Several reasons, in addition to rareness, may account for the lack of Tennessee records and collections. Except for the short period when flowers are emergent, the plant is difficult to observe and easily overlooked. Also, leaves often deteriorate soon after flowering, rendering the species unrecognizable. In addition, other emergent and floating aquatic species mask the dissected leaves and the temporary pools often become stagnant and obviously not inviting to collectors. Although locally abundant in a few sites, *R. flabellaris* meets the criteria established for threatened status in Tennessee and should be afforded protection where possible.

Specimens Examined

COFFEE CO.: Highway 50 at Elk River, 4 June 1984, *Souza, Chester 84-139* (APSU, TENN). FRANKLIN CO.: Elk River near Patterson's Bridge, 13 May 1939, *Svenson 9910* (BKL, GH). GRUNDY CO.: Highway 41 between Pelham and Mt. View at Elk River Bridge, 4 June 1984, *Souza, Chester 84-141* (APSU, TENN). LAKE CO.: Cranetown NE of Tiptonville, 25 June 1947, *Fairchild, Clebsch, Clebsch 7908* (TENN); Reelfoot Lake, 13 May 1972, *Stockdale, Sharma s.n.* (UTM); Reelfoot Lake, 12 May 1979, *McMinn s.n.* (APSU); Reelfoot Lake adjacent to airstrip, 5 May 1984, *Chester 84-44* (APSU). MONTGOMERY CO.: Long Pond Slough, 18 June 1970, *Chester 2341* (APSU); same site, 18 April 1984, *Souza, Chester 84-4* (APSU). OBION CO.: South of Walnut Log, Reelfoot Lake, 2 June 1970, *Bowers, Rogers 45199* (TENN, VDB); same site, 5 May 1984, *Chester 84-38* (APSU). ROBERTSON CO.: Nine miles N. of Springfield, 26 April 1946, *Quarterman 1619* (VDB)—Dr. Quarterman recollects that this collection was from Cedar Hill Swamp; Cedar Hill Swamp, 24 April 1949, *Helm 115* (VDB); same site, 21 April 1984, *Chester 84-9* (APSU).

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HORSEHAIR WORMS (NEMATOMORPHA, GORDIOIDEA) FROM TENNESSEE, WITH A REVIEW OF TAXONOMY AND DISTRIBUTION IN THE UNITED STATES

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Abstract

Gordian worms were collected from 11 sites in 10 counties of Tennessee. Both sexes of *Chordodes morgani* were taken from two sites, but it was abundant at only one of these. *Gordius robustus* was represented only by males and was collected from six sites, one of which had *C. morgani*. *Gordius* sp. were all females and came from three sites, each in a different county. Two females of *Paragordius varius* were found at two sites, each in a different county. These are the first records for *C. morgani* and *P. varius* in Tennessee, and six new sites in the state were recorded for *G. robustus*. A review of the pertinent literature revealed that 11 species of hairworms have been reported for the United States, which, in addition to the species from Tennessee, include: *Gordius paranensis, Neochordodes occidentalis, Parachordodes alascensis, Parach. densareolatus, Parach. lineatus, Parach. longareolatus, Parach. platycephalus,* and *Pseudochordodes manteri;* synonyms of the foregoing species are provided. Records of hairworms were tabulated for 35 states and the District of Columbia. These showed that *G. robustus, P. varius* and *C. morgani* were the most widely distributed, whereas *Parach. alascensis, Parach. longareolatus,* and *Pseud. manteri* were reported only from Alaska, California, and Nebraska, respectively.

Introduction

Horsehair worms (hairworms or gordian worms) have been studied since 1604 in Europe and were first referred to by Albertus Magnus in the 13th century (May 1919). However, little recent work on taxonomy and distribution

has been done on the group in the United States. Joseph Leidy pioneered studies in this country, but T. H. Montgomery, Jr. (1898a,1898b,1899,1900,1901,1907) contributed largely to the knowledge of the United States fauna. Some species of the United States are described in Camerano's monograph and revision (1897,1915) and in Heinze's review of European forms (1935,1941). Carvalho (1942) reviewed the taxonomy of North and South America nematomorphs, erected two new genera, and described three new species, one from the United States. Hyman (1951) treated the group in her classic work on the invertebrates, Chitwood (1959) prepared a key to 11 genera of North American forms, and Dorier (1965) listed four genera for the United States. Poinar and Doelman (1974) reassigned one of Montgomery's species from California to another genus, Pennak (1978) keyed seven genera for the United States and Redlich (1980) described a new species, *Gordius attoni,* from northern Canada.

Undoubtedly, gordian worms have been collected often in Tennessee, but only one record (Montgomery 1907) for the state is found in the preceding literature, and the exact location is not given. It seemed appropriate, therefore, to establish some records for Tennessee. Moreover, the taxonomic status and records of distribution of these worms in the United States are found in scattered and diverse sources, thus a review of current taxonomy and known distribution in the United States seemed to be in order.

Methods and Materials

Horsehair worms were collected from springs, streams, ponds, and puddles in Tennessee. Worms were examined with 20 to 40X magnification to observe color, shape of the anterior and posterior extremities, presence of grooves on the surface, and position of the cloacal aperture (terminal in females and subterminal in males). Specimens were usually preserved in 70 to 80% ethanol, but occasionally a mercuric chloride fixative was used when histological examination was desired. Pieces of the cuticle were removed from the midbody region, cleared in lactophenol, and mounted in a synthetic medium to examine the types, shapes, and distribution of cuticular areoles and other prominences. Some specimens of both sexes were sectioned transversely at 10 μm and stained with hematoxylin and eosin to give a vertical view of the areoles. All of the foregoing features are diagnostic for the identification of horsehair worms.

Some type specimens were examined on loan from the Museum of Comparative Zoology at Harvard University and from the Leidy Collection of The Academy of Natural Sciences of Philadelphia: *Chordodes morgani, C. occidentalis,* C. *gordioides, Gordius lineatus, G. aquaticus robustus, G. densareolatus, G. leidyi,* and *G. aquaticus difficilis.* Only the external features of these specimens could be examined because all were entire worms and slides of the cuticle were unavailable from the museums.

Results and Discussion

Collections from Tennessee

Three species and one unidentified species of hairworms were collected at 11 sites in 10 counties of Tennessee (Fig. 1). Sixty-nine specimens (60 males, nine females) of *Chordodes morgani* Montgomery 1898 were collected from 1980 to 1984 from a springbrook tributary of Carson Fork in western Cannon County. Specimens were found only from May through October and were usually coiled tightly around dead twigs in the water. Egg deposition and larvae were observed from the few females collected. The length of males ranged from 7 to 24 cm, and the diameter of the middle section seldom exceeded 0.5 mm. Females were from 17 to 23 cm long and most ranged in diameter from 0.5 to 1 mm. Another specimen (male) was collected on 11 Oct 1984 from a stream in the Rocky Fork Recreation Area, Unicoi County. *Chordodes morgani* had rounded (unlobed) posterior extremities in both sexes (Fig. 2A) and six types of cuticular areoles or prominences (Fig. 2B); these features correspond to those described by Montgomery (1898a,1901). The Tennessee specimens were yellowish-tan to dark brown, and most exhibited a mottled pattern of irregular brown blotches on a lighter background, a characteristic not described by Montgomery. This is the first record of *C. morgani* for Tennessee and only the second record for the southeastern United States.

Six collections of *Gordius robustus* Leidy 1851 were made: 1) one male from a puddle on S. First Street, Milan, Gibson County, on 21 Dec 1967; 2) one male from the springbrook in Cannon County that yielded *C. morgani,* collected by Mike Quinn on 7 Oct 1982; 3) one male from

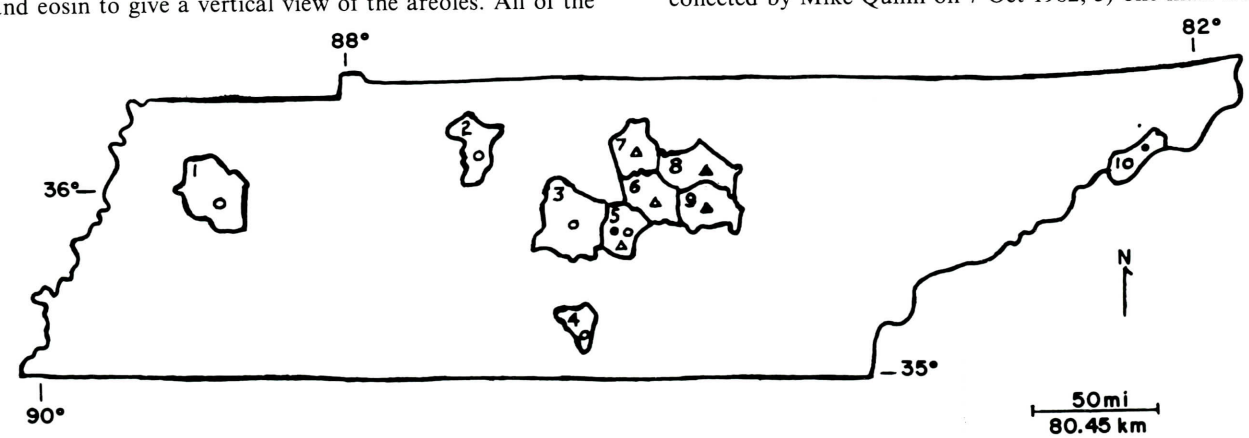

FIG. 1. *Counties (numerals) in Tennessee from which horsehair worms were collected. 1-Gibson, 2-Cheatham, 3-Rutherford, 4-Moore, 5-Cannon, 6-DeKalb, 7-Smith, 8-Putnam, 9-White, 10-Unicoi.* • Chordodes morgani, ▲ Paragordius varius, ⁰ Gordius robustus, △ Gordius *sp.*

the campus of Motlow State Community College, Moore County, collected by Bob Reeder on 10 Jan 1983; 4) two males from the seepage area of a spring on Short Mountain, Cannon County, collected by Doss Neal on 30 Sep 1983; 5) one male from a pond on the property of Prof. C. R. McGhee, Betty Ford Road, Rutherford County, on 23 Oct 1984; and 6) one male from a puddle atop a concrete platform near Ashland City, Cheatham County, collected by Benny Coleman on 21 Nov 1984. Each of these males had a bilobed posterior extremity and a crescentic cuticular ridge anterior to the cloacal aperture (Fig. 2C) as described by Camerano (1915). Montgomery (1907) reported *G. villoti* for Tennessee, but Camerano (1915) synonymized it with *G. robustus,* thus my report adds six sites for *G. robustus in* Tennessee.

Three poorly preserved females were assigned to *Gordius* sp. on the basis of a calotte or brown ring near the anterior extremity (Fig. 2D), shape of the posterior extremity, and lack of prominent areoles. Each specimen was from a different site: 1) a springbrook on the farm of Prof. Ronald Messier, Marshall Creek Road, Cannon County, 16 Mar 1983; 2) a swimming pool in Carthage, Smith County, sent to me on 3 Aug 1983; and 3) a stream in an abandoned limestone quarry along state road 141 below Center Hill Dam, DeKalb County, collected by James Bonner on 17 Oct 1983.

Two females of *Paragordius varius* (Leidy 1851) were taken, each at a different site: 1) Falling Water River near Burgess Falls, Putnam County, 24 May 1978, and 2) near Fancher's Falls on Taylor Creek, White County, summer, 1978. Each specimen had three lobes on the posterior extremity (Fig. 2E), a feature not present in females of any other species known from the United States. This is the first record of *P. varius* in Tennessee.

Many more males (67) than females (14) were collected in Tennessee. This seems to be the usual case as stated in earlier reports, perhaps because once a female has deposited eggs death soon follows.

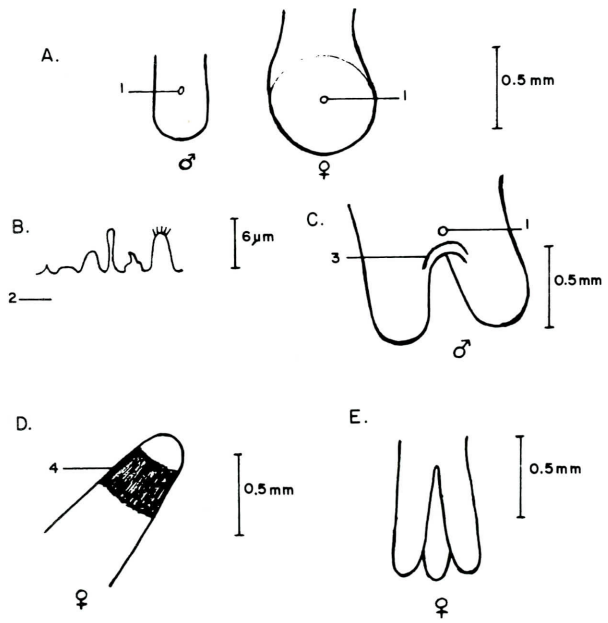

FIG. 2. *Extremities and areoles of hairworms from Tennessee. A.* Chordodes morgani: *ventral view of male posterior and oblique posterior view of female. B.* C. morgani: *composite of six types of cuticular areoles, vertical view from transverse sections. C.* Gordius robustus: *oblique ventral view of male posterior. D.* Gordius *sp.: anterior of female. E.* Paragordius varius: *posterior of female. 1-cloacal aperture, 2-cuticle, 3-crescentic ridge, 4-calotte.*

Taxonomy and Distribution in the United States

A study of the pertinent literature revealed that 11 species are known from the United States (Table 1). Hairworms have been reported for 35 of the 50 states of the United States and the District of Columbia (D.C.), with most of these records prior to 1950 (Table 2). Of the 11 species with known locations *G. robustus* and *P. varius* are most widespread across the conterminous United States. Each species is known for 17 states and D.C., but *G. robustus* is found in six states where *P. varius* has not been reported, and six other states have *P. varius* but not *G. robustus. Chordodes morgani* occurs in eight states, primarily eastern except for Iowa and Nebraska. *Neochordodes occidentalis, Parachordodes densareolatus, Parach. longareolatus* (known only from California), and *(Pseudochordodes manteri* (known only from Nebraska) are western species, whereas *G. paranensis* (known only from North Carolina) and *Parach. lineatus* are eastern species. *Parachordodes platycephalus* has a disjunct distribution: Pennsylvania in the east and Montana and Wyoming in the west. The only species reported from Alaska is *Parach. alascensis.* For 11 states, hairworms of unknown species were recorded as *Gordius* sp., Gordiacea, or Gordii. *Paragordius* sp. was reported for Arkansas and Kentucky; this was probably *P. varius* since it is the only known species of *Paragordius* in the United States.

TABLE 1. *Gordian worms of the United States, based on the pertinent literature (*pending reexamination).*

CHORDODIDAE

Chordodes morgani Montgomery 1898
Synonym: *Chordodes puerilis* Montgomery 1901

Neochordodes occidentalis (Montgomery 1898) Poinar and Doelman 1974
Synonym: *Chordodes gordioides* Montgomery 1898

Parachordodes alascensis (Montgomery 1907) Camerano 1915
Synonyms: *Gordionus alascensis* Heinze 1935*, *Gordius alascensis* Montgomery 1907, *Parachordodes alaxensis* Camerano 1915

Parachordodes densareolatus (Montgomery 1898) Camerano 1915
Synonyms: *Gordionus densareolatus* Heinze 1935*, *Gordius densareolatus* Montgomery 1898, *G. leidyi* Montgomery 1898

Parachordodes lineatus (Leidy 1851) Camerano 1915
Synonyms: *Gordionus lineatus* Heinze 1935*, *Gordius lineatus* Leidy 1851

Parachordodes longareolatus (Montgomery 1898) Camerano 1915
Synonyms: *Gordionus longareolatus* Heinze 1935*, *Gordius longareolatus* Montgomery 1898, *Parachordodes longoareolatus* Camerano 1915

Parachordodes platycephalus (Montgomery 1898) Camerano 1915
Synonyms: *Gordionus platycephalus* Heinze 1935*, *Gordius platycephalus* Montgomery 1898

Paragordius varius (Leidy 1851) Montgomery 1898
Synonym: *Gordius varius* Leidy 1851

Pseudochordodes manteri Carvalho 1942

GORDIIDAE

Gordius paranensis Camerano 1892
Synonyms: *G. aquaticus difficilis* Montgomery 1898, *G. danielis* Camerano 1894, *G. villoti difficilis* Montgomery 1899

Gordius robustus Leidy 1851
Synonyms: *G. aquaticus robustus* Montgomery 1898, *G. californicus* Camerano 1915, *G. villoti* Montgomery 1907

TABLE 2. *Records of horsehair worms in the United States. Numerals in parentheses refer to literature citations: 1-Montgomery 1898a, 2-ib. 1898b, 3-ib. 1900, 4-ib. 1901, 5-ib. 1907, 6-May 1919, 7-Murray 1938, 8-Tanner 1939, 9-Carvalho 1942, 10-Clifford 1966, 11-White 1966, 12-Holsinger & Peck 1971, 13-Sawyer 1971. 14-Eakin & Brandenburger 1974, 15-Poinar & Doelman 1974, 16-Zalmon 1977, 17-Campbell & Clark 1982, 18-Huggins & Harp 1983, 19-Whittaker & Barker 1983, 20-this study.*

Species/Other Taxon	State & Record of Literature Citation
Chordodes morgani	Fla.(5), Iowa(1,4,5), Md.(1,4,5), Mich.(5), Nebr.(5), Ohio(4,5), Pa.(1,4,5), Tenn.(20)
Gordius paranensis	N.C.(1)
G. robustus	Ark.(5), Calif.(1,5), D.C.(1,5), Ill.(6), Kans.(1,5), Me.(1), Md.(1,5), Mass.(1,5), Mich.(5), Mont.(1,5), N.C.(5), N.Y.(1,3,5), Okla.(5), Pa.(1,5), S. Dak.(5), Tenn.(5,20), Tex.(3,5), Vt.(5)
Neochordodes occidentalis	Ariz.(5), Calif.(1,2,5,15), Mont.(1,5), Nev.(1),Tex.(3,5), Wyo.(5)
Parachordodes alascensis	Alaska(5)
Parach. densareolatus	Calif.(1,5), Mont.(1,5), Wyo.(1,5), Md.(1,5), Mich.(5), N.Y.(1,5), Pa.(1,5)
Parach. longareolatus	Calif.(5)
Parach. platycephalus	Mont.(1,5), Pa.(1,5), Wyo.(1,5)
Paragordius varius	Ariz.(5), Calif.(1,2,5), D.C.(5), Ill.(5,6), Kan.(1,5), Me.(1,5), Mass.(1,5), Mich.(5), N.J.(1,5), N. Mex.(5), N.Y.(1,5), Pa.(1,5), S. Dak.(5), Tenn.(20), Tex.(3,5), Utah(8), Va.(1,5), Wisc.(11),
Paragordius sp.	Ark.(18), Ky.(19)
Pseudochordodes manteri	Nebr.(9)
Gordius sp.	Ariz.(16), Calif.(14), Ga.(12), Ind.(7,10), N.Y.(1), S.C.(13), Tenn.(20), Tex.(17)
Gordiacea	Oreg.(1), Va.(1)
Gordii	Kan.(1), Vt.(1)

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