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

The MES logo features an illustration of ***Euphydryas 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.

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Editor's Note

The Maryland Entomologist continues to attract accomplished authors, both within and outside of Maryland. This year's issue has featured several out-of-state authors. Of the seven articles, four were submitted from authors/coauthors outside of Maryland. Of the eleven authors/coauthors, eight are from states other than Maryland: Virginia (3), Maine (2), Georgia (1), Washington (1), and Wisconsin (1).

There is also an excellent diversity of topics this year, with three Coleoptera, one Lepidoptera, two Hymenoptera, and one Araneae articles.

I express my gratitude to all of the authors and peer reviewers that made this issue possible.

Eugene J. Scarpulla
Editor

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The Occurrence of Snail-eating Ground Beetles in the Genus *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini) on the Delmarva Peninsula and the Historical and Current Status of *S. elevatus* (Fabricius) and *S. unicolor* (Fabricius) in the Mid-Atlantic Region from New York to Virginia

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Abstract: Guarnieri (2015) discussed the historical distributions of all the snail-eating beetles in the genus *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini) that occur in or near Maryland after a review of published collecting records and a survey of the insect collections at the Carnegie Museum of Natural History, Cornell University, the United States National Museum of Natural History, and University of Maryland College Park. Although Bousquet (2012) reported that *S. elevatus* (Fabricius) and *S. viduus* (Dejean) occur in Delaware, Guarnieri (2015) did not list any confirmatory records. We now show data confirming the presence of *S. elevatus* and *S. viduus* in Delaware and Maryland on the upper Delmarva Peninsula, and of *S. elevatus* in the Maryland and Virginia sections of the lower Delmarva Peninsula. Guarnieri (2015) also suggested possible declines in the range and number of both *S. elevatus* and *S. unicolor* (Fabricius) in the Mid-Atlantic region (initially defined as Delaware, the District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia). In this paper, we describe additional records for these two species from the Academy of Natural Sciences of Drexel University, the American Museum of Natural History, the Maryland Department of Agriculture, the University of Delaware, the Virginia Museum of Natural History, and the personal collections of the second author and Todd Lawton. Furthermore, we expand our geographic coverage to include specimens from New Jersey and New York. This larger data set may indicate that the populations of *S. elevatus* and *S. unicolor* are stable in Virginia. However, both beetles appear to be quite rare and local in the remaining states studied, even in areas where they may have once been more abundant.

INTRODUCTION

Guarnieri (2015) investigated patterns in the historical distributions of all the snail-eating beetles in the genus *Scaphinotus* Dejean that occur or possibly occur in Maryland based on reports by Bousquet (2012) and Glaser (1996). These were: *Scaphinotus andrewsii mutabilis* (Casey), *S. elevatus* (Fabricius), *S. imperfectus* (Horn), *S. ridingsii monongahelae* Leng, *S. ridingsii ridingsii* (Bland), *S. unicolor* (Fabricius), and *S. viduus* (Dejean). Guarnieri (2015) described a survey of every specimen of the species listed above from the District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia that were housed at the Carnegie Museum of Natural History, Pittsburgh, Pennsylvania; the Cornell University Insect Collection, Ithaca, New York; the United

States National Museum of Natural History, Washington, District of Columbia; and the University of Maryland College Park, College Park, Maryland. Although nearly 1500 beetles were examined, no individuals of any *Scaphinotus* species were seen from Delaware or anywhere on the Delmarva Peninsula.

Assumptions were made regarding changes in range and relative abundance by comparing the numbers of older versus newer specimens in the collections. Further inferences were made after a review of recent published regional pitfall trap surveys. It was noted that the study methods were problematic in that many types of sampling bias could be present.

With that caveat in mind, Guarnieri (2015) made several assertions regarding the status of the Mid-Atlantic *Scaphinotus* fauna. *Scaphinotus a. mutabilis, S. imperfectus, S. r. monongahelae*, and *S. viduus* are secure within their historical ranges in the region surveyed. *Scaphinotus r. ridingsii* is probably extirpated from its primary habitat in northern Virginia. *Scaphinotus elevatus* has likely experienced a dramatic decline in both its range and numbers, even in areas where it seemed to be formerly common. *Scaphinotus unicolor* probably no longer occurs north of Maryland, and in that state the beetle appears to be quite scarce and local. However, *S. unicolor* may still be abundant in certain areas of Virginia.

This present work improves upon Guarnieri (2015) by including more records from additional collections over a larger geographic area. We begin with a brief note documenting the presence of *S. elevatus* and *S. viduus* on the Delmarva Peninsula and then focus on the status of *S. elevatus* and *S. unicolor* throughout the Mid-Atlantic region, including New Jersey and New York.

For this study, we define the Mid-Atlantic region to include Delaware, the District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, and West Virginia. We include data from the Carnegie Museum of Natural History, the Cornell University Insect Collection, the United States National Museum of Natural History, and the University of Maryland College Park that were obtained but not presented by Guarnieri (2015) (i.e., the exact collecting dates and locations, as well as data from New Jersey and New York). We present results from new surveys at the Academy of Natural Sciences of Drexel University, Philadelphia, Pennsylvania; the American Museum of Natural History, New York, New York; the Maryland Department of Agriculture, Annapolis, Maryland; the University of Delaware Insect Reference Collection, Newark, Delaware; and the Virginia Museum of Natural History, Martinsville, Virginia, that searched for all Mid-Atlantic records of *S. elevatus* and *S. unicolor* in those insect collections. Additional records of *S. unicolor* are from the personal collections of the second author and of Todd Lawton (Winnipeg, Manitoba, Canada). Delaware and Maryland records of *S. viduus* from the University of Delaware are also mentioned.

METHODS

All specimens and labels were examined by one of the authors except those at the Academy of Natural Sciences of Drexel University and one specimen in the Todd

Lawton collection. Species identifications were made or confirmed using Ciegler (2000). As is further discussed in the *S. elevatus* section below, we did not attempt to distinguish the nominate subspecies, *S. e. elevatus* (Fabricius), from the two other subspecies: *S. e. lengi* Van Dyke and *S. e. tenebricosus* Roeschke that may also occur in the region under study (primarily Virginia). Nomenclature otherwise follows Bousquet (2012).

RESULTS

Records are listed first in alphabetical and then chronological order. Miscellaneous collecting data or unverified location labels are inside quotations. Based on their condition relative to dated specimens, most of the undated specimens were probably collected between 1890 and 1940. Specimens collected in the last three decades have dates marked with **bold** text. Date ranges indicate pitfall trap collections. Numbers in parentheses indicate multiple specimens with the same label. (AMNH = American Museum of Natural History. ANSP = Academy of Natural Sciences of Drexel University. CMNH = Carnegie Museum of Natural History. CUIC = Cornell University Insect Collection. CWHC = personal collection of Curt W. Harden. MDAG = Maryland Department of Agriculture. UDCC = University of Delaware Insect Reference Collection. UMDC = University of Maryland College Park. USNM = United States National Museum of Natural History. VMNH = Virginia Museum of Natural History.)

***Scaphinotus* records from the Delmarva Peninsula**

Scaphinotus elevatus

DELAWARE: <u>New Castle Co.</u>, Newark, 15 October 1936 (UDCC); Stanton, 11 May 1907 (UDCC).

MARYLAND: <u>Worcester Co.</u>, Snow Hill, Mattaponi Landing, **10 October 1997** (CMNH).

VIRGINIA: <u>Accomack Co.</u>, Chincoteague National Wildlife Refuge, "pitfall trap", **1–14 October 1998** (2) (VMNH).

Scaphinotus viduus

DELAWARE: <u>New Castle Co.</u>, no other data, 1929 (UDCC); Mount Cuba Center, **16 July 2015** (UDCC); Newark, White Clay Creek State Park, **3 October 1997** (UDCC); Newark, White Clay Creek State Park; "pitfall trap in forest", **26 June 2000** (2) (UDCC); Newark, White Clay Creek State Park, "by hand", **3 September 2011** (2) (UDCC); Wilmington, July 1970 (UDCC).

MARYLAND: <u>Cecil Co.</u>, Elkton, Fair Hill Natural Resource Management Area, **14 September 2012** (UDCC).

Mid-Atlantic *Scaphinotus elevatus* records

DELAWARE: <u>New Castle Co.</u>, Newark, 15 October 1936 (UDCC); Stanton, 11 May 1907 (UDCC).

DISTRICT OF COLUMBIA: no other data (6) (USNM); 27 June 1936 (USNM); Rock Creek Park, 21 August 1898 (USNM); Rock Creek Park, 18 July 1899 (USNM); Rock

Creek Park, 3 September 1900 (USNM); Rock Creek Park, 2 June 1901 (USNM); Rock Creek Park, 6 September 1901 (USNM); Rock Creek Park, June 1947 (2) (USNM).

MARYLAND: no other data (USNM); 1970 (2) (MDAG). Anne Arundel Co., Odenton, 2 June 1918 (CUIC). Allegany Co., Rocky Gap State Park, 26 September 1983 (CMNH). Baltimore Co., Catonsville, 21 October 1934 (USNM); Catonsville, 19 May 1935 (USNM). Calvert Co., Chesapeake Beach, 3 August 1924 (USNM); Huntingtown, 0.5 Mile S Jct. Rts. 2 and 4, **8 May 1990** (USNM). Carroll Co., Westminster, 14 April 1931 (USNM). Charles Co., Indian Head, 13 June 1945 (2) (USNM). Frederick Co., Bennett Creek, 23 March 1959 (USNM); Frederick, 3 November 1940 (USNM). Harford Co., Riverside, 28 August 1935 (USNM). Montgomery Co., Cabin John, October 1926 (USNM); Woodside, 1 June 1924 (USNM). Prince George's Co., no date (UMDC); 25 September 1925 (USNM); Beltsville, 1972 (MDAG); Beltsville, 11 October 1974 (USNM); Bowie, Patuxent Wildlife Refuge, 24 September 1944 (USNM); College Park, 6 September 1897 (UMDC); College Park, 1903 (UMDC); College Park, 5 May 1915 (UMDC); Laurel, "pitcher plant", 14 July 1923 (USNM); Hyattsville, 4 June 1941 (USNM). Saint Mary's Co., Piney Point, 1 May 1927 (USNM). Washington Co., Charlton, 24 November 1895 (USNM); Harpers Ferry, 14 July 1930 (2) (CMNH) (Note that Harpers Ferry is in West Virginia on the border with Washington Co., Maryland.). Worcester Co., Snow Hill, Mattaponi Landing, **10 October 1997** (CMNH).

NEW JERSEY: no other data (CMNH). Bergen Co., Oradell, 15 August 1917 (USNM); Oradell, 18 August 1918 (USNM); Ramsey, 23 June 1934 (USNM). Burlington Co., Pemberton Township, Upton Station, 24 August 1940 (5) (CMNH); Woodland Township, **15 September 1986** (CMNH); Woodland Township, **30 September 1986** (3) (CMNH). Cape May Co., North Wildwood, no date (ANSP); North Wildwood, May 1926 (ANSP); Wildwood, Five Mile Beach, 11 July no year (USNM); Wildwood, Five Mile Beach, 20 October no year (USNM). Essex Co., South Orange, 14 April 1888 (ANSP); South Orange, 21 April 1889 (ANSP); South Orange, 20 October 1889 (ANSP). Hunterdon Co., Frenchtown, no date (2) (ANSP); Frenchtown, 1 July 1936 (5) (ANSP); Frenchtown, August 1936 (4) (USNM); Frenchtown, July 1937 (AMNH); Treasure Island, July 1939 (CMNH). Ocean Co., Lakehurst, 7 October 1939 (ANSP); Passaic Co., Clifton, 20 June 1906 (USNM).

NEW YORK: Kings Co. (Brooklyn), Forest Park, 25 October 1903 (USNM) (Note that Forest Park is in Queens Co. but on the border with Brooklyn, Kings Co.). Queens Co. (Queens), Little Neck, 4 November 1913 (CMNH). Richmond Co. (Staten Island), no other data (3) (AMNH); no other data (ANSP); no other data (USNM); 1911 (CUIC). Suffolk Co., Bay Shore, March 1911 (USNM); Cold Spring Harbor, July 1921 (CMNH); Huntington, 30 May 1921 (USNM); Huntington, 7 August 1921 (CUIC); Huntington, 12 September 1926 (CUIC); Melville, 15 May 1921 (CMNH); Sag Harbor, 4 July 1945 (CUIC); Wyandanch, 11 November 1914 (CMNH); Yaphank, 20 June 1911 (2) (ANSP); Yaphank, 3 September 1916 (USNM). Westchester Co., Ardsley, no date (AMNH); Somers, 6 October 1917 (AMNH); Somers, 26 December 1918 (AMNH); Somers, 2 October 1920 (AMNH); Somers, 8 October 1921 (AMNH); Somers, 29 July 1923 (AMNH); Somers, 30 April 1928 (AMNH); Somers, 24 September 1928 (AMNH); Somers, 29 May 1932 (AMNH).

PENNSYLVANIA: no other data (2) (USNM). Monroe Co., Water Gap, no date (AMNH). Westmoreland Co., Jeannette, June no year (CMNH).

VIRGINIA: "Coles St", 18 October 1958 (VMNH). Accomack Co., Chincoteague National Wildlife Refuge, "pitfall trap", **1–14 October 1998** (2) (VMNH). Albemarle Co., Cobham, no date (AMNH). Alexandria, 13 September 1913 (USNM); 15 September 1913 (AMNH); 17 September 1913 (USNM). Arlington Co., 17 May 1925 (USNM); 3 October 1937 (USNM); Glencarlyn Park, **6 May 2003** (USNM); Rosslyn, no date (2) (USNM). Bedford Co., Bedford, 11 May 1967 (VMNH). Campbell Co., S. of Lynchburg, Rt. 680, 37.3091°N 79.1179°W, "oak-hickory forest", 29 May 1957 (USNM). Clarke Co., Castlemans Ferry, September 1907 (2) (USNM). Dinwiddie Co., Addison, no date (USNM). Essex Co., Dunnsville, "pitfall trap", **23 September–19 October 1993** (USNM). Fairfax Co., 23 September 1921 (USNM); 28 September 1921 (USNM); 25 September 1925 (USNM); 22 September 1928 (USNM); 29 September 1928 (USNM); 29 September 1933 (USNM); 21 September 1935 (USNM); Black Pond, 15 July 1917 (USNM); Black Pond, 18 September 1919 (USNM); Clifton, 25 June 1933 (2) (USNM); Clifton, 29 June 1933 (USNM); Difficult Run, 24 September 1916 (USNM); Falls Church, 25 June no year (USNM); Falls Church, 4 July 1914 (3) (USNM); Falls Church, 30 May 1915 (USNM); Falls Church, 31 July 1916 (USNM); Falls Church, 5 June 1919 (4) (USNM); Falls Church, 18 September 1919 (USNM); Falls Church, 29 June 1928 (USNM); Falls Church, 10 May 1935 (2) (USNM); Falls Church, 19 May 1935 (USNM); Falls Church, 25 September 1948 (USNM); Great Falls, 6 August 1913 (USNM). Fluvanna Co., no date (2) (USNM); 22 October 1968 (VMNH). Giles Co., Newport, no date (2) (USNM). Goochland Co., Goochland, 19 June 1923 (USNM). James City Co., Williamsburg, 31 May 1941 (USNM). Mecklenburg Co., Boydton, J. H. Kerr Dam, 21 April 1973 (VNMH) teneral; Elm Hill, "Clyde's Pond", **26 August–20 September** 1995 (VNMH). Montgomery Co., 17 May 1913 (USNM); 6 June 1914 (USNM). Nelson Co., 16 June 1907 (2) (USNM); 3 June 1919 (USNM); 30 July 1924 (USNM); 28 July 1928 (USNM). Newport News, no date (2) (USNM); 17 May 1890 (USNM). Norfolk, no date (2) (USNM). Nottoway Co., Fort Pickett, "Shackles Road sink hole pond", **22 May 1992** (VMNH); Fort Pickett, "in savanna", **12 May 1993** (VMNH) teneral. Pittsylvania Co., Cascade, Solite Quarry, **8 June 1998** (VMNH). Pulaski Co., Radford Army Ammunition Plant, **6 May 1998** (VMNH) teneral. Richmond, University of Richmond Campus, no date (VMNH); University of Richmond Campus, June 1935 (VMNH); University of Richmond Campus, 7 May 1936 (VMNH) teneral; University of Richmond Campus, 8 May 1936 (VMNH); University of Richmond Campus, 25 April 1937 (VMNH); University of Richmond Campus, 5 November 1946 (VMNH). Stafford Co., Fredericksburg, 2 June 1889 (USNM); Fredericksburg, 16 May 1891 (USNM); Fredericksburg, 2 July 1891 (USNM); Fredericksburg, 11 August 1891 (USNM); Fredericksburg, 11 August 1894 (USNM); Quantico Marine Corps Base, **6 September 1990** (VMNH). York Co., Cheatham Annex Naval Supply Center, **12 October 1989** (4) (VMNH); Cheatham Annex Naval Supply Center, **2 November 1989** (6) (VMNH); Cheatham Annex Naval Supply Center, **30 May 1990** (2) (VMNH) one teneral; Yorktown Naval Weapons Station, **17 August 1990** (VMNH).

WEST VIRGINIA: Jefferson Co., Harpers Ferry, 9 September 1917 (USNM); Harpers Ferry, 12 September 1917 (USNM); Kearneysville, 22 August 1938 (USNM); Kearneysville, "pitfall trap in orchard", 9 May 1939 (2) (USNM).

Mid-Atlantic *Scaphinotus unicolor* records
(No specimens were seen from Delaware, New Jersey, or New York.)

DISTRICT OF COLUMBIA: no other data (6) (CMNH); no other data (3) (USNM); 2 July 1899 (USNM); 1906 (USNM); 16 October 1924 (USNM); Rock Creek Park, 1895 (CMNH); Rock Creek Park, 17 May 1896 (USNM); Rock Creek Park, 24 July 1898 (USNM); Rock Creek Park, 1 June 1907 (USNM).
MARYLAND: Allegany Co., Cumberland, 12 July 1914 (CMNH). Baltimore (city), Leakin Park, **19 July 2000** (Todd Lawton Collection). Baltimore Co., Catonsville, 6 July 1939 (USNM). Calvert Co., Calvert Cliffs, **8 October 2003** (USNM); Huntingtown, 0.5 Mile S Jct. Rts. 2 and 4, **8 May 1990** (USNM). Carroll Co., Marriottsville, "under mica rock hillside forest", 26 August 1959 (CMNH). Charles Co., Marbury, 2 October 1980 (CMNH). Howard Co., Columbia, "leaf litter", **12 October 2008** (UDCC). Montgomery Co., 29 June 1914 (CMNH); 23 September 1915 (USNM); Bethesda, 15 September 1928 (USNM); Brinklow, 27 September 1945 (UMDC); Cabin John, no date (CMNH); Chevy Chase, 7 November 1918 (USNM); Colesville, 28 September 1957 (USNM); Plummers Island, 11 September 1902 (2) (USNM); Plummers Island, 22 September 1905 (USNM); Plummers Island, 1 June 1909 (USNM); Plummers Island, 15 September 1909 (USNM); Plummers Island, 29 September 1909 (USNM); Plummers Island, 14 September 1918 (USNM); Plummers Island, 20 September 1918 (USNM); Plummers Island, 1 June 1921 (USNM); Plummers Island, 26 September 1943 (USNM); Woodside, 17 September 1919 (USNM). Prince George's Co., 1913 (UMDC), College Park, 1916 (AMNH).
PENNSYLVANIA: Cambria Co., Johnstown, no date (USNM).
VIRGINIA: Alexandria, no date (USNM); 6 June 1908 (USNM); 20 September 1913 (USNM); 23 September 1913 (USNM); 10 September 1915 (USNM); 23 September 1925 (USNM). Arlington Co., May 1939 (USNM). Carroll Co., "Allen Knob", no date (USNM). Chesterfield Co., South Richmond, Scotford Road, **18 May 1996** (VMNH) teneral. Cumberland Co., 2 km SW of Columbia, "hardwoods North", **21 September 1989** (VMNH); 5.5 km SW of Columbia, "clearcut South", **19 October 1989** (2) (VMNH); 7 km SW of Columbia, "hardwoods South", **19 October 1989** (VMNH); 2 km SW of Columbia, "clearcut North", **2 November 1989** (2) (VMNH); 2 km SW of Columbia, "hardwoods North", **16 April 1990** (VMNH); 7 km SW of Columbia, "hardwoods South", **1 May 1990** (VMNH); 2 km SW of Columbia, "hardwoods North", **16 June 1990** (VMNH); 2 km SW of Columbia, "hardwoods North", **1 August 1990** (VMNH); 5.5 km SW of Columbia, "clearcut South", **16 September 1990** (VMNH); 5.5 km SW of Columbia, "clearcut South", **30 September 1990** (2) (VMNH); 2 km SW of Columbia, "clearcut North", **19 October 1990** (VMNH); 5.5 km SW of Columbia, "clearcut South"; **2 November 1990** (VMNH). Danville, Anglers Park, **18 September 2016** (4) (CWHC); Anglers Park, **24 September 2016** (2) (CWHC). Fairfax Co., no date (5) (USNM); 19 September 1921 (USNM); 20 September 1921 (USNM); 22 September 1921 (USNM); 22 September 1921 (AMNH); 23 September 1921 (USNM); 24 September 1921 (2) (USNM); 23 September 1924 (USNM); 25 September 1924 (2) (USNM); 27 September 1924 (USNM); 18 September 1926 (2) (USNM); 21 September 1926 (USNM); 20 September 1927 (USNM); 24 September 1927 (USNM); 23 September 1928 (USNM); 29 September

1929 (USNM); 26 September 1931 (USNM); 21 September 1935 (USNM); 25 September 1937 (2) (USNM); Black Pond, 21 September 1911 (USNM); Black Pond, 15 September 1925 (USNM); Black Pond, 26 September 1925 (USNM); Dead Run, 23 June no year (USNM); Difficult Run, 24 September 1916 (USNM); Fairfax, 8 September 1933 (USNM); Fairfax, 2 miles east of Fairfax, 7 October 1945 (USNM); Falls Church, 1 September 1934 (USNM); Falls Church, "under honeysuckle, 609 Poplar Drive", 5 June 1948 (USNM); Great Falls, 23 September 1915 (USNM); Great Falls, 21 June 1917 (USNM); Great Falls, 27 September 1931 (USNM); Great Falls, "under log", 27 September 1931 (USNM); Great Falls, "in bottle", 8 October 1933 (USNM); Potomac River across from Plummers Island, 6 September 1934 (USNM). Giles Co., Mountain Lake, 1915 (2) (USNM). Hanover Co., 26 September 1981 (VMNH). Henrico Co., "Elko Natural Area", **23 October 1989 (5)** (VMNH); "Elko Natural Area", **6 November 1989** (VMNH); "Elko Natural Area", **15 June 1990** (VMNH). Henry Co., near Martinsville, "DuPont Property", **25 September–2 October 1995** (VMNH); near Martinsville, "DuPont Property", **4 October 1995** (VMNH). Isle of Wight Co., 7 km S of Zuni, Blackwater Nature Preserve, "LL Pine site", 9 November 1985 (VMNH). Lee Co., Powell River, "bluff below white shoals", **21 May 1990** (VMNH). Lynchburg, Ruskin Freer Nature Preserve, **29 May 1990** (VMNH). Mecklenburg Co., 2 mi SE of Boydton, VA Hwy 707, **6 June 1990** (VNMH); 2.5 mi SE of Boydton, **25 June 1990** (VNMH). Newport News, no date (USNM). Prince George Co., Fort Lee, **26 April 1993** (VMNH) teneral. Prince William Co., Prince William Forest Park, "floodplain", **3 October 1988** (VMNH). Pulaski Co., 0.5 mi S of Parrott, September 1978 (VNMH). Richmond, University of Richmond Campus, 29 October 1952 (VMNH); University of Richmond Campus, 3 October 1956 (VMNH). Spotsylvania Co., Fredericksburg, no date (USNM). Stafford Co., Quantico Marine Corps Base, **13 September 1990** (2) (VMNH). York Co., Cheatham Annex Naval Supply Center, **6 July 1989** (VMNH); Cheatham Annex Naval Supply Center, **1 September 1989** (VMNH); Cheatham Annex Naval Supply Center, **24 September–2 November 1989** (14) (CMNH); Cheatham Annex Naval Supply Center, **12 October 1989** (3) (VMNH); Cheatham Annex Naval Supply Center, **2 November 1989** (14) (VMNH); Cheatham Annex Naval Supply Center, **17 November 1989** (4) (VMNH); Cheatham Annex Naval Supply Center, **30 May 1990** (2) (VMNH) both teneral; Cheatham Annex Naval Supply Center, **3 December 1990** (5) (VMNH); Grafton Ponds Natural Area Preserve, "middle pitfall site", **9 November 1990** (VMNH); Yorktown Naval Weapons Station, **19 October 1990** (2) (VMNH). Westmoreland Co., 30 September 1982 (VMNH).

WEST VIRGINIA: Marion Co., Fairmont, no date (CMNH).

DISCUSSION

Scaphinotus records from the Delmarva Peninsula

We report a specimen of *S. elevatus* from Worcester Co., Maryland (Snow Hill, Mattaponi Landing, 10 October 1997) at the CMNH that was missed by Guarnieri (2015). This damaged specimen was originally found by Robert E. Acciavatti and John D. Glaser partly smashed between the vanes of a black light trap. *Scaphinotus* beetles are flightless and are not known to be attracted to lights, so this was a fortunate incidental capture. The presence of *S. elevatus* on the lower Delmarva Peninsula is further confirmed by two beetles in the VMNH from Accomack Co., Virginia (Chincoteague National Wildlife Refuge, pitfall trap, 1–14 October 1998). These collecting records are further discussed in the *S. elevatus* section below.

Based on the discrepancy between Bousquet (2012) and Guarnieri (2015) regarding the presence of *S. elevatus* and *S. viduus* in Delaware, we contacted the UDCC. Indeed, that collection contained five *Scaphinotus* beetles from New Castle Co. that had been identified to species. Two were *S. elevatus* (collected in 1907 and 1936) and three were *S. viduus* (one collected in 1929 and two in 2000). Furthermore, the first author received a loan of seven undetermined *Scaphinotus* specimens. One was a recent (2008) record of *S. unicolor* from Howard Co., Maryland (discussed later in the *S. unicolor* section below). The other six were *S. viduus* that had also been collected quite recently. One was from Cecil Co., Maryland (2012), while the remaining five were from New Castle Co., Delaware (1970–2015). These records (the complete collecting data are listed in the results section) show that *S. viduus* is likely firmly established in northern Delaware. Photographs of two *S. viduus* specimens from White Clay Creek State Park in New Castle Co., Delaware (male: 26 June 2000; female: 3 September 2011) are shown in the accompanying photo atlas by Harden and Guarnieri (2017).

Scaphinotus elevatus in the Mid-Atlantic Region

Scaphinotus elevatus is a large (up to 20 mm [0.8 in]) and attractive beetle found mainly on the Coastal Plain of the eastern United States from southern New Hampshire to northern Florida and eastern Texas (Bousquet 2012). *Scaphinotus e. elevatus* is the typical subspecies associated with the Mid-Atlantic region, although Bousquet (2012) does not report it as occurring in Virginia where the taxonomy of the beetle becomes confusing. One subspecies, *S. e. lengi*, is described from the unique holotype from the Great Dismal Swamp (Van Dyke 1938). Otherwise, the beetles from Virginia have been assigned to *S. e. tenebricosus*. According to Van Dyke (1938), this subspecies replaces *S. e. elevatus* in Virginia and parts of coastal New Jersey, North Carolina, and South Carolina.

According to Van Dyke (1938), the three Mid-Atlantic subspecies are largely differentiated by the color of the elytra and the geometry of the reflexed basal angles of the pronotum. *Scaphinotus e. elevatus* is described as having more contrast between the color of the elytra and pronotum. Also, the hind angles of the pronotum are described as being flatter and less convergent. *Scaphinotus e. tenebricosus* is described as being darker overall, with less color contrast between elytra and pronotum, and the pronotum is described as having more vertical and convergent reflexed hind angles. Lastly, Van Dyke (1938) states that for *S. e. lengi*, the elytra are darker and the reflexed basal margins of the pronotum are higher and more convergent than for *S. e. tenebricosus*.

However, the validity of the subspecies is doubtful. Even Van Dyke (1938) states that “specimens from the same region may vary greatly, particularly as to the character of the reflexed sides of the pronotum” and that *S. e tenebricosus* “might be considered as but a melanotic race of *elevatus*.” Erwin (2007) states: “In the very large NMNH [= USNM] collection of *Scaphinotus* (*Scaphinotus*) *elevatus* (Fabricius), intergrades between the named subspecies (with the exception of *S. e. neomexicanus* Van Dyke) are so numerous that I seriously doubt that real subspecies exist." An example of this variation is shown in Figure 1. The six beetles from Northern Delaware, central Maryland, and northern Virginia all show varying degrees of the characters discussed above. Thus, in this work we did not attempt to distinguish between possible subspecies; all records recorded here are listed only as *S. elevatus*.

Although one needs to be cautious in making determinations of relative abundance based on numbers of museum specimens, *S. elevatus* was probably fairly common and widespread in the Northeast based upon the large number of old specimens listed above. It is particularly compelling to see so many historic records in and around places such as New York, New York and Washington, District of Columbia. Somewhat anecdotal, but nevertheless interesting, is the fact that *S. elevatus* was the only *Scaphinotus* species listed by Dillon and Dillon (1961) in *A Manual of Common Beetles of Eastern North America*.

Guarnieri (2015) suggested this species may be in decline in the Northeast, and a similar trend is seen in the data presented here. In all the states surveyed except Virginia, only six out of 96 dated specimens were collected within the past 30 years; the most recent record being from 1997. The ratio of old to new specimens would have been even more dramatic had we counted another 23 beetles with unknown collection years, most of which were probably collected between 1890 and 1940 based on their physical conditions relative to the dated specimens in the collections.

Significant findings include the records from New Castle Co., Delaware; Worcester Co., Maryland; and Accomack Co., Virginia. While the two Delaware beetles are very old, the Maryland (1997) and Virginia (1998) records suggest there may still be an extant population on lower Delmarva. We list a recent (1990) record from Huntingtown in Calvert Co., Maryland. However, Steury and Messer (2017) do not report *S. elevatus* in their survey of Cove Point (also in Calvert Co.). The four beetles from Burlington Co., New Jersey may indicate this species still occurs in portions of the New Jersey Pine Barrens. But otherwise—and taking into consideration the caveats discussed in Guarnieri (2015)—the data suggest that *S. elevatus* has now become rare or even extirpated from much of its historic range in the Northeast.

Anderson et al. (1995) note that *S. elevatus* "is apparently scarce in Virginia." But the data here indicate this may not be entirely true. The results show that 23 of 84 dated Virginia specimens were collected within the past 30 years. As mentioned previously, one must be cautious of sampling biases and statistical aberrations in making conclusions from this type of data. For example, twelve of the most recent Virginia records are from only one location (Cheatham Annex in York Co.). Still, in comparison to the rare modern

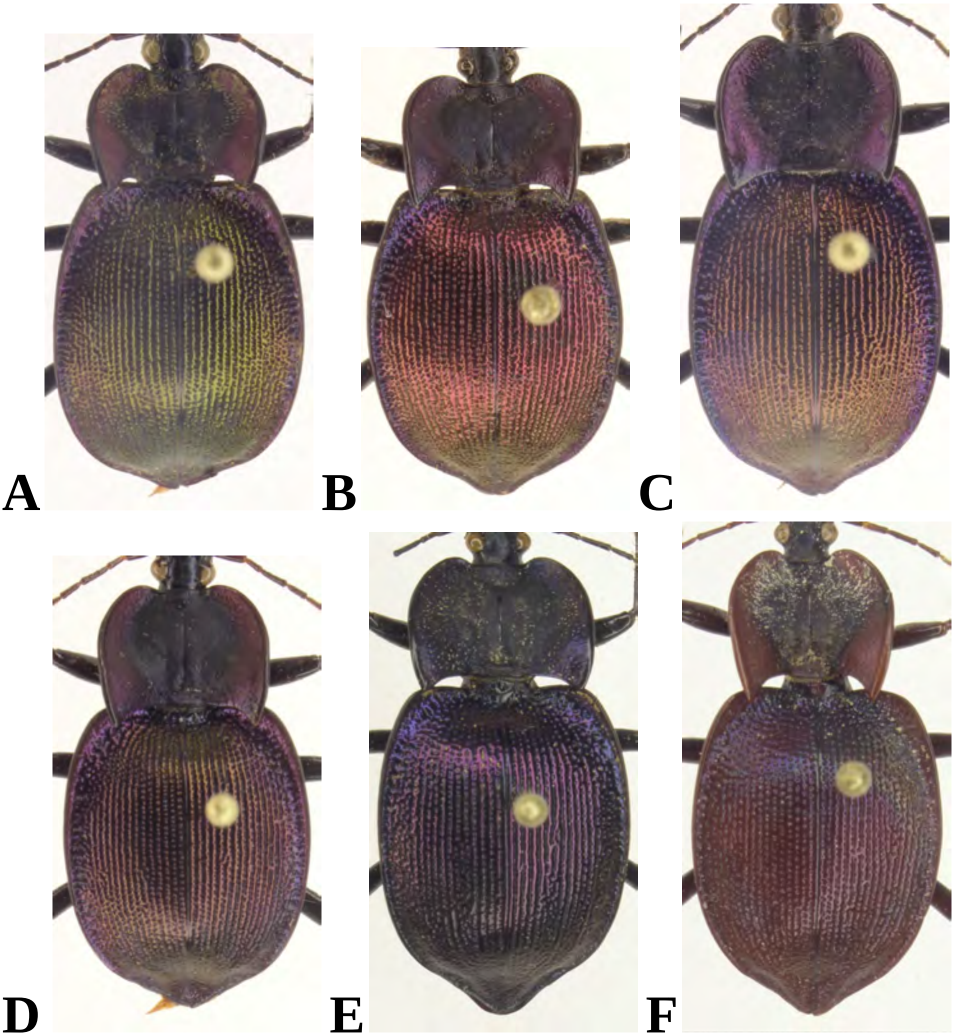

Figure 1. Variations in the color and shape of the pronotum and color of the elytra that are commonly seen in series of *Scaphinotus elevatus* (Fabricius). A. male, Delaware, Stanton, 11 May 1907 (UDCC); **B.** male, unlabeled specimen, probably Maryland, College Park, late 1800s to early 1900s (UMDC); **C.** male, Delaware, Newark, 15 October 1936 (UDCC); **D.** male, Virginia, Alexandria City, 15 September 1913 (AMNH); **E.** female, Maryland, College Park, 5 May 1915 (UMDC); **F.** male, College Park, (no day or month) 1903, (UMDC). Uncropped high resolution photos of D and E are published in Harden and Guarnieri (2017).

collecting records from the other Mid-Atlantic states, we suggest that *S. elevatus* is possibly faring much better in Virginia.

An interesting observation seen here is that 17 of the 23 modern Virginia records are from military bases (Cheatham Annex in York Co.; Fort Picket in Nottoway and Dinwiddie Counties; Marine Corps Base Quantico in Prince William, Stafford, and Fauquier Counties; Radford Army Ammunitions Plant in Pulaski and Montgomery Counties; and Naval Weapons Station Yorktown in York and James City Counties and Newport News). At first glance this may seem paradoxical, but as natural habitats in the Piedmont and Coastal Plain regions of Virginia are subjected to increasing development pressure, these military bases contain some of the largest remaining undisturbed tracts in the area. Still, sampling bias may be an issue as military bases are commonly subjected to detailed biological surveys, so it is unclear if multiple records are a reflection of abundance versus an artifact of intensive searching.

A final observation that may also relate to sampling bias is the spring and fall activity pattern observed here for *S. elevatus*. Collecting records occur every month March to December. Sixty-two records are seen March through June (including five teneral specimens in May). Thirty-one records are seen in July and August. Sixty-five records are seen September through December. September (n = 31) and May (n = 29) are the two most frequent collecting months. If the beetles are not particularly active during the mid-summer collecting season (typically July and August), this could give a false impression of rarity. What the beetles are doing or how they may avoid detection during the mid-summer months is unclear.

One clue may be found in Graves and Graves (1978). They described *S. elevatus* as "normally scarce," yet they unexpectedly discovered eleven specimens in a small hole in a clay bank on 4 July 1972 near Ludlow, Mississippi. Whether this aggregation represents a type of aestivation, or if similar behavior occurs in the Mid-Atlantic region remains to be seen. Larochelle and Larivière (2003) describe the species as being gregarious in the winter with up to 30 individuals found hibernating together (the geographic location was not given). Further reviews of the biology can be found in Larochelle and Larivière (2003) and Erwin (2007).

Photographs of a male specimen that was collected in 1913 from Alexandria City, Virginia and a female specimen that was collected in 1915 from College Park in Prince George's Co., Maryland are shown in the accompanying photo atlas by Harden and Guarnieri (2017).

Scaphinotus unicolor in the Mid-Atlantic Region

Scaphinotus unicolor is much larger (up to 30 mm [1.2 in]) and somewhat less vibrantly colored than *S. elevatus*. Bousquet (2012) lists the species from New Jersey and southwestern Illinois to northern Florida and east-central Louisiana. The survey by Guarnieri (2015) suggested a significant decline of this species north of Virginia and the data here show a similar trend.

No records of *S. unicolor* are seen from Delaware, New Jersey, or New York in any of the collections surveyed. One very old-appearing but undated specimen is seen each from Pennsylvania and West Virginia (note that Bousquet [2012] does not report this species from these two states). We suggest that Maryland now represents the northern limit for this species on the East Coast.

The District of Columbia shows no records after 1924. Many Maryland records are listed, but most are quite old. For the District of Columbia and Maryland combined, only four of 35 dated specimens were collected within the past 30 years. Ten very old-appearing but undated specimens were not included in this ratio. Steury and Messer (2017) do not report *S. unicolor* in their survey of Cove Point in Calvert Co., Maryland. However, there is limited data suggesting this species possibly still occurs in parts of central and southern Maryland. For example, we list one modern record from Baltimore (city) (2000), two records from Calvert Co. (1990 and 2003) (interesting to note that a specimen of *S. elevatus* was also collected on the same date in 1990 in Huntingtown, Calvert Co.), and an even more recent record from Howard Co. (2008). Guarnieri (2015) proposed surveys for *S. unicolor* in Maryland in areas such as Aberdeen Proving Ground in Harford Co., Cedarville State Forest in Charles and Prince George’s Counties, Patuxent Research Refuge in Anne Arundel and Prince George’s Counties, and St. Mary’s River State Park in St. Mary’s Co.

Guarnieri (2015) speculated that *S. unicolor* was locally common in Virginia based on a large series of the beetles seen at the CMNH from the Cheatham Annex in York Co. and also the surveys by Anderson et al. (1995) and Steury and Messer (2014). The data above support this notion of local abundance but also show the beetle to be widespread over the Coastal Plain of Virginia. One hundred thirty-five dated specimens are seen from Virginia, 86 of which are less than 30 years old.

Still, one needs to be cautious of sampling biases and statistical aberrations as all but 11 of the 86 most recent records are from only four locations (vicinity of Columbia in Cumberland Co., Anglers Park in Danville, “Elko Natural Area” in Henrico Co., and the three essentially adjacent sites listed from York Co.). Once again, we see that a large number of the more recent records (49) are from military bases (Cheatham Annex, Fort Lee, Marine Corps Base Quantico, and Naval Weapons Station Yorktown).

A final issue of note is the spring and fall activity pattern that was observed with *S. elevatus* appears to be even more pronounced with *S. unicolor*. Collecting records occur every month April to December. Twenty-three records are seen April through June (including one teneral specimen in April and three in May), only seven are seen from July and August, and 125 are seen September through December. September (n = 59) and October (n = 38) are the two most frequent collecting months. The second author reports collecting *S. unicolor* from Danville, Virginia in September in holes of eroding clay streambanks during the heat of day and on the bases of tree trunks at night.

The predominance of fall records over spring records noted in this survey is contradicted by Anderson et al. (1995). In that study, pitfalls were set for two six-week periods: 17 April–29 May and 30 August–11 October. They report 59 specimens in the spring but only seven in the fall. Robert L. Davidson (CMNH) (in litt.) recalls significant variability in the spring emergence of *S. unicolor* at the Edward J. Meeman Biological Station (University of Memphis) in Shelby Co., Tennessee over a five-year period. He speculates that although these beetles are quite abundant at that location, they could escape detection without setting "frost-to-frost" pitfalls. The biology is further discussed in Erwin (1981, 2007) and Larochelle and Larivière (2003).

Photographs of a male specimen of *S. unicolor* collected in 2008 from Columbia in Howard Co., Maryland and a female specimen collected in 2016 from Angler's Park in Danville City, Virginia are shown in the accompanying photo atlas by Harden and Guarnieri (2017).

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Illustrated Key and Photo Atlas of the Snail-eating Ground Beetles in the Genus *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini) Occurring in the Mid-Atlantic Region

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Abstract: An illustrated key and photo atlas are provided for all species in the genus *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini) that occur in the Mid-Atlantic region. The key will identify most *Scaphinotus* beetles in Delaware, the District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, and West Virginia.

INTRODUCTION

The snail-eating ground beetles in the genus *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini) are among the most strikingly beautiful and ecologically intriguing ground beetles in North America, yet little has been published on the eastern species in the past century. Many important questions about their natural history and phylogenetic relationships remain to be answered. Despite their attractive appearance and unique morphology, they have also gone largely unillustrated in published works.

In this paper, we provide a key and photo atlas that together should allow even the non-specialist to identify most species in the Mid-Atlantic region (defined here as Delaware, the District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, and West Virginia). According to the most recent catalog of North American carabid beetles (Bousquet 2012), 18 *Scaphinotus* species and subspecies occur within these political boundaries (Table 1).

Various aspects of the Mid-Atlantic *Scaphinotus* fauna are discussed in Glaser (1996), Guarnieri (2015), and Guarnieri and Harden (2017), such as habitat associations and trends in their historical distributions. However, those papers are limited in that they only included species that were known to occur (or possibly occur) in Maryland.

Bousquet (2010) and Ciegler (2000) are excellent and user-friendly tools for identifying *Scaphinotus* in northeastern North America and in South Carolina, respectively, yet they are inadequate for identifying many of the individuals that might be encountered in the Mid-Atlantic region. The primary reason for this is that *Scaphinotus* beetles exhibit a remarkable degree of biodiversity in the Southern Appalachians. Many of these species inhabit relatively small geographic ranges, and therefore a surprising number of taxa can be found between the areas covered by Bousquet (2010) and Ciegler (2000). This biodiversity increases in the complicated topography occurring farther south in the mountains of North Carolina and Tennessee. Thus, it is important to note that there are several additional endemic taxa existing in these highlands that are not included in Ciegler (2000) or in our paper despite the relatively small geographic gap between these two publications.

Table 1. List of *Scaphinotus* species in the Mid-Atlantic Region. Bousquet (2012) lists 18 species and subspecies that have been collected in at least one of the following jurisdictions: Delaware, the District of Columbia, Maryland, New Jersey, New York, Pennsylvania, Virginia, and West Virginia. The list is arranged alphabetically by subgenus and modified from Bousquet (2012). Nomenclature follows Bousquet (2012).

Taxon	DC	DE	MD	NJ	NY	PA	VA	WV
Subgenus *Irichroa* Newman								
Scaphinotus irregularis (Beutenmüller)							X	
Scaphinotus viduus (Dejean)	X	X	X	X	X	X	X	X
Scaphinotus webbi Bell						X	X	X
Subgenus *Maronetus* Casey								
Scaphinotus hoffmani (Barr)							X	
Scaphinotus imperfectus (G. Horn)			X			X	X	X
Scaphinotus incompletus (Schwarz)							X	
Scaphinotus schwarzi (Beutenmüller)							X	
Subgenus *Nomaretus* LeConte								
Scaphinotus bilobus (Say)					X			
Subgenus *Scaphinotus* Dejean								
Scaphinotus elevatus elevatus (Fabricius)	X	X	X	X	X	X	X	X
Scaphinotus elevatus lengi Van Dyke							X	
Scaphinotus elevatus tenebricosus Roeschke				X			X	
Scaphinotus unicolor (Fabricius)	X		X	X			X	
Subgenus *Steniridia* Casey								
Scaphinotus andrewsii amplicollis (Casey)							X	
Scaphinotus andrewsii germari (Chaudoir)							X	X
Scaphinotus andrewsii mutabilis (Casey)			X			X		X
Scaphinotus guyotii (LeConte)							X	X
Scaphinotus ridingsii monongahelae Leng			X			X	X	X
Scaphinotus ridingsii ridingsii (Bland)							X	X

Our key uses elements of Bousquet (2010), Ciegler (2000), Valentine (1935), and Barr (2009). Most of the well-known published keys for cychrine ground beetles (including Gidaspow 1973), utilize differences in the number of setae on the palps, labrum, and pronotum to separate species. This character can be problematic for three reasons: 1) rarely, the number of setae is variable; 2) commonly, the setae break off; and 3) practically, they can be difficult to see without high-quality optics, especially in the smaller species within the subgenus *Maronetus* Casey. The use of pronotal setae could not be avoided in our key; however, the photo atlas should provide a “gestalt” confirmation of species if the visualization of setae proves problematic to those without access to high-quality optics.

This key does have certain limitations that must be mentioned. For example, caution should be taken when identifying members of the subgenus *Maronetus* from the southern extreme of the Mid-Atlantic region. This group remains poorly studied, and at least one undescribed species (not included in the key) is known to occur locally in southwest Virginia. Also, our key does not separate *S. viduus* (Dejean) from *S. irregularis* (Beutenmüller) and *S. webbi* Bell due to taxonomic uncertainty. Similarly, we do not separate the named subspecies of *S. elevatus* (Fabricius) and *S. ridingsii* (Bland) because they are inadequately defined. These caveats are further described under the individual species descriptions, but overall we feel they are of only minor significance in the key’s ability to identify the vast number of *Scaphinotus* individuals that would be regularly encountered within the defined region.

Anyone familiar with carabid ground beetles can readily identify *Scaphinotus* beetles by their elongated and deeply notched labrum that resembles the letter “V” when the head is viewed dorsally (Figure 1A). Members of the closely related genus *Sphaeroderus* Dejean (Coleoptera: Carabidae: Cychrini) also have a deeply forked labrum (Figure 1B), but there are two rather than four setae at the base. This character separates *Sphaeroderus* species from all *Scaphinotus* species in the Mid-Atlantic region except members of the subgenus *Maronetus*. *Sphaeroderus* and *Maronetus* can be easily separated, however, by their size (*Sphaeroderus* > 10 mm [~ 0.4 in], *Maronetus* < 10 mm [~ 0.4 in]) and dissimilar appearances (compare Figure 2A with Figures 3–5).

Notch-mouthed ground beetles in the genus *Dicaelus* Bonelli (Coleoptera: Carabidae: Licinini) are not closely related to *Scaphinotus*, but also have a highly specialized labrum. Certain common species in the Mid-Atlantic region such as *D. purpuratus* Bonelli (Figure 2B) are superficially similar in dorsal view to *Scaphinotus* beetles that have a broad pronotum, but the former have notched rather than forked labrums (Figure 1C).

In general, there is only minor sexual dimorphism in *Scaphinotus* beetles. Males tend to be smaller than females and have larger maxillary and labial palps, and in most species the protarsal segments are dilated. Several male and female pairs are shown below to portray these characteristics (Figures 4, 7, 10, and 11).

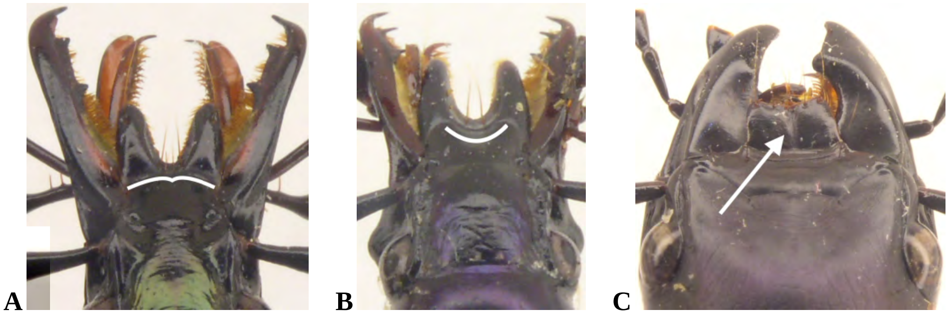

Figure 1. Comparison of features separating *Scaphinotus*, *Sphaeroderus*, and *Dicaelus*. A. *Scaphinotus* species typically have four setae at the base of the labral emargination (The middle two setae are often small and difficult to visualize. The subgenus *Maronetus* has only two setae – see text for details). Also, the anterior edge of the clypeus (white line) is straight, mildly convex, or slightly sinuate (See also Figure 13.). The entire beetle is shown in Figure 8. *Scaphinotus viduus*, West Virginia, Pocahontas Co., 6.4 km (4 mi) northwest of Hillsboro, 30 July 2015 (Frank G. Guarnieri collection). **B. *Sphaeroderus*** species have only two setae at the base of the labral emargination and the anterior edge of the clypeus (white line) is distinctly concave. The entire beetle is shown in Figure 2A. *Sphaeroderus schaumii* Chaudoir, Virginia, Fauquier Co., 4.8 km (3 mi) northeast of Linden, 19 May 2016 (Frank G. Guarnieri collection). **C. *Dicaelus*** species have a distinct notch in the labrum (white arrow) but not a deep emargination. The entire beetle is shown in Figure 2B. *Dicaelus purpuratus*, Maryland, Worcester Co., Pocomoke City, 11 August 2010 (Frank G. Guarnieri collection).

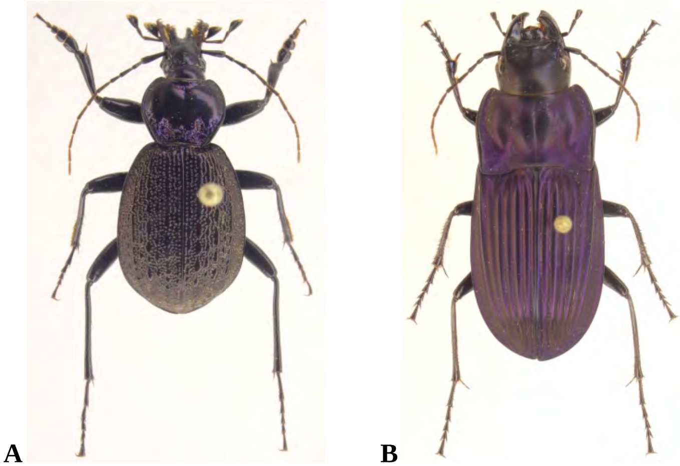

Figure 2. Representatives of two Mid-Atlantic genera that could be confused with *Scaphinotus*. See Figure 1 for further details. **A. *Sphaeroderus schaumii***, Virginia, Fauquier Co., 4.8 km (3 mi) northeast of Linden, 19 May 2016, 17.5 mm (0.7 in) (Frank G. Guarnieri collection). **B. *Dicaelus purpuratus***, Maryland, Worcester Co., Pocomoke City, 11 August 2010, 29 mm (1.1 in) (Frank G. Guarnieri collection).

ILLUSTRATED KEY AND PHOTO ATLAS TO MID-ATLANTIC SCAPHINOTUS BEETLES

1a. Small (10.5 mm [0.4 in] or less); body slender, dorsal surface shiny black or chestnut brown, without metallic sheen (subgenus *Maronetus*, Figures 3–5)..................................2
1b. Usually larger (10–33 mm [0.4–1.3 in]); body shape various, dorsal surface with metallic sheen (Figures 6–8, 10–12, 14, 15–17)..5

2a. Elytra each with two rows of discal setae; known from vicinity of Whitetop Mountain and Mount Rogers, Virginia...***S.* (*Maronetus*) *schwarzi*** (specimen unavailable for imaging)
2b. Elytra without discal setae...3

3a. Pronotum with marginal bead incomplete; if present, often obliterated and indistinct; elytral epipleuron without punctate margin adjacent to abdomen; widespread in Mid-Atlantic Appalachian region....................................***S.* (*Maronetus*) *imperfectus*** (Figure 3)
3b. Pronotum with marginal bead complete and distinctly impressed; elytral epipleuron with strongly punctate margin adjacent to abdomen; beetle from southwestern Virginia (Figures 4–5)..4

4a. Elytra each with 3 well-impressed abbreviated striae; males with protarsomeres 1–3 expanded, first protarsomere with ventral surface nearly entirely covered with spongy adhesive setae; known from Scott Co., Virginia, near Dungannon ....***S.* (*Maronetus*) *hoffmani*** (Figure 4)
4b. Elytra each with 5 or more well-impressed, less abbreviated striae; males with protarsomeres 1–3 hardly expanded, first protarsomere with less than half of ventral surface covered by adhesive setae; in the Mid-Atlantic region known only from vicinity of Stone Creek in Lee Co., Virginia......................***S.* (*Maronetus*) *incompletus*** (Figure 5)

5a Pronotum with four or more lateral setae on each side; body length 14 mm (0.6 in) or less; primarily boreal species, in the Mid-Atlantic region known only from upstate New York ....***S.* (*Nomaretus*) *bilobus*** (Figure 6)
5b. Pronotum without or with no more than two lateral setae on each side; body length greater than 14 mm (0.6 in) (Figures 7–8, 10–12, 14, 15–17)..6

6a. Pronotum with wide, markedly reflexed margins, especially prominent at the base (Figures 7–11)...7
6b. Pronotum with normal or narrowly reflexed margins (subgenus *Steniridia*, Figures 12, 14, 15–17)..9

7a. Pronotum narrowed at base, hind angles not strongly projected over the humeral portion of elytra...***S.* (*Irichroa*) *viduus*** (Figures 7 and 8)
7b. Pronotum wider at base, hind angles forming wings that project over the humeral portion or the elytra (subgenus *Scaphinotus*, Figures 9–11)..8

8a. Smaller (less than 24 mm [0.9 in]); pronotum usually proportionately wider (two-thirds or greater elytra width); disc of pronotum dull and wrinkled; pronotum without linear sulcus at hind angle (Figure 9A).....................***S.* (*Scaphinotus*) *elevatus*** (Figure 10)
8b. Larger (25 mm [1.0 in] or greater); width of pronotum usually proportionately narrower (less than two-thirds of elytra width); disc of pronotum smooth, shiny; pronotum with linear sulcus parallel to margin at hind angle (Figure 9B) ....
....***S.* (*Scaphinotus*) *unicolor*** (Figure 11)

9a. Dorsal coloration brilliant metallic purple; elytra flatter, striae regular and uninterrupted, even on sides; smaller (20 mm [0.8 in] or less) ....
....***S.* (*Steniridia*) *ridingsii*** (Figure 12)
9b. Dorsal coloration various; elytra more convex, striae irregular, with interruptions forming confluent costae, especially on sides; larger (usually greater than 20 mm [0.8 in]) (Figures 14, 15–17)...10

10a. Body length 25 mm (1.0 in) or greater; labrum with broader emargination that ends farther from anterior margin of clypeus (Figure 13A); in the Mid-Atlantic region known only from southwest Virginia and southern West Virginia ....
....***S.* (*Steniridia*) *guyotii*** (Figure 14)
10b. Body length less than 25 mm (1.0 in); labrum with narrower emargination that nearly reaches anterior margin of clypeus (Figure 13B); widespread in the Mid-Atlantic Appalachian region; *S.* (*Steniridia*) *andrewsii* subspecies complex (Figures 15–17).......11

11a. Beetle from the southern Blue Ridge in Virginia; pronotum more pronouncedly cordate (heart-shaped).............................***S.* (*Steniridia*) *andrewsii amplicollis*** (Figure 15)
11b. Beetle from west of the Blue Ridge, in southern Virginia and southern West Virginia; pronotum narrower, not pronouncedly cordate ....
....***S.* (*Steniridia*) *andrewsii germari*** (Figure 16)
11c. Beetle from highlands of the Ohio River watershed: southwestern Pennsylvania, western Maryland, and central and northern West Virginia; pronotum still narrower, sides straighter..***S.* (*Steniridia*) *andrewsii mutabilis*** (Figure 17)

Figure 3. *Scaphinotus* (*Maronetus*) *imperfectus* female. Virginia, Botetourt Co., Cornelius Creek Trail, N37.52° W79.55°, 27 August 2016, 8.5 mm (0.3 in) (Curt W. Harden collection).

A  **B** 

Figure 4. *Scaphinotus* (*Maronetus*) *hoffmani*. A. Male, 8 mm (0.3 in). **B. Female**, 8.5 mm (0.3 in). Both specimens: Virginia, Scott Co., 4.8 km (3 mi) northeast of Dungannon, Little Stony Trail, N36.86° W82.44°, 17 June 2106 (Curt W. Harden collection).

Figure 5. *Scaphinotus* (*Maronetus*) *incompletus* male. Kentucky, Laurel Co., Daniel Boone National Forest, East of Cumberland Falls State Park, 7 July 2014, 9.5 mm (0.4 in), collector: Todd Lawton (Curt W. Harden collection).

Figure 6. *Scaphinotus* (*Nomaretus*) *bilobus* female. Canada, Manitoba, 10 km (6.2 mi) east of Libau, 28 July 2012, 15 mm (0.6 in), collector: Todd Lawton (Curt W. Harden collection).

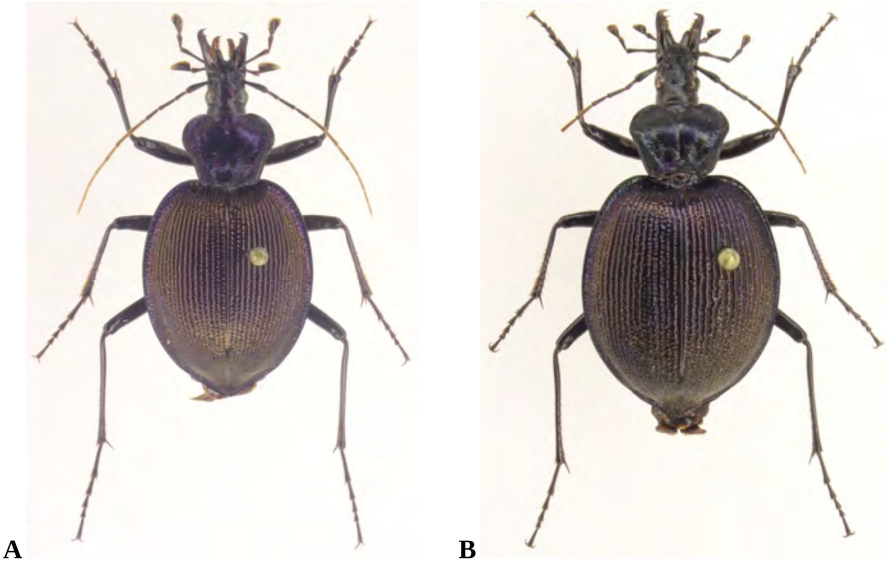

Figure 7. *Scaphinotus* (*Irichroa*) *viduus*. A. Male, Delaware, New Castle Co., White Clay Creek State Park, 26 June 2000, 28 mm (1.1 in), collector: Verryn Jennings (University of Delaware Insect Reference Collection [UDCC]). **B. Female**, Delaware, New Castle Co., White Clay Creek State Park, 3 September 2011, 33 mm (1.3 in), collector: Ashley Kennedy (UDCC).

Figure 8. *Scaphinotus* (*Irichroa*) *viduus* male (green highland morph). West Virginia, Pocahontas Co., 6.4 km (4 mi) northwest of Hillsboro, 30 July 2015, 24 mm (0.9 in) (Frank G. Guarnieri collection).

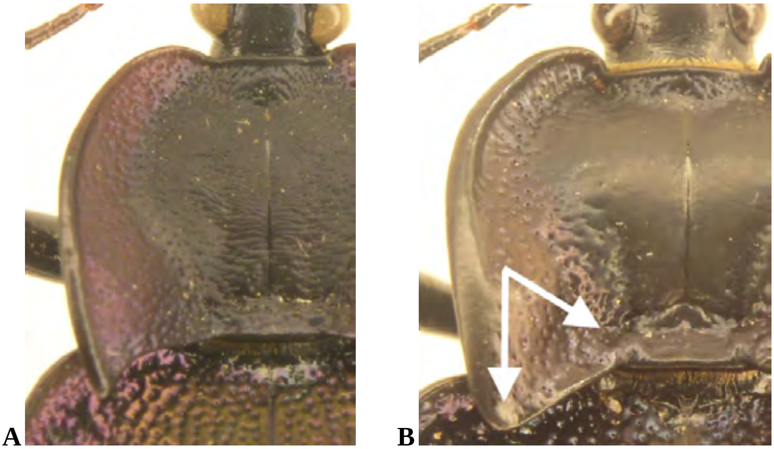

Figure 9. Comparison of pronota in *Scaphinotus* beetles in the subgenus *Scaphinotus*. A. *Scaphinotus elevatus*: The central portion of the pronotum is rough and the reflexed basal wing is flat. The entire beetle is shown in Figure 10A. Virginia, Alexandria City, 15 September 1913 (American Museum of Natural History [AMNH]). **B. *Scaphinotus unicolor***: The central portion of the pronotum is smooth and the reflexed basal wing contains a sulcus running between the two white arrows. The entire beetle is shown in Figure 11B. Virginia, Danville City, Angler's Park, 18 September 2016 (Curt W. Harden collection).

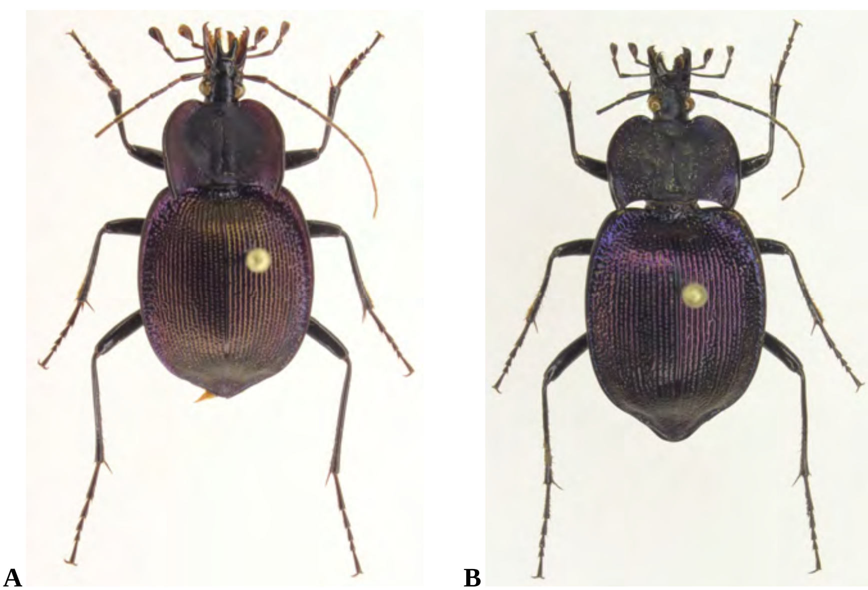

Figure 10. *Scaphinotus* (*Scaphinotus*) *elevatus*. A. Male, Virginia, Alexandria City, 15 September 1913, 23 mm (AMNH). **B. Female**, Maryland, Prince George's Co., College Park, 5 May 1915, 22 mm (0.9 in) (University of Maryland College Park [UMDC]).

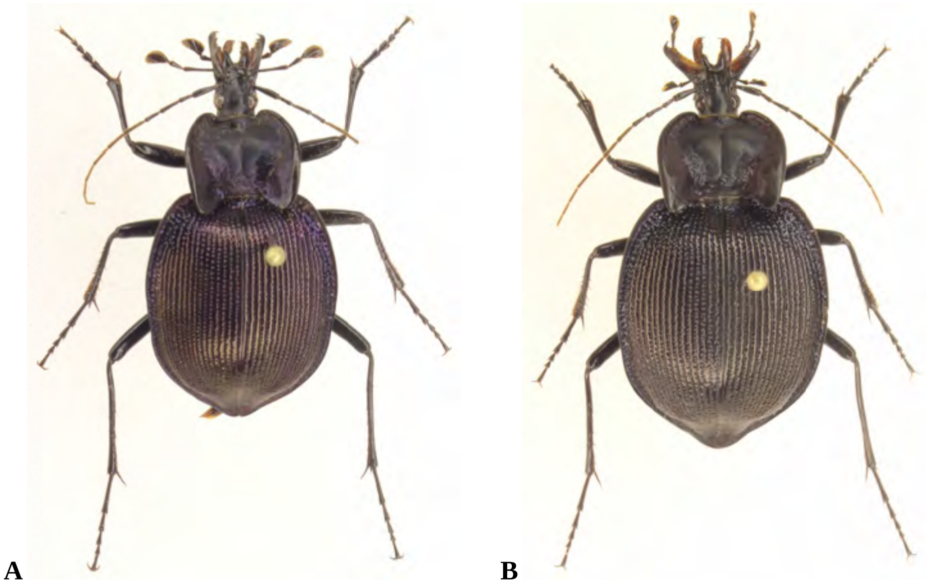

Figure 11. ***Scaphinotus* (*Scaphinotus*) *unicolor*. A. Male**, Maryland, Howard Co., Columbia, 12 October 2008, 26 mm (1.0 in), collector B.C. Cramer (UDCC). **B. Female**, Virginia, Danville City, Angler's Park, N36.56° W79.35°, 18 September 2016, 28 mm (1.1 in), collector Curt W. Harden (Frank G. Guarnieri collection).

Figure 12. ***Scaphinotus* (*Steniridia*) *ridingsii* female.** West Virginia, Pocahontas Co., 6.4 km (4 mi) northwest of Hillsboro, 1 August 2015, 16.5 mm (0.6 in) (Frank G. Guarnieri collection).

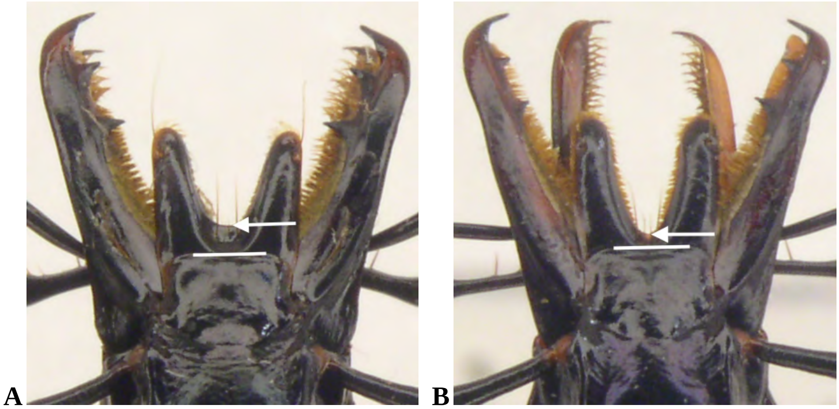

Figure 13. Comparison between the distance from the base of the emargination of the labrum to the anterior edge of the clypeus in *Scaphinotus* beetles in the subgenus *Steniridia*. A. *Scaphinotus guyotii*: The base of the labral cleft (white arrow) is far from the anterior edge of the clypeus (white line). The entire beetle is shown in Figure 14. Virginia, Scott Co., 4.8 km (3 mi) northeast of Dungannon, 17 June 2016 (Curt W. Harden collection). **B. *Scaphinotus andrewsii mutabilis***: The base of the labral cleft (white arrow) is close to the anterior edge of the clypeus (white line). The entire beetle is shown in Figure 17. West Virginia, Pocahontas Co., Hillsboro, 1 August 2015 (Frank G. Guarnieri collection).

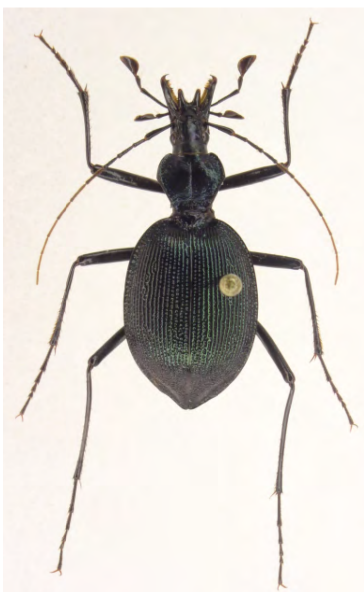

Figure 14. *Scaphinotus* (*Steniridia*) *guyotii* male. Virginia, Scott Co., 4.8 km (3 mi) northeast of Dungannon, Little Stony Trail, 17 June 2016, 24 mm (0.9 in) (Curt W. Harden collection).

Figure 15. ***Scaphinotus* (*Steniridia*) *andrewsii amplicollis* male.** Virginia, Smyth Co., N36.72° W81.49°, 19 June 2016, 21 mm (0.8 in) (Curt W. Harden collection).

Figure 16. ***Scaphinotus* (*Steniridia*) *andrewsii germari* female.** Virginia, Scott Co., 4.8 km (3 mi) northeast of Dungannon, N36.86° W82.44°, Little Stony Trail, 17 June 2016, 23 mm (0.9 in) (Curt W. Harden collection).

Figure 17. *Scaphinotus* (*Steniridia*) *andrewsii mutabilis* male. West Virginia, Pocahontas Co., 6.4 km (4 mi) northwest of Hillsboro, 1 August 2015, 21.5 mm (0.8 in) (Frank Guarnieri collection).

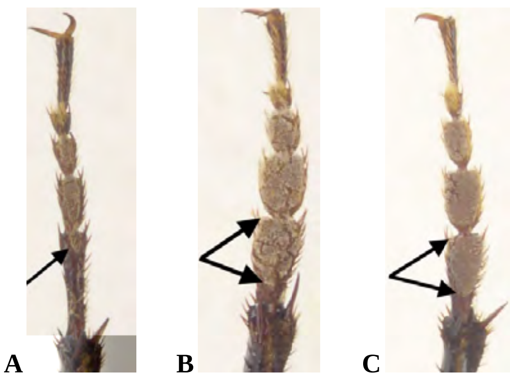

Figure 18. Comparison of the first protarsomere segment between male *Scaphinotus* beetles in the subgenus *Steniridia*. A. *Scaphinotus guyotii*: The first segment is long, narrow, and the ventral surface has only a tiny patch of pale distal setae (black arrow). The entire beetle is shown in Figure 14. Virginia, Scott Co., 4.8 km (3 mi) northeast of Dungannon, 17 June 2016 (Curt W. Harden collection). **B. *Scaphinotus andrewsii amplicollis***: The first segment is shorter, wider, and almost completely covered in setae (black arrows). The entire beetle is shown in Figure 15. Virginia, Smyth Co., N36.72° W81.49°, 19 June 2016 (Curt W. Harden collection). **C. *Scaphinotus andrewsii mutabilis***: The first segment is slightly longer and narrower than that of *S. a. amplicollis*, but the ventral surface is also mostly covered with setae (black arrows). The entire beetle is shown in Figure 17. West Virginia, Pocahontas Co., Hillsboro, 1 August 2015 (Frank G. Guarnieri collection).

SPECIES ACCOUNTS

(Accounts are listed alphabetically by subgenus, species, and subspecies.)

Subgenus *Irichroa* Newman

***Scaphinotus* (*Irichroa*) *irregularis* (Beutenmüller)** (not figured; not included in the key)
Scaphinotus irregularis is a species very similar to *S. viduus* whose taxonomic status is uncertain. Hoffman et al. (2006) support recognition of this taxon as a valid species distinct from *S. viduus*, but provide no further details to support its validity. In the excellent illustrations accompanying his original description, Beutenmüller (1903) shows the distinctive "irregular" sculpture of the elytra. The even-numbered intervals are obliterated by large irregular punctures, forming a scattered mesh separated by the alternate intervals, which form straight, elevated costae. More extensive collecting has revealed a degree of variation in the elytral texture of *S. irregularis* and *S. viduus* that challenges the original species concepts. Beutenmüller also cites the dark, nearly black color of *S. irregularis* to separate it from *S. viduus*. However, all the specimens identified as *S. irregularis* in the Virginia Museum of Natural History (VMNH) collection are a frosty metallic green. These were all collected in Grayson Co., Virginia, in the vicinity of Mount Rogers and Whitetop Mountain.

***Scaphinotus* (*Irichroa*) *viduus* Dejean** (Figure 7)
Scaphinotus viduus, along with *S. webbi* and *S. irregularis*, is the largest *Scaphinotus* beetle in the Mid-Atlantic region (24–33 mm [0.9–1.3 in]). The size and general appearance of *S. viduus* is distinctive, but in the southern Appalachians and adjacent foothills it could easily be confused with *S. webbi* and *S. irregularis*. There is a great deal of taxonomic uncertainty regarding the relationship between these three species. There is an additional *S. viduus*-like population restricted to the high elevations of south-central West Virginia (Figure 8) distinguished mainly by its brilliant solid-green color that may eventually prove to be specifically distinct (see discussions in Guarnieri 2015 and Barr 1969). *Scaphinotus viduus* itself is variable in color, but the typical coloration shows bright purple elytra contrasting with a darker, more bluish forebody.

***Scaphinotus* (*Irichroa*) *webbi* Bell** (not figured; not included in the key)
Scaphinotus webbi was described from a single male specimen collected near Lynchburg, Virginia (Bell 1959), possessing a pronotum shaped like *S. viduus*, but with reflexed margins nearly as wide as in *S. unicolor*. The aedeagus shows unusual characters as well that led Bell to conclude this was a distinct species. As is briefly discussed by Hoffman et al. (2006), the accumulation of larger series of *S. viduus*-like individuals in Virginia has revealed a great deal of variation in all these characters, such that the two species cannot be separated based on Bell's original description.

Subgenus *Maronetus* Casey

***Scaphinotus* (*Maronetus*) *hoffmani* (Barr)** (Figure 4)
Scaphinotus hoffmani is known only from a few specimens, all collected at the type locality in Scott Co., Virginia, near Dungannon. This species has been found on steep

hillsides, occupying isolated pockets of deep moist litter occurring in otherwise dry terrain.

***Scaphinotus* (*Maronetus*) *imperfectus* (Horn)** (Figure 3)
Scaphinotus imperfectus is the most common and widespread member of the subgenus *Maronetus*. It is distinguished from the other species in the Mid-Atlantic region by the pronotum, which lacks a distinct marginal bead. At lower latitudes, the species is most commonly found in deep moist litter near rocky streams. At high elevations and higher latitudes, it can be found away from water, under stones and logs as well as in deep litter.

***Scaphinotus* (*Maronetus*) *incompletus* (Schwarz)** (Figure 5)
Scaphinotus incompletus is a rare species known from only four localities in Kentucky and Virginia. It occurs in the Cumberland Mountains and Cumberland Plateau, and has been found in leaf litter at the base of rock faces as well as under large embedded stones on wooded hillsides.

***Scaphinotus* (*Maronetus*) *schwarzi* (Beutenmüller)** (specimen unavailable for imaging)
Scaphinotus schwarzi occurs mostly in the Black Mountains of western North Carolina. A single specimen has been collected in Virginia, near Whitetop Mountain in Grayson Co.. The beetle was found in litter beside a small rivulet (Hoffman et al. 2006).

Subgenus *Nomaretus* LeConte

***Scaphinotus* (*Nomaretus*) *bilobus* (Say)** (Figure 6)
Scaphinotus bilobus is primarily a northern species in the eastern United States. In the Mid-Atlantic region, it has been found only at high altitudes in upstate New York. The species is rare and usually found only by extensive pitfall trapping in suitable habitat.

Subgenus *Scaphinotus* Dejean

***Scaphinotus* (*Scaphinotus*) *elevatus* (Fabricius)** (Figure 10)
Scaphinotus elevatus is a rarely encountered species in the Mid-Atlantic region, usually occurring in open habitats at low elevations. Like *S. bilobus*, it is usually found through long-term pitfall sampling rather than intentional hand-collecting. Guarnieri and Harden (2017) discuss in detail the paucity of recent collection records from the region. Two additional subspecies, *S. e. lengi* and *S. e. tenebricosus* are described from the Mid-Atlantic region, but their validity is doubtful (Van Dyke 1938, Erwin 2007)

***Scaphinotus* (*Scaphinotus*) *unicolor* (Fabricius)** (Figure 11)
Scaphinotus unicolor is a species of relatively low elevations. Based on collection data, it most often occurs in more forested habitat than *S. elevatus*. Large series have been collected in Virginia (Anderson et al. 1995; Guarnieri and Harden 2017), but the species may have suffered in the northern extreme of its range due to loss of suitable habitat (Guarnieri and Harden 2017). Like *S. viduus* and species of the subgenus *Steniridia*, *S. unicolor* can most easily be encountered by checking tree trunks at night in suitable habitat.

Subgenus *Steniridia* Casey

***Scaphinotus* (*Steniridia*) *andrewsii* (Harris)** (Figures 15–17)
Scaphinotus andrewsii is distributed widely throughout the middle and southern Appalachians and was arranged into numerous subspecies by J. M. Valentine (1935, 1936). The subspecies are allopatric so geographic occurrence is the easiest character for putting a subspecies name on an *S. andrewsii*, in addition to the morphological features listed for each below.

***Scaphinotus* (*Steniridia*) *andrewsii amplicollis* (Casey)** (Figure 15)
Scaphinotus a. amplicollis mostly occurs in the Black Mountains of North Carolina but reaches its northernmost extent in southwestern Virginia. It is relatively distinctive among the S. andrewsii subspecies due to the markedly cordate pronotum and the greatly-expanded front tarsomeres of the males. The first male protarsomere is almost completely covered by adhesive vestiture on its ventral side (Figure 18B); in other subspecies occurring in the Mid-Atlantic, the coverage is less extensive.

***Scaphinotus* (*Steniridia*) *andrewsii germari* (Chaudoir)** (Figure 16)
Scaphinotus a. germari is primarily distributed in the Cumberland Mountains of Tennessee, Kentucky, and Virginia, though it has also been recorded from south-central West Virginia. It is very difficult to separate from *S. a. mutabilis* based on morphological characters. Both subspecies have a narrowed pronotum and reduced adhesive vestiture on the front tarsomeres of the males, but in *S. a. germari* the pronotum is slightly less narrowed and the adhesive vestiture is slightly more reduced.

***Scaphinotus* (*Steniridia*) *andrewsii mutabilis* (Casey)** (Figure 17)
Scaphinotus a. mutabilis inhabits the Ohio River valley and the highlands of its watershed according to Valentine (1936). Morphologically, it differs from *S. a. germari* by having an even more narrowed pronotum and a slightly more extensive covering of adhesive vestiture on the underside of the male front tarsomeres (Figure 18C).

***Scaphinotus* (*Steniridia*) *guyotii* (LeConte)** (Figure 14)
Scaphinotus guyotii is the largest species of the subgenus *Steniridia*. Like *S. viduus*, *S. unicolor*, *S. irregularis*, and *S. webbi*, this species has extremely reduced adhesive vestiture on the underside of the male front tarsomeres (Figure 18A). In the Mid-Atlantic region, it is known to occur only in southwestern Virginia and the New River Gorge in Fayette Co., West Virginia. It is quite variable in its appearance throughout its range and exists at a wide range of altitudes, often in the same habitats as *S. andrewsii*.

***Scaphinotus* (*Steniridia*) *ridingsii* (Bland)** (Figure 12)
Scaphinotus ridingsii is the smallest and smoothest member of the subgenus *Steniridia*. Two subspecies are currently recognized: *S. r. ridingsii*, occurring in the Potomac River Gorge in Northern Virginia, and *S. r. monongahelae*, occurring in Allegheny highlands and valleys. These subspecies concepts were accepted at a time when very few specimens were known and only from within these isolated regions. Valentine (1935), the most recently published taxonomic treatment of the species, characterized *S. ridingsii* as "… now found broken up into distinct races each occupying a river valley at relatively low

altitudes” with intervening highlands serving to separate them. Modern collecting has shown *S. ridingsii* to be more generally distributed, and certainly not isolated at low elevations (data from VMNH and the Carnegie Museum of Natural History [CMNH] collections; also note that the beetle shown in Figure 12 was collected at an elevation close to 1.2 km [4000 ft]). Much of the material seen fails to meet Valentine’s characterization of the subspecies, and since no published modern revision is available, no more can accurately be said concerning their validity and separation.

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Three Carabid Beetles (Coleoptera: Carabidae) New to Maryland and a Preliminary Annotated Checklist for Cove Point, Calvert County, Maryland

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Abstract: Sixty-nine carabid species (Coleoptera: Carabidae) in 37 genera and 19 tribes were documented from Cove Point, Calvert County, Maryland, during surveys from 2010 to 2016. Three species, *Anisodactylus haplomus* Chaudoir, *Pterostichus permundus* (Say), and *Stenocrepis mexicana* (Chevrolat) are documented for the first time from Maryland. A preliminary annotated checklist for Cove Point is provided. 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. Two species are adventive to North America.

INTRODUCTION

The well-known family Carabidae, whose adult (imago) members are informally called ground beetles, is one of the largest families of beetles in the world. The global systematic list by Lorenz (2005) accounted for 33,920 extant species according to his concept of the family which omits both Trachypachidae (false ground beetles) and Rhysodidae (wrinkled bark beetles). For North America north of Mexico, Bousquet (2012) cited 2664 carabid species-group taxa (species and subspecies). However, the list in that catalogue was carefully rechecked by the second author (PWM) and found actually to contain 2666 taxa. An ongoing post-2012 registry of new species, new taxonomic placements, and new geographic records affecting the North American Caraboidea is available online at http://bugguide.net/node/view/744417 (BugGuide 2016).

Ground beetles exhibit wide diversity in body form, coloration, and habitat preferences. Most adults are somber black befitting their mostly nocturnal activity. However, nearly every conceivable color is represented. Some are brightly bicolored or strikingly iridescent. Most are opportunistic omnivores favoring carnivory, though some lineages are largely herbivorous, favoring seeds. Some ground beetles are blind (e.g., genus *Anillinus* Casey) while others have eyes that are disproportionately large for their body size (e.g., genus *Notiophilus* Duméril). Many are strong fliers with well-developed wings, some are flightless with short or rudimentary wings, and still other species display wing polymorphism. Many genera are capable of producing rank defensive odors and sprays using chemicals stored in the pygidial glands of their abdomens. The genus *Brachinus* Weber can fire rounds of hot gas (100° C [212° F]) from their abdominal tips, capable of killing small adversaries. Body lengths of ground beetles range from just over 1 mm (0.04 in) in the North American species *Polyderis laeva* (Say), to 100 mm (3.9 in) in the south Asian genus *Mormolyce* Hagenbach. The largest species in our area at 30 to 36 mm (1.2–1.4 in) include the brilliant green, caterpillar hunting *Calosoma scrutator* (Fabricius); the brightly violaceous, snail-eating *Scaphinotus unicolor* (Fabricius); and the locally rare *Pasimachus depressus* (Fabricius) (possibly extirpated in the Washington, DC area) which is a generalist predator of insect larvae.

Ground beetles occupy a wide variety of habitats. *Platypatrobus lacustris* Darlington lives only in the walls and floor bedding of active or recently deserted beaver lodges (Bousquet 2012; Robert L. Davidson, in litt., 7 April 2017) and *Elaphropus saturatus* (Casey) can survive tidal submersion for at least six hours (Steury and Messer 2014). Some are strong diggers found in subsurface habitats, some are cave specialists, and others are primarily arboreal. They are found in swamps and marshes, upland forests, meadows, and deserts, from below sea level to 5,300 m (17,389 ft) in elevation (Mani 1968). It is not uncommon to find ground beetles in human habitations. Many species overwinter as adults. Adults live two to four years and the life cycle is completed within one year. Pupation occurs in the ground or in rotting wood and has been reported under the bark of dead standing trees and logs in the Tropics (Erwin and Erwin 1976). Carabid fossils are common in Quaternary age deposits, many representing extant species, and have been found in sediments as old as the late Tertiary Period (Matthews 1979, Matthews and Telka 1997).

Despite so much diversity, ground beetles share several anatomic similarities. Carabid antennae are inserted laterally between the circular eye and mandibular cavity (scrobe), or in tiger beetles (Cicindelinae), on the frons medial to the mandibular base. Abdomens consist of six visible segments called sterna, except in *Brachinus* species which have seven to eight. Tarsi have five segments, except in a couple of European anillines (subtribe Anillina [Bembidiini]) which have four. The front tibiae contain a comb-like structure used by the beetle for cleaning its antennae, or possess a longitudinal sulcus without a comb. The enlarged hind trochanters and long legs are adapted for running. The mouthparts project forward (prognathous) with prominent mandibles.

Recent ground beetle surveys of national parks near Washington, DC, have documented 192 species (Steury and Messer 2014, Steury et al. 2014, Steury and Messer 2015). Other recent studies at Quantico Marine Corps Base in Prince William and Stafford Counties, Virginia, documented 114 species (Hoffman 2010), and at Eastern Neck National Wildlife Refuge in Kent County, Maryland, 80 species were recorded (Staines and Staines 2011). Carabid inventories between 1970 and 1984 on Plummers Island in the Potomac River Gorge of Montgomery County, Maryland, yielded 117 species (Erwin 1981, Stork 1984). However, 214 carabid beetle species have been collected on Plummers Island over the last 100 years based on literature reviews and historical collections at the Smithsonian Institution, National Museum of Natural History (Erwin 1981, Brown 2008). Bousquet (2012) documented 414 carabid beetles from Maryland, and Steury et al. (2014) and this report added a total of five additional species bringing the current Maryland total to 419 species.

STUDY SITE

Cove Point, located at approximately 38º23′ north latitude, 76º24′ west longitude in Calvert County, Maryland, contains 406 ha (1,003 ac) owned by the Dominion Cove Point Liquefied Natural Gas (LNG) Limited Partnership. This area is bordered to the southwest by Cove Point Road, to the east by the Chesapeake Bay, and extends north almost to the main stem of Grays Creek. The site contains brackish and freshwater marshes separated by a barrier dune, the LNG industrial complex (44 ha [109 ac]), and upland areas (285 ha [704 ac]) which are comprised of young mixed deciduous and coniferous forest, managed meadows and lawns, ponds, creeks, and seeps. The 77 ha (190 ac) freshwater marsh lies within the truncated cuspate foreland of Cove Point Cape. The brackish marsh was created in 2010 by constructing an armor stone breakwater along the beach front to protect the freshwater marsh from breaches of the barrier dune. At least 698 vascular plant species have been documented from this area (Steury 2002). The freshwater wetlands are dominated by narrowleaf cattail (*Typha angustifolia* L.) and the non-native grass, common reed (*Phragmites australis* [Cav.] Trin. ex Steud.). The now well-developed brackish marsh is dominated by smooth cordgrass (*Spartina alterniflora* Loisel.). The upland canopy is dominated by chestnut oak (*Quercus montana* Willd.), although black oak (*Quercus velutina* Lam.), scarlet oak (*Quercus coccinea* Münchh.), mockernut hickory (*Carya tomentosa* [Lam.] Nutt.), and sand hickory (*Carya pallida* [Ashe] Engl. & Graebn.) are also common along with the conifers Virginia pine (*Pinus virginiana* Mill.) and loblolly pine (*Pinus taeda* L.). American holly (*Ilex opaca* Aiton.) occurs in the midstory while the shrub layer is dominated by patches of mountain laurel (*Kalmia latifolia* L.), highbush blueberry (*Vaccinium corymbosum* L.), Blue Ridge blueberry (*V. pallidum* Aiton), and black huckleberry (*Gaylussacia baccata* (Wangenh.) K. Koch).

CLIMATE

Cove Point lies in the Temperate Continental climate zone (Trewartha and Horn 1980). There is no distinct dry season and summers are hot and winters are mild. The mean daily maximum temperature was 19.6° C (67.3° F) and the mean daily minimum temperature 6.9° C (44.4° F) between 1951 and 1980. Mean annual precipitation is approximately 108 cm (42.5 in). Snowfall measuring 0.25 cm (0.1 in) or more occurs on an average of 72 days per year with a mean annual accumulation of 46.7 cm (18.4 in). Average frost penetration is about 12.7 cm (5.0 in) along the coast of southern Maryland (Ruffner and NOAA 1985).

SOILS

Upland soils are primarily composed of Evesboro loamy sand and Sassafras fine sandy loam. Soils are very deep and excessively well-drained. They contain low available moisture and are strongly to extremely acidic. Soils of Cove Point wetlands are mixed alluvial and consist of areas of saturated sand, peat, or muck. Elevations at Cove Point range from sea level to 34 m (112 ft) above sea level (Matthews 1971).

MATERIALS AND METHODS

Incidental collections of carabid beetles were made at Cove Point between 2010 and 2014, usually on two days per year in June and September while conducting vegetation monitoring at the marsh. In 2015, six days of survey effort targeted at land snails provided opportunities to collect carabid beetles, as well. In 2016, focused efforts to collect carabid beetles were conducted on 5, 12, 26, and 30 May; 13 June; and 16 and 19 September. Most specimens were obtained by looking under driftwood on the beach or barrier dune. Other productive sites were beneath loose bark of fallen trees, and under logs or stones in woods and meadows. Areas near vernal pools were especially productive. All collecting was done by hand picking. Splashing (pouring 3.8 L [1 gal] of water on soil) near vernal pools and along the edge of the salt marsh brought many species to the surface that would have otherwise gone undetected. Specimens are deposited at the Smithsonian Institution, National Museum of Natural History (NMNH).

RESULTS

A total of 69 carabid species in 37 genera and 19 tribes was documented from Cove Point. The most commonly collected genera were *Anisodactylus* Dejean (9), *Bembidion* Latreille (6), and *Cicindela* Linnaeus (4). Three species, *Anisodactylus haplomus* Chaudoir, *Pterostichus permundus* (Say), and *Stenocrepis mexicana* (Chevrolat) are documented for the first time from Maryland. Fourteen species found at Cove Point were not found at national park sites near Washington, DC, during recent inventories by Steury and Messer (2014), Steury et al. (2014), or Steury and Messer (2015). Although eight carabid species adventive to North America were found near the District of Columbia by Steury and Messer (2014), only two, *Amara familiaris* (Duftschmid) and *Harpalus affinis* (Schrank), were found at Cove Point. As recently as 1997, the federally-threatened *Habroscelimorpha dorsalis dorsalis* (Say), Eastern Beach Tiger Beetle, was found on the beach/dune habitats at Cove Point. This population was as high as 707 individuals in 1990; however, by 1997 the population had declined to only 32 individuals (Knisley 1997). By 2000, no *H. d. dorsalis* were found at Cove Point, and despite ample search effort in its habitat in 2015 and 2016, no *H. d. dorsalis* were observed.

LIST OF SPECIES

Taxa are listed by tribe following the nomenclature and taxonomic order used by Bousquet (2012). The number of each species collected or observed is indicated in parentheses after each taxon. The periods of adult activity are given based on dates when taxa were collected or observed at Cove Point. A taxon is noted as “common” if it was routinely encountered during surveys. Dates separated by a hyphen indicate that the taxon was documented on at least one day during each month of the stated interval, whereas dates separated by a comma represent individual observation dates. The habitat associations are described for each taxon along with other bionomic notes. Species marked with an asterisk (*) were not found at national park sites near Washington, DC, by Steury and Messer (2014), Steury et al. (2014), or Steury and Messer (2015).

NOTIOPHILINI

Notiophilus novemstriatus LeConte: (3); 16 Jun; under deep leaf litter in sandy loam soil at edge of pine woods, associated with *Elaphropus ferrugineus*.

CARABINI

Calosoma wilcoxi LeConte: (5); 23 Apr–5 May; under log in upland deciduous woods; under driftwood on beach.

**Calosoma externum* (Say): (1); 26 Sep; beach drift.

CICINDELINI

Cicindela punctulata punctulata Olivier: (6); 15 Jun; sandy beach dune.

Cicindela sexguttata Fabricius: (common); 23 Apr–16 Jun; roads; boardwalk in marsh; bare ground and open areas of woods and fields.

**Cicindela hirticollis hirticollis* Say: (4); 5 Oct, sandy beach dune.

Cicindela repanda repanda Dejean: (common); 5 May–2 Aug, sandy beach dune.

OMOPHRONINI

Omophron labiatum (Fabricius): (1); 30 May; under driftwood at edge of brackish *Spartina alterniflora* marsh.

SCARITINI

Scarites subterraneus Fabricius: (common); 5 May–10 Jun, 3 Sep; under logs in woods, meadows, and on beach dunes.

CLIVININI

Clivina americana Dejean: (3); 15 Jun; under driftwood on beach; under leaf litter in woods.

Paraclivina bipustulata (Fabricius): (1); 25 May; under leaf litter at woods/meadow ecotone.

BEMBIDIINI

Bembidion americanum Dejean: (2); 16 Jun; wet sand and algae at edge of salt marsh.

Bembidion affine Say: (8); 2–12 May; sandy beach dune under driftwood; muddy edge of vernal pool in meadow in full sun.

Bembidion impotens Casey: (3); 2 May; sandy beach dune under driftwood; muddy edge of vernal pool in meadow in full sun.

**Bembidion constrictum* (LeConte): (2); 26 May; under detritus at edge of brackish *Spartina alterniflora* marsh.

**Bembidion contractum* Say: (16); 12–30 May; under detritus at edge of brackish *Spartina alterniflora* marsh.

Bembidion rapidum (LeConte): (2); 15 Jun; under driftwood on beach.

**Elaphropus ferrugineus* (Dejean): (1); 16 June; under deep leaf litter in sandy loam soil at edge of pine woods. This tiny beetle is frequently found in the nests of ants (*Lasius* Fabricius spp.) (Larochelle and Larivière 2003) and may be an obligatory myrmecophile. This species is not yet recorded from Virginia.

Elaphropus xanthopus (Dejean): (7); 2 May–13 Jun; muddy edge of vernal pool in meadow under full sun.

PATROBINI

Patrobus longicornis (Say): (1); 10 Jun; beach dune/forest ecotone under log.

BRACHININI

**Brachinus alternans* Dejean: (7); 25 May–13 Jun; dry termite-tunneled pine log; under leaf litter at edge of mixed deciduous/coniferous woodland. Specimens possess the diagnostic setal patch on the medial mentum which distinguishes it from the otherwise similar *B. fumans* (Fabricius) and *B. tenuicollis* LeConte.

PTEROSTICHINI

**Poecilus chalcites* (Say): (2); 12 May–15 Jun; sandy beach dune under driftwood.

**Pterostichus ebeninus* (Dejean): (1); 12 May; under plant debris on beach.

Pterostichus permundus (Say): (2); 10 Jun; under log at beach dune/forest ecotone. <u>NEW STATE RECORD</u> (Figures 1 and 2). The known range for *P. permundus* is from southern Ontario and northern Michigan to southeastern South Dakota, northeastern Texas, and northeastern Florida (Bousquet 2012). It is distinguished from similar *P. sculptus* by possessing ventrally setose fifth tarsomeres and a margined prosternal process.

Pterostichus sculptus LeConte: (1); 30 May; under leaf litter at meadow/forest ecotone.

Cyclotrachelus furtivus (LeConte): (1); 16 Jun; under shallow leaf litter along fence row between rip-rap roadside and pine woods. The pronounced tapering of the stylomeres on

Figure 1. *Pterostichus permundus* (Say). Habitus. New state record, Cove Point, Calvert County, Maryland, 10 June 2016.

Figure 2. *Pterostichus permundus*. Ventrally setose fifth tarsomere.

this female specimen separates it from otherwise externally identical *C. sodalis* (LeConte).

ZABRINI

**Amara turbata* Casey: (1); 5 May; under driftwood on beach. This species is not yet recorded from Virginia.

Amara familiaris (Duftschmid): (3); 5–12 May; under driftwood on beach dune.

OODINI

Oodes amaroides Dejean: (1); 12 May; under plant debris on beach.

**Stenocrepis mexicana* (Chevrolat): (1); 26 May; under log at edge of vernal pool in meadow. NEW STATE RECORD (Figure 3). This species ranges along the Atlantic Coast from New Jersey to the Florida Keys, west to southern Wisconsin, southeastern Kansas, central Texas, and in Mexico to the Pacific Coast in the state of Colima. It has also been recorded from the Bahamas (Bousquet 2012). It is distinguished from the similar *S. duodecimstriata* (Chevrolat) by its larger size (10.2–12.5 mm [~ 0.4–0.5 in]) and its shorter, broader, truncate mentum tooth. The specimen from Cove Point measured 11.6 mm (~ 0.5 in) and possessed the short truncate mentum tooth illustrated in Figure 169 by Ciegler (2000) and in Figure 22 in Bousquet (1996).

CHLAENIINI

Chlaenius aestivus Say: (3); 23 Apr–30 May; under log in swamp; under board in meadow; under pine log in meadow.

Chlaenius tricolor tricolor Dejean: (1); 10 Jun; under log at beach dune forest ecotone.

LICININI

Dicaelus elongatus Bonelli: (2); 23 Apr–12 May; under log in dry upland woods; under decaying pine log in meadow.

HARPALINI

Anisodactylus nigerrimus (Dejean): (1); 12 May; under driftwood on beach dune.

Anisodactylus dulcicollis (LaFerté-Sénectère): (3); 5 May–13 Jun; under driftwood on beach dune; crossing road at midday. The specimen collected on 12 May 2012 at Cove Point was the first Maryland record for this species (Steury et al. 2014).

**Anisodactylus haplomus* Chaudoir: (1); 30 May; beach dune under driftwood. NEW STATE RECORD (Figure 4). Along the Atlantic Coast, this species ranges from Long Island, New York, to southern Florida. It is found west to northeastern Oklahoma and

Figure 3. ***Stenocrepis mexicana*** **(Chevrolat).** Habitus. New state record, Cove Point, Calvert County, Maryland, 26 May 2016.

Figure 4. ***Anisodactylus haplomus*** **Chaudoir.** Habitus. New state record, Cove Point, Calvert County, Maryland, 30 May 2016.

east-central Texas (Bousquet 2012). It is distinguished from *A. rusticus* by its larger size (12–14.5 mm [~ 0.5–0.6 in]), deeper subapical sinuation of the elytron, and less pronounced lateral pronotal bead and from *A. merula* by the absence of a small sharp tooth on the elytral humerus. The specimen from Cove Point measured 13 mm (~ 0.5 in).

Anisodactylus ovularis (Casey): (1); 5 May; under driftwood on beach.

**Anisodactylus merula* (Germar): (2); 10–15 Jun; under driftwood on beach; under log at upper edge of beach dune.

Anisodactylus rusticus (Say): (1); 6 Jun; under driftwood on beach.

Anisodactylus sanctaecrucis (Fabricius): (1); 2 May–15 Jun; sandy beach dune; bare open ground under leaf litter.

Anisodactylus verticalis (LeConte): (1); 12 May; under plant debris on beach.

**Anisodactylus caenus* (Say): (1); 5 May; under driftwood on beach.

Amphasia sericea (Harris): (6); 5 May; under driftwood on beach.

Amphasia interstitialis (Say): (1); 15 Sep; crawling on beach.

Stenolophus ochropezus (Say): (common); 5 May–15 Jun, 3–15 Sep; under driftwood on beach, under leaf litter in woods and meadows. This is the most commonly encountered carabid beetle at Cove Point.

Stenolophus lecontei (Chaudoir): (2); 11 Jun; under driftwood on beach.

Agonoleptus rotundatus (LeConte): (5); 5 May–15 Jun; under driftwood on beach.

Bradycellus rupestris (Say): (1); 10 Jun; under log at edge of freshwater marsh.

Bradycellus tantillus (Dejean): (3); 25–30 May; muddy edge of vernal pool in meadow.

Acupalpus pauperculus Dejean: (1); 25 May; muddy edge of vernal pool in meadow.

Acupalpus testaceus Dejean: (2); 12–25 May; muddy edge of vernal pool in meadow; beach dune under drift wood.

Harpalus pensylvanicus (De Geer): (15); 25 May–15 Jun, 3–26 Sep; under driftwood on beach; under log in woods; under log in meadow.

Harpalus affinis (Schrank): (2); 10 Jun; under driftwood on beach.

Selenophorus granarius Dejean: (6); 26 May–15 Jun, 16 Sep; crawling on dry, hot sand in full sun on upper beach dune; edge of brackish marsh; under driftwood on beach.

Trichotichnus autumnalis (Say): (2); 5–12 May; under driftwood on beach.

Trichotichnus fulgens (Csiki): (3); 22 Apr–25 May; under log in dry upland woods; pond edge under stone.

SPHODRINI

Calathus opaculus LeConte: (5); 10 Jun; beach dune/forest ecotone under log.

PLATYNINI

Agonum excavatum Dejean: (1); 2 May; muddy edge of vernal pool in meadow.

Agonum octopunctatum (Fabricius): (2); 2 May; muddy edge of vernal pool in meadow.

Agonum punctiforme (Say): (18); 2 May–13 Jun, 15 Sep; sandy beach dune under driftwood; in woods under log; under leaf litter in woods.

Platynus decentis (Say): (1); 2 May; in dry termite-riddled pine log in woods.

Platynus cincticollis (Say): (3); 5 May–15 Jun; under driftwood on beach.

CYCLOSOMINI

Tetragonoderus fasciatus (Haldeman): (2); 26 May; beach dune.

LEBIINI

Cymindis limbata Dejean: (1); 13 Jun; under driftwood on beach dune.

Apristus latens (LeConte): (14); 5–26 May, 3–16 Sep; under driftwood on beach dune.

Lebia lobulata LeConte: (1); 15 Jun; under leaf litter at edge of shaded vernal pool.

Lebia viridis Say: (3); 5–12 May; under driftwood on beach. Associated with chrysomelids of the genus *Altica* Geoffroy forming a union of Lindrothian mimicry. Adults feed on chrysomelid eggs, larvae, and pupae, and the larvae are ectoparasitic on chrysomelid pupae (Larochelle and Larivière 2003).

Plochionus timidus Haldeman: (1); 15 Jun, climbing vegetation on upper beach dune.

**Calleida punctata* LeConte: (1); 5 May; beach drift.

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Intercepted Lepidoptera Species Associated with Soybean, *Glycine max* (L.) Merr. (Fabaceae), at United States Ports-of-Entry

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Abstract: This study examines soybean, *Glycine max* (L.) Merr. (Fabaceae), as a pathway for the introduction of non-indigenous Lepidoptera species. In this paper, we extracted and analyzed records of Lepidoptera intercepted in association with soybean from databases maintained by the Animal and Plant Health Inspection Service, United States Department of Agriculture. This study shows that the majority of Lepidoptera species intercepted in association with soybean were not considered Quarantine Significant taxa, with less than 4% of all records consisting of non-indigenous taxa. Nevertheless this is the first characterization of Lepidoptera species intercepted in association with soybean at United States ports-of-entry and serves as an initial baseline to support future entomological and bio-invasion studies.

INTRODUCTION

The introduction of non-indigenous species as a byproduct of international trade has been shown to negatively impact ecosystems, biological diversity, agriculture, and forestry, resulting in the loss of billions of dollars annually (Pyšek et al. 2010, Bacon et al. 2012). Identifying the pathway of introduction by which non-indigenous species are introduced to new locations is an essential component in understanding and reducing biological invasions (Hulme et al. 2008). Soybean, *Glycine max* (L.) Merr. (Fabaceae), is considered one of the most important crops worldwide (Hartman et al. 2011). Ranked as the second largest source of vegetable oil (Patil et al. 2014), it is also important as quality livestock fodder (Hartman et al. 2011). In addition, soybean plants are a residual nitrogen supplier in soil, fixing atmospheric nitrogen (Blumenthal et al. 1988). Herein, we examine soybean as a pathway of introduction for non-indigenous Lepidoptera species at United States ports-of-entry. This study represents the first evaluation and review of Lepidoptera taxa intercepted in association with imported soybean.

METHODS

A dataset of 620 records of Lepidoptera intercepted on soybean was extracted from the Port Information Network (PIN) and the Agricultural Quarantine Activity Systems

(AQAS) databases, both administered by the United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS). The records are comprised of insect interceptions from preclearance and agricultural quarantine inspections conducted by both APHIS and Department of Homeland Security, United States Customs and Border Protection personnel between the dates of 6 October 1988 and 18 July 2016. Taxonomic identifications were provided by APHIS port entomologists and national specialists at the Systematic Entomology Laboratory (SEL), Agricultural Research Service (ARS), USDA.

RESULTS and DISCUSSION

We recorded a total of 11 families, 18 genera, and at least 21 species of Lepidoptera as alphabetically annotated (by family) in Table 1 below. There were eight records (1.3%) identified above the family level, 18 records (2.9%) to family, 13 records (2.1%) to subfamily, one record (0.2%) to tribe, 38 (6.1%) to genus, and 542 (87.4%) to species. Determinations resulting only in a higher-level rank (e.g., family, subfamily) are most often based on immature life-stages, many of which are either poorly known or difficult to identify using standard morphological techniques.

Lepidoptera species were intercepted (n = 620) at 33 port city locations in the United States and three points of entry in United States territories (Table 2, Figure 1). Ports in the Mid-Atlantic region (Maryland, New Jersey, New York, Pennsylvania, and Virginia) accounted for 59.2% (n = 367) of the records. However, more than 71.0% (n = 440) of all records were from just four port locations: 35.2% (n = 218) from Baltimore, Maryland; 16.1% (n = 100) from Norfolk, Virginia; 9.8% (n = 61) from Oakland, California; and 9.8% (n = 61) from Seattle, Washington. Overall, more than 90% of the interceptions originated from only three countries (Table 3). A total of 66.8% (n = 414) of the interceptions were from India, 19.4% (n = 120) from China, and 5.3% (n = 33) from Argentina. Origin was not identified for 0.5% (n = 3) of the interceptions.

Sixty-five of the records (10.5%), consisting of 22 taxa, were considered Quarantine Significant (QS) interceptions (Table 1). QS interceptions are those that pose a potential risk to agriculture and may result in quarantine mitigation on the commodity which can include destruction, re-exportation, or treatment (e.g., fumigation). Of these, *Nemapogon gerasimovi* Zagulajev (Tineidae) was the most commonly intercepted species accounting for 16.9% (n = 11) of the QS records. Both, "*Etiella* Zeller sp." (Pyralidae) and "Pyralidae sp." each comprised 10.8% (n = 7) of the QS records, while, "Phycitinae sp." (n = 9) and "Lepidoptera sp." (n = 6) accounted for 13.8% and 9.2% of the QS records, respectively. The quarantine status of a taxa not identified to the species level is dependent on whether there are QS species within that identified taxon.

Only six non-indigenous taxa, accounting for 3.5% (n = 22) of the records, were intercepted at ports-of-entry (Table 1). Of these, *N. gerasimovi* and *N. granella* (Linnaeus) comprised 50.0% (n = 11) and 27.3% (n = 6) of the records, respectively. The larvae of these two tineids feed mostly on seeds, grains, and cereals (Robinson and Nielsen 1993). *Nemapogon granella* is distributed throughout the temperate regions of the world as a result of the transportation of stored products by commerce (Robinson and

Table 1. Lepidoptera species intercepted on soybean, *Glycine max* (L.) Merr. (Fabaceae), at United States ports-of-entry between 6 October 1988 and 18 July 2016[1]. (* = a non-indigenous species; ψ = a Quarantine Significant taxon.)

Family	Species	Number of Interceptions	Origin[2]
Coleophoridae			
	Coleophora Hübner sp., ψ	1	MX
Crambidae			
	Maruca vitrata (Fabricius)*, ψ [Bean Pod Borer]	1	DO
Gelechiidae			
	Gelechiidae, species of ψ	1	AR
Gracillariidae			
	Gracillariidae, species of ψ	1	IN
Erebidae			
	Arctiinae, species of ψ	1	CA
	Hypena scabra (Fabricius) [Green Cloverworm]	1	CA
Hesperiidae			
	Epargyreus clarus (Cramer) [Silver-spotted Skipper]	1	CA
Noctuidae			
	Chrysodeixis includens (Walker) [Soybean Looper]	1	PR
	Copitarsia Hampson sp.*, ψ	2	CL, MX
	Elaphria nucicolora (Guenée) [Sugarcane Midget]	1	AR
	Helicoverpa Hardwick sp., ψ	1	IN
	Noctuidae, species of ψ	3	AR
Pieridae			
	Pieris rapae (Linnaeus) [Cabbage White]	1	MX
Pyralidae			
	Aphomia sociella (Linnaeus) [Bee Moth]	1	TR
	Cadra calidella (Guenée)* [Date Moth]	1	IN
	Cadra cautella (Walker) [Almond Moth]	354	AR, BR, CN, GR, IN, NP, PE, TR, TZ, UG, UN, UY
	Cadra Walker sp.	24	CN, IN, NP
	Corcyra cephalonica (Stainton) [Rice Moth]	41	BR, CN, IN
	Ephestia elutella (Hübner) [Tobacco Moth]	1	IN

Family	Species	Number of Interceptions	Origin[2]
	Ephestia kuehniella (Zeller) [Mediterranean Flour Moth]	8	IN
	Ephestia Guenée sp.	1	IN
	Etiella zinckenella (Treitschke) [Limabean Pod Borer]	1	BR
	Etiella Zeller sp., ψ	7	AC, CN, IN, JP, KP
	Phycitinae, species of ψ	9	AR, CN, IN
	Plodia interpunctella (Hübner) [Indian Meal Moth]	111	AR, BR, CA, CN, GR, IN, KP, TR, UA, UN
	Pyralidae, species of ψ	7	AR, IN, UN
	Pyralinae, species of ψ	2	IN, UG
Tineidae			
	Acrolophus arcanellus (Clemens) [Grass Tubeworm Moth]	1	PR
	Nemapogon gerasimovi Zagulajev*, ψ [no common name]	11	CN
	Nemapogon granella (Linnaeus)* [European Grain Moth]	6	CN, IN
	Nemapogon Schrank sp., ψ	1	CN
	Tineidae, species of ψ	2	CN, IN
Tortricidae			
	Archipini, species of ψ	1	CA
	Cryptophlebia Walsingham sp.*, ψ	1	JP
	Olethreutinae, species of ψ	1	KP
	Tortricidae, species of ψ	4	CN, JP, US
Undetermined			
	Lepidoptera, species of ψ	6	CN, IN, PR
	Microlepidoptera, species of ψ	1	PE
	Pyraloidea, species of ψ	1	IN
Total		**620**	**22**

[1]Data obtained from the PIN and AQAS databases maintained by the USDA-APHIS since 1984.

[2]Origin of *Glycine max*; abbreviations primarily follow the two letter code of the International Organization for Standardization (2017). AC: Asia (country unknown); AR: Argentina; BR: Brazil: CA: Canada; CL: Chile; CN: China; DO: Dominican Republic; GR: Greece; IN: India; JP: Japan; KP: Democratic People's Republic of Korea; MX: Mexico; NP: Nepal; PE: Peru; PR: Puerto Rico; TR: Turkey; TZ: United Republic of Tanzania; UA: Ukraine; UG: Uganda; UN: unknown; US: United States of America; UY: Uruguay.

Table 2. Port city and pathway locations of Lepidoptera species interceptions associated with soybean, *Glycine max*.

State or Territory	Port City	Pathway Location	Number of Interceptions
Arizona	Douglas	Land Border	1
California	Long Beach	Maritime Port	6
	Los Angeles	Airport	5
	Oakland	Maritime Port	61
	San Francisco	Airport	5
Florida	Miami	Airport	11
	Miami	Maritime Port	1
Georgia	Atlanta	Airport	4
	Savannah	Maritime Port	13
Hawaii	Hilo	Airport	1
	Honolulu	Airport	2
Illinois	Chicago	Inland Inspection (vessel)	6
Louisiana	New Orleans	Maritime Port	1
Maryland	Baltimore	Maritime Port	218
Michigan	Detroit	Airport	1
	Detroit	Land Border	6
	Romulus	Airport	1
Minnesota	International Falls	Rail port	1
	Minneapolis	Inland Inspection (railcar)	4
North Carolina	Wilmington	Maritime Port	1
North Dakota	Portal	Rail port	1
New Jersey	Newark	Maritime Port	31
New York	New York	Airport	2
Ohio	Cleveland	Inland Inspection (vessel)	8
Oregon	Portland	Maritime Port	11
Pennsylvania	Philadelphia	Airport	1
	Philadelphia	Maritime Port	15
Puerto Rico	Carolina	Airport	1
	Mayaguez	Airport	1
	Ponce	Airport	2
South Carolina	Charleston	Maritime Port	2
Texas	Dallas/Ft. Worth	Airport	4
	Houston	Airport	1
	Houston	Maritime Port	10
	Laredo	Land Border	2
Virginia	Norfolk	Maritime Port	100
Vermont	Derby Line	Land Border	1
Washington	Puget Sound	Maritime Port	4
	Seattle	Airport	1
	Seattle	Maritime Port	60
	Tacoma	Maritime Port	13
Total			**620**

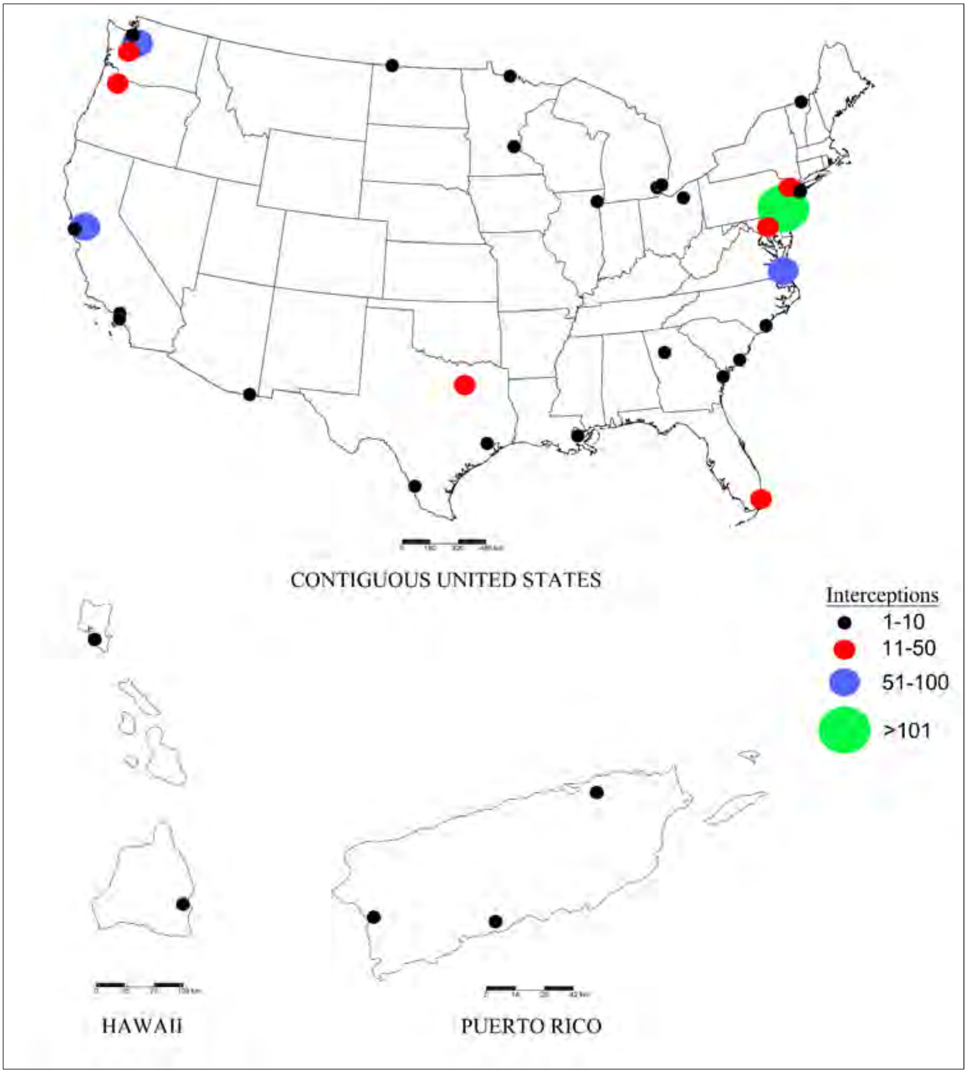

Figure 1. Port locations of Lepidoptera species interceptions (n = 620) associated with soybean, *Glycine max*. The distribution map of port locations was generated using SimpleMappr software (Shorthouse 2010) applying the North American Lambert map projection.

Table 3. Countries of Origin for Lepidoptera species interceptions associated with soybean, *Glycine max*.

Country of Origin	Number of Interceptions
Argentina	33
Asia (country unknown)	1
Brazil	6
Canada	5
Chile	1
China	120
Dominican Republic	1
Greece	3
India	414
Japan	4
Mexico	3
Nepal	4
Peru	3
Puerto Rico	3
South Korea	4
Tanzania	1
Turkey	4
Uganda	2
Ukraine	2
United States of America (Hawaii)	1
Uruguay	2
unknown	3
Total Number:	**620**

Nielsen 1993). Also notable was the interception of *Maruca vitrata* (Fabricius) (Crambidae), a flower- and pod-feeding species that causes serious yield loses to legumes in tropical and subtropical regions worldwide (Taylor 1978). This taxon is recognized as one of the most devastating legume pests as a result of an extensive host range, cosmopolitan distribution, and high damage potential (Taylor 1978, Sharma 1998).

The majority of intercepted Lepidoptera species consisted of widely distributed, common stored product pests. *Cadra cautella* (Walker) (Tineidae) was the most commonly encountered species, accounting for 57.1% (n = 354) of all records. *Plodia interpunctella* (Hübner) (Pyralidae) comprised 17.9% (n = 111) of the interceptions, and *Corcyra cephalonica* (Stainton) (Pyralidae) accounted for 6.6% (n = 41). These taxa are known to feed on a range of stored foods and products, notably spices, grains, cereals, and cereal products (Mbata 1989, Hagstrum et al. 2012).

Overall, the majority (n = 555) of Lepidoptera species intercepted in association with soybean were not considered QS taxa, with less than 4% (n =22) of all records consisting of non-indigenous taxa. This paper represents the first characterization of Lepidoptera species intercepted in association with soybean at United States ports-of-entry. Although it is possible that some species were not fully represented, the current study serves as an initial baseline to support future entomological and bio-invasion studies.

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Spatial Replication of "Bee Bowl" Transects in Passive Sampling of Bee Diversity by Multiple Inexperienced Volunteers

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Abstract: Wild bees (Hymenoptera: Apoidea: Anthophila) are important pollinators in both natural ecosystems and agricultural systems. Some species are restricted to special habitats that may be rare or vulnerable (e.g., deep sand, barrens, dunes, bogs, prairie remnants, and managed burns) or collect pollen from plants that are uncommon or vulnerable. However, little is known about the population status of most of our bees. Long-term, large-scale monitoring on a regional scale will be essential to detect population trends for our wild bees, but no such monitoring system currently exists and baseline data have not yet been systematically collected. The development of a regional or national monitoring program, which would likely require the participation of a large number of geographically dispersed volunteers, requires the investigation of some practical sampling issues. One important question is whether data from sampling by multiple, often inexperienced, volunteers will retain a sufficiently high signal-to-noise ratio to be useful in revealing population and community patterns through space and time. In the present study, community composition was examined based on multiple sample transects on multiple refuges in Region 5 of the United States Fish and Wildlife Service National Wildlife Refuge System (Northeast and Mid-Atlantic), a region that is home to approximately 500 bee species. Our key question was whether multiple fields selected and sampled on a refuge by volunteers provided with a simple protocol would be sufficiently homogeneous to be treated as statistical replicates in characterizing the bees of a refuge. Despite the heterogeneity in size and structure of the refuges sampled and the very low intensity of sampling, we found that replicate fields sampled within refuge units did indeed cluster strongly in "bee community space. This finding supports the feasibility of using multiple geographically dispersed and inexperienced collectors to select and sample multiple sites on a refuge to at least broadly characterize a refuge's bee community. Further investigation will be necessary to explore the realistic limits of power and resolution in using this approach to assess community differences through space and time.

Keywords: Anthophila, Apoidea, bee bowl, bee inventory, bee sampling, bees, pan trap

INTRODUCTION

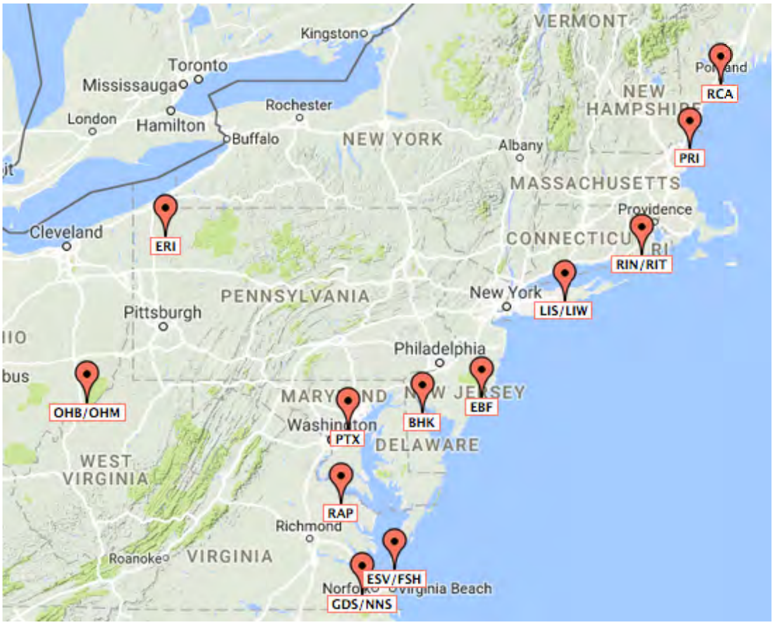
Around 770 species of bees (Hymenoptera: Apoidea: Anthophila) are known to occur in North America east of the Mississippi River (Colla et al. 2012). Many of these bees are important pollinators not only in natural ecosystems, but in agricultural systems as well. Some species are restricted to special and high quality habitats (e.g., deep sand, barrens, dunes, bogs or other wetlands, prairie remnants, or managed burns) like those often found in protected areas such as National Wildlife Refuges (NWR), or they collect pollen from plants that are uncommon or vulnerable (e.g., Droege et al. 2009; Fowler 2016a, 2016b; Droege and Fowler 2016; NANBC 2017). Little is known about the population status of most of our bees and long-term monitoring on a large regional scale will be essential to detect population trends for our wild bees (LeBuhn et al. 2013, Le Féon et al. 2016), but no such monitoring system currently exists and baseline data have not yet been systematically collected. Recently, a number of researchers have been working to change this situation by exploring the use of key biodiversity areas such as refuges and other protected areas as monitoring points for native bees. As part of this effort, it has been necessary to investigate some sampling issues. In the present study, we examined the composition of bee samples from multiple sample transects on multiple refuges in Region 5 of the United States Fish and Wildlife Service National Wildlife Refuge System (Northeast and Mid-Atlantic), a region that is home to nearly 500 bee species (Droege, in litt, July 2017). Our key question was whether multiple fields selected and sampled on a refuge by volunteers provided with very general guidelines would be sufficiently homogeneous to be treated as statistical replicates in characterizing the bees of a refuge.

Different sampling methods (e.g., pan-trapping, hand-netting, etc.) are known to capture different types of bees disproportionately (e.g., Toler et al. 2005, Roulston et al. 2007, Wilson et al. 2008; Grundel et al. 2011), so utilizing multiple sampling methods is important if one’s goal is to characterize a local bee community as completely and accurately as possible. In a large-scale volunteer-based sampling project, however, the use of multiple (and often inexperienced) collectors makes minimizing collector bias—which is much greater with active sampling than with passive methods such as pan-trapping (e.g., Westphal et al. 2008)—of paramount importance, even at the expense of a less comprehensive assessment of the bee community. For this study, therefore, we relied entirely on pan-trapping. An additional benefit of pan-trapping is that bee yield per unit of active effort (time spent placing and retrieving sampling containers) tends to be much higher than with active netting.

METHODS

Sampling

A request for volunteers for this study was sent out to all Region 5 refuges (this region includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and West Virginia). All refuges wishing to participate in this project were included (17 administrative refuge units [Figure 1], sampling a total of 77 transects [73 plus 4 spatial duplicates]). Participating refuges were sent a simple protocol to follow for selecting sites to sample and for sampling and processing bees (see Appendix). All sampling was carried out in early successional fields in mid to late August of 2008 and relied on pan-trapping using



Map data@2017 Google

Figure 1. The 17 Region 5 refuge units participating in the project. (See Table 1 for the listing of refuge unit codes.)

Figure 2. Bee bowls. 96.1-ml (3.25-oz) plastic "Solo® soufflé portion cups" (original white, painted fluorescent blue, and painted fluorescent yellow).

"bee bowls" (Figure 2) (Droege 2015; also see Wilson et al. 2016). These bee bowls are white, 96.1-ml (3.25-oz) plastic "Solo® soufflé portion cups" (used in original white, or painted fluorescent blue or fluorescent yellow), partly filled with slightly soapy water, and placed on the ground in potential bee habitat for approximately 24 hours. Bees are attracted to the bowls, but due to the reduced surface tension of the soapy water, they cannot fly out once they land. For this project, volunteers used one 15-bowl transect in each of at least four fields, with all the fields on a refuge unit sampled at the same time for approximately 24 hours. Collected bees were mailed to us at the United States Geological Survey Bee Inventory and Monitoring Laboratory (USGS-BIML), Beltsville, Maryland, for processing (washing, drying, pinning, labeling, identification, and databasing; with the exception of identification, however, volunteers can be easily trained to carry out all the other steps in this process).

Collection data for each individual bee collected in this study were incorporated in the publicly-available online Discover Life database at www.discoverlife.org, with sample identification numbers in the database as indicated in Table 1. All records for individual species in the Discover Life database (not only those from this study) can be viewed using the Global Mapper (http://www.discoverlife.org/mp/20m?act=make_map).

Analysis

As an important first step in assessing the question of whether multiple fields selected and sampled by inexperienced volunteers on a refuge can be treated as replicate samples drawing from the same pool of bees, I asked whether samples from fields within a refuge unit were in fact more similar to one another than to those from different units. Because the data consisted of counts and included many zeros, count values (x) were first transformed to [square root(x+0.5)] (Sokal and Rohlf 1995). I used the computer program Ginkgo, version 1.4 (part of the VegAna software package [Bouxin 2005]) to calculate a symmetric matrix of Bray-Curtis distances between all possible pairs of the 77 sites. The program zt (Bonnet and Van de Peer 2002) was then used to carry out a Mantel test (10,000 permutations) that I structured to serve as a nonparametric equivalent of an ANOVA using the matrix of Bray-Curtis distances and a second design matrix constructed specifically to test the hypothesis that samples within a refuge unit are more similar than those from different units (see Sokal and Rohlf 1995, pp. 818–819 for details). The power of this test has been shown to be nearly the same as that of an ANOVA (Sokal et al. 1993).

I also used Ginkgo to perform Nonmetric Multidimensional Scaling (NMDS), an ordination method, to visually reveal similarities and differences among our 77 samples in "bee community" space. In addition to the ordination itself, I used K-means clustering, defining 17 groups to see how well the cluster analysis recovered the true 17 refuge unit clusters of samples.

Finally, I used EstimateS (Colwell 2006) to calculate the Chao2 and ICE nonparametric incidence-based estimators of asymptotic species richness for each set of sites sampled. These estimators are based mainly on the frequencies of rare species in the original sampling data.

RESULTS

In total, 1753 bees were collected, representing a minimum of 79 species (there were 87 operational taxonomic units [OTUs] in the data matrix, but some of these are not mutually exclusive, e.g., *Ceratina* Latreille sp. and *Ceratina dupla* Say). In total, there were 77 samples from 17 refuge units, as shown in Table 1 (the four sites on Fisherman Island are included twice since they were inadvertently sampled once with plain styrofoam [i.e., expanded polystyrene foam] cups, which are known to capture many fewer bees, and subsequently, sampled correctly, with painted bee bowls). For completeness, we included all eight Fisherman Island samples in our data set and, in fact, one species, *Agapostemon splendens* (Lepeletier), which was captured on just two of our refuges (Fisherman Island and Parker River), was recovered from the Fisherman Island styrofoam cup sampling but not from the regular Fisherman Island sampling. Several species in this study were detected on most of the 17 refuge units sampled (e.g., *Agapostemon virescens* (Fabricius) and *Augochlorella aurata* (Smith), both found on 13 of the 17 refuge units), but most were collected on just a few units, with more than half the species collected from just one, often represented by just a single individual (Table 2). Average number of species collected per transect varied little among refuge units, but was lowest at Fisherman Island and highest at Rhode Island-Trustom Pond; the average number of individuals per transect was also similar across refuge units, with the exception of Eastern Shore of Virginia (which yielded very high numbers of a few species) and Fisherman Island (where very few bees at all were caught) (Table 3). Nonparametric incidence-based estimates of species richness (for the period sampled) also did not suggest major differences among the refuge units sampled, with the possible exceptions of Fisherman Island (with very low richness, an inevitable result given the small number of species captured) and higher richness at Rappahannock and Rhode Island-Trustom Pond (Table 4). It is important to recognize that these richness estimates are all likely dramatic underestimates of true richness given the very limited sampling effort through time and space (including the fact that sampling was limited to a single habitat type, i.e., early successional fields) and the known unreliability of these estimators when sampling has recorded fewer than around two-thirds to four-fifths of the species actually present (Walther and Morand 1998, Mao and Colwell 2005, Coddington et al. 2009). Thus, the richness estimates presented here cannot be taken at face value as reliable estimates of true bee species richness for entire refuge units. For example, Table 4 shows a richness estimate of 28–38 species based on samples from Patuxent Wildlife Research Center, but based on extensive collecting by Sam Droege (USGS-BIML), it is known that the total Patuxent bee fauna is more on the order of ~150 species.

The Mantel test of the hypothesis that within-refuge unit samples were more similar than among-refuge unit samples yielded an estimated Pearson r correlation coefficient of 33.6% with an associated 1-tailed probability of $p < 0.001$, indicating that samples from within the same unit were clearly more similar than samples compared from different units, as would be expected if our protocol adequately reflected real differences in bee communities at the scale of refuge unit. NMDS ordination of the samples can be seen in Figures 3A and 3B, with identically colored dots indicating samples from the same refuge unit (identified by associated label). In Figures 4A and 4B, the same ordination results are

Table 1. Refuge units and replicate fields sampled.

Refuge Unit	Refuge Abbreviation	Site Code	Sample	Latitude (°)	Longitude (°)
Bombay Hook (DE)	BHK	BHK4	5587	39.2854	-75.4873
Bombay Hook (DE)	BHK	BHK3	5588	39.2599	-75.4816
Bombay Hook (DE)	BHK	BHK1	5589	39.2589	-75.4761
Bombay Hook (DE)	BHK	BHK2	5590	39.2630	-75.4682
Edwin B. Forsythe (NJ)	EBF	EBF1	5591	39.4638	-74.4484
Edwin B. Forsythe (NJ)	EBF	EBF2	5592	39.4448	-74.4113
Edwin B. Forsythe (NJ)	EBF	EBF3	5593	39.4786	-74.4356
Edwin B. Forsythe (NJ)	EBF	EBF4	5594	39.4736	-74.4484
Eastern Shore of Virginia (VA)	ESV	ESV2	5546	37.1336	-75.9510
Eastern Shore of Virginia (VA)	ESV	ESV3	5547	37.1354	-75.9564
Eastern Shore of Virginia (VA)	ESV	ESV4	5548	37.1391	-75.9631
Eastern Shore of Virginia (VA)	ESV	ESV1	5549	37.1359	-75.9649
Erie (PA)	ERI	ERI1	5601	41.5965	-79.9733
Erie (PA)	ERI	ERI2	5602	41.6303	-79.9614
Erie (PA)	ERI	ERI3	5603	41.6288	-79.9628
Erie (PA)	ERI	ERI4	5604	41.6290	-79.9640
Erie (PA)	ERI	ERI5	5605	41.6283	-79.9641
Fisherman Island (VA) [bee bowls]	FSH	FSH1B	5579	37.0984	-75.9786
Fisherman Island (VA) [bee bowls]	FSH	FSH2B	5580	37.0984	-75.9763
Fisherman Island (VA) [bee bowls]	FSH	FSH3B	5581	37.0956	-75.9739
Fisherman Island (VA) [bee bowls]	FSH	FSH4B	5582	37.0944	-75.9724
Fisherman Island (VA) [styrofoam]	FSH	FSH1A	5575	37.0984	-75.9786
Fisherman Island (VA) [styrofoam]	FSH	FSH2A	5576	37.0984	-75.9763
Fisherman Island (VA) [styrofoam]	FSH	FSH3A	5577	37.0956	-75.9739
Fisherman Island (VA) [styrofoam]	FSH	FSH4A	5578	37.0944	-75.9724
Great Dismal Swamp (VA)	GDS	GDS1	5567	36.6593	-76.5280
Great Dismal Swamp (VA)	GDS	GDS2	5568	36.6815	-76.4930
Great Dismal Swamp (VA)	GDS	GDS3	5569	36.6815	-76.4930
Great Dismal Swamp (VA)	GDS	GDS4	5570	36.7451	-76.4562
Long Island-Sayville (NY)	LIS	LIS1	5554	40.7430	-73.1016
Long Island-Sayville (NY)	LIS	LIS2	5555	40.7454	-73.1060
Long Island-Sayville (NY)	LIS	LIS3	5556	40.7418	-73.1024
Long Island-Sayville (NY)	LIS	LIS4	5557	40.7427	-73.1033
Long Island-Wertheim (NY)	LIW	LIW1	5550	40.7692	-72.8984
Long Island-Wertheim (NY)	LIW	LIW2	5551	40.7812	-72.9055
Long Island-Wertheim (NY)	LIW	LIW3	5552	40.7888	-72.9103
Long Island-Wertheim (NY)	LIW	LIW4	5553	40.8000	-72.8895
Nansemond (VA)	NNS	NNS1	5571	36.8113	-76.5401
Nansemond (VA)	NNS	NNS2	5572	36.8133	-76.5424
Nansemond (VA)	NNS	NNS3	5573	36.8188	-76.5414

Refuge Unit	Refuge Abbreviation	Site Code	Sample	Latitude (°)	Longitude (°)
Nansemond (VA)	NNS	NNS4	5574	36.8219	-76.5386
Ohio River Islands-Buckley Mainland (WV)	OHB	OHB1	5616	39.3897	-81.4203
Ohio River Islands-Buckley Mainland (WV)	OHB	OHB2	5617	39.3902	-81.4203
Ohio River Islands-Buckley Mainland (WV)	OHB	OHB3	5618	39.3942	-81.4237
Ohio River Islands-Buckley Mainland (WV)	OHB	OHB4	5619	39.3899	-81.4180
Ohio River Islands-Middle Island (WV)	OHM	OHM1	5612	39.4122	-81.1959
Ohio River Islands-Middle Island (WV)	OHM	OHM2	5613	39.4114	-81.1967
Ohio River Islands-Middle Island (WV)	OHM	OHM3	5614	39.4104	-81.1970
Ohio River Islands-Middle Island (WV)	OHM	OHM4	5615	39.4057	-81.2022
Parker River (MA)	PRI	PRI1	5595	42.7455	-70.8041
Parker River (MA)	PRI	PRI2	5596	42.7719	-70.8057
Parker River (MA)	PRI	PRI3	5597	42.7558	-70.8026
Parker River (MA)	PRI	PRI4	5598	42.7381	-70.7921
Parker River (MA)	PRI	PRI5	5599	42.7344	-70.7918
Parker River (MA)	PRI	PRI6	5600	42.7932	-70.7875
Patuxent (MD)	PTX	PTX3	5620	39.0230	-76.7950
Patuxent (MD)	PTX	PTX2	5621	39.0470	-76.8010
Patuxent (MD)	PTX	PTX4	5622	39.0750	-76.7690
Patuxent (MD)	PTX	PTX5	5623	39.0440	-76.7660
Patuxent (MD)	PTX	PTX1	5624	39.0580	-76.7800
Rachel Carson (ME)	RCA	RCA1	5583	43.5832	-70.2582
Rachel Carson (ME)	RCA	RCA2	5584	43.5853	-70.2583
Rachel Carson (ME)	RCA	RCA3	5585	43.5840	-70.2596
Rachel Carson (ME)	RCA	RCA4	5586	43.5832	-70.2618
Rappahannock River Valley (VA)	RAP	RAP1	5607	38.0204	-76.8766
Rappahannock River Valley (VA)	RAP	RAP2	5608	38.0190	-76.8775
Rappahannock River Valley (VA)	RAP	RAP3	5609	38.0222	-76.8746
Rappahannock River Valley (VA)	RAP	RAP4	5610	38.0162	-76.8840
Rappahannock River Valley (VA)	RAP	RAP5	5611	38.0135	-76.8877
Rhode Island-Ninigret (RI)	RIN	RIN1	5558	41.3629	-71.6720
Rhode Island-Ninigret (RI)	RIN	RIN2	5559	41.3633	-71.6656
Rhode Island-Ninigret (RI)	RIN	RIN3	5560	41.3614	-71.6629
Rhode Island-Ninigret (RI)	RIN	RIN4	5561	41.3649	-71.6569
Rhode Island-Trustom Pond (RI)	RIT	RIT1	5562	41.3794	-71.5817
Rhode Island-Trustom Pond (RI)	RIT	RIT2	5563	41.3732	-71.5763
Rhode Island-Trustom Pond (RI)	RIT	RIT3	5564	41.3814	-71.5668
Rhode Island-Trustom Pond (RI)	RIT	RIT4	5565	41.3773	-71.5668

Table 2. Abundance and frequency of each bee species. Numbers of individuals captured per species, and the numbers of refuge units (maximum possible = 17) and transects (maximum possible = 77) where species were captured.

Species	Individuals	Refuge Units	Transects
Colletidae			
Colletes americanus Cresson	1	1	1
Colletes speculiferus Cockerell	1	1	1
Hylaeus affinis (Smith) or *H. modestus* Say	36	8	18
Hylaeus illinoisensis (Robertson) or *H.* Fabricius sp. A	6	1	2
Hylaeus mesillae (Cockerell)	1	1	1
Hylaeus schwarzii (Cockerell)	1	1	1
Andrenidae			
Andrena brevipalpis Cockerell	1	1	1
Calliopsis andreniformis Smith	9	4	5
Perdita boltoniae (Robertson)	2	1	2
Perdita consobrina Timberlake	1	1	1
Halictidae			
Agapostemon splendens (Lepeletier)	7	2	4
Agapostemon texanus Cresson	5	3	4
Agapostemon virescens (Fabricius)	166	13	35
Augochlora pura (Say)	4	3	4
Augochlorella aurata (Smith)	390	13	31
Augochloropsis metallica (Fabricius)	1	1	1
Halictus confusus Smith	14	8	13
Halictus ligatus Say or *H. poeyi* Lepeletier	103	11	28
Lasioglossum albipenne (Robertson)	1	1	1
Lasioglossum anomalum (Robertson)	1	1	1
Lasioglossum apocyni (Mitchell) or *L. fattigi* (Mitchell)	2	1	2
Lasioglossum bruneri (Crawford)	14	7	13
Lasioglossum callidum (Sandhouse)	12	3	5
Lasioglossum coreopsis (Robertson)	25	6	11
Lasioglossum coriaceum (Smith)	4	3	3
Lasioglossum creberrimum (Smith)	1	1	1
Lasioglossum cressonii (Robertson)	3	2	2
Lasioglossum imitatum (Smith)	7	2	3
Lasioglossum leucozonium (Schrank)	13	2	3
Lasioglossum marinum (Crawford)	2	1	1
Lasioglossum nelumbonis (Robertson)	1	1	1
Lasioglossum nymphaearum (Cockerell)	3	2	3
Lasioglossum oblongum (Lovell)	1	1	1
Lasioglossum pectorale (Smith)	9	5	5
Lasioglossum pilosum (Smith)	54	6	18
Lasioglossum planatum (Lovell)	14	3	7
Lasioglossum near *planatum* (Lovell)	1	1	1
Lasioglossum quebecense (Crawford)	1	1	1
Lasioglossum subviridatum (Cockerell)	1	1	1
Lasioglossum tegulare (Robertson)	76	10	19
Lasioglossum trigeminum Gibbs	21	3	4
Lasioglossum versatum (Robertson)	100	8	24
Lasioglossum near *versatum* (Robertson)	4	1	2
Lasioglossum vierecki (Crawford)	4	1	1

Species	Individuals	Refuge Units	Transects
Lasioglossum viridatum (Lovell) group	150	5	13
Lasioglossum Curtis sp. A	30	1	4
Lasioglossum Curtis sp. B	6	2	4
Sphecodes atlantis Mitchell	3	1	2
Sphecodes davisii Robertson	1	1	1
Sphecodes dichrous Smith	1	1	1
Sphecodes Latreille spp.	7	2	4
Megachilidae			
Anthidium manicatum (Linnaeus)	3	2	2
Coelioxys sayi Robertson	2	2	2
Heriades leavitti Crawford	1	1	1
Hoplitis producta (Cresson)	1	1	1
Hoplitis spoliata (Provancher)	1	1	1
Megachile brevis Say	12	7	11
Megachile latimanus Say	1	1	1
Megachile mendica Cresson	5	4	5
Megachile montivaga Cresson	1	1	1
Megachile rotundata (Fabricius)	1	1	1
Megachile Latreille sp.	1	1	1
Apidae			
Apis mellifera Linnaeus	15	7	11
Bombus auricomus (Robertson)	1	1	1
Bombus citrinus (Smith)	1	1	1
Bombus fervidus (Fabricius)	10	3	8
Bombus fervidus (Fabricius) or *B. pensylvanicus* (DeGeer)	2	1	1
Bombus griseocollis (DeGeer)	1	1	1
Bombus impatiens Cresson	17	7	9
Bombus vagans Smith	3	1	2
Ceratina calcarata Robertson[1]	61	12	25
Ceratina calcarata Robertson or *C. dupla* Say[1]	1	1	1
Ceratina dupla Say[1]	154	12	34
Ceratina strenua Smith	25	3	8
Ceratina Latreille sp.	1	1	1
Epeolus lectoides Robertson	1	1	1
Epeolus scutellaris Say	5	1	2
Melissodes bimaculata Lepeletier	25	7	13
Melissodes comptoides Robertson	44	3	7
Melissodes denticulata Smith	2	2	2
Melissodes desponsa Smith	7	3	4
Melissodes druriella (Kirby)	3	2	2
Peponapis pruinosa (Say)	6	4	5
Ptilothrix bombiformis (Cresson)	10	3	5
Svastra atripes (Cresson)	4	3	4
Triepeolus cressonii (Robertson)	1	1	1
Triepeolus lunatus (Say)	2	2	2

[1]*Ceratina calcarata* Robertson and *C. dupla* Say could include a fairly recently discovered cryptic species, *C. mikmaqi* Rehan and Sheffield (Rehan and Sheffield 2011, Shell and Rehan 2016).

Table 3. Observed species richness and abundance for each refuge unit.

Refuge Unit	Transects/ Unit	Species	Individuals	Species/ Transect (mean)	Individuals/ Transect (mean)
Bombay Hook (DE)	4	18	121	4.5	30.3
Edwin B. Forsythe (NJ)	4	16	62	4.0	15.5
Eastern Shore of Virginia (VA)	4	13	482	3.3	120.5
Erie (PA)	5	20	68	4.0	13.6
Fisherman Island (VA) [bee bowls]	4	5	6	1.3	1.5
Fisherman Island (VA) [styrofoam]	4	2	3	0.5	0.8
Great Dismal Swamp (VA)	4	11	26	2.8	6.5
Long Island-Sayville (NY)	4	6	24	1.5	6.0
Long Island-Wertheim (NY)	4	18	92	4.5	23.0
Nansemond (VA)	4	16	91	4.0	22.8
Ohio River Islands-Buckley Mainland (WV)	4	18	87	4.5	21.8
Ohio River Islands-Middle Island (WV)	4	9	178	2.3	44.5
Parker River (MA)	6	19	97	3.2	16.2
Patuxent (MD)	5	17	66	3.4	13.2
Rachel Carson (ME)	4	18	36	4.5	9.0
Rappahannock River Valley (VA)	5	16	73	3.2	14.6
Rhode Island-Ninigret (RI)	4	15	128	3.8	32.0
Rhode Island-Trustom Pond (RI)	4	25	113	6.3	28.3
Total for the 17 refuge units	77	79 (minimum)	1753		

Table 4. Estimated species richness for each refuge unit[1].

Refuge Unit	"Species" (OTU[2]s) Collected	Richness Estimate (Chao2/ICE)
Bombay Hook (DE)	18	21/25
Edwin B. Forsythe (NJ)	16	20/27
Eastern Shore of Virginia (VA)	13	15/16
Erie (PA)	21	31/44
Fisherman Island (VA) [bee bowls & styrofoam]	6	7/9
Great Dismal Swamp (VA)	11	14/21
Long Island-Sayville (NY)	6	11/14
Long Island-Wertheim (NY)	18	23/34
Nansemond (VA)	16	20/23
Ohio River Islands-Buckley Mainland (WV)	19	23/27
Ohio River Islands- Middle Island (WV)	9	10/11
Parker River (MA)	20	29/32
Patuxent (MD)	17	28/38
Rachel Carson (ME)	19	31/45
Rappahannock River Valley (VA)	16	88/56
Rhode Island-Ninigret (RI)	16	19/24
Rhode Island-Trustom Pond (RI)	26	51/47

[1]It is important to recognize that these richness estimates likely represent extreme underestimates of true species richness as a result of the low intensity of sampling through space and time. They should not be interpreted as reasonable estimates of true bee species richness for entire refuge units.
[2]Operational taxonomic units.

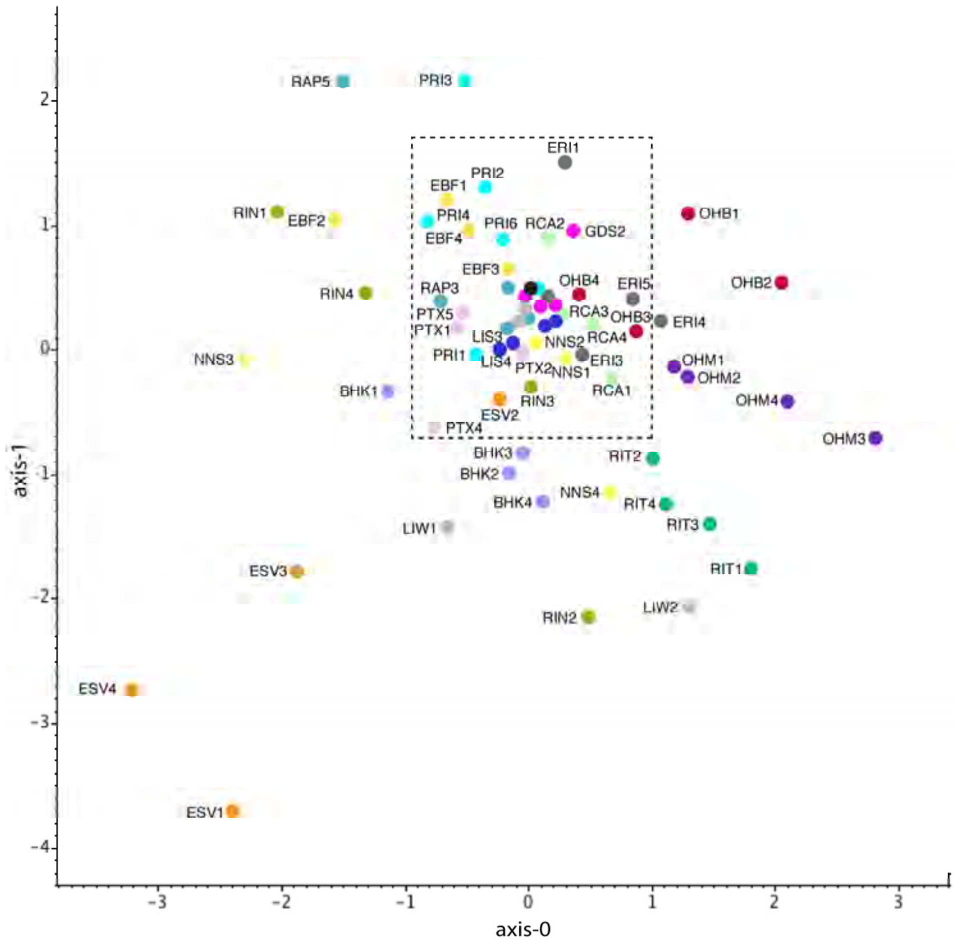


Figure 3A. Ordination (non-metric multidimensional scaling) of all 77 samples from 17 Region 5 refuge units. Within the dashed box, placement of circles without site labels is only approximately to scale and seven samples (PTX3, FSH1A, FSH2A, FSH3A, FSH4A, FSH1B, FSH3B, and FSH4B) could not be displayed at all (but see Figure 3B). Circles representing samples from the same refuge unit are indicated by both color and labeling.

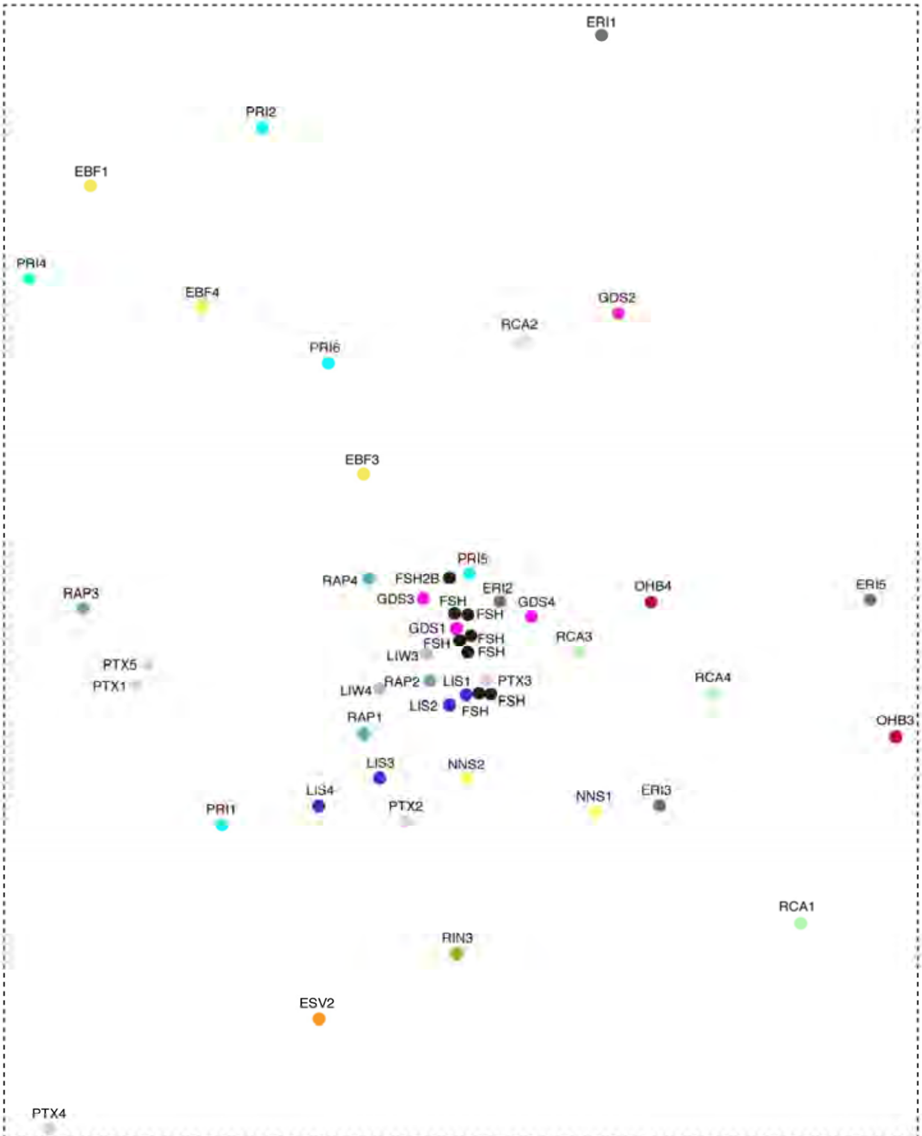


Figure 3B. Enlarged view of central dashed box in Figure 3A. Spacing of PTX3 and the seven unspecified FSH samples is approximate.

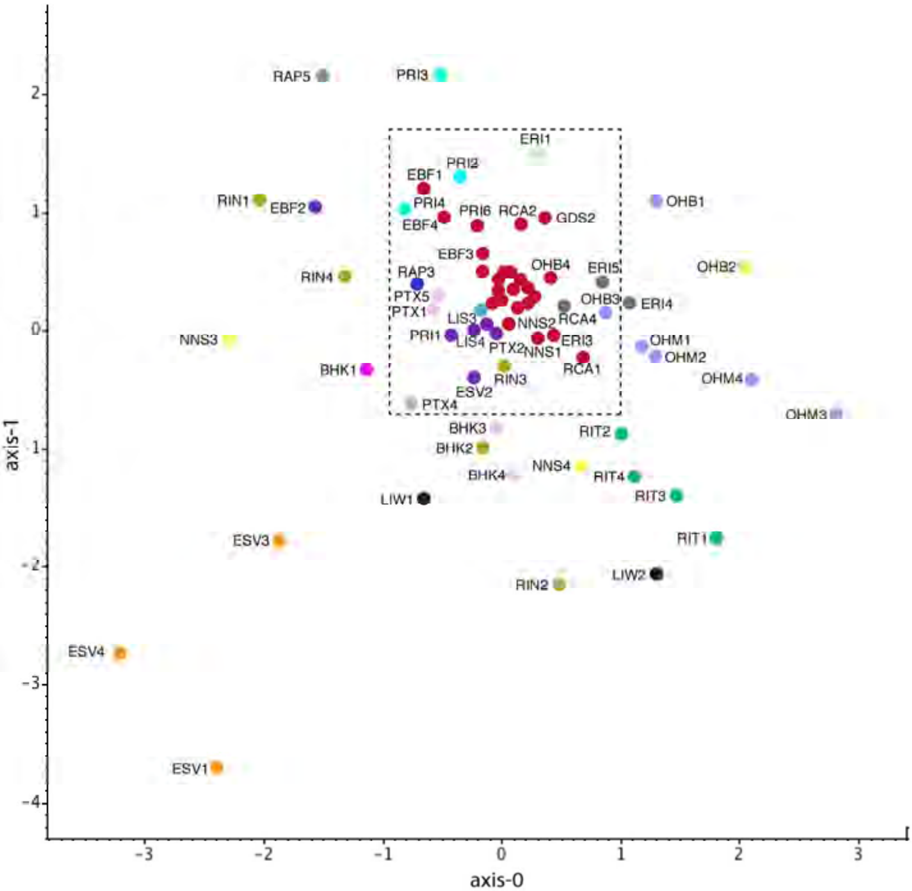


Figure 4A. Ordination as in Figure 3A, but circles are colored according to placement of all 77 samples into 17 groups based on Bray-Curtis distances using K-means clustering algorithm.

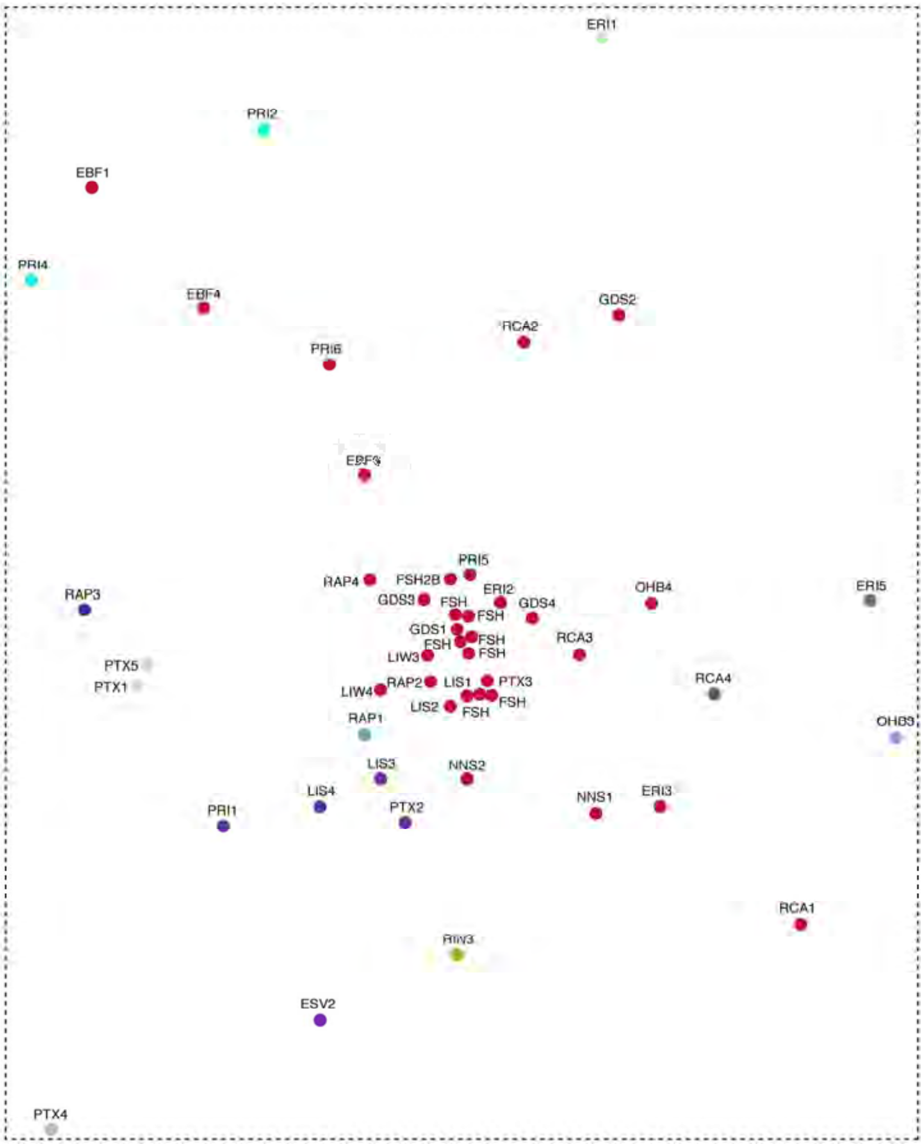


Figure 4B. Enlarged view of central dashed box in Figure 4A. Spacing of PTX3 and the seven unspecified FSH samples is approximate.

shown, but in this case the color of each dot indicates the group into which that sample was placed by the K-means clustering algorithm. Visual inspection of the NMDS ordination and cluster analysis is clearly consistent with the Mantel finding that samples from different sites on the same refuge unit appear to group together well based on species composition.

DISCUSSION

In this study we found that fields sampled within a refuge tended to be more similar to one another in species composition and species relative abundances than to fields on other refuges Although one would predict this tendency based on geographic proximity, the important empirical finding is that this effect is strong even given (1) very limited sampling (which would be expected to yield mainly just the most common bees present), (2) the heterogeneous sizes and layouts of the refuges sampled, and (3) the selection of “replicate” fields by multiple, geographically-dispersed, and mostly inexperienced volunteers.

Previous work has suggested there is little gain from increasing sample transect size beyond 15 bowls for estimating species richness (Shapiro et al. 2014). In the present study, we found that 15-bowl samples from fields selected and sampled from within the same administrative refuge unit are in fact more similar than those from different units within the same region, even when sampling is carried out by multiple inexperienced volunteers. This finding suggests that to increase overall sampling intensity most efficiently, additional 15-bowl transects (which require little additional time or effort on the part of volunteers already committed to putting out one set of bowls) can reasonably be used as statistical replicates of field (and likely other) habitats on refuges.

Drawing meaningful conclusions about native bee population trends will require a sampling program with adequate power and precision, which, in turn, will depend on large-scale sampling through space and across years (LeBuhn et al. 2013). In some regions, bee populations are known to fluctuate dramatically between years and without assessing this natural “background variation” over a number of years, it is difficult to detect population trends even if they are present (Roubik 2001). Long-term data sets for bees are very rare and would provide valuable insight into the dynamics of resident bee communities, as well as critical background information for designing statistically sound monitoring programs.

As environments outside of protected areas become increasingly exploited, highly managed, or urbanized, refuges and other parklands become the de facto repository for much of our biodiversity. For many invertebrates with small home ranges, even quite small refuges might be effectively managed to support invertebrate biodiversity, making a real difference in increasingly developed landscapes which are less likely to hold and retain biodiversity simply by chance or benign neglect. The use of simple, inexpensive bowl traps deployed by volunteers has great potential for assessing and monitoring the ability of refuges and other protected areas to retain populations of native bees. Further investigation will be necessary to explore the realistic limits of power and resolution in using this approach to assess community differences through space and time.

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APPENDIX

Sampling Protocol: 2008 USFWS Region 5 Native Bee Study

BACKGROUND

Recently there has been much concern about dramatic declines of the managed Honey Bee populations on which much of our agriculture depends. There is also strong evidence, however, that many of our native bees are declining as well—some quite precipitously—but in general very little is known about the status of our native bees. Roughly 800 species of bees occur in North America east of the Mississippi, including more than 500 species in Region 5. Many of these bees are very important pollinators not only in natural ecosystems, but in agricultural systems as well, and many are rare and restricted to the types of high quality habitats often found on refuges (e.g., deep sand, barrens, dunes, bogs, prairie remnants, managed burns). Large-scale, long-term monitoring on a regional scale will be essential to detect population trends for our native bees, but no such monitoring system exists and baseline data have not yet been systematically collected.

We hope to change this by using refuges and other protected areas as monitoring points for native bees. However, to better understand how best to accomplish this, we must first investigate some sampling issues. This is the primary motivation behind this small, easy to accomplish pilot study in which we hope you will participate. To give you an example of what data from refuges can add, in all the refuges we have worked on so far (Assateague, Carolina Sandhills, Patuxent, Heinz) we have found new state records and often quite rare species. On Carolina Sandhills alone we have found about 50 new state records!

We have two main goals for the present pilot survey of native bees on selected USFWS Region 5 units:

(1) Obtain initial assessments of bee species richness and diversity on fields across Region 5 refuge properties. This information can be used to guide habitat management and possibly more focused bee studies.
(2) Establish and test protocols for large-scale bee sampling using geographically distributed volunteers. The appropriateness and practicality of both our statistical sampling design and our methods for handling the mechanics of processing, identifying, and databasing a large flow of samples must be demonstrated before we scale up further.

The basic outline of this project is straightforward:

(1) We send you a bee sampling kit and simple instructions (below) for sampling at least four fields at least once in mid to late August (we strongly encourage at least one additional trial run before this, **AT A DIFFERENT SITE**, just to get comfortable with the very simple methods). A staff member or volunteer can set out the bowl traps (see below).
(2) You send us your bees with collection data.

That’s all you need to do. We will process and identify all the bees, compile and analyze the data, and come back to you with our report. For those of you willing to undertake additional sampling beyond the 4 fields/one day, please let us know so we can discuss possibilities.

THE SAMPLING METHOD: OVERVIEW

This project will rely on pan-trapping using what we refer to as “bee bowls”. Bee bowls are small plastic deli cups (painted white, blue, or yellow), partly filled with slightly soapy water, and placed out on the ground in potential bee habitat for ~24 hours. Bees are attracted to the bowls, but due to the reduced surface tension of the soapy water they cannot fly out.

Other collecting methods, such as netting bees, are also widely used by bee researchers, but to maximize consistency of data collection for this project--which relies on volunteers with varying levels of experience and skill--we will use only bee bowls.

WHERE TO SAMPLE

"*MACRO*" SCALE:

(a) At least four fields should be selected for sampling. Choose fields with mainly grasses and forbs and no more than scattered trees, shrubs, and vines—the habitat should look basically open, not scrubby. Use the data form below to supply basic information about each field. Along with this form, please supply one or more digital photos of each field.
(b) Fields should be chosen that are as close together as possible (e.g., across a road is fine). Going off-refuge to achieve this goal is OK, but staying on the refuge would be preferable if feasible.

"*MICRO*" SCALE:

(a) Bowls should be placed out in 15-bowl "transects", with one transect per field, and about 5 m between bowls (measure your pace and use this as an approximation for spacing bowls in the field).
(b) Transects should be placed roughly in the center of the field (or, at least, not near the edge)
(c) Tall grass or other obscuring vegetation should be avoided whenever possible. A bowl that is conspicuous to you is likely to be conspicuous to a bee as well. We have found that bowls placed in shade from a tree or dense herbaceous growth capture few or no bees. We will put together a few photos showing examples of well-placed and poorly-placed bowls and e-mail these to you soon.

WHEN TO SAMPLE

(a) All four fields should be sampled on the same day.
(b) Sample fields one time in mid to late August. If you would be willing to sample on one or more additional days, please contact us to discuss as this would both get you more information about the bees on your refuge and help with the overall study.
(c) We strongly encourage you to try an informal trial run **AT A DIFFERENT SITE** (even if just your back yard) in July or early August to become familiar with the method. Please save these samples and send them to us, with collection data, along with the bees you collect later.
(d) Bowls should be placed out for ~24 hours. Do not put out bowls if the weather forecast for this period predicts a greater than 30% probability of rain or daytime temperatures less than 60° F.

DAY 1: HOW TO PUT OUT BEE BOWLS

(a) In the field, all you will need is 15 bowls for each transect (supplied; bring some extras just in case) and soapy water in a jug you can pour from. A gallon of water is enough for about 60 bowls (i.e., four transects).

(b) Any water container that works for you is fine, but one very convenient strategy is to buy a gallon of distilled or spring water in a plastic jug and, before going into the field, adding a single good squirt of Original Blue Dawn dishwashing detergent (supplied). You may want to bring the dish detergent bottle into the field with you in case, for example, you have a major spill and need it again to prepare more soapy water. **Remember**: soap should always be added to water rather than soap first or you will get very excessive sudsing!

(c) Fill the first bowl about ¾ full with soapy water (bowls should have little or no "foam") and place it on the ground. Do the same with the remaining 14 bowls, placing them at ~5 m intervals. The route of your "transect" should be determined by the local terrain--you can shift it around to keep the bowls in the more open parts of the field. To easily find the bowls the next day, you may want to flag the first bowl or make a note of nearby landmarks.

(d) For each transect, use 5 yellow, 5 blue, and 5 white bowls alternating in a consistent order within a transect, but it doesn't matter which color you start with.

(e) On the data form below, record the geographic coordinates of the transect, approximate or measured size of the field, approximate % woody cover, date, weather conditions, and time transect was put out.

DAY 2: HOW TO RETRIEVE BEES

(a) To retrieve bees you will need a small brine shrimp net (supplied), one Whirl-Pak with label inside for each transect (supplied; bring along extras just in case), a plastic spoon (optional, but supplied), pencil for labeling (supplied), and a gallon Ziploc bag (supplied) into which you will place the four Whirl-Paks (each Whirl-Pak containing the catch from a single transect).

(b) Before going into the field, for each transect place a pre-printed label (supplied) in each Whirl-Pak, adding any additional information (e.g., the date) **IN PENCIL**, which will not run in alcohol. This label should include, at a minimum, refuge unit name, the date, and field number.

(c) Walk along the transect, pouring the contents of each bowl into the brine shrimp net until you have retrieved and emptied all 15 bowls. Note that when bees are collected, bees from all 15 bowls within a transect are pooled together in a single Whirl-Pak.

(d) Using your fingers and/or a plastic spoon, carefully transfer the catch from the net to the appropriate pre-labeled Whirl-Pak. Do this in a spot where your bees will not vanish if they happen to spill out (e.g., on a paved path, not in tall grass). Secure the bag by folding the top of the bag over several times, then twisting the ties together.

(e) Your catch will likely include many flies and other insects. There is no need to sort your catch—just bag it all (except for any slugs or snails that may show up as they will slime everything). As a very rough approximation, expect an average yield of ~1/2 bee/bowl—but your yield may be much lower or higher than this.

(f) On the form provided below, record weather conditions, time bowls were collected, and number of intact bowls collected, as well as any additional comments.
(g) Back in civilization, open each Whirl-Pak and add enough isopropyl alcohol (= isopropanol) to just cover your catch (*must be obtained by you from local supermarket or pharmacy, 70% or 91% are both fine*), then re-close bags, making certain they are closed securely (folded over several times and ties twisted tightly). Place Whirl-Paks together in a gallon Ziploc (supplied) together with a pre-printed label, adding any additional information **IN PENCIL** (even “alcohol-resistant” markers can run). At a minimum, the label should include your name, the date, and the refuge unit shared by the four transects. Samples can be kept like this until it is convenient for you to mail them.

MAILING US YOUR BEES

(a) Before mailing your bees, pour the alcohol out of each Whirl-Pak (to avoid any potentially significant leaking or any issues with confusing postal regulations about mailing ethanol), then fold over several times and twist it shut again.
(b) Place Whirl-Paks back inside the Ziploc bag. Add a paper towel to the Ziploc to soak up any loose moisture. Remember: if you sampled on more than one date, use a different Ziploc for each date.
(c) Carefully pack Ziploc(s) into the supplied, pre-addressed mailing tube, make sure tube ends are securely taped shut, add appropriate postage, and mail back to us.

WANT TO DO MORE?

If you are interested in sampling more than four sites or on more than just one day, please contact us and we will be very happy to discuss additional sampling that will yield more information for both your refuge and the broader study.

QUESTIONS, PROBLEMS, ETC.

We have automatically subscribed you to an electronic newsletter we have set up to distribute information about this project to participants. However, if you want to contact us regarding specific questions, problems, etc., please send an e-mail to Leo (lshapiro@umd.edu). This should generally get a quick response, but if it’s not quick enough, Sam can be reached (after mid-August) at 301-497-5840.

BEE SAMPLING KIT CONTENTS

Although we only require that four fields be sampled for participation in this project, we encourage you to contact us if you are willing and able to do more (we hope everyone will be able to do at least another site or two—if only their backyard—as a trial run before the main sampling). With this in mind, this sampling kit contains enough material for sampling 16 fields rather than just the required four. Please contact us if you need more of anything.

Note that due to safety/regulatory issues, we are NOT mailing you alcohol as we had hoped to do. Instead, please obtain your own isopropyl alcohol (= isopropanol) from your local supermarket or pharmacy, where it should be readily available (usually 70% or 91%) for a dollar or two. A pint of alcohol should be enough for storing bees in ~20 Whirl-Paks (= bees from 20 15-bowl transects).

Bee Sampling Kit Contents
Five complete sets of bowls (25 white, 25 blue, 25 yellow)
Two aliquots of original Blue Dawn dish soap in a plastic bottle, more than enough for 4 gallons of water.
Pre-printed labels for 20 Whirl-Paks and 5 Ziplocs
Two pencils
20 Whirl-Paks
One brine shrimp net
One plastic spoon
Five one-gallon Ziploc bags
One pre-addressed mailing tube to return bees (postage not included)

DATA FORM

NWR (or Unit):
Collector:

	COORDINATES	SIZE	% WOODY	DATE	WEATHER	START/STOP	# BOWLS	COMMENTS
FIELD 1	LAT: LONG:							
FIELD 2	LAT: LONG:							
FIELD 3	LAT: LONG:							
FIELD 4	LAT: LONG:							
FIELD 5	LAT: LONG:							
FIELD 6	LAT: LONG:							
FIELD 7	LAT: LONG:							
FIELD 8	LAT: LONG:							
FIELD 9	LAT: LONG:							
FIELD 10	LAT: LONG:							
FIELD 11	LAT: LONG:							
FIELD 12	LAT: LONG:							
FIELD 13	LAT: LONG:							
FIELD 14	LAT: LONG:							
FIELD 15	LAT: LONG:							
FIELD 16	LAT: LONG:							

EXPLANATIONS

COORDINATES: Obtain from GPS, preferably in degrees to four places after decimal

SIZE: Clearly specify ACRES or HECTARES and indicate whether size is estimated or measured

% WOODY: Provide estimate of % of field that is woody cover

DATE: Indicate date bowls put out

WEATHER: E.g., sunny, high 80°s F, light breeze

START/STOP: Time when bowls were put out/recovered

 # BOWLS: Number of bowls retrieved; don't count any lost bowls or bowls that are empty or dry when you recover them

COMMENTS: Any additional comments re. the site or the bee bowling episode

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Cuckoo Wasps (Hymenoptera: Chrysididae) of Hart-Miller Island, Chesapeake Bay, Baltimore County, Maryland

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INTRODUCTION

A survey of the bees (Hymenoptera: Apoidea) of Hart-Miller Island, Chesapeake Bay, Baltimore County, Maryland was conducted using "bee bowls" (pan traps) based on the methods in Droege (2008). The survey yielded 4446 bee specimens (Scarpulla 2013). In addition to the bees, 42 cuckoo wasps (Hymenoptera: Chrysididae) were also trapped, representing 1 subfamily, 2 tribes, 5 genera, and 7 species. Chrysididae are known as cuckoo wasps because of their behavior of laying their eggs in the nests of other insect species.

MATERIALS AND METHODS

The procedures used in this survey were based on (Droege 2008). Full sampling protocols can be found in Scarpulla (2013). Six 20-bowl transects were sampled every two to three weeks from mid-March to mid-December. Each of the six transects was placed in a different habitat (Table 1) and was composed of 20 "bee bowls" (white plastic, 96.1-ml [3.25-oz] "Solo® soufflé portion cups"). Of the 20 bowls, seven bowls were painted fluorescent blue, seven were painted fluorescent yellow, and six remained unpainted white. The different colored bowls were placed approximately 5 m (16.4 ft) apart with their colors alternating sequentially. Each bowl was two-thirds filled with water containing a small amount of Ultra Dawn® blue dishwashing liquid which lowered the water's surface tension so that any bees/wasps landing in the bowl sank below the water's surface. The bowls were deployed for approximately 5 hours per sampling day, which was the maximum available sampling time due to the time constraint of the boat's schedule to and from the island.

The chrysidid specimens were provisionally identified to species using Discover Life's "Draft Guide to the Chrysididae of North America, East of the Rocky Mountains" (Tucker and Shapiro 2009) and *A Synopsis of the Chrysididae in America North of Mexico* (Bohart and Kimsey 1982). The provisionally-identified specimens were sent to Lynn S. Kimsey (University of California – Davis) for confirmation and re-identification if needed.

Table 1. Habitat for each transect. Transect 2 (deciduous woodland) was sampled only before leaf out (six early spring dates) and after leaf fall (two late fall dates).

Transect	Habitat
1	sandy path and edge of sandy beach
2	deciduous woodland trail
3	grassy meadow path
4	gravel roadside along tidal marsh
5	gravel trailside along pond
6	gravel roadside along loblolly pines

RESULTS

Forty-two Chrysididae were trapped, representing 1 subfamily, 2 tribes, 5 genera, and 7 species. Table 2 shows the species captured per sampling transect; Table 3 shows the species captured per sampling date. All of the chrysidid specimens were in the subfamily Chrysidinae. Two of the species were in the tribe Elampini and five were in Chrysidini. One specimen was damaged and could not be assigned to a tribe.

The greatest number of chrysidids were collected in the two transects that were placed in areas with abundant flowering vegetation (Transects 3 [18 individuals] and 5 [14 individuals]) (Table 2). No specimens were collected in the deciduous woodland habitat (Transect 2) or the along the gravel roadside adjacent to the tidal marsh (Transect 4).

Specimens were found in the bowl traps from 19 May through 29 November, with the highest numbers found between 13 June and 21 September (Table 3).

Table 2. Chrysidinae species captured per sampling transect. Transect 2 (deciduous woodland) was sampled only before leaf out (six early spring dates) and after leaf fall (two late fall dates). [d] = damaged specimen.

		Transect						
Tribe	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
Elampini	*Hedychridium dimidiatum* (Say)			3		5	5	13
	Hedychrum parvum Aaron	1		7		2	4	14
Chrysidini	*Caenochrysis doriae* (Gribodo)			3		1		4
	Ceratochrysis declinis Bohart			2		5		7
	Chrysis conica Brullé			1				1
	Chrysis pellucidula Aaron			1				1
	Chrysis propria Aaron					1		1
	unidentified Chrysidinae species			1[d]				1
	Total Individuals	1		18		14	9	**42**
	Total Species	1		6		5	2	**7**

Table 3. Chrysidinae species captured per sampling date. Transect 2 (deciduous woodland) was sampled only before leaf out (six early spring dates) and after leaf fall (two late fall dates). * = Sampling dates that included Transect 2. [d] = damaged specimen.

Species	Mar 17*	Apr 04*	Apr 18*	May 06*	May 19*	May 30*	Jun 13	Jul 02	Jul 20	Aug 07	Aug 24	Sep 07	Sep 21	Oct 04	Oct 21	Nov 09	Nov 29*	Dec 15*	Total
Hedychridium dimidiatum							2	6	1	2	1			1					13
Hedychrum parvum							3	2		2	5		2						14
Caenochrysis doriae					1								1	2					4
Ceratochrysis declinis									1	2			2		2				7
Chrysis conica															1				1
Chrysis pellucidula																	1		1
Chrysis propria							1												1
unidentified Chrysidinae species										1[d]									1
Total Individuals					1		6	8	2	7	6		5	3	3		1		**42**
Total Species					1		3	2	2	3	2		3	2	2		1		**7**

GENUS AND SPECIES COMMENTARY

Tribe Elampini

Hedychridium Abeille de Perrin

North American Species: 31 (Kimsey 2006)
Known Hosts: Old World species: Crabronidae, Halictidae, and Megachilidae; New World species: Crabronidae, including species of *Solierella* Spinola and *Tachysphex* Kohl (Kimsey 2006)
Potential Hart-Miller Island Hosts: Crabronidae (18 spp.), including *Solierella* (1 sp.) and *Tachysphex* (1 sp.)

***Hedychridium dimidiatum* (Say)** (Figure 1)
U.S. Distribution: widespread in the west and east (Kimsey 2006)
Known Hosts:
Unknown (Kimsey 2006)

Hedychrum Latreille

North American Species: 9 (Kimsey 2006)
Known Hosts: Crabronidae: Philanthinae (Kimsey 1990, 2006)
Potential Hart-Miller Island Hosts: Crabronidae: Philanthinae (1 sp.)

***Hedychrum parvum* Aaron** (Figure 2)
U.S. Distribution: widespread in the west and east (Kimsey 2006)
Known Hosts:
Eucerceris fulvipes Cresson (Crabronidae: Philanthinae) (Evans 1970)

Tribe Chrysidini

Caenochrysis Kimsey & Bohart

North American Species: 6 (Kimsey 2006)
Known Hosts: Crabronidae: Crabroninae: Trypoxylonini [sic] (Kimsey 2006)
Potential Hart-Miller Island Hosts: Crabronidae: Crabroninae: Trypoxylini (1 sp.)

***Caenochrysis doriae* (Gribodo)** (Figure 3)
U.S. Distribution: widespread in the west, east, and interior (Kimsey 2006)
Known Hosts:
Trypoxylon backi Sandhouse (Crabronidae: Crabroninae) (Krombein 1979)
Trypoxylon bidentatum W. Fox (Crabronidae: Crabroninae) (Parker and Bohart 1966; Krombein 1979)
Trypoxylon fastigium W. Fox (Crabronidae: Crabroninae) (Krombein 1979)
Trypoxylon frigidum F. Smith (Crabronidae: Crabroninae) (Krombein 1979)
Trypoxylon sculleni Sandhouse (Crabronidae: Crabroninae) (Krombein 1979)
Trypoxylon (*Trypargilum*) *collinum rubrocinctum* (Packard) (Crabronidae: Crabroninae) (Krombein 1979)
Trypoxylon (*Trypargilum*) *tridentatum* (Packard) (Crabronidae: Crabroninae) (R. Coville, pers. comm., in Bohart and Kimsey 1982)
Possible Hart-Miller Island Hosts:
Trypoxylon frigidum

Ceratochrysis Cooper

North American Species: 27 (Kimsey 2006)
Known Hosts: Crabronidae and Vespidae: Eumeninae (Kimsey 2006)
Potential Hart-Miller Island Hosts: Crabronidae (18 spp.) and Vespidae: Eumeninae (7 spp.)

***Ceratochrysis declinis* Bohart** (Figure 4)
U.S. Distribution: Northeast, west to eastern North Dakota (Bohart and Kimsey 1982)
Known hosts:
Unknown

Chrysis Linnaeus

North American Species: 77 (Kimsey 2006)
Known Hosts: Crabronidae, Sphecidae, Megachilidae, Apidae, and Vespidae: Eumeninae (Kimsey 2006)
Potential Hart-Miller Island Hosts: Crabronidae (18 spp.), Sphecidae (9 spp.), Megachilidae (18 spp.), Apidae (18 spp.), and Vespidae: Eumeninae (7 spp.)

***Chrysis conica* Brullé** (Figure 5)
U.S. Distribution: southeast, central, and desert southwest (primarily Neotropical) (Bohart and Kimsey 1982)
Known Hosts:
Eumenes fraternus Say (Vespidae: Eumeninae) (Krombein 1979)

***Chrysis pellucidula* Aaron** (Figure 6)
U.S. Distribution: widespread in the west, east, and interior (Kimsey 2006)
Known Hosts:
Trypoxylon (*Trypargilum*) *collinum rubrocinctum* (Packard) (Crabronidae: Crabroninae) (Krombein 1967; 1979)
Trypoxylon (*Trypargilum*) *tridentatum* (Packard) (Crabronidae: Crabroninae) (Hicks 1934, Parker and Bohart 1966)
Trypoxylon (*Trypargilum*) *tridentatum tridentatum* (Packard) (Crabronidae: Crabroninae) (Krombein 1979)

***Chrysis propria* Aaron** (Figure 7)
U.S. Distribution: widespread west of the Mississippi River (Kimsey 2006)
Known Hosts:
Ancistrocerus Wesmael sp. (Vespidae: Eumeninae) (F. Parker, in litt., in Bohart and Kimsey 1982)
Leptochilus rufinodus (Cresson) (Vespidae: Eumeninae) (F. Parker, in litt., in Bohart and Kimsey 1982)
Odynerus Latreille sp. (Vespidae: Eumeninae) (E.T. Vest, specimen note, in Bohart and Kimsey 1982)
Possible Hart-Miller Island Hosts:
Ancistrocerus spp. (2)

DISCUSSION

Hart-Miller Island: Seven Chrysidinae species were identified from this survey on Hart-Miller Island. Kimsey (in litt.) stated that this was "unusually high diversity" for an East Coast location. Most of Hart-Miller Island is human-made from dredged materials received from the shipping channels in the Chesapeake Bay and the approaches to Baltimore Harbor. There is an abundance of open sandy substrate for ground-nesting bees and wasps. This diversity of bees and wasps provides a plethora of hosts for the cuckoo wasps.

Maryland: Although a published list of Maryland Chrysididae does not exist, Krombein (1963) documented twenty species occurring on Plummers Island, Montgomery County. Two of his species, *Hedychridium dimidiatum* and *Caenochrysis doriae* [listed as *Chrysogona verticalis* (Patton)] also occurred in the current survey.

Figure 1. ***Hedychridium dimidiatum*** **(Say) (Elampini). A.** frontal; **B.** dorsal; **C.** dorsal showing terminal abdominal segment.

Figure 2. ***Hedychrum parvum*** **Aaron (Elampini). A.** frontal; **B.** dorsal showing terminal abdominal segment.

Figure 3. ***Caenochrysis doriae*** **(Gribodo) (Chrysidini). A.** dorsolateral; **B.** lateral; **C.** dorsal.

Figure 4. ***Ceratochrysis declinis*** **Bohart (Chrysidini). A.** frontal; **B.** dorsal; **C.** lateral.

Figure 5. ***Chrysis conica*** **Brullé (Chrysidini). A.** frontal; **B.** lateral; **C.** dorsal showing terminal abdominal segment.

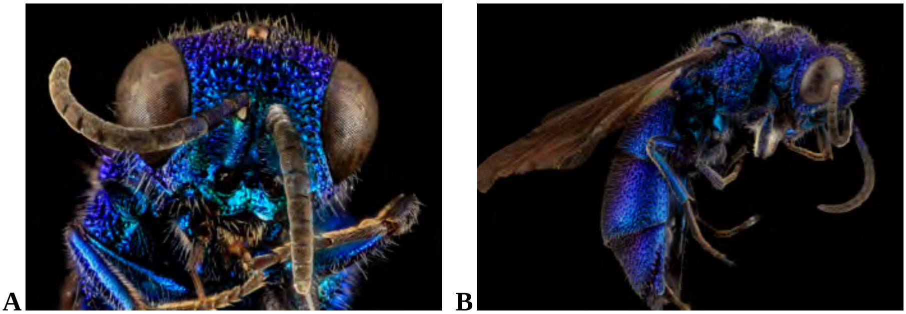

Figure 6. ***Chrysis pellucidula*** **Aaron (Chrysidini). A.** frontal; **B.** lateral.

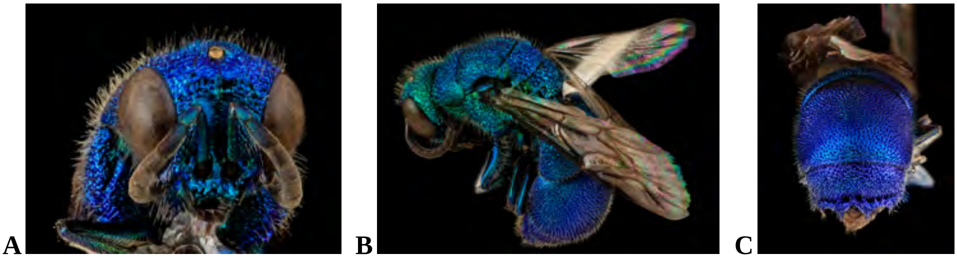

Figure 7. ***Chrysis propria*** **Aaron (Chrysidini). A.** frontal; **B.** lateral; **C.** dorsal showing terminal abdominal segment.

Adjacent States: Krombein (1952, 1954, 1956, 1958) created a list of the wasps at Lost River State Park, West Virginia. Of his twelve chrysidid species (Krombein 1958), *Hedychridium dimidiatum* and *Caenochrysis doriae* [listed as *Chrysis* (*Chrysogona*) *verticalis* Patton] also occurred on Hart-Miller Island.

Of the adjacent states, Pennsylvania has the only published statewide list (47 species) (Conrow et al. 2016). Six of the seven Hart-Miller Island species are also found on the Pennsylvania list. Only *Chrysis propria* is not on the Pennsylvania list. Discover Life (2017) shows only three eastern United States records for *C. propria*. Besides the Hart-Miller Island record, there is also one for Patuxent Wildlife Research Center (Prince George's County, Maryland, 19 May 2003) and another for Carolina Sandhills National Wildlife Refuge (Chesterfield County, South Carolina, 19 May 2007). Bohart and Kimsey (1982) showed only a western distribution for *C. propria*. Kimsey (in litt. 2014) was not surprised at the Hart-Miller Island record. She stated that *Chrysis* is a "devilishly difficult group" and postulated that in 1982, R.M. Bohart may have decided that eastern specimens were another species.

SUMMARY

Although this survey was conducted to document the bees of Hart-Miller Island, the bycatch yielded an interesting snapshot of the Chrysididae of the island and added five species to the Maryland list of published records.

ACKNOWLEDGMENTS

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Trapdoor Spiders, *Ummidia audouini* (Lucas) (Araneae: Ctenizidae), in Maryland

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The large trapdoor spiders of the genus *Ummidia* Thorell (Araneae: Ctenizidae) are known to occur along the Atlantic Coastal Plain as far north as Virginia (Bradley 2013). These are impressive spiders (Figures 1 and 2) and they attract attention when observed. However, their behavior ensures that they are very infrequently noted (Gertsch 1979). These spiders construct silk-lined burrows with a camouflaged “trapdoor” at the entrance. The door is normally opened only at night when the spiders feed so it is frequently overlooked. *Ummidia* occasionally wander from their burrows and it is at those times that they are usually discovered. Males frequently wander searching for mates in July and August (Howell and Jenkins 2004); females wander year-round (Bradley 2013). Individuals are also occasionally found when they are accidentally dug from burrows or uncovered when a flagstone or other object is moved from the surface of the ground.

Ummidia have short, stubby legs and can be recognized by a combination of size and color, six eyes in two groups of three, forward-opening U-shaped fovea, and a deep depression on the dorsal surface of tibia III (Kaston 1978, Gertsch 1979, Bond and Hendrixson 2005, Bradley 2013). Non-wandering individuals may be identified by their burrow, capped with the classic trapdoor.

These large, shiny black spiders are sexually dimorphic. Fully-grown females typically have a total body length of 28 mm (1.1 in); males, 15 mm (0.6 in) (Kaston 1978, Bradley 2013). Females are dark brown or black and have shorter legs than males; males are black (occasionally having a lighter-colored abdomen) with longer legs than females (Bradley 2013).

Bond and Hendrixson (2005) summarize the distribution of *Ummidia* as widespread in the eastern United States (north to Virginia [Bradley 2013]) and west to Texas and Colorado. They estimate that the genus contains 50 species, of which only ten have been described. For the purposes of this note, Maryland *Ummidia* are considered to be *U. audouini* (Lucas).

This note reviews a largely unknown historic record of *U. audouini* from Maryland. Additionally, it documents a recently preserved specimen, anecdotal reports from local biologists or naturalists, and four photo documented specimens posted on BugGuide (http://bugguide.net; hosted by the Department of Entomology, Iowa State University, Ames, Iowa).

RECORDS AND REPORTS

Previously Published Historical Record

Kent County

Ummidia audouini: Little published information is available on the distribution of trapdoor spiders in the eastern United States. As summarized by Bradley (2013), *U. audouini* is known to range northeast to Virginia. However, there is one frequently overlooked report of *U. audouini* from Maryland. Raabe (1938) recorded observations made by members of the Natural History Society of Maryland (NHSM) at Rock Hall in Kent County, Maryland on 2 July 1938. Since that report is not well known, it is summarized here. Two large, unusual spiders were dug from sandy soil at a depth of about 15 cm (6 in). They were later identified as trapdoor spiders, "*Pachylomerus audouinii* Lucas" (= *Ummidia audouini*). The specific location was:

> "Approximately 20 feet [6 m] from the edge of Swann Creek, on a small hill (elevation approximately 10 feet [3 m] from the level of the creek). The area was of a wooded nature with little underbrush. The character of the soil was a reddish-yellow, moist, sandy nature."

As noted by Bradley (2013), trapdoor spiders frequent banks and wooded hillsides, and Gertsch (1979) noted that in western Florida they dig their burrows in the sides of steep, stream-cut banks in moist and shady ravines. Unfortunately, the original Rock Hall specimens have been lost, and a subsequent trip to the same locality by NHSM members failed to produce additional examples.

Recent Specimen Record

Anne Arundel County

Ummidia audouini, female: Along Mill Creek, just northeast of Annapolis (39°00'10" N, 76°27'60" W). On 16 April 2004, Laurie Burr and her mother, Dorothy Burr, were working in a small flower garden when an adult female *Ummidia audouini* (Figure 1) was dug from sandy soil. That individual was collected, kept alive for a period in captivity, and preserved after it died. The garden was a small (2 m [~7 ft] by 1.5 m [~5 ft]) open area in a grassed lawn, about 3 m (10 ft) from the edge of a bank that slopes steeply to Mill Creek.

This specimen has been placed in the permanent invertebrate collection of the Archbold Biological Station, Lake Placid, Florida.

Anecdotal Reports

Calvert County

Ummidia sp.: A large, black spider was brought to the Battle Creek Cypress Swamp Sanctuary in Calvert County late in the summer of 2004. It was found wandering across the parking lot of Christ Church at 3100 Broomes Island Road in Port Republic, Calvert County. The spider was kept alive in captivity at the sanctuary nature center, but was not

Figure 1. *Ummidia audouini* (Lucas). Adult female, collected along Mill Creek, northeast of Annapolis, Anne Arundel County, Maryland, on 16 April 2004 by Laurie Burr. Dorsal (left) and ventral (right) views; scale = 10 mm (0.4 in). Images made with a Nikon D810 camera on an Ortery Photosimile light box to capture composite images using Helicon Focus stacking software (version 6.6.0.). Photographed by Stephanie Leon.

preserved when it died. It was identified as a trapdoor spider, *Ummidia* sp., by the sanctuary naturalist who compared it to photographs published on the internet (Dwight Williams, pers. comm.).

Ummidia sp.: While gathering information on the Broomes Island Road spider, I spoke with another sanctuary volunteer, Terri Ihnacik who owns property on Brandywine Street in St. Leonard, Calvert County. She informed us that large, black trapdoor spiders and their burrows were found around her home in past years. However, a search by her of the property during the summer of 2005 revealed no spiders or burrows. She noted that the soil around the residence had been disturbed on a number of occasions since the spiders were last observed.

Ummidia sp.: A third trapdoor spider report was related to me by David Bohaska. That large specimen was found by a resident of Scientists' Cliffs, Calvert County, during the summer of 2003 or 2004. It was collected as it walked across an unpaved path through mature woodland. The spider was transmitted to the Department of Entomology, National Museum of Natural History, Smithsonian Institution, Washington, DC, where it was identified as a trapdoor spider of the genus *Ummidia*. Unfortunately, the whereabouts of that specimen are presently unknown (David Bohaska, pers. comm.).

Photo Documented Records

Four additional Maryland records are documented by photographs posted on the website BugGuide (Figure 2). These records, including their BugGuide photo numbers, are listed below.

Anne Arundel County
Ummidia sp., male (Photo #1328544): Crownsville, 4 January2017 (Wixted 2017) (Figure 2A).

Howard County
Ummidia sp. (Photo #1162689): Columbia, 4 November 2015 (Muller 2015) (Figure 2B).

St. Mary's County
Ummidia audouini (Photo #1202509): Dameron, 16 March 2016 (Hays 2016) (Figure 2C).

Worcester County
Ummidia sp. (Photo #1218545): Snow Hill, 26 September 2014 (sastro 2016).

SUMMARY

The above reports and records suggest that large trapdoor spiders may be widespread in southern Maryland. The original Rock Hall report and the Snow Hill record also place them on the Delmarva Peninsula on the Eastern Shore of the Chesapeake Bay. However, additional field work will be required to determine the current distribution and status of these large and interesting spiders in Maryland.

ACKNOWLEDGMENTS

Appreciation is extended to David Bohaska, Terri Ihnacik, and Dwight Williams for relating their experiences with Maryland trapdoor spiders. Special thanks are due to Laurie Burr, who not only found and captured the Mill Creek spider, but kept it in her office until its demise. She graciously invited me to her home and allowed me to dig around on her property in search of additional trapdoor spiders. Kerry Wixted, Sue Muller, and Chris Hays allowed reproduction of their photographs of Maryland *Ummidia* that were originally posted on BugGuide. Gene Scarpulla made me aware of the very useful information available through BugGuide. Special thanks are also due to Stephanie Leon who produced the images of the Mill Creek *Ummidia* published in this note.

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Figure 2. Specimens of Maryland *Ummidia* previously posted on BugGuide website. **A**, *Ummidia* sp., male, Anne Arundel County, Crownsville, Kerry Wixted (2017); **B**, *Ummidia* sp., Howard County, Columbia, Sue Muller (2015); **C**, *Ummidia audouini*, St. Mary's County, Dameron, Christopher Hays (2016). Images published with the permission of the photographers. Images are not to scale. (Additionally, *Ummidia* sp., Worcester County, Snow Hill, sastro (2016) was posted on BugGuide, but attempts to contact sastro for permission to publish the photograph were unsuccessful.)

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CONTENTS

COVER PHOTOGRAPH

A female "green highland morph" of the snail-eating ground beetle *Scaphinotus viduus* (Dejean) (Coleoptera: Carabidae: Cychrini). Photographed near Cranberry Glades, Pocahontas County, West Virginia, 28 May 2017.

Photographed by Lily M. Thompson