

Note

Use of Camera Traps Provides Insight into the Feeding Ecology of Red Foxes (*Vulpes vulpes*)

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Red Foxes (*Vulpes vulpes*) often carry food items to caching sites and while making provisioning trips to litters. This behaviour provides opportunities to use camera traps to record Red Foxes carrying food that is likely prey. As part of a larger study using camera-trap surveys to monitor carnivore populations at Great Swamp National Wildlife Refuge, New Jersey, our cameras also recorded Red Foxes carrying food items allowing us to gain insight into the feeding ecology of this predator. Camera traps documented Red Foxes carrying food 71 times; items included mammals (78.9%), birds (19.7%), and fish (1.4%). Small mammals (unknown rodent or soricid species [23.9%] and voles [*Microtus* or *Clethrionomys* spp.; 5.6%]) were the most common groups of food items and Muskrat (*Ondatra zibethicus*; 15.5%) was the most common food item identified to species. Our surveys corroborate traditional diet assessments (e.g., scat analysis) of Red Foxes in North America, identifying them as a generalist forager that typically consumes smaller mammals. We also highlight the potential to apply camera trapping as a supplemental technique for gaining additional insight into the feeding ecology of this predator.

Key Words: Camera trap; diet; prey; Red Fox; *Vulpes vulpes*; Great Swamp National Wildlife Refuge

Identification of food remains in scats collected in the field and stomachs from carcasses of trapped individuals has been the primary source of dietary information for many species in the order Carnivora (Mills 1996; Klare *et al.* 2011), including the Red Fox (*Vulpes vulpes*; Doncaster *et al.* 1990; Sheldon 1992; Glen and Dickman 2008; Barrull *et al.* 2014). For example, Hockman and Chapman (1983) examined 128 Red Fox stomachs collected from trapped animals in Maryland during the autumn and winter seasons and concluded that Red Foxes primarily consumed small mammals (i.e., Meadow Voles [*Microtus pennsylvanicus*] and Eastern Cottontails [*Sylvilagus floridanus*]). Similarly, Ozoga *et al.* (1982) concluded that Deer Mice (*Peromyscus maniculatus*) and Meadow Voles were important food items identified in 367 Red Fox scats from Michigan's Upper Peninsula during the spring and summer. Red Foxes are generalist foragers and, in addition to consuming small mammals, have been reported to consume birds, fruits/seeds, invertebrates, carrion, and fish (Cypher 1982).

Camera-trap surveys are an effective method for investigating carnivore populations (Kays and Slauson 2008; O'Connell *et al.* 2011; McCallum 2013) and may offer a novel approach to document their feeding ecology. Red Foxes display foraging behaviours that may lend well to them being detected with food items by camera traps. For example, Red Foxes often cache prey instead of consuming it on site (Murie 1936; Macdonald 1976; Dekker 1983; Henry 1986; Lariviere and Pasitschniak-Arts 1996) and, thus, travel from capture to cache sites with prey in the mouth. Also, Red Foxes have been reported to carry food to den sites during the pup-rearing season (Sargeant *et al.* 1984). Consequent-

ly, monitoring likely travel corridors (e.g., natural or human-made pathways) with camera traps may provide opportunities to detect and identify food being carried by Red Foxes (Ballard *et al.* 2014). As part of a larger study using camera-trap surveys to monitor carnivores occupying Great Swamp National Wildlife Refuge (GSNWR), Morris County, New Jersey (40°42'40.73"N, 74°27'52.82"W), we identified food items being carried by Red Foxes from our image dataset. Here we provide a description of taxa carried by Red Foxes and highlight the potential for using camera traps to gain insight into the diet of this predator.

From 24 November 2013 to 25 October 2014, 20 camera traps (Cuddeback Attack Flash and Capture Flash, De Pere, Wisconsin, USA) were located at intervals of 250–550 m to monitor the refuge's 10.5 km of service roads. Camera traps (in a Cuddeback Bear Safe, De Pere, Wisconsin, USA) were attached to wooden stakes (150 cm by 5.08 cm by 5.08 cm) placed approximately 1.5–2 m from the edge of the roads and at a height of 0.3–1 m off the ground. Camera traps were positioned perpendicular to roads and no bait or lure was used during the surveys (see Wagnon 2015 for complete details of methods).

In total, camera traps surveyed roads for 4866 camera trap nights (CTN). Survey effort was greater in summer (June, July, and August; 1581 CTN) and spring (March, April, and May; 1200 CTN) and less in autumn (September, October, November; 1064 CTN) and winter (December, January, and February; 1021 CTN). Camera traps recorded 2883 independent events involving Red Foxes (i.e., images of a fox at a site separated by > 60 min) for an average of 240.3 events/month (range 35 in November 2013 to 528 in August 2014;

standard deviation 153.8). Among all Red Fox photos ($n = 3986$), 71 were of an individual animal carrying a food item. Red Foxes were photographed with food most frequently during the spring ($n = 40$) and summer ($n = 22$) and less frequently during autumn ($n = 1$) and winter ($n = 8$).

Food items were identified to the finest taxonomic level and the frequency of occurrence was calculated (i.e., number of images with the food item divided by the total number of images with food [$n = 71$] multiplied by 100). Food items represented three general taxonomic categories (i.e., mammal, avian, and fish; Table 1). Most of the food items were mammals (78.9%), comprising mainly unknown rodent or soricid species (23.9%), unknown mammals (23.9%), and Muskrats (*Ondatra zibethicus*, 15.5%; Figure 1, Table 1). However, Red Foxes were also recorded twice with a juvenile Raccoon (*Procyon lotor*; Figure 1), presumably examples of intraguild predation (Polis *et al.* 1989). Examples of Red Foxes carrying avian food items (birds 11.2% and eggs 8.5%) and a Largemouth Bass (*Micropterus salmoides*, 1.4%) were also represented in images (Table 1, Figure 1).

Similar to Red Fox scat/stomach analyses in North America, our image dataset indicates that Red Foxes are generalist foragers and frequently feed on mammals. During autumn, fruit/seeds may constitute 100% of their diet (Cypher 1982) and would not have been detected in our camera-trap images. Shifts in diet to fruits/seeds may explain the few events of foxes with food during autumn ($n = 1$), even though 730 events were recorded for that period. Moreover, adults would

no longer be engaged in provisioning trips after pups disperse in late summer and early autumn, likely reducing the chances of detecting Red Foxes with food. These examples demonstrate the limitations of camera traps in allowing comprehensive diet assessments for Red Foxes (and other wildlife). However, camera-trap surveys could complement traditional diet analyses (i.e., food identified in scats or stomachs) and provide additional details on the feeding ecology of Red Foxes. For example, egg predation would likely be missed or underestimated in traditional diet analyses, because foxes may only consume the nutrient-rich embryo and not the eggshell (i.e., the only evidence of egg predation discernible in scats or stomachs). Also, camera traps could provide useful insight into Red Fox consumption of species of management (e.g., rare, game, or invasive species) or economic interest (e.g., livestock). Our camera-trapping effort documented five incidents of Red Foxes with waterfowl, a group recognized as a management priority at GSNWR (United States Fish and Wildlife Service 2014). Further, our image dataset provided evidence of a potential ecological service carried out by Red Foxes; we documented three incidents of Red Foxes carrying a non-native rat (*Rattus rattus* or *R. norvegicus*), which are invasive species of considerable ecological concern (Maggs *et al.* 2015).

Examining the feeding ecology of Red Foxes was not the primary purpose of our study, but our camera-trap survey provided an opportunity to gain insight into Red Fox foraging habits through the unexpected collection of ancillary information. Our analysis under-

TABLE 1. The number and frequency of occurrence of food items carried by Red Foxes (*Vulpes vulpes*), and the total number of prey-carrying events recorded during camera-trap surveys at Great Swamp National Wildlife Refuge, New Jersey, from 24 November 2013 to 25 October 2014. Camera traps recorded 730, 296, 631, and 1226 independent events of Red Fox in the fall, winter, spring, and summer, respectively.

Food item	No. of records					%
	Fall ($n = 1$)	Winter ($n = 8$)	Spring ($n = 40$)	Summer ($n = 22$)	Total ($n = 71$)	
Mammals						
Unknown Rodentia or Soricidae	1	0	10	6	17	23.9
Unknown mammal	0	0	10	7	17	23.9
Muskrat (<i>Ondatra zibethicus</i>)	0	4	6	1	11	15.5
Vole (<i>Microtus</i> or <i>Clethrionomys</i> spp.)	0	0	4	0	4	5.6
Black or Brown Rat (<i>Rattus rattus</i> or <i>R. norvegicus</i>)	0	1	1	1	3	4.2
Eastern Cottontail (<i>Sylvilagus floridanus</i>)	0	1	1	0	2	2.8
Raccoon (<i>Procyon lotor</i>)	0	0	0	2	2	2.8
Total	1	6	32	17	56	78.9
Avian species						
Avian egg	0	0	6	0	6	8.5
Mallard (<i>Anas platyrhynchos</i>)	0	1	1	1	3	4.2
Unknown waterfowl	0	0	0	2	2	2.8
Wild Turkey (<i>Meleagris gallopavo</i>) poult	0	0	0	1	1	1.4
Rail (<i>Rallus</i> sp.)	0	1	0	0	1	1.4
Unknown bird	0	0	0	1	1	1.4
Total	0	2	7	5	14	19.7
Fish						
Largemouth Bass (<i>Micropterus salmoides</i>)	0	0	1	0	1	1.4



FIGURE 1. Images of Red Foxes (*Vulpes vulpes*) carrying food items recorded during camera-trap surveys at Great Swamp National Wildlife Refuge, Morris County, New Jersey, from 24 November 2013 to 25 October 2014. Prey items are (A) Muskrat (*Ondatra zibethicus*), (B) juvenile Raccoon (*Procyon lotor*), (C) avian egg, (D) Rail (*Rallus* sp.), and (E) Largemouth Bass (*Micropterus salmoides*). Photos: C. Wagnon.

scores the value of camera traps in collecting data that may address interesting questions and natural history observations not directly related to the scope of a study.

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