

First report of *Eubbranchipus stegosus* Rogers, Jensen, & Floyd, 2004 (Crustacea: Branchiopoda: Anostraca) from Florida

Barbara J. Dinkins^{1,*}, Gerald R. Dinkins², and D. Christopher Rogers³

Abstract - We present a new population of the fairy shrimp *Eubbranchipus stegosus* from a property in Taylor County, FL, protected by conservation easement. This is the first record in the state and represents a substantial increase in the known distribution of the species. *Eubbranchipus stegosus* meets the definition of critically endangered by the International Union of Conservation of Nature (IUCN) Red List criteria, and its discovery highlights the value of conservation easements and the need for additional surveys targeting large branchiopod crustaceans in the southeastern US.

Introduction. Fairy shrimp are branchiopod crustaceans that inhabit a variety of seasonally astatic aquatic habitats worldwide, ranging from hypersaline lakes to waters nearly devoid of dissolved substances (Brendonck et al. 2008, Rogers 2009). In the southeastern US (i.e., Alabama, Georgia, Florida, North and South Carolina, Mississippi, and Tennessee), 9 species in 3 families are reported: *Streptocephalus sealii* Ryder (Streptocephalidae); *Dendrocephalus alachua* (Dexter), *Dendrocephalus lithaca* (Creaser), *Dendrocephalus proeliator* Rogers et al. (Thamnocephalidae); *Dexteria floridana* (Dexter), *Eubbranchipus holmanii* (Ryder), *E. moorei* Brtek, *E. stegosus* Rogers et al., and *E. vernalis* (Verrill) (Chirocephalidae) (Rogers et al. 2004). Only 4 of these species are known to occur in Florida: *S. sealii*, *Dendrocephalus alachua*, *Dendrocephalus proeliator*, and *Dexteria floridana*. *Streptocephalus sealii* has a widespread distribution and is found on the Coastal Plain from New York south to Vera Cruz, Mexico (Rogers 2014a). *Dendrocephalus alachua* is restricted to Florida and is only known from 5 collections in Alachua County (all prior to 1950) and 2 more recent collections from Hillsborough County (2000 and 2008) (Rogers et al. 2019). *Dendrocephalus proeliator* is recorded from 2 localities in peninsular Florida (Rogers et al. 2019). *Dexteria floridana* is only known from the type locality, a temporary pool ~6 km south of Gainesville, FL; Rogers (2002) speculated this population may be extirpated, but the species might exist in some undeveloped portions of the state or possibly Cuba. Additionally, *Dendrocephalus lithica* is only known from a set of rock outcrop pools on Stone Mountain in Georgia and is presumed extinct, although it may be found in similar habitats in Florida at some point in the future (Rogers et al. 2019). Here we present the first record of the fairy shrimp *Eubbranchipus stegosus* Rogers, Jensen, & Floyd from Florida. This species was previously only known from 2 pools in the adjacent state of Georgia (Fig. 1).

Methods. We collected fairy shrimp from a 46-ha parcel in Taylor County, FL, during an aquatic macroinvertebrate survey (Fig. 2). This property is protected by a 2015 conservation easement. The site is characterized as a hydric hammock, which is a small but distinct community type that is part of the natural landscape north of Lake Okeechobee (Vince et al. 1989). In Taylor County, this community type has a short hydroperiod, often found where limestone formations are close to the ground surface. Hydric hammock comprises ~30% of the study area, and other types of forested wetland make up an additional ~6% (Basin Marsh, Cypress Dome Swamp, and Tupelo Dome Swamp). The study area is surrounded by

¹Dinkins Biological Consulting LLC, Powell, TN 37849. ²McClung Museum of Natural History and Culture, University of Tennessee, Knoxville, TN 37996. ³Kansas Biological Survey, and the Biodiversity Institute, University of Kansas, Lawrence, KS 66047. *Corresponding author - bdinkins@dinkinsbiological.com.

a former pine plantation that is regenerating to a forest community dominated by *Nyssa* spp. (tupelo) and other hardwoods, and contains soil mapped as Matmon–Wekiva–Rock outcrop complex, a shallow soil class that is somewhat poorly drained and composed of sandy and

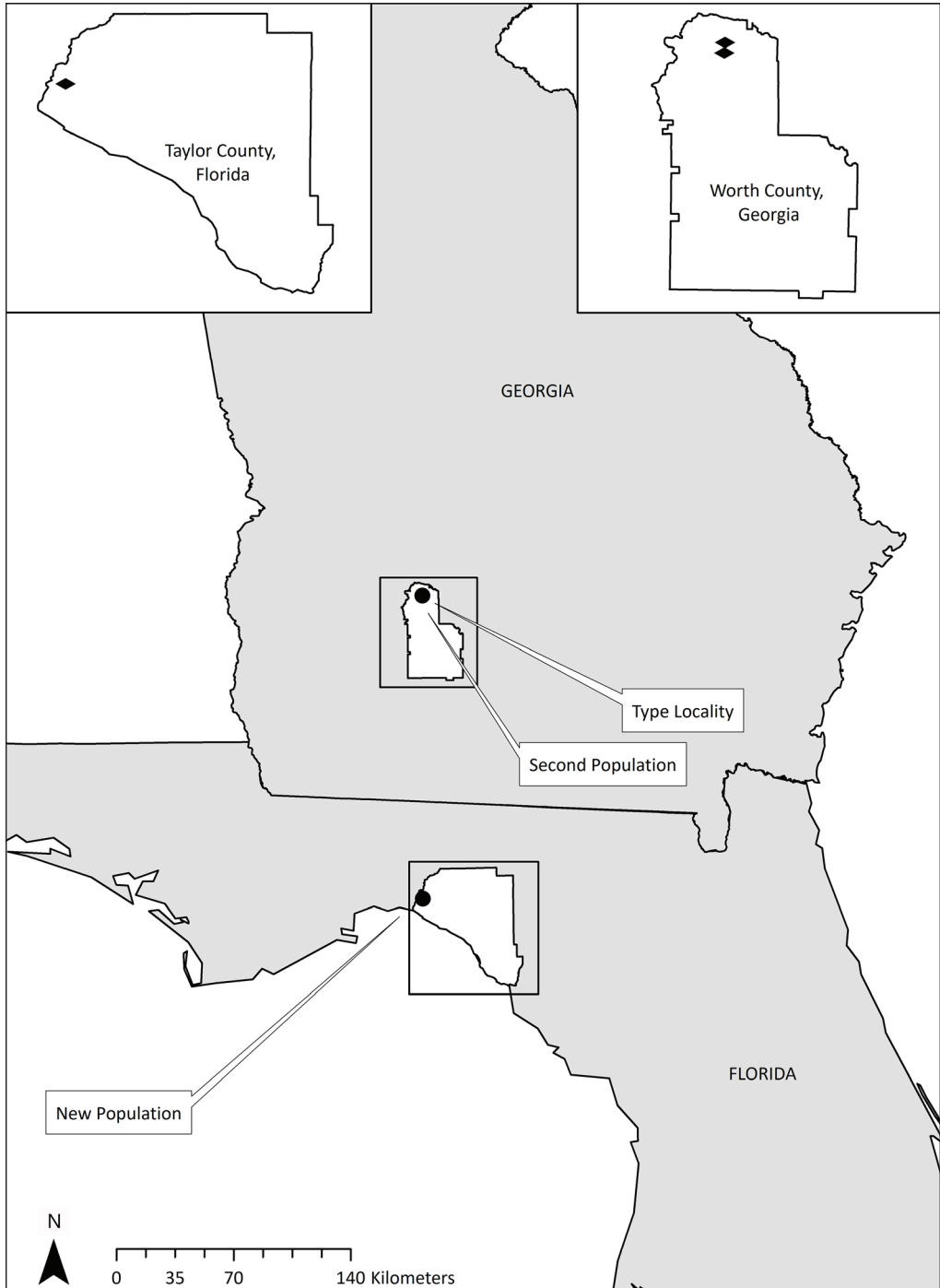


Figure 1. Occurrence of *Eubranchipus stegosus* in Georgia and Florida.

loamy marine sediments overlying limestone, with a salinity of 0.0–2.0 mS/cm (Soil Survey Staff 2021). Wetlands on the property are classified as hydric hummock and are part of a large wetland system lying between the Aucilla and Econfina rivers and draining south to the Gulf of Mexico.

At the time of sampling, 3 wetlands on the property contained standing water (W1, W2, and W3; Fig. 3). Satellite imagery indicates that the approximate sizes of these wetland



Figure 2. Depressional wetland occupied by *Eubbranchipus stegosus* in Taylor County, FL.

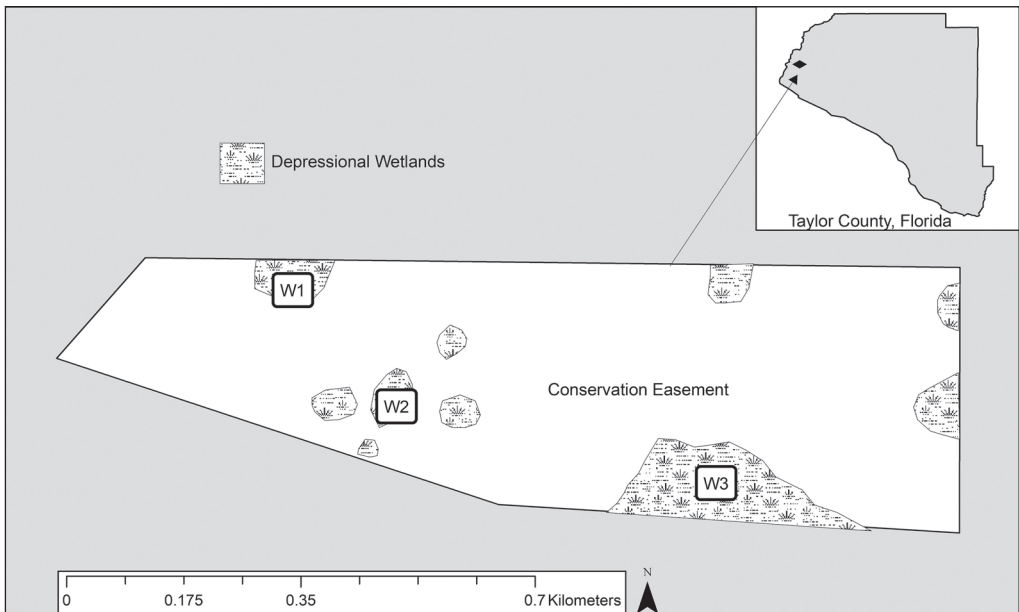


Figure 3. Diagram of wetlands W1, W2, and W3 in the conservation easement.

habitats are 0.6 ha (W1), 0.4 ha (W2), and 12.1 ha (W3). The wetted area of each wetland was similar, ~0.5 ha with a depth of 0.3–0.6 m, and the water was tannin-stained in each. We sampled all 3 on 11 March 2020 with a 1.2 m x 1.2 m seine net with 3.2-mm mesh and a D-frame kicknet (500 micron). The air temperature was ~24 °C; we did not measure the water temperature. We resampled W2 and W3 on 25 January 2021. In each wetland, we spent ~1.5 person hours collecting aquatic invertebrates and fish. We were unable to resample W1 in 2021 because of time constraints.

We carefully removed fairy shrimp removed from the seine net and preserved them in 70% ethanol. We preserved insects, fish, and mollusks from the D-frame kicknet in 10% formalin. For convenience, we combined samples from W1 and W2 before processing. D.C. Rogers identified fairy shrimp to species based on comparison with paratype specimens in his personal collections, the original description (Rogers et. al. 2004), and his professional experience. Our material was archived in D.C. Roger’s collection (accession number DCR-1158) and at the Smithsonian Museum of Natural History (catalogue number USNM1660528).

Results. Taxa documented during both sampling efforts is presented in Table 1. We collected 19 *E. stegosus* in March 2020 from wetland W3 but found none in the other 2 wetlands (W1 and W2). *Eubbranchipus stegosus* is readily identifiable by the unique form of the male antennal appendage, which is lamellar proximally and tentacular distally; the

Table 1. Aquatic animal species associated with *Eubbranchipus stegosus* in Taylor County, FL. Arthropod classifications follow Schwentner et al. (2018) and Lozano-Fernandez et al. (2019). [Table continued on following page.]

Taxon	Wetland and sampling time			
	W1, W2	W3	W1, W2	W3
	March 2020	March 2020	January 2021	January 2021
Annelida				
Enchytraeidae	x			
Naididae				x
Naidinae		x	x	
<i>Dero</i> sp.			x	x
Lumbriculidae		x		
Tubificinae		x	x	x
<i>Limnodrilus hoffmeisteri</i> Claparède (Red Worm)			x	x
Branchiobdellida		x		
Arthropoda/Pancrustacea				
Branchiopoda				
<i>Ceriodaphnia</i> sp.			x	
<i>Eubbranchipus stegosus</i>		x		
<i>Sida crystalline</i> (O.F. Müller)		x		
Copepoda				
Calanoida	x		x	
Cyclopoida	x			
Malacostraca				
<i>Caecidotea</i> sp.	x	x	x	x
<i>Crangonyx</i> sp.	x	x	x	x
<i>Procambarus paeninsulanus</i> (Faxon) (Peninsula Crrayfish)	x	x	x	x

species is unique in that the male abdomen bears a transverse, chitinized, rectangular projection on most segments (Fig. 4). *Eubbranchipus stegosus* was not found in the second sampling effort. Fish were not found in the 2020 survey, but *Gambusia holbrooki* (Eastern Mosquitofish) were present but uncommon in the 2021 survey.

Table 1, continued.

Taxon	Wetland and sampling time			
	W1, W2 March 2020	W3 March 2020	W1, W2 January 2021	W3 January 2021
Arthropoda/Hexapoda				
<i>Acillus fraternus</i> (Harris)			x	
<i>Anopheles</i> sp.			x	x
<i>Bidessonotus longovalis</i> (Blatchley)			x	x
Ceratopogonidae	x		x	x
<i>Chaoborus punctipennis</i> (Say)				x
<i>Chironomus</i> sp.		x	x	x
<i>Coptotomus longulus lenticus</i> Hilsenhoff				x
<i>Dicrotendipes simpsoni</i> Epler			x	x
<i>Dicrotendipes</i> sp.	x			
<i>Dineutus</i> sp.		x		
Dryopidae			x	
<i>Enochrus ochraceus</i> (Melshimer)			x	
<i>Glyptotendipes</i> sp.			x	x
<i>Hydrochus callosus</i> LeConte	x			
<i>Hydrochus</i> sp.	x			
<i>Kiefferulus dux</i> Johannsen	x			x
<i>Monopelopia</i> sp.	x			
<i>Neoporus</i> sp.				x
<i>Notonecta</i> sp.			x	
<i>Optioservus</i> sp.		x		
<i>Pachydiplax longipennis</i> (Burmeeister) (Blue Dasher)				x
<i>Polypedilum illinoense</i> group			x	
<i>Polypedilum tritum</i> (Walker)			x	x
<i>Pseudosmittia</i> sp.				x
<i>Ranatra</i> sp.		x		
<i>Tanytarsus</i> sp.			x	x
<i>Thermonectus basillaris</i> Harris				x
<i>Tribelos jucundus</i> (Walker)				x
<i>Trichocorixa</i> sp.		x		
Mollusca				
<i>Micromenetus dilatatus</i> (Gould) (Bugle Sprite)		x		
<i>Micromenetus brogniartianus</i> (Lea) (Disc Sprite)				x
Physidae				x
Chordata				
Vertebrata				
<i>Gambusia holbrooki</i> Girard (Eastern Mosquitofish)				x

Discussion. *Eubranchipus stegosus* was previously only known from 2 pools in the adjacent state of Georgia. The type locality and adjacent second locality for *E. stegosus* have a similar soil type (classified as sandy loam with calcium salts) to the Matmon–Wekiva–Rock outcrop complex found in our study area and the same salinity values as our new site in Florida (Rogers 2014b).

The discovery of this species in Florida reflects the paucity of surveys for large branchiopod crustaceans in the southeastern United States. Although at this time, the species is only associated with 1 specific set of soil types and salinities, additional surveys are needed to confirm that the species is limited to these geomorphic features. Anostracans, such as *E. stegosus*, are generally dispersed as eggs by predatory birds, amphibians, crayfish, and insects (Rogers 2009, 2014b, 2015); thus, similar habitat types should be surveyed to determine if predators have moved this species to additional localities. If *E. stegosus* is limited to a particular set of cation and salinity concentrations (as are most anostracans; Rogers 2014b, 2015), systematic surveys of wetland habitats on the same soil surfaces should yield more populations.

Mosquitofish are commonly used for mosquito control and are well known predators of fairy shrimp (Leyse et al. 2004). Eastern Mosquitofish inhabits lakes, ponds, swamps, and backwaters of and pools of streams, and is the most common freshwater fish in Florida (Robins et al. 2018). The 2020/2021 winter season was exceptionally wet, and according to flow data from the 2 nearest US Geological Survey gages (Aucilla River and Econfina Creek, approximately 6.1 km and 10.5 km distant, respectively), water levels were high enough to inundate all the Taylor study area, including the pool where *E. stegosus* was collected. Given the lack of topographical relief and the low elevation of the general area surrounding W1, W2, and W3, there are a number of sources from which Eastern Mosquitofish could have originated. We expect that in the future, W3 may naturally dry up, but fish will return when wet conditions allow repopulation from nearby aquatic features. Although *E. stegosus* swimming life stages may have been eliminated by the Eastern Mosquitofish, the egg bank should provide subsequent shrimp populations after the next inundation (Rogers 2015).

Eubranchipus stegosus was originally assessed under the IUCN Red List criteria (IUCN 2001) as critically endangered (CR B2ab), due to the species' fragmented distribution and its known extent of occurrence being less than 10 km². Although this new locality is a significant increase in the species' distribution, *E. stegosus* still meets the IUCN Red List criteria for a critically endangered species. Three other species ranked by NatureServe as imperiled or critically imperiled in Florida occur on this site protected by a conservation easement: (*Perimyotis subflavus* (F. Cuvier) (Tricolored Bat), *Pseudacris ornata* (Holbrook)

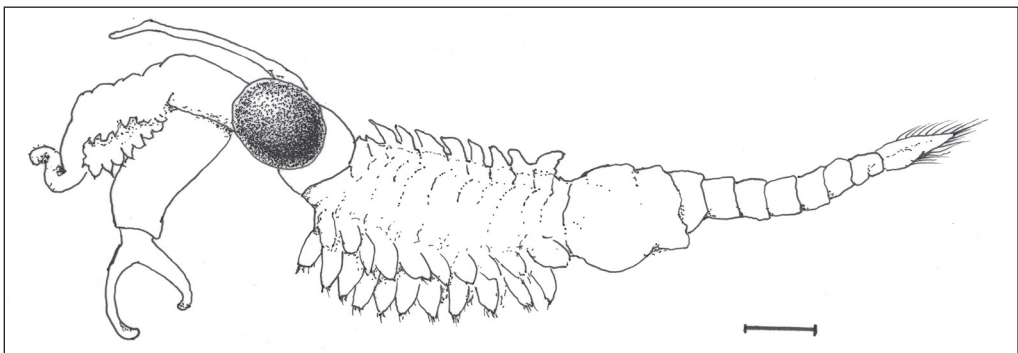


Figure 4. *Eubranchipus stegosus*, male, from Taylor County, FL. Scale bar = 1 mm. Illustration © B.J. Dinkins.

B.J. Dinkins, G.R. Dinkins, and D.C. Rogers

(Ornate Chorus Frog), and *Elanoides forficatus* (L.) (Swallow-tail Kite) (NatureServe Explorer 2021). The Tricolored Bat is a candidate for listing as threatened or endangered (US Fish and Wildlife Service 2017).

The discovery of this new population of *E. stegosus*, coupled with the other rare species present, demonstrates the value of establishing conservation easements and documenting biodiversity. We hope our discovery will spur future surveys for this and other fairy shrimp species.

Acknowledgments. We are greatly indebted to the following people for assisting in fieldwork and/or gathering information for this manuscript: Dottie Brown, Robert Butler, Robert Eldridge, Hugh Faust, Steve Fraley, Brian Mize, Lane Sauls, and David Cooper. We also acknowledge the Atlantic Coast Conservancy, Inc., for protecting habitats where the fairy shrimp was found. Partial funding for this study was provided by the University of Tennessee's McClung Museum of Natural History and Culture.

Literature Cited

- Brendonck, L., D.C. Rogers, J. Olesen, S. Weeks, and R. Hoeh. 2008. Global diversity of large branchiopods (Crustacea: Branchiopoda) in fresh water. *Hydrobiologia* 595:167–176.
- Leyse, K.E., S. P. Lawler, and T. Strange. 2004. Effects of an alien fish, *Gambusia affinis*, on an endemic California fairy shrimp, *Lindleriella occidentalis*: Implications for conservation of diversity in fishless waters. *Biological Conservation* 118:57–65.
- Lozano-Fernandez, J.M. Giacomelli, J.F. Fleming, A. Chen, J. Vinther, P.F. Thomsen, H. Glenner, F. Palero, D.A. Legg, T.M. Iliffe, D. Pisani, and J. Olesen. 2019. Pancrustacean evolution illuminated by taxon-rich genomic-scale data sets with an expanded remipede sampling. *Genome Biology and Evolution* 11:2055–2070.
- NatureServe Explorer. 2020. Database of rare and endangered species and ecosystems in the Americas. <https://explorer.natureserve.org/>. Accessed February 2021.
- Robins, R.H., L.M. Page, J.D. Williams, Z.S. Randall, and G.E. Sheehy. 2018. Fishes in the Freshwaters of Florida. University of Florida Press, Gainesville, FL. 467 pp.
- Rogers, D.C. 2009. Branchiopoda (Anostraca, Notostraca, Laevicaudata, Spinicaudata, Cyclestherida). Pp. 242–249, *In* G.F. Likens (Ed.). *Encyclopedia of Inland Waters*, Vol. 2. Elsevier, Oxford, UK. 859 pp.
- Rogers, D.C. 2014a. Two new cryptic anostracan (Branchiopoda: Streptocephalidae, Chirocephalidae) species. *Journal of Crustacean Biology* 34:862–874.
- Rogers, D.C. 2014b. Anostracan (Crustacea: Branchiopoda) biogeography II. Relating distribution to geochemical substrate properties in the USA. *Zootaxa* 3856:1–49.
- Rogers, D.C. 2015. A conceptual model for anostracan biogeography. *Journal of Crustacean Biology* 35:686–699.
- Rogers, D.C., J.B. Jensen, and T.M. Floyd. 2004. *Eubbranchipus stegosus* n. sp. (Crustacea: Anostraca), a bizarre new species of fairy shrimp from the southeastern United States. *Hydrobiologia* 528:201–207.
- Rogers, D.C., A. Dunn, and W.W. Price. 2019. A review of *Dendrocephalus* (*Dendrocephalinus*) (Crustacea: Anostraca) with the first records of male–male anostracan aggressive competition. *European Journal of Taxonomy* 509:1–14.
- Soil Survey Staff. 2021. Natural Resources Conservation Service, United States Department of Agriculture. Official soil series descriptions. Available online at https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/florida/FL123/0/Taylor.pdf. Accessed 8 January 2021.
- Schwentner, M., S. Richter, D.C. Rogers, and G. Giribet. 2018. Tetraconatan phylogeny with special focus on Malacostraca and Branchiopoda: Highlighting the strength of taxon-specific matrices in phylogenomics. *Proceedings of the Royal Society* 285:20181524.
- US Fish and Wildlife Service. 2017. Tricolored Bats: USFWS announces 90-day finding to determine if listing is warranted. Available online at <https://www.cecinc.com/blog/2017/12/26/tricolored-bat-usfws-announces-90-day-finding-to-determine-if-listing-is-warranted/>. Accessed 12 March 2021.
- Vince, S.W., S.R. Humphrey, and R.W. Simons. 1989. The ecology of hydric hammocks: A community profile. US Fish and Wildlife Service Biological Report. 85(7.26).