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SCIENTIFIC NOTE

Aquatic Beetles (Coleoptera) of Everglades Marshes with Additional Records from Everglades National Park, Florida, USA

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The Everglades of southern Florida is a large, subtropical wetland that has been heavily modified by humans. Restoration efforts have sought to restore historical hydrological conditions to the Everglades, but it remains a system where variation in water depth and hydrological patterns are a dominant driver of ecology (Gaiser *et al*. 2012; McCormick *et al*. 2002). Marshes are the most expansive freshwater habitat in the Everglades, while other aquatic habitats include alligator ponds, solution holes, larger ponds, sawgrass ridges, creeks, canals, and marsh/mangrove habitats (Gunderson and Loftus 1993). Studies of invertebrates, and insects in particular, have been largely overlooked in the Everglades relative to vertebrates (Trexler and Loftus 2016).

Since 1996, systematic sampling of aquatic animals has been conducted using 1-m^2, 2-mm mesh throw traps in marshes and sloughs with emergent vegetation types and densities conducive to the sampling method (Jordan *et al*. 1997; Turner and Trexler 1997). Our focus here is on sampling that has been conducted for two Everglades restoration projects: the Modified Water Deliveries monitoring project (MWD) and the Comprehensive Everglades Restoration Plan Monitoring and Assessment Plan project (CERP MAP). Regions covered by these sampling efforts range from Loxahatchee National Wildlife Refuge, south through Water Conservation Areas (WCA) 2 and 3, and into Everglades National Park (ENP) (Fig. 1). We reviewed 4,967 throw trap samples collected for these projects, and MRP identified all aquatic Coleoptera and Heteroptera in these samples to the lowest feasible taxonomic level. Coleoptera identifications were based primarily on Epler (2010), and identifications of some larvae are assumed to be of the same species as adults when differences among taxa for the larval stage are not known. We have excluded semiaquatic families Chrysomelidae and Curculionidae, as well as terrestrial families that occasionally occur in samples (*e.g.*, Carabidae). Pintar *et al*. (2021) provided further details on the methods and samples reviewed and showed that aquatic Heteroptera are among the most common and widespread aquatic animals in Everglades marshes, accounting for nearly 13,000 individuals and 17 species in the reviewed samples. While throw-trap sampling for these projects is not specifically intended for aquatic beetles and may be somewhat size-biased toward larger taxa, it provides valuable data on animal distribution and densities in the marsh habitats that are common and widespread in the Everglades.

We found 904 individuals of aquatic beetles, representing 28 species in seven families (Table 1); all specimens are stored in the museum room at Florida International University's Biscayne Bay Campus in North Miami, Florida, USA. While more speciose than Heteroptera, beetles accounted for only 7% as many individuals. A single species, *Gyrinus elevatus* LeConte, 1868, accounted for over 28% of beetles collected, while other relatively common species included *Enochrus sayi* Gundersen, 1977, *Tropisternus lateralis nimbatus* (Say, 1823), *Hydrocanthus oblongus*

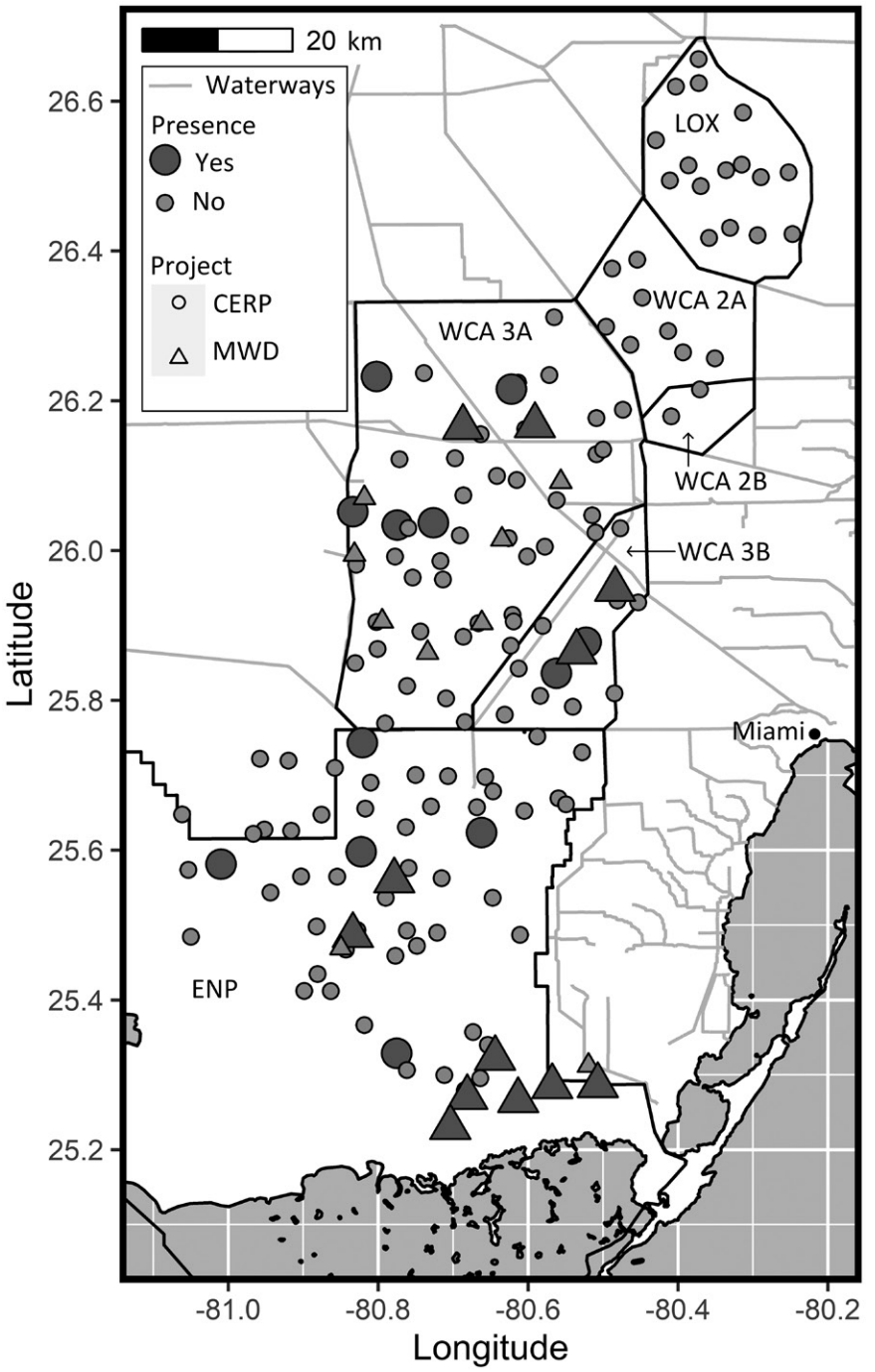

Fig. 1. Map illustrating the study area of the Everglades ecosystem in southern Florida and regions within: Everglades National Park (ENP), Water Conservation Areas (WCA 2A, 2B, 3A, 3B), and Loxahatchee National Wildlife Refuge (LOX = WCA 1). Points are sample sites for the Comprehensive Everglades Restoration Plan Monitoring and Assessment Plan project (CERP; circles) and Modified Water Deliveries to Everglades National Park (MWD; triangles) projects and illustrate the presence (larger dark gray symbols) or absence (smaller light gray symbols) of *Neoporus uniformis* throughout the region.

Table 1. List of aquatic Coleoptera taxa and their abundances from standardized marsh throw trap samples (Marshes) and pinned specimens in the South Florida Collections Management Center (SFCMC); abundances are of adults, with larvae in parentheses. Table lists whether taxa were present (X) or absent (-) in Everglades National Park (ENP) and the Water Conservation Areas (WCAs, including Loxahatchee National Wildlife Refuge).

Taxon	Marshes	SFCMC	ENP	WCAs
Dryopidae				
Pelonomus obscurus LeConte, 1852	25 (3)	10	X	X
Dytiscidae				
Bidessonotus Régimbart, 1895 spp.	0	2	X	-
Brachyvatus apicatus (Clark, 1862)	0	1	X	-
Celina imitatrix Young, 1979	16	2	X	X
Celina slossoni Mutchler, 1918	0	1	X	-
Celina Aubé, 1838 spp.	0	3	X	-
Copelatus caelatipennis princeps Young, 1963	1	5	X	X
Copelatus chevrolati chevrolati Aubé, 1838	0	5	X	-
Copelatus cubaensis Schaeffer, 1908	0	1	X	-
Cybister fimbriolatus (Say, 1825)	6 (27)	26	X	X
Derovatellus floridanus Fall, 1932	0	1	X	-
Desmopachria Babington, 1841 spp.	0	6	X	-
Hydaticus bimarginatus (Say, 1830)	0	7	X	-
Hydrovatus pustulatus (F. E. Melsheimer, 1844)	0	6	X	-
Laccophilus gentilis gentilis LeConte, 1863	1	6	X	X
Laccophilus proximus Say, 1823	0	6	X	-
Laccomimus pumilio (LeConte, 1878)	0	14	X	-
Matus ovatus blatchleyi Leech, 1941	14 (1)	8	X	X
Megadytes fraternus Sharp, 1882	0	7	X	-
Neobidessus pullus floridanus (Fall, 1917)	0	6	X	-
Neoporus uniformis (Blatchley, 1925)	73	21	X	X
Thermonectus basillaris (Harris, 1829)	9	23	X	X
Hydroporinae larvae	(1)	0		
unidentifiable larvae	(1)	0		
Elmidae				
Stenelmis fuscata Blatchley, 1925	0	10	X	-
Gyrinidae				
Dineutus carolinus LeConte, 1868	1	0	X	-
Dineutus serrulatus serrulatus LeConte, 1868	0	10	X	-
Gyrinus elevatus LeConte, 1868	260	11	X	X
Haliplidae				
Haliplus havaniensis Wehncke, 1880	0	2	X	-
Haliplus punctatus Aubé, 1838	0	2	X	-
Peltodytes oppositus Roberts, 1913	1	0	-	X
Hydraenidae				
Hydraena marginicollis Kiesenwetter, 1849	0	10	X	-
Hydrochidae				
Hydrochus Leach, 1817 spp.	0	5	X	-
Hydrophilidae				
Berosus exiguus (Say, 1825)	0	7	X	-
Berosus infuscatus LeConte, 1855	14	12	X	X
Berosus sayi Hansen, 1999	3	0	-	X
Berosus youngi Wooldridge, 1964	0	1	X	-
Cercyon praetextatus (Say, 1825)	0	7	X	-
Enochrus fimbriatus (Melsheimer, 1844)	25	-	X	X
Enochrus hamiltoni (Horn, 1890)	25	-	X	-
Enochrus ochraceus (Melsheimer, 1844)	37	-	X	X
Enochrus sayi Gundersen, 1977	135	-	X	X
Enochrus Thomson, 1859 spp.	0	41	X	-
Helobata larvalis (Horn, 1873)	5	4	X	-
Hydrobiomorpha casta (Say, 1835)	30	19	X	X
Hydrochara occulta (Orchymont, 1933)	0	12	X	-
Hydrophilus insularis Laporte, 1840	1	0	X	-
Hydrophilus triangularis Say, 1823	1	1	X	X
Novochares sallaei (Sharp, 1882)	0	6	X	-
Paracymus lodingi (Fall, 1910)	0	2	X	-
Paracymus nanus (Fall, 1910)	0	4	X	-

(*Continued*)

Table 1. (*Continued*)

Taxon	Marshes	SFCMC	ENP	WCAs
Paracymus reductus (Fall, 1910)	0	1	X	-
Phaenonotum exstriatum (Say, 1835)	0	6	X	-
Phaenonotum minus Smetana, 1978	7	9	X	-
Tropisternus collaris viridis Young and Spangler, 1956	0	7	X	-
Tropisternus lateralis nimbatus (Say, 1823)	87	8	X	X
Tropisternus natator Orchymont, 1938	2	0	-	X
Tropisternus quadristriatus (Horn, 1871)	0	6	X	-
Lampyridae				
Pyractomena LeConte, 1845 spp.	(5)	0	X	-
Noteridae				
Hydrocanthus oblongus Sharp, 1882	74	10	X	X
Hydrocanthus regius Young, 1953	8	0	-	X
Notomicrus sharpi Balfour-Browne, 1939	0	1	X	-
Suphis inflatus (LeConte, 1863)	5	3	X	X
Suphisellus gibbulus (Aubé, 1838)	0	5	X	-
Suphisellus puncticollis (Crotch, 1873)	0	1	X	-
Suphisellus semipunctatus (LeConte, 1878)	0	2	X	-
Scirtidae				
Ora texana Champion, 1897	0	2	X	-
Ora troberti (Guérin-Méneville, 1861)	0	9	X	-

Sharp, 1882, and *Neoporus uniformis* (Blatchley, 1925). Most other species were represented by fewer than 30 individuals (Table 1).

We further explored the aquatic beetles present in Everglades National Park by identifying pinned specimens deposited in the South Florida Collections Management Center (SFCMC) in ENP, Homestead, Florida, USA. The SFCMC also contained specimens in ethanol, which we were unable to access, and dissection of pinned specimens could not be performed if necessary (some were previously dissected). Furthermore, a series of *Enochrus* Thomson, 1859 were only identified to genus. Collection methods of SFCMC specimens varied (if mentioned), although most often black lights or light traps were used. The 406 pinned specimens represented at least 55 species in 10 families (Table 1). The many additional species in this collection illustrate that the often fish-dominated marshes sampled with throw traps are not necessarily the most preferred habitat type for many aquatic beetles.

Although most of the species recorded here have wide ranges that cover much of Florida or the eastern United States, a few are restricted to southern Florida. The SFCMC had two specimens of *Haliplus havaniensis* Wehncke, 1880 collected along Research Road in ENP during June 2000; this species is known from southernmost Florida, Cuba, the Bahamas, Hispaniola, and southern Mexico (Epler 1996; Vondel 2021; Vondel and Spangler 2008). A series of *Megadytes fraternus* Sharp, 1882, all collected during 1960 near Flamingo, Monroe County, were in the SFCMC; *M. fraternus* is a Neotropical species that reaches its northern known distribution in southernmost Florida (Epler 2010; Larson *et al.* 2000; Tremouilles and Bachmann 1980). A single specimen of *Copelatus cubaensis* Schaeffer, 1908 was collected from an unspecified location in the Miami-Dade County portion of ENP during August 1963, soon after this species was first recorded in the United States (Young 1963). *Notomicrus sharpi* Balfour-Browne, 1939, which in Florida is only known from Miami-Dade and Monroe counties (Epler 2010), was collected at an unspecified location in ENP during September 1998.

As currently defined, *N. uniformis* is a species unique to the Everglades ecosystem; it was originally described from the Royal Palm area in what is now Everglades National Park (Blatchley 1925) and is known from few records in Miami-Dade and Broward counties (Epler 2010). Our records document the distribution of this species across Everglades National Park into northeastern Monroe County and northward through WCA 3 (Fig. 1). No records were found in Loxahatchee National Wildlife Refuge, WCA 2, or much of southern and eastern WCA 3A, all of which tend to have longer hydroperiods than sites where *N. uniformis* was recorded. Furthermore, we have not observed this species in other habitats (ponds, canals, swamps, etc.) in southern Florida outside of the Everglades. *Neoporus uniformis* is similar to *Neoporus lobatus* (Sharp, 1882), which is common in northern Florida but is relatively unknown in central or southern Florida (Epler 2010). The similarities among these two species and others in the *undulatus* species group have long been recognized as requiring further work (Larson *et al*. 2000), but their relationships remain unknown. On historical biogeographic time frames, it might seem unlikely that *N. uniformis* is truly a unique species to the Everglades, as the ecosystem

is only approximately 5,000 years old (Gleason and Stone 1994). However, until the phylogenetics of the *undulatus* species group are resolved, it is important to identify and document this unique species.

Young (1954) surmised that *Brachyvatus apicatus* (Clark, 1862) was absent from the southern Everglades, and Epler (2010) reported it from Big Cypress National Preserve; the SFCMC has a single specimen from central Shark River Slough in ENP collected during July 2000, making this the southernmost record in Florida and the first from the southern Everglades. A tiny species (< 2 mm) like *B. apicatus* could easily be missed in throw trap sampling. Similarly, *Berosus youngi* Wooldridge, 1964, a species previously known from southern Georgia to as far south as Broward County (Epler 2010) was collected along Research Road in ENP during June 2000. We have personally observed only a few other aquatic beetle species in southern Florida (Broward, Miami-Dade, and Monroe counties); those that we have observed but were absent from the collections we reviewed here are: *Contacyphon* Des Gozis, 1886 sp.; *Derallus altus* (LeConte, 1855); *Enochrus consors* (LeConte, 1863); *Enochrus pygmaeus* (Fabricius, 1792); *Helochares maculicollis* Mulsant, 1844; *Hydrophilus ovatus* Gemminger and Harold, 1868; *Limnohydrobius tumidus* (LeConte, 1855); *Meridiorhantus calidus* (Fabricius, 1792); *Ochthebius attritus* LeConte, 1878; *Pachydrus princeps* (Blatchley, 1914); *Peltodytes dietrichi* Young, 1961; *Scirtes oblongus* Guérin-Méneville, 1861; *Scirtes tibialis* Guérin-Méneville, 1843; and *Tropisternus blatchleyi blatchleyi* Orchymont, 1922.

While other species that we do not report here are certainly present in the region, our data illustrate the relative lack of diversity and low abundance of aquatic beetles in southern Florida and the Everglades ecosystem. The diversity of aquatic beetles and other insect taxa in the Everglades is possibly lower relative to other parts of the state, as Epler (2010) documented records of over 400 species in the state overall. This decline in species richness could be attributable to the peninsula effect where low rates of immigration means it takes longer for a species to recover from a local extinction (Means and Simberloff 1987; Simpson 1964). In the relatively young Everglades, the peninsula effect is compounded by its oligotrophic state and the prevalence of fish in the ecosystem, with fewer resources supporting smaller populations and predators readily consuming many insects that are present (Ruehl and Trexler 2011; Trexler and Loftus 2016; Turner *et al*. 1999). Indeed, our most common species, *G. elevatus*, belongs to a family (Gyrinidae) that is known to produce strong defense compounds that make them unpalatable for fish (see summary in Dettner 2019). Another common species, *H. oblongus*, typically burrows into mud and plant roots, helping to evade predators. Among our other common species, *T. lateralis* was found predominantly at one site in WCA 3A with dense vegetation, while *E. sayi* was widely distributed, but this small species is likely vulnerable to predators and typically found among vegetation.

Southern Florida is uniquely positioned to receive both naturally-arriving aquatic insects from the Neotropics and those introduced through the pet and agricultural trades (Polhemus and Rutter 1997). Although there have been no documented invasions of aquatic beetles in the region (excluding semiaquatic Curculionidae) or the occurrence of species from distant parts of the planet, vagrant species have been documented in southern Florida, as has the possible establishment of species from the Caribbean. Beetle species that are potentially recent colonists or vagrant occurrences in southern Florida include *Copelatus cubaensis* (see Young 1963), *Cybister occidentalis* Aubé, 1838, and *Hydrophilus ensifer* Brullé, 1837 (Pintar and Keller 2020). There may likely be others, particularly on coastal areas of southern Florida. However, definitively distinguishing between recent arrivals from nearby lands and species that are native but were not previously documented can be difficult and inconclusive. Documentation of historic and current biodiversity is important for tracking newly detected species, understanding whether those species are new arrivals or previously undetected, and assessing changes in populations and communities through large-scale changes such as anthropogenic climate change or localized changes such as Everglades restoration.

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