CHAPTER 1

INTRODUCTION

1. Background and Rationale

Thale-Noi, a freshwater area of Songkhla lake, is an important bird sanctuary in Southern Thailand (Tunsakul and Sirimontraporn, 1982; 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. Between 1988 and 2002, the fish population in Thale-Noi declined and was not enough to support the people engaged in fishing activities (Thungwa *et al.,* 2002). Moreover, this problem seriously affected the villagers' livelihood, economy, and society in general (Hembanthid, 2001). 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).

Additionally, 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). They respond to low dissolved oxygen, high nutrient levels, toxic contaminants, poor food quality or abundance and predation (Kovalev *et al*., 1999). 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). Additionally, most zooplankton are filter feeders; they serve to cleanse the water column of suspended matter and hence contribute significantly to the improvement of water quality (Bekleyen, 2003).

Microzooplankton have long been thought to be a major consumer of small particles unavailable to meso-and macrozooplankton (Gifford, 1991) and these organisms also act as a significant food source for a variety of invertebrate and vertebrate predators (Godhantaraman, 2001). Thus, microzooplankton are an important link in transferring pico- and nanoplankton production to higher trophic levels (Eskinazi-Sant'Anna and Bjornberg, 2006). In aquatic ecosystems, mesozooplankton are the major secondary producers which graze on phytoplankton and in turn are preyed upon by planktivorous fish and carnivorous invertebrates such as jellyfish (Uye *et al*., 2000). The linkage between phytoplankton and zooplankton is a dynamic process controlled by several factors, including environmental and biological factors (Mageed and Heikal, 2006; Medina-Sanchez *et al*., 1999; Shinada *et al.,* 2000) which affect the growth of each community and the interaction between them. Grazing is one of the most important factors controlling the relationship between the two communities (Abdel Aziz *et al*., 2006; Leonard *et al.,* 2005).

Zooplankton have been intensively investigated in Thale-Noi, 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. The present study proposed to examine water quality and chlorophyll *a* in Thale-Noi to explain the factors that affect changes in the micro- and mesozooplankton communities along the lake during the different seasons and in different habitats.

2. Literature review

2.1 What are zooplankton?

Zooplankton are small animals that float freely in the water column of lakes and oceans and whose distribution is primarily determined by water currents and mixing. The zooplankton community of most lakes comprises individuals ranging in size from a few tens of microns (Protozoa) to > 2 mm (macrozooplankton). In terms of biomass and productivity, the dominant groups of zooplankton in lakes are Crustacea and Rotifera. The zooplankton in freshwater consists primarily of protozoans (ciliates and flagellates; which range in size from a few to a few hundred micrometers), rotifers (30 µm to 1 mm), and crustaceans (copepods and cladocerans; 100 µm to 1 cm) (Lampert *et al.,* 1997). A few coelenterates, larval trematode flatworms, gastrotrich, mite, and the larval stages of certain insects and fish occasionally occur among the true zooplankton, if only for a portion of their life cycles (Wetzel, 2001). These groups have different reproductive strategies which influence the rate of population increase and hence responses to food availability. Protozoa can reproduce by simple fission, with sexual reproduction confined to relatively rare periods as a response to adverse condition, such as low temperature. Rotifers and cladocerans usually reproduce parthenogenetically, with male individuals rare and the population consisting almost entirely of cloned females during periods favorable to growth. Sexual reproduction is confined to periods of adverse conditions such as low food or low temperature and involves resting, fertilized eggs. Calanoids and cyclopoids only reproduce sexually, with females carrying external egg sacs. As a consequence, population growth in these taxa is slower (Harper, 1992).

2.2 Classification of zooplankton

The zooplankton are classified according to their habitat, depth distribution, size and duration of planktonic life (life history). On the basis of habitat, the zooplankton is classified as marine plankton or 'haliplankton', and freshwater plankton or 'limnoplankton' (Pholpunthin, 2001).

Based on size, different fractions of zooplankton have been divided into seven groups as shown in Table 1.

Table 1. The seven groups of zooplankton separated based on size.

Group	Size limits	Major organisms
1. Ultrananoplakton	< 2 µm	Free bacteria
2. Nanozooplankton	2-20 µm	Fungi, small flagellates, small diatoms
3. Microzooplankton	20-200 µm	Most phytoplankton species, foraminiferans, ciliates, rotifers, copepods nauplii
4. Mesozooplankton	200 µm-2 mm	Cladocerans, copepods, larvaceans
5. Macrozooplankton	2-20 mm	Pteropods, copepods, euphausiids, chaetognaths
6. Megalozooplankton	>20 mm	Scyphozoans, thaliaceans
7. Micronekton	20-200 mm	Cephalopod, euphausiid, sergestids, myctophids

Sources: Omori and Ikeda (1984) cited by Pholpunthin (2001).

With regard to the duration of planktonic life, zooplankton may be grouped into 'holoplankton' and 'meroplankton'. Holoplankton is comprised of organisms which are planktonic throughout their life cycle (e.g. tintinnids, cladocerans, copepods, chaetonaths and pteropods). Meroplankton is comprised of organisms which remain planktonic only for a portion of their life cycle (e.g. larvae of benthic invertebrates and fish larvae ichthyoplankton) (Santhanam and Srinivasan, 1994).

2.3 The important of zooplankton

Zooplankton, especially rotifers and cladocerans, support the economically important fish populations (Howick and Wilhm, 1984; Santhannam and Srinivasan, 1994). Rotifers are highly nutritive to planktivorous fish. Their protein supports the fast growth of fish larvae and juveniles and, as such, they are of great importance to fish farmers (Fafioye and Omoyinmi, 2006), as are several other genera of Cladocera such as *Dahpnia*, *Moina, Diaphanosoma* and *Pseudosida* that are currently used in aquaculture (Maiphae, 2005). Zooplankton acts as the major mode of energy transfer between phytoplankton and the fish (Howick and Wilhm, 1984; Pedersen *et al*., 2005). Zooplankton play a pivotal role in aquatic food webs because they are an important food source for fish and invertebrate predators (Zhensheng *et al*., 2006). Because of their small size and high metabolic rate, protozoa play a substantial role in nutrient regeneration in the water column. Protozoa have been 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). Additionally, certain species of zooplankton are usually considered to be useful indicators of water quality, trophic status and pollution (Michaloudi *et al*., 1997). Moreover, zooplankton, especially *Brachionus calyciflorus* and *B. plicatilis*, have been employed as test organisms for toxicological studies (Chittapun, 2003). Recently, cyclopoid copepods have been used for the purpose of bio-controlling the larvae of mosquitoes to reduce the use of chemical compounds (Wansuang and Sanoamuang, 2006).

2.4 The trophic cascade in the lake

The ecological role of an organism is largely determined by its position and significance in the food web. Decisive characteristics are body size, food spectrum and feeding type (Harris *et al*., 2000). Trophic cascade theory holds that each trophic level in the food web is inversely and directly related to trophic levels above and below it. For example, if the abundance of large piscivorous fish is increased in a lake, the abundance of the zooplanktivorous fish on which they prey should decrease; the abundance of large herbivorous zooplankton should increase; and the phytoplankton biomass should decrease (Brett and Goldman, 1996). Recent studies in an oligotrophic Andean lake have shown that the large cladoceran *D. middendorffiana* exhibited a strong top down impact on different levels of the microbial food web. *Daphnia* was able to depress the nanoflagellates, ciliates and autotrophic picoplankton (Modenutti *et al.,* 2003). Havens (2002) pointed out that a simple conceptual model, based on zooplankton research in Southern Florida, indicated that while phytoplankton biomass is controlled by nutrients, zooplankton biomass is primarily controlled by the productivity of bacteria. In a system of this type it might be optimal to predict macrozooplankton biomass based on the combined biomass of phytoplankton and bacterioplankton.

2.5 Seasonal succession in zooplankton

The pattern of succession in lakes can be observed in the seasonal changes in the biomass, species composition and abundance of the plankton (Calbet *et al.,* 2001; Lampert *et al.,* 1997). There is also evidence of a seasonal pattern related to external factors (e.g. temperature) and sudden influences (e.g. rain and, indirectly, Mistral wind), which modify the succession of the plankton communities (Jamet *et al*., 2005). In addition, comprehensive descriptions of temporal cycles of the biological communities and of the abiotic environment are fundamental to understanding the overall range of this variability (Mazzocchi and Ribera d'Alcala, 1995). However, recent studies have shown that changes in biomass or the production of autotrophic food seem to play a small role in determining the seasonal succession of planktonic metazoans. Further, it has been suggested other factors, such as salinity and temperature, and possibly also food size-spectra, may be more important in determining the seasonality of the zooplankton species composition (Calbet *et al*., 2001). Equilibrium models assume that population densities are food limited and follow the fluctuations of their resources. However, such assumptions always yield outcomes that predict the exclusion of specific species. For example, the succession of small cladocerans in August was accompanied by a reduction in edible algae due to grazing (Eckert and Walz, 1998).

Figure 1 gives an example of the model of seasonal succession among zooplankton in eutrophic and oligotrophic lakes in the temperate region. In eutrophic lakes, a spring maximum of small phytoplankton algae is followed by a dominantly persisting summer maximum of large, grazing-resistant algae and cyanobacteria. These common phytoplankton maxima of eutrophic lakes are often separated by the "clear water phase," a very short-lived period when large zooplankton graze on phytoplankton voraciously to bring on conditions of acute food limitation and are then rapidly replaced by smaller zooplankton species. The phytoplankton "clear water phase" may persist somewhat longer into the summer, depending on the effectiveness of the grazing of the smaller zooplankton species and nutrient loading, particularly of phosphorus. The collective primary productivity of phytoplankton, however, particularly with regard to smaller species with higher reproductive rates and less biogenic "turbidity", is generally very high during the summer period. In oligotrophic lakes, the phytoplankton-zooplankton successional process is similar although highly muted and slower (Fig. 1) (Wetzel, 2001).

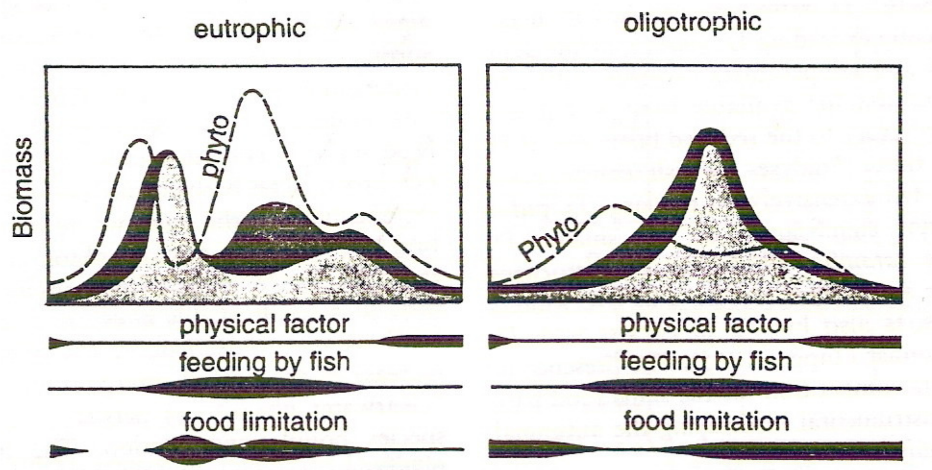

Figure 1. General model of seasonal succession of zooplankton in typical thermally stratified eutrophic (left) and oligotrophic (right) lakes of the temperate region. Phytoplankon: dashed line. Zooplankton: small species, dark shading; large species, lighter shading. Black lower bar indicates the relative intensity seasonal of factors noted (Wetzel, 2001).

2.6 Environmental variables influencing zooplankton communities

The environment in which an organism lives is never constant; it changes, for example, with the time of year. Also, within the life cycle of a species, the environmental pressures and the tolerances of the organism can change (Lampert *et al.,* 1997). The presence and success of an organism or group of organisms depend on a combination of conditions. Any condition that approximates or exceeds the limits of tolerance is said to be a limiting condition or limiting factor (Keppeler and Hardy, 2004). Species composition, abundance and distribution of zooplankton communities can be influenced by a number of physical, chemical and biological factors (Branco *et al*., 2002; David *et al.,* 2005; Sapaio *et al*., 2002). These factors can directly or indirectly influence the reproduction and survival of organisms (Espindola *et al*., 2000). In natural environments, factors such as temperature, salinity, pH and electrical conductivity can affect the community with regard to both composition and population density. However, the factors recognized as the most important are temperature, quality and availability of food, competition and predation. These factors act simultaneously and may also interact to different degrees, modifying the zooplankton structure in different ways (Sapaio *et al*., 2002).

Temperature and oxygen concentration are the key factors in restricting zooplankton occurrence (Yildiz *et al.,* 2007). Moreover, temperature is also important within the lethal limits, since it regulates the speed of the chemical, and ultimately, therefore, the biochemical and physiological processes. Some aquatic animals have blood pigment hemoglobin that has a high affinity for oxygen and enables the animals to live in habitats with extremely low oxygen concentrations (Lampert *et al.,* 1997). pH is related to many other variables in freshwaters that are correlated with zooplankton distribution and it is known that rotifers exhibit a very wide range of pH and turbidity tolerance (Berzins and Pejler, 1987). Total dissolved salt and electrical conductivity are important factors affecting zooplankton distribution in Lake Marmara (Yildiz *et al.,* 2007). Quality and quantity of food can alter species composition as well as the abundance of the species. In the study of rotifers *Brachionus angularis*, it was observed that food concentrations caused significant effects on population growth rate, body size and egg size in this species when *Chlorella pyrenoidosa* was used as food (Keppeler and Hardy, 2004). The degree of predation greatly affects the diversity of population of the species being preyed upon. Moderate predation often reduces the density of dominant species, thereby providing less competitive species with increased opportunities to utilize space and resources (Keppeler and Hardy, 2004).

2.7 A study of zooplankton communities in freshwater environments

Many studies have dealt with changes in zooplankton communities in temperate, subtropical and tropical zones (Table 2). Most studies of zooplankton communities have been carried out in temperate and subtropical zones, especially in the European region. However, studies of seasonal zooplankton change in the tropical zone have increased recently. Studies in several European countries, such as Norway, Germany and Denmark, have been conducted in freshwater lakes. Hessen and Lydersen (1996) and Primicerio (2000) gave accounts of seasonal changes in species composition in Norway. Eckert and Walz (1998) dealt with zooplankton succession in the shallow Müggelsee, Germany. Yakovlev (2001) detailed the spatial and temporal distribution of fish and zooplankton in a shallow lake in Denmark. The results of these studies showed that the dominant zooplankton was a similar group (rotifers, cladocerans) but a different species (Table 2). In New Zealand, Burns and Mitchell (1980) and James *et al.* (2001), observed seasonal changes in zooplankton communities. Calanoid copepod *Boeckella* was the dominant genus in both studies. In the subtropical region, abundance and seasonal fluctuation of zooplankton have been published by Maria-Heleni *et al*. (2000), Bonacila and Pasteris (2001), Ferrara *et al*. (2002), Manca and Comoli (2006) and Yildiz *et el*. (2007). In the tropical region, such studies conducted in Brazil have examined the distribution, composition and abundance of zooplankton in diverse habitats, such as in seven reservoirs of the Paranapanema River (Sampaio *et al.,* 2002), the Tucurui Reservoir (Espindola *et al.,* 2000), Ponte Nova and Guarapiranga Reservoirs (Sendacz *et al*., 2006), Furnas Reservoir, Ibirite Reservoir and Pampulha Reservoir (Pinto-Coelho *et al*., 2005b), Lake Souza Lima and Lake Parque Atalalia (Neves *et al.,* 2003), and Lake Lago Amapà (Keppeler and Hardy, 2004). In these studies, one group of Rotifera was dominant over the other groups, but the dominant genera *Synchaeta*, *Collotheca*, *Keratella*, *Polyarthra*, *Brachionus*, *Filinia*, *Ptygura*, *Conochilus,* differed in different habitats. In general, these genera are similar to those that have been studied in other tropical areas. Other investigations of zooplankton in tropical regions are as follows: Mengestou and Fernando (1991), Torres-Orozco and Zanatta (1998), Mageed and Heikal (2006) (Table 2).

2.8 A study of zooplankton in Thailand

The study of freshwater zooplankton in Thailand has increased recently. Most studies have concentrated on a specific aspect (species taxonomy and their distribution) of zooplankton communities in various water bodies, covering many provinces (Boonsom, 1984; Pholpunthin, 1997; Pipatcharoenchai, 2001; Wansuang and Sanoamuang, 2006). Large groups of zooplanktonic organisms are now known for the Rotifera, Cladocera and Copepoda. Minor zooplanktonic groups like Protozoa and Ostracoda are still poorly known systematically. The studies have often been limited to specific populations or groups, e.g., protozoan by Charubhun and Charubhun (2000), rotifers by Sergers and Pholpunthin (1997), Pholpunthin and Chittapun (1998), Sanoamuang and Savatenalinton (2001), Chittapun (2003), Chittapun *et al*. (2003), Savatenalinton and Segers (2005), cladocerans and copepods by Sa-ardrit (2002), Maiphae *et al*. (2004), Maiphae (2005), Maiphae *et al*. (2005), Sa-ardrit and Beamish (2005) and Sanoamuang and Faitakum (2005). As a result of these studies in all the parts of the country, the taxonomic knowledge of zooplankton has changed recently due to newcomers.

A few studies have investigated temporal variations (mainly diurnal and seasonal), spatial variations (both horizontal and vertical), and the distribution of zooplankton communities or species in diverse habitats (freshwater: Angsupanich and Rukkhiaw, 1984; Angsupanich, 1985; Chaiubol, 1998; Jithlang and Wongrat, 2004, brackish water: Ouppabullung and Angsupanich, 1995; Angsupanich, 1998; Chaleoisak, 2000; Charoenpol, 2003) (Table 3). In the bulk of these studies, abundance and species composition of zooplankton were seasonally different and related to environmental factors (e.g. precipitation, freshwater runoff, salinity, pH, dissolved oxygen, conductivity, transparency, etc.). Moreover, in most investigations, Protozoa and Rotifera were the most dominant groups in the community (Table 3).

In Thale-Noi lake, research has been conducted on the ecology of the zooplankton community. Angsupanich and Rukkhiaw (1984) studied the distribution of Rotifera in Thale-Noi between April 1982 and March 1983. Zooplankton samples were collected by both horizontal hauls and vertical hauls from five stations. The results indicated that rotifer density showed no significant differences between stations or seasons. Later in 1985, Angsupanich investigated the zooplankton communities in Thale-Noi. Comparison studies on composition and density of zooplankton between stations and seasons were carried out. Six major groups occurred in the community, namely protozoans, rotifers, nauplii, copepods, cladocerans, and ostracods. Of these, the rotifers were the most abundant. However, zooplankton density showed significant differences between station and season and it was suggested that dissolved oxygen content was the main environmental factor determining rotifer density. Pholpunthin (1997) studied the freshwater zooplankton (Rotifera, Cladocera, and Copepoda) in Thale-Noi, Southern Thailand. The study focused on taxonomy using samples collected from nine localities. He found 106 species of Rotifera, 17 species of Cladocera and three species of Copepoda and went on to describe 20 species of rotifers, seven species of cladocerans and two species of copepods which were new to Thailand. Later, Segers and Pholpunthin (1997) published an article on new and rare Rotifera from Thale-Noi Lake, Phatthalung Province, Thailand, with a note on the taxonomy of *Cephalodella* (Notommatidae). They found two new species of rotifer and 14 rotifer species that were recorded for the first time in Thailand. These results suggest that the Thale-Noi ecosystem has a special and specific zooplankton community, which includes rotifer, cladoceran and copepod species. Thus the study of changes in this zooplankton community is important for understanding the functioning of the lake.

Table 2. Studies of zooplankton communities in freshwater environments.

Regions	Area	Total zooplankton group	The dominant zooplankton group	Net mesh size	Source
Temperate	Lake Skjervatjern, Norway	Rotifers, Cladocerans and Copepods	Cladocerans: *Holopedium gibberum, Bosmina longisina* and *Diaphanosoma brachyurum*	45 µm	Hessen and Lydersen (1996)
	Lake Takvatn, Norway	Rotifers, Cladocerans, Copepods and Copepod nauplii	Nauplii of *Cyclops scutifer* Sars and *Eudiaptomus graciloides* ; Rotifers: *Keratella cochlearis*, *Conochilus unicornis Rousslet, Polyarthra* sp. and *Kellicottia longispina* (Kellicot)	50 µm	Primicerio (2000)
	Lake Muggelsee, Germany	Rotifers, Cladocerans and Copepods	Rotifers: *Keratella cochlearis, Synchaeta oblonga* and *K. quadrata*	30 µm	Eckert and Walz (1998)
	Lake Hanebjerg, Denmark	Cladocerans and Copepods	Cyclopoid copepods	45 µm	Romare *et al*. (2003)
	Lake Coleridge, New Zealand	Rotifers, Copepods and Copepod nauplii	Calanoid copepod: *Boeckella hamata*	55 µm	James *et al*. (2001)
	Lake Hayes and Lake Johnson, New Zealand	Rotifers, Cladocerans and Copepods	Cladocerans: *Ceriodaphnia dubia* Richard; Calaniod copepod: *Boeckella dilatata* Sars	77 µm	Burns and Mitchell (1980)

Table 2. Continued.

Regions	Area	Total zooplankton group	The dominant zooplankton group	Net mesh size	Source
Subtropical	Aliakmon river, Greece	Rotifers, Cladocerans, Copepods and Mollusca larvae	Rotifers and Mollusca larvae of *Dreissena polymorpha* Pal.	35 µm	Maria-Heleni *et al*. (2000)
	Lake Orta, Italy	Rotifers, Cladocerans, Copepods and Mollusca larvae	Rotifers: *Keratella quadrata, Brachionus urceolaris* and *Polyarthra dolycoptera-vulgaris*	76 µm	Bonacila and Pasteris (2001)
	Lake Bracciano, Italy	Rotifers, Cladocerans and Copepods	Copepods: *Eudiaptomus padanus etruscus*	80 µm	Ferrara *et al*. (2002)
	Lago Paione Superiore, Italy	Rotifers, Cladocerans, Copepods and Nauplii	Cladocerans: *Daphnia longispina*; Copepods: *Cyclops abyssorum tatricus*	200 µm	Manca and Comoli (2006)
	Lake Marmara, Turkey	Rotifers, Cladocerans and Copepods	Rotifers: *Keratella* spp., *Polyarthra* spp. and *Brachionus* spp.; Cladocerans: *Bosmina longirostris*	55 µm	Yildiz *et el*. (2007)

Table 2. Continued.

Regions	Area	Total zooplankton group	The dominant zooplankton group	Net mesh size	Source
Temperate	Ontario Coldwater lakes, Canada	Cladocerans and Copepods	Cyclopoid copepods	53 µm	Pinto-Coelho *et al.* (2005b)
Temperate	SFM lakes, Canada		Cyclopoid copepods	53 µm	
Temperate	TROLS lakes, Canada		Cyclopoid copepods	53 µm	
Subtropical	Florida lakes, USA		Cladocerans	150 µm	
Tropical	Volta Grande reservoir, Brazil		Cladocerans	90 µm	
Tropical	Furnas reservoir, Brazil		Cyclopoid copepods	90 µm	
Tropical	Ibirite reservoir, Brazil		Cyclopoid copepods	90 µm	
Tropical	Pampulha reservoir, Brazil		Cyclopoid copepods	90 µm	
Tropical	Tucurui reservoir, Brazil	Rotifers, Cladocerans, Copepods, Turbellaria, Ostracoda and Chaoborus	Copepods: *Thermocyclops minutus* and *Notodiaptomus henseni*; Cladocerans: *Ceriodaphnia cornuta* and *Bosminopsis deitersi*	68 µm	Espindola *et al.* (2000)

Table 2. Continued.

Regions	Area	Total zooplankton group	The dominant zooplankton group	Net mesh size	Source
Tropical	Jurumirim Reservoir, Brazil Piraju Reservoir, Brazil Xavantes Reservoir, Brazil Salto Grande Reservoir, Brazil Rio Pari Reservoir, Brazil Capivara Reservoir, Brazil Rio Novo Reservoir, Brazil	Rotifers, Cladocerans and Copepods	Rotifers: *Synchaeta* sp. Rotifers Rotifers; Cladocerans Rotifers Rotifers; Cladocerans Rotifers; Cyclopoid copepods Rotifers: *Collotheca* sp. ; Cyclopoid copepods: *Thermocyclops*	68 µm	Sampaio *et al*. (2002)
Tropical	Lake Souza Lima, Brazil Lake Parque Atalaia, Brazil	Rotifers, Cladocerans and Copepods	Rotifers: *Keratella americana* and *K. cochlearis*; Cladocerans: Diaphanosoma fluviatile and *Moina minuta* Rotifers: *Polyarthra vulgaris* and *Brachionus angularis* Cladocerans: Diaphanosoma fluviatile and *Moina minuta*	68 µm	Neves *et al*. (2003)

Table 2. Continued.

Regions	Area	Total zooplankton group	The dominant zooplankton group	Net mesh size	Source
Tropical	Lake Awasa, Ethiopia	Cladocerans and Copepods	Cladocerans: *Diaphanosoma excisum* Sars and *Alona diaphana* Sars; Copepods: *Mesocyclops aequatorialis similes* and *Thermocyclops consimilis*	64 µm	Mengestou and Fernando (1991)
	Lake Catemaco, Mexico	Protozoans, Rotifers, Ostracods, Cladocerans, Copepods, Fish larvae and Insect larvae	Rotifers: *Brachionus havanaensis* and *Conochilus unicornis*; Calanoid and Cyclopoid nauplii	100 µm	Torres-Orozco and Zanatta (1998)
	Lake Nasser, Egypt	Rotifers, Cladocerans and Copepods	Copepods: *Thermocyclops neglectus* (Sar) and *T. galebi* ; Cladocerans: *Ceriodaphnia reticulate* and *Diaphanosoma excisum*	55 µm	Mageed and Heikal (2006)
	Lake Lago Amapà, Brazil	Rotifers, Cladocerans, Copepods, Copepod naupii and Chaoborus	Rotifers: *Keratella cochlearis, Filinia longiseta, F. terminalis* and *Brachionus calicyflorus*	55 µm	Keppeler and Hardy (2006)
	Ponte Nova reservoir, Brazil Guarapiranga reservoir, Brazil	Rotifers, Cladocerans and Copepods	Rotifers: *Polyarthra vulgaris, Ptygura libera*, *Conochilus unicornis* and *Collotheca ornate* Rotifers: *P. vulgaris*, *Synchaeta oblonga* and *Keratella cochlearis*	40 µm	Sandacz *et al*. (2006)

Table 3. Zooplankton groups or phyla reported as numerically dominant in the water body, Thailand.

	Protozoa	Rhynchoceala	Cnidaria	Rotifera	Coelenterata	Ctenophora	Nematoda	Bryozoa	Chaetognatha	Annelida	Arthropoda	Mollusca	Echinndermata	Chordata	
Freshwater															
Thale-Noi				*											Angsupanich, 1995
Ang Kaew Reservoir				*											Chaiubol, 1998
Pasak Jolasid Reservoir				*											Jithlang and Wongrat, 2004
Brackish water															
Phawong Canal	*														Ouppabullung and Angsupanich, 1995
Thale Sap Songkhla	*														Angsupanich, 1997
Tha-Chin River	*														Chaleoisak, 2000
Bangpakong River	*														Charoenpol, 2003

Note: [grey box] present in the community * dominant group of community

[white box] absent in the community

3. Research questions

1. How do the zooplankton communities of different size fractions change annually in Thale-Noi?
2. What are the possible factors affecting the changes of zooplankton of different size fractions in Thale-Noi?

4. Hypothesis

1. Seasonal and spatial variations and environmental parameters influence changes in zooplankton communities
2. Food availability influences changes in zooplankton communities

5. Objectives

1. To investigate the seasonal and spatial variations of zooplankton communities of different size fractions in Thale-Noi
2. To investigate the effects of certain environmental factors on change of zooplankton communities of different size fractions in Thale-Noi