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Original research article

Birds be safe: Can a novel cat collar reduce avian mortality by domestic cats (*Felis catus*)?

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HIGHLIGHTS

- We tested the use of a novel cat collar in reducing bird and mammal mortality.
- Cats wearing collars killed 19 times fewer birds than uncollared cats.
- The Birdsbesafe® collar is highly effective at reducing bird deaths.
- We strongly suggest its use for owned and feral cats, primarily in the spring.
- The Birdsbesafe® collar is an effective conservation tool for use on domestic cats.

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ABSTRACT

The domestic cat (*Felis catus*) has been described as the largest anthropogenic threat to songbird populations in North America. We examined the effectiveness of a novel cat collar in reducing avian and small mammal mortality by cats. The 2-inch wide Birdsbesafe® collar cover (CC) is worn over a nylon quick-release collar, and the bright colors and patterns of the CC are hypothesized to warn birds of approaching cats. We conducted two seasonal trials, each lasting 12 weeks, in autumn 2013 ($n = 54$ cats) and spring 2014 ($n = 19$ cats). Cats were randomly assigned to two groups, and CCs with interior collars were removed or put on every two weeks, to control for weather fluctuations and seasonal change. Cats wearing Birdsbesafe® CCs killed 19 times fewer birds than uncollared cats in the spring trial, and 3.4 times fewer birds in the fall. Birdsbesafe® CCs were extremely effective at reducing predation on birds. Small mammal data were less clear, but did decrease predation by half in the fall. The Birdsbesafe® CC is a highly effective device for decreasing bird predation, especially in the spring season. We suggest that the CCs be used as a conservation tool for owned as well as feral cats.

1. Introduction

Encroachment and habitat alteration of natural areas has led to increased contact between domestic companion animals (dogs and cats) and wildlife (Riley et al., 2004; Alexander and Appel, 1994). Under this context, free ranging pet cats (*Felis catus*) are a major threat to passerine birds (Loss et al., 2013), as suburban residential areas may retain sufficient aspects of nearby wilderness to maintain high densities and diversities of passerine birds (Lerman and Warren, 2011) that have high probabilities of encountering predatory domestic cats. According to the American Veterinary Medical Association, approximately 95.6 million cats lived in 30.4% of American households in 2012. Due to their abundance, and their behavior as generalist predators, both pet and feral domestic cats have a high tendency to prey on other species, including small

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mammals, herpetofauna, and passerine birds (Loyd et al., 2013). A recent, well-publicized study by Loss et al. (2013) extrapolated local data to a national scale and provides the first glimpse of the depth of the problem—domestic cats are estimated to kill a median of 2.4 billion birds (with a range of 1.3–4.0 billion) and 12.3 billion mammals (with a range of 6.3–22.3 billion) per year in the United States, and point at cats as one of the largest anthropogenic threats to wildlife in the nation. This work is some of the latest examining domestic cats as predators, but certainly is not the only work highlighting the toll that cats take on birds and small mammals (Blancher, 2013; Dauphine and Cooper, 2009). The amount of literature in both the scientific and popular press (ASPCA online, Tweitt, 2013, Cooper, 2007) on this issue tells us two things: (1) cat owners are likely aware of the problem of allowing their cat(s) outdoors, and (2) the issue of keeping cats indoors is contentious to cat owners.

Paradoxically, while the high proportion of American cat owners may suggest that people value domestic animals over native fauna, 45.7 million Americans also consider themselves birdwatchers or otherwise encourage birds to forage near their homes (USFW, 2011). In 2011, Americans spent over four billion dollars on birdseed alone (USFW, 2011). Unfortunately, backyard bird feeders are often a site of predation as birds congregate into one area, providing cats with easy targets (Tessaglia and Dunn, 1994). Attracting songbirds to our backyards may in the end prove lethal to the birds we are trying to feed and view; citizen science data from the Cornell Lab of Ornithology found that more than thirty species of birds were killed by pet cats in their own urban and suburban backyards (Cooper, 2007).

Loss et al. (2013) estimated that the 30–80 million un-owned (i.e. feral) cats were responsible for 69% of cat predation events on wildlife in the United States. Although there are more owned cats overall, the authors suggested a predation rate on wildlife averaging three times higher for feral versus owned cats. While scientifically it makes sense to suggest euthanasia for feral cats, this controversial and contentious method of decreasing wildlife mortality by cats is not generally practiced except in areas of high endemicity (i.e. Galapagos Islands). The American Society for the Prevention of Cruelty to Animals (ASPCA) has suggested that feral cat populations be controlled by adoptions rather than euthanasia (ASPCA online). Unfortunately, this is unlikely to happen unless the general public becomes much more aware of the problem feral cats pose to wildlife, and enough individuals choose to become involved in the adoption process.

In order to monitor and reduce the incidence of cat predation on birds, various companies and private citizens have developed products designed as hunting deterrents to be worn by domestic cats. These products vary from simple bells worn on a cat collar, to patented devices that attach to a cat collar and act via size, shape, or color in deterring hunting success. A belled collar has been found to reduce the number of mammals and birds that cats bring back by 50%, compared with no collar (Gordon et al., 2010; Ruxton et al., 2002), though it is possible for cats to compensate for bell-wearing and develop different hunting strategies (Nelson et al., 2005). A product called CatAlert® also works on auditory detection, in that it produces a beeping sound every seven seconds (http://www.moggies.co.uk/html/newprod.html#catalert). While this product reduced prey rates, it did not significantly differ from cats wearing a belled collar (Nelson et al., 2005). The CatBib®, a product designed by Cat Goods Inc., is a hanging colored bib that is attached to a cat's collar (www.catgoods.com). It offers two main functions for reducing prey mortality—one, it serves as a visual cue to warn prey of the cat's presence, and two, the bib serves as a physical barrier to the paws when a cat attacks a prey animal. Calver et al. (2007) found that 81% of cats wearing the CatBib,® either with or without a bell, stopped catching birds and 45% stopped catching mammals. While the CatBib® is effective in reducing wildlife prey, it may receive tepid support from cat owners due to its large size and awkward appearance.

Our study examines a patent-pending device specifically intended to reduce avian mortality by domestic cats. Birdsbesafe® cat collar covers (CC), developed in 2008, are a unique design consisting of a two-inch wide tube-shaped fabric cover that fits easily over a buckled quick-release cat collar (www.birdsbesafe.com) (CC is hereafter understood to mean CC worn with interior quick-release collar), see Fig. 1. The bright colors and vivid patterns on the collar cover, as well as its width around the cat's head, are meant to serve as a visual cue to warn birds of an approaching cat. There are currently no published studies that have tested the efficacy of the Birdsbesafe® CCs in reducing avian or small mammal mortality, and that is our main objective here. We hypothesized that the Birdsbesafe® cat CC would be effective in mitigating domestic cat predation on birds due to its vibrant colors, which warn birds of impending danger from stalking cats. We were unsure whether the CC would have a similar effect on small mammals, which are generally scent oriented. However, we were interested in possible behavioral changes that may act to reduce overall hunting while cats wore the Birdsbesafe® CC.

2. Methods

2.1. Data collection

This study was carried out in St. Lawrence County, New York. To obtain cats for the study, we utilized local media as well as signs placed in churches and public buildings. We also found willing volunteers through the St. Lawrence University faculty/staff e-mail list-serve. One participant lived just outside of the county, and another lived in suburban Connecticut. We conducted two trials for the data collection process, each taking place over a span of twelve weeks. The first trial ran from September through November 2013 and the second trial ran from April through June 2014. Each trial was divided into six blocks of two weeks each. Households (and therefore all cats in the study) were randomly divided into two separate groups (group 1 and group 2), with group 1 starting the study with the Birdsbesafe® CC on (over an interior quick-release collar), and group 2 starting with no CCs or interior collar. Every two weeks, the Birdsbesafe® CCs and underlying quick release collar were either removed or put back on cats, depending on a given cat's group. If Birdsbesafe® CCs were not worn

Table 1
Survey of cat collar and/or collar cover comfort ($n = 52$ cats).

% of cats	# of cats	Category	Description
69%	36	0	No issues; cat got used to collar/cover within 30 min and did not seem to mind wearing it.
2%	1	1	Cat took up to 5 days to get used to collar/cover, but then seemed fine.
6%	3	2	Cat never fully accepted collar/cover, but wore it (i.e. occasionally pawed at collar or otherwise showed mild annoyance).
23%	12	3	Cat showed strong dislike of collar/cover (either tried to remove it often or never accepted it).

for the entire two-week period (i.e. were lost), those days were accounted for and added to a particular block so each cat in the end completed an equal amount of time over 12 weeks with and without CC.

We chose to use no collar as our control after weighing the benefits of various controls. There are no known studies that suggest that a standard quick-release collar is effective in mitigating bird mortality. Based on a review of bird advocacy websites and through discussions with numerous cat owners, we also found no anecdotal evidence that standard collars decrease bird mortality. We therefore chose to compare the Birdsbesafe® CC to a control of no collar, since if we found no difference, we would assume that the CC acted as the equivalent to a standard quick-release collar, and was not effective. Our anecdotal evidence also led us to believe that a majority of owned and feral cats do not wear any collar, and therefore using no collar as a control represents the reality in terms of wildlife mortality levels from cat depredation.

Cat selection for the study was based on cats meeting the following criteria:

(1) cats were known hunters of vertebrates, and (2) cats regularly left intact prey items on home doorsteps or porches (rather than eating their prey). By accepting cats under these criteria, we tried to explicitly utilize cats that were reliably bringing some percentage of prey items back to their home. Our study does not account for prey that may have been left outside and not found by owners, or was entirely eaten by the cat predator. When a prey item was found at a study household, the cat owner collected the specimen, placed it in a sealed plastic bag, labeled the bag with date and whether collar was on or off, and stored the prey item in the freezer until a later collection date. We also required participants to record any prey that they took from the cat and released alive. These specimens were still considered prey for the purposes of our data, though some were not identified to species.

To examine behavioral responses of the cats to the Birdsbesafe® CCs, owner participants completed an online survey at the end of the trials on CC comfort. Participants were asked to rate each cat's behavioral response to the CC on a 0–3 scale, as outlined in Table 1. Participants also completed a separate online survey regarding their plans to use the Birdsbesafe® CCs in the future.

2.2. Species identification

We identified all prey items to species when possible. Two small mammal species, the White-footed Mouse (*Peromyscus leucopus*) and the North American Deermouse (*Peromyscus maniculatus*), were lumped together under species identification, as they are extremely similar in appearance.

2.3. Statistical methods

To determine whether Birdsbesafe® cat CCs were effective at reducing avian and mammal mortality, we ran separate randomization of the mean tests in Statkey v 0.3.11 (Lock et al., 2014) for birds and mammals, comparing data for a given season while cats were with versus without CCs. For each analysis, we generated 5000 randomized samples for comparison. Since our spring trial consisted of a subset of our fall trial cats, we also compared the results from fall and spring trials only for cats that were present in both trials. We used a randomization test for a mean to examine whether the difference between total bird captures per cat with and without CC differed from zero in fall versus spring trials. We carried out the same analysis for mammal captures. We used the larger fall dataset to examine the factors of cat sex and location (rural versus village) for differences in bird and mammals capture rates, using randomization tests for differences in means. Cat age was broken into three categories: young (1–6 years), middle-aged (7–10 years), or older (11+ years), and analyzed using a randomization ANOVA test for difference in means.

3. Results

We obtained a study group of 56 domestic cats living within 27 households for the fall trial and a subset of 24 cats living within 12 households for the spring trial. Two cats from one household were excluded in the fall due to a non-communicative owner, and six cats from two households were excluded from the spring sample as the owners failed to respond to our attempts to collect prey items. Final sample sizes were thus 54 cats (fall trial) and 19 cats (spring trial). Over the course of both trials, we collected 19 species of depredated birds from 12 families, as well as 11 species of mammals from 8 families (Table 2). In total, we collected 50 birds and 136 small mammals that were depredated by our study cats.

Birdsbesafe® CCs were effective at reducing both mammal and bird mortality when collars were on cats. In our fall 12-week trial, cats killed 3.4 times more birds when not wearing CCs as compared to times that CCs were in use (randomization of the mean test, $p = 0.006$). In the spring, cats killed 19 times more birds without CCs when compared with times

Fig. 1. A domestic cat models the Birdsbesafe® collar cover worn by cats in this study. Collar covers are two-inch wide tubes of cotton fabric that allow for a quick-release cat collar to fit inside the cover. The cover width, bright colors and patterns may make the cat more visible to songbirds and other prey animals. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
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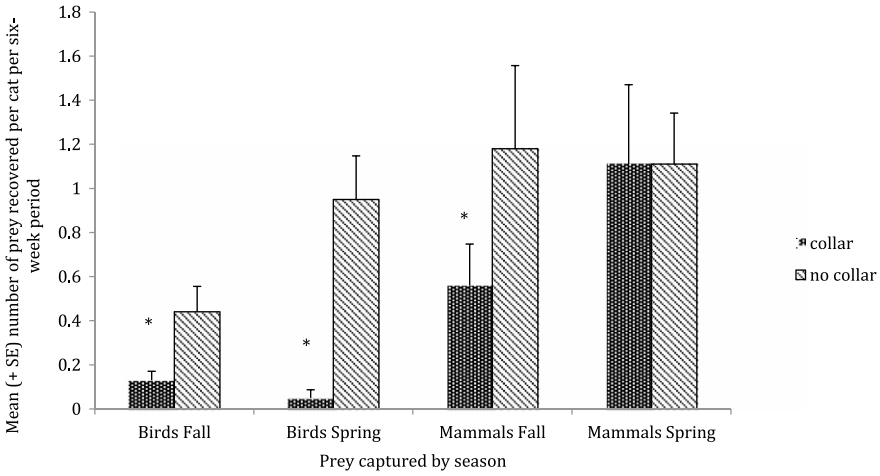

Fig. 2. Birdsbesafe® cat collar covers reduced the number of depredated birds recovered from cats by 3.4 to up to 19 times across the two seasonal trials, compared with no collar. Use of collar cover versus no collar was statistically significantly different each season (randomization test, $p < 0.05$). For mammals, results per cat varied across seasons. Cats in the fall trial depredated twice as many recovered mammals while not wearing collar covers (randomization test, $p < 0.05$). However, cats in the spring trial depredated an equal number of recovered mammals with and without collar covers ($n = 54$ cats for fall trial, $n = 19$ cats for spring trial). Figure displays each seasonal 12-week trial broken into the total time wearing versus not wearing the Birdsbesafe® collar cover and interior breakaway collar (six week periods).

CCs were worn (randomization of the mean test, $p = 0.000$) (Fig. 2). For mammals, cats killed twice as many animals when not wearing CCs as when CCs were in use during our fall trial (randomization of the mean test, $p = 0.008$). However, in the spring, cats killed an equal number of mammal prey items with and without CCs (randomization of the mean test, $p = 0.528$) (Fig. 2).

To examine differences in CC efficacy across seasons, we performed a randomization of the mean test for the subset of cats that were in both fall and spring trials. We found a significant difference when examining bird captures for this subset of cats in both seasonal trials ($p = 0.034$, $n = 18$). Specifically, CCs reduced avian mortality in both seasons, but were even more effective in the spring for the subset of cats that wore the CCs in both seasons. On the other hand, we found no significant difference in number of small mammal prey items with and without CCs across seasons for this subset of cats ($p > 0.5, n = 18$). These results suggest that the apparent difference in efficacy of Birdsbesafe® CCs across seasons for small mammals was due to the subset of cats that were only in our fall trial.

Because wearing the Birdsbesafe® CC had a strong effect in decreasing small mammal mortality in our fall trial, we re-ran our analysis of these data while excluding all Eastern Chipmunks (*Tamias striatus*), under the hypothesis that this diurnal visual forager could have been driving the results towards significance, in terms of cat predation with and without CCs.

However, our results for fall small mammal mortality were still significant ($p = 0.023$), suggesting that overall mammal mortality declines with the use of the Birdsbesafe® CC, at least seasonally.

Due to the large number of cats we tested, we were able to examine factors of cat sex, age, and home location (village versus rural) on bird and mammal mortality when cats were wearing versus not wearing Birdsbesafe® CCs. Using our larger dataset from the fall ($n = 54$ cats) in a randomization test for a difference in means, we found no difference in bird or mammal mortality due to cat sex ($p > 0.5$) or location ($p > 0.5$). For the three cat age categories (young, $n = 33$; middle-aged, $n = 13$; older, $n = 8$), we also found no differences across ages for mammal mortality ($F = 2.30$, $p > 0.05$), or bird mortality ($F = 2.41$, $p > 0.05$).

We asked all cat owners involved in our study to rate the comfort of wearing the Birdsbesafe® CC and interior cat collar in our study. An unknown number of cats in the study had never worn a collar before, while others regularly wore a store-bought nylon collar. We therefore present collar cover comfort results with the understanding that results may be due to the interior collar itself, and not the collar cover. We used four categories ranging from no problem with the collar to extreme discomfort to describe cat responses to the collar (Table 1). In general, cats tolerated wearing the interior quick-release collar and CC fairly well, with 69% of cats not responding to the collar or CC in any way. Twenty three percent of cats refused to wear the CC or seemed to be in distress while the CC was worn (Table 1).

4. Discussion

4.1. Bird mortality

Our study clearly demonstrated that the Birdsbesafe® CC is effective at reducing bird mortality by domestic cats. Across all cats in our study, the average cat will kill and bring home 0.72 birds per year with a Birdsbesafe® CC and 5.56 birds per year without a CC (using means for fall and spring trials, each multiplied to reflect 6 months of a year and added together). Since some cats seemed to specialize on mammal or bird prey, specifically, we can also examine the mean number of birds recovered solely by cats that killed and brought home birds in our study. This mean suggests a kill rate of 1.4 birds per year (brought home) while wearing Birdsbesafe® CCs, compared to 8.4 birds without CCs per year. Based on Loyd et al.'s (2013) study, we know the actual rate of kill may be much higher, since only 23% of prey items were returned to households in their study.

While some may question whether the Birdsbesafe® CC is worth using with numbers this low, the numbers add up—our 54 cat participants are expected to kill and bring home an average of 300 birds per year without CCs, compared to only 39 birds while wearing Birdsbesafe® CCs. We can project this difference out to the approximately 95.6 million cats living in American households in 2012 (American Veterinary Medical Association). For only 1% of these cats, if we assume they are bird killers, we can expect a conservative bird mortality toll of over 8 million recovered birds per year, compared with approximately a sixth of that, or 1.3 million recovered bird kills per year if that 1% of cats wore the Birdsbesafe® CC. For the spring season in particular, when bird mortality is highest, we can estimate a toll of 1.8 million recovered bird prey items, in just 12 weeks, for average, un-collared cats. Compare this with an estimate that is 19 times lower, or 95 600 birds, if that same 1% of American-owned cats wore the Birdsbesafe® CC in the spring season. The numbers are staggering when one extrapolates out, but the conservation implications are clear: if owners of outdoor cats choose to use the Birdsbesafe® CCs, a significant factor in the decline of songbird populations would drop precipitously.

We were surprised at the difference in avian mortality results between the fall and spring trials. Specifically, in the fall we found that 3.4 times more birds were killed when Birdsbesafe® CCs were not in use, but that number climbed to 19 times greater mortality when collars were not in use in the spring. We suspect these differences may have to do with seasonal changes in bird behavior and/or visibility. In the fall, some passerines are more likely to be drab-colored, and almost all flock-forage (Rodewald and Brittingham, 2002); in the spring, birds are showy, sometimes more colorful, and intent on setting up territories and initiating nesting. Individual birds are so intent on territorial and nesting behavior that they may become less attuned to predators, and therefore potentially more likely to be depredated by a domestic cat in the spring (Lima and Dill, 1990). Our results suggest that owners of outside cats should be particularly attentive to their cat's hunting in this season, and that the Birdsbesafe® CC may be most effective at reducing bird deaths in late spring and early summer. Another possible reason for the discrepancy between spring and fall trial results is that the specific Birdsbesafe® CC color pattern we tested was less effective in the fall. Interestingly, the colors orange, yellow, and red can match the pattern of autumn leaves on the ground, and may allow cats to more cryptically sneak up on unwary birds in the fall. Our results suggest that other color combinations that less closely mimic fall leaf drop may be more effective in the autumn season.

4.2. Mammal mortality

The intent of our study was to examine the efficacy of the Birdsbesafe® CC in reducing avian mortality. However, our study design allowed us to also ask whether the collar cover had an effect on hunting rates of small mammals as well. Interestingly, our fall trial results showed that over twice as many small mammals were killed when cats were not wearing the Birdsbesafe® CCs. However, results differed in the spring, when means for cats with and without collars were virtually even. One possibility is that seasonal snow cover, and subsequent tunneling by small mammals during our spring trial,

Table 2
A total of 50 individual birds and 136 mammals were recovered over the course of fall and spring trials (24 weeks) in Northern New York and vicinity by domestic cats (birds: 19 species, 12 families; mammals: 11 species, 8 families).

Prey category	Common name	Scientific name	Family	Total # recovered
Bird				
	Mourning dove	*Zenaida macroura*	Columbidae	3
	Downy Woodpecker	*Picoides pubescens*	Picidae	1
	Black-capped Chickadee	*Poecile atricapillus*	Paridae	6
	Red-breasted Nuthatch	*Sitta canadensis*	Sittidae	1
	White-breasted Nuthatch	*Sitta carolinensis*	Sittidae	1
	House Wren	*Troglodytes aedon*	Troglodytidae	1
	American Robin	*Turdus migratorius*	Turdidae	4
	European Starling	*Sturnus vulgaris*	Sturnidae	1
	Cedar Waxwing	*Bombycilla cedrorum*	Bombycillidae	4
	Magnolia Warbler	*Dendroica magnolia*	Parulidae	1
	Common Yellow throat	*Geothlypis trichas*	Parulidae	2
	Unidentified Warbler		Parulidae	1
	Chipping Sparrow	*Spizella passerina*	Emberizidae	1
	Field Sparrow	*Spizella pusilla*	Emberizidae	1
	Savannah Sparrow	*Passerculus sandwichensis*	Emberizidae	1
	Song Sparrow	*Melospiza melodia*	Emberizidae	4
	White-throated Sparrow	*Zonotrichia albicollis*	Emberizidae	1
	Unidentified Sparrow		Emberizidae	4
	Dark-eyed Junco	*Junco hyemalis*	Emberizidae	2
	Common Grackle	*Quiscalus quiscula*	Icteridae	1
	Purple Finch	*Carpodacus purpureus*	Fringillidae	1
	Unidentified bird			8
	19 species, 12 families			$N = 50$
Mammal				
	Northern Short-tailed Shrew	*Blarina brevicauda*	Soricidae	9
	Least/Masked Shrew	*Cryptotis parva/Sorex cinereus*	Soricidae	2
	Eastern Mole	*Scalopus aquaticus*	Talpidae	1
	Little Brown Myotis	*Myotis lucifugus*	Vespertilionidae	1
	Eastern Chipmunk	*Tamias striatus*	Sciuridae	38
	Southern Flying Squirrel	*Glaucomys volans*	Sciuridae	2
	White-footed/N. A. Deer Mouse	*Peromyscus leucopus/P. maniculatus*	Cricetidae	36
	Meadow Vole	*Microtus pennsylvanicus*	Cricetidae	8
	Brown Rat	*Rattus norvegicus*	Muridae	1
	Woodland Jumping Mouse	*Napaeozapus insignis*	Dipodidae	12
	Unidentified Cricetid/Dipodid			17
	Eastern Cottontail Rabbit	*Sylvilagus floridanus*	Leporidae	3
	Unidentified Mammals			6
	11 species, 8 families			$N = 136$

affected overall small mammal hunting. However, the mean number of prey items across seasons was actually higher in spring compared to fall, so we reject the idea that snow cover decreased overall capture rate to the point that collar effects were negated.

Another possibility is that variation in individual cat behavior may make the collar more or less effective at altering depredation rates on small mammals. This result is very different than what we see with birds, where predation rates presumably go down due to highly sensitive color vision that allows birds to see approaching cats wearing the Birdsbesafe® CCs. In mammals that presumably are primarily scent-oriented, it is possible that cat behavior itself may change when a cat wears the CC, and may decrease a cat's inclination to hunt. Interestingly, anecdotal evidence from cat owners during our study suggests that some cats seemed to hunt less in general while wearing CCs, or even "gave up" hunting while CCs were worn.

4.3. Prey animals

Although no one species of bird was over-represented in our sample, we see a general, and unsurprising trend for cats to depredate ground-feeding birds like sparrows (Table 2). Recovered birds represented 19 species and 12 families. Out of 50 recovered birds, we found that 28% were Emberizids (sparrows and allies). The rest of the birds in our sample make up a wide variety of backyard birds, and include both neotropical migrants and winter residents from 12 families. Birds varied from common species such as the European Starling and American Robin, to relatively rare and declining species like the Magnolia Warbler (Strode, 2003) and the Savannah Sparrow (Jobin et al., 1996).

Small mammal prey recoveries represented 136 individuals, 11 species, and 8 families (Table 2). White-footed/North American Deer Mice represented 26% of individuals, but this number could be as high as 39% if unidentified remains belonging to either Cricetidae/Dipodidae are included. Interestingly, 28% of our recovered mammals were Eastern

Table 3
Exit survey to assess whether owner participants planned to continue using the Birdsbesafe® collar cover on their cats ($n = 23$ responses).

1. Are you still using the Birdsbesafe® cat collar cover?	
	22% YES; 78% NO
2. If you answered NO, which of the following is most applicable:	
39%	(a) The collar and collar cover fell off.
28%	(b) The collar and collar cover is uncomfortable for my cat.
17%	(c) I do not like the collar and collar cover.
3. Do you plan on buying a Birdsbesafe® collar cover in the future for your cat?	
	26% YES; 61% NO; 9% maybe
4. If you answered NO, please pick any of the following as applicable (more than one is fine):	
7%	(a) The collar and collar cover is too expensive.
50%	(b) I am afraid it will just fall off.
21%	(c) I am afraid it puts my cat at risk since it is colorful (i.e. from dogs, coyotes, etc.)

Chipmunks, ranking this species as potentially even more sought as prey than the mice discussed above. We found no literature discussing long-term population trends of this species, but it is not considered a threatened mammal species in New York (NYSDEC, 2010). Cats seemed to focus on mammal prey smaller than rabbits, as only 2% of prey items were Eastern Cottontails.

4.4. Study limitations

Since our study was based in northern New York, we were unable to determine the effectiveness of the Birdsbesafe® CC in deterring cats from killing herpetofauna. Out of 55 cats over 24 weeks, we recovered only one amphibian, a Spring Peeper frog (*Pseudacris crucifer*). Loyd et al. (2013) found that cats fitted with a "kitty-cam" video camera caught more herpetofauna than animals in any other group. In locations where herpetofauna and/or small mammals are endemic or threatened, such as Australia and New Zealand, the Birdsbesafe® CC may be an important conservation device for reducing domestic cat predation on non-avian prey items.

4.5. Owner interest in continued use of the Birdsbesafe® CCs

One factor that greatly affects the use of the Birdsbesafe CC is its dependency on an interior nylon quick-release collar. In our fall trial, we utilized a national brand standard breakaway nylon collar underneath the CC. Immediately, we experienced high losses (approximately 50%) of interior collars and CCs. Upon switching to a different brand of interior breakaway collar, we experienced much lower collar losses (<10%) from our cat owners, but they did still occur. Collar loss raises the unfortunate question of whether cat owners will pay to replace lost CCs, especially if CCs are lost repeatedly. As of October 2014, a Birdsbesafe® CC and interior breakaway collar cost $15 USD plus shipping online (www.birdsbesafe.com). In addition to cost, cat owners may worry (perhaps needlessly) about cat safety from predators like dogs and coyotes while wearing the CC, or comfort for their cats. To assess some of these concerns, we performed an online exit interview with all of our 27 owner participants to determine whether they continued using the Birdsbesafe CC after the study termination, and if not, what caused them to stop using the CC. We received 23 responses to our survey (Table 3). Surprisingly, only 22% of owners were still using the Birdsbesafe® CC on their cat(s). Owners chose all three of the reasons presented for not using the CC, which included concern the CC would fall off, cat comfort, and owner dislike of the CC. Only 26% of owners responded that they would definitely buy the CC in the future for their cat. One caveat that we believe may have swayed a majority of owners to stop using the Birdsbesafe® CC is the major loss of CCs these owners experienced in our fall trial. This loss was likely due to faulty interior breakaway collars that we initially used. Since many of our owner participants did not choose to participate in our spring study, the CC loss may have left a negative impression on these individuals as to its long-term efficacy. Due specifically to our problems with the interior breakaway collar, the Birdsbesafe® company developed a new interior breakaway collar made of a stretchy nylon fabric, which apparently reduces CC loss.

4.6. Conservation implications

The cats in our study were well-fed, loved pets with access to go inside and outside their owner's homes. We do not know how our results compare with the hunting behavior of fully outside or feral cats. Loss et al. (2013) point at feral cats, defined as un-owned cats, as the major cause of avian mortality in the United States. Fully 69% of this mortality was attributed to feral cats in their highly cited paper. In urban and suburban environments, many feral cats are now cared for in outdoor cat "colonies", where NTR (neuter-trap-release) proponents maintain high densities of feral cats (see Alley Cat Allies; http://www.alleycat.org/casefortnr#stabilizes). Large cities like Austin, Texas now have upwards of 50 feral cat colonies within the city limits, and have neutered over 30,000 feral cats since 2007 (Austin Humane Society; http://www.austinhumanesociety.org/). Many feral cats in colonies are cared for, fed, and treated almost like pets by dedicated area cat-lovers; we highly suggest that in addition to the neutering programs that currently operate, NTR proponents advocate that these cats be fitted with Birdsbesafe® CCs.

The results of our study are a positive development at a time when almost all news about outdoor pet cats is negative for wildlife. The American Humane Society, the American Bird Conservancy, the Cornell Laboratory of Ornithology, and countless other organizations recommend that all domestic cats should remain indoors; however this may not feasible for some cat owners for a variety of reasons. Here, we provide strong scientific evidence that cat predation on birds can be curtailed by a factor of up to 19 times if owners and care-takers of free-ranging domestic cats, both owned and feral, fitted cats with the Birdsbesafe® collar covers. We strongly advocate that owners use the CCs in the spring season, when bird mortality is highest. It is unclear how much the CC may help to curtain small mammal and herpetofauna predation, but its use should be encouraged and evaluated in all regions, especially where these groups of animals are endemic or declining.

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