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# CYCLOPOIDS (CRUSTACEA: COPEPODA) REPORTED FOR CHILEAN INLAND WATERS

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**Abstract**

Cyclopoids are the worst studied copepods from Chilean inland waters, because the identity of the species and their occurrence reports need confirmation; there are only descriptions for species from large and deep Patagonian lakes (38-51º S). Chilean cyclopoids have low relative abundance in zooplankton assemblages. The scarce ecological studies indicate that they are opportunistic predators, grazing on phytoplankton or predating on small zooplankton (protists, rotifers, nauplii, copepodid stages and juvenile cladocerans). From a biogeographical view point there are endemic species in bioegeographical regions at extreme northern and southern Chile, whereas in the Central Chile it is possible found widespread species that had been reported for other zones in South America.

**Keywords:** Copepods, cyclopoids, Patagonia, zooplankton.

## Cyclopoids (Crustacea: Copepoda) reported for Chilean inland waters.

**Resumen**

Los copépodos ciclopoideos han sido poco estudiados en aguas continentales chilenas, porque la identidad de sus especies requiere de confirmación, solo hay descripciones para especies de lagos grandes y profundos de la Patagonia (38-51ºS). Los copépodos ciclopoideos tienen baja abundancia relativa en los ensambles zooplanctónicos y los escasos estudios biológicos indican que ellos son depredadores oportunistas, pastoreando sobre el fitoplancton o depredando sobre especies zooplanctónicas de menor tamaño (protozoos, rotíferos, nauplius, estadíos copepoditos y cladóceros juveniles). Desde un punto de vista biogeográfico hay especies endémicas en regiones biogeográficas como los extremos norte y sur de Chile, mientras que en la zona central de Chile, es posible encontrar especies que han sido reportadas para otras zonas de Sudamérica.

**Palabras clave:** Copépodos, ciclopoideos, Patagonia, zooplancton.

## Introduction

Cyclopoid copepods are among the worst studied zooplanktonic crustaceans in Chilean lakes, because this group is relatively scarce in comparison to other zooplanktonic crustaceans, such as calanoid copepods and cladocerans (Campos *et al.*, 1994a, 1994b; Wölfl, 1996; Villalobos, 1999,

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2006; Valdovinos, 2008). Additionally, their absolute abundance is rather low (Wölfl, 2007; Kamjunke *et al.,* 2009), like occurs in Argentinean Patagonian lakes (Modenutti *et al.,* 1998).

The first review of Chilean cyclopoids was provided by Araya & Zúñiga (1985), and many of the species recognized by them were confirmed by Reid (1985). Some mistakes from the literature have been corrected during the last years (*i.e.* Locascio de Mitrovich & Menu-Marque, 2001; Pilati & Menu-Marque, 2003; Gutiérrez-Aguirre *et al.,* 2006).

From an ecological point of view, cyclopoids are considered opportunistic predators, grazing on phytoplankton or predating on other zooplanktonic groups such like protists, rotifers, nauplii, and cladoceran juvenile life stages (Chang & Hanazato, 2003a, 2003b, 2005a, 2005b; Chang *et al.,* 2004; Sakamoto & Hanazato, 2008). In Chilean lakes, they predate mainly on mixotrophic ciliates (Wölfl, 2007; Kamjunke *et al.,* 2009). This was proposed by Wölfl (1996), who mentioned that cyclopoids are opportunistic in their diet, because they can predate on zooplankton according to the environmental status of its habitat. The aim of the present study is provide a checklist of cyclopoids copepods in Chilean inland waters, considering the geographical distribution of each species.

## Materials and methods

For revise the geographical distribution of the cyclopoids from Chilean inland waters we revised literature about cyclopoid copepods from Chilean inland waters (Mrázek, 1901; Brehm, 1936; Kiefer, 1936; Loeffler, 1961; Zúñiga & Araya, 1982; Araya & Zúñiga, 1985; Zúñiga & Domínguez, 1977; Campos *et al.,* 1982, 1983, 1987a, 1987b, 1988, 1990, 1992a, 1992b, 1994a, 1994b; Wölfl, 1996; Villalobos, 1999; Locascio de Mitrovich & Menu-Marque, 2001; Villalobos *et al.,* 2003; Soto & De los Ríos, 2006; De los Ríos, 2008). We compiled the localities where the species have been reported and their valid names (Reid, 1985; Locascio de Mitrovich & Menu-Marque, 2001; Pilati & Menu-Marque, 2003) and represented them on maps (Figures 1-9).

## Results and discussion

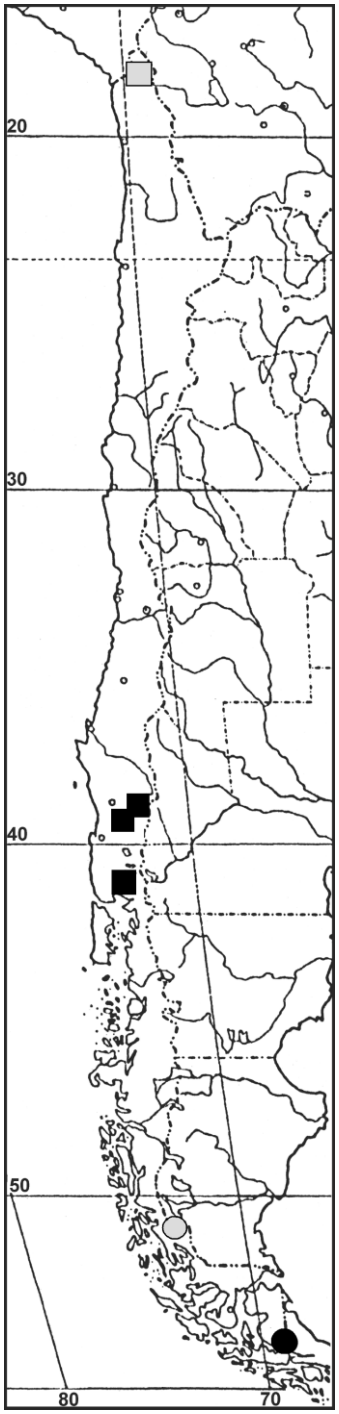
The following species has been previously reported for Chilean inland waters. The specific name followed by the geographical location with coordinates and respective references in parenthesis are detailed in the appendix.

### List of Chilean inland waters cyclopoids

Genus *Acanthocyclops* Kiefer, 1927.

*Acanthocyclops michaelseni* (Mrázek, 1901) (Figure 1).

*A. vernalis* (Fischer, 1853) (Figure 1).




Genus *Diacyclops* Kiefer, 1927.

*Diacyclops andinus* Locascio de Mitrovich & Menu-Marque, 2001 (Figure 1).

Genus: *Eucyclops* Claus, 1893.

*Eucyclops ensifer* Kiefer, 1936. (Figure 1)

*E. serrulatus* (Fischer, 1851).(Figure 2)

Genus: *Macrocyclops* Claus, 1893.

*Macrocyclops albidus* (Jurine, 1820). (Figure 3).

Genus: *Mesocyclops* Sars, 1914.

*Mesocyclops araucanus* Loefler, 1961 (Figure 4).

*M. longisetus* (Thiebaud, 1914) (Figure 5).

Genus: *Metacyclops* Kiefer, 1927.

*Metacyclops mendocinus* (Wierzejski, 1892) (Figure 6).

Genus: *Microcyclops* Claus, 1893.

*Microcyclops anceps* (Richard, 1897) (Figure 7).

Genus: *Paracyclops* Claus, 1893.

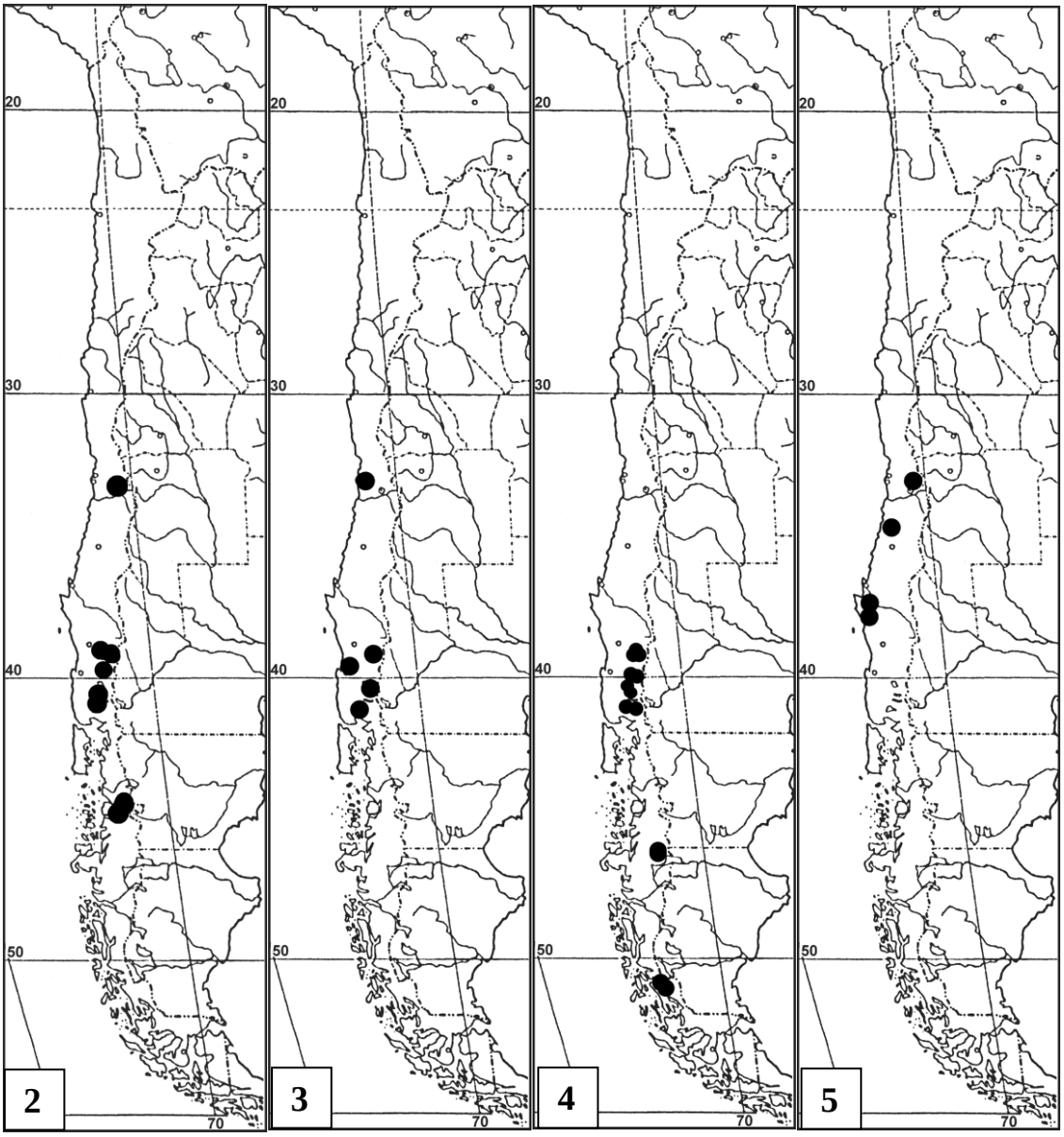
*Paracyclops chiltoni* (Thomson, 1883) (Figure 8).

Genus: *Tropocyclops* Kiefer, 1927.

*Tropocyclops meridionalis* Kiefer, 1927 (Figure 9).

**Figure 1.** Geographical distribution of Chilean copepods. *Acanthocyclops michaelseni*; (Mrázek, 1901)(black circle); *Acanthocyclops vernalis* (Fisher, 1853) (black quadrilateral); *Diacyclops andinus* (Locascio de Mitrovich & Menu-Marque, 2001)(grey quadrilateral with black border); *Eucyclops ensifer* (Kiefer, 1936)(grey circle with black border)

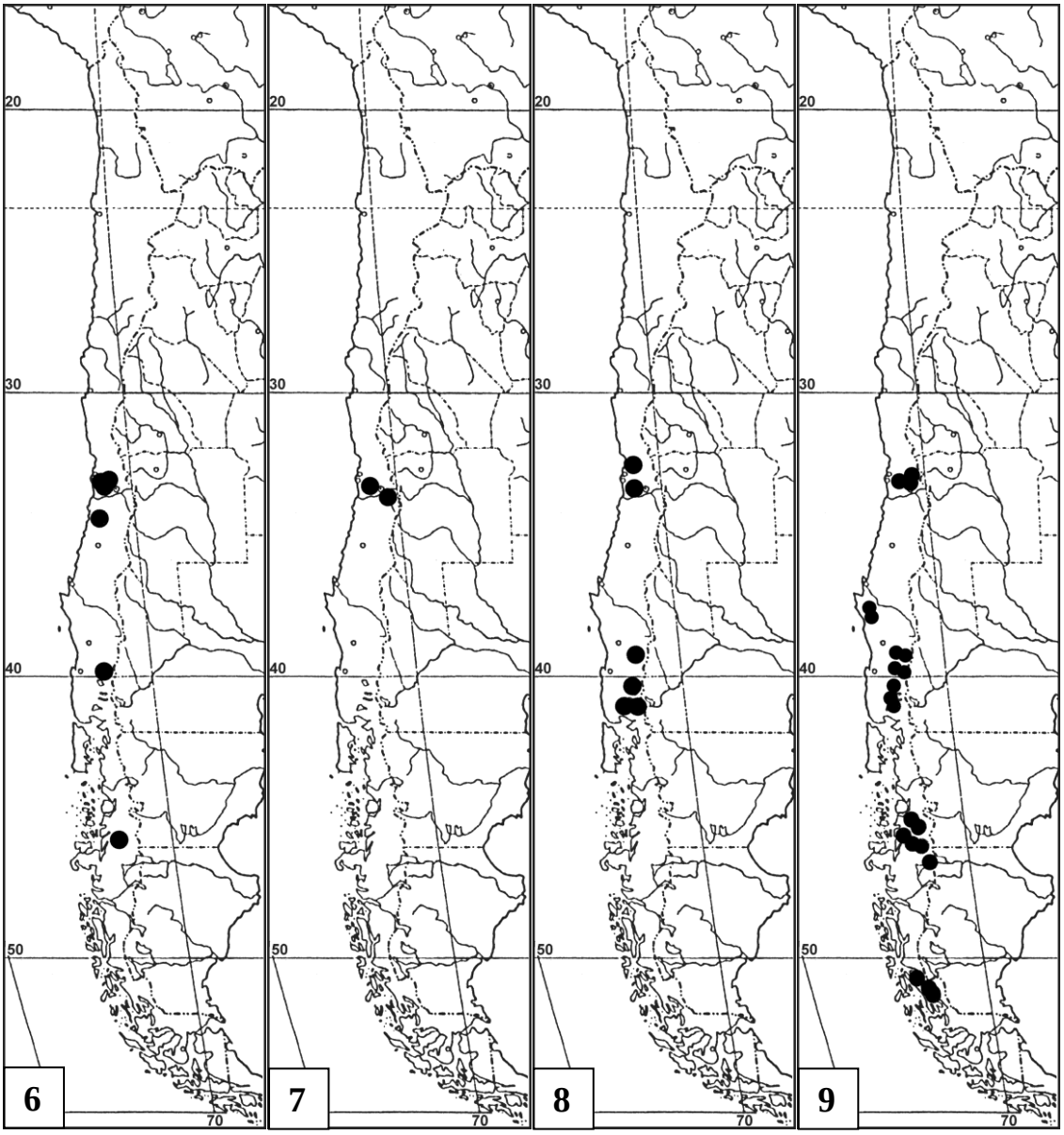
Figura 1. Distribución geográfica de copépodos chilenos. *Acanthocyclops michaelseni*; (Mrázek, 1901)(circulo negro); *Acanthocyclops vernalis* (Fisher, 1853) (cuadriláteros negros); *Diacyclops andinus* (Locascio de Mitrovich & Menu-Marque, 2001)(cuadrilátero gris con borde negro); *Eucyclops ensifer* (Kiefer, 1936)(circulo gris con borde negro)




**Figures 2-5.** Geographical distribution of Chilean copepods (left to right). 2: *Eucyclops serrulatus* (Fisher, 1851); 3: *Macrocyclops albidus* (Jurine, 1820); 4: *Mesocyclops araucanus* (Loefler, 1961); 5: *Mesocyclops longisetus* (Thiebaud, 1914).

Figuras 2-5. Distribución geográfica de copépodos chilenos (izquierda a derecha). 2: *Eucyclops serrulatus* (Fisher, 1851); 3: *Macrocyclops albidus* (Jurine, 1820); 4: *Mesocyclops araucanus* (Loefler, 1961); 5: *Mesocyclops longisetus* (Thiebaud, 1914).

The analysis revealed the existence of one species located in northern Chile (18° S; *Diacyclops andinus*), which corresponds to the Atacama province (Morrone, 2004, 2006). All the remaining species are found in the Andean region (Morrone, 2004, 2006). Five species are distributed in central Chile and northern Patagonia (33-41° S): *Macrocyclops albidus*, *Metacyclops mendocinus*,




**Figures 6-9.** Geographical distribution of Chilean copepods (left to right). 6: *Metacyclops mendocinus* (Wierzejski, 1892); 7: *Microcyclops anceps* (Richard, 1897); 8: *Paracyclops chiltoni* (Thomson, 1883); 9: *Tropocyclops meridionalis* (Kiefer, 1927).

Figuras 6-9. Distribución geográfica de copépodos chilenos (izquierda a derecha). 6: *Metacyclops mendocinus* (Wierzejski, 1892); 7: *Microcyclops anceps* (Richard, 1897); 8: *Paracyclops chiltoni* (Thomson, 1883); 9: *Tropocyclops meridionalis* (Kiefer, 1927).

*Microcyclops anceps*, *Mesocyclops longisetus* and *Paracyclops fimbriatus chiltoni*. Four species are restricted to Patagonia (40-51° S): *Tropocyclops meridionalis*, *Eucyclops serrulatus*, *Acanthocyclops vernalis* and *Mesocyclops araucanus*. Finally, two species are distributed in southern Patagonia (51-54° S): *Eucyclops ensifer* and *Acanthocyclops michaelseni*).

From a biogeographical point of view, we found four cosmopolitan species, namely *Eucyclops serrulatus*, *Macrocyclops albidus, Mesocyclops longisetus,* and *Paracyclops chiltoni;* and two species distributed in Central and South America, namely *Eucyclops ensifer* and *Metacyclops mendocinus* (Reid, 1985).

The species are reported in the South American transition zone and the Andean region (Morrone, 2004, 2006). The former includes the Atacama biogeographic province (northern Chile between 18-28° S), where only *D. andinus* was found. In the Andean region, the species reported were located mainly in the Santiago, Maule, Valdivian Forest, Magellanic Forest and Magellanic Moorland provinces (Morrone, 2004, 2006). Two species, *A. michaelseni* and *E. ensifer,* were found in a single province, the Magellanic Moorland.

The species with restricted geographical distribution correspond to species described only for South America, as *Acanthocyclops michaelseni* and *Tropocyclops meridionalis* (Reid, 1985). There are no endemic species at country level; however, *Mesocyclops araucanus*, restricted to southern Patagonian lakes, may be considered endemic (Pilati & Menu-Marque, 2003). This species was originally described as *Mesocyclops longisetus*, distributed along all continental Chile (Araya & Zúñiga, 1985; Campos *et al.* 1982, 1983, 1987a, 1987b, 1988, 1990, 1992a,b, 1994a, 1994b; Soto *et al.*, 1994; Wölfl, 1996; Villalobos, 1999; Villalobos *et al.,* 2003), but Pilati & Menu-Marque (2003) proposed that the populations from south to 38° S would belong to *M. araucanus*, originally described as a subspecies, *M. longisetus araucanus* (Loeffler, 1961). Two other possible endemic species are *Diacyclops andinus,* from northern Chile and northwestern Argentina (Locascio de Mitrovich & Menu-Marque, 2001), and *A. michaelseni,* from southern Argentina and Chile (Mrázek, 1901; Silva, 2008). As conclusion, it is possible found endemic species at biogeographical zones in the Atacama biogeographic, and Magellanic Forest and Magellanic Moorland provinces, whereas in the Andean region it is possible found widespread species that had been reported for other zones in South America.

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**APPENDIX**

## Apéndice

The species previously reported for Chilean inland waters with information about the geographical location with coordinates and respective references in parenthesis are detailed in this appendix:

*Acanthocyclops michaelseni* (Mrázek, 1901) (Figure 1): Fagnano lake (54°31′ S; 68°43′ W; Mrázek, 1901).

*A. vernalis* (Fischer, 1853) (Figure 1): Pirihueico lake (39°56′ S; 71°48′ W) (Araya & Zúñiga, 1985); Chapo lake (41°27′ S; 72°31′ W) (Villalobos *et al.*, 2003).

*Diacyclops andinus* Locascio de Mitrovich & Menu-Marque, 2001 (Figure 1): Chungará lake (18°15′ S; 69°10′ W; Araya & Zúñiga, 1985).

*Eucyclops ensifer* Kiefer, 1936 (Figure 1): Larga lagoon (51°02′ S; 72°55′ W; Kiefer, 1936).

*E. serrulatus* (Fischer, 1851) (Figure 2): Villarrica lake (39°16′ S; 72°07′ W), Quillelhue lake (39°33′ S; 71°32′ W), Puyehue lake (40°39′ S; 72°30′ W), Bonita lagoon (40°53′ S; 72°52′ W) (Loeffler, 1961); Inca lagoon (32°49′ S; 70°09′ W), Riñihue (39°49′ S; 72°19′ W), Polux lake (45°43′ S; 71°53′ W), Chiguay lake (45°56′ S; 71°50′ W) (Araya & Zúñiga, 1985); Llanquihue lake (41°07′ S; 72°50′ W) (Zúñiga & Domínguez, 1978).

*Macrocyclops albidus* (Jurine, 1820) (Figure 3): Quilpué (33°07′ S; 71°14′ W); Valdivia (39°49′ S; 73°15′ W) (Mrázek, 1901); Puyehue lake (40°39′ S; 72°30′ W), Llanquihue lake (41°07′ S; 72°50′ W) (Loeffler, 1961); Pellaifa lake (39°30′ S; 71°57′ W) (Zúñiga & Domínguez, 1977).

*Mesocyclops araucanus* Loefler, 1961 (Figure 4): Calafquén lake (39°31′ S; 72°08′ W), Pellaifa lake (39°30′ S; 71°57′ W), Riñihue lake (39°49′ S; 72°19′ W), Ranco lake (40°12′ S; 72°22′ W), Puyehue lake (40°39′ S; 72°30′ W), Rupanco lake (40°49′ S, 72°30′ W), Llanquihue lake (41°07′ S; 72°50′ W), Todos los Santos lake (41°46′ S; 73°15′ W), Bonita lagoon (40°53′ S; 72°52′ W) (Loeffler, 1961); Caburgua lake (39°07′ S; 71°47′ W), Panguipulli lake (39°41′ S; 72°15′ W), Pirihueico lake (39°56′ S; 71°48′ W), General Carrera lake (45°50′ S; 72°00′ W) (Araya & Zúñiga, 1985); Sarmiento lake (51°03′ S; 72°47′ W) (Campos *et al.*, 1994a); Del Toro lake (51°12′ S; 72°45′ W) (Campos *et al.*, 1994b).

*M. longisetus* (Thiebaud, 1914) (Figure 5): Rapel reservoir (34°10′ S; 71°29′ W) (Zúñiga & Araya, 1982); Negra lagoon (33°39′ S; 70°08′ W), Lanalhue lake (37°55′ S; 73°19′ W), Lleulleu lake (38°08′ S; 73°19′ W) (Araya & Zúñiga, 1985).

*Metacyclops mendocinus* (Wierzejski, 1892) (Figure 6): Catapilco reservoir (32°38′ S; 71°27′ W), Runge reservoir (33°01′ S; 70°54′ W), Orozco reservoir (33°14′ S; 71°25′ W), Elizalde lake (Araya & Zúñiga, 1985); Rapel reservoir (34°10′S; 71°29′ W) (Zúñiga & Araya, 1982); Pichilafquen lagoon (39°13′ S; 72°12′ W) (Loeffler, 1961).

*Microcyclops anceps* (Richard, 1897) (Figure 7): Peral (33°30′ S; 71°35′ W), Negra lagoon (33°39′ S; 70°08′ W) (Araya & Zúñiga, 1985).

*Paracyclops chiltoni* (Thomson, 1883) (Figure 8): Quilpué (33°07′ S; 71°14′ W) (Mrázek, 1901), Juan Fernández Island (33°38′ S; 78°51′ W) (Brehm, 1936); Villarrica lake (39°16′ S; 72°07′ W), Puyehue lake (40°39′ S; 72°30′ W), Llanquihue lake (41°07′ S; 72°50′ W), Margarita island (41°06′ S; 72°17′ W) (Loeffler, 1961); Peñuelas lagoon (Araya & Zúñiga, 1985).

*Tropocyclops meridionalis* Kiefer, 1927 (Figure 9): Villarrica lake (39°16′ S; 72°07′ W); Margarita island (41°06′ S; 72°17′ W), Pocuro (32°53′ S, 70°38′ W), Quillelhue lagoon (39°33′ S; 71°32′ W), Bonita lagoon (40°53′ S; 72°52′ W), Del Inca lagoon (Loeffler, 1961). El Plateado reservoir (33°04′ S; 71°39′ W), Pellaifa lake (39°30′ S; 71°57′ W), Puyehue lake (Zúñiga & Domínguez, 1977); Riñihue lake (39°49′ S; 72°19′ W) (Zúñiga & Domínguez, 1978); Ranco lake (40°12′ S; 72°22′ W) (Domínguez & Zúñiga, 1978); Runge reservoir (33°01′ S; 70°54′ W), Peñuelas reservoir (33°09′ S; 71°32′ W), Orozco reservoir (33°14′ S; 71°25′ W), Yeso reservoir (33°39′ S; 70°07′ W), Lanalhue lake (37°55′ S; 73°19′ W), Lleulleu lake (38°08′ S; 73°19′ W), Caburgua lake (39°07′ S; 71°47′ W), Calafquén lake (39°31′ S; 72°08′ W), Neltume lake (39°47′ S; 71°59′ W), Panguipulli lake (39°41′ S; 72°15′ W), Pirihueico lake (39°56′ S; 71°48′ W), Atravezado lake (45°45′ S; 72°54′ W), General Carrera lake (45°50′ S; 72°00′ W), Chiguay lake (45°56′ S; 71°50′ W), Riesco lake (45°39′ S; 72°20′ W), Lynch lake (48°33′ S; 75°34′ W) (Araya & Zúñiga, 1985); Foitzick lagoon (45°38′ S; 72°05′ W) (De los Ríos, 2008); Los Palos lagoon (45°19′ S; 72°42′ W), Escondida lagoon (45°49′ S; 72°40′ W) (Villalobos, 1999); Chapo lake (41°27′ S; 72°31′ W) (Villalobos *et al.*, 2003); Elizalde lake (45°44′ S; 72°20′ W) (De los Ríos & Soto, 2007); Sarmiento lake (51°03′ S; 72°47′ W) (Campos *et al.*, 1994a); Del Toro lake (51°12′ S; 72°45′ W) (Campos *et al.*, 1994b); Pehoe lake (51°03′ S; 73°04′ W), Norsdenkjold lake (51°03′ S; 72°58′ W) (Soto & De los Ríos, 2006).