SEASONAL VARIATIONS OF ZOOPLANKTON IN *THALE SAP SONGKHLA*, SOUTHERN THAILAND
การแปรผันตามฤดูกาลของแพลงก์ตอนสัตว์ในทะเลสาบสงขลา

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ABSTRACT

The abundance of zooplankton in Thale Sap Songkhla *was investigated at 2 to 3 month intervals from August 1991 to October 1993. About 99% of the total zooplankton density was microzooplankton. Protozoa were dominant, followed by Rotifera, Arthropoda (copepod nauplii and adult copepods), Mollusca (gastropod and pelecypod larvae), and Chordata (oikopleurids). Macrozooplankton were mostly found in brackish water. Predominant macrozooplankton were Hydrozoa, Ctenophora, Chaetognatha (Sagitta),* Arthropoda *(mysids,* Lucifer, Acetes *and decapod larvae), Echinodermata (ophiopleuteus larvae), Bryozoa (cyphonautes larvae) and Chordata (fish larvae). Seasonal variation of the zooplankton community structure was prominent. Abundance was greatest during the heavy rainy season ($19x10^3$ - $24x10^3$ ind l^{-1}), with a rapid increase in protozoans, rotifers and copepod nauplii.* Tintinnopsis *spp.,* Codonella *spp.,* Brachionus *spp.,* Keratella *spp.,* Synchaeta *spp. and* Trichocerca *spp. were predominant from October to December, but their peak periods were different. Variations in abundance and community structure were related to seasonal rainfall.*

บทคัดย่อ

จากการศึกษาปริมาณแพลงก์ตอนสัตว์ในทะเลสาบสงขลาตอนนอกโดยการเก็บตัวอย่าง ทุก ๆ 2-3 เดือน ตั้งแต่เดือนสิงหาคม 2534 ถึงเดือนตุลาคม 2536 พบว่า ประมาณ 99 เปอร์เซ็นต์ ของปริมาณแพลงก์ตอนสัตว์ทั้งหมดเป็นแพลงก์ตอนสัตว์ขนาดเล็ก Protozoa เป็นกลุ่มเด่นที่สุด ตามด้วย Rotifera, Arthropoda (ระยะตัวอ่อนและตัวเต็มวัย ของ copepod), Mollusca (ระยะตัวอ่อนของ gastropod และ polecypod) และ Chordata (oikopleurids) โดยส่วนใหญ่พบแพลงก์ตอนสัตว์ขนาดใหญ่ในบริเวณน้ำกร่อย แพลงก์ตอนสัตว์ขนาดใหญ่กลุ่มที่เด่น คือ Hydrozoa, Ctenophora, Chaetognatha (*Sagitta*), Arthropoda (mysids, *Lucifer*, *Acetes* และ decapod lavae), Echinodermata (ophiopleuteus larvae) Bryozoa (cyphonautes larvae) และ Chordata (fish larvae) การแปรผันตามฤดูกาลของโครงสร้างของประชาคมแพลงก์ตอนสัตว์เกิดขึ้นเด่นชัดและมีความชุกชุมที่สุดในช่วงฤดูฝนตกหนัก ($19x10^3$ - $24x10^3$ ตัว/ล.) โดยมีพวก protozoans, rotifers และ copepod nauplii เพิ่มจำนวนขึ้นอย่างรวดเร็ว *Tintinnopsis* spp. *Codonella* spp., *Brachionus* spp., *Keratella* spp., *Synchaeta* spp. และ *Trichocerca* spp. เป็นสกุลที่พบมากตั้งแต่เดือนตุลาคมถึงเดือนธันวาคม แต่มีช่วงที่มีปริมาณสูงสุดเกิดขึ้นต่างเวลากัน การแปรผันของความชุกชุมและโครงสร้างของประชาคมแพลงก์ตอนสัตว์เกี่ยวข้องกับปริมาณน้ำฝนตามฤดูกาล

INTRODUCTION

Thale Sap Songkhla is the largest brackish water lake in southern Thailand. It supports about 2,490 commercial fishermen who harvest about 3,361 tons per year of fishes for local and international markets[9]. Predominant among the commercial fishes of the region is the giant sea bass (*Lates calcarifer*), mullet (*Mugil* spp.), groupers (*Epinephelus* spp.) and an assortment of benthic fishes that spend part or all of their life in the lagoon[35,36]. In addition, many larval and adult invertebrates inhabit the lake, such as squids (*Loligo* spp. and *Ilex* spp.), the white banana prawn (*Penaeus merguiensis*), the white prawn (*Penaeus indicus*), the jumbo prawn (*Penaeus monodon*) and shrimp (*Metapenaeus* spp.) that are harvested commercially and which also provide food for basses and other finfishes in the Gulf of Thailand. Almost all these commercial fishes and shellfishes feed on zooplankton during their early life stages or as adults. The zooplankton play an important role in the vitality of the lake and without the zooplankton the productivity of the Gulf of Thailand would be curtailed.

The purpose of this study was to determine the abundance and composition of zooplankton in outer *Songkhla Lake* and information from this study will become

part of a data base for a development plan. It will be used for the subsequent rehabilitation of *Songkhla Lake*.

The zooplankton community in *Songkhla Lake* has received little attention. Until recently there have been very few published works on the zooplankton of the lake. Previous studies within the lake have reported on biomass[22]. Angsupanich[1] recorded rotifers as the dominant zooplankton in upper *Songkhla Lake* or *Thale Noi*, a freshwater area. Seasonal variation in rotifer density was not significant[3], however, zooplankton in *Thale Noi* are exclusively freshwater species. In contrast, zooplankton in lower *Songkhla Lake* are directly affected by marine tidal currents. The zooplankton community is complicated due to the wide range of salinity.

Study area

Songkhla Lake is shallow (average depth 1.2 m) with a surface area of 986.8 km^2. Because of its brackish-water (salinity 0-32 PSU), this lake is properly called a lagoon and Kjerfve[20] classified it as a choked coastal lagoon system. With its characteristic single entrance the lake is dominated by the hydrologic / riverine cycle (rainfall and runoff), a dynamic wind force, a highly variable circulation response, and a lack of significant tides. It is the only large lake in southern Thailand. It is considerably longer than wide and is divided into three parts (Figure 1): *Thale Noi* (the uppermost part), *Thale Luang* (the middle lake) and *Thale Sap Songkhla* (the lowermost part) that connects the lake with the open sea[5]. *Songkhla Lake* is affected by the SW monsoon season, the light rainy period from mid-May to mid-October) and the NE monsoon season (the heavy rainy period from mid-October to mid-February)[10]. After the NE monsoon, the dry season is from mid-February to mid-May. This division of seasons is similar to that described by Kjerfve[20]. The present study investigated only *Thale Sap Songkhla* (176 km^2) whose development, particularly housing and industrial growth, is rapidly occurring. Blue green algae and green algae in *Thale Sap Songkhla* were dominant during the heavy rainy season, while diatoms and dinoflagellates were dominant during the dry to the light rainy period[2].

MATERIALS AND METHODS

As the study area is affected by both tidal currents and freshwater runoff, the zooplankton community consisted of microzooplankton and macrozooplankton. The latter included chaetognaths, medusae, hydrozoans, shrimp larvae, crab larvae and fish larvae. Zooplankton were obtained by two sampling methods: Microzooplankton were filtered from 160 ℓ of subsurface water through a 20 μm plankton net. Nets were not towed because of the turbid lake water. This non-standard procedure of Havens[13] was used because the shallow waters prevented fine net tows. Macrozooplankton were obtained by horizontal five minute tows at speeds from 1.0-1.5 m sec^{-1}, with a 40 cm diameter opening conical plankton net of 334 μm mesh. Samples were collected at seven stations (Figure 1), from August 1991-October 1993, at two-month intervals in the first year and at three-month intervals in the second year. All samples were preserved in 4% buffered formaldehyde. Counts were done on a one ml Sedgewick Rafter Counting Cell for approximately 10% of the original sample volume. Due to the low density of macrozooplankton, the samples were concentrated to a known volume using a plastic cylinder with a 20 μm mesh window, and 5-10 ml aliquots in small glass plates were counted under a stereozoom microscope. For the purpose of reporting zooplankton abundance in this paper the author uses the term density to signify the number of individuals and diversity to represent the number of taxonomic units. These taxonomic units may be genera or higher taxonomic levels. Density was expressed as individuals per liter. The surface and mid-depth salinity, pH and temperature determinations were made with a salinometer (SAL- 50, Central Kagaku Co., Ltd., Japan), and a Horiba pH meter; zooplankton samples were collected during the high spring tides (± 2 h).

RESULTS

Physico-chemical characteristics

Figure 2 shows data for station 1, the highest salinity station, station 5, the lowest salinity station, and a composite of data from all stations combined. These chosen stations depict the physical and chemical characteristics of the water and the seasonal abundance of microzooplankton.

Water temperatures ranged from 33°C during the dry season (April), to 26°C in the heavy rainy season (December-January) (Figure 2a). PH ranged between 7.2 and 8.6 (Figure 2b). There were no major differences in pH among stations.

Thale Sap Songkhla is euryhaline with salinities ranging from 1 to 32 PSU (Figure 2c). Minimum salinity occurred in the heavy rainy season (December) as a result of increased river flow, with peaks in salinity at high spring tides during intrusion of high salinity waters in the dry season (April 1992). Throughout 1993, except in April, the salinity was significantly decreased at all stations. Heavy rainfall in March (Meteorological Department, unpublished data) may have been the cause. Generally the salinities at stations near the mouth of the lake (stations 1 and 2) were higher than those of the inner lake which exhibited slight differences.

Species composition and distribution

The zooplankton discussed in this paper exclude the taxa of autotrophic microplankton which are reported by Angsupanich and Rakkheaw[2].

There were 12 phyla of zooplankton recorded in *Thale Sap Songkhla* between August 1991 and October 1993: protozoans, coelenterates, ctenophores, rotifers, chaetognaths, bryozoans, nematodes, annelids, arthropods, mollusks, echinoderms and chordates (Table 1). Taxa frequently found with high diversity were protozoans, rotifers and arthropods that consisted of copepod nauplii, adult copepods, barnacle nauplii, mysids, *Lucifer*, *Acetes* and larvae of shrimp, crab and mantis shrimp (alima larvae).

Most zooplankton of either seawater (e.g. jellyfish, *Oikopleura*, *Lucifer* and *Sagitta*) or freshwater (e.g. rotifers) origin were found dispersed throughout *Thale Sap Songkhla* with dispersal controlled by salinity. Freshwater species were extensively distributed in the heavy rainy season. Exceptions were *Lucifer* and *Acetes* which tended to be more abundant at stations 1 and 2 than at the other stations. Shrimp larvae (0.002-0.076 ind l^{-1}) were very abundant, especially at station 1, during the SW monsoon season (June-October).

Seasonal pattern of zooplankton

Seasonal variations in the zooplankton density between August 1991 and June 1992 were evident. The zooplankton were more abundant in the rainy season than

in the dry season (Figure 3). The mean density of zooplankton in the rainy season was high, $24x10^3$ ind l^{-1} in October and $19x10^3$ ind l^{-1} in December; in the dry season it was lower and ranged from $0.2x10^3$ (February) to $0.8x10^3$ ind l^{-1} (April). On the average, approximately 99% of the total zooplankton density was microzooplankton. This abundance was noted continually despite the low total zooplankton density found in the second year. Macrozooplankton made up about 1% of the total zooplankton. Seasonal variations in zooplankton density among stations showed a similar pattern but the mean zooplankton density at station 1 was higher than at station 5.

Seasonal diversity of phyla was obvious from August 1991 to June 1992 (Table 2). In the dry and the light rainy season, there were many zooplankton phyla (7-12), but only four were taken in the heavy rainy period (December). In December 1991, the number of protozoans and rotifers increased to 8,533 protozoans l^{-1} and 9,564 rotifers l^{-1}. At the same time, other zooplankton taxa decreased dramatically or disappeared. However, the pattern of seasonal variation in zooplankton was not prominent in 1993.

Microzooplankton

The extensive microzooplankton community in *Thale Sap Songkhla* is characterized by seasonal variations (Figure 4). Protozoans were very abundant and ranged from 23-83% of all microzooplankton studied in the lake. Other common invertebrates included: rotifers (3-51%), nauplii (1-34%), copepods (0-10%), mollusk larvae (0.1-8%) and oikopleurids (0-21%).

Protozoans: protozoans were common in *Thale Sap Songkhla*. The percentage of protozoans at station 1 was slightly higher than at station 5. Twenty-two genera of protozoans were found, mostly ciliates. *Tintinnopsis* spp., the most frequently occurring protozoans, were most abundant in October (9,842 ind l^{-1}) at station 4 (Table 1). The other common protozoan, *Codonella* spp. was found mainly at station 4 (27,148 ind l^{-1}) in December and rarely found at other times.

Rotifers: Rotifers were most abundant in density and diversity in the heavy rainy season (December) while the percentage of rotifers at station 5 was slightly higher than at station 1. The percentage of rotifers at station 5 was slightly higher than at station 1. Among the 19 genera of rotifers recorded, 33 species were identified. Common *rotifer*

genera were *Brachionus*, *Keratella*, *Trichocerca* and Synchaeta. These genera were most evident in December, 1991, when salinity was less than 5 PSU (the freshwater period), while *Synchaeta* was dominant in October 1991 (the brackish water period).

Nauplii and copepods: Nauplii and copepods occur frequently during the dry season and the light rainy period but, very few remain in the heavy rainy period. Nauplii dominate in October (the transition period), while adult copepods are most common during the months from August to October. Copepods consist of two genera of cyclopoids (*Corycaeus* and *Oithona*), seven genera of calanoids (*Acartia*, *Acrocalanus*, *Centrophages*, *Calanopia*, *Paracalanus*, *Eucalanus* and *Tortanus*) and two genera of harpacticoids (*Microsetella* and *Euterpina*). Nauplii and copepods are more abundant at stations near the mouth of the lake than at the inner stations, except for the nauplius peak in October when they are common throughout the upper reaches of the lake.

Mollusk larvae: Gastropod and pelecypod larvae are abundant at the same time as copepods, but additionally some pelecypods were obtained in December.

Oikopleuridae: Small populations of oikopleurids were found only during the brackish water period at all stations.

Macrozooplankton

Macrozooplankton in *Thale Sap Songkhla* included holozooplankton and merozooplankton. Macrozooplankton were mostly found where the water salinity was brackish. Holoplankton consisted of *Sagitta*, *Lucifer*, Acetes, mysids, ctenophores and hydrozoans. Meroplankton were mainly decapod larvae, fish larvae and a few larvae of mantis shrimp, bryozoans and sea stars (ophiopluteus larvae). There were slight decreases in numbers of meroplankton from the inner to the outer lake. Each taxa of macrozooplankton appeared in low numbers year-round in *Thale Sap Songkhla* (Table 1).

DISCUSSION

Thale Sap Songkhla is a lagoonal lake; with zooplankton represented by freshwater, brackish water and marine species. Species diversity is prominent in *Thale Sap Songkhla* where one entrance to the lake connects to the open sea and the other joins the inner lake (*Thale Luang*), which is mainly freshwater. Moreover, freshwater

from the land drains to *Thale Sap Songkhla* through several major canals. The diversity of zooplankton consists of organisms with different niches, origins and sizes. These differences relate to environmental effects especially seasonal rainfall. Lowered salinity, attributed to freshwater runoff, is one of the major factors influencing zooplankton variation while water temperature is a minor factor. The constant pH did not influence zooplankton abundance.

The number of phyla found in *Thale Sap Songkhla* was higher than those reported in upper *Thale Noi* where few major phyla were found.[1] In the present study, several taxa of seawater macrozooplankton were found during the dry to the light rain period: Coelenterata, Ctenophora, Chaetognatha, and Oikopleuridae. Heavy rains follow the light rainy period and the mass movement of freshwater from other parts of *Songkhla Lake* has a stronger influence than tidal currents. This massive freshwater intrusion effectively flushes seawater species out of the lake and allows protozoans and rotifers to grow and displace the seawater species, even in areas close to the mouth of the lake; this was especially evident in the late 1991. The hydrodynamic process is important to the zooplankton distribution in lakes that connect to the open sea.[16] But, hydrology is only obvious in *Thale Sap Songkhla* from November to January during the heavy rainy period. Tidal differences in the long summer and SW monsoon months (eight months) are about 50-60 cm. Although a seasonal variation of zooplankton was obvious in the 1991-1992 season, it was not evident in the 1992-1993 season. Due to low rainfall in 1992 (Meteorological Department, unpublished data), patterns of zooplankton density of those two-year periods showed a similar trend. The total zooplankton densities reported herein were moderate to high an typical of those found in other shallow hypertrophic lagoons[25] and estuaries[14], although the zooplankton densities were lower in the second year.

In the present study microzooplankton contributed significantly to the total zooplankton community, similar to epipelagic zone in oceanic environments.[4,29,33] *Thale Sap Songkhla* tintinnid ciliates were 10^2-10^4 ind l^{-1}, similar to those found in other habitats, including highly productive estuarine zones.[11,27,34] Tintinnid ciliates are important components of microzooplankton communities in estuaries,[17,21,24] but the importance of physico-chemical factors in regulating tintinnid dynamics is poorly understood. Some biologists associated maximum tintinnid abundance with high temperatures.[7,38] Krsinic[21] reported low salinity and higher temperatures favorable for *Tintinnopsis radix* and

Tintinnopsis compressa; *Stenosemella nivalis* bloomed in low salinity and at low temperature.

The peak density of *Tintinnopsis* spp. in *Thale Sap Songkhla* was observed in the post SW monsoon period when water salinity and temperatures were moderate, while *codonella* spp. was dominant in the mid to heavy rainy season, when there was a lower salinity and a lower temperature. Irradiance may not inhibit tintinnids from excysting in the shallow coastal area.[18] The higher abundance of tintinnids from October to December 1991 may be due to the availability of food.[37] This corresponded increased concentrations of chlorophyll *a* in October, with a peak in December 1991.[39] This combination was not observed in the second year of the investigation when very low microzooplankton densities and chlorophyll concentrations were noted. Although, ciliate density has been correlated with cocci and total bacteria density[8] and tintinnids with nanoplankton[7], the concentrations of chlorophyll *a* have been used to measure grazing by microzooplankton.[6]

The increase of rotifers and their diversity occurred during periods of increasing chlorophyll concentrations,[39] and the blooming of *Songkhla* cyanophytes and chlorophytes occurred in December.[2] The dominance of *Brachionus angularis* occurred at the same time as cyanobacteria blooms in the Albufera Lagoon in Valencia, Spain.[25] Favorable conditions for *Synchaeta*, were in October, with a higher salinity. One species of the genus *Synchaeta* was common found in brackish or marine station (station 1). However, this species is in the process of being identified to the species level. In addition to food availability, salinity is significant as a primary regulator of rotifer dynamics and diversity. However, only a small number of cladocerans was found in the heavy rainy period at a time of a large phytoplankton bloom. Reasons for the disappearance or sparse occurrence of cladocerans in *Thale Sap Songkhla* are still obscure. Predation by planktivorous fishes which are abundant in the heavy rainy season[32] are possible.[12] The blooming of cyanophytes may inhibit cladocerans.[15,19,28]

Copepods were not abundant in *Thale Sap Songkhla*, which differs from the Albufera Lagoon,[25] however, copepods and their nauplii were found throughout the year.

Although juvenile or adult penaeids are common in *Thale Sap Songkhla*,[32] few shrimp larvae are found.[5] The ranges of salinity reflect the biogeographic distribution of the species of penaeid larvae.[30] It was found that several species of penaeid larvae

were abundant when salinities were greater than 31 PSU. *Penaeus merguiensis* larvae were always found near the estuary mouth.[31] Therefore, it is concluded that the low salinity of *Thale Sap Songkhla* is unsuitable for growth and survival of penaeid larvae, with the exception of the area near the mouth of the estuary where the ocean has the greatest influence.

Data concerning zooplankton in *Songkhla Lake* are limited. Limpadanai's[22] study did not allow to compare species and densities. His data however, revealed that several seawater zooplankton, such as *Sagitta* and *Oikopleura*, entered the lake and reached *Ban Pak Khat*, the juncture between the outer and middle lake.

CONCLUSION

After more than two years of study, it can be concluded that rainfall controlling salinity is the major factor controlling seasonal variation patterns of plankton in *Thale Sap Songkhla*. Changes in community structure depend upon seasonal replacements of freshwater-brackish water and brackish-seawater plankton. The first group is comprised mostly of protozoans, rotifers, cladoceran and copepods, while the second group consists of the remaining taxa of zooplankton and includes some protozoans and rotifers. Zooplankton immigrating from the sea include coelenterates, ctenophores, chaetognaths, oikopleurids and larvae of shrimp, crabs and some mollusks.

Besides, controlling population levels of bacteria[23] and regulating the phytoplankton species composition by their potential ability to control growth of food species,[26] microzooplankton are important food for macrozooplankton and developing larval fishes in *Thale Sap Songkhla*.

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Table 1. Zooplankton indentified in Thale Sap Songkhla during the months from August 1991 to October 1993.

Taxa	Distribution (station)	Peak (ind l^{-1})	1991	1992	1993
PROTOZOA*					
Acanthostomella sp.	1,2	10		**Apr**	
Amphorellpsis sp.	2,7	11		**Apr**	Jan
Bolivinila sp.	1	6			**Jan**
Brizalina sp.	1,2	8		Oct	
Carchesium sp.	1,2	254	**Dec**		
Cibicides sp.	1,5	752		**Aug**,Oct	Apr
Codonella sp.	1-7,4	27,148	Oct, **Dec**	Oct	Jan,Apr,Jul
Codonellopsis spp.	1-4,6,7	426	Aug,**Oct**	Apr,Jun,Oct	Jan,Oct
Conochiloides sp.	7	1			**Jan**
Eutinotinnus spp.	1,2,3	17		**Apr**,Jun,**Aug**,**Oct**	Jan,Apr,Jul
Favella spp.	1-7,2	1,463	Aug, **Oct**	Apr,Jun,Aug,Oct	Jan,Apr,Jul
Globigerina sp.	1-7	237	**Oct**	Jun,Aug,Oct	Jan,Apr,Jul,Oct
Globorotalia sp.	1	3	**Oct**		
Leprotintinnus spp.	1-4,6,7	468	Aug,**Oct**,De	Feb,Aug,Oct	Jan,Apr,Oct
Nonionella sp.	1	6		**Oct**	
Sigmidella sp.	1	4			**Jan**
Spiroloculina sp.	1	4		**Oct**	
Tintinnopsis spp.	1-7,4	9,842	Aug,**Oct**,De	Feb,Par,Jun,Aug,Oct	Jan,Apr,Jul,Oct
Trochilioides sp.	1,3,4-7	928		Aug,**Oct**	Jan
Undella sp.	1-5	6		Apr,**Aug**	Apr
Unidentified	1-7	85	Aug,Oct,**Dec**	Feb,Apr	
Vorticella sp.	5,7	147	**Aug**		Oct
ROTIFERA*					
Albertia sp.	1,2	522	**Dec**		
Anuraeopsis sp.	5-7	494	Aug,**Dec**		Oct
Asplanchna spp.	1-7	981	Aug,oct,Dec	Apr,Jun,**Aug**,Oct	Jan,Apr,Jul,Oct
Brachionus spp.	1-7	6,389	Oct,**Dec**	Feb,Apr,Aug	Jan,Apr,Jul,Oct
Colurella spp.	7	1		**Apr**	
Conochilus sp.	1-3,6	1,269	**Dec**		Jan
Dipleuchlanis sp.	4	1			**Oct**
Ephiphanes sp.	1,4-6	107	**Oct**		
Filinia spp.	1-7,4	4,242	Aug,**Dec**	Feb	Jan,Jul,Oct

Table 1. (continued)

Taxa	Distribution (station)	Peak (ind l^{-1})	1991	1992	1993
Hexarthra sp.	3-6,5	6		**Feb**	
Keratella spp.	1-7,4	11,029	Dec	Feb,Apr,Jun	Jan,Apr,Jul,oct
Lecane sp.	3-7,5	2			Apr,Jul,Oct
Lepadella sp.	3-6,5	7		Feb	Jul,Oct
Monostyla sp.	3-7	4	Aug	Feb	Oct
Notholca sp.	1-7,6	11		Feb,**Apr**	Oct
Platyias sp.	4	3			**Oct**
Polyarthra spp.	4-7	648	Dec	Feb,Apr,Aug,Oct	Oct
Synchaeta spp.	1-7,2	30,395	Aug,Oct		Jan,Apr,Jul
Trichocerca spp.	1-7,4	5,769	Aug,Oct,**Dec**	Feb,Jun,Aug,Oct	Jan,Apr,Jul,Oct
NEMATODA					
Nematode*	2-7,4	107	Aug,**Oct**	Feb,Apr,Jun,Aug,Oct	Jan,Jul
ANNELIDA					
Adult polychaete	1,2	0.015			**Jul**
Polychaete larvae	1-7,2	960	Aug,**Oct**	Aug,Oct	Jan,Apr,Jul,Oct
COELENTERATA				Jun,**Oct**	
Bougainvillia sp.	4,5,6	291	**Oct**		
Lensia sp.	1,2,5	1			**Jan**,Oct
Medusa	1-7,6	0.207			Jan,Apr,Oct
CTENOPHORA				Apr,Jun,Aug,Oct	
Unidentified	3-7	0.056			**Oct**
CHAETOGNATHA				Oct	
Sagitta spp.	1-7,6	11	**Oct**	**Aug**	Jan,Oct
ARTHROPODA					
Acetes spp.	1,2-4,7	0.015		Jun,Aug,Oct	Jul,Oct
Alima larvae	7	0.002		Feb,Apr,Jun,Aug,Oct	Apr,Jul
Arachnida	2	0.001			**Oct**
Barnacle larvae	1-7,2	503	**Oct**	Aug,Oct	Jan,Jul,Oct
Calanoida*	1-7,2	3,839	Aug,**Oct**,De	Feb,Apr,Jun,Aug,Oct	Jan,Apr,Jul,Oct
Cladocera*	7	62	**Dec**	Feb,Apr,Jun,**Aug**,Oct	
Crab larvae	1-3,6,7	0.092		Aug,Oct	Apr,Jul,Oct
Cyclopoida*	1-7,2	2,514	Aug,**Oct**	**Apr**	Jan,Apr,Jul
Harpacticoida*	1,2,3,5-	27	Aug,Oct	Feb,Apr,Jun,Aug,Oct	Jan,Apr,Jul

Table 1. (continued)

Taxa	Distribution (station)	Peak (ind l^{-1})	1991	1992	1993
Lucifer sp.	1-7,4	1.15		Aug,Oct	Jan,Apr,Jul,**Oct**
Mysid	1,2,6,7	4		**Apr**	Oct
Nauplius*	1-7,4	28,510	Aug,**Oct**,De	Feb,Apr,Jun,Aug,Oct	Jan,Apr,Jul,Oct
Shrimp larvae	1-6	0.076	Oct	Jun,**Aug**,Oct	Jan,Oct
BRYOZOA					
Cyphonautes larvae	1,2,4,6	4		Jun	Jan,Apr,**Jul**,Oct
ECHINODERMATA					
Ophiopluteus larvae	1,2,3,6	0.085			Jan,**Oct**
MOLLUSCA*					
Gastropod larvae	1-7,2	2,422	Aug,**Oct**,De	Feb,Apr,Jun,Aug,Oct	Jan,Apr,Jul,Oct
Pelecypod larvae	1-7	3,693	Aug,**Oct**,Dec		Jan,Apr,Jul,Oct
CHORDATA					
Fish larvae	1-3,5-7	0.054		**Aug**,Oct	Jan,**Jul**,Oct
Oikopleura spp.*	1-7	5,108	Aug, **Oct**	Feb,Apr,Jun,Aug,Oct	Jan,Jul,Oct

Data shown related to distribution (station), maximum density and monthly occurrence.

Bold print indicates station and month of maximum density.

*indicates microzooplankton

Table 2. Seasonal diversity of the zooplankton community in terms of phylum. Figures show the average density of zooplankton (ind l^{-1}) obtained from Thale Sap Songkhla.

Month	Pro	Coe	Cte	Rot	Cha	Nem	Ann	Bry	Art	Mol	Ech	Cho
August' 91	260	-	-	16	-	0.29	4	-	104	10	-	10
October	5,361	61	-	4,710	17	33	311	-	10,216	1,915	-	1,532
December	8,533	-	-	9,564	-	-	-	-	182	442	-	-
February' 92	120	-	-	371	-	0.29	0.86	-	38	9	-	1
April	439	-	-	24	0.43	-	13	-	187	11	-	10
June	709	0.005	-	34	0.01	0.14	7	0.14	106	3	-	1
August	604	0.006	-	145	0.44	0.71	18	-	226	57	-	8
October	358	0.04	-	25	0.49	0.14	46	-	234	23	-	39
January' 93	396	0.14	-	111	0.15	0.29	8	0.43	48	26	1	2
April	585	0.0001	-	838	-	-	0.28	0.0001	15	2	-	-
July	257	-	-	41	-	5	2	1	99	76	-	14
October	218	0.017	0.02	89	0.03	-	0.57	0.0002	38	8	0.02	2

Pro = Protozoa, Coe = Coelenterata, Cte = Ctenophora, Rot = Rotifera, Cha = Chaetognatha, Nem = Nematoda, Ann = Annelida, Bry = Bryozoa, Art = Arthropoda, Mol = Mollusca, Ech = Echinodermata, Cho = Chordata.

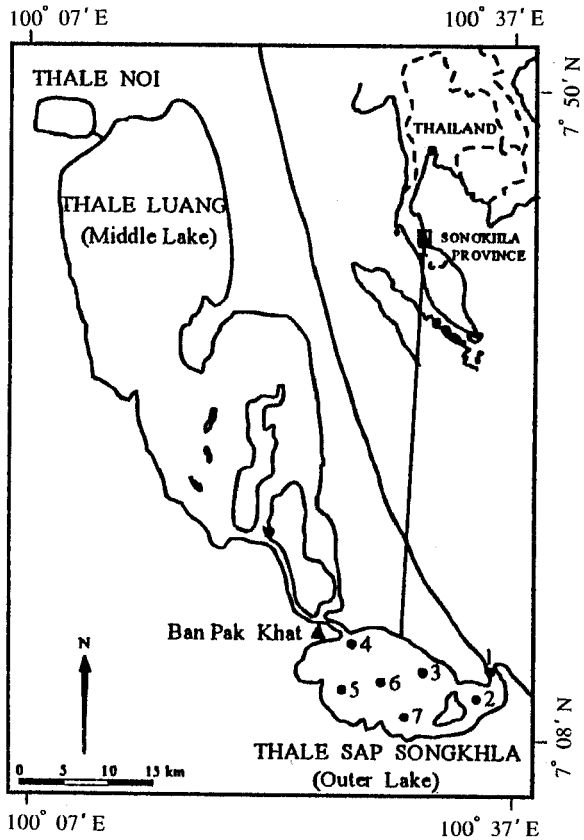

Fig. 1 Songkhla Lake (*Thale Sap Songkhla*) and study area

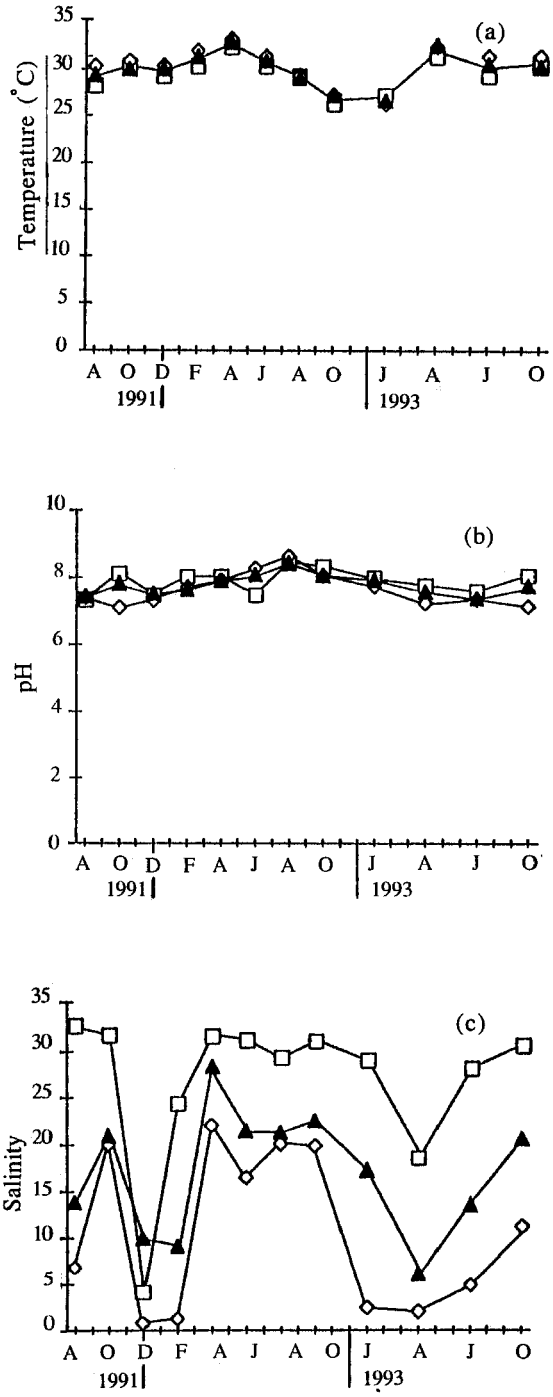

Fig. 2 Water temperature, pH and salinity of *Thale Sap Songkhla* (St. 1 □, St. 5 ◇ and overall mean ▲)

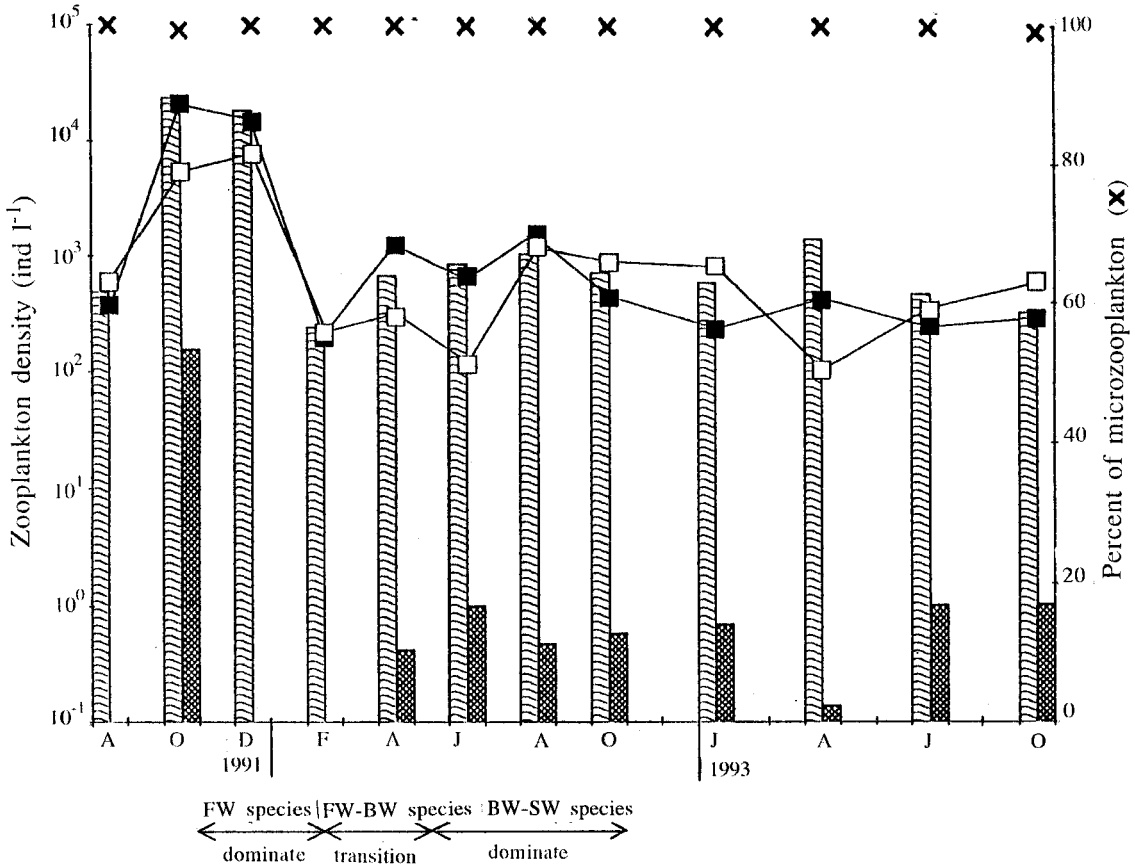

Fig. 3 The overall mean densities (ind l^{-1}) of microzooplankton (▨) and macrozooplankton (■), the percentages of microzooplankton (×) and zooplankton densities (ind l^{-1}) at St. 1 (■) and St. 5 (□) in *Thale Sap Songkhla* during the study. FW = freshwater, BW = brackish water, SW = seawater

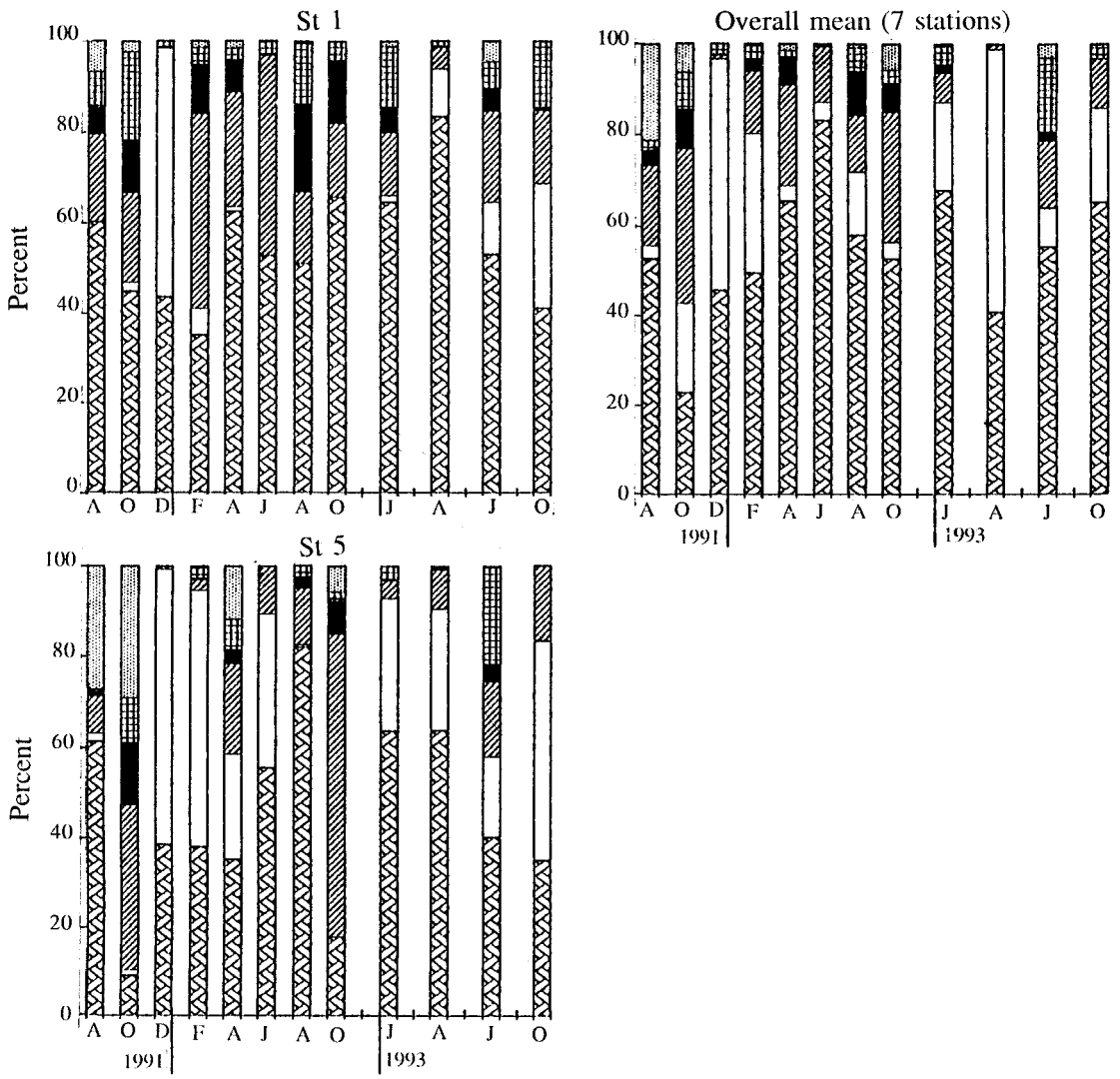

Fig. 4 Relative abundances of the important microzooplankton taxa (▨ - protozoan, □ - rotifer, ▨ - nauplius, ■ - copepod, ⊞ - mollusk larva, ▨ - oikoplcurid)