Veterinary Ophthalmology (2004) **7**, 1, 29–35

Prevalence of canine cataract: preliminary results of a cross-sectional study

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Abstract

Objective In this study 2000 dogs were examined ophthalmoscopically to determine presence of cataract.

Materials and methods The dogs examined were predominantly from veterinary hospital populations but also from the Waltham Center For Pet Nutrition, rehoming charities and breeding kennels. Prevalence of cataract was thus determined for different age groups (year cohorts). The age at which prevalence of cataract was 50% (C_{50}) was determined indirectly from a fitted prevalence curve.

Results The mean ± standard deviation of C_{50} for all dogs in the study was 9.4 ± 3.3 years. All dogs over 13.5 years were affected by some degree of lens opacity. C_{50} was determined for animals of different genders and different breeds. For dogs of six breeds sufficient data were available for calculation of breed-specific C_{50}. In these dogs C_{50} was positively correlated with longevity with a least squares correlation coefficient of 0.74.

Conclusion The study yields novel findings regarding the prevalence and incidence of cataract in the dog and forms the basis for considerable further work on the epidemiology and pathophysiology of age-related cataract in the dog.

Key Words: age-related, canine, cataract, epidemiology, lens

INTRODUCTION

Globally, over 20 million people are blinded by cataract. Several large cross-sectional population-based studies show that around 75% of people over the age of 75 have sight-impairing lens opacification.[1] With regard to the canine population, such population-based studies have not been undertaken to date. Yet it is widely accepted that older dogs have some degree of cataract, with comments in recent literature such as 'cataracts are commonly seen in older dogs' (p. 815)[2] and 'senile cataracts are common in dogs and most animals presenting for cataract surgery are middle aged and older' (p. 213).[3] This latter quotation highlights the problem for veterinary ophthalmologists seeking to investigate the prevalence of cataract in the canine population. Patients presenting to an ophthalmic clinic are a highly biased sample from which few conclusions can be drawn regarding cataract prevalence in the general population. It does, however, seem ironic that, given the interest in cataract extraction techniques in veterinary ophthalmology, no attempt has been made to survey a normal dog population and determine the prevalence of cataract in these animals. This study seeks to fill this gap in veterinary ophthalmic research.

The human ophthalmic literature is well served with large cross-sectional population-based studies of ocular disease. Examples include the Beaver Dam study involving ocular examination of 4926 people from one geographic area in Wisconsin, both to determine prevalence[4] and incidence[5] of various ocular conditions including cataract, and the Blue Mountains study in which 3654 people from a region west of Sydney in Australia were subject to detailed ophthalmic examination with similar epidemiologic endpoints.[6] Performing a geographic population-based survey of the pet animal population is exceptionally difficult, since census data for animals do not exist. It is possible, however, to examine dogs presenting for nonocular conditions in first opinion and referral clinics, and thus survey a relatively large number of animals from an ophthalmologically unremarkable population. The problem in such populations is that they cannot be deemed to be a group of completely normal animals; they are a hospital population and care must be taken to exclude from such a study animals with potentially cataractogenic

conditions such as diabetes. Including nonhospitalized dogs from the Waltham Center for Pet Nutrition (WCPN) and from rescue and re-homing centres, as well as a number from breeders' kennels, renders the animals examined a more representative sample of the normal population. While this sampling technique, drawing dogs from a number of different sources, yields a heterogeneous group of animals with potential associated sampling-related problems, it has allowed a relatively large case population size (2000 dogs in this report) to be examined in the relatively short period of 1 year. The results presented here document the prevalence and, indirectly, the incidence of cataract in a mixed dog population. Although these novel findings are only evaluated in a preliminary manner in this report, it is anticipated that they will lay the foundation for considerable further epidemiologic research into age-related cataract in this and other species.

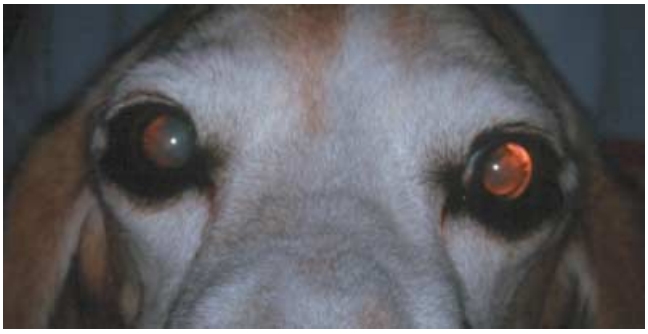

Figure 1. Distant direct ophthalmoscopy of a 13-year-old beagle without pharmacologic pupil dilation, demonstrating that, while not all peripheral cataract can be documented using this methodology, nuclear sclerosis, nuclear cataract and the majority of cortical cataract can readily be visualized.

MATERIALS AND METHODS

Animals

Dogs from a number of populations were examined ophthalmoscopically as detailed below. The predominant group were from animals referred to the Queen's Veterinary School Hospital, Department of Clinical Veterinary Medicine, University of Cambridge (1084 dogs). Others were drawn from hospital populations at eight first opinion clinics visited regularly by one observer (DLW) (563 dogs). Two hundred and sixty-seven dogs were examined at the Waltham Center for Pet Nutrition (WCPN). All dogs at this facility are housed in environmentally enriched accommodation, have access to outside paddocks, and are exercised daily. Fifty-three animals were also examined at the Wood Green Animal Shelter, a large rehoming center where most dogs were placed following elderly owners entering residential care or where owners could not care for the animal after marital break-up. Eighty-six dogs of the German Shepherd and West Highland White Terrier breeds were examined; 33 dogs were in two breeding kennels.

Historic details of medical conditions were examined in all animals to document those dogs with conditions, which might have cataractogenic effects, namely diabetes mellitus, hypocalcaemia and dehydration together with ocular trauma or progressive retinal atrophy. Such animals were excluded from the study as were those for which an accurate age (± 6 months) could not be determined.

Ophthalmic examination

All animals were screened by distant direct ophthalmoscopy at 0D and direct ophthalmoscopy at +10D. Pupils were dilated only by examining the animal in the dark, rather than by pharmacologic intervention, in order to ensure that the investigation was entirely noninvasive and thus ethically valid, since owner consent was not available for a significant proportion of the animals examined. As discussed below, this may be considered as a significant methodologic failing of the study, yet in darkness sufficient pupil dilation was achieved to examine the majority of the lenses (Fig. 1). The status of both lenses (either unaffected, with nuclear sclerosis or with frank cataract) was documented, and if cataract was present the lens was examined using portable slit-lamp biomicroscopy. The position and extent of the lens opacity was documented graphically and scored using a scale from 0 (clear lens or nuclear sclerosis without opacity) to 10 (mature cataract). To avoid interobserver error only one ophthalmologist (DLW) examined all dogs. Photographs were taken in a proportion of animals using a Kowa RC-2 fundus camera at +10D to ensure that the scale used accurately evaluated the extent of lens opacity. An estimate of area of lens opacified was made by projecting the photographic image onto a grid and counting number of squares opacified as a proportion of the total visible through the pupil. Twenty dogs were examined five times over 2 months to determine variability between assessments.

Statistics

The prevalence of cataract at different ages for the specific population sampled was derived from the cross-sectional data obtained in the study as described below. The proportion of animals affected in each year group was plotted to obtain a graph of prevalence proportion against age cohort (Fig. 2). The prevalence proportion of an age cohort for this irreversible condition is an estimate of the cumulative probability of onset up to and including that age. If it is assumed that the age at onset is normally distributed, by fitting a normal cumulative distribution curve to these data, using Microsoft Excel software, the mean and standard deviation of the underlying normal distribution of age of onset can be extracted. The age at which cataract prevalence was 50%, here termed C_{50} given the similarity to LD_{50} in toxicologic studies, is the mean from the cumulative probability curve. C_{50} for cataract for different subgroups may be compared by Student's *t*-test, using the means and standard deviations extracted from the fitted curve with the degrees of freedom

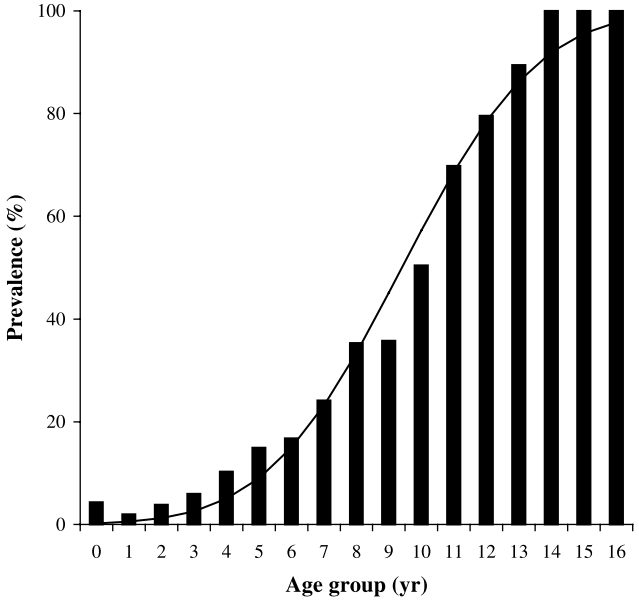

Figure 2. Prevalence data on all dogs by year group.

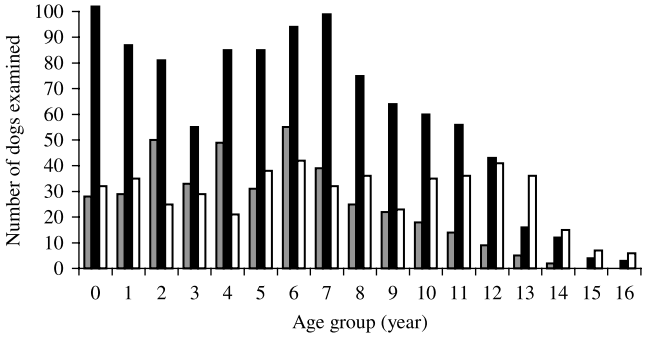

Figure 3. Age profiles of different populations of dogs sampled: first opinion clinics (white); referral hospital (black); non-hospital population (gray).

based on the number of age cohorts used to determine the curve. In types of cataract for which prevalence maximizes at less than 100%, the age at which prevalence reaches 50% of the observed maximum was determined; this was termed C_{50m}.

The populations sampled are unlikely to have an identical age structure to the general pet population. Nevertheless, the sampled animals have been selected to reduce bias, such as that related to disease entities seen in hospitalized patients, and while age profiles for the populations of dogs from the referral hospital, first opinion practices and dogs from rehoming charities and WCPN were somewhat different (Fig. 3), this did not affect the prevalence of cataract, which was the same in each group (Fig. 4). We therefore believe that the prevalence proportion of each age cohort generally reflects that to be found in the normal canine population.

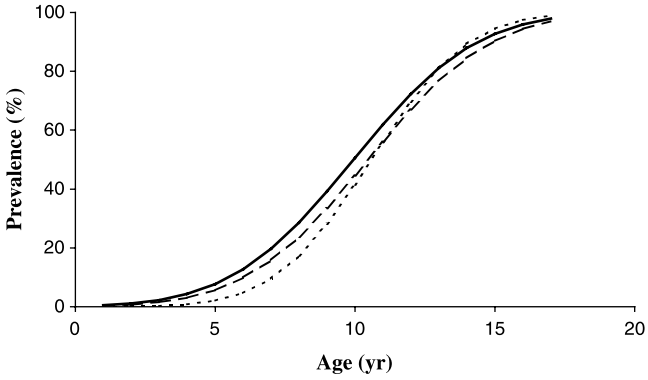

Figure 4. Prevalences of cataract in the different populations sampled (non-hospitalized population –, first opinion practices - - -, referral hospital — — —).

RESULTS

The median age of the 2000 dogs examined was 5.5 years. The age ranges in the three populations examined (referral hospital, first opinion clinic and nonhospital (rehoming center/breeding kennels/WCPN) populations) were somewhat different (Fig. 3), but differences in cataract prevalence between the various sampled populations (Fig. 4) were not statistically different, with C_{50} of 9.5 ± 3.5, 9.6 ± 2.7 and 9.0 ± 3.5 in referral hospital, first opinion clinic and nonhospital populations, respectively. The mean ± standard deviation of C_{50} for cataract in the affected population as a whole was 9.4 ± 3.3 years.

There were no statistically significant differences between animals of different gender (male entire, male castrated, female entire, female castrated) with C_{50} of 9.3 ± 2.6, 9.2 ± 3.4, 9.1 ± 3.2, 8.5 ± 4.2 years, respectively.

In this preliminary report of the ongoing study, three breeds were specifically targeted to give sufficient numbers of animals for a precise C_{50} to be calculated; Labrador Retriever (331 dogs), German Shepherd Dog (128 dogs) and West Highland White Terrier (95 dogs). These were specifically chosen because of their different longevities.[7]

In the German Shepherd Dog (with a median longevity of 10.3 years), C_{50} was 7.5 ± 3.1 years, while for the West Highland White Terrier (with a median longevity of 12.8 years) C_{50} was 11.2 ± 3.7 years. This interbreed difference was significant ($P = 0.009$) (Fig. 5). Analysis of cataract prevalence in the Labrador Retriever is complicated by the existence of inherited posterior polar subcapsular cataract. Other lens opacities in the breed show a C_{50} of 11.4 ± 2.2, but the graph of prevalence by age of the posterior polar subcapsular cataract shows a very different curve with an increased early prevalence together with a rising late prevalence (Fig. 6). For such data a single C_{50} is not considered an appropriate measure.

For three other breeds, Miniature Poodle (39 dogs), Cavalier King Charles Spaniel (42 dogs) and English Springer Spaniel (61 dogs), sufficient data were available to calculate a meaningful C_{50} value and thus C_{50} and longevity could be

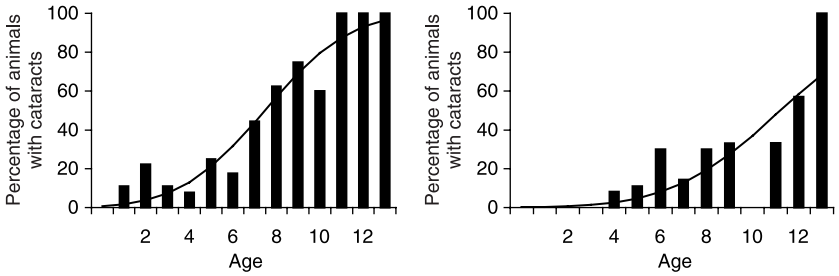

Figure 5. Prevalence curves for German Shepherd dogs (left) and West Highland White terriers (right) showing earlier onset of cataract in the German Shepherd dogs.

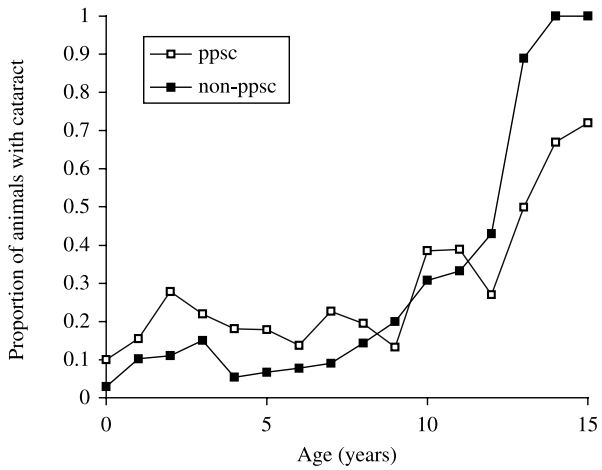

Figure 6. Proportion of Labrador Retrievers in each age group with posterior polar subcapsular (ppsc) cataract and other lens opacities (non-ppsc).

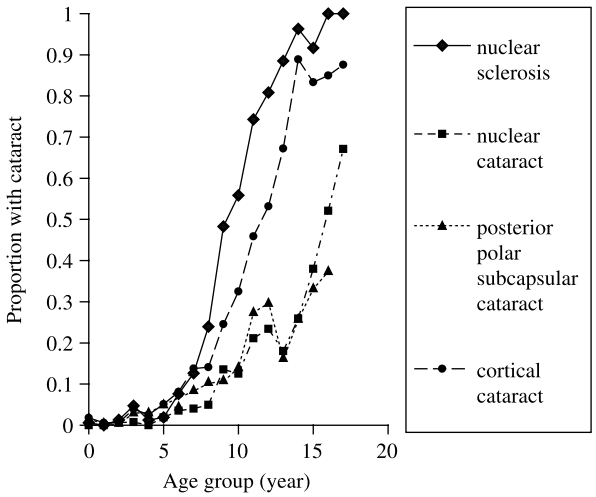

Figure 8. Proportion of animals in population with different types of cataract in each year group.

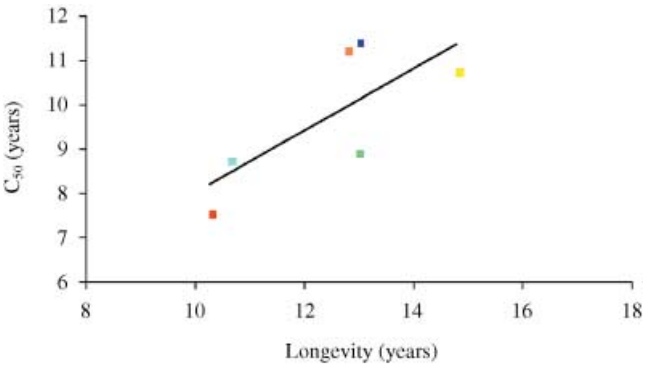

Figure 7. Graph comparing C_{50} with longevity in six breeds: German Shepherd Dog: red, Cavalier King Charles Spaniel: light blue, Labrador retriever non-ppsc: dark blue, English Springer Spaniel: green, Miniature Poodle: yellow, West Highland White Terrier: orange.

compared for these breeds (Fig. 7). For these breeds C_{50} was between 0.68 and 0.85 of longevity. An association between C_{50} and longevity was determined with a least squares correlation coefficient of 0.74 and a *P*-value of 0.082, nearing statistical significance.

The prevalence curves of different types of cataract in all dogs in the study are shown in Fig. 8. In this study nuclear sclerosis was recorded but not classified as a cataract. Nuclear sclerosis was the age-related lens change occurring earliest with a C_{50} of 9.6 ± 2.6. C_{50m} for posterior subcapsular cataract was 10.0 years with a wider standard deviation of 4.1. The age of this C_{50m} is affected by the substantial number of younger dogs with the cataract occurring presumably as an inherited condition, as noted above and shown in Fig. 6. The cataract occurring next in age is cortical cataract with a C_{50m} of 10.8 ± 3.0 years, while nuclear cataract showed a C_{50m} of 13.6 ± 3.0 years.

Mean severity score for all cataracts at different age groups is shown in Fig. 9. The severity of cataracts observed in older dogs increases as does the number of dogs affected. Cataract score was correlated with area of lens opacified, as demonstrated by photodocumentation of 45 dogs (Fig. 10), although the relationship was sigmoid rather than linear, reflecting the arbitrary nature of this preliminary scoring system.

DISCUSSION

The data accrued in this survey demonstrate that prevalence of cataract in the general canine population increases with age and that by the age of 13.5 years none of the dogs in this study population was free of some degree of lens opacity. These opacities are rarely mature cataract and we are not suggesting that all will progress to this stage. The lack of full pharmacologic mydriasis might well be seen as a defect in

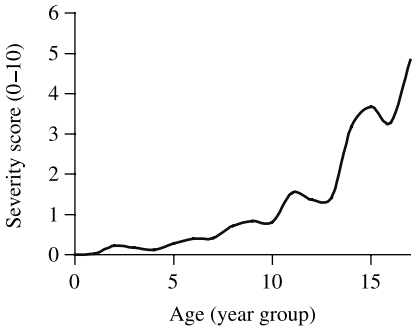

Figure 9. Mean severity score (arbitrary unit from 0 (clear lens) to 10 (mature cataract)) for cataracts in all dogs examined.

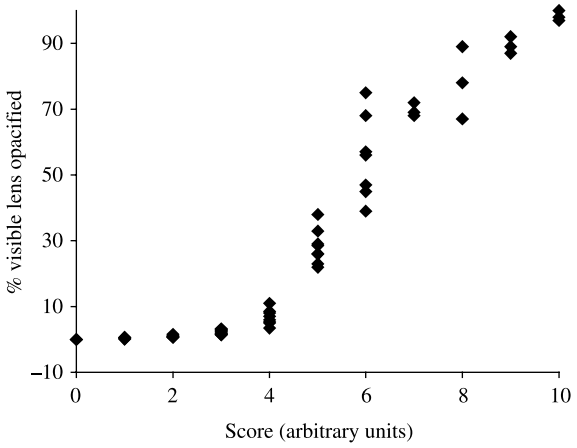

Figure 10. Correlation of score given to lens with estimated area of lens opacified for 55 lenses.

this study, as peripheral cataract will thus have been missed. This failure will, however, only have resulted in some degree of under-estimation of the prevalence of cataract in each age group. Even given this possible inaccuracy, the finding that cataract is at least this prevalent in older dogs is a novel one. The age at which cataract prevalence was 50% (C_{50}) was 9.4 years, which is younger than might have been expected, although the standard deviation of 3.3 years shows that there is considerable variation in this age at onset of cataract. What accounts for this variation?

Different types of cataract have different C_{50} values and this may reflect different etiopathologic pathways in the development of nuclear, cortical and subcapsular cataract, as first conjectured by Chylack in the mid 1980s.[8] Photo-oxidation of crystalline proteins is widely held to be a key factor in age-related cataractogenesis, and the fact that nuclear proteins are present in the eye prior to birth leads one to expect that they may be most affected by photo-oxidative change. A minority have argued against this hypothesis[9] and the fact that cortical, and here predominantly posterior cortical, cataract occurs before nuclear cataract suggests that there may be weight in their arguments.

It is already known that the posterior subcapsular cataract in Labrador and Golden Retriever breeds is inherited[10] and, while this accounts for the earlier onset of the condition at this position in the lens in these breeds, genetic factors are very likely to play a significant part in cataract in other breeds too. A significant point here, however, is that while many ophthalmologists would argue that many, if not most cataracts in dogs have an inherited basis, this is by no means clearly the case in age-related cataracts in many breeds and cross-breeds of dogs participating in this study. Most inherited cataracts occur at a specific age in a particular breed with a defined form.[3] The majority of cataracts detected in this study were of a more heterogeneous morphology and, apart from the posterior polar subcapsular cataracts in the Retrievers, were not specific to a particular dog breed. There does, however, appear to be a difference between different breeds of dog in the age at which age-related cataract is manifest, correlating with their different longevities as shown in Fig. 7. At one level this may be explained by differences in specific cataract-related genes. In breeds without obvious inherited late-onset cataract there does appear to be a difference in age at onset of cataract in this study. Investigation of two breeds, the West Highland White Terrier and the German Shepherd Dog with different longevities has shown a significant difference in age at onset of cataract, which may correlate with the difference in life-span. While there are fewer dogs of other breeds examined in this study, numbers are sufficient for calculation of C_{50} in four other breeds. In those breeds for which sufficient data are available, these results demonstrate that the finding for the West Highland White Terrier and the German Shepherd Dog holds with a positive correlation between C_{50} and longevity. Data have yielded a least squares correlation coefficient of 0.74 with a *P*-value nearing significance at 0.082. Further work is currently in progress to provide more data for other breeds and confirm this finding.

We have shown in concurrent work in other species, as yet unpublished, that while the dog has an average C_{50} of 9.4 ± 3.3 years, the cat has a significantly later C_{50} of 12.7 ± 3.5 ($P = 0.0005$) and the horse a still later C_{50} of 28.3 ± 9.1 ($P < 0.0001$). These differences are not particularly surprising, given that the longevities of cats and horses are greater than that of dogs.[11–13] Age-related cataract would seem to occur at a similar proportion of life-span for these different species, although considerable further research is required to substantiate such a hypothesis. For the different dog breeds investigated here C_{50} is between 0.68 and 0.85 of total longevity. Even if this relationship between age at cataract development and longevity were shown more generally to be the case, the factors that lead to differences in time to lens opacification are not at all clear.

A recent review of cataract epidemiology has usefully suggested six 'Ds' of age-related cataract pathogenesis in humans: daylight, diet, diabetes, dehydration, drugs and don't know![14] This last category of etiologic factor suggests that much is still to be determined regarding cataract

pathogenesis. But much is indeed known: the first factor, daylight, while initially disregarded by some,[15] is now recognized as being a key factor in age-related cataractogenesis, probably through UV-exposure and crystallin thiol group photooxidation.[16] Differences in light exposure between cats and dogs may explain the later age at incidence of cataract in the cat. It might be surmised that the cat, being more active nocturnally, has a lower overall light exposure than the dog, although this hypothesis requires considerable work to substantiate it. The present authors could find no published evidence of light exposure in different companion animal species. There are well documented substantial differences in diet between cats and dogs,[17] although the difference in dietary antioxidants between the two has not been fully researched. Such environmental or dietary differences are unlikely to explain variation in age at onset of cataract between different dog breeds. Were this difference to be confirmed by further examination of dogs in other breeds with different longevities, investigation of biochemical differences in the lens of different breeds within the same species may be valuable in understanding mechanisms, not only in cataractogenesis, but also in aging of the individual as a whole. The lack of correlation between C_{50} and longevity of dogs of different sexual status (male/female, neutered/entire) would suggest that this relationship between lens aging and whole body aging may not be applicable at an individual animal level. However, the preliminary finding of differences between these two breeds might lead to the hypothesis that an underlying genetically determined longevity is shared between the lens and the entire animal.

With regard to diabetes and dehydration, all animals with a history of such potentially cataractogenic medical conditions as these were excluded from the study. The potential cataractogenicity of drugs commonly used in veterinary medicine is unknown, and thus it was not possible to exclude animals where cataract might have been caused by therapeutic agents. This is unlikely to be a substantial cause of cataract and would not, again, explain the interbreed differences found in this study. The one remaining factor accounting for the differences in cataract incidence is the variation in mean life-span between the two different breeds investigated. Such a correlation hardly explains the difference though, merely changing the question from what causes variation in what we might call 'lens aging' to what causes aging in the whole organism.

Differences in intralenticular redox state may be important in the lens changes noted here,[18] as may variation in the chaperone activity of alpha crystallin in the lens.[19] But before further investigation of the mechanisms foundational to the pathogenesis of age-related cataract can begin, a considerable amount of further epidemiologic research is required. Is the correlation between age at onset of cataract and longevity supported by studies in other breeds and other species? Do precataractous changes in nuclear and cortical transparency and lens protein light scattering mirror the cataractogenic changes in these animals? Are the changes noted in this cross-sectional study supported by a longitudinal study of lens changes in older dogs?

The data here presented also show an increase in severity of cataract, although the system documenting severity needs considerable refinement before being able to document with precision changes in a longitudinal study. In the current study the single examiner's grading of the lenses in the 20 animals repeatedly examined did not change through time. Photographic documentation revealed that the scoring system did demonstrate the degree of lens opacity but was neither linear nor proportional in its grading of area opacified, and demonstrated a considerable range in area opacified for each of the higher scores. Systems such as the Oxford Cataract Classification System or the American LOCS III[20] rely on comparison of slit-lamp images with a photographic series of standards in order to avoid such inaccuracies. The Marcher 2000 system allows permanent computerized image to be stored for comparison and quantification of opacity in each part of the lens. Such refinements were not possible in this preliminary study but will be required for future studies building on this research, as will pharmacologic pupil dilation to maximize the proportion of lens observed. This was avoided in this preliminary study to ensure that animal welfare was not in any way compromised.

In conclusion, this study of cataract prevalence in a heterogenous canine population demonstrates novel findings which form the basis of further investigations, both epidemiologic and biochemical, into canine cataractogenesis. For the first time, anecdotal evidence of increasing cataract prevalence in older dogs is substantiated with documentary evidence from a sizeable normal dog population, with every dog over 13.5 years of age being affected by some degree of lens opacification. Age at onset of age-related cataract appears to be correlated with longevity of varying breeds of dog. Differences in cataract prevalence at varying ages between breeds offers a significant opportunity for further research into the mechanisms of age-related cataractogenesis in the dog, and potentially into canine aging in more general terms.

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