The thickness determinations for x-ray measurements were based on equation (2). The photometric cross section \( \sigma \) was assumed to be invariable (Singhal, 1965) and the intensities before and after the foil were obtained by exposing the area under the x-ray peak, in a pulse height spectrum. The area extension was accomplished by a computer routine which fit a Gaussian curve to the peak and a second degree polynomial to the background on either side of the peak. The integrated area under the Gaussian curve in the region of interest less that under the background curve was taken as the intensity of the x-ray beam. The results are presented in Table 2 together with a comparison of the results in Table 1. In making the comparison it will be noted that two or more of the foils, the alpha measurements were combined to serve as a single foil for the x-ray measurements.

From equation (2) it can be seen that a graph of the foil thickness (obtained from alpha energy loss measurements) vs. \( \ln(\text{L}/\text{L}_0) \) will yield the photometric cross section \( \sigma \). The result of a least-squares fit to such a graph gives a result (80.6 cm²/mg) which compares favorably with theory (48%). This uncertainty is comparable to that associated with the alpha energy loss measurements.

The exponential absorption of x-rays, one is not limited to thin foils as is the case for alpha studies. The accuracy of the method, in either case, will be limited by the uncertainties for either \( \text{dE}/\text{dx} \) or \( \alpha \).

**LITERATURE CITED**


The CLADOCEA AND COPEPODA OF TENNESSEE II. CYCLOPID Copepods

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**ABSTRACT**

An eight-year survey was conducted in Tennessee to determine the distribution and habitat preference of cyclopoid copepods. Twenty species in eight genera were recorded from the state, of which eight were reported for the first time. Nine species were collected from habitats, three were collected only in caves, seven were found in small streams, springs, and/or pools, and three were collected only in rivers and associated springs. Seventeen species were listed as expected to occur in Tennessee in future collections. The names *Cyclops bicuspitatus thomai* and *Cyclops varians rubellus* were rejected in favor of *Cyclops thomai* and *Cyclops rubellus*.

**INTRODUCTION**

The cyclopoid copepods of the southeastern states are not well known. Published studies are restricted to areas of some biological interest such as Reelfoot Lake, and to regions surrounding academic institutions containing individuals interested in the Cyclopidae. The present study is a local study that has resulted in distributional data that are complete and as Coker (1938) noted, even quite erroneous. The purpose of this paper, then, is to summarize and extend our present knowledge of the species composition and distribution of cyclopoids within Tennessee.

A literature review revealed reports concerning copepods from Reelfoot Lake (Elderd 1940; Hoff, 1944), the Elk River and Woods Reservoir (Yeatsman, 1959), and a few sinks, ponds, and lakes in the Knoxville area (Green, 1933, 1934). In addition to the studies, unpublished records were provided by the Tennessee Valley Authority and Dr. Harry C. Yeatsman.

**METHODS**

This report includes 653 samples taken from 476 localities over an eight year period. Most collecting done in mid and early Tennessee and a smaller number in other parts of the state. Collections were made by all means: nets and traps. In addition to the studies, unpublished reports were provided by the Tennessee Valley Authority and Dr. Harry C. Yeatsman.

**ANNOTATED LIST OF SPECIES**

- **Genus Cyclops O. F. Müller**
- **Cyclops carolinensis** (Yeatsman, 1944) (this species was described from pools in the vicinity of the city, N. C. He considered the only definite structural difference between this species and a closely related, *C. vernalis*, to be the presence of small hairs on the inner margins of the caudal rami of the former. In Tennessee, we have collected specimens in six temporary pools in Jefferson, Hamilton, and Blount counties; these specimens differ from the type in the variable nature of the hairs. A detailed discussion of the variability encountered in this and other cyclopoid species is in preparation.
- **Cyclops clasticus** (Yeatsman, 1964) (this species was described from specimens obtained in BigMouth Cave, Grundy County, Tennessee and from a drainage leading into Jordan Creek, Vermillion County, Illinois. To date, the BigMouth Cave collection is apparently the only record from the state. The species is considered a troglobite and it has never been collected epigean waters.
- **Cyclops crassicauda brauckereus** (Kiefer). Considered as unknown in North America, this species inhabits stagnant, temporary pools and wells (Yeatsman, 1959) and litoral areas of shallow lakes (Rylow, 1948). Specimens taken from a shallow, stagnant pool in Wilson County constitute the only record in the present study. Since Yeatsman did not include Tennessee in the distribution of the species, this represents the first published record for the state.
- **Cyclops donaldsoni** (Chappuis). Yeatsman (1959) indicated the distribution of this species is limited to a cave in Indiana, however, since he identified specimens from a small cave in Hamilton County, Tennessee (personal communication).
- **Cyclops evilla** (Coker). In March and April, 1969, I identified a few specimens of this species from two springs in Knox County. Other localities given by Yeatsman (1959) are North Carolina and New York. Very little is known concerning this copepod, and, as far as I can determine, previous distribution records are available. A study of the life history and morphology is presently being undertaken.
- **Cyclops haueri** (Kiefer). *Cyclops haueri* was considered a species rare in North America, recorded only from Connecticut and Ohio. The species is evidently confined to temporary pools in Winter and Spring. I have identified it containing the species from two temporary pools in northern Alabama.
- **Cyclops latipes** (Lowdnes). Yeatsman (personal communication) has collected this species in several small, intermittent streams in Franklin County. I have recorded it from a slowly flowing, temporary pool in Hamilton County. Yeatsman (1959) listed the North American distribution as North Carolina, Michigan, and Tennessee. Though little is known concerning the biology of this species, it evidently prefers cold, shallow bodies of water with some intermittent flow.
- **Cyclops thomai** (S. A. Forbes). During colder months, this limnetic species is the major planktonic cyclopoid in the reservoirs of the TVA system. It has apparently never collected in small shallow pools in the southeastern United States.
- **Cyclops thomai** has been considered by most authors to be a subspecies of *C. bicuspitatus*; I prefer to follow Reed (1963) in considering it a separate species. In addition to Reed's characteristics for separating the species, I have noted significant variation in the presence of small hairs on the inner margins of the caudal rami. Hairs are absent in *C. bicuspitatus* from other parts of the world. All authors, except Marsh (1910), have described *thomai* without hairs. A discussion of variation in this species is in preparation.
- **Cyclops rubellus** (Verrill). *Cyclops rubellus* has usually been considered a subspecies of *C. varicus*. The principal morphological differences between the two (see Yeatsman, 1944 and Rylow, 1948) appear to have been sufficient to accord *rubellus* specific status (Kiefer, 1929; Reed, 1963; Dussart, 1969). A typical and common species. A characteristic macrura vegetation in shallow waters of ponds and pools, little is known about the biology of the species. The writer has collected specimens in eight such habitats in the eastern part of Tennessee from January through April. Rylow (1948) considered it a bimodal summer form found typically in acid waters.
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River prior to and following impoundment of Wood River Reservoir. Recent samples from this locality contained only M. edax and intensive sampling during summer months will be required to clarify its status.

Genus Orthocoryphe E. B. Forbes

Orthocoryphe modesta (Herrick). The single species in the Tribe has been identified as a rare species in Tennessee though widely distributed throughout the United States. Most North American collections of the species are from the Southeast, including the single Tennessee record from Big Mound Creek in Grundy County (Yeatman, personal communication).

Genus Paracoryphe Claus

Paracoryphe lilianae poppei (Rehberg). Of the Paracoryphe species known from North America, only P. f. grandis from the Florida Keys has been identified. The species is worldwide in distribution and seems to prefer shallow weedy areas of lakes and ponds but may also occur in flowing water (Rylv, 1948). Green (1933) first reported the sub-species from the state in collections from Andrew Jackson Lake during January and February. Yeatman (personal communication) records its first occurrence from Franklin County, and has collected it in a small pond in Blount County. It may also occur in some larger reservoirs in the TVA system. Mr. Donald Wade and Mr. Don Dusch of the TVA system identified its vertical plankton hauls taken from Kentucky, Wilson, Barkley, Nickajack, Pickwick, and Sequoyah Reservoirs.

Genus Tropocypris Kiefer

Tropocypris prausin (Fischer). A common and widespread limnetic species in North America (Yeatman, 1959). Its distribution in Tennessee was not generally reported from the macrophyte vegetation in lakes. Marshall (1910) reported a preference for lakes rather than ponds, while Mapes (1934) reported the species to be rarely planktonic. Most of its collections have indicated that it is usually found in small ponds and lakes where it appears to reach maximum abundance during the summer and fall months. It may also be a major form in the plankton of lakes in the region. It has been identified from P. Plou, Fontana, Norris, Chilhowee, Watauga, and Melton Hill Reservoirs in Tennessee and North Carolina (Yeatman, personal communication). Published records for the species include the Elk River and Wood River Reservoirs (Yeatman, 1956). Red River at Mark (Hoff, 1944) and Andrew Jackson Lake and surrounding ponds in Knox County (Green, 1934).

SUMMARY

Of approximately 500 cyclopoid copepods known from North America, 22 are listed in this report from Tennessee; eight are reported for the first time. With additional collections from the western part of the state and from recently sampled sites, springs, small streams, temporary pools, and caves, the number should reach about 27. Species expected to occur in the state include those listed in Arizona and also reported from Kentucky (Geiling, 1962); Macrosychelet DATE, uncommon, but probably widespread; and North American species of

LITERATURE CITED


