PLANKTONIC COPEPODA
OF FURNAS RESERVOIR:
INITIAL SURVEY OF SPECIES
(1993) AND REVIEW OF LITERATURE

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ABSTRACT - Six species of Copepoda occurred in samples of plankton from seven locations in Furnas Reservoir in February and March 1993. Among calanoids, Argyrodiaptomus furcatus f. exilis and Notodiaptomus iheringi occurred throughout the reservoir. Scolodiaptomus corderoi occurred at two locations.

The cyclopoid Thermocyclops minutus also appeared throughout Furnas Reservoir, and its congener Thermocyclops decipiens appeared at two locations (Alpinópolis, Rio Turvo bridge). The Afro-Asian species Mesocyclops ogunnus was collected in two areas, and may represent an introduction.

Published data on the ecology of S. corderoi and T. decipiens has established that these species occur mainly in meso- to eutrophic conditions, while A. furcatus f. exilis and T. minutus inhabit primarily unpolluted waters of low productivity. Notodiaptomus iheringi may be a more gener-

alist species. For each species, available data on its taxonomy, distribution, biology and ecology, and possible utility as an indicator of environmental conditions are reviewed. An extensive bibliography is provided as a basis for future research.

KEYWORDS: Zooplankton, Copepoda, Calanoida, Cyclopoida, Brazil

INTRODUCTION

Copepod crustaceans comprise a significant proportion of zooplankton species, numbers and biomass in nearly all aquatic systems. They occupy a central position in aquatic food webs, translating energy either directly as herbivores or indirectly as carnivores or detritus-feeders, from macrophyte or phytoplankton producers into accessible protein for planktivorous fishes and other species at higher trophic levels. Because of their importance, copepods have attracted attention in many limnological studies, and a good deal is known of their biology and ecological relationships.

We review available data on the geographical distribution, biology and ecology, and possible utility as an indicator of environmental conditions for each planktonic copepod species collected from Furnas Reservoir during an initial survey. We provide taxonomic discussion for questionable or little-known species. The extensive list of references will serve as a basis for future research.

METHODOLOGY

Non-quantitative zooplankton samples were taken at several stations in Furnas Reservoir in early 1993. Furnas is a large reservoir on the Rios Grande and Sapucaí in the south of the state of Minas Gerais (MG), partly along the border with the state of São Paulo, at 20°40’S 46°19’W. The reservoir was closed in 1962; the present flooded area is 1459 km² and the volume is 22,950,000 m³; the maximum depth (at the dam) is 90 m and the mean depth 13 m (Furnas/Eletrobrás, 1992). The reservoir is highly dendritic, with the Rio Grande forming the north arm, and the Rio Sapucaí the south arm; there is a short (about 15 km) confluence near the dam. Five stations were selected:
Dam at Alpinópolis; 20 Feb 1993.

**Rio Turvo Bridge:** equidistant between dam and confluence of Rios Grande and Sapucaí; 16 Feb 1993.

**Fazenda Shangrilá:** confluence of Rios Grande and Sapucaí near ferry crossing to the town of Guapé (MG), about 20 km from the dam; approximate width of reservoir 2 km, maximum depth 16 m; bottom descending precipitately; March 1993, 1 May 1993.

**Porto Fernandes:** on Rio Grande (north arm) near old Guapé-Cristais ferry crossing; reservoir about 500 m wide, maximum depth 13 m; bottom on one side gradual, with beaches along shoreline, on other side precipitate; 27 Apr 1993, 23 Jun 1993, 28 Aug 1993.

**Itaci:** at town of Carmo do Rio Claro (MG) (south arm), near ferry crossing to Itaci (MG); reservoir about 1 km wide, depths to 10 m; bottom gently descending, with floodplain vegetation present; 25 Jun 1993.

**Fama:** near village of Fama (MG), on Rio Sapucaí (south arm); reservoir about 1.5 km wide, maximum depth 18 m; 29 Apr 1993, 24 Jun 1993.

Voucher specimens of all species of copepods found were deposited in the collections of the National Museum of Natural History, Smithsonian Institution (USNM).

**RESULTS AND DISCUSSION**

Six species of Copepoda occurred in the samples. Argyrodiaptomus furcatus (Sars) f. exilis, Notodiaptomus iheringi, and Thermocyclops minutus were taken at every locality, although not in every sample. Scolodiaptomus corderoi occurred at Rio Turvo Bridge in February and at Porto Fernandes in April, June, and August. *Thermocyclops decipiens* was taken in most samples except for Porto Fernandes in June and August. *Mesocyclops ogunnus* was present at the dam in February, Fama in April and June, Itaci in June, and Porto Fernandes in April.

specimens were deposited in the collections of the National Museum of Natural History, Smithsonian Institution.

A. Individual Species:

*Argyrodiaptomus furcatus* f. *exilis* Dussart, 1985
*Argyrodiaptomus exilis* - Dussart, 1985: 202-204, Fig. 2.
*Argyrodiaptomus furcatus exilis* - Dussart and Matsumura-Tundisi, 1986: 249, 253-254, Fig. 3.-Reid et al., 1988: 528, 533-534, 536.-Matsumura-Tundisi and Tundisi, 1986: 37-39, Tabs. 1, 2.

Dussart (1985) described a new diaptomid calanoid “species” *Argyrodiaptomus exilis* from Lago Dom Helvécio in the Rio Doce Valley, Minas Gerais. In a subsequent publication, the taxon was considered both a subspecies and a “variety” of *Argyrodiaptomus furcatus* (G. O. Sars, 1901) s. str. by Dussart and Matsumura-Tundisi (1986). In the same year, the taxon was termed both a form and a variety by Matsumura-Tundisi (1986).

The distinction between *A. furcatus* s. str. and *A. furcatus* f. *exilis* lies chiefly in size. The female of *A. furcatus* f. *exilis* is about 1.06 mm in length, and the male is 0.96 mm (Dussart, 1985; Dussart and Matsumura-Tundisi, 1986; Matsumura-Tundisi, 1986; Matsumura-Tundisi and Tundisi, 1986). Reported lengths for the female of the typical form of *A. furcatus* are 1.65-1.88 mm, and for the male, 1.41-1.58 mm (Sars, 1901; Sendacz and Kubo, 1982; Wright, 1937). Other morphological differences are most evident in the males, chiefly the relatively short spinous process of the right antennule article 15 and the relatively elongate right leg 5 exopodite article 2 with several small cuticular thickenings on the medial surface, in *exilis*. The morph from Furnas Reservoir collected in 1993 coincides with *exilis* in all these details.

The biological (and taxonomic) relationship between *A. furcatus* s. str. and *A. furcatus* f. *exilis* is unclear. Matsumura-Tundisi (1986) noted that morphs referable to both *A. furcatus* s. str. and to *A. furcatus* f. *exilis*
occur in Lago Dom Helvécio, and suggested that the latter “probably constitutes a population proceeding from different temperature and nutritional conditions” than the larger morph. Wright (1937) reported a population of *A. furcatus* from Sorocaba Reservoir, São Paulo, with males having a short spine on article 15 and a short spur on the antepenultimate article of the right antennule. Adults of this population were intermediate in length between *A. furcatus* s. str. and *exilis* (males 1.20-1.36 mm, females 1.30-1.69 mm). Rolla et al. (1990) reported a population similar to *exilis* from Volta Grande Reservoir, Minas/São Paulo. In view of the existence of intermediate morphs, as well as two morphs in the same body of water, we feel that Matsumura-Tundisi is probably correct in her opinion that environmental rather than genetic factors account for the morphological differences, and therefore we regard *exilis* as a form of *furcatus*. However, the question should be resolved through genetic and breeding studies.

Because of this uncertainty, we review studies of members of the entire *furcatus* species-complex. Ringuet (1958) and Sendacz and Kubo (1982) provided partial synonymsies and taxonomic discussion of *Argyrodiaptomus furcatus*. Dussart (1985) distinguished two Argentinian subspecies, *septentrionalis* and *meridionalis*. The species-complex occurs from about 19°50’ - 36°S in the Brazilian States of Minas Gerais, Rio de Janeiro, and São Paulo, and in Itaipu Reservoir, as well as in Uruguay and sporadically in northern Argentina (Brandorff, 1976; Matsumura-Tundisi, 1986; Reid et al., 1988; Ringuet, 1958). Previous records in Minas Gerais are only from Lago Dom Helvécio (Matsumura-Tundisi, 1986; Matsumura-Tundisi and Okano, 1982; Okano, 1980; Tundisi and Matsumura-Tundisi, 1981) and Volta Grande (Rolla et al., 1990). *Argyrodiaptomus furcatus* s. lat. has been collected from natural large and small lakes and temporary pools, reservoirs, and in rivers with slow-moving current (Brandorff, 1976; Ringuet, 1958).

Matsumura-Tundisi et al. (1989) and Okano (1980) claimed that *A. furcatus* has only four rather than the five copepodid stages normal for diaptomids; and the normal six naupliar stages. However, the developmental stages have never been formally described.

The species is common and frequently dominant in individual waters. Matsumura-Tundisi (1986) and Matsumura-Tundisi et al. (1981) considered *A. furcatus* one of the most common species in the “less eutrophic” of some 23 reservoirs in São Paulo. Sendacz and Kubo
(1982) found the species in only one (Itupararanga) of 17 reservoirs studied in that state. It was abundant in that reservoir, which had highly transparent water of low nutrient and chlorophyll a content. It is also abundant in Broa (Lobo) Reservoir in São Paulo, which has oligo- to mesotrophic characteristics; in fact the species comprises about 60% of the total crustacean biomass in Broa (Matsumura-Tundisi et al., 1989; Rocha and Matsumura-Tundisi, 1984). Both *A. furcatus* and *Scolodiaptomus corderoi* appeared in Rio Grande Reservoir, São Paulo, after water conditions improved after isolation of that section from Billings Reservoir, which was polluted by industrial and domestic wastes (Sendacz et al., 1984). In floodplain ponds of the Rio Tietê, São Paulo, Kleerekoper (1944) observed that *A. furcatus* dominated in summer (the rainy season, when the ponds are flushed), and was replaced in winter by *S. corderoi* (when the ponds presumably became enriched).

The biology of *A. furcatus* is well-studied, especially in Broa Reservoir where it is the only calanoid species. In Broa, the sex ratio is about 1:1 throughout the year (Matsumura-Tundisi et al. (1989)). Adults and copepodids persist throughout the year, their population in some years undergoing rapid, marked, patternless fluctuations (Matsumura-Tundisi and Tundisi, 1976). In other years, the populations fluctuated but peaked in the rainy season (summer, especially March) (Matsumura-Tundisi et al., 1989; Rocha et al., 1982; Rocha and Matsumura-Tundisi, 1984) and in one year during the relatively disturbed period of September (Matsumura-Tundisi et al., 1989). Reproductive success is lowest in the winter dry season, with most of the population consisting of adults and older copepodids. In deeper waters, females continuously produce subitaneous eggs, with production peaking in summer. In shallow waters, females produce subitaneous eggs in summer and disappear in winter (the dry season), possibly producing resting eggs. High numbers of nauplii in early summer (December) can only be accounted for by assuming recruitment from hatching resting eggs (Rocha et al., 1982). Evidence for the existence of resting eggs in this species comes from some records in ephemeral waters (Rocha et al., 1982), and from the fact that Sars (1901) first described the species from specimens hatched from dried mud. *Argyrodiaptomus furcatus* females showed high clearing (filtration) rates of several species of algae, but did not assimilate some (notably *Chlorella zoofingensis*) efficiently (Tavares and Matsumura-Tundisi, 1984).
Predation/prey relationships have been the topic of a few studies. Adults and copepods are prey of the planktivorous fish Astyanax fasciatus (Barbosa and Matsumura-Tundisi, 1984). In a mesocosm experiment, the planktivorous fish Holosthes heterodon also reduced the numbers of larger stages (Roche et al., 1993). Like other copepods, A. furcatus may be subject to predation by the planktonic flatworm Mesostoma sp. (Rocha et al., 1990).

Both Argyrodiaptomus furcatus s. l. and A. furcatus f. exilis have been studied in Lago Dom Helvécio, but the morphs were not always distinguished (Matsumura-Tundisi and Okano, 1982; Okano, 1980). In this deep monomictic natural lake, both morphs remain at low densities (fewer than 4000 ind/m³) year-round, much less numerous than the co-occurring Scolodiaptomus corderoi. The adults and “four” (CII-CV?) copepodid stages undergo diurnal vertical migration, with some sexual, and interstage, but not seasonal differences in pattern, remaining above the approximately 15 m thermocline (Okano, 1980).

Notodiaptomus iheringi (Wright, 1935)

Diaptomus iheringi Wright, 1935: 223-226, Pl. 1 Fig.4, Pl. 2, Figs. 3, 5-11.- Wright, 1936: 80-81.- Wright, 1938: 562.


Notodiaptomus iheringi was redescribed by Reid (1985b). This species is widely distributed and common in north and northeastern Brazil, and also occurs in the south; its latitudinal range from about 2°-24°S is unusually wide for a diaptomid. It has been recorded from the States of Ceará, Minas Gerais, Pará, Paraíba, Pernambuco, Rio de Janeiro, São Paulo, and in Itaipu Reservoir (Arcifa, 1984; Brandorff, 1976; Matsumura-Tundisi, 1986; Reid, 1985b; Rocha et al., 1990; Sendacz and Kubo, 1982; Tundisi et al., 1991; Wright, 1935). It does not occur near the coast in the Brazilian northeast (Wright, 1935), and all records from southern Brazil are inland except for two coastal ponds in the State of Rio de Janeiro (Reid, 1985b; Reid and Esteves, 1984). The type-locality
is Açude Puxinanã near Campina Grande, Paraíba. Rolla et al. (1990) first recorded the species in Minas Gerais, from Volta Grande Reservoir.

*Notodiaiptomus iheringi* is uncommon in the south of Brazil, possibly because of a preference for warm temperatures. Arcifa (1984) did not record it in ten São Paulo reservoirs examined. Sendacz and Kubo (1982) found the species in two of 17 São Paulo reservoirs, associated with conditions of relatively high temperatures, high nutrient and chlorophyll contents, and high water transparency. The two shallow Rio de Janeiro coastal ponds had highly transparent water, with moderate conductivity (410-645 μS/cm), and measured pH 6.6-9.0 (Reid, 1985b; Reid and Esteves, 1984). One was a blackwater pond, in contrast to the observation of Cipollì and Carvalho (1973) that the species was absent from black waters in Pará. Tundisi et al. (1991) found *N. iheringi* in all five reservoirs of the Rio Tietê system, São Paulo, in the same watershed as Furnas.

Nauplii and adults of this species were consumed by a planktonic flatworm (Rocha et al., 1990).

*Scolodiaiptomus corderoi* (Wright, 1936)


*Diaptomus s. lat. corderoi.* Pinto-Coelho et al. 1988: 605-620.-Reid et al., 1988: 527-528, 531, 533, 535-537, Fig. 2.

*Diaptomus sp.* Barbosa et al., 1984: 403.

*Diaptomus* (Notodiaiptomus) corderoi.-Cipollì, 1973: 567-610, Pls. 1-12, Tabs. 1, 2.


*Notodiaiptomus* (Notodiaiptomus) corderoi, comb. nov.-Dussart, 1985: 208.

This species was for a long time classified in the genus-group *Diaptomus* s. lat. Eventually Reid (1987), rejecting Dussart’s (1984, 1985) and Kiefer’s (1956) assignment to the poorly defined *Notodiaptomus*, proposed creation of a monospecific genus on the basis of several distinctive characters, primarily the unique spine on the anterior surface of leg 5 of the female. Cipólli (1973) described the external morphology of the five copepodid and six naupliar stages.

*Scolodiaptomus corderoi* occurs over a small range in southeastern Brazil, in the States of Minas Gerais and São Paulo, and in Itaipu Reservoir (Paraná) (Matsumura-Tundisi, 1986; Reid et al., 1988). Reported localities in Minas Gerais, besides the type-locality in Lagoa Santa, include Lago Dom Helvécio, Lagoinha (Municipalidade de Lagoa Santa), Lago Sumidouro, and the reservoirs Pampulha, Pontal, Vargem dos Flores, and Volta Grande (Dabés et al., 1990; Freire and Pinto-Coelho, 1986; Giani et al., 1986; Matsumura-Tundisi and Tundisi, 1986; Pinto-Coelho et al., 1988; Reid, 1987; Reid et al., 1988; Rolla et al., 1990).

This calanoid is the dominant copepod species in Lagoa Santa (Reid, 1987; Reid et al., 1988) and in Lago Dom Helvécio (Matsumura-Tundisi and Okano, 1982; Matsumura-Tundisi and Tundisi, 1986; Okano, 1980; Tundisi and Matsumura-Tundisi, 1981). It is common in reservoirs in São Paulo, where it is sometimes the most numerous copepod species. In these waters, it has been associated with conditions of low water transparency and relatively high conductivity (mean 36-45 μS/cm) in some studies (Matsumura-Tundisi, 1986; Sendacz and Kubo, 1982). However, Arcifa (1984) found it most abundant in the two least productive of ten São Paulo reservoirs, but also numerous in the most productive reservoir. Populations in Lagoa Santa were not high and consisted mainly of juveniles prior to 1985 (Barbosa et al., 1984), but increased considerably and attained a high proportion of adults after littoral macrophytes were removed and phytoplankton became abundant (Reid, 1987). It was the only calanoid in Pontal reservoir, which is subject to heavy siltation from tailings from iron ore processing plants, and also untreated domestic wastes (Dabés et al., 1990). It is one of three calanoids in the less polluted Volta Grande (Rolla et al., 1990). Freire and Pinto-Coelho (1986) observed that in Vargem das Flores Reservoir, *S. corderoi* maintains its highest populations in the central areas of the reservoir, which are relatively more transparent and have
lower electrical conductivity than areas more subject to silt and organic loading from tributaries. Reported populations of this species are sometimes very high, viz. a maximum density of $9.5 \times 10^3$ adults/m$^3$ in Pampulha (Giani et al., 1986).

In Lago Dom Helvécio, the adults and “four” (probably CII-CV) copepodid stages exhibit diurnal vertical migration, with some seasonal, sexual, and interstage differences in pattern, above the approximately 15 m thermocline (Okano, 1980).

Scolodiaptomus corderoi females from Pampulha Reservoir displayed high clearing (“filtration”) rates of *Chlorella vulgaris* under laboratory conditions when compared to temperate calanoids (Pinto-Coelho et al., 1988). These authors suggested that this feeding capacity might confer a competitive advantage, for instance over *A. furcatus*. However, the latter species also has a high clearing capacity for some algae, but may not necessarily assimilate them efficiently (Tavares and Matsunura-Tundisi, 1984).

*Mesocyclops ogunnus* Onabamiro, 1957


*Mesocyclops* sp. I.-Dumont et al., 1981: 615.

This species was redescribed by Van de Velde (1984); additional morphological details were provided by Dussart and Fernando (1988) and Reid and Kay (1992). Specimens from Furnas agree in all details with these descriptions.

*Mesocyclops ogunnus* is widely distributed in Africa, the Near East, and southeast Asia; the type-locality is the River Ogun, Nigeria. It has been collected in a wide variety of habitats, including lakes and large rivers (Van de Velde, 1984) and small eutrophic ponds (Reid and Kay, 1992); mainly in fresh, but also in brackish and saline waters (Bonou et al. 1991; Van de Velde, 1984).
This is the first record of the species in the Americas. This record satisfies several of the criteria of Chapman and Carlton (1991) for distinguishing introduced species: it has not been found previously on the continent, particularly in well-collected southeastern Brazil; it occurs in an artificial habitat, namely a reservoir; it appears to have a restricted distribution in Brazil; the population in Brazil is disjunct from its previously known distribution in Africa and Asia; and it is unlikely to have been passively dispersed naturally to Brazil from the Old World. The means of introduction is unknown. It appears unlikely that _M. ogunnus_ was brought in with fish. No African fishes have been introduced into Furnas Reservoir, and stocks of tilapias introduced into reservoirs in the State of São Paulo were brought from northeastern Brazil (D. M. Ribeiro, personal communication). Although the species was present in a sample from a tank at the Furnas Hydrobiological and Fish Culture Station taken in December 1993, it may have entered the tank with the water from the reservoir rather than along with the fish. The introduction into Furnas may have been quite recent, because Rolla et al. (1990) found the native congener _Mesocyclops longisetus_ and _Mesocyclops meridianus_ in Volta Grande, downstream from Furnas, but did not find _M. ogunnus_.

Matsumura-Tundisi et al. (1990) and Tundisi et al. (1991) reported another African species, _Mesocyclops kieferi_ Van de Velde, 1984, in the Tietê reservoirs. _Mesocyclops kieferi_ is broadly distributed across west Africa, the Rift Valley, and in the Arabian Peninsula (Van de Velde, 1984). Matsumura-Tundisi et al. (1990) noted that collections in Barra Bonita Reservoir in 1985-1986 did not contain _M. kieferi_, but that the species was present “in great abundance” in November 1988. This distribution pattern suggests that this species, like _M. ogunnus_, has been recently introduced into Brazil.

The ecological relationships and biology of _M. ogunnus_ are best known from studies in Lake Kinneret, Israel, where this and _Thermocyclops dybowskii_ are dominant planktonic copepod species (_ogunnus_ was identified as _Mesocyclops leuckarti_ or _M. thermocyclopoides_ in some references by Gophen and colleagues). _M. ogunnus_ is also present in the Jordan River, but river populations are small relative to those of the lake (Gophen, 1980a). Populations in Lake Kinneret are seasonally stable but declined in 1979-1983, possibly due to changes in predation pressure from fish, while relative densities of the smaller _T. dybowskii_ rose
(Gophen, 1986). Zooplankton biomass as a whole has declined over the long term in this lake, concurrently with increase in populations of zooplanktivorous fish; proportions of nutrients (nitrogen and phosphorous) have also altered (Gophen et al., 1990). *M. ogunnus* has comprised about 90% of the copepod biomass and 30% of the total zooplankton biomass (Gophen, 1981b).

During summer and fall, fish predation (mostly by the sardine *Mirogryex ltereaevandae*) controls zooplankton biomass, especially the larger species (reviewed by Gophen, 1988). Cladocerans are preferred prey of planktivorous fish, however, copepods are also taken (Azoulay and Gophen, 1992; Gophen et al., 1981b, 1988; Gophen and Landau, 1977; Gophen and Scharf, 1981; Gophen and Threlkeld, 1989). Females and older developmental stages of *M. ogunnus* are preferred by planktivorous fish, while filter feeding fish may suppress small nauplii (Gophen, 1988). Sex ratios may vary significantly from the expected 1:1, seasonally and between years, and may be affected by differential predation, different longevities of adults, and possibly cannibalism of males by females (Gophen, 1979b).

Nauplii and copepodit stages I-III of *M. ogunnus* are herbivorous while the copepodits IV-V and adults are carnivorous, consuming *Ceriodaphnia* and *Diaphanosoma* (but not *Bosmina*); adults may also cannibalize younger stages (Gophen, 1977, 1981a). Adults can be cultured successfully on *Artemia* (Gophen, 1980). Adults copepods consume slightly more than their own body weight per day (Gophen, 1977). The development time from egg to adult at 15 °C under laboratory conditions is 67 days for females (Gophen, 1986). At higher ambient temperatures within the range occurring in Lake Kinneret (14-28 °C), higher metabolic rates and respiration and smaller adult body sizes occur; however, development times decrease and egg production increases (Gophen, 1976). Specific growth rates are higher for males; nauplii and changes (r-values) of the herbivorous stages are lower than for the carnivorous stages (Gophen, 1978). The average productivity of *M. ogunnus* in Lake Kinneret is 2.2 gC/m².month, and the principal contributory stages are the copepodits (Gophen, 1978). All life stages of the copepods perform diurnal vertical migration moving toward the surface at night (Gophen, 1979a).
Thermocyclops decipiens (Kiefer, 1929)

Until recent taxonomic revisions (Reid, 1985, 1988, 1989), this pantropical species was frequently recorded in the Americas as the similar Thermocyclops crassus (syn. T. hyalinus). It is widely distributed throughout the neotropical lowlands, with a few populations in northern Argentina (Reid, 1989). In Minas Gerais it has been previously recorded in Lagoa Santa and in Pampulha, Pontal and Vargem das Flores Reservoirs (Dabés et al., 1990; Freire and Pinto-Coelho, 1986; Reid, 1989; Reid et al., 1988). This record is the first from Furnas Reservoir.

Thermocyclops decipiens is highly eurytopic but favors meso- to eutrophic natural and artificial waters. It is a common species in the more highly productive reservoirs in the State of São Paulo (Arcifa, 1984; Sendacz, 1984; Sendacz and Kubo, 1982; Tundisi et al., 1991). Sendacz et al. (1984) observed a dominance shift in formerly eutrophic Rio Grande reservoir after its closing; as water conditions improved, T. decipiens came to dominate the cyclopoid plankton year-round, while Metacyclops mendocinus was formerly more common during the dry season. Populations in reservoirs usually increase in the dry season when conditions become more “eutrophic,” but may fluctuate greatly at any season without apparent pattern (Freitas, 1983; Pinto-Coelho, 1987).

Large populations of T. decipiens are usually associated with productive conditions including the dominance of cyanophyceans (Reid, 1989). Infante (1978) found that diatoms and green algae comprised 49% and cyanophyceans only 9% of gut contents of wild-caught adults from Lake Valencia, Venezuela. Most cyanophyceans including Microcystis aeruginosa if ingested, were not broken down in the gut, but Lyngbia limnetica comprised about 4% of identifiable remains, and was over 80% digested. Infante and Riehl (1984) found no negative relationship between elevated cyanophycean populations and numbers of T. decipiens in Lake Valencia, although cladoceran populations were negatively affected. However, Carvalho (1984) noted declines of wild populations of T. decipiens during blooms of Anabaena spiralis and Microcystis sp. Questions of whether this species is able to consume and survive on which species of cyanophyceans, and whether other effects such as toxicity occur, remain for investigation.
Reproductive potential of *T. decipiens* is relatively high, with observed average clutch size of 13.6 (range 11.3-16.3) eggs/ovigerous female (López, 1993).

*Thromycyclops decipiens*, like many cyclopoids, is omnivorous, and has been observed to prey on cladocerans and larvae of chironomids, as well as to cannibalize its own nauplii (Carvalho, 1984). In a mesocosm, addition of the planktivorous fish *Holosthete heterodon* had the effect of increasing populations of this cyclopoid, possibly because of its small size relative to other plankters, and also possibly by increasing the population of rotifer prey (Roche et al., 1993).

*Thromycyclops minutus* (Lowndes, 1934)

Taxonomic and geographical references for *Thromycyclops minutus* were summarized by Reid (1985, 1989) and Reid et al. (1988). This small cyclopoid is found widely in the lowlands of tropical South America (Reid, 1989). In Minas Gerais, it has been previously recorded in Lago Carioca (Matsumura-Tundisi and Tundisi, 1986), Lago Dom Helvécio (Matsumura-Tundisi and Okano, 1983; Matsumura-Tundisi and Tundisi, 1986; Okano, 1980; Rocha et al., 1990), Lagoa Santa, Lagojinha (at Lagoa Santa), Lago do Sumidouro, Lago Poço Verde, and Rep. Vargem das Flores (Freire and Pinto-Coelho, 1986; Reid et al., 1988).

The species is usually associated with natural or artificial, relatively unpolluted waters of low productivity (Reid, 1988, 1989; Sendacz, 1984, 1993; Sendacz and Kubo, 1982). However, it is also sometimes found associated with its larger congener *T. decipiens* in more eutrophic waters (Matsumura-Tundisi et al., 1981). Reid and Moreno (1990) noted that in many co-association situations the bodies of water appear to be ecologically unstable or cyclic. An apparently stable co-association was documented by Sendacz (1993) for two floodplain lakes of the upper Rio Paraná, but both lakes are subject to intense alteration by annual flooding. *Thromycyclops decipiens* and *T. minutus* maintained roughly equal proportions of the total cyclopoid population in the more productive of these lakes (Lagoa Jota); while *T. decipiens* comprised 10% or less of the population of the less productive lake (Lagoa Comprida). In another co-association situation, López (1993) observed that in Socuy Reservoir, Venezuela, *T. decipiens* had egg production maxima in both
the dry season, when diatoms and green algae dominate the phytoplankton, and the rainy season when blue-greens become dominant; while *T. minutus* egg production peaked only in the dry season. Matveev et al. (1992) noted that population level of *T. minutus* was not much negatively affected by a bloom of filamentous cyanophyceans.

No direct observations are available on the natural food of *T. minutus*. Matveev (1991) inferred from population counts that *T. minutus* appeared to compete directly for food with *Daphnia* and other microcrustaceans. In Broa reservoir, *T. minutus* populations, like those of *A. furcatus*, peaked during periods of disturbance (September and March) and concurrent high algal productivity (Matsumura-Tundisi et al., 1989).

*Thermocyclops decipiens* is much larger than *T. minutus*, and the two species probably do not compete directly. Freire and Pinto-Coelho (1986) noted no horizontal separation of the two species in Vargem das Flores Reservoir, where in contrast to the pattern of *S. corderoi*, the cyclopoids maintained their highest populations in the shallower stations which had lower water transparency and higher electrical conductivity.

*Thermocyclops minutus* may undergo diurnal vertical migration, but the adults rarely approach the surface (Okano, 1980).

The copepodid developmental stages were described by Gouvêa (1978); however, the leg segmentation patterns as given by that author differ from those of some congeners (F. Ferrari, pers. comm. to JWR).

Reproductive potential of *T. minutus*, which is a small species, seems low, with average clutch size of 5.7 (range 4.3-7.6) eggs/ovigerous female (López, 1993).

*Thermocyclops minutus* may be a natural prey of the planktonic flatworm *Mesostoma* sp. (Rocha et al., 1990). However, this small species is not preferred by planktivorous fishes (Matveev et al., 1992).

**B. The Copepod Fauna of Furnas Reservoir**

The known ecological preferences of the individual copepod species in Furnas Reservoir indicate a species assemblage that is typical of mesotrophic conditions, in most of the sampling sites. However, several species are associated with less productive waters. An hypothetical
ranking of these species, in ascending order of preference (or tolerance) for productive waters, might be:

- *A. furcatus*, *S. corderoi*, *T. decipiens*
- *N. itheringi*
- *T. minutus*

The number of species in Furnas is rather high. Rolla et al. (1990) reported most of the same species (plus *M. longisetus* and *M. meridianus*, minus *M. ogunnus* as noted previously) in Volta Grande downstream, a similarly large system. By contrast, Arcifa (1984) reported not more than four species of copepods in any of ten São Paulo reservoirs; most had only two species present. The great extent and probably diverse set of conditions of the Furnas and Volta Grande systems may partly account for this species richness.

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