One dog's meat is another dog's poison—nutrition in the Dalmatian dog

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Summary

Dalmatian dogs have a predisposition to urate urolithiasis due to a metabolic defect inherent in this breed. It has been suggested that feeding low–protein diets can reduce the risk of producing urate calculi in these dogs, but caution must be exercised to ensure that adequate nutrient requirements are met. This paper discusses the results of a recent feeding trial in which Dalmatian dogs were fed one of four commercial diets, or an anti–uric acid (vegetarian) diet, or an all–meat diet. The crude protein content of these diets ranged from 10.4% to 62.5% in dry matter. Dalmatian dogs produced significantly lower amounts of precipitates in their urine when fed low–protein diets than when they were fed premium high–protein diets or meat. A commercial dry dog food with a crude protein content of 15% was found to be the most effective at reducing urinary precipitates, and equally effective as the special anti–uric acid diet. The effects of time and frequency of feeding were also found to be significant factors in the formation of urinary precipitates in Dalmatian dogs. Dogs produced the lowest levels of urinary precipitates when they were fed a single meal offered late in the day.

Keywords: Dalmatian, dog, protein, purine, digestion, uric acid, ammonium, calculi, urine, urolithiasis, meat, diets

Introduction

Dalmatian dogs are unique amongst the dog breeds in that they excrete uric acid in their urine, rather than allantoin, as the principal end product of purine metabolism; this is due to a metabolic defect inherent in all Dalmatian dogs (Keeler 1940). Homozygosity for a recessive gene has been shown to be the mode of inheritance (Schaible 1986), and there is evidence to suggest that this trait existed in the breed as long as 200 years ago (Keeler 1940).

Purines are the parent compound of the nitrogenous bases adenine and guanine present in the nucleotides of RNA and DNA. Nucleotides resulting from degradation of nucleic acids normally undergo hydrolysis to eventually yield free purines and pyrimidines. If not salvaged and reused, these are then degraded further, and the end products excreted (Lehninger 1970). In the majority of dog breeds, this end product is allantoin. In the Dalmatian dog however, the conversion of uric acid to allantoin occurs with reduced efficiency (Briggs and Harley 1986) resulting in the excretion of high levels of uric acid in the urine.

It is well documented that the administration of purines to Dalmatian dogs, both orally and intravenously, results in corresponding increases in uric acid excretions in the blood and urine (Briggs and Harley 1986; Giesecke *et al*. 1989; Giesecke *et al*. 1982). The ingestion of high purine foods by Dalmatian dogs (e.g. meats, especially organ meats such as liver) also results in increased uric acid excretion. Urates (uric acid and its salts) normally exist as colloidal suspensions in the urine of these dogs, but can be flocculated by an increase in ammonium or hydrogen ions. Increased protein consumption leads to an increase in ammonium ions in the urine, which are then available to form precipitates with uric acid (Sorenson and Ling 1993). Precipitates of ammonium urate are commonly found in the urine of Dalmatian dogs, and this predisposes them to urate urolithiasis.

Commercial dog foods cover a wide range of protein levels and sources, and as such, some of these diets would be considered more suitable to feed to Dalmatian dogs than others. Dog foods that are high in cereals and vegetable protein and lowest in meat content would theoretically be the most suitable diets (low in purines and protein) for Dalmatian dogs, and have been recommended by some authors (Thornhill 1980; Bartges *et al*. 1999). Others have questioned the effectiveness of this approach (Briggs and Sperling 1982; Greene and Scott 1983).

There is a commercially prepared diet specially formulated for the prevention and dissolution of urate calculi in dogs (Hill's Prescription Diet® Canine u/d®). However, the long term feeding of this diet, or other diets severely limited in protein, has been questioned as several cases of dilated cardiomyopathy resulting in congestive heart failure have been reported in Dalmatian dogs maintained on this diet (Freeman *et al.* 1996). There are no studies reported evaluating different commercial diets in Dalmatian dogs.

What is the best diet for Dalmatian dogs?

Most people feed their dogs commercially prepared dog foods. A study conducted in 1992 found that these accounted for more than 60 percent of all food fed to dogs in Australia (Anon 1992). Products can be tinned, dry, or semi–moist and selection is often based on price, palatability, and stool quality. The discerning pet owner might evaluate a product based on the ingredient list and nutrient analysis provided on the product label. In selecting a suitable dog food for feeding to Dalmatian dogs, the following general assumptions should also be considered:

- choose low–protein diets in preference to high–protein diets;
- select dry dog foods rather than tinned dog foods (tinned dog foods generally have a higher meat content);
- diets that are high in liver content should be avoided, as liver is high in purines (Story and Clifford 1976).

The protein content of any commercially prepared dog food should be stated on the label and this will normally be expressed as percentage crude protein. However, the energy density and moisture content of the diet must also be taken into account for this information to be useful, particularly when considering that tinned diets can have a moisture content of up to 85%. A tinned product that has a crude protein content of 7% might provide twice the amount of protein as a dry product that is 15% protein when both are fed at the recommended feeding levels and to achieve the same caloric value.

What is the best time to feed my Dalmatian dog?

It was hypothesised that it might be possible to reduce the risk of urate urolithiasis in the Dalmatian dog by adjusting the time and frequency of feeding. The elimination of purines in the Dalmatian dog has been shown to peak within 6 hours of oral administration, and to be nearly complete by 18 h (Briggs and Harley 1986). There is no information in the literature concerning the elimination rates of purine metabolites from normal dietary sources, but it is expected that these would be somewhat longer, due to the time required for digestion.

The amount of time that urine is retained in the bladder is longest overnight. The retention of urine with a high concentration of uric acid (and other metabolites) for this extended period might increase the likelihood of stone formation, particularly as the bladder is the site where most canine uroliths are found (Case *et al*. 1993; Kruger and Osborne 1986). By shifting the time of feeding, and therefore the time of entry of uric acid into the urine and subsequently into the bladder, theoretically it should be possible to alter the concentration of the urine retained in the bladder overnight. It was also hypothesised that it might be advantageous to feed smaller meals with greater frequency, thereby reducing the peak amounts of purine metabolites present at any one time.

To test these hypotheses, two studies were conducted using Dalmatian dogs. The first study evaluated 6 different diets, and the second examined the effect of time and frequency of feeding. These studies concluded just prior to the writing of this paper, leaving insufficient time to perform full chemical analyses of urine samples. The significance of our findings prompted the reporting of the preliminary data, presented here. The results of the chemical analyses will be presented in a later publication.

Materials and methods

Study 1: evaluating diets in Dalmatian dogs

This study was designed to evaluate 6 different diets fed to 6 Dalmatian dogs in a 6 x 6 Latin Square design. Diets were selected to represent a large range of protein levels (Table 1), and included four popular supermarket varieties (2 dry and 2 tinned), an all–meat diet, and the specially formulated (vegetarian) anti–uric acid diet (Hill's Canine u/d).

Six Dalmatian dogs comprising 2 males (1 desexed and 1 entire) and 4 females (3 desexed and 1 entire), aged between 2 and 9 years, were selected to participate in the study. Bodyweights ranged from 18 to 32 kg. All dogs were examined by a qualified veterinarian before commencing the study, and were deemed to be in good health. None of the dogs had a previous history of uric–acid urolithiasis.

Dogs were kept in individual pens at UNE's dog holding facilities for the duration of the study. The interior of the facilities is centrally heated where dogs are housed at night; the adjoining outdoor runs allow access to fresh air and sunshine during the day. Trampoline style dog beds were provided. Fresh water was freely available at all times, and exercise was provided by walking dogs on a lead twice each day.

Amounts of food given were calculated to meet individual maintenance energy requirements (MER) according to the following formula (Lewis *et al.* 1987) and based on the metabolizable energy (ME) of the diets:

$$MER/d = 0.585 \text{ MJ ME/kg } W^{0.75}$$

Test diets were fed as a single meal at 0900 h each day for a period of 6 d, and any refusals were weighed and recorded. Dogs were then fed Hill's anti–uric acid diet for a period of 3 d before crossing over to the next test diet. Allocation within the Latin Square was such that each diet followed every other diet only once to remove any carry over effect of the diets.

On the morning of the seventh day of each feeding period, prior to feeding, freshly voided urine was collected from each dog and immediately dispensed into sample containers. Earlier studies found that urinary nitrogen output in dogs has stabilised by the sixth day following the introduction of a new diet (Kendall *et al*. 1982).

Study 2: time and frequency of feeding

This study was designed to examine the effects of time and frequency of feeding using 6 Dalmatian dogs in a paired 3 x 3 Latin Square design. The following three feeding regimens were tested:

- am — the entire diet fed at 0900 h;
- pm — the entire diet fed at 1600 h;
- am & pm — half the diet fed at 0900 h and half at 1600 h.

Six Dalmatian dogs comprising 3 males (1 desexed and 2 entire) and 3 females (1 desexed and 2 entire) aged between 2 and 6 years were selected to participate in the study. Bodyweights ranged from 16 to 35 kg. Three non–Dalmatian dogs also participated in the study as controls. The control dogs comprised of one entire male German Short–haired Pointer, one desexed male Boxer, and one desexed crossbred female. Bodyweights for the control dogs ranged from 16 to 30 kg, and their ages ranged from 1 to 5 years. Health check, housing, and feeding levels were as described for Study 1.

A commercial, high–protein, tinned diet was fed to all dogs for 7 days, followed by a washout period of 3 days, during which dogs were fed Hill's anti–uric acid diet, before being crossed over to the next feeding regimen. Any food not consumed was weighed and recorded.

On the morning and afternoon of days 5, 6, and 7, freshly voided urine was collected from each dog prior to feeding, and the pH, specific gravity and quantities of urinary precipitate were measured (methodology as for study 1). The arithmetic means over the three days were calculated.

Measurements

- Urinary pH was measured with a Eutech EcoScan–6 pH meter;
- Urine specific gravity was measured with a Cosmo clinical refractometer;
- Urine was dipstick tested for leukocytes, nitrite, protein, glucose, ketones, urobilinogen, bilirubin, and blood with the Combur (9) Test strips (Roche);
- Urinary precipitates were visually quantified, and photographed, after storage for 4 h at 4°C, followed by centrifugation at 2000rpm for 10 minutes (Figure 1);
- Aliquots of urine were frozen and retained for chemical analyses. The results of these analyses were not available at the time of writing, but will be presented in a future paper;
- The nitrogen content of the diets was determined using a Leco Nitrogen Analyser (FP–2000), from which crude protein content was calculated (N x 6.25);
- The gross energy of the diets was determined with a bomb calorimeter (IKA C7000).

The quantification of urinary precipitates was chosen as a single measurement of the end products of protein and purine degradation in the Dalmatian dog. Precipitates were not normally visible in the fresh urine, but formed after cooling. As such, the urinary precipitates measured in this study represent the

Table 1 Crude protein (CP) content and metabolizable and gross energy density of diets fed to six Dalmatian dogs.

Diet		CP % as fed	CP % in DM	Daily protein intake, g per dog	ME (MJ/kg) as fed	GE (MJ/kg) as fed
Pedigree Pal	(tinned)	6.63	41.89	112	2.93	3.07
My Dog	(tinned)	7.48	46.19	112	3.35	3.61
Hill's Canine u/d	(dry)	9.53	10.36	30	16.80	19.99
Chum Crunchy	(dry)	14.86	16.51	52	14.64	17.41
Pedigree Principal	(dry)	25.34	28.16	86	15.48	19.14
Meat Diet	(fresh)	18.17	62.46	111	8.37*	8.99
Kangaroo (2 parts)		*20.08*	*79.84*	*82*		*5.51*
Lamb (1 part)		*14.34*	*27.71*	*29*		*15.97*

*calculated

precipitation potential of the urine, and give an indication of the degree of risk of forming urinary calculi. Other breeds of dogs do not normally form visible precipitates in their urine.

Statistical analysis

Data were subjected to analysis of variance appropriate to a Latin Square design using SuperANOVA (Abacus Concepts, Berkley, CA, USA). Where the effect of treatment was significant ($P<0.05$), the significance of differences between individual treatment means was determined using Duncan's new Multiple Range test in the SuperANOVA program. A significance level of $P<0.05$ is used throughout. Unless otherwise specified, data are presented as means ± SEM.

Results

Study 1

Differences among diets in effects on the acidity, concentration, and amounts of precipitate in the urine produced by the Dalmatian dogs in this study were all highly significant (Table 2).

The significant findings of this study can be summarised as follows:

- Dalmatian dogs that were fed either the anti–uric acid diet or Chum Crunchy produced the lowest amounts of urinary precipitates;

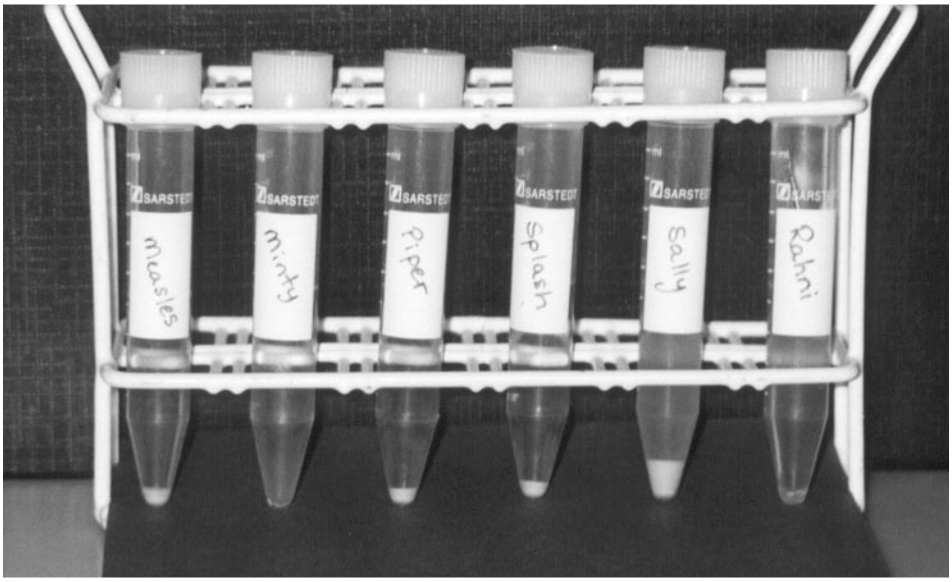

Figure 1 When present in sufficient quantities, ammonium urates readily form a characteristic white precipitate in the urine of Dalmatian dogs. Concentrations of precipitates shown in this photo range from 0 to 4%, and were produced by Dalmatian dogs fed different diets.

Table 2 Characteristics of urine produced by six Dalmatian dogs fed six different diets.

Diet		Crude protein g/day/kg BW	Urinary pH	Specific gravity	Precipitate %
Hill's u/d (Prescription Diet)	(dry)	1.3	7.15^{a}	1.013^{a}	0.33^{a}
Chum Crunchy	(dry)	2.2	6.54^{b}	1.016^{ab}	0.33^{a}
Pedigree Principal	(dry)	3.7	5.78^{c}	1.024^{c}	1.33^{b}
Pedigree Pal	(tinned)	4.8	5.81^{c}	1.025^{c}	1.50^{b}
My Dog	(tinned)	4.9	$5.96^{b\ c}$	1.020^{bc}	1.50^{b}
Meat (kangaroo & lamb)	(fresh)	4.8	$6.00^{b\ c}$	1.035^{d}	2.13^{b}
SEM			0.22	0.00002	0.60
P value			0.001	0.001	0.003

^{abc}Means within columns not sharing a common letter in the superscript differ significantly ($P<0.05$)

- dogs fed dry diets produced lower amounts of urinary precipitates than when they were fed tinned diets;
- the highest amounts of urinary precipitates were produced when dogs were fed the all–meat diet;
- dogs fed the anti–uric acid diet produced urine that was significantly more alkaline than all of the other diets. This product contains potassium citrate to promote urine alkalinity (Bartges *et al*. 1996);
- dogs fed either Chum Crunchy or the anti–uric acid diet produced urine with the lowest specific gravity;
- urine specific gravity was highest when dogs were fed the all–meat diet;
- a positive linear relationship was observed between dietary crude protein and urinary precipitates. Higher levels of protein produced more precipitate (Figure 2);
- a negative linear relationship existed between urinary pH and urinary precipitates. Lower urinary pH resulted in more precipitate (Figure 2).

Study 2

There was a significant effect of time and frequency of feeding on the levels of precipitates in the morning urine produced by the Dalmatian dogs in this study (Table 3) and in summary the results were:

- dogs fed at 1600 h had the lowest levels of urinary precipitates;
- dogs fed twice daily had the highest levels of urinary precipitates;
- dogs fed at 1600 h produced the most alkaline urine;
- dogs fed at 0900 h produced the most acidic urine;
- urine specific gravity was lowest when dogs were fed at 1600 h.

Urine samples collected in the afternoon showed no significant effects of either time or frequency of feeding on any of the urinary characteristics measured in this study (Table 4). The trends, however, were similar to those measured in the morning urine samples with the lowest amounts of urinary precipitates

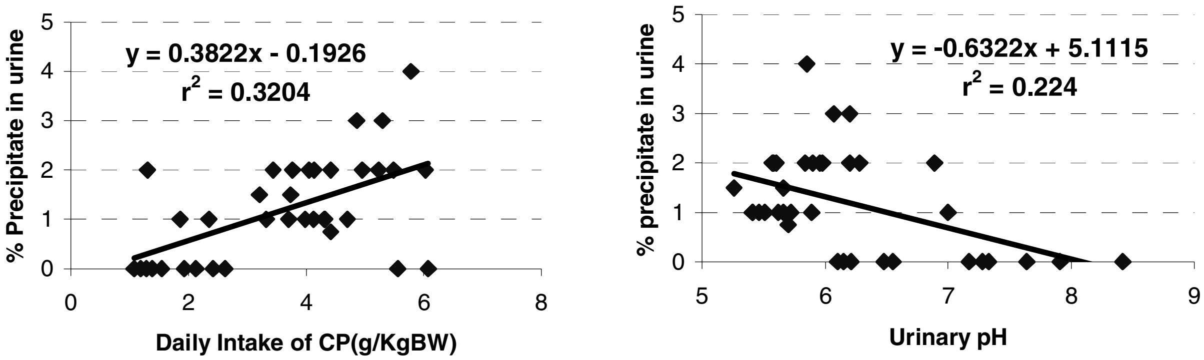

Figure 2 Dietary crude protein (CP) and urine acidity and relationships with the amount of precipitate produced in the urine of Dalmatian dogs (degrees of freedom = 34).

Table 3 Effect of time and frequency of feeding on characteristics of urine produced by Dalmatian dogs on their first urination of the day (prior to feeding).

Feeding regimen	Urinary pH	Specific gravity	Precipitate %
AM — fed once daily at 0900 h	6.22	1.025	1.22 [ab]
PM — fed once daily at 1600 h	6.52	1.020	0.58 [a]
AM and PM — fed twice daily (at 0900 and 1600 h)	6.50	1.026	1.97[b]
SEM	0.44	0.00002	0.40
P values	0.07	0.11	0.02

[abc]Means within columns not sharing a common letter in the superscript differ significantly (P<0.05)

being produced by the Dalmatian dogs that were fed at 1600 h. This is an important observation, as it indicates that there was an overall decrease in levels of precipitates produced by dogs fed at 1600 h, not just an apparent decrease due to a shift in the time of appearance of the uric acid and other metabolites. Another interesting observation was that for all feeding regimens the urine samples collected in the afternoon were significantly more alkaline than those collected in the morning. In both morning and afternoon samples the urine specific gravity was consistently lower in dogs fed at 1600 h.

Control animals

The non–Dalmatian dogs that participated in this study as controls differed significantly from the Dalmatian dogs in that they produced no urinary precipitates. Mean urinary pH and specific gravity of the non–Dalmatian control dogs, on the other hand, did not differ significantly from that of the Dalmatians. Like the Dalmatian dogs, urine samples collected in the afternoon were significantly more alkaline than the morning samples. Unlike the Dalmatians, urine specific gravity was consistently higher in samples collected in the afternoon than samples collected in the morning.

Discussion

In relation to the different diets tested, both Chum Crunchy and the anti–uric acid diet (Hill's Canine u/d) were equally effective at reducing urinary precipitates in the Dalmatian dogs. Chum Crunchy contains nearly twice the amount of crude protein as the anti–uric acid diet and, as such, can be safely fed for extended periods without the risk of problems associated with protein deficiencies.

The variable that contributed most significantly to the production of urinary precipitate in this experiment was the amount of crude protein ingested, as indicated by the highly significant (P<0.01) positive linear relationship (r^2 = 0.32) between protein intake and amount of precipitate produced in the urine (Figure 2). This suggests that the level of protein in the diet is the most important factor that both the Dalmatian dog owner and veterinarians should consider when attempting to reduce the risk of urate urolithiasis in these dogs. Seventy five percent of dogs receiving dietary crude protein levels of up to 2.6 g/kg BW (when fed Chum or the anti–uric acid diet) produced no precipitates in their urine, while the remaining twenty five percent produced small amounts of 1% or below.

Urine acidity has been given much attention in the past, and measures to reduce urine acidity have been employed in the treatment and prevention of urate urolithiasis in Dalmatian dogs. The negative linear relationship (r^2 = 0.22) that existed between urinary pH and urinary precipitate in this study, although significant (P<0.01), was weaker than the relationship between crude protein and urinary precipitate, and suggests that controlling urine acidity alone in Dalmatian dogs would be of limited usefulness, and not likely to prevent the formation of urate uroliths when Dalmatian dogs are fed high–protein diets. This is consistent with the findings of Porter (1963) on the solubility of urates. Reducing dietary protein reduces urine ammonium concentration and urine acidity, and diets low in purines reduce uric acid excretion. It is the combination of reducing these three urinary characteristics that results in an overall reduction in ammonium urate precipitates, and explains the efficacy of this dietary approach to reducing urolith formation in Dalmatian dogs. A significant (P<0.01) positive relationship (r^2 = 0.42) was also found between urinary specific gravity and urinary precipitate, highlighting the additional importance of maintaining dilute urine in this breed of dog.

Dalmatian dogs fed the all–meat diet produced significantly (P<0.05) more urinary precipitates than dogs fed either of the two tinned diets, despite the fact that all three of these diets provided the same amount of crude protein (112 g/d per dog). This might be attributable to a difference in purine content between these diets. The protein in the meat diet is 100% meat–based, and likely to be higher in purines than the two tinned diets that probably contain some vegetable–based protein. The purine content of the diets was not determined due to the unavailability of this analysis. It

Table 4 Effect of time and frequency of feeding on characteristics of urine voided by Dalmatian dogs at 1600 h (prior to feeding).

Feeding regimen	Urinary pH	Specific gravity	Precipitate %
AM — fed once daily at 0900 h	7.23	1.026	2.06
PM — fed once daily at 1600 h	6.81	1.021	1.20
AM and PM — fed twice daily (0900 and 1600 h)	7.07	1.026	1.97
SEM	0.24	0.00003	3.63
P values	0.32	0.25	0.72

is also possible that the higher salt content of the tinned diets (0.35% as fed) compared to the all–meat diet (no salt) resulted in higher water consumption and this could account for the differences observed in urinary precipitates. Urine produced by Dalmatian dogs was less concentrated (lower specific gravity) when they were fed the tinned diets than when they were fed the all–meat diet.

Consumption of dry diets has been considered by some authors to be a risk factor for urate urolith formation, due to decreased urine volume apparently associated with the feeding of dry diets (Bartges *et al.* 1999). Our study suggests that it is the daily protein intake, not the moisture content of the diet, that contributes most significantly to the production of urinary precipitates in Dalmatian dogs. Dogs produced urine with the lowest specific gravity when they were fed the low–protein dry diets. Urine specific gravity was positively correlated with daily protein intake (r^2 = 0.36), and with increased production of urinary precipitates. Dry commercial dog foods generally contain less meat and provide less protein than tinned diets when fed at recommended levels, and this explains why the lowest amounts of urinary precipitates were produced when dogs were fed the dry diets.

In relation to the time and frequency of feeding, the twice–daily feeding regimen resulted in the production of the highest levels of urinary precipitates, and these high levels persisted in urine collected in both the morning and afternoon (Figure 3). This was in contrast with the once–daily feeding regimens that produced considerably higher levels of precipitates in the afternoon than in the morning. It was surprising that higher levels of precipitates were produced when dogs were fed twice daily, given that the amounts fed in each meal were half that of the single daily meals.

If we examine the levels of precipitates produced relative to the time of feeding, rather than the time of day, we find that for both the AM and PM single–feeding regimens the levels of precipitates are nearly identical at 24 h post–feeding (approximately 1.2%). Urine voided 7 hours post–feeding from all dogs fed at 0900 h (from dogs fed either once or twice daily) had the highest concentrations of urinary precipitates (around 2%), and this is consistent with the results from earlier studies that found elimination from orally administered purines to peak around 6 h post–feeding (Briggs and Harley 1986).

When we are considering the fate of dietary protein in the Dalmatian dog, it is important to consider not just the ingestion of the protein, but its digestion, metabolism and assimilation in which there are many intricately woven pathways and processes. It is possible that feeding near the end of the day promotes a more effective digestion and assimilation of proteins and purines while the dog is resting overnight, leading to higher utilisation and lower levels of the end products that contribute to the formation of the urinary precipitates that were measured in this study. On the other hand, feeding twice daily permits the least amount of time between meals for the digestion and assimilation of nutrients. Although this simplistic explanation does not fully explain all of the effects of time and frequency of feeding observed in this study, it might prove worthy of consideration. It appears that there might be some influence of diurnal rhythms of metabolism on the results of this study. This could explain the higher pH values recorded when urine was collected in the afternoon from both Dalmatian and non–Dalmatian dogs, irrespective of time of feeding.

Meat or poison?

For owners wishing to feed meat to their Dalmatian dogs, a closer look at the different types of meat might be helpful. Lean red meats, particularly beef, have higher protein and purine levels than lamb or bacon (information provided by the Purine Research Laboratory, Guy's Hospital, London). It would be sensible to recommend to Dalmatian dog owners that they be careful in selecting the amount and type of meat to include in the diets for their dogs, rather than suggest

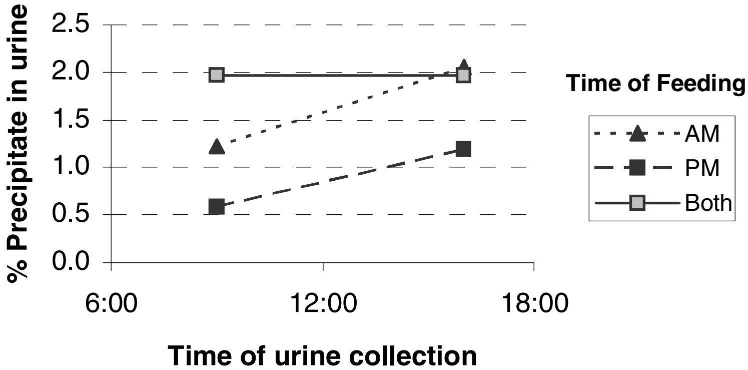

Figure 3 Levels of precipitates measured in urine voided at 0900 h and 1600 h in Dalmatian dogs fed once or twice daily (at 0900 and/or 1600 h).

that no meat be fed at all. Owners should also be aware that meat on its own does not provide a balanced diet for their dogs. The Dalmatian dog owner might find the following guideline helpful:

- lean muscle of red meats should be fed sparingly;
- liver, kidney, and sweetmeats would be best not to feed at all; and
- lamb, particularly off–cuts with a large fat component, could be fed more freely.

Complete and balanced nutrition

Dalmatian dogs can be fed normal commercial dog foods with safety, provided that some consideration is given to the choice of product. When selecting a commercial dog food, the overall nutritional needs should not be ignored. Selecting on the basis of crude protein alone would not be recommended. There is little point in feeding your dog a poor quality food that has the desired crude protein content, but does not meet other nutrient requirements. If the commercial dog food is to constitute the dog's entire diet, then it must be complete and balanced. While products can claim to be complete and balanced based on chemical analysis, a product can only prove this claim by passing a controlled feeding trial regulated by a food regulatory authority such as AAFCO (Association of American Feed Control Officials). In AAFCO feeding trials, dogs are fed the test product exclusively for 6 months, and dogs are then tested for signs of nutrient deficiencies. If the product has passed an AAFCO test, it will say so on the product label. All of the commercial diets used in the two studies reported here have passed AAFCO feeding tests for complete and balanced dog foods.

Urinary precipitates

Previous studies in Dalmatian dogs have focused on the uric acid concentrations of urine and serum as the primary measurements. Some authors have commented on the validity of uric acid data in urine from Dalmatian dogs due to inaccuracies invariably arising from the handling of the samples prior to analyses. It has been noted that uric acid readily precipitates from the urine of Dalmatian dogs, and the precipitates are subsequently left behind when samples are transferred to another container. It has been recommended that transfers of urine be accompanied by thorough mixing, heating to 50°C and alkalising to pH 12 to ensure that precipitates are dissolved (Schaible 1986). In our studies, urine was freshly collected directly into containers for analyses or storage, and heating and alkalising will accompany any transfers prior to analysis. When forwarding samples to a laboratory for analysis, however, it cannot be assured that these precautions will be taken, and most clinical laboratories do not provide a quantitative analysis for urates. For the veterinarian, who is also not likely to be equipped to perform quantitative urate analysis, the method of measuring precipitates used in this study can be easily performed in a clinical practice, is possibly more accurate, and might give a more valid assessment of risk for urate urolithiasis. Ammonium urate uroliths form when there are adequate concentrations of ammonium ions and uric acid present in the urine under favourable physiological conditions. Assessing the precipitation potential of urine produced by Dalmatian dogs by the method described in this paper is likely to be a more accurate indicator of the risk of urate urolithiasis than measuring uric acid concentration alone.

It is anticipated that a correlation will be found between the concentrations of uric acid and ammonium and the levels of precipitates in the urine collected in these studies, once the chemical analyses has been completed. It is almost certain that the chemical composition of the precipitates is ammonium urates given that they were produced by Dalmatian dogs and that significant increases in urinary precipitates accompanied dietary increases in the precursors of ammonium (protein) and uric acid (purines). In breeds other than Dalmatians visible urinary precipitates are rarely seen, especially of the magnitude produced by the Dalmatian dogs in this study. Precipitates were consistently produced by all of the Dalmatian dogs in this study whereas the non–Dalmatian control dogs produced no precipitates.

Conclusions

Many Dalmatian dog owners are unaware of any special dietary considerations for their dogs, and most Dalmatian dogs will not develop urate uroliths, even without special attention given to their diets. However, there are some simple measures that Dalmatian dog owners can easily apply to reduce the risks for their dogs, and there are no good reasons why these measure should not be taken. This is especially the case for male Dalmatians, which are 20 times more likely to require treatment for urate urolithiasis than females due to the narrowing of the urethra at the os penis in the male dog (Case *et al*. 1993). Dalmatian dog owners can greatly reduce the risk of forming urinary urate calculi in their dogs by feeding dry diets with 15% protein content. Whatever diet the Dalmatian dog owner chooses to feed, it appears that feeding a single meal late in the day will also reduce the risk of urate urolithiasis in these dogs. It should also be remembered to provide Dalmatian dogs with free access to water at all times, and plenty of opportunities to empty the bladder.

It is hoped that the information presented here will assist Dalmatian dog owners and veterinarians to provide better care for the population of Dalmatian dogs worldwide. In particular, it is hoped that dietary measures are considered first and foremost in the prevention and treatment of urate urolithiasis in this breed. The opportunity to share our recent discoveries has been offered by this publication. As the application of this knowledge has the potential to prevent a disease that can be life threatening, a decision was made to publish our findings at this opportune moment, rather than delay publication until all of the chemical analyses are at hand.

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