Songklanakarin J. Sci. Technol.
33 (6), 641-651, Nov. - Dec. 2011

SJST SONGKLANAKARIN JOURNAL OF SCIENCE AND TECHNOLOGY
http://www.sjst.psu.ac.th

Original Article

Marine copepods at Mo Ko Thale Tai, Gulf of Thailand

Supiyanit Maiphae[1]* and Phannee Sa-ardrit[2]

[1] *Plankton Research Unit, The Center of Excellence for the Biodiversity in Peninsular Thailand, Faculty of Science,*

[2]*Princess Maha Chakri Sirindhorn Natural History Museum, Faculty of Science,*
Prince of Songkla University, Hat Yai, Songkhla, 90112 Thailand.

Received 6 May 2011; Accepted 9 October 2011

Abstract

The taxonomic composition, abundance and spatio-temporal distribution of copepods were analyzed from bimonthly zooplankton samples collected at Mo Ko Thale-tai, Nakhon Si Thammarat Province. Sixteen copepod genera in families Calanoida (9), Harpacticoida (4), Poecilostomatoida (2), and Cyclopoida (1) were identified. This number accounted for 59% of the recorded Thai marine copepods (27 genera). The most common genera were *Oithona*, *Euterpina*, *Acrocalanus*, *Corycaeus,* and *Microsetella*. Copepod blooms were observed in October 2006 (103,044 individuals/m^3) and July 2007 (73,579 individuals/m^3). Their abundance was consistently high around Ko Tan where seaweeds, seagrasses ,and corals dominated the area. This evidence indicated that the prevalence of these microhabitats that most likely provide food and nursery grounds for the larval stages might be one of the key factors that determine the occurrence, abundance and distribution of copepods.

Keywords: copepod, Thai waters, Kanom, Mo Ko Thale-tai, Gulf of Thailand

1. Introduction

Studies of copepods in Thai waters eventually started by Rose (1926) in the Gulf of Thailand (referred by Suvapepun, 1981). After that, NAKA carried out an expedition between 1959 and 1961 around the South China Sea and Gulf of Thailand. The aims of that expedition were to study the physical and chemical parameters of the Gulf and various marine organisms including copepods. Since then, the Department of Fisheries began to explore plankton communities in Thai waters. Suvapepun and Suwanrumpha (1968) studied the distribution of copepods in the Inner Gulf of Thailand and the western part of the Gulf of Thailand. Later, Suvapepun (1978) and Suvapepun (1981) reported on the composition of zooplankton in the Gulf of Thailand. Since then there has been work on particular ecosystems such as mangroves (Suvapepun *et al.*, 1979; Angsupanich, 1985; Sikhantaka-samit, 1991; Paphavasit *et al.*, 1997; Chuaypanang, 1998; Satapoomin, 1999; Raungrut *et al.*, 2004), estuaries (Kaosirikul, 1979; Teeratecha, 1981; Suvapepun *et al.*, 1982; Angsupanich, 1997; Aiemsomboon, 2000), seagrass beds (Tantichaiwanit, 2005), and offshore studies (Suvapepun and Suwanrumpha, 1968; Boonruang, 1985; Punnarak, 2004; Satapoomin *et al.*, 2004). These research efforts mostly studied copepod diversity and abundance. However, some research works did focus on the relationships between copepods and environmental factors and some aimed to measure and monitor the conditions of an ecosystem. The rest were designed to explore the possibility for aquaculture. All this research work has provided knowledge and information that can assist with conservation and area management. However, there are more places that indeed need to be studied. Mo Ko Thale-tai in Gulf of Thailand is one of them. This area is a rich source of high-profit seafood especially fish and shrimp (Nakhon Sri Thammarat Fishery Office, 2003). It is still in original condition but potentially could be disturbed in the near future because of the increasing number of tourists. Thus, in spite of reviewing the previous works of the Thai marine copepods,

* Corresponding author.
Email address: supiyanit.m@psu.ac.th

this paper was aimed to contribute more data on the diversity and abundance of marine copepods at Mo Ko Thale-tai, Gulf of Thailand.

2. Materials and Methods

2.1 Study sites

Samples were taken from different habitats along the Kanom canal to Mo Ko Thale-tai, Nakhon Si Thammarat Province between October 2006 and September 2007, covering 14 stations (S1-S14) (Figure 1).

2.2 Zooplankton sampling

One hundred and sixty-eight zooplankton samples were collected from 14 stations, in October 2006, January, March, June, July and September 2007. Species richness was based on samples qualitatively collected with a tow net, 30 cm in diameter and fitted with a 60 and 200 μm mesh net. Tows were made vertically, obliquely, and horizontally for an approximate linear distance of 10 cm in open water. Abundance estimates were based on filtering 50 liter of water via a standard plankton net of 60 μm. After capture, samples were immediately preserved in 4% formalin.

2.3 Environmental measurement

Physical and chemical factors were measured at each site including depth, transparency, temperature, conductivity, salinity, pH, and dissolved oxygen (Table 1). Temperature, conductivity, salinity, pH and dissolved oxygen were measured using regularly calibrated meters. Depth and transparency (±1 cm) were estimated by Secchi disk.

2.4 Investigation of the plankton specimens

Samples were transported to the laboratory for sorting, identification, and enumeration. Zooplankton specimens were detected using a stereo binocular microscope at low magnification and extracted for identification. Specimens were mounted on a slide in glycerin for identification and counting using a compound microscope. The identifications were carried out using various keys, supplemented with up-to-date literature.

3. Results and Discussion

3.1 Marine copepods in Thai water from previous researches

Although the study of marine copepod in Thailand has not a long history, the research during the last eighty years has been very productive. All copepods found during that period are summarized in Table 2. The data can be divided into studies in the Gulf of Thailand and the Andaman Sea. Studies in the Gulf of Thailand can be subdivided into four habitats: mangrove, estuary, seagrass beds, and coastal areas and the studies in the Andaman Sea can be subdivided into two habitats: mangroves and coastal areas (Table 3).

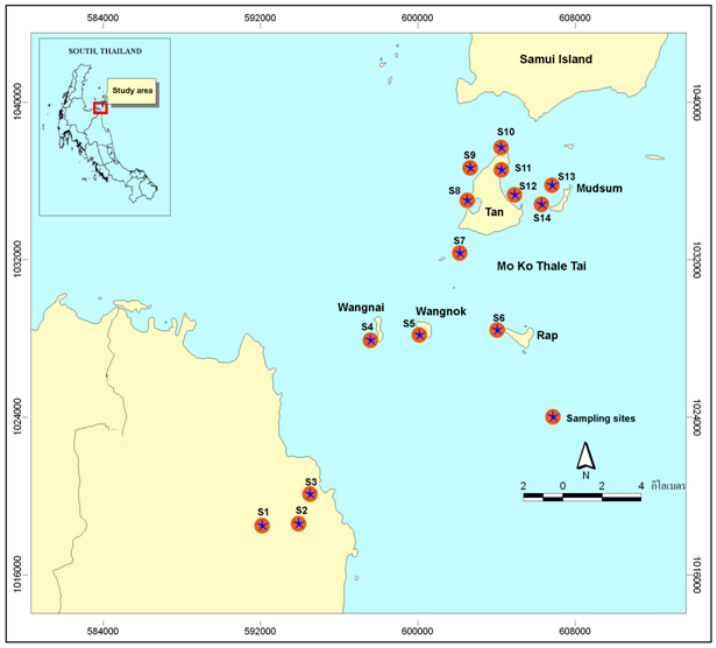

Figure 1. Sampling sites at Kanom canal and Mo Ko Thale-tai, Nakhon Si Thammarat Province : S1 = station 1, S2 = station 2, S3 = station 3, S4 = Station 4, S5 = station 5, S6 = station 6, S7 = station 7, S8 = station 8, S9 = station 9, S10 = station 10, S11 = station 11, S12 = station 12, S13 = station 13, S14 = station 14

Table 1. Characteristics of each sampling station.

Stations	position	Characteristics						
		Depth (m)	Transparency (m)	Temperature (°C)	Conductivity (mS)	Salinity (ppt)	pH	Dissolved oxygen (mgO_2/L)
1	Kanom canal, surrounded by mangrove forest	3.8-6.0	28.0-32.3	28.0-32.3	26.1-50.2	13.1-32.7	7.46-8.13	4.8-8.13
2	Kanom estuary, in front of the harborage	2.4-5.0	0.7-1.3	28.0-32.8	31.2-51.0	15.5-33.3	7.07-8.18	7.27-8.16
3	Kanom estuary, close to the power station	0.6-5.2	0.6-1.3	28.4-33.9	38.3-50.9	19.1-33.2	7.63-8.22	7.0-8.17
4	about 50 m away from the south of Ko Wang Nai	6.8-26.0	1.1-3.0	27.5-31.4	41.2-54.7	20.8-36.7	7.27-8.22	7.27-8.62
5	about 50 m away from the south of Ko Wang Nok	8.3-20.0	1.1-3.8	27.3-32.7	41.2-50.5	31.4-33.8	7.26-8.36	7.26-8.2
6	about 50 m away from the west of Ko Rap	10.8-18.0	1.6-4.0	27.4-32.6	45.5-54.2	31.6-33.7	6.96-8.24	6.96-7.86
7	about 50 m away from the south of Ko Tan	>25	1.9-5.4	26.9-31.3	19.99-50.7	31.7-33.8	7.55-8.22	5.69-8.16
8	about 50 m away from the west side of Ko Tan	1.1-3.0	1.1-3.0	26.5-30.9	39.1-54.5	21-33.4	8.01-8.24	5.44-7.86
9	about 50 m away from the north-west side of Ko Tan	5.0-15.0	1.3-4.5	27.2-30.9	39.8-54.1	31.6-33.6	7.99-8.25	7.80-8.33
10	about 50 m away from the north side of Ko Tan, with seaweed bed	9.2-20.0	2.3-3.7	27.4-34.7	30.4-49.8	19.8-33.5	8.04-8.22	6.89-7.86
11	about 50 m away from the north-east side of Ko Tan	6.0-7.9	1.9-5.0	27.4-36.2	40.3-50.4	31.9-33.4	7.54-8.23	5.74-7.86
12	about 50 m away from the east side of Ko Tan, with seaweed and coral bed	3.9-6.3	1.8-4.3	27.6-33.7	40.6-54.6	31.5-33.0	7.89-8.22	5.76-7.86
13	about 50 m away from the west side of Ko Mudsum	0.9-2.6	0.9-2.6	27.4-32.7	40.7-50.6	31.6-32.9	8.1-8.3	5.73-9.74
14	about 50 m away from the west side of Ko Mudsum	7.5-14.2	1.8-3.5	27.5-33.9	41.6-50.1	29.9-32.7	7.99-8.22	5.69-7.86

3.1.1 Copepod diversity in the Gulf of Thailand

Mangroves: Suvapepun *et al.* (1979) studied zooplankton at the Laem Phak Bia Subdistrict of Phetchaburi Province. Zooplankton was collected from five stations along a mangrove creek with a depth ranging between 1-2.55 m. Copepods were the major group of zooplankton found with *Acartia erythraea* and *A. spinicaud* being the most dominant species. Sikhantakasamit (1991) studied zooplankton communities in a mangrove swamp at Bann Klong Kone, Samut Songkhram Province. He found 18 copepod species within three orders (calanoid, cyclopoid, and harpacticoid). The dominant species was *Acartia clausi*, *Calanus vulgaris* and *Oithona brevicornis,* which comprised 95.53% of the total copepods. Paphavasit *et al.* (1997) studied a mangrove reaforestation area planted to enhance coastal fisheries in the Tha Chin estuary. The relationship between the conditions of the mangrove plantation, coastal fisheries and zooplankton communities was analyzed. It was reported that 20 groups in six phyla of zooplankton were found and copepods were the most common taxa.

Estuaries: In the Inner Gulf of Thailand, Kaosirikul (1979) observed zooplankton at the Chao Phraya estuary during 1976-1978 and reported that the major components of the zooplankton community were copepods, polychaete larvae, chaetognath, Lucifer, branchyura larvae, and gastropod larvae. Teeratecha (1981) studied zooplankton in the Tha Chin estuary, Samut Sakhon Province and reported 23 groups from eight phyla. The dominant groups were calanoid copepods, decapod larvae, chaetognaths and gastropod larvae respectively. Aiemsomboon (2000) also studied the zooplankton community in the Tha Chin estuary but at that time their emphasis was on shrimp, crab, and fish larvae. However, the zooplankton detected in this study consisted of 33 groups from 13 phyla. Copepods were the dominant group with a relative abundance of 88.04% of the total zooplankton density, followed by cirepedia larvae, gastropod larvae, bivalve larvae, chaetonaths, *Luficer* spp. and polychaete larvae, respectively.

Suvapepun *et al.* (1982) studied the composition of zooplankton at the Kanom estuary, Nakhon Si Thammarat Province and found that the most common groups were

Table 2. Marine copepod species in Thai waters.

Species	References	Species	References
Order Calanoida		*Pseudodiaptomus annandalei*	7, 14
Acartia australis	17	*Pseudodiaptomus aurivillii*	1, 3, 6, 7, 9, 10, 11, 12
Acartia erythaea	18	*Pseudodiaptomus bispinosus*	7, 13, 15
Acartia negligens	2, 3	*Pseudodiaptomus bowmani*	13, 15
Acartia amboienesis	2	*Pseudodiaptomus bulbiferus*	14
Acartia longiremis	3	*Pseudodiaptomus clevei*	2, 3, 9, 10, 11
Acartia erythraea	1, 3, 5, 7	*Pseudodiaptomus dauglishi*	3, 9, 10, 11
Acartia pacifica	18	*Pseudodiaptomus masoni*	13, 15
Acartia sinjiensis	18	*Pseudodiaptomus sewelli*	13, 15
Acartia spinicauda	1, 4, 7	*Scolecithricella tenuiserrata*	2
Acartia clausi	3	*Temora discaudata*	2, 3, 5, 9, 10, 11, 17
Acrocalanus longicornis	1, 2, 5	*Temora longicornis*	1, 3, 9, 10, 11
Acrocalanus gracilis	1, 2	*Temora stylifera*	3, 9, 10, 11
Acrocalanus gibber	1, 2, 17	*Temora turbinata*	1, 2, 3, 9, 10, 11
Acrocalanus similis	6	*Tortanus barbotus*	13, 14
Bestiolina similes	7	*Tortanus forcipatus*	2, 3, 5, 9, 10, 11, 12
Candacia bradyi	2, 3	*Tortanus gracilis*	3, 9, 10, 11
Candacia catula	2, 3	*Tortanus tropicus*	13, 15
Candacia discaudata	2, 3, 5		
Candacia truncata	2, 5	Order Cyclopoida	
Candacia simplex	2	*Copilia mirabilis*	1, 3, 9, 10, 11
Candacia curta	6	*Copilia quadrata*	3, 9, 10, 11
Calocalanus styliremis	2, 3, 9, 10, 11	*Copilia vitrea*	3, 9, 10, 11
Calocalanus pavo	1, 2, 3, 9, 10, 11	*Corycaeus asiaticus*	3, 9, 10, 11
Calocalanus plumulosus	2, 3, 9, 10, 11	*Corycaeus affinis*	3, 9, 10, 11
Calanopsia aurivillii	3, 9, 10, 11	*Corycaeus agilis*	3, 9, 10, 11
Calanopsia australica	13, 15	*Corycaeus andrewsi*	13, 15
Calanopia elliptica	1, 2, 3, 9, 10, 11	*Corycaeus concinnus*	3, 9, 10, 11
Calanopia minor	2, 3, 9, 10, 11	*Corycaeus catus*	3, 9, 10, 11
Calanopia seymouri	13, 15	*Corycaeus crassiusculus*	3, 9, 10, 11
Calanopia thomsoni	3, 9, 10, 11	*Corycaeus flaccus*	3, 9, 10, 11
Calanus minor	2	*Corycaeus gibbulus*	1, 3, 9, 10, 11
Calanus pauper	2, 3, 6	*Corycaeus gracilicaudatus*	1, 3, 9, 10, 11
Calanus vulgaris	1, 2, 3	*Corycaeus latus*	3, 5, 9, 10, 11
Calanus darwinii	3	*Corycaeus lautus*	6
Calanus tenuicornis	3	*Corycaeus longistylis*	3, 9, 10, 11
Centropages furcata	2, 3, 6, 17	*Corycaeus ovalis*	1, 3, 9, 10, 11
Centropages orsinii	1, 2, 3	*Corycaeus obtusus*	1, 3, 9, 10, 11
Centropages gracilis	2	*Corycaeus robustus*	1, 3, 9, 10, 11
Centropages tenuiremis	2	*Corycaeus rostratus*	3, 9, 10, 11
Clausocalanus arcuicornis	1, 3, 9, 10, 11	*Corycaeus speciosus*	3, 6, 9, 10, 11
Clausocalanus furcatus	1, 2, 3, 9, 10, 11	*Corycaeus trukicus*	3, 9, 10, 11
Eucalanus pileatus	2	*Oncaea conifera*	1, 3, 9, 10, 11
Eucalanus crassus	2	*Oncaea media*	1, 3, 9, 10, 11
Eucalanus subcrassus	2, 3, 5	*Oncaea venusta*	1, 3, 9, 10, 11, 17
Eucalanus monachus	1	*Oithona brevicornis*	3, 7, 9, 10, 11, 12, 14
Eucalanus attenuatus	1	*Oithona disimilis*	7
Euchaeta concinna	2, 6	*Oithona plumifera*	3, 9, 10, 11, 12, 14, 17
Euchaeta marina	1	*Oithona nana*	1, 3, 7, 9, 10, 11, 12
Euchaeta marinella	17	*Oithona oculata*	3, 7, 9, 10, 11, 12
Euchaeta plana	6	*Oithona rigida*	1, 3, 9, 10, 11, 12
Pontella forficula	13, 15	*Oithona similis*	1, 3, 9, 10, 11, 12, 14

Table 2. Continued

Species	References	Species	References
Pontella spinicauda	3, 9, 10, 11	*Oithona simplex*	3, 7, 9, 10, 11, 12
Pontellapsis perspicax	3, 9, 10, 11	*Sapphirina angusta*	3, 9, 10, 11
Pontellapsis regalis	3, 9, 10, 11	*Sapphirina gastrica*	3, 6, 9, 10, 11
Pontellapsis yamadae	3, 9, 10, 11	*Sapphirina gemma*	3, 9, 10, 11
Pontellina plumata	3, 9, 10, 11	*Sapphirina metallina*	1, 3, 9, 10, 11
Labidocera acuta	2, 3, 9, 10, 11	*Sapphirina nigromaculata*	3, 6, 9, 10, 11
Labidocera bipinnata	3, 4, 8, 9, 10, 11, 13, 15	*Sapphirina ovatolanceolata*	3, 9, 10, 11
Labidocera detruncata	3, 5, 9,10, 11	*Sapphirina scarlata*	3, 6, 9, 10, 11
Labidocera japonica	3, 9, 10, 11	*Sapphirina stellata*	3, 9, 10, 11
Labidocera kroyeri	1, 2, 3, 9, 10, 11	*Sapphirina vorax*	1, 3, 9, 10, 11
Labidocera laevidentata	2, 3, 9, 10, 11		
Labidocera minutum	1, 2, 3, 9, 10, 11	Order Harpacticoida	
Labidocera pavo	3, 7, 9, 10, 11	*Clytemnestra rostrata*	3, 6, 9, 10, 11
Labidocera rotundata	7	*Clytemnestra scutellata*	3, 9, 10, 11
Macandrewella scotti	13, 15	*Corynura denticulata*	1, 3, 9, 10, 11
Metacalanus aurivillii	1	*Corynura recticauda*	1, 3, 9, 10, 11
Paracalanus aculeatus	1, 2, 3, 9, 10, 11	*Macrosetella gracilis*	1, 3, 9, 10, 11
Paracalanus crassirostris	2, 6, 12, 14	*Microsetella atlantica*	1
Paracalanus denudatus	2, 3, 9, 10, 11	*Microsetella norvegica*	3, 6, 9, 10, 11, 12
Paracalanus nanus	3, 4, 9, 10, 11	*Microsetella rosea*	1, 3, 9, 10, 11, 12
Paracalanus parvus	1, 2, 3, 9, 10, 11	*Microsetella regalis*	1, 3, 9, 10, 11, 12
Pontella spinicauda	6	*Monops regalis*	3, 9, 10, 11
Pontellapsis perspicax	6	*Monops strenuus*	1, 14
Pontellapsis yamadae	6	*Euterpina acutifrons*	1, 3, 7, 9, 10, 11, 12
Pontellina plumata	2	*Mytis jousseaumei*	3, 9, 10, 11
Pseudodiaptomus andamanensis	13, 15	*Schizopera subterranea*	3, 4, 9, 10, 11, 16

Note: 1= Rose (1926), Suvapepun, (1981); 2 = Fleminger (1963); 3 = Suvapepun and Suwanrampha (1968); 4 = Suvapepun (1976); 5 = Suwanrampha (1978); 6 = Suvapepun (1978); 7 = Suvapepun *et al.* (1979); 8 = Suwanrampha (1978); 9 = Suwanrampha (1980a); 10 = Suwanrampha (1980b); 11 = Suwanrampha (1987); 12 = Sikhantakasamit (1991); 13 = Nishida *et al.* (2003); 14 = Pinkaew (2003); 15 = Punnarak (2004); 16 = Supongpun (1976); 17 = Satapoomin *et al.* (2004); 18 = Ohno (1996).

Table 3. Distribution of marine copepods in Thai waters.

Family	Species	Gulf of Thailand				Andaman Sea
		Coastal	Offshore	Mangroves	Estuaries	
Order Calanoida						
Acartiidae	*Acartia australis*					7
Centropagidae	*Centropages furcatus*					7
Euchaetidae	*Euchaeta marinella*					7
Paracalanidae	*Acrocalanus gibber*					7
	Bestiolina similes				4	
	Calocalanus styliremis	1				
	Calocalanus pavo	1				
	Calocalanus plumulosus	1				
	Paracalanus aculeatus	1				
	Paracalanus crassirostris		2	3		
	Paracalanus denudatus	1				
	Paracalanus nanus	1				
	Paracalanus parvus	1				

Table 3. Continued

Family	Species	Gulf of Thailand				Andaman Sea
		Coastal	Offshore	Mangroves	Estuaries	
Pontellidae	*Calanopsia aurivillii*	1				
	Calanopsia australica					5, 6
	Calanopia elliptica	1				
	Calanopia minor	1				
	Calanopia seymouri					5, 6
	Calanopia thomsoni	1				
	Pontella forficula					5, 6
	Pontella spinicauda	1				
	Pontellapsis perspicax	1				
	Pontellapsis regalis	1				
	Pontellapsis yamadae	1				
	Pontellina plumata	1				
	Labidocera acuta	1				
	Labidocera bipinnata	1				5, 6
	Labidocera detruncata	1				
	Labidocera japonica	1				
	Labidocera kroyeri	1				
	Labidocera laevidentata	1				
	Labidocera minutum	1				
	Labidocera pavo	1			4	
	Labidocera rotundata				4	
Pseudocalanidae	*Clausocalanus arcuicornis*	1				
	Clausocalanus furcatus	1				
Pseudodiaptomidae	*Pseudodiaptomus andamanensis*					5, 6
	Pseudodiaptomus annandalei		2		4	
	Pseudodiaptomus aurivillii	1		3		
	Pseudodiaptomus bispinosus				4	
	Pseudodiaptomus bowmani					5, 6
	Pseudodiaptomus bulbiferus		2			
	Pseudodiaptomus clevei	1				
	Pseudodiaptomus dauglishi	1				
	Pseudodiaptomus masoni					5, 6
	Pseudodiaptomus sewelli					5, 6
Scolecitrichidae	*Macandrewella scotti*					5, 6
Temoridae	*Temora discaudata*	1				7
	Temora longicornis	1				
	Temora stylifera	1				
	Temora turbinata	1				
Tortanidae	*Tortanus barbotus*					5, 6
	Tortanus forcipatus	1		3		
	Tortanus gracilis	1				
	Tortanus tropicus					5, 6
Order Cyclopoida						
Oncaeidae	*Oncaea conifera*	1				
	Oncaea media	1				
	Oncaea venusta	1				7
	Oithona brevicornis	1	2	3		
	Oithona disimilis				4	
	Oithona plumifera	1	2	3		7
	Oithona nana	1		3	4	

Table 3. Continued

Family	Species	Gulf of Thailand				Andaman Sea
		Coastal	Offshore	Mangroves	Estuaries	
	Oithona oculata	1		3	4	
	Oithona rigida	1		3		
	Oithona similis	1	2	3		7
	Oithona simplex	1		3	4	
Corcaeidae	*Copilia mirabilis*	1				
	Copilia quadrata	1				
	Copilia vitrea	1				
	Corycaeus asiaticus	1				
	Corycaeus affinis	1				
	Corycaeus agilis	1				
	Corycaeus andrewsi					5, 6
	Corycaeus concinnus	1				
	Corycaeus catus	1				
	Corycaeus crassiusculus	1				
	Corycaeus flaccus	1				
	Corycaeus gibbulus	1				
	Corycaeus gracilicaudatus	1				
	Corycaeus latus	1				
	Corycaeus longistylis	1				
	Corycaeus ovalis	1				
	Corycaeus obtusus	1				
	Corycaeus robustus	1				
	Corycaeus rostratus	1				
	Corycaeus speciosus	1				
	Corycaeus trukicus	1				
Sapphirinidae	*Sapphirina angusta*	1				
	Sapphirina gastrica	1				
	Sapphirina gemma	1				
	Sapphirina metallina	1				
	Sapphirina nigromaculata	1				
	Sapphirina ovatolanceolata	1				
	Sapphirina scarlata	1				
	Sapphirina stellata	1				
	Sapphirina vorax	1				
Order Harpacticoida						
Clytemnestidae	*Clytemnestra rostrata*	1				
	Clytemnestra scutellata	1				
	Corynura denticulata	1				
	Corynura recticauda	1				
Ectinosomidae	*Macrosetella gracilis*	1				
	Microsetella norvegica	1		3		
	Microsetella rosea	1		3		
	Microsetella regalis	1				
	Monops regalis	1				
	Monops strenuus		2			
Tachiidae	*Euterpina acutifrons*	1		3	4	
Mytidae	*Mytis jousseaumei*	1				
	Schizopera subterranea	1				

Note: 1=Suvapepun and Suwanrumpha (1968) and Suwanrumpha (1980a,b, 1987); 2=Pinkaew (2003); 3=Sikhantakasamit (1991); 4=Suvapepun *et al.* (1979); 5=Nishida *et al.* (2003); 6=Punnarak (2004); 7=Satapoomin *et al.*, 2004.

copepods, chaetonaths, polychaete larvae, *Lucifer* sp., shrimp larvae, branchyuran larvae, and fish larvae. Another study in the same province was the investigation of the zooplankton at the Pakpoon estuary. The major components were copepods, crustacean nauplii, mysid, shrimp larvae, cirripedia larvae, and mollusk larvae. Angsupanich (1997) studied the abundance of zooplankton in Thale Sap Songkla. 99% of the total zooplankton population was microzooplankton. Protozoa were the dominant taxa, followed by rotifers, copepods nauplii and adults with calanoids being the major component.

Seagrass beds: Tantichaiwanit (2005) studied the dynamics of the zooplankton population in Kung Kraben Bay, Chantaburi Province. 40 groups in 15 phyla were detected with the copepod nauplii being the major component. It was concluded that the presence of predators such as arrow worm, Hydromedusae, and fish larvae had a big effect on the density of copepods.

Coastal regions: Suvapephun and Suwanrumpha (1968) conducted research on the distribution of copepods in the inner Gulf of Thailand and the western Gulf of Thailand. 39 species in 18 genera of copepods were found and the dominant species were calanoid copepods: *Eucalanus subcrassus*, *Calanus pauper* and the cyclopoid copepod: *Oithona plumifera*.

3.1.2 Copepod diversity in Andaman Sea

The studies of copepod diversity in the Andaman Sea are fewer than those in the Gulf of Thailand. There have been studies only in the coastal area and mangrove forests.

Mangroves: Angsupanich (1985) carried out a preliminary survey of zooplankton in a mangrove area near the Krabi Power Plant. Copepods were the most abundant taxa, composed of Cyclopoidae, Oithonidae, Paracalanoidae, Eucalanoidae, Pseudocalanoidae, and Tachidiidae. Chuaypanang (1998) studied zooplankton in a mangrove forest at Sikao, Trang Province, and at the same time also studied at the Tha Chin estuary. It was found that copepods were the major component of the zooplankton in both areas. The highest population of copepods was found in the inner part of the mangrove forest, whereas for the other zooplankton groups the reverse trend was noticed. Satapoomin (1999) observed zooplankton communities at Kapur Mangrove Canal. This time 34 groups in 8 Phyla of zooplankton were recorded. The most dominant groups were copepods, cirripedia larvae, *Lucifer* sp., gastropod larvae, larvaceans, chaetognaths and branchyuran larvae. Raungrut *et al.* (2004) studied the abundance of zooplankton in a mangrove area and sandy beach, at Tanyong Po, Satun Province. 16 genera of copepods were found and the major groups were calanoid, harpacticoid and cyclopoid copepods, respectively.

Coastal area: Boonruang (1985) studied the population, abundance and distribution of zooplankton at Phangnga Bay and the eastern part of Phuket. 35 groups of Zooplankton were detected and copepods were the most abundant (30-45% of the total zooplankton). Punnarak (2004) studied the diversity of zooplankton at the coastal area of Pak-Meng Canal, Trang Province. He reported 22 species of calanoid copepod, seven species of cyclopoid copepod and two species of harpacticoid copepod.

3.2 Marine copepods composition and abundance at Mo Ko Thale-tai

Previous investigations have found that copepods were the main group of marine holoplankton found in Thai waters (Rose, 1926; Suvapepun, 1981; Fleminger, 1963; Suvapepun and Suwanrampha, 1968; Supongpun, 1976; Suvapepun, 1976; Suwanrampha, 1978; Suvapepun, 1978; Suvapepun *et al.*, 1979; Suwanrampha, 1980a; Suwanrampha, 1980b; Suwanrampha, 1987; Sikhantakasamit, 1991; Nishida *et al.*, 2003; Pinkaew, 2003 and Punnarak, 2004) and we have obtained the same result in the present study. One-hundred and five species in twenty-seven genera in four orders had been recorded pre-viously from various habitats in the Gulf of Thailand and Andaman Sea (Table 2). In the present study, a total of 16 copepod genera in four orders were found (Table 4). This accounts for 59% of all genera records. The numbers demonstrate a relatively high diversity of copepods in this study area. Among the four orders, order Calanoida had the most diverse genera (56.25%) followed by the order Harpacticoida (25%), order Poecilostomatoida (12.5%), and order Cyclopoida (6.25%), respectively. The Calanoida were mainly represented by *Acrocalanus* and *Paracalanus*. Poecilostomatoida were mainly represented by the genera *Corycaeus* and *Oncaea* while the Cyclopoida were represented by members of the genus *Oithona*. The most frequently found genera (found at all stations) were *Acrocalanus*, *Paracalanus*, *Oithona, Euterpia, Microsetella,* and *Corycaeus* (Table 4). However, the dominant genera at Mo Ko Thale-tai were different from those found in other areas such as in the study of zooplankton at Lam Pak Bia, Pechburi Province it was reported that *Acartia* was the most dominant genus (Suvapepun *et al.*, 1979). However, unfortunately, because of the difference of the study level the present data cannot be compared with the previous study at Kanom in 1982 (Suvapepun *et al.*, 1982). In addition, *Eucalanus* and *Oithona* were identified as the dominant genera at the Inner and Western Gulf of Thailand (Suvapepun and Suwanrampa, 1965).

The five most common copepod genera in the study area were *Oithona*, *Euterpina*, *Acrocalanus*, *Corycaeus,* and *Microsetella* (Figure 2). These five main copepod taxa comprised 88% (range 7-44%) of the total number of copepods encountered. The result showed that these genera occurred in all sampling stations at a monthly abundance of 4-439 individuals/m^3 for *Oithona*, 4-250 individuals/m^3 for *Euterpina*, 12-133 individuals/m^3 for *Acrocalanus*, 2-46 individuals/m^3 for *Corycaeus*, and 1-51 individuals/m^3 for *Microsetella* (Table 4).

The bi-monthly variations in copepod abundance at fourteen sampling stations are shown in Figure 3. The total copepod abundance reached a peak in October 2006

Table 4. Copepods at Mo Ko Thale-tai and their density of occurrence (individual/cm^3), means for all studied months. The frequent and relatively high density genera are shown in bold typeface.

Marine copepods	Station													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Order Calanoida														
Acartia	0	0	0	0	0	0	9	0	0	3	1	1	1	1
Acrocalanus	**12**	**22**	**14**	**16**	**15**	**14**	**74**	**16**	**16**	**18**	**32**	**133**	**19**	**43**
Calanopia	0	0	0	0	0	0	0	1	0	1	0	1	1	0
Centropages	0	0	3	0	0	0	0	0	1	0	1	0	0	0
Eucalanus	0	0	0	0	0	2	3	1	0	1	0	0	0	1
Labidocera	5	0	0	0	0	0	0	1	0	1	1	0	1	1
Paracalanus	**48**	**11**	**13**	**9**	**20**	**4**	**1**	**8**	**7**	**4**	**5**	**26**	**33**	**23**
Tortanus	0	3	0	0	0	0	0	1	1	0	0	0	0	1
Pontella	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Order Cyclopoida														
Oithona	**43**	**134**	**18**	**4**	**35**	**28**	**102**	**33**	**41**	**338**	**38**	**439**	**94**	**125**
Order Harpacticoida														
Clytemnestra	0	0	0	0	1	2	2	0	1	0	0	0	0	0
Euterpina	**29**	**21**	**17**	**16**	**31**	**38**	**20**	**8**	**20**	**4**	**12**	**250**	**6**	**17**
Macrosetella	6	0	0	0	2	15	10	1	0	0	2	0	1	1
Microsetella	**30**	**11**	**29**	**51**	**7**	**42**	**41**	**6**	**4**	**2**	**1**	**2**	**6**	**9**
Order Poecilostomatoida														
Corycaeus	**46**	**2**	**43**	**8**	**32**	**17**	**17**	**15**	**17**	**17**	**13**	**23**	**46**	**29**
Oncaea	2	0	0	0	17	22	24	2	1	1	1	4	4	3
Total number of copepod taxa	9	7	7	6	9	10	11	12	10	11	11	9	12	12

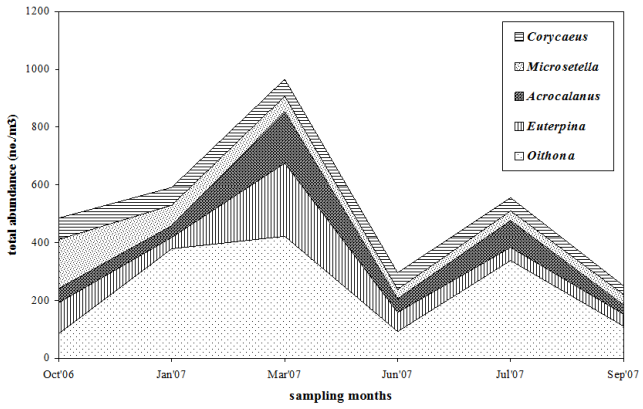

Figure 2. Total abundance of the five most abundant copepods throughout the whole sampling period.

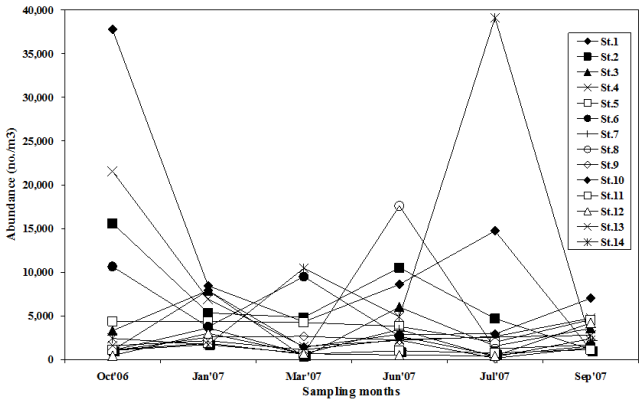

Figure 3. Abundance of total copepods (no./m^3) at each station at each time sampling.

(103,044 individuals/m^3) and again in July 2007 (73,579 individuals/m^3). In the present study, the highest abundance was recorded at station 8 (48-244 individuals/m^3), Station 12 (7-369 individuals/m^3) and Station 10 (30-224 individuals/m^3) located at the west side of Ko Tan (mangrove area), the east side of Ko Tan (seaweed bed) and the north side of Ko Tan (seaweed bed), respectively (Prathep, personal communication). These results indicated that the microhabitats that provide food (phytoplankton) and nursery grounds for the larval stages might be one of the key factors that determine their abundance and distribution.

4. Conclusion

A total of 16 copepod genera found at Mo Ko Thale-tai accounted for 59% of the all genus of marine copepods found in Thailand. Their high abundance around Ko Tan which is rich in seaweed, seagrass, and coral beds, including

part of a mangrove area indicated that the prevalence of these microhabitats that provide food and nursery grounds for the larval stages is one of the key factors to support the copepod occurrence, abundance, and distribution. Thus, conservation of these microhabitats will have a positive impact on these copepods that will later provide a food source for other animals in the system.

Acknowledgements

The authors thank A. Prathep for the information of seaweed and seagrass, S. Boonrod, P. Meksuwan, A. Tohmusor and R. Inpang for help in the field and laboratory work, K. Wongkamhang for preparing the information and B. Hodgson for suggestions and assistance with the English language. This work was supported by the TOTAL Corporate Foundation, TOTAL E&P Thailand and the TRF/BIOTEC Special Program for Biodiversity Research and Training (Grant BRT R_249003, BRT R_351001).

References

Aiemsomboon, N. 2000. Abundance of shrimp, crab and fish larvae in Tha-Chin estuary, Samut Sakhon Province. MSc Thesis, Chulalongkorn University, pp. 212.

Angsupanich, A. 1985. Preliminary survey of zooplankton in mangrove area near the Krabi power-plant. The fifth national seminar on mangrove ecology, Phuket, Thailand, July 26-29, 1985.

Angsupanich, S. 1997. Seasonal variations of zooplankton in Thale Sap Songkhla, Southern Thailand. Journal of National Research Council of Thailand. 29 (1), 27-47.

Boonruang, P. 1985. The community structure, abundance and distribution of zooplankton at the east coast of Phuket Island, southern Thailand, Andaman Sea. Research Bulletin. 39, 1-13.

Chuaypanang, S. 1998. Zooplankton in mangrove forest at Sikao District, Trang Province with emphasis on shrimp and crab larvae. MSc Thesis, Chulalongkorn University, pp.185.

Fleminger, A. 1963. The Calanoida (Copepoda, Crustaceans) in the Gulf of Thailand. Scripps Institution of Oceanography. (63-6), 92-98.

http://www.fisheries.go.th/fpo-nakhon/stat.html [April 15, 2006

Kaosirikul, P. 1979. Abundance and the relationship of zooplankton and environments at Chao Praya Estuary during 1976-1977. Department of Fisheries, Bangkok., pp. 41 (in Thai).

Nishida, M., Norikazu, S., and Shigemitsu, S., editors, 2003. The Flora and Fauna of Inland Waters in the Ryukyu Islands, Tokai University Press, Tokyo, pp. 572 (in Japanese).

Ohno, A. 1996. Seasonal availability of calanoid copepods (Genus Acartia) in Eastern Thailand using light trap, as food organisms for marine fish laval rearing. Asian Fisheries Science. 9, 231-234.

Paphavasit, N., Nishihira, M. and Piumsomboon, A. 1997. Impacts of mangrove reforestation on fishery resources : Case study of Ban Klong Kone mangrove swamps, Samut Songkhram province, In 10. Thailand national mangrove ecosystem seminar. National Research Council of Thailand. 4-2, 1-15.

Pinkaew, K. 2003. Taxonomy of Copepods in the Bangpakong River Estuary and the Sriracha Coast of Thailand. M.Sc. Thesis, Burapha University, Chonburi, Thailand, pp. 111.

Punnarak, P. 2004. Biodiversity of zooplankton in coastal area of klong pak-meng, Trang province. M.Sc. Thesis, Chulalongkorn University, Bangkok, Thailand, pp. 111.

Raungrut, W., Angsupanich, S. and Sompongchaikul, P. 2004. Seasonal abundance of zooplankton in the mangrove area and sandy beach, Tanyong Po, Satun Province, pp. 559-578.

Satapoomin, S. 1999. Zooplankton community in Kapur mangrove canal, Ranong province. Phuket Marine Biological Center Research Bulletin (Thailand). 33-56.

Satapoomin, S., Nielsen, T.G. and Hansen, P.J. 2004. Andaman Sea copepods: spatio-temporal variations in biomass and production, and role in the pelagic foodwebs. Marine Ecology Progress Series. 274, 99-122.

Sikhantakasamit, B. 1991. Variations in copepod, cladocera and rotifer populations in mangrove swamp at Baan Klong Kone, Samut Songkhram Province. MSc Thesis, Chulalongkorn University, Bangkok, Thailand, pp.135.

Supongpun, M. 1976. The development of *Schizopera subterranes* Lang (Copepoda: Harpacticoida). MSc Thesis, Department of Biology, Kasetsart University, pp. 90.

Suvapepun, S. 1976. Diurnal vertical variation in plankton volumes at two fixed-24-hours stations in the Gulf of Thailand, 1971-1972. Ibid MFL/76/9, pp.29.

Suvapepun, S. 1978. Check-list of Thai marine plankton, I. Phytoplankton, II. Copepoda. Marine Fisheries Laboratory Technical No.16/1978, pp.13.

Suvapepun, S. 1981. Zooplankton in the Gulf of Thailand. Thai Fisheries Gazette. 34 (2), 201-214.

Suvapepun, S. and Suwanrumpha, W. 1968. Distribution of Copepods in the Inner Gulf and the Western Coast of the Gulf of Thailand. Proceedings of the Indo-Pacific Fisheries Council. 3 (II), 19.

Suvapepun, S., Sripayat, P. and Piromnim, M. 1982. Plankton at Kanom Estuary. Department of Fisheries, Bangkok, pp.15 (in Thai).

Suvapepun, S., Sripayat, P. and Worakul, W. 1979. Zooplankton in mangrove. The third national seminar on mangrove ecology, Hatyai, Thailand, April 8-12, 1979.

Suwanrumpha, W. 1978. The seasonal abundance of plankton in the Inner Gulf of Thailand in relation to the ichthyoplankton, salinity and temperature. Marine

Fisheries Laboratory Technical No. 7/1978. pp.25.

Suwanrampha, W. 1987. A key for the identification of copepod collected in the Gulf of Thailand. Marine Fisheries Division, Department of Fisheries, Bangkok. Technical Paper No. 29/4.

Suwanrumpha, W. 1980a. Zooplankton in the Inner Gulf of Thailand. I. Seasonal abundance and distribution of zooplankton 1975-1976. Technical Paper No. 22/6. Marine Fisheries Environmental Group, Marine Fisheries Division, Department of Fisheries. pp.23.

Suwanrumpha, W. 1980b. Zooplankton in the Inner Gulf of Thailand. II. Species group and seasonal variation in the copepod 1975-1976. Technical Paper No. 22/7. Marine Fisheries Environmental Group, Marine Fisheries Division, Department of Fisheries. pp.89.

Tantichaiwanit, W. 2005. Zooplankton dynamics in Kung Krabaeng Bay Chantaburi Province. MSc Thesis, Chulalongkorn University, pp.210.

Teeratecha, L. 1981. Zooplankton in the Tha Chin Estuary. MSc Thesis, Chulalongkorn University, pp.133.