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Breed differences in canine aggression

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Abstract

Canine aggression poses serious public health and animal welfare concerns. Most of what is understood about breed differences in aggression comes from reports based on bite statistics, behavior clinic caseloads, and experts' opinions. Information on breed-specific aggressiveness derived from such sources may be misleading due to biases attributable to a disproportionate risk of injury associated with larger and/or more physically powerful breeds and the existence of breed stereotypes. The present study surveyed the owners of more than 30 breeds of dogs using the Canine Behavioral Assessment and Research Questionnaire (C-BARQ), a validated and reliable instrument for assessing dogs' typical and recent responses to a variety of common stimuli and situations. Two independent data samples (a random sample of breed club members and an online sample) yielded significant differences among breeds in aggression directed toward strangers, owners and dogs (Kruskal–Wallis tests, $P < 0.0001$).

Eight breeds common to both datasets (Dachshund, English Springer Spaniel, Golden Retriever, Labrador Retriever, Poodle, Rottweiler, Shetland Sheepdog and Siberian Husky) ranked similarly, $r_s = 0.723$, $P < 0.05$; $r_s = 0.929$, $P < 0.001$; $r_s = 0.592$, $P = 0.123$, for aggression directed toward strangers, dogs and owners, respectively. Some breeds scored higher than average for aggression directed toward both humans and dogs (e.g., Chihuahuas and Dachshunds) while other breeds scored high only for specific targets (e.g., dog-directed aggression among Akitas and Pit Bull Terriers). In general, aggression was most severe when directed toward other dogs followed by unfamiliar people and household members. Breeds with the greatest percentage of dogs exhibiting serious aggression (bites or bite attempts) toward humans included Dachshunds, Chihuahuas and Jack Russell Terriers (toward strangers and owners); Australian Cattle Dogs (toward strangers); and American Cocker Spaniels and Beagles (toward owners). More than 20% of Akitas, Jack Russell Terriers and Pit Bull Terriers were reported as displaying serious aggression toward unfamiliar dogs. Golden Retrievers, Labradors Retrievers, Bernese Mountain Dogs, Brittany Spaniels, Greyhounds and Whippets were the least aggressive toward both humans and dogs. Among English Springer Spaniels,

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conformation-bred dogs were more aggressive to humans and dogs than field-bred dogs (stranger aggression: Mann–Whitney U test, $z = 3.880$, $P < 0.0001$; owner aggression: $z = 2.110$, $P < 0.05$; dog-directed aggression: $z = 1.93$, $P = 0.054$), suggesting a genetic influence on the behavior. The opposite pattern was observed for owner-directed aggression among Labrador Retrievers, ($z = 2.18$, $P < 0.05$) indicating that higher levels of aggression are not attributable to breeding for show per se.

Keywords: Aggression; Dog; Breed; Agonistic behavior

1. Introduction

Canine aggression presents serious public health, economic and animal welfare concerns. Recent reports estimate that hospital emergency rooms treat over 300,000 dog bite injuries per year in the USA, nearly half of which involve children under the age of 15 years. Approximately 2–4% of all dog bite cases require hospitalization (Weiss et al., 1998; Centers for Disease Control and Prevention, 2003).

In a study of 12 different animal shelters across the USA, 40% of relinquishing owners cited behavioral problems as one of the reasons for surrendering a dog. When behavior was the only reported reason for relinquishment, aggression was the most frequently cited problem (40% of dogs) (Salman et al., 1998).

Four primary approaches have been used to investigate breed-related variation in aggressive behavior: analyses of dog bite statistics (e.g., Gershman et al., 1994; Lockwood, 1995; Guy et al., 2001b; Reisner et al., 2005), behavior clinic/consultant caseloads (e.g., Beaver, 1983; Borchelt, 1983; Blackshaw, 1991; Bamberger and Houpt, 2006), the opinions of dog experts (veterinarians and trainers; e.g., Hart and Hart, 1985; Bradshaw and Goodwin, 1998; Takeuchi and Mori, 2006; Notari and Goodwin, 2007) and the results of behavioral testing (e.g., Svartberg, 2006). Each method has its drawbacks.

Dog bite statistics are potentially misleading for several reasons: (a) most dog bites go unreported unless medical attention is sought (which may be more likely with larger breeds that have the ability to inflict more serious injury); (b) the total number of dogs of a given breed in the local community is seldom known, so the degree to which that breed is over-represented among reported dog bites is usually undetermined (Lockwood, 1995; however see Gershman et al., 1994; Guy et al., 2001b; Reisner et al., 2005); and (c) in many cases the breed of dog involved cannot be verified (Wright, 1991).

Breed-specific data on aggression derived from behavior clinic/consultant caseloads are also likely to be unrepresentative. Because of the greater risk of injury posed by larger, more powerful dogs, owners of these dogs are more likely to seek professional help in dealing with canine aggression. In addition, dog owners dealing with aggression directed toward themselves or members of their family are more likely to seek professional help compared to pet owners whose dogs are aggressive toward unfamiliar people or animals (Bamberger and Houpt, 2006).

Hart and Hart (1985) pioneered the use of animal 'experts' (e.g., veterinarians and obedience judges) as sources of information on the prevalence of various desirable and undesirable behaviors among popular dog breeds. Their methods, which involve asking experts to rank breeds on a series of traits, have also been applied to studies of breed differences in countries other than the USA, e.g., the UK (Bradshaw and Goodwin, 1998), Italy (Notari and Goodwin, 2007), and Japan (Takeuchi and Mori, 2006), and have provided evidence of agreement regarding

levels of aggression in some breeds. Unfortunately, with surveys of this type, it is difficult to ascertain whether agreement among experts about the aggressiveness of a particular breed, either within or between countries, reflects true consistencies in breed behavior or simply shared stereotypes.

In contrast to opinions based upon breed generalizations, assessments directed at individual dogs may be less susceptible to bias related to breed stereotypes (Notari and Goodwin, 2007). Such assessments include behavioral tests and dog owner surveys. Behavioral testing for aggression involves exposing dogs to one or more startling or potentially threatening stimuli and noting any signs of aggressive responses. A recent Swedish study using behavioral test scores of over 13,000 dogs representing 31 breeds found significant differences across breeds and among breed lines derived from different breeding stocks (e.g., show dogs, hunting, working or herding) (Svartberg, 2006). However, the accuracy with which behavioral tests reflect a dogs' typical behavior has been called into question (van den Berg et al., 2003). The tests used in the Swedish study have been extensively evaluated for reliability and validity and, although most traits measured by the test met validity criteria, aggressiveness was poorly associated with owner assessments (Svartberg, 2005). Several studies aimed at validating aggression tests using pet dog populations report some validity with respect to owner accounts (van der Borg et al., 1991; Planta and De Meester, 2007); however, there is often a large proportion (>20%) of cases in which dogs passed aggression tests despite having a history of biting (Netto and Planta, 1997; Kroll et al., 2004). A recent study has demonstrated that temperament testing of shelter dogs often fails to detect some forms of aggression (e.g., territorial, predatory and intra-specific) that are difficult to simulate in a test situation (Christensen et al., 2007).

Often used as means of validating behavioral tests, questionnaire surveys of dog owners typically provide more detailed information regarding a dog's tendency to display different classes of aggression because owners have the opportunity to observe the animal in a variety of situations over an extended period of time. However, dog owner reports have a greater potential for subjective bias compared to more objective behavioral observations (Hsu and Serpell, 2003).

The goal of the present study was to investigate breed differences in the prevalence and severity of different forms of aggressive behavior in dogs using a research design that avoids some of the problems described above. We utilized a survey method, the Canine Behavioral Assessment and Research Questionnaire (C-BARQ©), that has been demonstrated to meet validity and reliability criteria (Hsu and Serpell, 2003). The findings are compared with those of previous studies of breed differences in aggression that have used other sources of data.

2. Methods

2.1. Data collection and survey methods

Behavioral data on aggression were collected from dog owners using the C-BARQ. Details of this survey, its validation and its internal reliability, have been described elsewhere (Hsu and Serpell, 2003; Serpell and Hsu, 2005). Briefly, the C-BARQ is a standardized questionnaire designed to assess the prevalence and severity of behavior problems in dogs. It consists of 101 items that ask owners to indicate how their dogs have responded, ''in the recent past'' to a variety of common events and stimuli using a series of 0–4 rating scales (where 0 = none and 4 = serious). Originally, 68 of these items were condensed by factor analysis into 11 distinct subscales (Hsu and Serpell, 2003). Two new subscales, 'dog rivalry' and 'energy level', were added subsequently and were thus not included in the Breed club survey (described below). An example of a typical questionnaire aggression item and preamble can be viewed in Supplementary data.

For the purposes of analysis, subscale scores are calculated as the average of the scores for the questionnaire items comprising each factor. In the present paper, we focus on four subscales related to aggression. The aggression subscales address aggressive responses of dogs to different targets: unfamiliar people (stranger-directed aggression, SDA), familiar people (owner-directed aggression, ODA), unfamiliar dogs (dog-directed aggression, DDA), and familiar dogs living in the same household (dog rivalry, DR). Because fearful responses are often associated with the expression of aggressive behavior in dogs (Lindsay, 2001, pp. 171–172), we included two additional subscales that address fearful responses directed toward unfamiliar people (stranger-directed fear) and unfamiliar dogs (dog-directed fear) for some analyses.

Calculation of Cronbach's alpha coefficients (Cronbach, 1951) for the individual aggression subscales obtained coefficients greater than 0.80, indicating a high level of internal reliability for these scales (Nunnally, 1978, p. 245; Carmines and Zeller, 1979, p. 51). Similarly, independent (i.e. without conferring) C-BARQ ratings of a sample of 75 dogs by pairs of owners (e.g., spouses or partners) have also confirmed that the aggression subscales have good inter-rater reliability characteristics. Average weighted Kappa coefficients ranged from 0.4 to 0.6 ($P < 0.0001$), which is considered to be a moderate to substantial degree of inter-rater agreement (Landis and Koch, 1977). The average weighted percent agreement between pairs of raters exceeded 90% for all aggression subscales. Intraclass correlation coefficients (ICC) (Bartko, 1966; Shrout and Fleiss, 1979) of the calculated subscales also indicate a moderate to high degree of inter-rater reliability (SDA ICC = 0.84; ODA ICC = 0.91; DDA ICC = 0.69; DR ICC = 0.60). Using a sample of 200 clinical referral cases, the construct validity of these subscales was established by confirming their effectiveness at discriminating between dogs independently diagnosed as either displaying or not displaying corresponding behavior problems (Hsu and Serpell, 2003).

2.2. Participants

2.2.1. Breed club sample

Study participants consisted of members of 11 American Kennel Club (AKC) recognized national breed clubs (see Serpell and Hsu, 2005 for details). C-BARQ questionnaires were distributed to breed club members by ordinary mail together with an explanatory letter, and a pre-paid return envelope. In an effort to 'randomize' the samples, recipients from most of the clubs were selected from either the first or last 300 members listed alphabetically in each club's membership directory. The Labrador Retriever Club elected to distribute the C-BARQ to its own members, and sent questionnaires to the first 488 members listed alphabetically in its directory. The English Springer Spaniel Field Trial Association also chose to distribute the C-BARQ: all 187 members with field (working)-bred Spaniels were sent questionnaires, and the Trinity College (Dublin, Ireland) online random number generator (http://random.org/) was used as the basis for sampling 300 out of a total of 367 members with conformation (show)-bred Spaniels. In addition to the C-BARQ assessments, information was also collected on each dog's age, sex and neuter status. For the Labrador and English Springer Spaniel breeds, owners were also asked to state whether the dog was field or conformation (show)-bred, if known.

To ensure statistical independence, each respondent was asked to assess only one dog, preferably one that was well known, that was at least 1 year old at the time of assessment in order to reduce maturational effects (Serpell and Jagoe, 1995).

2.2.2. Online sample

Beginning in April 2006, free access to an online version of the C-BARQ (http://www.vet.upenn.edu/cbarq) became available to pet owners. The online survey was advertised via an article in the newsmagazine of the Veterinary Hospital of the University of Pennsylvania, USA (http://www.vet.upenn.edu/bellwether/v64/article10.shtml) and by notices sent to Philadelphia-area veterinary clinics and the top 20 USA breed clubs based on AKC registrations. Availability of the survey then spread via word of mouth. This sample of dog owners is therefore self-selected which we note as a potential source of bias. Breed designations are based entirely upon owner assertions.

Owners were permitted to complete questionnaires for as many dogs as they wished. However, for data analysis we used a random number generator (available as part of the statistics software, SPSS 15.0, SPSS, Inc.) to randomly select only one dog per owner to ensure statistical independence. Only breeds for which at least 45 dogs were surveyed were included in analyses.

2.3. Analyses

Data were analysed using SPSS 15.0 for Windows (SPSS, Inc.). Due to non-normality of the data that could not be corrected with transformation, non-parametric tests were used to analyse differences in C-BARQ subscale scores. Mann–Whitney U and Kruskal–Wallis tests were used for between-group comparisons of continuous variables (age and aggression subscale scores). Chi-square tests of independence were used for analyses of sex ratios and frequency of neutered/spayed dogs. To distinguish dogs that tended to engage in aggressive displays (e.g., barking, growling, etc.) from those that actually bit or attempted to bite, the proportion of dogs in each breed that scored at least one ''4'' (''snaps, bites or attempts to bite'') on items pertaining to each of the aggression subscales was calculated. Because inter-dog aggression within a household can only occur if there is more than one dog, 'dog rivalry' cases that had missing values for all four questions that comprise this subscale were excluded. Spearman rank order correlation coefficients were used to assess associations between breed means for C-BARQ subscale scores and percentages reported as biting.

Correlations among the subscales were determined using Spearman rank order correlation coefficients. Partial correlations were used to assess the relationship between ODA and DR while controlling for DDA and SDA. To assess breed differences in aggressiveness relative to fearfulness, we subtracted the population mean from the mean of each breed for stranger- and dog-directed aggression and fear.

To assess how breeds common to both the online and breed club datasets compared to one another, Spearman rank order correlation coefficients were used to compare mean subscale scores.

3. Results

3.1. Descriptive statistics

3.1.1. Breed club sample

A total sample of 1553 complete C-BARQs were returned (average return rate 49%). Twenty-four cases were removed due to missing data regarding the dog's sex (three cases) or age (21 cases). Despite our instructions, a small number of dogs were less than 1 year old ($n = 27$). Dogs that were less than 6 months old (five cases) or greater than 17 years old (three cases) were excluded from the data to eliminate possible effects of extreme immaturity and senility, respectively. Table 1 summarizes the primary descriptive characteristics of the sample. Breeds did not differ significantly from one another with respect to sex ratio but there were significant breed differences in the ratio of intact to neutered dogs ($\chi^2 = 60.81$, d.f. = 10, $P < 0.0001$). Overall, there were more intact dogs compared to neutered dogs among most breeds. Breeds also differed from one another in age (Kruskal–Wallis $H = 63.83$, d.f. = 10, $P < 0.0001$).

3.1.2. Online sample

A total of 8260 complete C-BARQs were available as of December 3, 2007. Of those, 1257 dogs whose breed status was reported as 'mixed/unknown' were removed from the data. Removing breeds with fewer than 45 dogs (2051 dogs representing 143 breeds) left 4952 dogs. Random selection of one dog for each owner provided 3791 C-BARQs that were included in analyses, representing 33 different breeds (Table 2). There were significant breed differences for sex ratio ($\chi^2 = 48.97$, d.f. = 32, $P < 0.05$) and in the ratio of intact to neutered dogs ($\chi^2 = 251.84$,

Table 1
Descriptive statistics of the breed club sample of dogs used in the study

Breed	*n*	Female (%)	Neutered (%)	Age in years (mean ± S.D.)
Basset Hound	151	52.98	50.99	5.65 ± 3.10
Dachshund	120	47.50	44.17	6.58 ± 3.46
English Springer Spaniel	247	51.01	27.94	5.06 ± 2.42
Golden Retriever	179	46.37	49.72	5.29 ± 2.83
Labrador Retriever	277	53.43	25.63	5.68 ± 2.83
Poodle[a]	69	60.89	34.78	6.87 ± 3.43
Rottweiler	92	50.00	41.30	6.00 ± 2.94
Shetland Sheepdog	112	47.32	49.11	7.48 ± 3.79
Siberian Husky	92	42.39	42.39	7.31 ± 4.08
West Highland White Terrier	92	60.87	44.57	6.66 ± 3.64
Yorkshire Terrier	90	60.00	44.44	6.12 ± 3.02
All breeds	1521	51.55	39.18	5.99 ± 3.20

[a] Includes standard, miniature, and toy varieties.

d.f. = 32, $P < 0.0001$). In contrast to the breed club survey, the proportion of neutered dogs was greater than intact dogs for all breeds. As in the breed club survey, breeds differed from one another in age (Kruskal–Wallis $H = 139.99$, d.f. = 32, $P < 0.0001$). Ages ranged from 6 months to 17 years.

The breed club and online samples differed from each other in three main respects. The ratio of intact to spayed/neutered dogs was significantly higher in the breed club sample ($\chi^2 = 567.66$, d.f. = 1, $P < 0.0001$), and the ratio of males to females was somewhat lower ($\chi^2 = 5.56$, d.f. = 1, $P < 0.025$). The dogs in the breed club sample were also, on average, older than the dogs in the online sample (Mann–Whitney *U* test: $z = 18.42$, $P < 0.0001$; Tables 1 and 2).

3.2. Breed differences in aggression

3.2.1. Breed club sample

As shown in Fig. 1A–C, significant differences were observed across the 11 breeds for scores on each of the C-BARQ aggression subscales, excluding dog rivalry which was not included in the breed club survey (Kruskal–Wallis $H = 232.06$, d.f. = 10, $P < 0.0001$; $H = 85.35$, d.f. = 10, $P < 0.0001$; $H = 52.23$, d.f. = 10, $P < 0.0001$ for SDA, ODA and DDA, respectively). A large effect size (Cohen, 1988, pp. 20–26) between subscale scores for the most and least aggressive breeds was observed for SDA (Cohen's $d = 1.55$; Dachshund vs. Siberian Husky, Fig. 1A) while medium to large effect sizes were found for DDA ($d = 0.647$; Dachshund vs. Shetland Sheepdog, Fig. 1C) and ODA ($d = 0.572$; Basset Hound vs. Labrador Retriever, Fig. 1B). To investigate the breed-specific prevalence of bites or bite attempts, as distinct from aggressive displays, we also calculated the percentage of dogs of each breed that scored at least one "4" ("snaps, bites or attempts to bite") among the questionnaire items pertaining to each subscale (Table 3). Breed average C-BARQ aggression scores were significantly positively correlated with the proportion of animals biting or attempting to bite in each breed (SDA: $r_s = 0.835$, $n = 11$, $P < 0.001$; ODA: $r_s = 0.639$, $n = 11$, $P < 0.05$; DDA: $r_s = 0.697$, $n = 11$, $P < 0.025$).

Significant positive correlations were found between subscale scores for aggression and fear directed toward both strangers ($r_s = 0.357$, $n = 1275$, $P < 0.0001$) and unfamiliar dogs

Table 2
Descriptive statistics of the online sample of dogs used in the study

Breed	*n*	Female (%)	Neutered (%)	Age in years (mean ± S.D.)
Airedale Terrier	66	51.5	75.8	4.39 ± 2.88
Akita	99	42.4	63.6	4.44 ± 2.98
Australian Cattle Dog	136	47.1	86.8	4.22 ± 3.35
Australian Shepherd	177	50.3	76.8	4.23 ± 2.95
Beagle	63	44.4	85.7	5.06 ± 3.65
Bernese Mountain Dog	67	46.3	76.1	3.87 ± 2.37
Bichon Frise	65	50.8	90.8	4.32 ± 3.14
Border Collie	163	49.7	79.1	4.41 ± 3.06
Boxer	70	47.1	82.9	4.13 ± 2.87
Brittany Spaniel	66	42.4	86.4	4.54 ± 3.34
Chihuahua	56	50.0	82.1	4.27 ± 3.28
Cocker Spaniel (American)	107	44.9	81.3	4.23 ± 3.30
Collie	132	48.5	51.5	4.72 ± 3.19
Dachshund	68	41.2	80.9	4.33 ± 3.55
Doberman Pinscher	144	59.0	56.9	4.51 ± 2.97
English Springer Spaniel	57	31.6	73.7	4.57 ± 3.64
German Shepherd	292	53.1	71.9	4.03 ± 3.10
Golden Retriever	181	48.6	81.2	4.56 ± 3.18
Great Dane	53	54.7	75.5	3.87 ± 2.92
Greyhound	62	54.8	100	5.48 ± 3.13
Havanese	73	49.3	63.0	3.05 ± 2.40
Jack Russell Terrier	78	39.7	76.9	5.33 ± 3.72
Labrador Retriever	349	50.4	79.9	4.31 ± 3.16
Mastiff (English)	126	31.7	52.4	2.27 ± 1.70
Pit Bull[a]	132	49.2	88.6	3.98 ± 3.20
Poodle[b]	169	42.6	75.7	4.71 ± 3.42
Portuguese Water Dog	75	61.3	68.0	4.41 ± 2.76
Rhodesian Ridgeback	69	46.4	52.2	4.56 ± 3.67
Rottweiler	210	47.1	55.2	3.74 ± 2.56
Shetland Sheepdog	57	50.9	82.5	5.42 ± 3.19
Siberian Husky	54	40.7	72.2	4.40 ± 3.33
Soft Coated Wheaten Terrier	216	48.1	78.2	5.12 ± 3.30
Whippet	59	49.2	71.2	4.93 ± 3.54
All breeds	3791	47.4	75.0	4.33 ± 3.15

[a] Includes American Pit Bull Terriers, American Staffordshire Terriers and Staffordshire Bull Terriers.
[b] Includes standard, miniature, and toy varieties.

($r_s = 0.311$, $n = 1356$, $P < 0.0001$), although breeds differed in their patterns of aggression relative to fear directed at strangers and dogs (Fig. 2A and B). Some breeds (e.g., Dachshund) showed high levels of both behaviors (Fig. 2A and B), some tended to be more aggressive than fearful, particularly in relation to unfamiliar dogs (e.g., West Highland White Terriers and Rottweilers, Fig. 2B), while none were markedly more fearful than aggressive.

3.2.2. Online sample

Significant differences were observed across the 33 breeds for subscale scores for each of the aggression subscales (Kruskal–Wallis $H = 383.21$, d.f. = 32, $P < 0.0001$; $H = 132.76$, d.f. = 32, $P < 0.0001$; $H = 306.93$, d.f. = 32, $P < 0.0001$; $H = 173.52$, d.f. = 32, $P < 0.0001$ for SDA,

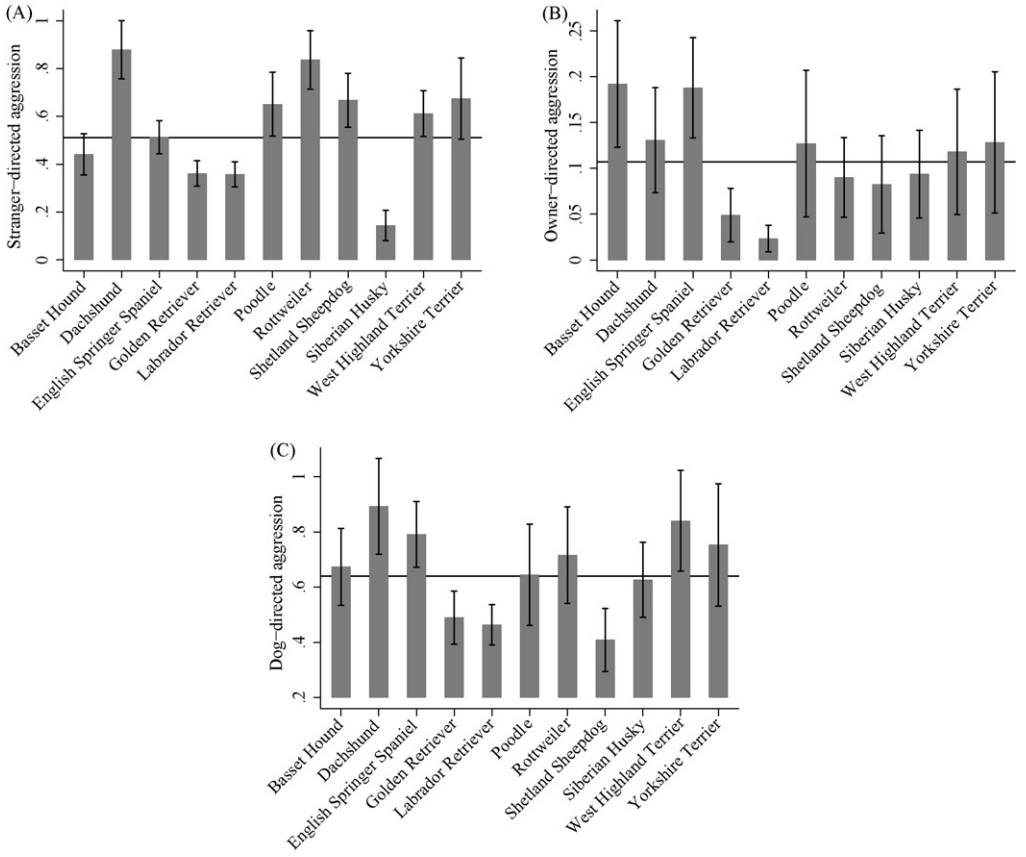

Fig. 1. Mean scores (±95% confidence intervals) for (A) stranger-, (B) owner- and (C) dog-directed aggression for each of the 11 dog breeds from the breed club survey. Horizontal bars indicate the population means.

ODA, DDA and DR, respectively; Fig. 3A–D). Large effect sizes between subscale scores for the least and most aggressive breeds were observed for SDA (Cohen's $d = 1.80$; Dachshund vs. Siberian Husky, Fig. 3A), DDA ($d = 1.16$; Akita vs. Greyhound, Fig. 3C) and DR ($d = 0.98$; Chihuahua vs. Brittany Spaniel, Fig. 3D); a medium effect size was found for ODA ($d = 0.60$; Dachshund vs. Rhodesian Ridgeback, Fig. 3B). The breed-specific prevalence of bites or bite attempts was examined as previously described (Table 4). As with the breed club sample, breed average C-BARQ aggression scores were significantly positively correlated with the tendency to bite (SDA: $r_s = 0.709$, $n = 33$, $P < 0.0001$; ODA: $r_s = 0.482$, $n = 33$, $P < 0.005$; DDA: $r_s = 0.921$, $n = 33$, $P < 0.0001$; DR: $r_s = 0.685$, $n = 33$, $P < 0.0001$).

Significant correlations were found between subscale scores for aggression and fear directed toward strangers ($r_s = 0.409$, $n = 3216$, $P < 0.0001$) and dogs ($r_s = 0.316$, $n = 3003$, $P < 0.0001$), and breeds differed in their patterns of aggression relative to fear directed at strangers and dogs (Fig. 4A and B). Again, some breeds (e.g., Dachshund and Chihuahua) displayed exceptionally high levels of aggression and fear (Fig. 4A and B), some were more aggressive than fearful, particularly with respect to other dogs (e.g., Akita, Jack Russell Terrier and Pit Pull, Fig. 4B) and only a minority was more fearful than aggressive (e.g., Greyhound and Shetland Sheepdog,

Table 3
Number of dogs of each breed from the breed club survey that received the maximum score of 4 for aggression (snaps, bites, or attempts to bite) for at least one question pertaining to each subscale

		"Snaps, bites, or attempts to bite"		
	n	Stranger aggr.	Owner aggr.	Dog aggr.
Basset Hound	151	1 (0.66)	4 (2.65)	3 (1.99)
Dachshund	120	8 (6.67)	1 (0.83)	5 (4.17)
English Springer Spaniel	247	3 (1.21)	6 (2.43)	11 (4.45)
Golden Retriever	179	0 (0)	0 (0)	1 (0.56)
Labrador Retriever	277	2 (0.72)	0 (0)	2 (0.72)
Poodle	69	3 (4.35)	0 (0)	0 (0)
Rottweiler	92	5 (5.43)	1 (1.09)	1 (1.09)
Shetland Sheepdog	112	3 (2.68)	1 (0.89)	1 (0.89)
Siberian Husky	92	0 (0)	0 (0)	1 (1.09)
West Highland WhiteTerrier	92	0 (0)	0 (0)	1 (1.09)
Yorkshire Terrier	90	7 (7.78)	1 (1.11)	5 (5.56)
Average	138	3 (2.68)	1 (0.82)	3 (1.96)

Within-breed percentage is given in parentheses.

Fig. 4A and B). A significant correlation was also found between subscale scores for ODA and DR ($r_s = 0.385$, $n = 2448$, $P < 0.0001$) that remained significant when controlling for SDA and DDA ($r_s = 0.326$, $n = 2446$, $P < 0.0001$).

3.2.3. Comparisons between samples

Limiting the analysis to the eight breeds common to both samples, small but significant differences were found between subscale scores for the breed club sample ($n = 1186$) and the online sample ($n = 1045$) for SDA (Cohen's $d = 0.05$; Mann–Whitney U test, $z = 4.86$, $P < 0.0001$), ODA ($d = 0.03$; $z = 2.85$, $P < 0.025$) and DDA ($d = 0.14$; $z = 2.35$, $P < 0.025$), with dogs from the breed club sample scoring somewhat higher for SDA and lower for the other

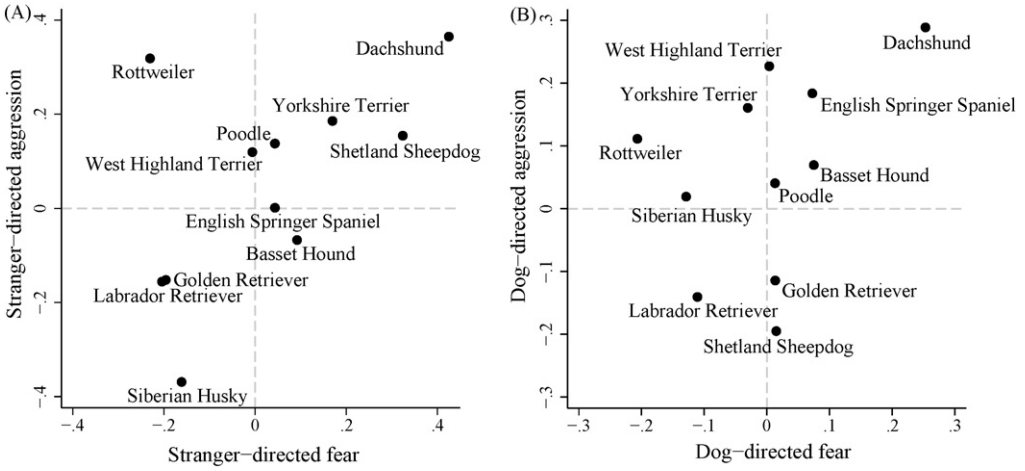

Fig. 2. (A) Stranger- and (B) dog-directed aggression plotted against stranger- and dog-directed fear for the 11 dog breeds from the breed club survey. Data points are breed averages relative to the mean scores for all breeds combined.

two forms of aggression compared to dogs from the online sample. Only the difference for SDA remained significant when the analysis was limited to intact dogs ($d = 0.21$; $z = 4.00$, $P < 0.0001$; online sample $n = 981$, breed club sample $n = 917$).

Significant correlations were observed between the two datasets when the breed averages for SDA and DDA were compared ($r_s = 0.723$, $n = 8$, $P < 0.05$; $r_s = 0.927$, $n = 8$, $P < 0.001$, respectively). The correlation for ODA approached but did not reach significance ($r_s = 0.592$, $n = 8$, $P = 0.123$) (Table 5).

3.3. Conformation vs. field stock

Among English Springer Spaniels in the breed club sample, conformation-bred dogs scored significantly worse for SDA (Mann–Whitney U test, $z = 3.820$, $P < 0.0001$), ODA ($z = 2.012$, $P < 0.05$) and DDA ($z = 1.839$, $P = 0.066$) compared with field-bred dogs (Fig. 5A). Labrador Retrievers showed the opposite pattern for ODA ($z = 2.18$, $P < 0.05$) with conformation-bred dogs scoring lower than field stock. The remaining two aggression subscales revealed no significant differences among Labrador Retrievers (Fig. 5B).

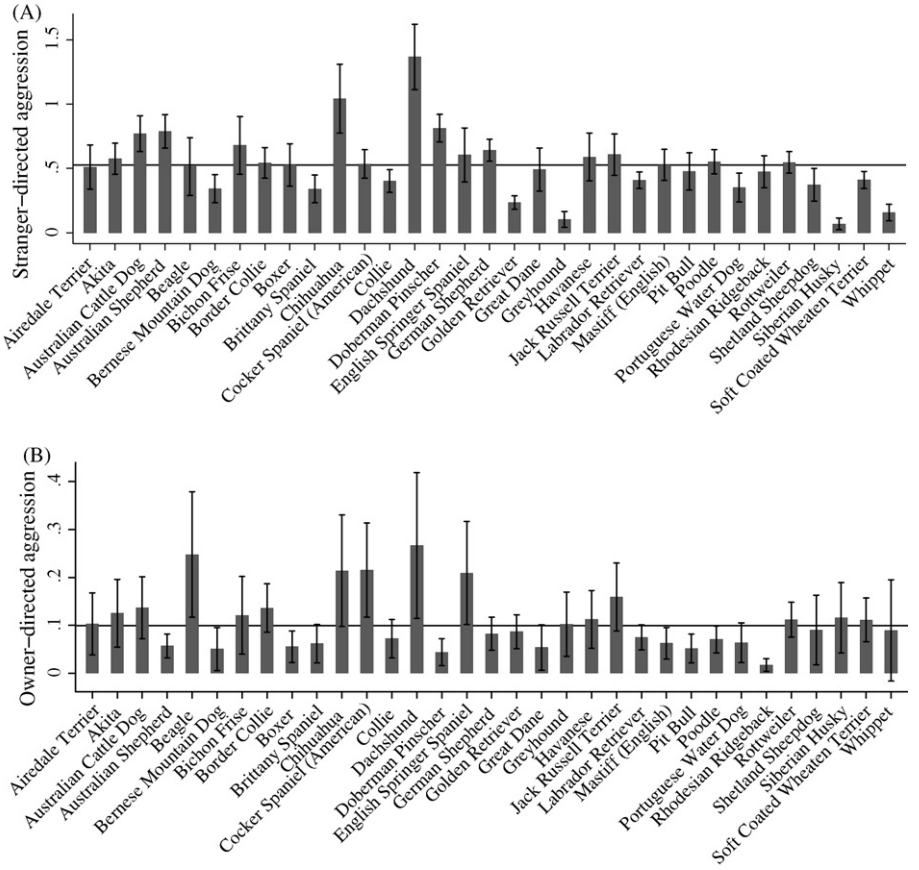

Fig. 3. Mean scores (±95% confidence intervals) for (A) stranger-, (B) owner- and (C) dog-directed aggression and (D) dog rivalry for each of the 33 breeds of dog from the online survey. Horizontal bars indicate the population means.

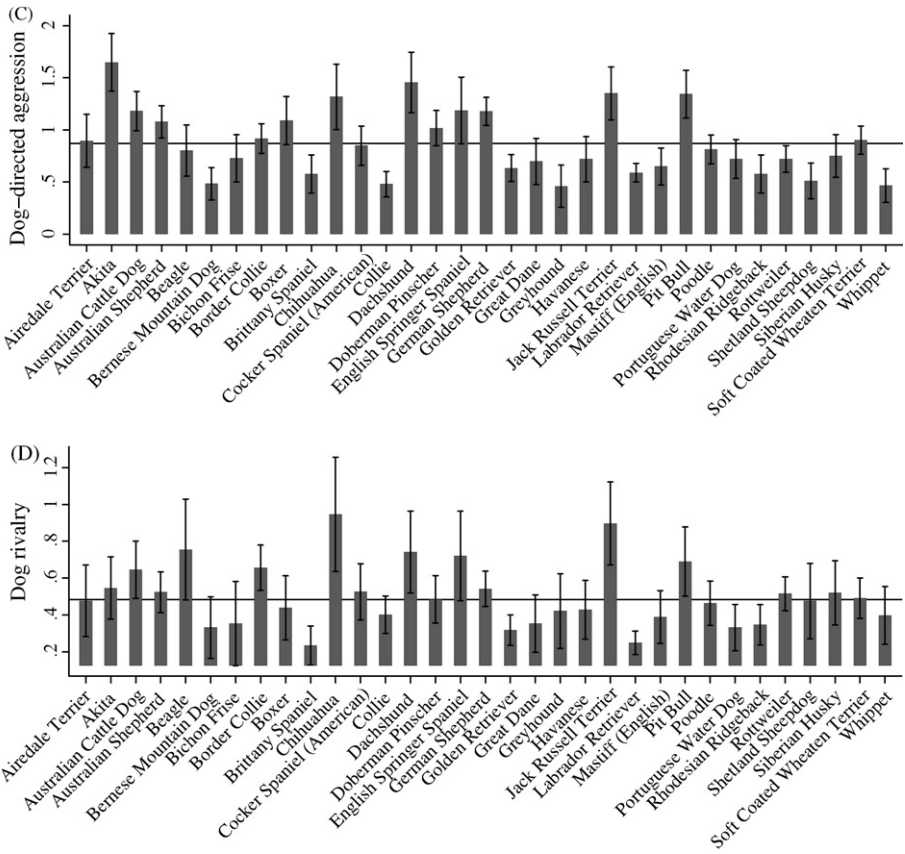

Fig. 3. (*Continued*).

4. Discussion

4.1. Breed differences in aggression

These findings demonstrate considerable variation among breeds in the prevalence and severity of aggression directed at different targets (strangers, owners, or other dogs). Although small differences were observed between the breed club and online samples, breeds were remarkably consistent relative to one another. To our knowledge, this is the first study to report replicated findings of breed differences in aggression using the same measure in two independent samples. Average subscale scores for each breed were significantly correlated with the proportion showing serious aggression (e.g., biting, snapping), indicating that the C-BARQ subscale scores provided a reasonably accurate reflection of the relative risks of biting. The findings also suggest that, for the purpose of obtaining information on the prevalence of behavior problems in the pet dog population, internet data collection methods provided results comparable to those obtained by more traditional paper-and-pencil surveys (Gosling et al., 2004).

The present findings should be interpreted with caution. The substantial within-breed variation in C-BARQ scores observed in this study suggests that it is inappropriate to make

Table 4
Number of dogs of each breed from the online sample that received the maximum score of 4 for aggression (snaps, bites, or attempts to bite) for at least one question pertaining to each subscale

		"Snaps, bites or attempts to bite"				
	n	Stranger aggr.	Owner aggr.	Dog aggr.	Dog rivalry	N (DR)[a]
Airedale Terrier	66	3 (4.5)	1 (1.5)	6 (9.1)	2 (3.6)	56
Akita	99	3 (3)	1 (1)	29 (29.3)	5 (7.1)	70
Australian Cattle Dog	136	13 (9.6)	2 (1.5)	28 (20.6)	5 (4.9)	103
Australian Shepherd	177	11 (6.2)	1 (0.6)	26 (14.7)	10 (6.5)	155
Beagle	63	5 (7.9)	5 (7.9)	6 (9.5)	4 (8)	50
Bernese Mountain Dog	67	1 (1.5)	2 (3)	3 (4.5)	1 (1.6)	61
Bichon Frise	65	3 (4.6)	1 (1.5)	3 (4.6)	2 (4.2)	48
Border Collie	163	13 (8)	3 (1.8)	22 (13.5)	7 (5.1)	137
Boxer	70	4 (5.7)	0 (0)	11 (15.7)	3 (5.3)	57
Brittany Spaniel	66	0 (0)	1 (1.5)	3 (4.5)	1 (2)	50
Chihuahua	56	9 (16.1)	3 (5.4)	10 (17.9)	2 (4.8)	42
Cocker Spaniel (American)	107	5 (4.7)	6 (5.6)	8 (7.5)	4 (5.2)	77
Collie	132	2 (1.5)	3 (2.3)	9 (6.8)	2 (1.6)	122
Dachshund	68	14 (20.6)	4 (5.9)	12 (17.6)	5 (8.8)	57
Doberman Pinscher	144	8 (5.6)	2 (1.4)	16 (11.1)	4 (3.4)	119
English Springer Spaniel	57	2 (3.5)	2 (3.5)	10 (17.5)	4 (9.5)	42
German Shepherd	292	13 (4.5)	6 (2.1)	48 (16.4)	13 (5.8)	225
Golden Retriever	181	2 (1.1)	1 (0.6)	13 (7.2)	3 (2)	150
Great Dane	53	3 (5.7)	1 (1.9)	5 (9.4)	2 (4.9)	41
Greyhound	62	1 (1.6)	0 (0)	1 (1.6)	0 (0)	45
Havanese	73	2 (2.7)	0 (0)	3 (4.1)	1 (1.8)	56
Jack Russell Terrier	78	6 (7.7)	3 (3.8)	17 (21.8)	7 (11.1)	63
Labrador Retriever	349	8 (2.3)	6 (1.7)	15 (4.3)	6 (2.2)	272
Mastiff (English)	126	3 (2.4)	1 (0.8)	8 (6.3)	5 (4.7)	106
Pit Bull	132	9 (6.8)	3 (2.3)	29 (22)	11 (11.5)	96
Poodle	169	2 (1.2)	0 (0)	13 (7.7)	2 (1.4)	139
Portuguese Water Dog	75	2 (2.7)	0 (0)	5 (6.7)	2 (3.3)	61
Rhodesian Ridgeback	69	1 (1.4)	0 (0)	4 (5.8)	1 (1.7)	59
Rottweiler	210	10 (4.8)	2 (1)	16 (7.6)	2 (1.1)	176
Shetland Sheepdog	57	2 (3.5)	2 (3.5)	2 (3.5)	2 (3.8)	52
Siberian Husky	54	0 (0)	1 (1.9)	3 (5.6)	1 (2.1)	48
Soft Coated Wheaten Terrier	216	9 (4.2)	4 (1.9)	35 (16.2)	9 (5.2)	172
Whippet	59	0 (0)	1 (1.7)	2 (3.4)	1 (1.9)	54
Average	115	5 (4.7)	2 (2)	13 (10.7)	4 (4.4)	93

Within-breed percentage is given in parentheses.

[a] Because "dog rivalry" is applicable only in households with more than one dog, the within-breed percentage is based on a smaller sample size "N (DR)" that eliminates cases in which all questions related to "dog rivalry" were left blank.

predictions about a given dog's propensity for aggressive behavior based solely on its breed. Furthermore, questionnaire reports inevitably involve a degree of subjectivity, and it is possible that respondents' answers were influenced by both popular breed stereotypes and/or perceptions of which answers would be deemed socially acceptable. The various C-BARQ items are designed to reduce systematic biases of this kind by focusing on the dog's recent responses to specific stimuli and situations. However, in practice, it is impossible to eliminate such biases entirely using survey methods (Nederhof, 1985). In addition, both the breed club and online samples will

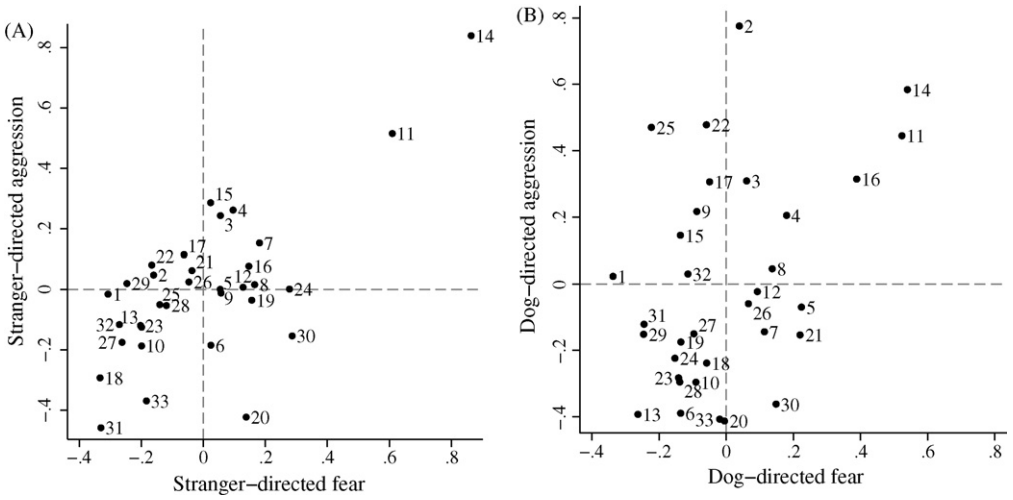

Fig. 4. (A) Stranger- and (B) dog-directed aggression plotted against stranger- and dog-directed fear for the 33 breeds from the online survey. Data points are breed averages relative to the mean scores for all breeds combined. ((1) Airedale Terrier, (2) Akita, (3) Australian Cattle Dog, (4) Australian Shepherd, (5) Beagle, (6) Bernese Mountain Dog, (7) Bichon Frise, (8) Border Collie, (9) Boxer, (10) Brittany Spaniel, (11) Chihuahua, (12) Cocker Spaniel (American), (13) Collie, (14) Dachshund, (15) Doberman Pinscher, (16) English Springer Spaniel, (17) German Shepherd, (18) Golden Retriever, (19) Great Dane, (20) Greyhound, (21) Havanese, (22) Jack Russell Terrier, (23) Labrador Retriever, (24) Mastiff (English), (25) Pit Bull, (26) Poodle, (27) Portuguese Water Dog, (28) Rhodesian Ridgeback, (29) Rottweiler, (30) Shetland Sheepdog, (31) Siberian Husky, (32) Soft Coated Wheaten Terrier, and (33) Whippet).

have been subject to self-selection biases that may have influenced the current findings. On the other hand, and in spite of these potential limitations, most of our findings were reasonably consistent with previous reports of breed differences in aggression (Borchelt, 1983; Hart and Hart, 1985; Wright and Nesselrote, 1987; Bradshaw and Goodwin, 1998; Svartberg, 2006; Takeuchi and Mori, 2006).

Although some breeds appeared to be aggressive in most contexts (e.g., Dachshunds, Chihuahuas and Jack Russell Terriers), others were more specific. Aggression in Akitas, Siberian Huskies, and Pit Bull Terriers, for instance, was primarily directed toward unfamiliar dogs. These findings suggest that aggression in dogs may be relatively target specific, and that independent

Table 5
Mean scores of aggression for dog breeds common to the breed club and online surveys

Breed	Stranger-directed		Owner-directed		Dog-directed	
	Online	Breed club	Online	Breed club	Online	Breed club
Dachshund	1.37 (1)	0.88 (1)	0.27 (1)	0.13 (2)	1.46 (1)	0.89 (1)
English Springer Spaniel	0.60 (2)	0.51 (5)	0.21 (2)	0.19 (1)	1.19 (2)	0.79 (2)
Golden Retriever	0.23 (7)	0.36 (7)	0.09 (6)	0.05 (7)	0.63 (6)	0.49 (6)
Labrador Retriever	0.41 (5)	0.36 (6)	0.07 (8)	0.02 (8)	0.59 (7)	0.46 (7)
Poodle	0.55 (3)	0.65 (4)	0.07 (7)	0.13 (3)	0.81 (3)	0.64 (4)
Rottweiler	0.55 (4)	0.84 (2)	0.11 (4)	0.09 (5)	0.72 (5)	0.72 (3)
Shetland Sheepdog	0.37 (6)	0.67 (3)	0.09 (5)	0.08 (6)	0.51 (8)	0.41 (8)
Siberian Husky	0.07 (8)	0.14 (8)	0.12 (3)	0.09 (4)	0.75 (4)	0.63 (5)

Rankings are in parentheses.

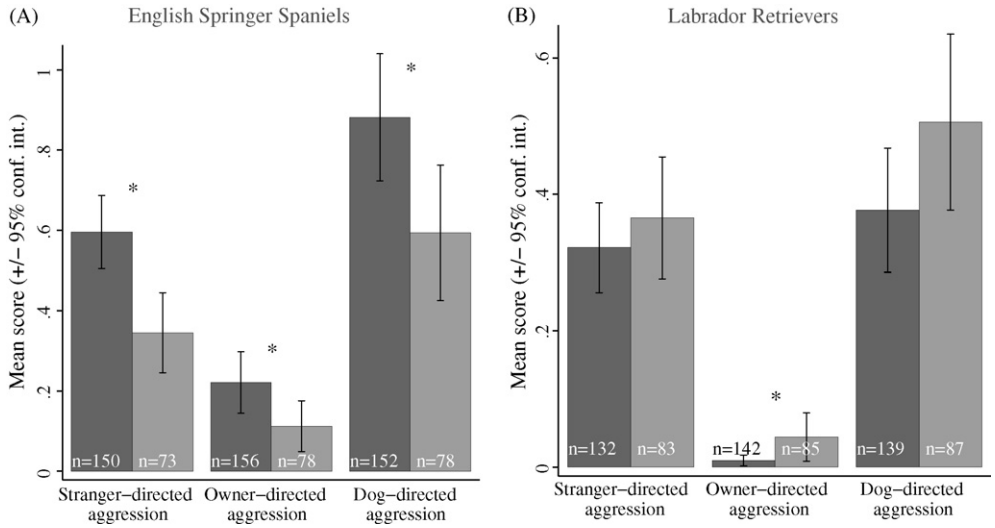

Fig. 5. Mean scores (±95% confidence intervals) of stranger-, owner- and dog-directed aggression of (A) English Springer Spaniels and (B) Labrador Retrievers comparing dogs bred for conformation (dark gray) vs. field stock (light gray). $^{*}P < 0.05$.

mechanisms may mediate the expression of different forms of aggression. Recent heritability analyses of aggression in a population of Dutch Golden Retrievers found a weak correlation between estimated breeding values for C-BARQ ratings of stranger- and dog-directed aggression, suggesting that these traits are partially related but genetically distinct (Liinamo et al., 2007).

4.1.1. Stranger-directed aggression (SDA)

There are few published reports describing breed variation in the degree of aggression directed toward strangers that do not rely on bite statistics. The most extensive and often cited report is a USA-based survey of veterinarians and obedience judges in which respondents were asked to rank several popular breeds based on various behavioral traits (Hart and Hart, 1988; see also Bradshaw and Goodwin, 1998; Takeuchi and Mori, 2006; Notari and Goodwin, 2007). The respondents' rankings for each behavior were then transformed into deciles, each containing five or six breeds, with higher deciles indicating more aggressive behavior. Two behavioral traits, 'watchdog barking' (barking to alert owners to an intruder) and 'territorial defense' (attacking an intruder) would be most relevant to our factor of stranger-directed aggression. Several of the breeds in our study found to be rated highest for stranger-directed aggression (Dachshunds, Chihuahuas, Doberman Pinschers, Rottweilers, Yorkshire Terriers and Poodles) scored in the eighth decile or higher for 'watchdog barking' and/or 'territorial defense' in Hart and Hart (1988) survey.

Breeds scoring low (below the median) for SDA in our study include Basset Hounds, Golden Retrievers, Labrador Retrievers, Siberian Huskies, Bernese Mountain Dogs, Brittany Spaniels, Whippets and Greyhounds. Four of these breeds (Basset Hounds, Golden Retrievers, Brittany Spaniels, and Labrador Retrievers) were ranked at or below the fourth decile for both 'watchdog behavior' and 'territorial defense' in Hart and Hart (1988) survey. Siberian Huskies ranked in the second decile for 'watchdog behavior' but in the sixth decile

for 'territorial defense' while English Springer Spaniels showed the opposite pattern (Hart and Hart, 1988). Bernese Mountain Dogs, Greyhounds and Whippets were not included in the Hart and Hart (1988) study.

The relatively average C-BARQ scores for stranger-directed aggression found among Pit Bull Terriers (Fig. 3A) were inconsistent with their universal reputation as a 'dangerous breed' and their reported involvement in dog bite-related fatalities (Sacks et al., 1996). In our survey, nearly 7% of Pit Bull owners indicated that their dogs had bitten or attempted to bite an unfamiliar person in the recent past, somewhat higher than the overall average (4.7%), while 22% reported bites directed at other dogs. This pattern is consistent with the view that this breed has been selectively bred for aggression toward other dogs rather than humans (Lockwood, 1995). It should be emphasized, however, that while the prevalence of human-directed bites or bite attempts among Pit Bull Terriers may be only slightly above average, the severity of their attacks is probably affected by other traits (e.g., the size and strength of the breed, its reputed failure to give warning signs, and its reported tenacity when attacking) that may also have been selected for in the development of this ''fighting'' breed. In contrast, although more than 20% of Dachshund owners in our study reported bites or attempts to bite against humans, the relatively small size of this and other highly aggressive breeds (e.g., Chihuahuas) substantially reduces the risks of serious injury.

4.1.2. Owner-directed aggression (ODA)

In general, scores for ODA were very low and most owners reported no signs of aggression towards themselves or other members of the household in any context. More than half of cases involving severe aggression (bites or attempts to bite) were associated with a household member taking food or other valued objects away from the dog. The low prevalence of ODA in all breeds makes sense from an evolutionary perspective, since this type of aggression, in contrast to that directed at strangers and other dogs, has probably never been encouraged by human owners, and is likely to have been actively selected against.

Breeds that stood out as being rated relatively high (above the median) for aggression toward household members in our study included the Basset Hound, Beagle, Chihuahua, American Cocker Spaniel, Dachshund, English Springer Spaniel and Jack Russell Terrier (Figs. 1B and 3B); all breeds in the small to medium size range. Presumably, aggression among larger more powerful breeds would be more difficult to tolerate or manage. The higher levels of ODA among English Springer Spaniels in both samples concur with recent published reports of problems with dominance-type aggression in this breed (Borchelt, 1983; Reisner et al., 1994; Guy et al., 2001a; Reisner et al., 2005). In their survey of clients sampled from a general veterinary caseload in Canada, Guy et al. (2001a) reported that English Springer Spaniels were the breed most often cited to have bitten members of the household (26.8% of owners reported biting). In general, percentages of dogs reported as having bitten household members by Guy et al. (2001a) were substantially greater than those reported here (average rate of all breeds combined 13.2% vs. $\leq$2%, respectively), a discrepancy that may be partly attributable to the present study's focus on aggression only in the recent past.

Aggression directed towards people living in the household is often interpreted as a result of conflicts related to social dominance (for review, see Lindsay, 2001, pp. 229–272). In support of this, we found a highly significant correlation between owner-directed aggression and rivalry among dogs living in the same home. This correlation was independent of aggression toward unfamiliar people or dogs, suggesting that some canine aggression is specific to those individuals with whom the dog is familiar and is consistent with the view that aggression towards owners is

sometimes related to social dominance, especially with respect to food or object possession/resource guarding.

4.1.3. Dog-directed aggression (DDA)

In general, we found higher levels of aggression directed toward unfamiliar dogs compared to unfamiliar people (parts A and C in Figs. 1 and 3); however, this pattern was highly breed-specific. Dachshunds, for example, showed similar levels of aggression to both dogs and humans (parts A and C in Figs. 1 and 3) while Akitas, Jack Russell Terriers and Pit Bull Terriers showed substantially greater aggression toward dogs (Fig. 3A and C).

Our study found significant differences across breeds in displays of aggression toward unfamiliar dogs and several breeds stood out as being particularly aggressive: Akita, Boxer, Australian Cattle Dog, German Shepherd, Pit Bull, Chihuahua, Dachshund, English Springer Spaniel, Jack Russell Terrier and West Highland White Terrier (Figs. 1C and 3C). Six of these breeds (Akita, Boxer, Chihuahua, Dachshund, German Shepherd, and West Highland White Terrier) were ranked at the sixth decile or higher for 'aggression toward other dogs' in Hart and Hart (1988) report. English Springer Spaniels ranked in the second decile, and Australian Cattle Dogs, Pit Bull Terriers and Jack Russell Terriers were not included in the Hart and Hart (1988) survey.

A detailed analysis of a German population of dogs revealed that, among other breeds, Pit Bull Terriers, German Shepherds, Great Danes and Rottweilers were often the aggressors in inter-dog conflicts, while Boxers, Cocker Spaniels (presumably English), Dachshunds, Doberman Pinschers, Poodles, Yorkshire Terriers and West Highland White Terriers were more often the victims (Roll and Unshelm, 1997). In our study, most of the breeds that Roll and Unshelm (1997) cited as being aggressors tended to score higher for aggression than fear relative to the population average (Figs. 2B and 4B).

4.2. Aggression and fear

The present findings point to an interesting balance of aggressive and fearful motivations underlying the expression of aggressive behavior in the various breeds. While aggression is often associated with fear in animals (Wingfield et al., 2006, pp. 179–182), this relationship appears to be stronger in some dog breeds than others. For example, Rottweilers were below average for fear of strangers but above average for stranger-directed aggression (Fig. 2A). Doberman Pinschers, Jack Russell Terriers, West Highland White Terriers, Australian Cattle Dogs and German Shepherds were also more aggressive than fearful towards strangers (Fig. 4A). In contrast, Dachshunds, Chihuahuas and Yorkshire Terriers were well above average for both aggression and fear (Figs. 2A and 4A), while Shetland Sheepdogs and Greyhounds tend to be more fearful than aggressive (Figs. 2A and 4A). These results make intuitive sense given that the more aggressive than fearful breeds in our study have historically held working roles that require some degree of assertiveness (protection, herding and hunting) (American Kennel Club, 1992). By expressing this balance between defensive (fear-mediated) and offensive aggression to widely different degrees, dog breeds may represent a useful model for studying the underlying causation of aggressive behavior.

4.3. Conformation vs. field stock

Our results indicate that owner-directed aggression is more pronounced in conformation-bred English Springer Spaniels compared to field stock dogs, replicating findings in the literature

(Reisner et al., 2005). In contrast, field-bred Labrador Retrievers obtained significantly higher ODA scores than conformation-bred dogs. The fact that these two breeds showed opposite patterns confirms Reisner et al.'s (2005) finding that the higher aggression in show-bred English Springer Spaniels is attributable to a popular sire effect rather than breeding for show per se. A Swedish study of 31 different breeds found that, in general, breeding for show was associated with lower levels of aggression, curiosity and playfulness, and with higher levels of fearfulness (Svartberg, 2006). In contrast, selection for use in field trials was correlated with higher levels of playfulness and aggression (Svartberg, 2006). Taken together, these findings suggest that canine aggression has some genetic basis, and that aggressiveness may be selected for either intentionally or inadvertently by different breeding practices.

While the results of the present study demonstrate striking and consistent variation in aggression among dog breeds, they shed little light on the underlying sources of this variation in behavior. Demographic and environmental risk factors for the development of canine aggression need to be investigated across a variety of breeds so that both generalized and breed-specific influences can be identified. More empirical data regarding the effects of hormones and neuter status among the various breeds are also needed. Genetic and environmental factors are likely to interact to mediate the expression of aggressive behavior during development. Genetic markers associated with aggressiveness in particular contexts are likely to be identified in the near future due to the recent sequencing of the dog genome (Lindblad-Toh et al., 2005). Using valid and reliable measures of canine behavioral phenotypes, such as the C-BARQ, behavioral genetic studies will further our understanding of how aggressive traits are inherited and mediated by experiential and environmental factors.

5. Conclusions

We found large and consistent differences among dog breeds in the prevalence and severity of aggression directed at different targets (familiar and unfamiliar humans and dogs), and the degree to which aggression was associated with fear. Reported levels of aggression in some cases are concerning, with rates of bites or bite attempts ''in the recent past'' rising as high as 20% toward strangers and 30% toward unfamiliar dogs in some breeds. In general, the highest rates of human-directed aggression were found in smaller breeds whose aggression is presumably easier to tolerate. Differences between lines of distinct breeding stock indicate that the propensity toward aggressive behavior is at least partially rooted in genetics, although substantial within-breed variation suggests that other factors (developmental, environmental) play a major part in determining whether aggressive behavior is expressed in the phenotype. The study also demonstrates the value of the internet for collecting population-level behavioral data on dogs. In the future, the use of standardized measures of canine behavioral phenotypes, such as the C-BARQ, by owners and breeders may help to illuminate the causes and reduce the prevalence of aggression in pet dogs.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.applanim.2008.04.006.

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