

Free-Ranging Domestic Cat Predation on Native Vertebrates in Rural and Urban Virginia

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ABSTRACT

Introduced as early as 1614 and imported into the United States in the early 1800s to control rodents in eastern cities, domestic cats (*Felis catus*) have become major predators of native vertebrates. We studied the diversity and seasonality of free-ranging domestic cat predation on native Virginia vertebrates in a rural environment July 1989 - November 1990 and in an urban environment January - November 1990. A total of 27 species (8 bird, 2 amphibian, 9 reptile, 8 mammal) was captured by a single rural cat. One was a mammal of special concern (star-nosed mole). Four urban cats captured 21 species (6 bird, 7 reptile, 8 mammal). The mean number of individuals caught per cat Jan.- Nov. 1990 was 26 in the urban area and 83 in the rural area. Extrapolation of the number of native vertebrates killed annually by the estimated 1,048,704 free-ranging cats reveals a large, but unrecognized and understudied, negative impact on the biota of Virginia.

Key Words: domestic cats, birds, mammals, amphibians, reptiles, predation, conservation

INTRODUCTION

Domestic cats are not native to North America. They first arrived in the company of British colonists as early as 1614 and were imported in the early 1800s to control rodents in eastern cities (George, 1974; Lloyd, 1986). Cats migrated from Europe to other continents and island chains with human travelers and are now important predators worldwide. Unfortunately, the introduction of domestic cats into ecosystems in which they previously did not occur has had a devastating effect on many native species, in some cases causing species extinctions (Atkinson, 1989).

The introduction of an alien species into an ecosystem usually causes a range of negative effects on populations of native species. These include predation, hybridization, competition for food or nest sites, introduction of diseases, parasitism, and indirect environmental chain reactions (Diamond and Case, 1986; Atkinson, 1989). Although several studies have demonstrated that cats are effective predators (e.g., George, 1974; Churcher and Lawton, 1987, 1989), their impact as competitors, disease vectors, and roles in environmental chain reactions have not been addressed.

To our knowledge cats have not been shown to be the primary cause of the loss of native species on mainland continents, although there is documentation of predation on extremely large numbers of native vertebrates (Llewellyn and Uhler, 1952; George, 1974; Liberg, 1984; Churcher and Lawton, 1987; Coleman and

Temple, 1989). Cats have, however, caused the extinction of native birds on at least one island (Ascension Island, Olson, 1977).

Recognition of the extent of predation by free-ranging domestic cats on native animals by the general public is not widespread. This paper, based on our observations in rural and urban Virginia, demonstrates the effect of free-ranging cats on native vertebrates inhabiting the Commonwealth. Our objectives are to quantify the diversity of species killed by these predators in each landscape type and to examine seasonal variation in prey taken. We extrapolate the quantitative results of this study to the estimated number of free-ranging cats in Virginia in order to obtain an estimate of the number of native vertebrates killed annually by this introduced species.

MATERIALS AND METHODS

We identified to the species level vertebrate prey killed by free-ranging domestic cats in 2 locations in Virginia. Observations in a rural landscape were made at a 25 acre New Kent County homesite July 1989 through November 1990. The site is located near an old, approximately 21 acre millpond, and is nearly surrounded by mixed hardwood forest with a variably sparse to dense understory of holly and rhododendron. Approximately half of the yard is landscaped with scattered shrubs and half is a vegetable garden. There are no other houses within sight of the study location.

Observations in an urban landscape were made in a western Henrico County subdivision January through November 1990. The area was formerly deciduous forest that had been used for farmland, abandoned, and allowed to succeed to mature oak-dominated woodlands. Suburban style homes were constructed in the 1950s, although several widely scattered older homes were present before that time. The homesite in which the urban observations were made contains several hardwood trees and natural landscaping. An adjacent, abandoned plot contains a former homesite with 3 large shade trees residing in a pine - mixed hardwood association.

We independently accumulated data on species killed by domestic cats. Observations at the rural site were made on a single free-ranging siamese cat, whereas observations at the urban site were made on 4 free-ranging long-haired cats. Free-ranging cats are those that have access to and utilize food supplied by humans, and are not entirely confined to the indoors. Feral cats, those that avoid humans and domestic food sources and reproduce in the wild (Berkeley, 1982), were not included in this study.

Prey killed and brought to the homesites by these cats were identified to species where possible and the dates noted. Systematic searches of the area were conducted on a routine basis, usually daily. These data do not include prey killed and completely consumed or prey that were killed and left elsewhere. Thus, the numbers presented in this study are minimal estimates. Nonnative vertebrate prey, such as house sparrows and house mice, are not included in the comparisons.

Data are tabulated on a monthly basis for comparison between landscape types. Statistical differences between samples were evaluated with a chi-square test, and a priori significance was set at $P \leq 0.05$.

RESULTS

Prey killed by the 5 domestic cats represent 5 of the 7 major groups of vertebrates found in Virginia (Table 1). No fish or salamanders were recorded in this study. During the period of overlap between the 2 studies, January - November 1990, the rural cat killed 8 species of birds compared to the 6 positively identified species killed by the 4 urban cats. Total numbers for each site per cat were 25 rural and 3 urban (Table 1). The difference is significant ($X^2 = 17.3$, $P < 0.001$).

A greater number and more species of small mammals were killed by the urban cats than the rural cat (Table 1). The average number killed per urban cat (18.8) is not significantly different ($X^2 = 1.2$, $P > 0.25$) from that killed by the rural cat (26).

Only the rural cat caught, killed, and partially consumed frogs (Table 1). In all cases only the posterior portion of the trunk and the hindlimbs were consumed. Frogs were reported a domestic cat prey in only 1 other North American study (Korschgen, 1957).

Significantly more lizards were killed by the rural cat than the 4 urban cats (Table 1) ($X^2 = 4.5$, $P < 0.05$). The number of snake taxa and number of individual snakes killed were similar between sites (Table 1). The difference is nonsignificant ($X^2 = 0.8$, $P > 0.75$). The difference between the average per cat (9.0 rural, urban 2.8) is marginally nonsignificant ($X^2 = 3.3$, $P = 0.075$).

The total average number of native vertebrates killed by the urban cats (26) during January - November 1990 was significantly fewer than the 83 killed by the single rural cat ($X^2 = 29.8$, $P \ll 0.001$).

The rural component of this study also included data from July through December 1989. During this period an additional 4 shrews, 16 rodents, 7 birds, 7 lizards, and 4 snakes were killed. Species not included in Table 1 are the southeastern shrew and northern ringnecked snake. One individual of a species of special concern (star-nosed mole, Handley, 1991) was taken on 9 May 1989 by the rural cat.

Seasonal variation in prey taken was pronounced only at the rural site (Figure 1 and 2). Birds were taken more frequently during December 1989 through April 1990, whereas reptiles dominated the number of prey taken May through August 1990 (Table 2). Small mammals were taken in small but similar numbers during the periods of August - November 1989 and March - November 1990. Rabbits and frogs were taken only in spring and summer. Although small mammals numerically dominated the prey taken by the urban cats, there are no obvious seasonal trends within this group or any of the other major taxonomic groups (Figure 2, Table 2).

Introduced vertebrates were also killed by the 5 cats. The rural cat killed 3 house mice in October 1989, and 1 in February, 2 in September, and 1 in October 1990. The urban cats killed 1 house sparrow in each of the months of June, July, and October 1990.

DISCUSSION

Why are cats broadly successful alien predators when most introductions of nonnative species result in limited local and regional effects? A successful invading species possesses a suite of characteristic traits, including vagility, broad diet, short generation time, high genetic variability, gregariousness, association with

TABLE 1. Vertebrates captured by free-ranging domestic cats in rural and urban Virginia January - November 1990.

Species	Rural (1 cat)	Urban (4 cats)
Birds		
Northern Cardinal	2	3
Gray Catbird	0	1
Carolina Chickadee	2	0
American Goldfinch	7	2
Dark-eyed Junco	3	0
Ruby-crowned Kinglet	1	0
White-throated Sparrow	5	0
Wood Thrush	0	1
Tufted Titmouse	2	2
Carolina Wren	3	1
Unidentified	0	2
Total	25	12
Mammals		
Least Shrew	1	0
Northern Short-tailed Shrew	0	35
Eastern Mole	2	2
Eastern Cottontail	2	0
Eastern Chipmunk	0	4
Gray Squirrel	1	4
Southern Flying Squirrel	0	4
White-footed Mouse	15	3
Meadow Vole	3	6
Woodland Vole	2	17
Total	26	75
Frogs		
Green Frog	3	0
Fowler's Toad	4	0
Total	7	0
Lizards		
Eastern Fence Lizard	7	0
Five-lined Skink	5	1
Broadhead Skink	4	0
Ground Skink	0	5
Total	16	6
Snakes		
Eastern Worm Snake	4	2
Black Racer	1	0
Northern Ringneck Snake	0	2
Black Rat Snake	2	0
Rough Green Snake	1	4
Redbelly Snake	0	1
Eastern Ribbon Snake	1	0
Smooth Earth Snake	0	2
Total	9	11
Grand Total	83	104
Average per cat	83	26

TABLE 2. Seasonal variation in native vertebrates killed by rural and urban free-ranging domestic cats in Virginia July 1989 through November 1990. Abbreviations: Sh - shrews and moles, Ro - rodents, Lag - lagomorphs, Bd = birds, Liz - lizards, Sn - Snakes, and Fg - frogs. Note that the urban database contains no lagomorphs or frogs.

Month	Sh	Ro	Lag	Bd	Liz	Sn	Fr
RURAL SITE							
1989							
July						1	
August	2	5			4	3	
September	2	4			3		
October		3					
November		4					
December				7			
1990							
January				4			
February				7			
March		4		4			
April	1	2	1	8	2	4	1
May		5	1		5	4	1
June		2		1	4	1	4
July	1				3	2	
August		1		1	1	2	
September	1	3			1	1	1
October		3					
November		2					
URBAN SITE							
1990							
January					3	1	
February	6	11				1	
March		2		3			
April	2	3				2	
May	2	2			1	2	
June	6	4		3	2	2	
July	14	2		3		1	
August	3	2		1			
September		1				1	
October	4	7		2		1	
November	1	5					

Homo sapiens, and ability to function in a wide range of physical conditions (Ehrlich, 1989). Anyone familiar with domestic cats will associate these characters with them.

Because our observations are based on domestic cats that brought prey to home sites where they could be counted, the logical assumption was made that all of the prey killed by the cats in this study were unknown to us. George (1974) estimated that about half of the prey killed by his farm cats were counted. The rest were eaten or left elsewhere and scavenged by other animals. On one occasion, after this study

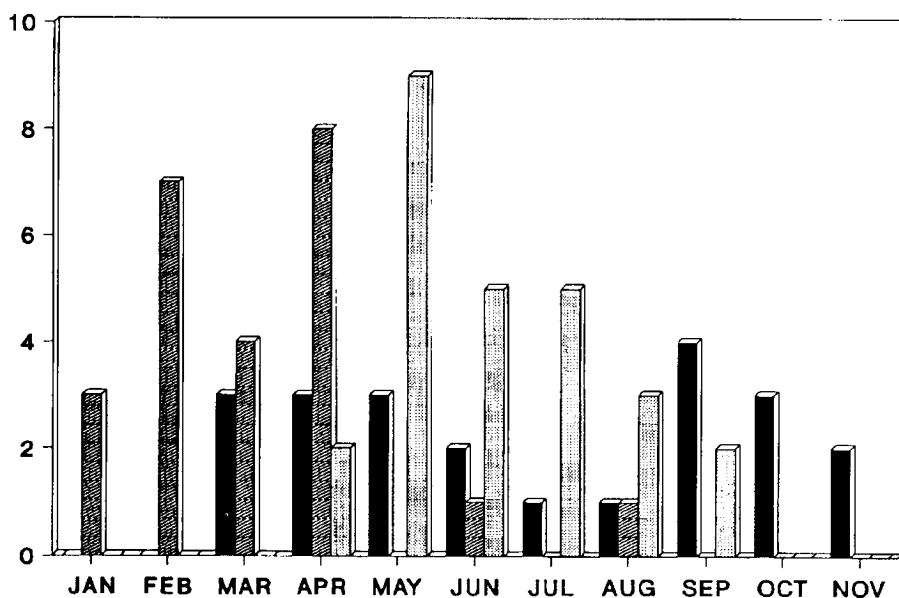


FIGURE 1. Seasonal variation in domestic cat predation on 3 groups of vertebrates in rural Virginia. Solid bars represent mammals, oblique lines represent birds, and stippling represents reptiles (lizards and snakes).

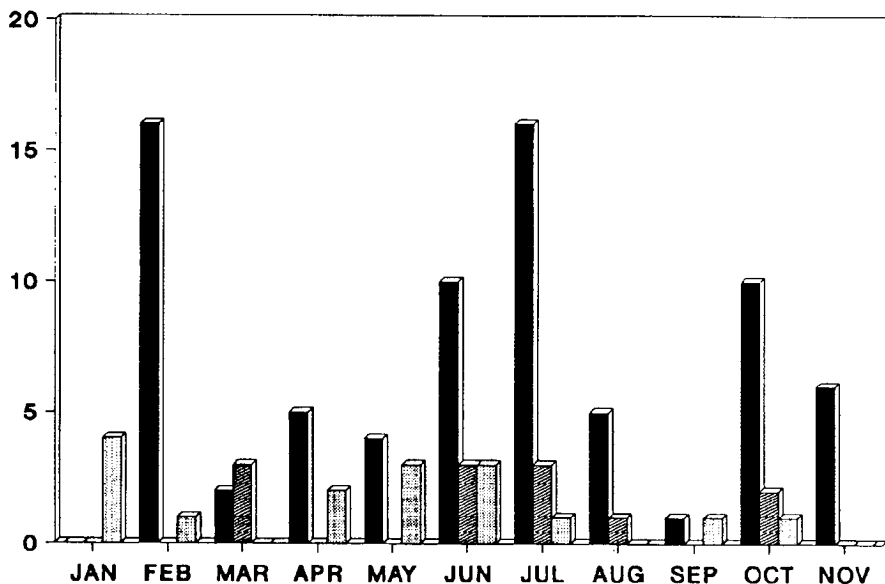


FIGURE 2. Seasonal variation in domestic cat predation on 3 groups of native vertebrates in urban Virginia. Legend for prey types as in Figure 1.

TABLE 3. Ranks of native vertebrates killed by free-ranging domestic cats in North America. Sources: 1 - Hubbs, 1951; 2 - Parmalee, 1953; 3 - Korschgen, 1957; 4 - Warner, 1985; 5 - George, 1974; 6 - Errington, 1936; 7 - Bradt, 1949; 8 - Toner, 1956; 9 - Eberhard, 1954; 10 - Llewellyn and Uhler, 1952; 11 - this study, 1990 data only.

Location	Shrews	Rodents	Lagomorphs	Birds	Reptiles	Other	Source
California	--	1	3	2	--	--	1
Texas	--	1	3.5	3.5	2	--	2
Missouri	5	1	3	4	6	2	3
Illinois	--	1	3	2	--	--	4
Illinois	4	1	2	3?	--	--	5
Wisconsin	5	1	4	2	--	3	6
Michigan	3	1	4	2	--	--	7
Ontario	2	1	--	3	--	--	8
Pennsylvania	4	1	2	3	--	--	9
Maryland	5	1	4	3	--	3	10
Virginia							
Rural	6	1	5	2.5	2.5	4	11
Urban	2	1	--	3	4	--	11

was terminated, one of us (JCM) witnessed a cat kill and entirely consume a chipmunk away from the homesite. Thus, the number of individuals and the diversity of species we tabulated in this study are less than those actually killed.

Of the prey observed in this study none was larger than about half the size of the cat predator. The rural cat was observed stalking gray fox, raccoon, and Virginia opossum but none was attacked or killed. Large snakes are probably avoided as 2 of the urban cats were extremely wary of a 1.3 meter black rat snake (*Elaphe obsoleta*) which struck at one of them. They remained so for at least 30 min. after the snake was removed from the homesite. Large snakes and mammals have not been reported as cat prey in the literature.

Comparisons of the numerical rank order of prey types killed by domestic cats in North America (Table 3) shows that rodents are, without exception, the primary prey taxon taken. All other groups have ranked second at least once.

Reptiles ranked high only in a study conducted in Texas (Parmalee, 1953) and in the rural site in this study. Although snakes were consumed, the majority of the prey in both these studies were lizards. Species listed under "other" include insects, other invertebrates, and frogs (Errington, 1936; Llewellyn and Uhler, 1952; Korschgen, 1957; this study).

Although birds were not the primary prey type killed in any of the published studies, they always ranked second or third behind rodents (Table 3). In most cases the species listed include those that nest on or near the ground or those that feed on the ground. Wilcove (1985) experimentally demonstrated that songbirds nesting on the ground or in low vegetation were subjected to very high levels of predation. He determined that domestic cats, along with raccoons, opossums, skunks, and blue jays, were the primary predators of migratory songbirds in isolated forested tracts in suburban Maryland.

Seasonal variation in prey taken by domestic cats in this study differed between sites. Such variation derives from (1) individual differences in cat behavior, (2) availability of prey types due to habitat and seasonal differences, and (3) variation in susceptibility of prey among taxa, age, and seasons. The rural cat, for instance, preyed almost exclusively on songbirds during the winter when they were using artificially stocked feeders. The birds were presumably more susceptible to predation at that time. However, the rural cat switched from 1 prey resource to another at will, as evidenced from the results in Table 2. The lack of seasonal variation in the urban site may have been partially due to individual variation in cat behavior. Two of the 4 cats demonstrated frequent prey capture success, a third was variable, and a fourth (a fixed male) was comparatively ineffective.

Using our results, we extrapolated the impact of free-ranging cats on native vertebrates in Virginia. We estimated the number of cats by dividing the 1990 human census estimate of 6,187,358 (Southeast Regional Census Bureau, Charlotte, NC, pers. comm.) by 5.9, the ratio of one cat (excluding feral cats) to every 5.9 humans (American Humane Association, 1972). The resulting 1,048,704 cats multiplied by the average number of songbirds killed by urban cats (3) and the total number killed by the rural cat (25) from January to November 1990 yields a range of 3,146,112 to 26,217,600 songbirds killed statewide. This number is certainly inaccurate to some degree, although the estimates are impressive. Similar computations yield 27,266,304 - 78,528,800 for small mammals and 2,883,936 - 9,438,336 for reptiles. Although we would concur that domestic cats may play a positive role in controlling some rodent populations in the absence of natural predators (e.g., large snakes, birds of prey), we point out that these introduced predators may play a significant role in the decline of our native wildlife. This is especially true when one considers that there are approximately 60 million cats in North America (Springston, 1991). Future conservation efforts on behalf of native vertebrates must include some measure of protection from free-ranging domestic cats.

We recognize the limitations of extrapolation to large areas from relatively small data sets such as ours. A primary purpose in presenting these data is to stimulate more careful and detailed studies that can reveal truer estimates of the impact of this introduced species. We strongly suggest that several well-placed, simultaneous studies in rural and urban Virginia be conducted using the techniques of Churcher and Lawton (1987). A more accurate ratio of cats to humans in Virginia is needed in order to provide a better extrapolation to the entire domestic cat population. We urge everyone to use this information to educate people of all ages to the role cats may play in the decline of Virginia's native wildlife. If Virginia's wildlife agency is convinced that the impact of cat predation on native species is important, as we think they should be, then their help with public awareness may lead to constraints in the growth of cat numbers and controls on their predatory behavior.

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APPENDIX 1. Scientific names of species mentioned in the text. Common and scientific names follow Ehrlich et al. (1988) for birds, Webster et al. (1985) for mammals, and Conant and Collins (1991) for amphibians and reptiles.

Birds

Northern Cardinal	<i>Cardinalis cardinalis</i>
Gray Catbird	<i>Dumetella carolinensis</i>
Carolina Chickadee	<i>Parus carolinensis</i>
American Goldfinch	<i>Carduelis tristis</i>
Dark-eyed Junco	<i>Junco hyemalis</i>
Ruby-crowned Kinglet	<i>Regulus calendula</i>
House Sparrow	<i>Passer domesticus</i>
White-throated Sparrow	<i>Zonotrichia albicollis</i>
Wood Thrush	<i>Hylocichla mustelina</i>
Tufted Titmouse	<i>Parus bicolor</i>
Carolina Wren	<i>Thryothorus ludovicianus</i>

Mammals

Least Shrew	<i>Cryptotis parva</i>
Northern Short-tailed Shrew	<i>Blarina brevicauda</i>
Southeastern Shrew	<i>Sorex longirostris</i>
Eastern Mole	<i>Scalopus aquaticus</i>
Star-nosed Mole	<i>Condylura cristata</i>
Eastern Cottontail	<i>Sylvilagus floridanus</i>
Eastern Chipmunk	<i>Tamias striatus</i>
Gray Squirrel	<i>Sciurus carolinensis</i>
Southern Flying Squirrel	<i>Glaucomys volans</i>
White-footed Mouse	<i>Peromyscus leucopus</i>
House Mouse	<i>Mus musculus</i>
Meadow Vole	<i>Microtus pennsylvanicus</i>
Woodland Vole	<i>Microtus pinetorum</i>

Frogs

Green Frog
Fowler's Toad

Rana clamitans melanota
Bufo woodhousii fowleri

Lizards

Eastern Fence Lizard
Five-lined Skink
Broadhead Skink
Ground Skink

Sceloporus undulatus undulatus
Eumeces fasciatus
Eumeces laticeps
Scincella lateralis

Snakes

Eastern Worm Snake
Black Racer
Northern Ringneck Snake
Black Rat Snake
Rough Green Snake
Redbelly Snake
Eastern Ribbon Snake
Smooth Earth Snake

Carphophis amoenus amoenus
Coluber constrictor constrictor
Diadophis punctatus edwardsii
Elaphe obsoleta obsoleta
Opheodrys aestivus
Storeria occipitomaculata occipitomaculata
Thamnophis sauritus sauritus
Virginia valeriae valeriae

