REPTILES & AMPHIBIANS

Early Season Diet of the Red-spotted Newt, *Notophthalmus viridescens viridescens*, from Artificial Vernal Pools in South-Central Pennsylvania: A Possible Trade-off Between Survival and Reproduction

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The Eastern Newt (*Notophthalmus viridescens*) is a geographically widespread polytypic species of eastern North America (Powell et al. 2016). In Pennsylvania, the Red-spotted Newt (*N. v. viridescens*) is found throughout the commonwealth (Meshaka and Collins 2012). A wide range of prey (Surface 1913), including amphibian eggs (Hulse et al. 2001; Meshaka et al. 2025), comprise its diet in Pennsylvania. Many females were gravid in March in a complex of small artificially created vernal pools adjacent to an artificial pond in south-central Pennsylvania; these provided information on clutch characteristics (Meshaka and Morales 2016). Using specimens from the Meshaka and Morales (2016) study and others from that site in March of previous years, we examined the composition of the diets of these ephemerally residential newts whose own reproductive success was jeopardized by the hydroperiod of the habitat.

The study site, known as Jerry's Flat, is a heavily wooded mixed deciduous forest located near Boiling Springs, Cumberland County, Pennsylvania. Adjacent to Ridge Road, an unimproved road that bisects the forest, is a ca. 50 x 25-m permanent pond created by the Civilian Conservation Corp during the late 1930s for use as a water source to fight fires. The pond is shallow and has an extensive littoral zone but at no time since 1972 has the pond dried completely (EW, pers. obs.). Jefferson Salamanders (*Ambystoma jeffersonianum*), Wood Frogs (*Rana sylvatica*), Spotted Salamanders (*Ambystoma maculatum*), and Red-spotted Newts breed in this pond, and generally in that order. Northern Spring Peepers (*Pseudacris crucifer crucifer*) first appeared at the site in the 1990s (EW, pers. obs.).

Seasonally inundated artificially created pools were immediately adjacent to as far as 35 m from the permanent pond. Maximum water depths were ≤ 50 cm, and hydropatterns mimicked that of vernal pools. Adjacent to Ridge Road is a ca. 10 x 8-m temporary pool fed by road drainage that was created incidentally by the construction of a haul road for logging. Two other rectangular seasonal pools (ca. 15 x 3 m) that occasionally connect as a horseshoe are 4 m from the temporary pool on one end and 8 m from the permanent pool on the other end. They, as well as a few distant pools that occasionally connect to a ca. 30 x 8 m pool, were created by off-road vehicle damage in the 1970s. These pools begin to fill during late fall–early winter and usually dry completely during most summers, but occasionally hold a small amount of water through the summer months. Concomitant with their creation, Wood Frogs, Spotted Salamanders, Red-spotted Newts, and Jefferson Salamanders began to use these pools to breed, the latter species of which were initially smaller in body size than those in the permanent pond (EW, pers. obs.).

Stomachs were removed and opened to access prey from individuals opportunistically collected with dipnets in March 2013–2016. Prey were identified to varying taxonomic levels. Longest length (to 0.1 mm) of each item was measured using an ocular micrometer. Composition of the diets was presented as frequency of each prey type (= no. prey of type x/total no. prey in the sample) and frequency of stomachs with each prey type (= no. stomachs containing prey type x/total no. stomachs). Two-tailed T-tests were conducted in Excel 2016. Statistical significance was established at $P \leq 0.05$.

The snout-vent lengths of 64 males (mean = 42.6 ± 2.3 mm; range = 36.7–46.6 mm) and 32 females (mean = 41.7 ± 1.9 mm; range = 37.2–45.9 mm). Neither variance ($F = 1.4625$, $df = 62, 31$, $P = 0.13$) nor mean ($t = 1.8679$, $df = 93$, $P = 0.07$) differed significantly. Fourteen prey categories were detected

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in 52 males and 25 females (Fig. 1). Ostracods comprised the majority of prey eaten by both sexes, followed distantly by *Daphnia* and amphibian eggs in similar frequencies to one another (Fig. 1a). A high degree of overlap was found in the prey frequency (r = 0.97, P = 0.002). Ostracods, followed closely by *Daphnia*, were found in the greatest number of stomachs of both sexes (Fig. 1b). Collectively and for males, amphibian eggs were the third most important prey by this measure; however, sphaerid clams were common in slightly more female stomachs than were amphibian eggs (Fig. 1b). A high degree of overlap was evident in the frequency of stomachs containing each prey type (r = 0.95, P < 0.0000). One male (SVL = 39.3 mm) had eaten a salamander larva on 17 March 2016.

The longest prey lengths, including insect parts and seeds, did not differ significantly between 46 males (mean = 2.0 ± 1.2 mm; range = 0.1–7.5 mm) and 23 females (mean = 2.2 ± 1.4 mm; range = 0.4–7.0 mm) with respect to variance (F = 1.4184, df = 45, 22, P = 0.16) or mean (t = 0.8430; df = 67, P = 0.40). Likewise, the number of prey, excluding seeds and insect parts, did not differ significantly between 52 males (mean = 17.0 ± 17.2 mm; range = 1–52 mm) and 25 females (mean = 15.1 ± 14.2 mm; range = 1–56 mm) with respect to variance (F = 0.6784, df = 51, 24, P = 0.54) or mean (t = -0.4686; df = 67, P = 0.64). Mean prey size, maximum prey length, and number of prey in a stomach were not significantly correlated (P > 0.05) with body sizes of either males or females. Thus, composition of the diets overlapped strongly between males and females in length and number of prey, although females showed greater variation in these attributes and were more apt to have prey in their stomachs.

The majority of males (82.5%) and females (78.1%) had eaten in March when many females were gravid (Meshaka and Morales 2016). The time spent by adults in these pools was generally brief. In most years the pools were dry before the end of July, at which time adults could move into the large adjacent artificial pond. Newts, which forage throughout the water column and on the substrate, took full advantage of amphibian eggs and larvae, a protein-rich resource that they might otherwise not encounter in natural vernal pools located too far from permanent ponds. In particular, Jefferson Salamanders, Spotted Salamanders, and Wood Frogs lay their eggs annually in these pools and in the adjacent pond, and we

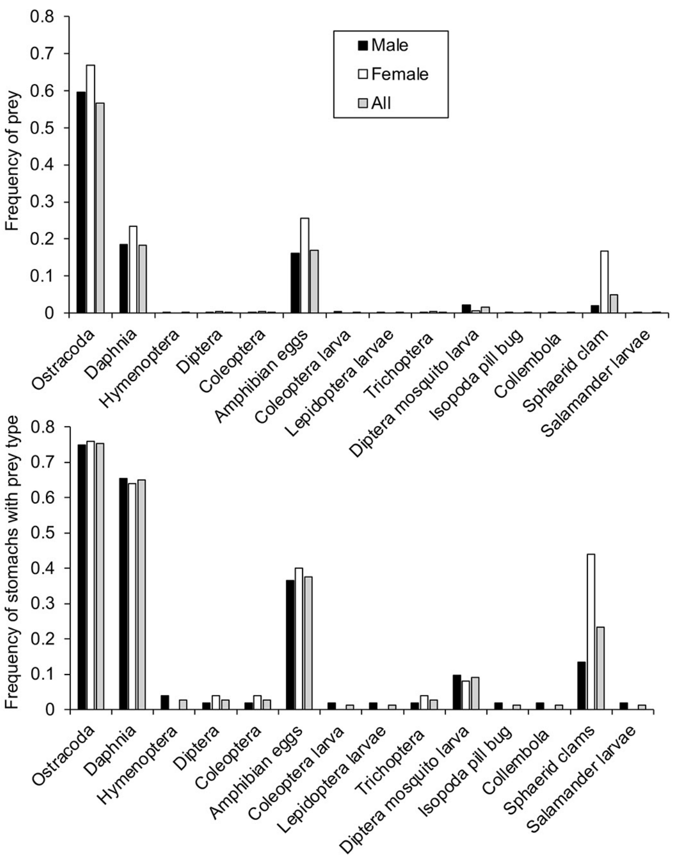

Figure 1. Frequency of prey types in stomachs of 52 male, 25 female, and all Red-spotted Newts (*Notophthalmus viridescens viridescens*) collected from artificial vernal pools on South Mountain, Cumberland County, Pennsylvania, in March 2011–2016 (top) and frequency of stomachs containing each prey type in males, females, and all individuals combined (bottom). Eggs from stomachs of three males could not be completely counted.

Figure 2. A male Red-spotted Newt (*Notophthalmus viridescens viridescens*) foraging on eggs of a Spotted Salamander (*Ambystoma maculatum*) in an artificial temporary pool in Cumberland County, Pennsylvania. Photograph by E. Wingert.

have observed newts foraging on egg masses of those species (Fig. 2), sometimes clustered in small groups on an egg mass. In turn, however, Red-spotted Newts, whose larvae generally transform during late summer–fall (e.g., July–late-October in south-central New York [Hurlbert 1970], 17 August–15 September in New York [Bishop 1941], and mid-August–November in Virginia [Gill 1978]) routinely faced a high likelihood of reproductive failure in pools that typically were dry by the end of July during the 25 years of our observations. These nutrient-rich artificial wetlands provided a short-term benefit in the form of abundant food to Red-spotted Newts that inhabited them seasonally — but at a cost to reproductive success.

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