical question to ask is – **how do I think we should be feeding our domestic cats?** Apart from my experience (described above) my recommendations have been strongly influenced by the writings of Drs Tom Lonsdale, Ian Billingham, Tom Hungerford, Niels Pedersen, Debra Zoran and Dianne Addie.

1. **Kittens should be fed largely commercial premium cat food.** A combination of canned food and dry food is ideal. Commercial dry kitten food is calorically dense and the best way to get them to grow rapidly. They additionally need to be introduced to different tastes, flavours and textures<sup>1</sup>, but changes in the diet should be gradual. Small meals typically are tolerated much better than large meals. There is no need to give them milk, but a little milk is acceptable as a treat if they are not lactose intolerant. Special cat milk is expensive and an indulgence, but I have no issue with it being given. **As well as this, raw food should be introduced several times a week in place of the normal ration from about 12 weeks of age** – to expose them to the taste and texture of things like chicken wings and lamb cutlets – but it should make up less than 10% of the total food intake over the course of a week. Chicken wings should be fed only when very fresh (i.e. the day it is delivered to the local butcher). Lamb cutlets can be fed raw, or after freezing (to kill *Toxoplasma* zootes) and thawing. The critical thing at this age is to give a varied ration with ideal calcium to phosphate ratio. The small number of *Campylobacter* and *Salmonella* organisms present on chicken skin is well tolerated by the gastrointestinal tract of kittens and cats, but the owners should wash their hands for *their* hygiene after feeding this type of food. Routine anthelmintic dosing for roundworms and tapeworms is critical at this stage in a cat's life, and use of a product that also kills lung worm larvae and fleas has a lot to recommend it.
2. **Young adult cats should be fed more natural food, and ideally I would suggest cats should get approximately 50% of their food from “natural” material that needs chewing to be ingested.** This needs dedicated owners, and the utilisation of the patio, shower recess, backyard or laundry as a feeding platform.

**Dry food should be phased out completely at this stage** because (i) it generally makes cats fat (unless owners feed it according to the manufacturers recommendations) (ii) it is not natural (iii) it generally has too much processed carbohydrate and thus an excessively high glycaemic index (iv) it often has too much fat and excessive content of antioxidants and other artificial chemicals (v) its use is associated with a higher risk of idiopathic cystitis developing. (vi) the diet has so many different ingredients that the risk of it containing things to which the cat can become allergic is higher than for a natural ration. Perhaps a very small amount of premium dry food can be given occasionally as a treat.

Canned food is fine. I favour meat based food over fish based food, as I think it's “more natural”. Allergy to fish is not uncommon in cats with allergic skin disease and food intolerance. Tuna perhaps can be fed as canned food once or twice a week. I think the Fancy Feast™ food by Nestle Purina gives excellent variety of flavours and ingredients and a convenient size. It's pricey however. . Young adult cats are active and burn calories rapidly. They need something in the order of 85 to 100 grams of canned food, or more, twice daily i.e. one can of Fancy Feast twice daily. This can be replaced by a chicken wing, a chicken drumstick, a lamb cutlet, or a

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<sup>1</sup> Kittens should be introduced to bone gnawing as early as possible after weaning. If they are not introduced to gnawing and chewing during the critical 6 to 14 weeks-of-age developmental stage when their eating habits are evolving and their peer competition for food is strong, it is much more difficult to succeed in this type of feeding strategy (Vic Menrath, personal communication)

piece of osso-bucco. Some cats need even more. A lamb shank has enough food to keep a young adult cat going for 24 hours – if they chew it to the bone.

3. **Older cats should be fed like younger cats, but they need less food as they are less active.** Cats older than 10 need about half as much as an active youngster. Being obese increases arthritis issues and causes a shorter lifespan in most species where the effect of obesity on lifespan has been well studied (e.g. rat, dog, humans). So, keep cats lean!
4. Free access to water is mandatory. Some cats prefer water that is running. Some cats don't like chlorine – so fill up the cat bowl with water from the kettle *after* it has cooled down (boiling 'blows off' much of the chlorine).
5. If cats develop renal insufficiency in their old age, a mixture of natural food (for oral hygiene) and Prescription canned (eg Hills canned k/d™) and dry renal prescription diets are ideal, to limit phosphorus retention and to optimise fatty acid balance. Avoid letting geriatric cats get fat on high fat palatable diets such as Hills Dry k/d or Royal Canin kidney diet, which are both excellent and palatable for most cats. "Cat milk" can be useful in older cats with renal insufficiency to get them to drink more, and canned foods are less dehydrating than dry foods.

### Final comments

Cats fed natural food as a large part of the ration have less tartar, and in my view periodontal disease progresses more slowly than in cats provided exclusively with a commercial ration. Even with natural food, cats develop gingival recession as a part of the aging process, and may still get cervical erosive lesions. Periodic dental attention is important to prevent oral cavity inflammation, which possibly contributes to an increased risk for development of cancer and renal disease. **This is especially important as it permits old cats to continue to have health benefits of a natural diet.** Grooming cats on a daily basis with metal comb, especially older cats, is important as hair causes large bowel issues (predisposing to constipation and even megacolon) and irritation to the stomach (resulting in vomiting). This is always important, and increasingly so in the older cat.

### Further reading

1. Bartges JW, Kirt CA. Nutrition and lower urinary tract disease in cats. VETERINARY CLINICS OF NORTH AMERICA-SMALL ANIMAL PRACTICE 36 (6): 1361 2006
2. Dierenfeld ES. Nutrition of captive cheetahs – food composition and blood parameters. ZOO BIOLOGY 12 (1): 143-150 1993
3. Fitch HM, Fagan DA. Focal palatine erosion associated with dental malocclusion in captive cheetahs. ZOO BIOLOGY 1:295-310 1982
4. German AJ. The growing problem of obesity in dogs and cats. JOURNAL OF NUTRITION 136 (7): 1940S-1946S Suppl. 2006
5. Hoening M. The cat as a model for human nutrition and disease. CURRENT OPINION IN CLINICAL NUTRITION AND METABOLIC CARE 9 (5): 584-588 2006

6. Kirk CA. Feline diabetes mellitus: Low carbohydrates versus high fiber? *VETERINARY CLINICS OF NORTH AMERICA-SMALL ANIMAL PRACTICE* 36 (6): 1297 2006
7. Lonsdale T. Raw meaty bones promote health. Rivetco, 2001.
8. Lindburg DG. Improving the feeding of captive felines through application of field data. *ZOO BIOLOGY* 7:211-218. 1988.
9. Malik R, Sibraa D. Thiamine deficiency due to sulphur dioxide preservative in 'pet meat' - a case of déjà vu. *AUSTRALIAN VETERINARY JOURNAL* 83 (7): 408-411 2005.
10. Markwell PJ, Earle KE. Taurine – an essential nutrient for the cat – a brief review of the biochemistry of its requirement and the clinical consequences of deficiency. *NUTRITION RESEARCH* 15 (1): 53-58 1995
11. Phillips JA. Bone consumption by cheetahs at undisturbed kills: evidence for a lack of focal palatine erosion. *JOURNAL OF MAMMALOGY* 74(2): 487-492 1993.
12. Reiter AM, Mendoza KA. Feline odontoclastic resorptive lesions - An unsolved enigma in veterinary dentistry. *VETERINARY CLINICS OF NORTH AMERICA-SMALL ANIMAL PRACTICE* 32 (4): 791 2002
13. Seawright AA, English PB, Gartner RJW. Hypervitaminosis A and deforming cervical spondylitis of cats. *JOURNAL OF COMPARATIVE PATHOLOGY* 77 (1): 29 1967
14. Stogdale L. Sources of information on canine and feline nutrition. *CANADIAN VETERINARY JOURNAL-REVUE VETERINAIRE CANADIENNE* 45 (1): 8 2004.
15. Shepherdson DJ, Carlstead K, Mellen JD, Seidensticker J. The influence of food presentation on the behavior of small, cats in confined environments. *ZOO BIOLOGY* 12:203-216 1993.
16. Watson ADJ. Diet and periodontal disease in dogs and cats. *AUSTRALIAN VETERINARY JOURNAL* 71 (10): 313-318 1994.
17. Watson ADJ. Treatment of nutritional secondary hyperparathyroidism in the cat. *CANADIAN VETERINARY JOURNAL-REVUE VETERINAIRE CANADIENNE* 24 (4): 107-107 1983.
18. Watson ADJ, Porges WL, Huxtable CR, et al. Pansteatitis in a cat. *AUSTRALIAN VETERINARY JOURNAL* 49 (8): 388-392 1973
19. Zoran DL. The carnivore connection to nutrition in cats. *JOURNAL OF THE AMERICAN VETERINARY MEDICAL ASSOCIATION* 221 (11): 1559-1567 2002.

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