Human directed aggression in domestic dogs (*Canis familiaris*): Occurrence in different contexts and risk factors

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ABSTRACT

The consequence for dogs of showing aggression towards people is often euthanasia or relinquishment. Aggression is also a sign of compromised welfare in dogs, and a public health issue for people. The aims of this study were to estimate the numbers of dogs showing aggression to people in three contexts (unfamiliar people on entering, or outside the house, and family members); identify whether these co-occur, and investigate risk factors for aggression in each context using multivariable analyses. In this cross-sectional convenience sample of UK dog owners, aggression (defined as barking, lunging, growling or biting) towards unfamiliar people was more common than towards family members. Most dogs did not show aggression in multiple contexts, suggesting that this behaviour may be a learnt response to situations rather than a general characteristic of individuals. Older owners were less likely to report family directed aggression or aggression to unfamiliar people entering the house than younger ones. Female owners were also less likely to report aggression to visitors. Increasing dog age was associated with increased risk of aggression to unfamiliar people both entering and outside the house. Female neutered dogs had a reduced risk of aggression in all three contexts. Dogs in the Utility and Hounds groups as defined by the UK Kennel Club had an increased risk of aggression to family members compared to cross-breeds, although post hoc analyses identified no specific increased individual breed risks. Gundogs has a reduced risk of aggression to unfamiliar people both entering and outside of the house. Where owners acquired their dog was a risk factor for aggression to household members. Attendance at puppy classes reduced risk of aggression to unfamiliar people both in and out of the house; attending ring-craft classes were associated with reduced risk when outside the house. The use of positive punishment or negative reinforcement based training methods was associated with increased chance of aggression to family and unfamiliar people outside the house. Importantly, for all types of aggression, the variables measured explained a relatively small amount of the variance (<10%) between aggressive and non-aggressive animals, suggesting a much greater importance of factors specific to the experience of individual dogs in the development of aggression. These data suggest that although general characteristics of dogs and owners may be a factor at population level, it would be inappropriate to make assumptions about an individual animal's risk of aggression to people based on characteristics such as breed.

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1. Introduction

Aggression directed towards people is the most common 'behaviour problem' referred to specialist clinics (Blackshaw, 1991; Bamberger and Houpt, 2006), and a common cause for relinquishment of owned dogs (Salman et al., 1998). The physical (Calkins et al., 2001), psychological (Peters et al., 2004) and financial consequences of bite injuries (Weiss et al., 1998) make human directed aggression an important public health concern. Gilchrist et al. (2008) have estimated 15.8 bites per 1000 people in USA, and a rate of 8.3 per 1000 has been cited in the Netherlands (Cornelissen and Hopster, 2010). Despite human directed aggression being a serious public health issue, there has been limited systematic research into potential risk factors. Existing studies provide useful insights but many have utilised populations with inherent biases, do not have controls for comparison, or have used multiple univariable analyses with associated risk of Type 1 errors. Previous studies have investigated four population types: hospital recorded bite victims (e.g. De Keuster et al., 2006; Morgan and Palmer, 2007); clinical populations from specialist behaviour clinics (e.g. Bamberger and Houpt, 2006; Fatjo et al., 2007) or general veterinary practices (e.g. Guy et al., 2001a,b,c); temperament screening for particular populations or breeds of dogs (e.g. Ott et al., 2008; Borg et al., 2010), and surveys of dog owners (e.g. O'Sullivan et al., 2008; Hsu and Sun, 2010). Inherent biases are associated with the first three populations, and the latter may be biased depending on recruitment. For example, large breed dogs are more likely to cause injuries to children requiring hospital treatment (Overall and Love, 2001), and incidences with owned dogs have been reported to be less likely to be associated with injuries requiring medical attention than those occurring in public places (Cornelissen and Hopster, 2010). Clinical populations are likely to involve a sub-set of owners willing to invest in treatment, may be biased towards larger breed dogs where aggression is less easy to tolerate, and towards family rather than stranger directed aggression (Bamberger and Houpt, 2006). Temperament testing studies generally utilise specific populations with putatively increased risk, such as rescue centres (Bollen and Horowitz, 2008), military dogs (Haverbeke et al., 2009) or associated with legislation (Schalke et al., 2008), and hence may also not necessarily be representative of the general population. Although owner surveys may overall seem a less biased population, biases can also occur due to different methods of recruitment (Asher et al., 2011). The aim of this study was to estimate the extent to which dogs show aggression to people in three different contexts (towards members of the household, unfamiliar people entering the house, and unfamiliar people when dogs are outside of the house, e.g. on walks); identify whether these co-occur, and investigate dog and owner related risk factors in each independently occurring context using multivariable analyses, using a population of UK dog owners recruited through veterinary practices, dog events and at popular dog walking locations.

2. Materials and methods

2.1. Questionnaires and subjects

A questionnaire was developed and piloted to test for question ambiguity with 15 dog owners. The questionnaire contained four sections: (i) information about owners: age, gender, geographical location, experience of owning and training dogs; (ii) information about dogs: gender, neuter status, age, breed, origin; (iii) information about training classes attended, age of dog when attended, and length of attendance, and (iv) the current and previous occurrence of undesirable behaviours, including aggression towards family members, unfamiliar people entering the house and when outside, withdrawal and hiding from family members or unfamiliar people. Aggression was defined as barking, lunging, growling or biting. Since this questionnaire asked about the occurrence of multiple behaviours, such as aggression towards other dogs (Casey et al., 2013), occurrence of human directed aggression noise was examined with a yes/no question for each context in which an aggressive response may occur. For example, owners were asked "Does your dog bark, lunge, growl or bite at unfamiliar people when out of the house?" Owners were also asked to report other behavioural responses potentially indicative of fear in these contexts, e.g. "Does your dog hide or run away from family members?" For each question, owners were asked to report whether the behaviour currently occurred, whether it had occurred in the past but not currently, and if it had ever occurred whether they considered it to be a problem.

A convenience sample of dog owners was recruited between May 2007 and August 2009, from a range of locations around the UK and at types of events and places where dog owners would be likely to frequent, such as dog shows, countryside events and veterinary practices (Table 1). Questionnaires were distributed by the research team to dog owners with a reply paid envelope to maximise returns. Owners of multiple dogs were asked to complete only a single questionnaire, regarding their youngest dog.

2.2. Statistical analysis

The age of dogs in months was log_{10} transformed. Other data were categorical. Breeds were combined into UK Kennel Club categories (Table 1) for regression models, but also into commonly occurring breeds and related groups of less common breeds for further interpretation. The percentage of owners reporting each type of aggression currently (i.e. at the time of questionnaire completion), in the past but not currently, and ever, were calculated (Table 2). The extent of co-morbidity between the occurrence of aggression in different contexts was evaluated using a Kappa measure of agreement.

Attendance at training classes was reduced to a 0/1 score. This was developed by including all cases attending classes for at least 4 weeks to exclude those attending classes only transiently. The exception was puppy classes, where attendance was scored where owners attended for at least 2 weeks when their dog was <12 weeks of age

Table 1
Characteristics of the population.

Characteristic	Categories	Number	Percentage
Location of questionnaire distribution	Veterinary practices	836	22
	Dog shows/dog related events	1940	50
	Agricultural/horse events	246	6
	Directly to dog walkers	539	14
	Pet or other shops	239	6
	Other/unknown	97	2
Owner gender	Female	3334	86
	Male	540	14
Owner age	<25 years	312	8
	25–40 years	844	22
	41–60 years	1868	48
	>60 years	851	22
Owner location in UK	Scotland/Wales	68	2
	NE England	95	2
	NW England	152	4
	E Midlands	369	10
	W Midlands	196	5
	E England	327	8
	SE England	121	3
	SW England	1396	36
	Unknown	659	17
Owner experience	Professional dog trainer	123	3
	Experienced owner and trainer	1414	36
	Experienced owner/new at training	1656	43
	New or inexperienced dog owner	688	18
Origin of dog	Breeder	2189	56
	Rescue centre	765	17
	Friend/relative	144	4
	Other (incl. pet shops)	384	10
	Home bred	386	10
Dog gender	Males	188	48
	Females	1993	51
Dog neuter status	Neutered	1995	51
	Entire	1738	45
Dog grouping by UK Kennel Club categories	Toys	185	5
	Terriers	438	11
	Utility	205	5
	Gundogs	1176	30
	Working	253	7
	Pastoral	725	19
	Cross breeds	679	17
Training class attended	Overall attendance at training classes	2746	71
	Puppy socialisation classes	1294	33
	Obedience classes	1616	42
	Agility training classes	729	19
	Flyball classes	97	3
	Gundog training classes	167	4
	Ring craft classes	669	17

(i.e. during the early sensitive period for learning). Training methods were reduced to two categories (Table 3): those using positive reinforcement or negative punishment only, and those where any methods involving positive punishment and negative reinforcement were used (terms as defined in Blackwell et al., 2012).

Where aggression in contexts was found to occur largely independently of others (Kappa measures were <0.7) these were retained separately for analysis. For each independently occurring context, potential risk factors were screened using univariable binary logistic regression. Dependent variables for each model were

whether or not dogs had ever shown aggression, calculated by positive scoring where owners had reported either 'occurred in the past', 'occurs currently' or both. Location of questionnaire distribution was included to check for sub-population biases. Variables where $P < 0.2$ were included in multivariable logistic regression models, built through a backward stepwise approach. Potential interaction terms were tested, and included in the model where significant. Hosmer–Lemeshow goodness-of-fit Chi-square statistics were used to test models, and residuals generated to identify any potential outliers with undue influence.

Table 2

Number and proportion of owners reporting aggression towards family members, unfamiliar people entering the house, and unfamiliar people encountered when outside, in the past and at the time of questionnaire completion.

Behaviour reported	Reported occurrence of behaviour	Number	Percentage of sample
Aggression towards family members	Occurred currently at time of questionnaire completion	59	1.5
	Occurred in past but not currently	67	1.7
	Reported to have ever occurred	126	3.2
Aggression towards unfamiliar people entering the house	Occurred currently at time of questionnaire completion	189	4.9
	Occurred in past but not currently	69	1.8
	Reported to have ever occurred	258	6.6
Aggression to unfamiliar people when outside the house	Occurred currently at time of questionnaire completion	133	3.4
	Occurred in past but not currently	64	1.6
	Reported to have ever occurred	197	5.1
Hide or run away from family members	Occurred currently at time of questionnaire completion	80	2.1
	Occurred in past but not currently	67	1.7
	Reported to have ever occurred	147	3.8
Hide or run away from unfamiliar people	Occurred currently at time of questionnaire completion	229	5.9
	Occurred in past but not currently	145	3.7
	Reported to have ever occurred	374	9.6

Where KC breed category was identified as a significant component of final models, a post hoc univariable analysis was conducted using breeds or breed types (divided as in Table 3; Blackwell et al., 2013) to further investigate these effects. Due to smaller categories, some breeds had zero reported occurrences in this post hoc analysis: in these cases dummy variables were created and tested in 2×2 contingency tables using Fisher's exact tests to test significance. For these analyses, cross breeds were used as a reference category, as a group of dogs with mixed or generic characteristics, a large N, and an approximately mid-range prevalence of each behaviour.

Table 3

Categorisation of training approaches, methods or devices into categories of positive reinforcement/negative punishment and positive punishment/negative reinforcement.

Category	Training methods included
Positive reinforcement or negative punishment only (owners reported only using one of these techniques and none of those listed in the category below)	Food treats Clicker training Verbal praise Withholding treats Shutting away Stroking/petting Ignoring Play
Positive punishment or negative reinforcement (owners reporting using one or more of these techniques)	Bark activated citronella collar Verbal punishment (shouting) Pet corrector Electric fence Physical punishment (smacking) Electric collar (remote activated) Choke chain Jerking back on lead Bark activated electronic collar Water pistol Husher Non-verbal distractor (e.g. can of stones) Prong collar Citronella collar (remote activated)

3. Results

3.1. Description of the population

14,566 questionnaires were distributed direct to dog owners, of which 3897 were returned completed and legible. Distribution of questionnaires and characteristics of the population are shown in Table 1. Dog ages ranged from 6 to 204 months (i.e. 17 years) with a mean of 48 months.

3.2. Prevalence of, and relationships between, different types of aggression

As summarised in Table 2, about three percent of owners ($N = 126$) reported occurrence of aggression to family members, approximately seven percent ($N = 258$) reported aggression towards unfamiliar people entering the house, and five percent ($N = 197$) reported that aggression to unfamiliar people had occurred when out of the house. Approximately four percent ($N = 147$) reported that dogs had hidden from or avoided family members, and about 10% ($N = 374$) from unfamiliar people. Comparisons of aggression occurring in different contexts revealed Kappa Measures of Agreement to be <0.4 in all cases. Since only values >0.7 are considered to represent good agreement (Peat, 2001), the three contexts were maintained as separate dependent variables for further analyses. Kappa measures of agreement were also <0.4 when comparing the occurrence and aggression and avoidance responses within each context. This suggests that most dogs show either aggressive behaviour or withdrawal responses within each context rather than both.

3.3. Risk factors for aggression to family members

The final model significantly distinguished between dogs which had shown aggression to family/household members and those which had not ($\chi^2 = 87.794$, df = 19, $P < 0.001$), but explained only between 2.3% (Cox & Snell R^2) and 9.8% (Nagelkerke R^2) of the variance. Variables

Table 4
Variables remaining in final multivariable logistic regression model for aggression directed towards members of the family/household.

Variable	Categories	Wald statistic	P value	Odds ratio (ExpB)	95% CI for ExpB	
					Lower	Upper
Owner age	Reference category: Under 25	16.346	0.01			
	25–40 years	1.535	0.215	0.674	0.361	1.258
	41–60 years	*4.886*	*0.027*	*0.516*	*0.287*	*0.928*
	Over 60 years	*14.917*	*<0.001*	*0.190*	*0.082*	*0.441*
Dog sex and neuter status	Reference category: Male neutered	9.269	0.001			
	Female neutered	*8.287*	*0.004*	*0.443*	*0.255*	*0.771*
	Male entire	0.140	0.708	0.907	0.544	1.513
	Female entire	0.015	0.903	0.968	0.571	1.640
Training category	*Any use of positive punishment/negative reinforcement as compared to reference category of only positive reinforcement/negative punishment*	*8.008*	*0.05*	*2.871*	*1.383*	*5.959*
Obedience classes	*Attending obedience classes for at least 4 weeks compared to reference of not attending*	*6.827*	*0.009*	*1.677*	*1.138*	*2.471*
Breed type	Reference category: cross breeds	19.425	0.007			
	Toy	0.321	0.571	1.389	0.446	4.330
	Terriers	1.153	0.283	1.512	0.711	3.215
	Utility	*13.444*	*<0.001*	*4.412*	*1.995*	*9.753*
	Hounds	*5.405*	*0.02*	*2.601*	*1.162*	*5.823*
	Gundogs	0.397	0.528	1.237	0.638	2.400
	Working	0.068	0.794	1.148	0.406	3.248
	Pastoral	2.079	0.149	1.608	0.843	3.065
Origin of dog	Reference category: Breeder	21.744	<0.001			
	Rescue centre	*14.102*	*<0.001*	*2.638*	*1.590*	*4.376*
	Bred by owner	*4.218*	*0.04*	*0.224*	*0.054*	*0.934*
	From friend/relative	0.647	0.421	0.555	0.132	2.332
	Other (incl pet shop)	*3.437*	*0.04*	*1.786*	*1.067*	*3.299*

Categories significantly different from reference at $P < 0.05$ shown in italics.
Variables included in the multivariate logistic regression model were: dog breed type; owner age category; dog gender; dog gender × neuter status; origin of dog; dog age (log_{10}); attendance at obedience classes; category of training methods used.

included in the final model were breed type, age category of owner, dog age and neuter category, origin of the dog, attendance at obedience classes, and category of training methods used (Table 4). Respondents being over 60 years of age was associated with a 5.3 times reduced risk, and respondents between 41 and 60 years had about 1.9 times reduced risk, of family directed aggression as compared to those less than 25 years of age. Female neutered dogs were 2.3 times less likely to show aggression as neutered males, whereas entire dogs of either sex had no significantly altered risk as compared to neutered males. Use of any form of positive punishment/negative reinforcement was associated with a 2.9 times increased risk of aggression. Attendance at training classes for four or more weeks was associated with a 1.7 times greater risk of family directed aggression as compared to those who had not attended. Dogs in the breed categories 'Utility' were 4.4 times, and those in the 'Hound' group 2.6 times, more likely, to show aggression than those in the 'crossbreed' category. Other breed groups had no significant difference from cross breeds. Finally, dogs acquired from rescue centres were 2.6 times more likely, and those acquired from 'other' sources (including pet shops) 1.8 times as likely, to show human directed aggression than those acquired from breeders. Dogs which were still owned by their breeder were 4.5 times less likely to show aggression to family members than those which were acquired from a breeder and moved to a new home.

3.4. Risk factors for aggression towards unfamiliar people entering the house

The final model was significantly ($\chi^2 = 81.535$, df = 16, $P < 0.001$) able to distinguish between dogs which had shown aggression to people entering the house and those which had not, but explained only between 2.2% (Cox & Snell R^2) and 5.8% (Nagelkerke R^2) of the variance. Female respondents were 1.6 times less likely than males to report aggression to people entering the house in their dogs. Respondents over 60 years of age were 1.8 times less likely to report this behaviour as those under 25 years, with other age categories not differing significantly. Risk of aggression to unfamiliar people significantly increased with increasing age of the dog. Female neutered dogs were 1.8 times less likely to show aggression in this context as male neutered dogs – entire dogs of either sex did not differ in risk significantly from male neutered dogs. Attending puppy classes on at least two occasions before 12 weeks of age was associated with 1.4 times reduced risk of aggression to unfamiliar people entering the house. The breed grouping of 'gundogs' had 2.4 times reduced risk of showing aggression in this context as compared to

Table 5
Variables remaining in final multivariable logistic regression model for aggression directed towards unfamiliar people entering the household.

Variable	Categories	Wald statistic	P value	Odds ratio (ExpB)	95% CI for ExpB	
					Lower	Upper
Owner gender	Female compared to reference category male	*6.514*	*0.011*	*0.634*	*0.447*	*0.900*
Owner age	Reference category: Under 25	12.378	0.006			
	25–40 years	0.152	0.697	1.104	0.671	1.816
	41–60 years	1.291	0.256	0.758	0.471	1.222
	Over 60 years	*4.686*	*0.030*	*0.545*	*0.314*	*0.944*
Dog age ($\log_{10}$)		12.678	<0.001	1.954	1.351	2.826
Dog sex and neuter status	Reference category: Male neutered	11.154	0.011			
	Female neutered	*10.491*	*0.001*	*0.551*	*0.384*	*0.790*
	Male entire	0.646	0.422	0.862	0.599	1.239
	Female entire	2.611	0.106	0.726	0.492	1.071
Puppy classes	Attending puppy socialisation class for at least 2 weeks before 12 weeks, compared to reference of not attending	*4.180*	*0.41*	*0.717*	*0.521*	*0.986*
Breed type	Reference category: cross breeds	22.237	0.002			
	Toy	0.892	0.345	0.732	0.369	1.418
	Terriers	1.074	0.300	0.784	0.494	1.243
	Utility	0.258	0.612	0.853	0.462	1.575
	Hounds	2.319	0.128	0.582	0.290	1.168
	Gundogs	*16.998*	*<0.001*	*0.415*	*0.273*	*0.630*
	Working	1.610	0.205	0.665	0.354	1.249
	Pastoral	0.010	0.919	0.980	0.661	1.453

Categories significantly different from reference at $P < 0.05$ shown in italics.
Variables included in the multivariate logistic regression model were: dog breed type; owner gender; owner age category; dog gender; dog neuter status; dog gender × neuter status; origin of dog; dog age ($\log_{10}$); attendance at puppy classes; attendance at ring-craft classes; category of training methods used.

Table 6
Variables remaining in final multivariable logistic regression model for aggression directed towards unfamiliar people outside of the household.

Variable	Categories	Wald statistic	P value	Odds ratio (ExpB)	95% CI for ExpB	
					Lower	Upper
Dog age ($\log_{10}$)		*4.779*	*0.029*	*1.565*	*1.047*	*2.338*
Dog sex and neuter status	Reference category: Male neutered	8.151	0.043			
	Female neutered	*6.171*	*0.013*	*0.601*	*0.403*	*0.898*
	Male entire	0.001	0.984	1.004	0.671	1.504
	Female entire	1.722	0.189	0.740	0.472	1.160
Puppy classes	Attending puppy socialisation class for at least 2 weeks before 12 weeks, compared to reference of not attending	*6.622*	*0.010*	*0.626*	*0.439*	*0.894*
Ringcraft classes	Attending ringcraft classes for at least 4 weeks compared to reference of not attending	*4.991*	*0.025*	*0.543*	*0.318*	*0.928*
Training category	Any use of positive punishment/negative reinforcement as compared to reference category of only positive reinforcement/negative punishment	*9.064*	*0.003*	*2.190*	*1.315*	*3.648*
Breed type	Reference category: cross breeds	29.928	<0.001			
	Toy	1.088	0.297	0.625	0.259	1.511
	Terriers	0.027	0.870	1.045	0.621	1.758
	Utility	0.866	0.352	0.675	0.295	1.544
	Hounds	0.269	0.604	0.820	0.387	1.737
	Gundogs	*7.307*	*0.007*	*0.510*	*0.313*	*0.831*
	Working	0.001	0.982	0.992	0.491	2.005
	Pastoral	*5.560*	*0.018*	*1.674*	*1.091*	*2.569*

Categories significantly different from reference at $P < 0.05$ shown in italics.
Variables included in the multivariate logistic regression model were: dog breed type; owner gender; owner age category; dog gender; dog neuter status; dog gender × neuter status; origin of dog; dog age ($\log_{10}$); attendance at puppy classes; attendance at ring-craft classes; category of training methods used.

Table 7

Table showing individual breed or breed type risks for aggression to unfamiliar people entering the house and outside of the house, as compared to cross breeds. Only associations significant at $P < 0.05$ are shown.

Analysis	Breed category	Wald statistic	P value	Odds ratio (ExpB)	95% CI for ExpB	
					Lower	Upper
Aggression to people entering the household	Reference category: crossbreeds ($N = 701$)					
	Labradors ($N = 395$)	12.089	0.001	0.34	0.185	0.625
	Golden Retrievers ($N = 176$)	9.289	0.002	0.162	0.050	0.523
	Cocker Spaniels ($N = 183$)	9.489	0.002	0.160	0.050	0.513
	Springer Spaniels ($N = 183$)	6.616	0.010	0.327	0.139	0.766
	Other retrievers (including Chesapeake Bay, Curly Coated, Flat Coated, Lagotto Romagnoto, Nova Scotia Duck Tolling and Spanish Water Dog; $N = 73$)	3.925	0.048	0.134	0.018	0.979
	Setters (including English, Gordon, Irish, Irish Red and White; $N = 79$)	4.559	0.033	0.115	0.016	0.837
	Other terriers (including Airedale, Bedlington, Cairn, Cesky, Fox, Wirehaired Fox, Glen of Imaal, Irish, Lucas, Norfolk, Kerry Blue, Lakeland, Manchester, Welsh, Norwich, Scottish, Patterdale and Soften Coated Wheaten; $N = 119$)	3.98	0.046	0.301	0.093	0.977
	Boxers ($N = 78$)	3.878	0.049	0.239	0.057	0.993
Aggression to people when outside of the household	Reference category: cross breeds ($N = 701$)					
	German and Belgian Shepherds ($N = 193$)	12.362	<0.001	2.54	1.511	4.271
	Golden Retrievers ($N = 176$)	5.369	0.021	0.185	0.044	0.771
	Cocker Spaniels ($N = 183$)	4.604	0.032	0.274	0.084	0.894

cross-breeds. There was no significantly increased risk in any breed type as compared to crossbreeds. Full results for variables in the final model are shown in Table 5.

3.5. Risk factors for aggression towards unfamiliar people outside of the household

The final model significantly distinguished between cases and controls ($\chi^2 = 75.760$, df = 14, $P < 0.001$), but explained only between 2% (Cox & Snell R^2) and 6.1% (Nagelkerke R^2) of the variance. In this model, risk of aggression increased with the age of dog ($\log_{10}$). Female neutered dogs were 1.7 times less likely to show aggression as male neutered dogs, but neither male nor female entire dogs significantly differed from male neutered dogs. Attending puppy classes on at least 2 occasions under 12 weeks of age had a protective effect: dogs with this experience had a 1.6 times reduced risk of showing aggression to unfamiliar people out of the house. Similarly, attending four or more ring-craft training sessions reduced the risk by about half. The use of any positive punishment/negative reinforcement type of training technique was associated with a 2.2 times increased risk of showing aggression to unfamiliar people outside of the house. The breed category of 'gundogs' had approximately half the risk, and 'pastoral' dogs just under twice the risk, of showing aggression in this situation as compared to cross-breeds. Full results for this model are shown in Table 6.

3.6. Univariable analysis of individual breed effects

Where breed was divided into individual common breeds and groups of similar types of less common breeds (see Table 3, Blackwell et al., 2013) no significant association was found between breed and aggression towards family members. For aggression to unfamiliar people entering the household the following breeds and breed types were less likely to be associated with aggression than the reference category of cross-breeds ($N = 701$): Labradors ($N = 395$); Golden Retrievers ($N = 176$); Cocker Spaniels ($N = 183$); Springer Spaniels ($N = 183$); other retrievers (including Chesapeake Bay, Curly Coated, Flat Coated, Lagotto Romagnoto, Nova Scotia Duck Tolling and Spanish Water Dog, $N = 73$); Setters (including English, Gordon, Irish, Irish Red and White, $N = 79$); other terriers (including Airedale, Bedlington, Cairn, Cesky, Fox, Wirehaired Fox, Glen of Imaal, Irish, Lucas, Norfolk, Kerry Blue, Lakeland, Manchester, Welsh, Norwich, Scottish, Patterdale and Soften Coated Wheaten, $N = 119$) and Boxers ($N = 78$) as shown in Table 7. No breeds had an increased risk of aggression as compared to crossbreeds.

In a univariable regression analysis investigating association with aggression to unfamiliar people when out of the house, German and Belgian Shepherds ($N = 193$) had an increased risk compared to cross-breeds. Golden Retrievers ($N = 176$) and Cocker Spaniels ($N = 183$) had a significantly reduced risk compared to crossbreeds (Table 7).

4. Discussion

4.1. Proportion of population showing aggressive behaviour towards unfamiliar people and family members

The results of this survey suggest that more dogs show aggression towards unfamiliar people, particularly when entering the house (7%) than towards family members (3%). Comparison with our previous research suggests that aggression towards people in all these contexts is less common than aggression directed towards other dogs (Casey et al., 2013).

There is little previous evidence with which to compare these prevalence data: other surveys have used factors derived from relative scales (such as the C-BARQ:

Duffy et al., 2008; Hsu and Sun, 2010) rather than presence/absence. Proportions of dogs showing aggression is unsurprisingly lower than in studies involving clinical populations without unaffected controls (e.g. Fatjo et al., 2007).

Data from studies measuring dog bite occurrence in people, particularly directed towards children, suggest that serious human directed aggression is most likely to occur in the home from known or family dogs (De Keuster et al., 2006; Rosado et al., 2009). In the study reported here, more owners reported aggression towards unfamiliar people, both outside and entering the home. The higher prevalence of aggression towards unfamiliar people reported here may relate to different outcome measures between this study (where owners were asked to report signs of aggression) and those based on bite statistics. In other words, this study investigates the occurrence of any signs of aggression in dogs, whereas those looking at statistics of bite injuries report the most serious incidences where actual biting has occurred. Owners of dogs aggressive to other people are likely to keep them under close control or avoid contact when in public places – in such cases owners may report aggressive behaviours such as lunging and barking, but have their dogs restricted such that there are limited opportunities for actual bite injuries. However, avoiding bite occurrence from dogs aggressive to family members, particularly children, in the home may be more difficult. Close contact between the dog and family members is more likely when the dog is inside the home. Contact is also more likely to occur around valued resources, such as food bowls, a context found important in child directed aggression in previous research (Reisner et al., 2007).

It is possible that this study under-estimates the prevalence of aggression directed to unfamiliar people when out for walks, as people with biting dogs may avoid places where other people are likely to be, including some of the locations used to enrol participants in the study.

Between 47% (family directed) and 73% (unfamiliar people entering the house) of owners reported that where aggression had *ever* occurred in their dog it was still currently occurring. This may suggest that in at least a proportion of cases aggression either resolves spontaneously, or the behaviour is successfully treated. However, it is also possible that owners do not report aggression as 'current' where they have developed ways in which to avoid aggressive incidents (and consequently no longer report them). For example, those with dogs showing aggression to people out of the house may walk away from other people or keep their animal leashed, such that the problem is controlled but not necessarily resolved. In family directed aggression, owners may also 'avoid' the problem rather than addressing it – for example by not approaching their dog whilst it is eating.

Although only three percent reported showing aggression to household members, this is the equivalent of 300,000 dogs if extrapolated to the estimated UK dog population (Murray et al., 2010). Caution should be exercised in making such an extrapolation however, because it is unknown the extent to which this opportunistic sample is representative, and any biases are difficult to evaluate. Half of questionnaires were distributed at dog shows or related

events: this possibly increased the relative proportion of pedigree animals, people who have bred their own dogs, and 'enthusiast' dogs owners in the sample.

The threshold at which dogs were classified as 'aggressive' or 'not aggressive' in this study was whether owners reported any aggression at all. This means that dogs defined as 'aggressive' here included those which might have growled once in an atypical situation through to those which show severe aggression in multiple situations, including cases of immediate or impulsive aggression described by some authors as 'pathological'. By including all aggressive dogs within a single category, factors which influence the differences between dogs showing milder and more severe types of aggression could not be evaluated.

4.2. Co-occurrence of aggression in different contexts

Dogs in this study did not tend to show aggression in multiple contexts. These findings support the current hypothesis in clinical behaviour practice that dogs usually learn to show aggression in response to specific perceived threats occurring in particular contexts (Bradshaw et al., 2009), rather than aggression being an overall characteristic of individuals. This is in contrast with the common public perception that aggression is a trait of an individual – or that particular dogs are either always 'perfectly safe' or 'vicious' (Bradshaw and Casey, 2007). It is important for dog owners and members of the public to be aware that any dog is capable of showing aggression, even where it has not done so in other situations (De Keuster et al., 2006). Equally, a dog which has shown aggression in one situation may not necessarily be 'dangerous' when in other contexts, an important factor in assessment of animals, for example in re-homing centres.

4.3. Owner gender effects

Female owners were 1.6 times less likely to report aggression to unfamiliar people entering the household than males. There were more female respondents (86%) to the questionnaire than males (14%). It is possible that this inequality in respondent gender resulted in a bias related to the recognition of, or admittance to, aggression in dogs. However, this is not supported by the findings that owner gender not being a significant risk factor for aggression to family members, or unfamiliar people outside of the household.

Differences in response between male and female owners just relating to aggression to unfamiliar people entering the household is difficult to interpret. It is possible that this effect may relate to gender differences in numbers or types of visitors to the house. More visitors could be argued to increase risk because of more opportunities for aggression occurring, although it is also possible that less routine visits increase risk because they are unexpected for dogs. There may also be attitudinal gender differences to interpreting dog behaviour specifically relating to visitors entering the house.

There are mixed findings on the association between owner gender and dog behaviour elsewhere, with some studies finding no relationship (e.g. Podberscek and Serpell,

1997). McGreevy and Masters (2008) found an increased number of females in the household associated with increased risk of food related aggression, although this may relate to numbers present when dogs are fed. Male owners scored their dog lower on owner-directed aggression scales than did females in Hsu and Sun (2010), although this may represent gender differences in perception of severity influencing sub-scale scores. In an observational study of interactions between dogs when out for walks, Řezáč et al. (2011) found that dogs were more likely to show a threat to each other, or bite each other, on walks if both owners were men than if they were women, suggesting a possible direct impact on gender differences in owner behaviour which impacts on the expression of behaviour in dogs.

4.4. Owner age effects

Owners in the over 60 year category ($N = 851$; 22%) were associated with a 5.3 times decreased risk of reporting owner directed aggression, and a 1.8 times decreased risk of reporting aggression to unfamiliar people entering the house, compared to those in the under 25 year old category. Owners in the 41–60 year category also had a 1.9 times decreased risk of reporting owner directed aggression compared to those under 25. It is possible that the reduced risk in older owner categories is related to differences in lifestyle, such as being more settled, and potentially predictable for dogs. Consistency of owners is suggested as important in the occurrence of undesired behaviour, and young owners may have young families or more variable patterns of activity. Retired owners may also have more time to give their dogs sufficient exercise and mental stimulation. It is also possible that younger and older owners differ in their relative tolerance of aggression: either in retention of animals showing aggressive behaviour, or reporting of the behaviour. This finding contrasts with O'Sullivan et al. (2008), where 79% of owners of biting dogs were in the 40–60 year age group, although this may be influenced by questionnaire return as this study did not have a comparison group of non-biting dogs.

4.5. Dog gender and neuter status effects

Female neutered dogs ($N = 1046$) had a lower risk of showing aggression in all three situations as compared to male neutered animals ($N = 946$; 2.3 times for both aggression to familiar people in the household; 1.8 times for unfamiliar people entering the house, and 1.7 times for unfamiliar people when out of the house). There was no significant difference in risk for male entire dogs ($N = 855$) or female entire dogs ($N = 882$) as compared to male neutered dogs.

Clinical and bite incidence studies tend to support a lower risk of aggression to people in female dogs (Bamberger and Houpt, 2006; Fatjo et al., 2007; Reisner et al., 2007; Rosado et al., 2009). In other surveys, Lund et al. (1996) suggested that male dogs had a higher risk for all types of aggression, Hsu and Sun (2010) found that being male, and (separately) neutered were risk factors for owner directed aggression, and Podberscek and Serpell (1996) found that male Cocker Spaniels were more likely to

show aggression to family members. In contrast, Guy et al. (2001b) found that dogs which bit were 3 times more likely to be female, with a weight × sex interaction such that biting by female dogs increased with decreasing body weight.

Overall, evidence from previous literature supports the finding that female dogs (at least neutered females) may have a reduced risk, although the opposite finding of Guy et al. (2001c) suggests the need for further investigation. No overall effect of neutering was identified, and longitudinal studies would be needed to clarify relationships between gender, neuter status, and aggressive behaviour.

4.6. Dog age effects

The risk of aggression to unfamiliar people entering the house, and outside the house, significantly increased with the age of the dog in this study. This is consistent with the other surveys (Bennett and Rohlf, 2007; Hsu and Sun, 2010), but contrast with clinical populations, where mean age of established cases is 3–4 years (Bamberger and Houpt, 2006; Fatjo et al., 2007). Further, O'Sullivan et al. (2008) found approximately half of biting dogs to be <2 years. These differences are likely to relate to the cumulative effect of risk of exposure to perceived threats and reinforcement of behaviour over time causing increased risk with age in cross sectional studies due to cumulative chance.

4.7. Dog breed effects

Categories of breed as defined by the KC were retained in all final models.

A 4.4 times increased risk of aggression to familiar people was found in the Utility group and a 2.6 times increased risk in Hounds. However, on post hoc analysis of individual breeds and breed types no specific breeds or breed types were found to have increased risk. Duffy et al. (2008) found a higher incidence of aggression in Dachshunds, although for stranger and dog directed aggression, neither of which were found in these data.

Gundogs had a reduced risk of aggression in both situations involving unfamiliar people (2.4 times reduced for people entering the house, and two times lower risk when outside the house, compared to crossbreeds). When post hoc analysis of individual breed types was conducted, Labradors, Golden Retrievers, Cocker Spaniels, Springer Spaniels, a combined category of 'other' retrievers, Setters, and a combined category of 'other' terriers, all had reduced risk with respect to unfamiliar people entering the house. In the context of aggression outside the house, Golden Retrievers and Cocker Spaniels had reduced risk of aggression compared to crossbreeds. The reduced risk in Cocker Spaniels is in contrast to Fatjo et al. (2007), although these discrepancies with both clinical and hospital populations may reflect differences between the chance of aggression occurring at all, and the severity of occurrence should it occur. Hence, this breed may be more likely to show aggression likely to result in referral or cause injury if aggression does occur, but be no more likely than other breeds to show aggression in the first place. Nevertheless, interest in the Cocker Spaniel as a breed with increased risk of

aggression (Lund et al., 1996; Podberscek and Serpell, 1996) is not substantiated by findings here, rather the converse with respect to unfamiliar people. Reduced risk in Golden Retrievers is consistent with Hsu and Sun (2010).

Post hoc analysis of breed risks for aggression to unfamiliar people outside of the household also suggested an increased risk in a combined category of German (GSD) and Belgian Shepherds (BSD). There is some consistency here with previous studies: GS type dogs are cited as having a higher risk of causing bite injury in some hospital based datasets (e.g. (Rosado et al., 2009), although these may over-represent large and easily identified dogs. GSD/BSDs were found to have higher bite risk in the Netherlands (Cornelissen and Hopster, 2010). Fatjo et al. (2007) found a higher proportion of BSDs (but not GSDs) showing aggression in a clinical population, and Lund et al. (1996) suggested GSDs to have an increased risk of aggression towards strangers. These findings may be related to underlying personality characteristics associated with these breed types, due to the types of owner or family which are likely to acquire such dogs, or a combination of these factors. Further research on underlying characteristics which may vary between breeds may help identify aggression risk in individuals.

Although the findings of this study have suggested some breed groups, or specific breeds with increased or decreased risk as compared to cross-breeds, it is important to note that these account for only a very small proportion of variance between groups. In other words, although breed seems to be a contributory factor influencing risk, other factors have a much greater influence. In addition, post hoc analyses of individual breeds or breed types here are univariable, and hence there is no adjustment for potential interaction effects with other variables. Hence, although these data may be valuable at population levels, it is inappropriate to make assumptions about an individual animal's risk of showing aggression based on breed. Further, it is interesting that different breed types vary with respect to risk for different types of aggression, consistent with previous studies (Duffy et al., 2008; Hsu and Sun, 2010). This may suggest that the development of aggression is not uniform, and varying characteristics and circumstances may predispose animals to aggressive responses in different situations. Finally, in this population, as elsewhere, breeds which are sometimes regarded as 'dangerous' (e.g. Staffordshire Bull terriers (SBT), other bull breeds and mastiff breeds) do not appear to have an increased risk of showing aggression. Indeed, SBTs showed a trend for reduced risk of showing aggression towards visitors to the house as compared to cross-breeds (OR 0.280, CI 0.067–1.170, $P = 0.061$).

4.8. Attendance at training classes

Attendance at obedience classes for at least four sessions was associated with a 1.7 times increased risk of aggression towards family members. As the causality of this relationship is unknown, this may indicate that attendance at such classes increases aggressive behaviour, or that those with dogs showing aggression are more likely to attend these classes. Elsewhere, lack of obedience training has been associated with aggression (Schöning and Bradshaw, 2005) and other undesired behaviours (Bennett and Rohlf, 2007), although this link was not found in Blackwell et al. (2008). The type of training method used in such classes may also influence the relationship with aggressive behaviour (see Section 4.9).

Attendance at puppy classes was associated with a decreased risk of aggression to unfamiliar people entering the house (1.4 times) and outside the house (1.6 times). Because only those which attended puppy classes at least twice when their dog was <12 weeks old were coded as 'attended', this effect was likely to reflect the influence of contact with people during the dogs' socialisation period (Serpell and Jagoe, 1995). The protective effect of such classes is consistent with previous findings (Appleby et al., 2002), and emphasizes the importance of adequate social contact during the early part of a dogs' life on later behaviour to strangers (Seksel, 2008).

4.9. Training methods used

Owners that reported use of training techniques associated with positive punishment/negative reinforcement were associated with a 2.9 times increased risk of aggression to family members, and a 2.2 times increased risk of aggression to unfamiliar people outside of the household. The causality of this relationship is unknown, since owners may resort to more coercive techniques when their dog shows aggression, or aggression may be induced where owners select such methods. These findings are consistent with those found in other studies, where use of punishment based techniques is associated with the occurrence of undesired behaviour (Hiby et al., 2004; Blackwell et al., 2008; Herron et al., 2009). Further research is required to confirm the direction of causality in this relationship.

4.10. Origin of dog

The origin of the dog was a significant factor in aggression towards family members, with a 2.6 times increased risk in dogs obtained from rescue centres and a 1.8 times increased risk from a combined category of 'other' sources, including pet shops and internet sites, as compared to those obtained directly from breeders. There was also a 4.5 times lower risk in dogs which were bred by their current owner as compared to those acquired from another breeder. It is perhaps unsurprising that dogs from re-homing facilities have an increased risk of owner directed aggression, since many are relinquished for undesired behaviours (Salman et al., 1998; Diesel et al., 2010). Individual rescue centres vary in approach, but the major UK charities actively work to rehabilitate dogs relinquished with undesired behaviours, particularly aggression. However, aggression to owners can be difficult to detect in a kennel environment, because some of the specific situations which may precipitate this behaviour (e.g. towelling off feet) may not occur. Dogs from rescue centres had no increased risk of showing aggression to unfamiliar people in either context, and this perhaps reflects the care taken by charities in evaluating admitted dogs for risk of human-directed aggression, and conducting rehabilitation work prior to

homing. Since the 'other' category includes a number of sources for dogs, it is difficult to identify why this category is associated with increased risk of aggression to owners, except that puppies from pet shops, purchased through adverts, or via other third parties may have had sub-optimal early environments, limited opportunity for appropriate socialisation, and/or may be passed on to owners with limited advice or information.

The decreased risk of aggression where dogs live in the environment in which they were bred may reflect the fact that the socialisation experiences of these animals would best prepare them for the environment in which they live as adults (Appleby et al., 2002; Casey and Bradshaw, 2008).

4.11. Models explain a low proportion of total variance

A low proportion of variance in each model is explained by the factors measured, suggesting that other factors better explain the difference between cases and controls. Other studies suggest that the nature of interaction which precedes the bite (Reisner et al., 2007; Rosado et al., 2009; Cornelissen and Hopster, 2010), general characteristics of interactions and owner knowledge or understanding of dog behaviour and training (Bennett and Rohlf, 2007) to be important. Medical or physiological factors may also cause, or contribute to, the development of aggressive behaviour in individual dogs (Fatjo and Bowen, 2009).

5. Conclusions

This study has identified some characteristics of owners and dogs which are risk factors for aggression. The prevalence for aggression to unfamiliar people entering the household was highest, but even here aggression was reported in less than seven percent of dogs. Aggression in different contexts appeared to not broadly co-occur, suggesting dogs learn to show aggression in specific situations rather than this being an overall characteristic for dogs. Breed risks varied with different types of aggression, although gundog breeds appear to have an overall reduced risk for aggression to unfamiliar people. Neutered female dogs had a reduced risk in two of the three contexts. Owners in older age categories appeared to report less aggression than those under 25 years. Attendance at puppy classes reduced risk of aggression to unfamiliar people, which is likely to reflect the importance of socialisation before 12 weeks of age. However, all factors measured explained a relatively small amount of the variance (<10%) between cases and controls in all contexts. Because other factors specific to the characteristics and experience of individual dogs are likely to explain remaining variance, it is important that cases at evaluated at the individual level.

References

Appleby, D.L., Bradshaw, J.W.S., Casey, R.A., 2002. Relationship between aggressive and avoidance behaviour by dogs and their experience in the first six months of life. Vet. Rec. 150, 434–438.

Asher, L., Buckland, E.L., Phylactopoulos, C.I., Whiting, M.C., Abeyesinghe, S.M., Wathes, C.M., 2011. Estimation of the number and demographics of companion dogs in the UK. BMC Vet. Res. 7, 74.

Bamberger, M., Houpt, K.A., 2006. Signalment factors, comorbidity, and trends in behavior diagnoses in dogs: 1644 cases (1991–2001). J. Am. Vet. Med. Assoc. 229, 1591–1601.

Bennett, P.C., Rohlf, V.I., 2007. Owner-companion dog interactions: relationships between demographic variables, potentially problematic behaviours, training engagement and shared activities. Appl. Anim. Behav. Sci. 102, 65–84.

Blackshaw, J.K., 1991. An overview of types of aggressive behaviour in dogs and methods of treatment. Appl. Anim. Behav. Sci. 30, 351–361.

Blackwell, E.J., Bolster, C., Richards, G., Loftus, B., Casey, R.A., 2012. The use of electronic collars for training domestic dogs: estimated prevalence, reasons and risk factors for use, and owner perceived success as compared to other training methods. BMC Vet. Res. 8, 93, http://dx.doi.org/10.1186/1746-6148-8-93.

Blackwell, E.J., Bradshaw, J.W.S., Casey, R.A., 2013. Fear responses to noises in domestic dogs: prevalence, risk factors and co-occurrence with other fear related behaviour. Appl. Anim. Behav. Sci. 145, 15–25.

Blackwell, E.J., Twells, C., Seawright, A., Casey, R.A., 2008. The relationship between training methods and the occurrence of behavior problems, as reported by owners, in a population of domestic dogs. J. Vet. Behav. Clin. Appl. Res. 3, 207–217.

Bradshaw, J.W.S., Blackwell, E.J., Casey, R.A., 2009. Dominance in domestic dogs – useful construct or bad habit? J. Vet. Behav. Clin. Appl. Res. 4, 135–144.

Bradshaw, J.W.S., Casey, R.A., 2007. Anthropomorphism and anthropocentrism in the assessment of quality of life in dogs. Anim. Welf. 16, 149–154.

Bollen, K., Horowitz, J., 2008. Behavioral evaluation and demographic information in the assessment of aggressiveness in shelter dogs. Appl. Anim. Behav. Sci. 112, 120–135.

Borg, J.A.M.v.d., Beerda, B., Ooms, M., Souza, A.S.d., Hagen, M.v., Kemp, B., 2010. Evaluation of behaviour testing for human directed aggression in dogs. Appl. Anim. Behav. Sci. 128, 78–90.

Calkins, C.M., Bensard, D.D., Partrick, D.A., Karrer, F.M., 2001. Life-threatening dog attacks: a devastating combination of penetrating and blunt injuries. J. Pediatr. Surg. 36, 1115–1117.

Casey, R.A., Bradshaw, J.W.S., 2008. The effects of additional socialisation for kittens in a rescue centre on their behaviour and suitability as a pet. Appl. Anim. Behav. Sci. 114, 196–205.

Casey, R.A., Loftus, B., Bolster, C., Richards, G., Blackwell, E.J., 2013. Inter-dog aggression in a UK owner survey: prevalence, co-occurrence in different contexts and risk factors. Vet. Rec. 172, 127.

Cornelissen, J.M.R., Hopster, H., 2010. Dog bites in The Netherlands: a study of victims, injuries, circumstances and aggressors to support evaluation of breed specific legislation. Vet. J. 186, 292–298.

De Keuster, T., Lamoureux, J., Kahn, A., 2006. Epidemiology of dog bites: a Belgian experience of canine behaviour and public health concerns. Vet. J. 172, 482–487.

Diesel, G., Brodbelt, D., Pfeiffer, D.U., 2010. Characteristics of relinquished dogs and their owners at 14 rehoming centers in the United Kingdom. J. Appl. Anim. Welf. Sci. 13, 15–30.

Duffy, D.L., Hsu, Y.Y., Serpell, J.A., 2008. Breed differences in canine aggression. Appl. Anim. Behav. Sci. 114, 441–460.

Fatjo, J., Amat, M., Mariotti, V.M., de la Torre, J.L.R., Manteca, X., 2007. Analysis of 1040 cases of canine aggression in a referral practice in Spain. J. Vet. Behav. Clin. Appl. Res. 2, 158–165.

Fatjo, J., Bowen, J., 2009. Medical and metabolic influences on behavioural disorders. In: Horwitz, D.F., Mills, D.S. (Eds.), BSAVA Manual of Canine and Feline Behavioural Medicine. , 2nd ed. BSAVA, Gloucseter, UK, pp. 1–9.

Gilchrist, J., Sacks, J.J., White, D., Kresnow, M.J., 2008. Dog bites: still a problem? Inj. Prev. 14, 296–301.

Guy, N.C., Luescher, U.A., Dohoo, S.E., Spangler, E., Miller, J.B., Dohoo, I.R., Bate, L.A., 2001a. A case series of biting dogs: characteristics of the dogs, their behaviour, and their victims. Appl. Anim. Behav. Sci. 74, 43–57.

Guy, N.C., Luescher, U.A., Dohoo, S.E., Spangler, E., Miller, J.B., Dohoo, I.R., Bate, L.A., 2001b. Demographic and aggressive characteristics of dogs in a general veterinary caseload. Appl. Anim. Behav. Sci. 74, 15–28.

Guy, N.C., Luescher, U.A., Dohoo, S.E., Spangler, E., Miller, J.B., Dohoo, I.R., Bate, L.A., 2001c. Risk factors for dog bites to owners in a general veterinary caseload. Appl. Anim. Behav. Sci. 74, 29–42.

Haverbeke, A., Desmet, A., Depiereux, E., Giffroy, J., Diederich, C., 2009. Assessing undesired aggression in military working dogs. Appl. Anim. Behav. Sci. 117, 55–62.

Herron, M.E., Shofer, F.S., Reisner, I.R., 2009. Survey of the use and outcome of confrontational and non-confrontational training methods in client-owned dogs showing undesired behaviors. Appl. Anim. Behav. Sci. 117, 47–54.

Hiby, E.F., Rooney, N.J., Bradshaw, J.W.S., 2004. Dog training methods: their use, effectiveness and interaction with behaviour and welfare. Anim. Welf. 13, 63–69.

Hsu, Y., Sun, L., 2010. Factors associated with aggressive responses in pet dogs. Appl. Anim. Behav. Sci. 123, 108–123.

Lund, J.D., Agger, J.F., Vestergaard, K.S., 1996. Reported behaviour problems in pet dogs in Denmark: age distribution and influence of breed and gender. Prev. Vet. Med. 28, 33–48.

McGreevy, P., Masters, A., 2008. Risk factors for separation-related distress and feed-related aggression in dogs: additional findings from a survey of Australian dog owners. Appl. Anim. Behav. Sci. 109, 320–328.

Morgan, M., Palmer, J., 2007. Dog bites. Br. Med. J. 334, 413–417.

Murray, J.K., Browne, W.J., Roberts, M.A., Whitmarsh, A., Gruffydd-Jones, T.J., 2010. Number and ownership profiles of cats and dogs in the UK. Vet. Rec. 166, 163–168.

O'Sullivan, E.N., Jones, B.R., O'Sullivan, K., Hanlon, A.J., 2008. The management and behavioural history of 100 dogs reported for biting a person. Appl. Anim. Behav. Sci. 114, 149–158.

Ott, S.A., Schalke, E., von Gaertner, A.M., Hackbarth, H., 2008. Is there a difference? Comparison of golden retrievers and dogs affected by breed-specific legislation regarding aggressive behavior. J. Vet. Behav. Clin. Appl. Res. 3, 134–140.

Overall, K.L., Love, M., 2001. Dog bites to humans – demography, epidemiology, injury, and risk. J. Am. Vet. Med. Assoc. 218, 1923–1934.

Peat, J., 2001. Health Science Research: A Handbook of Quantitative Methods. Allen & Unwin, Sydney.

Peters, V., Sottiaux, M., Appelboom, J., Kahn, A., 2004. Posttraumatic stress disorder after dog bites in children. J. Pediatr. 144, 121–122.

Podberscek, A.L., Serpell, J.A., 1996. The English cocker spaniel: preliminary findings on aggressive behaviour. Appl. Anim. Behav. Sci. 47, 75–89.

Podberscek, A.L., Serpell, J.A., 1997. Environmental influences on the expression of aggressive behaviour in English Cocker Spaniels. Appl. Anim. Behav. Sci. 52, 215–227.

Reisner, I.R., Shofer, F.S., Nance, M.L., 2007. Behavioral assessment of child-directed canine aggression. Inj. Prev. 13, 348–351.

Řezáč, P., Viziová, P., Dobešová, M., Havlíček, Z., Pospíšilová, D., 2011. Factors affecting dog–dog interactions on walks with their owners. Appl. Anim. Behav. Sci. 134, 170–176.

Rosado, B., Garcia-Belenguer, S., Leon, M., Palacio, J., 2009. A comprehensive study of dog bites in Spain, 1995–2004. Vet. J. 179, 383–391.

Salman, M.D., New Jr., J.G., Scarlett, J.M., Kass, P.H., Ruch-Gallie, R., Hetts, S., 1998. Human and animal factors related to relinquishment of dogs and cats in 12 selected animal shelters in the United States. J. Appl. Anim. Welf. Sci. 1, 207–226.

Schalke, E., Ott, S.A., von Gaertner, A.M., Hackbarth, H., Mittmann, A., 2008. Is breed-specific legislation justified? Study of the results of the temperament test of Lower Saxony. J. Vet. Behav. Clin. Appl. Res. 3, 97–103.

Schöning, B., Bradshaw, J.W.S., 2005. A behavioural test of aggression for adult dogs. In: Proceedings of the 37th International DVG Meeting of Applied Ethology, DVG, Aktuelle Arbeiten zur Artgemaessen Tierhaltung 2005, KTBL-Schrift 441. KTBL, Darmstadt, pp. 103–114.

Seksel, K., 2008. Preventing behavior problems in puppies and kittens. Veterinary Clinics of North America-Small Animal Practice 38, 971.

Serpell, J., Jagoe, J., 1995. Early experience and the development of behaviour. In: Serpell, J. (Ed.), The Domestic Dog: Its Evolution, Behaviour and Interaction With People. Cambridge University Press, Cambridge, pp. 79–102.

Weiss, H.B., Friedman, D.I., Coben, J.H., 1998. Incidence of dog bite injuries treated in emergency departments. J. Am. Med. Assoc. 279, 51–53.