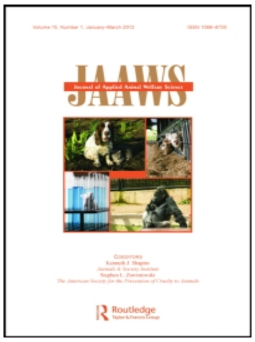

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ARTICLES

The Relationship Between Coat Color and Aggressive Behaviors in the Domestic Cat

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ABSTRACT
The authors explored a possible relationship between coat color and aggressive behaviors in the domestic cat. This study used an Internet-based survey to collect information on coat color, affiliative behaviors toward cats/humans, agonistic behaviors toward cats/humans, other "problem" behaviors, and cat and guardian demographic data. A total of 1,432 cat guardians completed the online survey; after exclusions based on study protocol, data analysis included 1,274 completed surveys. Guardians reported sex-linked orange female (tortoiseshells, calicos, and "torbies"), black-and-white, and gray-and-white cats to be more frequently aggressive toward humans in 3 settings: during everyday interactions, during handling, and during veterinary visits. Kruskal-Wallis 1-way analysis of variance was used to compare possible differences between the 2 sexes and among different coat colors. Analyses of aggression due to handling, as well as aggression displayed during veterinarian visits, showed little difference among coat colors in these settings.

KEYWORDS
Feline aggression; coat color

A nonhuman animal's coat color, once primarily the concern of fanciers and breeders of both companion animals and fur-bearing animals, has become a marker for other characteristics. White coat color has been associated with congenital deafness in dogs, cats, and others; lethal white foal syndrome is found in overo paint horses; and the "cross-eyed" appearance in Siamese cats is associated with partial albinism (Webb & Cullen, 2010). Research has also uncovered a connection between coat color and either affiliative or aggressive behavior in silver foxes, minks, Norway rats, English cocker spaniels, Korean Jindos, and Labrador retrievers (Amat, Manteca, Mariotti, de la Torre, & Fatjó, 2009; Belyaev, 1979; Cottle & Price, 1987; Houpt & Willis, 2001; Kim et al., 2010; Podberscek & Serpell, 1996; Trapezov, Trapezova, & Sergeev, 2008).

It has long been recognized that a mammal's coat color and pattern are inherited, but with possible variation (Bateson, 1894). Bateson (1894) attributed this variation to things like variability in "chemical stability" of the hair colors themselves; later, this variation became attributed to genetic variation. While early researchers relied on the Mendelian laws of heredity to study coat-color genetics, modern researchers are beginning to explore inheritance of these traits at the molecular level.

Coat-color pattern genes in the cat fall into four categories that dictate the amount of white ("spotting"); the intensity of pigment ("dilution"); the orange and agouti pelage ("pigment-type switching"); and the patterns of ticked, tabby, and spotted ("pattern"). Orange is of particular interest, as it is carried on the X chromosome, along with its "opposite" allele, black. Some females display an orange-black pattern determined by random X inactivation, leading to tortoiseshell, torbie

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(tortoiseshell tabbies, "striped torties"), and calico mosaic patterns. Males can display these patterns only by virtue of being XXY, making them extremely rare. Calicos express the white gene as well (Kaelin & Gregory, 2013).

Behaviors have also been studied as a group of inherited traits. Starting in 1945, Scott and Fuller (1965) bred individuals from five dog breeds to look at the behavioral traits that could reliably be isolated as heritable. They concluded that behavior was sufficiently complicated to render simple Mendelian genetics insufficient to explain it. Yet they were able to identify several aspects of behavior that appeared, in part, to be heritable, including sexuality, wildness/tameness, postural responses, problem solving, and reactivity; they also theorized about the connection between the inheritance of physical and behavioral characteristics.

In addition, the silver fox experiments by Belyaev (1979) selected foxes for behavioral changes, such as increased human affiliation and tameness, which bred true along many generations; these changes were, somewhat surprisingly, accompanied by physical changes (coat color, tail and ear shapes, etc.) that suggested behavior and appearance are somehow genetically related. These changes have recently been explored at the genomic level (Kukekova et al., 2011). In addition, much work has been done at the molecular level; in fact, more than 30 genes believed to be related to some aspect of behavior have been identified in the dog (Takeuchi & Houpt, 2003).

Researchers have examined the inheritance of behaviors in the domestic cat as well. A series of studies conducted from the mid-1980s to the mid-1990s showed some amount of sociability in kittens is inherited from their fathers, independent of maternal and environmental influences (McCune, 1995; Reisner, Houpt, Erb, & Quimby, 1994; Turner, Feaver, Mendl, & Bateson, 1986). Lowe and Bradshaw (2001) found that certain aspects of a kitten's personality remain relatively constant throughout his or her first few years, suggesting a genetic predisposition.

Meier and Turner (1985) theorized that a "trusting" personality develops during the early socialization period and that a "shy" personality develops during later experiences. Breed differences in interactions with humans have been noted; for instance, Siamese cats are more demanding and more vocal toward their guardians compared with other breeds (Turner & Bateson, 2000). Some behavioral problems tend to appear more frequently in some breeds; for example, wool sucking is more prevalent among Siamese cats (Turner & Bateson, 2000).

Among cat guardians and veterinarians, there are common assumptions about personalities associated with different cat color patterns. Some feel that calicos are "crazy" (Becker, 2012). Others claim tortoiseshells have a combination of stubbornness, independence, and unpredictability known as "tortitude" (Delgado, Munera, & Reevy, 2012, p. 436; Veterinary Pet Insurance, n.d.). Even in 1895, some veterinarians considered the tortoiseshell to be "not over affectionate, and sometimes even sinister and most ill-tempered in its disposition" (Huidekoper, 1895, p. 49). Orange cats are often thought of as friendly (Delgado et al., 2012). Some people perceive black cats as wild and unpredictable (Huntingford, 2009). Despite these and other similar perceptions, little research exists on the subject. In fact, in a recent study of cats communally housed in a single shelter, coat color did not appear to be related to feline behavior (Dantas-Divers, 2011; Dantas-Divers et al., 2011).

Perhaps due to this public perception, cats of certain coat-color patterns are either more sought after or at greater risk for being overlooked for adoption. Several studies have shown that appearance is a key factor in choosing a companion animal from a shelter, although coat color does not always appear to play a role (Brown, Davidson, & Zuefle, 2013; Gourkow, 2001; Podberscek & Blackshaw, 1988; Protopopova, Gilmour, Weiss, Shen, & Wynne, 2012). Posage, Bartlett, and Thomas (1998) found that certain breeds (terrier, hound, toy, and nonsporting) and certain coat colors (gold, gray, and white) were associated with quicker adoption from a Michigan shelter. However, Protopopova et al. (2012) found that color, along with age and sex, played no role in adoption success for dogs from a shelter. Lepper, Kass, and Hart (2002) found that brown and black cats were less likely to be adopted from a shelter than were white, color point, or gray cats. Furthermore, Kogan, Schoenfeld-Tacher, and Hellyer (2013) found that black cats take significantly longer to be adopted than do cats of other colors. What is not clear from these studies is whether people's interest in adopting cats of particular colors is mainly aesthetic or if it is based on a perception of association of coat color with personality or behaviors.

The objective of this research was to determine whether cats of any particular coat-color pattern are more likely to engage in the following: aggressive behaviors toward humans, aggression toward people during handling (punishing, petting, or grooming), or aggression during veterinary visits. While we were interested in exploring any relationship between coat color and aggression toward humans, we hypothesized that sex-linked females (tortoiseshells, calicos, and others) would be represented significantly more often than any other color pattern as being aggressive toward people. This hypothesis was based on our own and others' perceptions of cats with these coat patterns (Becker, 2012; Veterinary Pet Insurance, n.d.).

Materials and methods

Using an established Internet-based program (Survey Monkey, http://www.SurveyMonkey.com), we designed a survey that would take approximately 20 min to complete. The survey was posted on a social media website (http://www.facebook.com/ucdavisbehaviorservice), with instructions to share the link via other social media sites. At the time of posting, the site had approximately 2,700 "likes." Additionally, the survey was posted to two feline general interest Internet listservs, each with approximately 4,300 to 4,900 members at the time of posting: Cats and Kittens listserv (http://pets.groups.yahoo.com/group/catsandkittens) and For the Love of Cats listserv (http://pets.groups.yahoo.com/group/fortheloveofcats). The survey was accessible for 4 months.

The survey consisted of both closed- and open-ended questions. The survey was designed to mask the fact that coat color was the primary exposure of interest to avoid bias on the part of the responder; instead, survey takers were told that the purpose of the study was to collect information about cat behavior.

The survey was pilot-tested by having veterinary students answer both the closed- and open-ended questions, and it was modified before initiating data collection. The survey included the following sections: cat and guardian demographic information, frequency with which the cat reacted in aggressive and affiliative manners to people and other cats, likelihood of an aggressive reaction to particular stimuli, and whether the cat demonstrated other specified problem behaviors.

As the intent of the study was to gather data on coat color as it related to select behaviors, we included color categories with accompanying photos and written descriptions in the survey; where applicable, an image of a dilute version of the pattern was shown. Color patterns included black, black-and-white, gray, gray-and-white, white, tabby (either black/brown/gray or orange/cream/buff), calico, tortoiseshell, "points" (e.g., Siamese), and "other." After data collection, it was noted that "torbie," not originally included, was specified in the "other" category in eight usable surveys; thus, it was added as a separate category prior to data analysis.

The frequencies of aggressive behaviors toward people were recorded on a 6-point scale: 0 = *never*, 1 = *less than once every 6 months*, 2 = *more than once every 6 months*, 3 = *more than once per month*, 4 = *more than once per week*, 5 = *more than once per day*. The frequency with which the cat acted toward people was recorded in the following categories: hiss, stalk/chase, bite, slap/scratch, bite/scratch/stalk (in play), groom/lick, curl up next to, approach, and greet with head/body rubs. Because this category had four subcategories with a range of 0 to 5 possible, each cat could score 0 to 20 for human aggression.

Likelihood of aggression from handling was rated on the following scale: 0 = *very unlikely*, 1 = *somewhat unlikely*, 2 = *somewhat likely*, and 3 = *very likely*. The likelihood of a cat's reaction was recorded in the categories of hiss, bite, and slap/scratch for each of the following activities: punishment, petting, and brushing. The possible range of scores was 0 to 27. Aggression during a veterinary visit had the same scale and was also measured for hiss, bite, and slap/scratch; the range of possible scores was 0 to 9.

Exclusion criteria included the following: Duplicates from the same guardian were excluded to eliminate correlated data by a single individual; IP address and guardian demographic data were used to make this determination. If multiples were submitted by the same person, the survey for the cat whose name was closest to the beginning of the alphabet was included. Surveys completed by those not designating themselves as "primary caregivers" were excluded. Surveys for cats younger than 1 year old were excluded; the reason for these exclusions was twofold. First, it was believed that their current behaviors may not be reflective of their adult personalities. Second, aggression in these younger cats would be more likely to have an underlying motivation of play. Outdoor-only cats were excluded out of concern that their guardians could not correctly judge their behaviors.

Data were downloaded from the Internet survey site and imported into a statistics program (STATA, StataCorp LP, College Station, TX). The frequencies with which a cat hissed, stalked/chased, bit, and/or slapped/scratched a person were added to create the category of human aggression. The scores of the likelihood that a cat would hiss, bite, and/or slap/scratch a person in response to being punished, being petted, being groomed, and visiting a veterinarian were added to create the categories of response to punishment, response to petting, response to grooming, and response to veterinarian, respectively. The categories of response to petting and response to grooming were combined to create the category of response to handling. If a guardian had indicated that a cat was not exposed to one or more of these triggers (i.e., if they reported that they never verbally or physically punished their cats), the cat was not analyzed for that specific data set.

Because the study's primary hypothesis specifically related to increased aggression toward humans, data analysis was limited to the data collected in the human aggression, handling aggression, and veterinary aggression categories of the survey. These were separated out to determine if aggression was limited to handling or visits to the veterinarian or if it was more directly related to everyday interactions with the guardian.

Aggression data from cats aged at least 1 year old were analyzed using Kruskal-Wallis analysis of variance (ANOVA) with post-hoc pairwise Wilcoxon-Mann-Whitney tests to compare sexes and individual coat colors to one another. A Bonferroni-Holm multiple-comparison adjustment was used to preserve a nominal Type I error rate for each set of similar hypotheses tested following the ANOVA (Ludbrook, 1998). Chi-square tests were performed for any categorical comparisons. Where analyses involved fewer than 10 individuals in any group, Fisher's exact test replaced the chi-square analysis. Human aggression, handling aggression, and veterinarian aggression scores were compared between cats of different coat colors. Because the primary hypothesis involved sex-linked orange female cats as a whole, calicos, tortoiseshells, and torbies were grouped together for analysis; all other coat colors remained distinct. All tests were two-tailed, and significance was set at $p < .05$.

Results

Of the surveys, 91 were excluded: 66 for the cat being younger than 1 year of age, 13 for being a multiple survey from the same cat guardian, and 12 for the cat being outdoors only. Following the exclusions, 1,274 surveys were included in the statistical analyses. From the initial social media site, the posting was viewed 804 times and shared 110 times.

Of the respondents whose surveys were included in analysis, 1,126 were female and 130 were male; another 18 selected "prefer not to answer." The individuals were in the following age (years) categories: 18 to 20 ($n = 2$), 21 to 29 ($n = 137$), 30 to 39 ($n = 286$), 40 to 49 ($n = 319$), 50 to 59 ($n = 295$), 60 and older ($n = 213$), and "prefer not to answer, but at least 18 years" ($n = 22$). The respondents' current residences included: the United States or Canada ($n = 1{,}198$), Europe ($n = 47$), Australia or New Zealand ($n = 8$), Asia ($n = 4$), Mexico and Central America ($n = 3$), South America ($n = 2$), the Middle East ($n = 3$), and Africa ($n = 1$); 8 respondents did not report a location.

The 1,274 cats included in the statistical analysis for this project included 657 males and 617 females. They represented 13 coat-color categories (Table 1). One category of uncommon breeds included smoke, blue lavender, blue Somali, champagne, sable, lilac, fawn, toyger, agouti, unspecified tabby colors, and several versions of "red/ruddy" (often associated with Abyssinians). Table 2 shows the possible score ranges and actual minimums and maximums, medians, means, and standard errors

Table 1. Color patterns and sexes of cats included in data analysis.

	Males		Females		Total	
Color	$n = 657$	% of Males	$n = 617$	% of Females	$n = 1{,}274$	% of Total
Black	59	(9%)	49	(7.9%)	108	(8.5%)
Black-and-white	104	(15.8%)	82	(13.3%)	186	(14.6%)
Calico	1	(0.15%)	68	(11%)	69	(5.4%)
Color points	57	(8.7%)	46	(7.5%)	103	(8.1%)
Gray	21	(3.2%)	18	(2.9%)	39	(3.1%)
Gray-and-white	50	(7.6%)	27	(4.4%)	77	(6.0%)
Tabby (black, brown, and gray)	191	(29.1%)	192	(31%)	383	(30%)
Tabby (orange, cream, and buff)	131	(20%)	29	(4.7%)	160	(12.7%)
Tortoiseshell	1	(0.15%)	53	(8.8%)	54	(4.2%)
White	14	(2.1%)	12	(1.9%)	26	(2.0%)
Torbie	0	(0%)	8	(1.3%)	8	(0.6%)
Other	28	(4.2%)	33	(5.3%)	61	(4.8%)

Table 2. Measures of human aggression, handling aggression, and veterinary aggression.

	Possible range	Actual max/min	Median	Mean	Standard error
Human Aggression	0–20	0–20	0	1.8	0.087
Handling Aggression	0–36	0–27	2	3.4	0.127
Veterinary Aggression	0–9	0–9	0	1.7	0.074

for these 1,274 cats in the categories of human aggression, handling aggression, and veterinary aggression.

Human aggression

Female cats had a higher human aggression score than did males (mean for females $= 2.1$; mean for males $= 1.6$; $z = -2.06$, $p = .040$), which was not significant after multiple comparison adjustment. Comparisons of males of each color to females of the same color and comparisons of males to females for all colors combined showed no significant difference in frequency of aggression between the sexes ($X^2 = 3.46$, $p = .063$). Thus, sexes were combined in subsequent comparisons between coat colors, except where indicated.

Tortoiseshell/calico/torbie females had a higher score in human aggression than all other females combined (mean for tortoiseshell/calico/torbie $= 2.5$, mean for all other colors $= 2.0$; $z = -3.37$, $p = .001$). Black-and-white males were more frequently aggressive than males of other colors combined (mean for black-and-white males $= 2.0$, mean for all other colors $= 1.5$; $z = -2.68$, $p = .008$). Table 3 tabulates these results.

Table 4 demonstrates analyses that compared the frequency of human aggression reported for each coat color to each other color. This yielded significant differences when the tortoiseshell/calico/torbie

Table 3. Analyses of human aggression by sex and coat color.

	Males			Females				
	Mean	Range	Median	Mean	Range	Median	X^2 (1 df)	p Value
Black	1.66	0–9	0	1.71	0–15	0	0.001	.980
Black-and-white	1.95	1–13	1	1.80	0–16	0	1.86	.173
Calico/tortoiseshell/torbie	2.00	0–4	2	2.47	0–19	1	0.02	.896
Color points	1.56	0–13	0	1.91	0–20	0	0.04	.837
Gray	0.43	0–3	0	2.22	0–18	0.5	2.45	.118
Gray-and-white	1.82	1–7	1	3.07	0–16	1	0.56	.455
Tabby (black, brown, and gray)	1.32	0–16	0	1.64	0–16	0	1.98	.159
Tabby (orange, cream, and buff)	1.70	0–13	0	2.66	0–16	0	0.65	.419
White	1.36	0–10	0	3.58	0–17	0.5	0.52	.472
Other	1.25	0–9	0	0.79	0–5	0	0.001	.977

Table 4. Analyses of human aggression by coat color, both sexes combined.

	Black	B/W	Tort cal torb	Points	Gray	Gray/white	Tabby	Orange tabby	White	Other
Black	N/A	$\geq .05$	5.51[b] (.019)	$\geq .05$	$\geq .05$	$\geq .05$	$\geq .05$	$\geq .05$	$\geq .05$	$\geq .05$
B/W		N/A	4.0[b] (.046)	$\geq .05$	$\geq .05$	$\geq .05$	4.30[a] (.04)	$\geq .05$	$\geq .05$	4.92[a] (.03)
Tort Cal Torb			N/A	7.02[a] (.008)	7.14[a] (.008)	$\geq .05$	16.71[a] ($<.001$)	5.16[a] (.023)	$\geq .05$	13.26[a] ($<.001$)
Points				N/A	$\geq .05$	$\geq .05$	$\geq .05$	$\geq .05$	$\geq .05$	$\geq .05$
Gray					N/A	$\geq .05$	$> .05$	$\geq .05$	$\geq .05$	$\geq .05$
Gray/White						N/A	6.10[a] (.014)	$\geq .05$	$\geq .05$	6.54[a] (.011)
Tabby							N/A	$\geq .05$	$\geq .05$	$\geq .05$
Orange Tabby								N/A	$\geq .05$	$\geq .05$
White									N/A	$\geq .05$
Other										N/A

Note. B/W = black-and-white; Tort = tortoiseshell; Cal = calico; Torb = torbie.

p-values $< .05$ are given in parentheses, with the chi-square statistics given above.

[a] Row color has increased aggression over column color.

[b] Column color has increased aggression over row color.

category was compared to the following colors: black ($X^2 = 5.51$, $p = .019$), black-and-white ($X^2 = 4.0$, $p = .046$), having points ($X^2 = 7.02$, $p = .008$), gray ($X^2 = 7.14$, $p = .008$), black/brown/gray tabby ($X^2 = 16.71$, $p < .001$), orange tabby ($X^2 = 5.16$, $p = .023$), and "other" ($X^2 = 13.26$, $p < .001$). Comparisons between tortoiseshell/calico/torbie and gray-and-white and white were not significant ($X^2 = 0.36$, $p = .547$, and $X^2 = 1.38$, $p = .241$, respectively). Four other combinations showed significant results: black-and-white compared with black/brown/gray tabby ($X^2 = 4.30$, $p = .038$) and "other" ($X^2 = 4.92$, $p = .027$), and gray-and-white compared with black/brown/gray tabby ($X^2 = 6.10$, $p = .014$) and "other" ($X^2 = 6.54$, $p = .011$). All other comparisons yielded nonsignificant findings.

The medians, ranges, and means for human aggression, by coat color and with sexes combined, are included in Table 5. Due to the overall low scores in human aggression, we collapsed these data into categories of whether they were reported to display any aggression or none whatsoever. We compared the number of cats within a given coat color who scored > 0 and the number who scored 0 to the total number of cats who scored > 0 and who scored 0 in the category. This comparison yielded a higher-than-expected number of cats with a score > 0 for calico ($X^2 = 21.8$, $p < .001$) and combined tortoiseshell/calico/torbie ($X^2 = 15.72$, $p < .001$) compared with all coat-color cats combined. There was a lower-than-expected number of cats scoring > 0 in the black/brown/gray tabby category ($X^2 = 4.53$, $p = .033$) compared with all other cats combined.

Demographic data of the "human aggression" categories of tortoiseshell/calico/torbie, black-and-white, and gray-and-white were analyzed to assess for correlations with their aggression. These cats were no more likely to be either intact or neutered, either indoor-only or allowed outdoors, or either from a single cat household or from one with multiple cats.

Figure 1 shows an increased frequency of human aggression among tortoiseshell/calico/torbie and gray-and-white cats, as compared with cats of other coat colors.

Handling aggression

Analyses for handling aggression showed significant differences between sexes for points (mean for males = 2.3, mean for females = 4.0; $X^2 = 7.27$, $p = .007$) and gray-and-white (mean for males = 4.0, mean for females = 4.5; $X^2 = 4.58$, $p = .025$), with females being the more aggressive sex. All other sex comparisons yielded nonsignificant results. For all colors combined, there was no significant difference between males and females (mean for males = 3.2, mean for females = 3.7; $X^2 = 2.72$, $p = .099$).

The medians, ranges, and means for handling aggression, by coat color and with sexes combined, are included in Table 6. Due to the overall low scores in handling aggression, we collapsed these data into categories of whether they were reported to display any aggression or none whatsoever. We compared the number of cats within a given coat color who scored > 0 and the number who scored 0 to the total number of cats who scored > 0 and who scored 0 in the category. No coat color had a significantly higher or significantly lower handling aggression score than all colors combined.

Based on coat-color analyses, with sexes combined, black-and-white cats were significantly more aggressive during handling than "other" ($X^2 = 4.95$, $p = .026$); tortoiseshell/calico/torbie were more aggressive than points ($X^2 = 6.54$, $p = .011$), black/brown/gray tabby ($X^2 = 4.8$, $p = .028$), and "other" ($X^2 = 7.88$, $p = .005$); and gray-and-white cats were more aggressive than points ($X^2 = 4.30$, $p = .038$) and "other" ($X^2 = 6.17$, $p = .013$). All other comparisons yielded nonsignificant values. Figure 2 presents handling aggression scores showing a slightly increased frequency of aggression among tortoiseshell/calico/torbie, black/brown/gray tabby, and gray-and-white cats, as compared with cats of other coat colors.

Veterinary aggression

With all coat colors combined, females were identified by their guardians as more aggressive during veterinary visits compared with males ($X^2 = 10.36$, $p = .001$). Analyses showed that gray-and-white

Table 5. Categorical analysis of the presence or absence of human aggression in cats.

Coat color	Total cats per color	# Cats with human aggression score > 0	# Cats with human aggression score $= 0$	Mean human aggression score	Range $>(0–20)$	Median	% of individuals with score > 0	X^2	p value
Black	108	47	61	1.68	0–15	0	43.5%	<0.01	.968
Black-and-white	186	90	96	1.89	0–16	0	48.4%	1.43	.230
Calico	69	50	19	2.97	0–15	1	72.5%	21.8	$<.001$
Color points	103	39	64	2.17	0–20	0	37.9%	1.33	.249
Gray	39	15	24	1.26	0–18	0	38.5%	0.43	.510
Gray-and-white	77	41	36	2.26	0–16	1	53.2%	2.67	.10
Tabby (black, brown, and gray)	383	144	239	1.48	0–16	0	37.6%	4.53	.033
Tabby (orange, cream, and buff)	160	70	90	1.88	0–16	0	43.8%	<0.01	.990
Tortoiseshell	54	26	28	1.87	0–19	0	48.1%	0.41	.520
White	26	11	15	2.38	0–17	0	42.3%	0.21	.886
Torbie	8	5	3	2.12	0–6	1	62.5%	[a]	.309
Other	61	19	42	1.00	0–9	0	31.1%	3.75	.053
Tortoiseshell /calico/torbie	131	81	50	2.47	0–19	1	61.8%	15.72	$<.001$
Totals		557	717						

Note. Analyzed by color, both sexes combined. Shaded boxes indicate significance.

[a] Fisher's exact test was used.

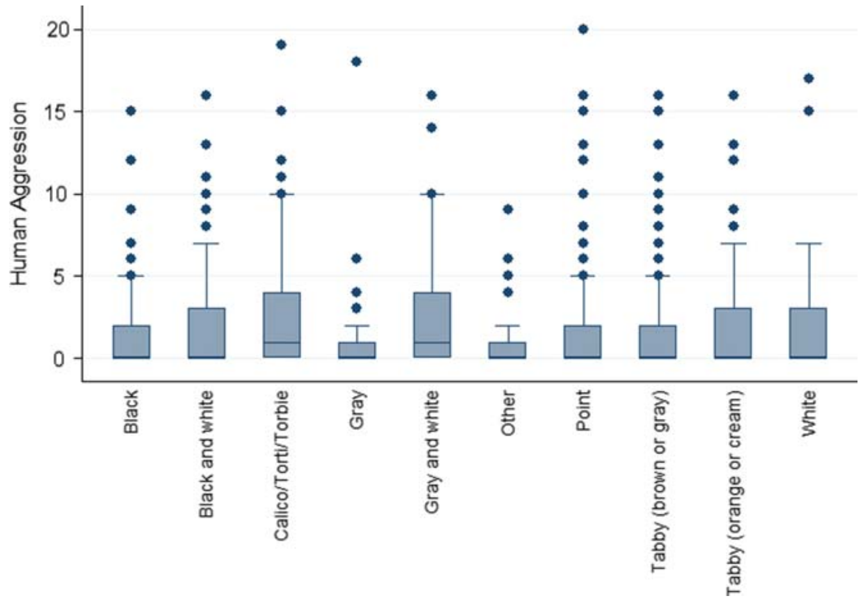

Figure 1. Human aggression scores. These scores show increased frequencies of aggression among tortoiseshell/calico/torbie and gray-and-white cats as compared with cats of other coat colors. *$p < .05$.

and black/brown/gray tabby females were more aggressive than their male counterparts at veterinarians' offices ($X^2 = 9.28$, $p = .002$, and $X^2 = 5.00$, $p = .025$, respectively).

The medians, ranges, and means for veterinary aggression, by coat color and with sexes combined, are included in Table 7. Due to the overall low scores in veterinary aggression, we collapsed these data into categories of whether they were reported to display any aggression or none whatsoever. We compared the number of cats within a given coat color who scored > 0 and the number who scored 0 to the total number of cats who scored > 0 and who scored 0 in this category. This comparison yielded a higher-than-expected number of cats with a score > 0 for calico ($X^2 = 8.53$, $p = .003$) compared with all other cats combined. Figure 3 presents veterinary aggression scores showing consistency of scores across all colors combined.

Discussion

These findings suggest that increased aggression toward humans may exist among sex-linked females, gray-and-white cats, and possibly black-and-white cats compared with cats of other colors. The finding that tortoiseshell/calico/torbie cats were significantly more frequently aggressive toward humans supports the contention that calicos and tortoiseshells can be challenging for some guardians (Delgado et al., 2012). Because aggression is usually multifactorial (Beaver, 2003), some aspects may be related to specific X inactivation that creates the coat-color patterns of these females. Increased aggression among black-and-white and gray-and-white cats compared with cats of other colors was not expected. Nowhere in the literature is there a suggestion of either of these coat colors being reported as more aggressive.

Despite the statistical significance, the median scores in all three categories of aggression suggest that the differences between sex-linked females, black-and-whites, or gray-and-whites and the other colors are relatively small and could potentially be explained by guardian differences in interpretation of the scoring criteria. It may also be due to the relatively low levels of aggression in cats overall, as evidenced by the low median scores, so that any difference, however small, comes out as significant.

The finding of increased aggression in certain coat colors has not been reported previously, which may reflect a lack of investigation into this issue. Dantas-Divers et al. (2011) focused on aggression among cats in a shelter setting and did not consider how these cats related to humans. Delgado et al. (2012)

Table 6. Categorical analysis of the presence or absence of handling aggression in cats.

Coat color	Total cats per color	# Cats with handling aggression score > 0	# Cats with handling aggression score $= 0$	Mean handling aggression score	Range (0–36)	Median	% of individuals with score > 0	X^2	p Value
Black	108	85	23	3.69	0–19	2	78.7%	0.005	.944
Black-and-white	186	153	33	3.58	0–20	2	82.3%	1.44	.230
Calico	69	57	12	4.54	0–27	3	82.6%	0.685	.408
Color points	103	75	28	3.06	0–21	1	72.8%	1.74	.187
Gray	39	29	10	2.97	0–16	1	74.4%	0.366	.545
Gray-and-white	77	64	13	4.17	0–21	3	83.1%	0.957	.328
Tabby (black, brown, and gray)	383	288	95	3.18	0–27	1	75.2%	1.759	.085
Tabby (orange, cream, and buff)	160	124	36	3.46	0–24	2	77.5%	0.07	.791
Tortoiseshell	54	47	7	3.69	0–24	2	87.0%	[a]	.173
White	26	24	2	3.35	0–18	2	92.3%	[a]	.094
Torbie	8	6	2	4.63	0–16	3	75.0%	[a]	.685
Other	61	47	14	2.02	0–10	1	77.0%	0.064	.80
Tortoiseshell/calico/torbie	131	110	21	4.19	0–27	3	84.0%	2.204	.138
Totals		999	275						

Note. Analyzed by color, both sexes combined.
[a] Fisher's exact test was used.

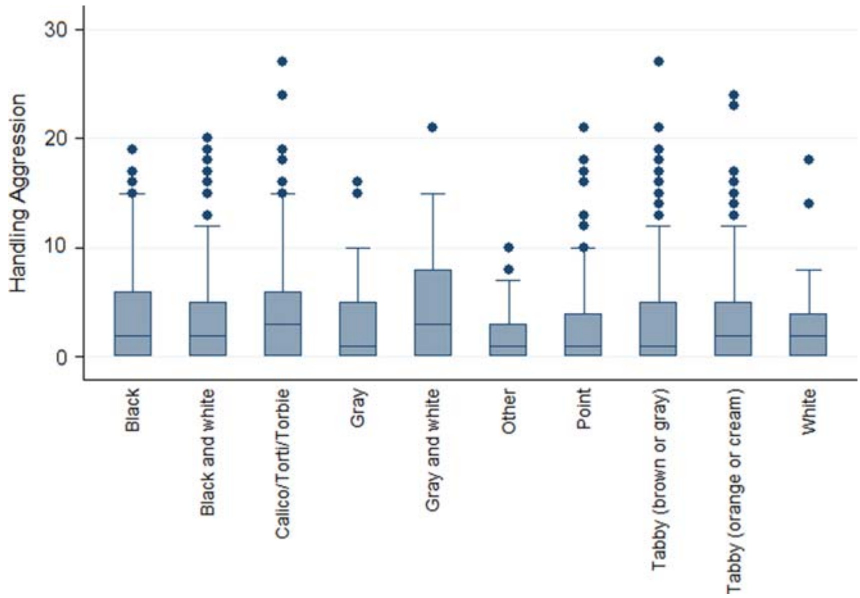

Figure 2. Handling aggression scores. These scores show increased frequency of aggression among tortoiseshell/calico/torbie, black/brown/gray tabby, and gray-and-white cats as compared with cats of other coat colors. *$p < .05$.

asked respondents to assign descriptors to cat color categories without reference to any particular cat. This study focused on individual cats. In addition, the Delgado et al. study did not include "aggressive" as a possible descriptor.

We were surprised to find the lack of difference among coat colors in likelihood of aggression during veterinary visits. Part of our surprise comes from the fact that veterinary staff members, in particular, have strong feelings about the behavior of cats in certain coat-color categories (Becker, 2012; Veterinary Pet Insurance, n.d.).

Although data were collected on affiliative behavior toward humans, aggressive and affiliative behaviors toward other cats, urine marking, spraying, furniture scratching, activity levels, and fearfulness, these questions were used, in part, as distractors to cloak the true subject of the survey. Studies have shown that a cat's neuter status and access to outdoors and the number of cats in a household (single vs. multiple cats) may be correlated with aggression toward people and other behavior problems (Amat, de la Torre, et al., 2009). In evaluation of these data, cats with coat colors that had higher frequencies of aggression were no more likely to be in any of these categories.

It is important to acknowledge the limitations of this study. First, it was composed of a convenience sample rather than a random sample of guardians of cats. The respondents to the survey were self-selected from a population of cat guardians who had access to the specific listservs and social media profiles that made the survey link available. Exposure to the link and willingness to participate likely skew the data in favor of guardians very interested in cats in general and, in particular, their cats. However, Internet surveys have been used to collect data for research in veterinary medicine (e.g., Jehn et al., 2003; Sueda, Hart, & Cliff, 2008; Tynes, Hart, & Bain, 2007). Internet approaches can provide access to samples and computerized processing of data that far exceed what is possible by more traditional techniques (Rankin et al., 2008). Gosling, Vazire, Srivastava, and John (2004) conducted a review of the preconceptions raised about limitations of Internet surveys. The authors concluded that data and findings through Internet methods are at least as good in quality as those provided by traditional methods. In addition, the role of online social networks has likewise been explored and shown to be a valid avenue for both disseminating and collecting research information (Wilson, Gosling, & Graham, 2012).

Second, the behaviors reported in each survey were the subjective opinions of the cats' guardians; no objective observations or observer validations were possible. However, there is evidence that survey

Table 7. Categorical analysis of the presence or absence of veterinary aggression in cats.

Coat color	Total cats per color	# Cats with vet aggression score > 0	# Cats with vet aggression score = 0	Mean vet aggression score	Range (0–9)	Median	% of individuals sith score > 0	X^2	*p* value
Black	108	56	52	2.01	0–9	0	51.9%	2.265	.132
Black-and-white	186	84	102	1.67	0–9	0	45.2%	0.043	.835
Calico	69	43	26	2.21	0–9	0	62.3%	8.531	.003
Color points	103	45	58	1.78	0–9	0	43.7%	0.017	.897
Gray	39	15	24	1.58	0–9	0	38.5%	0.532	.466
Gray-and-white	77	37	40	1.66	0–9	0	48.1%	0.403	.525
Tabby (black, brown, and gray)	383	164	219	1.61	0–9	0	42.8%	0.279	.597
Tabby (orange, cream, and buff)	160	65	95	1.23	0–9	0	40.6%	0.8	.371
Tortoiseshell	54	22	32	1.53	0–9	0	40.7%	0.273	.601
White	26	13	13	1.60	0–8	0	50.0%	0.33	.566
Torbie	8	1	7	2.38	0–9	0	12.5%	[a]	.085
Other	61	20	41	1.57	0–9	0	32.8%	3.161	.075
Tortoiseshell/calico/torbie	131	66	65	1.94	0–9	0	50.4%	1.748	.186
Totals		565	709						

Note. Analyzed by color, both sexes combined. Shaded box indicates significance.

[a] Fisher's exact test was used.

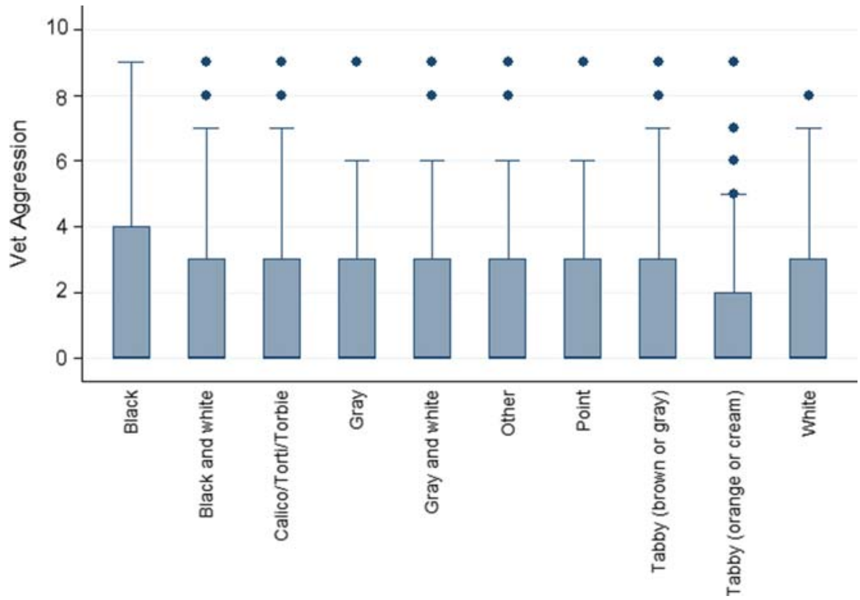

Figure 3. Veterinary aggression scores. There were no significant differences in aggression scores among coat colors.

answers are strongly correlated with observed behaviors. For instance, studies of temperament tests in horses, dogs, and sheep in which guardians (and other observers) had previously completed behavior questionnaires showed a high correlation between what the guardians reported and how the dogs or horses responded during the tests (Bennett, Litster, Weng, Walker, & Luescher, 2012; Momozawa et al., 2003, 2007; Phythiana, Michalopouloua, Duncana, & Wemelsfelder, 2013). Additionally, the questions in this survey were based on the types of observations often performed during feline temperament tests and assessments. For instance, Feaver, Mendl, and Bateson (1986) and Siegford, Walshaw, Brunner, and Zanella (2003) referred to many of the same affiliative and agonistic behaviors described in this study.

Third, some coat-color categories had relatively few representatives. For instance, there were relatively few females who were either orange tabby or white. There were also few solid gray cats of either sex. Ideally, the study would have included more raw data as the bases for our conclusions.

Fourth, we acknowledge that breed, neuter status, home environment, and other factors may account for some of the differences noted in our data. Further studies can begin to isolate these factors and determine their role in these findings.

Fifth, many categories of data were tested in the course of this study, which increases the probability of Type I errors. Despite adjustments for multiple comparisons, findings should advisedly be confirmed in additional populations.

Finally, early decisions regarding the design of the survey, which caused the handling and veterinarian aggressions to be tracked on a 4-point scale and the other types of aggression (play/hiss/bite) to be reported on a 5-point scale, dictated that data from these types of aggression could not be combined for analysis. Also, the categories measured behaviors differently (handling and veterinary aggressions as likelihoods and human aggression as frequency). Therefore, these data were analyzed separately, despite not being completely distinct phenomena. In retrospect, it would have been ideal to keep the scales consistent.

Conclusion

This study suggests that coat colors may be associated with aggressive behaviors in the cat but that the differences are relatively minor. These findings support some common assumptions about personalities associated with different cat color patterns and help current cat guardians better understand their companion cats. They may also help guardians, potential adopters, veterinarians, and others better anticipate what behaviors they may observe in cats.

The subtlety of the results of this study suggests the need for additional research on the topic of the relationship between coat color and aggression to support or refute our findings. Such research may include observational studies, larger guardian surveys, or even examination at the molecular or allelic level for clarification of these findings.

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