



Canine Research

Demographics and comorbidity of behavior problems in dogs



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ABSTRACT

Periodic canine population studies establish essential frames of reference for analyzing trends in demographics and the prevalence of problematic behaviors. An understanding of the correlations between individual behavior problems can shed light on the pathogenesis and comorbidity of various conditions. It is our hope that the results of this substantial study will help to confirm those of previous studies, provide new data about behavior problems, and, by association, help establish their etiology. In this study, we hosted a public, online questionnaire to capture up-to-date demographic and behavior problem metrics. Surveyed problematic behaviors include fear/anxiety, aggression, jumping, excessive barking, coprophagia, obsessive-compulsive/compulsive behaviors, house soiling, rolling in repulsive materials, overactivity/hyperactivity, destructive behavior, running away/escaping, and mounting/humping. The study sample consisted of 4114 dogs, spanning mixed and pure breeds, submitted by 2480 dog owners. Male and female dogs were equally represented, a majority of which were neutered. The prevalence of canine behavior problems was 85%. We found sex, neuter status, origin, and lineage to have a notable effect on the prevalence of behavior problems. We also found age, neutered status, origin, and lineage to have a notable effect on the number of behavior problems *per* dog. Owners were asked to provide details of any behavior problem they reported such as intensity, frequency, and situation in which the behavior problem occurred. We examined the problematic behaviors in terms of their overall prevalence, and characteristics, and computed correlations between the various behavior problems. The findings from our study provide insight into the magnitude of owner-reported canine behavior problems encountered by owners and hopefully will encourage veterinarians to further incorporate aspects of behavior problem management into their daily work.

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Introduction

There have been many publications about the demographics of canine behavior problems over the years. Some of these studies use older or unique classifications of behavioral issues (Beaver, 1994; Bamberger & Houpt, 2006), were designed to be condition specific (Blackshaw & Sutton, 1994; Guy et al., 2001; Blackwell et al., 2013; Casey et al., 2013a,b; Denenberg et al., 2013; Duffy et al.,

2008; Tiira et al., 2016; Kurachi et al., 2017), reflect specific or global populations (Blackwell et al., 2013; Flint et al., 2017; Kurachi et al., 2017), or represent analyses of behavior problems presented to particular clinics (Blackshaw & Sutton, 1994; Denenberg et al., 2005; Bamberger & Houpt, 2006; Cannas et al., 2018). In addition, the prevalence of behavioral diagnoses is variable with time (Bamberger & Houpt, 2006), so up-to-date prevalence studies are indicated periodically. Each of the previous studies has its own intrinsic and temporal value, as well as its limitations.

It is helpful for a variety of reasons to know the overall prevalence of behavior problems, including directing veterinarians' attention to the magnitude of the problems faced by dog owners. Armed with information on canine behavior problem prevalence, veterinarians may become more inspired to further incorporate aspects of

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behavior problem management into their daily work. This measure would have immense welfare implications and should eventually help reduce the currently unacceptable level of dog surrender to shelters and pounds and, when they cannot be rehomed, ultimately their euthanasia. According to the American Society for the Prevention of Cruelty to Animals, of the approximately 3.3 million dogs surrendered to shelters each year, many because of behavior problems, approximately 670,00 (22.3%) are euthanized.

In addition, for research and comparative or translational medicine purposes, it is helpful to know whether certain behaviors problems, such as undue anxiety and obsessive-compulsive/compulsive behavior, have similar comorbidity in humans and animals. Such findings could help support these behaviors' equivalence and validity as mutual representations. Validated interspecies comparisons would help point the way toward development of novel treatments by strengthening the parallels between canine behavioral issues and corresponding human conditions.

Equally important to knowing the overall and individual prevalence of behavior problems, any correlations between conditions will shed light on the pathogenesis of the various conditions. A relationship between separation anxiety and noise and thunderstorm phobias has previously been established (Overall et al., 2001). Various anxiety-related conditions such as separation anxiety and generalized anxiety disorder have been suggested to be comorbid with obsessive-compulsive/compulsive disorders (Overall & Dunham, 2002), and there is an alleged involvement of fear-based conditions and owner-directed aggression (Luescher & Reisner, 2008). To date, other behavioral conditions, although minor, have not been associated in terms of comorbidity.

In the present study, we set out to provide an overarching demographic study of canine behavior problems from visitors, and existing members, of the Center for Canine Behavior Studies (CCBS) 501(c) (3) charity website, which served as a landing page for the study questionnaire. It was our hope that results of our large study would help confirm results of previous studies, provide new data about behavior problems, and, by association, help establish their etiology.

Materials and methods

For this demographic study, we aimed to recruit as many dog owners as possible via social media, TV, and radio broadcasts to participate in our behavioral questionnaire by directing owners to the CCBS-hosted study landing page. The landing page contained information about the study and a publicly available link to the questionnaire. The questionnaire was developed and hosted using a version of the Vanderbilt University's Research Electronic Data Capture platform (REDCap) provided by the Tufts Clinical and Translational Science Institute (CTSI). REDCap was developed by Vanderbilt University's informatics team, with the support of the National Center for Research Resources and National Institutes of Health, as a browser-based, metadata-driven electronic data capture software solution and workflow methodology for designing clinical and translational research databases and is used by more than 2375 institutions in over 110 countries for academic research.

Access to the study link was unrestricted to the global public. The questionnaire was logically split into two parts. The first part of the questionnaire collected information about the dog owner. This owner-specific portion of the questionnaire was only presented once. The second part of the questionnaire collected information about a single dog. This dog-specific portion of the questionnaire was presented in a loop, which allowed the participant to answer the dog-specific portion of the questionnaire once for each dog they own.

The first question of the owner-specific portion of the questionnaire asked the participant to indicate their motivation for

enrolling in the study. Toward the beginning of each dog-specific portion of the questionnaire, the participant was asked to indicate if they believed the current dog had a behavior problem. These two questions defined our inclusion criteria that were aimed at minimizing response bias. Dogs that were marked as problematic by owners who had reported their dog's behavior problems as their motivation for enrollment were excluded from the study sample. Dogs with incomplete questionnaires were also excluded from the sample study. The aim of the inclusion criteria was to allow the results of the sample study to extend to the general population of dogs without misrepresentation. For further details on the questionnaire, see [Supplemental Material](#), where a logic-annotated copy has been provided.

Once the 90-day survey response period for the questionnaire had concluded, the data set was exported from REDCap and converted into a relational database. Analyses were performed using the Python programming language (Python Software Foundation). Numerical methods and cross-tabulation were performed with the assistance of the pandas, NumPy, and SciPy scientific programming libraries. The matplotlib, matplotlib-venn, and Seaborn plotting and visualization libraries were used for graphical data representation. Descriptive statistics were calculated. Ranges were provided for all medians. Ages were assigned to ranges. Pearson's chi-squared test (chi-squared test of independence) was used to assess the independence of unpaired observations on two variables. In all cases, the null hypothesis represented the statistically independent outcome. Where applied, the data set satisfied the assumptions for the chi-squared test of independence; the sample size was sufficiently large, and observations were not mutually exclusive. Odds ratios were calculated as a measure of effect size. Owing to the non-normal distribution of most variables, bootstrapping was used to estimate the confidence intervals for odds ratio and prevalence calculations (using 50,000 resamples per measure). Independent sample t-tests were used to calculate the associativity between binary and continuous data. Venn diagrams were used to visually show the relationship between two or more variables. A heat map was used to provide a visual overview of the relationships between surveyed behavior problem categories ([Figure 1](#)).

Results

Demographics

There were 5018 completed surveys submitted across 3201 dog owners. Eighteen percent of the survey responses were eliminated by the application of the inclusion criteria. The study sample consisted of 4114 dogs across 2480 dog owners. A majority participating dogs were located in the United States (76%), whereas the remaining were located among 16 identified different countries. The number of participating dogs per county is detailed in [Table 1](#). The median household consisted of a single dog (range: 1 to 13 dogs per household). The median age of the dogs was 72 months (range: 2–252 months). Forty-nine percent were male, 84% of which were castrated; 51% were female, of which 85% were spayed. The median age of neutering was 9 months (range: 2–180 months). The majority (57%) of the dogs spanned 142 pure breeds; the balance of the study sample was mixed breeds. The top ten most represented breeds in the study were Labrador retrievers ($n = 382$), golden retrievers ($n = 138$), German shepherds ($n = 132$), poodles ($n = 104$), Border collies ($n = 89$), cocker spaniels ($n = 71$), Australian shepherds ($n = 58$), dachshunds ($n = 43$), Shetland sheepdogs ($n = 36$), and Chihuahuas ($n = 33$). The two most prevalent acquisition sources were rescues (43%) and breeders (33%), whereas the least reported source was pet stores (1%). A majority of intact males (70%) and intact females (52%) were acquired from breeders. A majority of castrated males

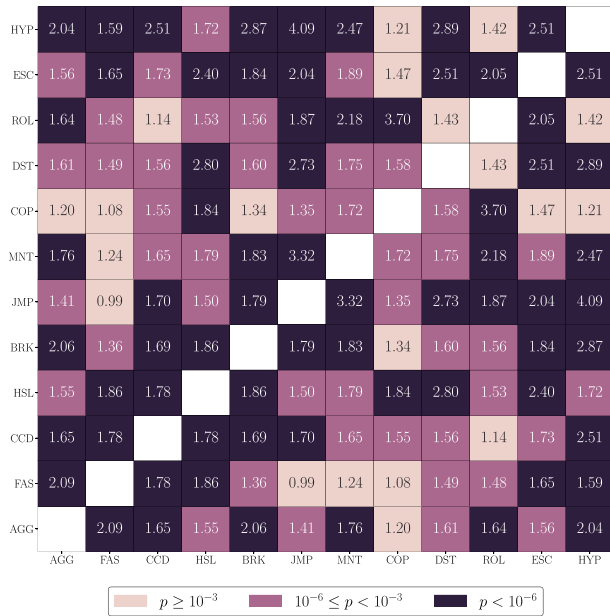


Figure 1. Pairwise asymptotic significance for all surveyed behavior problem categories. The odds ratio has been inlayed to convey the strength of the association. Key to heat map variables: AGG, aggression; FAS, fear/anxiety; CCD, compulsion; HSL, house soiling; BRK, excessive barking; JMP, jumping; MNT, mounting/humping; COP, coprophagia; DST, destructive behavior; ROL, rolling in repulsive materials; ESC, running away/escaping; HYP, overactivity/hyperactivity.

(51%) and spayed females (49%) were acquired from in-person and online rescues. The median age of onset for behavior problems was 12 months (range: 1–180 months) and 14% of dogs had behavior problems evident at the time of acquisition.

Prevalence of behavior problems

The prevalence of behavior problems in the study sample was 85%. Table 2 summarizes the prevalence of each of the twelve behavior problem categories covered in the questionnaire. Almost half (44%) of the study sample were reported to exhibit fear/anxiety

Table 1
Count of participating dogs, by country

Country	Count
United States	3122
Great Britain	387
Canada	326
Unidentified	96
Australia	85
Not provided	45
Russia	11
Mexico	8
Austria	6
Germany	6
Belgium	6
Switzerland	4
India	3
Portugal	2
Dominican Republic	2
Argentina	2
Italy	1
Poland	1
Spain	1

Postal codes that could not be mapped were marked as unidentified.

Table 2
Prevalence of behavior problems, by category

Behavior problem	Count	Prevalence (%) [CI _{95%}]
Fear/anxiety	1814	44 [43, 46]
Aggression	1239	30 [29, 31]
Jumping	1159	28 [27, 30]
Excessive barking	758	18 [17, 20]
Coprophagia	718	17 [16, 19]
Compulsion	639	16 [14, 17]
House soiling	614	15 [14, 16]
Rolling in repulsive material	515	13 [12, 14]
Overactivity/hyperactivity	505	12 [11, 13]
Destructive behavior	489	12 [11, 13]
Running away/escaping	442	11 [9.8, 12]
Mounting/humping	433	11 [9.6, 12]

behavior problems. All surveyed behavior problem categories had a prevalence of at least 10%. The prevalence of specific behavior problems for each of the surveyed categories is detailed in Table 3. Tables 4–7 summarize the prevalence of each behavior problem category by sex and neuter status, age range, source of origin, and purebred lineage, respectively. Associations were found between the prevalence of behavior problems and male sex (OR, 1.22; 95% CI: 1.02–1.45; $n = 4100$; $P < 10^{-6}$), neutering (OR, 1.90; 95% CI: 1.54–2.33; $n = 4092$; $P < 10^{-6}$), origination from a rescue (OR, 2.73; 95% CI: 2.27–3.36; $n = 4083$; $P < 10^{-6}$), and purebred lineage (OR, 0.38; 95% CI: 0.31–0.47; $n = 4058$; $P < 10^{-6}$). No association was found between the prevalence of behavior problems and male sex when dogs with mounting/humping behavior problems were removed (OR, 1.12; 95% CI: 0.94–1.34; $n = 3668$; $P = 0.20$). When broken into two age groups (12 months old and younger and older than 12 months), no association was found between prevalence and the age of onset (OR, 0.72; 95% CI: 0.19–2.71; $n = 650$; $P = 0.63$).

Number of behavior problems

The median number of reported behavior problems per dog was 2 (range: 0–12 behavior problems per dog). There was no significant difference in the number of behavior problems for male ($M = 2.32$; $SD = 1.84$) and female ($M = 2.22$; $SD = 1.81$) dogs; $t(4100) = 1.68$, $P = 0.09$. A significant difference was found between the number of behavior problems for neutered ($M = 2.36$; $SD = 1.84$) and intact ($M = 1.76$; $SD = 1.68$) dogs; $t(4092) = 8.12$, $P < 10^{-6}$, nonpurebred ($M = 2.62$; $SD = 1.87$) and purebred ($M = 2.02$; $SD = 1.75$) dogs; $t(4058) = 10.39$, $P < 10^{-6}$, and rescue ($M = 2.60$; $SD = 1.83$) and nonrescue ($M = 2.02$; $SD = 1.79$) dogs; $t(4083) = 10.13$, $P < 10^{-6}$.

Separation anxiety, noise phobia, and thunderstorm phobia

Figure 2 highlights the degree of intersection between separation anxiety, noise phobia, and thunderstorm phobia. Associations were found between separation anxiety and noise phobia (OR, 4.04; 95% CI: 3.32–4.90; $P < 10^{-6}$), separation anxiety and thunderstorm phobia (OR, 3.88; 95% CI: 3.1–4.77; $P < 10^{-6}$), and noise phobia and thunderstorm phobia (OR, 25.64; 95% CI: 20.75–32.07; $P < 10^{-6}$).

Separation anxiety, destructive behavior, and house soiling

An association was found between separation anxiety and destructive behaviors (OR, 3.35; 95% CI: 2.69–4.15; $P < 10^{-6}$) and anxiety and house soiling (of any kind) during the owner's absence (OR, 2.76; 95% CI: 2.18–3.46; $P < 10^{-6}$).

Table 3
Prevalence of specific behavior problems, by category

Behavior problem	Count	Prevalence (%) [CI _{95%}]
Fear/anxiety		
Fear of crowds	784	19 [18, 20]
Nonspecific situational anxiety	741	18 [17, 19]
Noise phobia	716	17 [16, 19]
Fear of veterinary visits	684	17 [16, 18]
Thunderstorm phobia	573	14 [13, 15]
Separation anxiety	550	13 [12, 14]
Travel anxiety	438	11 [9.7, 12]
Phobia of other dogs	428	10 [9.5, 11]
Generalized anxiety	359	8.7 [7.9, 9.6]
Other	231	5.6 [4.9, 6.3]
PTSD	176	4.3 [3.7, 4.9]
Aggression		
Unfamiliar dogs on walks (on lead)	674	16 [15, 18]
Another dog in the home	447	11 [9.9, 12]
Strangers visiting the home	391	9.5 [8.6, 10]
Unfamiliar dogs on walks (off lead)	371	9.0 [8.1, 9.9]
Unfamiliar dogs visiting the home	371	9.0 [8.1, 9.9]
Strangers away from the home	325	7.9 [7.1, 8.7]
Familiar people in the home	286	7.2 [6.4, 8.0]
Animals other than dogs in the home	172	4.2 [3.6, 4.8]
Veterinarians	159	3.9 [3.3, 4.5]
Groomers	55	1.3 [1.0, 1.7]
Trainers	34	0.83 [0.56, 1.1]
Jumping		
Family members	915	22 [21, 24]
Owners	763	19 [17, 20]
Strangers	694	17 [16, 18]
Excessive barking		
At triggers (inside)	498	12 [11, 13]
At triggers (outside)	497	12 [11, 13]
Owner present	402	9.8 [8.9, 11]
To get attention	304	7.4 [6.6, 8.2]
Owner away	214	5.2 [4.5, 5.9]
During car rides	98	2.4 [1.9, 2.9]
Coprophagia		
Other species'	420	10 [9.3, 11]
Other dogs'	416	10 [9.2, 11]
Their own	344	8.4 [7.5, 9.2]
Compulsion/obsessive-compulsive pattern		
Licking of wrist/hock	335	8.1 [7.3, 9.0]
Tail chasing	126	3.1 [2.6, 3.6]
Digging in the yard	106	2.6 [2.1, 3.1]
Other	97	2.4 [1.9, 2.8]
Tennis ball fetish	87	2.1 [1.7, 2.6]
Spinning	82	2.0 [1.6, 2.4]
Nail biting	73	1.8 [1.4, 2.2]
Compulsion/obsessive-compulsive pattern (cont.)		
Shadow/light chasing	65	1.6 [1.2, 2.0]
Sucking flank regions/blankets	58	1.4 [1.1, 1.8]
Running in geometric patterns	43	1.1 [0.75, 1.4]
Collecting/arranging objects	39	0.95 [0.66, 1.3]
Stone/rock chewing	32	0.78 [0.51, 1.1]
Fly snapping	25	0.61 [0.39, 0.85]
House soiling		
Urine	570	14 [13, 15]
Owner away	451	11 [10, 12]
Feces	434	11 [9.6, 12]
Owner present	420	10 [9.3, 11]
Specific locations	344	8.4 [7.5, 9.2]
Anywhere	292	7.1 [6.3, 7.9]
Excited/overwhelmed	127	3.1 [2.6, 3.6]
Rolling in repulsive material		
Dead stuff	436	11 [9.7, 12]
Feces	321	7.8 [7.0, 8.6]
Urine	72	1.8 [1.4, 2.2]
Garbage	66	1.6 [1.2, 2.0]
Overactivity/hyperactivity		
Difficulty settling	314	7.6 [6.8, 8.5]
Constant moving/jumping	276	6.7 [6.0, 7.5]
Impulsive	270	6.6 [5.8, 7.3]
Highly distractible	224	5.4 [4.8, 6.2]
Destructive behavior		

(continued on next column)

Table 3 (continued)

Behavior problem	Count	Prevalence (%) [CI _{95%}]
Owner is away	397	9.7 [8.8, 11]
Owner is home	222	5.4 [4.7, 6.1]
Running away/escaping		
Escaped from home	239	5.8 [5.1, 6.5]
Escapes when out	207	5.0 [4.4, 5.7]
Escapes from confinement	192	4.7 [4.0, 5.3]
Returns home after escape	147	3.6 [3.0, 4.2]
Mounting/humping		
Familiar dogs	259	6.3 [5.6, 7.1]
People	151	3.7 [3.1, 4.3]
Unfamiliar dogs	110	2.7 [2.2, 3.2]
Inanimate objects	102	2.5 [2.0, 3.0]

PTSD, post-traumatic stress disorder.

Fear/anxiety and house soiling

Of the 363 dogs that provided a location of house soiling and had behavior problems related to fear/anxiety, the majority (53%) were considered by their owners to be marking in specific locations, whereas the remainder were house soiling in random locations. Of the dogs with fear/anxiety, no association was found between maleness and inappropriate elimination (OR: 0.89; 95% CI: 0.71–1.13; $n = 1808$; $P = 0.3$), although the majority (54%) were female.

Fear/anxiety and aggression

Figures 3 and 4 highlight the degree of intersection between fearful/anxious behavior problems and overall aggression and owner-directed aggression, respectively. Associations were found between overall aggression and fear/anxiety (OR, 2.09; 95% CI: 1.83–2.40; $P < 10^{-6}$) and owner-directed aggression and fear/anxiety (OR, 2.58; 95% CI: 2.02–3.31; $P < 10^{-6}$). Figure 5 highlights the degree of intersection between owner-directed aggression and separation anxiety. An association was found between owner-directed aggression and separation anxiety (OR, 2.44; 95% CI: 1.81–3.20; $P < 10^{-6}$).

House soiling

The most prevalent form of house soiling involved elimination of both feces and urine (9.6%), followed by urine only (4.2%) and feces only (0.88%).

Bite severity

Nine percent ($n = 385$) of the dogs in the study were associated with at least one biting incident. Almost a third (29%) of the biting incidents involved more than one bite. A majority (92%) of biting incidents reported were for neutered dogs, which were also the common dogs in this study (84% of males were castrated and 85% of females were spayed). Castrated males accounted for 52% of the total reported bites, and spayed females accounted for 41%. Intact males accounted for 4% of the total reported bites and intact females accounted for 3%. Associations were found between male sex and biting (OR: 1.37; 95% CI: 1.11–1.70; $n = 4100$; $P = 0.003$) and being neutered and biting (OR: 2.64; 95% CI: 1.83–4.26; $n = 4096$; $P = 10^{-6}$). Of the dogs associated with biting incidents, 50% had bitten a person and 67% had bitten another dog. The median number of people bitten by aggressive dogs and dogs bitten by aggressive dogs was 3 (range: 1–100 people) and 3 (range: 1–100 dogs), respectively. Thirty-seven percent of the bites delivered to people, and 34% of the bites delivered to dogs, did not puncture the skin.

Table 4
Prevalence of behavior problem categories, by sex and neuter status

Behavior problem	Prevalence (%) [CI _{95%}]			
	Intact males	Castrated males	Intact females	Spayed females
Fear/anxiety	29 [25, 35]	46 [43, 48]	30 [25, 35]	48 [45, 50]
Aggression	20 [15, 24]	36 [33, 38]	16 [12, 20]	29 [27, 31]
Jumping	33 [28, 39]	27 [25, 29]	32 [27, 38]	27 [25, 30]
Excessive barking	10 [7.0, 14]	20 [18, 22]	12 [8.2, 15]	19 [18, 21]
Coprophagia	11 [7.3, 14]	18 [16, 20]	13 [9.6, 17]	19 [17, 21]
Obsessive-compulsive/compulsion	11 [7.5, 14]	17 [16, 19]	7.5 [4.7, 11]	16 [14, 18]
House soiling	11 [7.9, 15]	16 [14, 17]	9.7 [6.6, 13]	16 [14, 18]
Rolling in repulsive material	5.1 [2.8, 7.7]	11 [10, 13]	10 [7.1, 14]	15 [13, 17]
Overactivity/hyperactivity	12 [9.0, 16]	13 [12, 15]	11 [8.0, 15]	11 [9.8, 13]
Destructive behavior	12 [8.4, 16]	12 [10, 13]	12 [8.2, 15]	12 [10, 13]
Running away/escaping	7.7 [4.9, 11]	12 [10, 13]	10 [7.1, 14]	10 [9.0, 12]
Mounting/humping	17 [13, 22]	13 [12, 15]	6.8 [4.2, 9.8]	7.5 [6.3, 8.7]

n = 4080.

Fear/anxiety was the most common behavior problem category for dogs that had a biting incident. Sixty-five percent of the dogs that delivered bites to people and 59% of the dogs that delivered bites to another dog had underlying fear/anxiety. An association was found between fear/anxiety and biting (OR: 2.08; 95% CI: 1.68–2.60; $P < 10^{-6}$). Fear/anxiety-related behavior problems were still the most prevalent behavior problem category when segregated by bite target and bite severity. The most prevalent fear/anxiety-related behavior problems for dogs that had bitten a person without puncturing the skin were fear of crowds (38%), fear of veterinary visits (37%), and nonspecific situational anxiety (34%). The most prevalent fear/anxiety-related behavior problems for dogs that had bitten a person and punctured the skin were nonspecific situational anxiety (39%), fear of crowds (34%), and fear of veterinary visits (32%). The most prevalent fear/anxiety-related behavior problems for dogs that had bitten another dog without puncturing the skin were fear of crowds (26%), nonspecific situational anxiety (24%), and fear of veterinary visits (23%). The most prevalent fear/anxiety-related behavior problems for dogs that had bitten another dog and punctured the skin were nonspecific situational anxiety (34%), fear of veterinary visits (30%), and noise phobia (27%).

Fear/anxiety and compulsive behavior

Figure 6 highlights intersection between obsessive-compulsive/compulsive behavior problems and fear/anxiety. An association was found between compulsion and fear/anxiety (OR, 1.78; 95% CI: 1.51–2.11; $P < 10^{-6}$).

Coprophagia and age

No association was found between coprophagia and an age of onset of 12 months or younger (OR, 1.18; 95% CI: 0.79–1.78; n = 650; $P = 0.41$).

Overactivity/hyperactivity and age

An association was found between overactivity/hyperactivity and an age of onset of 12 months or younger (OR, 2.58; 95% CI: 1.63–4.10; n = 650; $10^{-6} \leq P < 10^{-3}$).

Jumping and mounting/humping

An association was found between jumping and mounting/humping (OR, 3.32; 95% CI: 2.71–4.08; $P < 10^{-6}$). No association was found between maleness and jumping (OR, 1.01; 95% CI: 0.88–1.16; n = 4100; $P = 0.91$), whereas an association was found between maleness and mounting/humping (OR, 2.01; 95% CI: 1.63–2.47; n = 4100; $P < 10^{-6}$). Other notable associations found for jumping included overactivity/hyperactivity (OR, 4.09; 95% CI: 3.36–4.97; $P < 10^{-6}$) and destructive behavior (OR, 2.73; 95% CI: 2.24–3.32; $P < 10^{-6}$). In addition, an association was also found between mounting/humping and overactivity/hyperactivity (OR, 2.47; 95% CI: 1.92–3.13; $P < 10^{-6}$).

Rolling in repulsive materials

An association was found between rolling in repulsive materials and coprophagia (OR, 3.70; 95% CI: 3.02–4.51; $P < 10^{-6}$).

Table 5
Prevalence of behavior problem categories, by age range of onset

Behavior problem	Prevalence (%) [CI _{95%}]					
	0–3 m	4–6 m	7–12 m	13–36 m	37 m+	Evident at acquisition
Fear/anxiety	43 [29, 57]	55 [47, 63]	53 [45, 61]	55 [48, 62]	47 [38, 56]	68 [64, 72]
Aggression	47 [32, 61]	46 [38, 54]	52 [44, 60]	62 [55, 69]	54 [45, 63]	39 [36, 43]
Jumping	38 [24, 52]	43 [35, 51]	34 [26, 41]	25 [19, 31]	13 [7.6, 20]	29 [25, 32]
Excessive barking	17 [7.0, 29]	26 [19, 33]	34 [26, 41]	24 [18, 30]	28 [20, 36]	23 [19, 26]
Coprophagia	19 [8.5, 31]	21 [15, 28]	18 [13, 25]	18 [13, 24]	15 [8.9, 22]	17 [14, 21]
Obsessive-compulsive/compulsion	17 [6.9, 29]	17 [11, 23]	18 [12, 25]	20 [14, 26]	23 [16, 31]	20 [17, 24]
House soiling	17 [6.8, 29]	16 [10, 22]	13 [7.8, 19]	13 [8.5, 18]	18 [12, 26]	28 [24, 31]
Rolling in repulsive material	15 [5.3, 26]	14 [8.8, 20]	14 [9.0, 20]	12 [7.7, 17]	15 [8.9, 22]	9.1 [6.9, 12]
Overactivity/hyperactivity	23 [12, 36]	22 [16, 29]	19 [13, 26]	9.0 [5.1, 13]	10 [5.0, 16]	19 [16, 23]
Destructive behavior	23 [12, 36]	19 [13, 26]	15 [9.5, 21]	14 [9.0, 19]	16 [9.8, 23]	17 [14, 21]
Running away/escaping	15 [5.3, 26]	14 [8.2, 19]	10 [5.6, 15]	14 [9.5, 19]	5.0 [1.6, 9.4]	17 [14, 20]
Mounting/humping	21 [10, 33]	16 [11, 22]	12 [6.8, 17]	11 [6.3, 15]	4.2 [0.89, 8.1]	10 [7.7, 13]

n = 1241.

Table 6
Prevalence of behavior problem categories, by source of origin

Behavior problem	Prevalence (%) [CI _{95%}]							
	Rescue	Online	Pet store	Breeder	Self-bred	Family/friends	Found	Other
Fear/anxiety	54 [52, 56]	40 [29, 51]	37 [24, 51]	34 [31, 36]	21 [14, 28]	45 [40, 50]	52 [43, 61]	40 [33, 46]
Aggression	36 [34, 39]	35 [25, 46]	33 [21, 47]	22 [20, 24]	20 [13, 27]	35 [30, 40]	32 [24, 41]	29 [23, 35]
Jumping	28 [26, 30]	40 [29, 51]	33 [20, 47]	29 [26, 31]	20 [13, 27]	29 [24, 34]	25 [17, 33]	27 [21, 33]
Excessive barking	20 [18, 22]	25 [15, 35]	29 [17, 43]	16 [14, 18]	6.6 [2.8, 11]	22 [18, 26]	22 [14, 30]	15 [11, 20]
Coprophagia	20 [18, 22]	16 [8.0, 24]	24 [12, 36]	16 [14, 18]	13 [7.8, 19]	16 [12, 20]	10 [5.1, 16]	15 [10, 20]
Obsessive-compulsive/compulsion	18 [16, 20]	19 [11, 29]	33 [21, 47]	12 [11, 14]	3.7 [0.76, 7.2]	17 [13, 21]	18 [11, 26]	15 [10, 20]
House soiling	19 [17, 21]	19 [11, 29]	29 [17, 43]	9.5 [7.9, 11]	2.9 [0.68, 6.1]	14 [10, 18]	18 [11, 26]	20 [15, 25]
Rolling in repulsive material	13 [11, 15]	22 [13, 32]	12 [3.6, 21]	12 [10, 13]	6.6 [2.8, 11]	11 [8.1, 15]	12 [6.4, 19]	16 [11, 20]
Overactivity/hyperactivity	14 [12, 15]	26 [16, 36]	12 [3.7, 21]	11 [9.0, 12]	5.9 [2.3, 10]	11 [8.1, 15]	12 [6.4, 18]	12 [7.6, 16]
Destructive behavior	15 [13, 17]	17 [8.8, 26]	12 [3.8, 21]	7.8 [6.4, 9.2]	5.9 [2.2, 10]	14 [10, 18]	9.6 [4.5, 15]	13 [8.7, 17]
Running away/escaping	13 [11, 14]	16 [7.9, 24]	12 [3.8, 21]	7.8 [6.4, 9.3]	2.9 [0.68, 6.1]	14 [11, 18]	16 [9.3, 23]	9.8 [6.0, 14]
Mounting/humping	10 [9.0, 12]	16 [7.8, 24]	16 [6.3, 26]	11 [9.0, 12]	3.7 [0.77, 7.1]	9.6 [6.6, 13]	16 [9.2, 23]	12 [7.6, 16]

n = 4083.

Owner-directed aggression

An association was found between owner-directed aggression and maleness (OR, 1.85; 95% CI: 1.45-2.36; n = 4100; $P < 10^{-6}$).

Running away/escaping and fear/anxiety

An association was found between running away/escaping and fear/anxiety (OR, 1.65; 95% CI: 1.36-2.01; $P < 10^{-6}$). Twenty-eight percent of dogs that ran away/escaped had nonspecific situational anxiety, 25% had fear of crowds, 24% had noise phobia, 23% had fear of veterinary visits, 21% had separation anxiety, and 19% had thunderstorm phobia. No association was found between dogs that escaped confinement and general fear/anxiety (OR, 0.93; 95% CI: 0.64-1.36; n = 439; $P = 0.70$).

Discussion

The prevalence of canine behavior problems was found to be 85% in the study sample. This puts our overall prevalence finding within the range of 42% to 87% found in previous studies (Beaver, 1994; Campbell, 1986), although the number and categories of behavior problems investigated varied considerably between studies. It stands to reason that if the net is cast wide when surveying owners about their dog's behavior problems, then the percentage of problems reported will be greater. Our study had a wide selection of major and minor behavior problems included, which probably accounts for the high percentage of problems identified and reported by owners.

Table 7
Prevalence of behavior problem categories, by lineage

Behavior problem	Prevalence (%) [CI _{95%}]	
	Purebred	Nonpurebred
Fear/anxiety	38 [36, 40]	53 [51, 55]
Aggression	26 [24, 28]	36 [34, 38]
Jumping	26 [24, 28]	31 [29, 33]
Excessive barking	16 [15, 18]	21 [19, 23]
Coprophagia	18 [17, 20]	17 [15, 19]
Obsessive/compulsive/compulsion	15 [13, 16]	17 [15, 19]
House soiling	14 [12, 15]	17 [15, 19]
Rolling in repulsive material	11 [9.9, 12]	14 [13, 16]
Overactivity/hyperactivity	11 [9.9, 13]	14 [12, 15]
Destructive behavior	9.5 [8.3, 11]	15 [14, 17]
Running away/escaping	8.5 [7.4, 9.7]	14 [12, 15]
Mounting/humping	9.2 [8.1, 10]	12 [11, 14]

n = 4058.

From our data, male dogs were found to be slightly more likely to have behavior problems than females. This trend did not hold when dogs that engage in mounting/humping behavior were excluded from the calculation. Neutered males and females were almost twice as likely to exhibit behavior problems as intact dogs. This finding supports those of Chung et al. (2016) who reported that neutered dogs showed more unacceptable behaviors than intact dogs. The cause of the difference is not immediately apparent and cannot be obtained in this type of study, although the increased prevalence of behavior problems in neutered females may be a result of the loss of the calming effect of progesterone after spaying. The fact that progesterone derivatives offset postspay aggression provides some evidence for this assertion (O'Farrell & Peachey, 1990). Because this study did not analyze at what age, why or changes in behavior associated with neutering procedure (e.g., hospitalization, fear, pain, intervention), and so forth, conservative interpretation is warranted. No causal associations are implied here. Dogs from rescue situations displayed significantly more behavior problems than dogs acquired from breeders (Table 6). This could be because of the rough start and adverse circumstances that many rescued, rehomed, and commercially traded dogs are forced to endure. However, it is also possible that dogs were surrendered to rescue organization because they had pre-existing behavior problems.

The median number of behavior problems per dog was 2, which is similar in magnitude to the 1.6 behavior problems per dog reported by Bamberger and Houpt (2006), although much lower than the 11.3 behavior problems per dog reported by Blackwell (2008). Dogs younger than 3 years had a median number of 3 problems

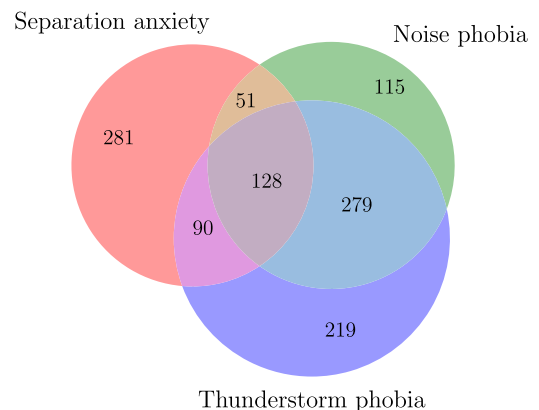


Figure 2. Separation anxiety, noise phobia, and thunderstorm phobia.

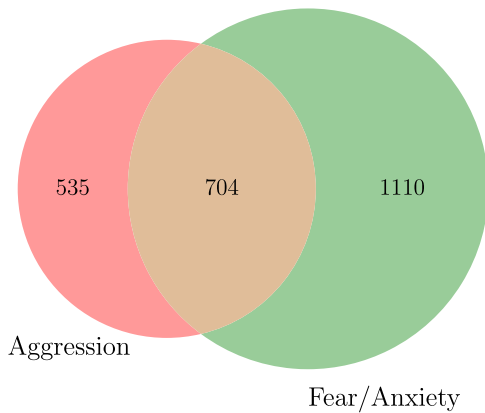


Figure 3. Overall aggression and fear/anxiety.

each, whereas dogs older than 3 years had a median number of 2 problems each. Surprisingly, there was no difference in prevalence of behavior problems in dogs less than, or greater than, 12 months of age, or by age of onset for most of the behavioral issues reported (Table 5). In comparison with dogs acquired from a rescue, dogs acquired from breeders had a lower prevalence of almost all (10 of 12) categories of behavior problems (Table 6) and lower number of behavior problems per dog. It is probable that dogs from breeders receive more positive attention during an early sensitive period of their development. In comparison with mixed breed dogs, purebred dogs had a lower prevalence of almost all (11 of 12) categories of behavior problems (Table 7) and a lower number of behavior problems per dog. Once again, this finding may be attributable to a better start in life. Fear- and anxiety-based problems, occurring in 44% of cases in our study, were the most prevalent behavior problems reported. This percentage is in the same order of magnitude found in other demographic studies of canine behavior (Tiira et al., 2016; Kurachi et al., 2017).

Separation anxiety was reported in 13% of dogs in this study. The percentage of dogs with owner-described separation anxiety is comparable to what has previously been reported (Novartis Round Table, 1999; Tiira et al., 2016). The association between separation anxiety and destructive behavior was an expected finding because destructive behavior is one of the classical signs of separation anxiety, occurring in over 70% of cases (Flannigan & Dodman, 2001). Similarly, the association between separation anxiety and house soiling was anticipated as house soiling in the owner's absence is another cardinal sign of separation anxiety.

Thunderstorm phobia, a frequently related fear/anxiety-based condition, was reported in 14% of dogs. Other specific anxiety-

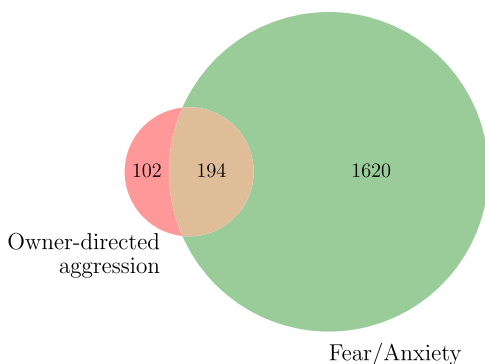


Figure 4. Owner-directed aggression and fear/anxiety.

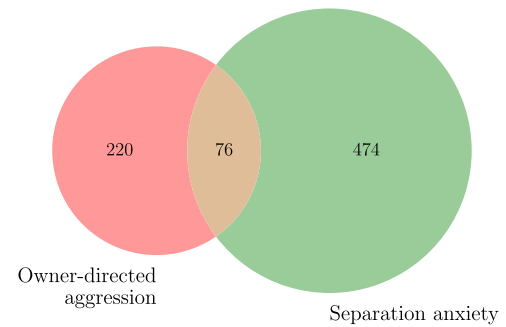


Figure 5. Owner-directed aggression and separation anxiety.

and fear-based conditions such as fear of crowds, fear of veterinary visits, travel anxiety, phobia of other dogs (without aggression), and generalized anxiety were reported in 19, 17, 11, 10, and 8.7% of dogs, respectively. The prevalence of these conditions has not been previously reported; neither has the prevalence of canine post-traumatic stress disorder, which owners ascribed to their dogs in 4.3% of cases. It can be argued that owners are incapable of diagnosing canine post-traumatic stress disorder but noting a sudden and profound change in a dog's behavior after a terrifying event may not be beyond most owners' grasp. The frequency reported here is in the same range (approximately 5%) as that estimated for deployed military working dogs (Burghardt & Holland, 2013).

In agreement with other studies, significant comorbidity existed between the various types of fear and anxiety. The substantial overlap between noise phobia and thunderstorm phobia, as seen in Figure 2, is striking. Overall et al. (2001) and Tiira et al. (2016) found similar comorbidity between these two conditions. Interestingly, noise phobia is not a necessary component of thunderstorm phobia, and thunderstorm phobia can exist in dogs that do not have noise phobia. There appears to be something unique about thunderstorm phobia that distinguishes it from simple noise phobias. That distinction may be the composite nature of thunderstorm phobia, which apparently involves multiple unpredictable cues including sound, light, and other fear-conditioned stimuli.

The overlap between thunderstorm phobia, noise phobia, and separation anxiety that we found was like that reported by Overall et al. (2001). Others, however, did not find such an association (Blackwell et al., 2013). In fact, according to our survey results, all three of these fear-related conditions frequently coexist in what might be referred to as global anxiety (Figure 2).

Aggression was the second most common behavior problem reported (30% of dogs). The percentage of dogs displaying aggression was much lower than that of some other studies, such as those

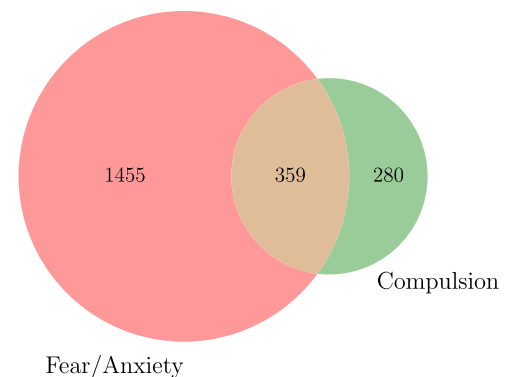


Figure 6. Compulsion/obsessive-compulsive and fear/anxiety.

of Bamberger and Houpt (2006) and Denenberg et al. (2005), who noted aggression in around 70% to 72% of cases. The difference is likely a result of the fact that the latter studies were behavioral-clinic-based studies and owners of aggressive dogs may be more likely to seek help in managing this problem. Interestingly, aggression to other dogs in its various forms accounted for 4 of the 5 top targets of aggression in our study, with aggression to other dogs on walks topping the list at 16% of the total number of dogs in our study. The prevalence of aggression toward other dogs, both outside and within the home, was in the same order of magnitude as that described by Casey et al. (2013b). Aggression toward strangers visiting the home (10%) and outside the home (7.9%) was slightly higher in prevalence than that reported by Casey et al. (2013a) who reported 4.9% and 3.4% prevalence of these behaviors, respectively.

Aggression toward familiar people in the home, currently termed conflict aggression, accounted for 7.2% of aggression in our study. This percentage is considerably different from that reported by Bamberger and Houpt (2006) who described owner-directed aggression in 44% of cases. The animal behavior clinic caseload of the Bamberger and Houpt study probably accounts for this difference, as discussed previously. Aggression to other animals in the home—presumably mostly cats and with a predatory motivation—came in at a 4.2% prevalence with aggression to veterinarians, groomers, and trainers all registering at less than 4% prevalence.

Fear/anxiety was a concurrent trait in over half of the dogs displaying any form of aggression. The degree of overlap can be seen in Figure 3. Furthermore, fear/anxiety was comorbid in many cases of owner-directed (conflict) aggression (Figure 4). However, not all cases of aggression or owner-directed aggression involved a fearful or anxious component. Forty-three percent and 35% of dogs displaying aggression or owner-directed aggression, respectively, had no reported concomitant fearful or anxious behaviors. It is possible that some owners were not aware of their dog's anxiety-related issues, but if our finding can be replicated in subsequent studies, it is in contrast with the results of another large survey-style study suggesting fear as the primary motivator for aggression (Tiira et al., 2016). Narrowing the focus to owner-directed aggression, we found an owner-reported absence of involvement of fear/anxiety conditions in approximately one-third of dogs displaying this form of aggression. Whether these nonanxious dogs are displaying some type of status-related aggression or conflict aggression is controversial (Luescher & Reisner, 2008). Perhaps the nonanxious dogs displaying owner-directed aggression are more irritable than fearful, responding to what they consider to be annoying behaviors on the part of their owners. It is possible that owners misinterpret normal canine behaviors as owner-directed aggression although such confusion seems unlikely. In support of this contention, male dogs were almost twice as likely to display owner-directed aggression as females, whereas anxiety/fear-related conditions tend to be evenly distributed between the sexes. Accordingly, owner-directed aggression in nonanxious/fearful dogs might be more precisely termed "instrumental," as defined by Moyer (1968), as all forms of aggression involve conflict.

Bite severity was interesting and different from what we expected. Of note is the high number of dogs (91%) that had never bitten a person or another dog. Also surprising was that almost a third of dogs that bit exhibited multiple bites per incident, and that many dogs had bitten multiple different people or other dogs. Around a third of dogs bit without penetrating the skin, which means around two-thirds of dog bites did penetrate the skin of their target. This is an alarming high figure of dogs showing little to no bite inhibition. Various specific anxiety-related problems were found to underlie biting, but none stood out as exceptional.

Jumping up on people was the third most prevalent behavior problem reported. The 28% of dogs reported to exhibit such

behavior is in the same range as that reported by Campbell (1986), but much higher than the 6.1% prevalence reported by Beaver (1994). Jumping up on people is a relatively easy problem to fix with appropriate training but is rarely the kind of problem referred to veterinarians, so its prevalence often goes under-reported or unreported in clinic-based behavior problem surveys.

Excessive barking was reported in 18% of the dogs in this survey. Previous studies have quoted the prevalence of excessive barking between 2.7% and 12.9% (Bamberger & Houpt, 2006; Beaver 1994; Campbell, 1986). Again, the higher prevalence reported in our study may be attributed to the fact that the survey question was asked and that it was asked to a more general audience.

A high percentage of dogs were reported to exhibit coprophagia (18%). Information about coprophagia by dogs is often unsolicited in surveys, but in those surveys where the question was addressed, the prevalence ranged from 0.2% (Beaver 1994) to 44% (Nijssen et al., 2014). In the latter study, the type of feces was not specified, although in our study we did ask whether the dogs consumed its own feces, other dogs' feces, or the feces of another species (e.g., horse). There did not appear to be an overall predilection for feces from any source.

The prevalence of compulsive behaviors in this study was 16%. Table 5 shows the breakdown of these owner-reported abnormal repetitive behaviors. The striking finding here was the high percentage (8.1%) of behaviors assigned as repetitive behaviors that involved licking the wrist or hock. If owners' observation of their dogs' behavior was accurate, there is no reason to think that this number is imprecise in terms of the question asked, although the repetitive wrist/hock licking they report may not be at a level formally diagnosable as "compulsive." Licking the wrist or hock can be a displacement behavior at times of boredom or stress that does not result in acral lick dermatitis and/or lick granuloma. In addition, painful conditions of the carpus or tarsus, for example, caused by arthritis, tumor, or foreign body, may cause dogs to lick the affected area. Wrist or hock licking from any cause can sometimes be a precursor trigger for compulsive licking of the extremities. Acral lick dermatitis *per se* no doubt contained within our prevalence demographic, but it is impossible to say with any accuracy what the prevalence of compulsive acral lick is without a formal veterinary diagnosis (which we could ascertain by going back to these owners with a request for such veterinary information). Other individual compulsive behaviors fell within the range of 0.61% to 3.1%. Prevalence rate for obsessive-compulsive disorder in people has been described as low as 0.7 and as high as 8% (Torres et al., 2017). Of course, considerable variation occurs in the reported rate in dogs and people because it depends on the scope of behaviors considered as compulsive as well as the study methodology.

House soiling was reported in 9% of cases in a retrospective, university-based study (Yeon et al., 1999). Beaver (1994) found 7.4% of cases involved house soiling in a meta-analysis of principally veterinary caseloads. Our finding of a 15% prevalence of this unwanted behavior is higher probably because, as previously mentioned, it involved questioning owners directly (not ones who sought veterinary assistance with the problem). In addition, we asked if house soiling had ever been a problem with their dog. Either way, house soiling is a significant problem in terms of its frequency and the serious consequences of it if it persists untreated. Salman et al. (2000) refer to it as one of the major causes of relinquishment of dogs to shelters. The breakdown of cases involving house soiling is shown in Table 3. A majority of dogs eliminated both urine and feces, indicating a house-training issue. Elimination issues were equally common whether the owner was at home or away, although many of the dogs eliminating while their owner was away probably had had separation anxiety. The idea of asking whether the dog eliminated in strategic locations was to determine the prevalence of urine marking. The 8% prevalence figure obtained

in this way may reflect that proclivity. Less common causes of house soiling were excited urination (3.1%) and fecal house soiling (0.88%).

Rolling in repulsive stuff was reported to occur at 13% prevalence. Most demographic studies fail to list this as a behavior problem, so we could not find prior evidence of its prevalence. As natural as this behavior may be, it is still one that most owners find disgusting and would prefer that it did not occur. Rolling in dead things topped the list in our study with rolling in feces being the second most common substrate in which to roll.

Overactivity/hyperactivity was reported to be problematic in 12% of dogs in this study. It is likely that a majority of these dogs were overactive, as opposed to having attention deficit hyperactivity disorder, as the latter diagnosis is rare and requires sophisticated diagnosis (Vas et al., 2007). The individual signs of overactivity we assessed, including difficulty settling, constantly moving/jumping, impulsivity, and distractibility, each ranged in prevalence from 5.4% to 7.6%. We found that dogs under 12 months of age (puppies) were more likely to be regarded as overactive by their owners. This could be because of puppies' high energy level. Overactivity is probably not so much a behavioral condition *per se* as a sign of youthful vigor and high energy in conjunction with insufficient acceptable behavioral outlets.

Destructive behavior was reported in 13% of dogs. Although puppy chewing behavior associated with teething or oral exploration is probably contained within the destructive dog cohort, separation anxiety–linked destructive behavior probably accounts for the vast majority of it. When we analyzed the possible link between separation anxiety and destructive behavior, it was found that destructive behavior was over three times more likely in dogs with separation anxiety. Furthermore, from the 13% prevalence of separation anxiety we found and the fact that destructive behavior occurs in approximately 70% of dogs with separation anxiety (Flannigan & Dodman, 2001), it would be anticipated that separation anxiety would account for around 9 of the 13% percent destructive behavior. The balance of destructive behaviors (4%) would result from other etiologies, such as puppy chewing behavior, barrier frustration, and thunderstorm phobia.

Running away/escaping was reported in 11% of dogs. Approximately six percent escaped from home, whereas 5% ran away while outside, presumably on walks. We did not ask if any of these dogs were confined within an invisible fence, but it is known that some dogs confined in this way may break out. Most, but not all, of the dogs that ran away from home returned after the escape. Our results confirmed that dogs that ran away/escaped tended to be those with nonspecific situational anxiety (28% of dogs that ran away/escaped) and other fears, including noise phobia, fear of crowds, separation anxiety, and thunderstorm phobia. We could not find any previous estimates of the prevalence or comorbidity of running away/escaping, so there is no yardstick for comparison. Five percent of dogs escaped from confinement. This behavior is often associated with dogs that have separation anxiety that tend to be “escape artists”; however, our results did not support this association.

Cannas et al. (2018) reported that 24.8% of dogs engaged in mounting people. Sixty-seven percent of these dogs were anxious in nature, whereas 33% were aggressive. Curiously, we found a much lower prevalence of dogs in our study that engaged in mounting people (3.7%). The percentage of dogs mounting other dogs was similar, ranging between 2.5% for mounting inanimate objects, such as stuffed toys, and 6.3% toward familiar dogs. Mounting directed toward unfamiliar dogs occurred at a comparable rate (2.7% of dogs in our study). No personality traits of dogs mounting people, or other dogs, were found to be significant. However, the observation that familiar dogs were twice as likely to be subjected to mounting behavior suggests anxiety, or lack thereof, may be a factor.

The strengths of this study are that it is large (4114 dogs) and that the population was not biased by the fact that only dogs referred to clinics or veterinary hospitals were involved. All studies are biased to some extent, and owners reporting on their dogs in this study were unique in the sense that they were members or visitors of the CCBS website willing enough to complete a detailed questionnaire, and several times in the case of a multiple dog household. They may not be typical dog owners in this regard, but the prevalence and concordance numbers we produced were compatible with what has been previously reported. In that sense, we believe our findings will make a useful contribution, helping guide people who have an interest in the prevalence and comorbidity of canine behavior problems.

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Conflict of interest

The authors of this article do not have a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the article.

Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jveb.2019.04.007>.

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