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PLECOPTERA OF CRANE HOLLOW NATURE PRESERVE, OHIO, COMPARISON TO SIMILAR EFFORTS

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ABSTRACT

A nearly 800 specimen collection of stoneflies from Crane Hollow Nature Preserve (CNHP) in Hocking County, Ohio was examined. These samples revealed a rich assemblage of 41 species, 40% of the species known from the state and 57% of the species known to occur in the lower Scioto River drainage. Species represented by the greatest abundance coincided well with those that were represented by the greatest number of sampling events. Of seven similar studies CHNP had substantially higher richness than all but Powdermill Preserve of southwestern Pennsylvania with 51 species. Assemblages varied greatly such that the average Jaccard dissimilarity between locations was 76%. Additional species are predicted for the CHNP. The value of aggregating literature and specimen data for comparative analyses is discussed as a way to place results of current biomonitoring and ecological studies into historical context.

Keywords: Plecoptera, Ohio, species assemblages, creeping baselines

INTRODUCTION

The first statewide compilation of Ohio stoneflies found that 102 species were present in the state and that several landscape level features governed the distribution of species richness (DeWalt et al. 2012). A more recent study (DeWalt et al. 2016a) compiled all literature reporting stoneflies occurring in Ohio, mapped all species, presented a phenology of adult presence, and summarized stream size usage for all species. The latter study also reported 102 species, though some turnover in composition was reported.

Crane Hollow Nature Preserve (CHNP, http://cranehollow.org/research.html) is a private, but state protected, nature preserve with restricted access (Fig. 1). This 769 hectare (1900 acre) preserve is located in Hocking County within mixed hardwood and coniferous forest in a series of sandstone ravines. All streams draining the preserve are tributaries to Pine Creek of the lower

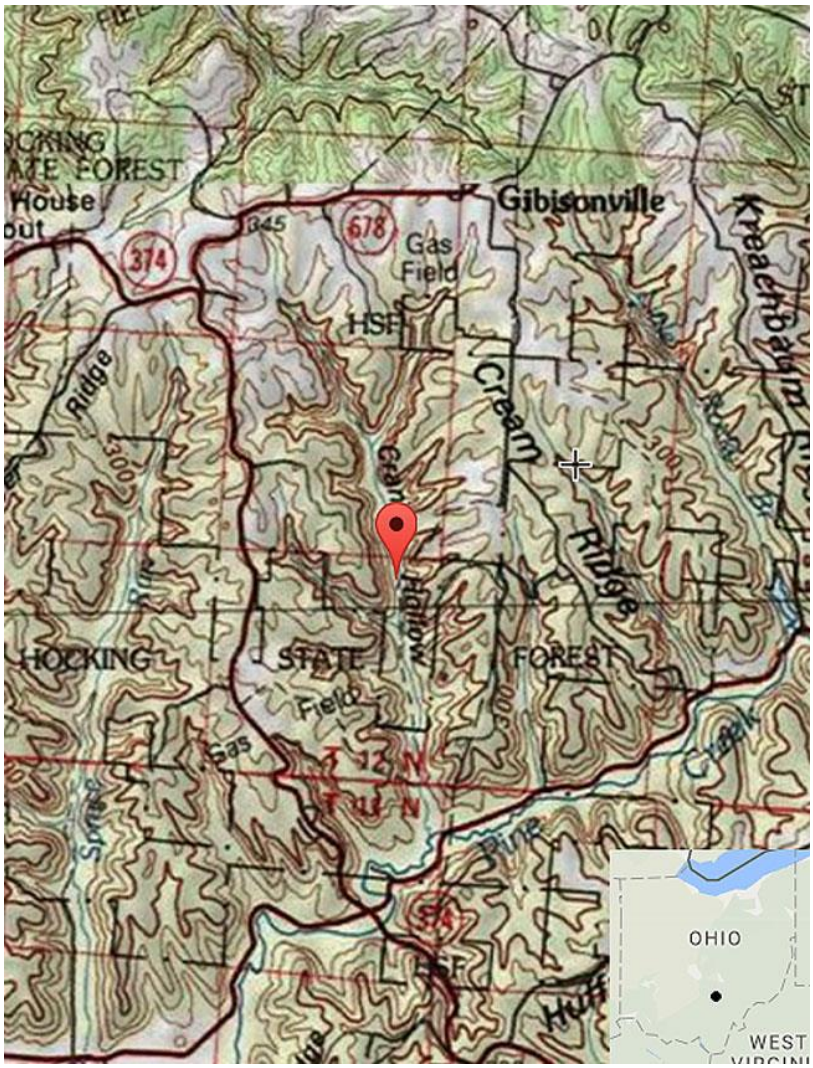

Fig. 1. Location of Crane Hollow Nature Preserve, Hocking County, Ohio. Inset is outline of Ohio.

Scioto River drainage. The preserve is contained within the Allegheny Plateau physiographic area that provided access for Appalachian Mountain fauna to disperse into the state. The preserve is located within the richest area for stonefly species in Ohio (DeWalt et al. 2016a).

During the work that led to the DeWalt et al. (2016a) paper, all stonefly specimens resulting from a decade-long insect survey within CHNP were made available to the authors. This constituted just over 800 specimens, resulting from the efforts of Dr. Gary A. Coovert who was employed by CHNP to conduct an all taxa biotic inventory (ATBI). This survey began in 2002 and continued through 2015. Coovert left behind field notes detailing his collecting efforts. Specimens resulting from his work were accompanied by labels with dates and field notebook numbers only, so linking of field notebook numbers to collecting events was key to associating locality, date, and collection method information with specimens. Coovert's methods collected only adult specimens.

Though most specimen data presented here are contained within DeWalt et al. (2016b), we felt it prudent to conduct a more fine-scaled analysis, given the 13 year collecting effort and the essentially undisturbed nature of Crane Hollow. We accomplished several objectives with these

specimens.

1. Identified all specimens to the highest taxonomic resolution possible.
2. Linked field notebook numbers found with the specimens to Coovert field notes.
3. Compiled a species list for the preserve.
4. Examined the frequency of stonefly collection events by year and month.
5. Examined the distribution of species with families.
6. Assessed the relative abundance and frequency of occurrence of species within the data set.
7. Compared species richness of CHNP to other similar efforts in the region.

All specimens were returned to Crane Hollow Nature Preserve, 18038 SR-374, Rockbridge, Ohio, 43149. The preserve has tentative plans to donate their entire collection to Ohio University, Athens, Ohio, creating a regional research collection, though this has not yet occurred. Loans in the near future may be arranged by contacting the preserve administrator through the preserve website.

MATERIALS AND METHODS

Collecting Methods. Stoneflies were collected for the CHNP ATBI between June 27, 2002 and May 9, 2015. We digitized Coovert's field notes, normalized the data, and imported the location, date, and method fields into our Illinois Natural History Survey (INHS) Insect Collection database, thereby linking event data with the specimens. All CHNP specimens were digitized using an INHS catalog number to represent the record. Coovert used several qualitative collecting techniques that targeted adult insects. Malaise traps were placed at several locations and checked approximately weekly. Overnight UV light traps were used on a more sporadic basis at many locations, usually on plateaus above ravines. These two methods yielded locations that could be georeferenced, the coordinates sometimes provided by Coovert. At other times text descriptions were specific enough to produce coordinates using ACME Mapper 2.1 (http://mapper.acme.com/). Sweep netting near streams also occurred, though this often resulted in long transects that were difficult to georeference. Those collecting event locations that could not be georeferenced to a specific location were given generalized coordinates for the middle of the preserve. Collecting occurred during all seasons of the year. While these methods provided a description of what species were present in the area, they rarely permitted association of species with particular streams.

Data Analysis. The raw specimen data were exported from our INHS Insect Collection database to an Excel spreadsheet. Eight additional records were exported from the Midwest Plecoptera Database resulting from specimens loaned to RED from the Monte L. Bean Museum at Brigham Young University (BYU). From these data we compiled a stonefly species list for CHNP. This list was compared against Grubbs et al. (2013), a list of rare stoneflies for Ohio based on the DeWalt et al. (2012) data, to determine what proportion of CHNP stonefly species were rare. The distribution of species within families for CHNP was compiled from the species list.

To demonstrate the distribution of collecting effort, the number of unique collecting events was generated for months across all years, and within years in the data set. The relative abundance and frequency of collection of each species within CHNP was estimated using modified rank abundance curves constructed from the total number of specimens and the number of unique collecting events for each species.

We compared the number of species and assemblage composition with several similar sampling efforts that have occurred within the Midwest. Species lists were compiled from Grubbs (1996) at Powdermill Preserve, Westmoreland County, southwestern Pennsylvania, Fishbeck (1987) at Gray's Run, Mahoning County, eastern Ohio, Tkac (1979) for a complex of tributaries of the East Fork Chagrin River in Stebbins Gulch, Lake County, northeast Ohio, Narf & Hilsenhoff (1974) at Otter Creek in Sauk County, southern Wisconsin, Masteller (1983) at Sixmile Creek, Erie County, northwestern Pennsylvania, Frison (1935)

Table 1. Plecoptera species list for Crane Hollow Nature Preserve, Hocking County, Rockbridge, Ohio. *Those species considered rare by Grubbs et al. (2013). **A recently discovered rare species (DeWalt et al 2016a).

Capniidae	*Amphinemura varshava* (Ricker, 1952)
Allocapnia frisoni (Ross & Ricker, 1964)*	*Ostrocerca albidipennis* (Walker, 1852)
Allocapnia illinoensis (Frison, 1935)*	*Ostrocerca truncata* (Claassen, 1923)
Allocapnia nivicola (Fitch, 1847)	*Prostoia similis* (Hagen, 1861)
Allocapnia ohioensis (Ross & Ricker, 1964)	*Soyedina vallicularia* (Wu, 1923)
Allocapnia recta (Claassen, 1924)	**Perlidae**
Allocapnia zola (Ricker, 1952)	*Acroneuria filicis* (Frison, 1942)
Paracapnia angulata (Hanson, 1942)	*Eccoptura xanthenes* (Newman, 1838)
Chloroperlidae	*Neoperla catharae* (Stark & Baumann, 1978)
Alloperla caudata (Frison, 1934)	*Neoperla stewarti* (Stark & Baumann, 1978)
Alloperla idei (Ricker, 1935)*	*Perlesta ephelida* (Grubbs & DeWalt, 2012)
Alloperla imbecilla (Say, 1823)	*Perlesta lagoi* (Stark, 1989)
Alloperla petasata (Surdick, 2004)	*Perlesta teaysia* (Kirchner & Kondratieff, 1997)
Alloperla usa (Ricker, 1952)	*Perlinella drymo* (Newman, 1839)
Haploperla brevis (Banks, 1895)	*Perlinella ephyre* (Newman, 1839)
Sweltsa hoffmani (Kondratieff & Kirchner, 2009)	**Perlodidae**
Leuctridae	*Clioperla clio* (Newman, 1839)
Leuctra rickeri (James, 1976)	*Diploperla robusta* (Stark & Gaufin, 1974)
Leuctra sibleyi (Claassen, 1923)	*Isoperla bilineata* (Say, 1823)
Leuctra tenella (Provancher, 1876)*	*Isoperla burksi* (Frison, 1942)*
Leuctra tenuis (Pictet, 1841)	*Isoperla holochlora* Klapálek, 1923*
Paraleuctra sara (Claassen, 1937)	*Isoperla montana* (Banks, 1898)
Nemouridae	*Isoperla orata* (Frison, 1942)**
Amphinemura delosa (Ricker, 1952)	

at Lusk Creek, Pope County, southern Illinois, and for Forest Glen of Vermilion County in east-central Illinois (unpub. data). Data for the latter two locations are largely derived from a combination of INHS Insect Collection and Midwest Plecoptera databases. Some augmentation of the Otter Creek, Wisconsin study was accomplished from the same databases. The name *Perlesta placida* (Hagen, 1861) was removed from the data set and all *Sweltsa onkos* (Ricker, 1936) records pre-Kondratieff & Kirchner (2009) were converted to *Sweltsa hoffmani* Kondratieff & Kirchner, 2009. A presence/absence data matrix was constructed containing 99 species and the eight locations/studies. This matrix is available as a comma separated values (CSV) file.

The relationship of site assemblages to each other was analyzed using the R package *vegan*. A Jaccard distance matrix for pairwise distances between samples was constructed using the *vegdist* function. This matrix was used to perform an agglomerative cluster analysis based on Jaccard average linkage with the function *hclust*. The site relationships were displayed as a dendrogram. Specimen data are available as a CSV file.

RESULTS

Coovert collecting events that included stoneflies totaled 278 and were heavily concentrated in the year 2003 with 160 events (58% of the total) (Fig. 2). The years spanning 2004-2011

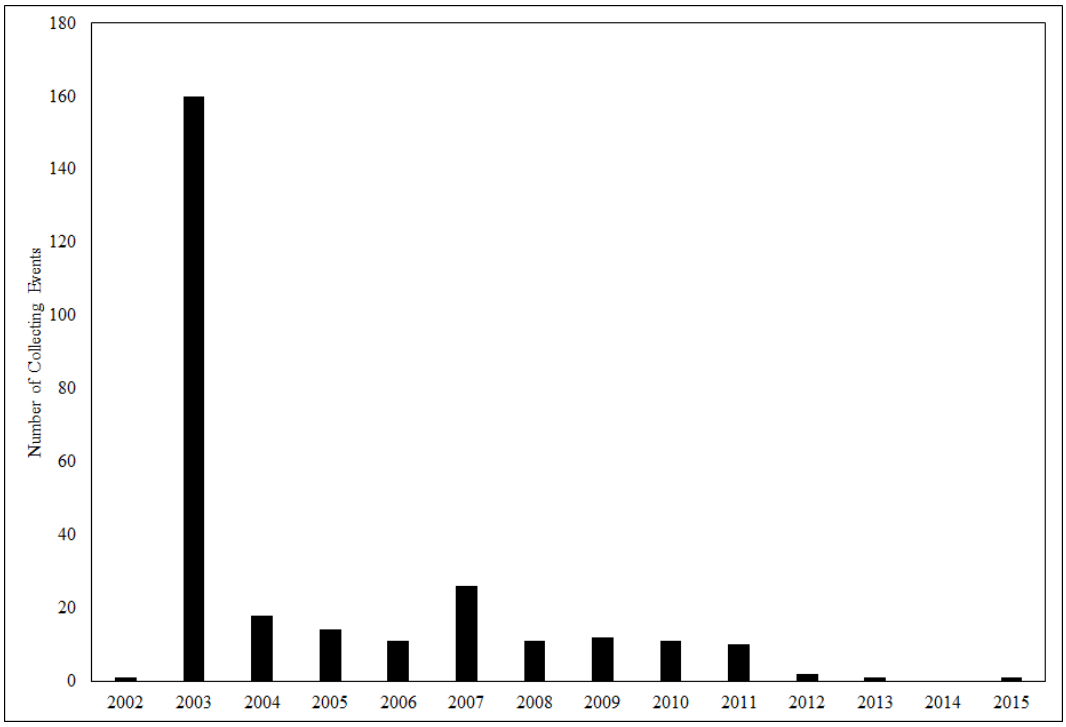

Fig. 2. Coovert collecting events in Crane Hollow Nature Preserve resulting in stoneflies tallied by year.

were a period of much lower activity, generally between 10-20 events per year. The number of events tapered off sharply thereafter. Stonefly collecting was most active during May and June, in combination representing 64% of all collecting events (Fig. 3).

We identified 39 stonefly species from CHNP and added two more with BYU data, bringing the total to 41 species found in the preserve (Table 1). This accounts for 40% of total Plecoptera species diversity found in Ohio and 57% of Plecoptera diversity known for the Lower Scioto drainage (DeWalt et al. 2016a). Six stonefly families were found in Ohio, the Perlidae being the richest with 9 species (Fig. 4). No representatives of the Peltoperlidae, Taeniopterygidae, or Pteronarcyidae were recovered. Of the species found, five were considered to be rare or uncommon, accounting for 33% of the rare Ohio species recognized by Grubbs et al. (2013) (Table 1).

The most abundant species recovered were *Leuctra sibleyi* Claassen, 1923, *L. tenuis* (Pictet, 1841), and *Sweltsa hoffmani* Kondratieff & Kirchner, 2009. Each were represented by 80 to 146 individuals, with *L. sibleyi* and *L. tenuis* being of near equal abundance (Fig. 5). These three most frequently collected species occurred between 12 to 30 times in collecting events (Fig. 6). The order of species was similar to Fig. 5, especially if the frequency of *Leuctra* sp. is discounted. However, in this analysis, *L. tenuis* was nearly twice as frequently collected as *L. sibleyi*.

DISCUSSION

Plecopterologists talk of rich faunas within particular streams or drainages, but comparative data have not been aggregated and critically assessed, leaving species richness expectations for streams of specific size ranges largely unquantified. This type of assessment would be best accomplished by identifying a large number of the highest quality streams within a region coupled with the sampling efforts of seasoned stonefly researchers. Qualitative methods including the

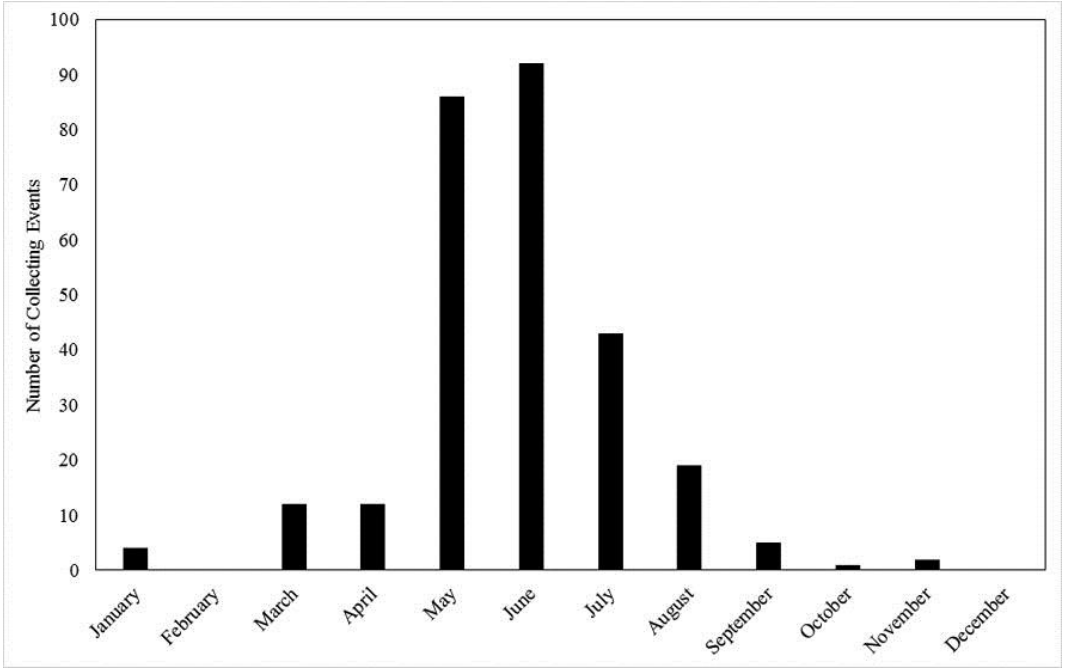

Fig. 3. Coovert collecting events in Crane Hollow Nature Preserve resulting in stoneflies tallied by month.

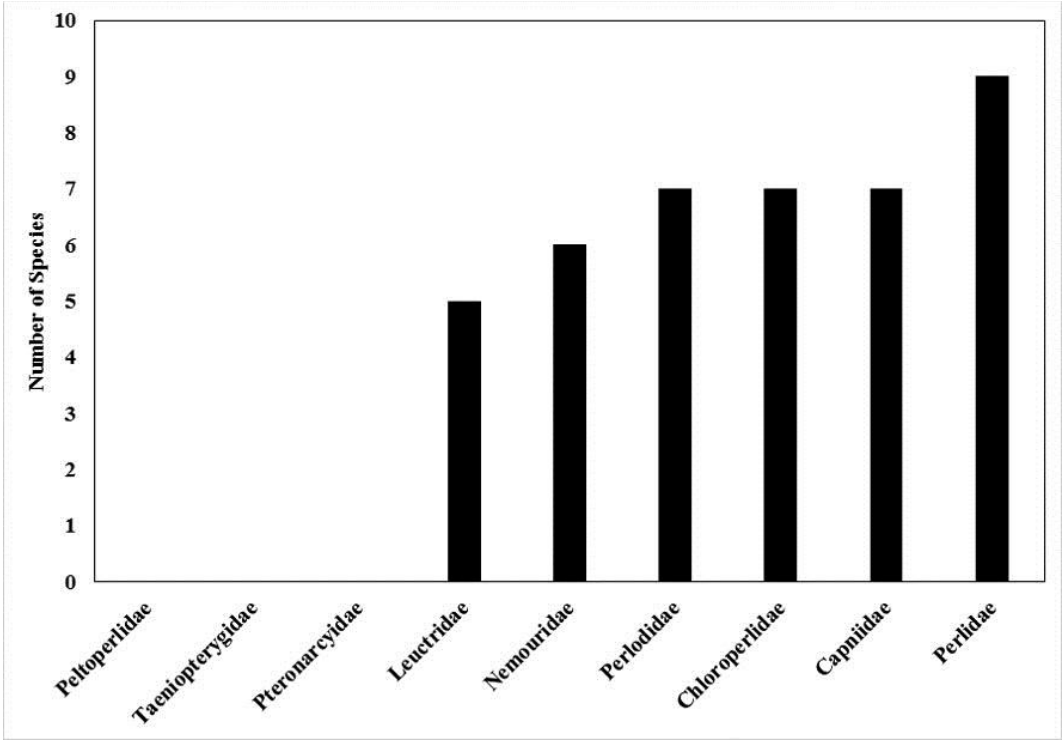

Fig. 4. Species richness by family for stoneflies found within Crane Hollow Nature Preserve.

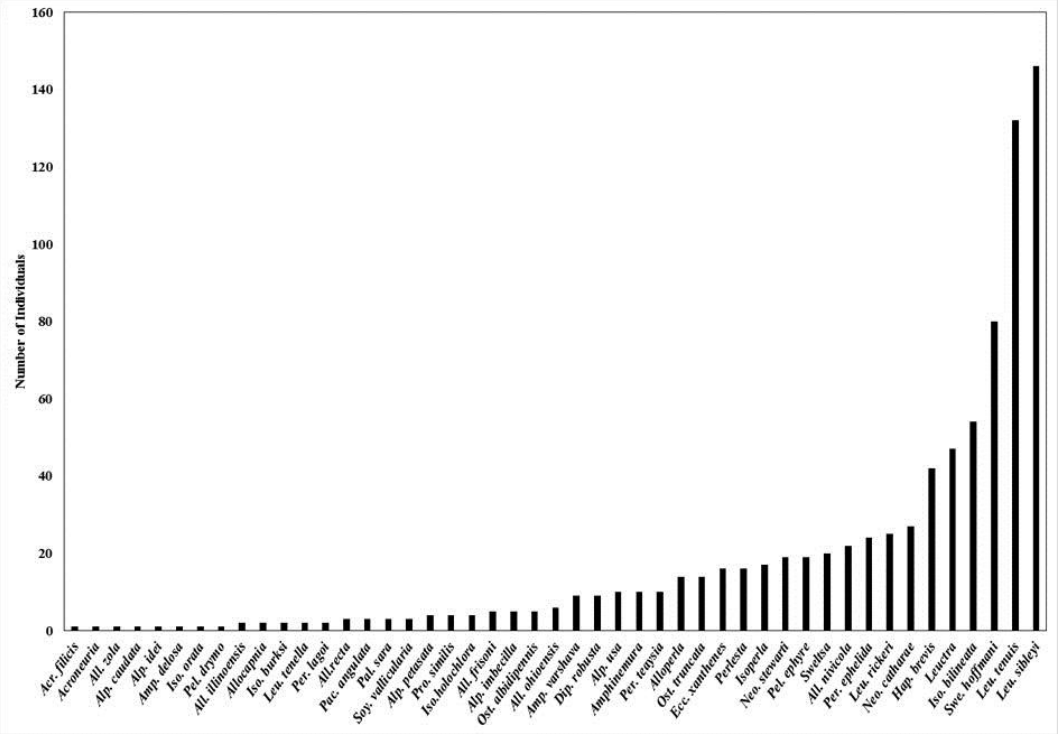

Fig. 5. Stonefly specimens collected for each species within Crane Hollow Nature Preserve. Genus names abbreviated.

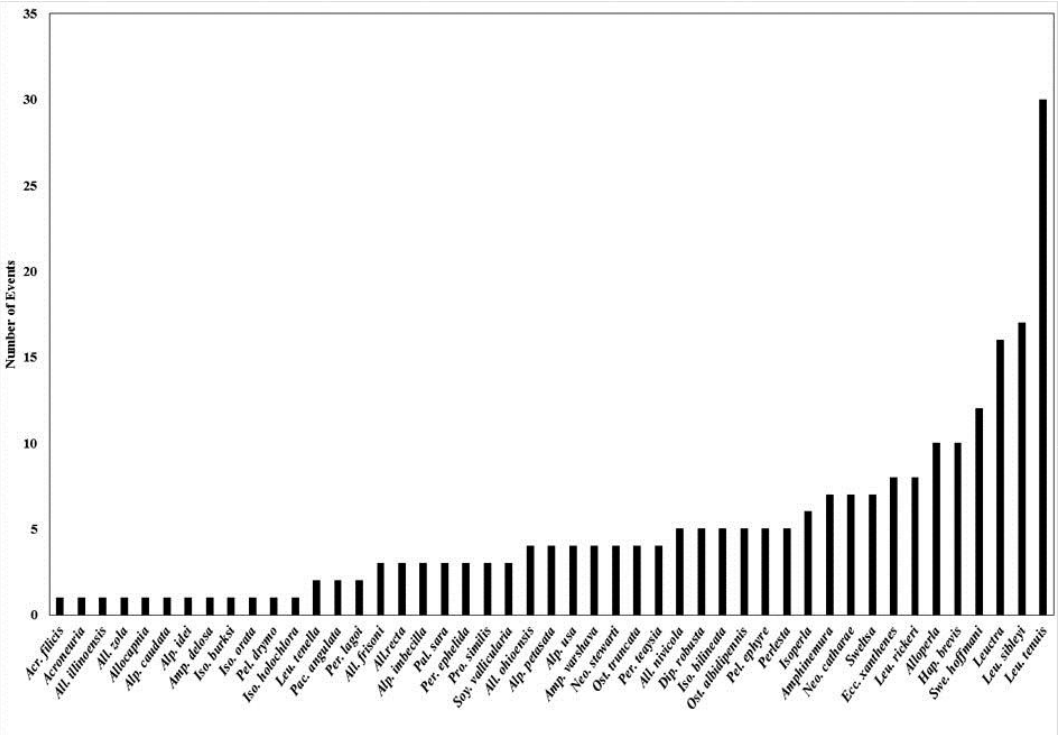

Fig. 6. Frequency of events resulting in stonefly specimens for each species within Crane Hollow Nature Preserve. Genus names abbreviated.

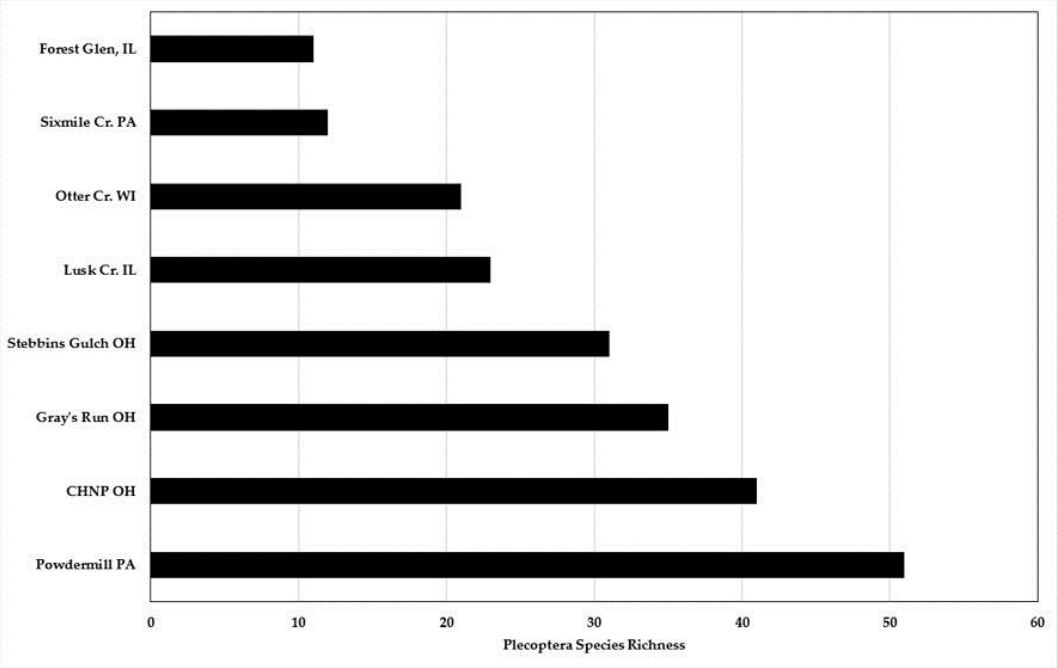

Fig. 7. Stonefly species richness for Crane Hollow Nature Preserve and seven other published regional locations/sites. See methods for specifics about sites.

collection of emergent adults and the rearing of larvae to adulthood would yield the highest species richness, yet the results might not be replicated by most stream ecologists, or even by non-specialist entomologists. Sampling using multiple methods including beating sheets, ultraviolet light traps, hand picking, and rearing of larvae to adulthood would be necessary. Multi-season sampling is essential given that adult emergence of species succeed each other throughout the year (DeWalt et al. 2016a). Unfortunately, stonefly researchers rarely work with this outcome in mind, and only infrequently conduct detailed work at this scale. We are left to aggregate museum and literature data from single locations, conducted by multiple researchers who have their own collection biases.

Does CHNP support a large number of stonefly species? We expect so given the known richness of the surrounding Lower Scioto River drainage and the physical features of CHNP (DeWalt et al. 2016a). In comparison to other detailed studies, CHNP supported the highest stonefly species richness of any location in Ohio (Fig. 7). Gray's Run (Fishbeck 1987) and Stebbin's Gulch (Tkac 1979) both yielded over 30 species. Alternatively, Powdermill Preserve of southwestern Pennsylvania produced 52 species (Grubbs 1996). Its high species richness is likely due to the preserve's location within the foothills of the Allegheny Mountains, an area of high gradient streams and thick, mixed coniferous forest cover. Masteller (1983) working in the much smaller Sixmile Creek drainage of northwestern Pennsylvania reported a modest stonefly fauna of 12 species, similar to that found for Forest Glen in eastern Illinois. The richness of these two streams is probably limited by their small drainage size. Lusk Creek (some data in Frison 1935 and unpubl. data) and Otter Creek of southern Wisconsin (Narf & Hilsenhoff 1974 and unpubl. data), streams up to 15 m width, produced 23 and 21 species, respectively. These are two of the highest quality streams for their size in Illinois and Wisconsin. They suggest the potential for stonefly species richness in unglaciated landscapes for near pristine

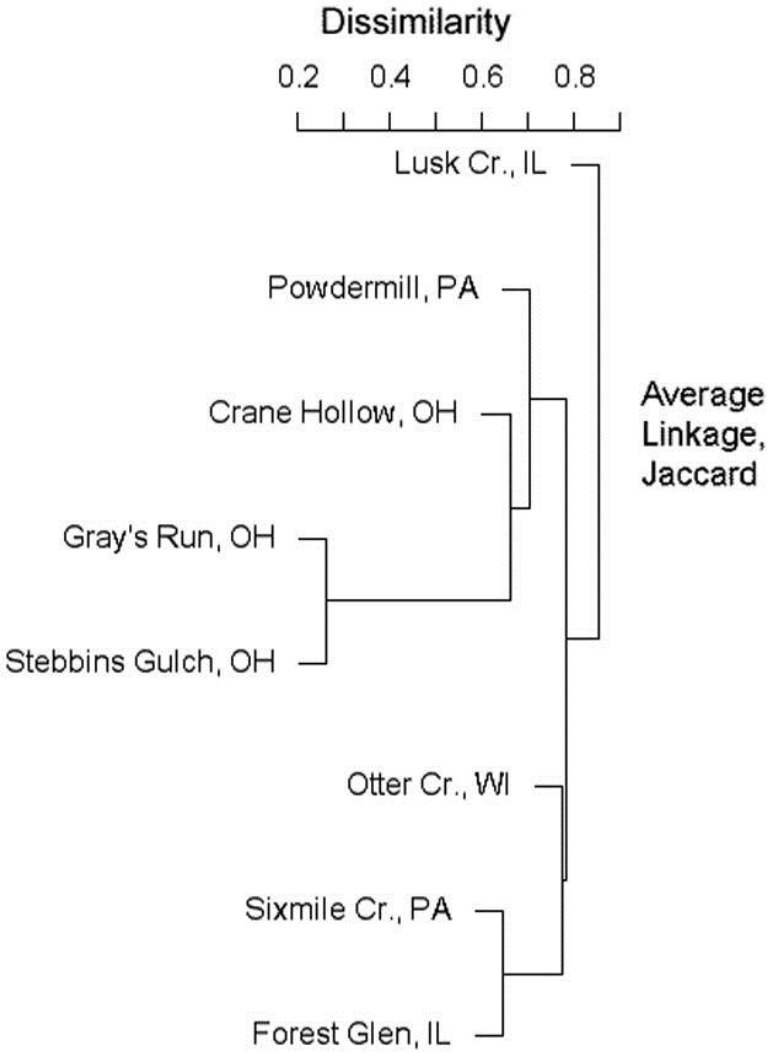

Fig. 8. Cluster analysis of eight Plecoptera assemblages.

warmwater and coldwater streams, respectively. The Otter Creek site is located within the unglaciated Driftless Area that encompasses southwestern Wisconsin and parts of neighboring Illinois, Iowa, and Minnesota (Wiggers 1997).

Species composition among the eight locations varied tremendously, with many paired dissimilarity values exceeding 60% (Fig. 8). Distance and glacial history (DeWalt et al. 2016a) likely accounted for most of the differences between locations. For instance, Gray's Run and Stebbins Gulch, 112 km distant from each other and both within Wisconsinan glaciated northeastern Ohio, were tightly grouped (26% dissimilarity) by the cluster analysis. Conversely, they were both 66% dissimilar to CHNP over 320 km away in the unglaciated southern half of the state. Powdermill Preserve, also unglaciated, supported a fauna that was 65% different from CNHP, over 300 km distant. Forest Glen and Sixmile Creek (800 km distance) were 65% different from each other. Otter Creek clustered with these two eastern locations, but still displayed a high degree of assemblage difference from them at 77-78%. Last to enter the cluster was

Lusk Creek with an average difference of 85% across all combinations. This stream supports a large number of species common to the unglaciated southern Midwest and some from the Interior Highlands, leading to a comparatively distinct fauna.

Eighteen of Ohio's 102 species were considered rare or uncommon in the state (Grubbs et al. 2013) and six of these species were found in Crane Hollow: *Allocapnia frisoni* Ross & Ricker, 1964; *A. illinoensis* Frison, 1935; *Leuctra tenella* Provancher, 1878; *Alloperla idei* (Ricker, 1935); *Isoperla burksi* Frison, 1942; and *Isoperla holochlora* Klapálek, 1923 (Table 1). Another rare species found in CHNP, but not contained in the Grubbs et al. (2013) list, was *I. orata* Frison, 1942. In Ohio, it is known only from a single male specimen. Gaufin (1956) reported the species from Ohio from one or more larval specimens. Because the Gaufin specimens have never been located and the state of larval taxonomy at the time was poor, these records have been largely discounted.

It is clear that CNHP supports the richest stonefly assemblage known for Ohio. Still, not all nine North American stonefly families have been recovered from CNHP. Coovert was not experienced at collecting stoneflies, so it is conceivable that he missed some species—his task was focused on all insects. The three families absent from his samples are Peltoperlidae, Taeniopterygidae, and Pteronarcyidae. Peltoperlidae are represented in Ohio by only *Peltoperla arcuata* Needham, 1905 (DeWalt et al. 2016a). This species inhabits small, coldwater, ravine streams similar to those found in CNHP. Ohio supports at least seven Taeniopterygidae species (DeWalt et al. 2016a). *Taeniopteryx metequi* Ricker & Ross, 1968, T. burksi Ricker & Ross, 1968, and *Strophopteryx fasciata* (Burmeister, 1839) are all possible at CHNP. Pteronarcyidae are known from only two species in Ohio, *Pteronarcys cf. biloba* Newman, 1838 and *Pteronarcys dorsata* (Say, 1823) (DeWalt et al. 2016a). Perhaps *P. biloba* is possible, but it has never been collected outside of northeastern Ohio (Tkac 1979, Bolton 2010). It is also possible that several other stonefly species might be found in the preserve. Conspicuously absent from the CHNP record are some species common to other nearby streams, *Acroneuria carolinensis* (Banks, 1905) and one or more *Zealeuctra* species. Conversely, several species taken at CHNP are highly unlikely to inhabit any of the lotic habitats present at CHNP, but probably flew there from nearby larger streams. These include *Isoperla bilineata* (Say, 1823); perhaps one or both *Perlinella* species; *Perlesta ephelida* Grubbs & DeWalt, 2012; *A. filicis* Frison, 1942; and *Neoperla stewarti* Stark & Baumann, 1978

CONCLUSIONS

Streams of CHNP provide rich habitat for stoneflies. Combined, their biotic potential appears to be near 40 species. The lower Scioto River drainage is known to support 72 stonefly species (DeWalt et al. 2016a). Additional sampling and rearing of larvae would surely add several species and confirm the identity of species that actually utilize CHNP as breeding habitat. This location and several nearby ravines have been protected within private and public properties, a condition that bodes well for conservation of stoneflies within the Allegheny Plateau region of south-central Ohio.

More data exist in literature and in natural history museums that could help establish the biotic potential of streams to support stonefly assemblages. This information is largely unknown to stream ecologists, biomonitoring specialists, and conservation biologists. Their concept of what is possible is modified by their lack of knowledge of historical assemblages decimated by a century of abuse of the landscape (DeWalt et. al. 2005, Bojková et al. 2012). The incomplete state of larval taxonomy also limits the non-specialist's ability to know how many species inhabit streams because they cannot recognize larval representatives of co-occurring species (Stewart & Stark 2002). In effect, we have a migrating baseline for biotic potential because few can place the assemblage they find into a historical context in the region. We, as taxonomists, must remind other researchers of this potential, lest the presence of even one stonefly species becomes indicative of good water quality.

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