THE MARYLAND ENTOMOLOGIST

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

Volume 8, Number 2 **September 2022**

MARYLAND ENTOMOLOGICAL SOCIETY
www.mdentsoc.org

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 phaëton*** (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, ***Phaëton***. Institutions may subscribe to ***The Maryland Entomologist*** but may not become members.

Annual Dues:	Individual Membership	$10.00
	Household Membership	$15.00
	Junior Membership (full-time student)	$5.00
	Institutional Subscription	$10.00

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: Timothy W. Thompson, 5158 Ilchester Road, Ellicott City, MD 21043-7006, tim.thompson1@verizon.net.

Back issues of ***The Maryland Entomologist*** and recent issues of the ***Phaëton*** 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.

Past Presidents of the MES

1971–1973	Austin P. Platt	1984–1985	Charles L. Staines, Jr.
1973–1974	Ronald W. Hodges	1985–1986	Thomas E. Wallenmaier
1974–1975	Douglas C. Ferguson	1986–1987	Eugene J. Gerberg
1975	Raymond B. Nagle	1987–1988	Austin P. Platt
1975–1977	William A. Andersen	1988–1989	Philip J. Kean
1977–1978	Robert T. Mitchell	1989–1990	Nathan Erwin
1978–1979	Elaine R. Hodges	1990–1991	Stephen J. Harrison
1979–1980	Richard H. Smith, Jr.	1991–1992	Thomas E. Wallenmaier
1980–1981	Timothy P. Karpetsky	1992–1993	Mary C. Fenton
1981–1982	John F. Carroll	1993–2013	Frederick Paras
1982–1983	Theodore L. Bissell	2013–2015	Timothy Foard & Frederick Paras
1983–1984	Robin G. Todd	2015–present	Frederick Paras

The Maryland Entomologist 8(2):1

Editor's Note

The 2022 issue features articles from three diverse orders. Caleb M. Kriesberg presents his observations during the 2021 emergence of the Brood X 17-year periodical cicada, *Magicicada* Davis (Hemiptera: Cicadidae). Eugene J. Scarpulla, Peter C. McGowan, and Carl R. Callahan document their 2015 yearlong bee (Hymenoptera: Apoidea) survey on the Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island in the Chesapeake Bay. Brent W. Steury and M. J. Paulsen report on the Scarabaeoidea (Coleoptera) of the George Washington Memorial Parkway. Donald S. Chandler and Brent W. Steury summarize the spider and death-watch beetles (Coleoptera: Ptinidae) of Virginia.

I look forward to receiving a wide variety of submittals for the 2023 issue.

Eugene J. Scarpulla
Editor
ejscarp@comcast.net

The Maryland Entomologist 8(2):2–27

Emergence Patterns and Species Distribution of the Brood X 17-Year Periodical Cicada, *Magicicada* Davis (Hemiptera: Cicadidae), near Downtown Silver Spring, Montgomery County, Maryland, 2021

Caleb M. Kriesberg

Fenton Village, Silver Spring, Maryland 20910
brindlebee@aol.com

Abstract: The identification of all three Brood X species is reported for the vicinity of downtown Silver Spring, Maryland, year 2021, with approximate timing of their first appearance and sample locations. Data describing the daily and seasonal emergence of *Magicicada septendecim* (Linnaeus) at different sites is provided, and contrasted with that for *M. cassinii* (Fisher). An apparent pattern of small-bodied adult cicadas emerging late in the season is also reported. Consideration is given to the role of weather and adaptive strategies in the emergence patterns, and discussion is offered on possible subtle changes to the future emergence and distribution of periodical cicadas in the study area.

Keywords: body size, phenology, population, protandrous arrival, sex ratio, urban ecology, warming

INTRODUCTION

This report observes the emergence and distribution of the species of Brood X periodical cicadas, *Magicicada* Davis (Hemiptera: Cicadidae), around downtown Silver Spring, Maryland, bordering Washington, District of Columbia, in May and June 2021.

Brood X is comprised of three species: *Magicicada septendecim* (Linnaeus), the largest in size and the dominant Brood X species in the study areas (Dybas and Lloyd 1974, Simon 1996); *M. cassinii* (Fisher); and *M. septendecula* (Alexander and Moore). The ratios among these three species vary with the region, nationally. *Magicicada septendecim* females generally lay eggs in branches of maples, *Acer* L. spp. (Aceraceae), and oaks, *Quercus* L. spp. (Fagaceae); *M. cassinii* lays eggs in a variety of smaller tree species; and *M. septendecula* possibly lays eggs most often in hickories, *Carya* Nutt. spp., and walnuts, *Juglans* L. spp. (both Juglandaceae) (Dybas and Lloyd 1974, Williams and Simon 1995). (The three cicada species are depicted among Figures 9, 10, 14, and 15.)

The nymphs hatch from the egg-nests in summer and drop to the ground where they tunnel and attach to rootlets to feed. The nymphs do not disperse much after hatching (Gilbert and Klass 2006, Smits et al. 2010, Simon 2021)

After the nymphs emerge from the ground 17 years later, they undergo ecdysis to an adult, winged form. Upon separating from the nymphal skin, the eclosion process, they are almost completely white. The adults darken gradually to black, over approximately a day, passing through an intermediate blonde stage, and for about four days their bodies remain relatively soft, the teneral period.

Protandrous arrival, or males arriving before females, which is widespread in periodical cicadas and many other animals (note Morbey and Ydenberg 2001), was manifest in the study sites, in a pattern of emergence generally similar to what this researcher observed here 17 years before (Kriesberg 2020). (In the literature, the term "protandrous arrival" can refer to any life form exhibiting this sex ratio behavior, while "protandrous emergence" is most often applied to ectothermic taxa. In cicadas, the term "emergence" pertains particularly to the above-ground activities or life stage associated with ecdysis. Both terms "emergence" and "arrival" will be used in this report for cicadas, depending on context.) According to the periodical cicada form of emergence, it is advantageous for individual males to emerge earlier because females can generally mate only once, and advantageous for females to emerge after some predator satiation sets in, and once many males have become available. Individuals of both sexes have a better chance of avoiding predation if they emerge at the same time as many others (Karban 1982). Eventually, predators apparently become satiated from eating the cicadas, and predation declines (Karban 1981, Williams and Simon 1995), to possibly resume again in a few weeks (Williams et al. 1993) in the end of the season when periodical cicadas are largely disappearing.

Cicadas cluster in high density in certain places, or are patchy (Simon et al. 1981). Dybas and Lloyd (1974) remarked that, contrary to published concerns from 19th century cicada researchers, the cicadas adapt surprisingly well to the human disturbance of tree-cutting (see also Collinge [2010] on the effects of habitat fragmentation). Kritsky et al. (2005) report from a site observed in Ohio that nymphs failed to emerge from disturbed ground of a new housing development, but adults dispersed into that area.

A decrease in emergent body sizes of periodical cicadas in a population during a season is not discussed as a typical phenomenon, in the literature. Late in the season, the goal of this investigator, counting the cicadas of different sizes near the study sites, was to check assumptions and ascertain from a sample at a certain time in the season what proportion of the *Magicicada septendecim* were smaller than the usual, mode length.

Seventeen-year periodical cicadas, appearing regularly, and in great numbers in the eastern and midwestern United States in late spring, even in residential areas, offer an opportunity to study varied aspects of easily accessible wildlife. At a time of well-documented, worldwide biological loss (e.g., Carrington 2017), and environmental change, their super-abundance and brief, regular return may seem—to some observers—uniquely reassuring.

STUDY SITES

This researcher observed two sites daily near downtown Silver Spring, Maryland, in 2004 (Kriesberg 2020), and returned to them, adding a new Site 3 for 2021 (Figures 1, 2, and 3). This researcher also explored parks around downtown Silver Spring (Figure 4) to discover where the three Brood X species might be found.

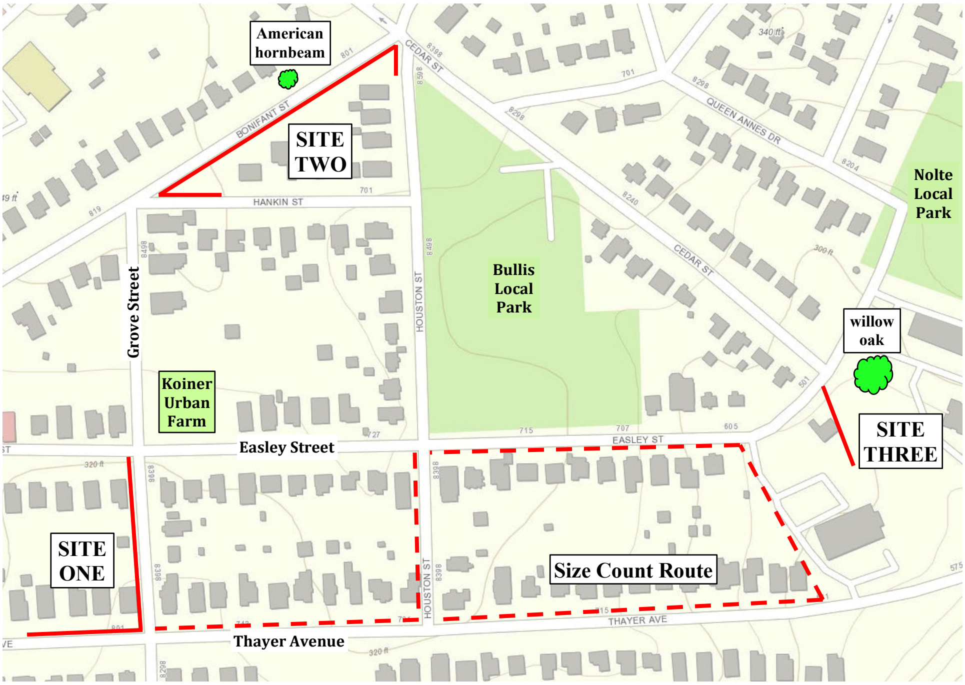


Figure 1. The three locations where cicadas were counted daily in Silver Spring, Maryland, May and June 2021. (The red dashed line indicates the route for sampling adult cicada sizes on 6 and 10 June.) The terrain sloped downward from Sites 1 and 2 (elevation ~102 m [~335 ft]) to Site 3 (~ 91 m [~300 ft]). Basemap obtained from MERLIN Online (2022).

Figure 2. Portions of Sites 1, 2, and 3 (left to right, respectively). For the Site 3 image of the willow oak tree, right, the photo was taken from the upper edge of the wooded "alley" (Figures 1 and 3).

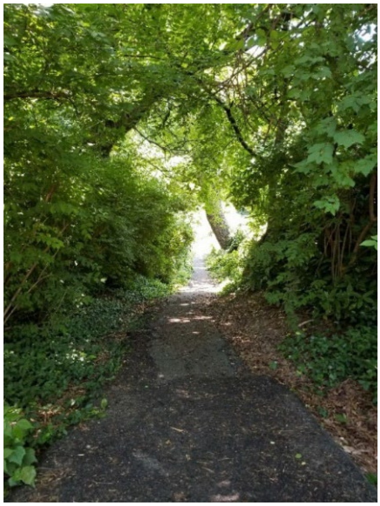


Figure 3. Wooded alley, part of study Site 3. Many *Magicicada cassinii* were found here.

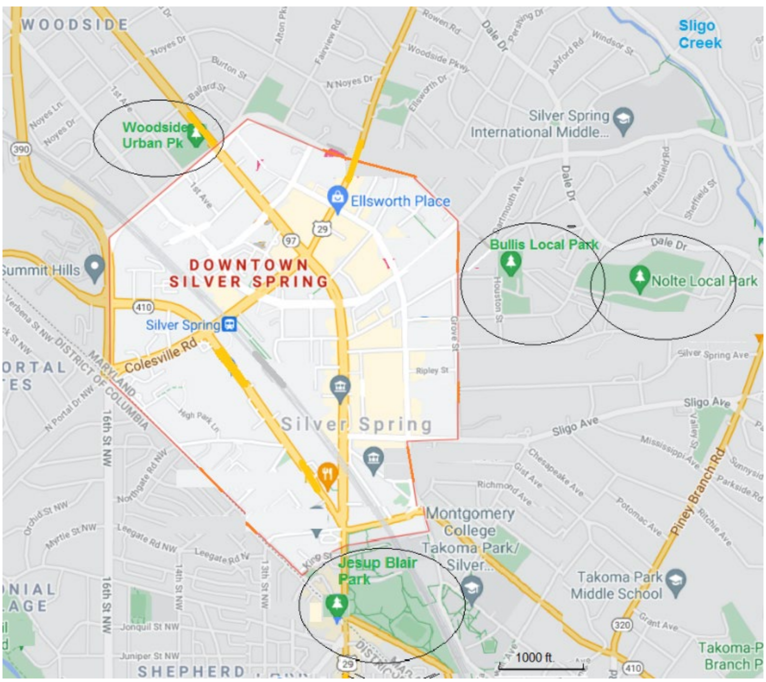


Figure 4. Parks in the area of downtown Silver Spring explored for Brood X cicada species. The three Study Sites mapped in Figure 1 were in the vicinity of Bullis Local Park and Nolte Local Park (middle right), with Site 1 close to downtown. Often visited was Jesup Blair Local Park (lower center). Also shown is Sligo Creek (upper right). The terrain slopes downward from a high point of Jesup Blair Local Park (elevation ~110 m [~360 ft]) down to Sligo Creek (~67 m [~220 ft]). Basemap obtained from Google Maps (2021).

Though the study area featured many trees, two very different trees were important for the *Magicicada septendecim* count at two Sites (Figure 1). At Site 2, a recently planted sapling, about 2 m (7 ft) high, American hornbeam, *Carpinus caroliniana* Walter (Betulaceae), supplied about half of the cicada count. Nymphs crawled from a nearby stump of a recently cut mature tree to gather densely and molt on and around this young tree. At Site 3, the mature, approximately 26 m (85 ft) high willow oak, *Quercus phellos* L. (Fagaceae) supplied most of the cicadas counted. Nymphs molted in the surrounding grass and ascending the large trunk of this shade tree.

METHODS

To track the daily emergence of the periodical cicadas, recently molted adult cicadas, white or near-white tenerals, were counted by sex each morning on street curbs and sidewalks and nearby foliage and tree trunks in an approximately seven square block area, divided into three study sites (Figures 1 and 2). The count was made from approximately 0800 to 0930 hours daily. The researcher counted at Site 1 first, followed by Site 2, and Site 3 last. Counting only new tenerals was especially important to avoid double counting, if some cicadas did not move much from where they had emerged the day before. Cicada counts for analysis ended when a daily minimum yield of six cicadas was reached with no increase on subsequent days.

Many researchers gather nymphal skins, exuviae, to count emergent cicadas. This study, counting new adult cicadas from both residential and public property, including those emerging in dense vegetation, would have had difficulty reliably gathering all of each morning's nymphal skins – especially for Sites 1 and 2. With such a methodology, new skins might have been inadvertently missed on the emergence day and included in a subsequent day's count, and old skins from a previous day might fall to the ground from branches. For Site 3, the counting of new nymphal skins was especially useful when all the *Magicicada septendecim* tenerals were apparently eaten or otherwise missing before the researcher's arrival for the morning count—the public lawn setting made it easier to find and collect all of that day's new skins—and for *M. cassinii* when the emergence of the adults was also missed. But especially for Site 3 late in the season, all three species may have been emerging, possibly including small *M. septendecim*; it could be difficult to identify with certainty species by the skins alone (Dybas and Lloyd 1974 provided diagrams of intact skins to show differences among the three species).

On 6 and 10 June, the researcher also counted dead and dying *Magicicada septendecim* in an approximately two square block area between Sites 1 and 3 (Figures 1 and 11), carefully observing on 10 June not to double count any of those previously noted, tallying those smaller than 3 cm (1.2 in) and 3 cm or larger.

OBSERVATIONS and RESULTS

The adult cicada arrivals in the study area were delayed in 2021 compared to 2004, because of cold weather. This was reported, also, elsewhere in Maryland. On 25 May 2021, the Chesapeake Bay Program noted, "Some areas of the Chesapeake watershed are already seeing many cicadas from Brood X, while others are still waiting.… Temperature is a big factor."

The one-day delayed beginning for the count of emerging periodical cicada adults in 2021 contrasted with 2004 (Kriesberg 2020) is not what this researcher expected, given, in recent years, the days-earlier arrival of the local annual ("dog-day") cicadas (Cicadidae spp.), and the weeks-earlier arrival of local fireflies (Coleoptera: Lampyridae) (pers. obs.). Despite this writer's experience observing these other insects, the 2021 periodical cicadas in the study areas did not arrive early. In fact, the first evidence detected by this observer of any cicadas in downtown Silver Spring—the finding of a cicada wing or an adult, indicating nymphs emerged days before—was on exactly the same calendar day, 10 May, for both 2004 (Kriesberg 2020) and 2021.

In each of the three study sites (Figures 1 and 2), mainly *Magicicada septendecim* were found. Starting 15 May, Sites 1 and 2 offered about 50 teneral *M. septendecim*. In Site 3 and to a lesser extent Site 1, *M. cassinii* were found in increasing numbers, particularly in late May and in June. *Magicicada cassinii* began and ended its emergence later than *M. septendecim*.

Site 3 was remarkable for its cicada emergence. On 10 May, five days before the *Magicicada septendecim* cicadas first appeared for counting at Sites 1 and 2, 75 *M. septendecim* nymphal skins were found around the willow oak tree of Site 3, but no evidence of any tenerals. Apparently, unless tenerals safely crawled away, almost all the tenerals were eaten, wings and all, by the many avian or other predators nearby, especially from the woods. Five days later, 15 May, with hardly any preamble, there was an explosion of emerging *M. septendecim* adults found at Site 3, mainly in the grass around the tree. A few *M. cassinii*, in increasing numbers with passing days, were noted at the bottom of the slope by the wooded, asphalt "alley" (Figures 1 and 3). By 20 May, the *M. septendecim* at Site 3 were emerging fewer than 20 per day, with 11 by 23 May. And this investigator was prematurely resigned to the Site 3 alley not being productive for finding cicadas.

Then, about a week later, 31 May, the alley (Figure 3) was full of recently cast *M. cassinii* nymphal skins—about 60 counted, with a few adults, also, that may have been two days old. The vegetation densely bordering the alley was mostly vines, including many invasives: Chinese yam, *Dioscorea oppositifolia* L. (Dioscoreaceae); grape, *Vitis* L. sp. (Vitaceae); Amur honeysuckle, *Lonicera maackii* (Rupr.) Herder (Caprifoliaceae); English ivy, *Hedera helix* L. (Araliaceae); American pokeweed *Phytolacca americana* L. (Phytolaccaceae); Amur peppervine, (*Ampelopsis brevipedunculata* (Maxim.) Trautv. (Vitaceae); as well as two mature Norway maple trees, *Acer platanoides* L. (Aceraceae); a large mulberry tree, *Morus* L. sp. (Moraceae); and a huge black walnut tree, *Juglans nigra* L. (Juglandaceae). This alley of Site 3, that seemed strangely almost devoid of *M. septendecim* or any other periodical cicada species during the previous week of study, revealed itself at the end of May to be a stronghold for *M. cassinii*.

The results of the daily counts are shown in Table 1 and Figure 5. Data from Sites 1 and 2 are amalgamated because they were in close proximity to each other and with similar habitats, and with a relatively small data set from each. See Discussion section for more about the emergence patterns.

Compare, also, Figures 5 and 6: Note the extent to which the number of emerging cicadas varies somewhat with temperature.

Table 1. Number of newly emergent adult *Magicicada septendecim* and *M. cassinii* found in daily morning counts in designated study sites 10–29 May 2021.

Emergence Day	Date	***M. septendecim* Sites 1 and 2**	***M. septendecim* Site 3**	***M. cassinii* Site 3**
1	10 May	0	75*	0
2	11 May	0	0	0
3	12 May	0	0	0
4	13 May	0	0	0
5	14 May	0	0	0
6	15 May	52	190	0
7	16 May	83	178	0
8	17 May	103	19	0
9	18 May	198	58	0
10	19 May	181	115	8
11	20 May	146	37	2
12	21 May	115	16	3
13	22 May	65	11	6
14	23 May	128	11	9
15	24 May	63	0	9**
16	25 May	15	0	9**
17	26 May	51	0	9**
18	27 May	37	0	9**
19	28 May	0	0	9**
20	29 May	0	0	60*

* These cicadas tallied were nymphal skins, not adults.
** No sampling for Site 3 May 24–28 May: interpolation of data, approximation. Because of continued low numbers of *M. cassinii* found here, and the absence of any emerging *M. septendecim*, and then rain, sampling stopped here for several consecutive days in late May. Field notes for 28 May observed increasing numbers *M. cassinii* between Site 2 and Site 3, and the researcher recalls continued numbers of *M. cassinii* at the Site 3 alley at the time, but at single digits. Pouring rain began late afternoon of 28 May and continued 29 May from late morning until early evening. On 30 May, light rain morning until afternoon. Then, on 31 May, the researcher discovered many *M. cassinii* skins under shrubbery in the Site 3 alley. Most of the skins appeared to be damaged by rainwater, so an estimate was made that many of the nymphs had emerged early in the morning or late at night of 29 May, two days earlier. Late in August, about 60 additional well-preserved nymphal skins of *M. cassinii* were found at the Site 3 alley, suggesting a relatively large, concluding June emergence there for the species, though it is unknown the rate of that daily emergence.

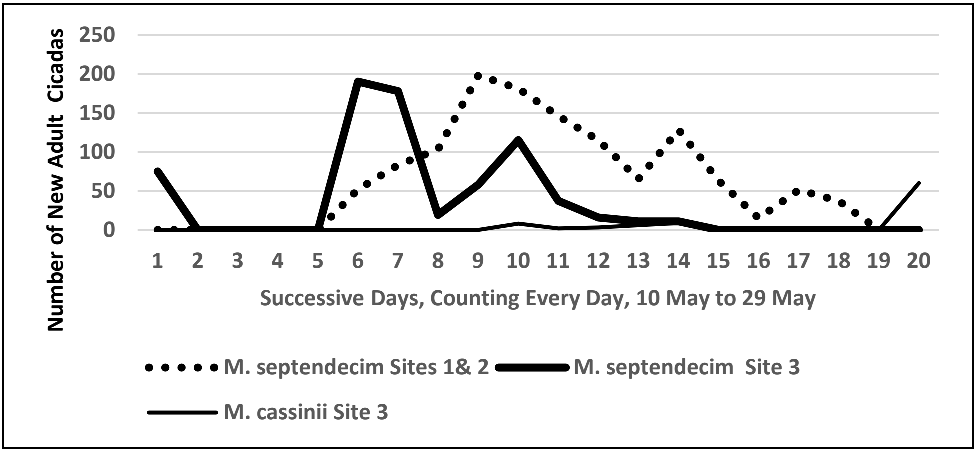


Figure 5. *Magicicada septendecim* and *M. cassinii* daily emergence tallied at the study sites, 10–29 May 2021. Day 1, 10 May, was a count of *M. septendecim* nymphal skins only. No complete, concluding count was made for *M. cassinii*. Note that for day 8, Site 3 count for *M. septendecim* is decreasing while Sites 1 and 2 are increasing. It is also intriguing to note that on day 10, at Site 3, populations of both *M. septendecim* and *M. cassinii*, in close proximity, had an uptick of emergence while the relatively distant proximate populations at Sites 1 and 2 together, were beginning a decline in emergence numbers. So, *M. septendecim* at the two graphed locations display similar seasonal patterns of emergence, with Site 3 starting earlier in the season. *Magicicada cassinii* did not show this pattern of emergence.

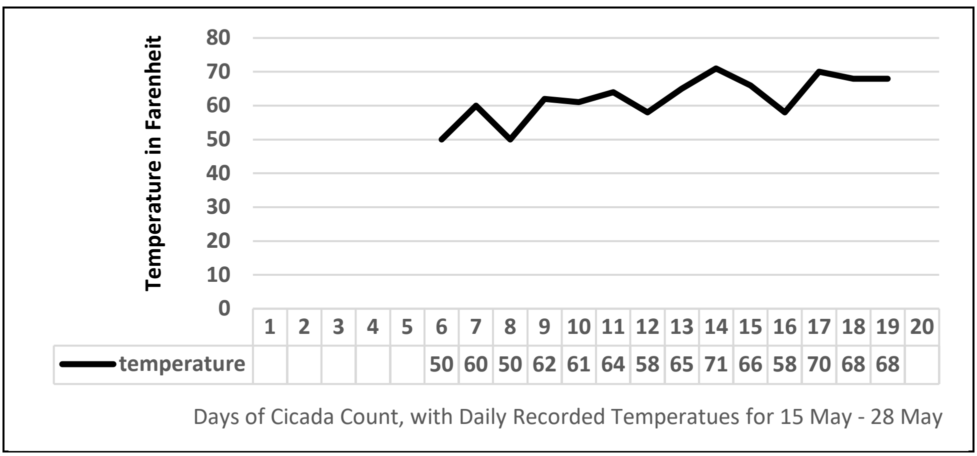


Figure 6. Daily reported temperatures during cicada count at the study area, 15 May–28 May. Compare Figures 6 and 5, temperature with *Magicicada septendecim* emergence, days 6 through 19. Cooler weather might have contributed to the plunge in *Magicicada septendecim* numbers Site 3, day 8 of count. But it only slowed the ascending numbers at Sites 1 and 2 on the same day. Then on day 14, warmer weather (22 °C [71 °F]) coincided with the second peak emergence for Sites 1 and 2. On days 13, 15 and 16, cold and/or rainy weather (from 19 °C [66 °F] to 14 °C [58 °F]) perhaps depressed this count, but the count for Sites 1 and 2 was not finished after day 16; with two days' improved weather on days 17 and 18 (21 °C [70 °F] and 20 °C [68 °F], respectively), there followed an uptick in emergence (Figures 5 and 6).

Figures 7 and 8 show more detail about the *Magicicada septendecim* emergence pattern at Sites 1 and 2 and at Site 3 by displaying the daily emergence of males and females. The disparity between numbers of males and females on most days is typical of a protandrous emergence pattern (Kriesberg 2020). No clear difference between daily or seasonal numbers of emergent males and females was found for the sample of *M. cassinii*. The Discussion section speaks of protandry and reports overall sex ratios for 2004 versus 2021; see also the Data Appendix.

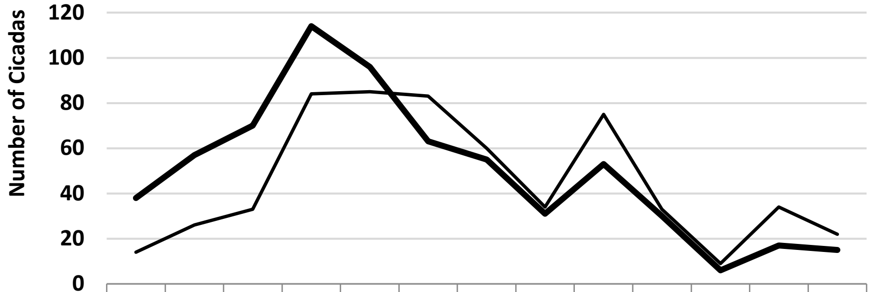
Starting 19 May, this investigator noted the puzzling discovery of small *M. septendecim*, late arrivals for their species. (In June, very small *M. cassinii* also appeared.) Early in their appearance, apparently most small *M. septendecim* were male, some misshapen; late in the season, most small *M. septendecim* were female.

Distinguishing among the three Brood X species was made complicated by the wide range of sizes discovered for *Magicicada septendecim* as measured in Figures 10 and 11. Among the Brood X species, the most immediate distinguishing feature of *M. septendecim* is its size: it is larger than the two other species. *Magicicada septendecim* is generally about 3.0 to 3.5 cm (1.2 to 1.4 in) in length from tip of abdomen to end of head (pers. obs. and University of Connecticut [2021]), while the two smaller species are often shorter than 3.0 cm (1.2 in) (Figure 9 for *M. septendecim and M. cassinii*). When there are small *M. septendecim*, the deciding feature is the red or orange patch or shading between each eye and its wing insertion. Only *M. septendecim* has this coloration (Figures 10 and 15), while both the smaller species, there, are black (Dybas and Lloyd 1974, University of Connecticut 2021; Figures 13 and 14 for *M. septendecula*).

In Bullis Local Park, 9 and 10 June, many tiny female *Magicicada septendecim* congregated on the trees and selected for mating the remaining, mostly larger, chorusing males. Smaller than typical *M. cassinii* found their mates, too, sometimes higher in the same trees as the *M. septendecim*. (Dybas and Lloyd [1974] also found the two species selecting the same location for mating.)

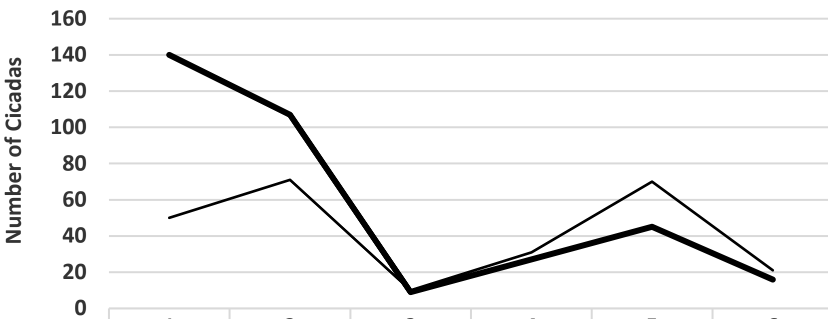
This researcher learned where *Magicicada septendecim* and *M. cassinii* coexisted, locally. Dybas and Lloyd (1974) described the environments *M. cassinii* prefers. In 1956 near Chicago, "*cassini* [sic] concentrated on the floodplain and *septendecim* concentrated on the upland, with a sharply defined zone on the slopes, where one species was replaced by the other." This describes, on a large scale, what this researcher found at Site 3. *Magicicada septendecula*, the third species, Dybas and Lloyd (1974) reported is "rarer and more patchy in its distribution than the other two species."

The iNaturalist website lists many community scientists or amateur entomologists reporting findings of Brood X throughout Maryland for 2021 (from dozens of people reporting *Magicicada septendecula*, scores reporting *M. cassinii*, and hundreds reporting *M. septendecim*). The ratio reported for *septendecula*:*cassinii*:*septendecim* in Maryland, 2021, from thousands of periodical cicada sightings, was approximately 1:4:14 (iNaturalist 2021a, 2021b, 2021c). Possibly reporter bias yielded an undercount for *M. septendecim* due to the preference for reporting the less abundant two species, a kind of "satiation" at observing the superabundant *M. septendecim* species.



Days	1	2	3	4	5	6	7	8	9	10	11	12	13
Males:	38	57	70	114	96	63	55	31	53	30	6	17	15
Females:	14	26	33	84	85	83	60	34	75	33	9	34	22

Figure 7. Total Number of male and female newly emergent adult periodical cicadas, *Magicicada septendecim* Brood X, found on successive mornings on 15–27 May 2021 at Sites 1 and 2 in a fixed route of a neighborhood of Silver Spring, Maryland. (This count begins five days later than in Figures 5 and 6.) A total of 645 recently emerged adult males and 592 recently emerged adult females were found (1,237 overall total cicadas).



Days	1	2	3	4	5	6
Males:	140	107	9	27	45	16
Females:	50	71	10	31	70	21

Figure 8. Total Number of male and female newly emergent adult periodical cicadas, *Magicicada septendecim* Brood X, found on successive mornings on 15–20 May 2021 at Site 3 in Silver Spring, Maryland. (This count begins five days later than in Figures 5 and 6.) A total of 344 newly emergent adult males and 253 newly emergent adult females were found (597 overall total cicadas). This chart excludes the early outlier, 10 May emergence, and the last emergences with small numbers on 21–23 May. Note that on day 2, anomalously, the number of emergent females increased while the number of emergent males decreased.

Figure 9. A female *Magicicada septendecim* (left) alongside a male *M. cassinii* (right), near Site 3. 25 May 2021. Especially in June, some *M. septendecim* found were as small as typical *M. cassinii*.

Figure 10. Size range in two small, male *Magicicada septendecim*, about 3.0 cm (1.2 in) or less in body length. May–June 2021.

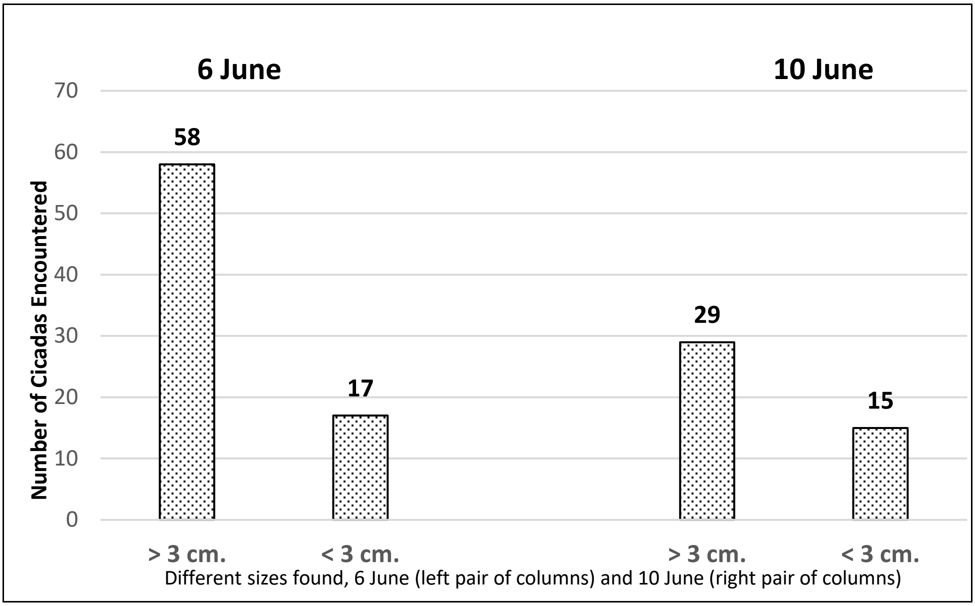


Figure 11. Total number of larger (3 cm [1.2 in] or greater) and smaller (less than 3 cm) dying and recently dead adult periodical cicadas, *Magicicada septendecim* Brood X, found in a fixed route of two blocks (Thayer Avenue and Easley Street) in Silver Spring, Maryland, on 6 and 10 June 2021. Excluded from this table are the 29 larger and small cicadas counted from Bullis Local Park walkways and parking lot on 10 June; there, the ratio was 16:13, almost 1:1. According to these samples, the proportion of small adult cicadas increased as the season ended. As the smaller cicadas effectively replaced the larger ones, the totals of these two particular counts were probably skewed in favor of the larger-sized, since if they emerged first, they should be dying first. Adults of this species are usually of the larger size. Late in the season, some cicadas discovered were perfectly formed miniatures.

This researcher discovered parks and other locales around downtown Silver Spring (Figure 4) where the three Brood X species could be found. *Magicicada septendecim* appeared throughout the Silver Spring study area. *Magicicada cassinii* was clearly favoring a few spots, in addition to Site 3, such as on Thayer Avenue and Easley Street and nearby parks, as well as along Sligo Creek; the researcher found *M. cassinii* also along streets on the north and west boundary of Woodside Urban Park. These cicadas at Woodside Urban Park were beneath large maple and mulberry trees, but at least one of the locations did not seem conspicuously toward the bottom of a slope – only about 3 m (10 ft) lower than Sites 1 and 2. A notable sight in one case was near the stumps of two recently cut down mulberry trees, without many places nearby for ecdysis, perhaps resulting in many *M. cassinii* nymphs dead on the sidewalk and in the street, which they had apparently attempted to traverse.

Then on 23 May, at historical Jesup Blair Local Park (Figure 12), this researcher finally found *Magicicada septendecula*. The researcher heard the distinctive long, uninterrupted male trilling in a tree nearby, then found the female cicada on a small hickory tree nearby. The cicada met the criteria for the species of black around the eye and both black and orange bands on the abdomen (Figures 13 and 14), in contrast to *M. cassinii* whose abdomen is all black and *M. septendecim* whose abdomen is almost all orange. But what was distinctive of this discovery was the combination of hearing clearly the song and seeing the physical traits. No *M. cassinii* were seen nor heard at the park that day; on 2 June, however, some *M. cassinii* were chorusing. On 8 June, one *M. cassinii* was found in this park, many others were chorusing, and *M. septendecim* chorusing seemed to decline (three very small female *M. septendecim* were also found there). There was no clear evidence of any *M. septendecula* in June. So Jesup Blair Local Park is a site where all three species might be detected, depending on the time of season.

Dybas and Lloyd (1974) recalled studying part of Bull Run Park in Virginia in late spring 1962: "when we visited…the open stand of hickories, for instance, we would hear a strong chorus of *septendecula…septendecula* appears most prominently in…open-grown scattered large hickory and oak trees with a grassy understory, a habitat it shares with *septendecim*." All this description, along with the "upland" preference for *Magicicada septendecula*, characterizes Jesup Blair Local Park, on a plateau, the highest elevation park around downtown Silver Spring, and even characterizes the specific tree and its surroundings within the park where the *M. septendecula* cicada was found. Possibly an *M. septendecula* vocalized from a small residential tree, and another rested on Grove Street (Figure 14), both near Bullis Local Park (Figures 1 and 4). And, perhaps to be expected near the large walnut tree at the Site 3 alley, among the *M. cassinii* nymphal skins was the remains of an adult *M. septendecula*.

The sound of *Magicicada septendecula* needs to be distinguished from *M. cassinii*. *Magicicada septendecim*, the most musical of the three, includes the "pharaoh" call (hence its nickname the Pharaoh Cicada). Dybas and Lloyd (1974) stated, "The only completely reliable criterion for distinguishing *septendecula* from *cassini* [sic] is male song." *Magicicada cassinii* is a wind-up clock, and then a whining song (or vice versa), and is relatively brief (University of Connecticut 2021). *Magicicada septendecula* is so rare in this area that this researcher did not hear it chorusing in a group. With the ubiquitous sound of auto traffic, as well as background bird song, it is difficult to detect the solitary call of *M. septendecula*. To this researcher's ear, the song of the *M. septendecula* is like a high-pitched chug-chugging of an old-fashioned wind-up toy, like a little robot, almost a ticking, and it continues for a long time, longer than most individual cicadas would vocalize.

Figure 12. Jesup Blair Local Park where *Magicicada septendecula* was discovered, 23 May 2021. The spacious park has old oak and hickory trees that have experienced several Brood X generations. A few days after this photo was taken, *M. cassinii* became audible in the park.

Figure 13. Likely *Magicicada septendecula*, female. Subtle orange bands on abdomen (visible in magnification), no orange patches near eyes. Jesup Blair Local Park, 23 May 2021.

Figure 14. Likely *Magicicada septendecula*, female. An abdomen pattern of mixed black and orange bands, no orange patches near eyes. Site 1, Grove Street, 28 May 2021.

Figure 15. *Magicicada septendecim* with diagnostic orange patch visible near eye. 4 June 2021.

DISCUSSION

Emergence Patterns

There is variation in reporting whether *Magicicada cassinii* and *M. septendecim* start emerging at the same time, seasonally, or *M. septendecim* emerges earlier. The study of Brood X from Indiana by Young (1970) showed that of the eight sites where emerging cicadas were tallied, at perhaps half of them, and the only places where one species appeared earlier than the other, *M. septendecim* appeared before *M. cassinii*. Dybas and Lloyd (1974), on the other hand, studying in Ohio in 1965, did not report these two species appearing in sequence, explaining, "the species are tied together in time." But apparently, many observers have noted that *M. septendecim* emerges before *M. cassinii*. "There is evidence that Decim emerge before Cassini" (Simon, in litt., 30 March 2021). Such was the case in this study.

This researcher observed a basic "M" shape pattern for the season's daily emergences of adult *Magicicada septendecim* (Figures 5, 7, and 8). Young (1970) in Indiana, counted emerging Brood X *M. septendecim* every other day for six visits, and for the two of eight sites with the most data, between 200 and 300 cicadas at each, Young also reported emergence patterns that vaguely suggest the "M" shape. Alternative emergence patterns for *M. septendecim* could resemble a forward tilting (italic) capital "*N*" if the population disappears abruptly after a high point at the end of the season; or the mirror image of this capital letter " И ," a backward tilting (italic), if the population has an explosive, sudden emergence on the first day. So, the plots of the emergence data appear to show a cyclical pattern.

This observer found this basic "M" pattern or sequential double chevron evident in a variety of populations and conditions: mapping only males or only females or both sexes together, independent of location, starting time for the cicada season, or emergence year 2004 versus 2021 (Kriesberg 2020). And this pattern was somewhat independent of weather (Figures 5 and 6). It seemed independent of timing for predator satiation, as well.

An explanation for these various emergence patterns for *Magicicada septendecim* may relate to a combination of the daily temperatures along with the protandrous emergence and its somewhat conflicting strategies for avoiding predation. The best predictor for the *M. septendecim* emergence pattern seems to be daily temperatures (compare Figure 5 alongside Figure 6). But in some populations, the number of emergent *M. septendecim* may be disproportionate to the season's daily temperatures; and, as shown in Figure 5, different locations may have somewhat different emergence patterns despite experiencing the same daily temperatures.

If protandrous arrival says that males arrive first, there must be a time in the season when females arrive second, and either stage of arrival could be explained, in part, as a strategy for avoiding predation (Kriesberg 2020). But the emergence patterns for males and females at Sites 1 and 2 combined, both in 2004 and 2021 (Figure 7 for 2021), and Site 3 in 2021 (Figure 8), show that, based on these samples, usually when the males emerge in relatively large numbers, the females emerge also, and vice versa. This may be an example of the safety in numbers phenomenon. Williams et al. (1993) pointed out that "males…emerged more synchronously than did females." So, the first, big peak of emerging cicadas tended to be mainly males, with some females; a subsequent, smaller peak tended to be mainly females, with some males, and females may also emerge in proportionately larger numbers at other times later in the season (Figure 7).

Williams et al. (1993) explained, "avian predators appear to be satiated for several weeks." Reptiles and amphibians may show satiation sooner than birds, the latter which may have young to feed. As a possible example of the start of such predator satiation in an amphibian: a large, captive Fowler's Toad *Anaxyrus fowleri* (Hinckley) (Anura: Bufonidae) in 2004, readily eating periodical cicada nymphs in its diet, refused to choose them as prey after eating them four successive days, choosing other prey items instead (pers. obs.). But the timing of predator satiation's beginning and end may be of doubtful relevance for the cicada emergence pattern, since in these samples the second peak was observed after 10 days at Site 3, yet after 14 days at Sites 1 and 2 (Figure 5). (It is unclear that predators would be satiated at different times at nearby locations.) Different sites apparently have different schedules.

This "M" or "N" emergence pattern seems not evident in this sample of *Magicicada cassinii* (Figure 5). And Young (1970), reporting Brood X *M. cassinii* from Indiana, counting every other day, in 1970, from a study site with more than 500 total *M. cassinii*, provided data forming a single convex chevron pattern, "ʌ". This researcher's data hint at the possibility of a similar single chevron pattern for *M. cassinii*. Whiles et al. (2001), reporting Kansas Brood IV *M. cassinii* emergence of 1998, characterized their discovery of *M. cassinii* as a "somewhat protandrous emergence pattern" in sex ratios. The absence of a second high point of nymph emergence in the season may be typical for *M. cassinii*. Perhaps the relatively small numbers of *M. cassinii* in most populations precludes a double-peak emergence as part of a strategy for individuals to elude predation; there would be too few individuals in the emerging populations of this species to support a second strong emergence.

Various studies help predict the timing of first emergence for periodical cicadas based on spring temperature (Kritsky et al. 2005, Raupp et al. 2020); and discussions of annual xylem flow influencing cicada emergence relate to the evolution of periodicity (Williams and Simon 1995, Karban et al. 2002). But explanations for how nymphs emerge later in a season are more gradually garnering attention. As a mechanism for cuing cicada emergence, in addition to temperature, perhaps underground nymphal vibrations play a part. The zoological analysis by Hill (2008, 2014), the study of adult cicadas by Alt and Lakes-Harlan (2018), and the study of *Magicicada* nymphs by Gibson (2015), considered cicadas' receptors for detecting substrate vibrations, which might cue nymphs to emerge proximate to each other. Such behavior could be selected consistent with the safety in numbers survival strategy (defined in Lloyd and Dybas 1966, Williams and Simon 1995, Holzapfel and Bradshaw 2002). Nymphs joining the emerging crowd later in the season might detect each other from underground.

Conducting further research of *Magicicada* emergence behavior, reporting on different populations and settings and their emergence patterns, especially *M. cassinii*, could enhance the literature on these species' natural histories.

This researcher also wondered what might account for so many small *Magicicada septendecim*, and smaller than typical *M. cassinii*, noted toward the end of the season. Beasley et al. (2017) hypothesized that a number of factors, including urbanization—with disturbance and pollution—could produce "stressors" that impact periodical cicada nymphs. (During the past 17 years, within a few city blocks of Site 1, ongoing construction of new apartment buildings and road repair created much noise; and a new apartment building had been constructed, inhabited, and maintained on the border of Site 1). Beasley et al. (2017) also indicated that the species shows plasticity in body size, and Lloyd and Dybas (1966) and Williams and Simon (1995) discussed flexibility in nymphal growth rate relating to the evolution of synchronous emergence.

Beasley et al. (2017) reported a mixed message about the impact of urbanization, recalling research that showed, instead of detrimental effects on cicadas, apparent benefits. The higher temperatures in cities, and the horticultural fertilization of trees, are associated with larger sizes of the cicada species (note White and Lloyd 1985), which could help both males and females in their reproductive roles (also note Koyama et al. [2015] and Moriyama and Numata [2019]). On the other hand, Beasley et al. (2017) reported the xylem sap flow of urban trees in some places is disrupted by "xylem cavitation," and there may also be urban noise that could inhibit nymphal growth. (Cooley et al. [2016] reported the contradictory hypotheses of beneficial vs. detrimental effects on periodical cicadas in the same habitat as "urban oasis" versus "suburban stress.")

Koyama et al. (2015) generally found that periodical cicadas were larger in habitats of warmer annual mean temperatures, findings about cicada size consistent with those by Beasley et al. (2017).Yet according to Verberk et al. (2021) and the Temperature-Size-Rule, which happens to agree with Bergmann's rule, terrestrial ectotherms such as many insects may tend to smaller size with warmer temperatures: "At high temperatures or low oxygen, animals may preferentially allocate resources towards development and away from growth." Beasley et al. (2017) concluded, "continued monitoring of periodical cicadas in urban habitats, including a more fine scale assessment of habitat conditions, is needed to understand how urbanization could affect cicadas over long time scales and in earlier developmental stages."

Smaller cicadas appearing toward the end of the season may simply be, in part, the "runt-of-the-litter" phenomenon, with those needing most growth waiting until the end to emerge. Whether the incidence of relatively small adult cicadas is widespread and increasing, perhaps related to climate change, or whether it could be mapped alongside other environmental factors, might be questions for community scientists and telephone apps.

Finally, this investigator was also curious whether the overall sex ratio might change in sequential generations, so compared combined data for Sites 1 and 2 from 2004 with those from 2021. Partly because tree cover changed in the intervening years, the author could not sample the exact same route or boundaries for the sites in both studies, in gathering an adequate sample. But data came from almost identical locations using the same methodology for counting (Kriesberg 2020). A two-proportion z-test of the data (Essa 2016), at a significance level of 5%, shows that a significantly greater proportion of adult male cicadas emerged in 2021 than in 2004. The seasonal sex ratio for the 2004 sample was significantly, disproportionately, female. There are confounding variables (some discussed in Frank 1983), so we cannot be sure what factors may have most contributed to the 2021 increase in the proportion of males.

One mechanism for maternal sex selection could be described, according to theory, as "selection favors mothers that produce sons when in good condition but daughters when in poor condition" (summarized in Wade et al. 2003). The logic would be that sons need sufficient fitness to compete for mates, and the "condition" might refer to nutrition available to the mothers, which in the case of cicadas, could be the xylem flow available to the females when they were nymphs. One might speculate that global warming could also contribute to a change in the sex ratios of the periodical cicadas (consider Moiroux et al. 2014, Edmands 2021). Various ectothermic taxa are changing sex ratios in response to changing temperatures (Edmands 2021). But, according to Kuznetsova and Aguin-Pombo (2015), the suborder Auchenorrhyncha, to which cicadas belong, has sex chromosomes (indicated also for *Magicicada* by Karagyan et al. 2020). Taxa with sex chromosomes, according to Edmands (2021), generally do not exhibit temperature-dependent sex determination. Williams et al. (1995) contend that sex ratios for emerging adult periodical cicadas are generally 1:1, "although temporary biases may occur." It might be interesting to test this hypothesis about sex ratios in other sites. The overall sex ratio for the 2021 Site 1 and 2 data, alone, was not significantly different from 1:1, measuring the adult *M. septendecim* emergence. (See Data Appendix.)

Species Distribution

Simon et al. (1981) studying periodical cicadas in stunted scrub oak environment of Long Island, New York, and Morton (1987) studying birds in an island ecology of Panama, wondered about the way their subject animals perceived the world, and whether people could envision the environment in a similar way. Morton, studying introduced wrens (Song Wren and White-breasted Wood-Wren, *Cyphorhinus phaeocephalus* and *Henicorhina leucosticta*, respectively), found that they chose, for nesting, the borders of trails unfortunately frequented by their predators, possibly because to the wrens, the trails looked like streambeds, their favored nesting environment. Similarly, one might speculate that *Magicicada cassinii* chose the alley site (Figure 3), perhaps also in part because it resembled a floodplain such as along Sligo Creek, which the species apparently prefers for chorusing and egg-laying.

Dybas and Lloyd (1974) and Young (1970) reported *Magicicada cassinii* as generally favoring the floodplain and sites along streams. But this investigator found that by June, *M. cassinii* apparently were present wherever periodical cicadas could be detected, though in lesser numbers than *M. septendecim* at their height. Notably, *M. cassinii* were chorusing in Jesup Blair Local Park and along busy Georgia Avenue nearby, relatively high elevation areas near downtown Silver Spring. Dybas and Lloyd (1974) examining cicada nymphs in Iowa, June 1963, and adults in Kansas, June 1964, were also surprised to find *M. cassinii* in "upland" habitats mixed with *M. septendecim*.

This researcher wonders whether environmental pressures favoring particular cicada features, if present, could yield, over generations, a relative increase in the number of *Magicicada cassinii*. Moriyama and Numata (2019) reported that in urban Osaka, Japan, starting a few decades ago, one cicada species, *Cryptotympana facialis* (Walker), prevalent in the south, began to supplant a native Osaka species, *Graptopsaltria nigrofuscata* (Motschulsky). Hypotheses explaining the incoming species' greater fitness and ability to extend its range included a warming trend favoring its hatching during a rainy season, and nymphs more adaptable to the compacted soil of the urban area.

Larson et al. (2019) explained that "insects are responding to climate change by altering the seasonal timing of adult emergence" (note also Moriyama and Numata 2019), and there is a "potential for climate change to influence species boundaries between closely related insect species." In the study areas, *Magicicada septendecim* generally began flying in mid-May, and *M. cassinii* about a week later. In 2021, the later date was about 5 °C (9 °F) warmer than earlier in the spring: 18 May was 17 °C (62 °F) and 23 May was 22 °C (71 °F). Temple (2021) explained that if species behaviorally related to each other respond differently to evolving temperature changes, the species might become out of sync with each other. Though some relevant cicada behavior may not be keyed to temperature, warming might adjust the adult arrival time and place of species in relation to each other.

It seems that in the reproductive process of *Magicicada cassinii* and *M. septendecim*, the females are ultimately patchier than the males: males and females of each species met and mated in close proximity, as in Bullis Local Park, but the females of both species apparently then went to particular places to lay their eggs, since the nymphs of *M. cassinii* generally emerged in locations different from the nymphs of *M. septendecim*.

In the last days of June, with the periodical cicada season ended, one can note the locations and quantities of egg-nests based on the browned leaves and withered branches tattering or marking (flagging) the trees; hence one could anticipate the disposition of emerging cicadas 17 years in the future. It is possible "nymphs do not fall straight to the ground" (Smits et al. 2010), and there might be high nymph mortality in certain locations. But since the nymphs do not disperse much after hatching (Gilbert and Klass 2006, Smits et al. 2010, Simon 2021), it might be possible to estimate roughly where and in what abundance the nymphs would emerge in year 2038—and from tree selection, which species might emerge, where.

Jesup Blair Local Park had many oak trees displaying browned branches, and relatively few branches of hickory; blackgum, *Nyssa sylvatica* Marshall (Cornaceae); and American sycamore, *Platanus occidentalis* L. (Platanaceae) apparently with egg nests. Sites 1 and 2 generally had relatively few egg-nests in evidence in the tree canopy; those two sites might yield fewer teneral cicadas in the next emergence than in this recent one. Site 3 had many egg-nests from the willow oak tree, hardly any evidence of them in the alley. Female cicadas may choose egg-laying sites in tree branches based on the amount of sunlight available there (Yang 2006).

Beyond recognizing tree species, this investigator could not visually detect any local pattern for where the females laid eggs, except for one observation. Neighborhood planners coincidentally experimented with a traffic route in part of Site 1. Grove Street had most car traffic blocked and the street given over to pedestrians and bicyclists. Subsequently, trees along Grove Street had a relatively large number of browned leaves from cicada egg-nests. So, many nymphs might emerge along Grove Street in 2038. And, based on the tree species with egg-nests, *Magicicada cassinii* may once again dominate Site 1 when their time for chorusing arrives.

Two Silver Spring parks this investigator found most suitable for *Magicicada* were Bullis Local Park and Jesup Blair Local Park. Both featured alternating sunny (Yang 2006, Sheppard et al. 2020) and shady settings with open ground and a wide variety of tree species (Maier 1980), including various tree heights and ages. Such habitats are recommended for cicada study, next emergence.

ACKNOWLEDGMENTS

The author thanks Allen Hirsch (CEO, CryoBioPhysica Inc., Chevy Chase, MD), who suggested focusing on patterns of emergence; David Kriesberg (instructor in engineering design, A. James Clark School of Engineering, University of Maryland, College Park, MD), for assistance with research; two anonymous peer reviewers for constructive critique; John R. Cooley (Assistant Professor in Residence, Department of Ecology and Evolutionary Biology, University of Connecticut, Hartford, CT) for insights into methodology in the field and the cicada emergence and distribution; and Gene Kritsky (Dean of Behavioral and Natural Sciences at Mount St. Joseph College, Cincinnati, OH), for information on the study of cicada phenology.

LITERATURE CITED

Alt, J.A., and R. Lakes-Harlan. 2018. Sensing of substrate vibrations in the adult cicada *Okanagana rimosa* (Hemiptera: Cicadidae). *Journal of Insect Science* 18(3):1–6. Available at: https://doi.org/10.1093/jisesa/iey029. Accessed 22 November 2021.

Beasley, D.E., C.A. Penick, N.S. Boateng, H.L. Menninger, and R.R. Dunn. 2017. Urbanization disrupts latitude-size rule in 17-year cicadas. *Ecology and Evolution* 8(5):2534–2541.

Carrington, D. 2017. Warning of 'ecological Armageddon' after dramatic plunge in insect numbers. *The Guardian*. Available at: https://www.theguardian.com/

environment/2017 /oct/18/warning-of-ecological-armageddon-after-dramatic-plunge-in-insect-numbers. Accessed 28 July 2021.

Chesapeake Bay Program. 2021. Facebook, Chesapeake Bay Program, 25 May 2021. Available at: https://www.facebook.com/chesapeakebayprogram/photos /a.413893385313200/4093743960661439/?type=3. Accessed 25 May 2021.

Collinge, S.K. 2010. Spatial ecology and conservation. *Nature Education Knowledge* 3(10):1–6.

Cooley, J.R., G. Kritsky, D.C. Marshall, K.B.R. Hill, G. Bunker, M.L. Neckermann, J. Yoshimura, J.E. Cooley, and C. Simon. 2016. A GIS-based map of periodical cicada Brood XIII in 2007, with notes on adjacent populations of Broods III and X. *American Entomologist* 62(4):241–246.

Dybas, H.S., and M. Lloyd. 1974. The habitats of 17-year periodical cicadas (Homoptera: Cicadidae: *Magicicada* spp.). *Ecological Monographs* 44(3):279–324.

Edmands, S. 2021. Sex ratios in a warming world: Thermal effects on sex-biased survival, sex determination, and sex reversal. *Journal of Heredity* 112(2):155–164.

Essa, S. 2016. Two Proportions Z Test. Statistics How To. Available at: https://www.youtube.com/watch?v=_58qBy9Uxks. Accessed 26 April 2022.

Frank, S.A. 1983. A hierarchical view of sex-ratio patterns. *Florida Entomologist* 66(1):42–75.

Gilbert, C., and C. Klass. 2006. Decrease in geographic range of the Finger Lakes brood (Brood VII) of the periodical cicada (Hemiptera: Cicadidae: *Magicicada* spp.). *Journal of the New York Entomological Society* 114(1–2):78–85.

Gibson, J.S. 2015. *Localization Mechanisms of Small Plant-dwelling Insects* (abstract only). Unpublished doctoral dissertation, Department of Biological Sciences, University of Missouri-Columbia.

Google Maps. 2021. Google Maps. Available at: https://www.google.com/maps/. Accessed 6 May 2021.

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.

Hill, P.S.M. 2008. *Vibrational Communication in Animals*. Harvard University Press, Cambridge, MA. 261 pp.

Hill P.S.M. 2014. Stretching the Paradigm or Building a New? Development of a Cohesive Language for Vibrational Communication. Pages 13–30 in: R. Cocroft, M.

Gogala, P. Hill, and A. Wessel (Editors) *Studying Vibrational Communication*. Animal Signals and Communication, Volume 3, Springer, Berlin, Heidelberg. Available at: https://doi.org/10.1007/978-3-662-43607-3_2. Accessed 2 February 2022

iNaturalist. 2021a. iNaturalist, Observations, Cassin's 17-Year Cicada, Maryland, USA. Available at: https://www.inaturalist.org/observations?place_id=39&subview=map&taxon_id=549305. Accessed 23 August 2021.

iNaturalist. 2021b. iNaturalist, Observations, Decula 17-Year Cicada, Maryland, USA. Available at: https://www.inaturalist.org/observations?place_id=39&subview=map&taxon_id=105099. Accessed 23 August 2021.

iNaturalist. 2021c. iNaturalist, Observations, Pharaoh Cicada, Maryland, USA. Available at: https://www.inaturalist.org/observations?place_id=39&subview=map&taxon_id=105098. Accessed 23 August 2021.

Karban, R. 1981. Effects of local density on fecundity and mating speed for periodical cicadas. *Oecologia* 51(2):260–264.

Karban, R. 1982. Increased reproductive success at high densities and predator satiation for periodical cicadas. *Ecology*. 63(2):321–328.

Karban, R., C.A. Black, and S.A. Weinbaum. 2002. How 17-year cicadas keep track of time. *Ecology Letters* 3(4):253–256.

Karagyan, G., N. Golub, and T. Sota. 2020. Cytogenetic characterization of periodical cicadas (Hemiptera: Cicadidae: *Magicicada*). *European Journal of Entomology* 117:474–480.

Koyama, T., H. Ito, S. Kakishima, J. Yoshimura, J.R. Cooley, C. Simon, and T. Sota. 2015. Geographic body size variation in the periodical cicadas *Magicicada*: implications for life cycle divergence and local adaptation. *Journal of Evolutionary Biology* 28(6):1270–1277.

Kriesberg, C.M. 2020. Protandrous arrival in a population of the periodical cicada *Magicicada septendecim* (Linnaeus) (Hemiptera: Cicadidae) in Montgomery County, Maryland. *The Maryland Entomologist* 7(4):17–30.

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.

Kuznetsova, V., and D. Aguin-Pombo. 2015. Comparative cytogenetics of Auchenorrhyncha (Hemiptera, Homoptera): A review. *ZooKeys* 538:63–93. Available at: https://doi.org/10.3897/zookeys.538.6724. Accessed 29 April 2021.

Larson, E.L., R.M. Tinghitella, and S.A. Taylor. 2019. Insect hybridization and climate change. *Frontiers in Ecology and Evolution* 7:348. (20 September 2019). Available at: https://doi.org/10.3389/fevo.2019.00348. Accessed 29 July 2021.

Lloyd, M., and H.S. Dybas. 1966. The periodical cicada problem. II. evolution. *Evolution* 20(4):466–505.

Maier, C.T. 1980. A mole's-eye view of seventeen-year periodical cicada nymphs, *Magicicada septendecim* (Hemiptera: Homoptera: Cicadidae). *Annals of the Entomological Society of America* 73(2):147–152.

MERLIN Online. 2022. MERLIN Online: Maryland's Environmental Resources and Land Information Network. Maryland Department of Natural Resources. Available at: https://dnr.maryland.gov/Pages/Merlin.aspx. Accessed 21 January 2022.

Moiroux, J., J. Brodeur, and G. Boivin. 2014. Sex ratio variations with temperature in an egg parasitoid: Behavioural adjustment and physiological constraint. *Animal Behaviour* 91:61–66.

Morbey, Y.E., and R.C. Ydenberg. 2001. Protandrous arrival timing to breeding areas: a review. *Ecology Letters* 4:663–673. Available at: https://onlinelibrary.wiley.com/doi/epdf/10.1046/j.1461-0248.2001.00265.x. Accessed 23 December 2021.

Moriyama, M., and H. Numata. 2019. Ecophysiological responses to climate change in cicadas. *Physiological Entomology* 44(2):65–76.

Morton, E.S. 1987. Reintroduction as a Way of Studying Bird Behavior and Ecology. Chapter 11, pages 165–172, in *Restoration Ecology: A Synthetic Approach to Ecological Research*. William R. Jordan, III, Michael E. Gilpin, John D. Aber (Editors), Cambridge University Press. 342 pp.

Raupp, M.J., C. Sargent, N. Harding, G. Kritsky. 2020. Combining data from citizen scientists and weather stations to define emergence of periodical cicadas, *Magicicada* Davis ssp. (Hemiptera: Cicadidae) *The Maryland Entomologist* 7(4):31–42.

Sheppard, L.W., B. Mechtley, J.A. Walter, and D.C. Reuman. 2020. Self-organizing cicada choruses respond to the local sound and light environment. *Ecology and Evolution* 10(10):4471–4482. Available at: https://doi.org/10.1002/ece3.6213. Accessed 24 July 2021.

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.

Simon, C. 2021. 13- and 17-year Cicadas; Insects that Count (in fours). Virtual lecture, 1 April 2021. Entomological Society of Washington, Washington, DC.

Simon, C., R. Karban, and M. Lloyd. 1981. Patchiness, density, and aggregative behavior in sympatric allochronic populations of 17-year cicadas. *Ecology* 62(6):1525–1535.

Smits, A., J. Cooley, and E. Westerman. 2010. Twig to root: Egg-nest density and underground nymph distribution in a periodical cicada (Hemiptera: *Magicicada septendecim* (L.)). *Entomologica Americana* 116(1–2):73–77.

Temple, S. 2021. Phenology and You: Bringing Leopold into Our Time. Virtual Lecture, 5 October 2021. The Aldo Leopold Foundation, Baraboo, WI.

University of Connecticut. 2021. Cicadas: Species. Available at: https://cicadas.uconn .edu/species/. Accessed 21 May 2021.

Verberk, W.C.E.P., D. Atkinson, K.N. Hoefnagel, A.G. Hirst, C.R. Horne, and H. Siepel. 2021. Shrinking body sizes in response to warming: explanations for the temperature–size rule with special emphasis on the role of oxygen. *Biological Reviews* 96(1):247–268.

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.

Whiles, M.R., M.A. Callaham, 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.

White, J., and M. Lloyd. 1985. Effect of habitat on size of nymphs in periodical cicadas (Homoptera: Cicadidae: *Magicicada* spp.). *Journal of the Kansas Entomological Society* 58(4):605–610. Available at: http://www.jstor.org/stable/25084703. Accessed 24 July 2021.

Williams, K.S., and C. Simon. 1995. The ecology, behavior, and evolution of periodical cicadas. *Annual Review of Entomology* 40:269–295.

Williams, K.S., K.G. Smith, and F.M. Stephen. 1993. Emergence of 13-yr periodical cicadas (Cicadidae: *Magicicada*): Phenology, mortality, and predators satiation. *Ecology* 74(4):1143–1152.

Yang, L.H. 2006. Periodical cicadas use light for oviposition site selection. *Proceedings of the Royal Society B, Biological Sciences* 273(1604):2993–3000.

Young, F.N. 1970. Observations on periodical cicadas Brood X in Indiana in 1970 (Homoptera-Cicadidae). *Proceedings of the Indiana Academy of Science* 80:247–252.

DATA APPENDIX

Two-Proportions Z-Test procedure derived from Essa (2016)

Purpose: To investigate whether overall sex ratios of emerging adult cicadas, in the same sites 17-years apart, were comparable and not significantly different (null hypothesis).

Comparing the totals of Sites 1 and 2 in the two generations, a greater proportion of males emerged in the 2021 generation.

- In 2004: 548 males of 1248 (n_1) total adults = 0.44 (p_1) or 44% of adult emergent cicadas.
- In 2021: 645 males of 1237 (n_2) total adults = 0.52 (p_2) or 52% of adult emergent cicadas.

Are these two ratios significantly different?

- P (overall proportion) = (548 + 645) / (1248 + 1237) = 1193 / 2485 = 0.48 or 48%.
- Subtract the smaller percentage (44%) from the larger percentage (52%) and divide by the Standard Error to obtain the z score.
- $Z = p_2 – p_1 / \sqrt{}$ (square root) of: $P (1-P) / (1/n_2 + 1/n_1)$
- $Z = 0.52 - 0.44 / \sqrt{}$ of: $0.48 (1 - 0.48) / (1/1237 + 1/1248) = 0.08 / \sqrt{0.0004} = 0.08 / 0.02 = 4.00$ $\therefore Z = 4.00$
- Significance at alpha level 5% would be z less than -1.96 or greater than 1.96.
- One would reject the null hypothesis if the z score falls at the outer edges of the bell curve or normal distribution.
- Result: In the 2021 sample, a significantly greater proportion of adult male cicadas emerged than in the 2004 sample. The two proportions (sex ratios) were significantly different.

Purpose: To compare the 2021 overall sex ratio at Sites 1 and 2 to a 1:1 ratio, to see if the experimental ratio for this emergence did not differ significantly from a 1:1 ratio (null hypothesis).

- Divide total males and females (n_2 = 1237) in half (618.5) and compare that 50% number with the sample number of males (645) or of females (592). (To determine closeness to 50%, data for either sex would be informative. For the following statistical test, the number of males is used.)
- P = 645.0 + 618.5 / 1237.0 + 1237.0 = 1263.5 / 2474.0 = 0.51 or 51%
- $Z = p_2 – p_1 / \sqrt{}$ (square root) of: $P (1-P) / (1/n_2 + 1/n_1)$
- $Z = 0.51 - 0.50 / \sqrt{}$ of: $0.51 (1 - 0.51) / (1/1237 + 1/1237) = 0.01 / \sqrt{0.25} / 0.0016 = 0.01 / 12.50 = 0.0008$ $\therefore Z = 0.0008$
- This sum is not negative, less than -1.95. And neither is it more than 1.95. So, the test result is not statistically significant.
- Result: The null hypothesis is accepted; this 2021 sex ratio is not significantly different from 1:1.

See the Discussion section for context and interpretation.

The Maryland Entomologist 8(2):28–57

A Yearlong Survey of the Bees (Hymenoptera: Apoidea) at a Large-scale Island Restoration Project Created from Dredged Material: Poplar Island, Chesapeake Bay, Maryland, USA

Eugene J. Scarpulla[1*], Peter C. McGowan[2], and Carl R. Callahan[2]

[1]*14207 Lakerun Court, Bowie, Maryland 20720-4861*
[2]*United States Fish and Wildlife Service, Chesapeake Bay Field Office, 177 Admiral Cochrane Drive, Annapolis, Maryland 21401*
[*]*Corresponding author: ejscarp@comcast.net*

ABSTRACT: In 2015, a continuously-trapping, propylene glycol cup, native bee survey was conducted on the Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island, which is located in the Chesapeake Bay, approximately 1.83 km (1.14 mi) west of the mainland of Talbot County, Maryland. Poplar Island is a large-scale island restoration project that uses dredged material from Chesapeake Bay shipping channels and the approach channels to Baltimore Harbor. Five propylene glycol three-color, nine-cup transects were run continuously in various habitats (i.e., sand flat, pond edge, footpath edge, and two dirt road edges) from 9 April 2015 through 23 November 2015. A total of 18,703 bees were collected, representing 5 families, 22 genera, and at least 94 species. Phenological data is presented showing the number of bees per species per sampling date during the yearlong survey. There were 27 first records for Talbot County, of which, three were first records for Maryland: one Halictidae, *Sphecodes* nr. *cressonii* (Robertson), and two Apidae, *Nomada erigeronis* Robertson and *Triepeolus rhododontus* Cockerell. The survey documented five non-native species, 12 cleptoparasitic species, and 11 oligolectic species. An island flora list was compiled documenting 47 families, 125 genera, and 166 plant species. Results are compared with a similar 2009 yearlong native bee survey on Hart-Miller Island, another dredged material containment facility in the Chesapeake Bay. The Poplar Island and the Hart-Miller Island yearlong surveys illustrate that islands restored with dredged material offer native bees beneficial nesting and foraging habitat.

Keywords: continuously-trapping, island flora, native bees, Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island, propylene glycol cup trap

INTRODUCTION

In 2009, Scarpulla (2013) conducted a yearlong bee bowl survey on Hart-Miller Island (Figure 1), Baltimore County, Maryland. Most of Hart-Miller Island's 526 ha (1,300 ac) footprint was human-made, created from dredged material from Chesapeake Bay shipping channels and the approach channels to Baltimore Harbor. The dredged material was contained within a perimeter dike connecting the remnants of the original Hart Island and Miller Island. The bee bowl survey found at least 86 species. ("At least" is used since some species are cryptic and can only be separated by DNA analysis.)

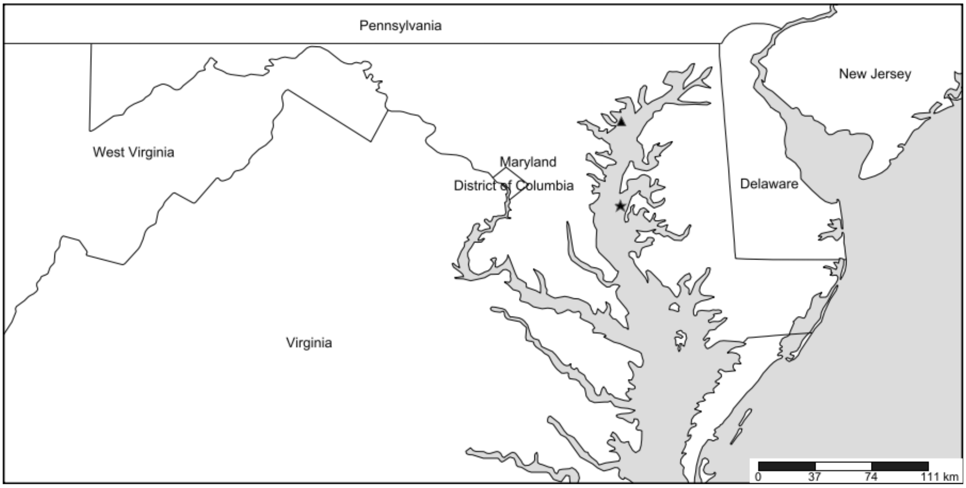


Figure 1. Locations of Poplar Island (★), Talbot County, and Hart-Miller Island (▲), Baltimore County, in Maryland's portion of the Chesapeake Bay. SimpleMappr geographic projection (Shorthouse 2010).

Following the Hart-Miller Island survey, Scarpulla was interested in conducting a similar survey on the Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island (hereafter referred to as Poplar Island), another human-made dredged material island (Figures 1 and 2). Poplar Island is located in the Chesapeake Bay, approximately 1.83 km (1.14 mi) west of mainland Talbot County, Maryland. Additionally, Poplar Island is adjacent to three small, privately-owned islands: Coaches Island (~26 ha [~66 ac], ~20 m [~66 ft] away); Jefferson Island (~3 ha [~8 ac], ~0.5 km [~0.3 mi] away); and Queen Anne Island (~0.9 ha [~2.3 ac], ~0.4 km [~0.2 mi]). The three islands collectively include woodland, field, and marsh habitats.

Scarpulla realized that the protocol used on Hart-Miller Island could not work on Poplar Island for logistical reasons. In talks with United States Fish and Wildlife Service (USFWS) personnel (P. C. McGowan and C. R. Callahan) who work on Poplar Island, it seemed feasible that by using a different protocol, a similar bee survey could be achieved.

STUDY SITE

In 1847, Poplar Island's footprint was more than 445 ha (1,100 ac). In the early 1900s, there were approximately 100 residents, several farms, a school, a church, a post office, and a sawmill. In the 1920s, much of the island was eroding into the Chesapeake Bay. In the 1930s and 1940s, the island was still being used as a presidential retreat and visited by Franklin D. Roosevelt and Harry S. Truman. By the early 1990s, the island remnants totaled around 1 ha (4 ac) of small islets (Maryland Environmental Service 2017).

Figure 2. Original transect locations, Poplar Island, Talbot County, Maryland, 9 April 2015, and the three nearby islands. Aerial photograph courtesy of Maryland Environmental Service.

In 1994, an interagency team composed of the United States Army Corps of Engineers (USACE), Maryland Department of Transportation Maryland Port Administration, and several other federal and state environmental agencies signed a Chesapeake Bay Ecosystem Management agreement for the beneficial use of dredged material to restore island habitat. It was decided to explore the possibility of using dredged material from the navigational channels leading to the Port of Baltimore for rebuilding Poplar Island to its approximate 1847 footprint. The project would create more than 688 ha (1,700 ac) of remote island habitat for wildlife (Maryland Environmental Service 2017).

In the 1990s, clusters of low, marshy knolls and tidal mudflats were all that remained of Poplar Island. Augmenting these remnants, more than 10.7 km (6.6 mi) of containment dikes were constructed using sand, stone, and riprap. The first dredged material was pumped within the dikes in 2001. It was then allowed to drain so as to maximize the island's dredged material placement capacity. After drying, the sediment was graded to construct beneficial habitat features that would serve as migratory resting and nesting spots for waterfowl, shorebirds, and other regionally important wildlife. The island restoration project created over 461 ha (1,140 ac) of habitat (Maryland Environmental Service 2017). During the bee survey, approximately 102 ha (252 ac) were still open water impoundments.

Table 1 shows the planted and the volunteer flora documented on Poplar Island. Reese (2002) recorded dominant species of mature plants assumed to have pioneered the island. Maryland Environmental Service (2008) listed the planted species for Cells 3D and 4D as well as pioneering species. Reese (2013) detailed some of the prominent and/or dominant flora and emphasized current or future problematic species. USFWS (2018) listed wetland plant species. USACE (2018) highlighted invasive and nuisance species. USACE (2019) listed planted species and in which cells they were planted. These six references document 47 families, 125 genera, and 166 plant species. At least 59% (n = 98) of the plant species are insect-pollinated and would be available for bee foraging (Droege, in litt., 30 October 2020). The connection between particular bee species and their associated host plants is elaborated on in the Results section.

MATERIALS and METHODS

Five sites in varied habitats (Table 2, Figure 2) were selected for the placement of five nine-cup continuously-trapping propylene glycol cup traps. The cups were 355-ml (12-oz) plastic cups (Figure 3) and were painted either fluorescent blue, fluorescent yellow, or left unpainted white. The transects were laid out by Scarpulla, McGowan, and Callahan on 9 April 2015. Since Poplar Island was an active construction site, the transect locations had to be relocated within their construction cells several times during the yearlong survey.

Table 1. Poplar Island Flora. Taxonomy is based on PLANTS Database (USDA, NRCS 2020).

Family and Species	Reese 2002	MES 2008	Reese 2013	USFWS 2018	USACE 2018	USACE 2019
ACERACEAE (maples)						
Acer rubrum L. – red maple		X				
AMARANTHACEAE (amaranths)						
Amaranthus blitoides S. Watson – mat amaranth		X				
Amaranthus cannabinus (L.) Sauer – tidalmarsh amaranth				X		X
Amaranthus palmeri S. Watson – carelessweed				X		
Amaranthus retroflexus L – redroot amaranth			X			
ANACARDIACEAE (cashews)						
Toxicodendron radicans (L.) Kuntze – eastern poison ivy					X	
APOCYNACEAE (dogbanes)						
Apocynum cannabinum L. – Indianhemp		X	X			X
AQUIFOLIACEAE (hollies)						
Ilex glabra (L.) A. Gray – inkberry		X				X
Ilex verticillata (L.) A. Gray – common winterberry		X				
ASCLEPIADACEAE (milkweeds)						
Asclepias incarnata L. (?) –swamp milkweed						X
Asclepias syriaca L. – common milkweed		X	X			X
Asclepias tuberosa L. – butterfly milkweed						X
ASTERACEAE (sunflowers)						
Ageratina altissima (L.) R.M. King & H. Rob. – white snakeroot						X
Ambrosia artemisiifolia L. – annual ragweed		X	X			
Ambrosia trifida L. – great ragweed						X
Arctium minus Bernh. – lesser burdock			X		X	
Artemisia absinthium L. – absinthium						X
Artemisia annua L. – sweet sagewort	X	X	X			
Artemisia vulgaris L. – common wormwood		X			X	X
Baccharis halimifolia L. – eastern baccharis		X		X		X
Bidens L. sp. – beggarticks						X
Cirsium arvense (L.) Scop. – Canada thistle		X	X		X	
Cirsium vulgare (Savi) Ten. – bull thistle					X	
Conoclinium coelestinum (L.) DC. – blue mistflower						X
Conyza canadensis (L.) Cronquist – Canadian horseweed	X	X	X			X
Echinacea purpurea (L.) Moench – eastern purple coneflower						X
Erigeron annuus (L.) Pers. – eastern daisy fleabane		X				
Iva frutescens L. – Jesuit's bark		X	X	X		X
Lactuca canadensis L. – Canada lettuce	X		X			
Lactuca serriola L. (?) – prickly lettuce		X				
Pluchea odorata (L.) Cass. – sweetscent						X
Pluchea odorata (L.) Cass. var. *odorata* – sweetscent	X	X		X		
Rudbeckia hirta L. – blackeyed Susan	X	X	X			X
Rudbeckia triloba L. – browneyed Susan		X				
Solidago nemoralis Aiton – gray goldenrod						X
Solidago sempervirens L. – seaside goldenrod				X		
Sonchus L. sp. – sowthistle		X				
Symphyotrichum lateriflorum (L.) Á. Löve & D. Löve var. *lateriflorum* – calico aster			X			X
Symphyotrichum novae-angliae (L.) G.L. Nesom – New England aster		X				X
Symphyotrichum tenuifolium (L.) G.L. Nesom – perennial saltmarsh aster				X		
Xanthium strumarium L. – rough cocklebur	X	X	X			X
BORAGINACEAE (borages)						
Heliotropium curassavicum L. – salt heliotrope				X		
BRASSICACEAE (mustards)						
Cakile edentula (Bigelow) Hook. – American searocket	X	X	X	X		

Family and Species	Reese 2002	MES 2008	Reese 2013	USFWS 2018	USACE 2018	USACE 2019
Lepidium virginicum L. – Virginia pepperweed		X				
CAPRIFOLIACEAE (honeysuckles)						
Sambucus nigra L. ssp. canadensis (L.) R. Bolli – American black elderberry		X				X
Viburnum dentatum L. – southern arrowwood		X				X
Viburnum lentago L. – nannyberry		X				
CARYOPHYLLACEAE (pinks)						
Arenaria serpyllifolia L. – thymeleaf sandwort	X	X				
chickweed sp.		X				
CHENOPODIACEAE (goosefoots)						
Atriplex patula L. – spear saltbush	X	X	X	X		
Chenopodium album L. – lambsquarters	X	X	X			X
Cycloloma atriplicifolium (Spreng.) J.M. Coult – winged pigweed	X	X				
Salicornia L. sp. – pickleweed				X		
CLETHRACEAE (pepperbushes)						
Clethra alnifolia L. – coastal sweetpepperbush		X				X
CONVOLVULACEAE (morningglories)						
Calystegia sepium (L.) R. Br. ssp. sepium – hedge false bindweed			X			
CORNACEAE (dogwoods)						
Cornus florida L. – flowering dogwood		X				
Cornus racemosa Lam. – gray dogwood		X				
Cornus sericea L. – redosier dogwood		X				
Nyssa sylvatica Marshall – blackgum		X				
CUPRESSACEAE (cypresses)						
Chamaecyparis thyoides (L.) Britton, Sterns & Poggenb. – Atlantic white cedar		X				
Juniperus virginiana L. – eastern redcedar		X				
CUSCUTACEAE (dodders)						
Cuscuta L. sp. – dodder				X		
CYPERACEAE (sedges)						
Bolboschoenus robustus (Pursh) Soják – sturdy bulrush				X		X
Cyperus esculentus L. – yellow nutsedge				X		
Cyperus strigosus L. – strawcolored flatsedge	X	X				X
Eleocharis rostellata (Torr.) Torr. – beaked spikerush				X		
Fuirena Rottb. sp. – umbrella-sedge		X				
Schoenoplectus americanus (Pers.) Volkart ex Schinz & R. Keller – chairmaker's bulrush				X		
EBENACEAE (ebonies)						
Diospyros virginiana L. – common persimmon		X				
ERICACEAE (heaths)						
Vaccinium angustifolium Aiton – lowbush blueberry		X				
Vaccinium corymbosum L. – highbush blueberry		X				
EUPHORBIACEAE (spurges)						
Chamaesyce maculata (L.) Small – spotted sandmat		X				
Euphorbia L. sp. – spurge				X		
FABACEAE (peas, legumes)						
Amorpha fruticosa L. – false indigo bush			X			
Amphicarpaea bracteata (L.) Fernald – American hogpeanut						X
Cercis canadensis L. – eastern redbud		X				
Chamaecrista fasciculata (Michx.) Greene – partridge pea		X	X	X		X
Chamaecrista fasciculata (Michx.) Greene var. *fasciculata* – partridge pea	X					
Desmodium canadense (L.) DC. – showy ticktrefoil		X	X			
Desmodium paniculatum (L.) DC. – panicledleaf ticktrefoil						X
Lespedeza cuneata (Dum. Cours.) G. Don – sericea lespedeza			X			X
Lespedeza frutescens (L.) Hornem. – shrubby lespedeza						X
Lupinus perennis L. – sundial lupine		X				
Medicago lupulina L. – black medick						X
Melilotus officinalis (L.) Lam. – sweetclover	X	X	X			

Family and Species	Reese 2002	MES 2008	Reese 2013	USFWS 2018	USACE 2018	USACE 2019
Securigera varia (L.) Lassen – crownvetch			X		X	
Senna hebecarpa (Fernald) Irwin & Barneby – American senna						X
Senna marilandica (L.) Link – Maryland senna		X				
Strophostyles helvola (L.) Elliott – amberique-bean			X			
Trifolium arvense L. – rabbitfoot clover						X
FAGACEAE (chestnuts, beeches, oaks)						
Fagus grandifolia Ehrh. – American beech		X				
Quercus alba L. – white oak		X				
Quercus bicolor Willd. – swamp white oak		X				
Quercus coccinea Münchh. – scarlet oak		X				
Quercus palustris Münchh. – pin oak		X				
Quercus phellos L. – willow oak		X				
Quercus rubra L. – northern red oak		X				
HAMAMELIDACEAE (witch hazels)						
Liquidambar styraciflua L. – sweetgum		X				
JUNCACEAE (rushes)						
Juncus gerardii Loisel. – saltmeadow rush						X
Juncus roemerianus Scheele – needlegrass rush		X		X		X
LAMIACEAE (mints)						
Pycnanthemum tenuifolium Schrad. – narrowleaf mountainmint						X
Teucrium canadense L. – Canada germander				X		
LAURACEAE (laurels)						
Lindera benzoin (L.) Blume – northern spicebush		X				X
LYTHRACEAE (loosestrifes)						
Lythrum lineare L. – wand lythrum				X		
MAGNOLIACEAE (magnolias)						
Liriodendron tulipifera L. – tuliptree		X				
Magnolia virginiana L. – sweetbay		X				
MALVACEAE (mallows)						
Abutilon theophrasti Medik. – velvetleaf					X	
Hibiscus moscheutos L. – crimsoneyed rosemallow			X			
Hibiscus L. sp. – rosemallow		X				
Kosteletzkya virginica (L.) C. Presl ex A. Gray – Virginia saltmarsh mallow				X		
MYRICACEAE (sweet gales)						
Morella cerifera (L.) Small – wax myrtle		X	X			X
Morella pensylvanica (Mirb.) Kartesz – northern bayberry		X				X
OLEACEAE (olives)						
Fraxinus pennsylvanica Marshall – green ash		X				
ONAGRACEAE (evening primroses)						
Chamerion angustifolium (L.) Holub – fireweed						X
Oenothera biennis L. – common evening primrose	X	X	X			X
PHYTOLACCACEAE (pokeweeds)						
Phytolacca americana L. – American pokeweed		X	X			
Phytolacca americana L. var. *americana* – American pokeweed				X		
PINACEAE (pines)						
Pinus strobus L. – eastern white pine		X				
Pinus taeda L. – loblolly pine		X				
PLUMBAGINACEAE (leadworts)						
Limonium Mill. sp. – sea lavender				X		
POACEAE (grasses)						
Agrostis gigantea Roth – redtop		X				X
Agrostis perennans (Walter) Tuck. – upland bentgrass						X
Ammophila breviligulata Fernald – American beachgrass				X		
Andropogon glomeratus (Walter) Britton, Sterns & Poggenb. – bushy bluestem		X				
Avena sativa L. – common oat						X

Family and Species	Reese 2002	MES 2008	Reese 2013	USFWS 2018	USACE 2018	USACE 2019
Bouteloua curtipendula (Michx.) Torr. – sideoats grama		X				
Bromus arvensis L. – field brome			X			
Dichanthelium clandestinum (L.) Gould – deertongue		X				X
Distichlis spicata (L.) Greene – saltgrass		X		X		X
Echinochloa walteri (Pursh) A. Heller – coast cockspur grass	X	X				
Elymus canadensis L. – Canada wildrye		X				X
Elymus virginicus L. – Virginia wildrye		X				X
Eragrostis curvula (Schrad.) Nees – weeping lovegrass		X				
Festuca brevipila Tracey – hard fescue		X				
Leersia oryzoides (L.) Sw. – rice cutgrass				X		
Lolium perenne L. – perennial ryegrass		X				X
Lolium perenne L. ssp. multiflorum (Lam.) Husnot – Italian ryegrass		X				X
Panicum amarum Elliott – bitter panicgrass		X				X
Panicum anceps Michx. – beaked panicgrass						X
Panicum virgatum L. – switchgrass	X	X				X
Phragmites australis (Cav.) Trin. ex Steud. – common reed	X	X	X	X	X	
Schedonorus arundinaceus (Schreb.) Dumort., nom. cons. – tall fescue		X				
Schizachyrium scoparium (Michx.) Nash – little bluestem		X				X
Secale cereale L. – cereal rye						X
Setaria faberi Herrm. – Japanese bristlegrass	X	X	X			X
Setaria magna Griseb. – giant bristlegrass				X		
*Setaria pum*ila (Poir.) Roem. & Schult. ssp. pumila – yellow foxtail		X				
Sorghastrum nutans (L.) Nash – Indiangrass		X				X
Spartina alterniflora Loisel. – smooth cordgrass		X		X		X
Spartina cynosuroides (L.) Roth – big cordgrass				X		X
Spartina patens (Aiton) Muhl. – saltmeadow cordgrass		X		X		X
Triticum aestivum L. – common wheat						X
POLYGONACEAE (knotweeds)						
Polygonum pensylvanicum L. – Pennsylvania smartweed						X
Polygonum perfoliatum L. – Asiatic tearthumb		X		X		
Polygonum persicaria L. – spotted ladysthumb	X	X	X			
Rumex crispus L. – curly dock				X		
PORTULACACEAE (purslanes)						
Portulaca oleracea L. – little hogweed		X				
ROSACEAE (roses)						
Amelanchier canadensis (L.) Medik. – Canadian serviceberry		X				
Aronia arbutifolia (L.) Pers. – red chokeberry		X				X
Prunus maritima Marshall – beach plum		X				X
Prunus serotina Ehrh. – black cherry		X				
Pyrus calleryana Decne. – Callery pear					X	
SALICACEAE (willows)						
Populus deltoides W. Bartram ex Marshall – eastern cottonwood		X	X			
SCROPHULARIACEAE (figworts)						
Paulownia tomentosa (Thunb.) Siebold & Zucc. ex Steud. – princesstree					X	
Penstemon digitalis Nutt. ex Sims – foxglove beardtongue						X
Verbascum thapsus L. – common mullein		X			X	
SIMAROUBACEAE (quassias)						
Ailanthus altissima (Mill.) Swingle – tree of heaven					X	
SOLANACEAE (nightshades)						
Solanum dulcamara L. – climbing nightshade					X	X
TYPHACEAE (cattails)						
Typha angustifolia L. – narrowleaf cattail	X	X				
ULMACEAE (elms)						
Celtis occidentalis L. – common hackberry		X				
VITACEAE (grapes)						
Parthenocissus quinquefolia (L.) Planch. – Virginia creeper				X		

Table 2. Original latitude, longitude, and habitat for each transect. Since Poplar Island was an active construction site, the original transect locations within four of the five cells had to be moved to other locations within the cell, in some cases more than once.

Transect	Cell and Original Location	Latitude	Longitude	Habitat
1	Cell 4 (sand flats)	38°45'17.11"N	76°22'48.29"W	mostly sand
2	Cell 6 (northwest corner pond edge)	38°45'23.92"N	76°23'20.72"W	near pond edge
3	Cell 3D (sampling pier footpath)	38°46'03.18"N	76°22'59.19"W	footpath edge
4	Cell 1B (south dirt road edge)	38°46'16.54"N	76°22'48.92"W	dirt road edge
5	Cell 1B (north dirt road edge)	38°46'26.87"N	76°22'39.66"W	dirt road edge

Figure 3. Continuously-trapping propylene glycol cup trap. This image (Droege 2015) shows a cup painted fluorescent yellow. Each transect contained nine cups placed in an alternating sequence of fluorescent blue, fluorescent yellow, and unpainted white.

Field Collection Procedures

Field collection procedures were based on those found in Droege (2011, 2015). Callahan and/or McGowan conducted the field collections. Ideally, each of the five transects were to be collected on the same day every other week so that data analysis could be compared by two-week periods. This was not always possible due to work scheduling.

A "healthy squirt" of original blue Dawn Ultra® dishwashing detergent was added to each 3.8 L (1 gal) jug of propylene glycol prior to use (Droege 2011). The detergent lowered the surface tension of the liquid. The first time that cups were put out, they were filled with approximately half propylene glycol and half water. The cups were filled to approximately 13 mm (0.5 in) from the top. Each transect contained nine cups, alternating the three colors—fluorescent blue, fluorescent yellow, and unpainted white.

Ideally, the best time for collection was in the morning about the same time each collection week, but that was not always possible due to site construction activities or work schedules.

On collection days, each transect's log sheet was filled out in pencil as each transect was visited. Before collection of specimens from each transect, a pencil was used to print the date, time, and location on a paper cone-shaped, commercial paint strainer (Droege 2011, 2015). Collection at the transect started by lifting the full cup out of its holder, straining the liquid from that cup through the paint strainer, and capturing the liquid for re-use in another empty cup that had been placed into the holder. Debris was removed from either the cup or strainer (e.g., leaves, twigs, large unwanted insects [especially butterflies because of their fouling scales], and slugs). Smaller insects (e.g., beetles, flies, and moths, etc.) were left in to be separated in the lab.

Cups were checked for damage before reuse. Each cup was topped off to about 13 mm (0.5 in) from the top with additional full-strength propylene glycol solution (i.e., blue Dawn Ultra already added). All nine cups from a transect on an individual day were poured through the same paint strainer, and this strainer and its insects were then placed in a 532-ml (18-oz) Nasco Whirl-Pak® bag along with a provided cardstock "transect tag" indicating the date, transect location, and the time of collection printed in pencil.

All five of each collection date's individual Whirl-Pak bags were placed into a 3.8-L (1-gal) Ziploc® bag with a provided cardstock "Ziploc bag tag" on which had been printed "Poplar Island," the collection date, and the collector's name. The specimen bags were stored in a freezer at the USFWS, Chesapeake Bay Field Office (CBFO), Annapolis, Maryland. The specimens were picked up periodically by Scarpulla for delivery to the United States Geological Survey, Bee Inventory and Monitoring Lab (BIML), Beltsville, Maryland (now located in Laurel, Maryland).

The use of continuously-trapping propylene glycol cup traps offered several advantages (Droege 2015). By continuously catching bees, the survey did not miss the occurrence of bees on non-sampling days. By collecting bees around the clock, this method avoided issues inherent with other survey methods (e.g., netting surveys, daily cup surveys) which generally tend to occur at specific times of day convenient to the human surveyors. This also addressed the actuality of varied daily activity patterns of different bee species. Once the cups were deployed, they could be scheduled for tending independent of the weather conditions. For subsequent yearlong surveys, this circumvented the problem of phenology shifts from year to year.

Processing at the Bee Inventory and Monitoring Lab

After the specimen bags had been picked up at CBFO, Scarpulla transported them to BIML where they were stored in a freezer. As time permitted, Scarpulla, or the technicians and student interns, washed, dried, pinned, and labeled the specimens generally following the methods in Droege (2015). Some specimens were identified by Scarpulla using Discover Life (Ascher and Pickering 2022) but due to the vast number of specimens, for expediency, the majority were identified by Samuel W. Droege (Head, BIML). Additionally, 19 of the 22 *Sphecodes* Latreille specimens were sent to Michael S. Arduser (Consultant, Midwestern Pollinator Specialists, Missouri) for identification, and a few *Lasioglossum* Curtis specimens were sent to Jason Gibbs (Assistant Professor and Curator, J.B. Wallis-R.E. Roughley Museum of Entomology, Department of Entomology, University of Manitoba, Winnipeg, Manitoba, Canada) for identification. Technicians or student interns entered the identifications into the BIML database. Scarpulla checked all database entries and then Droege uploaded the identifications into the Discover Life database (Ascher and Pickering 2022).

RESULTS

Due to procedural difficulties, both in the field and in the lab (i.e., inadvertent mislabeling of transects in the field and combining of transects in the lab, as well as the relocation of BIML along with the Poplar Island specimens from the Beltsville location to Laurel), results could only be presented by date, and not by transect location. During the 2015 continuously-trapping propylene glycol cup survey, a total of 18,703 bees were collected, representing 5 families, 22 genera, and at least 94 species (Table 3). The species breakdown by family was Colletidae 6, Andrenidae 14, Halictidae 35, Megachilidae 10, and Apidae 29. The Apidae had the most genera represented (n = 11), while the Halictidae had the most species (n = 35) and individuals (n = 18,076).

Table 3. Number of taxa caught per family.

Family	Common Name	Genera	Species	Individuals
Colletidae	plasterer bees	2	6	56
Andrenidae	mining bees	1	14	92
Halictidae	sweat bees	5	35	18,076
Melittidae	oil-collecting bees	0	0	0
Megachilidae	leafcutter, mason, resin bees	3	10	173
Apidae	bumble, carpenter, digger, honey bees	11	29	306
Total		**22**	**94**	**18,703**

Table 4 shows the numbers of each species captured on each of the 18 collection dates, with a spring peak on 6 May 2015 (n = 5,019) and a late summer peak on 25 August 2015 (n = 2,089). The overwhelmingly most numerous species was the green sweat bee, *Agapostemon splendens* (Lepeletier), making up 55.4% (n = 10,357; N = 18,703) of the specimens. *Agapostemon splendens* is the most common species of the genus in the southeastern United States and along the Gulf Coast; it prefers lower elevations; and it nests primarily in sand (Carril and Wilson 2021). Poplar Island's habitat embodies these criteria and is clearly attractive to this species.

There were 27 Talbot County first records (Table 4). They were comprised of two Colletidae: *Hylaeus mesillae* (Cockerell) and *H. schwarzii* (Cockerell); three Andrenidae: *Andrena arabis* Robertson, *A. atlantica* Mitchell, and *A. nida* Mitchell; twelve Halictidae: *Agapostemon splendens*, *Halictus parallelus* Say, *Lasioglossum halophitus* (Graenicher), *L. leucocomus* (Lovell), *L. lustrans* (Cockerell), *L. marinum* (Crawford), *L. nelumbonis* (Robertson), and *L. oceanicum* (Cockerell), *L. pilosum* (Smith), *L. simplex* (Robertson), *L. zephyrum* (Smith), and *Sphecodes* nr. *cressonii* (Robertson); three Megachilidae: *Hoplitis producta* (Cresson), *H. spoliata* (Provancher), and *Megachile brevis* Say; and seven Apidae: *Anthophora villosula* (Pallas), *Eucera hamata* (Bradley), *Habropoda laboriosa* (Fabricius), *Melissodes druriellus* (Kirby), *Nomada erigeronis* Robertson, *Triepeolus eliseae* Rightmyer (formerly undescribed "species 101" [Rightmyer 2017]), and *T. rhododontus* Cockerell. Of these 27, there were three Maryland first records (see Selected Species Commentary below).

Table 4. Poplar Island bee species captured per collection date. I = purposely introduced in North America, **A** = accidently introduced (or possibly naturally colonized) in North America, **P** = nest parasite, **T** = first Talbot County record, **M** = first Maryland record (Droege 2015; in litt., 20 April 2020).

Species	09 APR 2015	23 APR 2015	06 MAY 2015	21 MAY 2015	04 JUN 2015	16 JUN 2015	01 JUL 2015	16 JUL 2015	3 AUG 2015	14 AUG 2015	25 AUG 2015	08 SEP 2015	28 SEP 2015	13 OCT 2015	27 OCT 2015	09 NOV 2015	23 NOV 2015	17 DEC 2015	Total
COLLETIDAE (plasterer bees)																			
Colletes thoracicus Smith			16	1															17
Hylaeus leptocephalus (Morawitz) – **A**			1	3	1					1									6
Hylaeus mesillae (Cockerell) – **T**		1	26						1			1							29
Hylaeus modestus Say			1																1
Hylaeus ornatus Mitchell			2																2
Hylaeus schwarzii (Cockerell) – **T**				1															1
ANDRENIDAE (mining bees)																			
Andrena alleghaniensis Viereck or *A. atlantica* Mitchell											1								1
Andrena arabis Robertson – **T**			1																1
Andrena atlantica Mitchell – **T**				1															1
Andrena banksi Malloch		1																	1
Andrena barbara Bouseman and LaBerge	6	1									1								8
Andrena confederata Viereck			2																2
Andrena cressonii Robertson	1		1																2
Andrena erigeniae Robertson			2																2
Andrena imitatrix Cresson or *A. morrisonella* Viereck		2	6	3							1								12
Andrena miserabilis Cresson	1										1								2
Andrena nasonii Robertson			1	1															2
Andrena nida Mitchell – **T**	1																		1

Species	09 APR 2015	23 APR 2015	06 MAY 2015	21 MAY 2015	04 JUN 2015	16 JUN 2015	01 JUL 2015	16 JUL 2015	3 AUG 2015	14 AUG 2015	25 AUG 2015	08 SEP 2015	28 SEP 2015	13 OCT 2015	27 OCT 2015	09 NOV 2015	23 NOV 2015	17 DEC 2015	Total
Andrena perplexa Smith		12	27																39
Andrena pruni Robertson	2	4	1								3								10
Andrena (*Trachandrena* Robertson) species		1	4								1								6
Andrena Fabricius species	1		1																2
HALICTIDAE (sweat bees)																			
Agapostemon sericeus (Forster)			1	4	1				1										7
Agapostemon splendens (Lepeletier) – **T**	2066	2360	2955	893	192	24	13	12	12	10	1247	266	171	57	36	15	28		10,357
Agapostemon texanus Cresson										1									1
Agapostemon virescens (Fabricius)			1	13	4	12		2	1	1		2					2		38
Augochlorella aurata (Smith)	27	92	440	109	29	11	1		8	2	284	4	7	7		2			1023
Halictus confusus Smith	5	1	3					2			1	1	3						16
Halictus ligatus Say or *H. poeyi* Lepeletier	16	69	139	203	35	12	11	45	96	68	95	334	240	199	36	2	1		1601
Halictus parallelus Say – **T**			2				1												3
Halictus rubicundus (Christ)		1																	1
Lasioglossum admirandum (Sandhouse)	1																		1
Lasioglossum bruneri (Crawford)			3	2						1									6
Lasioglossum callidum (Sandhouse)	68	24	74	28	10	7		1	5	6	34		4	6		3	1		271
Lasioglossum coreopsis (Robertson)	3							2				1	4						10
Lasioglossum cressonii (Robertson)			1	1					1										3
Lasioglossum ephialtum Gibbs	1							1											2
Lasioglossum gotham Gibbs	1																		1
Lasioglossum halophitus (Graenicher) – **T**	10	17	108	150	57	5		2	3	1	11	2	9	23		3	2		403
Lasioglossum hitchensi Gibbs	26		6	3	2		1		1		18		1			1			59
Lasioglossum imitatum (Smith)														1					1
Lasioglossum leucocomus (Lovell) – **T**										8	1								9
Lasioglossum lustrans (Cockerell) – **T**			1																1
Lasioglossum marinum (Crawford) – **T**	13	20	34	30	3		2		2	3	23	1							131
Lasioglossum nelumbonis (Robertson) – **T**		1																	1
Lasioglossum oceanicum (Cockerell) – **T**		1																	1
Lasioglossum pectorale (Smith)				53															53
Lasioglossum pilosum (Smith) – **T**	946	359	1040	634	98	56	6	22	39	34	306	43	16	39		3	2		3643
Lasioglossum platyparium (Robertson) – **P**	4			1															5
Lasioglossum semicaeruleum (Cockerell)				1															1
Lasioglossum simplex (Robertson) – **T**	10	2	2	2							2			1					19
Lasioglossum tegulare (Robertson)	4	56	48	19	11	1	1		6	3	9	2	7	1		2	2		172
Lasioglossum trigeminum Gibbs	80	9	14	23	5	1			2	2	14	5		1					156
Lasioglossum weemsi (Mitchell)					1														1
Lasioglossum zephyrum (Smith) – **T**	5	4	4	4	1						4								22
Lasioglossum Curtis species	3		3		1				1		6		12			4	5		35
Sphecodes nr. *cressonii* (Robertson) – **P**, **T**, **M**		2	9	1	1	1													14
Sphecodes illinoensis (Robertson) – **P**		1	1								3								5
Sphecodes Latreille species – **P**			3																3
MEGACHILIDAE (leafcutter, mason, resin bees)																			
Hoplitis producta (Cresson) – **T**			1																1
Hoplitis spoliata (Provancher) – **T**			1																1
Megachile brevis Say – **T**			3	1							1	4	2						11
Megachile concinna Smith or *M. pusilla* Pérez – **A**						1													1
Megachile mendica Cresson			3	1								1							5
Megachile texana Cresson					1				1		1		1						4
Osmia bucephala Cresson		2	1																3
Osmia cornifrons (Radoszkowski) – **I**		1																	1
Osmia pumila Cresson	4		1																5
Osmia taurus Smith – **A**	132	6	1								2								141
APIDAE (bumble, carpenter, digger, honey bees)																			
Anthophora villosula (Pallas) – **T**	2																		2
Apis mellifera Linnaeus – **I**			1																1
Bombus griseocollis (De Geer)		5	3					3	1	3	5								20
Bombus impatiens Cresson		1								1			9	5					16
Ceratina dupla Say			1																1
Ceratina mikmaqi Rehan and Sheffield			2																2
Ceratina strenua Smith			1																1
Eucera hamata (Bradley) – **T**		1	6	3	3														13
Eucera rosae (Robertson)			1	7															8
Habropoda laboriosa (Fabricius) – **T**	11																		11
Melissodes bimaculatus (Lepeletier)									1										1
Melissodes boltoniae Robertson											3	25							28
Melissodes near *boltoniae* Robertson											1								1

Species	09 APR 2015	23 APR 2015	06 MAY 2015	21 MAY 2015	04 JUN 2015	16 JUN 2015	01 JUL 2015	16 JUL 2015	3 AUG 2015	14 AUG 2015	25 AUG 2015	08 SEP 2015	28 SEP 2015	13 OCT 2015	27 OCT 2015	09 NOV 2015	23 NOV 2015	17 DEC 2015	Total
Melissodes comptoides Robertson								3	8	10	6	8	1						36
Melissodes dentiventris Smith													1						1
Melissodes druriellus (Kirby) – **T**					1						1	19	57	3					81
Melissodes subillatus LaBerge					45	1						3							49
Melissodes trinodis Robertson						2							1						3
Melissodes Latreille species												1							1
Nomada bethunei Cockerell – **P**			1																1
Nomada denticulata Robertson – **P**					1														1
Nomada erigeronis Robertson – **P**, **T**, **M**					1														1
Nomada illinoensis Robertson – **P** or *N. sayi* Robertson – **P**			1																1
Nomada imbricata Smith – **P**			1																1
Nomada pygmaea Cresson – **P**			1																1
Nomada Scopoli bidentate group – **P**		1	1																2
Ptilothrix bombiformis (Cresson)		1						4	8										13
Triepeolus eliseae Rightmyer – **P**, **T**					1														1
Triepeolus rhododontus Cockerell – **P**, **T**, **M**												1							1
Xylocopa virginica (Linnaeus)			4								3								7
Total per collection date	**3450**	**3059**	**5019**	**2196**	**505**	**134**	**36**	**99**	**198**	**155**	**2089**	**724**	**546**	**343**	**72**	**35**	**43**	**0**	**18,703**

Table 5 shows the number of singleton (only one specimen during the survey), doubleton (only two specimens during the survey), and tripleton (only three specimens during the survey) taxa collected by traps during the survey. Singletons comprised 36% (n = 34) of the total taxa (N = 94), and singletons, doubletons, and tripletons combined comprised 51% (n = 48). Therefore, 51% of the total taxa were represented by three or less specimens.

Table 5. Singleton, doubleton, and tripleton taxa collected on Poplar Island. (singleton = only one specimen during the survey, doubleton = only two specimens during the survey, tripleton = only three specimens during the survey),

Family	Singletons	Doubletons	Tripletons	Total
Colletidae	2	1	0	3
Andrenidae	4	5	0	9
Halictidae	10	1	2	13
Melittidae	0	0	0	0
Megachilidae	4	0	1	5
Apidae	14	3	1	18
Total	**34 (36%)**	**10 (11%)**	**4 (4%)**	**48 (51%)**

SELECTED SPECIES COMMENTARY

First Maryland records

There were three first records for Maryland: one Halictidae, *Sphecodes* nr. *cressonii*, and two Apidae, *Nomada erigeronis* and *Triepeolus rhododontus*.

Halictidae

Sphecodes nr. *cressonii* (Robertson)

Fourteen female specimens (Figure 4) were collected and are currently being researched by Michael S. Arduser. This is potentially a new undescribed species in the atlantis-cressonii-carolinus group, closest to *S. cressonii* (Robertson) but not that species (Arduser, in litt., 7 August 2019). Though quite similar to *S. cressonii*, the pronotum is different, being dorso-laterally spiniferous, which is not the case with either *S. cressonii* or *S. atlantis* (Arduser, in litt., 6 November 2020).

Apidae

Nomada erigeronis Robertson

One male specimen (USGS_DRO557814) was collected on Poplar Island on 4 June 2015 (Figure 5). Mitchell (1962) gives the range as Kansas and Nebraska to Massachusetts. Bartholomew (2004) and Owens et al. (2018) document the species in Louisiana. Discover Life (Ascher and Pickering 2022) lists occurrences in Nebraska, and Texas (Bee Biology and Systematics Laboratory database); Iowa (Ai Wen, University of Northern Iowa database); Illinois (Illinois Natural History Survey); and the Poplar Island, Maryland specimen. This species normally has a more western distribution.

Triepeolus rhododontus Cockerell

One female specimen (USGS_DRO555234) was collected on Poplar Island on 8 September 2015 (Figure 6). Rightmyer (2006) lists *T. rhododontus* as occurring in Arizona, Arkansas, Colorado, Kansas, Minnesota, Mississippi, Missouri, New Mexico, New York, North Carolina, South Carolina, South Dakota, Tennessee, Texas, and Utah. Kilpatrick et al. (2020) shows Pennsylvania as having a record. Discover Life (Ascher and Pickering 2022) shows two eastern specimens: Wingate, North Carolina and the Poplar Island, Maryland specimen.

Noteworthy record

Lasioglossum semicaeruleum (Cockerell)

This species is widely distributed west of the Mississippi River. There are only six known records east of the Mississippi: three from Wisconsin and three from Maryland (Scarpulla, forthcoming). The three Maryland records are one female specimen each: in 2004 from Bowie, Prince George's County (USGS_DRO029678); in 2007 from Wittman, Talbot County (USGS_DRO141684); and this specimen (Figure7) on 21 May 2015 from Poplar Island, Talbot County (USGS_DRO556278) (Ascher and Pickering 2022). The 2007 Wittman and the 2015 Poplar Island specimens were collected approximately 8 km (5 mi) from each other. How these three specimens—so far east of their normal range—got to Maryland is enigmatic.

Figure 4. ***Sphecodes*** **nr.** ***cressonii*** **(Robertson).** First Maryland records, one of 14 female specimens (USGS_DRO526801), potentially an undescribed species, 21 May 2015. **Top:** frontal view; **middle:** dorsal view; **bottom:** lateral view.

Figure 5. ***Nomada erigeronis*** **Robertson.** First Maryland record (USGS_DRO557814), male, 4 June 2015. **Top:** frontal view; **middle:** dorsal view; **bottom:** lateral view.

Figure 6. ***Triepeolus rhododontus*** **Cockerell.** First Maryland record (USGS_DRO555234), female, 8 September 2015. **Top:** frontal view; **middle:** dorsal view; **bottom:** lateral view.

Figure 7. *Lasioglossum semicaeruleum* (Cockerell). Third Maryland record (USGS_DRO556278), female, 21 May 2015. **Top:** frontal view; **middle:** dorsal view; **bottom:** lateral view.

Non-native species

Five non-native species in three families were documented on Poplar Island: one Colletidae, three Megachilidae, and one Apidae. Two species were intentionally introduced in North America; three were accidental. A brief summary of each species follows. The number of collected specimens follows each species name.

Colletidae

Hylaeus leptocephalus (Morawitz) – Slender-faced Masked Bee – (6)

This species is native to Europe and was accidently introduced to North America (Droege 2015). It was first captured in 1912 in Fargo, North Dakota (Snelling 1970). It is currently found throughout the United States and southern Canada and is particularly associated with gardens, urban areas, and disturbed sites, often on sweetclover, *Melilotus* Mill. spp. (Fabaceae) (Droege 2015).

Megachilidae

Megachile concinna Smith or *M. pusilla* Pérez – Pale Leafcutting Bee – (1)

Megachile concinna Smith is native to Africa and was probably introduced to the West Indies in the early 1800s, accidently introduced (or possibly naturally colonized) in North America, and first found in the United States after World War II (Mitchell 1962). Recent molecular and morphological work has shown that two species of the concinna species complex are currently present in North America: *M. concinna*, introduced to the New World in the Caribbean and probably Central America, and *M. pusilla* Pérez, introduced in North America, Hawai'i, and Argentina (Soltani et al. 2017). Although there are some morphological differences between the two species (i.e., body length, white vestiture on tergum 6, scale-like pilosity on the mesonotum, and punctation on the disc of tergum 4), identifications based solely on morphology are not conclusive (Soltani et al. 2017).

Osmia cornifrons (Radoszkowski) – Hornfaced Bee – (1)

This species is native to eastern China, Korea, and Japan (Droege 2015). It was intentionally, but unsuccessfully, introduced in North America by the United States Department of Agriculture (USDA) in Logan, Utah, in 1965 for the pollination of fruit tree crops (Batra 1979, pers. comm.). Subsequently, it was successfully introduced by USDA at the Beltsville Agricultural Research Center, Beltsville, Maryland, on 8 April 1977 (Batra 1979). Feral populations occur in the Mid-Atlantic, Northeast, and Pacific Northwest (Droege 2015). The species is available commercially (Droege 2015).

Osmia taurus Smith – Taurus Mason Bee – (141)

This species is native to eastern China and Japan and was accidentally introduced to North America. It was first detected in North America on 16 April 2002 by Droege at the Patuxent Wildlife Research Center (PWRC) in Laurel, Maryland (USGS_DRO005420; Ascher and Pickering 2022), and is currently found in the Mid-Atlantic region and the Appalachian Mountains (Droege 2015). A study by LeCroy et al. (2020) showed a significant population increase of *O. taurus* in the Mid-Atlantic region and a concomitant decrease in six native *Osmia* Panzer species over a 15-year period (2003–2017).

Apidae

Apis mellifera Linnaeus – Honey Bee – (1)

Honey Bees were intentionally introduced to North America from Europe by at least the 1620s (Council of the Virginia Company 1621). They are an agriculturally-raised crop, although feral colonies are found throughout North America (Droege 2015). Feral colonies are not known to be present on Poplar Island.

Cleptoparasitic species (cuckoo bees)

In cleptoparasitism, an adult female cleptoparasitic bee enters the nest of a host bee and lays its egg in an existing cell. Usually, the parasitic adult then leaves. In some cases, the adult female parasite kills the host's egg or larva; in other cases, the hatched parasitic larva kills the host's egg or larvae. After the parasite's egg hatches, the parasitic larva feeds on what should have been the host larva's food (Michener 2007). These cleptoparasitic species are commonly called "cuckoo bees" since their egg-laying behavior is similar to Old World cuckoos (Aves: Cuculidae: Cuculinae) that lay their eggs in a different bird species' nest so that the host species will rear their young. Twelve parasitic taxa in two families were found on Poplar Island: three Halictidae and nine Apidae. Host bees are unknown for many parasitic species. The number of collected specimens follows each species name.

Halictidae

Lasioglossum platyparium (Robertson) – (5)

The host species are *Lasioglossum* (*Dialictus* Robertson) species (Michener 2007).

Sphecodes nr. *cressonii* (Robertson) – (14; first Maryland records)

Sphecodes illinoensis (Robertson) – (5)

Apidae

Nomada bethunei Cockerell – (1)

Nomada denticulata Robertson – (1)

The host species is an unknown *Andrena* Fabricius species (Mitchell 1962).

Nomada erigeronis Robertson – (1; first Maryland record)

Nomada illinoensis Robertson or *N. sayi* Robertson – (1)

The host species are *Andrena* species (John S. Ascher in Minnesota Department of Natural Resources 2019).

Nomada imbricata Smith – (1)

The host species are *Andrena* species (John S. Ascher in Minnesota Department of Natural Resources 2019).

Nomada pygmaea Cresson – (1)

The host species are *Andrena* species (John S. Ascher in Minnesota Department of Natural Resources 2019).

Nomada Scopoli bidentate group – (2)

Triepeolus eliseae Rightmyer – (1)

Triepeolus rhododontus Cockerell – (1; first Maryland record)

Oligolectic species

Polylectic bees (polyleges) collect pollen from a wide variety of plants. Alternatively, oligolectic bees (oligoleges) exhibit a narrow preference for one particular species or genus of plants. Fowler (2016) summarized oligolectic native-pollen collecting bees for the Mid-Atlantic region. He defined oligolecty as an association with one plant family or a few related genera or species. Using Fowler's definition, only 11 of the bee species found on Poplar Island would be considered oligolectic: three Andrenidae, one Halictidae, and seven Apidae. The number of specimens of each species is in parentheses following each name.

Andrenidae

Andrena arabis Robertson (1) is associated with Brassicaceae (mustards), specifically *Arabis* L. (rockcress) and *Cardamine* L. (bittercress). Neither plant species has been documented on Poplar Island.

Andrena erigeniae Robertson (2) is associated with Portulacaceae (purslanes), specifically *Claytonia* L. (springbeauty) which has not been documented on Poplar Island.

Andrena nida Mitchell (1) is associated with Salicaceae (willows), specifically *Salix* L. (willow) which has not been documented on Poplar Island.

Halictidae

Lasioglossum lustrans (Cockerell) (1) is associated with Asteraceae (sunflowers), specifically *Pyrrhopappus* DC. (desert-chicory). *Pyrrhopappus carolinianus* (Walter) DC. (Carolina desert-chicory) is suspected of occurring, but not positively documented, on Poplar Island.

Apidae

Habropoda laboriosa (Fabricius) (11) is associated with Ericaceae (heaths), specifically *Vaccinium* L. (blueberry). Two species have been documented on Poplar Island, *V. angustifolium* Aiton (lowbush blueberry) and *V. corymbosum* L. (highbush blueberry).

Melissodes boltoniae Robertson (28) is associated with Asteraceae which are plentiful on Poplar Island.

Melissodes dentiventris Smith (1) is associated with Asteraceae which are plentiful on Poplar Island.

Melissodes druriellus (Kirby) (81) is associated with Asteraceae which are plentiful on Poplar Island.

Melissodes subillatus LaBerge (49) is associated with Asteraceae which are plentiful on Poplar Island.

Melissodes trinodis Robertson (3) is associated with Asteraceae which are plentiful on Poplar Island.

Ptilothrix bombiformis (Cresson) (13) is associated with Malvaceae (mallows), specifically *Hibiscus* L. (rosemallow). One species has been documented on Poplar Island, *H. moscheutos* L. (crimsoneyed rosemallow). Two other mallows, *Abutilon theophrasti* Medik. (velvetleaf) and *Kosteletzkya virginica* (L.) C. Presl ex A. Gray (Virginia saltmarsh mallow), are also present on the island.

DISCUSSION

The Halictidae made up 97% (n = 18,076) of the collected specimens (N = 18,703). This could reflect their actual abundance on the island, although some studies have shown that the use of painted bowls or cups inordinately attracts halictids (Droege et al. 2010, Portman et al. 2020).

Seasonal abundance was highest on the four collection dates during April and May with 73% (n = 13,724) of the specimens being collected (Table 4, Figure 8). A late summer spike occurred on the 25 August 2015 collection date with 11% (n = 2,089) of the specimens being collected. The 25 August 2015 spike was primarily due to *Agapostemon splendens* (n = 1,247), *Lasioglossum pilosum* (n = 306), and *Augochlorella aurata* (Smith) (n = 284).

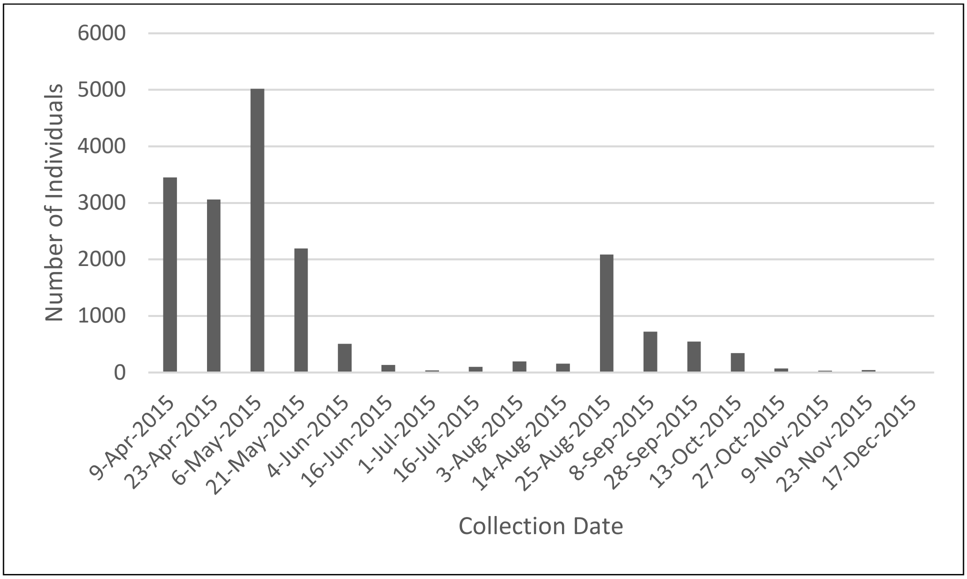


Figure 8. Seasonal bee abundance based on the number of individuals captured per collection date.

The rank abundance curve showed that four species made up the majority (89%) of the specimens, i.e., *Agapostemon splendens* (n = 10,357), *Lasioglossum pilosum* (n = 3,643), *Halictus ligatus* Say or *H. poeyi* Lepeletier (n = 1,601), and *Augochlorella aurata* (n = 1,023) (Table 4, Figure 9).

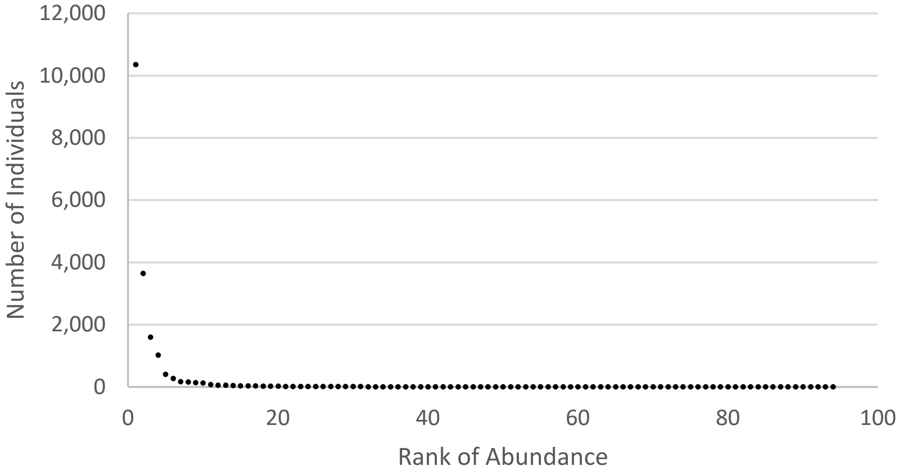


Figure 9. Rank-abundance curve of the number of individuals of each of the 94 species captured on Poplar Island.

A comparison of the Poplar Island results with the Hart-Miller Island results (Scarpulla 2013) show differences between the two dredged material containment facilities (Tables 6 and 7). Approximately four times as many bees were collected on Poplar Island as compared to Hart-Miller Island. This was to be expected due to the differing sampling protocols. Poplar's was continuously-trapping, while Hart-Miller's was 18 discrete sampling days for approximately 5 hours per sampling day. The two islands combined produced 128 taxa. Percentagewise, 40.6% (n = 52) were found on both islands, 26.6% (n = 34) only on Hart-Miller Island, and 32.8% (n = 42) only on Poplar Island.

Table 6. Comparison of numbers of taxa collected on Poplar Island versus Hart-Miller Island (Scarpulla 2013).

Family	Only Hart-Miller Island	Both Islands	Only Poplar Island	Total
Colletidae	3	2	4	9
Andrenidae	6	7	7	20
Halictidae	9	23	12	44
Melittidae	0	0	0	0
Megachilidae	10	8	2	20
Apidae	6	12	17	35
Total	**34**	**52**	**42**	**128**

Table 7. Comparison of bee species captured at Poplar Island and Hart-Miller Island (Scarpulla 2013). I = purposely introduced in North America, **A** = accidently introduced (or possibly naturally colonized) in North America, **P** = nest parasite (Droege 2015). [ ] = a taxon not included in the total number of taxa since the taxon could possibly be one of the species listed in the table.

Species	Hart-Miller Island	Poplar Island
COLLETIDAE (plasterer bees)		
Colletes nudus Robertson	1	
Colletes thoracicus Smith		17
Hylaeus affinis Smith or *H. modestus* Say	10	
Hylaeus leptocephalus (Morawitz) – **A**		6
Hylaeus mesillae (Cockerell)	8	29
Hylaeus modestus Say		1
Hylaeus nelumbonis (Robertson)	1	
Hylaeus ornatus Mitchell		2
Hylaeus schwarzii (Cockerell)	11	1
ANDRENIDAE (mining bees)		
[*Andrena alleghaniensis* Viereck or *A. atlantica* Mitchell]		[1]
Andrena arabis Robertson		1
Andrena atlantica Mitchell	2	1
Andrena banksi Malloch		1
Andrena barbara Bouseman and LaBerge	14	8
Andrena carlini Cockerell	1	
Andrena confederata Viereck		2
Andrena cressonii Robertson	2	2
Andrena erigeniae Robertson	5	2
Andrena imitatrix Cresson	2	
Andrena imitatrix Cresson or *A. morrisonella* Viereck		12
Andrena miserabilis Cresson	1	2
Andrena nasonii Robertson	8	2
Andrena nida Mitchell		1
Andrena perplexa Smith		39
Andrena pruni Robertson		10
Andrena vicina Smith	4	
Andrena violae Robertson	8	
Andrena (Trachandrena Robertson) species	3	6
[*Andrena* Fabricius species]		[2]
Calliopsis andreniformis Smith	1	
Perdita octomaculata (Say)	1	
HALICTIDAE (sweat bees)		
Agapostemon sericeus (Forster)	1	7
Agapostemon splendens (Lepeletier)	756	10,357
Agapostemon texanus Cresson	2	1
Agapostemon virescens (Fabricius)	33	38
Augochlora pura (Say)	2	
Augochlorella aurata (Smith)	574	1023
Augochloropsis metallica (Fabricius)	1	
Halictus confusus Smith	2	16
Halictus ligatus Say or *H. poeyi* Lepeletier	410	1601
Halictus parallelus Say		3
Halictus rubicundus (Christ)		1
Halictus tectus Radoszkowski – **A**	76	
Lasioglossum admirandum (Sandhouse)	61	1
[*Lasioglossum admirandum* (Sandhouse)?]	[2]	
Lasioglossum bruneri (Crawford)	59	6

Species	Hart-Miller Island	Poplar Island
Lasioglossum callidum (Sandhouse)	192	271
Lasioglossum coreopsis (Robertson)	13	10
Lasioglossum cressonii (Robertson)		3
Lasioglossum ephialtum Gibbs	3	2
[*Lasioglossum ephialtum* Gibbs?]	[1]	
Lasioglossum fuscipenne (Smith)	2	
Lasioglossum gotham Gibbs		1
Lasioglossum halophitus (Graenicher)		403
Lasioglossum hitchensi Gibbs	386	59
[*Lasioglossum hitchensi* Gibbs or *L. weemsi* (Mitchell)]	[31]	
Lasioglossum illinoense (Robertson)	1	
Lasioglossum imitatum (Smith)	1	1
Lasioglossum leucocomus (Lovell)	1	9
[*Lasioglossum leucocomus* (Lovell)?]	[2]	
Lasioglossum lustrans (Cockerell)	1	1
Lasioglossum marinum (Crawford)		131
Lasioglossum nelumbonis (Robertson)		1
Lasioglossum oblongum (Lovell)	4	
Lasioglossum oceanicum (Cockerell)		1
Lasioglossum pectorale (Smith)		53
Lasioglossum pilosum (Smith)	516	3643
Lasioglossum platyparium (Robertson) – **P**	32	5
Lasioglossum semicaeruleum (Cockerell)		1
Lasioglossum simplex (Robertson)		19
Lasioglossum tegulare (Robertson)	134	172
Lasioglossum trigeminum Gibbs	19	156
Lasioglossum versatum (Robertson)	2	
Lasioglossum weemsi (Mitchell)	1	1
Lasioglossum zephyrum (Smith)	37	22
[*Lasioglossum* Curtis species]	[6]	[35]
Sphecodes atlantis Mitchell – **P**	5	
Sphecodes confertus Say – **P**	1	
Sphecodes nr. *cressonii* (Robertson) – **P**		14
Sphecodes illinoensis (Robertson) – **P**	2	5
[*Sphecodes* Latreille species – **P**]		[3]
MEGACHILIDAE (leafcutter, mason, resin bees)		
Anthidium oblongatum (Illiger) – **A**	1	
Coelioxys octodentatus Say – **P**	1	
Coelioxys sayi Robertson – **P**	2	
Hoplitis pilosifrons (Cresson)	63	
Hoplitis producta (Cresson)	1	1
Hoplitis spoliata (Provancher)		1
Megachile brevis Say	13	11
Megachile concinna Smith or *M. pusilla* Pérez – A – **A**	1	1
Megachile gemula Cresson	1	
Megachile mendica Cresson	4	5
Megachile montivaga Cresson	1	
Megachile texana Cresson	3	4
Osmia atriventris Cresson	2	
Osmia bucephala Cresson		3
Osmia cornifrons (Radoszkowski) – **I**	7	1
Osmia georgica Cresson	1	
Osmia lignaria Say	1	
Osmia pumila Cresson	84	5
Osmia taurus Smith – **A**	16	141
Stelis lateralis Cresson – **P**	8	

Species	Hart-Miller Island	Poplar Island
APIDAE (bumble, carpenter, digger, honey bees)		
Anthophora villosula (Pallas)		2
Apis mellifera Linnaeus – **I**	33	1
Bombus fervidus (Fabricius)	2	
Bombus griseocollis (De Geer)	18	20
Bombus impatiens Cresson	52	16
Ceratina calcarata Robertson	2	
Ceratina dupla Say	318	1
Ceratina mikmaqi Rehan and Sheffield		2
Ceratina strenua Smith		1
Eucera hamata (Bradley)		13
Eucera rosae (Robertson)		8
Habropoda laboriosa (Fabricius)	23	11
Melissodes bimaculatus (Lepeletier)		1
Melissodes boltoniae Robertson		28
Melissodes near *boltoniae* Robertson		1
Melissodes comptoides Robertson	1	36
Melissodes dentiventris Smith		1
Melissodes druriellus (Kirby)		81
Melissodes subillatus LaBerge		49
Melissodes trinodis Robertson		3
[*Melissodes* Latreille species]		[1]
Melitoma taurea (Say)	1	
Nomada articulata Smith	13	
Nomada australis Mitchell	2	
Nomada bethunei Cockerell – **P**		1
Nomada denticulata Robertson – **P**	1	1
Nomada erigeronis Robertson – **P**		1
Nomada illinoensis Robertson – **P** or *N. sayi* Robertson – **P**		1
Nomada imbricata Smith – **P**	1	1
Nomada pygmaea Cresson – **P**	3	1
Nomada sayi Robertson – **P**	1	
Nomada Scopoli bidentate group – **P**	2	2
Ptilothrix bombiformis (Cresson)	302	13
Triepeolus eliseae Rightmyer – **P**		1
Triepeolus rhododontus Cockerell – **P**		1
Xylocopa virginica (Linnaeus)	6	7
Total Individuals	**4,446**	**18,703**

SUMMARY

The 2015 continuously-trapping propylene glycol cup survey conducted on Poplar Island collected 18,703 bees representing 5 families, 22 genera, and at least 94 species. This survey, as well as the Hart-Miller Island survey (Scarpulla 2013), have shown that dredged material, with its loose sandy soils, appears to provide superb nesting habitat for ground-nesting native bees. Two additional island projects, James Island and Barren Island, both in Dorchester County, Maryland, have been proposed for restoration by use of dredged material. It is likely that bee surveys on these two islands will show similar creation of beneficial nesting and foraging habitat for native bees.

ACKNOWLEDGMENTS

The authors thank Samuel W. Droege (Head, BIML) for guidance with the project, for being the primary identifier of the numerous specimens, and for specimen photography; the various technicians and interns (BIML) for the tedious processing of the specimens and the resultant database entering; Michael S. Arduser for identification of, and insight about, the *Sphecodes* specimens; and Jason Gibbs for identification of selected *Lasioglossum* specimens. The authors also thank Jan G. Reese (Consultant, Environmental Regulations Consultant, Inc., St. Michaels, Maryland) and Ryland Taylor (Environmental Specialist, Maryland Environmental Service, Tilghman, Maryland) for providing additional plant species lists. The authors are grateful for insightful reviews of the manuscript by Samuel W. Droege and by Jonathan R. Mawdsley (Chief, Cooperative Fish and Wildlife Research Units Program, United States Geological Survey, Reston, Virginia).

LITERATURE CITED

Ascher, J.S., and J. Pickering. 2022. Discover Life bee species guide and world checklist (Hymenoptera: Apoidea: Anthophila). Available at: https://www.discoverlife.org/mp/20q?search=Apoidea. Accessed 2015–2022.

Bartholomew, C.S. 2004. *Bees Associated with Louisiana Longleaf Pine Savannas*. Master of Science thesis. Department of Entomology, Louisiana State University, Baton Rouge, LA. 112 pp.

Batra, S.W.T. 1979. *Osmia cornifrons* and *Pithitis smaragdula*, two Asian bees introduced into the United States for crop pollination. In: *Proceedings of the IVth International Symposium on Pollination*. Maryland Agricultural Experiment Station Special Miscellaneous Publication 1:307–312.

Carril, O.M., and J.S. Wilson. 2021. *Common Bees of Eastern North America*. Princeton University Press, Princeton, NJ and Oxford, UK. 286 pp.

Council of the Virginia Company. 1621. Letter to the Governor and Council in Virginia, December 5, 1621. Manuscript records Virginia Company, III, Part ii, pages 21–21a, Document in Library of Congress, Washington, D.C., List of Records No. 283. Pages 530–534, in: S.M. Kingsbury (Editor). 1933. *The Records of the Virginia Company of London*, Volume III, from the manuscript in the Library of Congress. United States Government Printing Office, Washington, DC. 769 pp.

Droege, S. 2011. Glycol Cup Traps for Monitoring Native Bees. YouTube. Available at: https://www.youtube.com/watch?v=z0DAY7bNOR4. Accessed 17 February 2022.

Droege, S. 2015. *The Very Handy Manual: How to Catch and Identify Bees and Manage a Collection*. Bee Inventory and Monitoring Lab, Patuxent Wildlife Research Center, United States Geological Survey, Laurel, MD. 65 pp.

Droege, S., V.J. Tepedino, G. LeBuhn, W. Link, R.L. Minckley, Q. Chen, and C. Conrad. 2010. Spatial patterns of bee captures in North American bowl trapping surveys. *Insect Conservation and Diversity* 3(1):15–23.

Fowler, J. 2016. Specialist bees of the Mid-Atlantic: Host plants and habitat conservation. *The Maryland Entomologist* 6(4):2–40.

Kilpatrick, S.K., J. Gibbs, M.M. Mikulas, S.-E. Spichiger, N. Ostiguy, D.J. Biddinger, and M.M. López-Uribe. 2020. An updated checklist of the bees (Hymenoptera, Apoidea, Anthophila) of Pennsylvania, United States of America. *Journal of Hymenoptera Research* 77:1–86.

LeCroy, K.A, G. Savoy-Burke, D.E. Carr, D.A. Delaney, and T.H. Roulston. 2020. Decline of six native mason bee species following the arrival of an exotic congener. *Scientific Reports* 10:18745. Available at: https://doi.org/10.1038/s41598-020-75566-9. Accessed 8 November 2020.

Maryland Environmental Service. 2008. Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island Plant List: Cells 3D and 4D and Pioneering Species (19 August 2008). Unpublished document. 2 pp.

Maryland Environmental Service. 2017. About Poplar Island. Available at: http://www.poplarislandrestoration.com/Home/About. Accessed 6 June 2020.

Minnesota Department of Natural Resources. 2019. Minnesota Bees—A Preliminary List. 13 pp. Available at: https://files.dnr.state.mn.us/eco/mcbs/pollinators/bees_species_list_2019.pdf. Accessed 24 June 2020.

Michener, C.D. 2007. *The Bees of the World* (second edition). The Johns Hopkins University Press, Baltimore, MD. 953 pp.

Mitchell, T.B. 1962. *Bees of the Eastern United States*, Volume II. The North Carolina Agricultural Experiment Station, Technical Bulletin Number 152. 557 pp.

Owens, B.E., L. Allain, E.C. van Gorder, J.L. Bossart, and C.E. Carlton. 2018. The bees (Hymenoptera: Apoidea) of Louisiana: An updated, annotated checklist. *Proceedings of the Entomological Society of Washington* 120(2):272–307.

Portman, Z.M., B. Bruninga-Socolar, and D.P. Cariveau. 2020. The state of bee monitoring in the United States: A call to refocus away from bowl traps and towards more effective methods. *Annals of the Entomological Society of America* 113(5):337–342.

Reese, J. 2002. Pioneering Plants: Poplar Island Environmental Restoration Project (31 December 2002). Unpublished document. 2 pp.

Reese, J. 2013. Some Current Prominent and/or Dominant Poplar Island Flora Emphasizing Species Current or Future Problematic (July 2013). Unpublished document. 2 pp.

Rightmyer, M.G. 2006. *A Phylogenetic Analysis of the Bee Tribe Epeolini, with a Review of the Genus* Triepeolus. Doctor of Philosophy dissertation. Department of Ecology and Evolutionary Biology, University of Kansas, Lawrence, KS. 514 pp.

Rightmyer, M.G. 2017. *Triepeolus eliseae* Rightmyer. Pages 51–53, in: J. Gibbs, J.S. Ascher, M.G. Rightmyer, and R. Isaacs. The bees of Michigan (Hymenoptera: Apoidea: Anthophila), with notes on distribution, taxonomy, pollination, and natural history. *Zootaxa* 4352 (1):1–160. Available at: https://treatment.plazi.org/id/0392879B7347AB1343D5FB33FB99F8CC. Accessed 16 February 2022.

Scarpulla, E.J. 2013. A yearlong survey of the bees (Hymenoptera: Apoidea) of a human-made habitat created from dredged material: Hart-Miller Island, Chesapeake Bay, Baltimore County, Maryland. *The Maryland Entomologist* 6(1):56–84.

Scarpulla, E.J. (forthcoming). *Lasioglossum* (*Dialictus*) *semicaeruleum* (Cockerell, 1895) (Hymenoptera: Halictidae) in Maryland: A disjunct population in eastern North America? TBD.

Shorthouse, D.P. 2010. SimpleMappr, an online tool to produce publication-quality point maps. Available at: https://www.simplemappr.net. Accessed 28 October 2020.

Snelling, R.R. 1970. Studies on North American bees of the genus *Hylaeus*. 5. The subgenera *Hylaeus*, s. str. and *Paraprosopis* (Hymenoptera: Colletidae). *Contributions in Science* 180:1–59.

Soltani, G.G., D. Bénon, N. Alvarez, and C.J. Praz. 2017. When different contact zones tell different stories: putative ring species in the *Megachile concinna* species complex (Hymenoptera: Megachilidae). *Biological Journal of the Linnean Society* 121(4):815–832 + online appendix of supporting information.

USACE (United States Army Corps of Engineers, Baltimore District). 2018. *Paul S. Sarbanes Ecosystem Restoration Project at Poplar Island: Operations and Maintenance Manual: Invasive and Nuisance Species Identification*. 19 pp.

USACE (United States Army Corps of Engineers, Baltimore District). 2019. Planted Species List (13 May 2019). Unpublished Excel spreadsheet. 2 sheets.

USDA, NRCS (United States Department of Agriculture, Natural Resources Conservation Service). 2020. PLANTS Database. National Plant Data Team, Greensboro, NC. Available at: https://plants.sc.egov.usda.gov/java/. Last accessed 20 October 2020.

USFWS (United States Fish and Wildlife Service). 2018. Wetland Plant Species. Unpublished Excel spreadsheet. 1 sheet.

The Maryland Entomologist 8(2):58–79

The Scarabaeoidea (Coleoptera) of the George Washington Memorial Parkway, Virginia, USA

Brent W. Steury[1, *] and M. J. Paulsen[2]

[1]*United States National Park Service, 700 George Washington Memorial Parkway, Turkey Run Park Headquarters, McLean, Virginia 22101*
[2]*University of Nebraska State Museum, W436 Nebraska Hall, Lincoln, Nebraska 68588-0546*
[*]*Corresponding author: brent_steury@nps.gov*

Abstract: Field surveys utilizing ten collection methods over a 24-year period rendered a total of 84 scarabaeoid species (Coleoptera: Scarabaeoidea) in eight families (Bolboceratidae Scholtz and Browne, Geotrupidae Latreille, Hybosoridae Erichson**,** Lucanidae Latreille, Ochodaeidae Mulsant and Rey, Passalidae Leach, Scarabaeidae Latreille, and Trogidae MacLeay) from a National Park site in northern Virginia. One additional species, *Nicagus obscurus* (LeConte) (Lucanidae), is added based on literature records. *Maladera japonica* (Motschulsky) (Scarabaeidae) is reported as established for the first time in the United States. Twelve species are reported for the first time in Virginia. 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 specimens in the collection. Images of three species are provided. Eight non-native species were documented from the study site, including two species new to Virginia. Habitat associations are provided for species collected by hand. The productivity of each collection method is briefly discussed.

Keywords: bess beetles, bulbous burrowing scarabs, dor beetles, dung beetles, earth-boring dung beetles, flower chafers, fruit chafers, hide beetles, June beetles, lesser dung beetles, new state records, pill scarabs, Potomac Gorge, rhinoceros beetles, sand-loving scarab beetles, scarab beetles, scavenger scarab beetles, shining chafers, stag beetles

INTRODUCTION

Scarabaeoid beetles of the superfamily Scarabaeoidea (Insecta: Coleoptera) include some of the largest and most attractive insects such as the rhinoceros and stag beetles, as well as groups that are familiar to almost everyone such as the June beetles and dung beetles. Scarabs fill ecologically important functions, such as decomposition of dung (Aphodiinae Leach and Scarabaeinae Latreille), logs (Lucanidae Latreille, Passalidae Leach) and carrion (Trogidae MacLeay). Conversely, some species are regarded as pests of turfgrass (some Melolonthinae Leach and Aphodiinae), and ornamental plants and crops (Rutelinae MacLeay, Melolonthinae, and Cetoniinae Leach). Still, the majority of species, from small aphodiines living in leaf litter, to the large, horned *Dynastes* MacLeay*,* quietly pursue their existences feeding on native plants, fungus, and sap. Their tendency to be nocturnal, with some attracted to light, accounts for much of the human interaction with the group.

STUDY SITE

The study site includes lands managed by the National Park Service as units of the George Washington Memorial Parkway (GWMP) in northern Virginia (Fairfax and Arlington Counties). The sites are just west (within 20 km [12.4 mi]) of the center of Washington, District of Columbia. The GWMP sites that received inventory effort included in Fairfax County: Dyke Marsh Wildlife Preserve, Collingwood Picnic Area, Fort Marcy, Great Falls Park, Little Hunting Creek, and Turkey Run Park; and in Arlington County: Arlington Woods (at Arlington House) and Roaches Run Waterfowl Sanctuary. This area covers approximately 927 ha (2,291 ac). A map of these sites was provided by Steury (2011). Great Falls and Turkey Run Parks and Fort Marcy 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 Great Falls and Turkey Run Parks border the Potomac Gorge, an area with a long history of biodiversity studies (Brown 2008). Great Falls and Turkey Run Parks are characterized by 61-m (200-ft) palisades of metamorphic rock cut by steep streams draining into the Potomac River. The GWMP's vegetation includes a complex of upland and floodplain forest communities, riverside bedrock terrace prairies, and frequently flooded river shores (Fleming 2007). Although disturbed, secondary forests are common in formerly cleared areas of all GWMP sites, much of the contemporary forest consists of maturing second-growth stands greater than 100 years old, with several white oak, *Quercus alba* L. (Fagaceae), more than 200 years old documented along the northern ridge of Great Falls Park (Abrams and Copenheaver 1999). These deciduous and mixed deciduous/coniferous stands support a thick shrub layer and lush herbaceous flora. The largest wetland in GWMP is the 22.3 ha (55.1 ac) emergent, freshwater, tidal marsh dominated by narrowleaf cattail, *Typha angustifolia* L. (Typhaceae), at Dyke Marsh Wildlife Preserve. The vascular flora of the GWMP is diverse, with more than 1,323 taxa recorded (Steury 2011; GWMP Plants Database, unpublished data, accessed May 2021), 1,020 from Great Falls Park alone (Steury et al. 2008).

MATERIALS AND METHODS

Specimens were collected during a 24-year period (1998–spring 2021) by sporadically using 10 survey methods targeting arthropods, including: beating sheets, blacklight shone on sheets, blacklight (UV) bucket traps, hand picking, leaf litter samples processed in Berlese funnels, Lindgren funnels, Malaise traps, pan traps, pitfall traps, and examining the dung of White-tailed Deer, *Odocoileus virginianus* Zimmermann (Cervidae). A summary of these methods, including site descriptions and latitudes and longitudes of the traps, can be found in Table 1 of Steury (2018). Pan trapping methods are described in Steury et al. (2009). Deer dung sorting methodologies are provided in Steury and Brattain (2020). Collectors included Edward M. Barrows, John W. Brown, Arthur V. Evans, Oliver S. Flint, Jr., J. Ray Fisher, Cristina Francois, Daniel S. Kjar, Deblyn Mead, Erik T. Oberg, James Riggs, Michael J. Skvarla, David R. Smith, Warren E. Steiner, Brent W. Steury, Mireya P. Stirzaker, Jil M. Swearingen, Christopher C. Wirth, and Norman E. Woodley. State record determinations are based on reviews of Downie and Arnett (1996), Evans (2008, 2014), and other literature cited in the list of species. Specimens were pinned, labeled, and deposited in the collections maintained at GWMP, Turkey Run Park Headquarters in McLean, Virginia.

RESULTS and DISCUSSION

A total of 426 scarabaeoid specimens were collected over a 24-year period. The specimens included 84 species representing the families (Bolboceratidae (n=2), Geotrupidae Latreille (n=2), Hybosoridae (n=2), Lucanidae (n=4), Ochodaeidae (n=1), Passalidae (n=1), Scarabaeidae (n=67), and Trogidae (n=5) from eight sites within GWMP. One additional species, *Nicagus obscurus* (LeConte) (Lucanidae), was added based on literature records, bring the total documented scarabaeoid fauna of GWMP to 85 species. Twelve species marked by an exclamation point (!) in the list of species are first records for Virginia based on literature reviews. Eight non-native Scarabaeoid species (all in family Scarabaeidae) were detected (see list of species) including two species new to Virginia: *Labarrus cincticulus* (Hope) and *Maladera japonica* (Motschulsky). *Maladera japonica* is reported as established in the United States for the first time.

None of the species collected were abundant in the collection samples. Seventeen species are represented by a single specimen. The most commonly collected species were *Ataenius gracilis* (Melsheimer) (n=23), *Nipponoserica peregrina* (Chapin) (n=22), *Anomala orientalis* (Waterhouse) (n=19), *Maladera formosae* (Brenske) (n=18), *Germarostes aphodioides* (Illiger) (n=16) (although 14 of these were collected together under the same piece of lose bark), *Onthophagus hecate* Panzer (n=12), and *Macrodactylus angustatus* (Palisot de Beauvois), *Phyllophaga crenulata* (Froelich), and *Serica sericea* (Illiger) (n=11 each). Sites with the highest species richness were Great Falls Park (n=61), Turkey Run Park (n=49), Dyke Marsh Wildlife Preserve (n=15) and Little Hunting Creek (n=13). The most productive capture methods were Malaise traps (n=43 species), collecting by hand and blacklight (UV) bucket traps (n=36 each), and pitfall traps (n=11). Fifty-four species documented from Great Falls or Turkey Run Parks along the Potomac Gorge (an area that includes portions of the study site and Maryland-owned islands and shoreline of the Potomac River) were previously unrecorded from the Potomac Gorge by Brown (2008) or Evans (2008). Two species, *Ataenius simulator* Harold and *Calmosternus granarius* (Linnaeus), reported by Evans (2008) from GWMP are based on misidentified specimens.

LIST OF SPECIES

Taxa are listed alphabetically within families, subfamilies, and tribes following the nomenclature and taxonomic order used by Ratcliffe and Paulsen (2008). Twelve Scarabaeoidea species new to the Commonwealth of Virginia are marked by an exclamation point (!). Eight non-native species are marked with a dagger (†). Fifty-four species newly documented from the Potomac Gorge are indicated with an asterisk (*). The number of specimens in the collection is indicated in parentheses after each taxon. Sites where specimens were collected are given for Virginia: Arlington County: Arlington Woods (at Arlington House) (AW), and Roaches Run Waterfowl Sanctuary (RR); and Fairfax County: Collingwood Picnic Area (CP), Dyke Marsh Wildlife Preserve (DM), Fort Marcy (FM), Great Falls Park (GF), Little Hunting Creek (LH), and Turkey

Run Park (TR). Other collection sites are described when necessary. Collection methods are listed using the following abbreviations: black light shone on sheets (bl), leaf litter samples processed in Berlese funnels (bf), beating sheet (bs), blacklight (UV) bucket traps (bt), deer dung sorting (dd), hand picking (hp), Lindgren funnel (lf), Malaise trap (mt), pitfall trap (pf), and pan trap (pt). The periods of adult activity are given based on dates when taxa were captured in the GWMP. 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. Habitats of taxa collected by hand are provided.

Family PASSALIDAE Leach (bess beetles)

Recognition.
Passalids are easily recognized by their large size (20–43 mm [0.8–1.7 in]), distinctive elongate, flattened body, open and immobile antennal club and, when alive, their squeaking stridulation (Schuster 2002). They may be found in decaying logs where they care for their larvae subsocially, although they are most commonly encountered at lights.

Biodiversity. A predominantly tropical family of approximately 500 species with only two verified species occurring in the United States, one restricted to southern Florida (Schuster 1994), the other, *Odontotaenius disjunctus* (Illiger), is widely distributed from Massachusetts to northern Florida and west to Minnesota, Nebraska, and Texas (Ratcliffe and Paulsen 2008). *Odontotaenius disjunctus* was reported from Virginia by Schuster (1983).

Taxonomy. The Passalidae of the United States were discussed by Schuster (1983), and a key to the genus *Odontotaenius* Kuwert is given by Schuster (1994). No key is necessary to identify this distinctive species in the majority of its range, where it is the only passalid present.

List of Taxa

Subfamily Passalinae Leach

Odontotaenius disjunctus (Illiger) – (5); GF, TR; bt, hp; 14 Apr, 23 Jun–30 Jul; found dead on sidewalk, in rotten log, under bark. The specimen collected on 14 April 2010 is subteneral. This is one of the most conspicuous, summer beetles in GWMP and is much more common than the number of specimens in the collection indicate.

Family BOLBOCERATIDAE Mulsant (bulbous burrowing scarabs)

Recognition
Bolboceratid beetles are superficially similar to geotrupine and scarabaeine dung beetles solely due to their globose habitus but are not closely related to either group. Beetles in this family tend to be horned and testaceous to orange-brown in color and some genera

commonly display black maculations. They differ from Geotrupidae Latreille in their relatively large antennal clubs and having separated mesocoxae (Ratcliffe and Paulsen 2008).

Biodiversity

There are around 300 species across all habitable continents (Ratcliffe and Paulsen 2008). Howden (1955, 1964) treated the group in the North America, which is home to 43 species. Two species in the genus *Odonteus* Samouelle have been recorded in GWMP, both were listed for Virginia by Howden (1955). Two additional species in the genus are listed for Virginia in Howden (1955): *O. cornigerus* (Melsheimer) and *O. darlingtoni* Wallis. Identification of species of *Odonteus* in particular is quite challenging, and the females can often only be tentatively identified by association with males. Keys to *Odonteus* were provided by Wallis (1928a, 1928b, 1928c, 1929).

Taxonomy

Howden (1955, 1964) revised the family for the Nearctic as a subfamily of Geotrupidae, and little has been published on the group since. Because the family was rather recently elevated (Scholtz and Browne 1996), the former tribes have become subfamilies without any further subdivision. There are three genera containing species reported from Virginia but not yet located in GWMP: *Bolbocerosoma* Schaeffer (2 spp.), *Bradycinetulus* Cockerell (1 sp.), and *Eucanthus* Westwood (3 spp.) (Howden 1955, Virginia Department of Wildlife Resources 2020). All are frequently attracted to light or may be dug from pushed-up soil in trails in wooded areas.

List of Taxa

Subfamily Bolboceratinae Mulsant

**Odonteus liebecki* Wallis – (6); GF, TR; bt, mt, pf; 20 May–4 Sep.
**Odonteus thoracicornis* Wallis – (4); GF, TR; bt, mt; 1 May–13 Jul.

Family GEOTRUPIDAE Latreille (dor beetles or earth-boring dung beetles)

Recognition

Geotrupid beetles are superficially similar to scarabaeine dung beetles, including their generally dark coloration, often with metallic reflection. They differ in having ten rather than eleven antennomeres. They possess relatively small antennal clubs of three segments (Ratcliffe and Paulsen 2008).

Biodiversity

Howden (1955) treated the group in the Nearctic region, where 18 of the roughly 300 described species are found. Two species in the genus *Geotrupes* Latreille have been collected in GWMP, both were listed for Virginia by Howden (1955). Four additional species in the genus are listed for Virginia (Howden 1955). Most are attracted to light or may be found under horse droppings on trails in wooded areas, sometimes quite late into the autumn. Three other genera found in North America north of Mexico are confined to the extreme Southeast and Florida, or to California.

Taxonomy
Howden (1955, 1964) revised the family for the Nearctic. The status of the genus *Geotrupes* is not settled, with many subgenera considered to be valid genera by some authors. In general, this splitting has not yet been accepted by North American researchers. Keys to American *Geotrupes* were provided by Howden (1955).

List of Taxa

Subfamily Geotrupinae Latreille

**Geotrupes blackburnii* (Fabricius) – (1); GF; hp; 14 Apr; quarry.
**Geotrupes splendidus* (Fabricius) – (2); GF, TR; hp; 27 Jul, 4 Nov; gravel road, leaf litter in deciduous woods.

Family TROGIDAE MacLeay (hide beetles)

Recognition
Hide beetles are grayish brown and often dirt-encrusted, tuberculate, and bristly. They have ten-segmented antennae with a club of three lamellae, and the abdomen is uniquely flat (Ratcliffe and Paulsen 2008). They feed on late-stage carrion or other sources of keratin, such as feathers in bird nests or fur in coyote scat. Many species are also attracted to light.

Biodiversity
There are 41 species of trogids in the United States, 16 of which are found in Virginia (Virginia Department of Wildlife Resources 2020). Five species of *Trox* Fabricius were collected in GWMP, all previously recorded from Virginia (Vaurie 1955). Another four species of the genus are expected to occur in GWMP. Surprisingly, none of the five species of the genus *Omorgus* Erichson that occur in the area were collected during sampling.

Taxonomy
The family is divided into two subfamilies and six genera, globally, with around 300 species. Only the nominate genus *Trox* has been recorded in the study area.

List of Taxa

Subfamily Troginae

Trox aequalis Say – (3); GF; bt; 31 May, 7 July.
Trox hamatus Robinson – (1); GF; bt; 30 Jun.
Trox spinulosus simi Robinson – (2); GF, TR; bt; 27 May–23 Jun.
Trox unistriatus Palisot de Beauvois – (3); GF, TR; bt; 27 May–30 Jun.
**Trox variolatus* Melsheimer – (3); TR; pf, pt; 11 Apr–2 Jun.

Family LUCANIDAE Latreille (stag beetles)

Recognition. Nearctic stag beetles are generally recognized by possessing an open antennal club of 3–4 segments, elbowed antennae, and large mandibles in males, although there are exceptions to each character.

Biodiversity. There are nearly 2000 species of stag beetles worldwide. The United States contains less than 40 species in seven genera. Four species were found in GWMP and one additional species, *Nicagus obscurus*, was recorded from GWMP based on records in Paulsen and Smith (2005). A total of seven species could be expected from the GWMP area (Virginia Department of Wildlife Resources 2020). *Dorcus parallelus* (Say) and *D. brevis* (Say) are both recorded from Virginia (Paulsen 2010). *Dorcus brevis* (Say) has not been collected within GWMP but could occur at this site. It has been recorded in Virginia and it develops in stumps and logs of white oak, a common tree in GWMP. The elk stag beetle *Lucanus elaphus* Fabricius is also expected to occur in GWMP, since it is also recorded for Virginia (Fuchs 1882). The species *Nicagus obscurus* of the subfamily Aesalinae MacLeay is documented from Great Falls Park and Dead Run (Turkey Run Park) by (Paulsen and Smith 2005). Although not found during this survey, it is presumably still extant in GWMP and is usually found under logs or driftwood on sandbars in the spring.

Taxonomy. The Lucanidae are fairly stable at the subfamily level, but the tribal classification is in chaos. The genus level taxonomy of the five genera in eastern North America has been stable for *Ceruchus* MacLeay and *Lucanus* Scopoli, or recently updated for *Dorcus* MacLeay (Paulsen 2010), *Nicagus* LeConte (Paulsen and Smith 2005), and *Platycerus* Geoffroy (Paulsen and Caterino 2009, Smith and Paulsen 2017).

List of Taxa

Subfamily Aesalinae MacLeay

**Nicagus obscurus* (LeConte) – Recorded from GWMP from "Dead Run" in Turkey Run Park and "Great Falls" by Paulsen and Smith (2005) but not documented during this inventory.

Subfamily Syndesinae MacLeay

Tribe Ceruchini Jacquelin du Val and Fairmaire
Ceruchus piceus (Weber) – (10); GF, TR; bl, bt, bs, pf; 16 Jun–7 Jul.

Subfamily Lucaninae Latreille

Tribe Platycerini Mulsant
**Platycerus quercus* (Weber) – (9); LH, TR; hp, mt, pt; 10 Apr–18 May; under bark.

Tribe Lucanini Latreille
Dorcus parallelus (Say) – (2); GF, TR; bt, hp; 18–23 Jun; bluff above river.
**Lucanus capreolus* (Linnaeus) – (5); GF; bt, hp; 1 Jun–28 Jul; in building.

Family OCHODAEIDAE Mulsant and Rey (sand-loving scarab beetles)

Recognition.
Ochodaeids are easily recognized by their oval, convex body and lamellate antennal club combined with their uniquely pectinate metatibial spurs (Carlson 2002). The single species in the District of Columbia area is most easily found by digging in their burrows on compacted hiking trails, which can be located by looking for small 'pushups' of soil. They are also attracted to light.

Biodiversity. A small but widely distributed family of less than 200 species, ochodaeids are most common in sandy regions, especially Africa and the southwestern United States and Mexico. Relatively few species are adapted to clay soils in forested areas. Only two species occur in the eastern United States, and just one of these occurs as far north as the District of Columbia, *Xenochodaeus musculus* (Say). Although Ratcliffe and Paulsen (2008) recorded the species from Maryland to northern Florida and west to Nebraska and Oklahoma, this paper documents the first record specific to Virginia.

Taxonomy. The generic classification of the family has undergone recent clarification (Paulsen 2007), and new species are frequently described. The tribal classification of Ochodaeinae is not stable and requires modification as it is currently meaningless. No keys are available for ochodaeids of the United States, although identification of *X. musculus* is straightforward in Virginia as it is the only species in the family in the region.

List of Taxa

Subfamily Ochodaeinae Mulsant and Rey

!**Xenochodaeus musculus* (Say) – (9); GF, TR; mt; 10 Apr, 19 Jun–4 Sep.

Family HYBOSORIDAE Erichson (scavenger scarab beetles)

Recognition
Pill scarabs in the subfamily Ceratocanthinae Martínez are dark, frequently metallic, and can roll into a tight ball; they have 9 or 10-segmented antennae with a club of three lamellae (Ratcliffe and Paulsen 2008). Adults are likely to feed on fungus and are often collected under dead bark. Many species are also attracted to light.

Biodiversity
Being primarily tropical, there are only three species of ceratocanthines in the United States, all of which are found in Virginia (Hoffman 2006). Two species were collected during this study.

Taxonomy
The family is divided into five subfamilies with around 550 species (Ocampo and Ballerio 2006). One non-native species (*Hybosorus illigeri* Reiche) in the subfamily Hybosorinae Erichson is known from extreme southeastern Virginia (Evans 2009a).

List of Taxa

Subfamily Ceratocanthinae Martínez

**Germarostes aphodioides* (Illiger) – (16); GF, TR; bs, hp; 14 Apr, 18 Jun; under bark in Riverside Prairie, bluff above river. Fourteen of these 16 specimens were collected under the same piece of bark in the Riverside Prairie community in the Potomac Gorge.

Germarostes globosus (Say) – (4); GF, LH; bt, mt, pf; 18 May–13 Jul.

Family SCARABAEIDAE Latreille (June, rhinoceros, and dung beetles; shining, fruit and flower chafers)

List of Taxa

Subfamily Aphodiinae Leach

Recognition

Lesser dung beetles in the subfamily Aphodiinae are typically small and elongate, whereas scarabaeine dung beetles are oval in shape. In the Nearctic region they have 9-segmented antennae with a pubescent club of 3 lamellae (Gordon and Skelley 2007, Ratcliffe and Paulsen 2008). Adults of species that feed on dung are dwellers within the dung, although many other specialized life histories are present in the group including myrmecophily, termitophily, litter-feeding, turf-feeding, and particularly living in mammal burrows or tree holes. Many species are also attracted to light.

Biodiversity

The subfamily is particularly diverse in North America, where there are 400 species (Ratcliffe and Paulsen 2008). Thirteen species were recovered in the study.

Taxonomy

The subfamily is divided into several tribes that are not well-supported and variably recognized. The two large tribes in our area are distinguished by the presence (Aphodiini Leach) or absence (Eupariini Schmidt) of transverse setal ridges on the mesotibiae and metatibiae. Recently, the large cosmopolitan genus *Aphodius* Illiger, while clearly in need of redefinition, exploded into many dozens of poorly supported genera, however the Nearctic species are fairly well known (Gordon and Skelley 2007). The common, presumably adventive species *Labarrus pseudolividus* Balthasar was synonymized with *L. cincticulus* by Stebnicka (2009). Virginia records are known for *Aphodius fimetarius* (Linnaeus) (Arnaudin et al. 2014) and *Blackburneus stercorosus* (Melsheimer) (Dellacasa et al. 2011), but other species have only published generalized ranges that imply their presence in Virginia.

In the Eupariini, all species of *Ataenius* Harold recorded during this survey were reported from Virginia by Cartwright (1974). An additional six species of *Ataenius* are known from the Mid-Atlantic area near the District of Columbia and could occur in GWMP: *A. brevis* Fall, *A. cylindrus* Horn, *A. fattigi* Cartwright, *A. glaseri* Cartwright, *A. miamii* Cartwright and *A. wenzeli* Horn. As well, one species each in four other genera of

Eupariini are known from the area: *Aphotaenius carolinus* (Van Dyke), *Ataeniopsis figurator* (Harold), *Parataenius simulator* (Harold), and *Pseudataenius contortus* Cartwright (Cartwright 1974).

Tribe Aphodiini Leach

†**Aphodius fimetarius* (Linnaeus) (sensu lato, per Miraldo et al. [2014]) – (4); GF; dd; 4 Mar. This species is adventive from Europe.

Blackburneus stercorosus (Melsheimer) – (7); FM, GF, TR; bf, bl, bt, dd; 16 May–24 Jun; 25 Oct.

!**Dialytes truncatus* (Melsheimer) – (2); GF; lf, mt; 29 Jun–4 Sep.

!†**Labarrus cincticulus* (Hope) – (1); DM; bt; 30 Jul. This species is of uncertain origin, but is probably adventive from Africa.

!**Oscarinus rusicola* (Melsheimer) – (10); GF, TR; bt, dd, hp, mt; 2 May–4 Aug, 25 Oct; on sidewalk.

!**Pseudagolius bicolor* (Say) – (5); GF; dd, mt; 5 Sep–8 Nov.

Tribe Eupariini Schmidt

Ataenius abditus (Haldeman) (Figure 1) – (3); DM, LH; hp; 14 May–23 Jun; sandy cobble beach with *Scirpus* L. sp. (Cyperaceae) (bulrush), sandy beach under driftwood at freshwater tidal marsh edge, sandy beach under driftwood.

**Ataenius apicalis* Hinton – (4); GF; bt; 3 Aug.

Ataenius gracilis (Melsheimer) – (23); AW, GF, TR; bf, bl, bt, hp, mt; 15 Apr–25 Jun, 5 Sep–1 Dec; under driftwood on sandbar.

Ataenius imbricatus (Melsheimer) – (1); GF; bt; 23 Jun.

Ataenius ovatulus Horn – (4); TR; bf; 15 Apr.

**Ataenius spretulus* (Haldeman) – (8); AW, CP, DM, GF; bf, bt, hp, pf; 15 Apr–23 Jun, 3 Aug–13 Oct; in turf grass, sandy beach under driftwood.

Ataenius strigatus (Say) – (3); GF; bt, mt; 23 Jun–17 Aug.

Subfamily Scarabaeinae Latreille

Recognition

Dung beetles in the subfamily Scarabaeinae are typically more ovoid and less elongate than aphodiines. They have mostly membranous mandibles and 8- or 9-segmented antennae with a club of three lamellae (Gill 2002). Adults and larvae feed primarily on dung, with adults generally provisioning burrows with dung for larval development.

Some species may be found at carrion or fungus. They are primarily diurnal and thus are not often attracted to light.

Biodiversity

The family is divided into twelve tribes with over 5000 species (Gill 2002). The Nearctic region alone holds 17 genera and approximately 150 species (Gill 2002). Eight species were recorded during this study.

Taxonomy

Roble and Hoffman (2011) and Arnaudin et al. (2014) reported several species from Virginia, as did Howden and Cartwright (1963) for *Onthophagus* Latreille spp., and Matthews (1961) for *Copris* Geoffroy spp., thus including all species recorded during this study.

Figure 1. *Ataenius abditus* (Haldeman). Dyke Marsh Wildlife Preserve, 15 May 2012; sandy cobble beach with *Scirpus* L. sp. (Cyperaceae) (bulrush), collector Brent W. Steury; **top:** male, dorsal view, body length 3.4 mm (0.13 in); **bottom left:** male, face. **Bottom right:** female, face of specimen captured at Little Hunting Creek mouth on sandy beach under driftwood at freshwater tidal marsh edge, 14 May 2021, collector Brent W. Steury. Note variation in the clypeal rugae between the male and female specimens.

Tribe Onthophagini Burmeister

Onthophagus hecate Panzer – (12); DM, GF, TR; dd, hp, mt; 14 Apr–30 Jun, 1 Aug, 25 Oct–1 Nov; in scat on trail, under bark.

**Onthophagus orpheus canadensis* (Fabricius) – (10); DM, FM, GF, LH, TR; bf, hp, mt; 10 Apr–16 Jul; oak tree hole. Only the subspecies is unreported for the Potomac Gorge.

**Onthophagus pennsylvanicus* Harold – (3); GF; mt; 16 Jul–17 Aug.

Onthophagus striatulus (Palisot de Beauvois) – (4); LH, TR; pf, mt; 2 Jun–4 Aug.

†**Onthophagus taurus* (Schreber) – (3); DM, GF, TR; hp, pf, mt; 10–30 Apr, 9 Jun–15 Jul. This species is adventive from Europe and the Middle East.

Tribe Coprini Leach

**Copris fricator* (Fabricius) – (5); GF, TR; hp, mt; 20 Mar–24 May, 5 Sep–21 Oct; in building, in parking lot.

**Copris minutus* (Drury) – (6); DM, LH, TR; bf, hp, pf; 18 Apr, 8 Sep–1 Nov; in building, at marsh/floodplain forest ecotone.

Dichotomius carolinus (Linnaeus) – (1); GF; hp; 23 Jun; dead in parking lot.

Subfamily Melolonthinae Leach in Samouelle

Recognition

Chafers are a diverse and variable group, with glabrous antennae of 7–10 antennomeres and a lamellate club of from three to seven segments. The claws are usually equal in size, although *Hoplia* Illiger species have a single claw on the metatarsus (Ratcliffe and Paulsen 2008).

Biodiversity

There are over 800 genera and 12,000 species worldwide (Ratcliffe and Paulsen 2008). The Nearctic region alone holds eleven tribes, 122 genera, and approximately 620 species (Ratcliffe and Paulsen 2008), 25 of which were recorded during this study. Adults frequently feed on vegetation at night, while the larvae are sometimes injurious to crop roots, especially in Central America.

Taxonomy

The genera *Dichelonyx* Harris and *Macrodactylus* Dejean lack published treatments with detailed locality information for the United States, so the records for those genera are considered state records. In *Diplotaxis* Kirby, Fall (1909) reported *D. harperi* Blanchard from Virginia, although Vaurie (1960) in her revision of the genus disregarded this record because of the confusion of her species, *D. blanchardi* Vaurie, within material of the former species. However, there are older *D. harperi* specimens from Virginia in the USNM that Fall likely examined. Hardy (1977) reported the same *Hoplia* species found here from Virginia. Evans (2009c) indicates that 46 species of *Phyllophaga* Harris are found in the state and published a recent record for *P. spreta* (Horn). Most of the *Phyllophaga* species collected were reported for Virginia by Luginbill and Painter (1953), except *P. inepta* (Horn). Three of the five species found in tribe Sericini are adventive pests. Evans (2002) reported both *Maladera castanea* (Arrow) and *Nipponoserica peregrina* from Virginia. Fabrizi et al. (2021) subsequently synonymized

M. castanea with *M. formosae*. The third adventive species, *Maladera japonica*, is a new country record since it has not yet been published as occurring in the United States, although its presence has been known for some time. For native sericines, Dawson (1922) records *Serica sericea*, and Dawson (1932) records *S. georgiana* Leng from Virginia.

Tribe Dichelonychini Burmeister

!**Dichelonyx elongatula* (Schönherr) – (2); GF, TR; mt; 10–30 Apr.
!**Dichelonyx subvittata* LeConte – (2); TR; mt; 10 Apr–20 May.

Tribe Diplotaxini Kirby

!**Diplotaxis blanchardi* Vaurie – (2); DM, GF; bt, mt; 20 Jun–2 Jul.
**Diplotaxis harperi* Blanchard – (6); TR; mt; 1 May–4 Aug.
Diplotaxis liberta (Germar) – (3); GF; bt, hp; 14 Apr–23 Jun; dead on road, rock outcrop above river.

Tribe Hopliini Latreille

**Hoplia modesta* Haldeman – (3); GF; hp; 19–30 May; sandy beach.
**Hoplia trifasciata* Say – (4); GF, TR; mt; 10 Apr–20 May.
**Hoplia trivialis* Harold – (1); TR; hp; 29 Apr; herbs near river.

Tribe Macrodactylini Kirby

!**Macrodactylus angustatus* (Palisot de Beauvois) – (11); GF; mt; 30 Jun–17 Aug.

Tribe Rhizotrogini Burmeister

**Phyllophaga anxia* (LeConte) – (2); GF; bt, mt; 24 May, 3–17 Jul.
Phyllophaga crenulata (Froelich) – (11); GF, TR; bt, mt; 19 Jun–24 Aug.
**Phyllophaga drakii* (Kirby) – (1); GF; bt; 24 May.
Phyllophaga ephilida (Say) – (10); GF; bt; 23 Jun–12 Jul.
**Phyllophaga forsteri* (Burmeister) – (2); GF; pt; 22 May–29 Jun.
Phyllophaga hirsuta (Knoch) – (1); LH; pf; 28 Apr–18 May.
**Phyllophaga hornii* (Smith) – (4); GF; bt; 24–31 May, 7–12 Jul.
!**Phyllophaga inepta* (Horn) – (4); GF, TR; bt, mt; 7 Jul–24 Aug.
**Phyllophaga marginalis* (LeConte) – (2); GF; bt; 24 May.
**Phyllophaga quercus* (Knoch) – (2); GF; bt; 3 Aug.
**Phyllophaga spreta* (Horn) – (3); GF, TR; bt, pf; 27 Apr–31 May, 16 Jul.

Tribe Sericini Kirby

†*Maladera formosae* (Brenske) – (18); DM, GF, TR; bt, mt, pt; 23 Jun–17 Aug. This species is adventive from Asia.
†!**Maladera japonica* (Motschulsky) (Figure 2) – (4); LH, TR; mt; 21 May–30 Jul, 19 Sep–10 Oct. This species is recently adventive to North America from Asia. Our earliest record of this species in GWMP is from 2009.
†*Nipponoserica peregrina* (Chapin) – (22); DM, GF, LH, TR; bt, mt, pf; 10 May–21 Jul. This species is adventive from Japan.
**Serica georgiana* Leng – (5); GF, LH; hp, mt; 14 Apr, 1–14 Jun; dead on road, on *Hypericum prolificum* L. (Clusiaceae / Guttiferae), shrubby St. Johnswort.
**Serica sericea* (Illiger) – (11); TR; bt, hp, mt; 10 Apr–30 Jul; on trail.

Figure 2. ***Maladera japonica*** **(Motschulsky).** Turkey Run Park gulch, 21 May–18 June 2009, David R. Smith; **top:** dorsal view; **bottom:** face; length 8.4 mm (0.33 in).

Subfamily Rutelinae MacLeay

Recognition
Rutelines are often metallic or shining, moderate to large scarabs; they are best differentiated by their unequal claws that are often finely split (Ratcliffe and Paulsen 2008). The tribe Anomalini Streubel is further recognized by a membranous border on the elytra.

Biodiversity
There are around 12 genera and 67 species in the United States (Ratcliffe and Paulsen 2008).

Taxonomy
Virginia records for the Rutelini were given by Hardy (1991), although modern revisions are needed for most genera. Two non-native beetles of oriental origin, *Anomala orientalis* and *Popillia japonica* Newman, were reported in Virginia by Alm et al. (1999). No Virginia records were found for *Parastasia brevipes* (LeConte), a species with a troubled taxonomic history that has moved between Rutelinae and Dynastinae MacLeay.

Tribe Anomalini Streubel
**Anomala innuba* (Fabricius) – (1); TR; mt; 19–30 Jun.
Anomala marginata (Fabricius) – (2); DM; hp, mt; 1 Jun–18 Jul; marsh/floodplain forest ecotone.
†*Anomala orientalis* (Waterhouse) – (19); GF, LH, TR; bl, bs, bt, hp, mt; 4 Jun–12 Jul; mixed hardwood forest near pond, sandy beach. This species is adventive from Asia.
!**Parastasia brevipes* (LeConte) – (3); LH, TR; bl, mt; 14–28 Jul.
†*Popillia japonica* Newman – (7); DM, GF, TR; bs, mt, pt; 23 Jun–4 Aug. This adventive species is from Japan.

Tribe Rutelini MacLeay
Pelidnota punctata (Linnaeus) – (6); GF, TR; bt, hp, mt; 23 Jun–4 Aug; on building.

Subfamily Dynastinae MacLeay

Recognition
Dynastines include the conspicuous rhinoceros beetles, but also a larger number of species that are unarmed and often mistaken for June beetles or chafers. Members of the subfamily are often distinguished by displaying sexual dimorphism (horns, foveae, enlarged protarsal claws in males), mandibles often exposed, and with the claws of the mid- and hindlegs simple and equal (Ratcliffe and Paulsen 2008).

Biodiversity
It has been estimated that there are around 2000 species of rhinoceros beetles in the world, with 61 species in the Nearctic (Ratcliffe and Paulsen 2008).

Taxonomy
The taxonomy of dynastines in the United States is well known due to their recent revision by Ratcliffe and Cave (2017). These authors reported all dynastines reported herein as occurring in Virginia. *Dynastes tityus* (Linnaeus) and *Xyloryctes jamaicensis* (Drury) in Virginia were discussed in Bunch and Evans (2020).

Tribe Cyclocephalini Laporte
Cyclocephala borealis Arrow – (7); GF, TR; bt, mt; 23 Jun–17 Jul.
**Cyclocephala lurida* Bland – (9); DM, GF, TR; hp, mt; 7–30 Jul; mixed mature forest.

Tribe Pentodontini Mulsant
**Dyscinetus morator* (Fabricius) – (1); TR; hp; 22 Mar; attracted to light on building.
**Euetheola rugiceps* (LeConte) – (5); TR; CP, DM; hp; 14 Apr–23 May, 3 Oct; under log, in turf grass, dead in parking lot.

Tribe Oryctini Mulsant
**Xyloryctes jamaicensis* (Drury) – (1); TR; hp; 26 Sep; in parking lot.

Tribe Dynastini MacLeay
**Dynastes tityus* (Linnaeus) – (2); GF, TR; hp; 22 Jul, 7 Oct; found dead in parking lot, found dead at overlook.

Subfamily Cetoniinae Leach

Recognition
Flower chafers are variable in appearance but can be recognized by concealed mandibles, exposed antennal insertions, and mesepimera that are visible in dorsal view on the sides near the elytral base (Ratcliffe and Paulsen 2008). Adults are often found on flowers and fruit, in tree holes, or they may be associated with ants.

Biodiversity
There are around 4000 species of flower chafers worldwide, with 13 genera and 55 species in the Nearctic (Ratcliffe and Paulsen 2008).

Taxonomy
The taxonomy of the group is relatively well-known. Howden (1968) treated the tribes Trichiini Fleming and Osmodermatini Schenkling (then also considered trichiines). Hoffmann (1939) listed *Osmoderma eremicola* (Knoch) from Virginia. Orozco (2012) revised the genus *Euphoria* Burmeister. The genus *Cotinis* Burmeister was last revised by Goodrich (1966) without locality data, but Davis and Luginbill (1921) recorded *C. nitida* (Linnaeus) from the state. Two native species of *Valgus* Scriba have been recorded from Virginia by Evans (2009b). Another species from Europe, *V. hemipterus* (Linnaeus) is adventive in the Great Lakes region but all specimens studied from Virginia, including some previously misidentified as *V. hemipterus*, have been members of the native species.

Tribe Osmodermatini Schenkling
Osmoderma eremicola (Knoch) – (1); TR; hp; 25 Jun; dead in parking lot.

Tribe Gymnetini Kirby
Cotinis nitida (Linnaeus) – (1); TR; hp; 19 Jun; weedy yard. This specimen was collected from a large swarm of this species.

Tribe Cetoniini Leach
Euphoria inda (Linnaeus) – (6); GF, TR; hp, mt; 18 Mar–19 May; on trail.
Euphoria sepulcralis (Fabricius) – (1); Mount Vernon Trail; hp; 11 May; dead on trail near Mount Vernon.

Tribe Trichiini Fleming
Trichiotinus affinis (Gory and Percheron) – (1); GF; mt; 21 May–18 Jun.
Trichiotinus bibens (Fabricius) – (1); GF; mt; 23 May–5 Jun.
Trichiotinus piger (Fabricius) – (1); GF; hp; 27 Jun; no habitat data on label.

Tribe Valgini Mulsant
Valgus canaliculatus (Olivier) – (9); GF, RR, TR; hp, lf, mt; 27 Apr–30 Jun, 19–21 Oct, 15 Dec; on *Aruncus dioicus* (Walter) Fernald (Rosaceae), bride's feathers; under bark of dead standing *Carya tomentosa* (Lam. ex Poir.) Nutt. (Juglandaceae), mockernut hickory.
Valgus seticollis (Palisot de Beauvois) – (2); DM, LH; mt; 12 Apr–18 May.

SUMMARY

This inventory over a 24-year period is the first detailed, site-specific survey of the scarabaeoid fauna of Virginia. We hope that it will serve as a baseline for comparison to future inventories of other Virginian sites as well as locations across North America. The 84 taxa recorded during this survey is 29% of 289 scarabaeoid taxa documented from South Carolina (Harpootlian 2001) within an area that is only 0.0112% the size of that state. That 12 scarabaeoid species newly recorded for Virginia are documented by this inventory, and that 31 species found during this survey are documented by fewer than two specimens, is a strong indication that additional scarabaeoid taxa are likely to be discovered in GWMP and reemphasizes the importance of small, even semi-urban, protected areas as refugia for biodiversity.

ACKNOWLEDGMENTS

Our deepest gratitude is extended to the GWMP Bug Lab volunteers, Judy Buchino, M'Shae Dunham, Pat Findikoglu, Tom Hahn, Sarah Hill, Ann Kelly, Eileen Miller, Meredith Reed, Lynn Scholz, Susan Sprenke, and Jerry Taylor for their many hours of effort in sorting beetles from Malaise trap samples. Mireya Stirzaker, Evan Costanza, Austin Davis, Hugh Davis, and Richard Stirzaker helped with this inventory by collecting deer dung samples from Great Falls Park. The manuscript was much improved by comments received from Paul E. Skelley (Entomology Section Administrator, Division of

Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, FL), Eugene J. Scarpulla, and one anonymous reviewer.

LITERATURE CITED

Abrams, M.D., and C.A. Copenheaver. 1999. Temporal variation in species recruitment and dendroecology of an old-growth white oak forest in the Virginia Piedmont, USA. *Forest Ecology and Management* 124(2–3):275–284.

Alm, S.R., M.G. Villani., and W. Roelofs. 1999. Oriental beetles (Coleoptera: Scarabaeidae): Current distribution in the United States and optimization of monitoring traps. *Journal of Economic Entomology* 92(4):931–935.

Arnaudin, M.E., C.D. Teutsch, D.W. Watson, S.A.J. Wildeus, and A.O. Abaye. 2014. Dung beetle (Coleoptera: Scarabaeidae) abundance and diversity in alpaca pastures of Virginia USA. *Journal of Entomological Science* 49(2):97–109.

Brown, J.W. 2008. The Invertebrate Fauna of Plummers Island, Maryland: Introduction and Background, and Appendix List of the Invertebrates of Plummers Island, Maryland. *Bulletin of the Biological Society of Washington* 15(1):1–226.

Bunch, J., and A.V. Evans. 2020. Observations on the behavior, biology, and distribution of the Eastern Hercules Beetle, *Dynastes tityus* (Linnaeus) (Coleoptera: Scarabaeidae; Dynastinae) in Virginia. *Banisteria* 54:31–43.

Carlson, D.C. 2002. Ochodaeidae Mulsant and Rey 1870. Pages 28–31, in: R.H. Arnett, M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles, Volume 2, Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press LLC, Boca Raton, FL. 861 pp.

Cartwright, O.L. 1974. *Ataenius, Aphotaenius,* and *Pseudataenius* of the United States and Canada (Coleoptera: Scarabaeidae: Aphodiinae). *Smithsonian Contributions to Zoology* 154:1–106.

Davis, J.J., and P. Luginbill. 1921. The Green June Beetle or fig eater. *North Carolina Agriculture Experiment Station Bulletin* 242:1–35.

Dawson, R.W. 1922. New species of *Serica* (Scarabaeidae) V. *Journal of the New York Entomological Society* 30(4):154–169.

Dawson, R.W. 1932. New species of *Serica* (Scarabaeidae), VI. *Journal of the New York Entomological Society* 40(4):529–562.

Dellacasa, M., G. Dellacasa, and R.D Gordon. 2011. Systematic revision of the American taxa belonging to the genera *Alloblackburneus* Bordat, 2009, and *Blackburneus* Schmidt, 1913, with description of seven new species (Coleoptera: Scarabaeidae: Aphodiinae). *Insecta Mundi* 0204:1–52.

Downie, N.M., and R.H. Arnett, Jr. 1996. *The Beetles of Northeastern North America*. Volume 1. The Sandhill Crane Press, Gainesville, FL. 880 pp.

Evans, A.V. 2002. III. Melolonthinae Samouelle 1819. Pages 51–60, in: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors). *American Beetles, Volume 2, Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press LLC, Boca Raton, FL. 861 pp.

Evans, A.V. (Compiler). 2008. The 2006 Potomac Gorge BioBlitz: Overview and results of a 30-hour rapid biological survey. *Banisteria* 32:3–80.

Evans, A.V. 2009a. *Hybosorus illigeri* Reiche confirmed as part of the Virginia beetle fauna, with notes on *Germarostes* (Coleoptera: Hybosoridae). *Banisteria* 33:43–46.

Evans A.V. 2009b. Notes on *Valgus seticollis* (Palisot de Beauvois) (Coleoptera: Scarabaeidae) in Virginia. *Banisteria* 33:46–49.

Evans, A.V. 2009c. *Phyllophaga spreta* (Horn), a rare species of June beetle new to the fauna of Virginia, North Carolina, and Pennsylvania (Coleoptera: Scarabaeidae). *Banisteria* 33:37–42.

Evans, A.V. 2014. *Beetles of Eastern North America*. Princeton University Press, Princeton, NJ. 560 pp.

Fabrizi, S., W.-G. Liu., M. Bai, X.-K. Yang, and D. Ahrens. 2021. A monograph of the genus *Maladera* Mulsant & Rey, 1871 of China (Coleoptera: Scarabaeidae: Melolonthinae: Sericini). *Zootaxa* 4922(1):1–400.

Fall, H.C. 1909. Revision of the species of *Diplotaxis* of the United States. *Transactions of the American Entomological Society* 35(1):1–97.

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.

Fuchs, C. 1882. Synopsis of the Lucanidae of the United States. *Bulletin of the Brooklyn Entomological Society* 5(1):49–60.

Gill, B.D. 2002. II. Scarabaeinae Latreille 1802. Pages 48–51, in: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors). *American Beetles, Volume 2, Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press LLC, Boca Raton, FL. 861 pp.

Goodrich, M.A. 1966. A revision of the genus *Cotinis* Burmeister (Coleoptera: Scarabaeidae). *Annals of the Entomological Society of America* 59(3):550–568.

Gordon, R.D., and P.E. Skelley. 2007. A monograph of the Aphodiini inhabiting the United States and Canada (Coleoptera: Scarabaeidae: Aphodiinae). *Memoirs of the American Entomological Institute* 79:1–580.

Hardy, A.R. 1977. A revision of the *Hoplia* of the Nearctic realm (Coleoptera: Scarabaeidae) *Occasional Papers in Entomology* 23:1–48.

Hardy, A. 1991. *A Catalog of the Coleoptera of America North of Mexico, Family: Scarabaeidae, Subfamilies: Rutelinae and Dynastinae*. United States Department of Agriculture, Agricultural Research Service, Agricultural Handbook Number 529-34b. Washington, DC. 56 pp.

Harpootlian, P.J. 2001. *Scarab Beetles (Coleoptera: Scarabaeidae) of South Carolina*. Biota of South Carolina, Volume 2. Clemson University Public Service Publishing, Clemson, SC. 157 pp.

Hoffman, R.L. 2006. The volvating scarabaeid beetles of Virginia (Coleoptera: Scarabaeidae: Ceratocanthinae). *Banisteria* 28:49–52.

Hoffmann, C.H. 1939. The biology and taxonomy of the Nearctic species of *Osmoderma* (Coleoptera, Scarabaeidae). *Annals of the Entomological Society of America* 32(3):510–525.

Howden, H.F. 1955. Biology and taxonomy of North American beetles of the subfamily Geotrupinae, with revisions of the genera *Bolbocerosoma, Eucanthus, Geotrupes*, and *Peltotrupes* (Scarabaeidae). *Proceedings of the United States National Museum.* 104 (3342):151–319, 18 pl.

Howden, H.F. 1964. The Geotrupinae of North and Central America. *Memoirs of the Entomological Society of Canada* 96(S39):1–91.

Howden, H.F. 1968. A review of the Trichiinae of North and Central America. *Memoirs of the Entomological Society of Canada* 100(S54):5–77.

Howden, H.F., and O.L. Cartwright. 1963. Scarab beetles of the genus *Onthophagus* Latreille North of Mexico (Coleoptera: Scarabaeidae). *Proceedings of the United States National Museum* 114 (3467):1–133, 9 plates.

Luginbill, P., Sr., and H.R. Painter. 1953. *May Beetles of the United States and Canada*. United States Department of Agriculture Technical Bulletin 1060. Washington, DC. 102 pp. + 78 pl.

Matthews, E.G. 1961. A revision of the genus *Copris* Müller of the Western Hemisphere (Coleoptera, Scarabaeidae). *Entomologica Americana* 41(New Series):1–139.

Miraldo, A., F.-T. Krell, M. Smalén, R.B. Angus, and T. Roslin. 2014. Making the cryptic visible – resolving the species complex of *Aphodius fimetarius* (Linnaeus) and *Aphodius pedellus* (de Geer) (Coleoptera: Scarabaeidae) by three complementary methods. *Systematic Entomology* 39(3):531–547.

Ocampo, F.C., and A. Ballerio. 2006. Catalog of the subfamilies Anaidinae, Ceratocanthinae, Hybosorinae, Liparochrinae, and Pachyplectrinae (Scarabaeoidea: Hybosoridae). Pages 178–209, in: F.C. Ocampo, *Phylogenetic Analysis of the Scarab family Hybosoridae and Monographic Revision of the New World Subfamily Anaidinae (Coleoptera: Scarabaeoidea)* Bulletin of the University of Nebraska State Museum 19, Lincoln, NE. 210 pp.

Orozco, J. 2012. Monographic revision of the American genus *Euphoria* Burmeister, 1842 (Coleoptera: Scarabaeidae: Cetoniinae). *The Coleopterists Bulletin* 66 (Monograph 11):1–182.

Paulsen, M.J. 2007. Nomenclatural changes in the Nearctic Ochodaeinae and description of two new genera (Coleoptera: Scarabaeoidea: Ochodaeidae). *Insecta Mundi* 0021:1–13.

Paulsen, M.J. 2010. Stag beetles of the genus *Dorcus* MacLeay in North America (Coleoptera, Lucanidae). *ZooKeys* 34:199–207.

Paulsen, M.J, and M. Caterino. 2009. The *Platycerus* (Coleoptera, Lucanidae) of California, with the recognition of *Platycerus cribripennis* Van Dyke as a valid species. *ZooKeys* 8:89–94.

Paulsen, M.J, and A.D. Smith. 2005. A new species of stag beetle from sand dunes in west Texas, and a synopsis of the genus *Nicagus* (Coleoptera: Lucanidae: Aesalinae: Nicagini). *Zootaxa* 1050:45–60.

Ratcliffe, B.C., and R.D. Cave. 2017. *The Dynastine Scarab Beetles of the United States and Canada (Coleoptera: Scarabaeidae: Dynastinae)*. Bulletin of the University of Nebraska State Museum 30, Lincoln, NE. 297 pp.

Ratcliffe, B.C., and M.J. Paulsen. 2008. *The Scarabaeoid Beetles of Nebraska (Coleoptera: Scarabaeidae)*. Bulletin of the University of Nebraska State Museum 22, Lincoln, NE. 570 pp.

Roble, S.M., and R.L. Hoffman. 2011. Two austral dung beetles new to the Virginia fauna (Coleoptera: Scarabaeidae). *Banisteria* 37:30–33.

Scholtz, C.H., and D.J. Browne. 1996.Polyphyly in the Geotrupidae (Coleoptera: Scarabaeoidea): A case for a new family. *Journal of Natural History* 30(4):597–614.

Schuster, J.C. 1983. The Passalidae of the United States. *The Coleopterists Bulletin* 37(4):302–305.

Schuster, J.C. 1994. *Odontotaenius floridanus* new species (Coleoptera: Passalidae): a second U.S. passalid beetle. *Florida Entomologist* 77(4):474–479.

Schuster, J.C. 2002. Passalidae Leach 1815. Pages 12–14 in: R.H. Arnett, Jr., M.C., Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles, Volume 2,* *Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press LLC, Boca Raton, FL. 861 pp.

Smith, A.B.T., and M.J. Paulsen. 2017. Corrections to the nomenclature of three species of North American Lucanidae (Coleoptera). *The Coleopterists Bulletin* 71(3):571–577.

Stebnicka, Z.T. 2009. *Aphodiinae of Australia (Coleoptera: Scarabaeidae): Iconography.* Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Krakow, Poland. 187 pp.

Steury, 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.

Steury, B.W. 2018. Annotated checklist of some fungivorous beetles (Coleoptera: Anamorphidae, Biphyllidae, Derodontidae, Endomychidae, Erotylidae, and Tetratomidae) of the George Washington Memorial Parkway. *Banisteria* 50:21–28.

Steury, B. W., and R. M. Brattain. 2020. Six rove beetles (Coleoptera: Staphylinidae) new to Virginia. *Banisteria* 54:N4–N13.

Steury, 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.

Steury, 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.

Vaurie, P. 1955. A revision of the genus *Trox* in North America (Coleoptera, Scarabaeidae). *Bulletin of the American Museum of Natural History* 106(1):1–89.

Vaurie, P. 1960. A revision of the genera *Diplotaxis* (Coleoptera, Scarabaeidae, Melolonthinae). Part 2. *Bulletin of the American Museum of Natural History* 120(2):167–433.

Virginia Department of Wildlife Resources. 2020. Virginia Department of Wildlife Resources, List of Native and Naturalized Fauna of Virginia, August, 2020. Available at: https://dwr.virginia.gov/wp-content/uploads/virginia-native-naturalized-species.pdf. Accessed June 2021.

Wallis, J.B. 1928a. Revision of the genus *Odontaeus* Dej. (Coleoptera, Scarabaeidae). *The Canadian Entomologist* 60(5):119–128.

Wallis, J.B. 1928b. Revision of the genus *Odontaeus* Dej. (Coleoptera, Scarabaeidae). *The Canadian Entomologist* 60(6):151–156.

Wallis, J.B. 1928c. Revision of the genus *Odontaeus* Dej. (Coleoptera, Scarabaeidae). *The Canadian Entomologist* 60(7):168–176.

Wallis, J.B. 1929. A new species of *Odontaeus*, Dej. (Coleoptera). *The Canadian Entomologist* 61(10):239–241.

The Maryland Entomologist 8(2):80–94

The Spider and Death-Watch Beetles (Coleoptera: Ptinidae) of Virginia with an Annotated Checklist for the George Washington Memorial Parkway

Donald S. Chandler[1] and Brent W. Steury[2,3]

[1]*University of New Hampshire, Department of Biological Science, Spaulding Hall, Room 266, 38 Academic Way, Durham, New Hampshire 03824*
[2]*United States National Park Service, 700 George Washington Memorial Parkway, Turkey Run Park Headquarters, McLean, Virginia 22101*
[3]*Corresponding author: brent_steury@nps.gov*

ABSTRACT: Eight years of Malaise trap sampling between 1998 and 2019 at four sites in a national park (George Washington Memorial Parkway) in Fairfax County, Virginia captured 358 ptinid specimens. These specimens rendered 41 species, in 18 genera. A list of all ptinid beetle species recorded from Virginia is given documenting 58 species. Nineteen species of ptinids are reported for the first time from Virginia. Range extensions are documented for five species. 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. Images of six species new to Virginia are provided, including one probable undescribed taxon in the genus *Ernobius* Thomson.

Keywords: Anobiidae, biodiversity, Bostrichoidea, national park, new state records, Potomac Gorge.

INTRODUCTION

The Ptinidae Latreille are composed of two readily recognized groups with short, deflexed heads that have been periodically placed as two different beetle families: 1) the Ptinidae or spider beetles, characterized by having long legs and often a globular abdomen suggestive of a small spider or a large, engorged tick; and 2) the Anobiidae Fleming or death-watch beetles, characterized by short, retractable legs, and an elongate cylindrical body. These two groups have historically been treated as the same family (LeConte 1865, Fall 1905), as separate families (Arnett 1960, Downie and Arnett 1996), combined under the name Anobiidae (Lawrence and Newton 1995 [while pointing out Ptinidae has priority over Anobiidae], Philips 2002), and combined under the older name Ptinidae (Borowski and Zahradníc 2007, Philips and Bell 2010, Bouchard et al. 2011, Lawrence et al. 2011, Bell and Philips 2012). Still unsettled are the relationships within the Ptinidae, as well as the relationships to members of the Bostrichidae Latreille (false powderpost beetles) (Philips 2002, Philips and Bell 2010, Bell and Philips 2012).

Members of the groups historically placed in the Anobiidae have adults and larvae that typically feed on dead woody materials or on fungal fruit bodies, with some species feeding on dried plant materials such as tobacco, spices, and herbarium specimens. Some members of the Ptininae also bore in wood but have members that feed on a wide array of foods, such as dung, animal materials in bird and mammal nests, or even pollen in the nests of bees, or they live in ant nests, but are best known by the public for feeding on dried plant and animal materials in the home (Hinton 1941, Philips 2002, Philips and Bell 2010, Arango and Young 2012). Feeding on growing plants is rare, but a *Niptus* Boieldieu sp. from the West Indies has larvae that mine and adults that feed on the leaves of a tropical borage (Boraginaceae) plant species (Philips et al. 1998), and some *Ernobius* Thomson sp. bore in the living cones or shoots of young conifers (Ebeling 1975, White 1983).

This group was poorly known in North America until the landmark study by Henry C. Fall (1905) who treated the Ptinidae (including anobiines) of North America. This work remains an important reference for studies today. From 1962 through 1990, Richard E. White revised nearly all the anobiid genera in a series of small and large revisions, rendering this part of the Ptinidae very approachable in terms of identification to species, although many of the characters used continue to be challenging to observe due to the frequent retraction of legs and antennae in members of many genera. Some of White's critical papers are a key to the genera of North America (White 1971) and a catalog of the North American species (White 1982), plus the revision of *Tricorynus* Waterhouse (White 1965), the largest and one of the most challenging genera of the North American fauna. Significant papers on the Nearctic fauna by others during White's period of activity was the revision of the Ptininae (Papp 1962) and the revision of *Petalium* LeConte (Ford 1973). The two largest eastern genera, *Petalium* (23 species) and *Tricorynus* (82 species) are challenging to identify due to their small size and reliance on characters dealing to a large extent with surface sculpture/punctation but are manageable because many eastern species housed in the University of New Hampshire Insect Collection (Durham, New Hampshire) have been identified by White or Ford and were used to identify species in this study. *Caenocara* Thomson is the remaining genus where identifications may be problematic (see Arango and Young 2012) and is need of a modern revision.

STUDY SITE

The study site is located in northern Virginia, and includes lands managed by the National Park Service as units of the George Washington Memorial Parkway (GWMP). The GWMP sites that received inventory effort included: Arlington County: Arlington Woods (behind Arlington House); and Fairfax County: Dyke Marsh Wildlife Preserve, Great Falls Park, Little Hunting Creek, and Turkey Run Park. This area covers approximately 897 ha. (2,216.5 ac). 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°. 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 Great Falls and Turkey Run Parks border the Potomac Gorge, an area known for high species richness of plants and animals (Brown 2008). Turkey Run Park and Great Falls Park are dominated by maturing, second growth (although some trees are over 200 years old), primarily upland, deciduous woodlands with rich soils. The woodlands at Little Hunting Creek are drier, sandier, and have more pine and ericaceous shrubs, but some oaks, *Quercus* L. (Fagaceae), are nearly 200 years old. More open herbaceous habitats can be found in moist, narrow bands along the shore of Potomac River and in the emergent, freshwater, tidal marshes at Dyke Marsh Wildlife Preserve. The vascular plant flora of the GWMP is diverse, with more than 1,313 taxa recorded, 1,020 from Great Falls Park alone (Steury et al. 2008, Steury 2011).

MATERIALS AND METHODS

The list of 41 species taken at GWMP is based on Malaise trap captures at Dyke Marsh Wildlife Preserve (1998–1999), Great Falls and Turkey Run Parks (2006–2008), Little Hunting Creek (2017–2018) and Turkey Run Park (2019). A few other collection methods that captured ptinid beetles were utilized sporadically: beating sheets (Turkey Run Park, 2006), leaf litter processed by Berlese funnels (Arlington Woods, 2012), black-light bucket traps (Turkey Run and Great Falls Parks, 2006–2008), black-lights shone on white sheets (Great Falls Park, 2007), Lindgren funnel traps (Great Falls Park, 2010), and pitfall traps (Little Hunting Creek, 2010). Collectors contributing specimens to this survey included Christopher Acosta, Edward M. Barrows, John W. Brown, Colin Davis, Arthur V. Evans, Steven W. Lingafelter, Erik T. Oberg, David R. Smith, Warren E. Steiner, Brent W. Steury, and Jil M. Swearingen. Range extensions and new state records are based on reviews of Ulke (1903), Downie and Arnett (1996), Peck and Thomas (1998), Evans (2008, 2014), Arango and Young (2012), and other literature cited in the list of species.

Members of *Caenocara*, *Byrrhodes* LeConte, *Dorcatoma* Herbst, and *Tricorynus* were often disarticulated such that the antennae, maxillary or labial palpi, or ventral areas of the pro-/mesothoracic regions could be clearly seen. Before dissection the tissues were softened by placing in a vial holding water, and heated until the vial was hot to the touch. The specimen was removed from the vial and placed into a U.S. Bureau of Plant Industry miniature (25 mm [1 in] diameter) nematode watch glass containing 70% ethanol. Using a pair of fine tip forceps to grasp the widest part of the body, a #1 insect pin was used to carefully separate the head and then the prothorax from rest of the body, and the parts placed on a tissue in a Petri dish to start drying. After five minutes the antennae and palpi would be gently positioned for best viewing. Once identification was completed through use of the relevant keys/illustrations, the parts for each specimen were placed on a paper card and fixed using a water-soluble glue. The pinned specimens are deposited in the collections maintained at the Turkey Run Park Headquarters in McLean, Virginia.

RESULTS and DISCUSSION

Forty-one species placed in 18 genera of Ptinidae were collected from GWMP. To document which of these may be new records for the state, a literature search was conducted that produced a list of 58 species in 25 genera (including species newly recorded from GWMP) documented from Virginia (see list of species). Of the species taken at GWMP, nineteen species are new Virginia records, nearly half the total taken at GWMP. Based on published records, five of these nineteen species represent range extensions, and one is probably an undescribed taxon in the genus *Ernobius*. The ranges of two species are extended to the south, two to the east, and one in a southeasterly direction. The other 14 new state records fill a gap within the previously documented ranges of the species, or in one case, is likely an undescribed taxon. The only non-native ptinid species documented from GWMP was *Ptinus fur* (Linnaeus), which was also a first record for Virginia.

The most commonly collected species were *Protheca hispida* LeConte (n=102), *Caenocara oculatum* (Say) (62), *Ptinus concurrens* Fall (23), *Caenocara blanchardi* Fall (22), and *Tricorynus densus* (Fall) (20). The most species rich genera in GWMP were *Petalium* LeConte (n=7), *Tricorynus* (6), *Ptinus* Linnaeus (5), and *Caenocara* (4). Evans (2008) recorded the first records of ptinid beetles from the Potomac Gorge (placed in the family Anobiidae), documenting three species. Brown (2008) did not include the Ptinidae among the invertebrate fauna of the Potomac Gorge, so 25 of 28 species documented from Great Falls Park or Turkey Run Park by this survey are first records for the Potomac Gorge.

An *Ernobius* specimen collected near Little Hunting Creek could not be attributed to any described species known from North America. Taxonomic keys to this genus (Fall 1905, Downie and Arnett 1996) lead to *E. lacustris* for this specimen. However, *E. lacustris* specimens determined by H. C. Fall that are held in the Ulke Collection at the Carnegie Museum of Natural History that were collected in “Dakota” were examined using macro-photographs provided by Ainslie Seago and were determined to differ from this specimen, at least in the length or width of antennomeres 6–11 (Figure 2). Fall (1905) describes antennomeres 9–11 as “filiform” for *E. lacustris* but for this specimen, antennomeres 9–11 are much wider. Additionally, antennomeres 6–8 are longer than wide in *E. lacustris* but are of subequal length and width (6–7) or wider than long (8) in this specimen. The only external differences in male and female *E. lacustris* are the smaller eyes and slightly shorter antennomere 9 in females (Fall 1905). *Ernobius* species are generally restricted to feeding on conifers (Ebeling 1975, White 1983). *Ernobius lacustris* has been recorded only from Michigan (Marquette and Ann Arbor) and “Dakota” (Fall 1905). This specimen was captured under a stand of Virginia pine, *Pinus virginiana* Mill. (Pinaceae), and no other conifer species were observed nearby. The native range of Virginia pine does not reach Michigan nor the Dakotas (Critchfield and Little 1966, Carter and Snow 1990), extending northward only to New Jersey and Pennsylvania, and west to southern Indiana and western Tennessee. Unfortunately, only one female specimen of this probable new species was captured during this study. Reviews of collections containing *Ernobius* from the Mid-Atlantic area may uncover additional specimens of this taxon, including males, which will allow for it to be fully described.

LIST OF SPECIES

Taxa are listed alphabetically within subfamilies and tribes following the nomenclature and taxonomic order used by Bouchard et al. (2011). Note that several of the tribal names that appeared for the first time in White (1982) are not used here as they were not formally defined and thus are considered to be invalid. Nineteen ptinid species new to the Commonwealth of Virginia are marked by an asterisk (*). A citation is given for each species documented from GWMP that was previously recorded for Virginia. The number of identified specimens in the collection is indicated in parentheses after each taxon collected at GWMP. Specimens were collected at Arlington Woods (AW), Dyke Marsh

Wildlife Preserve (DM), Great Falls Park (GF), Little Hunting Creek (LH), and Turkey Run Park (TR). The periods of adult activity are given based on collection dates. 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: bf (Berlese funnel), bl (black-light shown on sheet), bs (beating sheet), bt (black-light bucket trap), lf (Lindgren funnel trap), mt (Malaise trap), and pf (pitfall trap). Taxa documented from Virginia, but not yet recorded from GWMP, are included in the list of species and a citation documenting their occurrence is provided. Non-native species are marked with an exclamation point (!) and their area of origin is given.

It should be noted that this list does not cover all the species that could be present in GWMP. A list of the beetles of the District of Columbia (Ulke 1903) includes 10 additional ptinid species: *Dorcatoma pallicornis* LeConte (as *D. pallicorne* LeConte), *Ernobius luteipennis* LeConte, *Eucrada humeralis* Melsheimer, *Ptinus interruptus* LeConte, *Ptinus quadrimaculatus* Melsheimer, *Stagetus profunda* (LeConte) (as *Theca profunda* LeConte), *Stegobium paniceum* (Linnaeus) (as *Sitodrepa panicea* Linnaeus), T*ricorynus gravis* (LeConte) (as *Hemiptychus gravis* LeConte), *Tricorynus punctatus* (LeConte) (as *Hemiptychus punctatus* LeConte), and *Tricorynus ventralis* (LeConte) (as *Hemiptychus ventralis* LeConte) that were recorded from District of Columbia that have not been reported from Virginia, and in scanning the bracketed state records in the literature (particularly Downie and Arnett 1996) other species documented from nearby states may eventually be discovered in Virginia as well. Out of 38 ptinid species listed by Ulke (1903), *Endecatomus rugosus* Randall has been transferred to the Bostrichidae and *Hadrobregmus errans* Melsheimer and *Hadrobregmus carinatus* Say are junior synonyms of *Hemicoelus carinatus* (Say), resulting in a current total of 36 ptinid species from District of Columbia. Also excluded are several stored product pest species that are simply stated as being “cosmopolitan” or widespread in the Mid-Atlantic states undoubtedly have been collected in the state, but the records have not yet been published.

Family PTINIDAE Latreille, 1802 (spider and death-watch beetles)

Subfamily Ptininae Latreille, 1802

Tribe Gibbiini Jacquelin du Val, 1860

!*Gibbium aequinoctiale* Boieldieu, 1854 (as *G. psylloides* [Czenpiński, 1778]) – VA (Leng 1920); Europe.

Tribe Ptinini Latreille, 1802

**Ptinus bimaculatus* Melsheimer, 1845 – (5); DM, GF, TR; 10–30 Apr, 5–20 Oct; mt.

**Ptinus concurrens* Fall, 1905 – (23); GF, LH, TR; 1 Mar–30 Jul; mt. These specimens represent the first published record for this species east of Illinois.

**Ptinus falli* Pic, 1904 – (2); LH, TR; 2–21 Jun; mt.

!**Ptinus fur* (Linnaeus, 1758) – (1); TR; 18 Aug–4 Sep; mt; Europe.

**Ptinus hystrix* Fall, 1905 – (1); GF; 31 Jul–17 Aug; mt. This specimen represents an eastward range extension from Texas. (Figure 1).

!*Ptinus latro* Fabricius, 1775 (as *P. clavipes* Panzer) – VA (Downie and Arnett 1996); Europe.

Figure 1. *Ptinus hystrix* Fall. Great Falls Park, swamp, 31 July–17 August 2009, David R. Smith. **Left:** dorsal; **right:** lateral; length 3.0 mm (0.12 in).

Subfamily Dryophilinae Gistel, 1848

Tribe Ptilineurini Böving, 1927

!*Ptilineurus marmoratus* (Reitter, 1877) – VA (Saint Elmo) (Fisher 1919); Japan.

Subfamily Ernobiinae Pic, 1912

Ernobius filicornis LeConte, 1879 – VA (Fall 1905).

Ernobius granulatus LeConte, 1865 – VA (Fort Monroe, Virginia Beach) (Fall 1905).

!*Ernobius mollis* (Linnaeus, 1758) – VA (Fall 1905); Europe.

**Ernobius* Thomson probable n. sp. ♀ (near *E. lacustris* Fall, 1905) – (1); LH; 20 Apr–17 May; mt. (Figure 2).

Ozognathus floridanus LeConte, 1878 – (2); LH; 5 May–14 Jun; mt; VA (Fort Monroe) (Fall 1905).

Figure 2. Comparison of *Ernobius* Thomson probable n. sp. (near *E. lacustris* Fall) female collected during this inventory and a female specimen of *E. lacustris* from the Carnegie Museum of Natural History. *Ernobius* probable n. sp. (near *E. lacustris*): Little Hunting Creek, 20 April–17 May 2018, Brent W. Steury. Length 5.2 mm (0.20 in). **Top left:** dorsal; **top right:** lateral; **bottom left two:** basal and distal antennomeres. **Bottom right two:** *E. lacustris*, basal and distal antennomeres.

Subfamily Anobiinae Fleming, 1821

!*Anobium punctatum* (De Geer, 1774) – VA (Roslyn) (Fall 1905); Europe.
Ctenobium antennatum LeConte, 1865 – VA (LeConte 1865).
Hadrobregmus notatus (Say, 1825) – (13); GF, LH, TR; 10 Apr–30 Jul; mt, pf; VA (Downie and Arnett 1996).
Hemicoelus carinatus (Say, 1823) – (12); GF, LH, TR; 28 Apr–16 Jul; bl, bt, mt, pf; VA (Downie and Arnett 1996).
Oligomerus alternans LeConte, 1865 – (7); GF, TR; 1 Jun–16 Jul; bt, mt.
Oligomerus brevipilis Fall, 1905 – VA (Downie and Arnett 1996).
**Oligomerus obtusus* LeConte, 1865 – (3); LH, TR; 2 Jun–30 Jul; mt. This is the first record of this species from Virginia. (Figure 3).

Figure 3. *Oligomerus obtusus* LeConte, female. Turkey Run Park, 16–30 July 2009, David R. Smith. **Left:** dorsal; **right:** lateral; length 7.0 mm (0.28 in).

Oligomerus sericans (Melsheimer, 1846) – (1); LH; 14–28 Jun; mt; VA (Fall 1905).
Priobium sericeum (Say, 1825) – (8); GF, LH, TR; 1 Jun–30 Jul, 5 Sep–21 Oct; mt; VA (Fall 1905).
Trichodesma gibbosa (Say, 1825) – VA (Downie and Arnett 1996).
Trichodesma klagesi Fall, 1905 – (9); GF, LH, TR; 30 Apr–21 Jul; bs, lf, mt; VA (Pennington Gap) (Fall 1905).

Subfamily Ptilininae Shuckard, 1839

**Ptilinus ruficornis* Say, 1823 – (1); LH; 30 Apr–18 May; mt.

Subfamily Xyletininae Gistel, 1848

Tribe Lasiodermini Böving, 1927
Lasioderma falli Pic, 1905 – VA (Pennington Gap) (Fall 1905).
!*Lasioderma serricorne* (Fabricius, 1792) – VA (Richmond) (Runner 1919). This species may be of Old World origin based on a report of it being found in dried resin from the tomb of the Egyptian King Tutankhamun (Alfieri 1931).

Tribe Xyletinini Gistel, 1848
**Euvrilletta harrisi* (Fall, 1905) – (2); DM, TR; 20 Jun–15 Jul; mt. This record represents a southern range extension from Pennsylvania.
Euvrilletta peltata (Harris, 1836) – (3); GF, LH; 2–30 Jun; bt, mt; VA (Fall 1905).
Xyletinus parvus White, 1977 – VA (Falls Church) (White 1977).

Subfamily Dorcatominae Thomson, 1859

**Byrrhodes incomptus* (LeConte, 1865) – (1); LH; 5–19 May; mt.
Byrrhodes intermedius (LeConte, 1878) – (7); GF, LH, TR; 5 May–14 Aug; mt; VA (Roslyn; Pennington Gap) (Fall 1905).
Caenocara bicolor (Germar, 1824) – (2); GF, LH; 1 Mar–11 Apr, 19 Sep–21 Oct; mt; VA (Fort Monroe) (Fall 1905).
**Caenocara blanchardi* Fall, 1905 – (22); DM, GF, LH, TR; 19 Apr–10 Oct; mt. This record represents a southern range extension from Massachusetts to Virginia.
**Caenocara oculatum* (Say, 1824) – (62); DM, GF, LH, TR; 1 Mar–21 Oct; mt. This species is the second most collected ptinid beetle in GWMP and a first record for Virginia. (Figure 4).
Caenocara tenuipalpum Fall, 1905 – (4); LH, TR; 5 May–17 Jun, 28 Aug–18 Sep; mt; VA (Downie and Arnett 1996).
**Calymmaderus nitidus* (LeConte, 1865) – (1); TR; 16–30 Jul; mt.
**Dorcatoma falli* White, 1965 – (6); DM, LH, TR; 30 Apr–28 Jun, 19 Sep–21 Oct; mt. This is the first record of this species from Virginia. (Figure 5).
Dorcatoma setulosa LeConte, 1865 – (3); AW, LH; 5–19 May; bf, mt; VA (Fall 1905).
Petalium alaseriatum Ford, 1973 – (1); LH; 1–14 Jun; mt; VA (Fairfax County) (Ford 1973).

Figure 4. *Caenocara oculatum* (Say). Great Falls Park, swamp, 5 September–21 October 2008, David R. Smith. **Left:** dorsal; **right:** lateral; length 2.0 mm (0.08 in).

Petalium bistriatum (Say, 1825) – (8); DM, GF, LH, TR; 1 Jun–4 Sep; mt; VA (Great Falls, Falls Church) (Ford 1973).

Petalium brevisetum Ford, 1973 – (1); TR; 5 Sep–21 Oct; mt; VA (White 1982).

**Petalium debile* Fall, 1905 – (2); LH, TR; 1–17 Jun; mt.

Petalium incisum Ford, 1973 – (7); DM, GF, LH, TR; 14 Jun–21 Oct; mt; VA (Falls Church) (Ford 1973).

Petalium seriatum Fall, 1905 – (3); LH, TR; 1 Jun–20 Jul; mt; VA (Pennington Gap, Fort Monroe) (Fall 1905).

Petalium whitei Ford, 1973 – (2); LH, TR; 2–20 Jun, 19 Sep–21 Oct; mt; VA (Fairfax County) (Ford 1973).

**Protheca hispida* LeConte, 1865 – (102); DM, GF, LH, TR; 1 Jun–21 Oct; lf, mt.

Sculptotheca puberula (LeConte, 1865) – (3); GF, LH, TR; 1 Jun–26 Jul; mt; VA (Fall 1905).

Subfamily Mesocoelopodinae Mulsant & Rey, 1864

Tribe Tricorynini White, 1971

**Tricorynus castaneus* (Hamilton, 1893) – (1); LH; 5–19 May; mt.

Tricorynus confusus (Fall, 1905) – (2); DM, LH; 20 Jun–2 Jul, 19 Sep–10 Oct; mt; VA (Falls Church, Springfield, Nelson County) (White 1965).

**Tricorynus densus* (Fall, 1905) – (20); DM, GF, LH, TR; 1 Jun–26 Jul; mt. This is the first record of this species from Virginia, representing a southeastern range extension from New York and Tennessee. (Figure 6).

Figure 5. ***Dorcatoma falli*** **White.** Little Hunting Creek, 2–20 June 2017, Brent W. Steury. **Top left:** dorsal; **top right:** lateral; **bottom:** frontal, head and antennae; length 2.8 mm (0.11 in). Little Hunting Creek, 5–19 May 2017, Brent W. Steury, Christopher Acosta, and Colin Davis.

Figure 6. *Tricorynus densus* (Fall). Little Hunting Creek, 2–20 June 2017, Brent W. Steury. **Left:** dorsal; **right:** lateral; length 2.5 mm (0.10 in).

Tricorynus dichrous (Fall, 1905) – VA (Pennington Gap) (Fall 1905).
**Tricorynus gracilis* (Fall, 1905) – (1); GF; 6 Aug; bl.
Tricorynus indistinctus (Fall, 1905) – (1); LH; 1–14 Jun; mt; VA (Roslyn) (Fall 1905).
Tricorynus nigritulus (LeConte, 1865) – (2); LH; 1 Jun-16 Jul; mt; VA (Roslyn) (Fall 1905).
Tricorynus rotundus (White, 1960) – VA (Falls Church) (White 1965).
Tricorynus similis (LeConte, 1878) – VA (Fairfax County) (White 1965).

Tribe Mesocoelopodini Mulsant and Rey, 1864
!*Mesocoelopus collaris* Mulsant & Rey, 1864 – VA (Roanoke) (White 1961); Europe.

SUMMARY

Despite the available framework for species identification, few papers have treated the Ptinidae as part of regional studies, particularly for the state of Virginia. White (1962) treated the fauna of Ohio documenting 52 species in 28 genera with 19 others being probably present. Arango and Young (2012) presented a modern faunal treatment with keys to species for Wisconsin, covering 64 species in 28 genera and documenting 14 new generic and 46 new species records for the state. The only other regional treatment of note is that for Northeastern North America (Downie and Arnett 1996), for which Virginia was the southernmost state for its coverage. Thirteen generic and 21 species records for Virginia were represented, which largely reflects records from Fall (1905), Ford (1973), and the collective papers of R.E. White. The undescribed *Ernobius* species probably new to science found during this survey near the highly trafficked Mount Vernon area, is an indication that there is still much to learn concerning Ptinidae taxonomy.

ACKNOWLEDGMENTS

This study would not have been possible without the assistance of our citizen science Bug Lab volunteers Judy Buchino, M'Shae Dunham, Pat Findikoglu, Tom Hahn, Sarah Hill, Ann Kelly, Eileen Miller, Meredith Reed, Lynn Scholz, Susan Sprenke, and Jerry Taylor who sorted beetle specimens from Malaise trap samples. T. Keith Philips (Professor, Department of Biology, Western Kentucky University, Bowling Green, KY) confirmed the identification of *Ptinus hystrix* Fall from images of the specimen. Crystal Maier (Curatorial Associate, Museum of Comparative Zoology (MCZ), Harvard University, Cambridge, MA) is thanked for graciously bringing two Fall ptinid types to University of New Hampshire for examination at a time when it was not possible to enter the MCZ collections. Ainsley E. Seago (Associate Curator, Invertebrate Zoology, Carnegie Museum of Natural History, Pittsburgh, PA) provided macro images of *Ernobius lacustris*, including those shown in Figure 2. T. Keith Philips, Eugene J. Scarpulla, and one anonymous reviewer provided helpful critiques of the draft manuscript.

LITERATURE CITED

Alfieri, A. 1931. Les insectes de la tombe de Toutankhamon. *Bulletin de la Société Royale Entomologique d'Égypte*. 15(3–4):188–189.

Arango, R.A., and D.K. Young. 2012. *Death-Watch and Spider Beetles of Wisconsin - Coleoptera: Ptinidae*. General Technical Report FPL-GTR-209. United States Department of Agriculture, Forest Service, Forest Products Laboratory. Madison, WI. 158 pp.

Arnett, R.H., Jr. 1962 (1960). *The Beetles of the United States (A Manual for Identification)*. The Catholic University of America Press, Washington, DC. xi + 1112 pp.

Bell, K.L., and T.K. Philips. 2012. Molecular systematics and evolution of the Ptinidae (Coleoptera: Bostrichoidea) and related families. *Zoological Journal of the Linnean Society* 165(1):88–108.

Borowski, J., and P. Zahradníc. 2007. Ptinidae, Pages 328–362, in: I. Löbl and A. Smetana (Editors). *Catalogue of Palaearctic Coleoptera. Volume 4: Elateroidea, Derodontoidea, Bostrichoidea, Lymexyloidea, Cleroidea, and Cucujoidea*. Apollo Books, Stenstrup, Denmark. 935 pp.

Bouchard, P., Y. Bousquet, A.E. Davies, M.A. Alonso-Zarazaga, J.F. Lawrence, C.H.C. Lyal, A.F. Newton, C.A.M. Reid, M. Schmitt, S.A. Ślipiński, and A.B.T. Smith. 2011. Family-group names in Coleoptera (Insecta). *ZooKeys* 88:1–972.

Brown, J.W. (Editor). 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.

Carter, K.K., and A.G. Snow, Jr. 1990. *Pinus virginiana* Mill., Virginia Pine. Pages 513–519, in: R.M. Burns and B.H. Honkala (Technical Coordinators), *Silvics of North America, Volume 1, Conifers*. United States Department of Agriculture, Forest Service Agricultural Handbook 654, Washington, D.C. 675 pp.

Critchfield, W.B., and E.L. Little, Jr. 1966. *Geographic Distributions of the Pines of the World*. United States Department of Agriculture Forest Service Miscellaneous Publication. No. 991, Washington, D.C. 97pp.

Downie, N.M., and R.H. Arnett, Jr. 1996. *The Beetles of Northeastern North America. Volume II: Polyphaga: Series Bostrichiformia through Curculionoidea*. The Sandhill Crane Press, Gainesville, FL, x + pp. 891–1721.

Ebeling, W. 1975. *Urban Entomology*. University of California, Division of Agricultural Sciences, Richmond, CA. 695 pp.

Evans, A.V. (Compiler). 2008. The 2006 Potomac Gorge BioBlitz: Overview and results of a 30-hour rapid biological survey. *Banisteria* 32:3–80.

Evans, A.V. 2014. *Beetles of Eastern North America*. Princeton University Press, Princeton, NJ. 560 pp.

Fall, H.C. 1905. Revision of the Ptinidae of Boreal America. *Transactions of the American Entomological Society* 31(2/3):97–296.

Fisher, W.S. 1919. Descriptions of new North American Ptinidae, with notes on an introduced Japanese species. *Proceedings of the Entomological Society of Washington* 21(8):181–186.

Ford, E.J., Jr. 1973. *A Revision of the Genus* Petalium *LeConte in the United States, Greater Antilles, and the Bahamas (Coleoptera: Anobiidae)*. United States Department of Agriculture, Agricultural Research Service, Technical Bulletin No. 1467. Washington, DC. 40 pp.

Hinton, H.E. 1941. The Ptinidae of economic importance. *Bulletin of Entomological Research* 31(4):331–381.

Lawrence, J.F., and A.F. Newton, Jr. 1995. Families and subfamilies of Coleoptera (with selected genera, notes, references and data on family-group names). Pages 779–1006, in: J. Pakaluk and S.A. Ślipiński (Editors), *Biology, Phylogeny and Classification of Coleoptera: Papers celebrating the 80th birthday of Roy A. Crowson*. Muzeum i Instytut Zoologii PAN, Warsaw, Poland. 1092 pp.

Lawrence, J.F., A. Ślipiński, A.E. Seago, M.K. Thayer, A.F. Newton, A.E. Marvaldi. 2011. Phylogeny of the Coleoptera based on morphological characters of adults and larvae. *Annales Zoologici* 61(1):1–217.

LeConte, J.L. 1865. Prodromus of a monograph of the species of the tribe Anobiini, of the family Ptinidae, inhabiting North America. *Proceedings of the Academy of Natural Sciences of Philadelphia* 17(4):222–244.

Leng, C.W. 1920. *Catalogue of the Coleoptera of America, North of Mexico*. The Cosmos Press, Cambridge, MA. x + 470 pp.

Papp, C.S. 1962. An illustrated and descriptive catalogue of the Ptinidae of North Amerika. *Deutsche Entomologische Zeitschrift* 9(5):367–423.

Peck, S.B., and M.C. Thomas. 1998. *A Distributional Checklist of the Beetles (Coleoptera) of Florida*. Arthropods of Florida and Neighboring Land Areas, Volume 16. 180 pp.

Philips, T.K. 2002. 70. Anobiidae Fleming 1821. Pages 245–260, in: R.H. Arnett, Jr., M.C. Thomas, P.E. Skelley, and J.H. Frank (Editors), *American Beetles, Volume 2, Polyphaga: Scarabaeoidea through Curculionoidea*. CRC Press LLC, Boca Raton, FL. 861 pp.

Philips, T.K., and K.L. Bell. 2010. 6.4. Ptinidae Latreille, 1802. Pages 217–225, in: R.A.B. Leschen, R.G. Beutel, and J.F. Lawrence (Editors), *Coleoptera Beetles, Volume 2: Morphology and systematics (Elateroidea, Bostrichiformia, Cucujiformia partim)*. A volume of: *Handbook of Zoology, Arthropoda: Insecta*, N.P. Kristensen and R.G. Beutel (Editors). Walter de Gruyter, Berlin, Germany/New York, NY. 786 pp.

Philips, T.K., M.A. Ivie, and L.L. Ivie. 1998. Leaf mining and grazing in spider beetles (Coleoptera: Anobiidae: Ptininae): an unreported mode of larval and adult feeding in the Bostrichoidea. *Proceedings of the Entomological Society of Washington* 100(1):147–153.

Runner, G.A. 1919. *The Tobacco Beetle: An important pest in tobacco products*. United States Department of Agriculture Bulletin No. 737. Washington, DC. 77 pp.

Steury, 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.

Steury, 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.

Ulke, H. 1903. A list of the beetles of the District of Columbia. *Proceedings of the United States National Museum* 25(1275):1–57.

White, R.E. 1961. A genus of Anobiidae unrecorded from the United States (Coleoptera). *The Ohio Journal of Science* 61(3):183–185.

White, R.E. 1962. *The Anobiidae of Ohio (Coleoptera)*. Bulletin of the Ohio Biological Survey, new series, 1(4):x + 58 pp.

White, R.E. 1965. A revision of the genus *Tricorynus* of North America (Coleoptera: Anobiidae). *Miscellaneous Publications of the Entomological Society of America* 4(7):283–378.

White, R.E. 1971. Key to North American genera of Anobiidae, with phylogenetic and synonymic notes (Coleoptera). *Annals of the Entomological Society of America* 64(1):179–191.

White, R.E. 1977. Ten new North American species of *Xyletinus* (Anobiidae: Coleoptera). *Proceedings of the Entomological Society of Washington* 79(4):521–537.

White, R.E. 1982. *A Catalog of the Coleoptera of America North of Mexico. Family: Anobiidae*. United States Department of Agriculture, Agriculture Handbook Number 529–70. 58 pp.

White, R.E. 1983. A new species of *Ernobius* (Coleoptera, Anobiidae) injurious to spruce. *Proceedings of the Entomological Society of Washington* 85(3):557–559.

The Maryland Entomologist 8(2):95–96

Protandrous Arrival in a Population of the Periodical Cicada *Magicicada septendecim* (Linnaeus) (Hemiptera: Cicadidae) in Montgomery County, Maryland: Addendum to METHODS and RESULTS Sections

Caleb M. Kriesberg

Fenton Village, Silver Spring, Maryland 20910; brindlebee@aol.com

Keywords: regression analysis, sex ratio

This writer reported on adult periodical cicadas, *Magicicada septendecim* (Linnaeus), emerging in Silver Spring, Maryland in 2004. It was useful to compare observations of *M. septendecim* from this study area with the data of Dybas and Lloyd (1974) from Ohio in 1965. They examined *M. septendecim* nymphal skins, exuviae (so avoiding possible double-counting adult cicadas), for several days, and reported in Table 15 a protandrous ratio of male and female emergent cicadas.

Regression analysis can provide a mathematical portrayal of the season's changing daily sex ratios for the cicadas. Typically for protandrous emergence, there is a maximum preponderance of males at the season's start, a 1:1 male:female ratio in the middle, and the maximum preponderance of females at the end. An R-squared score close to value of one generally means that a straight line can readily be drawn through the data array, and the data fit the hypothesized ratios (Frost 2020). Regression analysis for this writer's study yields a slope intercept and R-squared reflecting in part that for the 2004 sample, there was a high degree of agreement with the expected pattern for protandrous arrival.

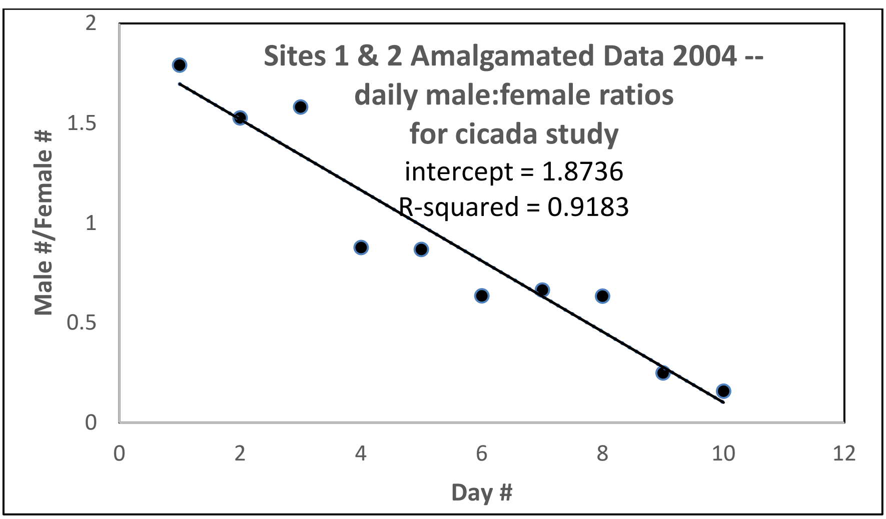


Figure 1: Daily male:female ratios for the 2004 study, 14–23 May, in Montgomery County, Maryland. Total of 548 males and 700 females.

Literature Cited

Dybas, H.S., and M. Lloyd. 1974. The habitats of 17-year periodical cicadas (Homoptera: Cicadidae: *Magicicada* Spp.). *Ecological Monographs* 44(3):279–324.

Frost, J. 2020. How To Interpret R-squared in Regression Analysis. Statistics by Jim. Available at: https://statisticsbyjim.com/regression/interpret-r-squared-regression/. Accessed 27 July 2021.

Kriesberg, C.M. 2020. Protandrous arrival in a population of the periodical cicada *Magicicada septendecim* (Linnaeus) (Hemiptera: Cicadidae) in Montgomery County, Maryland. *The Maryland Entomologist* 7(4):17–30.

THE MARYLAND ENTOMOLOGIST

NOTICE TO CONTRIBUTORS

Contributors should prepare manuscripts according to the following instructions.

Title: The title should be brief, concise, and pertinent.

Abstract: An abstract is required for all long articles; suggested for all biologic studies more than two (2) pages in length; but is not needed for notes, distribution reports, or short observations (especially if two pages or shorter in length). The abstract should provide a capsule description of the main thrust, methods, and essential findings of the article. It should contain the scientific name, including species author(s), of the main subject species for most biological studies.

Text: Manuscripts should be submitted by email in 12-point Times New Roman, single-spaced, MS Word™. Please identify respective file name(s) for text, figure titles, and descriptions of graphs or figures. First mention of a biological organism, in the abstract and text should include the full scientific name, including species author(s). Carefully check the spelling of all scientific names. All genera and species should be in italics. Capitalize "official" common names for faunal species. Short articles and general notes (20 pages or less) are preferred. Longer manuscripts may be assessed page charges. Color "copy ready" illustrations, pictures, or digital images are preferred.

References: References should be given in an author-date format: (Lynch 1987); (Lynch 1987, 1988); (Lynch, in press); (Lynch, in litt.); (Lynch, pers. comm.); (Lynch and Lynch 1989); and (Lynch et al. 1990) for 3 or more authors. Provide evidence of acceptance for works "in press," or cite as "unpublished", "in litt." (written), or "pers. comm." (verbal); written permission is suggested as well. Citations shall be listed alphabetically, under LITERATURE CITED and formatted as follows: **Articles:** Lynch, J.F. 1987. An annotated checklist and key to the species of ants (Hymenoptera: Formicidae) of the Chesapeake Bay region. *The Maryland Naturalist* 31(3–4):61–105. Do not abbreviate the titles of journals. **Books:** Fisher, B.L., and S.P. Cover. 2007. *Ants of North America: A guide to the genera*. University of California Press, Berkeley and Los Angeles, CA. 194 pp. **Internet:** Entomological Society of America. 2011. Common names of insects database. Available at: http://entsoc.org/common-names. Accessed 11 July 2011.

Tables: Tables, graphs, and line drawings should be created electronically in black and white. Color should only be used when absolutely necessary for clarity.

Illustrations: Photographs or high-definition images may be accepted if necessary or desired by the author(s) to support the text. Reproduction of photos or images may increase printing costs and authors will be expected to pay any extra charges. Photographs should be submitted in color. Figure numbers, as cited in the text, and figure legends should be keyed to each respective photograph.

The Maryland Entomologist is published annually by the Maryland Entomological Society. There are four numbers per volume. Original articles or reports on geographic or temporal distribution (primarily pertaining to Maryland and the Mid-Atlantic region), ecology, biology, morphology, genetics, systematics, behavior, etc., are welcome. Notes on distribution, behavior, occurrence, migration, life history, and other biological topics will be published. All submissions are subject to editorial review and acceptance. Articles will be peer-reviewed. E-mail submissions to Editor Eugene J. Scarpulla at ejscarp@comcast.net.

CONTENTS

COVER PHOTOGRAPH

A scarab beetle, *Phyllophaga* Harris sp. (Coleoptera: Scarabaeidae) (on the left), that has been preyed upon by a ground beetle, *Carabus vinctus* (Weber) (Coleoptera: Carabidae). Photographed in Newport News Park, Newport News, Virginia, 17 April 2019.

Photographed by Curt W. Harden