

## The Carabidae (Insecta: Coleoptera) of Eastern Neck National Wildlife Refuge, Maryland

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### ABSTRACT

We documented 80 species of Carabidae during inventory work conducted at Eastern Neck National Wildlife Refuge, Rock Hall, Maryland from April to September 2003. *Chlaenius erythropus* Germar and *Clivina striatopunctata* Dejean are reported from Maryland for the first time. This increases the total number of Carabidae recorded from Maryland from 368 to 370.

*Key words:* Carabidae, inventory, Eastern Neck National Wildlife Refuge, new state records.

### INTRODUCTION

The Carabidae (ground beetles) are commonly found under stones or bark, or running over the ground. Ground inhabitants are found on the shores of streams and ponds, sunlit marshes, swamp forests, wet or dry forests, wet meadows, dry grasslands, and exposed sandy areas. Some species live in trees or shrubs and may be taken by beating or sweeping foliage (Larochelle & Larivière, 2003). Most carabids are generalist predators or scavengers, eating dead and dying arthropods, or are specialist predators feeding on mollusks, millipedes, or various insect groups. Some species are day-active, relying on eyesight primarily to capture prey while others are nocturnal, locating prey by chemical means. Other carabids are plant feeders, especially on seeds. A few species are ant nest associates, feeding on ants and debris from the nest (Larochelle & Larivière, 2003). Many carabids are attracted to lights and can be collected this way as well as by head-lamping. Unbaited pitfall traps are another effective method of collecting these beetles. Malaise traps, flight-intercept traps, and Berlese funnel samples capture numerous species. The 2,635 North American species are fairly well-studied (Ball & Bousquet, 2000), but a few genera are in need of revision. Mid-Atlantic carabids can be identified using Ciegler (2000) and

Bousquet (2010).

The carabid fauna of Maryland includes 368 confirmed species, while 87 other species may occur in the state (Bousquet & Larochelle, 1993; Bailey et al., 1994; Clark et al., 2006; Steiner et al., 2007). By comparison, 504 carabids have been documented in Virginia (Davidson, 1995; Anderson et al., 1995; Hoffman & Roble, 2000; Hoffman et al. 2006; Evans 2009b). Very little has been published on Maryland carabids. Glaser (1976, 1986, 1992, 1995) reported on various Cicindelini and Staines (2005[2006]) reported on *Cicindela hirticollis hirticollis* Say colonizing a restored beach. Staines (1994) surveyed the genus *Calosoma* using black lights and he also (Staines, 1985) discussed the biology and distribution of the genus *Omophron* in the state. Bailey et al. (1994) reported on carabids collected in pitfall traps in western Maryland and Dively (2005) used this sampling method to study the impact of transgenic corn on carabid diversity and abundance. Glaser (1996) discussed the ten Cychrini species found in Maryland and Clark et al. (2006) compared the carabid faunas in two tillage systems. More recently, Evans (2009a) listed 46 species of carabids found at Maryland sites during the Potomac Gorge Bioblitz. The only published inventory of the carabid fauna of a Maryland location accounts for 214 species from Plummery Island, Montgomery County

collected over an 80-year period, but only 117 of these species were taken from 1970 to 1984 (Erwin, 1981; Stork, 1984).

Eastern Neck National Wildlife Refuge, located south of Rock Hall in Kent County, Maryland (39.0149°N, 76.1341°W), is a 2,285 acre (914 ha) Chesapeake Bay island at the mouth of the Chester River (Fig. 1). Habitats include 860 acres (344 ha) of brackish tidal marsh, 550 acres (220 ha) of cropland (primarily corn and soybeans with some clover and winter wheat), 700 acres (280 ha) of forest (composed of loblolly pine, hardwoods, and mature oak-sweetgum forest), 30 acres (12 ha) of grassland, and 40 acres (16 ha) of open water impoundments. The elevation varies from 13 to 23 feet (2.9 to 6.9 m) above mean sea level.

## METHODS

We used three methods to collect ground beetles on the refuge. Unbaited barrier pitfall traps containing soapy water as a killing agent were placed in various locations on the island and their contents were collected daily. Visual encounter surveys were conducted in specific habitats throughout the island. Finally, we used black lights for several nights each month, resulting in the collection of numerous species.

Inventories were conducted from 22 April to 20 September 2003. Voucher specimens have been deposited in the collections of Eastern Neck National Wildlife Refuge and the National Museum of Natural History, Smithsonian Institution.

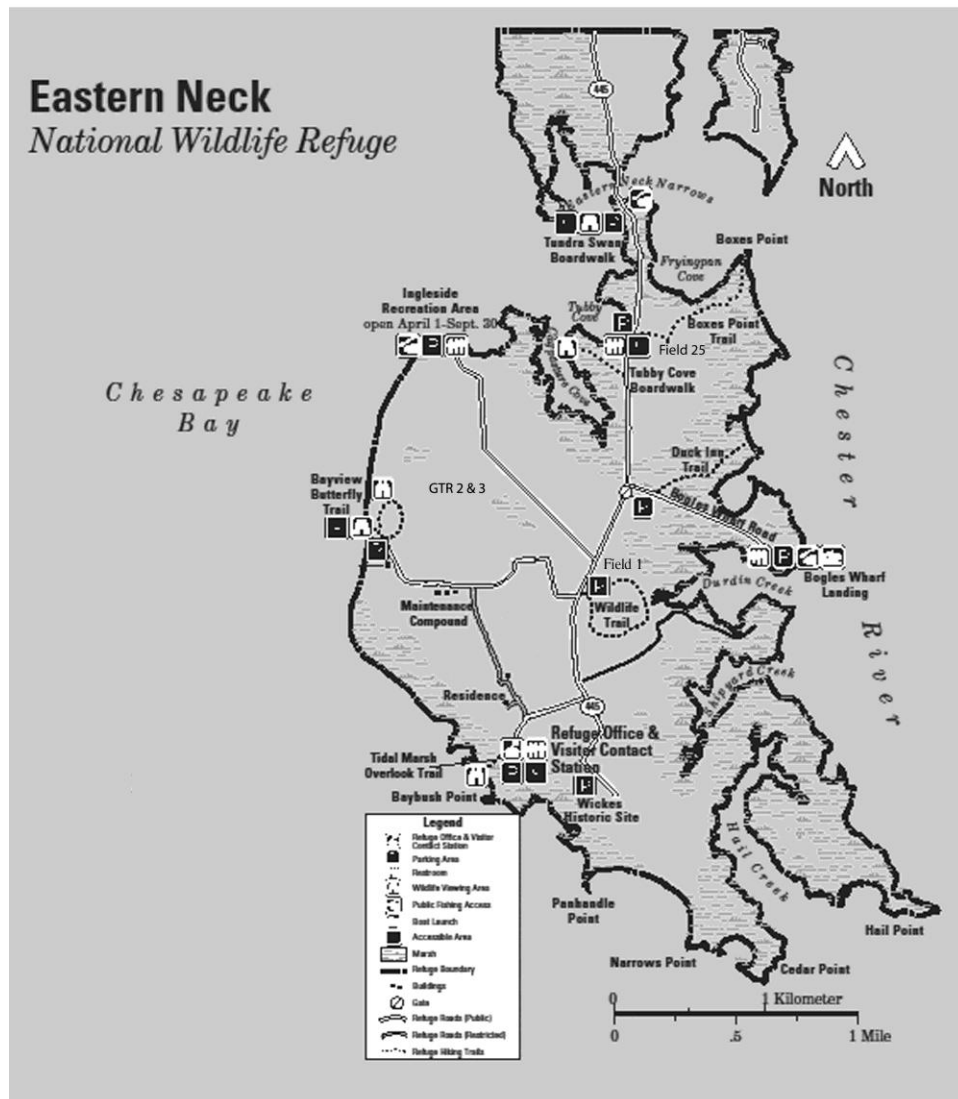


Fig. 1. Map of Eastern Neck National Wildlife Refuge.

## ANNOTATED LIST OF SPECIES

## Tribe Bembidiini

*Bembidion affine* Say, 1823 is commonly found in a variety of habitats characterized by open or slightly shady ground covered with moderate to dense vegetation. Adults are active for the entire season and are the overwintering stage (Lindroth, 1963; Erwin, 1981). Adults were collected in June along Bayview Butterfly Trail, Boxes Point, Cedar Point, and Ingleside Recreation Area at black light.

*Bembidion honestum* Say, 1823 is usually found along the banks of rivers and streams and prefers open, moist, gravelly soil. Adults are mostly nocturnal and found under rocks and stones during the day (Lindroth, 1963; Erwin, 1981). One specimen was collected along the shoreline at Cedar Point on 30 May 2003.

*Bembidion inaequale* Say, 1823 is usually found along the banks of rivers, streams, ponds, and pools, preferring wet soil with little vegetation. Adults are diurnal and feed on dead and dying arthropods (Lindroth, 1963; Erwin, 1981). Specimens were collected at black light in June and July at Ingleside Recreation Area and in the Maintenance Yard.

*Bembidion rapidium* (LeConte, 1848) is usually found along lake shores, the banks of rivers, streams, ponds, and pools as well as in orchards and cultivated fields. The species prefers open wet or moist ground with some vegetation. Adults are nocturnal and shelter in cracks in the soil or under dead leaves or stones during the day. They feed on immature Lepidoptera and the larvae and pupae of Diptera (Lindroth, 1963; Kirk, 1975; Erwin, 1981). Specimens were collected at black light at Ingleside Recreation Area on 27 June 2003.

*Elaphropus levipes* (Casey, 1918) is usually found on open ground along river banks (Erwin, 1981). Specimens were collected at black light from April to August at Bogles Wharf, Boxes Point, Ingleside Recreation Area, Maintenance Area, and along Wildlife Trail.

## Tribe Brachinini

*Brachinus cyanipennis* Say, 1823 is found along the banks of rivers and brooks, lake shores, floodplain forests, and borders of marshes. Adults are nocturnal and found on open or shaded ground. Larvae are ectoparasites of Gyrinidae pupae (Coleoptera)

(Lindroth, 1969; Erwin, 1970; Larochelle, 1974). One specimen was collected at black light on 26 June 2003 at Boxes Point.

*Brachinus tenuicollis* LeConte, 1844 is found along the margins of rivers, ponds, pools, reservoirs, and marshes. Adults are nocturnal and are found on open or half-shaded ground. The larvae are ectoparasites of Hydrophilidae larvae (Coleoptera) (Lindroth 1969; Erwin 1970; Larochelle, 1974). Specimens were collected in pitfall traps in July and August at Bogles Wharf, Boxes Point, Field 25, Ingleside Recreation Area, and Wicke's Historic Site.

## Tribe Carabini

*Calosoma sayi* Dejean, 1826 is found in a diversity of habitats. Adults are mostly active at sunset and sunrise, are attracted to lights, and feed on larvae of Heteroptera, Lepidoptera, and Coleoptera (Burgess & Collins, 1917; Kirk, 1969, 1970; Young, 1984; Ciegler, 2000). One specimen was collected at black light in GTR 2 and 3 on 26 June 2003.

*Calosoma scrutator* (Fabricius, 1775) is found in a wide variety of habitats but prefers shaded ground. Adults are nocturnal and will feed on anything they can overpower (Blatchley, 1910; Burgess & Collins, 1917; Lindroth, 1961; Erwin, 1981). Specimens were collected from May to August in pitfall traps, black lights, and during visual encounter surveys along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Cedar Point, Ingleside Road, and along Wildlife Trail.

*Calosoma wilcoxi* LeConte, 1848 is found on shaded ground in a wide variety of habitats. Adults feed on Lepidoptera larvae and grasshoppers (Orthoptera: Acrididae) (Burgess & Collins, 1917; Lindroth, 1961). One specimen was collected in a pitfall trap on 17 May 2003 along Wildlife Trail.

*Carabus goryi* Dejean, 1831 is found on shaded ground in a wide variety of habitats. Adults are nocturnal and gregarious; they feed on soft-bodied insect larvae (Blatchley, 1910; Lieberr & Mahar, 1969; Erwin, 1981). Specimens were commonly collected in pitfall traps in April and May at Bogles Wharf, Boxes Point, Field 25, and along Wildlife Trail.

## Tribe Chlaeniini

*Chlaenius aestivus* Say, 1823 is found in shaded moist habitats well away from open water. Adults are

nocturnal and gregarious. Eggs are laid in mud or clay cells placed on dead twigs, leaves, plant stems, and trunks of trees and shrubs (King, 1919; Lindroth, 1969; Erwin, 1981). Specimens were commonly collected in pitfall traps from April to June at Bogles Wharf, Boxes Point, Field 25, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

*Chlaenius cordicollis* Kirby, 1837 is found on open ground along the shores of large lakes and rivers, close to the water. Adults and larvae are active at night and are gregarious. They feed on dead or injured insects (Lindroth, 1969; Erwin, 1981). One specimen was collected in a pitfall trap on 29 July 2003 along the road to Ingleside Recreation Area.

*Chlaenius erythropus* Germar, 1824 is found on shaded ground of mature floodplain forests, edges of swamps, lakes, and ponds. Adults are nocturnal and gregarious. They feed on Lepidoptera larvae and earthworms (Blatchley, 1910; Lindroth, 1969). One specimen was collected in a pitfall trap at Ingleside Recreation Area on 24 July 2003. Bousquet & Larochelle (1993) reported that this species is widespread in eastern North America but they had no records from Maryland. This is the first documented record for the state. **NEW STATE RECORD**

*Chlaenius sericeus sericeus* (Forster, 1771) is found in a wide variety of habitats but especially around water. Adults are mostly nocturnal and gregarious. They feed on a variety of insects and earthworms (Blatchley, 1910; King, 1919; Lindroth 1969; Erwin, 1981). Specimens were collected in June at black light along Wildlife Trail.

*Chlaenius tricolor tricolor* Dejean, 1826 is found in a wide variety of habitats. Adults are nocturnal, and gregarious in the winter. They feed on Lepidoptera larvae and slugs (Blatchley, 1910; Lindroth, 1969). Specimens were collected from May to August at black light and in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, GTR 2 & 3, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

#### Tribe Cicindelini

*Cicindela hirticollis hirticollis* Say, 1817 is found on the seashore, the shores of rivers and lakes and may be abundant on wet beach sand (Graves et al., 1988). Adults were abundant from May to August at the restored beach near Bayview Butterfly Trail, Cedar

Point, and Ingleside Recreation Area.

*Cicindela marginata* Fabricius, 1775 is found in a variety of habitats but seems to prefer beaches and intertidal habitats with mud and debris (Knisley & Schultz, 1997). One specimen was collected on 25 July 2003 at black light at Cedar Point and a second was collected the same day during visual encounter surveys near Bayview Butterfly Trail.

*Cicindela punctulata punctulata* Olivier, 1790 occurs in a wide variety of habitats but is usually found in open areas or areas with sparse vegetation (Knisley & Schultz, 1997). Adults and larvae feed on a variety of small arthropods and adults are often taken at lights (Erwin, 1981; Ciegler, 2000). One specimen was collected at black light at Ingleside Recreation Area on 12 August 2003.

*Cicindela repanda repanda* Dejean, 1825 is commonly found in a wide variety of habitats, usually associated with water (Knisley & Schultz, 1997). Adults and larvae feed on a variety of small arthropods and adults are reported to feed on earthworms (Erwin, 1981). The species was common along the beach at Ingleside Recreation Area.

*Cicindela sexguttata* Fabricius, 1775 is found in forested areas and open areas adjacent to woodlands (Knisley & Schultz, 1997). Adults feed on small spiders, Lepidoptera larvae, gnats, beetles, and ants (Erwin, 1981). Specimens were collected from May to July in pitfall traps and during visual encounter surveys at Bogles Wharf, GTR 2 & 3, and along Wildlife Trail.

#### Tribe Clivinini

*Clivina bipustulata* (Fabricius, 1801) is found in open ground in a wide variety of habitats. Adults are nocturnal and spend the day in burrows dug in the soil. They are associated with Staphylinidae (Coleoptera) and Formicidae (Hymenoptera) (Lindroth, 1961; Kirk, 1969; Erwin, 1981). Specimens were collected in May and June at black light along Bayview Butterfly Trail, Boxes Point, and along Wildlife Trail.

*Clivina dentipes* Dejean, 1825 is found on open ground in floodplain forests, along the banks of rivers, streams, and other bodies of water. Adults are nocturnal and shelter in burrows dug in the soil and under rocks, logs, pieces of wood, and leaf litter (Kirk, 1969; Erwin, 1981). Specimens were collected in May and June at black light along Bayview Butterfly Trail, Boxes Point, and along Wildlife Trail.

*Clivina ferrea* LeConte, 1857 is found on moist open ground in a wide variety of habitats. Adults are nocturnal and shelter during the day in burrows dug in the soil or under stones and debris (Lindroth, 1961; Erwin, 1981). Specimens were collected from May to July at black light and during visual encounter surveys along Bayview Butterfly Trail, Cedar Point, Maintenance Area, and the Staff Residence.

*Clivina striatopunctata* Dejean, 1831 is found in swamps, along the shores of lakes and streams, and in cultivated fields. Adults are nocturnal and shelter during the day in burrows dug in the soil or under debris (Leng, 1915). Specimens were collected in May and June in pitfall traps and at black light along Bayview Butterfly Trail and Boxes Point. Bousquet & Larochelle (1993) reported this species from Alabama, Delaware, Florida, Georgia, Louisiana, Mississippi, South Carolina, and Texas. This is the first report from Maryland. **NEW STATE RECORD**

*Dyschiriodes sphaericollis* (Say, 1823) is found on open ground close to water. Adults are nocturnal and gregarious. They have been associated with Staphylinidae (Coleoptera) (Lindroth, 1961; Kirk 1975; Erwin, 1981). One specimen was collected at black light on 26 June 2003 in GTR 2 & 3.

#### Tribe Cychnini

*Sphaeroderus stenostomus stenostomus* (Weber, 1801) is found mostly on shaded ground in deciduous forests and along the borders of marshes. Adults are mostly nocturnal and feed on slugs and snails (Ulke, 1902; Erwin, 1981). Specimens were collected from April to July in pitfall traps at Boxes Point, Field 25, along Ingleside Road, and along Wildlife Trail.

#### Tribe Galeritini

*Galerita bicolor* (Drury, 1773) is found on shaded ground mostly in deciduous forests. Adults are nocturnal and feed on a variety of insects and on carrion (Blatchley, 1910; King, 1919; Erwin, 1981; Ciegler, 2000). Specimens were collected from May to July in pitfall traps and at black light at Field 25, GTR 2 & 3, Hail Point, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

#### Tribe Harpalini

*Amphasia interstitialis* (Say, 1823) is found on shaded ground in deciduous floodplain forests. Adults are nocturnal and feed on insects and decaying

vegetable matter (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). One specimen was collected at black light on 14 June 2003 along Bayview Butterfly Trail.

*Anisodactylus agricola* (Say, 1823) is found on shady ground of floodplain forests. Adults are nocturnal and are found during the day under stones and leaf litter (Erwin, 1981; Noonan, 1996). Specimens were commonly collected from April to June in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Field 25, and Visitor Center.

*Bradycellus rupestris* (Say, 1823) is found on open ground in a wide variety of habitats. Adults feed on small worms (Lindroth, 1968; Kirk, 1969; Erwin, 1981). Specimens were collected from May to July at black light along Bayview Butterfly Trail, Boxes Point, Cedar Point, Maintenance Area, and along Wildlife Trail.

*Cratacanthus dubius* (Palisot de Beauvois, 1811) is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and feed on small insects (Blatchley, 1910; Lindroth, 1968; Erwin, 1981; Ball & Bousquet, 2000). One specimen was collected in a pitfall trap on 20 June 2003 at Ingleside Recreation Area.

*Harpalus caliginosus* (Fabricius, 1775) is found on open ground in a wide variety of habitats. Adults are both diurnal and nocturnal and feed on seeds, plant pollen, and a variety of insects (Blatchley, 1910; Lindroth, 1968; Erwin, 1981; Noonan, 1991). Specimens were collected in June and July at black light and in pitfall traps along Bayview Butterfly Trail, GTR 2 & 3, Ingleside Recreation Area, and Staff Residence.

*Harpalus erythropus* Dejean, 1829 is found on open ground in a wide variety of habitats. Adults are nocturnal and feed on beetle larvae (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). Specimens were collected in May and June at black light along Bayview Butterfly Trail, Boxes Point, GTR 2 & 3, Ingleside Recreation Area, and along Wildlife Trail.

*Harpalus herbivagus* Say, 1823 is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and active in the spring and fall; they feed on grass seeds, fungi, and a variety of insects (Lindroth, 1968; Erwin, 1981; Noonan, 1991). Specimens were collected in May and June at black light and during visual encounter surveys along Bayview Butterfly Trail, GTR 2 & 3, and Ingleside Recreation Area.

*Harpalus longicollis* LeConte, 1848 is found on open ground in a wide variety of habitats. Adults are nocturnal and feed on Scarabaeidae larvae (Coleoptera) (Lindroth, 1968; Erwin, 1981). One specimen was collected on 26 June 2003 at black light along Bayview Butterfly Trail.

*Harpalus pensylvanicus* (DeGeer, 1774) is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and feed on plant seeds, plant tissue, pollen, and a wide variety of insects (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). Specimens were collected from April to September in pitfall traps, at black light, and during visual encounter surveys along Bayview Butterfly Trail, Boxes Point, Cedar Point, along Duck Inn Trail, Hail Point, along Ingleside Road, Visitor Center, and Staff Residence.

*Harpalus* sp. One specimen that we could not identify to species was collected on 14 June 2003 at black light along Bayview Butterfly Trail.

*Notiobia nitidipennis* (LeConte, 1848) is found in light or open deciduous forests. Adults are nocturnal and feed on various insects (Blatchley, 1910; Leng, 1915; Lindroth, 1968; Noonan, 1973; Erwin, 1981). Numerous specimens were collected on 29 May 2003 at black light at Boxes Point.

*Stenolophus comma* (Fabricius, 1775) is found on open ground in a wide variety of habitats. Adults are mostly nocturnal and feed on a variety of insects (Johnson, 1949; Lindroth, 1968; Hsin et al. 1979; Erwin, 1981). Specimens were collected from May to July at black light at Boxes Point, Cedar Point, GTR 2 & 3, along Bayview Butterfly Trail, Ingleside Recreation Area, Staff Residence, and along Wildlife Trail.

*Stenolophus ochropezus* (Say, 1823) is found in a variety of habitats associated with water. Adults are nocturnal and feed on seeds (Blatchley, 1910; Leng, 1915; Lindroth, 1968; Erwin, 1981). Specimens were collected from May to August at black light along Bayview Butterfly Trail, Boxes Point, Cedar Point, along Duck Inn Trail, GTR 2 & 3, Ingleside Recreation Area, along Ingleside Road, Maintenance Area, Staff Residence, and along Wildlife Trail.

*Stenolophus rotundicollis* (Haldeman, 1843) is found on open ground in various field-like habitats. Adults are nocturnal and hide under debris during the day (Lindroth, 1968; Kirk, 1970). Specimens were collected in May and June at black light and during

visual encounter surveys along Bayview Butterfly Trail, Boxes Point, Cedar Point, and GTR 2 & 3.

*Trichotichnus fulgens* (Csiki, 1932) is found on open and shaded ground in a wide variety of habitats. Adults are mostly diurnal and fly readily (Erwin, 1981; Noonan 1991). Specimens were collected in May and June in pitfall traps and at black light at the Visitor Center and along Wildlife Trail.

#### Tribe Lebiini

*Calleida viridipennis* (Say, 1823) is found in open forests and swamps. Adults are mostly diurnal and feed on Lepidoptera larvae (Leng, 1915; Erwin, 1981; Braun et al. 1990). One specimen was collected at black light on 29 May 2003 at Boxes Point.

*Cymindis limbatus* Dejean, 1831 adults are largely arboreal and taken on tree trunks and in the canopy at night and under bark and in cracks in trees during the day. Adults feed on Lepidoptera larvae and carrion (Blatchley, 1910; Liebherr & Mahar 1979; Erwin, 1981; Ciegler, 2000). Specimens were collected in May and June at black light at Boxes Point and GTR 2 & 3.

*Lebia analis* Dejean, 1825 is found on open ground in a variety of habitats. Adults are mostly diurnal and feed on a wide variety of insects (Blatchley, 1910; Whitcomb & Bell, 1960; Lindroth, 1971; Erwin, 1981). Specimens were collected from June to August at black light at GTR 2 & 3 and along Wildlife Trail.

*Lebia fuscata* Dejean, 1825 is found on shaded or open ground in light or open forests and adjacent meadows and clearings. Adults are mostly diurnal and feed on the immature stages of Chrysomelidae (Coleoptera) (Cushman & Isely, 1916). One specimen was collected at black light on 26 June 2003 at Boxes Point.

*Lebia grandis* Hentz, 1830 is found on open ground in a variety of habitats. Adults are mostly diurnal and feed on a variety of insects but especially immature Chrysomelidae (Coleoptera) (Blatchley, 1910; Hemenway & Whitcomb, 1967). Specimens were collected from May to August at black light along Bayview Butterfly Trail, Boxes Point, Ingleside Recreation Area, and along Wildlife Trail.

*Lebia solea* Hentz, 1830 is found on slightly shaded or open ground in a variety of habitats. Adults are mostly diurnal and are ectoparasites of Chrysomelidae pupae (Coleoptera) (Blatchley, 1910; Larochelle, 1974;

Erwin, 1981). Specimens were collected in June at black light along Bayview Butterfly Trail.

*Lebia viridis* Say, 1823 is found on open or slightly shaded ground in a wide variety of habitats. Adults are mostly diurnal and feed on the immature stages of Chrysomelidae (Coleoptera) (Blatchley, 1910; Hemenway & Whitcomb, 1967; Lindroth, 1969; Erwin, 1981). Specimens were collected from June to September during visual encounter surveys and at black light along Bayview Butterfly Trail, Cedar Point, GTR 2 & 3, along Ingleside Road, and Staff Residence.

*Plochionus timidus* Haldeman, 1843 is found on shaded ground in deciduous forests and swamps. Adults are both nocturnal and diurnal and feed on Lepidoptera larvae (Blatchley, 1910; Emden, 1942; Erwin, 1981). One specimen was collected in a pitfall trap on 14 July 2003 at Bogles Wharf.

#### Tribe Licinini

*Badister notatus* Haldeman, 1843 is found on open ground in disturbed habitats and forest clearings. Adults are nocturnal (Lindroth, 1969; Larochelle, 1974; Kirk 1975; Erwin, 1981). Specimens were collected in June at black light along Bayview Butterfly Trail, Boxes Point, and GTR 2 & 3.

*Dicaelus elongatus* Bonelli, 1813 is found on shaded ground mostly in deciduous forests. Adults are nocturnal and feed on Lepidoptera larvae (Lindroth, 1969; Kirk, 1970, 1975; Erwin, 1981). One specimen was collected in a pitfall trap on 9 May 2003 along Wildlife Trail.

*Dicaelus politus* Dejean, 1826 is found on shaded ground in deciduous forests. Adults are nocturnal and feed on Lepidoptera larvae (Lindroth, 1969; Erwin, 1981). Specimens were collected in June and July in pitfall traps at Bogles Wharf and along Wildlife Trail.

*Dicaelus teter* Bonelli, 1813 is found on shaded ground in forests. Adults are nocturnal and feed on snails and Lepidoptera larvae (Ball, 1959; Barr, 1969; Erwin, 1981). Specimens were collected from April to July in pitfall traps and during visual encounter surveys at Bogles Wharf, Boxes Point, Field 1, Field 25, Hail Point, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

#### Tribe Loxandriini

*Loxandrus velocipes* Casey, 1918 is found on wet

soil covered by debris along the margins of streams and marshes and on deciduous forest floodplains. Adults are nocturnal and spend the day hidden in leaf litter (Lindroth, 1966; Allen, 1972; Erwin, 1981). Specimens were collected in June in pitfall traps along Bayview Butterfly Trail and Wicke's Historic Site.

#### Tribe Notiophilini

*Notiophilus aeneus* (Herbst, 1806) is found on shaded ground in various forest habitats and is often found in leaf litter. Adults are mostly diurnal and feed on Lepidoptera larvae (Lindroth, 1961; Erwin, 1981; Reeves et al. 1983; Ciegler, 2000). Specimens were collected in April in pitfall traps at Bogles Wharf and Field 25.

*Notiophilus novemstriatus* LeConte, 1848 is found on open ground in various forest habitats. Adults are diurnal and feed on Diptera (Frost, 1941; Thompson & Allen, 1974; Erwin, 1981). One specimen was collected on 9 May 2003 in a pitfall trap at Bogles Wharf.

#### Tribe Odacanthini

*Colliuris pensylvanica* (Linné, 1767) is found on open ground in a wide variety of habitats. Adults are active both day and night and feed on a variety of insects (Blatchley, 1910; Kirk, 1969; Erwin, 1981). Specimens were collected in June and July at black light along Bayview Butterfly Trail and Staff Residence.

#### Tribe Oodini

*Oodes amaroides* Dejean, 1831 is found on shaded ground in swamps, and the borders of marshes, lakes, and ponds. Adults are active day and night and when alarmed will dive into the water to escape (Leng, 1915; Kirk, 1969; Lindroth, 1969; Erwin, 1981). Specimens were collected from June to August at black light at Boxes Point, Cedar Point, Field 25, GTR 2 & 3, along Ingleside Road, and along Wildlife Trail.

*Oodes americanus* Dejean, 1826 is found on shaded soft, muddy soil covered with dead leaves and some vegetation; adults are nocturnal (Bousquet, 1996). One specimen was collected on 9 May 2003 in a pitfall trap at Bogles Wharf.

#### Tribe Platynini

*Agonum extensicolle* (Say, 1823) is found on open or shaded ground close to water. Adults are mostly

nocturnal and feed on a variety of insects (Lindroth, 1966; Erwin, 1981). Specimens were collected from April to August in pitfall traps and at black light along Bayview Butterfly Trail, Bogles Wharf, Ingleside Recreation Area, along Ingleside Road, and along Wildlife Trail.

*Agonum octopunctatum* (Fabricius, 1798) is found on open, moist ground usually close to water. Adults are mostly nocturnal and feed on Lepidoptera larvae (Blatchley, 1910; Lindroth, 1966; Kirk 1969; Erwin, 1981). Specimens were collected from June to August at black light along Bayview Butterfly Trail, Ingleside Recreation Area, and along Ingleside Road.

*Agonum palustre* Goulet, 1969 is found on ground shaded by trees in deciduous woodland swamps, floodplain forests, and marshes. Adults are nocturnal (Goulet, 1969). Specimens were collected at black light on 7 June 2003 along Wildlife Trail.

*Agonum rigidulum* (Casey, 1920) is found on moist soil near river banks in floodplain forests. Adults are nocturnal (Erwin, 1981). Specimens were collected in June at black light in GTR 2 & 3 and along Wildlife Trail.

*Agonum tenue* (LeConte, 1854) is found on open ground along the margins of bodies of water. Adults are nocturnal and feed on various insects (Lindroth, 1966; Kirk, 1969; Erwin, 1981). Specimens were collected in June in pitfall traps and at black light along Bayview Butterfly Trail and Wicke's Historic Site.

*Calathus opaculus* LeConte, 1854 is found on open or shady ground in a wide variety of habitats. Adults are gregarious and mostly nocturnal (Lindroth, 1966; Anderson et al., 1995). Specimens were collected in June and July in pitfall traps at Cedar Point, Ingleside Recreation Area, and Wicke's Historic Site.

*Olisthopus parmatus* (Say, 1823) is found on shaded ground in deciduous forests. Adults are nocturnal and feed on various insects and earthworms (Lindroth, 1966; Larochelle, 1974; Erwin, 1981). One specimen was collected on 26 June 2003 at black light along Bayview Butterfly Trail.

*Platynus cincticollis* (Say, 1823) is found on shaded ground in low deciduous forests near lakes, ponds, running water, or in swamp or floodplain forest. Adults are mostly nocturnal and feed on plant seeds (Blatchley, 1910; Kirk, 1970; Erwin, 1981). Specimens were

collected in June at black light along Bayview Butterfly Trail.

*Platynus decentis* (Say, 1823) is found on shaded ground in deciduous forests and usually close to water. Adults are mostly nocturnal and feed on Lepidoptera larvae (Gilbert, 1957; Lindroth, 1966; Reeves et al. 1983). Specimens were collected from April to June in pitfall traps and at black light at Bogles Wharf, Boxes Point, Field 25, GTR 2 & 3, and along Wildlife Trail.

#### Tribe Pterostichini

*Gastrellarius honestus* (Say, 1823) is found on shaded ground with thick leaf litter in deciduous forests found mostly under bark or in wood except when foraging. Adults are nocturnal and feed on Lepidoptera larvae (Blatchley, 1910; Lindroth, 1966; Barr, 1969; Erwin, 1981). One specimen was collected on 14 June 2003 at black light along Bayview Butterfly Trail.

*Myas coracinus* (Say, 1823) is found on shaded ground in deciduous forests. Adults are nocturnal and shelter under dead leaves, logs, and stones (Lindroth, 1966; Erwin, 1981). Specimens were collected in May in pitfall traps at Boxes Point and Field 25.

*Poecilus lucublandus lucublandus* (Say, 1823) is found on open or slightly shaded ground in a wide variety of habitats. Adults are mostly nocturnal and may be active at low temperatures under the snow. They feed on a wide variety of insects (Blatchley, 1910; Lindroth, 1966; Barlow, 1970; Erwin, 1981). Specimens were collected from April to July in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Field 25, Hail Point, Ingleside Recreation Area, along Ingleside Road, Visitor Center, Maintenance Area, and along Wildlife Trail.

*Pterostichus coracinus* (Newman, 1838) is found on shaded or open ground, mostly in forests but also in a wide variety of habitats. Adults are nocturnal and feed on a wide variety of insects (Blatchley, 1910; Lindroth, 1966; Barr, 1969; Erwin, 1981; Reeves et al. 1983). Specimens were collected from April to June in pitfall traps at Bogles Wharf, Boxes Point, Field 25, and along Wildlife Trail.

*Pterostichus hamiltoni* G. H. Horn, 1880 is found on shaded ground in open deciduous forests. Adults are gregarious and nocturnal (Larochelle & Larivière, 2003). One specimen was collected on 3 July 2003 in a pitfall trap at Boxes Point.



*Pterostichus trinarius* (Casey, 1918) is found on shaded ground in deciduous forests and along rivers, streams, ravines, and slopes. Adults are nocturnal and feed on insects (Kirk, 1975; Erwin, 1981). Specimens were collected in May at black light along Wildlife Trail.

#### Tribe Scaritini

*Scarites subterraneus* Fabricius, 1775 is found on open ground in a wide variety of habitats, where it is subfossorial, in burrows during the day and often deeper in the litter at night. Adults are nocturnal and feed on a wide variety of insects (Blatchley, 1910; Leng, 1915; Lindroth, 1961; Erwin, 1981). Specimens were collected in May and June in pitfall traps and at black light along Bayview Butterfly Trail, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

#### Tribe Zabritini

*Amara aenea* (DeGeer, 1774) is found on open ground in a wide variety of habitats. Adults are mostly diurnal and feed on a wide variety of insects and seeds (Lindroth, 1968; Erwin, 1981; Laroche & Larivière, 2003). Specimens were collected from April to July in pitfall traps, at black light, and during visual encounter surveys along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Cedar Point, Field 25, GTR 2 & 3, Visitor Center, Staff Residence, Wicke's Historic Site, and along Wildlife Trail.

*Amara basillaris* (Say, 1823) is found in lowland habitats. Adults are nocturnal and spend the day under leaves or in clumps of vegetation (Blatchley, 1910; Kirk, 1969, 1970, 1975). Specimens were collected from April to June in pitfall traps along Bayview Butterfly Trail, Bogles Wharf, Ingleside Recreation Area, Visitor Center, Wicke's Historic Site, and along Wildlife Trail.

*Amara musculus* (Say, 1823) is found on open ground in a wide variety of habitats. Adults are mostly diurnal and feed on seeds, pollen, and animal matter (Blatchley, 1910; Lindroth, 1968; Erwin, 1981). Specimens were collected from April to September in pitfall traps and during visual encounter surveys along Bayview Butterfly Trail, Bogles Wharf, Boxes Point, Field 25, Ingleside Recreation Area, Visitor Center, and along Wildlife Trail.

## DISCUSSION

Our documentation of 80 species of Carabidae at Eastern Neck National Wildlife Refuge indicates that the refuge has a diverse fauna. Since our sampling was limited to one collecting season, this number represents only a fraction of the total fauna. Using EstimateS (Colwell, 2009), the estimated carabid fauna of Eastern Neck NWR is 116 species. Our collection of 68% of the estimated fauna in one season is an excellent start in documenting the total fauna of the island.

Our results compare well with the 117 species recently found at Plummers Island (Erwin, 1981; Stork, 1984) and the 114 species found at Quantico Marine Corps Base in northern Virginia (Anderson et al., 1995; Hoffman, 2010). However, comparing the survey efforts of the sites shows a much longer and intensive effort at Plummers Island (1970-1979) and Quantico (parts of 4 years). Furthermore, the survey methods were quite different. Sampling at Plummers Island did not involve the use of pitfall traps and very little black lighting was conducted. Instead, almost all of the sampling effort was by visual encounter surveys of specific habitats by experienced field collectors. The Quantico samples were obtained by using unbaited pitfall traps for two years and black lighting for parts of two seasons.

Also, both Plummers Island and Quantico are along the Fall Line where the Coastal Plain and Piedmont abut, which provides the potential for a wider diversity of microhabitats and may increase the number of species found. Eastern Neck is entirely in the Coastal Plain and mainly consists of seasonally flooded woodlands and meadows with a few higher points of drier pine-oak woods. This difference in habitat is reflected in the fact that only 63 (78%; Sørensen's Index of Similarity 0.639) of the species found at Eastern Neck were also found at Plummers Island and only 32 species (40%; Sørensen's Index of Similarity 0.329) were shared with Quantico (see Table 1 for a list of species).

The literature on carabid inventory and ecological assessment deals mostly with the use of pitfall traps (Luff, 1975; Adis, 1979; Baars, 1979; Durkis & Reeves, 1982; Boyd, 1985; Halsall & Wratten, 1988; van den Berghe, 1992; Spence & Niemelä, 1994) as the sole method of estimating diversity and abundance. However, numerous researchers have raised questions about the effectiveness of pitfall traps and the interpretation of the results (see Koivula, 2011 and Kotze, 2011 for reviews of the issues).

Table 1. Species of Carabidae collected at Eastern Neck National Wildlife Refuge that have been found at Plummers Island, Maryland, and Quantico Marine Corps Base, Virginia.

Tribe/ Species	Eastern Neck	Plummers Island	Quantico MCB	Tribe/ Species	Eastern Neck	Plummers Island	Quantico MCB
<b>Bembidiini</b>				<b>Harpalini (continued)</b>			
<i>Bembidion affine</i>	x	x		<i>Trichotichnus fulgens</i>	x		
<i>Bembidion honestum</i>	x	x					
<i>Bembidion inaequalis</i>	x	x		<b>Lebiini</b>			
<i>Bembidion rapidum</i>	x	x		<i>Calleida viridipennis</i>	x	x	x
<i>Elaphropus levipes</i>	x	x		<i>Cymindis limbatus</i>	x	x	
				<i>Lebia analis</i>	x	x	
<b>Brachinini</b>				<i>Lebia fuscata</i>	x		
<i>Brachinus cyanipennis</i>	x	x		<i>Lebia grandis</i>	x	x	x
<i>Brachinus tenuicollis</i>	x			<i>Lebia solea</i>	x	x	
				<i>Lebia viridis</i>	x	x	x
<b>Carabini</b>				<i>Plochionus timidus</i>	x	x	x
<i>Calosoma sayi</i>	x						
<i>Calosoma scutator</i>	x	x		<b>Licinini</b>			
<i>Calosoma wilcoxi</i>	x		x	<i>Badister notatus</i>	x	x	x
<i>Carabus goryi</i>	x		x	<i>Dicaelus elongatus</i>	x	x	x
				<i>Dicaelus politus</i>	x	x	x
<b>Chlaeniini</b>				<i>Dicaelus teter</i>	x	x	
<i>Chlaenius aestivus</i>	x	x	x				
<i>Chlaenius cordicollis</i>	x	x		<b>Loxandriini</b>			
<i>Chlaenius erythropus</i>	x			<i>Loxandrus velocipes</i>	x	x	
<i>Chlaenius sericeus</i>	x	x	x				
<i>Chlaenius tricolor</i>	x	x	x	<b>Notiophilini</b>			
				<i>Notiophilus aeneus</i>	x	x	x
<b>Cicindelini</b>				<i>Notiophilus novemstriatus</i>	x	x	
<i>Cicindela hirticollis</i>	x						
<i>Cicindela marginata</i>	x			<b>Odacanthini</b>			
<i>Cicindela punctulata</i>	x	x		<i>Colliuris pensylvanica</i>	x	x	
<i>Cicindela repanda</i>	x	x					
<i>Cicindela sexguttata</i>	x	x	x	<b>Oodini</b>			
				<i>Oodes amaroides</i>	x	x	
<b>Clivinini</b>				<i>Oodes americanus</i>	x		
<i>Clivina bipustulata</i>	x	x	x				
<i>Clivina dentipes</i>	x	x	x	<b>Platynini</b>			
<i>Clivina ferrea</i>	x	x		<i>Agonum extensicolle</i>	x	x	
<i>Clivina striatopunctata</i>	x			<i>Agonum octopunctatum</i>	x	x	
<i>Dyschiriodes sphaericollis</i>	x	x		<i>Agonum palustre</i>	x		
				<i>Agonum rigidiulum</i>	x	x	
<b>Cydrini</b>				<i>Agonum tenue</i>	x	x	
<i>Sphaeroderus stenostomus</i>	x	x	x	<i>Calathus opaculus</i>	x		
				<i>Olisthopus parmatus</i>	x	x	x
<b>Galeritini</b>				<i>Platynus cincticollis</i>	x	x	
<i>Galerita bicolor</i>	x	x	x	<i>Platynus decentris</i>	x	x	x
<b>Harpalini</b>				<b>Pterostichini</b>			
<i>Amphasia interstitialis</i>	x	x	x	<i>Gastrellarius honestus</i>	x	x	
<i>Anisodactylus agricola</i>	x	x	x	<i>Myas coracinus</i>	x	x	x
<i>Bradycellus rupestris</i>	x	x		<i>Poecilus lucublandus</i>	x	x	x
<i>Cratacanthus dubius</i>	x	x	x	<i>Pterostichus coracinus</i>	x	x	x
<i>Harpalus caliginosus</i>	x	x	x	<i>Pterostichus hamiltoni</i>	x		
<i>Harpalus erythropus</i>	x	x	x	<i>Pterostichus trinarius</i>	x		x
<i>Harpalus herbivagus</i>	x	x	x				
<i>Harpalus longicollis</i>	x	x		<b>Scaritini</b>			
<i>Harpalus pensylvanicus</i>	x	x	x	<i>Scarites subterraneus</i>	x	x	
<i>Harpalus</i> sp.	x						
<i>Notioba nitidipennis</i>	x	x		<b>Zabrini</b>			
<i>Stenolophus comma</i>	x	x		<i>Amara aenea</i>	x	x	
<i>Stenolophus ochropezus</i>	x	x		<i>Amara basillaris</i>	x		
<i>Stenolophus rotundicollis</i>	x	x	x	<i>Amara musculus</i>	x	x	

The three inventory projects conducted in the mid-Atlantic revealed some of the weaknesses of using one collection technique to determine carabid diversity at a locality. At Quantico, black lights collected 36 species (32% of the total fauna) not found in pitfall traps (Anderson et al., 1995; Hoffman, 2010). At Eastern Neck, black lights collected 40 species (50% of the total fauna) not found in pitfall traps. Three additional species (4% of the fauna) were only collected during visual encounter surveys. Even at well-collected sites like Plummers Island, the use of black lights for only four nights yielded 11 species not previously documented on the island (Stork, 1984). This indicates that a variety of techniques are needed to obtain a good sample of the carabid fauna and that no one technique is the best for all sites.

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