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Marine zooplankton studies in Thailand during 2001–2010

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Abstract—Studies on marine zooplankton in Thailand during 2001–2010 are reviewed. Most of the studies were written in Thai, with or without English abstract. Field of studies covered ecology, taxonomy, and some in environmental assessment. The studies were mostly conducted in coastal habitats, especially estuarine and mangrove, both in the Gulf of Thailand and in the Andaman Sea. Obstacles of zooplankton studies in Thailand mainly due to lack of resource person in zooplankton taxonomy, cooperative projects are thus important in enhancing this field of study. A number of training workshops on zooplankton taxonomy supported by JSPS multilateral programs were the examples those facilitate the taxonomic work.

Key words: zooplankton, Gulf of Thailand, Andaman Sea

Introduction

Researches on marine zooplankton in Thailand were continuously conducted though limited number of institutions and researchers involved. During the past 10 years, the taxonomic work were conducted through educational staff, while monitoring projects in general groups (higher taxa) were done by the research departments. Taxonomy was restricted in specific groups, mainly copepods of which so far has no complete list of species in the area. Fish larvae have also been studied but the identification beyond family level is not yet possible. Some studies on other groups of zooplankton, such as small shrimps (mysids, *Lucifer* spp. and *Acetes* spp.) and jellyfish, were done. Apart from these, the small proto-zooplankton, ciliates, were also included in some of the studies.

Gears and mesh size used for sampling varied according to habitats and authors, which was also among the obstacles in comparing diverse types of information. As most of the researchers know each other quite well, many recent researches have been based on the same techniques. A number of training courses have been conducted from various sources of support which brought the researchers to come together and be trained for advanced techniques as well as to have the methods standardized as much as possible. Yet still variations do exist.

Publication categories

Most of the articles and theses were published in the local languages, with/without English abstracts. Some of the recent thesis titles could be accessed on line from the universities' library and at least abstracts are downloadable. A total of 55 papers were tracked in this review, and classified into 4 groups, i.e. articles, technical papers, reports, and theses. The percentage fractions are shown in Fig. 1.

The total article-type checked here are 31 documents, in which 21 were published in different sources or journals (14 in local journals, 7 in international journals), and 10 articles were published in proceedings (in Thai) of local seminars/conferences. There are 19 thesis books (only 3 were written in English), apart from studies those summarized and published in local journals/proceedings. In the case of taxonomic studies, the thesis books are quite important as they normally include the lists of species and contain more primary data, e.g. list of copepods in Bangprakong Estuarine

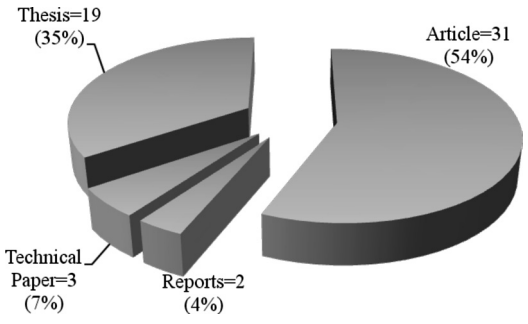

Fig. 1. Publication on zooplankton studies in the waters of Thailand from 2001 onwards. Article (Journals): English=7, Thai=13. Article (Proceedings): Thai=11. Reports: Thai=2. Technical Papers: Thai=3. Thesis: English=3, Thai=16.

and Siracha coast (Pinkaew 2003), copepods in the upper Gulf of Thailand (Salakit 2009), and calanoid copepods in the Andaman Sea (Phukham 2008). Apart from those, there were 3 technical papers and 2 reports all of which are written in Thai and in general difficult to reach the original copy.

From all documents available here, about half are considered as gray literatures, which normally should not be included as references, but in this case, they are all counted in order to have a better picture of zooplankton study in the waters of Thailand.

Study areas and habitats

From a total of 55 articles, 38 were conducted from the Gulf of Thailand, 16 from the Andaman Sea, and one study included both seas in their article. The habitats/ecosystems encountered varied by the study purposes mainly in the coastal area. The studies in the Gulf of Thailand focused more on the estuarine and mangrove areas, sandy beaches, coastal areas, islands, and shrimp ponds. In the Andaman Sea, studies were done mainly in mangrove areas, some in the coral islands and some in the offshore areas. Studies in the coral communities are still rare.

Mesh size

Mesh size of plankton net used in zooplankton sampling varied from 30 μm to a few millimeters, but the size of 330 μm was used mostly in the coastal area. Some studies in the mangrove channels used 103 μm (Punnarak et al. 2007, Sikhantoksamit 2002, Sivaipram et al. 2007, Sivaipram et al, 2004, Srinui et al. 2008). The 30-μm net was used in a study on population dynamics of copepods in Sriracha Bay, in the inner Gulf of Thailand (Chuchit et al. 2005). Only one study that used 50 μm net was the production study of copepods in the Andaman Sea (Satapoomin et al. 2004). Studies on fish larvae used nets with mesh size of 330, 500 or 1000 μm. A study on *Acetes* in the Andaman Sea (Pengjamrat and Upanoi 2005) used a beam trawl and a beach seine with 2 and 4 mm mesh size, respectively.

Zooplankton abundance and composition

In general, studies on zooplankton have been done by both research institutes and academic institutes but, especially during the past 10 years, most of the taxonomic studies were done by academic staffs. Studies in the research institutions focused more on ecological aspects and/or identified zooplankton only to higher taxonomic groups in their estimation of abundance and biomass.

Zooplankton studies in the Andaman Sea have been mainly on community structure and distribution. The secondary data from various studies revealed 228 species from 88 genera and 14 phyla. Punnarak (2004) studied zooplankton diversity in the coastal Pak Meng Canal, Trang Province in April and December 2003, reporting occurrence of 40 groups from 13 phyla, including 22 groups from 7 phyla of holoplankton and 18 groups from 8 phyla of meroplankton. He also reported density of zooplankton larger than 100 μm.

Satapoomin and Pornchai (2002) studied temporal variation of abundance and composition (groups) of zooplankton community in Sapam Bay (connected mangrove area), Phuket, using 330-μm net for monthly sampling in 1994–1996 reporting zooplankton density between 84–5859 ind./100 m^3 and ash free dry weight between 0.74–46.33 mg m^{-3} with no apparent seasonal pattern. The zooplankton community comprised 60% of holoplankon and 40% of meroplankton (by density), half of which belonged to fisheries resources.

Jitchum et al. (2006) studied species composition, density and distribution of zooplankton in the Andaman Sea in 2004 (13 stations). They reported at least 65 groups of holoplankton and meroplankton, in which copepod were dominant and common without apparent spatial pattern.

Biodiversity of zooplankton in a mangrove canal (Klong Pak Meng) facing the Andaman Sea, was studied in April and December 2003, to compare the zooplankton communities between before and after the southwest monsoon season (Punnarak 2004). He also reported the copepod diversity in the studied area: 22 species from 10 families of Order Calanoida, 2 species from 1 family of Order Cyclopoida, 2 species from 2 families of Oder Harpacticoida, and 7 species from 2 families of Order Poecilostomatoida.

Distribution and abundance of zooplankton in estuaries along the eastern coast of Thailand were studied by Srinui in 2007. The zooplankton in the area composed of 42 groups from 15 phyla, with 30 species of copepods (from 18 genera, 14 families). Density of zooplankton and copepods wee compared between dry and wet seasons.

Ecology of zooplankton was studied continuously. Sivaipram et al. (2004) studied the changes of plankton community in traditional shrimp ponds at Samut Somgkhram and Nakhon Si Thammarat Province; Permsirivanich (2007) studied the relationships between environmental factors and distribution of zooplankton at Mu Koh Chang National Park, Trat Province; Sikhantoksamit (2002) studied the annual variation of coppeods, cladocerans, and rotifers in the mangrove area of Klong Kone, Samut Sonkram Province; Ruangrat (2003) studied seasonal variation of zooplankton in the mangrove area of Ban Bagunkuey and along the beach of Ban Had Sai Yao, Satun Province.

Copepods

A total of 10 articles were found dealing with copepod taxonomy with species list (Sikhantoksamit 2002, Pinkaew 2003, Patarajinda et al. 2007, Jitchum and Wongrat 2007, Chullasorn et al. 2008, Phukham 2008, Promkaew et al. 2008, Jitchum and Wongrat 2009a, Salakit 2009, Promkaew et al. in press 2009) and 2 articles studied copepod produc-

tion, one in the Gulf of Thailand (Jitchum 2010) and the other in the Andaman Sea (Satapoomin et al. 2004).

Punnarak (2004) studied zooplankton in Pak Meng mangrove canal, Trang Province on the Andaman Sea coast, from 100- and 330-μm nets, and reported a total of 31 species of copepods; 22 calanoids, 2 cyclopoids, and 2 harpacticoids and 7 pocillostomatoids.

Chuchit et al. (2005) studied population dynamics of copepod in Sri Racha Bay, Chonburi Province in 2003 by vertical tows of 30-μm net. They reported the annual average abundance of calanoids, cyclopoids and harpactcoids as 10250, 1920, 330 ind. m^{-3}, respectively. The calanoids were the most abundant and found all year round with the highest abundance in August (26,000 ind. m^{-3}).

Patarajinda et al. (2007) studied copepods in Similan Islands National Park (January 2006) and reported 53 species, from 27 genera, of which 39 species (2 genera) were new records in the Andaman Sea. Eight species (from 5 genera) were new records from Thai waters: *Centropages calanius*, *C. elongatus*, *Miracia efferata*, *Pontella fera*, *P. spinipes*, *P. diagonalis*, *Pontellopsis armata*, *Sapphirina opalina* and *S. darwinii*.

Jitchum and Wongrat (2009a) studied the community structure and abundance of copepods in a shallow protected bay in the central Gulf of Thailand. Sampling were done from September 2006 to August 2007 at Manao Bay, Prachuab Khirikhan Province. The samples were taken by vertical tows of a 200-μm net. They reported 28 species of copepods from 19 genera, including 17 species of calanoids, 5 species of pocilostomatoids, 4 species of harpacticoids, and 2 speices of cyclopoids. Jitchum and Wongrat (2009b) studied seasonal relationships between the plankton community and hydrographic conditions in a shallow oligotrophic bay in the upper Gulf of Thailand.

A total of 199 epipelagic copepod species were reviewed in the thesis book of Jitchum (2010), belonging to 17 families of Calanoida (135 species), 6 families from Hapacticoida (15 species), 2 families from Cyclopoida (13 species) and 4 families from Poecilostomatoida (36 species). This covered 8 studies in the Gulf of Thailand and 2 studies from the Andaman Sea.

In the Gulf of Thailand, there were at least 174 species of copepods reported: 111 species from 16 families of Calanoida, 15 species from 6 families of Harpacticoida, 13 species from 2 families of Cyclopoida, and 35 species of Poecillostomatoida.

At least 94 species were reported from the Andaman Sea: 84 species from 15 families of Calanoida, 2 species from 2 families of Harpacticoida, 3 species from 1 families of Cyclopoida, and 5 species from 2 families of Poecillostomatoida.

Fish larvae

Researches on fish larvae have mainly been conducted for fishery purposes and mostly for the recruitment of fisheries resources. Unfortunately, the identification of fish larvae in Thai waters has been mostly limited to the family level, with exception only in the cultivated species. The studies have mainly dealt with abundance and distribution of fish larvae (e.g. Chalee et al. 2007, Chamchang 2006, Wongchinvit 2002). Mesh size of the net used varied as 330, 500, or 1000 μm.

Other aspects were studied but only limited to those in some co-operative projects, such as feeding habits of tropical fish larvae of four species from the Andaman Sea (Østergaard et al. 2005), in which they compared feeding habits of fish larvae, using morphological characters on feeding, and looked for common patterns in larval prey preference. They also compared the gut contents of 300 larvae with local zooplankton composition.

A number of trainings on fish larvae were held both nationally and regionally. The Training department of SEAFDEC held a couple of trainings on identification of fish larvae recently to enhance the knowledge of the local research among the regions: "The Regional Training Course on the Larval Fish Identification and Fish Early Life History Science", 16–31 May 2007 and "An Advanced Regional Training Workshop on Larval Fish Identification and Fish Early Life History Science", 26 May–15 June 2008.

Small shrimps

Acetes

Only one study (Pengjamrat and Upanoi 2005) reported species composition and distribution of *Acetes* shrimp in seagrass beds and mangrove creeks in the Andaman Sea. They reported 3 species: *Acetes erythraeus*, *A. indicus*, and *A. japonicus*. *A. indicus* and *A. erythraeus* were found in both mangrove and sea grass ecosystems, with *A. indicus* as dominant species in mangrove canal, while *A. japonicus* was found only in seagrass beds.

Mysids

Mysidacea from the south-eastern Andaman Sea was studied on the basis of samples collected during the Project "Biodiversity of Crustaceans in the Andaman Sea" (Fukuoka and Murano 2002). A total of 37 species of Mysidacea were reported, including 6 new species: *Erythrops phuketensis*, *Hypererythrops validiseta*, *Acanthomysis brucei*, *Acanthomysis longispina*, *Heteromysis thailandica*, and *Pseudomysidites nudus*. Eight species were new records and there were probably 3 more new species remained unnamed due to the incomplete/insufficient specimens. Two new species, *Nipponomysis patula* and *Orientomysis calida* were reported from the Gulf of Thailand by Fukuda and Pinkaew (2003) and Fukuda et al. (2005), respectively.

Jellyfish

Recently a few studies on jellyfish were conducted in the Gulf of Thailand, while this group has generally been enumerated in total numbers of hydromedusae/scyphomedusae or simply of medusae. One obstacle to check the old preserved specimens is that they are degraded over time in fixative.

A study on diversity and abundance of planktonic Hydrozoan in the Upper Gulf of Thailand (Wutticharoenmongkol and Wongrat 2004) revealed a total of 63 species from 6 Orders of hydrozoans. The study also provided data on density from the 2 different cruises in pre-monsoon and post-monsoon period.

Tandavanitj (2001) studied the species diversity and abundance of Rhizostomeae on the coastal area of Chon Buri and Phetchaburi Provinces, which are important jellyfish harvesting areas. Monthly samplings were done between December 1999 and December 2000. Of the total of 6 species recorded, 2 were commercial species (sand jellyfish, *Rhopilema hispidum* Vanhoffen 1888, and white jellyfish, *Lobonema smithii* Mayer, 1910) and 4 were non-commercial species [*Cassiopea andromeda* (Forskal 1775), *Acromitus flagellatus* (Maas 1903), *Acromitus hardenbergii* Stiasny 1934, and *Catostylus townsendi* Mayer 1915]. *Rhopilema hispidum* was found more frequently in Chon Buri than in Phetchaburi, while *Lobonema smithii* was found only in Phetchaburi province. The highest number of jellyfish in Chon Buri was recorded in March 1999 ($>23\times10^4$ ind. m^{-3}), while $>302\times10^4$ ind. m^{-3} was recorded in Phetchaburi in November 1999. *Acromitus flagellates* was the dominant species found at both provinces, with $>30\times10^4$ ind. m^{-3} in November 1999.

Tentative list of institutions involved and cooperation in marine zooplankton research

There are a number of institutions and universities that actively conduct research on marine zooplankton in Thailand, such as:

1. Department of Fisheries: Marine Fisheries Research and Development Bureau
2. Department of Marine and Coastal Resources: Phuket Marine Biological Center (Andaman Sea) and 4 research centers (Gulf of Thailand).
3. Universities:
   Chulalongkorn University
   Kasetsart University
   Ramkhamkang University
   Burapha University
   Rajamangala University of technology Srivijaya
   Rajabhat University
   Prince of Songkhla University
4. Southeast East Asian Fishery Development Centre (SEAFDEC): Training Department.

The above institutions have been working in parallel or in some cooperative projects. Recently, a national level of cooperation and network of plankton research, Algal and Plankton Society of Thailand, was established in 2000. Its objective is to develop research methods and directions to be applied for and respond to the need of the country in the field of algal and plankton researches. It also conducts bi-annual conferences and trainings, where researchers and public would share their information and experiences.

There were at least 3 trainings/workshops supported by JSPS those were conducted in Thailand.

1) JSPS-CU-NRCT Training Course on Methods of Zooplankton Ecology and Identification, at Chulalongkorn University, Bangkok, in November 2003.
2) The NRCT-JSPS Workshop on Zooplankton Biodiversity in Southeast Asia, at Institute of Marine Science, Burapha University, and Si Chang Training Centre, Chulalongkorn University, in October 2009.
3) PMBC-JSPS Training Workshop on Identification of Small Shrimps in Thai Waters, at Phuket Marine Biological Center, Phuket, in March, 2010.

Conclusion

Problems in zooplankton studies in Thailand can be classified into at least 2 groups, i.e. lack of manpower in zooplankton taxonomy and limited skill in identification. Hence, though the studies have been conducted continuously for decades, acquisition of knowledge in this field has been relatively slow. There are also many other problems/obstacles, such as (1) inadequate references which is a major obstacle of the taxonomic study and (2) database of zooplankton in Thailand waters, which is well aware of its importance but not yet established. Until now there are still a lot under-studied zooplankton groups and area, but with limited manpower and limited budget (for basic research) these gaps will not be easily filled.

There is no database of zooplankton available at present. Data published in articles were mostly analyzed/secondary data, so to extract primary information are not possible. Raw data from those publications were not stored in any kinds of database and scattered, so most of them were gradually disappeared. Effort must be put more seriously in zooplankton database establishment.

Other activities that should be done to overcome the problem in literatures reviews include: (1) to translate the existing publications published in local language, (2) collecting all these publications and mapping them based on localities and habitats, and (3) to have all those information uploaded on a webpage so that they can be accessed more widely.

Networks in zooplankton studies have been initiated with a certain level of success, mostly among the educational

institutions. To overcome the existing problems on zooplankton study in Thailand, such networks need more research activities and enhancement of the cooperation, not only among the local research groups, but also in the regional/international levels.

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