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High Conservation Value of the Odonata Assemblage in the Upper Ohio River Mainstem: A Large, Regulated River in North America

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ABSTRACT.—Like many large rivers in modern industrialized regions, the Ohio River mainstem is a heavily modified riverine habitat comprised of various reservoir-dam series and shaped channels, rather than a free-flowing system. However, many odonate species in such habitats, even species of conservation concern, have been shown to prosper in degraded lotic habitats due to key life history attributes, such as rapid recolonization following large disturbances. In this study we characterize the assemblage of odonates in a Pennsylvania section of the Ohio River mainstem and determined if any species of conservation concern were present. We also tested hypotheses on distributions in the channel by testing if proximity to banks and channel depths helped predict odonate abundance. Samples were acquired as bycatch to benthic fish sampling conducted using electrified benthic trawling, a novel approach for collecting benthic macroinvertebrates in large freshwater rivers. We found seven odonate species, all of which were known to be species of conservation concern in one or more U.S. states. We also concluded that gradients of bank distance and river depth only weakly predicted odonate abundance, suggesting that the Ohio River species regularly use mid-channel habitat that is several meters deep. Life histories of most of the species collected are typical of those living in large lotic, and occasionally lentic, environments. Studies of other large, temperate rivers show that the ability to persist is not uncommon for odonates in these modified environments, and may be due to their ability to use mid-channel resources successfully. Despite the substantial differences between contemporary and historic conditions of habitats in the Ohio River basin, an odonate assemblage worth conserving continues to be present in the mainstem channel.

INTRODUCTION

Like most large, temperate large rivers, the Ohio River is a highly altered river ecosystem, capable of supporting only relic proportions of its pre-industrial biological assemblage (Taylor, 1989; Applegate *et al.,* 2007; Elderkin *et al.,* 2007; Drauch *et al.,* 2008). The Ohio River mainstem is 1580 km long, originates in the city of Pittsburgh, Pennsylvania, drains parts of twelve U.S. states, and terminates at the confluence of the Mississippi River in Cairo, Illinois. Land cover within the Ohio River watershed is a matrix of forest, agricultural, urban,

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and industrial parcels. The Ohio mainstem and its two large tributaries, the Allegheny and Monongahela rivers, are also heavily impounded by locks and dams built for navigation and flood control. Consequently, the Ohio River, while still transporting substantial volumes of water, contains sizable portions of distinct lotic and lentic environments (Thomas *et al.* 2004). Flow regimes structure the physical, chemical, and thermal properties of large rivers and therefore the biological communities that live within them (Monk *et al.,* 2008; Palmer and Ruhi, 2019). Subsequently, regulated rivers like the Ohio have experienced large losses in insect abundance and diversity due to altered flow regimes (and other physicochemical attributes) that do not align with the life histories of native lotic species (Poff *et al.,* 2007; Wang *et al.,* 2016). However, a number of invertebrate primary consumer taxa, such as Orthoclad midges, do proliferate under these flow regimes of large rivers (Munn *et al.,*, 1996) and, as a result, can potentially support more complex food webs that include predators, such as odonates and larger fish.

One insect assemblage that could demonstrate the impacts of flow alteration in large rivers of North America are damselflies and dragonflies (Odonata). An estimated 228 species of odonates, 162 dragonfly (suborder Anisoptera) and 66 damselfly (suborder Zygoptera), breed in the northeastern and midwestern U.S. (White *et al.*, 2015). The eastern half of North America contains a greater number of odonate species than in the western counterpart, which is likely a result of the more favorable humid conditions along the eastern half of the continent (Kalkman *et al.*, 2008; Paulson 2011). Here, the odonate assemblage can be used as an effective bioindicator for large riverine habitats due to the sensitivity of some species for certain breeding site requirements and the high capacity for flying adults to disperse in response to adverse changes in environmental quality (Chovanec and Waringer, 2001; Kutcher and Bried, 2014).

Despite the high likelihood that the contemporary insect faunal assemblage of the Ohio River is greatly reduced relative to pre-industrialized conditions, the system may still be capable of supporting populations of a number of odonate species. For example, Buczyński *et al.* (2017) determined that a large river could support abundant and diverse assemblages of anisopterans when variety in structural habitats (*i.e.,* building of groynes) was introduced into the river mainstem. Although dredging in rivers to improve navigability does destroy odonate nymph habitat, they may recolonize within a year of such disturbance (Buczyński *et al.,* 2016). Even in urban environments, large rivers may be capable of supporting large populations of odonates, if habitat along the banks remains relatively intact (Principe and del Corigliano, 2006), although zygopterans are more sensitive to vegetation removal along river banks (de Carvalho *et al.,* 2013). In Ohio counties bordering the Ohio River, there have been incidental reports of odonate species being discovered outside of their previously described ranges, and this may indicate that certain species are able to repopulate areas as habitats become more suitable (Glotzhober, 1999).

There is a need to understand more of how odonate assemblages are impacted by habitat alteration (Bried and Samways, 2015). Given that odonates are observed in other large modified rivers, our odonatology study aimed to characterize the assemblage in a portion of the Ohio River at two sites. Because benthic habitats of large rivers have proven difficult to sample with traditional gear, here we report data from electrified benthic trawling, a method that has revolutionized benthic fish sampling in large rivers (Herzog *et al.,* 2009; Koryak *et al.,* 2008; Freedman *et al.,* 2009), but has not been previously used for collecting benthic freshwater macroinvertebrates. We tested hypotheses related to the spatial distributions of odonates within the Ohio River mainstem and predicted that abundance would be higher in greater proximity to banks and at shallower depths of the channel due to the likelihood that

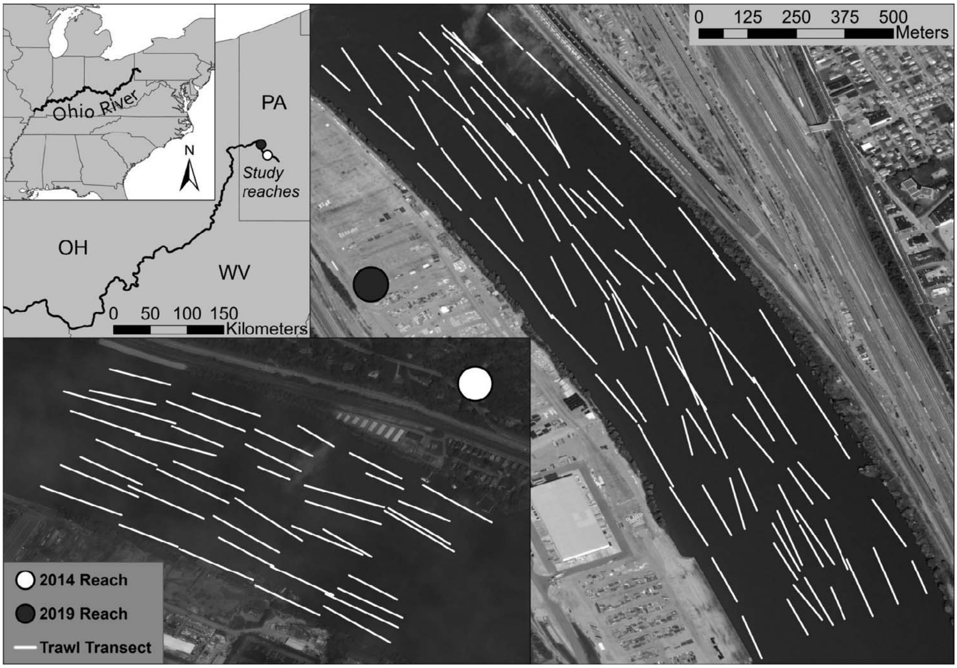

FIG. 1.—Map depicting the sections of the Ohio River mainstem sampled for the study and specific locations of trawl transects from the study years 2014 and 2019

more complex habitat would be associated with the banks and that deep habitat would be associated with potentially unfavorable conditions, such as low dissolved oxygen. We also summarized the vulnerability of species collected at global and state scales to assess the overall conservation value of the Ohio River mainstem.

METHODS

STUDY AREA

We surveyed the uppermost reach of the Ohio River mainstem in the state of Pennsylvania in the United States (Fig. 1). The reaches of the river that we sampled drains from a basin of approximately 50,764 km^2. In our study reaches, banks are characteristic of an urban environment with residential, commercial, and industrial land uses. Along the Ohio River, there are a number of metal and chemical manufacturers, refineries, and recyclers. Bankside vegetation is dominated by invasive shrubs and trees (*Ailanthus altissima* (Mill.) Swingle, *Reynoutria japonica* Houtt.) and a few native, mature trees (*Liriodendron tulipifera* Linn., *Salix nigra* Marsh.). Our study area encompassed reaches between the Emsworth and Montgomery Locks and Dam systems, both of which are gated to manually control the flow and enable commercial boat navigation. In between the two study pools and separating each study site is the Dashields Lock and Dam, which is a fixed crest system that has no gates to maintain pool elevation. Our 2014 reach (40°31′32″N, 80°09′59″W) is situated 7.0 km downstream from Emsworth Lock and 4.5 km upstream from Dashields Lock. The 2019

TABLE 1.—Estimated density of odonates per m^2 in the Ohio River by species and sample year

Family	Species	Authority	Odonates/m^2	
			2014	2019
Gomphidae	*Stylurus notatus*	Rambur, 1842	$1.30 * 10^{-4}$	$2.28 * 10^{-3}$
Gomphidae	*Stylurus scudderi*	Selys, 1873	$2.60 * 10^{-4}$	$1.51 * 10^{-3}$
Gomphidae	*Stylurus spiniceps*	Walsh, 1862	0	$5.92 * 10^{-5}$
Gomphidae	*Gomphurus vastus*	Walsh, 1862	0	$2.96 * 10^{-5}$
Macromiidae	*Macromia illinoiensis*	Walsh, 1862	$1.17 * 10^{-3}$	$5.62 * 10^{-4}$
Macromiidae	*Didymops transversa*	Say, 1839	0	$3.55 * 10^{-4}$
Coenagrionidae	*Argia translata*	Hagen in Selys, 1865	0	$2.96 * 10^{-5}$

reach (40°39′16″N, 80°14′37″W) is situated 12.8 km downstream from Dashields Lock and 16.5 km upstream from Montgomery Lock.

DATA COLLECTION

Electrified benthic trawl sampling was conducted at river reaches 16.6 to 17.4 km from August 6 to 9, 2014 and 33.3 to 35.1 km from September 24 to 29, 2019. Samples were collected using an electrified Missouri-type trawl measuring 2.4 m × 1.2 m × 3.2 mm internal mesh (Herzog *et al.,* 2005, Freedman *et al.,* 2009) deployed by hand from the bow of a 6.1 m Sea Ark johnboat with 115 hp outboard motor. Electricity was supplied by a 5000 w generator regulated through a Smith-Root VI-A Electrofisher (Smith-Root, Vancouver, WA) to control output to 6.0 amps, 120 PPS DC, and 6.0 ms pulse width (Honick *et al.,* 2017). Sampling occurred between 2 h after sunrise and 2 h before sunset and each trawl was deployed for approximately 2 min while running downstream, slightly faster than the current. The length of trawl rope released for each sample was dependent on river depth, which was recorded by sonar; at depths of 5 m or less, 5 to 10 m, and 10 to 20 m, the length of rope released was 15.2, 30.5, and 45.7 m, respectively. Individual trawls extended for approximately 160 m at varied distances from the left and right descending banks (four trawls on each half of the channel). Forty trawls were conducted in 2014 and 88 trawls in 2019 for a total of 128, approximately 16 m trawls. Specimens collected from trawls were immediately preserved in 95% ethanol. Odonate specimens were separated from fishes and placed in new labeled containers. The odonate specimens were identified to species using Westfall and May (1996) and Needham *et al.* (2012). Conservation statuses of identified odonate species were collected from and defined using the public database tool NatureServe Explorer (2020). We noted the statuses for the species at their global extents and for states in the Ohio River watershed (Table 2).

STATISTICAL ANALYSES

We quantitatively assessed if odonates were more likely to be collected along gradients of trawl depth and distance to the nearest bank. Trawl depth was recorded in the field at the start, midpoint, and end of each sampling location, and these measurements were averaged per trawl. Distance to the nearest bank was derived from GIS data. The correlation between distance to bank and depth was quantified using a Pearson's product-moment correlation test. To statistically assess if either variable could be used to predict total odonate abundance per trawl, we assessed an additive generalized linear mixed model (GLMM) that assumed a

TABLE 2.—Conservation status of species by state (S) and globally (G). These status rankings were provided by NatureServe Explorer (2020). (SH) = Possibly Extirpated, (S1) = Critically Imperiled, (S2) = Imperiled, (G3 or S3) = Vulnerable, (S4) = Apparently Secure, (G5 or S5) = Secure, (-) = No Data. (https://explorer.natureserve.org/AboutTheData/Statuses)

	States in the Ohio River Watershed											
	Ohio mainstem states						Non Ohio mainstem states					
Species	PA	OH	WV	IN	KY	IL	NY	VA	TN	NC	MD	Global
Argia translata	S4	S4	S5	-	S5	S1	S1	S3	S5	S4	S4	G5
Didymops transversa	S5	S3	S4	S3	S5	S2	S5	S4	S5	S5	S5	G5
Gomphurus vastus	S4	S2	S2	S3	S4	S3	S1	S3	S5	S3	S4	G5
Macromia illinoiensis	S5	S4	S3	S4	S5	S4	S5	S5	-	S5	S4	G5
Stylurus notatus	S2	S1	S1	S1	S1	S1	SH	SH	S2	-	-	G3
Stylurus scudderi	S3	-	SH	S1	S1	-	S3	S1	S3	S2	S1	G5
Stylurus spiniceps	S4	S2	S2	S3	S3	SH	S3	S3	S5	S3	S3	G5

Poisson error distribution and included sample year as a random effect. The model formula was structured as follows:

$$A = \alpha(distance) + \beta(depth) + \gamma(year) + \varepsilon$$

Distance represents the nearest bank in meters; depth is the sample depth in meters; α, β and γ are modeled co- efficients; and A = the abundance of all collected odonates. Both fixed-effect variables (depth and distance) were rescaled by subtracting the mean and dividing by the standard deviation of the original values to reduce the GLMM model eigenvalue. The model fit was assessed for uniformity, over/underdispersion, and zero inflation by assessing the distribution of simulated residuals. Statistical analysis was conducted in R version 3.6.3 (R Foundation, Vienna, Austria); the GLMM was assessed using the 'lmerTest' (Kuznetsova *et al.*, 2017) and 'MuMln' (Bartoń 2020) packages; and model fit was assessed using the 'DHARMa' package (Hartig 2020).

Benthic densities of odonate species collected (Table 1) were estimated for each year with the following formula:

$$density = \frac{odonates\ collected}{average\ trawl\ length\ (160\ m) * trawl\ width\ (2.4\ m) * number\ of\ trawls}$$

RESULTS

Twenty-four specimens of three odonate species were collected in 2014 and 163 specimens from 7 odonate species were collected in 2019, resulting in 187 specimens from six anisopteran and one zygopteran species total (Table 1). S*tylurus notatus* (Rambur, 1842) was the most dominant species, followed by *Stylurus scudderi* (Selys, 1873), *Macromia illinoiensis* (Walsh, 1862), *Didymops transversa* (Say, 1839), *Stylurus spiniceps* (Walsh, 1862), *Gomphurus vastus* (Walsh, 1862), and *Argia translata* (Hagen in Selys, 1865). A mean of 0.6 ± 1.0 (SD) specimens per trawl (among all species) were collected in 2014, and in 2019, the mean was 1.9 ± 2.8 specimens per trawl. Other arthropod taxa collected included *Hexagenia* (Ephemeroptera: Ephemeridae), *Sialis* (Megaloptera: Sialidae), and *Pteronarcys* (Plecoptera: Pteronarcyidae).

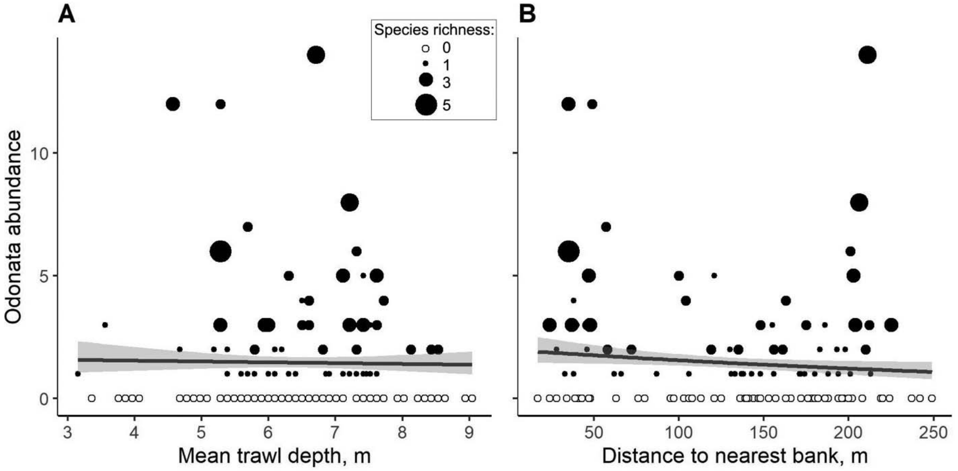

FIG. 2.—Odonata abundance related to trawl depth (**A**) and distance to nearest bank (**B**). Lines represent slopes from GLMM models and the shading represents ±95% confidence intervals. All species were pooled for these analyses

According to NatureServe Explorer (2020), every species collected is listed on rosters of conservation concern in at least one U.S. state (Table 2). All but *A. translata* are known to be "of conservation concern" in at least one of the three states closest to the study sites (PA, OH, WV), although *A. translata* is of "heightened concern" elsewhere. In Pennsylvania *S. notatus* is listed as "imperiled," whereas *S. scudderi* is "vulnerable." *S. notatus* is "critically imperiled" in Ohio, whereas *S. spiniceps* and *G. vastus* are "imperiled" and *D. transversa* is "vulnerable." In West Virginia *S. scudderi* is "possibly extripated," *S. notatus* is critically "imperiled," *S. spiniceps* and *G. vastus* are both "imperiled" and *M. illinoiensis* is "vulnerable."

Fixed effects in the GLMM very weakly predicted Odonate abundance. Diagnostic tests indicated it was suitable to use a Poisson error distribution for the model: although uniformity was somewhat low (D = 0.14, P = 0.0129), the model was not over- or underdispersed (ratio of observed to simulated residuals = 1.93, P = 0.064), and there was no evidence of zero-inflation (ratio of observed to simulated residuals = 1.32, P = 0.456). Bank distance and mean depth were weakly, but statistically significantly correlated to each other ($t = 5.1$, df = 126, $P < 0.0001$, r = 0.41). Although both distance to nearest bank (z = –1.8, P = 0.0659) and mean depth (z = –1.9, P = 0.0541) exhibited negative slopes, both effects conveyed low predictive power of Odonate abundance and richness (α and β co-efficients ± 95% confidence intervals of –0.14 ± 0.16 and –0.17 ± 0.18, respectively; Figs. 2A, B). Including year as a random effect suggested that the difference between years was more important, as the marginal and conditional R^2 values were 0.056 and 0.393, respectively. Unexpectedly, the most diverse and abundant sample (12 organisms from four species) was collected near the deepest point of the sites at 6.7 m deep and 211 m from shore.

DISCUSSION

Despite significant modification, the mainstem Ohio River has some ability to support an Odonate assemblage that includes species of conservation concern. All of the Odonate species that we collected are considered "vulnerable" in some states, and some of which are listed as "critically imperiled" in states with Ohio River mainstem reaches. All life history and habitat attributes described below are provided by Paulson (2011), unless otherwise cited. The dominant species that we encountered, *S. notatus* (Elusive Clubtail), is specialized to large, slow-moving rivers such as the Ohio, but such ecosystems in temperate zones are often highly degraded (Nilsson *et al.,* 2005; Dudgeon *et al.*, 2006; Arthington *et al.*, 2010). *Stylurus notatus* is of conservation concern throughout its global range and is critically imperiled in five of six states with Ohio River mainstem reaches (Table 2). Adult individuals tend to spend much of their life high in forest canopies and only visit water to breed, which makes population monitoring difficult. *Stylurus scudderi* (Zebra Clubtail) was previously listed as vulnerable throughout its global range but has since been reassessed as secure (NatureServe Explorer 2020, USGS 2020). With respect to states adjacent to the Ohio River, however, *S. scudderi* is largely imperiled (Table 2). *Stylurus spiniceps* (Arrow Clubtail) and *D. transversa* (Stream Cruiser) both tend to live in forested streams and rivers and could be impacted by the diminished native vegetation along the banks (Principe and del Corigliano, 2006). *Gomphurus vastus* (Cobra Clubtail) and *A. translata* (Dusky Dancer) prefer sandy riverbeds, but this habitat is easily degraded by dredging to maintain river navigability (Grygoruk *et al.,* 2015). All species found during our trawling are of conservation concern in at least one state in the Ohio River basin, including *M. illinoiensis* (Swift River Cruiser), whose generalist characteristics allows it to survive in most large bodies of water in its widespread range (though it is listed as vulnerable in West Virginia).

Industrialization has led to a highly altered flow regime along with increased pollution from various point and nonpoint sources in the Ohio River over the last 200 y. Reference site-based bioassessment of the Ohio River is impossible due to a lack of ecologically intact rivers with similar attributes. Regardless, macroinvertebrate sampling to assess ecological integrity throughout the Ohio mainstem has been regularly conducted since the early 1960s by the United States Environmental Protection Agency (Wooten *et al.*, 2006). Early samples of the Ohio River from this program were dominated by Trichoptera and Chironomidae, with odonates accounting for less than 1% of individuals in the assemblage (Anderson and Mason, 1968; Wooten *et al.*, 2006). More recent surveys of macroinvertebrates (including odonates) and the fish assemblages in the Ohio River indicate improvements in invertebrate taxa diversity and the presence of sensitive species related to declines in point and nonpoint water pollution (Thomas *et al.,* 2004, Wooten *et al.,* 2006, Honick *et al.*, 2017). Such biomonitoring efforts did not stress focus odonates and never identified specimens to species. To gain additional insights on species abundances over time, we surveyed the Global Biodiversity Information Facility (GBIF, 2020) for specimen records of the seven species we collected in counties bordering the Ohio in all six states (Table 3). Although we cannot conclude if these records indicate inhabitation of the Ohio River given they reflect adult samples, evidence suggests that at least five out of the seven species we encountered were historically present in the region along the Ohio River.

While species richness of odonates is typically lessened with increased river alteration like the reach of the Ohio River we sampled, localized habitat attributes (from natural variances in riverbed substrates as well as human-made structures) may allow the system to be more diverse (Golfieri *et al.,* 2016; Villalobos-Jiménez *et al.,* 2016). Other large, temperate rivers in the U.S. and Europe have found comparable odonate species richness in rivers that have been modified for boat navigation (DuBois and Pratt, 2017; Willigalla and Fartmann, 2012). DuBois and Pratt (2017) sampled for odonates with drift nets in the St. Louis and St. Croix

TABLE 3.—Occurrence records of five odonate species we collected in the Ohio River mainstem from counties along the Ohio River as recorded in the Global Biodiversity Information Facility (GBIF 2020). Two species we collected, *Stylurus spiniceps* and *Gomphurus vastus*, were not found within the records of occurrences

Species	Description of occurrence records
Argia translata	Records span 1917–2020 and include 80 observations, most of which were reported from Ohio and West Virginia.
Didymops transversa	Records span 1884–2020 and include thirteen observations from Ohio, Illinois, Indiana, and a single record from West Virginia.
Macromia illinoiensis	Records span 1884–2020 and include 49 observations, mostly from Ohio. A majority (38) were reported within the last 20 yr.
Stylurus notatus	Records span 1888–2014 and include twelve observations, with all but two occurrences recorded before 1940 and only one occurrence within the last 20 yr. Ten observations were made in Illinois, the other two were reported from Kentucky and Ohio.
Stylurus scudderi	Records span 1889–2020 and include nine observations, with three records noted in Ohio during 2020. A single record from Allegheny County, Pennsylvania but does not include a date.

Rivers, both large tributaries of the Mississippi River in the midwestern U.S. The St. Louis represents a highly modified, large river while the St. Croix is similar in size but with a protected riparian corridor. They collected six species in the St. Louis and 12 species in the St. Croix Rivers. Though all species collected in the St. Louis River were listed as globally secure in their conservation status, three species were listed as species of concern in some states (NatureServe, 2020). In a study in the Austrian reach of the Danube River, odonate richness was found to be much higher than North America's large rivers, although with alternate sampling methods designed specifically to target odonates. For instance, at one site on the Danube River, 42 total species including 22 sensitive species of odonates were collected in association with river habitat rehabilitation projects, including the lowering of riverside embankments to reestablish a less altered flow regime (Tockner *et al.,* 1998; Chovanec *et al,*. 2004).

We detected little evidence to suggest that odonate assemblages are associated with depth or proximity to riverbank gradients. Individuals were found only slightly more frequently towards the banks and at shallower depths, which suggests at least some odonate species can use mid-channel habitat in large, modified, deep rivers. These findings align with other studies observing that odonate abundance is not affected by water depth in large temperate rivers (Buczyński *et al.,* 2017; Staentzel *et al.,* 2019). Jones (2011) found odonate abundance at varied transects was not affected by distance to bank in both modified and natural rivers. An ability to persist in mid-channel habitat may explain why the odonate assemblage we characterized is able to survive in highly modified habitats despite significant habitat and flow regime degradation.

Our results contribute to observations of persisting freshwater assemblages, including taxa of conservation concern, despite modification to large rivers. In addition to odonates, our sampling of the Ohio River found numerous incidental samples of *Hexagenia,* a mayfly genus known to be sensitive to water pollution (Harwood *et al.,* 2014; Bartlett *et al.,* 2018; Nowghani *et al.,* 2019), but with some species that thrive in impounded rivers (Fremling, 1973). We also collected specimens of the stonefly *Pteronarcys* and dobsonfly *Sialis* during sampling. In the

Chattahoochee River in Georgia U.S., insect assemblages were found to be more diverse further from dams, likely due to reduced hydrologic influence on benthic habitat (Holt *et al.,* 2015). Electrified benthic trawling, the sampling technique of this study, revealed that three formally imperiled darter fish species have extended their range throughout the Upper Ohio River system by acclimating to the atypical habitats of dam tailwaters (Honick *et al.,* 2017). These findings are consistent with other studies finding lotic fish species in greater abundance in tailwaters of dams associated with high flow and oxygenation, whereas lentic-adapted species were found in the impounded reaches above dams (Argent and Kimmel, 2010; Freedman *et al.,* 2014). Despite the ability for some taxa to acclimate to altered conditions, others, such as mussel assemblages, typically lose considerable diversity in large rivers along gradients of urbanization due to impoundments and are often characterized by species representative of smaller stream orders (Kriege, 2018; Hamstead *et al.,* 2019).

Our findings must be contextualized with respect to our sampling methodology. Electrified trawling is not typically used to target benthic macroinvertebrates and may not prove to be a reliable means of collecting representative samples. The 3.2 mm mesh size is not typically used for macroinvertebrate sampling, as it is large enough to allow many smaller individuals to pass through. We suspect smaller odonates may have been missed during our sampling and it is unclear how this would have affected results assessing if depth and distance to bank can be used to successfully predict odonate abundance. We found this mesh size (as opposed to the typical 0.5 mm used to sample macroinvertebrates) necessary due to the large quantities of benthic debris that would otherwise have halted sampling. Traditional means of sampling benthic macroinvertebrates from large rivers, such as a ponar sampling (Bartsch *et al.*, 1998), may be more suitable for comprehensively assessing community structure. However, our incidental catch using an atypical sampling methodology may have allowed us to detect more species by collecting a large volume of coarse organic matter.

Although substantial environmental degradation and habitat modification continue to occur, this study demonstrates that the Ohio River mainstem is capable of supporting ecologically vulnerable biota that can benefit from conservation efforts aimed to reduce the impacts of river modification. Historic difficulties in sampling benthic habitats of large modified rivers has been facilitated for fishes by electrified benthic trawling. This study indicates that this gear is also effective in sampling large benthic odonate nymphs, providing further insight into benthic habitat quality and community conservation monitoring. Odonates participate in many important ecological interactions as predators of smaller animals in aquatic food webs as nymphs and in terrestrial food webs as adults, while also experiencing predation from amphibians, fish, spiders, birds, and other taxa (Stoks and Córdoba-Aguilar, 2012; Buckland-Nicks *et al.,* 2014). Additionally, they are useful biological indicators of ecosystem health in relation to pollution, altered flow regimes, and climate change (Chovanec and Waringer, 2001; Kutcher and Bried, 2014; White *et al.,* 2015). While the Ohio River's historic odonate assemblage is unlikely to be fully recovered (Hobbs *et al.,* 2009), efforts that reduce flow alteration such as the selected removal of river embankments can be made to improve the contemporary ecosystem that currently exists with respect to its potential diversity.

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