ELSEVIER

Applied Animal Behaviour Science 74 (2001) 29–42

APPLIED ANIMAL BEHAVIOUR SCIENCE

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Risk factors for dog bites to owners in a general veterinary caseload

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Accepted 11 May 2001

Abstract

In order to determine risk factors for biting behaviour by dogs in a household setting, a detailed telephone survey of dog owners was undertaken using individuals selected from a cross-sectional population of veterinary clientele in the Canadian provinces of New Brunswick, Nova Scotia, and Prince Edward Island. Interviews were successfully completed with 515 of 640 individuals selected from a study population of 3226 dogs by a formal random process. For the purpose of risk factor analysis, 227 biting and 126 non-biting dogs were selected according to strict criteria to evaluate the association of potential risk factors with biting behaviour. Biting behaviour was carefully defined in the telephone interview to avoid including activity associated with playful mouthing by the dog. All dogs were at least 6 months of age. Both the mean weight and age of biting dogs were significantly lower ($P < 0.05$) than that of non-biting dogs. Significant risk factors for an outcome of biting were: the dog being female (particularly if small), the presence of one or more teenage children in the home, a history of a pruritic or malodorous skin disorder which had received veterinary treatment, aggression over food in the first 2 months of ownership, the dog having slept on someone's bed in the first 2 months of ownership, and the dog having been given a significantly higher ranking for excitability based on its behaviour in the first 2 months of ownership. Small dogs were also determined to be at a higher risk of having bitten than large dogs when exposed to certain lifestyle and health factors, suggesting a relationship between body size and reactivity, or possibly

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PII: S0168-1591(01)00154-X

greater owner tolerance of aggression in smaller dogs. Biting dogs were more likely to have exhibited fear of children, men, and strangers. The risk factors identified provide a useful focus for the veterinarian in general practice when counselling owners in the prevention of canine aggression.
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Keywords: Dog; Aggression; Dog bites; Risk factors; Human–animal relationships

1. Introduction

Most people who obtain a dog do so out of a belief that their relationship with the animal will be a rewarding experience. Many dogs fulfil the role of companion, confidant, playmate, and protector. They can exhibit extraordinary patience with children or other pets. The relationship, however, is not always so perfect. Statistics indicate that many people are bitten every year, and that most are actually victims of their own dog, or at least of a dog they know (Kizer, 1979; Wright, 1990). Presumably, if only some dogs bite human members of their household, then there may be some detectable characteristics that increase the risk for aggression.

Identifying risk factors requires that biting dogs be compared to non-biting dogs. Characterisation of biting dogs has received considerable attention by veterinary behaviourists, but their examination of dogs which do *not* bite has been less intense. This is a natural outcome of the referral process, in which behavioural specialists, who generally work in teaching hospitals or other speciality referral centres, are presented with only those dogs that have ongoing problems. Defining a valid control population of non-biting dogs that would otherwise match the referral population is difficult. Some authors have elected to compare their caseload to that of the other medical or surgical specialities within the same facility, but under such circumstances the investigator is often limited to demographic information with very little behavioural background (Voith, 1981; Line and Voith, 1986; Wright and Nesselrote, 1987; Lund et al., 1996). As a result, comparisons have been made only on the basis of sex, reproductive status, or breed. In addition, the effect of referral bias may mean that the population of dogs receiving any medical attention at a veterinary teaching hospital is very different from those dogs and owners that utilise primary veterinary services (Fletcher et al., 1988, p. 59).

Obtaining a reference population for owned dogs is not a straightforward matter. There is no complete list of owned dogs, as not all dogs are licensed, and not all dogs are purebred and registered. Even specifically identifying a control group using formal random selection processes can be difficult. For example, Gershman et al. (1994) conducted a case-control study of dogs based on the reported bite incidents in Denver in 1991. Using a geographically matched random digit dialling procedure, the authors were only able to include 50% of eligible cases, largely because of the inability to contact the owner and complete the interview. This comprised only 18% of the cases of reported dog bites for that year.

The objective of this survey was to identify risk factors for canine household aggression by using a study design that had the capability to produce clinically relevant results. This necessitated obtaining detailed information about a large number of both biting and

non-biting dogs so that the two groups could be compared. It was decided that the population of dog owners who are veterinary clientele were the most accessible for research purposes, that they would be likely to have positive attitudes towards veterinarians and behaviour research and could be expected to provide information that was representative of the general population of dogs taken to veterinarians.

Using a population derived from a multi-clinic survey in maritime Canada (Guy et al., 2001), a phone survey was undertaken to identify any significant differences between biting and non-biting dogs and their respective households. As most dog bites to humans are considered to be preventable injuries, the identification of significant risk factors could be expected to be useful in reducing the number of victims of canine household aggression.

2. Materials and methods

2.1. Subjects

In 1996, 20 general veterinary practices in the Canadian provinces of New Brunswick, Nova Scotia, and Prince Edward Island were recruited to administer a simple one page questionnaire to their dog-owning clients (Guy et al., 2001). Dogs were not selected for inclusion on the basis of their behaviour, but were a cross-section of the canine caseload. Three questions on the form pertained to a history of aggression, and were worded to detect even those incidents that may have occurred by accident, over the relinquishment of objects, or in play. A total of 3226 questionnaires were completed, giving a response rate of 81.4%. These individuals formed the study population for the telephone survey described in this article.

In response to the question: ''Has your dog ever bitten any member of your household, even if you think it may have happened by accident while playing?'' 15.6% of respondents replied positively. These individuals were designated members of a tentative case population solely for the purpose of selection for the telephone survey. All other respondents were designated members of a control (presumptively non-biting) population, even if they had demonstrated less severe forms of aggression such as growling. A formal random sampling procedure was used to draw a group of 500 individuals from the control population using the STATA statistical software package (Stata Corporation, College Station, TX, USA). Using the randomly selected control group ID numbers, cases were selected by matching first for clinic and then choosing the next largest ID number among the biting dogs. Although the matching of cases to controls by clinic was initially done on a 1 to 1 basis, as interviewing progressed it became apparent that many of the dogs who were classified as biters by the simple one page questionnaire had only engaged in harmless mouthing. As a result, the matching process was altered to increase the detection of dogs who had actually bitten. This was accomplished by matching case to control subjects on a 4 to 1 basis. Overall, approximately 3 case animals were matched to each control. The matching procedure was continued until there were no more case animals remaining unselected. A total of 640 owners were selected for inclusion in the telephone survey.

2.2. Telephone questionnaire design

The telephone questionnaire was 17 pages in length, including a standard cover sheet and introductory page.[1] All questions except one were in closed-end format, requiring either a yes/no/do not know response, a numerically ranked response, or selection from a list of possible responses by either the respondent or the interviewer. Text was worded in a conversational style to include the name of the dog, and separate questionnaires were produced for male and female dogs. Telephone interviewers knew the clinic of origin for each dog, but were blinded to its case or control assignment.

The questionnaire contained 140 questions which were divided into the following six sections: (1) information about the home, (2) demographic information about the dog, (3) behaviour in the first 2 months of ownership, (4) general behaviour of the dog, (5) behaviour of the dog in the last 2 months of ownership, and (6) specific behaviour of the dog in respect to biting. Only those owners who reported during the course of the telephone survey that their dog had ever bitten a member of their household were required to complete the last section on biting behaviour. A bite was carefully defined in the instructions to the interviewers as ''the upper or lower teeth making contact with the victim's skin with sufficient pressure to cause a visible injury such as an indentation, welt, scrape, bruise, puncture, or tear in the skin. A dog mouthing a person's skin without applying sudden pressure is not considered a bite''. All respondents were given the opportunity to ask questions or make comments at the end of the survey.

2.3. Telephone survey implementation

The survey was conducted by four female interviewers. Training was provided related to the objectives of the survey, and in telephone survey techniques as described by Dillman (1978, pp. 257–269). Each interviewer pre-tested the questionnaire with three respondents without difficulty. No changes to the questionnaire were necessary after pre-testing. The survey was conducted mainly during the evening and weekend hours of November 1996 to January 1997. There were no limits on the number of attempts that could be made to contact a respondent. Respondents were given the opportunity to select a more convenient time to complete the questionnaire if they were reluctant to co-operate when first contacted. The questions were to be answered by an adult who lived in the home and took some responsibility for the care of the dog, but who did not have to be the same individual who completed the original clinic questionnaire. Every reasonable effort was made to contact owners who had moved or who had incorrect telephone numbers.

2.4. Data management

All questionnaires were coded by one individual, and data was entered by three individuals. Any response of ''do not know'' was recorded as missing data. Interviewers were instructed to record the details of a response if they were unsure of how to assign it to a category. Such entries were subsequently categorised by the first author. Demographic

[1] A copy of the original telephone questionnaire is available from the first author on request.

information from each dog was checked against the results from the original clinic survey to detect any errors or mis-classifications. The originating clinic or respondent was contacted if the correct response could not be determined by comparing the two questionnaires. Unusual values were double-checked against the original telephone questionnaire form, but were not altered if they were deemed biologically plausible and were not the result of a data entry error. Any values which did not seem plausible and which could not be substantiated were re-coded as missing.

A positive response to the following question: ''Has your dog ever bitten any member of your household or any person who is a frequent visitor in your home and is well known to the dog, even once, even if you think it may have happened by accident while he was playing?'' resulted in the dog being classified as a case for the purpose of risk factor analysis. Dogs belonging to owners who responded negatively to both this question and to the question on biting from the original clinic survey were classified as controls. Some dogs, therefore, shifted position from their original case or control designation based on their response to the more definitive question in the telephone questionnaire.

Univariate statistics were performed on the responses to each question to determine the significance of their association with the outcome of biting as defined above. Means for continuous variables were compared between case and control dogs using Student's *t*-test. Categorical variables were analysed using contingency table Chi-square analysis. Independent variables found to be significantly different between biting and non-biting dogs at a liberal cut-off point of $P \leq 0.10$ were grouped into the following four categories: (1) demographic and health, (2) early behaviour in first 2 months of ownership, (3) training and behaviour, and (4) recent behaviour. Variables in each of the first three groups were selected for a risk factor analysis as predictors of biting behaviour using multiple logistic regression and stepwise, forward, and backward selection procedures. For our purposes, a risk factor was any variable which could be associated with an increased risk of a dog developing household aggression (Fletcher et al., 1988, p. 91). This does not mean that the presence of a risk factor predicts aggression absolutely in an individual dog, but rather that it is a measure of an increased potential for the problem to occur in a dog. Variables identified as possibly useful predictors of eventual aggression at the $P < 0.05$ level were included in the final model building procedure. Four variables (sex, age, neuter status, and weight) were locked in during model building due to their potential to act as confounders. The model generated by this process was tested for the presence of significant ($P < 0.05$) interaction terms. A significant interaction between sex and body weight was detected and included in the model. The general fit of the model to the data was assessed with the Hosmer–Lemeshow goodness-of-fit Chi-square statistic with the data divided into 10 groups. The Pearson residuals, the standardised Pearson residuals, and the delta betas ($\Delta\beta$) were computed for all 267 covariate patterns to rule out the possibility that any specific pattern was having an undue influence on the model (Hosmer and Lemeshow, 1989, pp. 135–175).

The fourth category of independent variables, ''recent behaviour'', contained a number of measurements which were very highly associated with the outcome of biting using univariate statistical techniques (Chi-square and Student's *t*-test) and which also produced a number of significant interaction terms in logistic regression. These variables were not included in the aforementioned model, as the temporal relationship between exposure to

these risk factors and the outcome of aggression was unclear, and the number of overlapping interactions occurring made interpretation impossible.

As body weight showed the potential to be a confounding factor for biting behaviour, a number of odds ratios were calculated after stratification of the population into large ($\geq$20 kg) and small (<20 kg) dogs. A confounding factor is defined as being related to both the risk factor of interest (i.e. being allowed on the furniture) and the outcome of interest (i.e. biting) (Dohoo and Waltner-Toews, 1985). A stratified analysis, where the risk factor and outcome relationships were calculated separately for large and small dogs, was used to determine whether body weight was a confounding factor and whether some relationships with biting (i.e. being allowed on the furniture) were spurious. In some cases, an interaction was detected, indicating that the effect of one variable (i.e. weight) was altering the effect of another (i.e. being allowed on the furniture). These additional interaction terms were not significant, however, when included in the multiple logistic regression model.

3. Results

3.1. Interview completion rates

Phone interviews were successfully completed with 515 (80.5%) of the 640 selected subjects. Unsuccessful interviews were due to the respondent no longer having the dog (58, 9.1%), inability to make contact with the respondent due to a wrong, disconnected, or unlisted number, or no one being home (46, 7.1%), and refusals to participate (21, 3.3%). Table 1 lists the reasons given by respondents for no longer having their dog, the majority of which were death due to advanced age or illness. A report of biting behaviour on the clinic survey was not associated with an increased risk of the respondent no longer owning the dog by the time of the phone survey. There was no significant difference among the

Table 1
Reasons given by phone survey respondents for no longer owning their dog ($n = 58$)[a]

Reasons given by respondents for no longer owning dog at the time of the phone survey	*n*	Response from clinic survey	
		Biting	Non-biting
Died or euthanised due to advanced age or illness	33	26	7
Given away due to moving or allergies	6	3	3
Euthanised due to a behaviour problem	5	4	1
Died or euthanised, no reason provided	5	2	3
Given away, no reason provided	4	3	1
Lost	2	1	1
Other	2	1	1
Given away due to a behaviour problem	1	1	0
Relinquished to humane society	0	N/A	N/A
Total (%)	58	41 (70.7)	17 (29.3)
Comparative values for dogs who were still in their homes at the time of the phone interview (%)	515	358 (69.5)	157 (30.5)

[a] Respondents ceased to own their dogs in the 6 month time period between the clinic and phone surveys.

interviewers in their ability to successfully complete an interview or record a case of biting behaviour. The mean time to complete an interview was 22.9 min, although interviews with owners of biting dogs took significantly longer ($P < 0.01$) due to the additional questions regarding biting incidents. Of the successful phone contacts for which gender was recorded, 72% of the respondents were female.

3.2. Case and control designation

For the purposes of risk factor analysis, 227 dogs were classified as biting (cases) and 126 were classified as non-biting (controls) for a total of 353 dogs. A positive response to the biting question on the phone survey resulted in a dog being designated a case, a negative response on *both* the phone and the clinic survey were required for a dog to be designated a control (Table 2). The estimated predictive value of a positive test on the clinic survey completed 6 months earlier to detect injurious biting as described in the phone survey was 0.57. The estimated predictive value of a negative response on the clinic survey to detect a non-biting dog as described in the phone survey was 0.81.

3.3. Demographic characteristics of the dogs

The demographic characteristics of case and control dogs are described in Table 3. The mean weights and ages of biting dogs were significantly lower ($P < 0.05$) than those of non-biting dogs. The majority of dogs were neutered (87.5%), although significantly more males than females were still sexually intact ($P < 0.01$). There were no significant differences in either gender or neuter status between the case and control groups.

Among the 353 dogs which met either the case or control criteria, 202 dogs were purebred, of which 196 were reported to be registered with either the Canadian or American Kennel Club. The remaining 151 dogs were classified as of mixed or unspecified type. Purebred status was not associated with whether or not a dog had bitten ($P > 0.05$). The most frequently reported breeds were the Labrador Retriever (22 dogs), the Golden Retriever (18), the Springer Spaniel (11), the Lhasa Apso (10), the Shih Tzu (9), and the Shetland Sheepdog (9). In all there were 62 different breeds reported, the majority of which were represented by only a few individuals.

Table 2
Responses to the question on biting in the original clinic survey as compared to the response on the phone survey 6 months later[a]

		Phone survey		Total
		Biting	Non-biting	
Clinic survey	Biting	198	151	349
	Non-biting	29	126	155
	Total	227	277	504

[a] For the purpose of risk factor analysis, 227 dogs were designated as ''cases'' and 126 dogs were designated as ''controls''.

Table 3
Demographic characteristics of the case (biting) and control (non-biting) dogs used in the risk factor analysis

Variable	All dogs *n*	Biting dogs *n* (% or range)	Non-biting dogs *n* (% or range)
Total dogs	353	227 (64.3)	126 (35.7)
All females	176	110 (62.5)	66 (37.5)
Intact females	12	8 (66.7)	4 (33.3)
Neutered females	164	102 (62.2)	62 (37.8)
All males	177	117 (66.1)	60 (33.9)
Intact males	32	20 (62.5)	12 (37.5)
Neutered males	145	97 (66.9)	48 (33.1)
Mean age (years)	5.0	4.7 (0.5–15)	5.6 (0.6–17)
Mean weight (kg)	20.5	19.5 (1.8–58.5)	22.4 (3.6–58.5)

3.4. Risk factors for biting

This survey collected information on a large number of variables (approximately 140). Many of these factors were significantly associated with biting behaviour at both the univariate and multivariate levels. In the interest of space, however, only the most significant associations with aggression will be reported here.

3.4.1. The final model

Variables included in the final multiple logistic regression model are shown in Table 4. Female dogs were almost 3 times more likely to have bitten than male dogs. This was most apparent when the (sex × weight) interaction term was included, indicating that reports of biting by female dogs increased as body weight decreased, an association which was not detected in male dogs. With every additional teenager in the household, the odds of biting

Table 4
Multiple logistic regression model of risk factors for injurious biting of human members of the same household[a]

Variable	Coefficient	Probability	Odds ratio	95% CI[b]
Intercept	−0.819			
Sex (female = 1)	1.092	0.055	2.98	0.98–9.07
Age (years)	−0.042	0.261	0.96	0.89–1.03
Neuter status (neutered = 1)	−0.184	0.660	0.83	0.37–1.89
Weight (kg)	0.013	0.380	1.01	0.98–1.04
(Sex × weight) interaction term	−0.052	0.021	0.95	0.91–0.99
Number of teenagers in home	0.735	0.002	2.09	1.30–3.35
History of treatment of a skin disorder by a veterinarian	0.625	0.039	1.87	1.03–3.38
Slept on someone's bed in first 2 months of ownership	0.659	0.032	1.93	1.06–3.53
Aggression over food in first 2 months of ownership	1.125	0.040	3.08	1.05–9.01
Score for excitability in first 2 months of ownership on a scale of 1–10	0.128	0.018	1.14	1.02–1.26

[a] Hosmer–Lemeshow goodness-of-fit, $\chi^2 = 9.43$, d.f. = 8, $P = 0.31$.
[b] 95% Confidence interval.

increased. Dogs which had a history of veterinary treatment for a skin disorder were almost twice as likely to have bitten, a similar association to that determined for dogs which had slept on someone's bed in the first 2 months. Biting dogs were 3 times as likely to have a history of aggression over food in the first 2 months of ownership and were given higher excitability rankings by the owners for the same time period.

The variable for ''biting strangers'', although highly associated on a univariate basis with biting a household member, also acted as an indicator variable for the outcome of interest. As only 8.5% of owners reported this behaviour, its inclusion in the model severely restricted the number of usable observations, and excluded several other potentially useful predictors. ''Biting strangers'' was therefore deliberately left out of the final model.

3.4.2. Associations between recent behaviour and biting

A number of additional variables were strongly associated with an outcome of biting but could not logically be included in a model as predictors of biting. They describe the current behaviour or lifestyle of the dog, and might be associated with biting because they are actually the outcome of aggressive behaviour. For example, the amount of time the dog currently spends outdoors, or whether it is currently afraid of men, could easily be a result of its aggressive behaviour, not a cause. Being confined to a leash, yard, or pen when outdoors was associated with biting ($P < 0.01$), as was the dog spending less than 3 h outdoors on an average weekday ($P = 0.004$). Sleeping on someone's bed, being allowed on the furniture, and playing tug-of-war in the last 2 months were all positively associated with biting ($P < 0.05$). Biting dogs were more frequently reported to be afraid of children, men, strangers, delivery people, or dog groomers ($P < 0.10$), but were not significantly more fearful of other dogs, thunder, vacuum cleaners, or cars. Based on their behaviour in the most recent 2 months, dogs that had bitten were given higher scores for excitability, lack of trustworthiness with children, and general aggressiveness ($P < 0.005$).

Table 5
Odds ratios (OR) and confidence intervals (95% CI) for the risk of biting in small and large dogs exposed to various lifestyle and health factors

Variable	All dogs		Small dogs (<20 kg, $n = 176$)		Large dogs (≥20 kg, $n = 166$)	
	OR	95% CI	OR	95% CI	OR	95% CI
Slept on someone's bed in first 2 months of ownership	1.90	1.12–3.22	2.58	1.17–5.69	1.46	0.68–3.11
Aggression over food in first 2 months of ownership	3.21	1.23–8.32	4.69	1.14[a]	1.46	0.39–5.41
History of treatment of a skin disorder by a veterinarian	1.60	1.01–2.55	2.09	1.04–4.21	1.30	0.68–2.49
Allowed on furniture in past 2 months	2.24	1.41–3.57	4.03	1.78–9.09	1.50	0.81–2.81
Fear of children	1.97	0.92–4.23	2.89	0.98–8.43	1.03	0.34–3.15
Played tug-of-war in past 2 months	1.70	1.08–2.66	1.27	0.65–2.47	2.23	1.18–4.22
Slept on someone's bed in past 2 months	1.83	1.18–2.85	1.79	0.94–3.45	1.70	0.88–3.26

[a] Unable to estimate upper limit of 95% CI due to small number of dogs (2) who had shown aggression over food in the first 2 months of ownership and who had *not* bitten.

3.4.3. The relationship between body weight and other variables

When the dogs were stratified into 2 groups according to weight, a number of interactions were detected between body size and the risk of another variable being associated with biting (Table 5). Small dogs (<20 kg) were at a greater risk of biting than large dogs (≥20 kg) if they had either shown aggression over food or had been allowed to sleep on the bed in the first 2 months of ownership. They were also more likely than large dogs to have bitten if they had been treated for a skin disorder, were currently allowed on furniture, or were afraid of children. For dogs that played tug-of-war, being larger increased the risk of biting. Size was a confounding factor for dogs that had been allowed to sleep on someone's bed in the past 2 months. If the analysis was controlled for size, the risk associated with sleeping on someone's bed in the past 2 months became non-significant.

4. Discussion

4.1. Use of general veterinary clientele in behavioural research

This study has utilised a unique population for the investigation of risk factors into canine household aggression. It has neither relied on the population of dogs involved in reported bite incidents or the population seen by behavioural specialists in referral centres, but it is based on a cross-sectional sample of owned dogs seen by veterinarians in general practice. These are not necessarily dogs which are on the verge of relinquishment or euthanasia, but are for the most part on-going members of a household, some of whom happen to have bitten a family member. This data provides a new perspective on the problem, as victims may tend not to report bites by their own dogs (Wright, 1990), and problems in those dogs that do reach the level of tertiary behavioural care are likely to be more severe (Fletcher et al., 1988, p. 59).

Of the 58 respondents who no longer owned their dog, it is interesting that none were reported to have been relinquished to a humane society. Patronek et al. (1996) have identified lack of veterinary care as a strong risk factor for relinquishment of dogs to the humane society. It is impossible to know if respondents who no longer had their dog were being truthful when they reported that it had died, been given away, or was lost. Some of these dogs may have in fact been taken to an animal shelter. On the other hand, interview completion rates were very high, with only 3.3% those contacted refusing to participate, suggesting that dog owners were interested in sharing information about their pets.

4.2. Study design and the use of multivariate analytical techniques

In this study, logistic regression was utilised to determine significant risk factors for the outcome of the dog biting a household member. With such exceptions as Gershman et al. (1994), who examined risk factors for non-household aggression, and Reisner et al. (1994), who established risk factors for behaviour-related euthanasia in dogs seen for dominance aggression, the use of multivariate analysis is unusual in canine behavioural research. Patronek et al. (1996) used multiple logistic regression to determine risk factors for the

relinquishment of dogs to an animal shelter, but was not specifically looking at behaviour as an outcome. The advantage of a multivariate technique is that it allows for the possibility of interaction, both seen and unseen, between a number of factors, rather than proceeding on the assumption that factors are acting independently of each other. Examining the combined effects of environmental and inherited variables on a dog's behaviour may identify factors which would not otherwise have been recognised as significant.

If a factor has a subtle effect, it may only be detected if there is a relatively large number of subjects and if the study design is appropriate. Many published veterinary case-control studies and case reviews have tended to involve quite small numbers of dogs and have been based on referral populations (Voith, 1981; Beaver, 1983; Borchelt, 1983; Wright and Nesselrote, 1987; Chapman and Voith, 1990; Blackshaw, 1991). The cohort study, a prospective examination of the effect of a treatment on a particular group, is relatively uncommon (Neilson et al., 1997; Salmeri et al., 1991). Surveys using larger numbers of dogs have been reported, but there are frequently underlying problems with validity in that they have been voluntary, unintentionally haphazard, or conducted solely within referral centres (Campbell, 1974, 1986; Adams and Clark, 1989; Voith et al., 1992). One example of good survey design is the work by Podberscek and Serpell (1996) into the relationship between coat colour and aggressive behaviour by the English Cocker Spaniel. In a similar manner to this study, it relies on a large cross-sectional survey, and not just those dogs with a history of aggression.

4.3. Case definition for purposes of risk analysis

For our purposes, biting was used as a surrogate measure of the severity of aggression. This excluded all dogs which may have snapped and missed the victim, although there is no doubt that some of those incidents involved the intent to actually injure. It was necessary, however, to be able to clearly define our outcome of interest in the course of the telephone interview. On the other hand, given our definition of a case, we believe it is unlikely that an owner would accidentally report their dog as having bitten when it had not. Respondents appeared to be quite willing to report misbehaviour by their dog, but it is impossible to know how many responses to the question on biting were false negatives because the owners had forgotten, not been aware of, or had not wished to reveal a bite incident. The selection of a control animal was equally conservative. The process reduced the number of subjects available for the analysis of risk factors, but it did enhance our confidence in stating that the control dogs were free of a history of biting.

4.4. Demographic risk factors

Reisner et al. (1994) have described body weight greater than 18.2 kg as being a risk factor for behaviour-related euthanasia in dominant-aggressive dogs. Owners may perceive bites by larger dogs to be a more serious problem, and our results may reflect not just relatively more household aggression by small dogs, but perhaps increased relinquishment of large biting dogs. It is also possible that owners of large biting dogs were less likely to present them to the veterinarian. This could have the effect of making small dogs appear to be relatively more aggressive.

Small female dogs formed the riskiest group, which runs contrary to previous reports that males are the predominant sex seen for problems with aggression (Borchelt, 1983; Line and Voith, 1986; Wright and Nesselrote, 1987; Landsberg, 1991; Wright, 1991). This inconsistency with published results may either reflect an important difference between general and referral populations, or possibly that the type of aggression seen in male dogs is more serious or frightening, and therefore more likely to cause the owner to seek help.

Ovariohysterectomy has previously been associated with aggression by a number of authors, including ourselves (Guy et al., 2001; O'Farrell and Peachey, 1990; Podberscek and Serpell, 1996; Wright and Nesselrote, 1987). In this analysis, reproductive status was not detected as a risk factor for biting. Of the female dogs in our study, however, only a fraction (12.5%) were actually still intact, meaning any differences between spayed and intact dogs would have to be quite dramatic to be detected.

4.5. Using risk factors to prevent aggression

The identification of significant risk factors for a problem is often an important first step in its control. Even without direct evidence of a causal relationship, it may be possible to reduce the incidence of a problem simply by reducing exposure to the risk factor. Good preventive medicine (through both veterinarians and animal shelters) should probably include advising dog owners of the most significant risk factors for aggression as detected by this analysis.

Owners with biting dogs were more likely to have ranked them as having been excitable puppies. Inconsistent interactions between the owner and the dog may cause both excitability and aggression. Whether or not the dog was aggressive first or excitable first, or both simultaneously, is irrelevant to the usefulness of this information. Veterinarians should simply be aware that owners who find that their puppy is too excitable need to be offered effective behaviour modification strategies for resolving the problem. In addition, there may be elements in the behaviour of teenage children that stimulate excitement and aggression in dogs. As the number of teenagers in a household was also a risk factor, owners with teenage children should be made aware of this possibility, or counselled to select breeds with low reactivity.

A puppy sleeping on the bed may be an indicator of the owner's attitude, the puppy's temperament, or both. Since not allowing a puppy to sleep on the bed is a relatively simple lifestyle change (if done early) that may ultimately reduce the risk of aggression, it is worth counselling owners to find other sleeping arrangements for their dog when they first bring it home, at least until the mechanism of this association is better understood.

Early evidence of possessive behaviour, demonstrated by the puppy showing aggression over food in the first 2 months of ownership, is an important and very useful risk factor for biting. It is possible to modify this behaviour in puppies without much risk of human injury. A dog protecting its own food or toys is rationalised by many owners to be showing normal and acceptable canine behaviour, but owners should be educated that this behaviour is associated with a high risk of eventual bite injury.

The association between biting and a history of a skin disorder is very interesting. Dermatological conditions involving pruritus are very common in dogs (Scott et al., 1995, pp. ix–x), and their treatment may involve medications that have been known to affect

behaviour, such as glucocorticoids or antihistamines (Plumb, 1999, pp. 215, 306). From a psychological standpoint, the outcome of aggression may not be too difficult to understand given the potential for irritability secondary to pruritus and sleep deprivation.

5. Conclusions

This study has isolated a number of clinically useful risk factors for canine household aggression. By using a two-stage survey, it was possible to identify a representative study population from the general veterinary caseload, and from that foundation, investigate the details of each dog's life in a case versus control format. The information presented here should be applicable to the majority of North American companion animal practice situations.

Acknowledgements

We would like to thank the Sir James Dunn Animal Welfare Centre and the Department of Anatomy and Physiology of the Atlantic Veterinary College, University of Prince Edward Island, for their financial and technical support of this work. The interest and contributions of both local veterinary practitioners, their staff, and their clientele are greatly appreciated. We would also like to thank the telephone interviewers, Tanja Bihr, Maria Coombs, Tracy Doucette, and Jody Sark for their dedication to the data collection; and Suzette Acorn, Sharon Gormley, and Karen Van Lunen for their assistance with data entry.

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