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New records of earthworms (Clitellata: Oligochaeta) from Georgia, USA, including eight new state records

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Abstract

We present here new county records for 13 counties within Georgia, USA from the collections of the Georgia Museum of Natural History and the authors. These include four families, eight genera, and 23 species. Of these, eight species are new state records: *Amynthas carnosus* (Goto & Hatai, 1899); *Aporrectodea longa* (Ude, 1885); *Bimastos parvus* (Eisen, 1874); *Diplocardia deborahae* Damoff & Reynolds, 2017; *Diplocardia gatesi* Murchie, 1965; *Diplocardia michaelseni* Eisen, 1899; *Metaphire hilgendorfi* (Michaelsen, 1892); and *Murchieona minuscula* (Rosa, 1906). These findings are presented alongside an updated checklist for Middle Georgia building on data compiled by Reynolds (2015) to create a practical record for the region.

Key Words: pheretimoid, non-native species, biodiversity, Megascolecidae, Acanthodrilidae, Lumbricidae, Ocnerodrilidae

Introduction

Earthworms serve as ecosystem engineers in many terrestrial ecosystems and are among the most important soil fauna due to their ability to change the physical, chemical, and biological properties of soil (Kooch & Jalilvand 2008). Although they are diverse in North America (Reynolds 1995), their biogeography has long been understudied with much of the United States and Canada having few, if any, organized surveys (Reynolds 2012). Reynolds (2015) provides the most recent species checklist for the state of Georgia, listing 49 species from 19 genera. Recently, Bingham *et al.* (2021) provided additional records from Muscogee County for *Microscolex phosphoreus* (Dugès, 1837), *Amynthas* sp., and what they referred to as an "uncertain species of microdrile"; and two *Bimastos* species were described from North Georgia (Carrera-Martínez *et al.* 2021). Despite this recent progress, 59 of Georgia's 159 counties (37%) still lack published records.

Our aim is to publish new county and state records from the Grace Thomas Invertebrate Collection of the Georgia Museum of Natural History (GMNH), Athens, Georgia and in the collections of the authors (MAC and BAS). With a few exceptions, all specimens will ultimately be accessioned into GMNH or the collections at the William P. Wall Natural History Museum at Georgia College & State University (GCSU), Milledgeville, Georgia. Additional records which are not new county or state records (based on Reynolds 2015) have been omitted. We also excluded recently discovered species of *Sparganophilus* as these are yet to be formally described (Carrera-Martínez, R., unpublished data). We present these findings alongside an updated checklist for Middle Georgia, as delineated by the Georgia Association of Regional Commissions (GARC 2023), to establish a baseline reference for the region.

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Methods

Specimens were identified using a combination of taxon-specific keys and original descriptions: non-native Lumbricidae (Schwert 1990; Sims & Gerard 1999), native Lumbricidae (Csuzdi *et al.* 2017), Asian pheretimoid earthworms (Chang *et al.* 2016), and Ocnerodrilidae (Jamieson 1970). *Diplocardia* spp. were keyed using James (1990) and confirmed with original species descriptions (e.g., Damoff & Reynolds 2017).

New Records and Collection Data

New earthworm county records are presented in alphabetical order of family, species, and county. Total number of clitellate individuals collected are denoted in parentheses preceding the location of each collection site. Counties where each species has been previously recorded within the state of Georgia are also listed (per Reynolds [2015], unless otherwise mentioned), along with a brief summary of broader distributions. Abbreviations used: BS = Biological Station, Co. = County, Coll = Collection (method)/Collector(s), Crk = Creek, E = East, EF= Experimental Forest, Nat. = National, NF = National Forest, NHS = National Historic Site, NWR = National Wildlife Refuge, Rd = Road, Rvr = River, SP = State Park, Trib = Tributary, WMA = Wildlife Management Area.

Acanthodrilidae Claus, 1880

Diplocardia deborahae Damoff & Reynolds, 2017: New state record

Towns Co.: (2) Swallow Creek WMA, upland of Dismal Creek, 2 July 2007, Coll: MA Callaham, CN Lowe, BA Snyder, S Rostkowski; (5) Near Dismal Creek, Chattahoochee NF, 34.8985°N, 83.6676°W, Soil, Hardwood Forest, SW James, MA Callaham, MK Taylor, R Carrera-Martínez, 26 Sep 2017.

Previously recorded: N/A. This species was described from five counties in Tennessee; this record represents the southernmost record.

Remarks. These specimens were collected in part by hand-digging, and in large part by a vibrational technique known as "grunting" (Mitra *et al.* 2009), whereby a wooden stake is driven into the ground and caused to vibrate with a piece of smooth metal. Several members of the genus *Diplocardia* exhibit an evacuation to the soil surface in response to this stimulus, and while this behavior is not unique to the genus, it is remarkable that an entire fish-bait industry is sustained by this activity in parts of Florida (Hendrix *et al.* 1994).

Diplocardia gatesi Murchie, 1965: New state record

Towns Co.: (3) Chattahoochee NF, 34° 57' 18" N, 83° 34' 04" W, Rock Mountain fire, Burned Plot 5, soil monolith, 27 Mar 2018, Coll: BA Snyder, MA Callaham, *et al*.; (2) Chattahoochee NF, 34° 57' 18" N, 83° 34' 04" W, Rock Mountain fire, Burned Plot 2, soil monolith, 27 Mar 2018, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 57' 18" N, 83° 34' 04" W, Rock Mountain fire, Burned Plot 2, soil monolith, 11 Jul 2018, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 57' 18" N, 83° 34' 04" W, Rock Mountain fire, Burned Plot 4, soil monolith, 27 Mar 2018, Coll: BA Snyder, MA Callaham, *et al*.

Union Co.: (4) Near Rock Crk, Chattahoochee NF, 34.67788°N, 84.13324°W, Soil, MA Callaham, H Ikeda, 6 May 2011.

Previously recorded: N/A. This species is previously known only from North Carolina.

Remarks. Specimens of *D. gatesi* reported here from Union Co. were collected as part of a study by Ikeda *et al.* (2020) examining the distribution and speciation patterns of two major North American native genera. These were not identified to species for that study. Later morphological confirmation resulted in the record reported here.

Diplocardia longa Moore, 1904

Baldwin Co.: (2) Lake Laurel BS, 33.1175°N, 83.1852°W, Soil, Grass, SW James, MA Callaham, MK Taylor, R Carrera-Martínez, 28 Sep 2017.

Greene Co.: (1) Near Oconee River, Scull Shoals EF, 33.7691°N, 83.28407°W, on soil surface, floodplain forest, R Carrera-Martínez, MK Taylor, 1 Jun 2017.

Previously recorded: Baker, Berrien, Bibb, Early, Grady, Hall, Harris, Houston, Jackson, Jefferson, Lanier, Miller, Oconee, Pulaski, Sumter, Thomas, Troup, Wayne, Wilcox, Worth. This species has a broad distribution in the southern US from North Carolina and Florida to Oklahoma and Arkansas (Gates 1977).

Diplocardia michaelseni Eisen, 1899: New state record

Clarke Co.: (1) House garden on Hill Street, Athens, 33.9591°N, 83.3971°W, Soil, E Wenk, 24 Nov 2011.

Previously recorded: N/A. This species has a broad distribution in the southern US from North Carolina to Texas (Gates 1977).

Remarks. *Diplocardia michaelseni* was first mentioned (with a misspelling in the specific epithet) by Lobe *et al.* (2014) without locality data, but we include this record in our counts of new state and county records. Unfortunately, these specimens were not deposited in a museum and have likely been lost. Unpublished data from that study indicate that *D. michaelseni* was collected in Clarke and Greene Counties.

Lumbricidae Rafinesque-Schmaltz, 1815

Aporrectodea caliginosa (Savigny, 1826)

Murray Co.: (3) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Unburned Plot 1, soil monolith, 5 Oct 2017, Coll: BA Snyder, MA Callaham, *et al*.; (2) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Burned Plot 2, soil monolith, 12 Apr 2018, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Burned Plot 1, soil monolith, 5 Oct 2017, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Unburned Plot 1, soil monolith, 12 Apr 2018, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Unburned Plot 5, soil monolith, 26 Jun 2018, Coll: BA Snyder, MA Callaham, *et al*.

Previously recorded: Chattooga, Cherokee, Clarke, Fulton, Gilmer, Greene, Monroe, Rabun, Towns, White, Whitfield. This European earthworm is distributed in temperate regions including a wide distribution in eastern North America (Sims & Gerard 1999).

Aporrectodea longa (Ude, 1885): New state record

Sumter Co.: (1) Jimmy Carter NHS, Boyhood Farm, ~32° 1’ 37” N, 84° 25’ 55” W, 24 Mar 2017, Hand coll., Coll: BA Snyder.

Previously recorded: N/A. This European earthworm is widely distributed in temperate regions including eastern North America (Sims & Gerard 1999). This may be one of the southernmost records in the US.

Bimastos longicinctus (Smith & Gittins, 1915)

Murray Co.: (1) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Unburned Plot 3, soil monolith, 13 Apr 2018, Coll: BA Snyder, MA Callaham, *et al*.

Towns Co.: (1) Chattahoochee NF, 34° 57’ 18” N, 83° 34’ 04” W, Rock Mountain fire, Burned Plot 3, soil monolith, 11 Jul 2018, Coll: BA Snyder, MA Callaham, *et al*.

Previously recorded: Clarke. This species is widely distributed in the eastern US (Csuzdi *et al.* 2017).

***Bimastos parvus* (Eisen, 1874): New state record**

Baldwin Co.: (1) Lake Laurel BS, Champion Creek, 33.117794°N, 83.182433°W, 29 Oct 2022, Electroshock, Coll: JM McGee.

Previously recorded: N/A. This North American species is found worldwide (Gates 1972).

***Bimastos tumidus* (Eisen, 1874)**

Baldwin Co.: (3) Lake Laurel BS, 33.1175°N, 83.1852°W, Decomposing leaf litter in decommissioned boat, SW James, MA Callaham, MK Taylor, R Carrera-Martínez, 28 Sep 2017.

Previously recorded: Bartow, Bryan, Chatham, Glynn, Gordon, Grady, Haralson, Thomas, Whitfield, Worth. This species is known from California and a wide distribution from Kansas eastward (Csuzdi *et al.* 2017).

Remarks. These specimens were reported in Carrera-Martínez *et al.* (2021) as part of their phylogenetic analyses, but without any collection information.

***Lumbricus rubellus* Hoffmeister, 1843**

Lumpkin Co.: (1) Cane Crk, 250 m downstream from Oak Grove Road, 34.46943611°N, 83.97528056°W, Soil, MA Callaham, H Ikeda, 6 May 2011.

Sumter Co.: (2) Jimmy Carter NHS, Boyhood Farm, ~32° 1' 37" N, 84° 25' 55" W, 24 Mar 2017, Hand coll., Coll: BA Snyder.

Previously recorded: Bartow, Catoosa, Chattooga, Cherokee, Clarke, Clayton, Dade, Dawson, DeKalb, Fannin, Floyd, Franklin, Gordon, Haralson, Hart, Henry, Rabun, Walker, White. This European species is globally distributed (Gates 1972; Sims & Gerard 1999).

***Lumbricus terrestris* Linnaeus, 1758**

Murray Co.: (4) Chattahoochee NF, 34° 51' 59" N, 84° 38' 38" W, Rough Ridge fire, Unburned Plot 4, litter, hand coll., 5 Oct 2017, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 51' 59" N, 84° 38' 38" W, Rough Ridge fire, Unburned Plot 2, soil monolith, 25 Jun 2018, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 51' 59" N, 84° 38' 38" W, Rough Ridge fire, Unburned Plot 3, litter, hand collection, 13 Apr 2018, Coll: BA Snyder, MA Callaham, *et al*.

Previously recorded: Banks, Bibb, Clarke, Monroe. This European species is globally distributed (Gates 1972; Sims & Gerard 1999).

Remarks. These records of *Lumbricus terrestris* were from a study on the effects of large wildfires. Interestingly, *L. terrestris* was only found in the unburned plots (see Discussion)

***Murchieona minuscula* (Rosa, 1906): New state record**

Towns Co.: (1) Chattahoochee NF, 34° 57' 18" N, 83° 34' 04" W, Rock Mountain fire, Burned Plot 2, soil monolith, 27 Mar 2018, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 57' 18" N, 83° 34' 04" W, Rock Mountain fire, Burned Plot 5, soil monolith, 27 Mar 2018, Coll: BA Snyder, MA Callaham, *et al*.

Previously recorded: N/A. This European species is documented in Indiana, Michigan, and Tennessee (Sims & Gerard 1999).

***Octolasion cyaneum* (Savigny, 1826)**

Clarke Co.: (1) UGA Campus, Planted bed along E. Greene St., 21 Mar 2006, Coll: BA Snyder.

Murray Co.: (1) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Unburned Plot 5, litter, hand coll., 5 Oct 2017, Coll: BA Snyder, MA Callaham, *et al*.

Previously recorded: DeKalb, Gwinnett, Oconee, Rabun, Thomas, Towns, Upson. This European species has a global distribution, although records are patchy in the US and Canada (Sims & Gerard 1999).

Remarks. The Murray Co. records of *Octolasion cyaneum* were from a study on the effects of large wildfires. Interestingly, *O. cyaneum* was only found in the unburned plots.

Octolasion tyrtaeum (Savigny, 1826)

Greene Co.: (3) Unnamed tributary to Sandy Creek, Scull Shoals EF, 33.7431°N, 83.2523°W, Sediment, R Carrera-Martínez, MK Taylor, MA Callaham, 17 Apr 2017.

Previously recorded: Clarke, Dade, Fannin, Harris, Lamar, Lumpkin, Murray, Pickens, Rabun, Rockdale, Towns, Troup, Twiggs, Union, Washington, Whitfield, Wilkinson. This European species is globally distributed (Sims & Gerard 1999).

Megascolecidae Rosa, 1891

Amynthas agrestis (Goto & Hatai, 1899)

Murray Co.: (4) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Unburned Plot 4, litter, hand coll., 5 Oct 2017, Coll: BA Snyder, MA Callaham, *et al*.; (1) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Unburned Plot 1, litter, hand coll., 4 Oct 2017, Coll: BA Snyder, MA Callaham, *et al*.

Previously recorded: Catoosa, Clarke, Dade, Fannin, Thomas, Towns, Walker, Whitfield. This Asian species is widely distributed in the eastern US and Canada (Chang *et al.* 2016).

Amynthas carnosus (Goto and Hatai, 1899): New state record

DeKalb Co.: (1) Atlanta, Under decomposing log, J Wheeler-Toppen, 11 Apr 2017.

Glynn Co.: (2) Jekyll Island, Yard waste dump off Irma Rd., 26 June 2023, Coll: BA Snyder, L Andrew, J Colbert.

Previously recorded: N/A. This Asian species is only known from a few locations in the midwestern US (see Discussion).

Amynthas corticis (Kinberg, 1867)

Baldwin Co.: (1) Milledgeville, Hancock St. near courthouse, 30 Sep 2016, Coll: BA Snyder; (1) Lake Laurel, 20 Apr 2017, Coll: BA Snyder; (6) Lake Laurel BS, 1 Nov 2017, Pit digging, Soil Ecology Class Fall 2017; (3) Lake Laurel BS, Milledgeville, 1 Nov 2017, Grunting + mustard extraction, Snyder Soil Ecology Class. (2) Lake Laurel BS, Class Collection Soil Ecology, 33° 7’ 10.676” N, 83° 11’ 0.12” W, 5 Nov 2021, Electroshock, Coll: BA Snyder; (1) Lake Laurel BS, 33° 7’ 10.676” N, 83° 11’ 0.12 “ W, 5 Nov 2021, Mustard extraction, Coll: L Andrew; (2) Bartram Forest WMA, Vogt *et al*. (2020) plots: Bartram1, 33.00101°N, 83.21450°W, Plot 19, Plot 35, 23 Apr 2022, Soil monolith, Electroshock, Coll: JM McGee, BA Snyder, *et al*.; (5) Front Campus, Beeson Hall sidewalk, 33.083314°N, 83.23116°W, 23 Sep 2022, Hand coll., Coll: JM McGee; (1) Georgia College front campus E side, on sidewalk, 26 Sep 2022, Coll: B Hendrix *et al*.; (1) Georgia College Front Campus by Terrell Hall, 33.081551°N, 83.230393°W, 27 Oct 2022, Electroshock, Coll: JM McGee; (1) Andalusia, Tobler Trail, 33.121736°N, 83.269501°W, 28 Oct 2022, Electroshock, Coll: JM McGee; (2) Lake Laurel, Champion Creek, 33.117794°N, 83.182433°W, 29 Oct 2022, Electroshock, Coll: JM McGee.

Jones Co: (1) Piedmont NWR, Intersection of B. Russell Rd and Little Falling Creek shoals, 16 May 2018, Hand coll., Coll: BA Snyder.

Madison Co: (1) Watson Mill Bridge SP, on spur to Ridge Loop Trail, 27 Aug 2022, Hand coll., Coll: BA Snyder.

Stewart Co.: (1) Florence Marina SP, Forest South of boat ramp parking, 24 May 2022, Hand coll., Coll: BA Snyder, L Andrew.

Previously recorded: Atkinson, Baker, Bartow, Ben Hill, Berrien, Bibb, Brooks, Bryan, Bulloch, Butts, Camden, Carroll, Chatham, Chattahoochee, Clarke, Clinch, Colquitt, Cook, Decatur, Dodge, Dougherty, Early, Echols, Effingham, Fulton, Glynn, Gordon, Grady, Habersham, Harris, Houston, Irwin, Jasper, Lamar, Lanier, Liberty, Lowndes, Macon, McIntosh, Monroe, Oconee, Pulaski, Putnam, Rabun, Rockdale, Schley, Seminole, Sumter, Thomas, Toombs, Towns, Troup, Twiggs, Union, Ware, Washington, Wayne, Wheeler, White, Wilkinson. This Asian species is widely distributed in the eastern US (Chang *et al.* 2016).

***Amynthas gracilis* (Kinberg, 1867):**

Baldwin Co.: (1) Lake Laurel, 17 Dec 2016, Coll: BA Snyder and SW James; (1) 407 Forest Rd, Milledgeville, On garage door, 7 Apr 2022, Coll: BA Snyder; (1) 407 Forest Rd, Milledgeville, 7 July 2022, Coll: BA Snyder.

Glynn Co.: (1) 11 Conch Shell Lane, St. Simons Island, soil and litter around beach house, hand coll., 13 Oct 2019, Coll: M Olliff.

Previously recorded: Baker*, Bibb, Brooks*, Camden, Carroll, Chattahoochee*, Chatham, Clarke, Crisp, Dodge*, Grady, Hall, Harris*, Lanier, Lowndes, Pulaski, Thomas, Tift, Ware*, Wayne, Wilcox (counties marked with an asterisk were listed in Gates [1982], but not Reynolds [2015]). This Asian species is widely distributed in the eastern US (Chang *et al.* 2016).

***Amynthas minimus* (Horst, 1893)**

Baldwin Co: (26) Bartram Forest WMA, Vogt *et al*. (2020) plots: Bartram1, 33.00101°N, 83.21450°W, Plot 1, Plot 5, Plot 8, Plot 14, Plot 21, Plot 27, Plot 32, Plot 35, 23 Apr 2022, 15 Oct 2022, 16 Oct 2022, Electroshock, Soil monolith, Coll: JM McGee, BA Snyder, *et al*.

Previously recorded: Berrien*, Colquitt*, Cook*, Dade, Grady, Lowndes*, Mitchell, Thomas, Wayne* (counties marked with an asterisk were listed in Gates [1982], but not Reynolds [2015]). This Asian species is recorded across the southern US in Virginia and from South Carolina to Louisiana (Gates 1982).

***Amynthas tokioensis* (Beddard, 1892)**

Murray Co.: (2) Chattahoochee NF, 34° 51’ 59” N, 84° 38’ 38” W, Rough Ridge fire, Burned Plot 1, litter, hand coll., 5 Oct 2017, Coll: BA Snyder, MA Callaham, *et al*.

Previously recorded: Harris, Henry. This Asian species is widely distributed in the eastern US (Chang *et al.* 2016).

Remarks. Because *Amynthas agrestis* is present at this site as well, this represents the first reported co-occurrence in Georgia of two of ‘the big three’ pheretimoid earthworms that often co-invade further north in North America (see Chang *et al*. 2018). *Metaphire hilgendorfi* is only reported once from Georgia (Clarke Co., see below), and *Amynthas tokioensis* has only been reported from Harris and Henry Counties (as junior synonym *Metaphire levis*, see Chang *et al*. 2021).

***Metaphire californica* (Kinberg, 1867)**

Baldwin Co.: (2) Georgia College campus, Apr 2017, Coll: BA Snyder.

Previously recorded: Chatham*, Thomas (county marked with an asterisk was listed in Gates [1982], but not

Reynolds [2015]). This Asian species was described from California, and its distribution in the US includes Florida, Georgia, Louisiana, and Texas (Gates 1982).

Metaphire hilgendorfi (Michaelsen, 1892): New state record

Clarke Co.: (4) near Sandy Creek Nature Center, in privet removal plots, 33.9853°N, 83.3795°W, Fall 2010, Coll: Joshua W. Lobe.

Previously recorded: N/A. This Asian species is widely distributed in the eastern US (Chang *et al.* 2016).

Remarks. *Metaphire hilgendorfi* was first mentioned by Lobe *et al*. (2014) without locality data, but we include this in our counts of new state and county records. Unfortunately, these specimens were not deposited in a museum and have likely been lost.

Ocnerodrilidae Beddard, 1891

Eukerria saltensis (Beddard, 1895)

Greene Co.: (3) Sandy Creek, Scull Shoals EF, 33.74339°N, 83.2557°W Sediment R Carrera-Martínez, MK Taylor, MA Callaham, 18 Apr 2017, 6 Jul 2017, 21 Sep 2017; (5) Unnamed trib to Sandy Creek, Scull Shoals EF, 33.7431°N, 83.2523°W, Sediment, R Carrera-Martínez, MK Taylor, MA Callaham, 17 Apr 2017, 6 Jul 2017, 21 Sep 2017; (1) Oconee River, Scull Shoals EF, 33.76915°N, 83.28407°W, Sediment, R Carrera-Martínez, MK Taylor, MA Callaham, 24 Jul 2017, 19 Sep 2017.

Jones Co.: (4) Falling Creek, Hitchiti EF, 33.03521°N, 83.71082°W, Sediment, R Carrera-Martínez, MK Taylor, 2 May 2017, 11 Jul 2017.

Previously recorded: Clarke, Fannin, Grady, Harris, Lowndes, Thomas, Whitfield. This South American species is distributed in the eastern US (Texas to North Carolina) and along the US west coast (California and Oregon) (Gates 1982).

Remarks. *Eukerria saltensis* is the second most common earthworm collected in semiaquatic environments, with the native *Sparganophilus* spp. dominating the communities (Carrera-Martínez, R. unpublished data). As both groups inhabit the same habitats (sandbars, mud, and stream shorelines), it is likely that some competition might be occurring between the native *Sparganophilus* and the invasive *E. saltensis*. Furthermore, the presence of *E. saltensis* raises concern for more rare semiaquatic species, such as those undescribed *Sparganophilus* species, some members of *Diplocardia*, and the elusive *Lutodrilus* in Louisiana. Therefore, there is a need to study and monitor these traditionally neglected semiaquatic earthworm taxa.

Middle Georgia Checklist

This checklist (Table 1) is made for the Middle Georgia region as defined by GARC (2023), based on Reynolds (2015) with additions from the new records listed above. Counties, families, and species are listed in alphabetical order.

TABLE 1: Earthworm species documented in Middle Georgia. Species originating from Europe are signified by superscript "E" (^{E}), those from Asia by superscript "A" (^{A}), from South America superscript "S" (^{S}), new county records an asterisk (*), and new state records a dagger (†).

County / Families	Species
Baldwin County	
Acanthodrilidae	*Diplocardia longa** Moore, 1904

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TABLE 1. (Continued)

County / Families	Species
Lumbricidae	*Bimastos parvus**† (Eisen, 1874)
	*Bimastos tumidus**† (Eisen, 1874)
Megascolecidae	*Amynthas corticis**[A] (Kinberg, 1867)
	*Amynthas gracilis**[A] (Kinberg, 1867)
	*Amynthas minimus**[A] (Horst, 1893)
	*Metaphire californica**[A] (Kinberg, 1867)
Bibb County	
Acanthodrilidae	*Diplocardia longa* Moore, 1904
Lumbricidae	*Aporrectodea trapezoides*[E] (Dugès, 1828)
	Lumbricus terrestris[E] Linnaeus, 1758
Megascolecidae	*Amynthas corticis*[A] (Kinberg, 1867)
	Amynthas gracilis[A] (Kinberg, 1867)
Crawford County	
No published records	
Houston County	
Acanthodrilidae	*Diplocardia longa* Moore, 1904
	Diplocardia singularis Ude, 1893
Lumbricidae	*Aporrectodea trapezoides*[E] (Dugès, 1828)
Megascolecidae	*Amynthas corticis*[A] (Kinberg, 1867)
Jones County	
Megascolecidae	*Amynthas corticis**[A] (Kinberg, 1867)
Ocnerodrilidae	*Eukerria saltensis**[S] (Beddard, 1895)
Monroe County	
Acanthodrilidae	*Diplocardia caroliniana* Eisen, 1899
Lumbricidae	*Aporrectodea trapezoides*[E] (Dugès, 1828)
	Aporrectodea turgida[E] (Eisen, 1873)
	Lumbricus terrestris[E] Linnaeus, 1758
Peach County	
No published records	

.....Continued on the next page

TABLE 1. (Continued)

County / Families	Species
Pulaski County	
Acanthodrilidae	*Diplocardia longa* Moore, 1904
Megascolecidae	*Amynthas corticis*[A] (Kinberg, 1867)
	Amynthas gracilis[A] (Kinberg, 1867)
Putnam County	
Lumbricidae	*Aporrectodea trapezoides*[E] (Dugès, 1828)
	Eisenia fetida[E] (Savigny, 1826)
Megascolecidae	*Amynthas corticis*[A] (Kinberg, 1867)
Twiggs County	
Lumbricidae	*Bimastos palustris* (Moore, 1895)
	Eisenoides carolinensis (Michaelsen, 1910)
	Octolasion tyrtaeum[E] Savigny, 1826
Megascolecidae	*Amynthas corticis*[A] (Kinberg, 1867)
Wilkinson County	
Lumbricidae	*Eisenoides carolinensis* (Michaelsen, 1910)
	Octolasion tyrtaeum[E] Savigny, 1826
Megascolecidae	*Amynthas corticis*[A] (Kinberg, 1867)

Discussion

Here we report new records of 23 species from four families. Eight species originate from Asia, seven from Europe, one from South America, and seven from North America. The family Acanthodrilidae has new records for four species. *Diplocardia deborahae* (new state record) is known from seven clitellate individuals from Towns County, *D. michaelseni* (new state record) a single clitellate specimen found in Clarke County, *D. longa* two from Baldwin County and one from Greene County, and *D. gatesi* (new state record) is known from four clitellate individuals from Union County and seven from Towns County.

From Lumbricidae we report new records of 10 species. *Aporrectodea caliginosa* is known from eight clitellate individuals from Murray County and *Ap. longa* (new state record) a single specimen from Sumter County. The latter was collected as part of the Jimmy Carter NHS BioBlitz, 24–25 Mar 2017. *Bimastos longicinctus* is known from one clitellate individual each from Murray and Towns Counties. *Bimastos parvus* (new state record) was identified from a single clitellate individual from Baldwin County but it lacks male pores; *B. tumidus* was also collected from Baldwin County. Two *Lumbricus rubellus* from Sumter County were collected as part of the Jimmy Carter NHS BioBlitz and one from Lumpkin County separate from the event. Six *L. terrestris* were found in Murray County. *Murchieona minuscula* (new state record) is known from two clitellate individuals from Towns County. One *Octolasion cyaneum* is reported each from Clarke and Murray Counties and one *O. tyrtaeum* from Greene County.

Eight species from Megascolecidae have new distribution records here. *Amynthas agrestis* is known from five clitellate individuals from Murray County, *A. carnosus* (new state record) from one individual from DeKalb County and two from Glynn County, and *A. corticis* from 26 individuals from Baldwin County, one from Jones County, one

from Madison County, and one from Stewart County. Twenty-six *A. minimus* were found in Baldwin County, three *A. gracilis* in Baldwin County and one in Glynn County, and two *A. tokioensis* in Murray County. *Metaphire californica* is reported from one specimen from Baldwin County and *M. hilgendorfi* from four specimens from Clarke County.

To our knowledge, this represents the third state in which *A. carnosus* has been found since its discovery in Kansas in 2015 (Carrera-Martínez & Snyder 2016), the second being Oklahoma (Damoff & Reynolds 2019). This is also the first report in eastern North America (east of the Mississippi River). While the accumulation of new records may suggest that *A. carnosus* and other pheretimoid earthworms are expanding their range, a lack of data prevents us from drawing this conclusion. Most earthworm collecting is opportunistic and no monitoring program exists to establish a baseline. It is likely that nearly all records reported here, including those of *A. carnosus*, represent increased sampling effort in the state over the last ~6 years, increased public awareness of "jumping worms" (Chang *et al.* 2021), and improvements in identification resources for these species (e.g., Chang *et al.* 2016). The additions of *A. carnosus* and *Metaphire hilgendorfi* represent the 13th and 14th pheretimoid earthworm species known from Georgia, likely making Georgia the US state with the most diverse pheretimoid community. Only two other species in this group are known from North America thus far: *M. posthuma* (Vaillant, 1868), which is only reported from Florida, and *Polypheretima elongata* (Perrier, 1872) which is only reported from Louisiana (Chang *et al*. 2016).

The family Ocnerodrilidae has a new record for *Eukerria saltensis*, which is known from nine clitellate specimens from Greene County and four from Jones County. This species is a semiaquatic specialist, frequently found in sediment, sandbanks, and mud associated with freshwater systems. It originates from South America (Jamieson 1970), and has become peregrine worldwide in the past few decades (Rota 2013), even becoming a pest in rice fields (Stevens *et al.* 2016). *Eukerria saltensis* reported here were frequently collected with *Sparganophilus* spp. (Carrera-Martínez, R., unpublished data). The actual distribution of this species is likely much greater in extent, but given its small size and its preferred habitat, it has likely escaped detection due to lack of sampling. Alternatively, the range is currently expanding, and we are detecting it in real time.

Our updated checklist only covers the eleven counties of Middle Georgia (GARC 2023) and thus contains four families, ten genera, and 18 species. Of these, four (22%) originate from Asia, six (33%) from Europe, one (6%) from South America, and seven (39%) are native to North America. The number of species known within each county ranges anywhere from zero (Crawford and Peach Counties) to seven (Baldwin County). Outside of Middle Georgia, our new records bring the Sumter County species records up to six: *Amynthas corticis, Aporrectodea longa*, *Ap. trapezoides* (Dugès, 1828), *Diplocardia longa*, *Eisenia fetida* (Savigny, 1826), and *Lumbricus rubellus*. It is worth noting that counties have not been sampled with equal effort. The highest species richness within a county in Georgia so far is 22 (Thomas County, Reynolds 2015), and the new records here bring Clarke County to 21 species.

Records are reported here with the intent of furthering knowledge of earthworm biodiversity within the state of Georgia. Of the 159 counties within Georgia, only 99 had published earthworm records spanning 52 species prior to this paper (Bingham *et al.* 2021, Carrera-Martínez *et al.* 2021, Reynolds 2015). We bring these numbers up to 102 counties spanning 60 species, including first earthworm records for Baldwin, Jones, and Stewart Counties. Baldwin Co. now has seven species from four genera, Jones Co. two species from two genera, and Stewart Co. one species. Even with these additions, knowledge of earthworm distributions and biodiversity remains woefully incomplete: 35% of counties in Georgia still entirely lack earthworm records. Across all parts of the state, county-level species richness numbers have the potential to change as more thorough sampling is completed. While less-disturbed areas where native species may be found are typically a target for new records, disturbed areas are likely to produce many new records of non-native species (e.g., Callaham *et al.* 2016), which make up 60% of the species in Middle Georgia (and most of the records presented here).

The distributions of native and non-native species in Georgia is of obvious interest to biologists, ecologists, and land managers, and now increasingly is of interest to the general public. We have observed patterns with respect to the ecological categories of earthworms represented in the native and introduced faunas, and in particular that the native fauna of the southeastern portion of North America appears to be depauperate in truly epigeic or anecic species (i.e., those that live strictly or part-time in the leaf litter, and which use leaf litter as a principal food resource). The few exceptions are species that live in saturated or very wet conditions (e.g., the genera *Sparganophilus* and *Eisenoides*), and some others which occupy epigeic habitats that don't involve leaf litter itself (namely some *Bimastos* spp. which live under the bark or inside the wood of decaying logs). Thus, the great majority of native species in southeastern USA are endogeic species belonging to the genus *Diplocardia*. The reasons for this pattern are not clear, but we

propose that it may be partly due frequent occurrence of wildland fires and the resulting unreliability of leaf litter as a habitat or food resource. Such fires are known to have occurred in the region prior to the period of European Colonization. Natural ignitions from lightning strikes, and the well-documented use of landscape-scale fire by native peoples are thought to have resulted in most of the region being burned at least every 10 years, and much more frequently in many locations (Guyette *et al.* 2012, Lafon *et al.* 2017, Leigh 2016). In fact, the prevalence of fire in the eastern portions of post-glacial North America is responsible for shaping major vegetation types covering hundreds of millions of hectares including tallgrass prairie (Collins & Steinauer 1998); the vast oak-pine-hickory forests in the Ozark Mountains (Nanavati & Grimm 2020), Cumberland Plateau, and Southern Appalachian Mountains (Lafon *et al.* 2017); as well as the Atlantic and Gulf Coastal Plain longleaf pine forests (Mitchell *et al.* 2009): all ecosystems with vegetative communities that have historically been dominated by pyrophilic species. It is further notable that many (but not all, by any means) of the introduced species are anecic or epigeic (e.g., *Lumbricus* spp. and several *Amynthas* spp., such as those newly reported to occur in Georgia in this article), and we suggest that the success of these introduced species may be partly attributable to the widespread availability of leaf litter habitat across the eastern half of North America. Such habitat has developed only in the past 200+ years of fire exclusion in most natural areas. Indeed, prescribed fire has been proposed as a potential means of controlling epigeic invasive earthworms (Ikeda *et al.* 2015), and this approach may hold promise not only for control of non-native invasive species, but also represent an important tool for the conservation of native earthworm diversity.

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