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Foraging Ecology of Spotted Turtles (*Clemmys guttata*) in Ontario, Canada

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The conservation of animal species relies on the identification and protection of suitable habitat. While general habitat features are important to the success of vertebrate ectotherms because they provide structures for thermoregulation (Blouin-Demers and Weatherhead 2001; Downes and Shine 1998) and predator avoidance (Spencer 2002), biotic elements such as food resource use and distribution are often overlooked in studies of habitat selection. Qualitative descriptions of diet do little to further the understanding of resource use and requirements, which ultimately affect the fitness of individuals. The recent use of stable isotope analysis has shed light on the relationship between foraging ecology and nutrient assimilation in some turtle species (Aresco and James 2005; Bulte and Blouin-Demers 2008; Hatase et al. 2006; Seminoff et al. 2007). Detailed observations of species-specific foraging behavior assist in the implementation of stable isotope analysis by focusing sampling efforts on likely prey, reducing potential costs and time spent in the field.

The Spotted Turtle (*Clemmys guttata*) is a species for which diet and foraging behavior have been qualitatively described (Ernst 1976; Milam and Melvin 2001; Surface 1908). Stomach content analyses of 27 Spotted Turtles revealed three individuals with plant material, while all individuals contained aquatic and terrestrial invertebrates in their guts (Surface 1908). These findings were supported by Ernst's (1976) observations of Spotted Turtles ingesting both plant and animal materials. Spotted Turtles are noted to be opportunistic omnivores, with a highly variable list of diet items including cranberries, earthworms, aquatic insect larvae, crustaceans, snails, salamanders, fish, birds, algae, and tadpoles (Ernst 1976). The relative importance of these food items has not been reported. Spotted Turtles are cold-tolerant and most active in the early spring (Ernst 1976, 1982; Haxton and Berrill 1999; Litzgus and Mousseau 2004; Milam and Melvin 2001; Ward et al. 1976), but they have not been recorded foraging in water cooler than 14°C (Ernst 1976). The broad distribution of this species, as well as differing habitat use between northern and southern populations (Haxton and Berrill 1999; Litzgus and Mousseau 2004; Milam and Melvin 2001; Ward et al. 1976), indicate that detailed dietary and foraging choices should be documented to further our understanding of resource use and habitat selection. In Canada, Spotted Turtles are listed as an endangered species (COSEWIC 2004), and declines and local extirpations have been documented within Ontario despite habitat protection (Browne and Hecnar 2007). Recovery plans should take into account resource distribution, as well as general habitat qualities, in order to create effective management guidelines for this species. The purpose of our study was to quantify dietary choices in a population of Spotted Turtles and describe foraging behaviours observed in natural settings.

Materials and Methods.—The foraging ecology of Spotted Turtles in a population on the shores of Lake Huron in Ontario, Canada was documented during a radio telemetry study in 2007 and 2008. The study site consists of a 95-ha mosaic of Great Lakes coastal wetlands bounded by forested swamps, upland forests, and minimal human development. One hundred and seventeen individuals (54 females, 49 males, 14 juveniles) were captured and marked (Cagle 1939), with an equal distribution of adult males and females ($\chi^2 = 0.24$, df = 1, $p > 0.05$). Fifteen individuals (5 males, 10 females) were located 2–4 times a week from April to August 2007 and 2008 using radio telemetry, with up to 16 additional females located daily during June of both years. Transmitters (SI-2F and SI-2T, 12g, Holohil Systems Ltd, Carp, Ontario) were attached to the rear marginal scutes using copper wire and putty epoxy. Turtles without transmitters were also observed opportunistically. Behavior was characterized for each turtle sighting over the entire study period. Foraging behavior was defined as any aquatic or semi-aquatic activity in which the turtle was actively searching, grabbing, or biting at items. Target items were identified by observing the item during the foraging period, and any unidentifiable items were recorded as "unknown." For each individual turtle observed foraging, ambient air (10 cm from the ground in shade), substrate surface (direct sunlight on substrate), and water temperature (mid-depth of water column) were measured to 0.1°C using a digital thermometer. Temperature-sensitive transmitters allowed the estimation of turtle body temperature from the pulse rate.

Results.—Two hundred and twenty-seven foraging observations were made during the study (Table 1), all within 2–40 cm of water. The greatest proportion of foraging observations were of turtles taking aquatic invertebrates (74%), followed by fish (~16%). Foraging was observed throughout the active season (April to August) in both years; however, observations of foraging were more numerous in the earlier months (Fig. 1). While the number of observers (MLR and JEP) remained constant over both years of the study, it is likely that experience gained in 2007 contributed to an increase in overall sightings in 2008. To account for this, monthly observations are presented as percentages of the total observations per year (Fig. 1).

In 2007, water temperatures recorded during foraging ranged from 13°C to 33.8°C. In 2008, water temperatures ranged from 7.7°C to 31.7°C. For individuals outfitted with radio transmitters in 2008, estimated body temperature during foraging ranged from 9.9°C to 31.9°C. Prey items chosen were not related to differences in water temperatures ($F = 0.44$, $df = 3,164$, $p = 0.72$) or estimated turtle body temperatures ($F = 0.09$, $df = 3,113$, $p = 0.96$).

TABLE 1. Observations of foraging by Spotted Turtles (*Clemmys guttata*) in Ontario, Canada over the course of a two-year (2007, 2008) radio telemetry study. Targets indicated by * were consumed as carrion.

Target Item	2007	2008	Total	% of Foraging Observations (excluding unidentified targets)
Aquatic Invertebrates Total	13	19	32	74.0
Freshwater snails	8	8	16	37.2
Trichoptera	1	4	5	11.6
Leech	1	0	1	2.3
Crayfish	1	0	1	2.3
Unidentified	2	7	9	20.9
Vegetation	0	1	1	2.3
Rainbow Trout (*Onchorhynchus mykiss*)*	0	1	1	2.3
Carp (*Cyprinus carpio*)*	0	2	2	4.6
Small Ciprinids and other minnows*	2	2	4	9.3
Leopard Frog (*Rana [Lithobates] pipiens*)*	1	0	1	2.3
Tadpoles (*Bufo [Anaxyrus] americanus*)	0	1	1	2.3

Discussion.—The large proportion of invertebrates in Spotted Turtle diets observed in our study agrees with findings of the stomach content analysis by Surface (1908), and foraging observations by Ernst (1976). When consuming hard-shelled snails, individuals would repeatedly bite and release the snail, eventually consuming the soft body and discarding the hard shell. While the majority of animal materials were assumed to be consumed post-mortem, tadpoles were consumed live. Stomach content analysis by Surface (1908) indicated the presence of land-dwelling invertebrates. Whether these items were captured on land or accidentally fell into the water was unknown. Foraging for terrestrial prey was confirmed once during our study. An individual male was observed in shallow water (3 cm) positioning himself vertically using his front legs, and biting at the remains of a spider's web hung between short rushes. Capture and consumption of the spider or items in the spider web was not directly observed. This observation would suggest that while Spotted Turtles are confined to consuming prey items aquatically, these prey items could be captured in a terrestrial environment.

Observations of foraging behavior were most numerous in May, June, and July, with few observations in August (Fig. 1). Foraging is probably most important in early spring after emergence from hibernation, and during the mating and nesting seasons. The energetic demands of sperm production, egg production, copulation, and nesting (Hughes and Brooks 2006; Morreale et al. 1984; Pearse and Avise 2001) require a large effort to be expended in resource gathering early in the season for turtles at northern latitudes. The lack of foraging observations in August could be due to periods of inactivity. Aestivation has been observed in Spotted Turtles and is thought to conserve energy and water during high temperatures in the summer months (Ernst 1982; Perillo 1997). However, temperature data gathered in one Ontario population documented that inactive individuals were not choosing cooler microclimates, and therefore may not be aestivating (Litzgus and Brooks 2000). Alternatively, higher August temperatures may allow turtles to forage in more heavily-vegetated waters reducing our ability to observe foraging behavior later in the season. Capital energy acquired during foraging late in the summer may help supplement income energy gains during the limited time available for foraging between emergence and reproductive activities the following year (Gregory 2006).

Prior to our study, Spotted Turtles were not recorded foraging in waters cooler than 14°C (Ernst 1976). In both years, we observed individuals foraging in water cooler than this minimum. In 2007, we observed foraging at 13°C and made multiple observations of foraging in water temperatures as low as 7.7°C in 2008. We

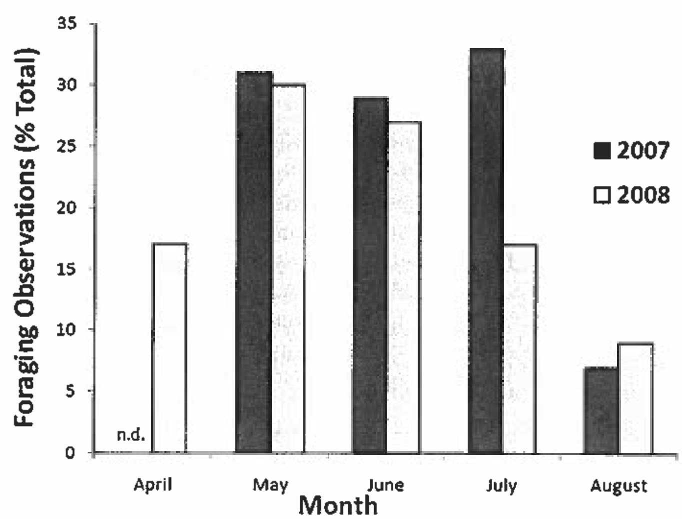

FIG. 1. The percentage of foraging behavior observations for Spotted Turtles (*Clemmys guttata*) in Ontario, Canada for the active seasons of 2007 (black, N = 58 observations) and 2008 (white, N = 170 observations). In April 2007, a lack of researcher presence resulted in no data being collected, denoted as "n.d." on the graph.

did not detect prey choice differences at different environmental temperatures, and this can be explained by the apparently opportunistic nature of foraging. The ability of Spotted Turtles to forage at low temperatures may give them a fitness advantage in the unpredictable and short active seasons typical of northern climates. The acquisition of resources during the active season is vital to an individual's survival from year to year, and also to their ability to produce offspring (Litzgus and Brooks 1998; Litzgus et al. 2008). If Spotted Turtles are restricted by variable water levels in their shallow wetland habitats, then the ability to forage successfully in the cooler months of April and May would certainly be advantageous.

Our study quantitatively highlights the relative importance of food items in the diet of a population of Spotted Turtles. The importance of vegetative matter in Spotted Turtle diets, at least in our population, appears to be minimal. Close observation revealed that although they may appear to be targeting aquatic vegetation, it is in fact most likely that individuals are seeking small freshwater snails and benthic invertebrates within the matrix of aquatic vegetation. This vegetative material may not contribute to energy stores. Stable isotope analysis combined with stomach content analysis in Snapping Turtles (*Chelydra serpentina*) showed that although large amounts of vegetation may be found within the stomach, little of this is translated into tissues (Aresco and James 2005). It appears as though Spotted Turtles are most dependent on macroinvertebrates, with a strong tendency to detect and consume carrion. Future studies of Spotted Turtle foraging ecology should examine the importance of various diet items through stomach content analysis coupled with radio-isotope analysis to explore the relative importance of various food items in tissues, as well as the turtle's trophic position in aquatic ecosystems. This information should be used to supplement habitat selection studies in dictating protection and enhancement guidelines for the continued presence of this species in our ecosystems.

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