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Juliet Hernandez and Matthew J. Lundquist

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Cover Photograph: Juliet Hernandez stands in the Bronx RIver at Crestwood Station site (Tuckahoe, NY) in spring 2023 testing out techniques for collecting Eastern Blacknose Dace in preparation for this gut content study. These techniques included hand netting and seining (shown here). Hand netting was ultimately chosen as the most effective dace collecting technique. Photo by: Matthew J. Lundquist.

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Limited Diets of Eastern Blacknose Dace *(Rhinichthys atratulus* Hermann) Within the Highly Urbanized Bronx River, New York, USA

Juliet Hernandez[1] and Matthew J. Lundquist[1, *]

Abstract - Urbanization, the transformation of natural landscapes into cities, can cause altered hydrology, increased pollutants, and habitat fragmentation in nearby rivers. While biodiversity loss in urban rivers is well documented, the impact of urbanization on food webs is understudied. We examined urban trophic dynamics by analyzing gut contents of *Rhinichthys atratulus* (Eastern Blacknose Dace) from the highly urbanized Bronx River in New York in the summer of 2023. The diets of *R. atratulus* were dominated by midge larvae (Chironomidae), with some individuals also containing various combinations of caddisflies (Hydropsychidae), amphipods (Gammaridae), and cladocerans (Diplostraca). Despite other invertebrate taxa documented in the river, *R. atratulus* consumed only this limited subset. While they are considered generalists in non-urban environments, our findings suggest their dietary specialization in this urban system. This narrowed dietary breadth may reduce aquatic food web resilience against further urbanization impacts.

Introduction

Urbanization, the transformation of natural landscapes into cities, is rapidly increasing worldwide (Violin et al. 2011) with more than half the world's population living in cities (United Nations et al. 2019). Urbanization increases both human population density and the concentration of impervious surfaces like concrete, steel, and asphalt. Impervious surfaces prevent rainwater from being absorbed into the soil (Violin et al. 2011), delivering runoff directly into sewers and into rivers, instead (Kushal and Belt 2012). Changes in chemistry and hydrology, as well as the loss of habitat in urban rivers often leads to greatly reduced biodiversity (Walsh et al. 2005). This loss of biodiversity may also impact river trophic dynamics. For example, aquatic invertebrate communities, which are important basal components of river food webs (Lundquist and Zhu 2018) and organic matter processing (Macadam and Stockan 2015), are typically dominated by few pollution tolerant taxa, and pollution sensitive taxa are reduced or lost (Urban et al. 2006).

In this study we investigated the feeding preferences of *Rhinichthys atratulus* Hermann (Eastern Blacknose Dace) in the highly urbanized Bronx River. *R. atratulus*, a generalist minnow common in eastern North American rivers and an invertebrate generalist in non-urban systems (Rollwagen and Stainken 1980), likely serves as a food source for larger predatory fish. Studies of *R. atratulus* in urban environments are typically limited to morphological and behavioral analyses (Fraker et al. 2002; Nelson et al. 2008), and little is known about *R. atratulus* diets in urban rivers. We postulated that low invertebrate biodiversity in the river (Baladrón and Yozzo 2020; Lundquist and Scott 2023; Mahmud et al. 2023, 2024) would be reflected in low invertebrate diversity within *R. atratulus* guts.

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Methods

Sampling was done in summer 2023 within 6 100-m reaches along the freshwater portion of the Bronx River which flows from Westchester County and enters the Long Island Sound in Bronx County, New York. The sites match those used in the aquatic invertebrate study by Lundquist and Scott (2023). While the land cover types in the Bronx River watershed varies, it is primarily covered in development at varying degrees of intensity (i.e., shades of red; Fig. 1).

Individual *R. atratulus* were collected opportunistically from the wadeable portions of the river within each site using hand nets (9.5 mm mesh) and seins (6.4 mm mesh). River habitats were similar among sites, consisting primarily of cobble and small boulders. While each site was visited once per sampling attempt (n = 2), *R. atratulus* were only found in four sites: Scarsdale (SC), Crestwood Station (CW), Bronxville (BR), and Mount Vernon (MV). Individual fish were sorted by location and transported to the lab for gut analysis.

Total body length of each individual was measured in mm from the tip of the snout to the end of the tail and then dissected along their ventral midline. All fish samples contained both full and partial invertebrates (e.g., head capsules), which were recovered from the stomach and intestine and identified to family (except Diplostraca) using Merritt et al. (2019). Ad-

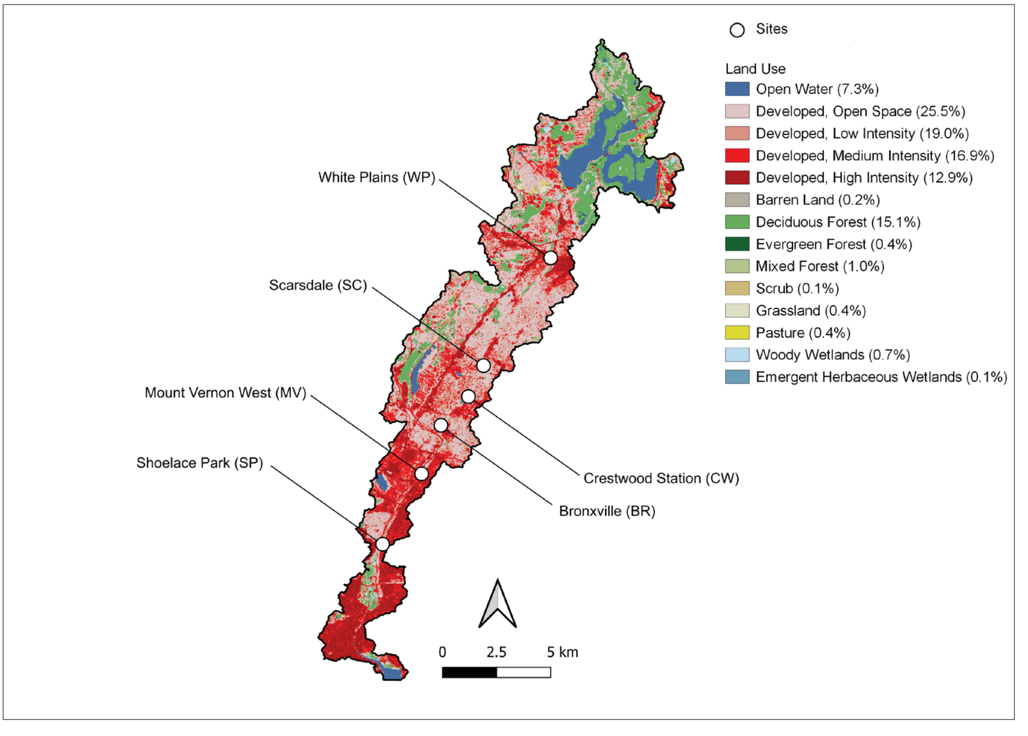

Figure 1. Map of the Bronx River Watershed which flows through Westchester County and Bronx County, NY. Colors represent land cover types with the majority of land cover (approx. 75%) developed land (shades of red). Sampling sites are indicated. Data from USGS.gov (Dewitz 2023). Graph modified from Lundquist and Scott (2023).

ditional invertebrate samples were collected from each site using kick nets for comparative biomass estimates. Body mass was determined by drying the invertebrates at 60 °C for at least 24 hr and were then weighed to the nearest 0.01 mg. Chironomids were too small to weigh individually and therefore were pooled by site for biomass determination. The distribution and abundance of these invertebrates in the Bronx River have been reported elsewhere (Lundquist and Scott 2023; Mahmud et al. 2023, 2024).

A two-way analysis of variance test (ANOVA) was used to compare dace gut content between sites (n = 4) and sampling months (n = 2). Tukey HSD post-hoc tests were performed for ANOVA p-values <0.05. Count data was Tukey-Freeman transformed before ANOVA or post-hoc tests. We utilized two generalized linear models (GLMs) assuming a Poisson distribution to (1) explore the relationship between the number of invertebrate taxa found and *R. atratulus* length (n = 25), and (2) the total number of invertebrates in the guts and *R. atratulus* body length (n = 25). All statistics were run using the *statsmodels* library in Python 3.13.3.

Results

A total of 25 *R. atratulus* were collected through June and July 2023, and every site had a similarly low abundance (between 1 and 9 per site, per sampling time). Dace lengths ranged between 19.5 and 36.0 mm, likely in Stage II (the active feeding and growth stage) of development (Fraker et al. 2002). Midge larvae (Chironomidae) were found in all 25 *R. atratulus* sampled and was the most abundant aquatic invertebrate within mixed species gut contents (Fig. 2). Net-spinning caddisfly larvae (Hydropsychidae) were found in 15 *R. atratulus* gut, amphipods (Gammaridae) were found in 10, and cladocerans (Diplostraca) were found in six. The average number of invertebrates within guts was (22.70 ±2.20 individuals gut^{-1}), and the average number of individuals of each taxa within guts were significantly different ($F = 105.63$, $P < 0.001$; Fig. 2). Pairwise Tukey HSD comparisons revealed that Chironomidae were significantly more abundant in guts than all other invertebrates, and Hydropsychidae were more abundant than all but Chironomidae (Fig. 2). The GLMs revealed a significant, positive effect of number of individuals within the gut and length for Chironomidae ($P < 0.001$, pseudo $R^2 = 0.47$; Fig. 3a) and total gut content ($P < 0.001$, pseudo $R^2 = 0.50$; Fig. 3e), but not Hydropsychidae (Fig. 3b), Gammaridae (Fig. 3c), or Diplostraca (Fig. 3d).

Representative samples of Chironomids, Hydropsychidae, and Gammaridae collected for biomass analysis were all significantly different in mass from each other ($F = 59.14$, $P < 0.001$; Fig. 4). Regardless of site, Chironomidae were significantly smaller than either Hydropsychidae or Gammaridae (Fig. 4). While Diplostraca were not collected for biomass analysis, they were markedly smaller than Chironomidae in gut samples (pers. obs.).

Discussion

Chironomidae were found in all gut samples and comprised the majority of *R. atratulus* diets, which on average was four times more abundant than other invertebrates. Many of members of Chironomidae are highly pollution tolerant and are dominant taxa in urban rivers (Walsh et al. 2005). Chironomidae are likely the preferred food source for *R. atratulus* in the Bronx River due to their small size. This preference is indicated both by the average number of Chironomidae per gut and the dominance of Chironomidae in guts within all *R. atratulus* size classes. Larger invertebrates like Hydropsychidae and Gammaridae were likely consumed opportunistically. Beyond this preference for Chironimidae, the *R. atratulus* guts contained only a small subset of the biodiversity of invertebrates found in the Bronx River (Baladrón and Yozzo 2020; Lundquist and Scott 2023; Mahmud et al. 2023, 2024). Previous work on *R. atratulus* diets in non-urban rivers have found that *R. atratulus* are generalists and had gut content that included not only what we observed in this study, but also oligochaetes*,* coleopterans*,* and ephemeropterans, (Rollwagen and Stainken 1980) Rhinichthys atratulus (Cyprinidae: Cypriniformes, all of which were reported in the Bronx River previously (Baladrón and Yozzo 2020; Lundquist and Scott 2023; Mahmud et al. 2023). It is possible that while these taxa exist in the Bronx River, they are not in dense enough to be viable food sources for *R. atratulus* (Tófoli et al. 2013). The preference for small, easily handled prey may also indicate a feeding ecology where quantity is preferred over quality, as smaller insects contain fewer nutrients per individual (Lundquist and Zhu 2018), but are easier to handle (Tófoli et al. 2013).

While *R. atratulus* is a predator of aquatic invertebrates, it is also likely a prey item for larger fish and riparian vertebrates. Although no comprehensive survey of fish communities

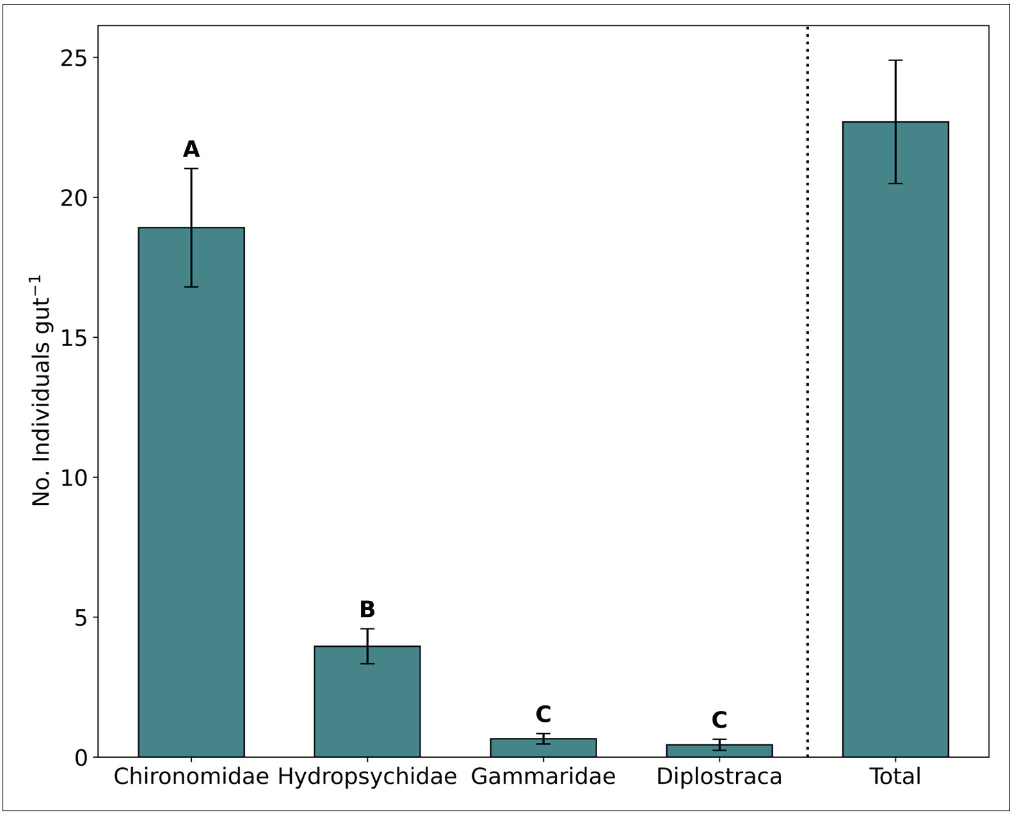

Figure 2. Bar graph representing average number of individuals Chironomidae, Hydropsychidae, Gammaridae, and Diplostraca per individual *R. atratulus*. The rightmost column, “Total,” represents the average number of individuals per individual *R. atratulus*. Bars are means ± SE, and different letters represent $P < 0.05$.

in the Bronx River has been conducted since 2007 (Rachlin et al. 2007), we found it difficult to locate populations of *R. atratulus* within our study sites. This scarcity may reflect broader ecological constraints. The dietary limitations we observed in *R. atratulus* could be mirrored at higher trophic levels, where predators may depend on it as a primary food source. Conversely, the reduced abundance of *R. atratulus* may be causing diet narrowing among these predators, where they rely on other, potentially smaller or less nutritious, prey species. Increased specialization in fish diets has been observed in urban environments across the globe (Gámez et al. 2022); therefore, understanding trophic dynamics in urban rivers may be key to conserving and restoring biodiversity in these systems.

While our study provides valuable insights into the dietary patterns of *R. atratulus* in an urban river system, the relatively small sample size (n = 25) and limited temporal scope may not capture seasonal dietary variations. To our knowledge, this is the first description of *R. atratulus* diet composition in urban rivers, and more work is needed to understand invertebrate and fish trophic dynamics in urban rivers.

The impact of urbanization on river trophic dynamics is an open question, and while our study is limited in scope, the apparent specialization of *R. atratulus* on Chironomidae in the

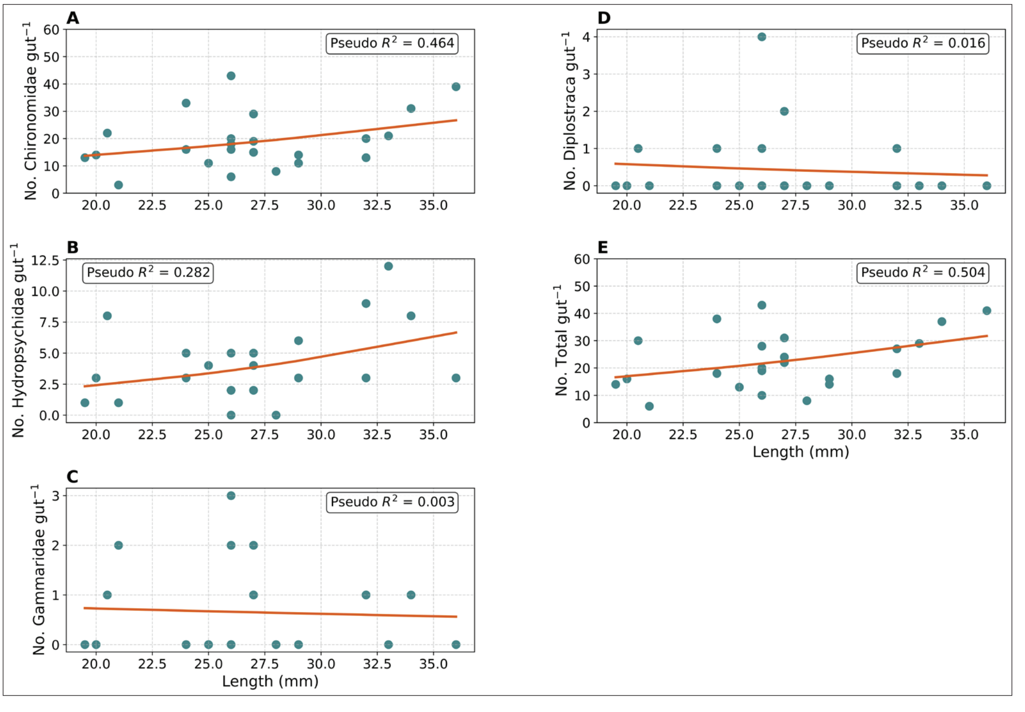

Figure 3. Generalized Linear Models (Orange lines represent the best fit of data derived from Poisson GLMs.)
Figure 3a. Number of Chironomidae in gut per length of individual R. *atratulus* (mm)
Figure 3b. Number of Hydropsychidae in gut per length of individual *R. atratulus* (mm)
Figure 3c. Number of Gammaridae in gut per length of individual R. *atratulus* (mm)
Figure 3d. Number of Diplostraca in gut per length of individual *R. atratulus* (mm);
Figure 3e. Total number of aquatic invertebrates recovered from gut per length (mm) of individual *R. atratulus*.

Bronx River suggests broader environmental consequences of urbanization on community dynamics. The loss of biodiversity in urban environments can simplify food webs, reduce food choices, and change predator behavior (Faeth at al. 2005).This can reduce overall resilience to further degradation (Nelson et al. 2021). Our results also suggest that changes in diet are happening even though potential prey taxa are not completely extirpated from urban river communities. It is imperative that future studies of urbanization and restoration efforts not only aim to improve biodiversity in general, but also to rebuild and support river food webs. Furthermore, our study demonstrates the utility of predator gut content diversity and dietary flexibility as an indicator of ecosystem health beyond simple species inventories.

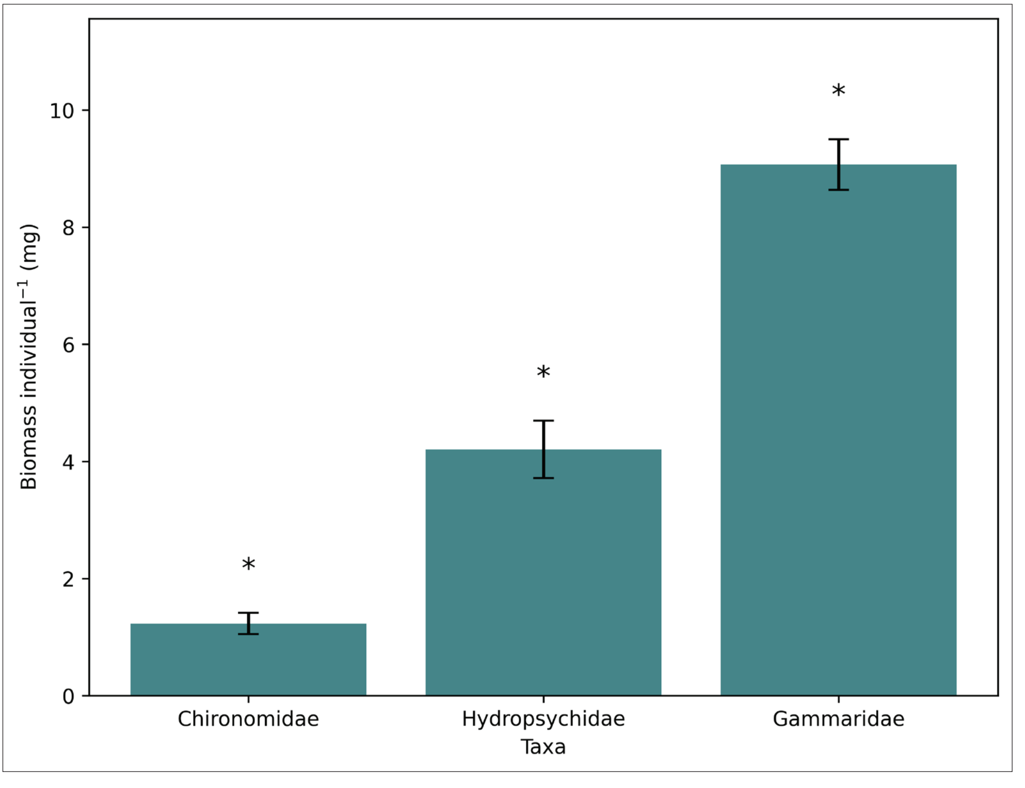

Figure 4. Bar graph representing average biomass (mg) per individual of Chironomidae, Hydropsychidae taxa, and Gammaridae. Bars are means ± SE, and * represents $P < 0.05$.

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