Transactions of the Missouri Academy of Science, Volume 50 (2024), pp. 1–5
doi:10.30956/MAS-43
Published online August 19, 2024

Notes on Habitat and Environmental Parameters Associated With Adult *Heterosternuta* and First Records for *Heterosternuta wickhami* (Coleoptera: Dytiscidae) in Missouri

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Abstract: *We report records on habitat characteristics and environmental parameters found associated with adult specimens of the predacious diving beetle genus* Heterosternuta *Strand identified in aquatic macroinvertebrate community samples collected from reaches of 80 wadeable stream sites during years 2002 through 2018 and first documentation on occurrence of* Heterosternuta wickhami *(Zaitzev) in Missouri, USA.*

Key words: *Missouri, wadeable streams, aquatic Coleoptera, Dytiscidae,* Heterosternuta

Introduction

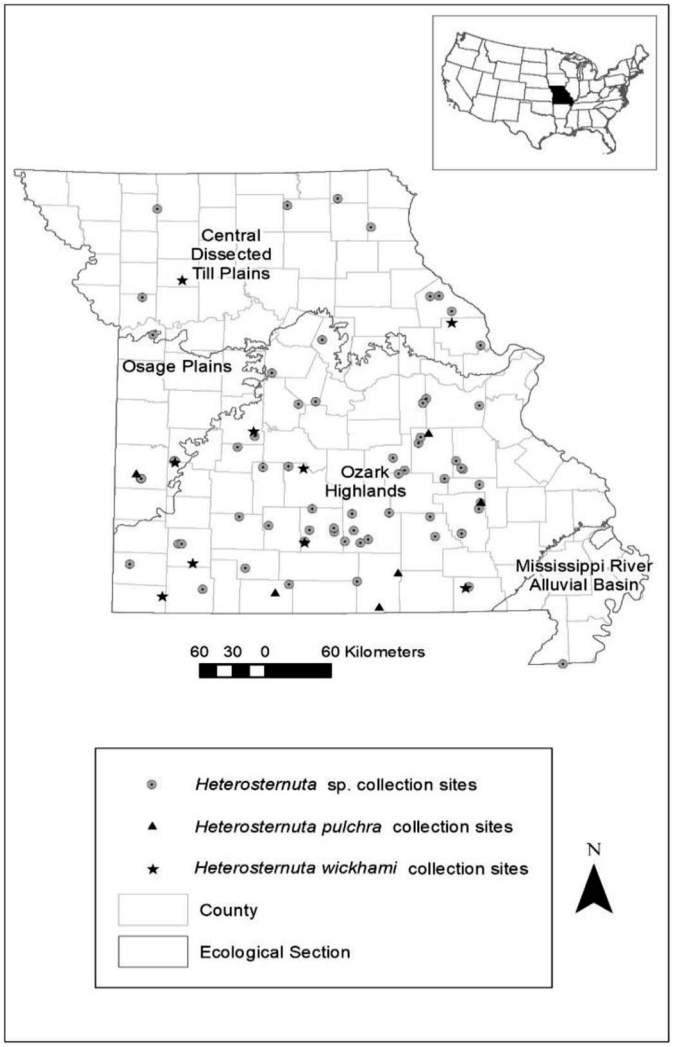
In addition to potential genomic value of all species to humanity, the aquatic Coleoptera serve an important role in transfer of nutrients and energy to other trophic levels. The water beetle family Dytiscidae (predacious diving beetles) serve as prey for some other invertebrates and a variety of vertebrates in food-webs of aquatic ecosystems (Larson et al. 2000). Also, in combination with other taxa in aquatic communities, the Dytiscidae are useful as indicators for monitoring and assessment of biodiversity and quality of aquatic ecosystems (Larson et al. 2000). The Dytiscidae occur throughout much of the world and are comprised of 188 genera and over 4,300 recognized species (Miller and Bergsten 2016), with the genus *Heterosternuta* Strand represented by 14 recognized species restricted in range to eastern half of North America (Larson et al. 2000; Nilsson 2001; Wolfe and Harp 2003) and predominantly occur in lotic environments (Miller and Bergsten 2016).

We collected aquatic macroinvertebrate community samples from 1,213 reaches of wadeable stream sites from throughout Missouri during years 2002 through 2018 as part of a statewide wadeable stream assessment and monitoring program. Majority of the sites sampled were chosen at random, but some were targeted as part of research projects. We found a total of 159 adult specimens of *Heterosternuta* in material collected from 80 of the sites sampled. The primary purpose of this report is to summarize habitat characteristics and environmental parameters associated with adult specimens of *Heterosternuta* identified from the aquatic macroinvertebrate community samples we collected. In addition, a subset of the adult *Heterosternuta* we collected were identified to taxonomic level of species to serve as reference material, and this report provides first documentation on occurrence of *Heterosternuta wickhami* (Zaitzev) in Missouri.

Materials and Methods

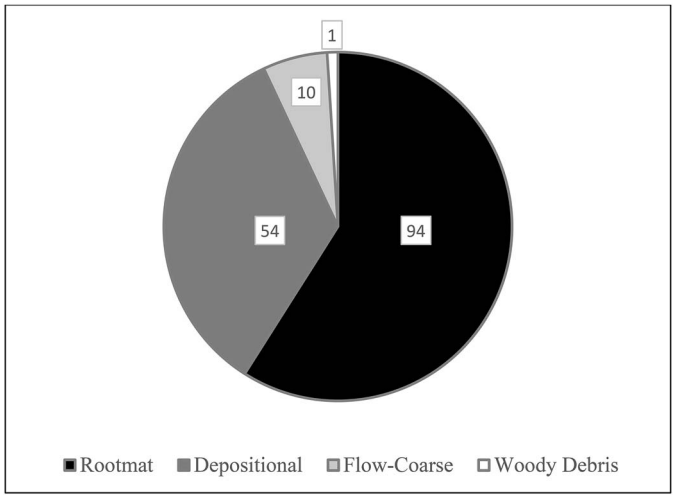
Aquatic macroinvertebrate community samples were collected from reaches of wadable stream sites using 500 μm mesh aquatic kick nets in riffle (flow-coarse), pool (depositional), and submerged rootmat habitats according to methods outlined by Sarver et al. (2002) and MDNR (2012). If a site had no flow-coarse habitat and woody debris habitat was present, submerged surfaces of woody debris were brushed into a 500 μm mesh bag and collected also

Figure 1. Locations of reaches of 80 wadeable stream sites where adult specimens of *Heterosternuta* were collected in Missouri during years 2002 through 2018.



following Sarver et al. (2002) and MDNR (2012). Aquatic Coleoptera found within the samples were examined with a dissection microscope at magnifications up to 80x. Taxonomic keys and descriptive information provided by Larson et al. (2000), Ciegler (2003), White and Roughley (2008), Epler (2010), and Short and White (2019) were used to identify aquatic beetles from the samples. Reference specimens of adult *Heterosternuta wickhami* (Zaitzev) and *Heterosternuta pulchra* (LeConte) are retained in a collection at the Missouri Department of Conservation, Central Region Office and Conservation Research Center, Columbia, Missouri, USA and will be deposited at the University of Missouri Enns Entomological Museum in Columbia, Missouri, USA upon completion of study of aquatic macroinvertebrates of wadeable streams in Missouri.

Figure 2. Habitats sampled from reaches of 80 wadeable stream sites in Missouri positive for a total of 159 adult specimens of *Heterosternuta* and number of the specimens found in collections from each habitat sampled during years 2002 through 2018.



Physical characteristics of the collection sites were obtained by direct observation and using methods outlined by Kaufmann et al. (1999), Peck et al. (2006), and USEPA (2013). Water temperature, dissolved oxygen concentration, pH, conductivity, and turbidity were recorded on-site using either a Hach/HydroLab®

Figure 3. Dominant substrates of 80 wadeable stream sites positive for adult specimens of *Heterosternuta* in Missouri during years 2002 through 2018 and frequency of occurrence of the specimens at sites with each dominant substrate.

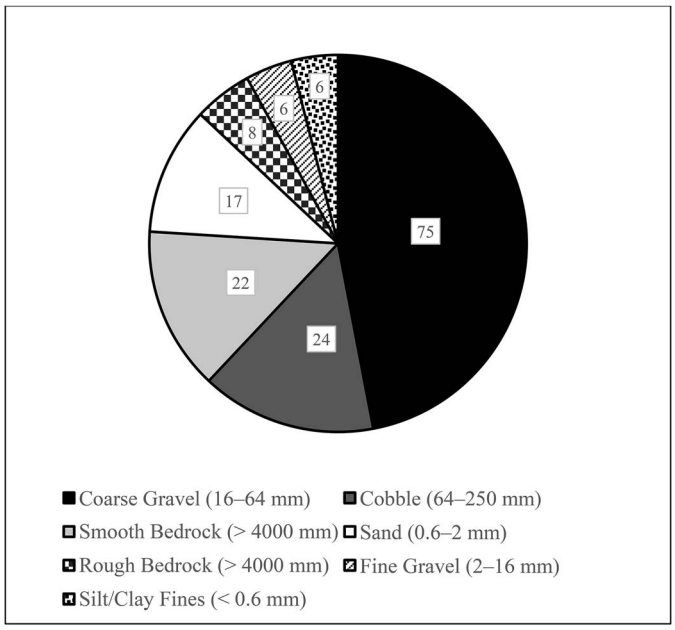


Table 1. Mean, standard deviation (SD), and range of select physico-chemical characteristics from reaches of wadeable stream sites where adult *Heterosternuta* were collected in Missouri during years 2002 through 2018. Temp = water temperature (°C), DO = dissolved oxygen (ppm), Cond = conductivity (μS/cm), pH = standard units (pH), Turb = turbidity (Nephelometric Turbidity Units), Chlor = total chlorophyll (μg/L).

	Temp	DO	Cond	pH	Turb	Chlor
Mean	19.9	7.1	372	7.7	18.4	6.2
SD	± 4.7	± 2.1	± 178	± 1.0	± 30.2	± 8.0
Range	(8.3-30.3)	(2.5-12.5)	(39-1090)	(6.1-9.1)	(0.0-190.0)	(0.2-39.4)

quanta or a YSI® water quality meter equipped with a calibrated sensor for each respective variable. Chlorophyll samples were collected by filtering a known volume of water at the collection sites. The chlorophyll samples were kept in the dark at 4°C during transport to the laboratory and kept frozen at the laboratory until processed according to methods provided by Knowlton (1984) and by Sartory and Gobbelaar (1984). Data for all other water quality parameters were obtained from grab samples of water collected in pre-cleaned cubitainers, stored and transported at 4°C, and processed at the University of Missouri Limnology Laboratory using methods provided by Crumpton et al. (1992), APHA (1995), Switala (1997), and Pritzlaff (2003).

Results

159 adult specimens of *Heterosternuta* were identified from samples collected from reaches of 80 wadable stream sites sampled from within all Ecological Sections of Missouri (Cleland et al. 1997; Nigh and Schroeder 2002) during years 2002 through 2018 with specimens of *H. wickhami* identified in material collected from nine and specimens of *H. pulchra* identified in material collected from six of the total 80 locations found positive for the genus (Fig. 1). *Heterosternuta pulchra* is previously documented to occur in Missouri by Larson et al. (2000), and our records add additional Missouri localities in Crawford, Howell, Reynolds, Taney, and Vernon counties to Missouri distributional information for *H. pulchra* (Fig. 1). Although *H. wickhami* has been reported by Larson et al. (2000) to occur in all states bordering Missouri except Nebraska, our collections represent first records on occurrence of *H. wickhami* in Missouri where we collected adult specimens of *H. wickhami* from localities in Benton, Caldwell, Laclede, Lawrence, Lincoln, McDonald, Ripley, St. Clair, and Wright counties (Fig. 1).

We found adult specimens of *Heterosternuta* in collections from all four of the habitats we sampled, but primarily in samples collected from submerged rootmat habitat (Fig. 2). We also found adult specimens of *Heterosternuta* in samples from reaches of streams with various dominant substrates, but the specimens were most frequently found in samples from reaches of streams with a coarse gravel (16–64 mm) dominant substrate (Fig. 3). Stream order of reaches where we collected *Heterosternuta* ranged from 1st to 5th order. Mean, standard deviation, and range of watershed area, discharge, wetted-width, and depth of those stream reaches were, respectively, 93.6 km^2 (± 100.8 km^2) and 0.1–1495.8 km^2; 0.144 m^3/s (± 0.220 m^3/s) and 0.000–0.967 m^3/s; 8.2 m (± 4.7 m) and 0.9–22.2 m; and 31 cm (± 16.1 cm) and 3.9–72.0 cm. Range and standard deviation for riparian corridor over-story and understory canopy of streams where the specimens were collected was 0%–100% (± 28%) while that for groundcover of those riparian corridors was 86%–100% (± 2.5%). Mean, standard deviation, and range for water temperature, dissolved oxygen concentration, conductivity, pH, turbidity, and total chlorophyll concentration of reaches of stream sites where adult *Heterosternuta* were collected are provided in Table 1, and those for other water quality characteristics of the reaches where we collected the specimens are provided in Table 2.

Table 2. Mean, standard deviation (SD), and range of select water quality characteristics from reaches of wadeable stream sites where adult *Heterosternuta* were collected in Missouri during years 2002 through 2018. TP = total phosphorus (μg/L), TN = total nitrogen (mg/L), NO = nitrate/nitrite (mg/L), NH = ammonia (mg/L), NVSS = nonvolatile suspended solids (mg/L), VSS = volatile suspended solids (mg/L), DOC = dissolved organic carbon (mg/L).

	TP	TN	NO	NH	NVSS	VSS	DOC
Mean	101	1.06	0.7	0.02	6.3	1.5	3.6
SD	± 303	± 1.53	± 1.3	± 0.02	± 16.1	± 2.1	± 5.4
Range	(3-2011)	(0.08-8.71)	(0.0-7.0)	(0.00-0.10)	(0.1-118.0)	(0.1-14.0)	(0.4-41.3)

Discussion

We did not target collection of dytiscid beetles in our sampling efforts and recognize the diversity of *Heterosternuta* species in Missouri is likely greater than is represented in this report. Researchers have documented several species of *Heterosternuta* to occur in some states bordering Missouri. For example, north of Missouri there are four taxa: *Heterosternuta diversicornis* (Sharp), *Heterosternuta oppositus* (Say)*/wickhami*, *H. pulchra*, and *H. wickhami* reported to occur in Iowa by IOWADNR (2020). South of Missouri *H. pulchra* and *H. wickhami* also occur in Arkansas plus three species: *Heterosternuta ouachita* (Matta and Wolfe), *Heterosternuta phoebeae* Wolfe and Harp, and *Heterosternuta sulphuria* (Matta and Wolfe) are reported endemic to Arkansas by Longing and Haggard (2009). Longing and Haggard (2009) found the rare *H. sulphuria* associated with groundwater influenced habitat, and Larson et al. (2000) noted *H. sulphuria* may, possibly, also occur in southern Missouri. Therefore, it is possible there are unreported *Heterosternuta* species inhabiting groundwater influenced zones of some streams, or some of the more than 1,100 documented springs and associated spring brooks in Missouri (Vineyard et al. 1982) where a comprehensive systematic survey of aquatic Coleoptera has not been conducted. Although clearly comprehensive targeted collecting efforts combined with detailed taxonomic resolution of *Heterosternuta* are warranted to fully assess species diversity of this group of aquatic beetles in Missouri, this report contributes to knowledge of habitat characteristics and environmental parameters associated with adult *Heterosternuta* in wadeable streams, adds to Missouri distributional information for *H. pulchra*, and provides first documentation on occurrence of *H. wickhami* in the state.

Acknowledgments

We thank the numerous field and laboratory technicians that have assisted with collection and processing of samples enabling our production of this report. We are also grateful to Kristin Simpson at the University of Missouri Enns Entomology Museum for reviewing museum records for *Heterosternuta* collected in Missouri. We also thank Alicia Struckhoff for preparing the map and anonymous reviewers for input that helped improve the manuscript. Our use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the authors or their affiliations.

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