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Insect and related-arthropod studies in the Mid-Atlantic region



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MARYLAND ENTOMOLOGICAL SOCIETY
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The Maryland Entomological Society (MES) was founded in November 1971, to promote the science of entomology in all its sub-disciplines; to provide a common meeting venue for professional and amateur entomologists residing in Maryland, the District of Columbia, and nearby areas; to issue a periodical and other publications dealing with entomology; and to facilitate the exchange of ideas and information through its meetings and publications. The MES was incorporated in April 1982 and is a 501(c)(3) non-profit, scientific organization.

The MES logo features an illustration of *Euphydryas phaeton* (Drury) (Lepidoptera: Nymphalidae), the Baltimore Checkerspot, with its generic name above and its specific epithet below (both in capital letters), all on a pale green field; all these are within a yellow ring double-bordered by red, bearing the message “● Maryland Entomological Society ● 1971 ●”. All of this is positioned above the Shield of the State of Maryland. In 1973, the Baltimore Checkerspot was named the official insect of the State of Maryland through the efforts of many MES members.

Membership in the MES is open to all persons interested in the study of entomology. All members receive the annual journal, *The Maryland Entomologist*, and the monthly e-newsletter, *Phaeton*. Institutions may subscribe to *The Maryland Entomologist* but may not become members.

Annual Dues:	Individual Membership	\$10.00
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Prospective members should send to the Treasurer full dues for the current MES year (October – September), along with their full name, address, telephone number, e-mail address, and entomological interests. Applications can be downloaded from the MES website: www.mdentsoc.org. Send remittances, payable to the Maryland Entomological Society, and any address changes to the Treasurer: Edgar J. Cohen, Jr., 5454 Marsh Hawk Way, Columbia, MD 21045-2246, edcohenfam@yahoo.com.

Back issues of *The Maryland Entomologist* and recent issues of the *Phaeton* are available to members, via the Journal Editor, Eugene J. Scarpulla, ejscarp@comcast.net. Please contact the Journal Editor for availability and cost.

Meetings are held on the third Friday of October, November, February, March, April and May at 7:00 p.m. in Room 4 of the Biological Sciences Building, University of Maryland Baltimore County (UMBC), or occasionally at another announced site.

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Editor's Note

The regional scope of *The Maryland Entomologist* is apparent again this year. The 2020 issue highlights studies conducted in Maryland, Virginia, Ohio, and Kentucky. The current year's authors hail from Maryland (8), Ohio (1), Virginia (2), and Ontario, Canada (1).

For 2020, *The Maryland Entomologist* received more manuscripts than could possibly be printed in one issue. This may have been a byproduct of authors having more time for writing due to the current COVID-19 pandemic. Unprecedentedly, the maximum issue size (96 pages) was reached this year! A bit of creative formatting was necessitated to fit the manuscripts within the 96-page production limit. Three additional manuscripts were deferred until the 2021 issue.

Call for Potential Authors

I encourage you to publish your entomological observations in *The Maryland Entomologist*. As the late Joseph C. Mitchell, founder and longtime coeditor of the Virginia Natural History Society's journal *Banisteria*, often said, **"If it ain't published, it didn't happen!"** (*Banisteria* 52:52–73; 2019). Put your findings in print for the world to see. Please e-mail first drafts to me by April 1, 2021. Thank you for your consideration.

Eugene J. Scarpulla
Editor

Freshwater Isopods (Crustacea: Isopoda: Asellidae) Inhabiting Upland Vernal Pools in Maryland

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Abstract: Three species of surface-dwelling freshwater isopods—*Caecidotea forbesi* (Williams), *C. nodula* (Williams), and *C. scrupulosa* (Williams)—inhabit upland vernal pools in Maryland (temporary waters that are dry a substantial part of each year, and are not connected to permanent surface water). All three also occur in permanent surface waters, but were found in every ecologically uncompromised upland temporary pool examined. Despite comments in the literature to the contrary, these isopods should be considered normal members of the aquatic community of these fragile habitats. They survive the seasonal dry period by moving below the surface of the substrate and lying dormant, a mechanism identified by Kenk (1949), Belk and Cole (1975), and Wiggins et al. (1980) as a specialization exhibited by certain vernal pool inhabitants. These three species show distinctive patterns of distribution within Maryland.

Key Words: freshwater ecology, freshwater isopods, *Caecidotea forbesi* (Williams), *Caecidotea nodula* (Williams), *Caecidotea scrupulosa* (Williams), vernal pools, Maryland

INTRODUCTION

In 1980, Dr. Thomas E. Bowman (Smithsonian Institution) and I initiated a survey of the freshwater isopods of Maryland. Over 400 collections were ultimately made, and we also examined material preserved in the collection of the National Museum of Natural History, Smithsonian Institution (USNM), as well as reviewing the pertinent literature. Effort was made to sample a wide variety of permanent and temporary waters throughout Maryland, including all of its 23 counties and Baltimore (city). Those collections showed that about ten species of pigmented surface-dwelling isopods inhabited Maryland's freshwaters, as many as three of which had not been named. The fieldwork was conducted primarily by me. Dr. Bowman made or confirmed identifications and was to have completed the taxonomic portion of the study. Unfortunately, he passed away in 1995, leaving the new taxa undescribed.

Because the local fauna was found to be unexpectedly rich, we originally intended to jointly publish a single paper describing the new species and recording data on distribution and natural history. I attempted to follow that plan, however, in the absence of a taxonomist to complete the descriptions, it proved to be impractical. In order to make the range extensions and other natural history information available, I decided to publish

the information in several segments, the first being a discussion of the three species—*Caecidotea forbesi* (Williams), *C. nodula* (Williams), and *C. scrupulosa* (Williams)—that inhabit upland vernal pools in Maryland. Vernal pool residents were selected first due to concern over threats to these special aquatic habitats and their fauna (Williams 1997, Zedler 2003, Brown and Jung 2005, Williams 2006). The second installment will consider the remaining pigmented surface dwellers, including *Caecidotea communis* (Say), *C. kenki* (Bowman), *C. racovitzi* (Williams), *Lirceus brachyurus* (Harger), and as many as three undescribed species of *Caecidotea* Packard.

A review of the Maryland subterranean isopods—*Caecidotea alleghenyensis* Lewis and Bowman; *C. franzi* (Holsinger and Steeves); *C. holsingeri* (Steeves); *C. mausi* Lewis and Bowman; *C. nordeni* Lewis and Bowman; *C. pricei* Levi; and *C. vandeli* (Bresson)—was given by Lewis and Bowman (2010) and Lewis et al. (2011).

VERNAL POOL HABITATS

A wide variety of temporary water bodies are found in eastern North America (Williams 1997, 2006). They differ primarily in the timing of their wet and dry cycles, and the length of time during which they remain wet. They are frequently grouped as seasonal pools even though they fall into several distinct types. The pools to be considered here typically fill in fall or early winter and usually remain wet until June, generally giving them a wet period of up to seven months. They are isolated habitats unconnected to permanent surface water and filled exclusively by rain, snowmelt, or groundwater (Brooks 2004). In the eastern United States, these have been termed vernal pools and typically support breeding mole salamanders, *Ambystoma* Tschudi spp. (Amphibia: Caudata: Ambystomatidae), and fairy shrimp, (Crustacea: Branchiopoda: Anostraca), (Brown and Jung 2005). Those species are assumed to utilize vernal pools because they lack effective defenses against predatory fishes, and the yearly summer dry period of vernal pools precludes fish populations. These habitats have often been referred to as woodland pools. (See Zedler [2003] for a more detailed discussion of terminology.)

Although the three species of isopods considered here also occur in permanent freshwater habitats (Figures 1–3), they occurred in vernal pools so regularly that they should be considered a significant part of the normal fauna. All examples of ecologically uncompromised vernal pools examined during this study supported a population of at least one of these three species. Vernal pools that occurred on floodplains receive floodwater and typically lacked these three species. Such pools in Maryland often support populations of *C. communis*, which is a common species occurring in a wide variety of freshwater habitats including streams, rivers, and permanent ponds. Because *C. communis* did not occur in upland vernal pools it is not considered here.

METHODS

Starting in the spring of 1980, freshwater habitats throughout Maryland were surveyed for asellid isopods. They were searched for in beds of aquatic vegetation, accumulations of detritus, and beneath rocks, logs and other places of concealment. Freshwater isopods in vernal pools were occasionally observed at night with the aid of a light. Whenever

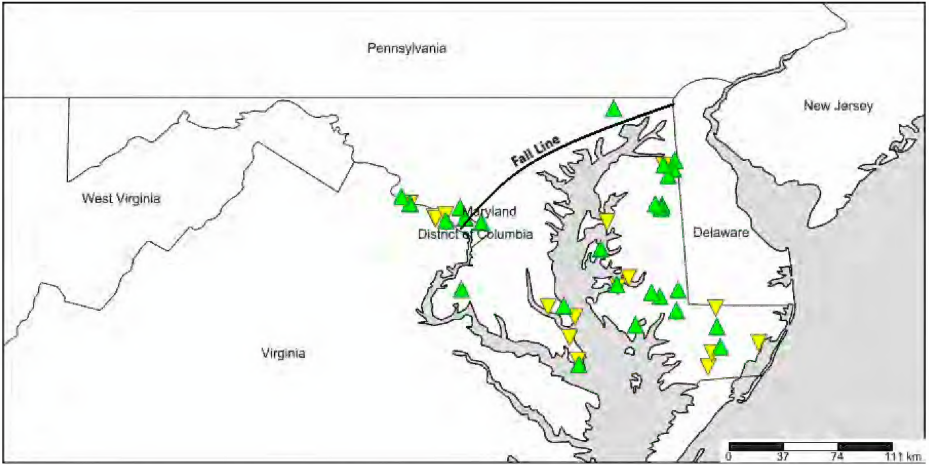


Figure 1. Map of Maryland showing locations for 48 collections of *Caecidotea forbesi* (Williams). Green triangles (▲) represent vernal pool habitats. Other habitats are indicated by yellow inverted triangles (▼). The transverse line shows the approximate location of the Fall Line, which separates the Atlantic Coastal Plain and the Piedmont Plateau physiographic provinces (after Vokes 1957). Some symbols encompass more than one collection site. The map was created using SimpleMappr (Shorthouse 2010).

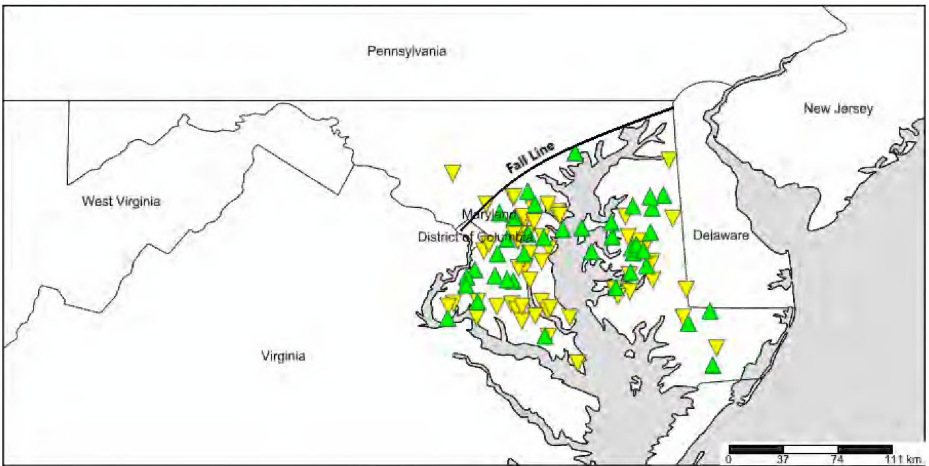


Figure 2. Map of Maryland showing locations for 112 collections of *Caecidotea nodula* (Williams). Green triangles (▲) represent vernal pool habitats. Other habitats are indicated by yellow inverted triangles (▼). The transverse line shows the approximate location of the Fall Line, which separates the Atlantic Coastal Plain and the Piedmont Plateau physiographic provinces (after Vokes 1957). Some symbols encompass more than one collection site. The map was created using SimpleMappr (Shorthouse 2010).

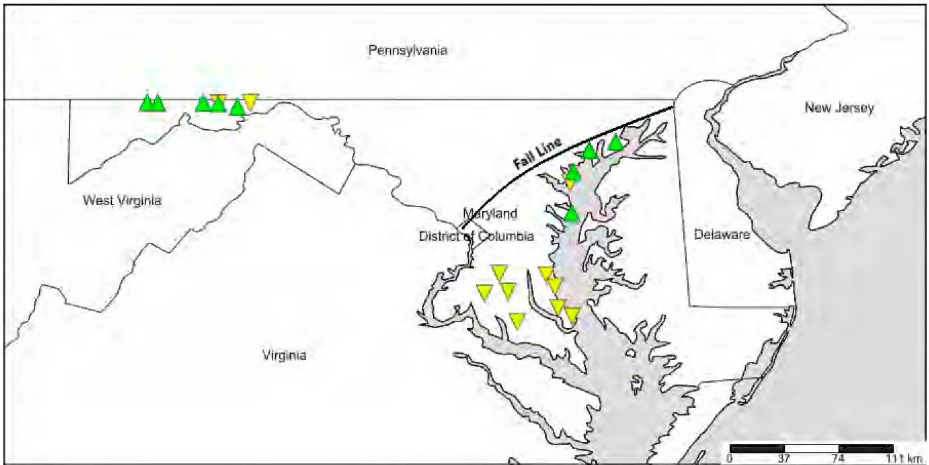


Figure 3. Map of Maryland showing locations for 20 collections of *Caecidotea scrupulosa* (Williams). Green triangles (▲) represent vernal pool habitats. Other habitats are indicated by yellow inverted triangles (▼). The transverse line shows the approximate location of the Fall Line, which separates the Atlantic Coastal Plain and the Piedmont Plateau physiographic provinces (after Vokes 1957). The map was created using SimpleMappr (Shorthouse 2010).

encountered, series of specimens were preserved in 70% ethyl alcohol and deposited in the USNM invertebrate collection. Maryland freshwater isopods already in the USNM collection were also examined and have been included in this study. Distributional data for Maryland asellids are given under the heading Material Examined in each of the following species accounts. Habitat data is taken from the literature, or the USNM catalogue entry. Records from the literature are discussed under the heading Range. Catalog numbers are given for all specimens in the USNM collection. Complete label data for USNM material is available at the Invertebrate Zoology Division's online collections database (<https://collections.nmnh.si.edu/search/iz/>). In the Material Examined sections, the collector "AN" refers to me.

The three isopods discussed here were described in detail, and features having taxonomic significance illustrated, by Williams (1970, 1976).

SPECIES ACCOUNTS

Caecidotea forbesi (Williams)

Material Examined: Maryland: Calvert Co.: Vernal pool at Flag Ponds, AN, 19 Apr 1985 (241813). Webster Pond at Cove Point, J. McKnight, 2 Mar 1987 (241841). Caroline Co.: Vernal pool 4 miles WNW of Goldsboro, AN & M. Dircks, 25 Apr 1985 (241811). Vernal pool at Bridgetown, J. Hill, 6 Feb 1986 (264537). Cecil Co.: Vernal pool along Rt 222 SE of Octoraro Creek, AN, 7 Mar 1987 (241848). Charles Co.: Vernal pools at Myrtle Grove WMA, AN, 30 Jan 1991 (258534). Dorchester Co.: Swamp W of

Cambridge, R. Jackson, 21 Mar 1943 (264533). Vernal pools at Nanticoke Boy Scout Reservation, AN & B. Norden, 2 Feb 1980 (264531). Vernal pools along Rt 50 E of Big Millpond, AN, 5 May 1986 (264536). Vernal pools along Lovers Lane S of Horn Point Rd, AN, 9 Mar 1993 (264539). Vernal pool along Johnson Rd N of Vienna, AN, 18 Apr 1984 (264536). Kent Co.: Vernal pool along Peacock Corner/No. 10 School Rd, AN, 18 Mar 1987. Vernal pool S of Walnut Tree Rd, AN, 18 Mar 1987 (241845). Vernal pool at Golts, AN, 14 Apr 1989 (250160). Swamp along Rt 301 S of Rt 313, AN, 30 Jan 1990 (250428). Montgomery Co.: Great Falls, C. Shoemaker & W. Appel, no date (45599). Ice pond, J. Benedict, 28 Feb 1926 (60283). Shore ponds near Plummrs Island, W. Appel, 12 January 1935 (135762). Temporary pond on shore near Plummrs Island, W. Appel, 5 May 1935 (122653). Temporary pond near Plummrs Island, W. Appel, 19 May 1935 (135762). Pond at McKee Beshers WMA, J. Norvell, 4 Apr 1983 (250925). Vernal pool along Rock Creek in Kensington, AN, 22 Apr 1985 (241814). Pothole on Plummrs Island, AN, 10 Jul 1986 (241903). Vernal pools along Meadowbrook Rd near entrance to Rock Creek Park, AN, 29 Apr 1993 (264551). Pothole at S end of Bear Island, D. Mehlman, 21 Apr 1984 (264560). Vernal pool at McKee Beshers WMA, AN, 1 May 1984 (264561). Small stream at McKee Beshers WMA, AN, 12 May 1984 (264562). Seepage area along Seneca Creek N of River Rd, AN, 1 May 1984 (264564). Prince George's Co.: Hyattsville, R. Greenfield, 18 Feb 1928 (61739). Hyattsville, R. Greenfield, 10 Feb 1929 (62659). Vernal pool along Oxon Hill Rd E of Henson Creek, AN & B. Norden, 17 May 1981 (264535). Queen Anne's Co.: Pond at Hess Rd and Rt 50, M. Dircks, 18 Mar 1985 (250921). Vernal pool along Rt 301 S of Rt 290, AN, 18 Mar 1987 (241844). Vernal pools along Roe Ingleside Rd N of Roe, AN, 30 Jan 1990 (250427). Somerset Co.: Ditch along Rt 24 N of Rt 675, AN, 17 Mar 1987 (241855). St. Mary's Co.: Rain water in ditch at Ridge, W. Ball, 26 Apr 1930 (67620). Vernal pool at Point No Point, W. Ball, 27 Apr 1930 (67619). Swamp SE corner of Patuxent Naval Air Station, AN, 20 May 1985 (241818). Vernal pools along Rt 5 S of Harry James Rd, AN, 27 Apr 1993 (254554). Talbot Co.: Vernal pool along Rt 33 W of St. Michaels, AN, 16 Mar 1987 (241850). Stream crossing Rt 50 N of Choptank River, AN, 29 Mar 1990 (250429). Wicomico Co.: Mayer Creek at Gordy Mill Rd, AN, 23 May 1984 (264558). Vernal pool along Rt 50 W of Maiden Forest Rd, AN, 17 Mar 1987 (241852). Vernal pool along Rt 347 NE of Athel Rd, AN, 29 Mar 1990 (250430). Worcester Co.: Permanent pond inland of Chincoteague Bay at Saint Lawrence Neck, D. Boone & F. Hirst, 10 Apr 1984 (264559). Vernal pool along Old Furnace Rd E of Dividing Creek, AN, 17 Mar 1987 (241858). Swamp along Dividing Creek at Rt 364, AN, 22 May 1988 (241945). Swamp along Dividing Creek at Five Bridges Rd, AN, 12 Apr 1990 (250431). Swamp along Dividing Creek at Fleming Millpond Rd, AN, 12 April 1990 (250432). Vernal pool along Fleming Millpond Rd N of Rt 364, AN, 12 Apr 1990 (250443).

Range: Williams (1970) recorded *C. forbesi* from the District of Columbia, Indiana, Kentucky, Maryland, Michigan, Missouri, North Carolina, Ohio, South Carolina, Virginia, West Virginia, and Ontario, Canada. Lewis (2009) gave records for Virginia and, citing Williams (1970), noted that it had a preference for vernal pools. It was also reported from northwestern Pennsylvania by Wissinger and Gallagher (1999) and from Wisconsin by Watermolen (2017). In addition, there are specimens at the USNM from Arkansas (171445), Georgia (123799), Illinois (128900), Iowa (108835), and Tennessee (1230345). This shows *C. forbesi* to be a very wide-ranging species. However, records

are absent for the area north of Maryland into New England, east of the Great Lakes and Saint Lawrence River.

In Maryland, *C. forbesi* is an inhabitant of the Atlantic Coastal Plain, with encroachment onto the Piedmont Plateau along the Potomac River and Susquehanna River valleys (Figure 1). Figure 1 shows several gaps in the Maryland distribution of this species. For instance, on the Western Shore of the Chesapeake Bay it was not found in a large area drained by the Patuxent River, and on the Eastern Shore it appears to be absent from the entire middle portion of the drainage of the Choptank River. However, Figure 2 shows that both areas had numerous vernal pools that supported *C. nodula*, indicating that habitat for *C. forbesi* was present.

Habitat: Williams (1970) noted that this isopod had been recorded from a variety of microhabitats. He reported it from “temporary pools, flood pools, and sloughs. However, the species has also been collected from marshes, small creeks, and at least on a few occasions from lakes. One of the lakes from which it has been collected was Lake Huron where the species was obtained from a depth of 15 m [49 ft].”

Analysis of the 48 Maryland records that include specific habitat data shows that 29 (60%) were from vernal pools, six were from swamps, five were from permanent ponds, four were from small streams, two were from potholes along the Potomac River, one was from a ditch, and one was from a large river.

Life History Notes: *Caecidotea forbesi* was found from January through May, and once in July. It was absent from collections made in June, and August through December. Most collections occurred during March and April. Sexually mature males were found in every collection and clasping pairs were noted on 7 and 16 March. Females carrying eggs or young in their brood pouches were found on 30 January, 7 March, 16 March, 18 March, 12 April, and 14 April. Some of those earlier dates were for specimens found active beneath a layer of ice.

Caecidotea nodula (Williams)

Material Examined: Maryland: Anne Arundel Co.: Seepage area along Rt 3 S of Crofton, AN, 14 Apr 1979 (230173). Pond at N end of Crofton Industrial Park, AN, 10 June 1979 (230183). Seepage area along Rt 295 S of Rt 175, AN, 25 Mar 1980 (230116). Muddy Creek at Rt 468, P. Dresler, 10 Mar 1981 (250929). Spring along Mill Swamp Rd E of Rt 2, AN, 23 Mar 1981 (230125). Seepage area along Rt 450 W of Rutland Rd, AN, 5 Apr 1984 (230987). Vernal pool along Severn Run N of Dicus Mill Rd, AN & D. Mehlman, 25 Apr 1984 (230997). Vernal pools along Sandpiper Ln, AN & D. Mehlman, 3 May 1984 (230998). Spring above Rucker’s Pond, C. Rucker, 1 Jun 1985 (241827). Seepage area along Rt 2 N of Towneck Rd, C. Rucker, 15 Jan 1986 (241910). Vernal pools at west end of BWI Airport runway, AN, 10 Apr 1986 (230154). Spring at Rucker’s Pond, AN, 20 Jun 1986 (241904). Vernal pools at Jug Bay Nature Center, AN, 24 Mar 1988 (241935). Seepage area along Rt 50 E of Rt 2, AN, 4 Apr 1990 (250421). Seepage area in woods along Rt 2 N of Rt 261, AN, 27 Apr 1993 (264552). Jug Bay Wetlands Sanctuary, springs in woods, AWN, 18 Mar 1994 (268794). Seepage area along

Rt 295 N of Rt 32, AN, 21 Mar 1994 (268789). Baltimore Co.: Vernal pools at Days Cove in Gunpowder Falls SP, AN, 15 Nov 1989 (250165). Calvert Co.: Boggy ground in Gray's Cypress Swamp, C.R. Shoemaker, 17 Apr 1938 (122058, 122059). Seepage area along Patuxent River S of Ferry Landing Rd, AN, 7 Mar 1987 (241843). Seepage area along Battle Creek Cypress Swamp, AN, 20 Apr 1984 (230993). Seep along Bromes Island Rd, AN, 20 Apr 1984 (230994). Spring-seep along Ross Rd, AN, 20 Apr 1984 (230995). Seepage area along Grays Creek in Calvert Cliffs State Park, AN, 14 Jan 1990 (250405). Seepage areas at Kings Landing Park, AN, 27 May 1987 (241862). Caroline Co.: Spring along Choptank River N of Red Bridges, AN, 15 Jun 1980 (230364). Seepage area along Tanyard Rd S of Rt 331, AN, 10 May 1984 (230999). Vernal pool along Alternate Rt 404 E of Hillsboro, AN, 20 Feb 1990 (250414). Vernal pool along Skeleton Creek Rd W of Poplar Neck Rd, AN, 10 Apr 1990 (250875). Spring seep along Marsh Creek S of Marsh Creek Rd, AN, 10 Apr 1990 (250876). Charles Co.: Rill 2.7 miles S of La Plata, L. Hubricht, 29 Feb 1959 (230193). Stream crossing Rt 301 S of La Plata, AN, 19 Apr 1982 (229827). Seepage area at head of Gilbert Swamp Run, AN, 7 Mar 1987 (241842). Seepage area along Popes Creek, AN, 25 Apr 1989 (250161). Vernal pools along lake at Cedarville State Forest, AN, 25 Apr 1989 (250404). Vernal pools along Pomfret Rd SW of Mattawomen Creek, AN, 19 Feb 1990 (250410). Spring-fed stream along Rt 6 E of Wards Run, AN, 19 Feb 1990 (250411). Swamp along Rt 425 E of Friendship Landing Rd, AN, 19 Feb 1990 (250412). Vernal pools along Rt 224 W of Rt 6, AN, 19 Feb 1990 (250413). Vernal pool along Rt 301 N of Cherry Ln, AN, 25 Mar 1994 (268790). Dorchester Co.: Ditch SW of Cambridge, R. Jackson, 21 Mar 1943 (241886). Swamp 3.3 miles W of Cambridge, R. Jackson, 21 Mar 1943 (230191). Ditch 3 miles SW of Cambridge, R. Jackson, 21 Mar 1943 (230192). Seepage area along Reliance-Delaware Rd in Galestown, AN, 30 Mar 1980 (230119). Spring seep along Rt 16 NE of Rt 50, AN, 29 Mar 1990 (250417). Swamp along Dividing Creek at Fleming Millpond Rd, AN, 12 Apr 1990 (250422). Vernal pools along Lovers Ln S of Horn Point Rd, AN, 9 Mar 1993 (264540). Seepage area along stream crossing Rt 16, AN, 25 Mar 1993 (264545). Swamp along Rt 16 N of Rt 50, AN, 22 Apr 1993 (268787). Howard Co.: Seepage area along Patuxent River W of Rt 94 in Patuxent River State Park, AN, 23 Mar 1990 (1250441). Seepage swamp along Rt 94 in Patuxent River State Park, AN, 23 Mar 1990 (250415). Kent Co.: Swamp between Sassafras River and Rt 299, AN, 30 Jan 1990 (250408). Swamp along Rt 301 S of Rt 313, AN, 30 Jan 1990 (250409). Prince George's Co.: Drinking water of home in Bowie, D. Glover, 23 Dec 1952 (95719). Seepage area along Suitland Road S of Suitland, J. Holsinger, 4 Feb 1973 (144062). Vernal pools along Rt 30 at Missouri Av, AN, 14 Apr 1979 (230176). Vernal pool along Rt 301 S of Rt 5, AN, 14 Apr 1979 (230174). Seepage area along Rt 32 SE of Rt 3, AN, 24 Apr 1979 (230175). Seepage area along Brinkley Rd E of Henson Creek, AN, 7 Feb 1982 (230123). Vernal pool along Indian Head Hwy SW of Accokeek Rd, AN, 19 Apr 1982 (229882). Spring along Rt 382 E of Charles Co. line, AN, 1 May 1982 (229823). Vernal pool along Central Av W of Patuxent River, AN, 20 Apr 1984 (230992). Seepage area along Rt 301 S of Rt 50, AN, 20 Apr 1984 (241547). Seepage area along Greencastle Rd near County line, AN, 17 Mar 1985 (241805). Vernal pool along Rt 197 at Horsepen Branch, AN, 22 Mar 1985 (241806). Seepage area along Church Rd N of Rt 214, AN, 9 Nov 1985 (230170). Vernal pools along Powder Mill Rd E of Rt 295, AN, 9 Apr 1986 (230153). Vernal pools, Accokeek, AN, 18 Mar 1987 (241847). Seepage area along Rt 50 E of Church Rd, AN, 8 Mar 1987 (241849). Seepage-fed stream along Croom Rd N of

Tanyard Rd, AN, 21 Jul 1987 (241870). Vernal pool along Brown Station Rd N of Old Marlboro Pike, AN, 27 Nov 1989 (250167). Seepage swamp along Collington Branch at Leeland Rd, AN, 26 Mar 1993 (264546). Vernal pools along White House Rd NW of Rt 202, AN, 26 Mar 1993 (264547). Vernal pools at Andrews Air Force Base, D. Feller and D. Davis, 7 Jul 1993 (264594). Mill Swamp at Marshall Rd, AN & N. Robbins, 30 Jun 1998 (250878). Queen Anne's Co.: Vernal pools along Rt 50 W of Rt 301, AN, 23 Feb 1980 (230105). Vernal pool along Rt 8 S of Matapeake, AN, 6 Mar 1984 (230982). Vernal pool along Rt 301 S of Rt 302, AN, 6 Mar 1984 (230984). Vernal pools along Wye Island Rd, AN & D. Richerson, 11 Apr 1985 (241807). Vernal pools on Wye Island, AN, 23 Nov 1989 (250164). Vernal pool along Roe Ingleside Rd N of Roe, AN, 30 Jan 1990 (250406). Vernal pools along Rt 302 E of Barkley, AN, 30 Jan 1990 (250407). Spring along Rt 50 N of Rt 404, AN, 29 Mar 1990 (250416). Saint Mary's Co.: Rain water in ditch at Ridge, W.H. Ball, 26 Apr. 1930 (122655). Stream at Mechanicsville, W.H. Ball, 11 May 1937 (122656). Spring at Bristol, A. Pizzini, 31 Oct. 1937 (122657). Ye Coole Spring in Charlotte Hall, S. Fuller, 30 Jun 1969 (230592). Seepage area along Indian Bridge Rd S of St. Andrews Church Rd, AN, 25 Aug 1986 (241907). Seepage area along Rt 301 W of Rt 213, AN, 26 Mar 1988 (241936). Vernal pool along Rt 213 at Schelhouse Rd, AN, 26 Mar 1988 (241938). Spring along Rt 6 W of Flora Corner Rd, AN, 10 Jun 1988 (229811). Seepage area along Rt 5 S of Rt 238, AN, 2 May 1989 (250162). Vernal pools along St. Andrews Church Rd W of Indian Bridge Rd, AN, 27 Apr 1993 (264555). Vernal pools along stream crossing Rt 235 N of Rt 489, AN, 27 Apr 1993 (264553). Somerset Co.: Vernal pool along Rt 13 N of Rt 675, AN, 17 Mar 1987 (241854). Seepage swamp along Dividing Creek at Old Furnace Road, AN, 17 Mar 1987 (241856). Talbot Co.: Vernal pool along Beaverdam Branch S of Rt 328, AN, 10 May 1984 (230101). Seepage area along Mill Creek N of Rt 662, AN, 10 May 1984 (230102). Spring-seep along Rt 328 W of Kittys Corner Rd, AN, 10 May 1984 (230100). Seepage area in Trappe, AN, 17 Mar 1987 (241851). Vernal pools along Rt 50 S of Rabbit Hill Rd, AN, 3 Feb 1989 (250157). Vernal pools along Rt 50 S of Tarbutton Rd, AN, 9 Mar 1993 (264541). Vernal pools along Rt 309 SW of Klondike Rd, AN, 25 Mar 1993 (264542). Vernal pools along Beaverdam Branch at Rt 328, AN, 25 Mar 1993 (264543). Seepage swamp along Rt 309 SW of Cordova, AN, 25 Mar 1993 (264544). Vernal pools in mixed woods at Wittman, Steiner & Swearingen, 29 Mar. 1993 (268792). Vernal pools in woods at Wittman, Steiner & Swearingen, 10 Apr. 1994 (268801). Wicomico Co.: Seepage swamp along Rt 50 W of Salisbury, AN, 17 Mar 1987 (241853). Vernal pool along Rt 513 S of Rt 13, AN, 22 May 1988 (241943). Swamp along Rt 50 E of RT 50 bridge, AN, 29 Mar 1990 (250418). Vernal pool along Rt 349 E of Rt 347, AN, 29 Mar 1990 (250419). Seep-fed ditch along Athel Rd N Rt 347, AN, 29 Mar 1990 (250420). Spring along Camp Road E of Rt 3, AN & J Norden, 8 May 1994 (268800). Worcester Co.: Vernal pools along Fleming Mill Rd N of Rt 364, AN, 12 Apr 1990 (250423).

Range: Williams (1970) reported *C. nodula* from a “small peninsula southeast of Washington, D.C., bordered by the Potomac River and Chesapeake Bay.” The records he cited were all from three counties (Anne Arundel, Calvert, and St. Mary's) in southern Maryland. Lewis (2009) subsequently reported it from Virginia. As Figure 2 shows, *C. nodula* occurs throughout the Maryland portion of the Atlantic Coastal Plain on both sides of the Chesapeake Bay. There is also encroachment onto the Piedmont Plateau along the Patuxent River valley. The only specimens at the USNM from outside of

Maryland are two series (1436190, 1436191) from Virginia reported by Lewis (2009), and a specimen lot from the District of Columbia (241986).

The type locality for *C. nodula* is “boggy ground in Gray’s Cypress Swamp, below Prince Frederick, Calvert County, Maryland” (Williams 1970). Gray’s Cypress Swamp is now known as Battle Creek Cypress Swamp, most of which is a nature preserve owned by The Nature Conservancy and leased to Calvert County.

Habitat: Williams (1970) examined four series of *C. nodula* and noted that they came from “a variety of habitats: boggy ground in a swamp, rainwater in a roadside ditch, a woodland stream, and the outlet of a spring.” Among the 112 Maryland collections that we examined, label data specifically mentions vernal pools 44 times (39%), seepage areas 33 times, springs 14 times, swamps 11 times, streams/creeks six times, ditches twice, ponds once, and drinking water brought to a home once. If the groundwater-fed habitats (springs, seeps, drinking water) are grouped they account for 48 (43%) of the *C. nodula* collections, while vernal pools account for 44 (39%). The remaining 20 (18%) collections (ditches, swamps, ponds, streams/creeks) could have been groundwater influenced.

Life History Notes: *Caecidotea nodula* was found during every month of the year except September and December, although most collections were made in March and April. Sexually mature males were present in all collections. Oviparous females were present in collections made on 14 January, 30 January, 3 February, 19 February, 20 February, 23 March, 29 March, 4 April, 25 April, and 2 May.

Caecidotea scrupulosa (Williams)

Material Examined: Maryland: Allegany Co.: Vernal pool in gorge below dam, Rocky Gap State Park, AN, 28 Apr 1988 (229814). Vernal pool N I-70 (I-68), 0.2 mi E of (Frank) Davis (Road), AN, 1 Apr 1986 (230156). Vernal pool along Town Creek, 0.3 mi S of Rt 40, E. Thompson, 17 Apr 1985 (241826). Stream along Rt 40, 5.8 mi E Flintstone, AN, 30 May 1985 (241823). Spring along Flintstone Creek just S Black Valley Road, AN, 10 Jan 1990 (250424). Anne Arundel Co.: Vernal pools, Corcoran Environmental Study Area, AN, 14 Apr 1981 (230124). Baltimore Co.: Vernal pools along Hollyneck Rd, 4 mi E Essex, AN, 24 Mar 1986 (230155). Swamp, Black Marsh, AN, 5 May 1987 (241860). Calvert Co.: Swamp, Camp Kaufmann, AN, 24 Apr 1982 (229833). Swamp along Parran Rd W of Route 4, AN, 20 Apr 1984 (230996). Swamp along Fishing Creek at Dalrymple Rd, AN, 20 Apr 1984 (230991). Swamp, Calvert Cliffs State Park, AN, 11 May 1987 (241861). Charles Co.: Pond, Myrtle Grove Wildlife Management Area, AN, 19 Apr 1982 (229828). Swamp along Rt 488, 3 mi E La Plata, AN, 1 May 1982 (229822). Garrett Co.: Spring pools along reservoir 3 mi E Frostburg, AN, 28 Apr 1988 (229815). Vernal pools along Swamp Rd, AN, 13 May 1986 (230157). Harford Co.: Vernal pools along Beach Rd, Edgewood, AN, 15 Mar 1990 (250425). Vernal pools, Aberdeen Proving Ground, AN, 15 Mar 1990 (250426). Prince George’s Co.: Stream at Cedarville Rd 1 mi E of Rt 301, AN, 1 May 1982 (229826). Saint Mary’s Co.: Tributary of St. Clements Creek SW of Helen, AN, 27 Apr 1993 (264556).

Range: The specimens described by Williams (1970) were all from vernal pools (including “woodland pools”). Subsequently, Fleming (1972) recorded this species from caves in Virginia and West Virginia, small streams in Virginia, and three localities in Georgia. A fourth Georgia occurrence was given by Nickol and Heard (1973) and one of Heard’s Georgia specimens is at the USNM (238970). Additional occurrences of *C. scrupulosa* from caves and springs in Virginia and West Virginia were given by Steeves (1969), Holsinger et al. (1976), and Holsinger and Culver (1988).

Habitat: During this survey *C. scrupulosa* was collected at 20 locations in Maryland. Nine of these were vernal pools (45%), seven were freshwater swamps, two were low order streams, one was a spring, and one was the edge of a permanent pond. Thirteen of these Maryland localities were located in the east-central portion of the state on the Atlantic Coastal Plain (Figure 3). The other seven were in the western two counties, within the Allegheny Plateau and the Valley and Ridge portions of the Appalachian Plateau physiographic province (Vokes 1957). This species was not found east of the Chesapeake Bay, and the eastern and western populations are disjunct. These Maryland records represent the first reports of this species from the state, the northernmost localities for the species, and its first recorded occurrence on the Atlantic Coastal Plain.

Life History Notes: This species was the least frequently encountered of the isopods inhabiting upland vernal pools in Maryland. Collections were made during January, March, April, and May, with most in the latter two months. Sexually mature males were present in all collections, and clasping pairs were noted at two different sites on 20 April 1984. One collection made on 15 March 1990 included ovigerous females.

Remarks: Vernal pool and swamp habitats are abundant throughout the Maryland Atlantic Coastal Plain, where they are frequently occupied by *Caecidotea forbesi* and *C. nodula* (Figures 1 and 2). However, *C. scrupulosa* replaces those species on the northern extension of the Atlantic Coastal Plain along the western side of the Chesapeake Bay north of Baltimore.

Although *C. scrupulosa* inhabits caves in Virginia and West Virginia, it has not been found in any Maryland cave. Holsinger et al. (1976) and Steeves (1969) reported that cave populations of *C. forbesi* show varying adaptation to subterranean waters and range from normally pigmented individuals to lightly pigmented isopods with no apparent eyes. Steeves further stated that some cave populations in Virginia are more attenuate with longer appendages than non-cave populations in the same drainage. This degree of morphological variation is notable, and those cave-inhabiting populations deserve close study. Specimens from apparently eyeless cave-inhabiting populations in the USNM collection were found to have very small eyes (Thomas E. Bowman, personal communication).

DISCUSSION

Dry Period Survival

Since upland vernal pools are typically dry for as much as five months each year, aquatic species inhabiting them must have some way of surviving the dry period. Kenk (1949) suggested that the life history of vernal pool inhabitants must allow for at least one of the following: 1) must not be exclusively aquatic and move to and from the pool each year; 2) must produce a dormant egg or cyst; 3) must become a drought-resistant dormant adult; or 4) must follow groundwater down into the soil column. Belk and Cole (1975), Wiggins et al. (1980), and Williams (1997) discussed these adaptations in greater detail. Subsequent authors have treated aquatic isopods as having no such adaptations for dry season survival. For instance Colburn (2004) believed that aquatic isopods have no adaptations for dry season survival so should not be considered typical vernal pool residents, and Kenny and Burne (2000) stated that they “have no specialized adaptations, such as drought-resistant eggs or a diapause phase to survive the dry periods characteristic of vernal pools.” Batzer and Sion (1999) studied temporary pools in western New York and noted that the occurrence of abundant isopods was surprising because they were thought to lack “desiccation-resistant stages and are poorly adapted to disperse into newly created habitat.” This determination made despite the fact that isopods (*Caecidotea racovitzi*) were present in 25 temporary pools examined by them.

Kenk (1949) discussed isopods from vernal pools in Michigan—as *Asellus militaris* Hay, a junior synonym of *Caecidotea intermedia* (Forbes)—and suggested that they followed the retreating water table into the soil column and lived a subterranean existence until the pools filled again. He based this on the observation that isopods in the pools he studied appeared as small but adult individuals just after the pools filled. He thought that they could move directly down into the substrate, or occupy the water-filled chambers at the bottom of crayfish burrows as observed by Creaser (1931).

Batzer and Sion (1999) discussed the transportation of isopods into temporary pools through groundwater, by surface flooding or on the feathers or feet of water birds, but determined these mechanisms to be improbable for the pools that they studied in western New York. Although their sites were identified as “autumnal” pools, they would fall into the category of vernal pools as defined here. The isopods present at their sites were *Caecidotea racovitzi*, a species also occurring in Maryland but not found in vernal pools during this study. They believed that the isopods survived in pockets of permanent water or in “damp organic detritus in dry basins.” This conclusion was based on the assumption that they had no resistant dry-season stages and did appear soon after rains began to fill the pool’s basin. They were able to find small numbers of isopods in the dry substrate of a pond bed, and showed in laboratory studies that their aquatic isopods were able to survive at least three weeks in damp detritus.

Among the adaptations exhibited by vernal pool obligate macroinvertebrates in the mid-Atlantic region, dormancy in dry soil by adults is least common. The only other animals that I am aware of relying on it are mollusks, particularly some pisidiid clams (Mollusca: Pisidiidae) (Herrington 1962, McKee and Mackie 1980). Pisidiid clams are of regular occurrence in mid-Atlantic vernal pools (Brown and Jung 2005, personal observation),

and several species are restricted to temporary waters (Herrington 1962). McKee and Mackie (1980) studied desiccation resistance in one of these, *Sphaerium occidentale* (J. Lewis), and found that it burrowed into the substrate when the pool dried, and lay dormant until the pool again filled. Gladden and Smock (1990) found that *Pisidium* L. Pfeiffer sp. on floodplains also survived dry periods by simply closing their valves and lying dormant in the substrate until water returned.

Williams (2006) gives an interesting summary of the occurrence of crustaceans in temporary waters in relation to hydroperiod in Ontario, Canada. *Caecidotea* was listed as occurring only in habitats that are wet for a minimum of 70 days. Since there is evidence that adults appear soon after pools fill (Kenk 1949, Batzer and Sion 1999), I suggest that this is the minimum time required for a generation to reproduce, allowing for multiple generations in a single wet cycle.

Seasonal Occurrence

Although isopod collections were made in Maryland during every month of the year, field effort was least during the coldest months (December, January and February) and collecting effort was greater from March through November. Collecting effort during those months was relatively even. Data collected for this study shows that all three species appeared in winter, reached peak numbers (estimated) in March–April–May then dwindled in June. That periodicity coincides with the times that vernal pools in Maryland fill (fall–winter) and then experience their dry period (late June–July through November).

It is interesting that populations of these same three species inhabiting non-vernal pool habitats (i.e., springs, seepage areas, swamps, etc.) persist slightly longer, but also decline and disappear during those months when vernal pools are dry. As noted previously, observation of a population of *Caecidotea scrupulosa* in Anne Arundel County showed them to be present and active throughout the winter, even when the pool was covered by a layer of ice. Observations made during this study showed that populations of all three species in Maryland vernal pools reached their highest density in May, then decreased in number and disappeared several weeks before the pools actually dried in June or July. Although the disappearance of the isopods was probably due to some biotic/abiotic seasonal change in the aquatic habitat, available data does not suggest what that change might be.

Co-occurrence of Species

Among the collections made or examined during this study, *Caecidotea scrupulosa* did not occur with either of the other two species while *C. nodula* and *C. forbesi* occurred together seven times. Since *C. scrupulosa* was found relatively few times, it is possible that had it been encountered more frequently it might have been found with another species. The substrate of vernal pools in Maryland is characteristically fallen deciduous leaves over soil. The leaves are intact at the top, but lower down the leaf material becomes more finely divided. On a number of occasions, I had the opportunity to observe isopods undisturbed atop the leaf layer. Typically, the species observed was *C. nodula*. In addition, *C. nodula* were “clean” when captured while other species frequently carried bits of detritus or other material. Based on these observations, I believe that where *C.*

nodula and *C. forbesi* occur together in vernal pools, they occupy different levels in the leaf/detritus layer, *C. nodula* near the top where the leaves are intact, and *C. forbesi* lower down, in the more finely divided detritus near the soil surface. Such a distribution would serve to partition the habitat as well as food resources.

Maryland Distribution

As Figures 1–3 show, these three isopods have distinctive distributions within Maryland. *Caecidotea forbesi* and *C. nodula* were both found on the Atlantic Coastal Plain along both sides of the Chesapeake Bay, and both were found to have gaps in their apparent distribution in the interior of the Coastal Plain. *Caecidotea forbesi*, in particular, was not found in large areas of the Western Shore.

Caecidotea scrupulosa inhabits Maryland's Atlantic Coastal Plain wetlands but only on the western side of the Bay. It also shows a cluster of occurrences in the western part of the State (Figure 3). This is interesting because the freshwater habitats are profoundly different. The Atlantic Coastal Plain sediments are deep unconsolidated clays, sands, and gravels, while surface and near-surface substrates in Western Maryland are typically hard, consolidated shale, sandstones, and limestone (Vokes 1957). However, as discussed above, *C. scrupulosa* occurs in Virginia and West Virginia, including solution caves in the hard rocks of the Appalachian Mountains. It is possible that when we understand the wider distribution of this isopod, it may be found to occur along the Appalachian Front, linking the Western Maryland population with *C. scrupulosa* farther south. The eastern population and the western population are clearly disjunct in Maryland.

Since the freshwater habitats available are generally similar on both sides of the Bay, the absence of *C. scrupulosa* on the Delmarva Peninsula is likely a result of the timing of recolonization of freshwater habitats in eastern Maryland at the end of the Wisconsin Glaciation when melting ice sheets restored the Chesapeake Bay, limiting habitat and restricting the movement of non-flying invertebrates.

Although vernal pool habitats are more abundant on Maryland's Atlantic Coastal Plain, they are present west of the Fall Line (separating the Atlantic Coastal Plain and the Piedmont Plateau), making the general absence of these three species from the Piedmont Plateau physiographic province surprising.

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not have come to completion without his guidance, encouragement, and assistance. His knowledge of this group was truly encyclopedic, and his loss leaves a void that will not easily be filled. It was a great pleasure to spend time with Dr. Bowman, in field and in office. Appreciation is also expressed to Eugene J. Scarpulla, Editor of this journal. His attention to detail improved this paper, and he also produced Figures 1 through 3. Thanks are also due to the two anonymous reviewers who provided comments on this paper. Their efforts are much appreciated.

LITERATURE CITED

- Batzer, D.P., and K.A. Sion. 1999. Autumnal woodland pools of western New York: Temporary habitats that support permanent water invertebrates. Pages 319–332, in D.P. Batzer, D., R.B. Rader, and S.A. Wissinger (Editors). *Invertebrates in Freshwater Wetlands of North America: Ecology and Management*. John Wiley & Sons, Inc., New York, NY. 1120 pp.
- Belk, D., and G.A. Cole. 1975. Adaptational biology of desert temporary pond inhabitants. Pages 207–226 in N.F. Hadley (Editor), *Environmental Physiology of Desert Organisms*. Dowden, Hutchinson and Ross, Inc, Stroudsburg, PA. 283 pp.
- Brooks, R.T. 2004. Weather-related effects on woodland vernal pool hydrology and hydroperiod. *Wetlands* 24(1):104–114.
- Brown, L.J., and R.E. Jung. 2005. *An Introduction to Mid-Atlantic Seasonal Pools*. EPA/903/B-05/001. United States Environmental Protection Agency, Mid-Atlantic Integrated Assessment, Fort Meade, Maryland. 92 pp.
- Colburn, E.A. 2004. *Vernal Pools: Natural History and Conservation*. McDonald & Woodward Publishing Company, Blacksburg, VA. 426 pp.
- Creaser, E.P. 1931. Some cohabitants of burrowing crayfish. *Ecology* 12(1):243–244.
- Fleming, L.E. 1972. The evolution of the eastern North American isopods of the genus *Asellus* (Crustacea: Asellidae). Part I. *International Journal of Speleology* 4(3):221–256.
- Gladden, J.E., and L.A. Smock. 1990. Macroinvertebrate distribution and production on the floodplains of two lowland headwater streams. *Freshwater Biology* 24(3):533–545.
- Herrington, H.B. 1962. *A Revision of the Sphaeriidae of North America (Mollusca: Pelecyopoda)*. University of Michigan, Museum of Zoology, Miscellaneous Publications 118. 74 pp. + plates.
- Holsinger, J.R., and D.C. Culver. 1988. The invertebrate cave fauna of Virginia and a part of eastern Tennessee: zoogeography and ecology. *Brimleyana* 14:1–162.
- Holsinger, J.R., R.A. Baroody, and D.C. Culver. 1976. *The Invertebrate Cave Fauna of West Virginia*. West Virginia Speleological Survey, Bulletin 7. 82 pp.
- Kenk, R. 1949. *The Animal Life of Temporary and Permanent Ponds in Southern Michigan*. University of Michigan, Museum of Zoology, Miscellaneous Publications 71. 66 pp. + plates.
- Kenney, L.P., and M.R. Burne. 2000. *A Field Guide to the Animals of Vernal Pools*. Massachusetts Division of Fisheries & Wildlife, Natural Heritage & Endangered Species Program (Westborough, MA), and Vernal Pool Association (Reading, MA). 73 pp.
- Lewis, J.J. 2009. Three new species of *Caecidotea*, with a synopsis of the asellids of Virginia (Crustacea: Isopoda: Asellidae). Pages 251–266, in S.M. Roble and J.C.

- Mitchell (Editors). *A Lifetime of Contributions in Myriapodology and the Natural History of Virginia: a Festschrift in Honor of Richard L. Hoffman's 80th Birthday*. Virginia Museum of Natural History Special Publication No. 16. Martinsville, VA. 458 pp.
- Lewis, J.J., and T.E. Bowman. 2010. The subterranean asellids of Maryland: description of *Caecidotea nordeni*, new species, and new records of *C. holsingeri* and *C. franzi* (Crustacea: Malacostraca: Asellidae). *Journal of Cave and Karst Studies* 72(2):100–105.
- Lewis, J.J., T.E. Bowman, and D.J. Feller. 2011. A synopsis of the subterranean asellids of Maryland, U.S.A., with description of *Caecidotea alleghenyensis*, new species (Crustacea: Isopoda: Asellota). *Zootaxa* 2769(1):54–64.
- McKee, P.M., and G.L. Mackie. 1980. Desiccation resistance in *Sphaerium occidentale* and *Musculium securis* (Bivalvia: Sphaeriidae) from a temporary pond. *Canadian Journal of Zoology* 58(9):1693–1696.
- Nickol, B.B., and R.W. Heard, III. 1973. Host-parasite relationships of *Fessisentis nectororum* (Acanthocephala: Fessisentidae). *Proceedings of the Helminthological Society of Washington* 40(2):204–208.
- Shorthouse, D.P. 2010. SimpleMappr, an online tool to produce publication-quality point maps. Available at: <https://www.simplemappr.net>. Accessed 1 June 2020.
- Steeves, H.R., III. 1969. The origin and affinities of the troglobitic asellids of the southern Appalachians. Pages 51–65, in P.C. Holt (Editor), *The Distributional History of the Biota of the Southern Appalachians. Part I: Invertebrates*. Virginia Polytechnic Institute Research Division, Monograph 1, Blacksburg, VA. 295 pp.
- Vokes, H.E. 1957. *Geography and Geology of Maryland*. State of Maryland, Department of Geology, Mines and Water Resources, Bulletin 19. Waverly Press, Baltimore, MD. 243 pp.
- Watermolen, D.J. 2017. *Wisconsin Freshwater Isopod Atlas*. Miscellaneous Publication PUB-SS-1176. Wisconsin Department of Natural Resources, Madison, WI. 6 pp.
- Wiggins, G.B., R.J. Mackay, and I.M. Smith. 1980. Evolutionary and ecological strategies of animals in annual temporary pools. *Archiv für Hydrobiologie* Supplement 58:97–206.
- Williams, D.D. 1997. Temporary ponds and their invertebrate communities. *Aquatic Conservation: Marine and Freshwater Ecosystems* 7(2):105–117.
- Williams, D.D. 2006. *The Biology of Temporary Waters*. Oxford University Press, Oxford, UK. 337 pp.
- Williams, W.D. 1970. *A Revision of North American Epigeal Species of Asellus (Crustacea: Isopoda)*. Smithsonian Contributions to Zoology, No. 49. 80 pp.
- Williams, W.D. 1976. *Freshwater Isopods (Asellidae) of North America*. United States Environmental Protection Agency, Water Pollution Control Research Series 18050 ELD05/72 (second printing), Cincinnati, OH. 45 pp.
- Wissinger, S.A., and L.J. Gallagher. 1999. Beaver pond wetlands in northwestern Pennsylvania: modes of colonization and succession after drought. Pages 333–362, in D.P. Batzer, R.B. Rader, and S.A. Wissinger (Editors), *Invertebrates in Freshwater Wetlands of North America: Ecology and Management*. John Wiley & Sons, Inc. 1120 pp.
- Zedler, P.H. 2003. Vernal pools and the concept of “isolated wetlands”. *Wetlands* 23(3):597–607.

Protandrous Arrival in a Population of the Periodical Cicada *Magicicada septendecim* (Linnaeus) (Hemiptera: Cicadidae) in Montgomery County, Maryland

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Abstract: Differences in number and arrival time of male and female adult periodical cicadas, *Magicicada septendecim* (Linnaeus), Brood X, in a small geographic area of Maryland in 2004, are described and discussed. Newly emergent cicadas were counted, by sex, along various suburban streets. A probable incidence of protandry—the arrival of adult males before adult females—was observed. Data analyses by test of proportions show that for some of the first days of counting, in one of the two sample sites and in both sites combined, the disproportionate appearance of adult males was statistically significant, while for the last few days, the disproportionate appearance of adult females was also statistically significant. In one of the two sites and in both sites combined, significantly more females than males for the season as a whole were also observed. Though this study appears to confirm previous findings, there is little discussion in the literature on protandry in periodical cicadas, and no other study on this subject and species with detailed methodology for sampling, that avoids double counting. It might be useful to conduct field counts of periodical cicadas in other locations to discover where such protandry may or may not occur. It is believed that this mode of protandry is adaptive for the species, and that it evolved to enhance survivability or reproductive opportunity for both sexes.

INTRODUCTION

Once every 17 springtimes in certain parts of the United States, periodical cicadas (Hemiptera: Cicadidae) emerge in massive numbers (Figure 1). The various populations are called broods, numbered according to their cycles. Brood X of the three 17-year species appears in Mid-Atlantic states and in some proximate areas west. *Magicicada septendecim* (Linnaeus) is the predominant Brood X species in the study area (Simon 1996).

While in the nymph stage (Figure 1), the cicadas emerge from holes in the ground; then, about 30 minutes to an hour later, they metamorphose into adults. After separating from the nymphal skin, they are almost completely white (Figure 2) for about 40 minutes. They darken to black gradually, but their bodies remain relatively soft for about four days the “teneral” period, during which time the males cannot sing, the females cannot lay eggs, and neither acquires its full adeptness at flying (Cooley and Marshall 2001).



Figure 1. *Magicicada septendecim*: mass emergence of nymphs from the ground. (Maryland, Michael J. Raupp, 15 May 2004)



Figure 2. *Magicicada septendecim*: newly eclosed teneral. (Maryland, Michael J. Raupp, 16 May 2004.)

During the first week of emergence, their large numbers and poor escape behavior make them desirable prey (Williams and Simon 1995). But after an initial time-span, predators may become satiated from eating the cicadas, and net predation declines (Karban 1981, Williams and Simon 1995).

The females can readily be distinguished from the males by the ovipositor (Figures 3 and 4). The males eventually chorus loudly in trees. Studies have indicated that males can mate more than once, but females typically only once (Williams and Simon 1995, Cooley and Marshall 2001, Saisho 2010).

“Protandry is the emergence or arrival of males before females into a seasonal population and is widespread among both plants and animals” (Holzapfel and Bradshaw 2002; see also Morbey and Ydenberg 2008). Note that in biological science, another, very different meaning of protandry is “sequential hermaphroditism,” in which males become females, i.e., “the individual changes sex at some point of the life history. If the initial sex is male, the condition is known as protandry” (Warner 1975). This latter meaning of protandry is not the subject of this study.

In 1958, Tinbergen (1969) reported this phenomenon of differential arrival of males and females for the Snow Bunting, *Plectrophenax nivalis* (Linnaeus) (Passeriformes: Calcariidae). Protandry has been analyzed by researchers studying the European Pied Flycatcher, *Ficedula hypoleuca* (Pallas) (Passeriformes: Muscipidae) (Canal et al. 2012). Entomological examples have been reported for a butterfly, Black Swallowtail, *Papilio polyxenes* Fabricius (Lepidoptera: Papilionidae) (Lederhouse et al. 1982); for the Pitcherplant Mosquito, *Wyeomyia smithii* (Coquillett) (Diptera: Culicidae) (Holzapfel and Bradshaw 2002); for a grasshopper, *Sphenarium purpurascens* Charpentier (Orthoptera: Pyrgomorphidae) (Cueva del Castillo and Núñez-Farfán 2003); and for a parasitic wasp, *Trichogramma evanescens* Westwood (Hymenoptera: Trichogrammatidae) (Doyon and Boivin 2006). This writer may also have observed protandry in the Fowler’s Toad, *Anaxyrus fowleri* (Hinckley) (Anura: Bufonidae), in Chevy Chase, Maryland, about 3 km (1.9 mi) due west of this cicada study area; over successive years, on the first evening of spring emergence, the toads were observed converging on a pond, with a statistically significant preponderance of males, in an apparently random sample count, showing a male to female ratio of approximately 5:1.

A report by Charles V. Riley (1869), the 19th century naturalist and later employee of the United States Department of Agriculture, describes the 1868 17-year periodical cicada’s habits, mainly in Missouri and Maryland. Riley’s study supplies us an early reference to protandry in *Magicalicada*. It observes, “As is the case with a great many other insects, the males make their appearance several days before the females, and also disappear sooner.”

The observation of protandry has been mentioned in more recent studies outside of Maryland for several cicada genera and species, for example, *Magicalicada septendecim*, *M. cassinii* (Fisher), and *M. septendecula* Alexander and Moore (Dybas and Lloyd 1974, Whiles et al. 2001); the Chorus Cicada, *Amphipsalta zelandica* (Boisduval) (Logan et al. 2014); *Meimuna mongolica* (Distant) (Hou et al. 2015); and the Giant Cicada, *Quesada gigas* (Olivier) (de Carvalho Andrade et al. 2017).



Figure 3. *Magicicada septendecim*: male, ventral view of abdomen. (Note: this specimen is a four-year early emergent of the 2021 Brood X; Maryland, Michael J. Raupp, 24 May 2017.)



Figure 4. *Magicicada septendecim*: female, ventral view of abdomen showing ovipositor. (Note: this specimen is a four-year early emergent of the 2021 Brood X; Maryland, Michael J. Raupp, 29 May 2017.)

Studying Brood X *M. septendecim* in a Western Maryland apple orchard in 1953, Graham and Cochran (1954) apparently observed protandry, “During the first week of emergence there were more males than females.” The Graham and Cochran study, which includes data on sex ratios, was based on a site located approximately 64 km (40 mi) northwest from this study’s area. Protandry in Maryland for *M. septendecim* was also suggested by Michael J. Raupp (in litt., 19 May 2004).

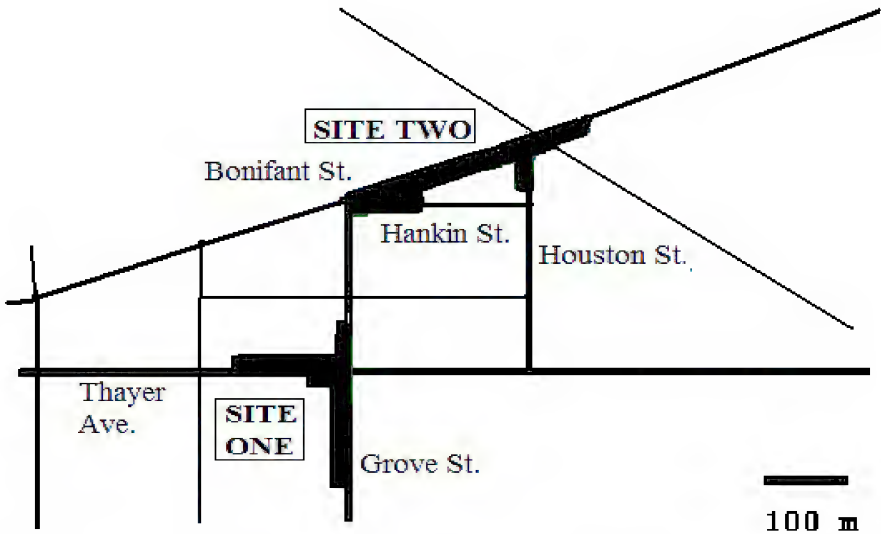
This paper, after outlining methodology, describes protandry as observed in the study location, and discusses the survival value of the phenomenon for both male and female cicadas.

METHODS AND STUDY SITES

Newly metamorphosed adult cicadas, teneral, were counted near and on streets and sidewalks of three suburban blocks, in an approximately seven square block area, subsequently divided into two study sites (Figure 5), in Silver Spring, Maryland. The count for this statistical study was taken from approximately 0800 to 1000 hours daily, from 14 May 2004—four days after their first appearance—until 23 May 2004. On the last day of the count, the number of newly metamorphosed adults had been declining for six days and a total of only five were found in the second sample site. During the study, the researcher walked the same route once each morning. Whenever a soft white or near-white adult cicada was found, its sex was recorded. (Generally, it should be methodologically possible to augment the data sample by counting the teneral late at night, as well. But in the residential area of the study, walking the route nightly in the darkness with a flashlight might well prompt concerns from the residents.)

It was assumed this method would produce a random count because at any moment of this brief adult cicada emergence period, neither sex would have a higher mortality rate than the other (John R. Cooley, in litt., 12 September 2005). Statistical analyses were conducted comparing the proportion of male and female newly emerged cicadas found for each day, in each site, and for the season as a whole, using the hypothesis test of a single proportion (McClave and Sincich 2000).

It was important to count only teneral cicadas, because once the cicadas begin to fly, the sexes may selectively disperse to different heights, and the females are easier to find and count than the males, i.e., males gather in trees to chorus (Lloyd and Karban 1983). But in the early study providing numbers for protandry (Graham and Cochran 1954), there is unclear methodology for obtaining a random sample. We do not know whether the adults they counted each day were newly emerged, and there is also no assurance that the writers were avoiding counting the same cicadas twice on successive days—their sample included “daily adults collected randomly in the orchard,” but we do not know which adults.



latitude: 38° N 59' 40" longitude: 77° W 01' 15"

CICADA COUNT STREET ROUTE

Figure 5. The two locations where periodical cicadas, *Magicicada septendecim* Brood X, were counted in Silver Spring, Maryland, May–June 2004.

Likewise, in a more recent study, Dybas and Lloyd (1974) thoroughly compare and report habitat preference among the three species of *Magicicada* by counting nymphal skins and dead adults, and quantify in field notes the preponderance of male nymphal skins on the first day of records. But these skins do not appear to come from *M. septendecim*, and the field notes do not follow up with data for sex ratios on subsequent days. And though it is possible to identify the sex of the cicada by examination of the nymphal skin, one cannot be sure what day that cicada emerged.

In this study area, though personal observation indicated that the predominant Brood X species was *M. septendecim*, some adults of *M. cassinii* were found in very small numbers, and their calls heard, near the study sites.

RESULTS

According to the hypothesis tests of single proportions, the number of newly emerged adult male cicadas found for both sites combined was significantly greater than the number of females at $\alpha = 0.05$ on the first and third day of counting, which is evidence of protandry. The number of newly emerged adult female cicadas found was significantly

greater than the number of males at $\alpha = 0.01$ for the ninth and tenth days of counting (Figure 6).

When separating out the two sites to replicate the experiment, we see evidence for protandry at Site 2, but not at Site 1. At Site 1, there were significantly more females than males at $\alpha = 0.05$ on the sixth and seventh day—but no statistically significant number of males at the start of the season, hence no protandry there (Figure 7). But at Site 2, there were significantly more males than females at $\alpha = 0.05$ on the first and third day—evidence for protandry. If we group days 1 through 3 at Site 2, at approximately $\alpha = 0.01$, we again see there was a significantly greater number of males than females at the start of the season (Figure 8).

Even without statistical analysis, the differential seemed apparent in one instance, though not at a day or site that was statistically significant. On 16 May 2004, the fifth day of counting, one fence had clinging to it 15 metamorphosing males and only one female. Three days later, the same fence was covered with new adult females and no males.

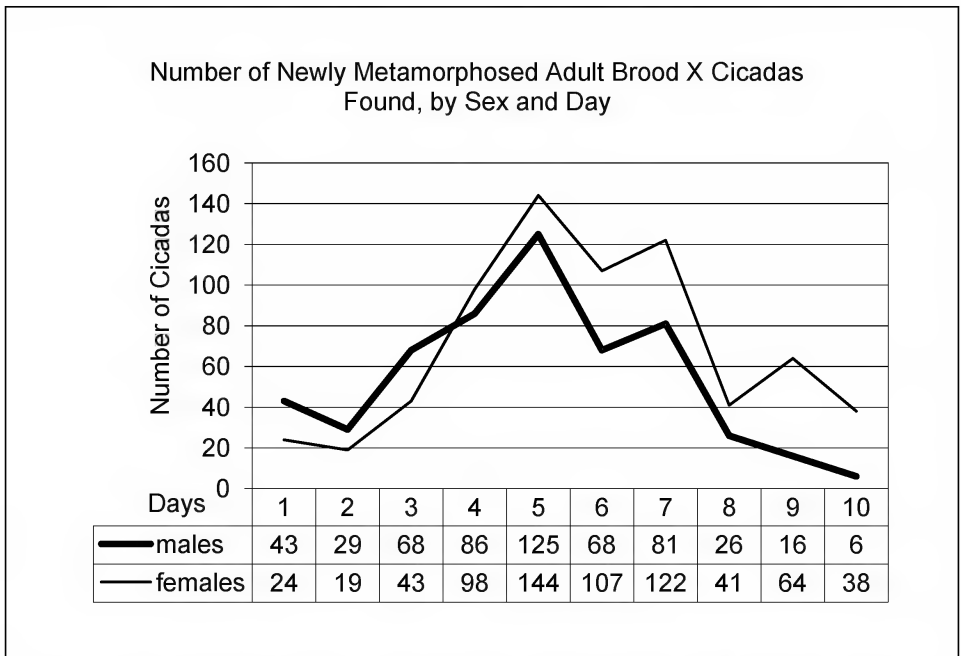


Figure 6. Total Number of male and female newly metamorphosed adult periodical cicadas, *Magicicada septendecim* Brood X, found on successive mornings on 14–23 May 2004 in a fixed route of random sampling of a neighborhood of Silver Spring, Maryland. A total of 548 newly metamorphosed males and 700 newly metamorphosed females were found. According to hypothesis tests of single proportions, the number of males is significantly greater than the number of females at $\alpha 0.05$ for days 1 and 3, and the number of females is significantly greater than the number of males at $\alpha 0.01$ for days 9 and 10. On days 1 and 3, this result is evidence for protandry. At $\alpha 0.01$, there are also significantly more females than males for the season as a whole.

There was another observation on adult sex ratios. Over the entire season, at Site 1 and at both sites combined, at $\alpha = 0.01$, there were also significantly more newly emergent females than males found (Figures 6 and 7). This observation is consistent with the finding of significantly more female than male *M. septendecim* cicadas by other researchers: Graham and Cochran (1954) in Maryland, and Jacobs (1953) in Indiana. Hunter and Lund (1960) in Georgia found significantly more female *M. cassinii* but not significantly more female *M. septendecim*. But in the other studies, unlike in this study, the question arises whether the researchers were counting only newly emergent cicadas. Other researchers reported male:female cicada ratios of 1:1 for the season (Williams and Simon 1995). Simon (1996) suggested that “temporary biases may occur” in the sex ratios in some areas.

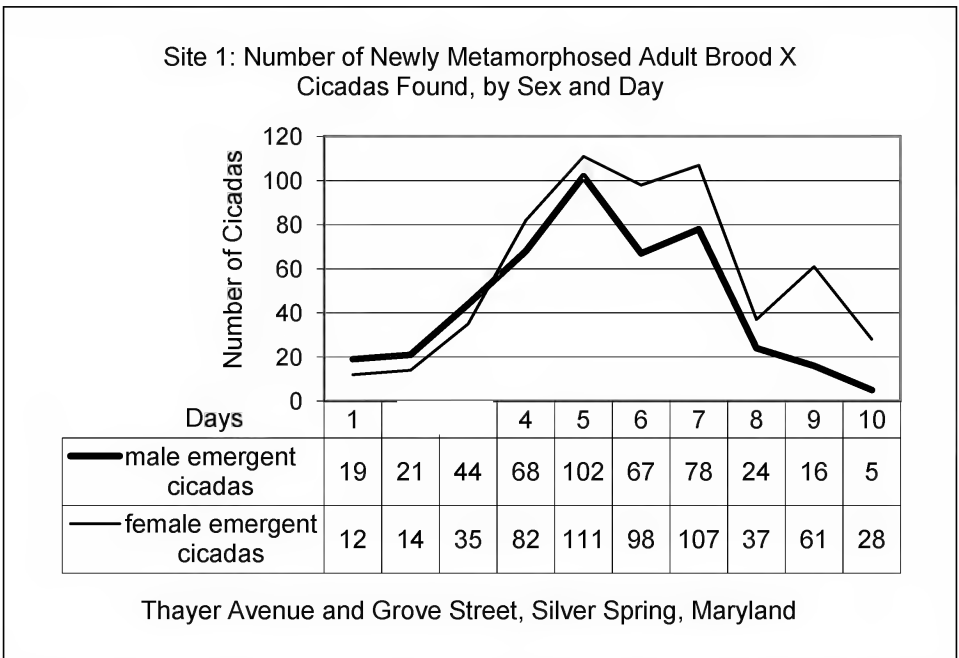


Figure 7. Site 1: Number of male and female newly metamorphosed adult periodical cicadas, *Magicicada septendecim* Brood X, found on successive mornings on 14–23 May 2004 in a fixed route of random sampling in Silver Spring, Maryland. A total of 444 newly metamorphosed males and 585 newly metamorphosed females were found. According to hypothesis tests of single proportions, the number of females is significantly greater than the number of males at $\alpha 0.05$ for days 6, 7, and 9.

The newly emergent cicadas were found in greatest density under red maple, *Acer rubrum* L. (Aceraceae); black oak, *Quercus velutina* Lam. (Fagaceae); and scarlet oak, *Q. coccinea* Münchh. Proximate to high numbers of cicadas were also flowering dogwood, *Cornus florida* L. (Cornaceae); black cherry, *Prunus serotina* Ehrh. (Rosaceae); and

black locust, *Robinia pseudoacacia* L. (Fabaceae). The physical environment had remained fairly stable during the previous 17 years, though, across the street from one part of the study site, two large trees were cut down about 10 days prior to cicada emergence, not preventing the nymphs beneath from emerging.

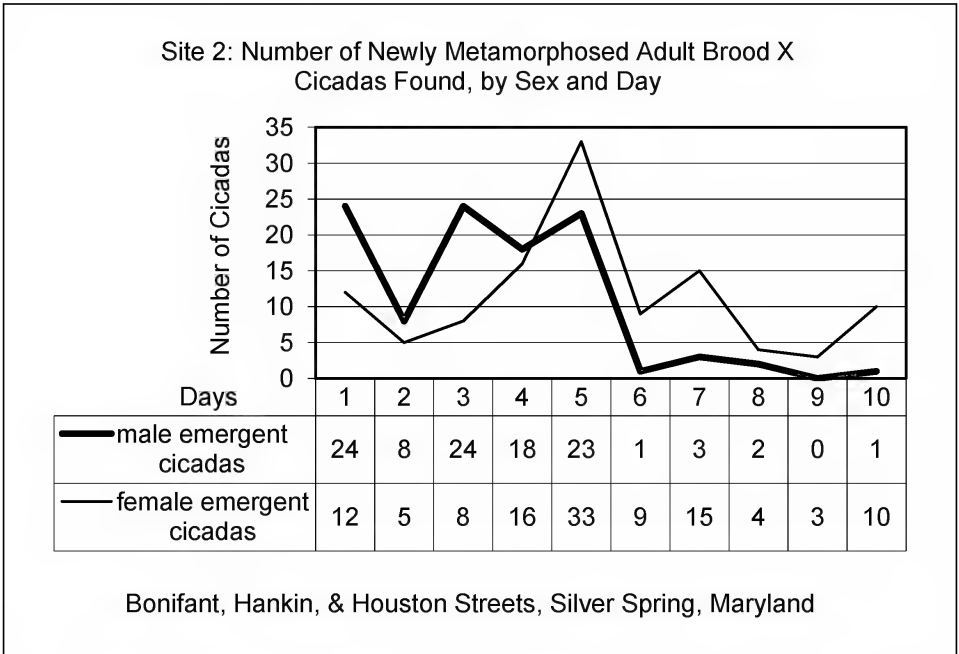


Figure 8. Site 2: Number of male and female newly metamorphosed adult periodical cicadas, *Magicicada septendecim* Brood X, found on successive mornings on 14–23 May 2004 in a fixed route of random sampling, in Silver Spring, Maryland. A total of 104 newly metamorphosed males and 115 newly metamorphosed females were found. According to hypothesis tests of single proportions, the number of males is significantly greater than the number of females at α 0.05 for days 1 and 3 and at approximately α 0.01 for days 1–3. This result is evidence for protandry.

Observed in the general area during the study, the principle agents of cicada mortality were cars and pedestrians; House Finches, *Haemorhous mexicanus* (P. L. Stadius Müller) (Passeriformes: Fringillidae), and Northern Mockingbirds, *Mimus polyglottos* (Linnaeus) (Passeriformes: Mimidae); Eastern Gray Squirrels, *Sciurus carolinensis* Gmelin (Rodentia: Sciuridae); domestic cats, *Felis catus* Linnaeus (Carnivora: Felidae); domestic dogs, *Canis lupus familiaris* Linnaeus (Carnivora: Canidae); fungi; arrested metamorphosis; wasps (Hymenoptera); and spiders (Araneae).

DISCUSSION

Reporting of protandry has tended to focus on benefits to either males or females, and theoretical arguments have become increasingly mathematical. The principle endures that natural selection acts on individuals, but it produces changes in populations.

Protandry is most often described from the male's point of view. "Early emerging males risk death before mating and late-emerging males miss opportunities to mate" (Holzapfel and Bradshaw 2002). Since female periodical cicadas typically mate only once, male cicadas would need to emerge early enough to find available females, mate with the first females that appear, and mate with as many as possible. Among the males there develops "an intense scramble competition for mates" (Cooley and Marshall 2004). Early arrival is especially advantageous if there are enough other males present to reduce the probability of any one male being preyed upon. "For any given male, the optimal emergence time may depend on the mean and distribution of emergence of other males" (Holzapfel and Bradshaw 2002). A strategy of emerging in large numbers is "selectively advantageous to individual cicadas" (Williams and Simon 1995). Natural selection would favor males that arrive early, if they were in large numbers, because they would have more mating opportunities.

But factors could act on female cicada timing of emergence, as well. According to Cueva del Castillo and Núñez-Farfán (2003), "the possible advantage of the time of emergence for females in their mating success in protandrous insect species" might be studied. Females would have increased chance of mating success "if female maturation occurs when the population... is biased to males." Protandry could be viewed not just as males arriving early but as females arriving late. Predator satiation after male emergence also could give a survival advantage to females emerging late. These rationales are listed by Morbey and Ydenberg (2008) in their review of overlapping hypotheses explaining protandry: there could be a selection for males to arrive early for multiple mating opportunities and simultaneously a selection for females to arrive late because of the mating benefits of finding many males and also the survival benefits of waiting and avoiding predation. Those late-arriving female cicadas need not wait to hear singing for a day or even a few hours compared to earlier-arriving females.

Researchers have sought to discover, through testing hypotheses in the field and laboratory, which possible evolutionary explanation for protandry might best be represented by which species (Doyon and Boivin 2006, Canal et al. 2012). Morbey and Ydenberg (2008) conclude, what seems to be a current consensus about insects and other arthropods, that "the most important contributing factor selecting for protandry seems to be the maximization of mating opportunities with females, especially virgin females."

Saisho (2010) adds a somewhat different analysis of female cicadas and protandry. Pointing out that female cicadas in the nymph and teneral stage may have oocytes not yet developed, Saisho reasons that the eclosion, or emergence, of the female cicada might be relatively delayed if the cicada is not yet ready to mate. "It is often said that it takes times to grow eggs in the females' abdomens, which causes the shift of the eclosion period." Saisho also recalls that male cicadas can mate more than once while females mate only

once, and includes this feature in mathematical modeling. From mathematical modeling, Saisho infers, as have other investigators, that it is apparently to the cicada's reproductive advantage for females to delay arrival and mating relative to males. Saisho's consideration of developing oocytes can also correspond theoretically to one of the Morbey and Ydenberg (2008) hypotheses for protandry; they hypothesize that an "indirect" cause of protandry through "constraint" on one of the sexes could correlate with or lead to the differential arrival time.

It might be interesting to inquire whether protandry in *M. septendecim* is typical, or repeats in a geographic area from one generation to the next, and, if not, to consider why protandry is not found among certain populations of periodical cicadas. Certainly, protandry may not always occur in *M. septendecim*. Alexander and Moore (1962) recall a site in Ohio in 1959 where almost all the season's cicadas emerged in a few hours on a single night.

It might also be rewarding to investigate whether the finding of more female than male periodical cicadas at a site for the season as a whole might coincide with the finding of protandry—this correlation was not found consistent in this study. Frank (1983) cautions that there are many possibly conflicting factors that influence overall sex ratios (see also Wade et al. 2003).

Additional study sites might provide a more fine-grained picture to substantiate the possible absence of protandry in the periodical cicada for some areas. Scientific investigators and all those curious about nature are invited to observe the return of the 17-year Brood X cicadas, emerging in some locales next year. Comparing different study sites and regions and implementing a protocol similar to the one used in this study, researchers could collect data on sex ratios, and specifically protandry for further study.

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LITERATURE CITED

Alexander, R.D., and T.E. Moore. 1962. *The Evolutionary Relationships of 17-year and 13-year Cicadas, and Three New Species (Homoptera, Cicadidae, Magicicada)*.

- University of Michigan, Museum of Zoology, Miscellaneous Publications No. 121. 59 pp.
- Canal, D., R. Jovani, and J. Potti. 2012. Multiple mating opportunities boost protandry in a Pied Flycatcher population. *Behavioral Ecology and Sociobiology* 66(1):67–76. Available at: <https://doi.org/10.1007/s00265-011-1253-8>. Accessed 25 May 2020.
- Cueva del Castillo, R., and J. Núñez-Farfán. 2003. Female mating success and risk of pre-reproductive death in a protandrous grasshopper. *OIKOS* 96(2):217–224.
- Cooley, J.R., and D.C. Marshall. 2001. Sexual signaling in periodical cicadas, *Magicicada* spp. (Hemiptera: Cicadidae). *Behaviour* 138(7):827–855.
- Cooley, J.R., and D.C. Marshall. 2004. Thresholds or comparisons: mate choice criteria and sexual selection in a periodical cicada, *Magicicada septendecim* (Hemiptera: Cicadidae). *Behaviour* 141(6):647–673.
- de Carvalho Andrade, S., N.M. Martinelli, G.D. Rossi, and D.J. Andrade. 2017. Giant Cicada emergence, protandry and chorus centers formation as revealed by studies using a sound trap. *Journal of Insect Behavior* 30(3): 300–307.
- Doyon, J., and G. Boivin. 2006. Impact of the timing of male emergence on mating capacity of males in *Trichogramma evanescens* Westwood. *BioControl* 51(6):703–713. Available at: <https://doi.org/10.1007/s10526-006-9001-0>. Accessed 25 May 2020.
- Dybas, H.S., and M. Lloyd. 1974. The habitats of 17-year periodical cicadas (Homoptera: Cicadidae: *Magicicada* Spp.) *Ecological Monographs* 44(3):279–324.
- Frank, S.A. 1983. A hierarchical view of sex-ratio patterns. *Florida Entomologist* 66(1):42–75.
- Graham, C., and A.B. Cochran. 1954. The periodical cicada in Maryland in 1953. *Journal of Economic Entomology* 47(2):242–244.
- Holzapfel, C.M., and W.E. Bradshaw. 2002. Protandry: the relationship between emergence time and male fitness in the Pitcher-Plant Mosquito. *Ecology* 83(3):607–611.
- Hou, Z., Q. Li, M. Yang, Y. Liu, and C. Wei. 2015. Ecology of *Meimuna mongolica* (Hemiptera: Cicadidae) nymphs: instars, morphological variation, vertical distribution and population density, host-plant selection, and emergence phenology. *Journal of Insect Science* 15(1):1–6. Available at: <https://academic.oup.com/jinsectscience/article/15/1/42/2583144>. Accessed 25 May 2020.
- Hunter, P.E., and H.O. Lund. 1960. Biology of the periodical cicada in Georgia. *Journal of Economic Entomology* 53(5):961–963.
- Jacobs, M. 1953. Observations on the two forms of the periodical cicada, *Magicicada septendecim* (L.). *Proceedings of the Indiana Academy of Science* 63:177–179.
- Karban, R. 1981. Effects of local density on fecundity and mating speed for periodical cicadas. *Oecologia* 51(2):260–264.

- Lederhouse, R.C., M.D. Finke, and Scriber, J.M. 1982. The contributions of larval growth and pupal duration to protandry in the Black Swallowtail butterfly, *Papilio polyxenes*. *Oecologia* 53(3):296–300.
- Lloyd, M., and R. Karban. 1983. Chorusing centers of periodical cicadas. *Journal of the Kansas Entomological Society* 56(3):299–304.
- Logan, D.P., C.A. Rowe, and B.J. Maher. 2014. Life history of Chorus Cicada, an endemic pest of kiwifruit (Cicadidae: Homoptera). *New Zealand Entomologist* 37(2):1–11. Available at: <https://www.tandfonline.com/doi/full/10.1080/00779962.2014.897302>. Accessed 28 May 2020.
- McClave, J.T. and T. Sincich. 2000. *A First Course in Statistics, Annotated Instructor's Edition*, (Seventh Edition), Prentice Hall, Upper Saddle River, NJ. Pp. 293–297.
- Morbey, Y.E., and R.C. Ydenberg. 2008. Protandrous arrival timing to breeding areas: a review. *Ecology Letters* 4(6):663–673. Available at: <https://onlinelibrary.wiley.com/doi/full/10.1046/j.1461-0248.2001.00265.x>. Accessed 26 May 2020.
- Riley, C.V. 1869. The periodical cicada. (Homoptera Cicadidae). Seventeen and thirteen year broods. Pages 18–42, In: *First Annual Report on the Noxious, Beneficial and Other Insects of the State of Missouri*. Jefferson City, MO. 145 + 6 pp.
- Saisho, Y. 2010. Mathematical observations on the relation between eclosion period and the copulation rate of cicadas. *Mathematical Biosciences and Engineering* 7(2):443–453.
- Simon, C. 1996. The Periodical Cicada. Department of Ecology and Evolutionary Biology, University of Connecticut. Available at: <http://hydrodictyon.eeb.uconn.edu/people/simon/cicada.htm>. Accessed 9 November 2005.
- Tinbergen, N. 1969. *Curious Naturalists*. The Natural History Library, Doubleday Anchor Books, New York, NY. 301 pp.
- Wade, M.J., S.M. Shuster, and J.P. Demuth. 2003. Sexual selection favors female-biased sex ratios: the balance between the opposing forces of sex-ratio selection and sexual selection. *The American Naturalist* 162(4):403–414.
- Warner, R.R. 1975. The adaptive significance of sequential hermaphroditism in animals. *The American Naturalist* 109(965):61–82.
- Whiles, M.R., M.A. Callahan, Jr., C.K. Meyer, B.L. Brock, and R.E. Charlton. 2001. Emergence of periodical cicadas (*Magicicada cassini* [sic]) from a Kansas riparian forest: densities, biomass and nitrogen flux. *The American Midland Naturalist* 145(1):176–187.
- Williams, K.S., and C. Simon. 1995. The ecology, evolution, and behavior of periodical cicadas. *Annual Review of Entomology* 40:269–295.

DATA APPENDIX**Both Sites Combined (Figure 6)**

<u>Day 1</u>	$P\Box = 43/67 = 0.642$ $Z = 2.32$	Proportion of males > 50% p value 0.0203	Significant at 0.05
<u>Day 3</u>	$P\Box = 68/111 = 0.613$ $Z = 2.77$	Proportion of males > 50% p value 0.0176	Significant at 0.05
<u>Day 9</u>	$P\Box = 16/80 = 0.200$ $Z = -5.37$	Proportion of males < 50% p value $8 \times 10^{-8} \approx 0$	Significant at 0.01
<u>Day 10</u>	$P\Box = 6/44 = 0.136$ $Z = -4.82$	Proportion of males < 50% p value $1.4 \times 10^{-6} \approx 0$	Significant at 0.01
<u>Overall</u>	$P\Box = 544/1228 = 0.443$ $Z = -4.00$	Proportion of males < 50% p value 0.0007	Significant at 0.01

Site 1 (Figure 7)

<u>Day 6</u>	$P\Box = 67/165 = 0.406$ $Z = -2.41$	Proportion of males < 50% p value 0.0158	Significant at 0.05
<u>Day 7</u>	$P\Box = 78/185 = 0.421$ $Z = -2.31$	Proportion of males < 50% p value 0.0330	Significant at 0.05
<u>Day 9</u>	$P\Box = 16/77 = 0.208$ $Z = -5.16$	Proportion of males < 50% p value $8 \times 10^{-8} \approx 0$	Significant at 0.01
<u>Overall</u>	$P\Box = 444/1029 = 0.431$ $Z = -4.40$	Proportion of males < 50% p value 0.00001	Significant at 0.01

Site 2 (Figure 8)

<u>Day 1</u>	$P\Box = 24/36 = 0.667$ $Z = 2.00$	Proportion of males > 50% p value 0.0455	Significant at 0.05
<u>Day 3</u>	$P\Box = 24/32 = 0.750$ $Z = 2.83$	Proportion of males > 50% p value 0.0047	Significant at 0.01
<u>Days 1-3</u>	$P\Box = 56/81 = 0.690$ $Z = 3.44$	Proportion of males > 50% p value 0.0006	Significant at 0.01

Combining Data from Citizen Scientists and Weather Stations to Define Emergence of Periodical Cicadas, *Magicicada* Davis spp. (Hemiptera: Cicadidae)

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Abstract: The appearance of periodical cicadas, *Magicicada* Davis spp. (Hemiptera: Cicadidae), in the United States has been a source of wonder, confusion, and consternation from the time of colonization to the present. The ability to forecast the emergence of periodical cicadas has practical implications to homeowners, urban foresters, nursery growers, and orchardists trying to protect young trees from cicada damage, and to educators and the media as they teach and inform diverse audiences. By linking large numbers of cicada sightings collected on cellular phones by citizen scientists using the Cicada Safari app with widely available web-based weather data, we define dates, days of the year, and accumulated degree days for sightings of 17-year Brood X straggler cicadas. We present a procedure for coupling observations made by citizen scientists with data from weather stations to track patterns of cicada emergence which may have applicability throughout the range of periodical cicadas in the United States.

INTRODUCTION

Massive synchronous appearances (Figures 1 and 2) of periodical cicadas, *Magicicada* Davis spp. (Hemiptera: Cicadidae), in North America have been a source of wonder, confusion, and consternation from the time of the colonists' first documented observations made in Plymouth, Massachusetts in 1663 to the present (Kritsky 2004). One of the earliest accounts of a pending emergence of periodical cicadas in the colony of Maryland was reported in the 3 April 1751 issue of *The Maryland Gazette*. A dire excerpt of this account read "...in some Places the Locusts have been found in great plenty, just under the surface of the Earth, almost at their full growth. *May God avert our impending Calamities.*" (Anonymous 1751). This ominous report most likely refers to Brood XIX, a brood of thirteen-year cicadas found in what is now St. Mary's County, Maryland which was then the former colonial capital of Maryland and an important agricultural center.

Beyond the intrinsic value of understanding the phenology of cicada emergence, knowing when cicadas appear and being able to predict their appearance has several practical implications. Established mature trees appear to suffer little long-term damage caused by ovipositing female cicadas as they insert eggs into small woody branches (Miller and



Figure 1. Mass emergence of periodical cicadas. After spending 17 years underground, Brood XIII periodical cicadas emerged in massive numbers in Elmhurst, Illinois during the last week of May 2007. Thousands of cicadas clinging to ancient trees were a common sight in suburban neighborhoods. Their exuvia accumulated in deep piles beneath trees and in lawns. Photographed by Michael J. Raupp.



Figure 2. Mass emergence of periodical cicadas. Piled one atop of another, shed skins and teneral adult periodical cicadas of Brood XIII festooned leaves of maples and other shade trees in Elmhurst, Illinois in late May 2007. Photographed by Michael J. Raupp.

Crowley 1998). However, oviposition injury on young trees and shrubs can lead to severe damage including reduced rates of growth, branch breakage, reduced flowering, and destruction of fruit bearing terminals in young fruit trees (Hogmire et al. 1990, Williams and Simon 1995, Miller 1997, Miller and Crowley 1998). Knowing when cicadas will emerge in a location can inform decisions of urban foresters planning to plant trees in cities and along roadways. Commercial nurseries, fruit growers, and homeowners need phenological information to plan and implement interdiction measures such as the use of exclusionary netting put into place to reduce cicada injury (Hogmire et al. 1990, Ahern et al. 2005). The appearance of periodical cicadas has far-reaching sociological impacts as well. Entomologists will be asked by brides and wedding planners when cicadas will emerge in geographic locations to avoid conflict with scheduling outdoor weddings in the season of cicada emergence. Teachers and others involved in scientific outreach will want to know when cicadas will emerge to plan curricula for students. Entomologists will receive numerous requests from reporters and media outlets anxious to photograph, record, and share information about cicadas and their behaviors. While entomophiles will eagerly await the arrival of cicadas, those fearful of insects will seek guidance for scheduling prophylactic counseling and planning travel to avoid encountering cicadas.

The primacy of temperature in driving what has been called the short-term synchronization of periodical cicada emergence within a season was first investigated by Heath (1968). His work provided a physiological explanation for the emergence of periodical cicadas linked to soil temperatures. By measuring the body temperature of emerging cicada nymphs and linking these data with soil temperatures at various depths, he found strong concordance of synchronous cicada emergence with a soil temperature of 17.890 °C at a 20 cm depth (64.202 °F at 7.87 in). This study forms the basis for many popular accounts predicting the emergence of cicada nymphs when soil temperatures reach 18 °C (64.4 °F) (Fitzgerald 2016, Sheikh 2017, McKeever 2020). Kritsky et al. (2005) refined the use of meteorological data to predict cicada emergence by correlating historical records of emergence dates of Broods X and XIV with ambient air temperatures from the month of April preceding the emergence. The formula to predict the beginning of a cicada emergence was $E = (19.465 - t)/0.5136$, where E = emergence start date in May and t = average April temperatures in °C. This strong correlation explained 99% of the observed variation and was highly accurate in predicting the emergence of Brood X cicadas in Cincinnati, Ohio in 2004. This robust model also predicted 17-year cicada emergence within three days in locations beyond Ohio including Tennessee, North Carolina, Massachusetts, and Kentucky (Kritsky et al. 2009). Further developments in temperature-based predictions of cicada emergence were presented by Kritsky et al. (2009) who linked ambient air temperatures to soil temperatures. Using data loggers placed in the ground at the depth of 15 cm (5.9 in) in May, Kritsky et al. (2009), found that the previous two- and three-day running average air temperatures correlated strongly ($r^2 = 0.89$) with soil temperatures. They concluded that cicada emergence forecasts might be fine-tuned using extended weather forecast information.

One of the limitations to developing predictive models for cicada emergence has been gathering large sets of data distributed in time and space. The value of involving the general public in generating data useful in clarifying geographic distribution patterns of periodical cicadas has long been recognized (Dybas 1969, Kritsky et al. 2005). While the

primary concern of data quality is sometimes called into question when citizens participate in data collection, studies show that effective training coupled with clear protocols and appropriate oversight enables volunteers to collect data comparable to those of experts (Bonney et al. 2014). With citizen science programs becoming more widely implemented and accepted, it is now possible to overcome some sample size limitations and gather large amounts of data to describe spatial and temporal patterns of insects including those of periodical cicadas. In 2019, Mount St. Joseph University released an app for Android and Apple IOS phones called Cicada Safari. The goal of Cicada Safari is to allow volunteers to take images of adult periodical cicadas that can be matched to precise locations and dates of appearance, thus enabling scientists to track cicadas in space and time. After citizen scientists snap an image of an insect and load it into the app, thoroughly trained staff at Mount St. Joseph University verify that the image is indeed a periodical cicada, an exuvia of a periodical cicada, or a red-eyed cicada nymph and enter into the database the date, latitude, and longitude of the sighting. At the time of this writing thousands of vetted records from Broods VIII, IX, and “stragglers” (cicadas that emerge off-cycle from the rest of their brood, Marshall 2001) from several other broods including Brood X in the metropolis of Maryland, the District of Columbia, northern Virginia, and the Midwest including parts of Ohio and Kentucky have been entered into the data base.

By virtue of the fact that insect development is strongly linked to temperature (Taylor 1981), entomologists regularly use weather data to forecast insect activity (USPEST.ORG [2020]). Herms (2004) provided a concise explanation on the use of growing degree days for predicting phenological events such as egg hatch, colonization, and adult emergence for more than 40 important arthropod pests of trees and shrubs. Recently, a consortium of universities including Oregon State and Ohio State, several government agencies including the United States Department of Agriculture – Animal and Plant Health Inspection Service – Plant Protection and Quarantine (USDA-APHIS-PPQ), the National Plant Diagnostic Network, the USDA Regional IPM Centers, and others have created a website that provides weather data to assist in pest prediction. Included at this site are models to generate local growing degree-day accumulations used by extension personnel, growers, field persons, consultants, researchers, and students in making timely pest management decisions. Data is collected from more than 32,000 weather stations nationwide (USPEST.ORG [2020]). This database makes degree day information readily available throughout all 50 states in the United States.

The primary objective of this study was to link sightings of periodical cicadas collected by citizen scientists using the Cicada Safari app to weather data available at the USPEST.ORG (2020) website. By linking these data, we describe in degree days when Brood X stragglers emerged in the greater Baltimore-Washington metropolitan region, nearby locations in northern Virginia, and stragglers that emerged in the Midwest in southern Ohio and northern Kentucky during the spring of 2020. We also summarized the day of the year on which cicadas were sighted. A secondary objective was to compare emergence patterns of Brood X stragglers in the Baltimore-Washington metropolis, northern Virginia, and the Midwest using data collected by Cicada Safari volunteers in 2020.

METHODS

Data on cicada emergence was collected using the Cicada Safari app. Brood X data consisted of 406 sightings made between 19 April 2020 and 14 June 2020. These cicadas, known as stragglers, emerged one year prematurely from the rest of their massive brood that will emerge in 2021. For the Baltimore-Washington metropolitan (DCMD) there were 154 reported sightings; for northern Virginia (VA) there were 153 reported sightings; and for Midwest stragglers (OHKY) there were 99 reported sightings. The first step in linking data from citizen scientists via the Cicada Safari app to an appropriate weather station nearby was accomplished by entering the latitude and longitude of the cicada sighting from Cicada Safari into Google Maps at <https://www.google.com/maps/>. This allowed visualization of the location of the sighting. Google Maps provides the town, state, and zip code for the sighting. Degree day accumulations were generated from the database maintained by USPEST.ORG (2018) at https://uspest.org/dd/model_app. The zip code of the cicada sighting from Google Maps was entered into the USPEST.ORG (2018) station search by clicking on the “Station” tab on the tool bar and clicking “search for stations.” By clicking on the “(MAP)” tab, a searchable map of weather stations near the cicada sighting appeared. We then selected a weather station to generate degree days based on two criteria. The first criterion was proximity to each cicada sighting. The second and more important criterion was the quality of the data collected by the weather station. USPEST.ORG (2018) defines and calculates the quality of weather data provided by each station in the following way. “Quality scores range from 0 to 100%; stations with scores less than 75% are not shown. Higher scores are better, but differences less than 10% are probably not important. Quality score calculation: for each day, we expect a station to report a temperature and a dewpoint at least once in each hour. We calculate the percentage of these measurements which are present. (The remainder of the data is estimated.) Each quality score is a weighted average of these daily percentages, covering the period ending yesterday and starting about as long ago as is relevant for this application. Note that the score is only an estimate of the fraction of observed data used by the model you will run, and that outages in prior years do not affect the scores.” Weather data used in our analyses were taken only from stations with scores ranked 90–99%.

Following the selection of the appropriate weather station, to calculate accumulated degree days for each cicada sighting, parameters were set for the online degree day models by clicking the “Model” tab on the toolbar. These parameters include “Model category” which was set at “all models”, “Select Model” which was set at “degree-day calculator (general purpose)”, “calculation method” which was set to “simple averaging/growing dds”, “lower” threshold which was set to “50 °F”, and “upper” threshold which was set to “95 °F”, “Start” date which was set to “Jan. 1 2020” and “End” date which was set at the date to the day at which each cicada sighting was made. Clicking the “Output” tab runs the model. By selecting the “show full table” button on the output page a complete list of accumulated degree days leading up to the cicada sighting appears. This degree day was linked to the cicada sighting and used for analysis. Parameter settings were selected due to their widespread use in pest prediction (Hermes 2004, Davidson and Raupp 2014, Siminsky 2017, Shrewsbury 2018).

Data on which day of the year cicadas were sighted was generated by converting the reported date of the sighting to the corresponding day of the year. For example, a sighting on 24 May 2020 would be day 145 of 2020.

In addition to recording the accumulated degree days for each sighting, the distance between each cicada sighting and the weather station was determined by copying latitudes and longitudes of both locations into the Movable Type Scripts website (Veness 2002–2020) which calculates the distance between two latitude/longitude points (<https://www.movable-type.co.uk/scripts/latlong.html>). Average distances between cicada sightings and locations of the nearest weather stations were summarized using the Descriptive Statistics procedure of Statistix (Analytical Software 2013).

Visualization of cicada emergence patterns for Broods X stragglers was constructed using the Box and Whisker chart function of Microsoft Windows Excel version 2016. A Shapiro-Wilk Test was conducted on data from DCMD, VA, and OHKY to determine if assumptions of normality were met prior to further statistical analysis (Zar 1999, Statistix [Analytical Software 2013]). Differences in degree day accumulations and the day of sighting were compared among the three geographic regions with a nonparametric analysis of variance (Kruskal-Wallis test, Zar 1999) followed by a Dunn's All-Pairwise Comparisons test to separate ranks into homogeneous groups (Zar 1999, Statistix [Analytical Software 2013]).

RESULTS

The earliest and latest dates of sightings for Brood X stragglers were 19 April 2020 and 14 June 2020 for DCMD, 2 May 2020 and 14 June 2020 for VA, and 15 May 2020 and 7 June 2020 for OHKY. The range of degree days from least to most for each region were 147 to 938 for DCMD, 276 to 1125 for VA, and 332 to 949 for OHKY (Figure 3, Table 1). The earliest and latest days of sightings for Brood X stragglers were days 110 and 166 for DCMD, days 123 and 166 for VA, and days 136 and 159 for OHKY (Figure 4, Table 1).

Results of Shapiro-Wilk tests for normality revealed values for degree days and day of the year not to be normally distributed: degree days DCMD, $n = 154$, $W = 0.97$, $P = 0.003$; degree days VA, $n = 153$, $W = 0.93$, $P = 0.000$; degree days OHKY $n = 99$, $W = 0.95$, $P = 0.001$; day of year DCMD, $n = 154$, $W = 0.90$, $P = 0.000$; day of the year VA, $n = 153$, $W = 0.91$, $P = 0.000$; day of the year OHKY $n = 99$, $W = 0.96$, $P = 0.004$. Results of the Kruskal-Wallis test for degree day accumulations revealed significant differences among regions (Kruskal-Wallis Statistic, corrected for ties = 11.31, $P = 0.003$). Sightings of cicadas occurred at significantly fewer degree days in DCMD than in VA while sightings in OHKY were intermediate between DCMD and VA (Dunn's All-Pairwise Comparisons, $P < 0.05$) (Figure 3). Results of the Kruskal-Wallis test for day of the year sightings also revealed significant differences among regions (Kruskal-Wallis Statistic, corrected for ties = 10.05, $P = 0.007$) (Figure 4). Sightings of cicadas occurred significantly earlier in the year in VA than in OHKY with DCMD intermediate between these locations (Dunn's All-Pairwise Comparisons, $P < 0.05$).

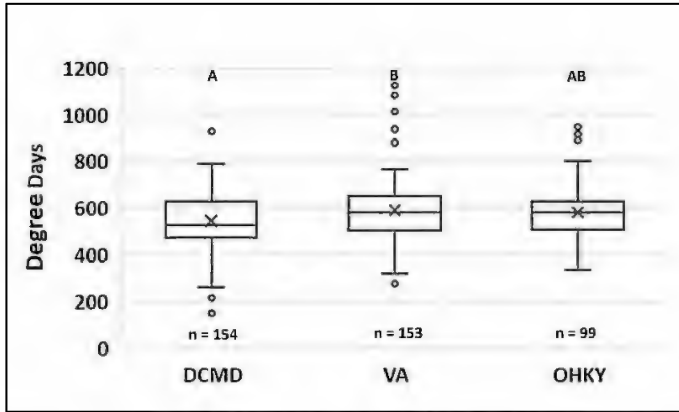


Figure 3. Box whisker plot of accumulated degree days for Brood X stragglers in the Baltimore-Washington metropolitan region (DCMD), northern Virginia (VA), and southern Ohio and northern Kentucky (OHKY) that appeared in 2020. Broods VIII and Brood X stragglers that appeared in 2019 and 2020, respectively. The middle line of the box represents the median, the x in the box represents the mean, the bottom line of the box represents the median of the bottom half or first quartile of the data, the top line of the box represents the median of the top half or third quartile of the data, the whiskers (vertical lines) extend from the ends of the box to the minimum value and maximum value. Outliers are represented by single data points above or below whiskers. Geographic regions that share the same letter do not differ (Dunn’s All-Pairwise Comparisons, $P < 0.05$).

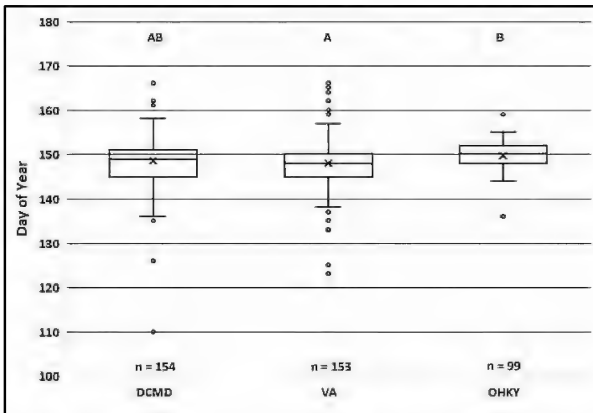


Figure 4. Box whisker plot of day of the year for Brood X stragglers in the Baltimore-Washington metropolitan region (DCMD), northern Virginia (VA), and southern Ohio and northern Kentucky (OHKY) that appeared in 2020. The middle line of the box represents the median, the x in the box represents the mean, the bottom line of the box represents the median of the bottom half or first quartile of the data, the top line of the box represents the median of the top half or third quartile of the data, the whiskers (vertical lines) extend from the ends of the box to the minimum value and maximum value. Outliers are represented by single data points above or below whiskers. Geographic regions that share the same letter do not differ (Dunn’s All-Pairwise Comparisons, $P < 0.05$).

Table 1. Summary of descriptive parameters of Brood X cicada sightings made by citizen scientists in the Baltimore-Washington metropolitan area (DCMD), northern Virginia (VA), and southern Ohio and northern Kentucky (OHKY) in 2020.

Parameter	DCMD (n = 154)	VA (n = 153)	OHKY (n = 99)
Degree days of sightings			
First degree days	147	276	332
Last degree days	938	1125	949
Mean degree days	544.99	590.71	579.94
Variance degree days	19,277	17,603	15,628
Standard deviation degree days	138.84	132.68	125.01
Coefficient of variation degree days	25.476	22.460	21.556
Median degree days	525.00	579.00	582.00
Day of the year of sightings			
First day	110	123	136
Last day	166	166	159
Mean day of year	148.38	148.01	149.63
Variance day of year	49.284	34.928	11.115
Standard deviation day of year	7.02	5.91	3.34
Coefficient of variation day of year	4.731	3.993	2.232
Median day of year	149.00	148.00	150.00

Estimates of cicada emergence using degree days were far more variable than estimates based on the actual day of the year (Table 1). While the median degree days among locations spanned a range of 46 degree days from about 545 to 591, the median day of the year ranged between day 148 and 150, a span of two days among locations. The coefficients of variation in accumulated degree days for DCMD, VA, and OHKY were approximately 25%, 22%, and 22%, respectively (Table 1). The coefficients of variation in days of the year for DCMD, VA, and OHKY were approximately 5%, 4%, and 2%, respectively. Mean distances in kilometers between sightings reported to Cicada Safari and nearby weather stations used for degree day calculations for DCMD, VA, and OHKY were 4.06 (± 0.22 s.e.), 2.95 (± 0.26 s.e.), and 5.03 (± 0.34 s.e.), respectively.

DISCUSSION

The first objective of this study, to link meteorological data from weather stations to vetted sightings of periodical cicadas from the Cicada Safari app, revealed differences in both degree day accumulations and day of the year patterns of appearance over the relatively small geographic distance between the Baltimore-Washington metropolitan region and northern Virginia. Cicadas in the Baltimore-Washington metropolitan region were the first to appear both by date, day, and degree day in 2020 (Figures 3 and 4) despite the fact that this region lies in close proximity to northern Virginia separated only by the Potomac River. One possible explanation for the earlier emergence in the

Baltimore-Washington region compared to northern Virginia is the level of urbanization and attendant levels of impervious surfaces. Impervious surfaces are well known to raise ambient temperatures and accelerate insect development (Raupp et al. 2012). The rapid accumulation of degree days in urbanized areas is exemplified by comparing degree days in Washington, DC to those in northern Virginia on the median day of cicada sightings, days 149 (28 May) and 148 (27 May), respectively. At a weather station nearest the greatest number of reported cicada sightings in urbanized Washington, DC, on day 149, 757 degree days had accumulated. At a weather station nearest the greatest number of cicada sightings in suburban northern Virginia on day 148, only 527 had accumulated. More than 90% of the cicada sightings in the Baltimore-Washington metropolitan region were made in counties and cities where impervious surfaces accounted for 6 to 26% of the land area. In Fairfax and Loudon Counties in Virginia where more than 90% of cicada sightings were made, impervious surfaces accounted for 9% and 16%, respectively. It is likely that warmer temperatures in highly urbanized locations may have advanced cicada development resulting in earlier emergences and sightings of adult cicadas. This hypothesis should be tested and evaluated using data specifically gathered across urbanization gradients. Urbanization gradients have been used as surrogates for predicating impacts of climate change on insects (Lahr et al. 2018). By dispersing the synchronization of cicada emergence, urbanization could disrupt the critical predatory satiation strategy for survival utilized by periodical cicadas (Karbon 1982).

Smaller variation observed in the day of the year that a sighting occurred relative to the degree days at which the sighting took place may be attributed to one of several factors acting alone or in concert (Figures 3 and 4, Table 1). Dale and Frank (2014 a, 2014 b) demonstrated that temperature regimes can vary dramatically over relatively short distances within cities as urban green spaces intermix with buildings and hardscape. Local variation in temperature regimes could explain in part the relatively greater variation observed in degree day accumulations where the built environment interdigitates with green spaces and natural areas. The fact that the median ranks of sightings in the Baltimore-Washington metropolis compared to northern Virginia differed by only one day, 149 compared to 148, is surprising. Heath (1968) and Kritsky (2004) noted that the great majority of cicadas emerge during the same week and sometimes on a single night in a given location. Clearly, one environmental variable with little variation at similar latitudes is photoperiod. Williams and Simon (1995) suggested that photoperiod along with air and soil temperatures could serve as cues synchronizing emergence. The role of photoperiod in synchronizing cicada emergence likely deserves further investigation.

The second objective of this study, to compare temporal patterns of cicada sightings between Midwestern Brood X stragglers and those in the Baltimore-Washington metropolitan region and northern Virginia, revealed similarities in sightings with respect to degree day accumulations and the days at which cicadas were sighted. The most striking similarity was the concordance of the median day of the year on which cicadas emerged (Figure 4). This is not unexpected due to the latitudinal similarities between sightings in the Baltimore-Washington metropolis and northern Virginia and those in the Midwest. The average latitudinal difference between Brood X cicadas studied in the Baltimore-Washington metropolis and northern Virginia and those in the Midwest was

merely 0.047 degrees. Buckley et al. (2017) found that the number of cumulative degree days required by insects to complete development changes with respect to changing latitude. In this study there was virtually no change in latitude. Future comparisons of cicada broods more widely distributed along latitudinal gradients could provide a way to elucidate and separate the relative contributions of temperature and photoperiod in synchronizing emergence of cicadas.

Recent citizen science projects have enabled entomologists to accumulate large amounts of data at lower costs for projects ranging from the vanishing of native lady beetles (Coleoptera: Coccinellidae) in the United States and United Kingdom (Gardiner et al. 2012, Losey et al. 2012) to elucidating temporal and spatial patterns of Monarch butterflies, *Danaus plexippus* (Linnaeus) (Lepidoptera: Nymphalidae), and their parasitoids (Oberhauser and Prysby 2008, Oberhauser et al. 2017). By combining data generated by citizen scientists through the Cicada Safari app and linking this data to readily available degree day data available at the USPEST.ORG website (2018, 2020), we characterized the appearance of Brood X periodical cicada stragglers. It will be interesting to compare our findings to those of Brood X cicadas when they appear en masse in spring of 2021. According to our findings, people living in Washington, DC, Maryland, northern Virginia, southern Ohio, and northern Kentucky can expect to see approximately half of Brood X cicadas appearing between day 147 and 149 (2021 is not a leap year as is 2020) when degree days have accumulated between 525 and 582 locally. We hope that the methodology outlined in this report will assist the general public, urban foresters, nursery growers, educators, and the media in predicting when periodical cicadas will appear not only at locations studied herein, but also in other regions in the United States.

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LITERATURE CITED

- Ahern, R.G., S.D. Frank, and M.J. Raupp. 2005. Comparison of exclusion and imidacloprid for reduction of oviposition damage to young trees by periodical cicadas (Hemiptera: Cicadidae). *Journal of Economic Entomology* 98(6):2133–2136.
- Analytical Software. 2013. Statistix. Version 10. Analytical Software, Tallahassee, FL.
- Anonymous. 1751. *The Maryland Gazette*. 3 April 1751. Page 1367.
- Bonney, R., J.L. Shirk, T.B. Phillips, A. Wiggins, H.L. Ballard, A.J. Miller-Rushing, and J.K. Parrish. 2014. Next steps for citizen science. *Science* 343(6178):1436–1437.
- Buckley, L.B., A.J. Arakaki, A.F. Cannistra, H.M. Kharouba, and J.G. Kingsolver. 2017. Insect development, thermal plasticity and fitness implications in changing, seasonal environments. *Integrative and Comparative Biology* 57(5):988–998.

- Dale, A.G., and S.D. Frank. 2014a. The effects of urban warming on herbivore abundance and street tree condition. *PLoS ONE* 9(7):e102996. Available at: <https://doi.org/10.1371/journal.pone.0102996>.
- Dale, A.G., and S.D. Frank. 2014b. Urban warming trumps natural enemy regulation of herbivorous pests. *Ecological Applications* 24(7):1596–1607.
- Davidson, J.A., and M.J. Raupp. 2014. *Managing Insects and Mites on Woody Plants: An IPM Approach*. 2014. Third Edition. Tree Care Industry Association, Londonderry, NH. 174 pp.
- Dybas, H. S. 1969. The 17-year cicada: A four-year “mistake”? *Bulletin Field Museum of Natural History* 40(8):10–12.
- Fitzgerald, K. 2016. How Do Cicadas Know When to Emerge from the Ground? Entomology Today. Entomological Society of America, Annapolis, MD. Available at: <https://entomologytoday.org/2016/03/22/how-do-cicadas-know-when-to-emerge-from-the-ground/>. Accessed 17 June 2020.
- Gardiner, M.M., L.L. Allee, P.M.J. Brown, J.E. Losey, H.E. Roy, and R.R. Smyth. 2012. Lessons from lady beetles: accuracy of monitoring data from US and UK citizen-science programs. *Frontiers in Ecology and Environment* doi:10.1890/110185. Available at: <http://nora.nerc.ac.uk/id/eprint/20992/1/N020992JA.pdf>.
- Heath, J.E. 1968. Thermal synchronization of emergence in periodical “17-year” cicadas (Homoptera, Cicadidae, *Magicicada*). *The American Midland Naturalist* 80(2):440–448.
- Herms, D.A. 2004. Using degree-days and plant phenology to predict pest activity. Pages 49–59. In: V. Krischik and J. Davidson (Editors), *IPM (Integrated Pest Management) of Midwest Landscapes*. Minnesota Agricultural Experiment Station Publication SB-07645, St. Paul, MN. 316 pp.
- Hogmire, H.W., T.A. Baugher, V.L. Crim, and S.I. Walter. 1990. Effects and control of periodical cicada (Homoptera: Cicadidae) oviposition injury on nonbearing apple trees. *Journal of Economic Entomology* 83(6):2401–2404.
- Karban, R. 1982. Increased reproductive success at high densities and predator satiation for periodical cicadas. *Ecology* 63(2):321–328.
- Kritsky, G. 2004. *Periodical Cicadas: The Plague and the Puzzle*. Indiana Academy of Science Press, Indianapolis, IN. 147 pp.
- Kritsky, G., J. Webb, M. Folsom, and M. Pfiester. 2005. Observations on periodical cicadas (Brood X) in Indiana and Ohio in 2004 (Hemiptera: Cicadidae: *Magicicada* spp.). *Proceedings of the Indiana Academy of Science* 114(1):65–69.
- Kritsky, G., A. Hoelmer, and M. Noble. 2009. Observations on periodical cicadas (Brood XIV) in Indiana and Ohio in 2008 (Hemiptera: Cicadidae: *Magicicada* spp.). *Proceedings of the Indiana Academy of Science* 118(1):83–87.
- Lahr, E.C., R.R. Dunn, and S.D. Frank. 2018. Getting ahead of the curve: cities as surrogates for global change. *Proceedings of the Royal Society B: Biological Sciences* 285(1882):20180643. DOI: 10.1098/rspb.2018.0643
- Losey, J., L. Allee, and R. Smyth. 2012. The lost ladybug project: Citizen spotting surpasses scientist’s surveys. *American Entomologist* 56(1):22–24.
- Marshall, D.C. 2001. Periodical cicada (Homoptera: Cicadidae) life-cycle variations, the historical emergence record, and the geographic stability of brood distributions. *Annals of the Entomological Society of America* 94(3):386–399.
- McKeever, A. 2020. Millions of cicadas are emerging in the U.S. right now. Here’s why. National Geographic Society. Available at: <https://www.nationalgeographic.com/animals/2020/06/millions-cicadas-emerging-now-united-states/>. Accessed 17 June 2020.

- Miller, F.D. 1997. Effects and control of periodical cicada *Magicicada septendecim* and *Magicicada cassini* [sic] oviposition injury on urban forest trees. *Journal of Arboriculture* 23(6):225–232.
- Miller, F., and W. Crowley. 1998. Effects of periodical cicada ovipositional injury on woody plants. *Journal of Arboriculture* 24(5):248–253.
- Oberhauser, K.S., and M.D. Prysby. 2008. Citizen science: Creating a research army for conservation. *American Entomologist* 54(2):97–99.
- Oberhauser, K., D. Elmquist, J.M. Perilla-López, I. Gebhard, L. Lukens, and J. Stireman. 2017. Tachinid fly (Diptera: Tachinidae) parasitoids of *Danaus plexippus* (Lepidoptera: Nymphalidae). *Annals of the Entomological Society of America* 110(6):536–543. doi: 10.1093/aesa/sax048.
- Raupp, M.J., P.M. Shrewsbury, and D.A. Herms. 2012. Disasters by design: outbreaks along urban gradients. Pages 313–340. In: P. Barbosa, D.K. Letourneau, and A.A. Agrawal (Editors), *Insect Outbreaks Revisited*. John Wiley & Sons, Ltd, Chichester, UK. 465 pp.
- Sheikh, K. 2017. Brood Awakening: 17-Year Cicadas Emerge 4 Years Early. Scientists search for the mysterious cause, as millions of hatching bugs loudly buzz the night away. *Scientific American*. Available at: <https://www.scientificamerican.com/article/brood-awakening-17-year-cicadas-emerge-4-years-early/>. Accessed 17 June 2020.
- Shrewsbury, P. 2018. Growing Degree Days: Getting Them and How to Use Them. University of Maryland Extension. Available at: <https://extension.umd.edu/ipm/growing-degree-days-getting-them-and-how-use-them>. Accessed 17 June 2020.
- Simisky, T. 2017. Growing Degree Days for Management of Insect Pests in the Landscape. Center for Agriculture, Food and the Environment, University of Massachusetts Amherst. Available at: <https://ag.umass.edu/landscape/fact-sheets/growing-degree-days-for-management-of-insect-pests-in-landscape>. Accessed 17 June 2020.
- Taylor, F. 1981. Ecology and evolution of physiological time in insects. *The American Naturalist* 117(1):1–23.
- USPEST.ORG. 2018. Online Phenology and Degree-day Models for agricultural and pest management decision making in the United States, app version 0.93. (This app is produced by uspest.org at the Integrated Plant Protection Center at Oregon State University with support from the USDA National Plant Diagnostic Network, The OSU Agricultural Experiment Station, various USDA CSREES/NIFA grants, USDA SARE, USDA RMA, and USDA IPM Centers - Western Region. Climate map data provided by OSU PRISM Group, real-time public weather data provided by U. Utah Mesowest and other networks including WSU AgWeatherNET, AGRIMET, CPS Adcon Networks, IFPNet Automata, California CIMIS, California PestCast, and others. Geo-coding (location search using place names) by OpenCage, using data© OpenStreetMap contributors.) Available at: https://uspest.org/dd/model_app. Accessed July 2020.
- USPEST.ORG. 2020. Welcome to the USPEST.ORG web server at the Integrated Plant Protection Center of Oregon State University. Available at: <https://uspest.org/>. Accessed July 2020.
- Veness, C. 2002–2020. Movable Type Scripts. Available at: <https://www.movable-type.co.uk/scripts/latlong.html>. Accessed July 2020.
- Williams, K.S., and C. Simon. 1995. The ecology, behavior, and evolution of periodical cicadas. *Annual Review of Entomology* 40:269–295.
- Zar, J.H. 1999. *Biostatistical Analysis*, Fourth Edition. Prentice Hall, Saddle River, NJ. 929 pp.

The Curculionoidea (Weevils) of the George Washington Memorial Parkway, Virginia

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ABSTRACT: One-hundred thirty-five taxa (130 identified to species), in at least 97 genera, of weevils (superfamily Curculionoidea) were documented during a 21-year field survey (1998–2018) of the George Washington Memorial Parkway national park site that spans parts of Fairfax and Arlington Counties in Virginia. Twenty-three species documented from the parkway are first records for the state. Of the nine capture methods used during the survey, Malaise traps were the most successful. Periods of adult activity, based on dates of capture, are given for each species. Relative abundance is noted for each species based on the number of captures. Sixteen species adventive to North America are documented from the parkway, including three species documented for the first time in the state. Range extensions are documented for two species. Images of five species new to Virginia are provided.

Keywords: beetles, biodiversity, Malaise traps, national parks, new state records, Potomac Gorge.

INTRODUCTION

This study provides a preliminary list of the weevils of the superfamily Curculionoidea within the George Washington Memorial Parkway (GWMP) national park site in northern Virginia.

Although there are more recent, phylogenetically-based classifications (e.g., Gillett et al. 2014, Gunter et al. 2016, Shin et al. 2018), we use the classification of Curculionoidea as utilized in *American Beetles* (Arnett et al. 2002) since this is the reference most likely to be used by, and most available to, readers of this paper.

The superfamily Curculionoidea contains seven North American families of weevils and weevil-like beetles, characterized by an elongated rostrum (Arnett et al. 2002). Of the seven families, six were documented from habitats within the GWMP.

The Nemonychidae (long-toothed or pine flower snout beetles) is a small family with a worldwide distribution (Oberprieler et al. 2007), containing only five North American genera. Adults are found in association with pollen of *Pinus* L. species (Pinaceae). They are similar to the Anthribidae in possessing straight antennae and a distinct labrum, but differ in the form of the rostrum which is elongate in the nemonychids but short, very broad and flat in anthribids (Anderson 2002c). Although treated as a subfamily in this paper per Arnett et al. (2002), the Cimberidinae has recently been elevated to family status as Cimberididae (Shin et al. 2018).

The Anthribidae (fungus weevils) comprise over 4,000 species and have a worldwide distribution. They are primitive weevils characterized by straight (not geniculate) antennae, very broad flat rostrum, exposed pygidium, and pronotal pubescence that is directed anteriorly (Valentine 2002). Like Nemonychidae, the adults possess a separate labrum and clypeus, unlike other Curculionoidea where these two parts of the head are fused together. Adults feed on the pollen of larval host plants or, in fungivorous species, on the fungi in which the larvae develop (Valentine 2002).

The Attelabidae (leaf-rolling weevils, tooth-nose snout beetles, and thief weevils) are represented in GWMP by all three known subfamilies (Attelabinae, Rhynchitinae, and Pterocolinae). They are considered primitive weevils based on their straight antennae. Familial characteristics include a concealed eighth tergite and exposed pygidium in both sexes; abdominal ventrites decreasing in length, the proximal three or four fused; and a body that is setose and without broad scales, and often metallic or otherwise brightly colored in many species (Hamilton 2002). The females of Attelabinae (leaf-rolling weevils) lay eggs on leaves that they have prepared by cutting with their mandibles so that the leaf can be rolled into a barrel-shaped structure that nourishes and protects the developing larvae (Hamilton 2002). In Rhynchitinae (tooth-nose snout beetles), the female oviposits in plant stems, leaves, or flowers and the larvae develop as miners of the living or dead tissue. The plant part containing the developing larvae is cut by the adult female using her mandibles and is either severed from the plant or latter dies and eventually drops. In the New World, 180 species of leaf-rolling weevils and 162 species of tooth-nose snout beetles have been described (Hamilton 2002). The female Pterocolinae (thief weevils) of the genus *Pterocolus* Say parasitize attelabid leaf-rolling weevils, preying on the eggs of the host and ovipositing in the leaf rolls prepared for the host larva. The pterocoline larvae feeds on the decaying leaf tissue and falls out to pupate in the ground (Vogt 1992).

The Brentidae (straight-snouted weevils and pear-shaped weevils) are represented in GWMP by two of the six North American subfamilies. The Apioninae are small pear-shaped weevils recognized by a long cylindrical trochanter with the femur attached at its apex. It contains approximately 140 species in North America (Anderson and Kissinger 2002). The Brentinae have elongate, parallel-sided bodies and a long, generally straight rostrum that often exhibits sexual dimorphism. The subfamily contains three species in three genera in North America (Anderson and Kissinger 2002).

The Ithyceridae (The New York Weevil) contains a single species recognized by its large size (12–18 mm [0.5–0.7 in]), distinct pubescence, and straight antennae (Anderson

2002b). This family is included in the Brentidae by some authors (e.g., Oberprieler et al. 2007).

The Curculionidae (true weevils, and snout, bark, and ambrosia beetles) are one of the most diverse beetle families in the world, following perhaps only the Staphylinidae (rove beetles) or Carabidae (ground beetles). More than 60,000 species have been described worldwide (Arnett et al. 2002). Eighteen subfamilies occur in the Nearctic, twelve of which are found in GWMP. The Curculionidae are recognized by the combination of their elongate rostrum with mouthparts that are situated at the apex and by their geniculate antennae with a compact antennal club, however some subfamilies, especially Scolytinae and Platypodinae, have the rostrum reduced and not markedly produced anteriorly (Anderson 2002a).

STUDY SITES

The study site includes lands managed by the National Park Service as units of the GWMP in Fairfax County, Virginia. Park sites that received the greatest inventory effort included Dyke Marsh Wildlife Preserve, Great Falls Park, Little Hunting Creek, and Turkey Run Park. Additionally, one species (*Trachyphloeosoma advena* Zimmerman) was documented from the study site in Arlington County. A map of these sites is provided in Steury (2011). The area is located between latitudes 38.985° and 38.717° and longitudes -77.246° and -77.078°. The site covers an area of approximately 1,615 ha (3,991 ac). Great Falls Park and Turkey Run Park fall within the Piedmont Plateau physiographic province while all other collection sites are on the Coastal Plain. Most sites are situated along the shore of the Potomac River, and the Piedmont Plateau sites border the Potomac Gorge, an area known for high species richness of plants and animals (Evans 2008). The Potomac Gorge (Cohn 2004) is a 24 km (15 mi) long, area of the Potomac River located just west of Washington, District of Columbia, and includes a steeply dissected landscape of bluffs, ravines, and floodplains along a high-gradient reach of the river (Fleming 2007). Most of the study sites are dominated by maturing, second growth, primarily upland, deciduous woodlands. More open, herbaceous-dominated, habitats can be found along the shore of Potomac River and in the freshwater, tidal, swamp, and marsh habitats at Dyke Marsh. More than 1,313 vascular plant taxa have been recorded in GWMP and 1,020 from Great Falls Park alone (Steury et al. 2008, Steury 2011).

MATERIALS AND METHODS

Specimens were collected during a 21-year period (1998–2018) using a variety of sporadic survey methods targeting arthropods, including: Malaise traps, Lindgren funnel traps, blacklight (UV) bucket traps, blacklight shone on sheets, leaf litter samples processed in Berlese funnels, beating sheets, pitfall traps, hand collecting, and bee bowls (96 ml [3.25 oz] white soufflé cups painted fluorescent yellow, fluorescent blue, or left non-fluorescent white and filled with a dilute mixture of detergent and water). Six Townes-style Malaise traps (Townes 1962) were set at Dyke Marsh, April 1998–December 1999; three each at Great Falls and Turkey Run Parks (March 2006–December 2009); and four at Little Hunting Creek (March–November 2017 and 2018). Traps at Dyke Marsh were set each year in the same locations: in open, tidal, freshwater marsh

dominated by narrowleaf cattail (*Typha angustifolia* L. [Typhaceae]); in floodplain forest dominated by red maple and silver maple (*Acer rubrum* L. and *A. saccharinum* L. [Aceraceae]) and tuliptree (*Liriodendron tulipifera* L. [Magnoliaceae]); and at the marsh/forest ecotone. In Great Falls Park, a trap was set in each of three habitats: quarry site (dry, upland, mixed deciduous/coniferous forest), swamp (dominated by red maple), and floodplain forest (dominated by oaks [*Quercus* L. sp. (Fagaceae)], and tuliptree). In Turkey Run Park, one trap was set in upland forest dominated by oaks and tuliptree and two traps in floodplain forest along the Potomac River (dominated by oaks, American basswood [*Tilia americana* L. (Tiliaceae)], and American sycamore [*Platanus occidentalis* L. (Platanaceae)]). At Little Hunting Creek, four traps were set in upland forest dominated by an ericaceous understory and a canopy of oaks, hickory (*Carya* Nutt. sp. [Juglandaceae]), American beech (*Fagus grandifolia* Ehrh. [Fagaceae]), and some Virginia pine (*Pinus virginiana* Mill. [Pinaceae]).

Additional collections were also made by sporadically using other collecting methods, including pitfall traps set at Dyke Marsh (five years), and at Little Hunting Creek, Great Falls Park, and Turkey Run Park (three years); Lindgren funnel traps and blacklight (UV) bucket traps set at Dyke Marsh, Great Falls Park, Little Hunting Creek, and Turkey Run Park (two years); blacklight shone on sheets at Great Falls Park and Turkey Run Park (three years); leaf litter from Dyke Marsh, Great Falls Park, and Turkey Run Park processed in Berlese funnels (two years); bee bowls set in riverside prairie at Great Falls Park (one year; Steury et al. 2009); and using beating sheets and hand collecting at all sites over seven years. Collectors included Christopher Acosta, Edward M. Barrows, Michael J. Blymyer, Karolyn Darrow, Colin Davis, Arthur V. Evans, Cristina Francois, Christy Jo Geraci, Steven W. Lingafelter, Jerry A. Louton, Deblyn Mead, Erik T. Oberg, David R. Smith, Warren E. Steiner, Brent W. Steury, Jil M. Swearingen, Jessica L. Ware, and Christopher C. Wirth. Citizen scientist volunteers in the GWMP bug lab sorted weevils from Malaise trap collection jar samples. Specimens were determined by Robert S. Anderson, Arthur V. Evans, Jens Prena, Charles L. Staines, and Brent W. Steury using a variety of literature sources, most notably: Blatchley and Leng (1916), O'Brien and Wibmer (1982), Downie and Arnett (1996), and Ciegler (2010). In addition, when possible, identifications were made or confirmed by comparison of GWMP specimens with specialist-identified specimens in the Canadian Museum of Nature Insect Collection (CMNC), Ottawa, Ontario, Canada, and the Department of Entomology, National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC. In spite of these efforts, four taxa could be identified reliably only to genus in the list below. New state record determinations are based on examination of the collections and the literature (mainly O'Brien and Wibmer [1982]). Specimens from GWMP were pinned, labeled, and deposited in the collections maintained at the GWMP, Turkey Run Park Headquarters in McLean, Virginia.

RESULTS AND DISCUSSION

LIST OF SPECIES

Subfamilies, genera, and species are listed alphabetically within each family for the 604 specimens collected. Tribe and subtribe are included alphabetically when these are used within a subfamily. An exclamation mark (!) is used to indicate taxa not previously

documented in Virginia. A double dagger (‡) indicates the six new Virginia records reported from the 2006 Potomac Gorge BioBlitz (Evans 2008) and includes one species, *Perigaster cretura* (Herbst), not then noted as a new state record. Adventive (non-native) species are indicated by a dagger (†). The number of specimens in the collection at GWMP is indicated in parentheses after each taxon. Collection sites are abbreviated as Dyke Marsh Wildlife Preserve (DM), Little Hunting Creek (LH), Great Falls Park (GF), and Turkey Run Park (TR). Other locations or collection methods are spelled out if necessary. The periods of adult activity are based on dates when live individuals were captured in the park. Dates separated by an en dash (–) indicate that the taxon was documented on at least one day during each month within this continuum of months, whereas dates separated by a comma represent individual observation dates. For traps set over multiple weeks, the first day of the set is used as the earliest date and the last day of the set as the latest date. Collection methods are designated as: bb (bee bowl), bf (Berlese funnel), bl (black-light shown on sheet), bs (beating sheet), bt (black-light bucket trap), hc (hand collected), lf (Lindgren funnel trap), mt (Malaise trap), and pf (pitfall trap). Some specimens of Apioninae were unidentifiable to species as species level identifications require examination of males and only females were available. Additionally, some specimens of the genus *Baris* Germar (Curculionidae) were unidentifiable to species as this genus requires taxonomic revision.

Superfamily CURCULIONOIDEA

Family NEMONYCHIDAE (long-toothed or pine flower snout beetles)

Subfamily CIMBERIDINAE

Tribe CIMBERIDINI

Cimberis pilosa (LeConte) – (6); DM; 12 Apr–10 May; mt.

Family ANTHRIBIDAE (fungus weevils)

Subfamily ANTHRIBINAE

Tribe CRATOPARINI

Euparius marmoreus (Olivier) – (11); DM, GF, LH, TR; 9 Apr–11 Sep; mt.

Euparius paganus Gyllenhal – (1); DM; 12–28 Aug; mt.

Tribe ISCHNOCERINI

Ischnocerus infuscatus Fåhraeus – (7); GF, TR; 22 Jun–30 Jul; bs, mt.

Tribe PIESOCORYNINI

Brachycorynus rectus (LeConte) – (1); TR; 19–30 Jun; mt.

Piesocorynus mixtus LeConte – (1); GF; 27 Jul–14 Aug; mt.

Piesocorynus plagifer Jordan – (1); TR; 24 Jun; bs.

Tribe PLATYSTOMINI

Toxonotus cornutus (Say) – (3); GF, TR; 10–30 Apr, 24 Jun–21 Jul; bs, mt.

Tribe TROPIDERINI

Eurymycter tricarinatus Pierce – (5); GF, TR; 21 May–24 Aug; bs, mt.

Tribe ZYGAENODINI

Eusphyrus walshi LeConte – (15); DM, GF, LH, TR; 10 Apr–4 Sep; mt.

Ormiscus saltator LeConte – (1); LH; 1–14 Jun; mt.

Subfamily CHORAGINAE

Tribe CHORAGINI

! *Choragus harrisi* LeConte – (1); LH; 1–14 Jun; mt. Valentine (1998) reported this species in the United States from Massachusetts to Maryland, west to Michigan and Oklahoma; it has also been recorded in Louisiana (Ferro and Nguyen 2016).

! *Choragus zimmermanni* LeConte – (2); LH, GF; 1–14 Jun, 15–30 Jul; mt. Valentine (1998) recorded this species in the United States as occurring from Massachusetts to Florida, west to Ohio and Texas. Although these two specimens are the first published records for Virginia, Chamorro (in litt., 12 March 2020) stated that Virginia specimens exist in the USNM as part of the recently acquired Barry D. Valentine collection.

Family ATTELABIDAE (leaf-rolling weevils, tooth-nose snout beetles, and thief weevils)

Subfamily ATTELABINAE

Synolabus bipustulatus (Fabricius) – (5); GF, LH; 21 May–30 Jul; mt. Hamilton (2002) mentions this species as *Attelabus bipustulatus* Fabricius, but Riedel and Hamilton (2007) have elevated the former subgenus *Synolabus* Jekel to generic status.

Subfamily RHYNCHITINAE

Tribe RHYNCHITINI

Eugnamptus angustatus (Herbst) – (10); DM, GF, TR; 10 Apr–14 Aug; bs, mt.

Subfamily PTEROCOLINAE

Pterocolus ovatus (Fabricius) – (1); GF; 21 May–18 Jun; mt.

Family BRENTIDAE (straight-snouted and pear-shaped weevils)**Subfamily APIONINAE****Tribe APIONINI**

Apionini sp. 1 – (4); DM, GF, TR; 19 Apr–30 Jun, 19 Sep–21 Oct; mt.

Apionini sp. 2 – (2); DM; 8 Aug–21 Sep; mt. Many subgenera of *Apion* Herbst were recently elevated to genera. Genera formerly assigned to *Apion* documented in North America include: *Apion*, *Apionion* Kissinger, *Bothryopteron* Wagner, *Chrysapion* Kissinger, *Coelocephalapion* Wagner, *Stenapion* Wagner, and *Trichapion* Wagner (Anderson and Alonso-Zarazaga 2019, de Sousa et al. 2019).

Tribe PIEZOTRACHELINI

Fallapion Kissinger sp. – (2); DM, LH; 28 Jul–11 Aug, 11–26 Oct; mt.

Tribe OXYSTOMATINI**Subtribe Synapiina**

† *Ischnopterapion virens* (Herbst) – (3); Collingwood Picnic Area, TR; 2 Jun, 22 Oct–1 Dec; hc (dry turf grass), mt.

Subtribe Trichapiina

Trichapion nigrum (Herbst) – (6); DM; 30 Jul–12 Sep; mt.

Trichapion rostrum (Say) – (5); DM, TR; 1–20 May; mt.

Subfamily BRENTINAE**Tribe ARRHENODINI**

Arrenodes minutus (Drury) – (9); GF, TR; 21 May–26 Jul; bs, mt.

Family ITHYCERIDAE (The New York Weevil)

Ithycerus noveboracensis (Forster) – (1); GF; 23 Jun; bs.

Family CURCULIONIDAE (weevils, and snout, bark, and ambrosia beetles)**Subfamily BAGOINAE**

Bagous magister LeConte – (1); DM; 2–18 Jul; mt.

Subfamily BARIDINAE**Tribe BARIDINI**

! *Baris aeneomicans* Casey – (1); GF; 19 Sep–21 Oct; mt. This species occurs from Massachusetts to Florida, west to Illinois and Louisiana (O'Brien and Wibmer 1982).

Baris Germar sp. – (2); TR; 7–30 Jul; mt.

Desmoglyptus crenatus (LeConte) – (1); DM; 29 Aug–12 Sep; mt.

Tribe MADARINI**Subtribe Madarina**

Ampelogypter ampelopsis (Riley) – (2); TR; 6–30 Jul; mt.

Glyptobaris lecontei Champion – (10); GF, TR; 1–20 May, 19–30 Jun, 7 Jul–7 Sep; mt.

Madarellus undulatus (Say) – (6); DM, GF, TR; 10 Apr–2 Jul; mt.

Tribe MADOPTERINI**Subtribe Torcina**

! *Sibariops concinna* (LeConte) – (2); DM; 14–24 Jun, 21 Nov–5 Dec; mt. (Figure 1).

This species occurs from New York to Florida, west to Texas (O'Brien and Wibmer 1982).

! *Sibariops confinis* (LeConte) – (1); DM; 10–17 May; mt. (Figure 2). This record documents a slight southern range extension along the East Coast from New Jersey to northern Virginia. It was previously recorded from New York and New Jersey west to Iowa (O'Brien and Wibmer 1982).

Subtribe Zygobaridina

Buchananius striatus (LeConte) – (1); LH; 5–19 May; mt.

! *Buchananius sulcatus* (LeConte) – (4); LH, TR; 5 May–17 Jul; mt. O'Brien and Wibmer (1982) recorded this species from New York to Florida, west to Missouri and Louisiana.

Geraeus penicillus (Herbst) – (1); GF; 23 Jul; netted on nodding onion, *Allium cernuum* Roth (Liliaceae).

Geraeus picummus (Herbst) – (1); DM; 24 Jun–8 Jul; mt.

! *Nicentrus lecontei* Champion – (1); GF; 27–28 Aug; bb. This species occurs from New Jersey and New York to South Carolina, west to Indiana (O'Brien and Wibmer 1982).

Odontocorynus salebrosus (Casey) – (1); GF; 11–12 Jul; bb.

Plocamus echidna (LeConte) – (1); LH; 16 Oct; hc (in leaf litter).

Subfamily CEUTORHYNCHINAE**Tribe CEUTORHYNCHINI**

! *Ceutorhynchus americanus* Buchanan – (1); TR; 23 May–5 Jun; mt. A widespread species in North America that reaches to South Carolina and Texas in the eastern United States (O'Brien and Wibmer 1982).

! *Ceutorhynchus anthonomoides* Dietz – (1); TR; 10–30 Apr; mt. This species was previously recorded from Indiana, Kansas, Missouri, Ohio, and the District of Columbia (O'Brien and Wibmer 1982).

† *Ceutorhynchus obstrictus* (Marshall) – (1); DM; 17–28 May; mt. Earlier North American records for this European species are under the name *C. assimilis* (Paykull). It has been recorded throughout western and eastern North America (Gillespie et al. 2006).

Glocianus punctiger (Sahlberg) – (1); TR; 28 Apr–12 May; mt.



Figure 1. *Sibariops concinna* (LeConte). Dyke Marsh Wildlife Preserve, ecotone, Malaise trap, 21 November–5 December 1999, E. M. Barrows. Left, dorsal view, right, lateral; length 3 mm (0.12 in). This is the first record of this species in Virginia.



Figure 2. *Sibariops confinis* (LeConte). Dyke Marsh Wildlife Preserve, marsh, Malaise trap, 10–17 May 1998, E. M. Barrows. Left, dorsal view, right, lateral; length 3.3 mm (0.13 in). This is the first record of this species in Virginia.

Tribe CNEMOGONINI

Orchestomerus eisemanni Yoshitake and Anderson – (4); GF, TR; 3 Jul–14 Aug; mt.

! *Parauleutes nebulosus* (LeConte) – (2); DM, GF; 10–17 May, 27–28 Aug; bb, mt. This species also occurs throughout the eastern United States from New York to Florida, west to Nebraska and Texas (O'Brien and Wibmer 1982).

‡ *Perigaster cretura* (Herbst) – (1); GF; 24 Jun; bs. This species occurs from Ontario to Florida, west to Kansas and Texas (O'Brien and Wibmer 1982).

Tribe PHYTOBIINI

Pelenomus pusillus Dietz – (1); DM; 12–26 Sep; mt.

Subfamily CONODERINAE**Tribe LECHRIOPINI**

‡ *Acoptus suturalis* LeConte – (5); GF, LH, TR; 14 Apr–21 Jul; bs, mt. This species is widely distributed in the east from Georgia and North Carolina, north into Ontario and Quebec (O'Brien and Wibmer 1982).

Lechriops oculata (Say) – (22); DM, GF, LH, TR; 10 Apr–1 Dec; mt, pf.

Tribe ZYGOPINI

! *Cylindrocopturus binotatus* (LeConte) – (1); DM; 8–21 Nov; mt. This species occurs from New Jersey and New York south to Georgia, west to Ohio and Texas (O'Brien and Wibmer 1982).

Subfamily COSSONINAE**Tribe COSSONINI**

Cossonus impressifrons Boheman – (23); DM, GF, TR; 23 May–26 Jul; bs, mt.

Tribe DRYOTRIBINI

! *Caulophilus dubius* (Horn) – (2); DM, GF; 15 Jun–8 Aug; mt. This species is widespread in eastern North America, occurring in Quebec and New York to Florida, west to Illinois, Kentucky, and Texas (O'Brien and Wibmer 1982, Douglas et al. 2013).

Tribe ONYCHOLIPINI

! *Pseudopentarthrum nitens* Horn – (1); TR; 19–30 Jun; mt. (Figure 3). O'Brien and Wibmer (1982) recorded this species as *Pentarthrinus nitens* (Horn) from the District of Columbia and Florida.

! *Pseudopentarthrum simplex* (Casey) – (1); TR; 19–30 Jun; mt. This species was previously known from Indiana, Mississippi, Nebraska, North Carolina, and South Carolina (O'Brien and Wibmer 1982).

Stenoscelis brevis (Boheman) – (7); DM, GF, LH; 18 May–15 Jul; lf, mt, pf.

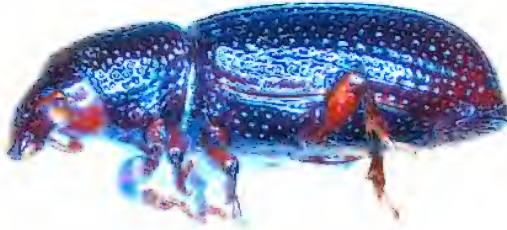


Figure 3. *Pseudopentarthrum nitens* (Horn). Turkey Run Park, river, Malaise trap, 19–30 June 2009, D. R. Smith. Lateral view; length 2.0 mm (0.08 in). This is the first record of this species in Virginia.

Tribe RHYNCOLINI

Subtribe Rhyncolina

! *Tomolips quercicola* (Boheman) – (1); TR; 19–30 Jun; mt. This species occurs throughout eastern North America from New England to Florida, west to Indiana, Missouri, and Texas (O'Brien and Wibmer 1982).

Subfamily CRYPTORHYNCHINAE

Tribe CRYPTORHYNCHINI

Subtribe Cryptorhynchina

Apteromechus ferratus (Say) – (23); DM, GF, LH, TR; 10 Apr–26 Jul; lf, mt.

Cryptorhynchus obliquus (Say) – (13); DM, GF, TR; 28 May–21 Oct; mt.

Cryptorhynchus fuscatus LeConte is a junior synonym of *C. obliquus* (Say) (fide Prena [2018]).

Cryptorhynchus tristis LeConte – (2); GF; 23 Jun; bt.

Eubulus bisignatus (Say) – (8); GF, LH; 10 Apr–23 Jun; bt, mt.

Eubulus obliquefasciatus (Boheman) – (41); DM, GF, LH, TR; 10 Apr–19 May; mt.

Thirty-three of these were captured in the same malaise trap set in Great Falls swamp from 10–30 April.

! *Phyrdenus divergens* (Germar) – (1); TR; 7–12 Jul; mt. This species is widely distributed in the eastern United States from New Jersey to Florida, west to Indiana and Texas (O'Brien and Wibmer 1982).

Subtribe Tylodina

‡ *Acalles carinatus* LeConte – (6); GF, TR; 28 Apr–30 Jul; bs, mt, pf. O'Brien and Wibmer (1982) recorded this species from New Jersey to Georgia, west to Ohio, Nebraska, Missouri, and Arkansas.

Acalles minutissimus LeConte – (1); GF; 27 Jul–14 Aug, mt.

Tribe GASTEROCERCINI

Cophes fallax (LeConte) – (2); GF, TR; 25 Jun, 19 Sep–21 Oct; hc, mt.

‡ *Cophes obtentus* (Herbst) – (3); LH, TR; 1 Jun–30 Jul; bs, mt. This species is widespread in the eastern United States, occurring from New Jersey to Florida, west to Illinois, Missouri, Arkansas, and Texas (O'Brien and Wibmer 1982).

Subfamily CURCULIONINAE

Tribe ANTHONOMINI

Anthonomus signatus Say – (2); DM; 28 Apr–20 Jun; mt.

‡ *Anthonomus suturalis* LeConte – (3); GF, LH; 10 May–24 Jun; bs, mt. This species is widespread in eastern North America, ranging from Ontario and Québec to Florida, west to Kansas and Texas (O'Brien and Wibmer 1982, Bousquet et al. 2013).

Pseudanthonomus helvolus (Boheman) – (1); GF; 22 Oct–1 Dec; mt.

Pseudanthonomus rufulus Dietz – (4); GF; 16–30 Jul; mt.

Pseudanthonomus validus Dietz – (1); GF; 16–30 Jul; mt.

Tribe CURCULIONINI

Curculio caryae (Horn) – (1); DM; 12–27 Aug; mt.

Curculio confusor (Hamilton) – (1); DM; 18–23 Jul; mt.

Curculio strictus (Casey) – (1); LH; 19 Sep–10 Oct; mt.

Curculio sulcatulus (Casey) – (3); DM; 12 Aug–26 Oct; mt.

Tribe ELLESCINI

Subtribe Ellescina

Ellescus ephippiatus Say – (1); GF; 10–30 Apr; mt.

Tribe MECININI

† *Mecinus pyraster* (Herbst) – (4); DM; 11–28 Apr; mt.

Tribe OTIDOCEPHALINI

Myrmex myrmex (Herbst) – (7); GF, LH; 5 May–14 Aug; bs, mt.

Tribe SMICRONYCHINI

Smicronyx amoenus (Say) – (2); DM, TR; 1–20 May, 23 Jul–8 Aug; mt.

Tribe TYCHIINI

Subtribe Tychiina

† *Tychius picirostris* (Fabricius) – (8); DM, GF; 19 Apr–23 Jun, 11–26 Oct; bt, mt.

Subtribe Lignyodina

Lignyodes fraxini (LeConte) – (2); DM; 12–28 Apr; mt. This species was previously recorded as occurring from Quebec to New Jersey, west to Saskatchewan, Kansas, and Missouri (O'Brien and Wibmer 1982, Bousquet et al. 2013).

Lignyodes helvolus (LeConte) – (1); GF; 27 Jul–14 Aug; mt.

Subfamily CYCLOMINAE

Tribe RHYTHIRININI

Subtribe *Listroderina*

! *Listronotus frontalis* LeConte – (7); GF; 6 Aug; bl. This species is widely distributed in North America (O'Brien and Wibmer 1982, Bousquet et al. 2013).

‡ *Listronotus humilis* Gyllenhal – (2); DM, GF; 23 Jun, 24 Oct–8 Nov; bt, mt. This species is widely distributed in North America (O'Brien and Wibmer 1982, Bousquet et al. 2013).

Listronotus punctiger LeConte – (1); DM; 20 Jun–2 Jul; mt.

Subfamily DRYOPHTHORINAE

Tribe DRYOPHTHORINI

Dryophthorus americanus Bedel – (1); GF; 1 May; bs.

Tribe RHYNCHOPHORINI

Subtribe *Sphenophorina*

Rhodobaenus quinquepunctatus (Say) – (3); DM, GF; 21 May–2 Jul; mt.

! *Sphenophorus sayi* Gyllenhal – (2); TR; 10 Apr–20 May; mt. This widespread North American species occurs in the East as far south as Georgia and Louisiana (O'Brien and Wibmer 1982).

Sphenophorus venatus vestitus Chittenden – (5); DM, TR; 8 May–4 Aug; mt.

Subfamily ENTIMINAE

Tribe CYPHICERINI

Subtribe *Acanthotrachelina*

† *Calomycterus setarius* Roelofs – (1); GF; 24 Jun; bs.

Subtribe *Cyphicerina*

† *Cyrtepiptomus castaneus* (Roelofs) – (26); GF, LH, TR; 10 Apr–1 Dec; mt.

!† *Myosides seriehispidus* Roelofs – (3); LH, TR; 15 Apr, 16 Oct; bf, hc (in leaf litter).

This Asian species has been recorded from Québec, Connecticut, District of Columbia, Maryland, New Jersey, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Tennessee, and West Virginia (O'Brien 2000, Carlton and Anderson 2004, de Tonnancour et al. 2017).

† *Pseudoeodophrys (Oedophrys) hilleri* (Faust) – (21); DM, GF, TR; 14 Jun–21 Oct; bs, mt, pf.

Tribe EUSTYLINI

Brachystylus sayi Alonso-Zarazaga – (2); DM, LH; 5 May–6 Jun; mt.

Tribe PHYLLOBIINI

Aphrastus taeniatus Say – (8); GF, TR; 23 Jun–30 Jul; bs, bt, mt.

Tribe SCIAPHILINI

† *Barypeithes pellucidus* (Boheman) – (5); Collingwood Picnic Area, LH, TR; 24 Mar–16 Jun; hc, pf.

Tribe SITONINI

† *Sitona hispidulus* (Fabricius) – (8); DM, TR; 12 Sep–8 Nov; mt, pf.

† *Sitona lineatus* (Linnaeus) – (2); DM; 26 Sep–5 Dec; mt.

Tribe TANYMECINI**Subtribe Tanymecina**

Pandeleiteius hilaris (Herbst) – (5); LH; 5 May–28 Jun, 19 Sep–10 Oct; mt.

Tribe TRACHYPHLOEINI**Subtribe Trachyphloeina**

† *Pseudocneorhinus bifasciatus* (Roelofs) – (12); DM, GF, TR; 25 Apr–17 Aug; bs, mt.

!† *Trachyphloeosoma advena* Zimmerman – (1); Roaches Run; 15 Apr; hc. (Figure 4).

Originally described from Hawaii, O'Brien (1984) first reported this species in the continental United States based on specimens collected in Alabama and Florida. It also occurs in South Carolina (Ciegler 2010). This record documents a northern range extension of at least 643 km (400 mi).

Subfamily ERIRHININAE**Tribe ERIRHININI****Subtribe Stenopelmina**

Onychylis nigristrotris (Boheman) – (1); DM; 20 Jun–2 Jul; mt.

Subtribe Tanysphyrina

!† *Tanysphyrus lemnae* (Fabricius) – (1); GF; 6 Aug; bl. (Figure 5). This European species is widespread across the eastern half of the United States (O'Brien and Wibmer 1982).

Subfamily HYPERINAE**Tribe HYPERINI**

† *Hypera nigristrotris* (Fabricius) – (3); DM; 21 Nov–5 Dec; mt.

Subfamily LIXINAE**Tribe LIXINI**

Lixus concavus Say – (1); DM; 23 May; mt.

Lixus scrobicollis Boheman – (2); GF; 19 Jun–30 Jul, mt.

Subfamily MESOPTILIINAE**Tribe LAEMOSACCINI**

Laemosaccus nephele (Herbst) – (4); LH, 1–14 Jun, mt.



Figure 4. *Trachyphloeosoma advena* Zimmerman. Roaches Run Waterfowl Sanctuary, 15 April 2012, B. W. Steury. Left, dorsal view, right, lateral; length 2.5 mm (0.10 in). This is the first record of this non-native species in Virginia.

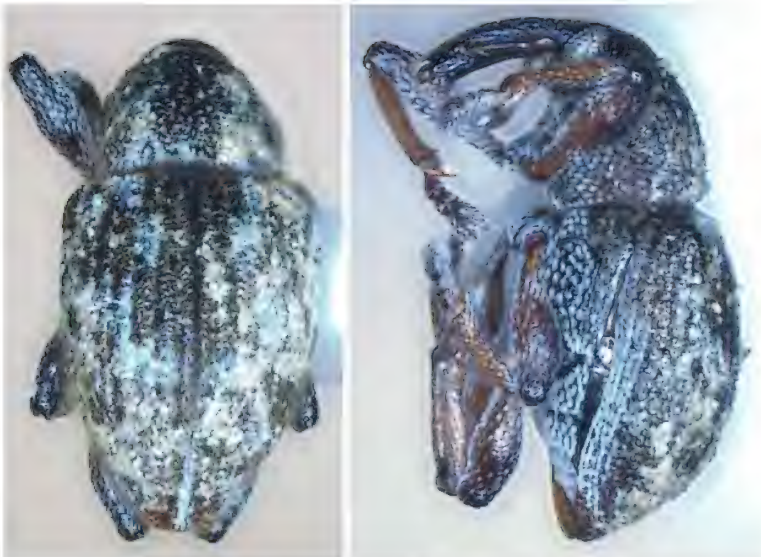


Figure 5. *Tanysphyrus lemnae* (Fabricius). Great Falls Park, blacklight in mixed forest gap near river, 6 August 2007, W. E. Steiner and J. M. Swearingen. Left, dorsal view, right, lateral; length 1.5 mm (0.06 in). This is the first record of this non-native species in Virginia.

Tribe MAGDALIDINI

! *Magdalis barbata* (Say) – (1); DM; 8–21 Nov; mt. This species is widely distributed throughout eastern North America south to Georgia and Texas (O'Brien and Wibmer 1982, Bousquet et al. 2013).

Subfamily MOLYTINAE**Tribe CLEOGONINI**

Rhysomatus lineaticollis (Say) – (1); TR; 1–17 Jun; mt.

Tribe CONOTRACHELINI

Conotrachelus affinis Boheman – (4); TR; 19 Jun–4 Aug, mt.

Conotrachelus anaglypticus (Say) – (9); GF, LH, TR; 1 May–21 Oct; lf, mt.

Conotrachelus buchanani Schoof – (5); TR; 19 Sep–1 Dec; mt.

Conotrachelus elegans (Say) – (8); DM, GF, LH, TR; 10 Apr–18 Jun; bl, mt.

Conotrachelus geminatus LeConte – (7); DM, LH; 1–14 Jun, 8–15 Aug; mt.

Conotrachelus naso LeConte – (3); LH; 28 Jul–10 Oct; mt.

Conotrachelus nenuphar (Herbst) – (3); DM, GF, TR; 19–28 Apr, 16 Jul–17 Aug; mt.

Conotrachelus posticatus Boheman – (11); GF, LH, TR; 21 May–11 Aug; lf, mt.

Conotrachelus seniculus LeConte – (1); GF; 25 Jun; bs.

Microhyus setiger LeConte – (8); GF, LH, TR; 10–30 Apr, 1 Jun–20 Jul; mt.

Tribe HYLOBIINI**Subtribe Hylobiina**

Hylobius pales (Herbst) – (1); LH; 18 May–3 Jun; pf.

Tribe PIAZORHININI

! *Piazorhinus pictus* LeConte – (4); DM, GF, LH; 1 Jun–13 Jul, 22 Oct–1 Dec; mt. A species widespread in eastern North America that occurs from Atlantic Canada to Florida, west to Manitoba, Wisconsin, and Missouri (O'Brien and Wibmer 1982, Bousquet et al. 2013).

Piazorhinus scutellaris (Say) – (2); GF; 10–30 Apr, 15 Aug–7 Sep, mt.

Subfamily PLATYPODINAE**Tribe PLATYPODINI**

Euplatypus compositus (Say) – (13); GF, TR; 10 Apr–1 Dec; mt.

Subfamily SCOLYTINAE**Tribe HYLESININI****Subtribe Hylastina**

Hylastes Erichson sp. – (1); DM; 21 Nov–5 Dec; mt.

Subtribe Hylesinina

Hylesinus aculeatus Say – (4); DM, GF, TR; 10 Apr–8 May; mt.

Subtribe Tomicina

Dendroctonus valens LeConte – (2); LH; 12 Apr–18 May; lf, pf.

Tribe SCOLYTINI**Subtribe Corthylina**

Corthylus columbianus Hopkins – (1); DM; 11–27 Sep; mt.

Monarthrum fasciatum (Say) – (22); DM, GF, LH; 15 Jan, 1 Mar–14 Aug, 8–21 Nov; hc (dry leaf clusters on fallen branch of northern red oak, *Quercus rubra* L. [Fagaceae]), mt.

Subtribe Scolytina

Scolytus multistriatus (Marsham) – (1); LH; 10 Jun; hc (tidal gravel shore with driftwood).

Subtribe Xyleborina

Anisandrus sayi Hopkins – (1); DM; 25 Apr–8 May; mt.

Cnestus mutilatus (Blandford) – (2); LH; 5 May–14 Jun; mt.

Xyleborus celsus Eichhoff – (2); GF; 23 Jun; bt.

Xyleborus ferrugineus (Fabricius) – (1); GF; 23 Jun; bt.

† *Xylosandrus crassiusculus* (Motschulsky) – (3); DM, GF; 25 Apr–23 Jun; bt, mt.

CONCLUDING COMMENTS

The first published record of Curculionoidea from GWMP was by Evans (2008), who documented 26 taxa (25 identified to species) during a 30-hour BioBlitz of the Potomac Gorge: Anthribidae (3 species), Attelabidae (1 species), Brentidae (1 species), Ithyceridae (1 species), and the Curculionidae (20 taxa, 19 identified to species, including six species new to Virginia. Evans also documented three additional species from the Maryland side of the Gorge).

The current study, spanning 21 years of collection effort targeting the superfamily Curculionoidea from GWMP, documented 604 specimens comprising 135 taxa (130 identified to species) in at least 97 genera. Approximately 100 Scolytini specimens remain unidentified and are not included in the list of species. Within GWMP, the Curculionoidea contains six families consisting of the Nemomychidae (1 species), Anthribidae (12 species), Attelabidae (3 species), Brentidae (7 taxa, 4 identified to species), Ithyceridae (1 species), and the Curculionidae (111 taxa, 109 identified to species). The tribes with the most species were Conotrachelini (10), Madopterini (9), and Cryptorhynchini and Scolytini (8 each). The most species-rich genera were *Conotrachelus* Dejean (9), *Curculio* Linnaeus (4), and *Ceutorhynchus* Germar and *Pseudanthonomus* Dietz (3 each). The most abundant species collected in the survey area were the native species *Eubulus obliquefasciatus* (Boheman) (41), *Apteromechus ferratus* (Say) (23), and *Monarthrum fasciatum* (Say) (22), and the non-native species *Cyrtepestomus castaneus* (Roelofs) (26) and *Pseudoedophrys (Oedophrys) hilleri* (Faust) (21). Twenty-three species are first records for the Commonwealth of Virginia. Range extensions are documented for a native species, *Sibariops confinis* (LeConte), and a non-native species, *Trachyphloeosoma advena*.

The GWMP sites with the highest species richness were Great Falls Park (68 taxa), Dyke Marsh Wildlife Preserve (58), Turkey Run Park (54), and Little Hunting Creek (38). Sixteen species (11.9%; N = 135) found in GWMP are considered adventive (non-native)

to Virginia, including three species new to the state: *Myosides seriehispidus* Roelofs, *Tanysphyrus lemnae* (Fabricius), and *Trachyphloeosoma advena*. For comparison, 6.8% (4 of 59) of the weevils documented from the Potomac Gorge are non-native (Brown 2008). These four species include one species, *Sitona hispidulus* (Fabricius), documented from GWMP and three species not yet recorded from the park: *Gymnetron tetrum* (Fabricius), *Hypera punctata* (Fabricius), and *Mecinus pascuorum* (Gyllenhal). Malaise traps proved to be the most successful method of capturing weevils during this study, yielding 114 taxa. Results of the other most productive sampling methods were: beating sheets (20) and black-light bucket traps, pitfall traps, and hand collecting (8 each).

Evans (2008) documented 26 taxa from the Piedmont Plateau sites along the Potomac Gorge at Great Falls and/or Turkey Run Parks, two species of which, *Eurymycter fasciatus* (Olivier) and *Mylocherus hilleri* Faust (both Curculionidae), were not observed in the current study. Evans (2008) also documented four additional Curculionidae from the Maryland side of the Gorge, three of which, *Listronotus oregonensis* (LeConte), *Sphenophorus minimus* Hart, and *Xyleborus pubescens* Zimmermann, were not observed in the current study. Brown (2008) documented 59 species at Plummers Island on the Maryland side of the Gorge, 37 of which were not observed in the current study. Of the 92 taxa documented from Piedmont Plateau sites along the Potomac Gorge at Great Falls or Turkey Run Parks in the current study, 51 are first records for the Gorge, increasing the number of Curculionoidea documented from the Gorge to 134 (i.e., 2+3+37+92) taxa (coincidentally, the same number of taxa as are documented from GWMP).

Despite 21 years of sporadic survey effort using nine collecting techniques, 53 taxa (39.6%) documented by the current study are represented by a single specimen, indicating that the list of GWMP Curculionoidea is preliminary and much remains to be learned concerning the fauna of the parkway and of Virginia.

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LITERATURE CITED

- Anderson, R.S. 2002a. Curculionidae Latreille 1802. Pages 722–815, In: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles. Volume II. Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press, Boca Raton, FL. 861 pp.
- Anderson, R.S. 2002b. Ithyceridae Schönherr 1823. Pages 720–721 in: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles. Volume II. Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press, Boca Raton, FL. 861 pp.

- Anderson, R.S. 2002c. Nemonychidae Bedel 1882. Pages 692–694, In: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles. Volume II. Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press, Boca Raton, FL. 861 pp.
- Anderson, R.S., and D.G. Kissinger. 2002. Brentidae Billberg 1820. Pages 711–719, In: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles. Volume II. Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press, Boca Raton, FL. 861 pp.
- Anderson, R.S., and M.A. Alonso-Zarazaga. 2019. *Apion carrorum* Anderson and Alonso-Zarazaga, new species, the first representative of the genus *Apion* Herbst (Coleoptera: Brentidae: Apioninae) in North America. *The Coleopterists Bulletin* 73(4):889–892.
- Arnett, Jr., R.H., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors). 2002. *American Beetles. Volume II. Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press, Boca Raton, FL. 861 pp.
- Blatchley, W.S., and C.W. Leng. 1916. *Rhynchophora or Weevils of North Eastern America*. The Nature Publishing Company, Indianapolis, IN. 682 pp.
- Bousquet, Y., P. Bouchard, A.E. Davies, and D.S. Sikes. 2013. *Checklist of Beetles (Coleoptera) of Canada and Alaska*. Second Edition. Pensoft, Sofia-Moscow, Bulgaria-Russia. 402 pp.
- Brown, J.W. 2008. The invertebrate fauna of Plummers Island, Maryland. Contribution XXX to the Natural History of Plummers Island, Maryland. *Bulletin of the Biological Society of Washington* 15:1–226.
- Carlton, C., and R.S. Anderson. 2004. Occurrence of the introduced weevil *Myosides seriehispidus* Roelofs in Great Smoky Mountains National Park (Coleoptera: Curculionidae). *The Coleopterists Bulletin* 58(3):343.
- Ciegler, J.C. 2010. *Weevils of South Carolina (Coleoptera: Nemonychidae, Attelabidae, Brentidae, Ithyceridae, and Curculionidae)*. Biota of South Carolina, Volume 6. Clemson University, Clemson, SC. 276 pp.
- Cohn, J.P. 2004. The wildest urban river: Potomac River Gorge. *BioScience* 54(1):8–14.
- de Sousa, W.O., C.S. Ribeiro-Costa, and G.H. Rosado-Neto. 2019. A preliminary overview of the Brazilian Apioninae (Coleoptera: Brentidae) with an illustrated key for genera, and a checklist with distribution information. *Biota Neotropica* 19(4): e20190813.
- de Tonnancour, P., R.S. Anderson, P. Bouchard, C. Chantal, S. Dumont, and R. Vigneault. 2017. New Curculionoidea (Coleoptera) records for Quebec, Canada. *ZooKeys* 681:95–117.
- Douglas H., P. Bouchard, R.S. Anderson, P. de Tonnancour, R. Vigneault, and R.P. Webster. 2013. New Curculionoidea (Coleoptera) records for Canada. *ZooKeys* 309:13–48. doi: 10.3897/zookeys.309.4667.
- Downie, N.M., and R.H. Arnett, Jr. 1996. *The Beetles of Northeastern North America*. Volume II. Sandhill Crane Press, Gainesville, FL. Pages 891–1721.
- Evans, A.V. (Editor). 2008. The 2006 Potomac Gorge BioBlitz. Overview and results of a 30-hour rapid biological survey. *Banisteria* 32:3–80.
- Ferro, M.L., and N.H. Nguyen. 2016. Survey of twig-inhabiting Coleoptera in Louisiana, USA. *The Coleopterists Bulletin* 70(3):551–558.
- Fleming, G.P. 2007. Ecological communities of the Potomac Gorge in Virginia: composition, floristics, and environmental dynamics. Natural Heritage Technical Report 07-12. Unpublished report submitted to the National Park Service. Virginia Department of Conservation and Recreation, Division of Natural Heritage, Richmond, VA. 341 pp. + appendices.
- Gillespie, D.R., P.G. Mason, L.M. Dossdall, P. Bouchard, and G.A.P. Gibson. 2006. Importance of long-term research in classical biological control: an analytical review of a

- release against the cabbage seedpod weevil in North America. *Journal of Applied Entomology* 130(8):401–409.
- Gillett, C.P.D.T., A. Crampton-Platt, M.J.T.N. Timmermans, B.H. Jordal, B.C. Emerson, and A.P. Vogler. 2014. Bulk de novo mitogenome assembly from pooled total DNA elucidates the phylogeny of weevils (Coleoptera: Curculionoidea). *Molecular Biology and Evolution* 31(8):2223–2237.
- Gunter, N.L., R.G. Oberprieler, and S.L. Cameron. 2016. Molecular phylogenetics of Australian weevils (Coleoptera: Curculionoidea): exploring relationships in a hyperdiverse lineage through comparison of independent analyses. *Austral Entomology* 55(2):217–233.
- Hamilton, R.W. 2002. Attelabidae Billberg 1820. Pages 703–710. In: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles. Volume II. Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press, Boca Raton, FL. 861 pp.
- Oberprieler, R.G., A.E. Marvaldi, and R.S. Anderson. 2007. Weevils, weevils, weevils everywhere. *Zootaxa* 1668(1): 491–520.
- O'Brien, C.W. 1984. *Trachyphloeosoma advena* Zimmerman, new to the continental United States, with a key to U.S. genera of Trachyphloeini (Coleoptera: Curculionidae: Otiorhynchinae). *The Coleopterists Bulletin* 38(2):181–184.
- O'Brien, C.W. 2000. *Myosides seriehispidus* Roelofs, an Asian weevil new to the United States (Coleoptera, Curculionidae). *Insecta Mundi* 14(4):229–231.
- O'Brien, C.W., and G.J. Wibmer. 1982. *Annotated Checklist of the Weevils (Curculionidae sensu lato) of North America, Central America, and the West Indies (Coleoptera: Curculionoidea)*. Memoirs of the American Entomological Institute, Number 34. 382 pp.
- Prena, J. 2018. An annotated inventory of the weevils (Coleoptera: Curculionoidea) described by Thomas Say. *Bulletin of the Museum of Comparative Zoology* 161(9):323–401.
- Riedel, A., and R.W. Hamilton. 2007. On the genera *Attelabus* Linnaeus and *Synolabus* Jekel (Curculionoidea: Attelabidae: Attelabinae). *The Coleopterists Bulletin* 61(3):447–452.
- Shin, S., D.J. Clarke, A.R. Lemmon, E.M. Lemmon, A.L. Aitken, S. Haddad, B.D. Farrell, A.E. Marvaldi, R.G. Oberprieler, and D.D. McKenna. 2018. Phylogenomic data yield new and robust insights into the phylogeny and evolution of weevils. *Molecular Biology and Evolution* 35(4):823–836.
- Steurly, B.W. 2011. Additions to the vascular flora of the George Washington Memorial Parkway, Virginia, Maryland, and the District of Columbia. *Banisteria* 37:3–20.
- Steurly, B.W., G.P. Fleming, and M.T. Strong. 2008. An emendation of the vascular flora of Great Falls Park, Fairfax County, Virginia. *Castanea* 73(2):123–149.
- Steurly, B.W., S.W. Droege, and E.T. Oberg. 2009. Bees (Hymenoptera: Anthophila) of a riverside outcrop prairie in Fairfax County, Virginia. *Banisteria* 34:17–24.
- Townes, H. 1962. Design for a Malaise trap. *Proceedings of the Entomological Society of Washington* 64(4):253–262.
- Valentine, B.D. 1998. A review of Nearctic and some related Anthribidae (Coleoptera). *Insecta Mundi* 12(3–4):251–296.
- Valentine, B.D. 2002. Anthribidae Billberg 1820. Pages 695–700. In: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles. Volume II. Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press, Boca Raton, FL. 861 pp.
- Vogt, G.B. 1992. Leaf rolling weevils (Coleoptera: Attelabidae) their host plants, and associated rhynchitid weevils in North America (Canada through the Republic of Panama): Summary of a long term field study. Pages 392–420. In: D. Quintero and A. Aiello (Editors), *Insects of Panama and Mesoamerica: Selected Studies*. Oxford University Press, Oxford, England. 692 pp.

Neuropterans Collected at Flag Ponds Nature Park, Calvert County, Maryland

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The Flag Ponds Nature Park is a 132 ha (327 ac) property along the west side of the Chesapeake Bay in Calvert County, Maryland. It is publically owned and managed by the Natural Resources Division of the Calvert County Department of Parks and Recreation as a natural area. It was acquired because it was considered to be one of the most ecologically diverse properties on the Atlantic Coastal Plain (John Zyla, pers. comm.).

The property includes upland deciduous forest atop bayside uplands and an adjacent forested slope exhibiting a 24- to 30-m (80- to 100-ft) drop in elevation from the bluff to the shore of the Bay. At the base of the bluff there is a broad expanse of level, sandy flat several hundred meters wide leading to an actively accreting sandy cape that merges with sea level. As sand was deposited to form this broad beach, it formed a series of ponds that range from a fresh forested vernal pool at the base of the bluff, to several smaller ponds of varying salinity, ending with one just inside the existing beach line. Beyond the beach is a shoal that is developing offshore of the accreting cape, which may eventually become beach encircling another saline pond. The sandy expanse has been little studied ecologically but is comparable to a similar site present just to the south at Cove Point. The biota of that area has been the subject of numerous studies published by the Cove Point Natural Heritage Trust (2017).

During the summer of 1987 two Malaise traps were set at Flag Ponds as part of an effort to census the insect fauna of the site. The traps were installed on 1 June 1987 and operated through the end of September 1987. Both traps were situated in open sand flat with old field vegetation interspersed with scattered patches of woody vegetation dominated by Virginia pine, *Pinus virginiana* Mill. (Pinaceae). The contents of the traps were removed at approximately weekly intervals, labeled and stored in alcohol. The contents of the jars were rough-sorted and the resulting material was placed in the collection of the Department of Entomology, National Museum of Natural History (USNM), Smithsonian Institution, Washington, DC. Among the numerous insect groups represented were a number of antlions (Myrmeleontidae) and other neuropteroids. These were identified to species by Dr. Oliver S. Flint, Jr. (Emeritus Curator of Neuropteroids, Department of Entomology, USNM), and form the basis for this note. The specimens, pinned and alcoholic, were deposited at the USNM.

The material from the Flag Ponds samples, including representatives of four families, eight genera, and 13 species, is identified in the following list. Collection dates, numbers, and sexes of individuals collected are given for each species. The dates given are the dates that the specimens were retrieved from the traps and represent about one week of trap time.

BEROTHIDAE (beaded lacewings)

Lomamyia flavicornis (Walker): 17 August 1987 (1♂).

CHRYSOPIDAE (common lacewings, green lacewings)

Chrysoperla rufilabris (Burmeister): 10 July 1987 (1♀), 20 July 1987 (1♀), 24 August 1987 (1♂).

Chrysopa incompleta Banks: 5 June 1987 (2♂), 9 June 1987 (1♂, 3♀), 15 June 1987 (2♂, 1♀), 23 June 1987 (1♀).

Chrysopa nigricornis Burmeister: 5 June 1987 (4♂), 9 June 1987 (2♂), 15 June 1987 (2♂), 23 June 1987 (2♂), 6 July 1987 (1♂), 14 July 1987 (1♂).

Chrysopa oculata Say: 30 June 1987 (1♂), 10 July 1987 (1♂), 14 July 1987 (3♂), 20 July 1987 (1♀).

Chrysopa quadripunctata Burmeister: 5 June 1987 (7♂), 9 June 1987 (3♂), 15 June 1987 (2♀), 20 July 1987 (1♀).

HEMEROBIIDAE (brown lacewings)

Micromus subanticus (Walker): 5 June 1987 (1♂, 2♀).

MYRMELEONTIDAE (antlions)

Brachynemurus abdominalis (Say): 15 June 1987 (1♂, 3♀), 23 June 1987 (1♀), 26 June 1987 (1♀), 6 July 1987 (1♂, 1♀), 10 July 1987 (3♀), 3 August 1987 (1♂), 11 August 1987 (3♀), 17 August 1987 (1♂, 2♀), 8 September 1987 (1♂, 1♀).

Brachynemurus longicaudus (Burmeister): 23 June 1987 (10♂, 2♀), 26 June 1987 (12♂, 4♀), 6 July 1987 (49♂, 17♀), 10 July 1987 (7♂, 10♀), 14 July 1987 (4♂, 6♀), 20 July 1987 (4♂, 1♀), 24 July 1987 (4♂, 1♀), 3 August 1987 (8♂, 8♀), 11 August 1987 (4♂, 2♀), 17 August 1987 (6♂, 4♀), 24 August 1987 (1♂, 2♀), 8 September 1987 (1♂, 1♀), 28 September 1987 (1♀).

Brachynemurus nebulosus (Olivier): 9 June 1987 (2♂, 1♀), 15 June 1987 (5♂, 2♀), 23 June 1987 (6♂, 2♀), 26 June 1987 (2♂), 30 June 1987 (2♂), 6 July 1987 (2♂, 1♀), 10 July 1987 (1♂), 14 July 1987 (1♂), 20 July 1987 (1♀), 24 July 1987 (1♂), 3 August 1987 (2♂), 17 August 1987 (4♂, 1♀).

Myrmeleon carolinus Banks or *M. crudelis* Walker: 5 June 1987 (1♀), 15 June 1987 (5♀), 18 June 1987 (1♀), 26 June 1987 (2♀), 30 June 1987 (2♀), 6 July 1987 (3♀), 14 July 1987 (3♀), 20 July 1987 (2♀), 24 July 1987 (1♀), 3 August 1987 (3♀), 7 August 1987 (1♀), 11 August 1987 (3♀), 17 August 1987 (1♀), 24 August 1987 (1♀).

Euptilon ornatum (Drury): 6 July 1987 (1♀).

Vella americana (Drury): 24 July 1987 (1♀), 24 August 1987 (1♀).

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LITERATURE CITED

Cove Point Natural Heritage Trust. 2017. Completed Studies. Available at: <http://www.covepoint-trust.org/studies.html>. Accessed 19 October 2019.

A Survey of the Lepidoptera of the Serpentine Barrens Area of Lake Roland Park, Baltimore County, Maryland

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Abstract: Lake Roland Park is owned by the City of Baltimore and was leased to Baltimore County after its original purpose as a raw water supply reservoir had become obsolete. The northern part of the park contains a tract of land that is geologically classified as serpentine barrens. This unique habitat is degrading due to clearcutting and subsequent replanting of pines approximately 70 years ago, coupled with increasing pressure from exotic species. This survey was conducted from 22 April to 21 September 2019 to provide information for an ecological restoration management plan for the serpentine barrens area of Lake Roland Park.

INTRODUCTION

Serpentine barrens represent a unique ecosystem where the plant community is adapted to living in shallow, well drained, nutrient-poor soils that have high levels of heavy metals including nickel, cobalt, and chromium (Pollard 2016). In Maryland, many of these habitats are rich in chromite and copper and were once mined for these minerals (Friedman 2016). The plant communities in these environments frequently have endemic species not found in adjacent communities where they are unable to compete (Brady et al. 2005).

The focus of this survey was to determine the Lepidoptera species present in the persisting serpentine barrens located in Lake Roland Park, Baltimore County, Maryland, an area historically known as the Bare Hills. No attempt was made to quantify the abundance of species.

METHODS

This survey was primarily focused in the vicinity around a large, managed clearing in the interior of the geological formation (39.3874°, -076.652°) (Figure 1). The clearing is in close proximity to an ephemeral stream and within 30 m (100 ft) of an oak grove, *Quercus* L. (Fagaceae), that was not part of the aforementioned clearcut.

Data on diurnal species was collected on 11 occasions between 22 April and 21 September and included live observation, net collection, and hand-collection of resting butterflies at night. Specimens collected by hand or net were retained for positive identification and vouchering. Additional records were provided by Debbie Terry who

made visual butterfly observations on 22 April and 31 August 2019.

Nocturnal collections were conducted on 11 nights from 9 May through 21 September and utilized different methods of sampling. A 225-watt self-ballasted mercury-vapor (MV) light powered by a 1000-watt gasoline-powered generator was used during each of the 11 collections. The MV light was placed on a 122 cm x 122 cm (48 in x 48 in) white sheet that was adjacent to a vertically-hanging white sheet (216 cm x 254 cm [85 in x 100 in]). Additionally, two or three different black-light traps were placed each night within the clearing. Two 22-watt black-light Circline tube lights (BioQuip® Products #2807C) were placed on bucket traps (BioQuip® Products #2851A). One trap was powered by an 18-volt battery while another was supplied AC power by the generator. The third black-light trap used a 10-watt LED UV-light (Aplstar®) powered by a 17000mAh battery pack. The LED light was set across the top of a 19-L (5-gal) bucket topped with a funnel. All bucket traps were lined with a white plastic bag and contained permethrin-infused compressed-paper egg cartons and one Vaportape® Mini-Strip. At the conclusion of trapping each night, bags were removed, tied shut, and placed in a cooler with ice packs and then frozen overnight in a freezer. The following morning the contents of each trap were sorted by trap and returned to the freezer until pinning.

Adult specimens were prepared on foam spreading boards using size 2 or 3 stainless steel insect pins or on custom-made micro spreading boards using minutens. Specimens will be deposited into the collection of the Natural History Society of Maryland.



Figure 1. Serpentine barrens at Lake Roland Park, Baltimore County, Maryland. Large open area that has been expanded through mechanical removal of trees and mowing. A sheet with a mercury vapor lamp for the attraction of insects can be seen in the distance.

Specimens were identified using a variety of field guides, monographs, and journal articles. When required, specimens were dissected and/or compared to specimens in the collections of the Department of Entomology, National Museum of Natural History (USNM), Smithsonian Institution, Washington, District of Columbia, and of The Natural History Society of Maryland, Baltimore, Maryland. Resources used extensively included: Opler and Malikul (1998), Gilligan et al. (2008), Beadle and Leckie (2012), Lotts and Naberhaus (2017), the *Moths of America North of Mexico* series (Wedge Entomological Research Foundation 1971–2019), and the Moth Photographers Group website (2019). The collection, pinning, and identification of specimens is estimated to have taken ~450 hours. Approximately 2,400 specimens were collected, of which 2,315 were identified. The remaining specimens were too badly damaged to be identified by morphological methods.

RESULTS

Diurnal species were collected on nine different collecting events from 9 May through 21 September 2019; additionally, butterflies were observed on 22 April and 31 August 2019. Nocturnal surveys were conducted from 9 May through 21 September 2019 for a total of 11 collecting events. Conditions for each nocturnal collection event are provided in Table 1.

Table 1. Dates of nocturnal collections with time and air temperature at sundown, cloud cover, and lunar conditions.

Date	Sundown (24 hour)	Air Temperature °F (°C)	Cloud Cover	Lunar Phase and % Illumination
09 MAY 2019	2008	72 (22)	none	waxing 23%
17 MAY 2019	2016	80 (27)	thin clouds	waxing 98%
31 MAY 2019	2027	80 (27)	cloudy	waning 10%
15 JUN 2019	2035	80 (27)	partly cloudy	waxing 96%
28 JUN 2019	2035	84 (29)	thin clouds	waning 21%
12 JUL 2019	2032	86 (30)	none	waxing 81%
27 JUL 2019	2022	85 (29)	none	waning 26%
10 AUG 2019	2005	80 (27)	thin clouds	waxing 78%
24 AUG 2019	1948	74 (23)	clear	waning 74%
06 SEP 2019	1928	70 (21)	clear	waxing 54%
21 SEP 2019	1904	78 (26)	clear	waxing 56%

Three hundred and seventy-five (375) taxa from 39 families of Lepidoptera were collected during the survey period. A list of the taxa encountered on each date is provided for diurnal taxa (Table 2) and nocturnal taxa (Table 3). Species richness of each family encountered on the site is presented in Figure 2. Taxa are arranged taxonomically with primitive families at the bottom of the table near the x-axis and more advanced families at the top. The superfamilies Noctuoidea (Erebidae, Noctuidae, Nolidae, Notodontidae), Pyraloidea (Crambidae, Pyralidae), Tortricoidea (Tortricidae) and Geometroidea (Geometridae) were found to be the most speciose with 109, 62, 51, and 44 species, respectively.

Table 2. Diurnal taxa encountered on each survey date arranged alphabetically by family, then genus and species. Dates followed by a plus sign (+) were visual observations conducted by Debbie Terry.

Taxa	22 APR 2019 ⁺	09 MAY 2019	02 JUN 2019	15 JUN 2019	28 JUN 2019	06 JUL 2019	11 AUG 2019	24 AUG 2019	31 AUG 2019 ⁺	06 SEP 2019	21 SEP 2019
Hesperiidae (skippers)											
<i>Ancyloxypha numitor</i> (Fabricius) – Least Skipper			X				X		X		
<i>Atalopedes campestris</i> (Boisduval) – Sachem									X	X	
<i>Atrytonopsis hianna</i> (Scudder) – Dusted Skipper			X								
<i>Epargyreus clarus</i> (Cramer) – Silver-spotted Skipper							X				
<i>Erynnis baptisiae</i> (W. Forbes) – Wild Indigo Duskywing						X	X				
<i>Erynnis juvenalis</i> (Fabricius) – Juvenal’s Duskywing						X					
<i>Hylephila phyleus</i> (Drury) – Fiery Skipper										X	
<i>Nastra therminier</i> (Latreille) – Swarthy Skipper								X			
<i>Polites peckius</i> (W. Kirby) – Peck’s Skipper									X		
<i>Polites themistocles</i> (Latreille) – Tawny-edged Skipper			X								
Lycacnidae (gossamer-wing butterflies)											
<i>Celastrina</i> sp. [prob. <i>ladon</i> (Cramer) – Spring Azure]	X										
<i>Celastrina neglecta</i> (W.H. Edwards) – Summer Azure									X		
<i>Cupido comyntas</i> (Godart) – Eastern Tailed-Blue		X	X			X		X	X		
Nymphalidae (brush-footed butterflies)											
<i>Boloria bellona</i> (Fabricius) – Meadow Fritillary				X							
<i>Euptoieta claudia</i> (Cramer) – Variegated Fritillary			X	X			X				
<i>Junonia coenia</i> Hübner – Common Buckeye				X	X		X		X		X
<i>Limenitis arthemis astyanax</i> (Fabricius) – Red-spotted Purple				X			X		X		
<i>Megisto cymela</i> (Cramer) – Little Wood-Satyr			X	X							
<i>Phyciodes cocyta</i> (Cramer) – Northern Crescent							X			X	X
<i>Phyciodes tharos</i> (Drury) – Pearl Crescent	X		X			X	X		X	X	X
<i>Polygonia interrogationis</i> (Fabricius) – Question Mark				X							
<i>Vanessa atalanta</i> (Linnaeus) – Red Admiral	X				X	X			X		
<i>Vanessa virginiensis</i> (Drury) – American Lady	X		X	X					X		
Papilionidae (swallowtail butterflies)											
<i>Battus philenor</i> (Linnaeus) – Pipevine Swallowtail				X							
<i>Papilio glaucus</i> Linnaeus – Eastern Tiger Swallowtail	X		X	X					X		
<i>Papilio troilus</i> Linnaeus – Spicebush Swallowtail			X				X		X		
Pieridae (whites and sulphur butterflies)											
<i>Anthocharis midea</i> (Hübner) – Falcate Orangetip	X		X	X							
<i>Colias eurytheme</i> Boisduval – Orange Sulphur	X		X	X					X		X
<i>Colias philodice</i> Godart – Clouded Sulphur										X	
<i>Phoebis sennae</i> (Linnaeus) – Cloudless Sulphur			X								
<i>Pieris rapae</i> (Linnaeus) – Cabbage White	X				X	X			X		
Sphingidae (hawk moths, sphinx moths)											
<i>Hemaris diffinis</i> (Boisduval) – Snowberry Clearwing						X					

Table 3. Nocturnal taxa encountered on each survey date arranged alphabetically by family, then genus and species. Names followed by an asterisk (*) were confirmed by inspection of the genitalia and comparison to published literature or specimens in the USNM.

Taxa	09 MAY 2019	17 MAY 2019	31 MAY 2019	15 JUN 2019	28 JUN 2019	12 JUL 2019	27 JUL 2019	10 AUG 2019	24 AUG 2019	06 SEP 2019	21 SEP 2019
Attevidae (tropical ermine moths)											
<i>Atteva aurea</i> (Fitch) – Ailanthus Webworm	X	X	X	X		X	X	X	X	X	X
Autostichidae (autostichid moths)											
<i>Gerdana caritella</i> Busck – Gerdana Moth							X				
<i>Sceptea aequipulvella</i> Chambers – (no common name)								X			
<i>Symmoca signatella</i> Herrich-Schäffer – (no common name)					X						
Blastobasidae (scavenger moths)											
<i>Asaphocrita aphidiella</i> (Walsingham) – (no common name)*			X								
<i>Blastobasis glandulella</i> (Riley) – Acorn Moth*			X		X		X	X			
Bucculatricidae (ribbed cocoon-making moths)											
<i>Bucculatrix canadensisella</i> Chambers – Birch Skeletonizer					X						
<i>Bucculatrix</i> sp. [poss. <i>angustata</i> Frey & Boll – Narrow Bucculatrix]			X								
Coleophoridae (casebearer moths)											
<i>Coleophora borea</i> Braun – (no common name)			X					X	X	X	
<i>Coleophora cratipennella</i> Clemens – Streaked Coleophora								X			
Cosmopterigidae (cosmet moths)											
<i>Limnaecia phragmitella</i> Stainton – Shy Comet				X							
<i>Cosmopterix floridanella</i> (Beutenmüller) – (no common name)*							X				
Crambidae (crambid moths)											
<i>Agriphila vulgivaellus</i> (Clemens) – Vagabond Crambus											X
<i>Anageshna primordialis</i> (Dyar) – Yellow-spotted Webworm			X	X	X						
<i>Apogeshna stenialis</i> (Guenée) – Checkered Apogeshna						X					
<i>Blepharomastix ranalis</i> (Guenée) – Hollow-spotted Blepharomastix			X	X	X						
<i>Chrysoteuchia topiarius</i> (Zeller) – Topiary Grass-Veneer					X						
<i>Conchylodes ovalis</i> (Guenée) – Zebra Conchylodes							X				
<i>Crambus agitatellus</i> Clemens – Double-banded Grass-Veneer						X					
<i>Crambus laqueatellus</i> Clemens – Eastern Grass-Veneer	X										
<i>Crambus saltuellus</i> Zeller – Pasture Grass-Veneer		X	X	X	X	X	X				
<i>Crocidophora tubercularis</i> Lederer – Pale-winged Crocidophora		X	X	X	X		X				
<i>Desmia funeralis</i> (Hübner) – Grape Leafroller			X	X	X		X	X			
<i>Desmia maculalis</i> Westwood – White-headed Grape Leafroller							X				
<i>Diacme adipaloides</i> (Grote & Robinson) – Darker Diacme		X	X	X	X		X	X			
<i>Diastictis argyralis</i> Hübner – White-spotted Orange Moth					X						
<i>Diastictis ventralis</i> (Grote & Robinson) – White-spotted Brown Moth	X			X				X			
<i>Diathrausta harlequinialis</i> Dyar – Harlequin Webworm						X	X				
<i>Dicymolomia julianalis</i> (Walker) – Julia’s Dicymolomia											X
<i>Donacula sordidellus</i> (Zincken) – (no common name)			X	X			X				
<i>Elophila oblitalis</i> (Walker) – Waterlily Leafcutter				X							
<i>Glaphyria sesquialis</i> Hübner – White-roped Glaphyria							X				
<i>Hahncappsa mancalis</i> (Lederer) – (no common name)							X				
<i>Herpetogramma abdominalis</i> (Zeller) – (no common name)					X						
<i>Herpetogramma aeglealis</i> (Walker) – Serpentine Webworm			X								
<i>Herpetogramma sphengealis</i> Handfield & Handfield – (no common name)					X				X		
<i>Herpetogramma thestealis</i> (Walker) – Zigzag Herpetogramma							X	X			X

Taxa	09 MAY 2019	17 MAY 2019	31 MAY 2019	15 JUN 2019	28 JUN 2019	12 JUL 2019	27 JUL 2019	10 AUG 2019	24 AUG 2019	06 SEP 2019	21 SEP 2019
<i>Microcrambus biguttellus</i> (Forbes) – Gold-stripe Grass-Veneer								X		X	
<i>Microcrambus elegans</i> (Clemens) – Elegant Grass-Veneer			X	X	X		X	X	X	X	
<i>Neodactria</i> sp. [poss. <i>murellus</i> (Dyar) – (no common name)]					X						
<i>Neodactria zeellus</i> (Fernald) – (no common name)			X								
<i>Nomophila nearctica</i> Munroe – Lucerne Moth							X	X	X	X	X
<i>Palpita magniferalis</i> (Walker) – Splendid Palpita			X	X		X	X	X			
<i>Pantographa limata</i> (Grote & Robinson) – Basswood Leafroller							X	X			
<i>Parapediasia decorellus</i> (Zincken) – Graceful Grass-Veneer				X	X						
<i>Parapediasia teterrellus</i> (Zincken) – Bluegrass Webworm			X	X							
<i>Pediasia trisecta</i> (Walker) – Sod Webworm					X						
<i>Saucrobotys fimoferalis</i> (Hulst) – Dusky Saucrobotys	X										
<i>Scoparia biplagiata</i> Walker – Double-striped Scoparia			X			X					
<i>Udea rubigalis</i> (Guenée) – Celery Leaf-tier		X	X	X	X		X	X	X		
<i>Urola nivalis</i> (Drury) – Snowy Urola			X	X			X		X		
Depressariidae (flat-bodied moths)											
<i>Agonopterix thelmae</i> Clarke – Thelma's Agonopterix								X			
<i>Psilocorsis cryptolechiella</i> (Chambers) – Black-fringed Leaf-tier								X			
<i>Psilocorsis reflexella</i> Clemens – Dotted Leaf-tier	X										
Elachistidae (grass leafminer moths)											
<i>Elachista illectella</i> (Clemens) – (no common name)									X		
Erebidae (tussock moths, lichen moths, tiger moths, litter moths, owlets, snouts, underwings, zales)											
<i>Allotria elonympha</i> (Hübner) – False Underwing					X		X				
<i>Apantesis figurata</i> (Drury) – Figured Tiger Moth		X	X			X					
<i>Apantesis nais</i> (Drury) – Nais Tiger Moth	X	X	X		X	X	X	X	X		X
<i>Apantesis</i> Walker sp. – (no common name)							X				
<i>Arugisa lutea</i> (Smith) – Common Arugisa								X			
<i>Bleptina caradrinalis</i> Guenée – Bent-winged Owlet			X	X	X						
<i>Caenurgia chloropha</i> (Hübner) – Vetch Looper				X					X		
<i>Cisthene plumbea</i> Stretch – Lead-colored Lichen Moth									X		
<i>Crambidia pallida</i> Packard – Pale Lichen Moth										X	
<i>Crambidia uniformis</i> Dyar – Uniform Lichen Moth										X	
<i>Euparthenos nubilus</i> (Hübner) – Locust Underwing							X				
<i>Halysidota harrisii</i> (Walsh) – Sycamore Tussock Moth*				X							
<i>Halysidota tessellaris</i> (Smith) – Banded Tussock Moth*							X				
<i>Hypena baltimoralis</i> Guenée – Baltimore Bomolocha (Baltimore Snout)						X					X
<i>Hypena humuli</i> Harris – Hop Vine Moth			X								
<i>Hypena madefactalis</i> Guenée – Gray-edged Bomolocha (Gray-edged Snout)			X	X							
<i>Hypena scabra</i> (Fabricius) – Green Cloverworm			X		X			X	X	X	
<i>Hypena sordidula</i> Grote – Sordid Bomolocha (Sordid Snout)						X					
<i>Hypenodes fractilinea</i> (Smith) – Broken-line Hypenodes			X	X	X			X	X		
<i>Hypenula cacuminalis</i> (Walker) – Long-Horned Owlet						X					
<i>Hyperstrotia nana</i> (Hübner) – White-lined Graylet			X				X	X			
<i>Hyphantria cunea</i> (Drury) – Fall Webworm			X				X				
<i>Idia aemula</i> Hübner – Common Idia					X						
<i>Idia americana</i> (Guenée) – American Idia		X							X		X
<i>Idia denticularis</i> (Harvey) – Toothed Idia*			X								
<i>Idia diminuendis</i> (Barnes & McDunnough) – Orange-spotted Idia				X	X	X	X				
<i>Lascoria ambigua</i> (Walker) – Ambiguous Moth	X	X		X				X			
<i>Macrochilo orciferalis</i> (Walker) – Bronzy Macrochilo											X

Taxa	09 MAY 2019	17 MAY 2019	31 MAY 2019	15 JUN 2019	28 JUN 2019	12 JUL 2019	27 JUL 2019	10 AUG 2019	24 AUG 2019	06 SEP 2019	21 SEP 2019
<i>Metalectra discalis</i> (Grote) – Common Fungus Moth							X				
<i>Metalectra richardsi</i> Brower – Richards' Fungus Moth								X			
<i>Mocis texana</i> (Morrison) – Texas Mocis	X	X	X				X		X		
<i>Orgyia leucostigma</i> (Smith) – White-marked Tussock Moth											X
<i>Palthis angulalis</i> (Hübner) – Dark-spotted Palthis	X	X	X	X		X	X				X
<i>Palthis asopialis</i> (Guenée) – Faint-spotted Palthis											X
<i>Panopoda rufimargo</i> (Hübner) – Red-lined Panopoda								X			
<i>Phalaenophana pyramusalis</i> (Walker) – Dark-banded Owlet		X				X					
<i>Phalaenostola larentioides</i> Grote – Black-banded Owlet			X	X						X	
<i>Phyprosopus callitrichoides</i> Grote – Curve-lined Owlet			X								
<i>Pyrrharctia isabella</i> (Smith) – Isabella Tiger Moth			X					X			
<i>Renia adspersgillus</i> (Bosc) – Speckled Renia								X	X	X	
<i>Renia discoloralis</i> Guenée – Discolored Renia					X	X					
<i>Renia fraternalis</i> Smith – Fraternal Renia				X				X			
<i>Rivula propinqualis</i> Guenée – Spotted Grass Moth									X		X
<i>Rivula salusalis</i> (Walker) – (no common name)									X		
<i>Spargaloma sexpunctata</i> Grote – Six-spotted Gray Moth		X									
<i>Spilosoma virginica</i> (Fabricius) – Virginian Tiger Moth	X										
<i>Tetanolita floridana</i> Smith – Florida Tetanolita											X
<i>Virbia opella</i> (Grote) – Tawny Holomelina (Tawny Virbia)			X								
<i>Zale helata</i> (Smith) – Brown-spotted Zale			X								
<i>Zale lunata</i> (Drury) – Lunate Zale			X								
<i>Zale undularis</i> (Drury) – Black Zale			X				X				
<i>Zanclognatha cruralis</i> (Guenée) – Early Zanclognatha (Early Fan-Foot)								X			
<i>Zanclognatha lituralis</i> (Hübner) – Lettered Zanclognatha (Lettered Fan-Foot)	X		X								
<i>Zanclognatha martha</i> Barnes – Pine Barrens Zanclognatha			X				X				
<i>Zanclognatha obscuripennis</i> (Grote) – Dark Zanclognatha			X	X				X			
Gelechiidae (twirler moths, gelechiid moths)											
<i>Aroga epigaella</i> (Chambers) – (no common name)*								X			
<i>Battaristis vittella</i> (Busck) – Stripe-backed Moth (Orange Stripe-backed Moth)		X	X	X	X						
<i>Chionodes discoocellella</i> (Chambers) – Eye-ringed Chionodes		X									
<i>Chionodes imber</i> Hodges – (no common name)*		X	X								
<i>Chionodes mediofuscella</i> (Clemens) – Black-smudged Chionodes	X	X				X	X	X			
<i>Chionodes sevir</i> Hodges – (no common name)*				X							
<i>Chionodes thoraceochrella</i> (Chambers) – (no common name)					X						
<i>Coleotechnites quercivorella</i> (Chambers) – (no common name)	X		X	X							
<i>Coleotechnites</i> sp. [poss. <i>florae</i> (Freeman)] – Coleotechnites Flower Moth]			X								
<i>Dichomeris copa</i> Hodges – Copa Dichomeris											X
<i>Dichomeris flavocostella</i> (Clemens) – Cream-edged Dichomeris				X							
<i>Dichomeris kimballi</i> Hodges – (no common name)*	X		X	X	X		X		X		
<i>Dichomeris ligulella</i> Hübner – Palmerworm Moth		X					X	X	X		
<i>Dichomeris setosella</i> (Clemens) – (no common name)		X									
<i>Dichomeris offula</i> Hodges – (no common name)*						X					
<i>Dichomeris ventrellus</i> (Fitch) – (no common name)		X	X	X							
<i>Exoteleia pinifoliella</i> (Chambers) – Pine Needleminer Moth	X	X	X	X							
gen. nova et sp. nova 420495.97 – (no common name)						X					
<i>Glauce pectenataeella</i> Chambers – (no common name)*			X								
<i>Helcystogramma hystricella</i> (Braun) – Lanceolate Helcystogramma											

Taxa	09 MAY 2019	17 MAY 2019	31 MAY 2019	15 JUN 2019	28 JUN 2019	12 JUL 2019	27 JUL 2019	10 AUG 2019	24 AUG 2019	06 SEP 2019	21 SEP 2019
(Lanceolate Moth)											
<i>Keiferia lycopersicella</i> (Walsingham) – Tomato Pinworm Moth*				X				X		X	
<i>Recurvaria nanella</i> ([Denis & Schiffmüller]) – Lesser Bud Moth*						X					
<i>Stereomita</i> Braun sp. nova – (no common name)*			X					X	X	X	
Geometridae (geometer moths)											
<i>Aethalura intertexta</i> (Walker) – Four-Barred Gray								X			
<i>Anavitrinella pampinaria</i> (Guenée) – Common Gray	X										
<i>Campaea perlata</i> (Guenée) – Pale Beauty											X
<i>Chlorochlamys chloroleucaria</i> (Guenée) – Blackberry Looper	X	X									
<i>Cleora projecta</i> (Walker) – Projecta Gray			X								
<i>Costaconvexa centrostrigaria</i> (Wollaston) – Bent-line Carpet		X		X	X	X	X		X	X	X
<i>Cyclophora packardi</i> (Prout) – Packard’s Wave											X
<i>Digrammia continuata</i> (Walker) – Curve-lined Angle											X
<i>Epimecis hortaria</i> (Fabricius) – Tulip-Tree Beauty							X		X		
<i>Eubaphe mendica</i> (Walker) – The Beggar			X	X							
<i>Euchlaena madusaria</i> (Walker) – Scrub Euchlaena*	X		X								
<i>Eulithis gracilineata</i> (Guenée) – Greater Grapevine Looper				X							
<i>Eupithecia miserulata</i> Grote – Common Eupithecia (Common Pug)*	X										
<i>Eusarca confusaria</i> Hübner – Confused Eusarca			X		X						
<i>Eutrapela clemataria</i> (Smith) – Curved-Toothed Geometer						X					
<i>Hypagyrtis esther</i> (Barnes) – Esther Moth							X	X	X		
<i>Hypagyrtis unipunctata</i> (Haworth) – One-spotted Variant			X	X							
<i>Hypomecis umbrosaria</i> (Hübner) – Umber Moth					X						
<i>Ilexia intractata</i> (Walker) – Black-dotted Ruddy	X				X						
<i>Iridopsis defectaria</i> (Guenée) – Brown-shaded Gray										X	X
<i>Lomographa vestaliata</i> (Guenée) – White Spring Moth						X	X	X			
<i>Macaria aemulataria</i> Walker – Common Angle			X		X						
<i>Macaria bicolorata</i> (Fabricius) – Bicolored Angle							X				X
<i>Macaria bisignata</i> Walker – Red-headed Inchworm				X							
<i>Macaria granitata</i> Guenée – Granite Moth				X			X	X	X	X	X
<i>Macaria notata</i> (Linnaeus) – Birch Angle						X	X			X	
<i>Melanolophia canadaria</i> (Guenée) – Canadian Melanolophia					X						
<i>Melanolophia signataria</i> (Walker) – Signate Melanolophia	X										
<i>Mellilla xanthometata</i> (Walker) – Orange Wing						X		X			
<i>Metarranthis angularia</i> Barnes & McDunnough – Angled Metarranthis			X								
<i>Metarranthis hypochraria</i> (Herrich-Schäffer) – Common Metarranthis			X								
<i>Orthonama obstipata</i> (Fabricius) – The Gem	X					X	X		X		
<i>Patalene olyzonaria</i> (Walker) – Juniper Geometer (Juniper-twig Geometer)							X	X			
<i>Pero ancetaria</i> (Hübner) – Hubner’s Pero*							X				
<i>Pero honestaria</i> (Walker) – Honest Pero*	X	X					X		X		
<i>Pero morrisonaria</i> (Edwards) – Morrison’s Pero*							X				
<i>Petrophora subaequaria</i> (Walker) – Northern Petrophora							X				
<i>Pleuroprucha insularia</i> (Guenée) – Common Tan Wave							X	X	X	X	X
<i>Prochoerodes lineola</i> (Goeze) – Large Maple Spanworm				X							
<i>Protitame virginialis</i> (Hulst) – Virgin Moth	X	X									
<i>Protoarmia porcelaria</i> (Guenée) – Porcelain Gray								X	X		
<i>Scopula limboundata</i> (Haworth) – Large Lace-border				X	X				X		
<i>Selenia kentaria</i> (Grote & Robinson) – Kent’s Geometer							X				
<i>Speranza pustularia</i> (Guenée) – Lesser Maple Spanworm				X	X						

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Glyphipterigidae (sedge moths)											
<i>Diploschizia impigritella</i> (Clemens) – Yellow Nutsedge Moth				X	X						
Gracillariidae (leaf blotch miner moths)											
<i>Leucospilapteryx venustella</i> (Clemens) – Snakeroot Leafminer								X			
<i>Macrosaccus robinella</i> (Clemens) – (no common name)		X									
<i>Marmara fasciella</i> (Chambers) – White Pine Barkminer	X										
<i>Marmara</i> sp. [nr. <i>viburnella</i> Eiseman & Davis – (no common name)]*							X				
<i>Neurobathra strigifinitella</i> (Clemens) – Finite-channeled Leafminer			X								
<i>Phyllocnistis insignis</i> Frey & Boll – (no common name)			X								
Heliozelidae (leaf miners, shield bearers)											
<i>Antispila viticordifoliella</i> Clemens – (no common name)*								X			
Incurvariidae (fairy moths, incurvarid moths, yucca moths)											
<i>Phylloporia bistrigella</i> (Haworth) – (no common name)	X										
Lasiocampidae (tent caterpillar moths)											
<i>Malacosoma americana</i> (Fabricius) – Eastern Tent Caterpillar Moth			X								
Limacodidae (slug caterpillar moths)											
<i>Apoda biguttata</i> (Packard) – Shagreened Slug Moth				X							
<i>Euclea delphinii</i> (Boisduval) – Spiny Oak-Slug Moth			X	X							
<i>Heterogenea shurtleffi</i> Packard – Red-eyed Button Slug Moth					X	X		X			
<i>Isa textula</i> (Herrich-Schäffer) – Crowned Slug Moth						X	X				
<i>Lithacodes fasciola</i> (Herrich-Schäffer) – Yellow-shouldered Slug Moth						X					
<i>Natada nasoni</i> (Grote) – Nason’s Slug Moth			X								
<i>Parasa indetermina</i> (Boisduval) – Stinging Rose Caterpillar Moth					X						
Momphidae (momphid moths)											
<i>Mompha murtfeldtiella</i> (Chambers) – (no common name)			X								
Nepticulidae (pygmy moths, midget moths)											
<i>Ectoedemia</i> sp. [poss. <i>nyssaeifoliella</i> (Chambers)] – (no common name)*					X						
<i>Stigmella</i> Schrank sp. – (no common name)				X	X						
Noctuidae (dagger moths, noctuid moths, owlet moths, underwings)											
<i>Abrostola urentis</i> Guenée – Spectacled Nettle Moth (Variegated Brindle)					X						
<i>Acrionicta americana</i> (Harris) – American Dagger		X									
<i>Acrionicta haesitata</i> (Grote) – Hesitant Dagger				X			X				
<i>Acrionicta modica</i> (Walker) – Medium Dagger			X				X				
<i>Agrotis ipsilon</i> (Hufnagel) – Ipsilon Dart					X						
<i>Amphipyra pyramidoides</i> Guenée – Copper Underwing										X	
<i>Anicla forbesi</i> (Franclemont) – Forbes’ Dart*							X				
<i>Anicla illapsa</i> (Walker) – Snowy Dart*						X	X				X
<i>Anicla infecta</i> (Ochsenheimer) – Green Cutworm*						X		X	X	X	
<i>Autographa precationis</i> (Guenée) – Common Looper*						X					
<i>Calophasia lumula</i> (Hufnagel) – Toadflax Brocade								X			
<i>Chloridea virescens</i> (Fabricius) – Tobacco Budworm								X			
<i>Chrysodeixis includens</i> (Walker) – Soybean Looper								X		X	
<i>Chytonix palliatricula</i> (Guenée) – Cloaked Marvel		X									
<i>Condica mobilis</i> (Walker) – Mobile Groundling	X	X									
<i>Condica sutor</i> (Guenée) – The Cobbler										X	
<i>Condica vecors</i> (Guenée) – Dusky Groundling					X	X	X	X	X		
<i>Dichagyris acclivis</i> (Morrison) – Inclined Dart									X		

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<i>Elaphria grata</i> Hübner – Grateful Midget					X	X		X			X
<i>Elaphria versicolor</i> (Grote) – Variegated Midget		X				X	X				X
<i>Feltia herilis</i> (Grote) – Master’s Dart									X		X
<i>Galgula partia</i> Guenée – The Wedgling			X								X
<i>Hyperstrotia pervertens</i> (Barnes & McDunnough) – Dotted Graylet				X	X						
<i>Lacinipolia renigera</i> (Stephens) – Bristly Cutworm			X						X	X	X
<i>Leucania adjuta</i> (Grote) – Adjutant Wainscot*				X		X	X		X	X	X
<i>Leucania commoides</i> Guenée – Comma Wainscot*				X							X
<i>Leucania inermis</i> (Forbes) – Unarmed Wainscot*									X		
<i>Leucania linda</i> Franclemont – Linda Wainscot*									X		
<i>Leucania multilinea</i> Walker – Many-lined Wainscot*								X			
<i>Leucania phragmitidicola</i> Guenée – Phragmites Wainscot*							X				
<i>Leucania ursula</i> (Forbes) – Ursula Wainscot*		X						X			
<i>Lithacodia musta</i> (Grote & Robinson) – Small Mossy Lithacodia (Small Mossy Glyph)				X			X		X		
<i>Maliattha synochitis</i> (Grote & Robinson) – Black-dotted Maliattha (Black-dotted Glyph)			X	X							
<i>Marimatha nigrofimbria</i> (Guenée) – Black-bordered Lemon				X	X	X	X	X			X
<i>Mythimna oxygala</i> (Grote) – Lesser Wainscot	X										
<i>Mythimna unipuncta</i> (Haworth) – Armyworm (The White-Speck)	X		X	X			X		X		
<i>Nephelodes minians</i> Guenée – Bronzed Cutworm											X
<i>Orthodes majuscula</i> Herrich-Schäffer – Rustic Quaker							X	X			
<i>Panthea furcilla</i> (Packard) – Eastern Panthea	X							X	X		
<i>Phosphila miseliodes</i> (Guenée) – Spotted Phosphila				X							
<i>Phosphila turbulenta</i> Hübner – Turbulent Phosphila							X	X			
<i>Protodeltote muscosula</i> (Guenée) – Large Mossy Lithacodia (Large Mossy Glyph)			X	X							
<i>Pseudeustrotia carneola</i> (Guenée) – Pink-barred Lithacodia (Pink-barred Pseudeustrotia)							X				
<i>Raphia frater</i> Grote – The Brother			X								
<i>Schinia arcigera</i> (Guenée) – Arcigera Flower Moth										X	X
<i>Spodoptera frugiperda</i> (Smith) – Fall Armyworm											X
<i>Spodoptera ornithogalli</i> (Guenée) – Yellow-striped Armyworm							X	X	X	X	
<i>Spragueia leo</i> (Guenée) – Common Spragueia							X	X			
<i>Xestia c-nigrum</i> (Linnaeus) – Lesser Black-letter Dart (Setaceous Hebrew Character)							X	X	X	X	
Nolidae (nolid moths)											
<i>Meganola phylla</i> (Dyar) – Coastal Plain Meganola	X	X				X	X				
<i>Meganola spodia</i> Franclemont – Ashy Meganola	X						X				
Notodontidae (prominents)											
<i>Dasylophia thyatroides</i> (Walker) – Gray-patched Prominent				X							
<i>Heterocampa biundata</i> Walker – Wavy-Lined Heterocampa							X				
<i>Schizura concinna</i> (Smith) – Red-humped Caterpillar Moth					X						
Oecophoridae (oecophorid moths)											
<i>Epicallima argenticinctella</i> (Clemens) – Orange-headed Epicallima						X					
<i>Promalactis suzukiella</i> (Matsumura) – Suzuki’s Promalactis					X						
Plutellidae (diamondback moths)											
<i>Plutella xylostella</i> (Linnaeus) – Diamondback Moth	X	X	X	X			X				
Pterophoridae (plume moths)											
<i>Emmelina monodactyla</i> (Linnaeus) – Morning-glory Plume Moth*					X						X
<i>Stenoptilia zophodactylus</i> (Duponchel) – Dowdy Plume Moth*											X
Pyralidae (grass moths, snout moths)											

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<i>Acrobasis exsulella</i> (Zeller) – Cordovan Pyralid							X				
<i>Acrobasis</i> sp. [poss. <i>juglandis</i> (LeBaron) – Pecan Leaf Casebearer]											X
<i>Aphomia sociella</i> (Linnaeus) – Bee Moth	X										
<i>Ephestia kuehniella</i> Zeller – Mediterranean Flour Moth											X
<i>Ephesiodes infimella</i> Ragonot – (no common name)										X	
<i>Eulogia ochrifrontella</i> (Zeller) – Broad-banded Eulogia			X				X				X
<i>Macalla zelleri</i> (Grote) – Zeller’s Macalla			X								
<i>Moodna ostrinella</i> (Clemens) – Darker Moodna				X							
<i>Oneida lumulalis</i> (Hulst) – Orange-tufted Oneida								X			
<i>Oreana unicolorella</i> (Hulst) – (no common name)								X	X		
<i>Palatka nymphaeella</i> (Hulst) – (no common name)								X			
<i>Peoria gemmatella</i> (Hulst) – (no common name)								X			
<i>Pococera expandens</i> (Walker) – Striped Oak Webworm (Double-humped Pococera)							X				
<i>Pococera robustella</i> (Zeller) – Pine Webworm					X	X					
<i>Pococera scorteaalis</i> (Lederer) – Lespedeza Webworm								X			
<i>Pyla aenigmatica</i> Heinrich – (no common name)*			X	X							
<i>Salebriaria engeli</i> (Dyar) – Engel’s Salebriaria					X		X				
<i>Salebriaria turpidella</i> (Ragonot) – (no common name)*				X							
<i>Sciota wvinella</i> (Ragonot) – Sweetgum Leafroller								X			
<i>Tosale oviplagalis</i> (Walker) – Dimorphic Tosale				X			X				
<i>Varneria postremella</i> Dyar – (no common name)							X				
<i>Vitula broweri</i> (Heinrich) – Brower’s Vitula		X			X						
<i>Vitula edmandsii</i> (Packard) – Dried Fruit Moth					X						
Saturniidae (giant silkworm moths, royal moths)											
<i>Dryocampa rubicunda</i> (Fabricius) – Rosy Maple Moth	X		X	X			X	X			
<i>Eacles imperialis</i> (Drury) – Imperial Moth								X			
Scythrididae (flower moths)											
<i>Scythris eboracensis</i> (Zeller) – (no common name)				X							
Sphingidae (hawk moths, sphinx moths)											
<i>Lapara coniferarum</i> (Smith) – Southern Pine Sphinx							X				
<i>Smerinthus jamaicensis</i> (Drury) – Twin-spotted Sphinx							X				
Tineidae (fungus moths, cloths moths, tube moths)											
<i>Acrolophus arcanellella</i> (Clemens) – Grass Tubeworm*			X								
<i>Acrolophus panamae</i> Busck – Panama Grass Tubeworm			X		X	X	X				
<i>Acrolophus plumifrontella</i> (Clemens) – Eastern Grass Tubeworm							X	X			
<i>Acrolophus propinqua</i> (Walsingham) – Walsingham’s Grass Tubeworm							X		X		
<i>Homostinea curvilineiella</i> Dietz – (no common name)			X								
<i>Tinea apicimaculella</i> Chambers – Dark-collared Tinea											X
Tortricidae (leaf rollers, leaf tiers)											
<i>Aethes angulatana</i> (Robinson) – Angular Aethes*				X				X	X		X
<i>Aethes promptana</i> (Robinson) – (no common name)*											X
<i>Aethes razowskii</i> Sabourin & Metzler – Razowski’s Aethes*				X							X
<i>Aethes seriatana</i> (Zeller) complex – (no common name)*						X					X
<i>Amorbia humerosana</i> Clemens – White-line Leafroller	X	X									
<i>Ancylis comptana</i> (Frölich) – Strawberry Leafroller							X		X		
<i>Ancylis discigerana</i> (Walker) – Yellow Birch Leafroller		X	X								
<i>Ancylis laciniata</i> (Zeller) – (no common name)	X										
<i>Archips purpurana</i> (Clemens) – Omnivorous Leafroller				X							
<i>Archips rosana</i> (Linnaeus) – Rose Tortrix							X				
<i>Argyrotaenia pinatubana</i> (Kearfott) – Pine Tube Moth	X	X	X	X	X						

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<i>Argyrotaenia tabulana</i> Freeman complex – (no common name)*		X			X	X	X		X	X	
<i>Argyrotaenia velutinana</i> (Walker) – Red-banded Leafroller					X	X	X	X	X		
<i>Celypha cespitana</i> (Hübner) – Celypha Moth			X								
<i>Cenopis pettitana</i> (Robinson) – Maple-basswood Leafroller		X	X								
<i>Choristoneura conflictana</i> (Walker) – Large Aspen Tortrix	X										
<i>Choristoneura rosaceana</i> (Harris) – Oblique-banded Leafroller			X	X				X	X	X	
<i>Clepsis peritana</i> (Clemens) – Garden Tortrix*								X	X	X	
<i>Cydia candana</i> (Forbes) – (no common name)*		X									
<i>Cydia caryana</i> (Fitch) – Hickory Shuckworm*		X									
<i>Cydia latiferreana</i> (Walsingham) – Filbertworm Moth		X					X		X	X	X
<i>Cydia toreuta</i> (Grote) – Eastern Pine Seedworm			X	X							
<i>Dichrorampha leopardana</i> (Busck) – (no common name)							X				
<i>Ecdytolopha insiticiana</i> Zeller – Locust Twig Borer							X				
<i>Endothenia hebesana</i> (Walker) – Verbena Bud Moth (Dull-barred Endothenia)							X				
<i>Epiblema obfuscana</i> (Dyar) – (no common name)*			X								
<i>Eucopina monitorana</i> (Heinrich) – Red Pinecone Borer		X			X						
<i>Eucopina tocullionana</i> (Heinrich) – White Pinecone Borer					X						
<i>Eucosma ambodaidaleia</i> (Miller) – (no common name)	X										
<i>Eucosma parmatana</i> (Clemens) – (no common name)									X		X
<i>Eugnosta sartana</i> (Hübner) – (no common name)*			X	X	X			X	X		
<i>Grapholita packardi</i> (Zeller) – Cherry Fruitworm	X										
<i>Gretchena concitricana</i> (Heinrich) – (no common name)				X	X						
<i>Gymnandrosoma punctidiscanum</i> Dyar – Dotted Ecdytolopha (Dotted Gymnandrosoma)						X	X				
<i>Gypsonoma fasciolana</i> (Clemens) – (no common name)							X				
<i>Olethreutes connectum</i> (McDunnough) – Bunchberry Leafroller										X	
<i>Olethreutes inornatana</i> (Clemens) – Inornate Olethreutes					X						
<i>Pandemis limitata</i> (Robinson) – Three-lined Leafroller						X	X	X			
<i>Phaenocarpa confixana</i> (Walker) – Macramé Moth			X	X							
<i>Platphalonidia magdalenae</i> (Metzler & Albu) – (no common name)						X					
<i>Platynota flavedana</i> Clemens – Black-shaded Platynota		X	X					X	X		
<i>Platynota idaeusalis</i> (Walker) – Tufted Apple-Bud Moth		X	X					X	X		
<i>Proteoteras crescentana</i> Kearfott – Northern Boxelder Twig Borer (Black-crescent Proteoteras)			X								
<i>Retinia comstockiana</i> Fernald – Pitch Twig Moth	X	X	X								
<i>Retinia gemistrigulana</i> (Kearfott) – Gray Retinia				X							
<i>Retinia virginiana</i> (Busck) – Wenzel’s Pitch-blister Moth	X		X								
<i>Rhyacionia frustrana</i> (Comstock) – Nantucket Pine Tip Moth*								X			
<i>Sparganothis sulfureana</i> (Clemens) – Sparganothis Fruitworm			X	X				X	X	X	
<i>Sparganothis xanthoides</i> (Walker) – Mosaic Sparganothis		X									
<i>Sparganothis lentiginosana</i> (Walsingham) – Lentiginos Moth	X	X	X								
<i>Zomaria interruptolineana</i> (Fernald) – Broken-line Zomaria	X										
Yponomeutidae (ermine moths, needleminer moths)											
<i>Yponomeuta multipunctella</i> (Clemens) – American Ermine				X							
Zygaenidae (leaf skeletonizers)											
<i>Pyromorpha dimidiata</i> Herrich-Schäffer – Orange-patched Smoky Moth				X							

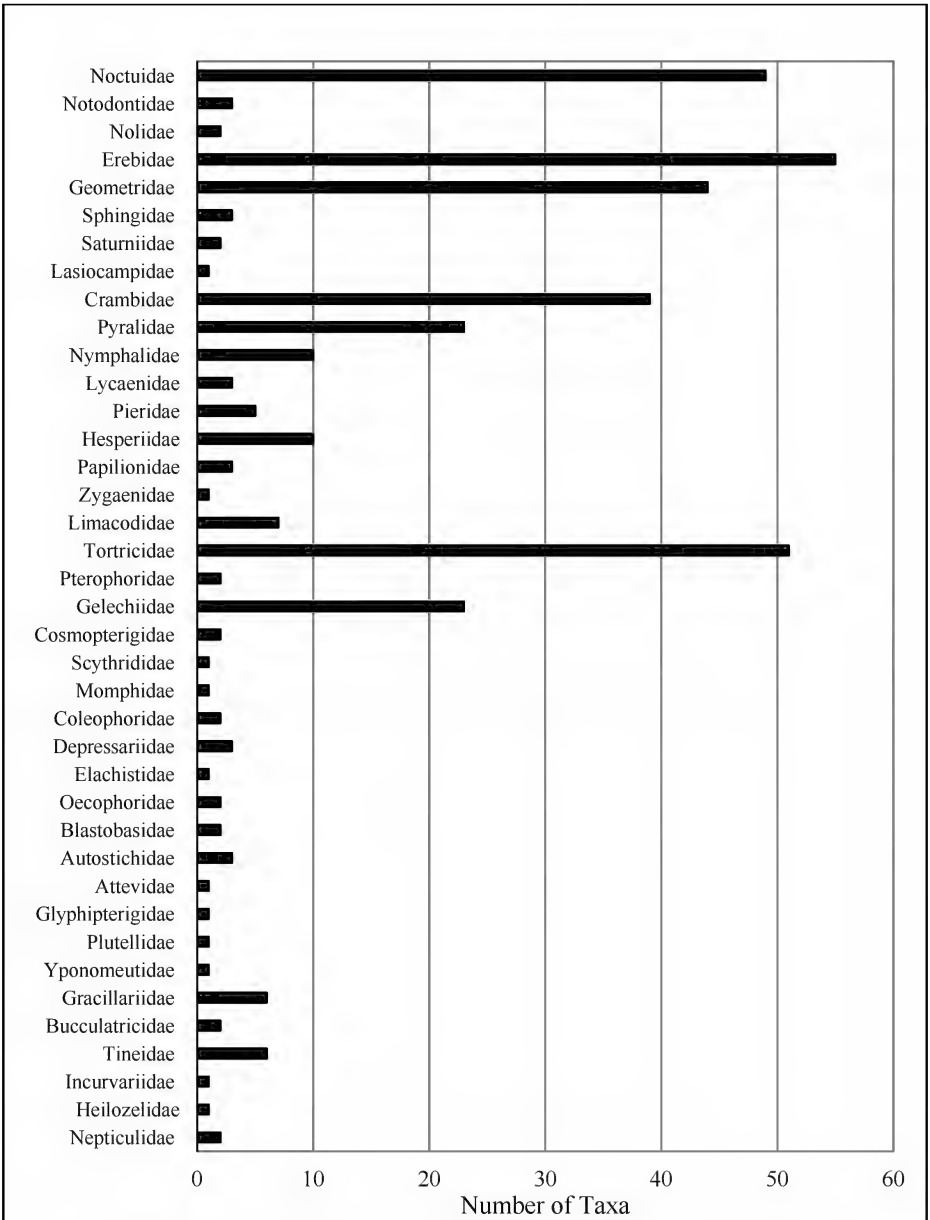


Figure 2. Observed species richness of each family of Lepidoptera encountered. Arranged taxonomically with primitive families at the bottom of the table near the x-axis and more advanced families at the top according to van Nieukerken et al. (2011).

DISCUSSION

During the course of this study, no threatened or endangered Lepidoptera, as determined by the Maryland Natural Heritage Program (2016), were encountered. The plants associated with serpentine soils in the list of Rare, Threatened, and Endangered Plants of Maryland (Maryland Natural Heritage Program 2019) were cross referenced with the caterpillar host lists in Tietz (1972). In total, the Maryland Natural Heritage Program lists 41 rare, threatened or endangered plants being associated with serpentine soils the majority of which appear in Tietz (1972). However, only a few of the associated Lepidoptera were found during this survey. Those that were found are all generalists—e.g., Silver-spotted Skipper, *Epargyreus clarus* (Cramer) (Hesperiidae); Tobacco Budworm, *Chloridea virescens* (Fabricius) (Noctuidae); and Lesser Black-letter Dart, *Xestia c-nigrum* (Linnaeus) (Noctuidae)—and therefore could not be linked to a specific host. It is worth noting that many species of Lepidoptera, especially the Microlepidoptera encountered in this study, have unknown larval hosts (Robinson et al. 2010). This is largely due to their small size, quick larval development, and cryptic feeding habits.

In total 32 species of diurnal Lepidoptera were encountered during the six-month study of the site. In comparison a three-year study of the butterflies of the serpentine barrens of Soldiers Delight Natural Environment Area (approximately 13 km [8 mi] WNW as the crow flies) found 51 species of butterflies on the site (Smith 1981, 2010). Of the 51 species, 19 were found at both sites. Seventeen of these species are common throughout the region and do not infer a unique association to any plants that are specific to serpentine soils. The Dusted Skipper, *Atrytonopsis hianna* (Scudder), and the Swarthy Skipper, *Nastra lherminier* (Latreille) (both Hesperiidae), are exceptions. The Dusted Skipper was reported by Smith (1981, 2010) to be “special” to the serpentine barrens of Soldiers Delight due to the abundance of its hosts, bluestem grasses, *Andropogon* L. spp. (Poaceae) but further explanation was not provided. The Dusted Skipper is reported from 14 counties in Maryland (Hubick and Brighton 2012–2020); it is possible that Smith’s comments may relate more to the abundance of the species and not its uniqueness. The Swarthy Skipper is recorded by Steinberg (2002) to feed on little bluestem, *Schizachyrium scoparium* (Michx.) Nash (Poaceae), which is a species that is commonly associated with serpentine oak and pine barrens, *Quercus* L. (Fagaceae) and *Pinus* L. (Pinaceae) respectively, in Maryland and Pennsylvania and benefits from a fire regime.

A restoration and management plan created for the Unionville Serpentine Barrens (Latham and McGeehin 2012) lists five taxa that are of special conservation concern in Pennsylvania: Falcate Orangetip, *Anthocharis midea* (Hübner) (Pieridae); Swarthy Skipper; Esther Moth, *Hypagyrtis esther* (Barnes) (Geometridae); Inclined Dart, *Dichagyris (Richia) acclivis* (Morrison) (Noctuidae); and Pine Barrens Zanclognatha, *Zanclognatha martha* Barnes (Erebidae). None of these species are known to be of concern in Maryland (Maryland Natural Heritage Program 2016). The Maryland Biodiversity Project (Hubick and Brighton 2012–2020) was used to determine the distribution of these five species in Maryland. The Falcate Orangetip is recorded from 23 of the 24 Maryland jurisdictions (i.e., 23 counties plus Baltimore), Swarthy Skipper from 21, Esther Moth from 18, Inclined Dart from 11, and Pine Barrens Zanclognatha from 5. This suggests that at least the Inclined Dart and the Pine Barrens Zanclognatha may be

under-collected or have limited or restricted distributions in Maryland and warrant further investigation to determine the stability of these species.

There are potentially two undescribed taxa, *Stereomita* Braun (Gelechiidae), and *Stigmella* Schrank (Nepticulidae), and an almost entirely black *Apantesis* Walker (Erebidae) that were encountered during the course of this study and could not be identified. They will be addressed in future studies and subsequent publications if warranted.

ACKNOWLEDGMENTS

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LITERATURE CITED

- Beadle, D., and S. Leckie. 2012. *Peterson Field Guide to Moths of Northeastern North America*. Houghton Mifflin Harcourt Publishing Company, Boston, MA. 611 pp.
- Brady, K.U., A.R. Kruckeberg, and H.D. Bradshaw, Jr. 2005. Evolutionary ecology of plant adaptation to serpentine soils. *Annual Review of Ecology, Evolution, and Systematics* 36:243–266.
- Brown, K.S., Jr. 1991. Chapter 14. Conservation of Neotropical environments: insects as indicators. Pages 349–404. In: N.M. Collins and J.A. Thomas (Editors), *The Conservation of Insects and their Habitats*. 15th Symposium of the Royal Entomological Society of London, 14–15 September 1989, at the Department of Physics Lecture Theatre, Imperial College, London, UK. Academic Press, London, UK. 449 pp.
- Brown, K.S., Jr. 1997. Diversity, disturbance, and sustainable use of Neotropical forests: insects as indicators for conservation monitoring. *Journal of Insect Conservation* 1:25–42.
- Friedman, H. 2016. Chromite Mining History in Maryland. Available at: <https://news.minerals.net/post/chromite-from-the-baltimore-area>. Accessed 18 April 2020.
- Gilligan, T.M., D.J. Wright, and L.D. Gibson. 2008. *Olethreutine Moths of the Midwestern United States. An Identification Guide*. Ohio Biological Survey Bulletin New Series. 16(2) vii + 334 pp.

- Hubick, W.J., and J.D. Brighton. 2012–2020. Maryland Biodiversity Project. Available at: <https://www.marylandbiodiversity.com/>. Accessed 3 May 2020.
- Latham, R.E., and M. McGeehin. 2012. *Unionville Serpentine Barrens Restoration and Management Plan*. Continental Conservation, Rose Valley, Pennsylvania and Natural Lands Trust, Media, PA. 157 pp. + 10 maps.
- Lotts, K., and T. Naberhaus (Coordinators). 2017. Butterflies and Moths of North America. Available at: <http://www.butterfliesandmoths.org/>. Accessed 12 December 2019.
- Maryland Natural Heritage Program. 2016. List of Rare, Threatened, and Endangered Animals of Maryland. Maryland Department of Natural Resources, Annapolis, MD. 23 pp. Available at: https://dnr.maryland.gov/wildlife/Documents/rte_Animal_List.pdf. Accessed 3 May 2020.
- Maryland Natural Heritage Program. 2019. Rare, Threatened, and Endangered Plants of Maryland, C. Frye (Editor). Maryland Department of Natural Resources, Annapolis, MD. 224 pp. Available at: https://dnr.maryland.gov/wildlife/Documents/rte_Plant_List_expanded.pdf. Accessed 3 May 2020.
- Moth Photographers Group. 2019. Digital Guide to Moth Identification. Available at: <http://mothphotographersgroup.msstate.edu/>. Accessed 15 December 2019.
- Opler, P.A., and V. Malikul. 1998. *A Field Guide to Eastern Butterflies*. Easton Press, Norwalk, CT. 486 pp.
- Pollard, A.J. 2016. Heavy metal tolerance and accumulation in plants of the southeastern United States. *Castanea* 81(4):257–269.
- Robinson, G.S., P.R. Ackery, I.J. Kitching, G.W. Beccaloni, and L.M. Hernández. 2010. HOSTS - A Database of the World's Lepidopteran Hostplants. Natural History Museum, London. Available at: <http://www.nhm.ac.uk/hosts>. Accessed 1 July 2020.
- Smith, R.H. 2010. Butterflies of Soldiers Delight NEA. Friends of Soldiers Delight Serpentine Wildlands Natural Environment Area. Soldiers Delight Conservation, Inc. Available at: <https://soldiersdelight.org/article/butterflies-of-soldiers-delight-nea/>. Accessed 3 May 2020.
- Smith, R.H., Jr. 1981. The butterflies of Soldiers Delight, Baltimore County, Maryland. *Maryland Entomologist* 2(1):16–18.
- Steinberg, P.D. 2002. *Schizachyrium scoparium*. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available at: <https://www.fs.fed.us/database/feis/plants/graminoid/schscsco/all.html>. Accessed 3 May 2020.
- Tietz, H.M. 1972. *An Index to the Described Life Histories, Early Stages and Hosts of the Macrolepidoptera of the Continental United States and Canada*. The Allyn Museum of Entomology, Sarasota, FL. iv + 1041 pp.
- van Nieuwerkerken, E.J., L. Kaila, I.J. Kitching, N.P. Kristensen, D.C. Lees, J. Minet, C. Mitter, M. Mutanen, J.C. Regier, T.J. Simonsen, N. Wahlberg, S.-H. Yen, R. Zahiri, D. Adamski, J. Baixeras, D. Bartsch, B.Å. Bengtsson, J.W. Brown, S.R. Bucheli, D.R. Davis, J. De Prins, W. De Prins, M.E. Epstein, P. Gentili-Poole, C. Gielis, P. Hättenschwiler, A. Hausmann, J.D. Holloway, A. Kallies, O. Karsholt, A.Y. Kawahara, S. Koster, M.V. Kozlov, J.D. Lafontaine, G. Lamas, J.-F. Landry, S. Lee, M. Nuss, K.-T. Park, C. Penz, J.Rota, A. Schintlmeister, B.C. Schmidt, J.-C. Sohn, M.A. Solis, G.M. Tarmann, A.D. Warren, S. Weller, R.V. Yakovlev, V.V. Zolotuhin, A. Zwick. 2011. Order Lepidoptera Linnaeus, 1758. In: Zhang, Z.-Q. (Editors) Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. *Zootaxa* 3148. Available at: <http://www.mapress.com/zootaxa/2011/f/zt03148p221.pdf>. Accessed 13 July 2020.
- Wedge Entomological Research Foundation. 1971–2019. *Moths of America North of Mexico*, (multiple fascicles).

**Maryland Entomological Society BugBlitz at the Maryland Ornithological Society's
Carey Run Sanctuary, Garrett County, Maryland, 12–14 July 2019
(abbreviated entomology version)**

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[*Editor's note: The complete version of this article, which includes fish, amphibian, reptile, bird, mammal, fungi, and flora results, will be published in the fall 2020 issue of Maryland Birdlife (Scarpulla 2020).*]

ABSTRACT: The Maryland Entomological Society conducted a BugBlitz on 12–14 July 2019 at the Maryland Ornithological Society's Carey Run Sanctuary in Garrett County, Maryland. This was a cooperative effort between the two societies to help develop an inventory of the fauna of the sanctuary. Although the emphasis was on insect species, all identifiable fauna and flora were included in the results.

With reinvigoration of the Maryland Ornithological Society (MOS) Sanctuary Committee, it became apparent that little was known about the fauna and flora present at the Society's ten sanctuaries. It was decided to hold BioBlitzes at individual sanctuaries to help obtain this information. The first effort was trimmed down to a BugBlitz at the Carey Run Sanctuary (Figure 1) over the 12–14 July 2019 weekend that was coordinated by Gene Scarpulla and Marcia Watson, both members of MOS and the Maryland Entomological Society (MES).

LOCATION

Location information is excerpted from the "Carey Run MOS Sanctuary" and the "Carey Run Sanctuary (Garrett County)" websites (MOS 2020a, 2020b).

Carey Run Sanctuary was the first property to be purchased by MOS, which now owns ten sanctuaries across the state. The original purchase in 1962 was a 52-ac (21-ha) farm, complete with a farmhouse (Figure 2), which had been abandoned for several years. In 1973, MOS purchased another 110 ac (45 ha), bringing Carey Run to its current size of 162 ac (66 ha).

The sanctuary is located in eastern Garrett County and is named for the stream, Carey Run, which flows through the property (Figure 3). Carey Run is a tributary of the Savage River and joins the river just outside the entrance to the sanctuary. Another stream, Hefner Run, flows into Carey Run within the sanctuary. The two stream valleys form a Y-shape that cradles the old farmhouse, built in 1887 from white pines, *Pinus strobus* L., grown on the property. A small freshwater pond (Figure 4), formed by damming Carey Run, is located a short distance from the house. The original dam was manmade but American Beavers, *Castor canadensis* Kuhl, occasionally assist in dam remodeling. There are also North American River Otters, *Lontra canadensis* (Schreber), at Carey Run Sanctuary, as well as American Black Bears, *Ursus americanus* Pallas, Coyotes, *Canis latrans* Say, and Timber Rattlesnakes, *Crotalus horridus* Linnaeus.



Figure 1. Entrance to Carey Run Sanctuary, Garrett County, Maryland.
Photographed by Dominic Nucifora.



Figure 2. The farmhouse at Carey Run Sanctuary. Photographed by Dominic Nucifora.

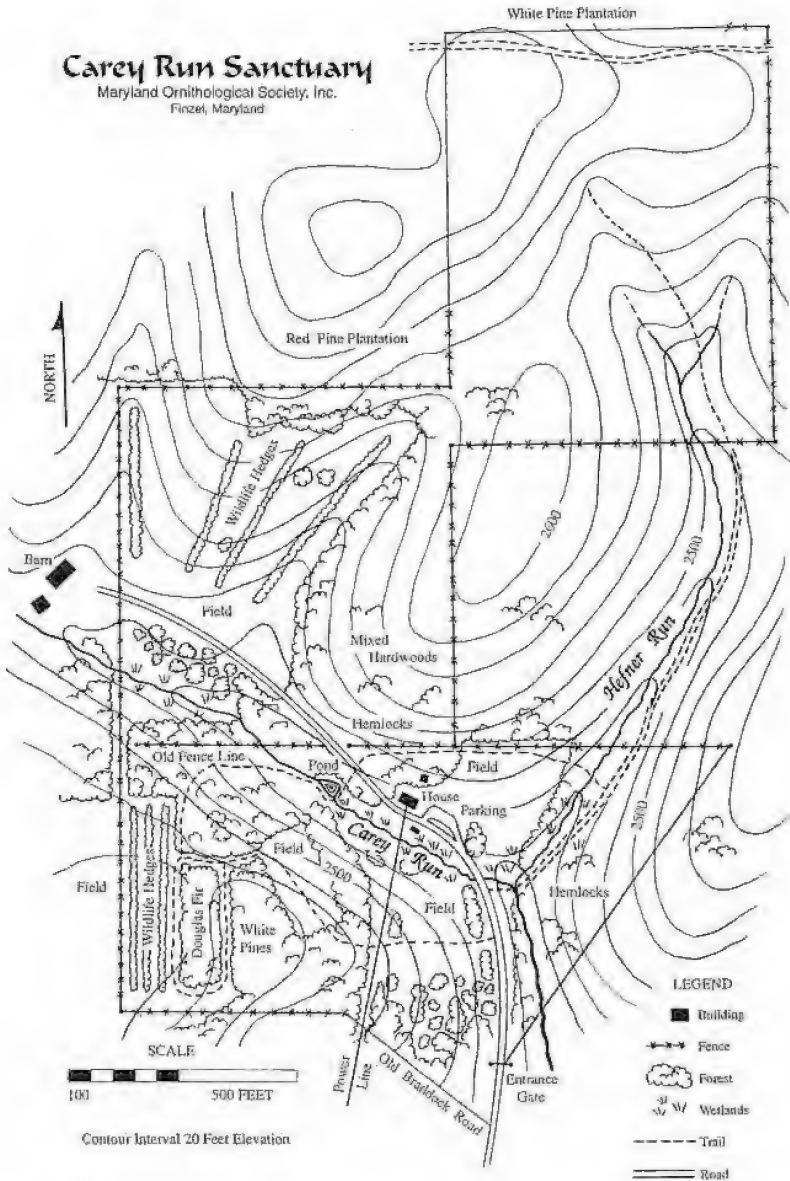


Figure 3. Carey Run Sanctuary.



Figure 4. The pond located on Carey Run at the Carey Run Sanctuary.
Photographed by Dominic Nucifora.



Figure 5. Wildlife hedges and grassy meadows at Carey Run Sanctuary.
Photographed by Dominic Nucifora.

Carey Run Sanctuary has diverse plant communities. The majority of the land is covered by mixed deciduous forest interspersed with eastern hemlock, *Tsuga canadensis* (L.) Carrière, groves. The sanctuary also holds plantations of white pine and Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, planted when these species were important timber crops. There is a small meadow near the house; a large field and hedgerow combination, along with an old orchard, at the northwest border; and a set of wildlife hedges and grassy meadows in the southwest corner (Figure 5). The fields and meadows are mown once annually to maintain good habitat for a diverse assortment of grassland birds as well as for pollinators.

The many trails at Carey Run Sanctuary guide visitors through each of its habitats. The Old Braddock Road, which runs along the Sanctuary's southern border, has significant historical importance as the route created by British Major General Edward Braddock's troops during the French and Indian War in the mid-1700s. Interpretive signage marks the nature trail that parallels the historic road; the placards present a unique interweaving of the military history of the war, the natural history of the land, and the use of the land and its resources by the indigenous Native Americans. The interpretive trail and its signage were created by T. C. Hager as an Eagle Scout project.

The Carey Run Sanctuary farmhouse is available from spring through fall for overnight stays by individuals or organized groups engaging in natural history projects. The house has a modernized kitchen, three bedrooms with bunk beds, and a small parlor, and is heated with two wood stoves. Advance reservations are necessary (MOS 2020b).

METHODS

The 13 participants of the 12–14 July 2019 BugBlitz were John Bocan, Sam Droege, Tim Foard, Bob Gardner, Peggy Israel, Phil Kean, Sue Muller, Gene Scarpulla, Andrew Sharp, Joanne Sharp, Jackie Sin, Bob Trumbule, and Marcia Watson.

The participants employed various methods to document the fauna and flora of Carey Run Sanctuary. These methods included netting, bee bowls, four black light sheet arrays, photography, and acoustic recording of flyover bats.

RESULTS and DISCUSSION

Participants have provided summaries for taxa that have numerous observations.

ARACHNIDS

The sequence of arachnid orders is based on Zhang (2011). Taxonomy is based on Bradley (2013) and ITIS (2020).

Opiliones (harvestmen)

Sclerosomatidae

Leiobunum aldrichi (Weed) – a harvestman

Leiobunum aldrichi, which was photographed by me, represents a first record for the Maryland Biodiversity Project database. — *Marcia Watson*

Ixodida (ticks)**Ixodidae (hard ticks)**

Dermacentor variabilis (Say) – American Dog Tick

Araneae (spiders)**Tetragnathidae (long-jawed orbweavers)**

Leucauge venusta (Walckenaer) – Orchard Orbweaver

Thomisidae (crab spiders)

Misumessus oblongus (Keyserling) – a crab spider

INSECTS

The sequence of insect orders is based on Zhang (2011).

Ephemeroptera (mayflies)**Ephemeridae (common burrowing mayflies)**

Ephemera blanda Traver – a mayfly

Odonata (dragonflies, damselflies)**Libellulidae (common skimmers)**

Libellula luctuosa Burmeister – Widow Skimmer

Libellula vibrans Fabricius – Great Blue Skimmer

Plathemis lydia (Drury) – Common Whitetail

Orthoptera (grasshoppers, crickets, katydids)**Acrididae (short-horned grasshoppers)**

Chortophaga viridifasciata (De Geer) – Northern Green-striped Grasshopper

Pseudochorthippus curtipennis (Harris) – Marsh Meadow Grasshopper

The Marsh Meadow Grasshopper was photographed by me and identified by Brandon Woo. Brandon noted that “This is a male *Pseudochorthippus curtipennis* (often seen under the old name *Chorthippus curtipennis*). Likes open wet meadows, and is more of a northern species, although it does sneak down into the Appalachians - so makes sense that it occurs in Garrett County. Doesn’t look like there are any Maryland records on BugGuide, iNaturalist, or Maryland Biodiversity Project as of yet!” — *Marcia Watson*

Phasmida (phasmids)**Diapheromeridae**

Diapheromera femorata (Say) – Northern Walkingstick

Plecoptera (stoneflies)**[family unknown]**

an adult stonefly sp.

Hemiptera (true bugs)**Aphididae: Eriosomatinae (woolly aphids)**

a woolly aphid sp.

Cicadellidae (leaf hoppers)

Graphocephala Van Duzee sp. – a leafhopper sp.

Some BugBlitz participants reported not seeing any Hemlock Woolly Adelgids, *Adelges tsugae* Annand (Adelgidae), in the eastern hemlock groves. — *Gene Scarpulla*

Hymenoptera (bees only)

Taxonomy is based on Michener (2007), Ascher and Pickering (2020), and ESA (2020).

Colletidae (plasterer bees, polyester bees)

Hylaesus affinis (Smith) – a yellow-faced bee

Hylaesus affinis (Smith) or *H. modestus* Say – a yellow-faced bee

Andrenidae (mining bees)

Andrena wilkella (Kirby) – a mining bee

Halictidae (sweat bees)

Agapostemon texanus Cresson – a green sweat bee

Augochlora pura (Say) – a green sweat bee

Augochlorella aurata (Smith) – a green sweat bee

Halictus ligatus Say – a sweat bee

Halictus rubicundus (Christ) – a sweat bee

Lasioglossum acuminatum McGinley – a sweat bee

Lasioglossum coeruleum (Robertson) – a sweat bee

Lasioglossum coriaceum (Smith) – a sweat bee

Lasioglossum cressonii (Robertson) – a sweat bee

Lasioglossum gotham Gibbs – a sweat bee

Lasioglossum hitchensi Gibbs – a sweat bee

Lasioglossum lineatulum (Crawford) – a sweat bee

Lasioglossum nigroviride (Graenicher) – a sweat bee

Lasioglossum oceanicum (Cockerell) – a sweat bee

Lasioglossum pectorale (Smith) – a sweat bee

Lasioglossum tegulare (Robertson) – a sweat bee

Lasioglossum versans (Lovell) – a sweat bee

Lasioglossum versatum (Robertson) – a sweat bee

Megachilidae (leafcutting bees, resin bees)

Megachile inermis Provancher – a leafcutting bee

Megachile mendica Cresson – a leafcutting bee

Megachile relativa Cresson – a leafcutting bee

Apidae (long-horned bees, honey bees, bumble bees, carpenter bees)

Bombus bimaculatus Cresson – Two-spotted Bumble Bee

Bombus impatiens Cresson – Common Eastern Bumble Bee

Bombus vagans Smith – Half-black Bumble Bee

Bombus terricola Kirby – Yellow-banded Bumble Bee

Melissodes desponsus Smith – a long-horned bee

For bee diversity, July is the ebb tide of the year; the spring bees have finished flying and the fall bees have yet to begin. Remaining are mostly bees that are either colonial (*Bombus* species), eusocial (*Lasioglossum* species), and a few bees that are just beginning to exploit the late summer flowers or may have multiple generations (*Megachile* species). Additionally, we have *Andrena wilkella* which is an introduced late-spring species with a

broad range of preferences for weedy plant species and *Melissodes desponsus* which is a thistle specialist (a few thistles were just beginning to bloom on the Sanctuary).

While most of the species on the list are common and expected, it was significant to see the two female specimens of *Bombus terricola* (Yellow-banded Bumble Bee) that were captured at the Sanctuary on 14 July 2019. This is an “S1 Critically Imperiled / Highly State Rare” species “At very high risk of extinction or extirpation due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.” (Maryland Natural Heritage Program 2016). These specimens represent only the second recent record of the species in Maryland (there was one previous Garrett County specimen, a male at Rock Lodge Trust, near McHenry on 7 July 2012) and it is one of the few known records for the state. This species underwent population decreases throughout its range over the past few decades, most likely from introduced pathogens; thus, it is significant and nice to see that this species is still present in the state on the protected grounds of the Sanctuary. — *Sam Droege*

Hymenoptera (wasps only)

Taxonomy is based on Bohart and Menke (1976), Bohart and Kimsey (1979, 1982), Kimsey and Bohart (1990), Goulet and Huber (1993), Buck et al. (2008), and ITIS (2020).

Chrysididae (cuckoo wasps)

Hedychrum confusum Buysson – a cuckoo wasp

Hedychrum parvum Aaron – a cuckoo wasp

Crabronidae (sand wasps)

Ectemnius borealis (Zetterstedt) – a sand wasp (♂)

Ectemnius lapidarius (Panzer) – a sand wasp (♂ and ♀)

Ichneumonidae (ichneumon wasps)

an ichneumon wasp sp.

Tenthredinidae (common sawflies)

a common sawfly sp.

Vespidae (hornets, paper wasps, potter wasps, yellowjackets)

Polistes Latreille sp. – a paper wasp sp.

Symmorphus canadensis (de Saussure) – a potter wasp

Hymenoptera (ants only)

Taxonomy is based on Ellison et al. (2012) and ITIS (2020).

Formicidae (ants)

Aphaenogaster rudis Enzmann – Rough Aphaenogaster

Aphaenogaster picea (Wheeler) – Pitch-black Aphaenogaster

Camponotus pennsylvanicus (De Geer) – Black or Eastern Carpenter Ant

Camponotus nearcticus Emery – Nearctic Carpenter Ant

Crematogaster lineolata (Say) – Small-lined Crematogaster

Formica incerta Buren – Uncertain Ant

Formica neogagates Viereck species 1 – New World Black Ant species 1

Formica neogagates Viereck species 2 – New World Black Ant species 2

Formica subsericea Say – Somewhat Silky Ant

Lasius umbratus (Nylander) – Shaded Fuzzy Ant
Lasius nearcticus Wheeler – New World Fuzzy Ant
Lasius americanus Emery – New World Cornfield Ant
Myrmecina americana Emery – American Myrmecina
Myrmica punctiventris Roger – Punctured Ant
Myrmica species code AF-smi – an undescribed species
Prenolepis imparis (Say) – Winter Ant
Solenopsis molesta (Say) – Thief Ant
Stenamma impar Forel – Odd Stenamma
Tapinoma sessile (Say) – Odorous House Ant

Most of the ants identified during the BugBlitz were species which are widely distributed throughout the state. No habitat specialists, state records, or invasive species were found. Despite that, there were several observations of the ant fauna which are worthy of note. The first is that three unnamed species were collected during the survey. Within the *Formica neogagates* species group, Fisher and Cover (2007) recognized a few valid species and posited that additional ones might currently be lumped within “*F. neogagates*” and “*F. lasioides* Emery”. One of the two collected species could very well be identified as “*F. neogagates sensu stricto*” once the taxonomy of the species group is finally resolved.

Another observation, also pertaining to the genus *Formica*, was that there were fewer species recorded from this survey than expected. Within the state, the genus reaches its greatest diversity in the western half and in the higher elevations. At least twice the number of collected species were expected at the start of the BugBlitz. The species which were collected are very common species elsewhere in the state, but were not observed to be common on the property. Conspicuously absent were the mound-building *Formica* species. The low diversity was the most surprising observation, given the large open areas present at Carey Run Sanctuary which would be ideal for the establishment of several species in this genus.

The final observation may help explain in part the low *Formica* diversity observed. Extensive sweeping in the grassland area resulted in large numbers of a species of *Myrmica*. At first, so many were recovered from the sweep net that they were suspected of being the invasive European species *M. rubra* (Linnaeus). This suspicion was also coupled with the observation that there was an abundance of small low mounds (five were counted in 1 m² [10.8 ft²]). It was not until much later after the BugBlitz that identification of the *Myrmica* species was made and it turned out to be *Myrmica* species code AF-smi. The abundance of *Myrmica* colonies may have prevented the establishment of *Formica* colonies and it would explain why very few *Formica* species were encountered in this habitat and it opens up promising research into the biology of an undescribed species. — *Tim Foard*

Coleoptera (beetles)

Taxonomy is based on Arnett et al. (2001, 2002), Evans (2014), and ITIS (2020).

Carabidae (ground beetles)

Dicaelus teter Bonelli – a ground beetle
Pterostichus Bonelli sp. – a ground beetle sp.

Silphidae (carrion beetles)*Necrophila americana* (Linnaeus) – American Carrion Beetle*Nicrophorus tomentosus* Weber – Tomentose Burying Beetle**Scarabaeidae (scarab beetles)***Popillia japonica* Newman – Japanese Beetle**Lampyridae (fireflies)***Photuris* Dejean sp. – a firefly sp.**Cantharidae (soldier beetles)***Pacificanthia rotundicollis* (Say) – a soldier beetle**Nitidulidae (sap beetles)***Glischrochilus sanguinolentus* (Olivier) – a sap beetle**Endomychidae (handsome fungus beetles)***Mycetina perpulchra* (Newman) – a handsome fungus beetle**Coccinellidae (ladybird beetles)***Harmonia axyridis* (Pallas) – Multicolored Asian Lady Beetle**Meloidae (blister beetles)***Epicauta funebris* Horn – Margined Blister Beetle**Cerambycidae (long-horned beetles)***Lepturoopsis biforis* (Newman) – a flower long-horned beetle*Saperda candida* Fabricius – Round-headed Apple Tree Borer*Typocerus velutinus* (Olivier) – Banded Longhorn**Chrysomelidae (leaf beetles)***Chrysoschus auratus* (Fabricius) – Dogbane Beetle*Deloyala guttata* (Olivier) – Mottled Tortoise Beetle*Leptinotarsa juncta* (Germar) – False Potato Beetle*Trirhabda* J.L. LeConte sp. – a skeletonizing leaf beetle sp.**Megaloptera (alderflies, dobsonflies, fishflies)****Corydalidae (dobsonflies, fishflies)***Chauliodes pectinicornis* (Linnaeus) – Summer Fishfly**Lepidoptera (butterflies only)**

Taxonomy is based on Glassberg (1999) and ITIS (2020).

Papilionidae (swallowtails)*Battus philenor* (Linnaeus) – Pipevine Swallowtail*Papilio polyxenes* Fabricius – Black Swallowtail*Papilio glaucus* Linnaeus – Eastern Tiger Swallowtail**Pieridae (whites, yellows)***Pieris rapae* (Linnaeus) – Cabbage White*Colias philodice* Godart – Clouded Sulphur*Colias eurytheme* Boisduval – Orange Sulphur*Phoebis sennae* (Linnaeus) – Cloudless Sulphur**Lycanidae (gossamer-wings)***Satyrrium titus* (Fabricius) – Coral Hairstreak*Cupido comyntas* (Godart) – Eastern Tailed-Blue*Celastrina neglecta* (W. H. Edwards) – Summer Azure

Nymphalidae (brushfoots)

- Speyeria cybele* (Fabricius) – Great Spangled Fritillary
Speyeria aphrodite (Fabricius) – Aphrodite Fritillary
Phyciodes tharos (Drury) – Pearl Crescent
Euphydryas phaeton (Drury) – Baltimore Checkerspot
Polygonia comma (T. Harris) – Eastern Comma
Vanessa atalanta (Linnaeus) – Red Admiral
Junonia coenia Hübner – Common Buckeye
Limnitis arthemis astyanax (Fabricius) – Red-spotted Purple
Lethe anthedon (A. Clark) – Northern Pearly-eye
Lethe appalachia R. Chermock – Appalachian Brown
Cercyonis pegala (Fabricius) – Common Wood-Nymph
Danaus plexippus (Linnaeus) – Monarch

Hesperiidae (skippers)

- Epargyreus clarus* (Cramer) – Silver-spotted Skipper
Pyrgus communis (Grote) – Common Checkered-Skipper
Polites origenes (Fabricius) – Crossline Skipper
Wallengrenia egeremet (Scudder) – Northern Broken Dash
Pompeius verna (W. H. Edwards) – Little Glassywing
Anatrytone logan (W. H. Edwards) – Delaware Skipper
Euphyes vestris (Boisduval) – Dun Skipper

In surveying the property for butterflies, 29 species of butterflies and skippers were recorded. The majority were common species that are virtually statewide in distribution, one exception being *Speyeria aphrodite* (Aphrodite Fritillary) which is primarily found in the Appalachian Plateau and Ridge and Valley regions (Smith 2014). Its numbers seem to be declining in some of its usual locations.

One notable migrant was *Phoebis sennae* (Cloudless Sulphur). While this southern species regularly reaches Maryland in most years, it is usually to be expected in late summer or fall. Our sighting of this species was probably a little earlier than normal this far from Maryland's coastal counties.

Three species of satyrines (Nymphalidae: Satyrinae) were also observed. They were *Cercyonis pegala* (Common Wood-Nymph), *Lethe anthedon* (Northern Pearly-eye), and *Lethe appalachia* (Appalachian Brown). While fairly widespread in Maryland, all three of these species tend to be found in localized colonies.

The most notable species recorded was *Euphydryas phaeton* (Baltimore Checkerspot) (Figure 6) which is an "S2 Imperiled / State Rare" species that is "At high risk of extinction or extirpation due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors." (Maryland Natural Heritage Program 2016). Two definite sightings of this species, our Maryland State Insect, were made during the survey.

On a final note, there was one other interesting find made on the trip. Among the skippers found on the Sanctuary was *Anatrytone logan* (Delaware Skipper). While being fairly widespread in Maryland, it is also known to be a rather uncommon species. Indeed, during our survey, only a couple of individuals were sighted during the entire day.

However, over a dozen specimens were found as bycatch in Gene Scarpulla's "bee bowls". — *Phil Kean*



Figure 6. Baltimore Checkerspot, *Euphydryas phaeton* (Drury) at Carey Run Sanctuary. Photographed by Tim Foard, 13 July 2019.

Lepidoptera (moths only)

Taxonomy is based on Beadle and Leckie (2012) and ITIS (2020).

Bucculatricidae (ribbed cocoon-making moths)

Bucculatrix ainliella Murtfeldt – Oak Skeletonizer (caterpillar)

Limacodidae (slug moths)

Prolimacodes badia (Hübner) – Skiff Moth

Isa textula (Herrich-Schäffer) – Crowned Slug Moth

Pyralidae (grass moths, snout moths)

Pyralis farinalis Linnaeus – Meal Moth

Crambidae (crambid snout moths)

Udea rubigalis (Guenée) – Celery Leaf-tier

Pantographa limata (Grote and Robinson) – Basswood Leafroller Moth

Geometridae (geometer moths, looper moths)

Rheumaptera prunivorata (Ferguson) – Cherry Scallop Shell

Euphyia intermediata (Guenée in Boisduval and Guenée) – Sharp-angled Carpet

Trichodezia albovittata (Guenée in Boisduval and Guenée) – White-striped Black

Scopula limboundata (Haworth) – Large Lace-border

Speranza pustularia (Guenée in Boisduval and Guenée) – Lesser Maple Spanworm

Digrammia ocellinata (Guenée in Boisduval and Guenée) – Faint-spotted Angle

Protoboarmia porcelaria (Guenée in Boisduval and Guenée) – Porcelain Gray

Biston betularia (Linnaeus) – Pepper-and-salt Geometer

Cabera variolaria Guenée in Boisduval and Guenée – Pink-Striped Willow Spanworm (The Vestal)

Phaeoura quernaria (Smith in Smith and Abbot) – Oak Beauty
Eugonobapta nivosaria (Guenée in Boisduval and Guenée) – Snowy Geometer
Eutrapela clemataria (Smith in Smith and Abbot) – Curved-Toothed Geometer
Prochoerodes lineola (Goeze) – Large Maple Spanworm

Saturniidae (giant silkworm moths, royal moths)

Dryocampa rubicunda (Fabricius) – Rosy Maple Moth
Automeris io (Fabricius) – Io Moth
Callosamia promethea (Drury) – Prometheus Silkworm

Sphingidae (hawk moths, sphinx moths)

Ceratomia undulosa (Walker) – Waved Sphinx
Paonias excaecata (J. E. Smith) – Blinded Sphinx
Paonias myops (J. E. Smith) – Small-eyed Sphinx

Notodontidae (prominents)

Peridea basitriens (Walker) – Oval-based Prominent

Erebidae (tiger moths, tussock moths, underwings, zales)

Lymantria dispar (Linnaeus) – Gypsy Moth (egg masses)
Hypoprepia fucosa Hübner – Painted Lichen Moth
Phragmatobia fuliginosa (Linnaeus) – Ruby Tiger Moth
Halysidota tessellaris (J. E. Smith) – Banded Tussock Moth
Lophocampa caryae Harris – Hickory Tussock Moth
Cynia tenera Hübner – Delicate Cynia
Ctenucha virginica (Esper) – Virginia Ctenucha
Zanclognatha laevigata (Grote) – Variable Fan-Foot
Catocala crataegi Saunders – Hawthorn Underwing
Catocala blandula Hulst – Charming Underwing
Zale lunata (Drury) – Lunate Zale
Zale minerea (Guenée) – Colorful Zale
Euparthenos nubilis (Hübner) – Locust Underwing
Panopoda rufimargo (Hübner) – Red-lined Panopoda

Noctuidae (cutworms, dagger moths, owlet moths)

Panthea acronyctoides (Walker) – Black Zigzag
Loscopia velata (Walker) – Veiled Ear Moth
Polia nimbosea (Guenée) – Stormy Arches

On the evenings of 13 and 14 July 2019, moths were observed and recorded via black light or mercury vapor lights. Over the two evenings, a total of 41 moth species were recorded representing ten families. Two more species were added during the day: *Bucculatrix ainshliella* (an Oak Skeletonizer caterpillar) and *Lymantria dispar* (Gypsy Moth egg masses). The families with the most species were Geometridae (13) and Erebidae (14). Of the 43 total species recorded, five (three erebids and two noctuids) are to be noted as more northerly United States species. The first erebid, *Phragmatobia fuliginosa* (Ruby Tiger Moth), is primarily a much more northerly species. In Maryland, it occurs in Garrett and Allegany Counties and occasionally has been found along the northern tier of Maryland counties. The two other erebids are *Catocala blandula* (Charming Underwing), a more northerly species, and *Catocala crataegi* (Hawthorn Underwing), a more northerly and westerly species, both of their distributions extending south along the Appalachian Mountains. Both species are primarily found in Western

Maryland, with *C. blandula* records extending eastward in Maryland counties just south of the Mason-Dixon Line. The two noctuids, *Panthea acronyctoides* (Black Zigzag) and *Polia nimbosa* (Stormy Arches), are more northerly species whose distribution extends down the Appalachian Mountains. While *P. nimbosa* occurs in Western Maryland, *P. acronyctoides* only occurs in far Western Maryland. — *Bob Gardner*

Diptera (gnats, mosquitoes, true flies)

Taxonomy is based on McAlpine (1981, 1987, 1989) and ITIS (2020).

Tipulidae (crane flies)

Tipula metacomet Alexander – a large crane fly

Ptychopteridae (phantom crane flies)

Bittacomorpha clavipes (Fabricius) – a phantom crane fly

Culicidae (mosquitoes)

Aedes Meigen sp. – a mosquito sp.

Tabanidae (deer flies, horse flies)

Chrysops Meigen sp. – a deer fly sp.

Asilidae (robber flies)

Laphria Meigen sp. – a bee-like robber fly sp.

Syrphidae (flower flies)

Eristalis tenax (Linnaeus) – Common Drone Fly

Spilomyia fusca Loew – Bald-faced Hornet Fly

Toxomerus marginatus (Say) – Margined Calligrapher

Agromyzidae (leafminer flies)

Phytoliriomyza melampyga (Loew) – Jewelweed Leafminer

Mecoptera (scorpionflies, hangingflies, snowflies)

Panorpidae (common scorpionflies)

Panorpa Linnaeus sp. – a common scorpionfly sp.

SUMMARY

Table 1 summarizes the results of the three-day Carey Run BugBlitz. The 13 participants detected 337 taxa (4 arachnids, 166 insects, 1 fish, 7 amphibians, 54 birds, 7 mammals, 15 fungi, 83 flora). The arachnids included 1 Opiliones, 1 Ixodida, and 2 Araneae. The insects included 1 Ephemeroptera, 3 Odonata, 2 Orthoptera, 1 Phasmida, 1 Plecoptera, 2 Hemiptera, 55 Hymenoptera, 18 Coleoptera, 1 Megaloptera, 72 Lepidoptera, 9 Diptera, and 1 Mecoptera.

The data are a mere one-weekend snapshot of the biodiversity of Carey Run Sanctuary. There are undoubtedly numerous additional species that remain to be documented on the Sanctuary. More faunal and floral specialists are needed to survey the property throughout the different seasons of the year. We hope that this preliminary list will inspire others to visit and conduct surveys on the property.

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during, and after the BugBlitz; and Dominic Nucifora (Sanctuary Committee Chair, MOS) for facilitating this event. I also thank Jeffrey W. Shultz (Associate Professor, Department of Entomology, University of Maryland, College Park) for confirming the *Leiobunum aldrichi* identification; Brandon Woo (Contributing Editor, BugGuide and Maryland Biodiversity Project) for identifying *Pseudochorthippus curtipennis* and *Diaperomera femorata*; John F. Carr (Contributing Editor, BugGuide) for identifying *Tipula (Nippotipula)*; and Curt W. Harden (Department of Plant & Environmental Sciences, Clemson University) for identifying *Dicaelus teter*.

Table 1. Taxa observed during the 12–14 July 2019 Carey Run Sanctuary BugBlitz.

	Orders	Families	Genera	Species
Arachnids	Opiliones	1	1	1
	Ixodida	1	1	1
	Araneae	2	2	2
Insects	Ephemeroptera	1	1	1
	Odonata	1	2	3
	Orthoptera	1	2	2
	Phasmida	1	1	1
	Plecoptera	1	1	1
	Hemiptera	2	2	2
	Hymenoptera (bees)	5	10	28
	Hymenoptera (wasps)	5	6	8
	Hymenoptera (ants)	1	11	19
	Coleoptera	11	18	18
	Megaloptera	1	1	1
	Lepidoptera (butterflies)	5	25	29
	Lepidoptera (moths)	10	40	43
	Diptera	7	9	9
Mecoptera	1	1	1	
Fishes		1	1	1
Amphibians		4	5	7
Reptiles		0	0	0
Birds		23	43	54
Mammals		6	6	7
Fungi		14	15	15
Flora		43	78	83
Total		148	282	337

LITERATURE CITED

- Arnett, R.H., Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors). 2001 and 2002. *American Beetles* (two volumes). CRC Press, Boca Raton, FL. 443 and 861 pp.
- Ascher, J. S., and J. Pickering. 2020. Discover Life Bee Species Guide and World Checklist (Hymenoptera: Apoidea: Anthophila). Available at: http://www.discoverlife.org/mp/20q?guide=Apoidea_species. Accessed February 2020.
- Beadle, D., and S. Leckie. 2012. *Peterson Field Guide to Moths of Northeastern North America*. Houghton Mifflin Harcourt, Boston, MA. 611 pp.
- Bohart, R.M., and L.S. Kimsey. 1979. A key to the species of *Ectemnius* in America north of Mexico with notes and description of a new species (Hymenoptera: Sphecidae). *Proceedings of the Entomological Society of Washington* 81(3):486–498.

- Bohart, R.M., and L.S. Kimsey. 1982. *A Synopsis of the Chrysididae in America North of Mexico*. Memoirs of the American Entomological Institute Number 33. The American Entomological Institute, Anne Arbor, MI. 266 pp.
- Bohart, R.M., and A.S. Menke. 1976. *Sphecid Wasps of the World: A generic revision*. University of California Press, Berkeley, CA. 695 pp.
- Bradley, R.A. 2013. *Common Spiders of North America*. University of California Press, Berkeley, CA. 271 pp.
- Buck, M., S.A. Marshall, and D.K.B. Cheung. 2008. Identification Atlas of the Vespidae (Hymenoptera, Aculeata) of the Northeastern Nearctic Region. Canadian Journal of Arthropod Identification Number 5. Available at: https://cjai.biologicalsurvey.ca/bmc_05/bmc_05.html. Accessed 20 July 2020.
- Ellison, A.M., N.J. Gotelli, E.J. Farnsworth, 2012. *A Field Guide to the Ants of New England*. Yale University Press, New Haven, CT. 398 pp.
- ESA (Entomological Society of America). 2020. Common Names of Insects Database. Available at: <https://www.entsoc.org/common-names>. Accessed February 2020.
- Evans, A.V. 2014. *Beetles of Eastern North America*. Princeton University Press, Princeton, NJ. 560 pp.
- Fisher, B.L., and S.P. Cover. 2007. *Ants of North America: A Guide to the Genera*. University of California Press, Berkeley, CA. 194 pp.
- Glassberg, J. 1999. *Butterflies through Binoculars, The East: A Field Guide to the Butterflies of Eastern North America*. Oxford University Press, New York, NY. 242 pp.
- Goulet, H., and J.T. Huber. 1993. *Hymenoptera of the World: An identification guide to families*. Research Branch Agriculture Canada Publication 1894/E. Centre for Land and Biological Resources Research, Ottawa, ON, CA. 668 pp.
- ITIS (Integrated Taxonomic Information System). 2020. Integrated Taxonomic Information System. Available at: <http://www.itis.gov>. Accessed February–July 2020.
- Kimsey, L.S., and R.M. Bohart. 1990 (reprinted 2011). *The Chrysidid Wasps of the World*. Oxford University Press, New York, NY. 652 pp.
- Maryland Natural Heritage Program. 2016. List of Rare, Threatened, and Endangered Animals of Maryland. Maryland Department of Natural Resources, Annapolis, MD. 23 pp.
- McAlpine, J.F. (Editor). 1981, 1987, and 1989. *Manual of Nearctic Diptera* (three volumes). Research Branch, Agriculture Canada, Monographs No. 27, 28, and 32. Biosystematics Research Centre, Ottawa, ON, Canada. 1581 pp.
- Michener, C.D. 2007. *The Bees of the World* (second edition). The Johns Hopkins University Press, Baltimore, MD. 953 pp.
- MOS (Maryland Ornithological Society). 2020a. Carey Run MOS Sanctuary. Birder's Guide to Maryland & DC, Maryland Ornithological Society. Available at: <https://birdersguidemdc.org/site/carey-run-mos-sanctuary/>. Accessed 3 April 2020.
- MOS (Maryland Ornithological Society). 2020b. Carey Run Sanctuary (Garrett County). Sanctuaries, Maryland Ornithological Society. Available at: <https://mdbirds.org/conservation/refuges-sanctuaries/carey-run/>. Accessed 3 April 2020.
- Scarpulla, E.J. (Compiler) 2020. Maryland Entomological Society BugBlitz at the Maryland Ornithological Society's Carey Run Sanctuary, Garrett County, Maryland, 12–14 July 2019. *Maryland Birdlife* 69(2):[page numbers to be determined]
- Smith, R.H. 2014. Butterflies of Maryland: A Biological Summary and Checklist (revised and updated). (Original compilation by: L. Davidson, Wildlife & Heritage Division, Maryland Department of Natural Resources with assistance from R.H. Smith, Maryland Entomological Society, 31 August 2000). Available at: https://dnr.maryland.gov/wildlife/Pages/plants_wildlife/butterfliesofmaryland.aspx. Accessed 13 April 2020.
- Zhang, Z-Q (Editor). 2011. Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness. *Zootaxa* 3148: 1–237. Available at: <https://www.mapress.com/zootaxa/list/2011/3148.html>. Accessed 5 April 2020.

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COVER PHOTOGRAPH

Mating by Brood X periodical cicadas, *Magicicada septendecim* (Linnaeus) (Hemiptera: Cicadidae). Photographed in Howard County, Maryland, 22 May 2004. *Billions will return to our region in spring 2021!*

Photographed by Michael J. Raupp