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MARYLAND ENTOMOLOGICAL SOCIETY
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Editor's Note

I thank the MES member and guest authors for their submittals that continue to increase our knowledge of Maryland's insect fauna. I extend my gratitude to the named and anonymous peer reviewers for their insightful comments that have enhanced each article.

The Maryland Entomological Society needs your submittals to keep the journal publishing annually. As said on previous occasions, "**It benefits no one if your natural history records remain in your field notebook, computer database, or insect cabinet.**" Many MES members have been conducting studies or surveys on their entomological specialty. Some have first Maryland records or first county records. Some document a specific geographic area. Some show trends over time. Several members have said that they have studies to publish – now is the time to do this. To reiterate, if you do not put your data into print, it is benefiting no one. Publish your data and put it into the permanent record. Please consider submitting an article or note for an upcoming issue of *The Maryland Entomologist*. Thank you.

Eugene J. Scarpulla
Editor

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Notes on the Historical Distribution of Species in the Genus *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini), the Snail-eating Ground Beetles, in Maryland

Frank G. Guarnieri

16 Brooklyn Avenue, Waterville, Maine 04901
fguarnieri@aol.com

Abstract: Six species of *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini), the snail-eating ground beetles, have been reported from Maryland: *S. andrewsii mutabilis* (Casey), *S. elevatus elevatus* (Fabricius), *S. imperfectus* (Horn), *S. ridingsii monongahelae* Leng, *S. unicolor* (Fabricius), and *S. viduus* (Dejean). *Scaphinotus unicolor* and *S. e. elevatus* appear to have declined significantly in Maryland; the latter, in fact, may no longer occur in the state. An additional subspecies of *S. ridingsii*, *S. r. ridingsii* (Bland), that has not been collected in Maryland, but once occurred in northern Virginia, may also be extirpated from that location. Populations of *S. a. mutabilis*, *S. imperfectus*, *S. r. monongahelae*, and *S. viduus* appear to be stable in Maryland.

INTRODUCTION

Bousquet (2012) and Glaser (1996) both list six species of *Scaphinotus* Dejean (Coleoptera: Carabidae: Cychrini), the snail-eating ground beetles, that have been collected in Maryland: *S. andrewsii mutabilis* (Casey), *S. elevatus elevatus* (Fabricius), *S. imperfectus* (Horn), *S. ridingsii monongahelae* Leng, *S. unicolor* (Fabricius), and *S. viduus* (Dejean). Comparative dorsal habitus photos of the six species herein discussed are shown in Glaser (1996).

Scaphinotus beetles are remarkable in several aspects. They are variable in size but tend to be among the larger carabids; exceptional specimens of *S. unicolor* and *S. viduus* can reach or exceed 3 cm [1.2 in] in length. The beetles are flightless, but have long legs and are fast runners. The majority have some degree of, and often quite striking, iridescent blue, bronze, copper, green, or purple coloration on their dorsal surfaces (Figure 1). Yet, the most striking common feature of the group is their elongated mouthparts (Figure 2) specially suited for attacking and eating snails through the apertures of their shells (Cover Photo).

Scaphinotus beetles are not commonly seen in the Mid-Atlantic region. They are strictly nocturnal but do not come to lights. Generally, one must set large numbers of pitfall traps in remote settings to obtain specimens. However, it is not unusual to see drawers containing dozens, if not hundreds, of pinned specimens of each species in museum collections. Many of these records are old, with a significant number dating from 1890 to 1940. This contrasts with much sparser modern collecting data for many of the beetles, giving the impression that there may be an overall decline in their abundance in this region.

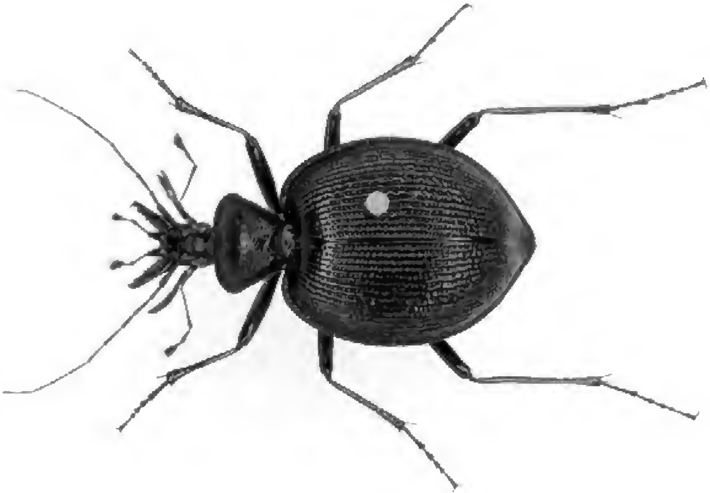

Figure 1. Dorsal habitus. *Scaphinotus viduus* (Dejean). Paw Paw, Morgan County, West Virginia, 26 August 2000.

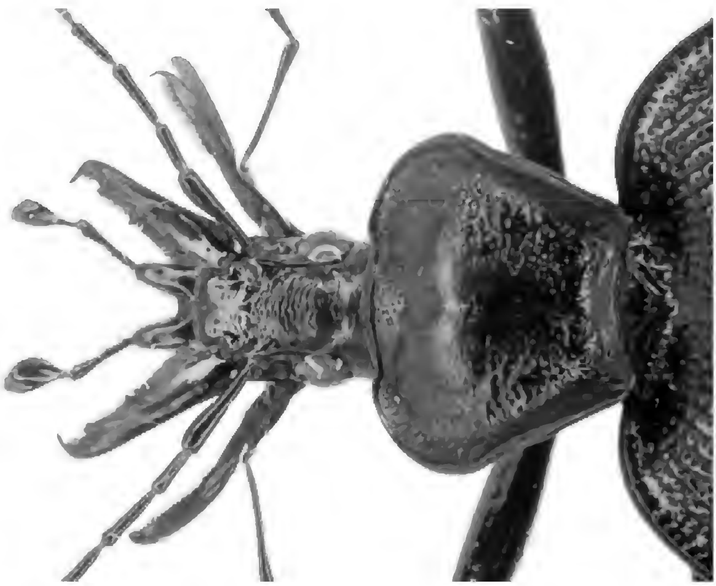

Figure 2. Elongated mouthparts. *Scaphinotus viduus*. Paw Paw, Morgan County, West Virginia, 26 August 2000.

METHODS

I made visits to four academic collections with significant holdings of Mid-Atlantic *Scaphinotus* beetles: the Carnegie Museum of Natural History in Pittsburgh, Pennsylvania (CMNH); the Cornell University Insect Collection in Ithaca, New York (CUIC); the Smithsonian Institution National Museum of Natural History in Washington, District of Columbia (USNM); and the University of Maryland Department of Entomology in College Park, Maryland (UMDC) and recorded every representative of the six species listed above from Delaware, the District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia, as well as *Scaphinotus ridingsii ridingsii* (Bland) known only from Virginia and West Virginia. Nearly 1500 specimens were examined (Table 1). Further collecting records were gathered from published sources. Nomenclature follows Bousquet (2012).

RESULTS / SPECIES ACCOUNTS

Table 1 summarizes the Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, and West Virginia specimens located at CMNH, CUIC, USNM, and UMDC. All states and the District of Columbia were represented by at least one species, except for Delaware, from which no *Scaphinotus* specimens were located.

Table 1. *Scaphinotus* specimens located at the Carnegie Museum of Natural History, the Cornell University Insect Collection, the Smithsonian Institution National Museum of Natural History, and the University of Maryland Department of Entomology.

Species	DC	DE	MD	PA	VA	WV	Total
Scaphinotus andrewsii mutabilis (Casey)	0	0	44	157	63	111	375
Scaphinotus elevatus elevatus (Fabricius)	18	0	27	3	65	5	118
Scaphinotus imperfectus (Horn)	0	0	14	104	13	159	290
Scaphinotus ridingsii monongahelae Leng	0	0	31	151	34	84	300
Scaphinotus ridingsii ridingsii (Bland)	0	0	0	0	66	1	67
Scaphinotus unicolor (Fabricius)	16	0	24	1	67	1	109
Scaphinotus viduus (Dejean)	0	0	23	116	6	42	187
Total *Scaphinotus* Dejean specimens	34	0	163	532	314	403	1446

***Scaphinotus andrewsii mutabilis* (Casey)**

Scaphinotus a. mutabilis is part of a complicated species and subspecies complex within the subgenus *Steniridia* Casey. Valentine (1935) described 17 subspecies within six species that are typically found at higher elevations in the southern Appalachian Mountains. Only two species are known to occur in Maryland, the other being *S. ridingsii monongahelae* (discussed below). Valentine speculated that mountaintop isolation in these flightless beetles created the opportunity for multiple distinct forms to evolve. According to Valentine, the subspecies occurring in western Maryland would be

S. a. germari (Chaudoir) as he considered *S. a. mutabilis* to be a mere variant of the former, rather than a valid subspecies. Bousquet (2012) separated the two subspecies with *S. a. mutabilis* having a more northerly distribution and being the only subspecies occurring in western Maryland and southwestern Pennsylvania. The two subspecies are superficially quite similar, and I did not separate them while reviewing the collections. Thus, the records listed below from Virginia and West Virginia likely include populations of both subspecies. In any event, over 300 total specimens were seen from four states. MARYLAND: The majority of records were from Garrett County, including 38 beetles taken in pitfall traps 1985–1996 at Big Run State Park, Garrett State Forest, and Savage River State Forest (CMNH). There were four undated but very old-appearing (E. A. Klages collection – likely 1900–1920) specimens from Smithsburg in Washington County (CMNH). Lastly, two specimens collected by John D. Glaser at Douglas Point in Charles County dated 6 September 1985 (CMNH) are of significant interest in that they are far outside the usual range and habitat for this beetle. PENNSYLVANIA: Records were from Allegheny, Beaver, Cambria, Fayette, Indiana, Lawrence, McKean, Somerset, and Westmoreland Counties. VIRGINIA: Records were from Giles, Greene, Lee, Montgomery, Rockbridge, Scott, Smyth, and Wise Counties. WEST VIRGINIA: Records were from Braxton, Fayette, Grant, Monroe, Pocahontas, Raleigh, Randolph, Roane, Tucker, Webster, and Wyoming Counties. Of the 355 dated specimens examined over the entire region, 233 were collected after 1980. PUBLISHED RECORDS: Bailey et al. (1994) reported 122 beetles taken in pitfall traps from May to August 1992 in the vicinity of Big Savage Mountain in Garrett County, Maryland. Given the large number of contemporary records over a wide geographic area, there are no current concerns about declines in the range or numbers of this species.

***Scaphinotus elevatus elevatus* (Fabricius)**
Many old specimens were seen, mostly from the Coastal Plain and Piedmont regions of Maryland and Virginia. DISTRICT OF COLUMBIA: The beetle occurred in Rock Creek Park, but no specimens collected after 1947 were found. DELAWARE: Bousquet (2012) listed the species from the state, but no physical specimens from Delaware were found in any of the collections examined. MARYLAND: Records were from Allegany, Anne Arundel, Baltimore, Calvert, Carroll, Charles, Frederick, Harford, Prince George’s, Saint Mary’s, and Washington Counties. Of the 25 dated specimens from Maryland, only three were collected during the past 50 years: Prince George’s County, Beltsville, 11 October 1974 (USNM); Allegany County, Rocky Gap, 26 September 1983 (CMNH); and Calvert County, Huntington, 8 May 1990 (USNM). PENNSYLVANIA: No dated specimens were seen. There were two beetles labeled “PA” in the USNM and one beetle in the Klages collection at the CMNH from Jeannette in Westmoreland County that were all likely collected prior to 1920. VIRGINIA: Records were from Arlington, Campbell, Clarke, Dinwiddie, Essex, Fairfax, Fluvanna, Giles, Goochland, James City, Montgomery, Nelson, and Stafford Counties, as well as the cities of Newport News and Norfolk. Of the 54 dated specimens from Virginia, only two were collected during the past 50 years: Essex County, Dunnsville, 23 September–19 October 1993, “pitfall trap” (USNM); and Arlington County, Glencarlyn Park, 6 May 2003 (USNM). WEST VIRGINIA: Five specimens collected between 1917 and 1939 were examined; all from Jefferson County. PUBLISHED RECORDS: Only one modern record was found for the region. Anderson et al. (1995) reported one specimen in a pitfall trap, 17 April–29 May

1991, from the Stafford County, Virginia section of the Quantico Marine Corps Base. Based on the very few recent records for this once widespread species, it is possible that *S. e. elevatus* may be extirpated, or at least now is very rare in the area studied.

***Scaphinotus imperfectus* (Horn)**
The smallest *Scaphinotus* species in the Mid-Atlantic region is predominately a highland species. George Henry Horn (1860) wrote, "this beautiful little insect, of which but a few specimens have been obtained, has only been found in Hampshire County, Virginia, in the most rocky portions of the Allegheny ridge, which traverses that section." Recent pitfall surveys have shown that *S. imperfectus* is far more common than previously thought. Almost 300 specimens were examined from four states. MARYLAND: The majority of records were from Garrett County including 11 from Big Run State Park, 7 September–1 October 1985 (CMNH) and one from Potomac State Forest, 17 May 1995 (CMNH). There were two beetles collected by John D. Glaser from Douglas Point in Charles County dated 6 and 7 September 1985 (CMNH). As was the case with the specimens of *S. a. mutabilis* that were found at the same time and location (discussed above), these records are of significant interest in that they are far outside the typical range and habitat for *S. imperfectus* as well. PENNSYLVANIA: Records were from Bedford, Erie, Fayette, Indiana, McKean, and Westmoreland Counties. VIRGINIA: Records were from Bedford, Carroll, Giles, Madison, Page, Pulaski, and Rockbridge Counties. WEST VIRGINIA: The Hampshire County type specimen collected by Horn (Harvard Museum of Comparative Zoology, Cambridge, MA) is labeled "VA", but in 1863, that county became part of the newly formed state of West Virginia (Williams 2013). Further records were from Greenbrier, McDowell, Monongalia, Pocahontas, Preston, Raleigh, Randolph, and Tucker Counties. Of 288 dated specimens over the entire area, 269 were collected after 1980. PUBLISHED RECORDS: Bailey et al. (1994) reported eight specimens taken in pitfall traps from May to August 1992 in the vicinity of Big Savage Mountain, in Garrett County, Maryland. Glaser (1996) described *S. imperfectus* as "relatively common in pitfall traps in Garrett County, Maryland."

***Scaphinotus ridingsii monongahelae* Leng**
Along with *S. a. mutabilis*, *S. r. monongahelae* is the other member of the *Steniridia* species and subspecies complex occurring in Maryland. The range, habitat, and relative abundance are presumed to be similar to *S. a. mutabilis*. Nearly 300 total specimens from four states were examined. MARYLAND: Records were from Garrett County, including 27 beetles taken in pitfall traps 1985–1987 at Big Run State Park, Garrett State Forest, and Savage River State Forest (CMNH). PENNSYLVANIA: Records were from Allegheny, Fayette, Indiana, and Westmoreland Counties. VIRGINIA: Records were from Augusta, Giles, Greene, Page, Rockingham, and Shenandoah Counties. WEST VIRGINIA: Records were from Fayette, Hampshire, Monroe, Pendleton, Preston, Pocahontas, Randolph, Tucker, and Summers Counties. Of the 260 dated specimens examined over the entire region, 129 were collected after 1980. PUBLISHED RECORDS: Bailey et al. (1994) reported 20 beetles taken in pitfall traps from May to August 1992 in the vicinity of Big Savage Mountain, in Garrett County, Maryland. Again, similar to *S. a. mutabilis*, *S. r. monongahelae* appears to be stable in terms of its range and numbers in the region.

Scaphinotus ridingsii ridingsii **(Bland)**
VIRGINIA: Thirty-three specimens were examined in the USNM dated between 1902 and 1933 that were labeled “Plummers Island”, which is located in Montgomery County, Maryland. However, one of these specimens was also labeled “VA” and another was labeled “VA side of the river.” Valentine (1935) recorded specimens from “Great Falls and Plummer’s Island, Fairfax Co, Virginia.” In his study of the Carabidae of Plummers Island, Erwin (1981) stated that the species was not found on the island, but rather on the opposite Virginia shoreline. Valentine (1935) describes *S. r. ridingsii* as a subspecific colony occurring in the Potomac River valley that is morphologically distinct from the more western *S. r. monongahelae*. These multiple lines of evidence strongly suggest that the specimens labeled “Plummers Island” were actually collected in Virginia, and the species can be presumed absent in Maryland. In addition to the 33 specimens labeled “Plummers Island”, there were another 33 beetles in the USNM from Fairfax County that were collected between 1919 and 1934. Five were labeled “Black Pond”; two were labeled “across from Cabin John, MD”; and two were labeled “across from Plummers Island, MD”. WEST VIRGINIA: One specimen was examined from Jefferson County, Harpers Ferry, on 20 June 1970, “in cave” (USNM), whose location, I suppose, would be somewhat intermediate between the ranges of the two subspecies. No other more recent museum specimens were seen from the Potomac River Valley in my survey. PUBLISHED RECORDS: The subspecies was not reported by Steury and Messer (2014) over a nine-year survey (2004–2013) of carabid beetles along the George Washington Memorial Parkway in the District of Columbia and Northern Virginia (Arlington and Fairfax Counties and the city of Alexandria). Also, the beetle was not detected on either side of the river in Montgomery County, Maryland or Fairfax County, Virginia in the Potomac Gorge BioBlitz, 23–25 June 2006 (Evans 2008). Thus, *S. r. ridingsii* may now be extirpated, or at the least very rare, in its only known habitat.

Scaphinotus unicolor **(Fabricius)**
As was the case with *S. e. elevatus* in the Mid-Atlantic region, *S. unicolor* is generally confined to the Coastal Plain, and a preponderance of older collecting data suggests a significant decline in its overall abundance. DISTRICT OF COLUMBIA: Sixteen specimens were examined, with the most recent collecting date being 1924. MARYLAND: Twenty-four dated specimens were examined from Allegany, Baltimore, Calvert, Carroll, Charles, and Montgomery Counties. Only three were collected in the past 50 years: Charles County, Marburg, 2 October 1980 (CMNH); Calvert County, 8 May 1990, “0.5 miles S jct Rt. 2+4” (USNM) (The label indicates the beetle was found just north of Huntington. Note that a specimen of *S. e. elevatus* was collected in Huntington on the same day.); and Calvert County, Calvert Cliffs, 8 October 2003 (USNM). PENNSYLVANIA: The only record was from an undated but very old-appearing specimen collected in Johnstown in Cambria County (USNM). VIRGINIA: Records were seen from Arlington, Carroll, Fairfax, Spotsylvania, and York Counties, as well as the city of Newport News. Of the 57 dated specimens from Virginia, 43 were collected prior to 1945, while the remaining 14 were taken at a single location: York County, Cheatham Annex Naval Supply Center, 24 September–2 November 1989 (presumed pitfall trap survey [CMNH]). WEST VIRGINIA: There was one undated but very old-appearing specimen from Marion County (CMNH). With the exception of the beetles from Cheatham, the paucity of recent records suggests that *S. unicolor* has

become very rare in the Mid-Atlantic region. PUBLISHED RECORDS: According to Erwin (1981), this species formerly occurred on Plummers Island: "Many examples were collected on the island and adjacent Virginia shore between 1902 and 1943. There are no recent records." Yet, Steury and Messer (2014) report four specimens from Great Falls Park in Alexandria County collected between 2004 and 2013 in their survey of carabid beetles along the George Washington Memorial Parkway. Also, they report that an additional specimen of *S. unicolor* was collected from the same location but misidentified as *S. viduus* in Evans (2008). They go on to mention that these records of *S. unicolor* are the first in the Potomac River Gorge since 1943. Furthermore, Anderson et al. (1995), in their survey of the Carabidae from the Quantico Marine Corps Base in Virginia, made the remarkable observation that "this striking big species is among the most abundant ground beetles found at Quantico." Incredibly, 66 specimens were taken in pitfall traps in the fall of 1990 and spring of 1991 from the Stafford County section of the base. Thus, the data from Cheatham, Great Falls, and Quantico suggest that, unlike *S. e. elevatus*, *S. unicolor* may still be abundant in local populations.

***Scaphinotus viduus* (Dejean)**
This large beetle is widespread throughout the Mid-Atlantic area but most often is associated with Piedmont and mountain habitats. DELAWARE: Bousquet (2012) listed the species from the state, but no specimens were found in the museums visited. DISTRICT OF COLUMBIA: Bousquet (2012) listed the species from the District, but again, no specimens were found in the museums visited. MARYLAND: Records were from Allegany, Carroll, Garrett, Prince George's, and Washington Counties. One specimen from Hereford in Baltimore Country (30 July 2005) is in my personal collection. PENNSYLVANIA: Records were from Allegheny, Clarion, Clearfield, Delaware, Elk, Erie, Fayette, Forest, Franklin, McKean, Philadelphia, Potter, and Westmoreland Counties. VIRGINIA: Records were from Albemarle, Campbell, and Shenandoah Counties and from Stony Man Mountain, which could be either Madison or Page County. WEST VIRGINIA: Records were from Berkeley, Braxton, Hampshire, Monongalia, Pocahontas, Randolph, and Tucker Counties. One specimen from Paw Paw, Morgan County, West Virginia, (26 August 2000) is in my personal collection. Of the 176 dated specimens examined over the entire region, 105 were collected after 1980. PUBLISHED RECORDS: Numerous recent records exist for this species. Bailey et al. (1994) reported eight specimens taken in pitfall traps from May to August 1992 in the vicinity of Big Savage Mountain, in Garrett County, Maryland. Kim and Piechnik (2009) reported two specimens from 1999 on Big Round Top, Gettysburg National Military Park, Adams County, Pennsylvania. Fritzler and Strazanac (2012) reported 28 specimens taken in a pitfall survey from 1 June–19 October 2011 from Catoctin Mountain Park, Frederick County, Maryland. These data suggest that populations of *S. viduus* are likely stable over the Mid-Atlantic region.

Two close allies of *S. viduus* in the Mid-Atlantic region bear mentioning.

"Scaphinotus viridis" is a manuscript name commonly used for a large bright, golden-green *Scaphinotus* beetle occurring at higher elevations of Pendleton, Pocahontas, Randolph, and Tucker Counties in West Virginia. Prior to his death, Thomas Barr had speculated that "*S. viridis*" was a unique species, although it is presently unclear whether it is more likely a subspecies or high altitude color morph of *S. viduus*. Specimens were seen at the CUIC and the USNM, although the vast majority was at the CMNH including Barr's collection of 122 beetles from Kennison Mountain in Pocahontas County. Of 229 dated specimens, 204 were collected after 1980. These are not included in the *S. viduus* numbers listed in Table 1.

Scaphinotus webbi **Bell** is very closely related to *S. viduus*; the two are separated by subtle differences in the shape of the pronotum and also by fine details of the male genitalia (Bell 1959). Bousquet (2012) lists *S. webbi* from Pennsylvania, Virginia, and West Virginia. Glaser (1996) speculated that *S. webbi* would eventually be found in Maryland, but so far there have been no published reports. I did not see any specimens labeled as *S. webbi* in this survey, yet it is possible that some were mixed in with the *S. viduus* holdings.

DISCUSSION

Special note must be made of the apparent absence of *Scaphinotus* beetles from the Delmarva Peninsula. Bousquet (2012) reported *S. e. elevatus* and *S. viduus* from Delaware. However, no specimens were examined for any species east of the Chesapeake Bay. If anything, the habitat seems most suitable for *S. unicolor*, which Bousquet (2012) did list from New Jersey. Yet, no specimens were reported in recent surveys from Eastern Neck National Wildlife Refuge (Staines and Staines 2011) or from Tuckahoe and Pocomoke River State Parks (Guarnieri 2010).

Special note must also be made addressing the difficulty in making absolute conclusions regarding comparative population levels based on this type of study. Large numbers of museum specimens do not prove abundance in nature, nor do small numbers prove rarity, as many types of sampling bias could be present. The only point I wish to make is that certain historical trends are suggested. For example, *S. a. mutabilis*, *S. imperfectus*, and *S. r. monongahelae* are probably secure in Garrett County, Maryland. Likewise, the numerous recent collecting records of *S. viduus* suggest that its population is stable in the Piedmont and mountainous regions of Maryland. The situation, however, is less favorable for the species of *Scaphinotus* more typically associated with lowland habitats. This is not surprising as these are the regions in Maryland undergoing the greatest human disturbance. Numbers of *S. e. elevatus* and *S. r. ridingsii* appear to have been severely reduced from historical levels and it is possible that both are now extirpated from this region.

The situation is more complicated with *S. unicolor*. On the one hand, there has probably been an overall reduction in its range and number in the state. Yet, the surveys at Cheatham, Great Falls, and Quantico in Virginia suggest that *S. unicolor* may still be abundant in unidentified local populations in Maryland. Further surveys would be encouraged on the Delmarva Peninsula and in areas such as the Aberdeen Proving Ground in Harford County, the Cedarville State Forest in Charles and Prince George's Counties, the Patuxent Research Refuge in Anne Arundel and Prince George's Counties, and St. Mary's River State Park in St. Mary's County.

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Maryland Collection Records of *Dioedus punctatus* LeConte (Coleoptera: Tenebrionidae: Phrenapatinae), a Small Darkling Beetle Found in Rotten Wood

Warren E. Steiner, Jr.[1] and Jil M. Swearingen[2]

[1]*c/o Department of Entomology, NHB-187, Smithsonian Institution, Washington, DC 20560*
[1]*steinerw@si.edu;* [2]*elytra@earthlink.net*

ABSTRACT: Known specimen records of *Dioedus punctatus* LeConte (Coleoptera: Tenebrionidae: Phrenapatinae) from Maryland are listed by county. Specimen data from the District of Columbia are also given. All life stages of the beetle are found in soft wood of "red-rotten" logs and fallen trunks in late stages of decay, usually in mature forest habitats.

INTRODUCTION

Dioedus punctatus LeConte (Coleoptera: Tenebrionidae) is the only member of the subfamily Phrenapatinae Solier, Tribe Penetini Lacordaire, known to occur in eastern North America (Aalbu et al. 2002). Most species of the subfamily are tropical and all inhabit rotten wood (Matthews et al. 2010). A widespread beetle of eastern North American forests, *D. punctatus* occurs from Ontario, Canada (Bousquet et al. 2013), south to Florida and Puerto Rico (Peck and Thomas 1998) and probably occurs in all states east of the Mississippi River. This small, saproxylic (dependent on dead or decaying wood) beetle (body length 2.5-3.3 mm [0.10-0.13 in]) is often overlooked by collectors, and family identity is commonly questioned. It is not well known, nor mentioned in popular field guides, but can be found frequently if the habitat is recognized and carefully searched. BugGuide (2015) provides some images, distribution and habitat data. Triplehorn (1952) provided a detailed description of the beetle; the distinctive larva was described (Young 1976) from Michigan, "from a dead log, probably *Ulmus americana*, in the red-rotten stage of decay." Some pupal characters and habitats were described for it and a few relatives (Steiner 1995).

Specimens and/or literature records of *D. punctatus* have been seen for most of the eastern United States. In this study we present the known specimen data for Maryland and the District of Columbia and include descriptions of habitats and some life history observations not published elsewhere. These records substantiate the earlier listing of the species for the state (Steiner 2008; Maryland Biodiversity Project 2015).

METHODS

Specimens are deposited in the United States National Museum of Natural History, Smithsonian Institution, Washington, DC. Specimen label data below are quoted verbatim, with commas inserted for clarity; breaks between labels are separated by a forward slash. Inferred data and additional characters added in abbreviations are given in brackets. Most of the specimen records were collected by the authors, with names spelled out on labels, but abbreviated here as "WES" and "JMS." The numbers of specimens bearing the same data follow in parentheses.

RESULTS

Maryland Records

Anne Arundel County: "MARYLAND: Anne Arundel County, Crofton, 38°59'33"N, 76°41'58"W, 27 March 2015, colls. WES & JMS / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (2 hind bodies + 1 small larva); "MARYLAND: A. Arundel Co., 6 km SE Laurel (North Tract Patuxent Res[earch]. Ref[uge].), 39°04'26"N, 76°46'51"W, 15 April 2015 / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest; Coll. WES" (3).

Baltimore County: "Towson, Md., Nov. 6.[19]13 / H L Parker" (1).

Howard County: "Ellicott City, Md., 9 Nov.'[19]15 / H L Parker Collector" (2).

Montgomery County: "MARYLAND: Montg. Co., Blockhouse Point area 2.8 km ESE Seneca, 39°04'10"N, 77°18'32"W, 1 January 2005 / WES, JMS et al. collectors / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (3); "MARYLAND: Montg. Co., Carderock area, 38°58'27"N, 77°12'10"W, 9 November 2002, coll. WES & JMS / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (5); same data except "11 April 2010 / In red-rotten barkless log, probably oak" (1); "Jacksons Isl. Md. [presumably near Plummer's Island on Potomac River], July 16.[19]13, HSBarber / In red-rotten oak with *Micromalthus*" (1, + 2 larvae in alcohol); same data except "Plummers Isl note #135' / Jacksons I. Md, 19.VI.[19]13 / HSBarber Collector (2); same data except "5.V.13 / in red rotten log" (2); same data except "in red rotten wood (oak), Aug. 5. 1913, Schwarz & Barber" (1, teneral with larval exuvia, + 1 larva in alcohol); same data except "in old oak, Aug. 24, 1913" (3 + 2 larvae in alcohol); same data except "20.VI.13 / Schwarz & Barber Coll" (1); same data except "5 Aug. 1913" (3) and "10 Aug. 1913" (1); same data except "In red-rotten oak with *Micromalthus*, bred July 1913, Schwarz & Barber" (1 teneral + 2 larvae in alcohol); "Pre-pupa ex. Pupal cell & young larva in rotten oak, June 21, 1914, H. S. Barber" (2 larvae in alcohol); "MARYLAND: Montg. Co., Plummers Island, west slope near summit, 38°58'11"N, 77°10'35"W, 1 January 2006 / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest / WES, JMS, J. M. Hill, C. & P. Bergmann collectors" (1); same data except "swale NW of summit, 38°58'12"N, 77°10'37"W, 11 April 2015 / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest / WES, JMS et al. collectors" (4); "MARYLAND: Montgomery Co., Potomac, May 1973, WES" (2); "MARYLAND: Montg. Co., Rachel Carson Consv. Park, 4 km SW Unity, 39°13'N, 77°05'W, 1 January 2008 / In soft damp wood of red-rotten oak log in mixed forest / WES, JMS, C. & P. Bergmann collectors" (1).

Prince George's County: "MD.; Bladensburg, V-8-1917" [no other data] (7); "Pr. Georges Co. Md., I.18-IV [19]48, George B. Vogt / under bark of advanced rotten log /

red or black oak" (1); MARYLAND: Pr. Geo. Co., Cheverly, 38°56'N, 76°55'W, 1 November 1992 / WES & JMS collectors / In red-rotten wood of fallen *Pinus virginiana*" (13); same data except "3 January 1993" (10), "31 Dec. 1993" (2); same data except "38°55'58"N, 76°54'58"W, 1 December 2008 / WES, JMS et al. collectors / In soft red-rotten wood of log *Pinus virginiana* in mixed forest slope" (11); same data except "18 March 2012" (4); same data except "near Town Park, 38°55'29"N, 76°54'21"W, 31 December 2013 / In red-rotten moist wood of fallen pine in mixed forest" (2); same data except "38°55'25"N, 76°54'22"W, 20 March 2014 / In red-rotten pine log, mixed forest edge" (1); "MARYLAND: Pr. Geo. Co., Nat. Agr. Research Ctr. near Beltsville, 39°2'N, 76°51'W, 7 Feb. 1999, / WES & JMS collectors / In red-rotten moist wood of fallen pine in mixed forest" (1); "MARYLAND: Pr. Geo. Co., Greenbelt, 39°59'35"N, 76°53'46"W, 28 October 2011, coll. WES & JMS / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (1); "MARYLAND: Pr. Geo. Co., Greenbelt (forest near Greenbelt Lake), 39°0'04"N, 76°53'30"W, 22 April 2000, coll. WES / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (6); same data except "11 September 2001" (6), 19 February 2011 (7); "MARYLAND: Pr. Geo. Co., Landover, 38°56'N, 76°54'W, 24 December 1993, WES & JMS / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (1); same data except "19 Jan. 1998 / WES, JMS, M. J. & R. Molineaux collectors" (3); "MARYLAND: Pr. Georges Co., Snowden Pond area, 39°02'42"N, 76°49'53"W, 13 March 2015, coll. WES / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (8).

Talbot County: "MARYLAND: Talbot Co., 5 km WSW Cordova near Woodlawn Park, 38°51'35"N, 76°03'33"W, 16 March 2015, coll. WES / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (13); "Md. Talbot Co., 2 mi. N. Easton, under bark, 26 IV 1970, M. Druckenbrod" (1); "MARYLAND: Talbot Co., 3 km SE Easton, Seth Forest, 38°45'N, 76°02'W, 25 Oct. 1997 / WES, J. M. McCann, JMS collectors / In red-rotten moist wood of fallen pine in mixed forest" (2); "MARYLAND: Talbot Co., St. Michaels; forest near Perry Cabin, 38°47'40"N, 76°13'40"W, 21 February 2012, coll. WES / In red-rotten moist wood of fallen pine in mixed forest" (1); "MARYLAND: Talbot Co., Wittman, 7 Mar. 1982, WES" (1); same data except "38°48'N, 76°17'W, 25 Dec. 1992 / WES & JMS collectors / In red-rotten moist wood of fallen *Pinus taeda*" (6); same data except "29 March 1993" (31); same data except "16 October 1993 / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (1); same data except "24 May 1997" (4); same data except "12 October 2002 / In red-rotten moist wood of fallen *Pinus taeda* in mixed forest" (2); same data except "11 September 2004" (2); same data except "18 November 2007 / In red-rotten moist wood of fallen pine in mixed forest" (1).

Queen Anne's County: "MARYLAND: Q. Annes Co., Stevensville, 38°58'57"N, 76°19'20"W, 31 December 2011, K. Kanda & WES / In moist red-rotten wood of crumbling prostrate oak log, mixed mature forest" (3).

Washington County: "MARYLAND: Washington Co., Ferry Hill area 4 km SW Sharpsburg, 39°26'22"N, 77°47'50"W, 30 April 2015, In moist red-rotten wood of crumbling prostrate oak log, mixed open forest slope; Colls. WES & JMS" (4); "Hagerstown, Md., May 15, [19]19 / C M Packard Collector" (2).

Locality unknown: "Reed's, Md., Apr. 22. [19]19 / C M Packard Collector" (2); same data except "W B Turner Collector" (3).

District of Columbia Records

Ulke (1902) listed *D. punctatus* as "very common under bark". More recent specimens in USNM include a large series labeled "in red rotten oak, March 13, 1938, Washington, D.C." (6 point-mounted and 100+ loose specimens in gelatin capsule on pin). The collector is not identified, but specimens in alcohol with similar data, "Red rotten oak log, very abundant, D.C., 13-III-1938, Coll. Wm. H. Anderson" include 10 adults and 94 larvae. Other records include: "Washington D.C., VII [19]20 / HFWickham Collector / Wickham Colln." (1); "Rock Cr. Prk., Washington DC, Mar. 6, '[19]30, W. H. Ball" (1); "DISTRICT OF COLUMBIA, NW Washington, Soldiers Home, 38°55'N, 77°01'W, 28 May 1997 / WES et al. / In corky moist wood of large oak log in shade, forest edge" (14); same data except "5 June 1997" (1).

In addition to the label data, excerpts from field notes (WES) help define the niche of *D. punctatus*. On 1 November 1992, in a forest tract in Cheverly, MD, "some time picking at an old fallen Va. pine after finding *Dioedus* larvae in the rotten wood—tree had broken over ~2 m. above base + the mid-section of trunk was leaning ~30° from horizontal; most of bark gone. At a section ~2 m. off ground were loose chunks of rotten wood in a side cavity—broke some of these out + split them to find many larvae of all sizes, + several adult *Dioedus*, mostly still teneral; all in a damp, red-rotten layer 3-6 cm deep in sapwood, not in outer brown dry wood or in harder interior. Trunk here is about 3 dm. diameter." On 3 January 1993, "the same tree, still leaning...Pulled out another chunk of the red-rotten wood layer + got another series of *Dioedus* adults + larvae; one of the few tenebs. that occurs in both stages, in the same microhabitat, throughout the year" and on 31 December 1993 "wood still frozen hard but took some red-rotten chunks back [indoors]—got a few adults, 1 still teneral had apparently not survived freeze, but another and several larvae were lively when thawed."

DISCUSSION

Identification: *Dioedus punctatus* in general appearance resembles a miniature member of *Uloma* Dejean of which several species occur in Maryland and are also commonly found in the same rotten wood with *D. punctatus*. *Dioedus punctatus* is a shining oblong beetle with large punctures (Figures 1A and B) and with antennae bearing a distinct 2-segmented club (Figure 1C). Color varies from yellow-brown in teneral individuals to nearly black in older specimens. In keys to genera of Tenebrionidae (Aalbu et al. 2002; Dunford et al. 2005), *Dioedus* runs to couplets 18 and 13, respectively, but with difficulty, because some ventral features are difficult to see. The scutellum is small; elytra are without scutellar striae. The front tibiae have a slightly widened apex and the sharp outer (posterior) edge bears a few small teeth (Figure 1D).

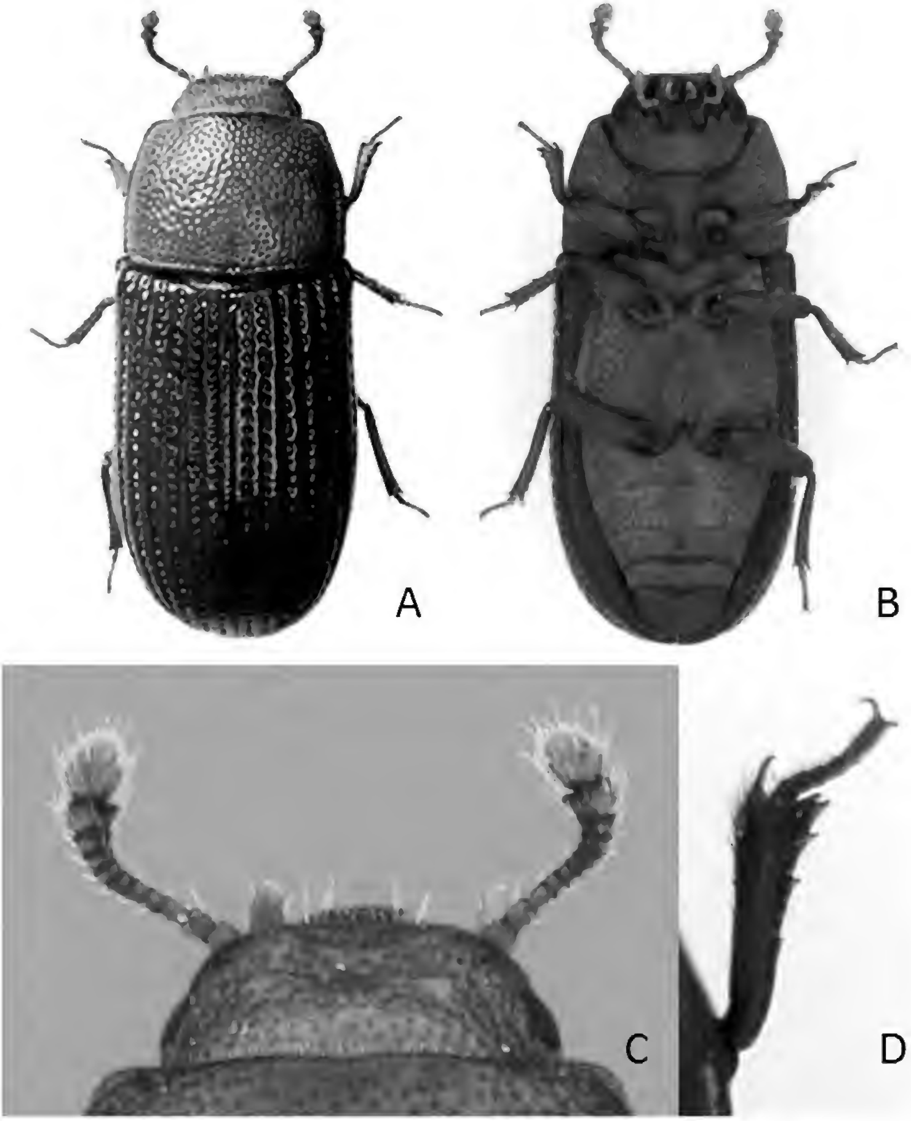

Figure 1. ***Dioedus punctatus*** **LeConte, adult images.** A, dorsal habitus; B, ventral view; C, head and antennae, dorsal view; D, right front tibia. Length of beetle 3 mm [0.12 in]. Specimen from Wittman, Maryland.

The slender whitish larvae, often associated with adults in the same wood (Figure 2A), are unique in having the abdominal apex (9th tergum) concave, spoon-shaped, with a pair of darkly sclerotized, fixed, slender, sinuate processes with sharp tips which arc posteriorly over the concavity (Figures 2B, C, and D). Whether these processes are homologous to the urogomphi in other beetle larvae is open to question. While incapable of any pinching action, they likely serve to defend the larva from small predators coming from behind in the narrow tunnel, as described for other wood-inhabiting larvae of Tenebrionidae (Steiner 2014). The globular head (Figure 2E) is unpigmented except for the very dark apices of the mandibles. Pupae are rarely collected, but occur in small cells prepared by the larva in the soft wood (Steiner 1995); abdominal segments laterally bear paired, tapered, spine-tipped appendages, with a fine, sub-apical seta; urogomphi are slender, tapered, and widely separated by a U-shaped cleft.

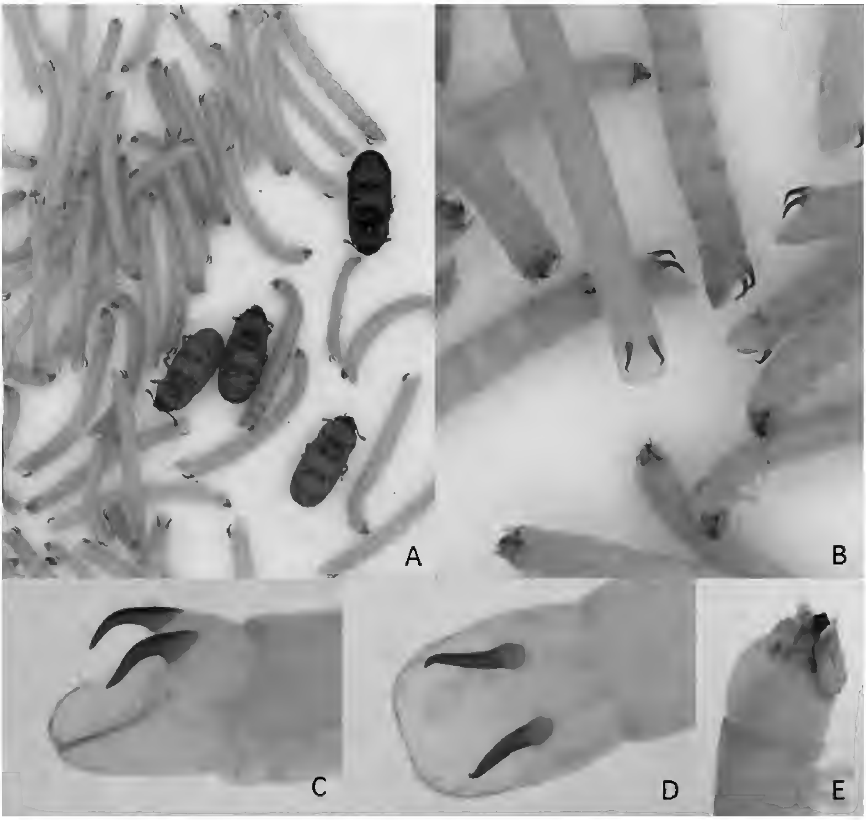

Figure 2. *Dioedus punctatus*, larval images. A, larvae with adults; B, larvae enlarged; C, abdominal apex, oblique lateral view; D, abdominal apex, dorsal view; E, head, lateral view, showing sclerotized mandibles. Length of larvae 6-8 mm [0.24-0.31 in]. Specimens from Washington, DC, collected by W. H. Anderson, 1938.

Habitat: Many references list "under bark" for the principal habitat of *D. punctatus*, for example, Ciegler (2014) in South Carolina, Dunford and Young (2004) in Wisconsin, Spilman (1973) in Michigan, and Triplehorn (1952) in Ohio. However, label data, field notes, and our observations indicate that the beetles are found much more often and sometimes abundantly within the wood of rotten logs, as described by Young (1976) for wood containing associated larvae. The term "red-rotten" has been often used by collectors, referring to the rusty red color of such logs (Figure 3) in late stages of decay, which typically have no bark remaining, making tree species identification difficult. In Maryland, *D. punctatus* have been found in logs of both pines (*Pinus* L. spp. [Pinaceae]) and oaks (*Quercus* L. spp. [Fagaceae]), suggesting that they are more specific to the type and stage of wood decay and not the species of wood. Apparently beetles most commonly breed in prostrate logs, but stump wood is occasionally inhabited, as are elevated, leaning trunks, as described above. A multi-year study of the successional insect fauna of dead standing Virginia pine, *Pinus virginiana* Mill., in College Park (Howden and Vogt 1951) did not find *D. punctatus*.

Figure 3. Red-rotten wood habitat. Left, prostrate oak trunk where *Dioedus punctatus* was found, Snowden Pond, Anne Arundel County, March 2015; Right, detail of crumbling wood.

Logs in this late stage of deterioration fit the "decay class 4" of coarse woody debris classification (Woodall and Williams 2005). The wood is soft, easily pulled apart by hand into chunks; beetles are most often found several centimeters deep between split layers, sometimes at the interface of sapwood and hardwood, and the wood is typically moist. The slender larvae (Figures 2A and 2B) have been seen in tunnels undoubtedly made by them, the diameter matching that of the body. They apparently consume the wood tissue as they burrow, probably getting nourishment from fungal tissue. What makes beetles colonize particular logs is unknown; many logs appearing suitable for *D. punctatus* have been examined but with no specimens discovered. More study is needed to identify the fungi, slime molds, and other agents that create the red-rotten wood.

Among the more common beetles recorded in a study of loblolly pine logs, *Pinus taeda* L., subjected to fire (Ulyshen et al. 2010), *D. punctatus* was the only species not found following a burn (low-intensity surface fire), suggesting that it may suffer from drying of the wood substrate with exposure to sunlight due to the removal of undergrowth and surrounding litter. Collections of *D. punctatus* all have been from wood in shaded situations of interior forest tracts.

Life history: It is unusual for a beetle to occur in both larval and adult stages throughout the year. Breeding colonies can be very large and last for several years. Pupation is probably limited to warmer months; small cells in the rotten wood are formed by the larvae before pupation (Steiner 1995). Pale, teneral adults are found frequently, suggesting that hardening of the cuticle is taking a long time compared to the typically rapid sclerotization in most other beetles.

Dioedus punctatus is known for having mineralized cuticular calcium, found in other members of the Phrenapatinae but not in any other Coleoptera (Leschen and Cutler 1994). Perhaps this is the source of a white encrustation commonly seen on ventral surfaces of dry specimens after being mounted from alcohol.

Specimens have been collected only by hand or by sifting rotten wood material. We have found many Tenebrionidae at black lights and other artificial light traps, but never a specimen of *D. punctatus*. Beetles are fully winged; it is thought that dispersal to new breeding logs is diurnal, probably on warm summer days, but this has not been documented. *Dioedus punctatus* is a member of a specialized assemblage of saproxylic beetles that appear to target the late decay, red-rotten wood, a subject needing more survey and study.

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Urban Populations of a Declining Bumble Bee Species, *Bombus pensylvanicus* (De Geer) (Hymenoptera: Apidae), in the District of Columbia, USA

Jonathan R. Mawdsley[1]* and Corinne M. Carter[2]

[1]*Department of Entomology, MRC 187, Smithsonian Institution, P.O. Box 37012, MRC 187, Washington, District of Columbia 20013-7012 USA; mawdsleyj@si.edu*
*Corresponding Author
[2]*Department of Geography, 2138 LeFrak Hall, University of Maryland, College Park, College Park, Maryland 20742; corinne.m.carter@nasa.gov*

Abstract: We document nesting and foraging activities of the American Bumble Bee, *Bombus pensylvanicus* (De Geer) (Hymenoptera: Apidae), in urbanized areas of the District of Columbia, USA, in 2013 and 2014. Two areas were located within the District that supported populations of *B. pensylvanicus*: the United States National Arboretum in the northeastern portion of the District, and the Shaw neighborhood located north of the central urban core. Adults of *B. pensylvanicus* were observed foraging on flowers of 18 plant species in 8 plant families, primarily non-native ornamental plants such as lavender, *Lavandula* L. spp. (Lamiaceae); larkspur, *Delphinium* L. spp. (Ranunculaceae); and orange eye butterflybush, *Buddleja davidii* Franchet (Scrophulariaceae). Urban nests of *B. pensylvanicus* were observed in ornamental grass clumps, a grassy meadow, and an overgrown vacant lot. These observations suggest that ornamental plantings in urban areas have the potential to provide habitat for rare and declining bumble bee species such as *B. pensylvanicus*.

Keywords: *Bombus*, bumble bee, conservation, urban, nesting, foraging, non-native plant

Significant declines have been observed in recent decades in populations of several North American species of the genus *Bombus* Latreille (Hymenoptera: Apidae), including the formerly widespread eastern North American species *Bombus pensylvanicus* (De Geer) (American Bumble Bee) (Shepherd et al. 2005, Brown 2011, Cameron et al. 2011) (Figure 1). According to Cameron et al. (2011), the geographic area occupied by populations of *B. pensylvanicus* has declined nearly 23 percent in recent decades, with the declines most prominent in the northern and eastern portions of the species' range (see Figure 1D in Cameron et al. 2011). The species has also apparently declined in overall abundance in those parts of its range where it can still be found (Droege, in litt.).

Bombus pensylvanicus has traditionally been considered a grassland species, nesting on the ground surface or in grass clumps (Colla et al. 2011, Williams et al. 2014).). Rau (1924) states that this species appears to nest preferentially in "situations where the grass grows tall and falls over, year after year, thus making a thick, soft mat." Although Droege (2007) included *B. pensylvanicus* on a list of bee species occurring within the District of Columbia region, it has not generally been associated with urban areas.

Figure 1. American Bumble Bee, *Bombus pensylvanicus* (De Geer). Female foraging on orange eye butterflybush, *Buddleja davidii* Franchet. 1225 O Street NW, Shaw Neighborhood, Washington, District of Columbia, 4 August 2014.

While conducting observational studies of a large nesting aggregation of the Eastern Carpenter Bee, *Xylocopa virginica* (Linnaeus) (Hymenoptera: Apidae), at the United States National Arboretum in Washington, District of Columbia, USA, we also observed adults of *B. pensylvanicus* and several other *Bombus* species visiting flowers in the formal planted gardens. Given the considerable conservation interest associated with these species, we expanded our initial field study to include observations of floral visitation by *B. pensylvanicus* and other *Bombus* species. These observations extended throughout the 2013 and 2014 field seasons (March-October each year).

During the summer of 2014, the senior author observed adults of *B. pensylvanicus* on flowers in the Shaw neighborhood of Washington, DC. This is a densely urbanized area with adjoining row houses and landscaped gardens and parks. Given the unusual nature of this observation, we initiated a systematic search of the entire neighborhood during the month of August 2014, for additional individuals of *B. pensylvanicus*.

The observations reported here demonstrate that *B. pensylvanicus* will nest in urban areas, that these nests can produce new reproductive individuals in the late summer, and that individuals of this species will forage on a range of native and non-native plant species. It is hoped that this initial study will help stimulate further investigations of the activity patterns of rare or declining native bees such as *B. pensylvanicus* in urban areas, not just in North America, but throughout the world.

METHODS

We initiated observational studies of a nesting aggregation of *Xylocopa virginica* at the National Arboretum in the spring of 2013. During the course of those observations, we also observed adults of *B. pensylvanicus* and other *Bombus* species (*B. auricomus* [Robertson] (Black-and-Gold Bumble Bee), *B. bimaculatus* Cresson (Two-spotted Bumble Bee), *B. griseocollis* [DeGeer] (Brown-belted Bumble Bee), and *B. impatiens* Cresson) (Common Eastern Bumble Bee) visiting flowers in the same areas where adult carpenter bees were active. Because of the conservation interest in certain species of *Bombus* (Brown 2011, Cameron et al. 2011), we added observations of *Bombus* species to our field observation protocols.

A set of standard linear observation walking transects were established along the major trails and footpaths in each of three areas at the National Arboretum: the National Bonsai and Penjing Museum, the National Herb Garden, and the Fern Valley Native Plant Collection. Transects were designed to facilitate examination of all inflorescences of flowering plant species within each garden without duplication. Each transect was walked by both authors at least once weekly and the activity patterns and floral associates of *Bombus* and *Xylocopa* species were recorded. Adults of *Bombus* species were identified in the field using published identification guides (principally Colla et al. 2011, but also Williams et al. 2014) and voucher specimens were collected for comparison with authoritatively identified specimens in the collections of the National Museum of Natural History, Smithsonian Institution, Washington, DC.

A chance observation on 31 July 2014 of a single worker of *B. pensylvanicus* in a private garden located on O Street NW in the Shaw neighborhood of the District of Columbia led us to initiate systematic surveys for additional adults of this species in the same neighborhood. Each street and alley within a 0.5-km (0.3-mi) radius of the original observation site was walked at least twice during August 2014, and all flowers in private yards, public rights-of-way, and parks were examined for individuals of this species.

Adults of *B. pensylvanicus* in the District of Columbia are similar in coloration to adults of *B. auricomus*, a species which co-occurs with *B. pensylvanicus* at the National Arboretum. Given the strong similarity between adults of these two species, we accordingly took steps to make certain that our field identifications of these two species were accurate. The coloration of the pubescence on the vertex of the head is commonly given as the character for separating these two species (vertex with yellow pubescence in *B. auricomus*; entirely black in *B. pensylvanicus* [Colla et al. 2011, Williams et al. 2014]). In practice, this character is not always readily visible in the field, especially when the bees are taking nectar from flowers or are covered in pollen. In cases when the coloration of the head pubescence was not readily apparent, we collected bees in glass vials for closer observation and examination of the pubescence. Voucher specimens were also collected for study under a compound dissecting scope to confirm species identifications.

Urban nest sites of *B. pensylvanicus* were identified by a three-step process: we first plotted the direction of flight of returning foragers on a base map derived from the Google Maps imagery (https://maps.google.com), identified those areas where flight vectors from multiple foraging bees converged, and then conducted careful visual inspections of these areas in order to detect bees returning to and departing from the actual nest sites.

RESULTS

We recorded the following observations of *B. pensylvanicus* in the District of Columbia during the 2013 and 2014 field seasons. A gazetteer with latitude and longitude coordinates for all sites is provided in Table 1. Botanical names follow those on labels provided by the National Arboretum, including varietal names for cultivars. For plant species with variably colored flowers, we record the color of the flowers that were visited by adults of *B. pensylvanicus*. No adults of *B. pensylvanicus* were observed at the National Bonsai and Penjing Museum, which was the site of a large nesting aggregation of *Xylocopa virginica*.

Table 1. Gazetteer of sites where adults of *Bombus pensylvanicus* were observed in 2013 and 2014 within the District of Columbia.

Site	Latitude	Longitude
National Arboretum – Fern Valley Native Plant Collection	38.9089°	-76.9658°
National Arboretum – National Herb Garden	38.9116°	-76.9693°
1328 9th Street NW	38.9081°	-77.0241°
900 O Street NW	38.9086°	-77.0242°
935 O Street NW	38.9086°	-77.0254°
1225 O Street NW	38.9014°	-77.0291°
1113 R Street NW	38.9127°	-77.0276°
949 T Street NW	38.9157°	-77.0258°
1800 Vermont Avenue NW	38.9148°	-77.0268°
1838 Vermont Avenue NW	38.9153°	-77.0265°
Stead Park (1625 P Street NW)	38.9097°	-77.0374°

<u>USA: District of Columbia: United States National Arboretum</u>

Fern Valley Native Plant Collection: 1.IX.2013, 2 workers on flowers of *Chelone obliqua* L. (Scrophulariaceae); 18.V.2014, 1 queen on flowers of *Baptisia sphaerocarpa* Nuttall X *B. alba* (L.) Ventenat 'Carolina moonlight' (Fabaceae); 26.V.2014, 1 queen on flowers of *Baptisia australis* (L.) Robert Brown; 24.VIII.2014, 1 queen on flowers of *Silphium integrifolium* Michaux (Asteraceae), 1 worker on flowers of *Chelone glabra* L. (Scrophulariaceae); 14.IX.2014, 4 workers on flowers of *Chelone obliqua*; 28.IX.2014, 1 queen and 1 worker on flowers of *Chelone obliqua*.

National Herb Garden: 2.VI.2013, 2 workers on flowers of *Delphinium* L. sp. (Ranunculaceae); 10.VI.2013, 8 workers on flowers of *Delphinium* sp.; 30.VI.2013, 1 worker on flowers of *Lavandula angustifolia* Miller (Lamiaceae) 'rosea', 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'abrialii', 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'silver', 1 worker on flowers of *Cynara cardunculus* L. (Asteraceae), 1 worker on flowers of *Delphinium* sp.; 14.VII.2013, 1 worker on flowers of *Cynara cardunculus*; 28.VII.2013, 1 worker on flowers of *Cynara cardunculus*; 21.IV.2014, 1 queen on flowers of *Myrrhis odorata* (L.) Scopoli (Apiaceae); 22.VI.2014, 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'Provence,' 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'Hidcote giant,' 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'super,' 1 worker on flowers of *Lavandula angustifolia* 'Blue Ridge,' 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'abrialii,' 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'Sussex,' 3 queens and 13 workers on flowers of *Delphinium* sp., 1 worker on flowers of *Cephalanthus occidentalis* L. (Rubiaceae); 29.VI.2014, 2 workers on flowers of *Lavandula* ^{x}*intermedia* 'Hidcote giant,' 1 worker on flowers of *Lavandula* ^{x}*intermedia* 'abrialii,' 2 workers on flowers of *Lavandula* ^{x}*intermedia* 'silver,' 6 workers on flowers of *Delphinium* sp., 1 worker on flowers of *Geranium* L. sp. (Geraniaceae); 13.VII.2014, 1 queen on flowers of *Delphinium* sp., 1 queen on flowers of *Hibiscus* L. sp. (Malvaceae), 1 worker on flowers of *Alcea* L. sp. (Malvaceae); 27.VII.2014, 3 workers on flowers of *Cynara cardunculus*; 11.VIII.2014, 2 workers on flowers of *Salvia* L. sp. (Lamiaceae); 31.VIII.2014, 1 worker on flowers of *Coreopsis tinctoria* (Nuttall) (Asteraceae), 1 queen on flowers of *Lablab purpureus* (L.) Sweet (Fabaceae); 14.IX.2014, 1 worker on flowers of *Salvia microphylla* Kunth (Lamiaceae) 'San Carlos festival.'

USA: District of Columbia: Shaw Neighborhood

1328 9th Street NW: 6.VIII.2014, 3 workers on flowers of *Buddleja davidii* Franchet (Scrophulariaceae) (pink); 11.VIII.2014, 1 worker on flowers of *Buddleja davidii* (pink).

900 O Street NW: 29.VIII.2014, 1 male, dead on ground.

935 O Street NW: 31.VII.2014, 1 worker on flowers of *Monarda* L. sp. (Lamiaceae) and *Hibiscus* sp.

1225 O Street NW: 4.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 13.VIII.2014, 1 male on flowers of *Buddleja davidii* (purple).

1113 R Street NW: 7.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 11.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 13.VIII.2014, 1 male on flowers of *Buddleja davidii* (purple).

949 T Street NW: 11.VIII.2014, 1 queen on flowers of *Passiflora* L. sp. (Passifloraceae).

1800 Vermont Avenue NW: 6.VIII.2014, 1 worker on flowers of *Buddleja davidii* (white); 7.VIII.2014; 1 worker on flowers of *Buddleja davidii* (white); 11.VIII.2014, 2 queens on flowers of *Buddleja davidii* (white); 15.VIII.2014, 2 queens and 1 worker on flowers of *Buddleja davidii* (white); 18.VIII.2014, 2 queens on flowers of *Buddleja davidii* (white); 19.VIII.2014, 1 queen on flowers of *Buddleja davidii* (white); 22 VIII 2014, 2 queens on flowers of *Buddleja davidii* (white).

1838 Vermont Avenue NW: 11.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple); 18.VIII.2014, 1 queen on flowers of *Buddleja davidii* (white).

Stead Park (1625 P Street NW): 19.VIII.2014: 1 worker on flowers of *Buddleja davidii* (purple); 20.VIII.2014, 1 worker on flowers of *Buddleja davidii* (purple).

NESTING SITES

Three nesting sites for *B. pensylvanicus* were identified during the course of the field observations. One nest was located in a large, grassy meadow at the National Arboretum located due south of the National Herb Garden and due west of the Fern Valley Native Plant Garden. This area may have contained additional nests, judging by the large number of foraging workers that were observed in both years. A second nest was located in dense grassy and herbaceous vegetation in an overgrown vacant lot at 1328 9th Street NW. Finally, a third nest was located in dense clumps of ornamental grasses in a small public park directly across the street from the house at 1838 Vermont Avenue NW. All three nests were hidden in dense grassy and/or herbaceous vegetation; within large grass clumps for the nests at the National Arboretum and Vermont Avenue sites, and in a dense tangle of grass clumps and weedy herbaceous vegetation for the nest at the 9th Street NW site. The location and appearance of these sites generally corresponds to the description of the preferred nesting habitat for this species provided by Rau (1924): "situations where the grass grows tall and falls over, year after year, thus making a thick, soft mat."

DISCUSSION

Our observations document the presence of *Bombus pensylvanicus* within the Washington, DC, urban environment, as well as the use of anthropogenic habitat features such as vacant lots, grassy meadows, and ornamental plantings for foraging and nesting activities of this species. Particularly interesting from a conservation standpoint are the use of non-native ornamental grass species for nesting, and the extensive foraging activities that we observed on non-native flowering plants, particularly *Buddleja davidii*. Although this plant species is frequently used in ornamental garden plantings in the urban areas we studied, it also has undesirable invasive properties, to the extent that it has been included in the book *Plant Invaders of Mid-Atlantic Natural Areas* (Swearingen et al. 2010). At the same time, flowers of *Buddleja davidii* clearly offer important late-summer foraging opportunities to *B. pensylvanicus* as well as other native bee species. *Buddleja davidii* was one of the few plant species offering floral rewards in the Shaw neighborhood at the time of our surveys in August 2014. This plant species provides important resources for pollinator species that are active later in the summer such as *B.*

pensylvanicus. The role of non-native plant species in supporting populations of rare or declining pollinator species such as *B. pensylvanicus* clearly merits further investigation.

At the National Arboretum, adults of *B. pensylvanicus* were observed foraging at the same time as adults of four other species of the genus *Bombus*: *B. auricomus*, *B. bimaculatus*, *B. griseocollis* and *B. impatiens*. Of these five species, *B. impatiens* was clearly the most abundant. In 2014, for example, we recorded 405 observations of floral visitation by *B. impatiens* queens, workers, or males at the National Arboretum (compared with the 58 observations of floral visitation by individual *B. pensylvanicus* at the National Arboretum in 2014 reported above). *Bombus impatiens* is apparently even more adapted to urban life than *B. pensylvanicus*; adults of this species are ubiquitous throughout the Washington, DC metropolitan area and are commonly found on flowers of ornamental plantings, including both native and non-native plant species. We have observed nests of *B. impatiens* in ornamental plantings on the National Mall, in urban garden plots, in vacant lots, in debris piles, and in abandoned building foundations.

Our observations suggest that *B. pensylvanicus* may be capable of sustaining populations over multiple years and multiple generations at sites in urban areas. We observed nests of this species in multiple successive years at the National Arboretum, and also noted the presence of adult reproductives in August at both the National Arboretum and Shaw neighborhood sites. Further research is needed to determine whether these urban populations of *B. pensylvanicus* are indeed self-sustaining, or whether colonization of suitable urban sites by female reproductives from outside the urban area may also be occurring.

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An Assessment of Two Passive Trap Methods for Sampling Naturally Occurring Bees in Three Different Habitats on the Delmarva Peninsula

Catherine E. Stragar[1], Samuel W. Droege[1], and John D. Pesek[2]

[1]*United States Geological Survey, Patuxent Wildlife Research Center, Bee Inventory and Monitoring Laboratory, Beltsville Agricultural Research Center-East, Building 308, Room 124, 10300 Baltimore Avenue, Beltsville, Maryland 20705*
[2]*Department of Applied Economics and Statistics, University of Delaware, 227 Townsend Hall, Newark, Delaware 19716*
(CES) *cstragar@usgs.gov*; (SWD) *sdroege@usgs.gov*; (JDP) *pesek@udel.edu*

ABSTRACT: Inexpensive bowl traps have been used by researchers to monitor native bees throughout the United States for many years. Vane traps are a more recent development, but have also proven effective for bee monitoring in the western United States. In this study, three colors of bowl traps were compared to blue vane traps in three different habitats on the Delmarva Peninsula (in Delaware and Maryland, USA) using paired 50-m (164-ft) transects. Per trap capture rates by transect were analyzed with a two-way ANOVA with factors of method (bowl and vane) and period (month of sample, March through September). Blue vane traps captured significantly more bees per trap during some seasons at all three sites but capture rates were not significantly different for all sample events. Community similarity of bee captures for each trap type on all three sites was similar. Blue vane traps had higher per trap capture rates for Apidae (greatly so for the tribe Eucerini). In contrast, bowl traps had higher per trap capture rates than did blue vane traps for Andrenidae, *Lasioglossum* Curtis, and *Nomada* Scopoli.

INTRODUCTION

In order to obtain accurate baseline and monitoring measurements of bee populations, investigation of the sampling characteristics of sampling methods and protocols is essential (Williams et al. 2001, Eardley et al. 2006, National Research Council 2006). The sampling method of choice for bees has traditionally been aerial netting from floral hosts, but this method is biased by the collector's netting skills, time of day, and bloom phenology, as well as accessibility of flowers (Williams et al. 2001). In contrast, passive traps reduce or eliminate most problems associated with variations in observer ability and perception bias and more readily control for differences in skill and effort. Surveys using pan and bowl traps have increased during the past two decades (Droege 2000, S.W. Droege, unpublished data; LeBuhn et al. 2003). Another passive trapping method, the use of vane traps, has produced bee samples with large numbers of bees on western sites (Stephen and Rao 2005). To learn more about how these two types of traps perform in comparison to one another in eastern North America, paired bowl and vane traps surveys were conducted in three different habitats on the Delmarva Peninsula (in Delaware and Maryland, USA) from March through September 2006.

MATERIALS AND METHODS

Vane Traps
Unscented, semi-transparent, fluorescent blue vane traps, type BVT1, from SpringStar® LLC (P.O. Box 2622, Woodinville, WA 98072) were used. This trap has a clear plastic collecting jar with a screw-on plastic lid to hold the blue UV-reflective vanes. Each vane trap was suspended 1 m (3.3 ft) from the ground on a solid metal pole. The 1-m height is the lowest optimal height for bee sampling (W.P. Stephen, in litt.). Only blue traps were used based on preliminary data from Stephen and Rao (2005) showing a strong overall preference by bee species for blue traps, which was consistent with the results of preliminary trials in Maryland (S.W. Droege, unpublished data). A 2.54-cm (1-in) piece of Hot Shot® No-Pest® Strip was used as a knock-down agent in each trap's clear catch bowl (Figure 1).

Bowl Traps
"Solo® soufflé portion cups" (96.1 ml [3.25 oz], white, #p325w-0007) were used as bowl traps. Bowl traps were painted with either fluorescent blue or fluorescent yellow paint or left non-fluorescent white. Each trap was three-quarters filled with a mixture of water and a drop of Dawn® Non-Concentrated (non-Ultra) dishwashing liquid to lower the surface tension of the water and act as a knock-down agent (Figure 2).

Experimental Unit
A transect length of 50 m [164 ft] for each trap type was used. For the block design, both trap types were run simultaneously with a separation of 25 m [82 ft] when sampling occurred. This design was best for eliminating direct competition for bee species between trap types, while still being able to compare per trap captures on similar landscapes during the same sampling time with standardized effort. In each block, a 50-m transect of 15 bowls, 5 of each color randomized and placed evenly along the ground, was separated by 25 m from a 50-m transect of 3 evenly spaced vane traps, producing a 50-m transect for each trap type (Figure 3). Fewer vane traps were used because of their significantly larger size and potential for high trap catches (Stephen and Rao 2005). These paired transects ran simultaneously for 6 to 8 hours during peak foraging times and only on sunny, clear days.

Sampling Sites
Three different locations within the Delmarva Peninsula were used to help assess whether differences in capture patterns were comparable across landscapes (Cane et al. 2000).

"Wooded" sites were located within the Nanticoke Wildlife Area, which encompasses 1105 ha (2730 ac) along the southeastern side of the Nanticoke River in Delaware. This site contains xeric sand ridges, supporting unusual regional plant communities (Bowman 2000). All the wooded sites were small openings in forested areas, including roads, footpaths, and small clearings. Early spring dates were chosen for this site to take advantage of the open canopy. The sampling effort for this habitat was 5 days.

Figure 1. Vane Trap. Unscented, semi-transparent, fluorescent blue vane trap, type BVT1, from SpringStar® LLC showing the clear plastic collecting jar with a screw-on plastic lid to hold the blue UV-reflective vanes. (Photographed by Richard L. Orr)

Figure 2. Bowl Traps. "Solo® soufflé portion cups" (96.1 ml [3.25 oz], white, #p325w-0007), painted either fluorescent blue or fluorescent yellow or left white, three-quarters filled with a mixture of water and Dawn® dishwashing liquid. (Photographed by Eugene J. Scarpulla)

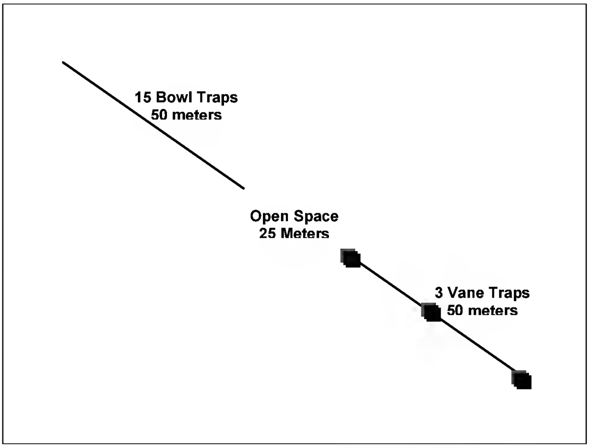

Figure 3. Layout of a combined transect.

"Conservation Agriculture/No Till" sites were located within Wye Island Natural Resources Management Area (NRMA), an 1133-ha (2800-ac) island located between the Wye River and the Wye East River on the Chesapeake Bay in Maryland. Current agricultural practices were conservation-oriented with the entire island practicing no-till field management and crop rotations. The sampling effort for this habitat was 6 days.

"Conventional Agriculture" sites were located on farms throughout Sussex and Kent Counties in Delaware. All farms practiced standard tillage and used black plastic as a soil cover to reduce weed growth and water loss. The sampling effort for this habitat was 20 days.

Methods of Analysis

A block design of paired 50-m transects for each trap type was used for sampling on all three sites to standardize effort and landscape effects on trap capture rates. Since each site is treated as a true replicate of the trap experiment, data across sites were not pooled, but analyzed independently. For means testing between methods, the treatment structure consisted of a two-way ANOVA with factors of method (bowl and vane) and period (month of sample). A generalized linear model was used since the data were not normally distributed. A negative binomial distribution was chosen over the Poisson because the negative binomial's dispersion parameter allows more flexibility. A natural log link was used to transform the data (McCullagh and Nelder 1989, Ott and Longnecker 2001). Since each method was repeated on each block, the generalized estimating equation of Liang and Zeger (1986) was used to estimate the model. The GENMOD procedure was used to generate results from SAS® 6.09 (SAS Institute Inc., Cary, North Carolina).

The community similarity between methods was measured using Sorenson's index. Finally, a simple cost analysis of both methods was included.

RESULTS

Table 1 contains a list of bee species and the number of bees of each species captured by each sampling method in each of the three sites for all the sampling events in 2006. Total number of bees per trap catch rate (average number of bees per trap) and total number of species sampled are listed for each trap type under each site for total bees captured over all seasons.

Table 1. Bees captured by vane and bowl traps in three different habitats in 2006.

	Wooded		Conservation Agriculture /No Till		Conventional Agriculture	
Species	**bowl**	**vane**	**bowl**	**vane**	**bowl**	**vane**
Family Colletidae						
Colletes inaequalis Say	1			1		
Hylaeus affinis (Smith)	2				2	1
Hylaeus modestus Say				1		
Hylaeus ornatus Mitchell				7		
Colletidae subtotals	**3**	**0**	**0**	**9**	**2**	**1**
Family Andrenidae						
Andrena barbara Bouseman and LaBerge			3			
Andrena barbilabris (Kirby)			1			
Andrena carlini Cockerell			1			
Andrena commoda Smith			2			
Andrena cressonii Robertson			16			
Andrena fenningeri Viereck			1			
Andrena imitatrix Cresson			3			
Andrena personata Robertson			1			
Andrena pruni Robertson			1			
Andrena robertsonii Dalla Torre			1			
Andrena violae Robertson			2			
Andrena wilmattae Cockerell			1			
Andrena ziziae Robertson			8			
Andrena Fabricius unknown species**			7			
Calliopsis andreniformis Smith			11		17	
Andrenidae subtotals	**0**	**0**	**59**	**0**	**17**	**0**
Family Halictidae						
Agapostemon sericeus (Forster)			2	2	2	11
Agapostemon splendens (Lepeletier)	2				19	19
Agapostemon texanus Cresson	1		14	10	1	2
Agapostemon virescens (Fabricius)			19	23	6	15
Agapostemon Guerin-Meneville unknown species**						1
Augochlora pura (Say)	1	1		2	28	47
Augochlorella aurata (Smith)	3		70	4	10	3
Augochloropsis sumptuosa (Smith)					1	
Halictus confusus Smith			21	3	10	2
Halictus ligatus Say	3					
Halictus ligatus Say or *H. poeyi* Lepeletier			13	31	25	9
Halictus rubicundus (Christ)			2	5	2	1
Lasioglossum near *admirandum* (Sandhouse)			64	29	22	
Lasioglossum near *admirandum* (Sandhouse) or *L. versatum* (Ellis)**					6	1

Species	Wooded		Conservation Agriculture /No Till		Conventional Agriculture	
	bowl	vane	bowl	vane	bowl	vane
Lasioglossum albipenne (Robertson)						11
Lasioglossum bruneri (Crawford)	1		4	5	32	10
Lasioglossum callidum (Robertson)			6	4	38	4
Lasioglossum coeruleum (Robertson)				1		2
Lasioglossum coreopsis (Robertson)			7	5	2	
Lasioglossum cressonii (Robertson)			3	5	3	1
Lasioglossum foxii (Robertson)					1	
Lasioglossum fuscipenne (Smith)					2	1
Lasioglossum illinoense (Robertson)					16	
Lasioglossum imitatum (Smith)			1	3	4	
Lasioglossum laevissimum (Smith)	1		3		1	
Lasioglossum lineatulum (Crawford) or *L. versatum* (Ellis)**						1
Lasioglossum lustrans (Cockerell)					2	
Lasioglossum macoupinense (Robertson)			1		2	
Lasioglossum nelumbonis (Robertson)	1				7	
Lasioglossum nymphaearum (Cockerell)			1			
Lasioglossum oblongum (Lovell)	1		11	2	17	33
Lasioglossum near *oblongum* (Lovell)			1	8		1
Lasioglossum pectorale (Smith)	30	3			40	17
Lasioglossum pilosum (Smith)	27	4	38	38	359	147
Lasioglossum platyparium (Robertson)			1			
Lasioglossum pruinosum (Robertson)					24	1
Lasioglossum quebecense (Crawford)					1	
Lasioglossum tegulare (Robertson)	40		21		118	5
Lasioglossum versatum (Ellis)			16	6	37	6
Lasioglossum vierecki (Crawford)	14	1			19	
Lasioglossum zephyrum (Smith)			3			
Lasioglossum (*Dialictus* Robertson) unknown species**	1		11	10	19	3
Lasioglossum (*Sphecodogastra* Ashmead) unknown species					1	
Sphecodes Latreille unknown species	1		1		3	
Halictidae subtotals	**127**	**9**	**334**	**196**	**880**	**354**
Family Megachilidae						
Anthidium manicatum (Linnaeus)						1
Coelioxys immaculata Cockerell		1				
Hoplitis pilosifrons (Cresson)	3		1			
Megachile brevis Say		1	3		2	1
Megachile mendica Cresson					1	1
Megachile pugnata Say						1
Megachile sculpturalis Smith				4	1	1
Osmia atriventris Cresson	4	3				1
Osmia georgica Cresson	1					
Osmia pumila Cresson	9	4	12			
Stelis lateralis Cresson					1	
Megachilidae subtotals	**17**	**9**	**16**	**4**	**5**	**6**
Family Apidae						
Anthophora abrupta Say						1
Apis mellifera Linnaeus – Honey Bee	2		2	1	58	28
Bombus bimaculatus Cresson – Two-spotted Bumble Bee		5		7	2	19
Bombus citrinus (Smith) – Lemon Cuckoo Bumble Bee				6	1	2
Bombus fervidus (Fabricius) – Yellow Bumble Bee		1	3	7	2	9
Bombus griseocollis (DeGeer) – Brown-belted Bumble Bee			2	5	4	7
Bombus impatiens (Cresson) – Common Eastern Bumble Bee		1		2	3	10

Species	Wooded		Conservation Agriculture /No Till		Conventional Agriculture	
	bowl	vane	bowl	vane	bowl	vane
Bombus pensylvanicus (DeGeer) – American Bumble Bee				1		2
Ceratina calcarata Robertson*	2	5	18	128	37	71
Ceratina calcarata Robertson or *C. dupla* Say*,**	1	1			3	3
Ceratina dupla Say*	9	3	20	64	10	7
Ceratina strenua Smith	12	1	16	17	43	9
Ceratina Latreille unknown species					2	4
Eucera atriventris (Smith)						1
Eucera dubitata (Cresson)				11		2
Eucera hamata (Bradley)		1	9	26		3
Habropoda laboriosa (Fabricius) – Southeastern Blueberry Bee	4	6				
Melissodes agilis Cresson		1				16
Melissodes bimaculata (Lepeletier)			20	70	69	194
Melissodes communis Cresson						3
Melissodes comptoides Robertson						4
Melissodes druriella (Kirby)	1					
Melissodes illata Lovell and Cockerell or *M. subillata* LaBerge						3
Melissodes trinodis Robertson			27	637		125
Melitoma taurea (Say)		1		1	7	21
Nomada articulata Smith	1		2		1	
Nomada cressonii Robertson	1	1				
Nomada illinoensis Robertson			2			
Nomada imbricata Smith			5			
Nomada lehighensis Cockerell	1					
Nomada maculata Cresson			3			
Nomada obliterata Cresson			2			
Nomada pygmaea Cresson			1			
Nomada rubicunda Olivier	1					
Nomada Scopoli "bidentate species group"	1					
Peponapis pruinosa (Say)		1		2	8	110
Ptilothrix bombiformis (Cresson)			1	13		7
Svastra obliqua (Say)						1
Xylocopa virginica (Linnaeus) – Eastern Carpenter Bee				1		5
Apidae subtotals	**36**	**28**	**133**	**999**	**250**	**667**
Total bees	183	46	542	1208	1154	1028
Total transects	23	23	22	22	73	73
Total bees per transect	7.95	2.00	24.63	54.90	15.80	14.08
Total bees per trap (15 bowl traps or 3 vane traps per transect)	0.53	0.66	1.64	18.30	1.05	4.69
Total bees per trap without the No Till *Melissodes trinodis* outlier	0.53	0.66	1.56	8.65	1.05	4.69
Total species captured by trap method	31	20	57	41	53	54

**Ceratina* identifications were completed before the description of *Ceratina mikmaqi* (Rehan and Sheffield 2011) and specimens are unavailable for further identification.
**These listings were not included in the "Total species captured by trap method" since they might duplicate species elsewhere on the list.

The local bee community composition shifts throughout the year. At any point in time, each bee species in those seasons has at least a slightly different probability of capture in each of the trap types depending on what is being foraged upon, weather, and individual preferences for color and placement. In order to detect these possible differences associated with date and species composition, a two-way ANOVA was performed for the seasonal effect of bees per trap for each trap type for each location (Table 2). The 664 *Melissodes trinodis* Robertson captured in both traps at Wye, representing 38% of the overall captures of all bees at the Wye location, were considered an outlier and removed before the analysis. Blue vane traps consistently captured more bees per trap than bowl traps, however those differences were only significant for the two September samples and the April and May samples (Table 2). Community similarity measures for each trap type on all three sites were quite similar (Table 3). Blue vane traps had higher per trap capture rates of Eucerini (*Eucera* Scopoli, *Melissodes* Latreille, *Peponapis* Robertson, and *Svastra* Holmberg) and bumble bees (*Bombus* Latreille) than did bowl traps. In contrast, bowls had much higher per trap capture rates for Andrenidae, *Lasioglossum* Curtis, and *Nomada* Scopoli genera than did blue vane traps (Table 1).

Sorenson's similarity index (Wolda 1981, Magurran 1988) was used to compute community similarity between methods for each site (Table 3). Both Agriculture sites had complete agreement and the 76% similarity between bowl trap and vane trap samples on the Wooded site is still considered highly similar.

Table 2. ANOVA for vanes vs. bowls by site and season. Values in the Pr > ChiSq column, which can be interpreted as p-values, are marked with an asterisk if they indicate statistically significant differences in means ($p < 0.05$) between bowl and vane rates of capture during a season. Sites with no asterisk have transect means that do not show a difference between bowl and vane capture rates for the indicated period. Estimate, SE (Standard Error) and ChiSq values were generated by a general linear model with a negative binomial distribution.

Site and Season	Estimate	SE	ChiSq	Pr > ChiSq
Wooded				
March	-0.3857	0.3202	1.45	0.2284
Early May	-1.6635	0.3804	19.12	* <0.0001
September	-1.8405	0.5450	11.41	* 0.0007
Conservation Agriculture /No Till				
April	-0.8532	0.3387	6.35	* 0.0118
Late May/June/July	0.3662	0.2261	2.62	0.1053
Conventional Agriculture				
June/July	-0.0058	0.1279	0	0.9641
August	-0.1452	0.3231	0.20	0.6531
September	-0.9410	0.2623	12.87	* 0.0003

Table 3. Sorenson's community similarity index. Representing the overlap of species occurrence between the vane and bowl captures on each site.

	Site		
Sampling Method	Wooded	Conservation Agriculture /No Till	Conventional Agriculture
Bowl vs. Vane	76%	100%	100%

DISCUSSION

Bowl traps and vane traps employ a similar mechanism to attract and subsequently capture bees—color. Color is what attracts bees initially to the traps, but differences in trap type, colors, and placement create several possible mechanisms for differences in capture rates to occur. Despite their single color, vane traps performed reasonably well, capturing a large fraction of the bee species detected in this study (with the exception of Andrenidae and their nest parasites). Additionally, vane traps appear to be particularly attractive to some bees in the family Apidae such as the eucerines and bumble bees. The relative contribution of trap design and location to bee capture rates cannot be disentangled in this current study, but future comparisons should attempt to isolate these other factors by painting the vane traps the same color as the ground traps and placing all the traps at the same height. Additionally, further general comparisons may show additional preferences among bee species not represented here in this study as additional locations and additional species groups are sampled. Because of the unusual attraction of some species to the vane traps there is a greater concern that these traps could impact the population size of bees in subsequent seasons, so until the possible impacts of these sampling rates is clearer, caution would dictate to not over sample, or at least to reduce trapping during times when bumble bees and eucerines are highly active. Experiments with vane traps as long-term sampling devices filled with propylene glycol could make them particularly effective in remote areas, especially if a piece of plastic was placed over the top of the vanes to minimize additional rain entering the traps.

The biggest difference between these two trap methods may be cost and ease of use. The size of the bowl traps used in this study (7 cm [2.8 in] across and 7.5 cm [3.0 in] high) makes them easy to transport, quick to set up, and practical for use by inexperienced volunteers. Vane traps can't be stacked for carrying because of their larger size and must be set up suspended on metal poles 1 m (3.3 ft) in height. Set-up time for vanes takes longer and the traps are somewhat cumbersome, making them probably more appropriate for use as stationary traps similar to malaise traps or for studies involving the live capture, marking, and releasing of bees.

Cost and logistical comparisons present another layer of consideration when deploying these traps. For a large scale monitoring program, vane traps costing $7 to $8 per trap would clearly be more expensive than bowl traps, which cost just $0.03 to $0.06 apiece. For a program with 10 sampling sites and 5 transects per sampling site, the cost for vane traps with 3 per transect would be $1050 to $1200.00 just for the vane traps and for each trap there would be an additional cost of $2 to $5 per pole to suspend it. For the same 10 sampling sites, the cost for bowls with 15 per transect would be $22.50 to $45. While these figures would change depending on the number of bowls and vane traps used, the cost and slow pace of set-up, transport, and tending make the larger, more expensive vane traps less appealing for large scale monitoring run by volunteers on tight budgets.

The 2006 National Academy of Sciences report on the status of pollinators in North America recognizes a paucity of long-term and baseline data on pollinator populations. The report directly recommends implementing long-term data collection on pollinator populations using standardized protocols (National Research Council 2006). Essential to such sampling initiatives is an understanding of how sampling methods compare and function through assessment studies. Our comparison of the performance of bowl and vane traps suggests that, although some differences in capture rates are apparent and important to understand, bowl and vane traps are functionally more similar than different and both are appropriate for use as standardized passive trapping methods for long-term bee monitoring programs for which documenting effort is important.

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A Simple Trap Design for the Collection and Sampling of Subterranean Ants (Hymenoptera: Formicidae)

Timothy Foard

i2LResearch USA, Inc., 1330 Dillon Heights Avenue, Baltimore, Maryland 21228
bmorebugman@yahoo.com

Abstract: A trap designed for sampling subterranean ants was constructed from chlorinated polyvinyl chloride (CPVC) pipe and given a preliminary trial in a forested site on Maryland's Eastern Shore. The trap design was able to trap ants foraging between 6.35 cm (2.5 in) and 8.89 cm (3.5 in) below the surface. Ants were captured in 36.8% of the traps. Of particular interest were members of the genus *Lasius* Fabricius, which include several subterranean species. *Lasius flavus* (Fabricius), a partially subterranean species, was present in 28.6% of traps containing ants. The major advantages of this design are that it is simple to construct and that it does trap ants below ground level. The trap needs further evaluation compared to other traps when sampling for truly subterranean species in various habitats before its efficacy can be proven.

INTRODUCTION

Ants occupy such a wide variety of ecological niches that no single sampling method exists that collects all species in a given area. This is especially true in the tropics, where ants are at their highest diversity. The development of the ALL (Ants of Leaf Litter) Protocol was borne out of a need to maximize the efficiency of sampling utilizing a number of sampling methods (Agosti et al. 2000). The number of sampling methods depends on habitat and the objectives of the investigator, but in its most basic form the ALL Protocol utilizes pitfall traps, which collect those species active above the ground, and Winkler extractors, which are suited for species which forage among the leaf litter. While these two trap methods will collect a majority of species in an area, species which are truly subterranean will often escape capture using these methods. The most productive technique for these species involves systematic searching by hand through soil cores excavated to a depth set by the investigator. While the hand search produces the largest number of species and individuals, there are several disadvantages to this method, the most apparent being the amount of labor required to transport soil and the amount of time spent in locating specimens. Processing soil through Berlese funnels is only partially successful, as soils, especially the compact clayey types, retain moisture for much longer periods, thus requiring much longer extraction times. Other soils display the opposite properties, rapidly losing moisture, resulting in the insects dying inside the drying soil before they can be extracted. In addition, many subterranean species are not only very small, but are also very slow-moving and often cryptically colored, making it likely that specimens will be overlooked.

Recent interest in subterranean ants has led to the development of traps which selectively sample those species which live and forage several inches to several feet below the leaf litter. Based on their findings, Pacheco and Vasconcelos (2012) question the necessity of using subterranean traps as a supplement to conventional traps. In their study, they observed that conventional pitfall traps were just as efficient in capturing subterranean species as did the subterranean traps. In addition, combining the two trap types did not greatly improve the rate in which new species were added to the species inventory when compared to either trap used alone. Other studies, however, illustrate the contributions made by utilizing subterranean traps. One of the more noteworthy studies (Wilkie et al. 2007) sampled subterranean ants in Ecuador using two 50-cm (19.7-in) circular traps, one of which fits within the other and both contain drilled holes that line up when the inner tube is inserted. Furthermore, both are compartmentalized in such a way to prevent ants from moving from one zone into another. Their work using this trap led to the discovery of both new and rarely reported species. Another study using subterranean traps of a different design (Brandão et al. 2008, Schmidt and Solar 2010) resulted in the rediscovery of *Simopelta minima* (Brandão), a rare subterranean species initially believed to have become extinct.

During my survey of Maryland's ant fauna at sites where I employed the ALL Protocol, I was concerned whether conventional methods were excluding some species of the genus *Lasius* Fabricius. In the United States, certain members of the genus *Lasius*, especially in the *claviger*, *flavus*, and *umbratus* species groups, are typically pale yellowish to yellowish-brown and largely subterranean, coming to the surface mainly to release alates. They are the only subterranean ants occurring in the northern regions of the United States. Of at least 12 species that have been recorded in Maryland, 9 of these species belong to one of these three species groups. The *claviger* species group contains 5 species that are most common in the moist rocky deciduous forests of the central and western parts of the state. Two species of the *flavus* group are represented in Maryland. They occur in different habitats, with *L. nearcticus* Wheeler being found in the same habitats (and distribution) as ants of the *claviger* group, and *L. flavus* (Fabricius) most common in dry Coastal Plain mixed or coniferous forests. Of the two species in the *umbratus* group—*L. umbratus* (Nylander) and *L. speculiventris* Emery—the first species occurs statewide but is uncommon or absent in habitats where *L. flavus* occurs, favoring more moist forests. The other member of that group is an uncommon species with a spotty distribution in Maryland. The remaining 3 species, all members of the *niger* species group, are epigaeic (above ground foragers) in behavior and are often captured with conventional pitfall traps.

I was looking for a method to trap subterranean forms without having to process sizeable quantities of soil. A literature search revealed little beside the article from Wilkie et al. (2007) in which, ironically, the trap was too labor intensive to construct for my use. The development of a simple trap design resulted from these concerns. There were two objectives: to determine whether my trap design was able to trap ants; and to determine whether species of the genus *Lasius* could be captured with this trap.

METHODS

The trap (Figure 1) consisted of chlorinated polyvinyl chloride (CPVC) pipe 25.4 cm (10 in) long and 1.9 cm (¾ in) inside diameter. At one end of the pipe, beginning at 6.35 cm (2½ in) from the opening, a slit 2.54 cm (1 in) long and 0.32 cm (⅛ in) wide was cut into the side using a rotary tool with a cutting disc attachment. This process was repeated on the opposite side of the slit. Two additional 2.54-cm (1-in) slits were cut, with each between the two previously cut openings and opposite of each other. When finished, each trap had four openings. At the other end of the pipe, a 30° cut was made using a band saw. The shape of the resulting elliptical opening was then traced with a fine-point marker onto a 0.32 cm (⅛ in) thick clear acrylic sheet and the shape was cut out with a band saw. The cut acrylic piece was then taped over the elliptical opening of the pipe with vinyl tape. A glass, 2-dram shell vial, 6.03 cm (2⅜ in) long and 1.43 cm (9/16 in) outside diameter, had the top 1.27 cm (½ inch) wrapped with vinyl tape to slightly increase its diameter for better fitting within the trap. Propylene glycol was added to the vial before inserting it into the trap. Following the insertion of the vial into the trap, the opening was capped with a rubber stopper. A soil corer was used to create a starter hole for the trap. The trap was inserted into the starter hole and then pushed further into the hole until the rim was flush with the ground surface below the leaf litter. In theory, the trap works in one of two ways: either by intrusion of either the subterranean nest chambers or foraging tunnels, or by interrupting the formation of new foraging tunnels. If the trap damages part of the nest chamber or established foraging trails, the workers in the process of repairing the structures enter one of the slit openings and fall into the propylene glycol preservative. In the latter instance, workers in the process of excavating new tunnels will encounter the walls of the trap, and attempt to tunnel around it, encounter one of the slits, enter it, and become entrapped.

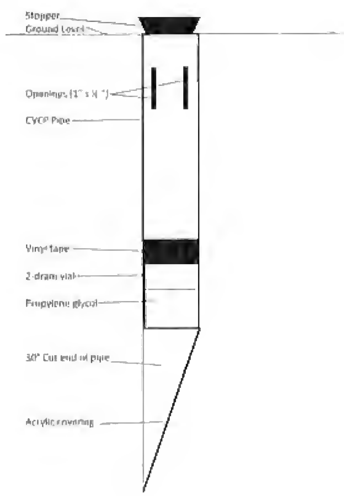

Figure 1. Subterranean trap design. (not shown to scale)

A preliminary trial was conducted to determine whether the design would capture ants below ground. The study site used for the test was located on Maryland's Eastern Shore in the Maryland Department of Natural Resources' Wicomico Demonstration Forest (Campbell Complex, between U.S. Route 50 and Sixty Foot Road), Wicomico County, Maryland. The habitat is a conifer-dominated mixed forest with a shrubby understory occurring on loose sandy soil. Twenty traps were placed along a 200-m (656.2-ft) transect, spaced every 10 m (32.8 ft). They were left in place for one week, 13-20 September 2012. After that time, traps were collected, 95% ethanol was added to the vials, and the contents were capped and stored for later processing.

RESULTS and DISCUSSION

Nineteen of the 20 traps were recovered after one week (Table 1). Seven traps (36.8%) contained ants of five species. *Aphaenogaster rudis* Enzmann and *Nylanderia faisonensis* (Forel) were the most common species captured, present in 4 (57.1%) and 3 (42.8%) of the occupied traps, respectively. Two of the occupied traps (28.6%) trapped *Lasius flavus*. *Solenopsis molesta* (Say) and *Myrmecina americana* Emery each were present in only 1 (14.3%) occupied trap. None of the species are truly subterranean, but *L. flavus* and *S. molesta* exhibits largely subterranean tendencies. Both of these species will also nest in decaying wood and had been collected from other sampling methods at this site as well. Two species of *Lasius* are common at this site, the other species being *L. alienus* (Forester), which were taken from trees baited with jelly and from Winkler extractors.

Table 1. Trial results for 19 subterranean traps after one-week deployment.

Species Captured	Number of Traps Capturing Specimens	Percentage of Occupied Traps (N = 7) Capturing Each Species	Percentage of Total Traps (N = 19) Capturing Each Species
Aphaenogaster rudis Enzmann	4	57.1%	21.1%
Nylanderia faisonensis (Forel)	3	42.8%	15.8%
Lasius flavus (Fabricius).	2	28.6%	10.5%
Solenopsis molesta (Say)	1	14.3%	5.3%
Myrmecina americana Emery	1	14.3%	5.3%
Any Species	7	100%	36.8%

It is not surprising that the trap collected the observed species, since the opening only extended to a depth of 6.35 cm (2½ in) to 8.89 cm (3½ in) below the surface. At this position, it is possible to place two vials into the trap without disturbance (Figure 2), with the second vial placed at a set time following the insertion of the first vial. Longer traps can be constructed, making it possible to add more vials at specific time intervals. The openings can be made much further down the trap to the desired depth, although this may limit the number of vials which can be stacked inside the tube. Even if the opening is cut to collect organisms at the greater depth, vials within the trap can be replaced with fresh vials by inserting a wire inside a stopper and pushing the stopper on the vial inside the trap and then carefully pulling it out. In this way, long term assessments or monitoring are possible.

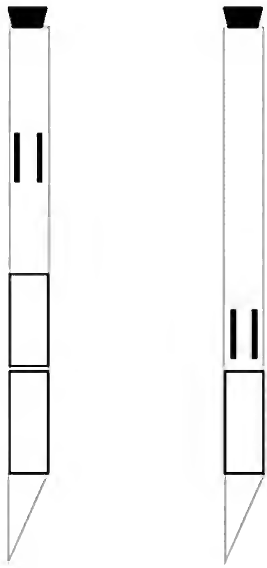

Figure 2. Subterranean trap, showing different positions of entry slits and stacking of vials.

The advantage of the trap design is that it is simple to construct, it traps ants, including *Lasius* sp., and continuous collecting and monitoring is possible. The significance in the trapping of *L. flavus* is that so little is known about the behavior of subterranean ants that at least this species responds to the trap in a way that is expected based on the rationale of the trap design. This trap has not yet been evaluated in different habitats while sampling for truly subterranean species or compared with other traps for efficiency of capture. Much more work is planned in the future to further improve the design, to evaluate the design with pitfall traps, and to test in various sites.

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

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

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

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

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

The Maryland Entomologist is published annually by the Maryland Entomological Society. There are four numbers per volume. Original articles or reports on geographic or temporal distribution (primarily pertaining to Maryland and the Mid-Atlantic region), ecology, biology, morphology, genetics, systematics, behavior, etc., are welcome. Notes on distribution, behavior, occurrence, migration, life history and other biological topics will be published. All submissions are subject to editorial review and acceptance. Articles will be peer-reviewed. Send submissions to the Editor: Eugene J. Scarpulla, 14207 Lakerun Court, Bowie, MD 20720-4861, ejscarp@comcast.net.

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COVER PHOTOGRAPH

A captive female snail-eating ground beetle, *Scaphinotus viduus* (Dejean) (Coleoptera: Carabidae: Cychrini), preying on a snail (Mollusca: Gastropoda). Collected at G. Richard Thompson Wildlife Management Area, Fauquier County, Virginia, 11 June 2015.

Photographed by Curt W. Harden