APPENDIX A

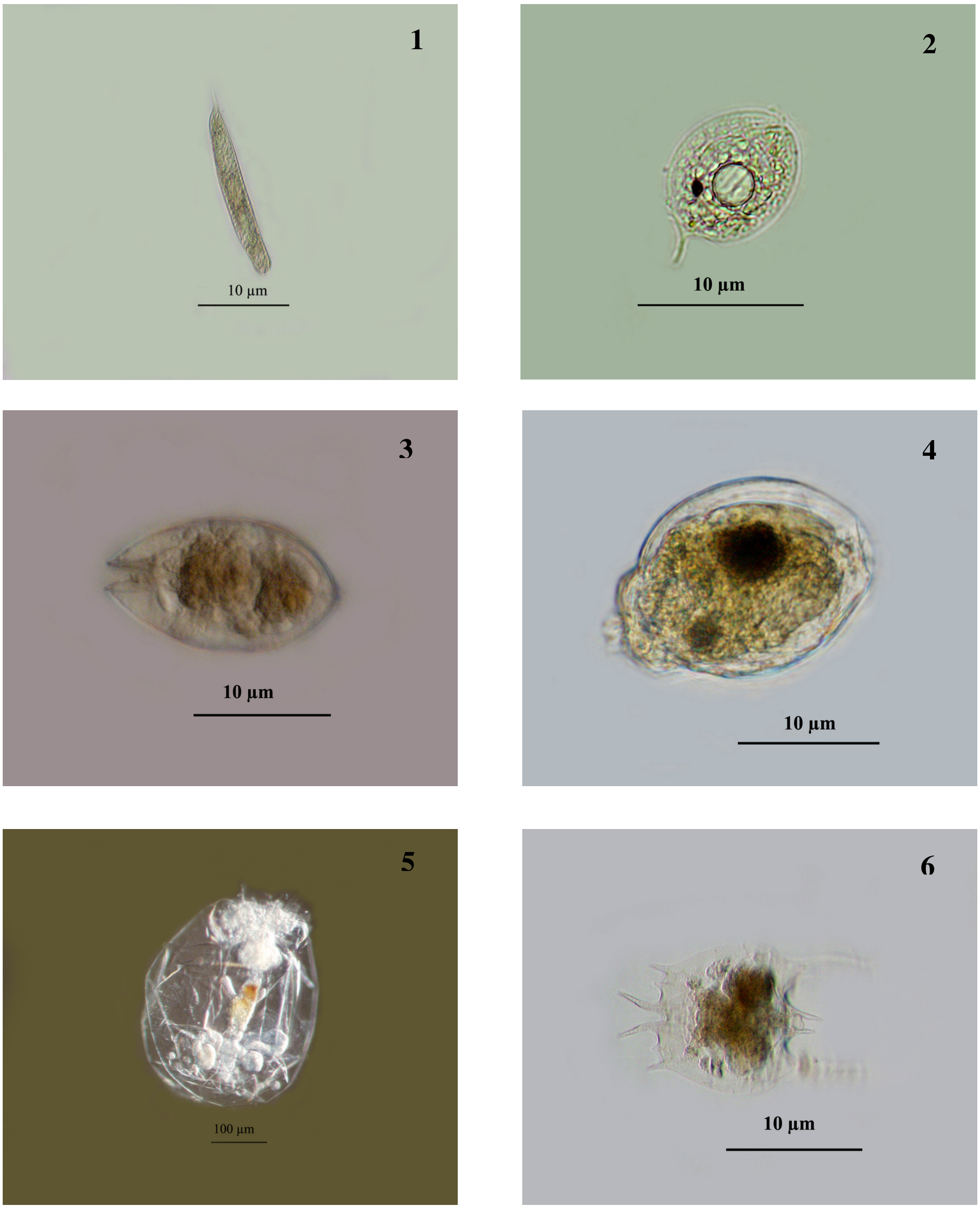


Figure 1 : *Euglena* sp. 2 : *Phacus* sp.

3 : *Anuraeopsis fissa* 4 : *Ascomorpha* sp.

5 : *Asplanchna* sp. 6 : *Brachionus quadridentatus*

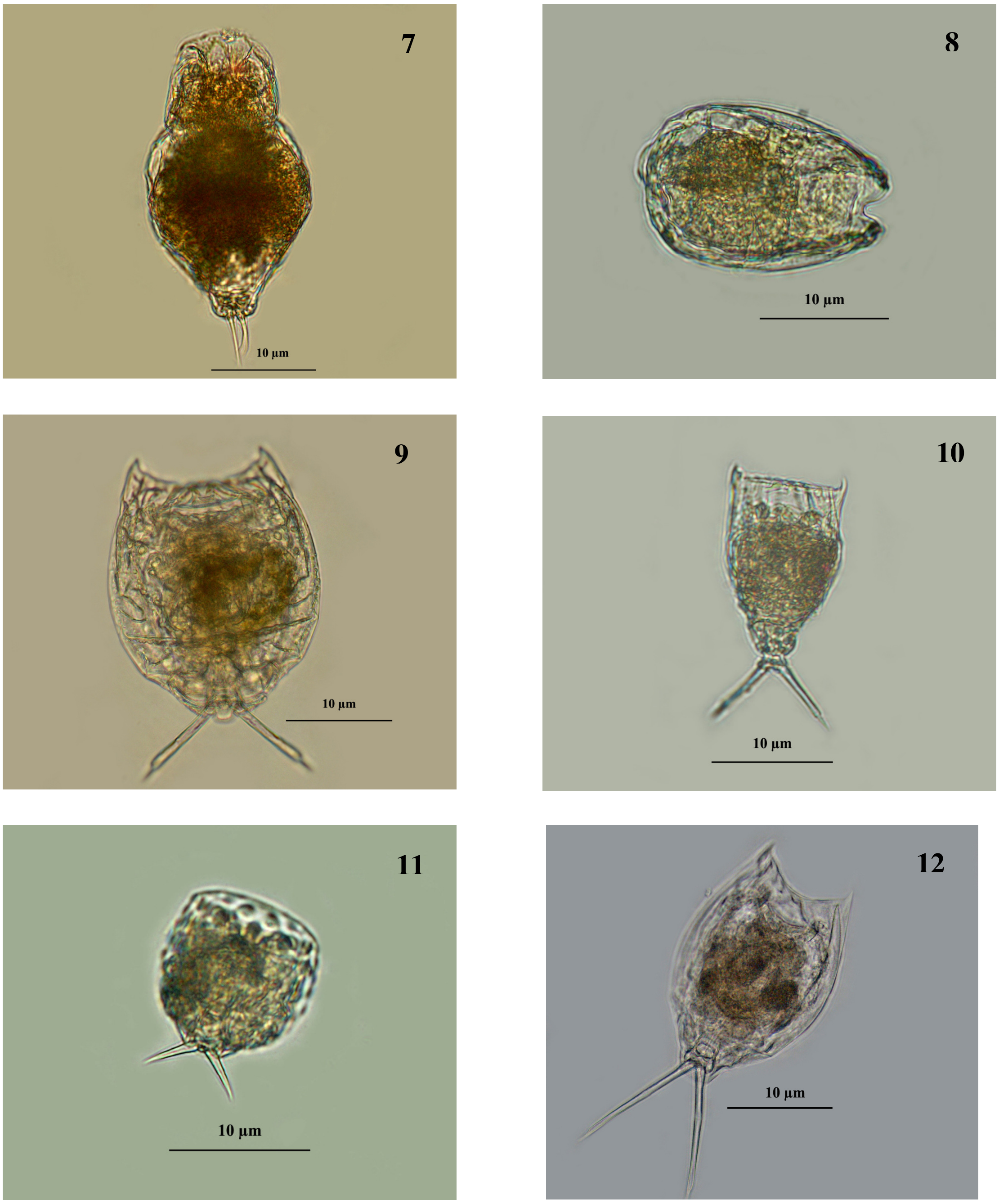


Figure 7 : *Dicranophoroides* sp. 8 : *Lecane bulla*

9 : *Lecane curvicornis* 10 : *Lecane crepida*

11 : *Lecane hornemanni* 12 : *Lecane leontina*

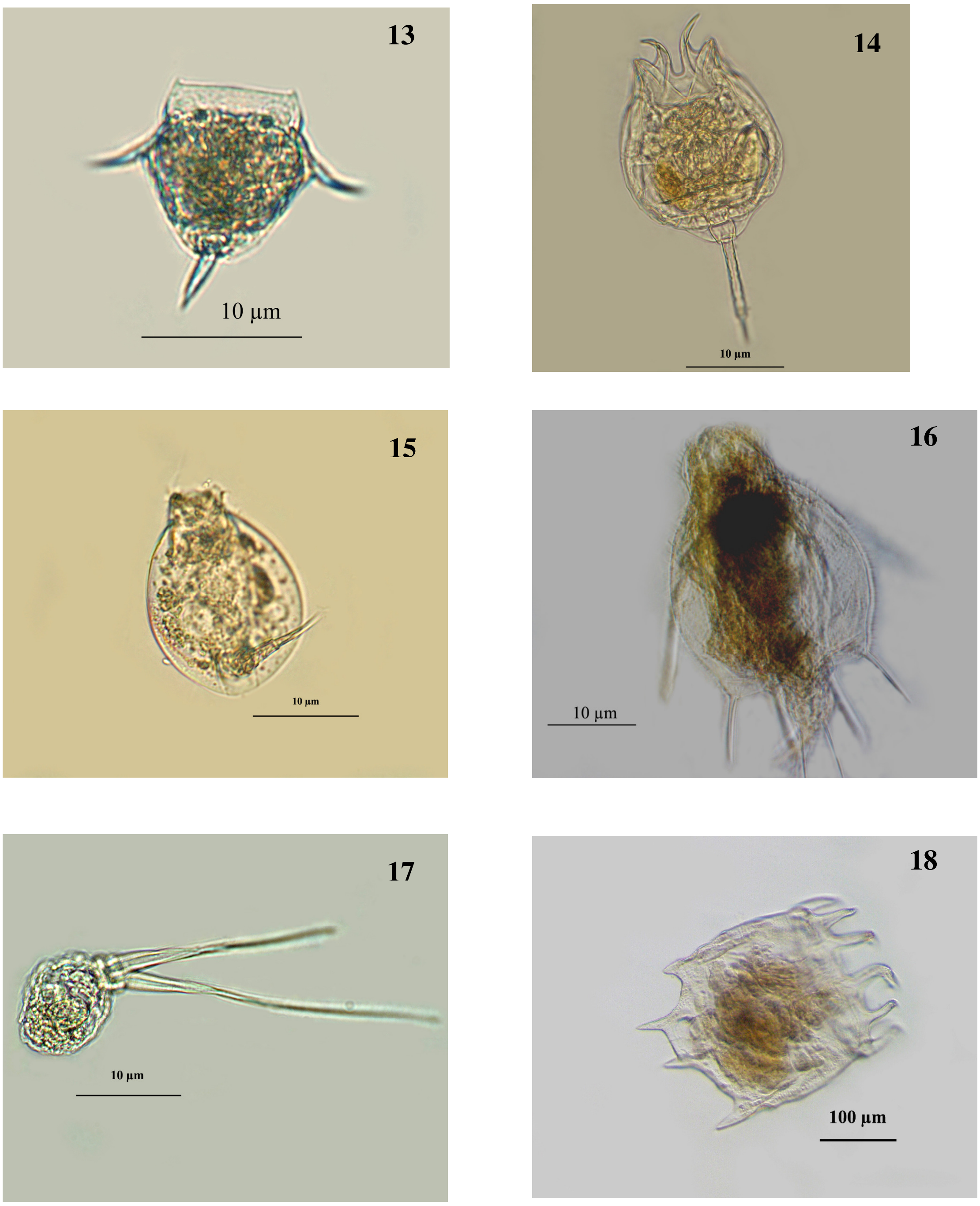


Figure 13 : *Lecane monostyla*

14 : *Lecane quadridentata*

15 : *Lepadella* sp.

16 : *Macrochaetus* sp.

17 : *Monommata* sp.

18 : *Plationus* sp.

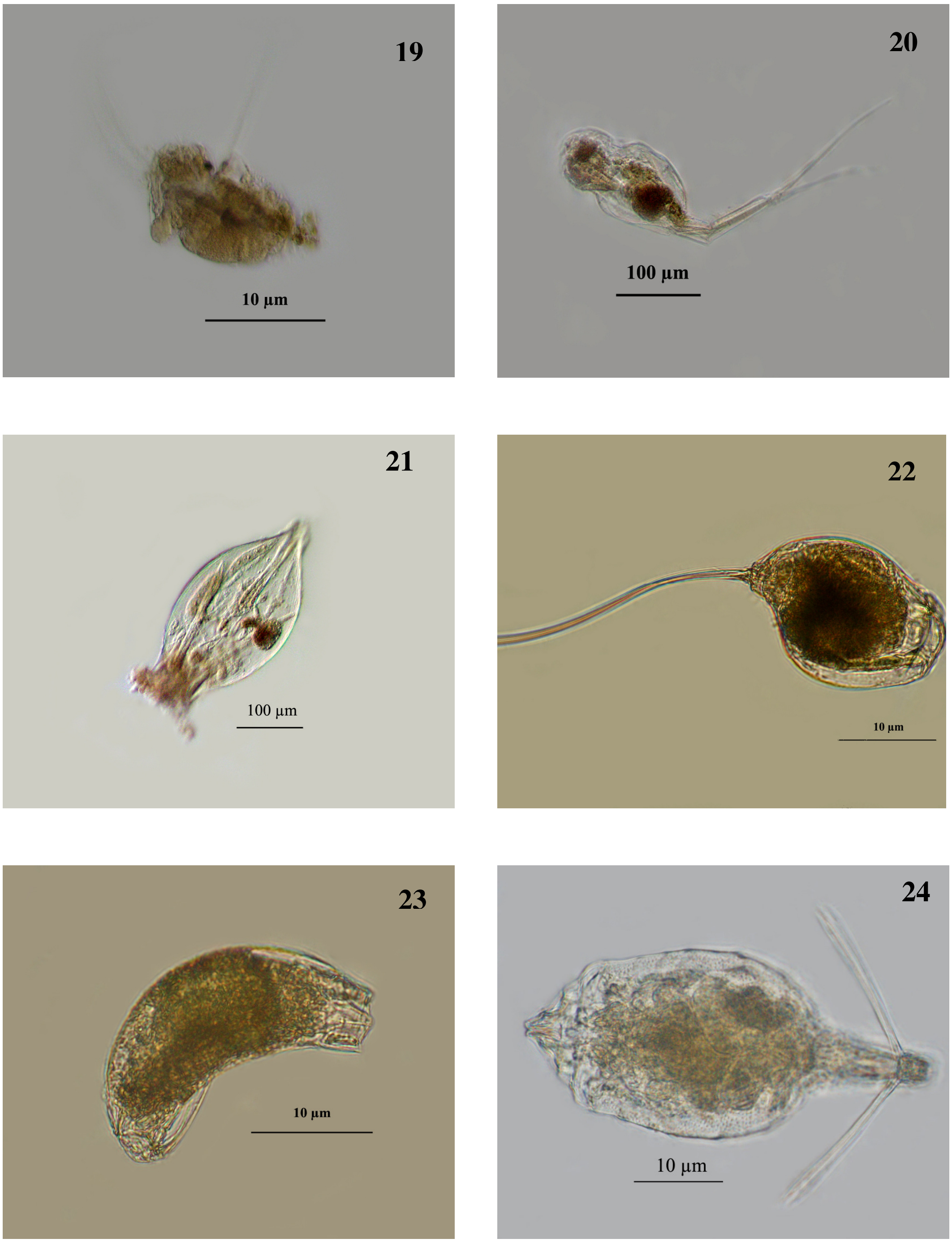
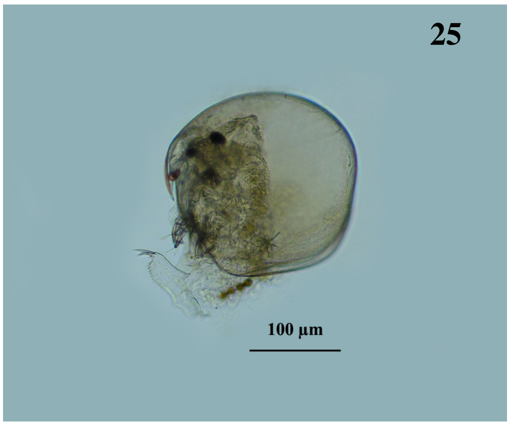
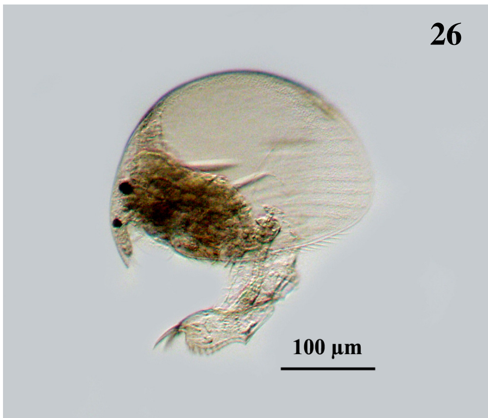


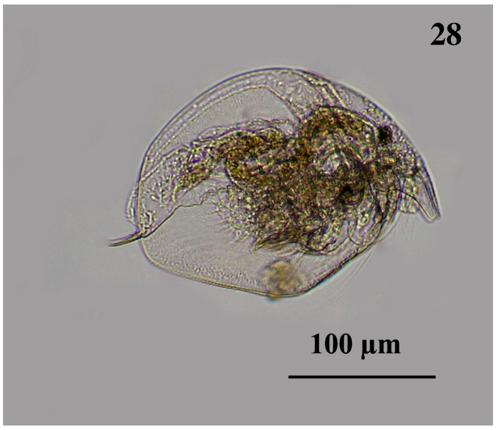
Figure 19 : *Polyarthra* sp. 20 : *Scaridium* sp.

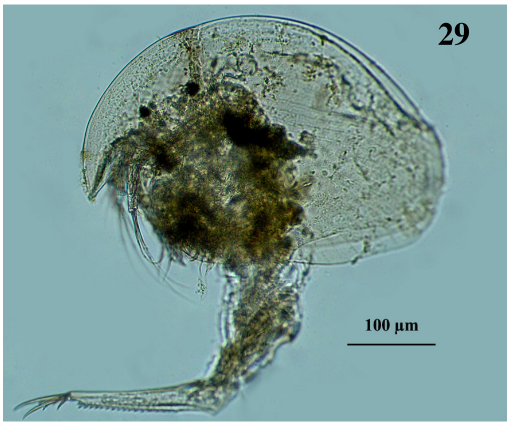
21 : *Testudinella* sp. 22 : *Trichocerca flagellata*

23 : *Trichocerca tropis* 24 : *Trichotria* sp.









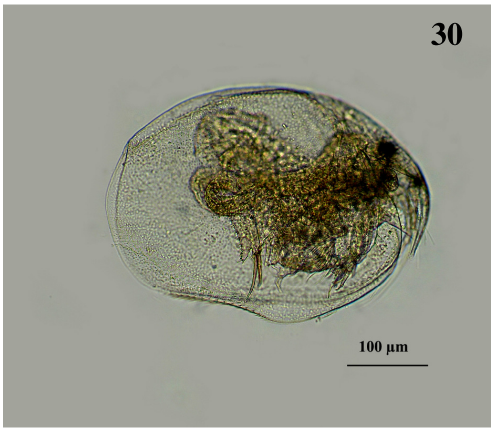


Figure 25 : *Chydorus* sp. 26 : *Alona verucosa*

27 : *Alona* sp. 28 : *Alona sarasinorum*

29 : *Camptocercus australis* 30 : *Kurzia* sp.

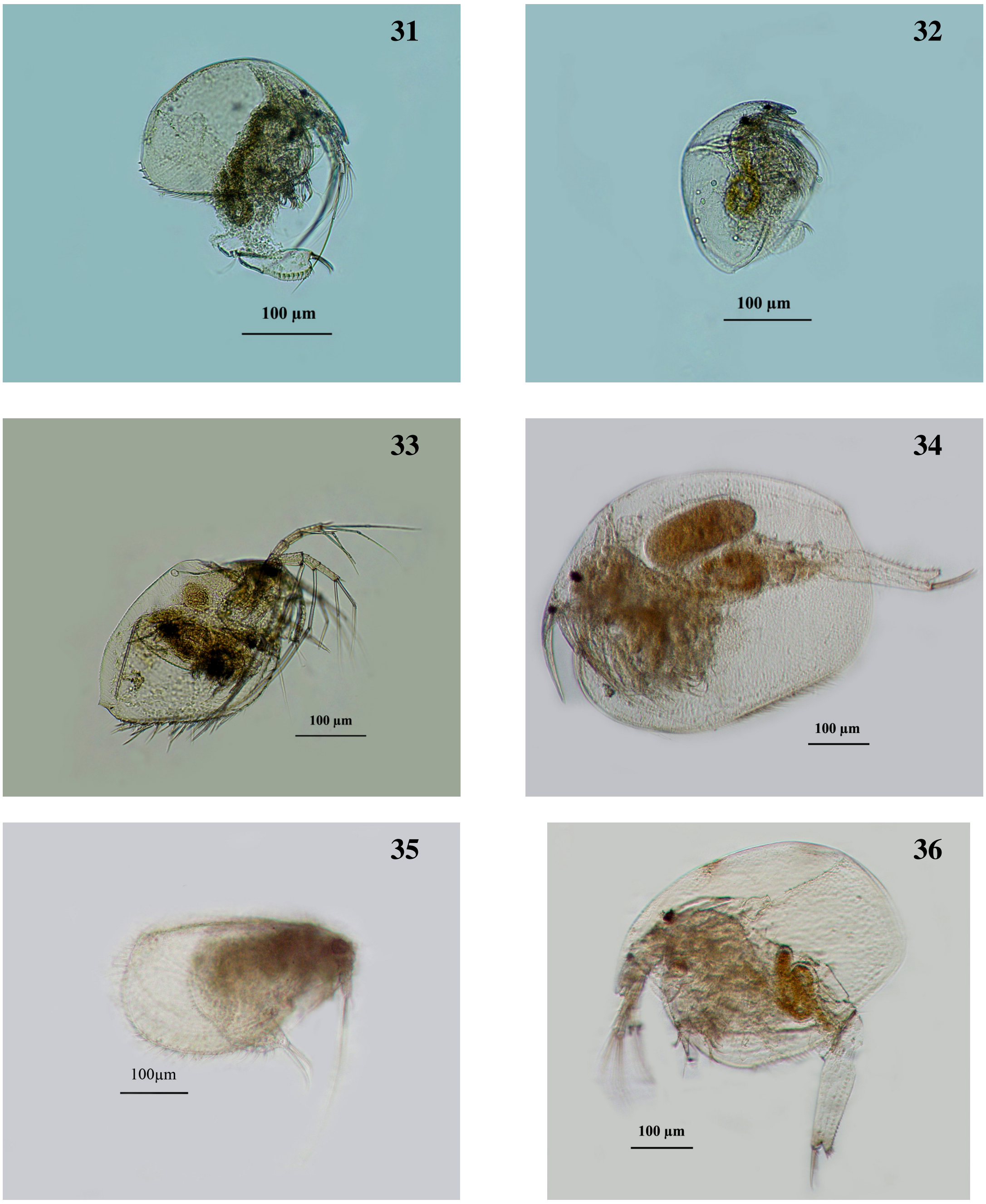


Figure 31 : *Karaualona* sp. 32 : *Dunhevedia crassa*

33 : *Macrothrix* sp. 34 : *Kurzia longirostris*

35 : *Ilyocryptus* sp. 36 : *Euryalona* sp.

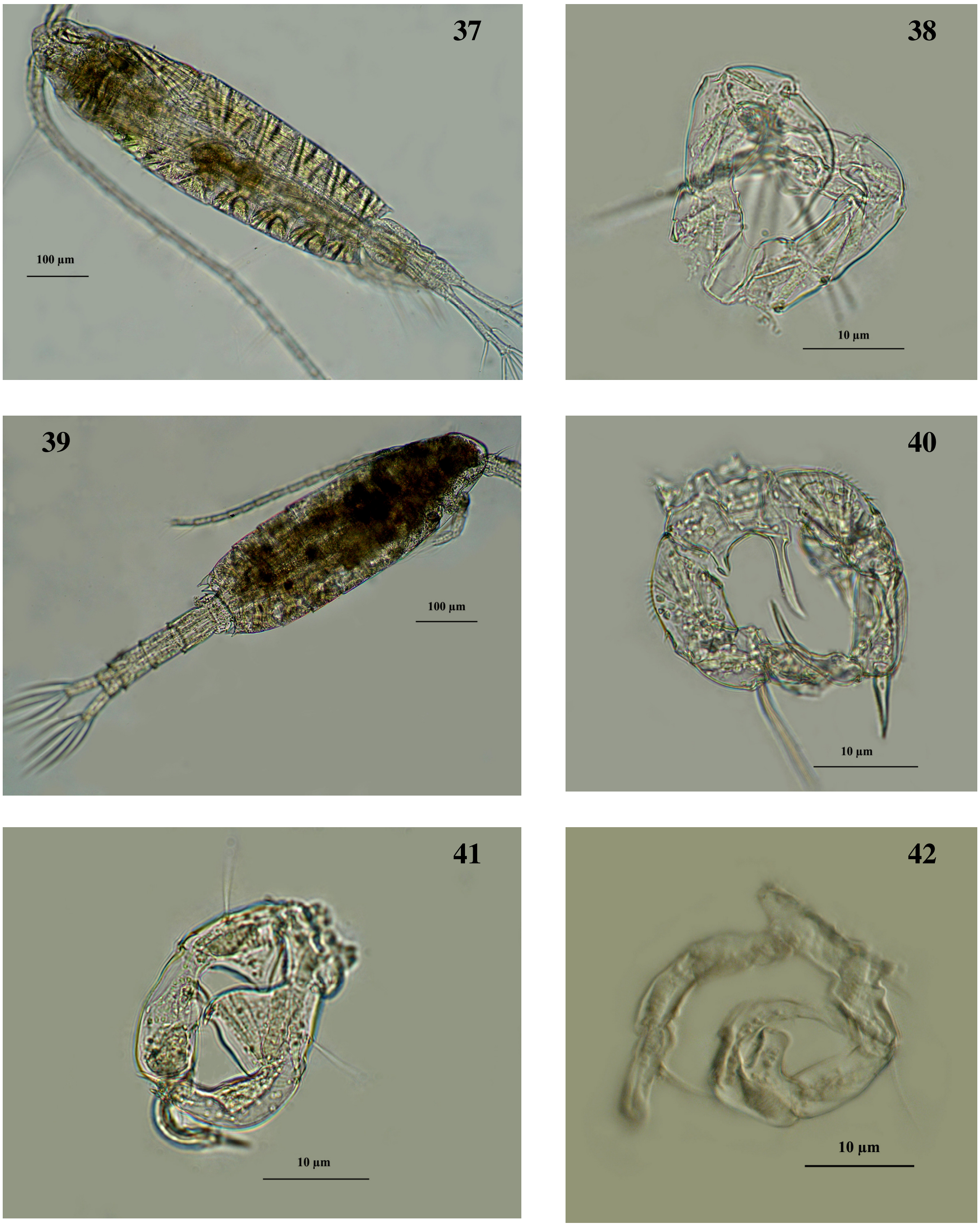


Figure 37 : *Sinocalanus* sp.

38: P5 *Sinocalanus* sp.

39 : *Pseudodiaptomus* sp.

40 : P5 *Pseudodiaptomus* sp.

41 : P5 *Acartiella sinensis*

42 : P5 *Acartia* cf. *southwelli*

Annual Changes of Zooplankton Communities of Different Size Fractions

in Thale-Noi, Phatthalung Province

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ABSTRACT

Annual changes of zooplankton communities of different size fractions in Thale-Noi, Phatthalung province were investigated over three periods: the light rainy period (July, August 2004), the rainy period (November, December 2004), and the dry period (March, April 2005); and in four different zones: the peat swamp, small inlet, resident and pelagic zones. Measurements of 10 physical, chemical and biological variables, species composition, and the abundance of micro- and mesozooplankton were taken twice a month. Microzooplankton of fraction size 20-200 µm consistently dominated in the total abundance (95%). However, two seasonal microzooplankton peaks were observed: one during the rainy period ($1.57x10^6$ $ind.m^{-3}$) and the other during the dry period ($1.36x10^6$ $ind.m^{-3}$). Protozoa were dominant, followed by Rotifera, crustacean nuaplii, juvenile ostracods, Cladocera, Copepodite copepods and Copepoda, respectively. Mesozooplankton of fraction size >200 µm showed a clear peak ($3.9x10^5 ind.m^{-3}$) in the rainy period. Predominant mesozooplankton were Cladocera, Copepoda, Rotifera, Protozoa, Ostracoda, shrimp larvae, mollusk larvae, crab larvae and fish larvae, respectively. The results showed that there were spatial and temporal differences in dominance of zooplankton genera. However, the dominant microzooplankton groups in all zones were Protozoa *Trachelomonas* spp. and *Peridinium* sp., particularly during the rainy to dry periods, and Rotifera *Polyarthra* spp. and *Anuraeposis* spp. in the light rainy period. In the mesozooplankton community found that Cladocera was the most abundant group in all zones and during all periods, except in the small inlet and pelagic zones where Copepoda was the most abundant group during the low water period. The dominant species of Cladocera were *Bosminopsis deitersi* and *Chydorus* spp. and of Copepoda were *Acartiella sinensis* and *Pseudodiaptomus* sp. CCA analysis revealed that most of a significant variables influencing different zooplankton assemblage in the three sampling periods were temperature, pH, transparency, conductivity, total solids, dissolved oxygen.

KEYWORDS: Annual Changes, Zooplankton Communities, Size Fractions, Thale-Noi

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Introduction

Thale-Noi is an important bird sanctuary in Southern Thailand (Pholpunthin, 1997). It contains a rich biodiversity, the resources of which enable local residents to earn a living from activities such as fishing, agriculture, handicraft and especially tourism (Leingpornpan and Leingpornpan, 2005; Tunsakul *et al.,* 1986). Because of this, Thale-Noi has been named the first Ramsar Site in Thailand (Aiumnau *et al.,* 2000). This area has complex and sensitive ecosystems, thus, it is necessary for conservation and preservation biodiversity to utilize the resources sustainably. However, due to the ongoing expansion of near-shore villages, waste water is being constantly discharged into the lake (Nookua, 2003; Tunsakul, 1983). The result is that the Thale-Noi ecosystem and its water quality are subject to continuously changing and unnatural sources (Leingpornpan and Leingpornpan, 2005). The waste water adds nutrients to the lake, which affects the aquatic community structure and may lead to the destruction of the food web in the area. Understanding the factors involved in the control of the aquatic food web structure is key to understanding the changes in recruitment success for aquatic animals (Pedersen *et al*., 2005). Moreover, any changes to the zooplankton community can be an indicator of status changes within the lake.

Zooplankton communities are highly sensitive to environmental variation. Changes in their abundance, species diversity, or community composition can provide important indications of environmental change or disturbance (Branco *et al*., 2002). Some species of rotifers, such as *Brachionus calyciflorus* Pallas and *Keratella tecta* (Gosse) are species indicators in waste water (Sanoamuang, 2002). Rotifers often respond quickly to environmental change because most species have short generation times (Keppeler and Hardy, 2004). Protozoa are considered a major link in the limnetic food web and perform key functions in energy flow and element cycling in freshwater ecosystems (Xu *et al*., 2005).

The previous study of zooplankton in Thale-Noi has been intensively investigated especially with regard to their taxonomy and spatial distribution (Pholpunthin, 1997; Segers and Pholpunthin, 1997). Few studies had provided information on seasonal changes in the abundance of zooplankton (Angsupanich, 1985; Angsupanich and Rukkhiaw, 1984). Although ecological knowledge of zooplankton in freshwaters is important for understanding the functioning of aquatic ecosystems, such knowledge is still rather scarce regarding Thale-Noi.

Therefore, in order to find out, the seasonal and spatial variations of zooplankton different size fractions in Thale-Noi, as well as the possible influence of environmental parameters on the zooplankton community.

Materials and Methods

Study site

Thale-Noi, a shallow roundish lake, is located at the northernmost end of the overall Songkhla lake system in Phatthalung Province, Southern Thailand (Buapetch, 2002) between latitude 7° 45′ N to 7° 55′ N and longitude 100° 05′ E to 100° 15′ E (Pholpunthin, 1997). It covers an area of 30 km^2, has a shoreline of about 20 km, and contains about 32 M m^3 of water (Kuwabara, 1995). Thale-Noi is one of the few surviving intact freshwater wetland ecosystems in Thailand. It comprises several distinct topological areas: swamp forest, lake, moist evergreen forest and agricultural lands (Storer, 1977). All of these areas are important feeding sites for bird and wildlife species including aquatic animals, phytoplankton and zooplankton. Thale-Noi is an important waterfowl reserve in Southern Thailand (Leingpornpan and Leingpornpan, 2005). More than 187 species of waterfowl, including both migratory and indigenous birds, make their home at Thale-Noi. The principal inflow to the lake is the runoff from the steep forested slopes of the Banthad Mountains to the west. Outflow is via the Klong Nang Riam, Klong Ban Glang and Klong Yuan canals into Thale Luang, Lake Songkhla. The lake is rather shallow with a mean depth of 1.2m but water levels can fluctuate up to one meter, typically reaching their lowest level in August. The lake is normally fresh to slightly saline (1.48 ppt). The salinity may rise during the driest months (to 3.5 ppt) when saline water from Lake Songkhla may intrude. The pH varies spatially and seasonally from 1.2 - 8.1 (average 4.4). The northern end (near the *Melaleuca* swamp forest) is more acidic than the south. Acidity increases during the rainy season from the leaching of acidic humus. The climate is tropical monsoon with an average annual rainfall of 2,208 mm, and the mean pan evaporation rate is 1,753 mm (Aiumnau *et al.,* 2000).

Zooplankton sampling and analysis

Quantitative zooplankton samples were taken using two sampling methods. The first was a horizontal towing using a 200 μm plankton net fitted with a flow meter towed by a low speed boat for three minutes. The second was a filtration of 20-50 liters of water through a 20 μm plankton net. The zooplankton samples were immediately preserved in a 5% formaldehyde solution and brought to the laboratory for further analysis. Zooplankton sampling was conducted twice a month in three bimonthly periods, comprising the moderate-water phase (light rainy period) in July and August 2004, the high-water phase (rainy period) in November and December 2004, and the low-water phase (dry period) in March and April 2005. Plankton samples were collected at twelve stations of four different habitats in Thale-Noi: a peat swamp zone (Station 1, 2, 3), a small inlet zone (Station 4, 5, 6), a resident zone (Station 7, 8, 9) and a pelagic zone (Station 10, 11, 12) (Fig. 1).

In the laboratory, the 20 µm net samples were separated into two nominal size fractions: 20-200 µm (microzooplankton), and > 200 µm (mesozooplankton) by filtering plankton samples through a 200 µm sieve. Between 50% and 100% of all specimens, from the two sampling methods, were counted and identified to genus or species levels using Olympus CH-2 Compound and Olympus SZ-40 Stereo microscopes. At each station, depth, transparency, conductivity, temperature, salinity and pH were measured *in situ*. Water samples were analyzed for total solids, dissolved oxygen and chlorophyll *a* in laboratory conditions following the Standard Method (APHA, AWWA, and WEF, 1998). The correlation between the abundance of each zooplankton genus and environmental factors was investigated at each zone and during each period by Canonical Correspondence Analysis (CCA).

Results and Discussion

Species composition and diversity

The microzooplankton composition of Thale-Noi consists of 22 genera of Protozoa, 32 genera of Rotifera, 13 genera of Cladocera and 3 genera of Copepoda, including larvae and juvenile forms such as Ostracod juvenile, Crustracean nauplii and copepodite of Copepoda (Table 1). While the mesozooplankton composition consists of three genera of Protozoa, two genera of Rotifera, 28 genera of Cladocera, three genera of Ostracoda and 11 genera of Copepoda, including other invertebrates such as Shrimp larvae, Gastopod larvae, Bivalve larvae, Crab larvae and Fish larvae (Table 2). The largest number of genera was found in the rainy period. It may be due to the freshwater movement from other parts of the lake has a strong influence and the intrusion effect flushes several species out of the lake. This, in turn, allows protozoans, rotifers, cladocerans and copepods to grow, even in areas covered with macrophyte, such as the peat swamp and resident zones which have a higher number of taxa, especially rotifers and cladocerans than those of other areas. This observation is similar to those found by Jithlang and Wongrat (2004) and Pinto-Coelho *et al.* (2005). Rotifera was the group with the highest taxonomic richness (33 genera) in Thale-Noi. This result concurs with reports from other freshwater environments, especially in the tropical region (Starling, 2000; Sampaio *et al.*, 2002; Akin-Oriola, 2003; Keppeler, 2003; Wansuang and Sanoamuang, 2006). The large species number of this group is due to the fact it is considered to be an opportunistic species in different environments (Keppeler, 2003). Cladocera was the second most diverse group of the community. This may have been due to Thale-Noi having diverse aquatic plants which act as a habitat, food source and refuge for cladocerans.

Relative abundance and density of zooplankton

In Thale-Noi, microzooplankton community was dominated by Protozoa and Rotifera, which made up nearly 70% of the total microzooplankhton (Fig. 2). In this study, the dominant zooplankton groups exhibit differences with previous research (Chiayvareesajja *et al.,* 1988; Angsupanich, 1995). They reported that rotifers were the most abundant group throughout the study, followed by nauplii larvae or copepodite stages. The scarcity of protozoans in their samples suggests that they could have used a mesh diameter wider than 20 µm, and this could have led to underestimating the quantity of smaller organisms. This may be one reason why there was a lack of small groups in previous studies as compared to this study. However, it is difficult to make definite conclusions on the causes of group differences between different studies because of the differences in sample size, differences in sampling methods and differences in sampling frequencies. There was a succession of microzooplankton species throughout the year. During the light rainy period, different species of rotifers alternated in dominance, represented mainly by *Polyarthra* and *Anuraeopsis*. This is supported by the fact that these genera were commonly found in many other lakes (Naves *et al*., 2003; Yildiz *et al*., 2007) and were dominant species in tropical freshwater environments (Jithlang and Wongrat, 2004). In the rainy period, low water temperature and high rainfall led to a decrease in rotifer populations and they were replaced by protozoans, represented by *Trachelomonas* and *Peridinium*. Up until the dry period, protozoans were strongly dominant in the community. This is similar to the findings of Graham *et al.* (2004), who found that *Peridinium limbatum* was the dominant dinoflagellate in the sense that it persisted throughout the entire open-water season and was the dominant community in the summer. The high population density of rotifers has been attributed to their parthenogenesis reproductive pattern, short life cycles and wide tolerance to a variety of environmental factors (Akin-Oriola, 2003; Keppeler and Hardy, 2004; Park and Marshall, 2000). The abundance of protozoans suggests that it plays a substantial role in nutrient regeneration in the water column, indicating that they often become the main zooplankton in the community. This suggests that protozoans must have a key trophic role that may contribute to the high productivity of the lake food web (Pirlot *et al*., 2005). Regarding spatial variation, there were no significant differences in microzooplankton density among zones. However, microzooplankton densities at stations located at the small inlet zone, connected to Songkhla Lake, were high as compared to those of other zones. It may be that this zone had high water level and inputs of suspended sediments.

The Mesozooplankton group, Cladocera was found to have a relatively high abundance of > 80% in the rainy period while Copepoda and other groups showed a relatively high level of abundance in the light rainy and dry periods (Fig. 3). The higher densities of mesozooplankton in the rainy period associated with eutrophic water mass may be due to increased quantities of pico-nanophytoplankton and microzooplankton, which are consumed by the mesozooplankton (Pedersen *et al*., 2005). In addition, the absence or low density of fish, crab and shrimp larvae (predators of zooplankton) during the rainy period may be one of the main causes of the increase in small mesozooplankton. There was a succession of mesozooplankton species throughout the year. Cladocera, mainly *Chydorus* spp., *Bosminopsis deitersi*, Copepoda *Neodiaptomus yangtsekiangensis* and *Acartiella sinensis* alternated in community dominance in the light rainy period while high densities of Cladocera were registered mainly in the rainy period, especially *Bosminopsis deitersi*. In the dry period, the mesozooplankton community was dominated by Cladocera *Chydorus* spp. and *Dunhevedia crassa.* Regarding spatial variations, total mesozooplankton abundance was higher for the small inlet and pelagic zones than for the peat swamp and resident zones. This high abundance could possibly be due to high densities of cladoceran *Bosminopsis deitersi* during late November, copepods, mainly *Pseudodiaptomus* sp. in early March, and *Metacyclops* sp. in late march. The food supplied by freshwater inflow through the small inlets during the rainy period in November and December seemed to be important for inducing growth of all zooplankton taxa when salinity was very low (Angsupanich and Rukkheaw, 1997).

Relationships between zooplankton densities and environmental parameters

From CCA analysis it was revealed that, besides changes in seasonal temperature, salinity and total solids, the main environmental gradients were due to pH, transparency and dissolved oxygen. According to the present results, the conductivity and pH increased while depth and transparency decreased during the light rainy period. This was due to very low rainfall and a lack of sediment flow which caused inorganic matters to accumulate, especially at the bottom. Similar results have been found in Thale-Noi (Nookua, 2003). The most abundant microzooplankton, such as *Loxodes, Peranema, Stentor, Anuraeopsis, Brachionus, Colurella, Collotheca, Euchlanis, Filinia, Hexathra, Lepadella, Macrochaetus, Testudinella, Trichocerca, Proales, Mytilina* and *Alona,* and species within the mesozooplankton community, such as *Moina, Moinodaphnia, Neodiaptomus* and *Mesocyclops,* reacted positively to conductivity and pH, but negatively to depth and transparency (Fig. 4 and Fig. 5). It can be suggested that most of these genera have an optimum set of environmental conditions to ensure their survival. These findings were similar to those findings from the Funil Reservoir (Branco *et al.,* 2002), where *Hexathra mira* and amoeba related to low water transparency, while *Filinia longiseta* were the taxa most positively correlated with high water transparency. Wang *et al.* (2007) found that *Moina micrura* peaked in lakes with low SD (secchi disk visibility) and depth, and suggested that temperature seemed to be an important factor when determining the dominance of *Moina micrura*. Some taxons appeared in Lago Amapa at basic or neutral pH and relatively low dissolved oxygen levels, such as *Platyas guadricornis, Lepadella ovalis, Trichocerca similis and Testudinella patina*. The researchers suggested that these factors are not considered limiting for those species studied in the lake (Keppeler and Hardy, 2004). However, among rotifers, along with *Euchlanis dilatata, Trichocerca* sp., *Pompholyx* sp., *Keratell quadrata* and *Filinia longiseta* were often found in eutrophic lakes (Bekleyen, 2003).

Protozoans *Centropyxis, Euglyphra, Halteria, Tracheomonas, Undella,* rotifers *Plationus,* cladocerans *Alona, Chydorus, Ephmeroporus*, *Karualona, Macrothrix*, *Latonopsis*, ostracods*, Cypricercus, Stenocypris,* and copepods *Acartia, Euryalona, Metacyclops* and *Thermocyclops* were the most abundant and frequently observed taxa during the dry period. Although, this period has generally low rainfall, it was higher than that in the light rainy period. On the other hand, there was a gradient of moderate to high total solids, salinity, pH, conductivity, and the highest levels of dissolved oxygen and water temperature. The favourable combination of several factors, including intrusion effects from Thale Luang, results in Thale-Noi being colonized by a high biomass during the dry period, that is, phytoplankton, small zooplankton, vegetation, birds and shrimp (Storer, 1977; Tunsakul, 1983; Nookua, 2003; Leingpornpan and Leingporpun, 2005; Inpang, 2007). Protozoans are important components of microzooplankton communities in lakes during the dry period (Pirlot *et al.*, 2005). Dabes and Velho (2001) reported that the protozoan genus *Centropysis* was equally abundant in both the dry and the rainy seasons. Moreover, they found that some groups of species such as *Centropyxis* spp. and *Diffugiella* sp. were more abundant in the dry season, while *Diffugia, Euglypha* and *Trinema* spp. were more abundant during the rainy season (Dabes and Velho, 2001). Among factors that strongly influence the population density of planktonic protozoans are water quality, quantity of available food, temperature, and predation (Beaver and Crisman, 1990 cited by Xu *et al,* 2005). Cladoceran populations have been associated with trophic gradients in other lakes (Branco *et al.,* 2002). Pinto-Coelho *et al*. (2005a) suggested that cladocerans often occurred simultaneously with blooms of cyanobacteria and floating macrophytes, similar to Nookua (2003) who documented that high densities of blue green algae in Thale-Noi were observed in the dry period and who also found that Cyanophyta has a positive correlation with temperature in April. In addition, the studies of Leingpornpan and Leingpornpan (2005) on aquatic plants and their distribution mapping in Thale Noi Lake, found that the covering of aquatic plants in the dry period was higher than that in the rainy period. Thus, the presence of macrophyte beds in Thale-Noi also influences the zooplankton composition by including Cladocera (Fam.Chydoridae) as observed in the Formosa Pond, Brazilia (Starling, 2000) and in Lake Hanebjerb, Denmark (Romare *et al.,* 2003). Cladoceran species, especially *Chydorus,* live in vegetation habitats most probably to avoid predators such as midges (Goulden, 1971). Among the copepods, *Thermacyclops and Mesocyclops* are predominant in the lake during this period, and are associated with feeding, hunting for large phytoplankton cells, or eating colonies of Cyanophyceae and small zooplankton, such as the nauplii of other species of Copepoda (Sampaio *et al*., 2002).

In the rainy period, a period associated with the greatest water depth, were found *Arcella*, *Peridinium, Phacus, Lepocinclis, Asplanchna, Ascomorpha, Lecane, Polyarthra*, *Bosminopsis, Ceriodahnia, Diaphanosoma, Ilyocryptus* and

Microcyclops. These findings can be related to low levels of salinity, total solids, pH and temperature, but moderate dissolved oxygen. Due to high rainfall during the rainy season, the lake water composition is affected by the ingress of water from the upper stream, the swamp forest, and the land which brings nutrient enrichment into the lake. As a result, some species of microzooplankton such as flagellate phytoplankton, become the primary producer and are well represented in terms of total density in Thale-Noi, similar to Chaohu Lake (Xu *et al*., 2005). One might expect that small rotifer populations would be correspondingly large later on. *Polyarthra* can consume diverse food particles and it appears that niche differentiation among related species has a strong influence on Rotifera assemblage composition and diversity via competitive interactions (Sampaio *et al*., 2002). The three dominant cladocerans, *Bosminopsis, Ceriodaphnia and Diaphanosoma,* occurred frequently and were relatively dominant in Thale-Noi, although being less competitive in exploiting resources than daphnia (Wang *et al.,* 2007). Some researchers believe that the predominance of small cladocerans (*Bosmina* and *Ceriodaphnia*) is related to the interference of filamentous blue green algae, which dominate the phytoplankton under eutrophic conditions (Sampaio *et al*., 2002).

Acknowledgments

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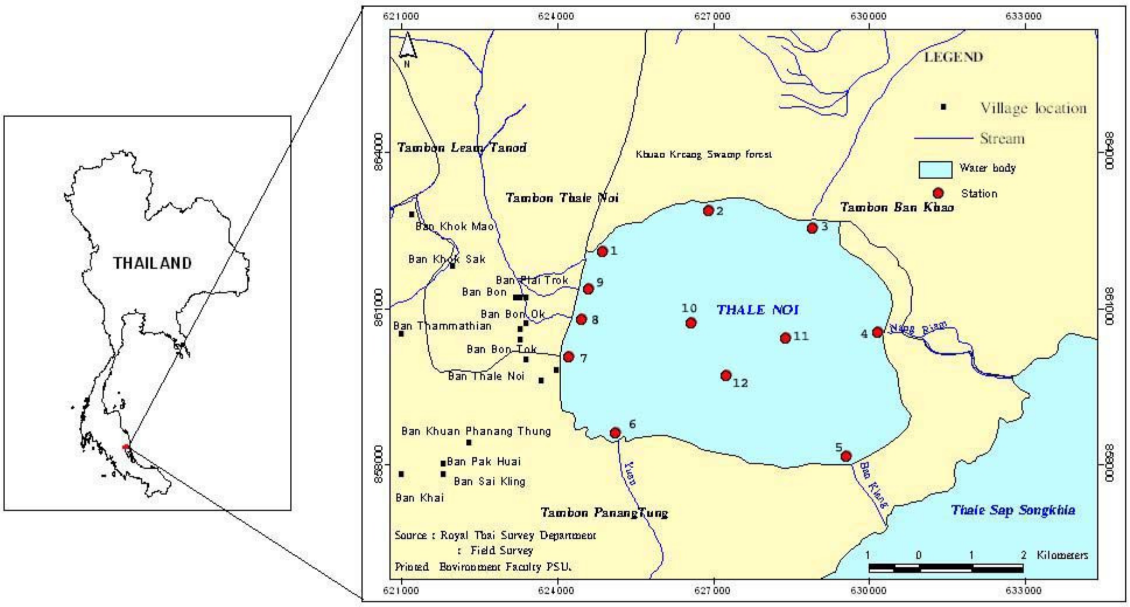

Figure 1. Study area and sampling stations in Thale-Noi, Phatthalung Province.

Table 1. Taxonomic composition, density, peak and occurrence of microzooplankton community from Thale-Noi lake in four different habitats (Z1; Peat swamp, Z2; Small inlet, Z3; Resident and Z4; Pelagic) during three periods (light rainy period; July to August 2004, rainy period; November to December 2004 and dry period; March to April 2005). + = present and - = absent in the waterbody.

Taxa	**Total density** (ind.m^{-3})	**Peak** (ind.m^{-3})	**Light rainy**				**Rainy**				**Dry**			
			Z 1	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**
Phylum Protozoa														
Genus *Actinophrys*	10463	5250	-	-	-	-	-	+	+	-	-	-	-	-
Arcella	274921	42857	+	-	-	-	+	+	+	+	+	+	+	+
Centropyxis	210150	27429	+	+	+	+	+	+	+	+	+	+	+	+
Ceratium	67	67	-	-	-	-	-	-	-	-	-	-	-	+
Codonella	24598	11400	-	-	-	-	+	-	-	-	+	+	+	-
Coleps	99473	22200	+	-	+	-	+	-	-	-	+	+	+	+
Diffugia	146214	100000	+	-	-	-	+	-	+	+	+	+	+	+
Dinobryon	1549414	1250000	-	-	-	+	+	-	-	+	+	-	-	+
Euglena	3588050	310714	+	+	+	+	+	+	+	+	+	+	+	+
Euglyphra	80482	7650	+	+	+	-	+	-	+	-	+	+	+	+
Halteria	178145	28560	+	+	+	+	+	+	+	+	+	+	+	+
Holophrya	60136	48000	-	-	-	-	+	-	-	+	+	+	+	+
Lepocinclis	368963	114793	-	-	-	-	+	+	+	+	+	+	+	+
Loxodes	45636	8571	+	+	+	+	+	-	+	-	+	-	-	-
Paramecium	15643	4003	+	+	+	+	-	-	+	-	+	-	-	-
Peranema	40170	8571	+	-	+	+	+	-	+	+	+	+	+	+
Peridinium	10231411	1343232	-	-	-	-	+	+	+	+	+	+	+	+
Phacus	4193500	692861	+	+	+	+	+	+	+	+	+	+	+	+
Stentor	620831	142286	+	+	+	+	+	+	+	+	+	+	+	+
Tintinopsis	328389	174825	+	+	+	+	-	+	-	+	+	+	+	+
Trachelomonas	33316025	4950000	+	-	+	-	+	+	+	+	+	+	+	+
Undella	47451	20571	-	-	-	-	+	+	-	+	+	+	+	+
Phylum Rotifera														
Genus *Anuraeopsis*														
A. coelata (De Beauchamp)	46435	723	+	+	-	+	+	+	+	+	-	-	-	-
A. fissa (Gosse)	3844231	543000	+	+	+	+	+	+	+	+	+	+	+	+
A. navicula (Rousselet)	341737	128143	+	+	+	+	-	+	+	+	+	+	-	+
Genus *Ascomorpha*														
Ascomorpha spp.	724099	141964	+	+	-	+	+	+	+	+	+	+	-	+
Genus *Asplanchna*														
Asplanchna sp.	131843	45911	+	+	+	+	+	+	+	+	-	+	+	+
Genus *Brachionus*														
Brachionus spp.	611677	125571	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Cephalodella*														
Cephalodella spp.	257555	72616	+	+	+	+	+	+	+	+	+	+	-	-
Genus *Collotheca*														
Collotheca spp.	225302	66000	-	+	+	+	-	-	+	+	+	-	-	+
Genus *Colurella*														
C. obtusa (Gosse)	79541	21827	+	+	+	+	+	-	+	-	-	-	-	-
C. sulcata (stenroos)	32273	7809	+	+	+	+	-	-	-	-	-	-	-	-
C. spp.	191405	14282	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Dicranophorus*														
Dicranophorus spp.	6760	2250	+	-	-	+	-	+	-	-	-	-	-	-
Genus *Dicranophoroides*														
Dicranophoroides sp.	529	461	-	-	-	-	-	-	-	-	+	-	-	+
Genus *Dipleuchlanis*														
Dipleuchlanis propatula (Gosse)	2243	1200	-	-	-	-	+	-	-	-	+	-	+	-
Genus *Euchlanis*														
Euchlanis dilatata Ehrenberg	76261	375000	+	+	+	+	+	+	+	+	+	+	+	+

Table 1. Continued.

Taxa	**Total density (ind.m^{-3})**	**Peak (ind.m^{-3})**	**Light rainy**				**Rainy**				**Dry**			
			Z 1	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**
Genus *Filinia*														
Filinia spp.	221925	91286	+	+	+	+	+	+	+	+	-	+	-	+
Genus *Floscularia*														
Floscularia sp.	1936	1500	-	-	-	-	-	-	-	-	+	+	-	+
Genus *Hexathra*														
Hexathra spp.	704179	339806	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Keratella*														
Keratella spp.	5881884	4813714	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Lecane*														
L. aculeata (Jakubski)	3003	2000	+	-	-	+	-	-	-	-	+	-	-	-
L. batillifer (Murray)	44715	28575	+	+	+	+	-	-	-	-	-	-	-	-
L. bifurca (Bryce)	8547	2500	-	+	+	+	+	+	+	+	-	-	-	-
L. bulla (Gosse)	351007	72535	+	+	+	+	+	+	+	+	+	+	+	+
L. clara (Bryce)	33429	7864	+	+	+	+	+	+	-	+	+	+	-	-
L. closterocerca (Schmarda)	105457	1442	+	+	+	+	+	+	+	+	+	+	+	+
L. crepida Harring	18898	3568	+	-	+	-	+	+	+	+	+	-	+	-
L. curvicornis (Murray)	25204	7286	+	-	+	-	+	+	-	+	+	-	+	-
L. furcata (Murray)	43425	7077	+	+	+	+	+	+	+	+	+	+	+	+
L. hamata (Stokes)	32338	12040	+	+	+	+	+	+	+	+	+	-	+	+
L. hornemanni (Ehrenberg)	11054	2775	+	+	+	-	+	+	+	+	+	+	-	-
L. inermis (Bryce)	84120	14571	+	+	+	+	+	+	+	+	+	+	+	-
L. leontina (Turner)	9997	1907	-	-	+	+	+	+	+	+	+	+	+	-
L. ludwigi (Eckstein)	5636	3000	-	+	+	+	-	-	-	-	-	-	-	-
L .luna (O.F. Müller)	4421	860	+	+	+	+	-	+	-	-	-	-	-	-
L. lunaris (Ehrenberg)	33376	8571	+	+	+	+	-	+	+	+	+	+	+	+
L. minuta Segers	7348	2571	+	+	+	+	+	-	+	+	-	-	-	-
*L. monostyla (*Daday)	3419	1714	+	-	-	+	+	+	-	-	+	-	-	-
L. nana (Murray)	13865	2863	+	+	-	+	-	+	-	+	+	+	-	-
L. obtusa (Murray)	40364	9000	+	+	+	+	-	+	+	+	+	+	-	-
L. papuana (Murray)	14644	7146	+	+	+	+	+	+	-	-	+	-	+	-
L. pertica Harring & Myers	6207	2301	-	-	-	+	+	-	-	-	+	-	-	-
L. quadridentata (Ehrenberg)	18162	7329	+	+	+	+	-	-	-	+	+	-	+	-
L. signifera (Jennings)	9226	5571	+	-	+	+	-	-	-	-	+	-	+	-
L. sympoda Hauer	214	214	+	-	-	-	-	-	-	-	-	-	-	-
L. undulata Hauer	31721	6515	+	-	+	+	+	+	+	+	+	+	-	+
L. unguitata (Fadeev)	43137	25800	+	+	+	+	+	+	+	+	+	+	+	-
L. ungulata (Gosse)	3540	1315	-	+	-	+	+	+	-	+	+	-	-	-
Genus *Lepadella*														
L. heterostyla Murray	8513	3578	+	-	+	-	-	+	-	-	-	-	+	-
L. spp.	360553	78429	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Macrochaetus*														
M. sericus (Thorpe)	11611	2621	+	+	+	+	-	-	-	-	-	-	-	-
Genus *Monommata*														
Monommata spp.	26299	4800	+	+	+	+	+	+	+	+	+	-	-	-
Genu*s Mytilina*														
M. compressa (Gosse)	11132	4286	+	+	+	-	+	-	-	-	-	-	+	-
Genus *Notommata*														
Notommata sp.	4363	1900	-	-	+	-	+	-	+	+	-	-	-	-
Genus *Plationus*														
P. patulus (O.F. Müller)	35470	12294	-	-	+	-	-	+	+	+	+	+	+	+
Genus *Platyias*														
P. quadricornis (Ehrenberg)	3585	2571	-	-	+	-	-	-	-	+	-	-	+	-
Genus *Polyarthra*														
Polyarthra spp.	10038490	970971	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Proales*														
Proales spp.	927615	207429	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Ptygura*														
Ptygura sp.	14199	9994	+	-	-	+	+	-	+	-	-	-	-	-

Table 1. Continued.

Taxa	Total density (ind.m^{-3})	Peak (ind.m^{-3})	Light rainy				Rainy				Dry			
			Z 1	Z 2	Z 3	Z 4	Z 1	Z 2	Z 3	Z 4	Z 1	Z 2	Z 3	Z 4
Genus *Scaridium*														
Scaridium spp.	5074	4025	+	-	+	-	+	-	-	-	-	-	-	-
Genus *Squatinella*														
S. lamellaris (O.F. Müller)	907	479	+	-	+	-	-	-	-	-	-	-	-	-
Genus *Synchaeta*														
Synchaeta sp.	22344	20000	-	-	-	-	-	+	+	+	+	-	-	-
Genus *Testudinella*														
Testudinella spp.	74534	10714	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Trichocerca*														
Trichocerca spp.	2161372	260370	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Trichotria*														
T. tetractis (Ehrenberg)	8441	3429	+	-	-	+	-	-	+	+	+	-	-	-
*Bdelloid group	403640	41143	+	+	+	+	+	-	+	+	-	-	-	-
Phylum Arthropoda **Ostracoda**														
Ostracod juvenile	119094	25149	+	+	+	+	+	+	+	+	+	+	+	+
Cladocera Genus *Alona*														
A. monacantha Stingelin	429	429	-	-	+	-	-	-	-	-	-	-	-	-
A. rectangula Sars	287	287	-	-	+	-	-	-	-	-	-	-	-	-
A. sarasinorum Stingelin	43	43	-	-	+	-	-	-	-	-	-	-	-	-
A. verrucosa Sars	7582	2000	+	-	+	+	+	+	-	+	-	-	+	+
A. spp.	5943	5000	-	-	-	-	-	-	-	-	-	+	+	-
Genus *Alonella*														
A. excisa (Fischer)	43	43	+	-	-	-	-	-	-	-	-	-	-	-
Genus *Bosminopsis*														
B. deitersi Richard	293765	28286	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Ceriodaphnia*														
C. cornuta Sars	974	717	-	-	-	-	+	+	+	-	-	-	-	-
Genus *Chydorus*														
C. eurynotus Sars	3514	790	+	+	+	+	-	-	-	-	-	+	+	+
C. parvus Daday	357	357	-	-	+	-	-	-	-	-	-	-	-	-
C. pubescens Sars	3151	2000	+	-	-	-	-	-	-	-	+	-	+	-
C. reticulatus Daday	3141	2057	-	-	-	-	+	-	-	+	-	-	+	-
C. ventricosus Daday	644	357	-	+	+	-	-	-	-	-	-	-	-	-
Genus *Dunhevedia*														
D. crassa King	6173	2400	-	+	+	-	-	-	+	-	-	+	+	-
Genus *Ephemeroporus*														
Ephemeroporus spp.	53747	9200	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Karualona*														
K iberica Dumont & Silva- Briano	6988	2713	-	+	-	-	-	+	+	-	-	+	+	-
Genus *Latonopsis*														
L. australis Sars	86	86	-	-	+	-	-	-	-	-	-	-	-	-
Genus *Macrothrix*														
M. spinosa King	514	429	-	-	+	+	-	-	-	-	-	-	-	-
M. triserialis Brady	2259	1580	+	-	+	-	-	-	-	-	-	+	+	-
Genus *Moina*														
M. micrura Kurz	786	643	-	-	-	-	+	-	-	+	-	-	-	-
Genus *Moinodaphnia*														
M. macleayi King	236	236	-	-	+	-	-	-	-	-	-	-	-	-
Genus *Notoalona*														
N. globulosa (Daday)	357	357	-	-	+	-	-	-	-	-	-	-	-	-
Calanoid Copepoda Genus *Neodiaptomus*														
N. yangtsekiangensis Mashiko	2571	2571	-	-	-	-	-	-	-	+	-	-	-	-
Calanoid copepodites	7149	3570	+	+	+	+	+	-	+	+	+	+	-	+

Table 1. Continued.

Taxa	Total density (ind.m^{-3})	Peak (ind.m^{-3})	Light rainy				Rainy				Dry			
			Z 1	Z 2	Z 3	Z 4	Z 1	Z 2	Z 3	Z 4	Z 1	Z 2	Z 3	Z 4
Cyclopoid Copepoda														
Genus *Mesocyclops*	2891	857	-	-	+	-	+	-	-	+	+	+	-	-
Metacyclops	214	214	-	-	-	-	+	-	-	-	-	-	-	-
Cyclopoid copepodites	170635	25714	+	+	+	+	+	+	+	+	+	+	+	+
Harpacticoid Copepoda														
Harpacticoid copepodites	8	3	-	-	-	-	-	-	+	+	-	+	+	+
Crustacean nauplii	5738895	324107	+	+	+	+	+	+	+	+	+	+	+	+

Table 2. Taxonomic composition, density, peak and occurrence of mesozooplankton community from Thale-Noi lake in four different habitats (Z1; Peat swamp, Z2; Small inlet, Z3; Resident and Z4; Pelagic) during three periods (light rainy period; July to August 2004, rainy period; November to December 2004 and dry period; March to April 2005). + = present and - = absent in the waterbody.

Taxa	**Total density (ind.m^{-3})**	**Peak (ind.m^{-3})**	**Light Rainy**				**Rainy**				**Dry**			
			Z 1	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**
Phylum Protozoa														
Genus *Echinoshaerium*	214	214	-	-	-	-	+	-	-	-	-	-	-	-
Epistylis	2154	771	-	+	+	+	-	-	-	-	-	-	-	-
Voticella	156770	82711	+	-	+	-	+	+	-	+	+	+	-	-
Phylum Rotifera														
Genus *Testudinella*														
Testudinella spp.	26655	18000	+	+	+	+	-	-	-	-	-	-	-	-
Genus *Trochosphaera*														
Trochosphaera sp.	5200	3827	-	+	+	+	-	-	+	-	-	-	+	-
Phylum Arthropoda **Ostracoda**														
Genus *Cypricercus*	4493	1751	+	+	-	-	-	+	+	-	-	+	+	-
Cyprinotus	141	68	-	+	+	+	+	+	+	+	+	+	+	+
Stenocypris	10372	4200	+	+	+	+	+	+	+	+	+	+	+	+
Cladocera Genus *Alona*														
A. affinis Leydig	1748	950	+	+	+	-	+	-	-	-	-	-	-	-
A. intermedia Sars	110	86	-	-		-	-	+	+	-	-	-	-	-
A. monacantha Stingelin	140	140	-	-		-	-	-	-	+	-	-	-	-
A. sarasinorum Stingelin	1001	187	+	-	+	-	+	-	-	+	-	-	-	-
A. verrucosa Sars	1645	300	+	+	+	-	+	+	+	-	-	+	-	+
Genus *Alonella*														
A. excisa (Fischer)	288	171	+	-	+	-	-	-	-	-	-	-	+	-
Genus *Bosminopsis*														
B. deitersi Richard	3643432	1512000	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Camptocercus*														
C. australis Sars	3099	3000	-	-	-	+	-	+	+	+	-	-	+	-
Genus *Ceriodaphnia*														
C. cornuta Sars	47580	25200	+	+	+	+	+	+	+	+	+	-	+	-
Genus *Chydorus*														
C. eurynotus Sars	10997	7500	+	+	+	+	+	+	-	+	-	+	+	+
C. parvus Daday	1125	214	-	+	+	+	-	+	-	+	+	+	+	-
C. pubescens Sars	11697	4500	+	+	+	+	-	+	+	+	+	+	+	+
C. reticulatus Daday	13819	7002	+	+	+	+	+	+	+	+	-	-	+	-
C. ventricosus Daday	7622	3000	+	+	+	+	+	-	+	-	-	-	-	-
Genus *Dadaya*														
D. macrops (Daday)	201	200	-	-	-	+	-	-	+	-	-	-	-	-
Genus *Diaphanosoma*														
Diaphanosoma spp.	67919	25200	+	+	+	+	+	+	+	+	+	+	-	-
Genus *Dunhevedia*														
D. crassa King	230565	198098	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Ephemeroporus*														
Ephemeroporus spp.	535427	10333	+	+	+	+	+	+	-	-	-	-	-	-
Genus *Euryalona*														
E. orientalis (Daday)	332	86	-	-	+	-	-	-	-	+	+	+	+	+

Table 2. Continued.

Taxa	Total density (ind.m^{-3})	Peak (ind.m^{-3})	Light Rainy				Rainy				Dry			
			Z 1	Z 2	Z 3	Z 4	Z 1	Z 2	Z 3	Z 4	Z 1	Z 2	Z 3	Z 4
Genus *Guernella*														
G. raphaelis Richard	1	1	-	-	-	-	-	-	+	-	-	-	-	-
Genus *Grimaldina*														
G. brazzai Richard	475	475	+	+	+	+	+	+	+	+	+	-	+	-
Genus *Indiaalona*														
I. macronyx	1427	375	+	-	+	-	-	-	+	-	-	+	+	-
Genus *Ilyocryptus*														
I. spinifer Herrick	9860	6000	+	-	+	-	+	+	+	+	+	+	-	+
Genus *Karualona*														
K.. iberica Dumont &Silva-Briano	4985	1751	+	+	+	-	+	+	+	+	-	+	+	+
Genus *Kurzia*														
K. longirostris (Daday)	2130	1500	-	-	-	-	-	+	-	-	-	-	-	-
Genus *Latonopsis*														
Latonopsis sp.	30642	6564	+	+	+	+	+	+	+	+	+	+	+	+
Genus *Leberis*														
L. diaphanous	4380	2438	+	-	+	-	-	-	+	-	-	+	+	-
Genus *Leydigia*														
Leydigia sp.	1450	857	+	+	+	+	-	-	-	-	-	+	-	-
Genus *Macrothrix*														
M. spinosa King	1715	429	+	-	+	-	+	-	-	+	-	-	+	-
M. triserialis Brady	10198	1249	+	+	+	+	+	+	+	+	+	+	+	+
M. spp.	2992	943	+	-	+	+	-	-	-	-	+	+	+	+
Genus *Moina*														
M. micrura Kurz	45085	21000	+	+	+	+	+	+	+	+	+	+	-	+
Genus *Moinodaphnia*														
M. macleayi (King)	4144	1751	+	+	+	+	+	+	+	-	+	-	-	-
Genus *Notoalona*														
N. globulosa (Daday)	13	13	-	+	+	-	-	+	-	+	-	-	-	-
Genus *Oxyurella*														
O. singalensis (Daday)	598	528	-	-	-	-	+	-	-	-	-	-	-	-
Genus *Pseudosida*														
Pseudosida bidentata Herrick	792	560	-	-	+	+	-	+	+	-	-	-	-	-
Genus *Scapholeberi*s														
Scapholeberis kingi Sars	12067	8400	-	-	+	-	-	+	+	-	-	-	-	-
Genus *Simocephalus*														
S. serrulatus (Koch)	287	171	+	-	+	-	-	-	+	-	-	-	-	-
Calanoid Copepoda Genus *Acartia*														
A. cf. *southwelli*	821	407	-	+	-	+	-	+	-	-	-	-	-	-
Genus *Acartiella*														
A. sinensis Shen & Lee	26627	20053	+	+	+	+	-	+	+	-	+	+	+	+
Genus *Mongolodiaptomus*														
M. botulifer (Kiefer)	129	86	+	+	-	-	-	-	-	-	+	+	-	-
Genus *Neodiaptomus*														
N. yangtsekiangensis Mashiko	74342	50714	+	+	+	+	+	+	+	+	+	+	+	-
Genus *Pseudodiaptomus*														
Pseudodiaptomus sp.	1219	648	+	+	-	-	-	+	-	-	-	+	-	+
Genus *Sinocalanus*														
Sinocalanus sp.	1258	655	-	+	-	-	+	+	-	-	-	-	+	-
Calanoid copepodites	66483	7600	+	+	+	+	+	+	+	+	+	+	+	+
Cyclopoid Copepoda														
Genus *Mesocyclops*	29696	4800	+	+	+	+	+	+	+	+	+	+	+	+
Metacyclops	5534	1286	-	-	-	-	-	-	+	-	+	+	+	+
Microcyclops	47509	21000	+	+	+	+	+	+	+	+	-	+	+	+

Table 2. Continued.

Taxa	**Total density (ind.m^{-3})**	**Peak (ind.m^{-3})**	**Light Rainy**				**Rainy**				**Dry**			
			Z 1	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**	**Z 1**	**Z 2**	**Z 3**	**Z 4**
Genus *Thermocyclops*	2041	1013	+	-	+	+	+	+	+	+	+	+	+	-
Eucyclops	836	700	-	-	-	-	+	-	-	+	-	-	-	+
Cyclopoid copepodites	126888	30196	+	+	+	+	+	+	+	+	+	+	+	+
Harpacticoid Copepoda														
*Unidenified harpacticoid species	143	143	+	-	-	-	-	-	-	-	-	-	+	-
Harpacticoid copepodites	1406	642	+	+	-	-	-	+	+	+	+	+	+	+
Shrimp larvae	7807	4200	+	+	-	+	-	+	+	-	+	+	+	+
Crab larvae	86	86	+	-	-	-	-	-	-	-	-	-	-	-
Crustacean nauplii	534377	126144	+	+	+	+	+	+	+	+	+	+	+	+
Phylum Mollusca														
Gastropod larvae	466	237	+	+	+	+	-	-	-	-	-	-	+	-
Bivalve larvae	205	100	-	-	-	-	-	-	-	-	-	-	-	+
Phylum Chordata														
Fish larvae	3	2	-	+	-	-	-	-	-	-	-	-	-	-

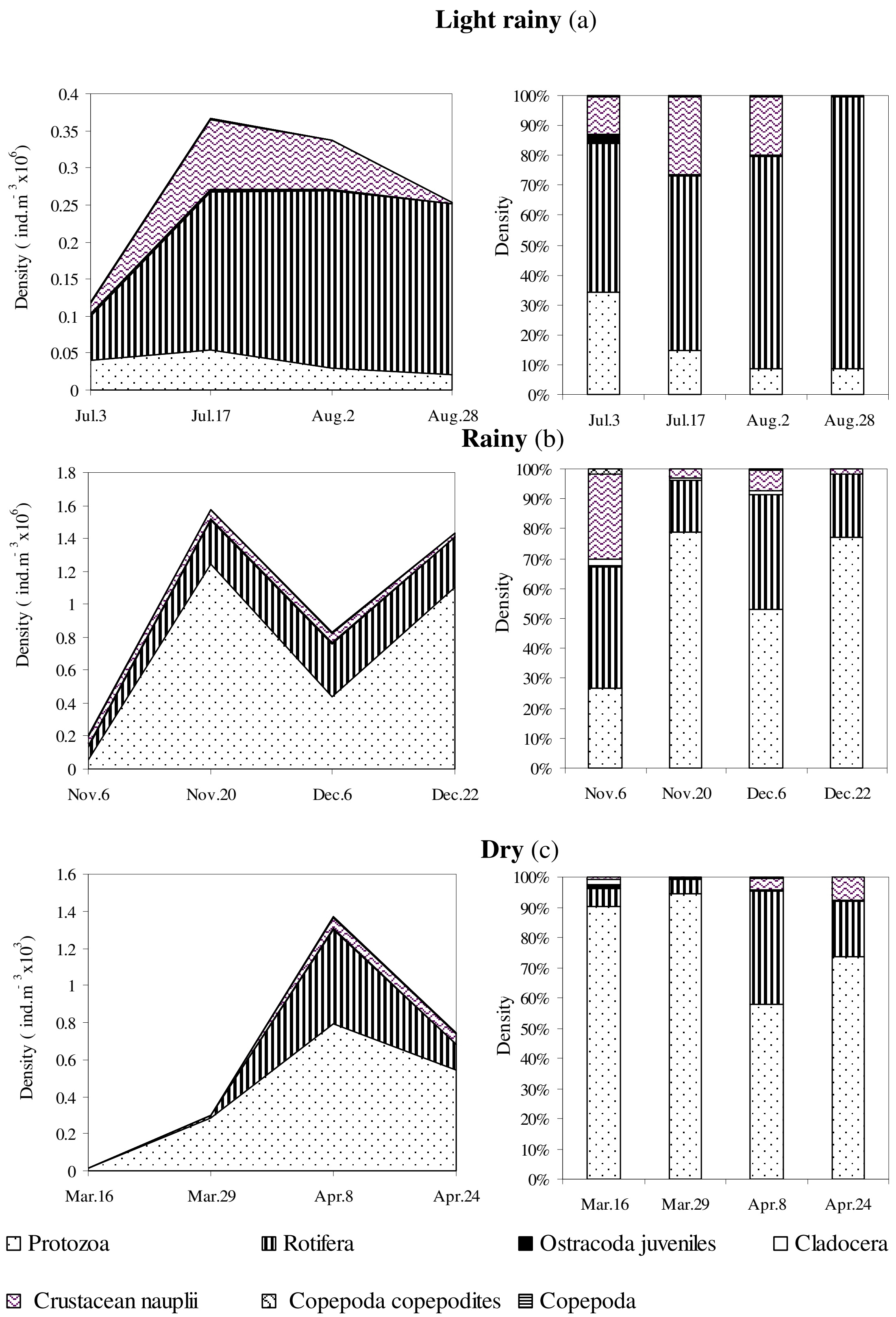

Figure 2. Changes in absolute density and relative abundance of microzooplankton in Thale- Noi during July 2004 to April 2005.

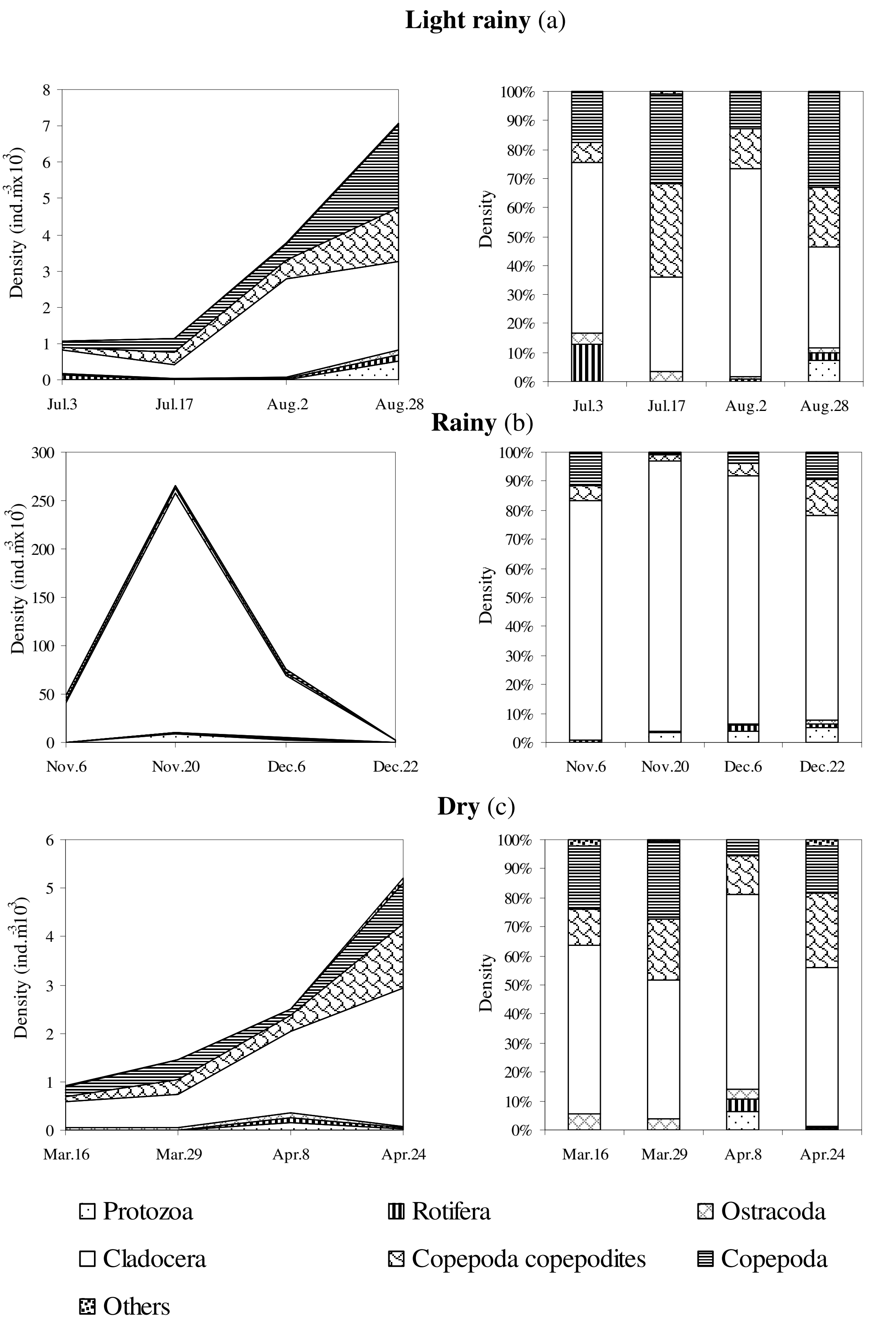

Figure 3. Changes in absolute density and relative abundance of mesozooplankton in Thale- Noi during July 2004 to April 2005.

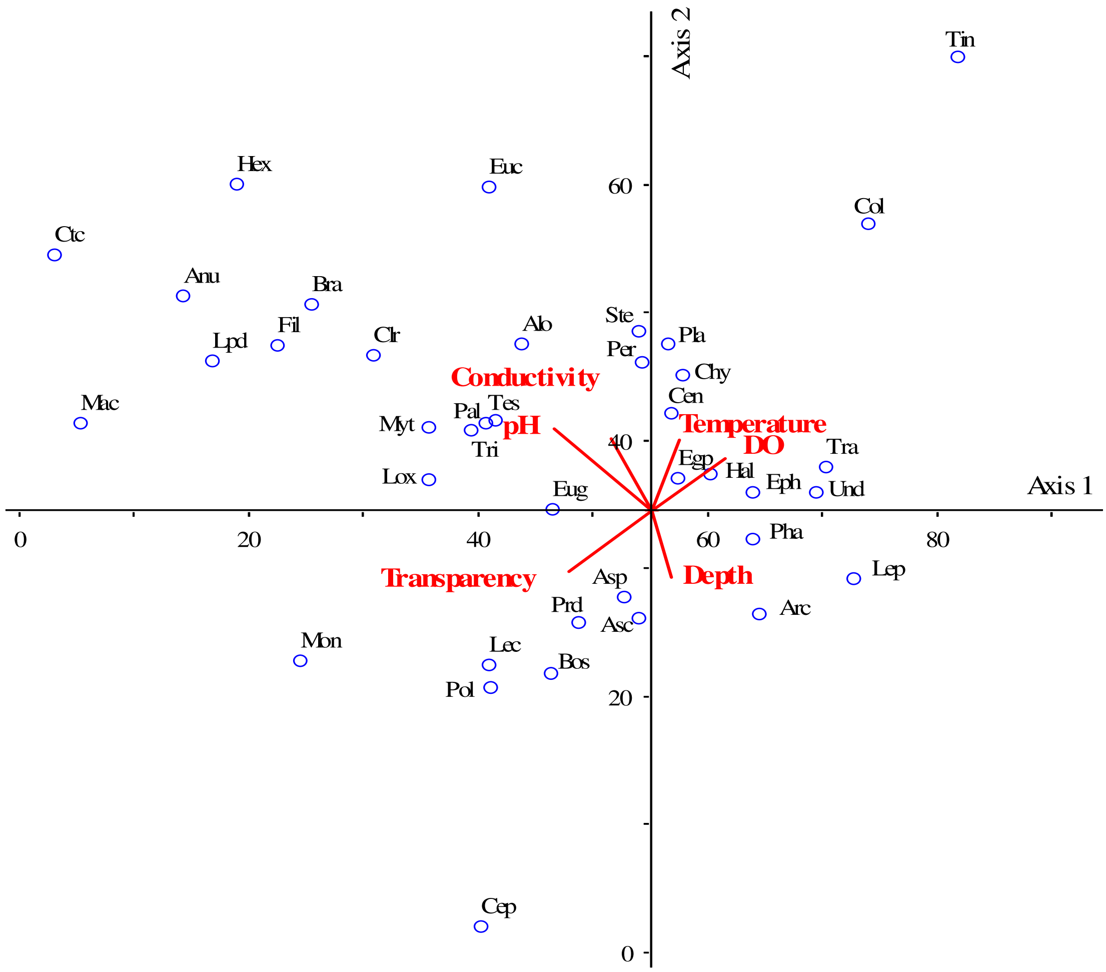

Figure 4. Canonical correspondence analysis (CCA) ordination diagram with 39 genera and 10 quantitative environmental variables. The zooplankton are *Arc* = *Arcella, Cen* = *Centropyxis, Eug* = *Euglena, Egp* = *Euglyphra, Hal* = *Halteria, Lep* = *Lepocinclis, Lox* = *Loxodes, Per* = *Peranema, Pdn* = *Peridinium, Pha* = *Phacus, Ste* = *Stentor, Tin* = *Tintinopsis, Tra* = *Trachelomonas, Und* = *Undella, Anu* = *Anuraeposis, Asc* = *Ascomorpha, Asp* = *Asplanchna, Bra* = *Brachionus, Cep* = *Cephalodella, Ctc* = *Collotheca, Clr* = *Colurella, Euc* = *Euchlanis, Fil* = *Filinia, Hex* = *Hexathra, Lec* = *Lecane, Lpd* = *Lepadella, Mac* = *Macrochaetus, Mon* = *Monommata, Myt* = *Mytilina, Pla* = *Plationus, Pol* = *Polyarthra, Pro* = *Proales, Tes* = *Testudinella, Tri* = *Trichocerca, Alo* = *Alona, Bos* = *Bosminopsis, Chy* = *Chydorus* and *Eph* = *Ephemeroporus*. The environmental factors are temperature, pH, salinity, conductivity, transparency, depth, total solid, dissolved oxygen, chlorophyll *a* <20 µm and chlorophyll *a* 20-200 µm. Circles represent genera and arrow lines represent environmental gradients. Length of lines reflects strength of their effect. Genera and lines in the same quadrate indicate a positive correlation whereas genera and lines in opposite quadrates represent a negative correlation.

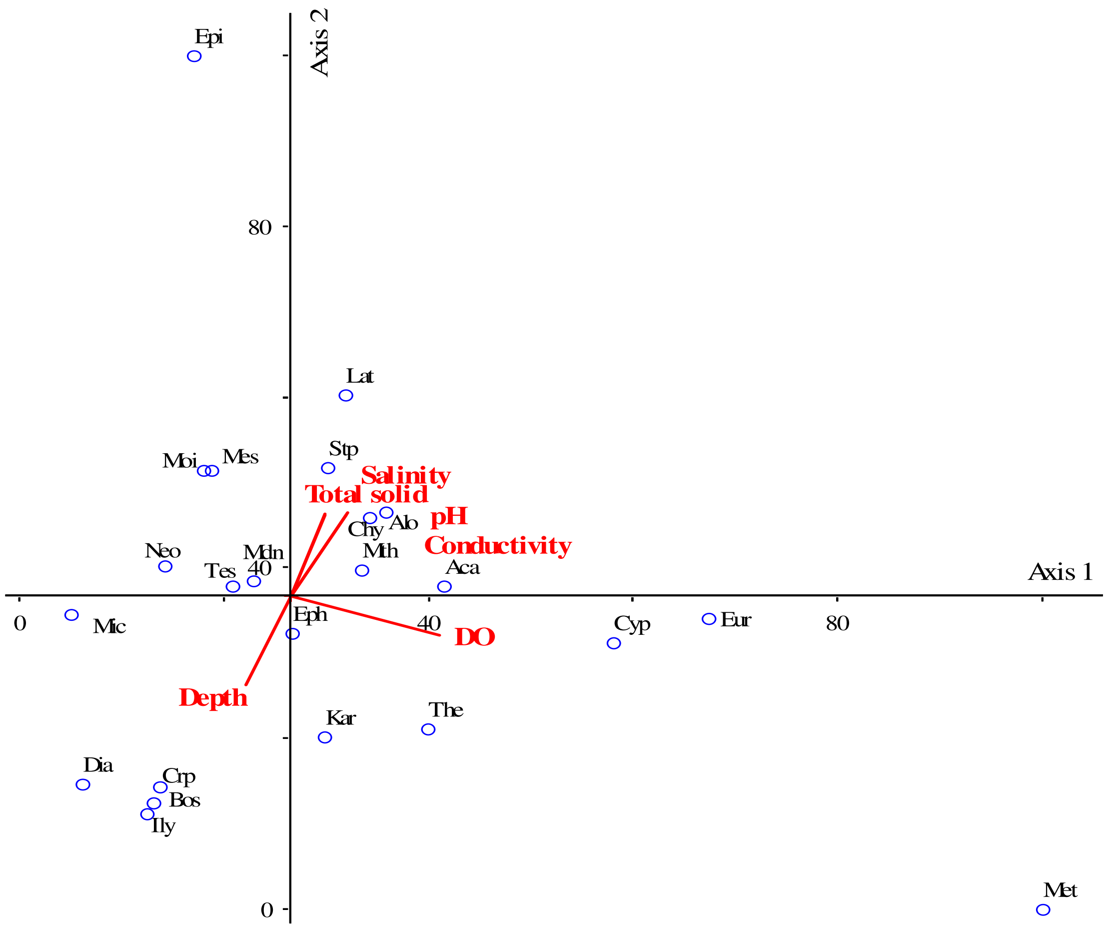

Figure 5. Canonical correspondence analysis (CCA) ordination diagram with 23 genera and 10 quantitative environmental variables. The zooplankton are *Epi* = *Epistylis, Tes* = *Testudinella, Cyp* = *Cypricercus, Stp* = *Stenocypris, Bos* = *Bosminopsis, Alo* = *Alona, Chy* = *Chydorus, Eph* = *Ephemeroporus, Kar* = *Karualona, Eur* = *Euryalona, Crp* = *Ceriodaphnia, Moi* = *Moina, Mdn* = *Moinodaphnia, Mth* = *Macrothrix, Lat* = *Latonopsis, Dia* = *Diaphanosoma, Ily* = *Ilyocryptus, Met* = *Metacyclops, Mic* = *Microcyclops, Mes* = *Mesocyclops, The* = *Thermocyclops*, *Aca* = *Acartiella* and *Neo* = *Neodiaptomus*. The environmental factors are temperature, pH, salinity, conductivity, transparency, depth, total solid, dissolved oxygen, chlorophyll a <20 µm and chlorophyll a 20-200 µm. Circles represent genera and arrow lines represent environmental gradients. Length of lines reflects strength of their effect. Genera and lines in the same quadrate indicate a positive correlation whereas genera and lines in opposite quadrates represent a negative correlation.