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Potential Food Item Distractions during Raccoon ORV Baiting Campaigns on Cape Cod, Massachusetts: Would You Like Fries With That?

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ABSTRACT: USDA APHIS Wildlife Services has been a primary cooperator in the Cape Cod Oral Rabies Vaccination Program (CCORVP) in southeastern Massachusetts since 2001. The CCORVP (1994 - present) was originally designed to reduce the incidence of terrestrial rabies adjacent to the Cape Cod Canal in order to prevent its spread on to peninsular Cape Cod. However, since the barrier breach in 2004, CCORVP is now focused on rabies control in this coastal resort area southeast of Boston, MA. An integral component of wildlife rabies management is oral vaccination with vaccine-laden baits. Consequently, maximizing bait uptake rates is critical to achieving sufficient population immunity to reduce rabies prevalence and achieve control. To that end, knowledge of raccoon food habits, especially at ORV bait delivery times (spring and fall on Cape Cod) is crucial. We undertook a study of raccoon food selection in southeastern Massachusetts to assess the presence of and interest in competing food resources. We collected intact stomachs from raccoons found dead or euthanized for rabies testing within the CCORVP zone during 2006 ($n = 33$) and 2007 ($n = 109$) for analysis. Stomach contents were dominated by vegetation (80%), followed by invertebrates (43%), non-food items (41%), vertebrates (35%), and hair (primarily raccoon based on appearance) (15%). Food item occurrence appears to be related to age. We present findings, potential management implications, and suggestions for assessing food use related to rabies control in other locations.

KEY WORDS: Cape Cod, disease, food habits, oral rabies vaccination, ORV, *Procyon lotor*, rabies, raccoon, stomach contents analysis

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INTRODUCTION

In 2001, USDA APHIS Wildlife Services (WS) began full-time collaboration on the Cape Cod Oral Rabies Vaccination Program (CCORVP) as part of national wildlife rabies control efforts. The primary objective of the CCORVP was to prevent the spread of raccoon rabies to peninsular Cape Cod using ORV (Robbins et al. 1998) in tandem with the physical barrier created by the Cape Cod Canal.

In addition to the goal of rabies control, WS has used participation in the CCORVP as an opportunity to learn more about raccoon (*Procyon lotor*) ecology and rabies control in densely populated and pine/oak eastern seaboard habitats in preparation for efforts to eliminate raccoon-variant rabies from Atlantic coastal areas (Algeo et al. 2008). The objective of the raccoon food use project we describe was to increase our understanding of raccoon food use in southeast Massachusetts, and to provide critical information for planning oral rabies vaccination campaigns on Cape Cod, MA and in similar locations elsewhere.

Although raccoon rabies arrived in New England in the early 1990s, peninsular Cape Cod remained rabies-free due in part to the CCORVP (Robbins et al. 1998), the physical barrier to raccoon movement presented by the Cape Cod Canal, or both. USDA APHIS Wildlife Services began full-time involvement in the CCORVP in 2001. In 2004, the first case of raccoon-variant rabies was detected on peninsular Cape Cod. While ensuing emergency ORV and trap-vaccinate-release campaigns may have slowed the spread of the virus these strategies were unable to stop it, and rabies ultimately appeared at the far end of the peninsula in 2006 (Algeo et al. 2008). As part of continued rabies control efforts, fishmeal-coated ORV baits have been distributed from Yarmouth through Provincetown (2006 - present; Figure 1) with the goal of reducing the occurrence of rabies occurrence for eventual elimination of the virus from Cape Cod.

Our project was designed to provide information on seasonal variation in food use by raccoons to assess potential competing food interests that might affect ORV bait uptake.

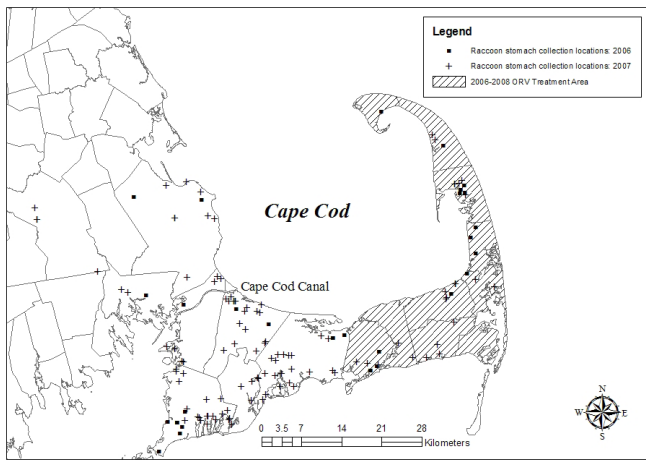


Figure 1. ORV zone on Cape Cod (2006 - 2008) and raccoon diet sampling locations in southeastern, MA, 2006 - 2007.

METHODS

Specimen Acquisition

Raccoon stomachs were collected concurrent with CCORV enhanced rabies surveillance efforts (Bjorklund et al. 2006), during every month in Barnstable and Plymouth Counties during 2006 - 2007 (Figure 2). Samples were obtained as road-kills, public health investigation specimens, sick/strange-acting specimens, and from nuisance mitigation activities. Pre-weaning juveniles were not sampled, and stomachs not containing any contents or only unidentifiable contents were omitted from further analysis. Specimens were aged and sexed prior to stomach extraction.

Sample Preparation and Separation of Food Items

Raccoon stomachs were removed from carcasses as soon as possible after collection to reduce further decomposition of contents, and preserved by freezing at -5°C until preparation could resume. Stomach contents were preserved in 10% buffered formalin for ≥ 4 days after being partially thawed (partial thawing facilitates separation of

stomach tissues from contents). Preserved contents were dried for 2 - 4 days in shallow metal pans lined with paper, then stored at room temperature in plastic freezer bags until item identification could occur. Stomach contents were sorted and categorized as vegetation, vertebrate, invertebrate, hair (primarily raccoon, based on appearance), non-food, and unknown items with a $10\times$ dissecting microscope. Non-food items included sand, dirt, trash, and other man-made items.

Data Analysis

Percent occurrence of stomach contents was calculated in this particular study rather than percent volume due to differing rates of digestion and digestibility of food items. Raccoon hair was not considered a food item and its occurrence was analyzed separately from other items. A Fisher's Exact Test was used to test for association between food types by age, sex, rabies status, and season (Pagano and Gauvreau 2000). Statistical significance for all analyses was set at $P = 0.05$. For the purpose of this analysis, animals >9 months old were considered adult and those <9 months were characterized as juvenile. All rabies diagnoses were made by direct fluorescent antibody test (dFA) conducted by the Massachusetts Department of Public Health State Laboratory Institute. Seasons were winter (December - February), spring (March - May), summer (June - August), and fall (September - November).

RESULTS

Stomach Content Type Occurrence

During 2006, 33 stomachs were collected, but only 30 were analyzed as 3 were empty or contained only unidentifiable contents. These were found to contain vegetation (83%), invertebrates (63%), vertebrates (47%), non-food items (53%), and raccoon hair (30%). During 2007, 109 stomachs were collected, but only 50 of these were analyzed as the remaining were either empty or contained only unidentifiable contents. Identified items for 2007 included vegetation (78%), invertebrates (30%),

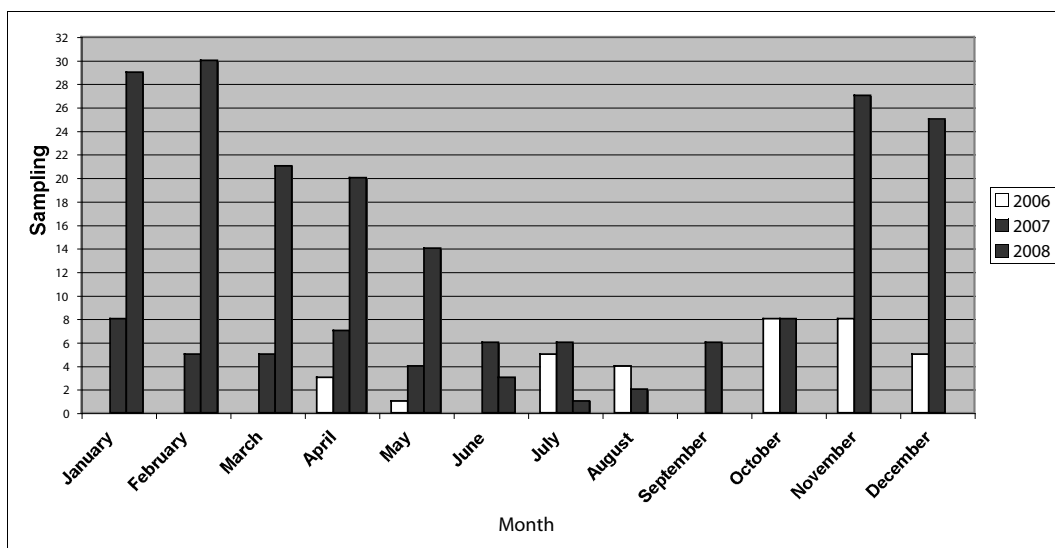


Figure 2. Southeastern MA raccoon stomach sampling events by month, 2006 - 2008 ($n = 261$).

Table 1. Occurrence of food types among raccoon stomach samples during 2006 - 2007 from southeastern MA.

Food Type	2006 - 2007 (n = 80)	2006 (n = 30)	2007 (n = 50)
	Occurrence (%)	Occurrence (%)	Occurrence (%)
Vegetation	64 (80)	25 (83)	39 (78)
Invertebrate	34 (43)	19 (63)	15 (30)
Vertebrate	28 (35)	14 (47)	14 (28)
Non-food	33 (41)	16 (53)	17 (34)
Hair (raccoon)	12 (15)	9 (30)	3 (6)

Table 2. Occurrence of food type vs. age (Adult /Juvenile) among raccoon stomach samples during 2006 - 2007 from southeastern MA.

No. sampled:	2006			2007		
	Adult	Juvenile	P	Adult	Juvenile	P
	n = 24	n = 6		n = 29	n = 21	
Occurrence (%)			Occurrence (%)			
Vegetation	18 (75)	6 (100)	1.00	23 (79)	16 (76)	0.53
Invertebrate	14 (58)	5 (83)	0.95	7 (24)	8 (38)	0.92
Vertebrate	12 (50)	2 (33)	0.40	12 (41)	1 (5)	<0.01*
Non-food	15 (63)	1 (17)	0.06	12 (41)	4 (19)	0.09
Raccoon hair	8 (33)	0 (0)	0.13	3 (10)	0 (0)	0.19

* significant at $P \leq 0.05$ (Fisher's Exact Test)

Table 3. Occurrence of food type vs. rabies status (+/-) among raccoon stomach samples during 2006 - 2007 from southeastern MA.

No. sampled:	2006 (n = 21)			2007 (n = 39)		
	+	-	P	+	-	P
	n = 11	n = 10		n = 4	n = 35	
Occurrence (%)			Occurrence (%)			
Vegetation	9 (82)	9 (90)	0.88	4 (100)	28 (80)	0.94
Invertebrate	9 (82)	5 (50)	0.14	1 (25)	11 (31)	0.79
Vertebrate	8 (73)	4 (40)	0.14	2 (50)	6 (17)	0.18
Non-food	7 (64)	5 (50)	0.42	1 (25)	10 (29)	0.75
Raccoon hair	7 (64)	0 (0)	<0.01*	1 (25)	1 (3)	0.20

* significant at $P \leq 0.05$ (Fisher's Exact Test)

vertebrates (28%), non-food items (34%), and hair (6%). Overall, (2006 - 2007 samples combined), vegetation was the most abundant stomach contents item identified, occurring in 80% of all stomach samples, followed by invertebrates (43%), vertebrates (35%), non-food items (41%), and hair (15%) (Table 1).

Gender Differences

Sixty-four raccoons were sampled during 2006-2007 and identified to sex (2006 n = 17 male and 7 female; 2007 n = 24 male and 16 female). Male and female raccoon stomach contents did not differ ($P = >0.05$).

Age Differences

A total of 53 adult and 27 juvenile raccoons were examined in 2006 and 2007. Adult and juvenile stomach contents differed only in terms of vertebrates found in stomach contents in 2007 ($P = <0.01$), with adults consuming significantly more vertebrates than juveniles. No other categories for either year differed (Table 2).

Rabies Prevalence

Rabies prevalence was examined in relation to food items consumed. Rabies testing occurred for 60 specimens from 2006 (n = 21) and 2007 (n = 39). Rabies-positive and -negative raccoons differed in stomach contents only in terms of an increased presence of raccoon hair among stomach contents of rabies-positive raccoons in 2006 ($P = <0.01$) (Table 3).

Seasonal Differences

Hair (2006 $P = 0.04$) and vertebrates (2007 $P = <0.01$) varied by season (Table 4). The occurrence of hair in stomachs varied significantly ($P = 0.04$) by season during 2006, but not during 2007, while the occurrence of vertebrates varied significantly ($P = <0.01$) by season only in 2007.

Stomach Content Highlights

The vegetation component of our sample consisted primarily of leaves, seeds, and berries. Two stomachs

Table 4. Occurrence of food type vs. season among raccoon stomach samples during 2006 - 2007 from southeastern MA.

Season:	2006 (n = 30)					2007 (n = 49)				
	Winter	Spring	Summer	Fall	P	Winter	Spring	Summer	Fall	P
No. sampled:	n = 4	n = 4	n = 8	n = 14		n = 16	n = 8	n = 8	n = 17	
	Occurrence (%)					Occurrence (%)				
Vegetation	2 (50)	4 (100)	6 (75)	10 (71)	0.49	14 (88)	6 (75)	6 (75)	12 (71)	0.64
Invertebrate	3 (75)	4 (100)	4 (50)	7 (50)	0.28	2 (13)	2 (25)	2 (25)	9 (53)	0.08
Vertebrate	4 (100)	3 (75)	3 (38)	5 (36)	0.09	2 (13)	7 (88)	1 (13)	1 (6)	<0.01*
Non-food	4 (100)	2 (50)	3 (38)	6 (43)	0.25	4 (25)	3 (38)	4 (50)	4 (24)	0.51
Raccoon hair	2 (50)	3 (75)	1 (13)	2 (14)	0.04*	2 (13)	1 (13)	0 (0)	0 (0)	0.25

* significant at $P \leq 0.05$ (Fisher's Exact Test)

from 2006 contained berries from the European yew (*Taxus baccata*), while two others contained large numbers of acorns (*Quercus* sp.). Crabs, caterpillars, and American dog ticks (*Dermacentor variabilis*) made up the majority of invertebrates. Raccoon roundworm (*Baylisascaris procyonis*) was prominent in a handful of samples as well. Vertebrates included a redback salamander (*Plethodon cinereus*), a masked shrew (*Sorex cinereus*), and a killifish (*Fundulus* sp.). Non-food items included soil, sand, gravel, and trash (e.g., fast food wrapper, fruit sticker, trash bags, foam and rubber fragments).

DISCUSSION

Vegetation was the most common food type found within raccoon stomachs for both years in southeastern Massachusetts (2006 = 83% and 2007 = 78%), which is similar to the findings of MacClintock (1981) and Stuewer (1943). Vegetation occurred in a relatively uniform fashion throughout the sampling period, and by combining the two years' data, it appears that vegetation has an important role in the diet of raccoons throughout the seasons, occurring in 72% - 90% of the samples depending on season (Figure 3). Vertebrates appear to be relatively abundant in spring stomach samples while invertebrates and non-food items appeared consistently throughout the seasons.

While the increased consumption of animal matter we noted for the spring and early summer months corresponds with another study (Stuewer 1943) we saw an

increase in the number of vertebrate food items during winter and spring, which agrees with conclusions of a winter raccoon study conducted in Oklahoma (Tyler et al. 2000). The increase in vertebrate items may be related to increased duration in the availability of carcasses, or increased protein needs during winter (MacClintock 1981). Overall, the proportion of invertebrates in our samples was relatively stable.

Age also appears to play a role in food use by raccoons in southeastern Massachusetts. Adult raccoons may be more adept at hunting for vertebrate food items than juveniles or simply may prefer to consume vertebrate food items more than juveniles do. Ingestion of hair by raccoons was different by season and rabies status in 2006. The phenomenon of hair in raccoon stomach contents may be related to agonistic behaviors or self-mutilation (Hamir et al. 1996).

Due to the wide array of food items consumed by raccoons during spring and fall ORV baiting periods, it appears that they focus on no single food item during these times of year. From this, we may infer that fishmeal-coated ORV baits may be ingested along with other foods. While the methods developed in the course of this project may be applicable to other geographic areas, the relatively unique habitat of southeastern Massachusetts may make these results particularly interesting to ORV projects along the eastern seaboard.

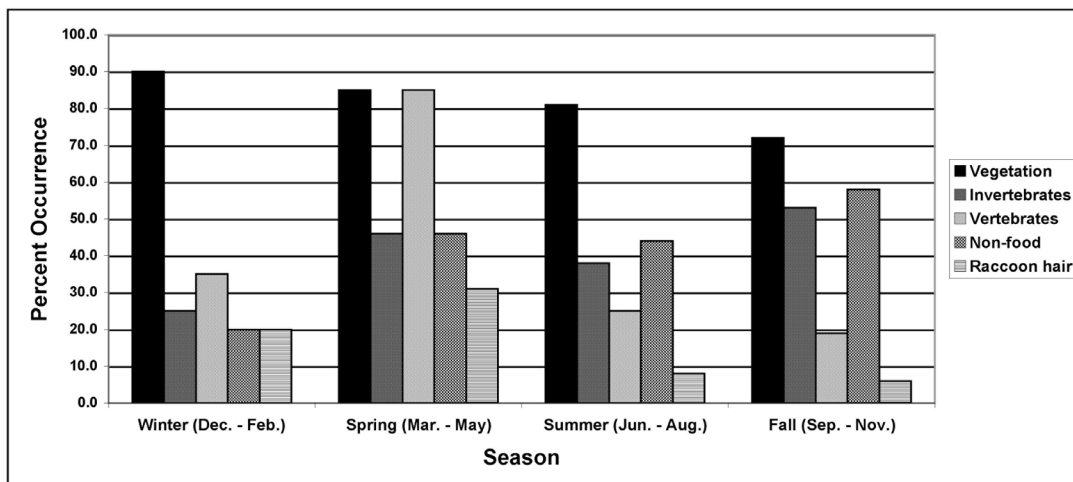


Figure 3. Percent occurrence of food types by season among samples during 2006 - 2007 from southeastern MA.

Study Limitations

Samples with identifiable food items were somewhat limited ($n = 80$), possibly due to relatively rapid digestion, which may be especially problematic among captured animals that are not sampled promptly (MacClintock 1981). Also, various food types digest at different rates, presenting limitations in terms of identifying items and quantifying proportions. In the interest of increasing power to detect food preferences, sampling has continued into 2008 ($n = 119$ to mid-July, 2008).

Future Goals

Sampling for this project was conducted concurrent with rabies surveillance efforts. Future goals of this project may include other procedures such as scat and intestinal contents analysis as adjuncts to the procedure undertaken to date (Greenwood 1982, Stuewer 1943). Further study of the apparent age-related differences in vertebrate use may be pursued for its potential to inform ORV baiting timing decisions. Finally, assessing samples from other habitat types may give this project broader applicability to the National Rabies Management Program, and a pilot project is currently under consideration for another location.

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