

THE CYCLOPOID COPEPOD (CRUSTACEA) FAUNA OF NON-PLANKTONIC CONTINENTAL HABITATS IN LOUISIANA AND MISSISSIPPI

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ABSTRACT

Cyclopoid copepod crustaceans were collected in benthic and littoral samples from spatially limited mosquito-breeding habitats including a canal, small perennial and ephemeral ponds, sloughs, swales, rice fields, ditches, puddles, cemetery pits, and old tires in southern Louisiana, principally in greater New Orleans, and in Mississippi. The local fauna is relatively diverse, with 25 species in this collection and a total of 34 recorded from the region. An unexpectedly large neotropical faunal component included *Apocyclops panamensis*, *Diacyclops bernardi*, *Mesocyclops longisetus*, *Mesocyclops reidae*, *Thermocyclops inversus*, and *Thermocyclops tenuis*. The known ranges of *D. bernardi*, *M. reidae*, and *T. inversus* are extended to the United States. *Metacyclops cushae*, described from New Orleans, closely resembles neotropical species. *Mesocyclops ruttneri*, newly recorded from the United States, may have been introduced from tropical East Asia.

INTRODUCTION

During 1989-91, cyclopoid copepods (Crustacea) were collected from mosquito breeding sites in southern Louisiana and northwestern Mississippi as part of a search for copepod species that would be potentially useful for biological control of larvae of *Aedes albopictus* (Skuse) (Marten, 1989, 1990a-c). We list the species collected and compare the species richness of the Louisiana-Mississippi assemblage with cyclopoid faunas of other regions of North America, especially the south-central United States. We discuss the known geographical distributions and habitats of species of particular interest.

MATERIALS AND METHODS

Copepods were collected throughout the year at ca. 200 sites in the New Orleans-Slidell area (southeastern Louisiana). Habitats included canals, *Spartina* marshes, permanent and ephemeral ponds, ephemeral pools, and ditches. Sev-

eral hundred discarded tires and 40 tree holes were also sampled. Copepods were collected from 32 rice fields in Jefferson Davis Parish (southwestern Louisiana) and 10 rice fields in the vicinity of Cleveland (northwestern Mississippi).

The copepods were collected with a standard dipper used to collect mosquito larvae. The dipper consisted of a 400 ml plastic cup at the end of a one-meter wooden pole. Copepods were also collected from canals and ponds by dragging a plankton net parallel to the shore. They were collected from tires by removing the water with a hand-held plastic cup, and from tree holes by sucking out the water with a turkey baster. Water dipped from each site was passed through a 200 μ m Nitex net to strain out copepods. The contents of the net were suspended in a small amount of water, and copepods were removed with a Pasteur pipette and fixed and preserved in 70% ethanol. For species determination, specimens were mounted temporarily in glycerin or lactic acid media, or permanently in commercial polyvinyl lactophenol medium with a little chlorazol black E added, and examined using a Wild M20 compound microscope. Representative specimens were deposited in the National Museum of Natural History, Smithsonian Institution; the remaining material is in the collection of GGM.

RESULTS

Species inventory and nomenclature.

The collections contained a total of 25 cyclopoid species (Table 1). Identification of most species was straightforward, but explanation is necessary for some of the names employed in this article. We use the old name *Eucyclops elegans* for the American species that is frequently identified as the European *Eucyclops speratus* (Lilljeborg, 1901), and have listed records of *E. speratus* by other authors as *E. elegans* in Table 1. The systematics of *Megacyclops* is presently confused; specimens from New Orleans, reported as "*Megacyclops viridis* species group" by Marten (1990b) were eventually identified as *M. latipes* according to unpublished criteria developed by A. A. Weaver (in litt. to JWR, 1993). Most of the specimens of *Mesocyclops longisetus* were congruent with *M. longisetus* subspecies *curvatus* Dussart, 1987. *Mesocyclops ruttneri* was identified with some difficulty because of its resemblance to several Caribbean species, and is redescribed elsewhere (Reid, 1993). *Metacyclops cushae* was earlier listed as *M. denticulatus* by Marten (1989). *Microcyclops rubellus* (Lilljeborg, 1901) is considered by Reid (1992) and other authors as a separate species rather than a subspecies of *Microcyclops variicans* (G. O. Sars, 1863). The species of *Tropocyclops* encountered in this study fit the current diagnoses of *T. prasinus* sens. str. or *T. extensus*, as presented by Dussart and Fernando (1990) and Reid (1991), but not that of the commonly reported *T. prasinus mexicanus* (Kiefer, 1938).

Species reported from several other general collections in the region are listed in Table 1 under their currently recognized generic names. In the case of the very old records listed by Penn (1947), the species are listed under our best guess as to the taxa meant: *Cyclops brevispinosus* Herrick, 1884, is possibly a synonym of *Acanthocyclops vernalis*; *Cyclops serrulatus* Fischer, 1851, is a synonym of *E. agilis*; and *Cyclops fluviatilis* Herrick, 1882, is a synonym of *Tropocyclops prasinus*. *Diacyclops navus* was reported by Nasci et al. (1987) as *Thermocyclops dybowskii* (Lovén, 1890); this record was corrected by Reid et al. (1989).

TABLE 1. Copepoda Cyclopoida species records from five surveys in the south-central United States. Locales are as follows: present report, southern Louisiana and northwestern Mississippi; Penn (1947), New Orleans; Nasci et al. (1987), southwestern Louisiana; Harris (1978), northern Mississippi; Binford (1978), southern Louisiana.

	Present Study	Penn (1947)	Nasci et al. (1987)	Harris (1978)	Binford (1978)
COSMOPOLITAN SPECIES					
<i>Ectocyclops rubescens</i> Brady, 1904	•	•	•		
<i>Eucyclops agilis</i> (Koch, 1838)	•	•	•	•	
<i>Paracyclops chiltoni</i> (Thomson, 1883)	•				
<i>Paracyclops fimbriatus</i> (Fischer, 1853)				•	
<i>Macrocyclus albidus</i> (Jurine, 1820)	•		•	•	•
<i>Macrocyclus fuscus</i> (Jurine, 1820)				•	
NORTH AMERICAN OR CIRCUMBOREAL SPECIES					
<i>Halicyclops</i> sp.			•		
<i>Eucyclops agilis montanus</i> (Brady, 1878)				•	
<i>Eucyclops prionophorus</i> Kiefer, 1931	•			•	
<i>Eucyclops elegans</i> (Herrick, 1884)	•		•	•	•
<i>Megacyclops latipes</i> (Lowndes, 1927)	•		•		
<i>Megacyclops viridis</i> (Jurine, 1820)		•			
<i>Orthocyclops modestus</i> (Herrick, 1883)	•				
<i>Paracyclops poppei</i> (Rehberg, 1880)	•		•	•	
<i>Tropocyclops extensus</i> (Kiefer, 1931)	•				
<i>Tropocyclops prasinus</i> (Fischer, 1860)	•	•	•	•	•
<i>Tropocyclops prasinus mexicanus</i> Kiefer, 1938				•	
<i>Acanthocyclops exilis</i> (Coker, 1934)			•		
<i>Acanthocyclops venustoides</i> (Coker, 1934)			•		
<i>Acanthocyclops vernalis</i> (Fischer, 1853) s.l.	•	•?	•	•	•
<i>Diacyclops crassicaudis</i> var. <i>brachycercus</i> (Kiefer, 1929)	•			•	
<i>Diacyclops navus</i> (Herrick, 1882)	•		•		
<i>Diacyclops thomasi</i> (S.A. Forbes, 1882)			•	•	•
<i>Mesocyclops edax</i> (S.A. Forbes, 1891)	•			•	•
<i>Metacyclops cushae</i> Reid, 1991	•				
<i>Microcyclus rubellus</i> (Lilljeborg, 1901)	•		•	•	
NORTH AND SOUTH AMERICAN SPECIES					
<i>Homocyclops ater</i> (Herrick, 1882)	•	•	•	•	
NEOTROPICAL SPECIES					
<i>Apocyclops panamensis</i> (Marsh, 1913)	•		•		
<i>Diacyclops bernardi</i> (Petkovski, 1986)	•				
<i>Mesocyclops longisetus</i> (Thiébaud, 1914) s.l.	•				
<i>Mesocyclops reidae</i> Petkovski, 1986	•				
<i>Thermocyclops inversus</i> Kiefer, 1936	•				•
<i>Thermocyclops tenuis</i> (Marsh, 1909)	•			•	
ASIAN SPECIES [?]					
<i>Mesocyclops ruttneri</i> Kiefer, 1981	•				
SPECIES TOTAL	25	6	16	17	7

Species-habitat relationships.

Large permanent water bodies (canals, golf course ponds) in the New Orleans-Slidell area contained *Acanthocyclops vernalis*, *Eucyclops agilis*, *Eucyclops elegans*, *Homocyclops ater*, *Macrocyclus albidus*, *Mesocyclops ruttneri*, *Microcyclops rubellus*, and *Tropocyclops prasinus*. Nine species were common in the New Orleans-Slidell area in marshes, roadside ditches, temporary ponds, and temporary pools holding water for extended periods: *Acanthocyclops vernalis*, *Diacyclops navus*, *Ectocyclops rubescens*, *Eucyclops agilis*, *Eucyclops elegans*, *Macrocyclus albidus*, *M. rubellus*, *Thermocyclops inversus*, and *Tropocyclops extensus*. In addition to these, pools in wooded areas contained *Megacyclops latipes* and *Orthocyclops modestus*. Only one tree hole contained copepods, and they were *Paracyclops poppei*. Discarded tires in wooded areas contained some of the same species found in the surrounding woods, namely *A. vernalis*, *D. navus*, *E. rubescens*, *E. agilis*, *M. albidus*, *P. poppei*, and *O. modestus*. *Eucyclops elegans*, *P. chiltoni*, and *T. prasinus* were each collected from a single tire, and a single specimen of *M. ruttneri* was collected from a marsh.

In the New Orleans-Slidell area, pools and small depressions (swales) holding water only for short periods of time contained *Acanthocyclops vernalis*, *Diacyclops navus*, *Metacyclops cushae*, *Microcyclops rubellus*, and *Thermocyclops tenuis*. These species often appeared as soon as there was water. *Diacyclops crassicaudis* var. *brachycercus* and *Diacyclops bernardi* were also collected, but each was found in only one swale. *Apocyclops panamensis* was found in a freshwater swale that was sometimes flooded with brackish water. The Louisiana rice fields contained *Acanthocyclops vernalis*, *Ectocyclops rubescens*, *Eucyclops elegans*, *Macrocyclus albidus*, *Mesocyclops ruttneri*, *Mesocyclops reidae*, *Microcyclops rubellus*, *Paracyclops chiltoni*, *Paracyclops poppei*, *Thermocyclops inversus*, *T. tenuis*, and *Tropocyclops extensus*. The Mississippi rice fields contained *A. vernalis*, *Diacyclops crassicaudis* var. *brachycercus*, *Eucyclops agilis*, *E. elegans*, *Macrocyclus albidus*, *Mesocyclops ruttneri*, *M. reidae*, *Microcyclops rubellus*, and *Tropocyclops extensus*. Either *Acanthocyclops vernalis* or *Mesocyclops ruttneri* occurred in almost every field that was sampled in Louisiana and Mississippi, but never together.

DISCUSSION

These collections, although limited primarily to small bodies of standing or very slowly flowing water, revealed a species-rich cyclopoid fauna (Table 1). Previous studies in the region collected many fewer species on average. Only six species were recorded previously from New Orleans proper (Penn, 1947). Binford (1978) collected seven species of cyclopoids during monthly samples over a one-year period in the Atchafalaya River and associated swamps in south-central Louisiana. Harris (1978) listed 17 species from collections in northern Mississippi made over a one-year period from a wide variety of lentic and lotic habitats. Nasci et al. (1987) recorded 16 species from similar mosquito-breeding habitats in southwestern Louisiana.

The fauna of ephemeral pools reported here is like that occurring in similar waters elsewhere. Nasci et al. (1987) reported that *Acanthocyclops vernalis* was almost constantly present in three woodland ponds in southwestern Louisiana. In those ponds, two of which frequently dried, *Diacyclops navus* was collected less often but also persisted through the year. Nasci et al. (1987) reported a total of

6-11 species from each pond. In New Orleans, similar woodland ponds contained a total of 11 species, most of these the same that were recorded by Nasci et al. (1987). Taylor and Mahoney (1990) reported an analogous association of *Acanthocyclops vernalis* and *Diacyclops haueri* Kiefer, 1931, in an ephemeral bay lake in South Carolina, which supported an assemblage of nine cyclopoid species.

Some 96 species of cyclopoid copepods of the family Cyclopidae are presently recorded from North America north of Mexico. Usually, about one-fourth of this number inhabit any particular region. The 34 copepod taxa now reported from Louisiana and Mississippi constitute the most species-rich assemblage so far recorded from North America. Although such comparisons are not well founded because the few intensive investigations of regional cyclopoid copepod faunas on this continent differed in their objectives and collecting techniques, a review of some other local totals provides perspective. One of the most comprehensive faunistic studies in the United States is the eight-year survey reported by Bunting (1973) for Tennessee, in which 22 species were recorded from 653 samples from 476 localities including a wide variety of habitats. The copepod fauna of North Carolina is almost equally well known, thanks to the investigations of Yeatman (summarized in 1944) and subsequent workers. From North Carolina there are 27 species recorded to date (Adams et al., 1992). Smith and Fernando (1978) reported 25 species from lacustrine and non-lacustrine habitats in southern Ontario. In tropical regions of comparable extent, cyclopoid copepod species diversity may be slightly higher. For instance, from Cuba, 35 species and subspecies of cyclopids have been reported, although several records need to be substantiated (Reid, 1990). The 25 species recorded in our collections is a higher total than would be expected from the limited types of habitats sampled. Even though the local list may be slightly inflated because of taxonomic problems, the area total of 34 taxa is surprising.

Characterization of the geographical distribution of the cyclopoid species collected in Louisiana and Mississippi (Table 1) reveals that the relatively high number of species is due mainly to a significant neotropical component. Southern Louisiana lies within the northern ranges of six neotropical species, three of these documented from the United States for the first time in this study. A seventh, previously undescribed species with neotropical affinities (*Metacyclops cushae*) was discovered in New Orleans, and an eighth, probably introduced species (*Mesocyclops ruttneri*) is recorded for the first time in the Americas.

Apocyclops panamensis is a common inhabitant of brackish coastal lagoons and ponds around the Gulf and Caribbean, and has been recorded from the mid-Atlantic coast of the United States, south as far as the northern coast of South America (Reid, 1990). *Mesocyclops longisetus* occurs commonly from southern South America to the Antilles and Mexico, and sporadically in the southern conterminous United States, where the New Orleans find is only the third confirmed record, the others being from Texas and Florida (reviewed by Reid, 1993). The subspecies *M. longisetus curvatus* may be distributed through Central America, the Antilles, and southern North America, with the nominate species restricted to continental South America (Dussart, 1987).

Mesocyclops reidae, an Antillean and Central American species, is common in small bodies of water in Honduras (Marten and Reid, unpublished). The record from Mississippi rice fields extends its known range significantly northward from tropical Mexico (Reid, 1990, 1993).

Thermocyclops tenuis extends throughout the lowland neotropics, with sporadic records in the southwestern and south-central United States. Many records of this species are from ephemeral waters (Reid, 1989).

The record of *Thermocyclops inversus* was previously reported briefly by Reid (1989). This species is common in southern Mexico, Central America, and Cuba, with a few records from Brazil, but was unknown north of the Tropic of Cancer until the New Orleans find. The Louisiana record thus represents a northward range extension of about 900 km. *Thermocyclops inversus* is a common plankter in large Central American lakes, but has also been recorded from reservoirs, ponds, wells, and caves (Reid, 1989).

The find of *Diacyclops bernardi* represents an equally surprising northward range extension. It is known elsewhere only from San Andrés Island off Nicaragua, and from Yucatán, Mexico (Reid, 1993). The species was collected from brackish water (salinity up to 30 ‰) in a dug well and a shallow cave on San Andrés, and in Mexico from a coastal pond.

Metacyclops cushae, described from New Orleans, resembles an Argentinian species, *M. denticulatus* Dussart and Frutos, 1986, and is most likely neotropical in origin. This is the first confirmed published report of a species of *Metacyclops* in North America, although the genus is widespread in tropical and temperate regions of other continents including Europe and Asia (Reid, 1991). *Metacyclops cushae* was found at only three localities in greater New Orleans, two grassy sloughs and one ditch, all containing water only seasonally.

The eighth species of probable tropical origin is *Mesocyclops ruttneri*, which is newly recorded for North America in this study. *Mesocyclops ruttneri* was originally described from a greenhouse in Austria, now destroyed; no wild populations are known to exist in Europe (Kiefer, 1981). Specimens of *M. ruttneri* were recently identified by Reid (1993) in samples from wild populations in China, Thailand, and Viet Nam, and the species is morphologically similar to several Asian congeners. It seems likely that *M. ruttneri* was introduced from Asia into both Austria and the southern United States. Specimens of *M. ruttneri* were collected in abundance from a permanent pond-like canal in New Orleans, and in rice fields in Louisiana and Mississippi. The species is obviously well established in the region.

This study confirms the supposition of Reid (1992) that the neotropical cyclopoid copepod faunal component in the southern United States is more significant than previously estimated. However, most of the cyclopoids of neotropical affinities present in southern Louisiana and Mississippi may be near the northern limit of their ranges. Most have been collected only sporadically, and are probably existing alongside rather than directly competing with members of the North American fauna. The only suggestion of competition in the available collection data is the apparent mutual exclusion of *Acanthocyclops vernalis* and *Mesocyclops ruttneri* in rice fields.

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