

Systematics, species diversity and new taxa of mesozooplankton in the West Pacific Ocean and its marginal seas: a brief compilation of monographs in China

WANG Yu¹, HUANG Zongguo¹, WANG Chunguang¹, HUANG Jiangshiou², LIU Zhensheng³, XU Zhenzu⁴, HUANG Jiaqi⁴, CHEN Ruixiang¹, LIAN Guangshan¹, DAI Yanyu¹, LIN Jinghong¹, LIN Mao^{1*}

¹Laboratory of Marine Biology and Ecology, Third Institute of Oceanography, State Oceanic Administration, Xiamen 361005, China

²Institute of Marine Biology, National Taiwan Ocean University, Keelung 20224, Taiwan, China

³Second Institute of Oceanography, State Oceanic Administration, Hangzhou 310012, China

⁴College of Ocean and Earth Sciences, Xiamen University, Xiamen 361102, China

Received 21 September 2017; accepted 25 December 2017

© Chinese Society for Oceanography and Springer-Verlag GmbH Germany, part of Springer Nature 2018

Abstract

Research and protection of biodiversity is generally started with species recognizing guided by achievement of cataloguing and illustration obtained through *in situ* investigation data accumulation and literature learning. Facing the shortage of taxonomist, it is getting harder to maintain important specimen collections and handle loans. The West Pacific Ocean has been operating as a center of the origin of global marine biodiversity result of the richest species diversity of marine taxa found in these waters. The present work is a compilation and summary of systematics, species diversity and new taxa of mesozooplankton major group known in West Pacific Ocean and its marginal seas (0°–45°N, 105°–152°E) according to 6 203 mesozooplankton samples acquired from 701 stations during 1965 and 2008. A total of 2 657 species belonging to 686 genera and 206 families of 10 mesozooplankton groups have been found through taxonomic identification and document consulting. In details, 697 species from 251 genera of 99 families belong to the Medusozoa, 59 species from 22 genera of 12 families to the Ctenophora, 85 species from 36 genera of 14 families to the pelagic Mollusca (Pteropoda and Heteropoda), 416 species from 91 genera of 8 families to the Ostracoda, 908 species from 156 genera of 51 families to the Copepoda, 202 species from 60 genera of 4 families to the Mysidacea, 56 species from 8 genera of 2 families to the Euphausiacea, 105 species from 23 genera of 8 families to the Decapoda, 48 species from 13 genera of 5 families to the Chaetognatha and 81 species from 26 genera of 5 families to the Tunicata. The dominant species of each group are enumerated. Moreover, 2 new species of Medusozoa, Tubulariidae, *Ectopleura*, 1 new species of Medusozoa, Protiridae, *Halitiarella*, 1 new genus and 1 new species of Medusozoa, Corymorphidae are established. An amount of 806 species are expanded with an increase of 43.5% on the basis of 1 852 species recorded before 2008, including 1.4% increase from tropical sea around equator, 4.0% from the frigid water in high latitude region, and 3.0% of bathypelagic-associated waters. The authors also summarized future prospects into five major areas in marine mesozooplankton research in China. Such information of qualitative phyletic classification could be of high relevance to studies on biodiversity and biogeography of marine mesozooplankton, especially for monographs contributed to make an overall and systematic conclusion on the species of marine life in China after 2008.

Key words: marine mesozooplankton, systematics, species diversity, new taxa, compilation, the West Pacific Ocean, marginal sea

Citation: Wang Yu, Huang Zongguo, Wang Chunguang, Huang Jiangshiou, Liu Zhensheng, Xu Zhenzu, Huang Jiaqi, Chen Ruixiang, Lian Guangshan, Dai Yanyu, Lin Jinghong, Lin Mao. 2018. Systematics, species diversity and new taxa of mesozooplankton in the West Pacific Ocean and its marginal seas: a brief compilation of monographs in China. Acta Oceanologica Sinica, 37(10): 229–242, doi: 10.1007/s13131-018-1328-8

1 Introduction

The generalized biodiversity research includes four levels from microcosmic to macrocosmic view point, namely, gene, species, ecological system and landscape (Barnes, 1989; Ma, 1993). The first step to investigate, develop and protect biodiversity is to recognize the species. It will not be realistic to rationally develop and protect biological resources without scientifically classification and objectively identification of species (May, 1992; Gaston, 2000; Xu, 2011). Moreover, the conservation of

biodiversity needs comprehensive, international linked data base, including species composition, community structure, and so forth, which relies on the research findings of catalogue and illustration obtained by *in situ* investigation data and understudying literature to large extent (Huang, 1994, 2008; Liu, 2008; Huang and Lin, 2008; Wiebe and Allison, 2015).

The West Pacific Ocean is considered as the provenance center of global marine life (Gaston, 2000; Briggs, 2005; Allen, 2007), and the highest species diversity of numerous marine taxa oc-

Foundation item: The National Natural Science Foundation of China under contract Nos 41506217 and 41506136; the Basic Research of the National Department of Science and Technology under contract Nos GASI-01-02-04 and 201105022-2.

*Corresponding author, E-mail: linmao@tio.org.cn

curs in these waters (Jensen, 2006; Tittensor et al., 2010). The global model for marine biodiversity and predictive study reveals that the marine biodiversity near the shore in the mid-latitude West Pacific region is the richest, where the waters with high species richness distribute unevenly at the areas impacted by mankind moderately or highly (Aguiar et al., 2009; Tittensor et al., 2010). Therefore, biodiversity research and conservation efforts in this area are necessary in order to promote the integrative and international management at transnational level of this resource (Allen, 2002; Huang and Lin, 2012). Moreover, marine biodiversity is changing in response to altered physical environment, subsequent ecological changes as well as anthropogenic disturbances (Peterson et al., 1998; De Aguiar et al., 2009). The premise of biology protection and sustainable development is the baseline of biodiversity, inventory and checklist, which encouraged plenty of taxonomists and ecologists energetically continuing studying. The potential of the qualitative biogeographical analyses could be of high relevance to studies on biodiversity and biogeography of marine taxa. Facing the shortage of taxonomist, it is getting harder to maintain important specimen collections and handle loans. The taxonomist is currently an endangered race (Wägele et al., 2011). Meanwhile, research data also need to accumulate for a long time and to bring historic data into public data repositories (Wiebe and Allison, 2015).

Marine mesozooplankton is rich in species richness, abundant and widely distributed, and they are regarded as the most important biological taxa in marine ecosystem (Voronina, 1998; Hays et al., 2005). In the marine food web, mesozooplankton controls the primary productivity by grazing on phytoplankton, meanwhile, it is the prey of animals at high trophic level, such as fish, shrimp, whale, seabird, acting as the role of secondary producers. The species diversity, population dynamics and community structure of mesozooplankton influence the amount of fish and other marine animal resources. Thus, mesozooplankton is the key link in the marine food web, and the biological and ecological processes of mesozooplankton drive the ecosystem dynamics in global ocean (Hobday et al., 2006; Longhurst, 2007; Liu et al., 2013). Many international research programs have focused on the biological diversity, inter-annual variability and long-term trend of the plankton communities, plus the relation to global climate change (Liu et al., 2013). Therefore, the research on mesozooplankton has become one of the cores of marine ecology.

Marine biodiversity research in China has been conducted for a long time through generations. Research of marine life performed mainly concentrates on China seas which are located at the edge of West Pacific Ocean. There are four monographs contributed to make an overall and systematic conclusion on the species of marine life in China seas so far (Fig. 1), which are *Marine Species and Their Distribution in China's Seas* chiefly edited by the second author Huang of this study (Fig. 1a) (Huang, 1994), *Marine Species and Their Distribution in China's Seas* (revised edition) (Fig. 1b) also chiefly edited by the second author Huang of this study (Huang, 2008), *Checklist of Marine Biota of China Seas* (Fig. 1c) chiefly edited by the academician Liu of Chinese Academy of Sciences (Liu, 2008), 10 volumes of *The Living Species and Their Illustrations in China's Seas* chiefly edited by the corresponding author Lin of this study (Fig. 1d) (Huang and Lin, 2013). The basic knowledge of species diversity supports these aspects including the establishment of new species, the evaluation and protection of marine biodiversity, the impacts of climate changes and human activities on marine ecosystem (Xu, 2011; Huang and Lin, 2012; Wiebe and Allison, 2015).

Based on identification, catalogue and document learning, the authors summarized and compiled the systematics, species diversity and new taxa of all the families, genera and species of mesozooplankton major group known in West Pacific Ocean and its marginal seas, conducting by a group of 12 marine taxonomists (the authors of this study) with 6 assistants and 4 qualified specialists, and with the reference to more than 96 domestic and foreign documents on mesozooplankton taxonomy and phyletic classification. The major species including dominants of each group, and new taxa established were enumerated. Besides, species with regard to occurrences in different habitats of tropical sea around equator, the frigid water in high latitude region and bathypelagic-associated waters were recorded as an expand to counting. This study is an attempt to assist species classification and catalogue in marine mesozooplankton for monographs in China after 2008. The present work is also expected to provide scientific basis and reference for the more thorough research on the marine life in Western Pacific Ocean from the perspectives of species' origin and spread, fauna, and biogeography in future.

2 Materials and methods

2.1 Study area and sample amount

As the study area defined during this work, West Pacific Ocean and its marginal seas (0°–45°N, 105°–152°E) in this work stretched across about 47° longitudes from east to west and nearly 45° latitudes from north to south, i.e., from the south end at Russian Far East Region to the northern sea area along the equatorial line. The sampling stations for joint investigation were established at these places, such as the eastern waters of Taiwan Island, and the coastal waters of the Philippines, Malaysia, Papua New Guinea, Japan and South Korea (Fig. 2). There were 701 stations and 6 203 mesozooplankton samples in total, where contained the sampling of five large-scale investigation items, namely four seasonal cruises of the Sino-Japan Joint Investigation of International Cooperative Study of Kuroshio and Adjacent Regions (CSK) from 1965 to 1975 (hollow circle ○ in Fig. 2); two seasonal cruises of the Joint Investigation on the Western Central Pacific (FGGE) from 1978 to 1979 (hollow circle ○ in Fig. 2); four seasonal cruises of the Comprehensive Survey of the Marine Environment Resources at Central South China Sea from 1980 to 1982 (hollow pentagon ☆ in Fig. 2); four seasonal cruises of the Sino-Japan Cooperative Investigation of Subtropical Gyre in West Pacific from 1995 to 1997 (hollow triangle △ in Fig. 2); four seasonal cruises of the Comprehensive Investigation and Assessment on Chinese Offshore Environment–Section of Northern South China Sea and East China Sea from 2006 to 2008 (solid rhombus ◆ in Fig. 2).

2.2 Mesozooplankton sampling

Mesozooplankton samples were achieved by plankton net of 505 μm pore diameter of boulding silk cloth. (1) The standard plankton net, with the inner diameter of 80 cm net pore and 280 cm net length, was employed to collect mesozooplankton samples of the waters more than 30 m in depth by vertical trawling. If the water depth was more than 200 m, mesozooplankton samples were vertically trawled from 200 m to the surface by the standard plankton net. (2) The shallow-water plankton net, with the inner diameter of 50 cm net pore and 145 cm net length, were utilized to collect mesozooplankton samples of the waters with the depth of less than 30 m by vertical trawling.

The above samples obtained were immediately placed into plastic bottles *in situ*. Then the formaldehyde solution with



Fig. 1. The four volumes of monographs contributed on the taxonomy of marine life in China seas. a. *Marine Species and Their Distribution in China's Seas*; b. *Marine Species and Their Distribution in China's Seas* (revised edition); c. *Checklist of Marine Biota of China Seas*; and d. *The Living Species and Their Illustrations in China's Seas*.

volume fraction of 5% was added to fix and preserve, then brought back to laboratory and transferred into glass bottles for subsequent identification and classification.

2.3 Species identification and phyletic classification

Re-examined mesozooplankton samples were those of Kur-

oshio and Adjacent Regions (CSK) from 1965 to 1975, the western central Pacific (FGGE) from 1978 to 1979, and Subtropical Gyre in the West Pacific from 1995 to 1997, while the others were originated from unpublished data in China. Mesozooplankton species were identified by using optical binocular dissection microscopes (Leica M165FC Germany, Nikon AZ100M Japan) and

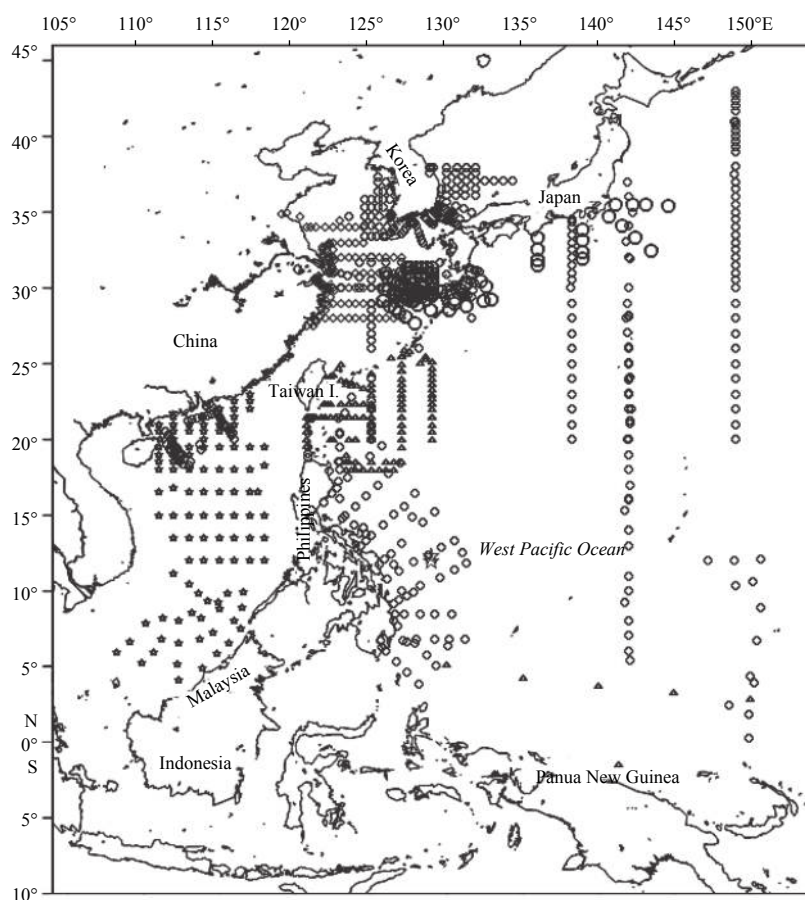


Fig. 2. Atlas and mesozooplankton sampling stations in West Pacific Ocean and its marginal seas during 1965 and 2008. Hollow circle \circ indicates stations of CSK from 1965 to 1975 and FGGE from 1978 to 1979. Hollow triangle \triangle indicates stations of Subtropical Gyre in the West Pacific from 1995 to 1997. Hollow pentagon \star indicates stations at the central South China Sea from 1980 to 1982. Solid rhombus \blacklozenge indicates stations at the northern South China Sea and East China Sea from 2006 to 2008.

upright optical microscope (Nikon Eclipse 80i Japan). All mesozooplankton in the samples were identified to the lowest taxonomic category known. The phyletic classification for species went into 10 major mesozooplankton group according to the 4 monographs mentioned above, and identification guides of 81 domestic and foreign documents on mesozooplankton taxonomy and systematics, which were provided as references listed, i.e., Davis, 1955; Bouillon et al., 1986, 2006; Kramp, 1959, 1961, 1968; Pousen, 1962, 1965, 1969, 1973; Park, 1968; Ohtsuka, 1984, 1985, 1992; Ohtsuka and Hiromi, 1987; Hsiao et al., 2004; Chihara and Murano, 1997; Kubota, 2003; Yin et al., 2006; Kubota and Gravili, 2007; Wong et al., 1993; Chen, 1982a, b, 1985; Dai, 1989, 1995, 1996, 2006; Chiu, 1996; Zhang, 1979; Zhang and Xu, 1980; Zhang and Lin, 1997; Zhang et al., 2003; Xu, 2005; Xu and Chen, 2005; Xu et al., 2004, 2006a, 2006b, 2010; Lin, 1988, 1992; Lin and Zhang, 1989, 1993; Lin et al., 2000, 2010; Cai, 1989; Chen and Lin, 1993; Chen et al., 1983, 2000, 2003; Dai et al., 2000; Hu et al., 2008; Huang et al., 2000; Li, 1992, 1993; Li et al., 2004; Li and Meng, 1990; Lin and Lian, 1988; Lin and Lin, 2006; Ma and Meng, 1992, 1993; Wang, 1991; Xu and Lin, 2007; Xu and Zhang, 2006; Yang et al., 1999; Zhang and Chen, 1984, 1991.

For the reason that the study area is wide and with a lot of cruises, the analysis and process of obtained data were performed under strict quality control (State Bureau of Technical Supervise, 2007). As for the same mesozooplankton species with different names, they were assimilated to guarantee the authenti-

city and accuracy of the survey data on the guide of the 4 monographs, and the World Register of Marine Species (WoRMS) using the Taxon Match Tool (<http://www.marinespecies.org>). Through the above analysis, the authors screened out the potential synonyms and homonyms, and determined the scientific names and Chinese names of mesozooplankton species to form a species inventory so as to compile systematics, species diversity of all the families, genera and species of mesozooplankton major group including some new taxa established in West Pacific Ocean and its marginal seas.

3 Results

3.1 Mesozooplankton species diversity and composition

Totally, there were 2 657 species of 10 major mesozooplankton group in the West Pacific Ocean and its marginal seas identified from taxonomic classification and compiled from 81 literatures on mesozooplankton taxonomy and systematics, where pelagic larva were excluded, which were affiliated with 686 genera of 206 families (Table 1). Among them, 99 families, 251 genera and 697 species classified as the Medusozoa, 12 families, 22 genera and 59 species as the Ctenophora, 14 families, 36 genera and 85 species as the Pelagic Mollusca (Pteropoda and Heteropoda), 8 families, 91 genera and 416 species as the Ostracoda, 51 families, 156 genera and 908 species as the Copepoda, 4 families, 60 genera and 202 species as the Mysidacea, 2 families, 8 genera

Table 1. Summary of major taxa of mesozooplankton known with richness of families, genera and species in West Pacific Ocean and its marginal seas

Taxa group	Family	Genus	Species
Medusozoa (Hydromedusae, Cubozoa, Staurozoa and Scyphozoa)	Cuninidae	2	8
	Solmarisidae	2	6
	Tetraplatiidea	1	1
	Geryoniidae	2	2
	Halicreatidae	4	5
	Petasidae	1	1
	Rhopalonematidae	9	17
	Australomedusidae	2	4
	Bougainvillidae	6	46
	Cytaeididae	2	6
	Clavidae	2	3
	Eucodoniidae	1	1
	Hydractiniidae	2	18
	Ptilocodiidae	2	2
	Rathkeidae	2	2
	Bythotiaridae	8	14
	Niobiidae	1	1
	Pandeidae	17	55
	Proboscidactylidae	1	5
	Protiaridae	4	9
	Halimedusidae	1	1
	Moerisiidae	2	5
	Polyorchidae	2	2
	Urashimeidae	1	1
	Hydrocorynidae	1	2
	Sphaerocorynidae	2	3
	Zancleopsidae	1	5
	Cladonematidae	2	7
	Corynidae	5	14
	Corymorphidae	6	23
	Euphysidae	4	7
	Margelopsidae	1	1
	Pennariidae	1	5
	Tubulariidae	2	16
	Porpitidae	2	2
	Teissieridae	1	4
	Zancleidae	3	17
	Magapiidae	3	3
	Aequoreidae	3	20
	Blackfordiidae	1	3
	Cirrholoveniidae	1	3
	Dipleurosomatidae	1	3
Eirenidae	8	43	
Laodiceidae	3	4	
Hebellidae	2	12	
Lovenellidae	3	15	
Malagazziidae	2	16	
Melicertidae	3	3	
Octocannoidae	2	3	
Orchistomatidae	1	2	
Phialellidae	1	4	
Sugiuridae	1	2	
Tiaropsidae	2	4	
Campanulariidae	5	25	
Phialucidae	1	1	

to be continued

Continued from Table 1

Taxa group	Family	Genus	Species
	Olindiidae	7	9
	Physaliidae	1	1
	Rhizophysidae	1	2
	Agalmatidae	4	6
	Apolemiidae	1	1
	Athorybiidae	2	2
	Erennidae	1	1
	Forskaliidae	1	2
	Nectalidae	1	1
	Physophoridae	1	1
	Pyrostephidae	1	1
	Abylidae	5	15
	Clausophyiidae	4	6
	Diphyidae	9	39
	Hippopodiidae	2	7
	Prayidae	6	12
	Sphaeronectidae	1	3
	Aureliidae	1	3
	Tamoyidae	1	2
	Tripedaliidae	1	1
	Chirodropidae	1	2
	Kishinouyeidae	2	3
	Lucrenariidae	2	6
	Thaumatoscyphidae	1	1
	Atollidae	2	4
	Linuchidae	1	2
	Nausithoidae	2	5
	Paraphyllinidae	1	1
	Periphyllidae	2	2
	Cyaneidae	1	5
	Pelagiidae	3	7
	Ulmaridae	8	12
	Cepheidae	2	7
	Mastigiidae	3	8
	Versurigiidae	1	1
	Thysanostomatidae	1	3
	Cassiopeidae	1	4
	Lychnorhizidae	2	3
	Catostylidae	4	11
	Lobonematidae	2	4
	Rhizostomatidae	1	3
	Stomolophidae	1	1
	Subtotal	251	697
Ctenophora	Haeckeliidae	1	1
	Pleurobrachidae	2	12
	Ganeshidae	1	2
	Bolinopsidae	1	6
	Eurhamphaeidae	2	2
	Leucotheidae	1	2
	Ocyropsidae	5	7
	Lobatolampeidae	1	1
	Cestidae	1	1
	Cryptolobatidae	1	1
	Coeloplanidae	5	18
	Beroidae	1	6
	Subtotal	22	59

to be continued

Continued from Table 1

Taxa group	Family	Genus	Species	
Pelagic Mollusca (Pteropoda and Heteropoda)	Janthinidae	1	4	
	Atlantidae	3	13	
	Carinariidae	3	8	
	Pterotracheidae	2	5	
	Limacinidae	2	6	
	Cavoliniidae	11	27	
	Peraclidae	1	3	
	Cymbuliidae	3	4	
	Desmopteridae	1	1	
	Pneumodermatidae	3	8	
	Clionidae	3	3	
	Phyllirrhoidae	1	1	
	Scyllaeidae	1	1	
	Glaucidae	1	1	
	Subtotal	36	85	
	Ostracoda	Cypridinidae	24	137
		Rutidermatidae	2	2
Sarsiellidae		16	51	
Asteropidae		18	52	
Thaumatocypridae		2	3	
Halocypridae		25	163	
Cylindroleberidae		3	7	
Cyclasteropinae	1	1		
Subtotal	91	416		
Copepoda	Acartiidae	2	21	
	Aetideidae	18	89	
	Arietellidae	4	17	
	Augaptilidae	7	67	
	Bathypontiidae	2	8	
	Calanidae	8	18	
	Calocalanidae	1	7	
	Candaciidae	2	20	
	Centropagidae	2	18	
	Clausocalanidae	5	21	
	Diaptomidae	5	6	
	Eucalanidae	4	16	
	Euchaetidae	2	54	
	Heterorhabdidae	7	31	
	Lucicutiidae	1	27	
	Mecynoceridae	1	1	
	Megacalanidae	2	4	
	Metridinidae	3	23	
	Paracalanidae	4	19	
	Parapontellidae	1	1	
	Phaennidae	8	31	
	Phyllopodidae	1	6	
	Pontellidae	7	59	
Pseudocyclopidae	1	4		
Pseudocyclopiidae	1	2		
Pseudodiaptomidae	1	26		
Ridgewayiidae	2	4		
Ryocalanidae	1	1		
Scolecithricidae	11	80		
Spinocalanidae	3	16		
Stephidae	1	4		
Temoridae	3	11		

to be continued

Continued from Table 1

Taxa group	Family	Genus	Species
	Tharybidae	2	4
	Tortanidae	1	25
	Misophridae	1	2
	Cyclopidae	4	6
	Cyclopinidae	1	2
	Oithonidae	3	29
	Mormonillidae	1	2
	Clytemnestridae	1	2
	Ectinosomatidae	1	2
	Euterpinidae	1	1
	Miraciidae	2	2
	Clausidiidae	1	1
	Corycaeidae	2	31
	Lichomolgidae	4	9
	Oncaeidae	3	23
	Pseudanthessiidae	1	6
	Rataniidae	1	1
	Sapphirinidae	3	30
	Monstrillidae	2	18
	Subtotal	156	908
Mysidacea	Lophogastridae	4	10
	Eucopiidae	1	3
	Petalophthalmidae	1	2
	Mysidae	54	187
	Subtotal	60	202
Euphausiacea	Bentheuphausiidae	1	1
	Euphausiidae	7	55
	Subtotal	8	56
Decapoda	Luciferidae	2	9
	Sergestidae	3	31
	Benthescymidae	2	10
	Penaeidae	1	2
	Pasiphaeidae	11	48
	Pandalidae	2	2
	Thalassocarididae	1	2
	Physetocaridoidea	1	1
	Subtotal	23	105
	Chaetognatha	Spadellidae	4
Eukrohniidae		1	6
Sagittidae		6	33
Krohnittidae		1	2
Pterosagittidae		1	1
	Subtotal	13	48
Tunicata	Oikopleuridae	5	19
	Fritillaridae	6	16
	Doliolidae	1	8
	Pyrosomatidae	1	5
	Salpidae	13	33
	Subtotal	26	81

and 56 species as the Euphausiacea, 8 families, 23 genera and 105 species as the Decapoda, 5 families, 13 genera and 48 species as the Chaetognatha and 5 families, 26 genera and 81 species as the Tunicata (Table 1). In addition, a novel genus and 4 new species of Hydromedusae were established (Table 2), i.e., 2 new species of Tubulariidae, *Ectopleura*, 1 new species of Protiaridae, *Hali-tiarella*, 1 new genus and 1 new species of Hydromedusae, *Cory-morphidae*.

Table 2. New species of mesozooplankton established and described in West Pacific Ocean and its marginal seas

New genus and new species	Systematics	Reference
<i>Ectopleura elongata</i> sp. nov.	Class Hydroidomedusa Claus, 1877 Subclass Anthomedusae Haeckel, 1879 Order Capitata Kühn, 1913 Suborder Tubulariida Fleming, 1828 Family Tubulariidae Fleming, 1828 Genus <i>Ectopleura</i> L. Agassiz, 1862	Lin et al. (2010)
<i>Ectopleura triangularis</i> sp. nov.	Class Hydroidomedusa Claus, 1877 Subclass Anthomedusae Haeckel, 1879 Order Capitata Kühn, 1913 Suborder Tubulariida Fleming, 1828 Family Tubulariidae Fleming, 1828 Genus <i>Ectopleura</i> L. Agassiz, 1862	Lin et al. (2010)
<i>Halitiarella nudibulbus</i> Xu, Huang et Guo, sp. nov.	Class Hydroidomedusa Claus, 1877 Subclass Anthomedusae Haeckel, 1879 Order Filifera Kühn, 1913 Suborder Panderida, Haeckel, 1879 Family Protiaridae Haeckel, 1879 Genus <i>Halitiarella</i> Bouillon, 1980	Xu et al. (2010)
<i>Octovannuccia zhangjinbiaoi</i> Xu, Huang et Lin, gen. nov., sp. nov.	Class Hydroidomedusa Claus, 1877 Order Capitata Kühn, 1913 Suborder Tubulariida Fleming, 1828 Family Corymorphidae Allman, 1872 Genus <i>Octovannuccia</i> Xu, Huang et Lin, 2010	Xu et al. (2010)
<i>Octovannuccia</i> Xu, Huang et Lin, gen. nov.	Class Hydroidomedusa Claus, 1877 Order Capitata Kühn, 1913 Suborder Tubulariida Fleming, 1828 Family Corymorphidae Allman, 1872 Genus <i>Octovannuccia</i> Xu, Huang et Lin, 2010	Xu et al. (2010)

3.2 Enumerated species diversity of Medusozoa (*Hydromedusae*, *Cubozoa*, *Staurozoa* and *Scyphozoa*)

Totally, 5 classes of phylum Cnidaria, including 697 species from 251 genera of 99 families were compiled, which accounted for 26.3% of all the recorded species. Among them, 4 families, 10 genera and 20 species of Subclass Narcomedusae, and 25 species, 16 genera and 4 families of Subclass Trachylina were classified as Class Automedusae. The other 87 species, 87 genera and 31 families of Subclass Anthomedusae, 3 species, 3 genera and 1 family of Subclass Laingiomedusae, 161 species, 39 genera and 16 families of Subclass Hydroidolina, 9 species, 7 genera and 1 family of Subclass Limnomedusae, 99 species, 40 genera and 15 families of Subclass Siphonophorae were classified as Class Hydromedusae. There were 8 species, 4 genera and 4 families of Class Cubozoa, 10 species, 5 genera and 3 families of Class Staurozoa and 83 species, 38 genera and 18 families of Class Scyphozoa. The 10 major species including dominants of Medusozoa were as follows: *Aglaura hemistoma*, *Rhopalonema velatum*, *Chelophyes appendiculata*, *C. contorta*, *Eudoxoides mitra*, *Abylopsis tetragona*, *A. eschscholtzi*, *Bassia bassensis*, *Muggiaea atlantica*, and *Lensia subtiloides*.

3.3 Enumerated species diversity of Ctenophora

The recorded Ctenophora included 2 classes, 7 orders, 12 families, 22 genera 59 species in total. There were 53 species, 21 genera, 11 families and 6 orders of Class Tentaculifera, i.e., Cydippida, Ganeshida, Lobata, Cestida, Cryptolobatidae and Platyctenea. Another one order of Class Nuda, namely Beroda with 1 family, 1 genus and 6 species. The major species of Ctenophora were *Pleurobrachia globosa* and *Beroe cucumis*.

3.4 Enumerated species diversity of Pelagic Mollusca (*Heteropoda* and *Pteropoda*)

There were 85 species, 36 genera, 14 families and 3 orders of Pelagic Mollusca found, where Order Archaeogastropoda contained 30 species, 9 genera and 4 families, Order Thecosomata included 42 species, 18 genera and 5 families, and Order Gymnobia covered 14 species, 9 genera and 5 families. The 11 major species including dominants were as follows: *Agadina stimpsoni*, *Atlanta peroni*, *Desmopterus papilio*, *Hyalocylis striata*, *Diacavolinia longirostris*, *Heliconoides inflatus*, *Limacina trochiformis*, *Creseis clava*, *C. virgula*, *Firoloida desmaresti*, *Paraclione longicaudata*.

3.5 Enumerated species diversity of Ostracoda

Totally, 1 order, 2 suborders, 8 families, 91 genera and 416 species of Ostracoda were classified, which occupied for 15.6% of the total mesozooplankton species, where 4 families, 60 genera and 242 species of Suborder Cypridina and 4 families, 31 genera and 174 species of Suborder Halocypriformes were summarized. The 8 major species were *Archiconchoecia striata*, *Halocypris brevisrostris*, *Metaconchoecia rotundata*, *Mickoconchoecia curta*, *Paraconchoecia oblonga*, *Porroecia porrecta*, *P. spinirostri*, and *Euconchoecia maimai*.

3.6 Enumerated species diversity of Copepoda

In all, 7 orders, 51 families and 156 genera and 908 species of pelagic Copepoda were found, which accounted for 34.1% of the total mesozooplankton species. Among them, 34 families, 124 genera and 741 species of Order Calanoida; 1 family, 3 genera and 4 species of Order Gelyelloida; 3 families, 10 genera and 42

species of Order Cyclopoida; 1 family, 1 genus and 2 species of Order Mormonilloidea; 4 families, 5 genera and 7 species of Order Harpacticoida; 7 families, 15 genera and 101 species of Order Poecilostomatoida; and 1 family, 2 genera and 18 species of Order Monstrilloidea were compiled. There were 24 major species (including dominant species): *Copilia mirabilis*, *Subeucalanus subtenuis*, *Subeucalanus subcrassus*, *S. crassus*, *S. pileatus*, *Nannocalanus minor*, *Acrocalanus gibber*, *Canthocalanus pauper*, *Euchaeta rimana*, *E. plana*, *E. concinna*, *Haloptilus longicornis*, *Scolecithrix danae*, *S. nicobarica*, *Scolecithricella longispinosa*, *Temora turbinata*, *T. discaudata*, *Oncaea venusta*, *Pleuromamma gracilis*, *Oithona similis*, *Paracalanus parvus*, *Corycaeus affinis*, *Cosmocalanus darwinii*, and *Calanus sinicus*.

3.7 Enumerated species diversity of Mysidacea

A total of 4 families, 60 genera and 202 species to Mysidacea were recorded, including 4 genera and 10 species of Lophogasteridae; 1 genus and 3 species of Eucopiidae; 1 genus and 2 species of Petalophthalmidae, and 54 genera and 187 species of Mysidae. The 12 major species were *Lophogaster pacificus*, *Paralophogaster glaber*, *Promysis orientalis*, *Gastrosaccus hibii*, *Iiella pelagica*, *Acanthomysis laticauda*, *Hemisirriella pulchra*, *Archaeomysis kokuboi*, *Erythroptis minuta*, *Euchaetomeropsis merolepis*, *Sirriella thompsonii*, and *S. sinensis*.

3.8 Enumerated species diversity of Euphausiacea

There were 2 families, 8 genera and 56 species of Euphausiacea found, where 1 genus and 1 species of Benteuphausiidae, and 7 genera and 55 species of Euphausiacea were compiled. The 8 major species were *Stylocheiron carinatum*, *Stylocheiron affine*, *Euphausia tenera*, *E. nana*, *Pseudeuphausia sinica*, *P. latifrons*, *Euphausia pacifica*, and *Thysanopoda tricuspidata*.

3.9 Enumerated species diversity of Decapoda

A total of 8 families, 23 genera and 105 species to Decapoda were classified, of which 2 genera and 9 species of Luciferidae; 3 genera and 31 species of Sergestidae; 2 genera and 10 species of Benthescymidae; 1 genus and 2 species of Penaeidae; 11 genera and 48 species of Pasiphaeidae; 2 genera and 2 species of Pandalidae; 1 genus and 2 species of Thalassocarididae, and 1 genus and 1 species of Phytocariidae were compiled. The 4 major species were *Belzebub intermedius*, *Lucifer typus*, *Belzebub penicillifer*, and *L. orientalis*.

3.10 Enumerated species diversity of Chaetognatha

There was only 1 class, 1 order, 5 families, 13 genera and 48

species to Chaetognatha, including 4 genera and 6 species of Spadellidae, 1 genus and 6 species of Eukrohniidae, 6 genera and 33 species of Sagittidae; 1 genus and 2 species of Krohnittidae; and 1 genus and 1 species of Pterosagittidae. The 6 major species were *Pterosagitta draco*, *Flaccisagitta enflata*, *Zonosagitta bedoti*, *Serratosagitta pacifica*, *Mesosagitta minima*, and *Zonosagitta nagae*.

3.11 Enumerated species diversity of Tunicata

A total of 2 classes, 5 families, 26 genera and 81 species of Tunicata were compiled, including 2 families, 11 genera and 35 species of Appendicularia and 3 families, 15 genera and 46 species of Thaliacea. There were 7 major species: *Doliolum denticulatum*, *Doliolletta gegenbauri*, *Thalia democratica*, *T. orientalis*, *Oikopleura (Coecaria) longicauda*, *Oikopleura (Vexillaria) dioica*, and *Oikopleura (Vexillaria) rufescens*.

4 Discussion

4.1 Comparison with species richness and diversity of monographs before 2008 in China

Systematics and species catalogue is not simply the compilation of species inventory and data statistics but a scientific study with high academic level for phyletic classification and species identification, which has to rely on the long-term practical work experience and abundant literature. Facing the shortage of taxonomist, it is getting harder to maintain important specimen collections and handle loans. The taxonomist is currently an endangered race (Wägele et al., 2011). In the West Pacific Ocean and its marginal seas, the authors compiled 2 658 species of 10 mesozooplankton group from taxonomic identification and literature consulting. Compared with the 1 852 species recorded before 2008 in China (Huang, 2008; Liu, 2008), 806 more species were expanded with an increase of 43.5%. It indicated that great success and progress of taxonomy and biodiversity studies had been achieved in this period of 7 years. The input of the new species established was an issue which had not been collected or identified at the earlier stage. It revealed the reason why the richness of mesozooplankton species is greater than those at the earlier stage.

Table 3 shows the comparison of major mesozooplankton group and species richness found from the world ocean, recorded in the West Pacific Ocean and its marginal seas during this study and recorded in China seas before 2008. It primarily indicated the current situation for species diversity of mesozooplankton was consisted of 697 species of Medusozoa in the West Pa-

Table 3. Species richness of major taxa of mesozooplankton known in the world ocean, West Pacific Ocean and China seas

Taxa (Phylum, Class or Order)	Species richness		
	World registered	West Pacific Ocean	China seas before 2008
Medusozoa (Hydromedusae, Cubozoa, Staurozoa and Scyphozoa)	1 187+	697	507
Ctenophora	90+	59	14
Pelagic Mollusca (Pteropoda and Heteropoda)	approximate 138	86	63
Ostracoda	–	416	233
Copepoda	2 000+	908	727
Mysidacea	approximate 700	202	110
Euphausiacea	approximate 86	56	49
Decapoda	–	105	46
Chaetognatha	approximate 93	48	41
Tunicata	134+	81	62
Total	6 000+	2 658	1 852

Note: – means data need to be defined.

cific Ocean and its marginal seas, where 195 more species were found with an increase of 38.5% by comparing with the species previously recorded in China seas (Huang, 2008; Liu, 2008). Meanwhile, 59 species of Ctenophora (45 more species with an increase of 321.4%), 86 species of Pelagic Mollusca (23 more species with an increase of 36.5%), 416 species of Ostracoda (183 more species with the growth of 78.5%), 908 species of Copepoda (181 more species with an increase of 24.9%), 202 species of Mysidacea (92 species increased, namely 83.6%), 56 species of Euphausiacea (7 more species with the growth of 14.2%), 105 species of Decapoda (59 more species with an increase of 128.3%), 48 species of Chaetognatha (7 more species with an increase of 17%), and 81 species of Tunicata (19 more species with an increase of 30.6%) were included. The increase of mesozooplankton species in richness was particularly high in the non-dominant group such as the Ctenophora and Decapoda which amounted to 59 and 105 species, an increase of 321.4% and 128.3% respectively.

As shown in Table 3, the ratio of species richness in the West Pacific Ocean and its marginal seas to that in the world ocean was between 28.9% (Mysidacea) and 65.6% (Ctenophora), which suggested the higher species richness and species diversity in the former region. Therein, the ratios of Ctenophora, Euphausiacea, Pelagic Mollusca and Tunicata were more than 60%, namely 65.6%, 65.1%, 62.3% and 60.4%; while the ratios of Hydromedusae and Chaetognatha were 59.1% and 51.6% respectively. Besides, the ratios of Copepoda and Mysidacea were 45.4% and 28.9%.

4.2 Enumeration of new species occurred in different habitats for compilation of monographs in China after 2008

Species with regard to occurrences in different habitats were listed in comparison with the 1 852 species recorded before 2008 in China (Huang, 2008; Liu, 2008). There were three major groups in terms of geographical distribution. The following examples illustrated some new species recorded.

(1) 1.4% increase of species distributed in tropical sea around equator, i.e., Philippines, Papua New Guinea, Australia, Malaysia, Fiji Islands, such as 5 species of Medusozoa and 6 species of Ostracoda. They were *Clytia pacifica*, *Catostylus mosaicus*, *C. townsendi*, *Crambione bartschi*, *C. mastigophora*; and *Vargula matrix*, *Philomedes psedolofthouseae*, *P. ptyx*, *Vargula dentata*, *V. fugax*, *V. hex*.

(2) 4.0% increase of species inhabited in the frigid water in high latitude region, i.e., Japan and the Russian Far East sea area, for instance, 1 species of Medusozoa, 4 species of Pelagic Mollusca, 8 species of Ostracoda, 7 species of Mysidacea, 4 species of Copepoda, 1 species of Euphausiacea and 7 species of Decapoda. They were *Clytia gardineri*; *Carinaria japonica*, *Clione limacina*, *Paedocione doliiformis*, *Crrucibranchae macrochira*; *Vargula puppis*, *V. norvegica*, *V. norvegica orientalis*, *Pyrocypis noctiluca*, *Philomedes macandrei*, *P. multidentatus*, *P. sagittatus*, *P. subarcuatus*; *Mysidella nana*, *Nipponomysis misakiensis*, *N. lingvura*, *N. tenuiculus*, *N. toriumii*, *N. takitai*, *N. imparis*; *Bradyidius pacificus*, *Pseudocalanus minutus*, *P. newmani*, *Xanthocalanus kurilensis*; *Tessurabrachion oculatum*; and *Hymenodora gracilis*, *Spadella cephalopter*, *S. angulata*, *Paraspadella gotoi*, *Heterokohnia bathybia*, *Sinisteroffia magunum*, *Cyclosalpa foxtoni*.

(3) 3.0% increase of bathypelagic-associated species, for example, 4 species of Medusozoa, 5 species of Copepoda, 4 species of Mysidacea, 1 species of Euphausiacea, 8 species of Decapoda, 1 species of Chaetognatha and 1 species of Tunicata. They were *Nectadamas diomedae*, *Nectopyramis thetis*, *N. natans*, *N. natans*; *Aetideus pacificus*, *Lucicutia pacifica*, *Ryocalanus infelix*,

Paraeuchaeta abyssalis, *Neorhabdus latus*; *Fagegnathophausia gracilis*, *G. longispina*, *Eucopia sculpticauda*, *E. grimaldii*; *Bentheogennema borealis*; *Pasiphaea amplidens*, *P. tarda*, *Ephyrina benedicti*, *E. ombango*, *Heterogenys microphthalmia*, *Hymenodora acanthitelsonis*, *H. frontalis*, *Meningodora compsa*; *Bathyspadella edentata*; and *Sinisteroffia scrippsi*.

4.3 New species established for compilation of monographs in China after 2008

Nowadays, as the marine environment is continuously in anthropogenic disturbances, particularly, we cannot make a large number of species extinct or endangered due to the altering habitat before they are recognized. Especially, there were 4 new species and 1 new genus of Medusozoa established based on this study (Table 2). Two new species of genus *Ectopleura*, i.e., *Ectopleura elongata* sp. nov. (Fig. 3) and *E. triangularis* sp. nov. (Fig. 4) were described in publication based on type specimens from the northern Taiwan Strait by the corresponding author Lin of this study (Lin et al., 2010). Another 1 new species *Halitiarella nudibulbus* Xu, Huang et Guo, sp. nov. (Fig. 5), one new genus *Octovannuccia* Xu, Huang et Lin, gen. nov., and 1 new species *Octovannuccia zhangjinbiaoi* Xu, Huang et Lin, gen. nov. et sp. nov. (Fig. 6) were described in publication based on specimens from Minnan-Yuedong upwelling area, southern Taiwan Strait by the sixth author Xu of this study (Xu et al., 2010).

4.4 Research prospects enhanced in China

To summarize and compile an inventory and systematics for the known species is the core of biodiversity conservation and it also lays a foundation for promoting the biodiversity research. Taxonomy of mesozooplankton can effectively promote the study on mesozooplankton ecology, including species diversity, population dynamics, community structure, life history, the effect of ingestion, microbial food web, size spectra, and so forth (Gaston, 2000; Hobday et al., 2006; Longhurst, 2007; Liu, 2008; De Aguiar et al., 2009; Tittensor et al., 2010).

Some scholars in China have studied the response of the key population of mesozooplankton to global climate change, but they have mainly discussed about the changes in the richness and distribution of some populations (Wang et al., 2003; Gao et al., 2009). The geographic boundary of major population distribution, the variability of maxima abundance, and the long-term change of key function group, etc. have been rarely reported (Liu et al., 2013).

At present, among the studies on the microbial food web, scientists have focused on revealing the global marine ecological dynamics process and the role of mesozooplankton as a “biological pump” in geochemical carbon cycle through exploring the grazing and energy conversion mechanism of mesozooplankton, which is the experimental ecology and controlled *in situ* ecological study of mesozooplankton (Gorokhova and Engstrom, 2009; Soussi et al., 2010; Liu et al., 2013).

Overall, the future prospects and enhanced areas in research of marine mesozooplankton in China are summarized into five major areas: (1) species diversity and community structure of mesozooplankton, (2) mesozooplankton habitats, population distributions and proliferation dynamics, (3) experimental ecology and *in situ* ecological study of mesozooplankton, (4) mesozooplankton responses to global climate change, and (5) new technologies and methods for mesozooplankton research.

5 Conclusions and implications

Species diversity is an important part of biodiversity. Re-

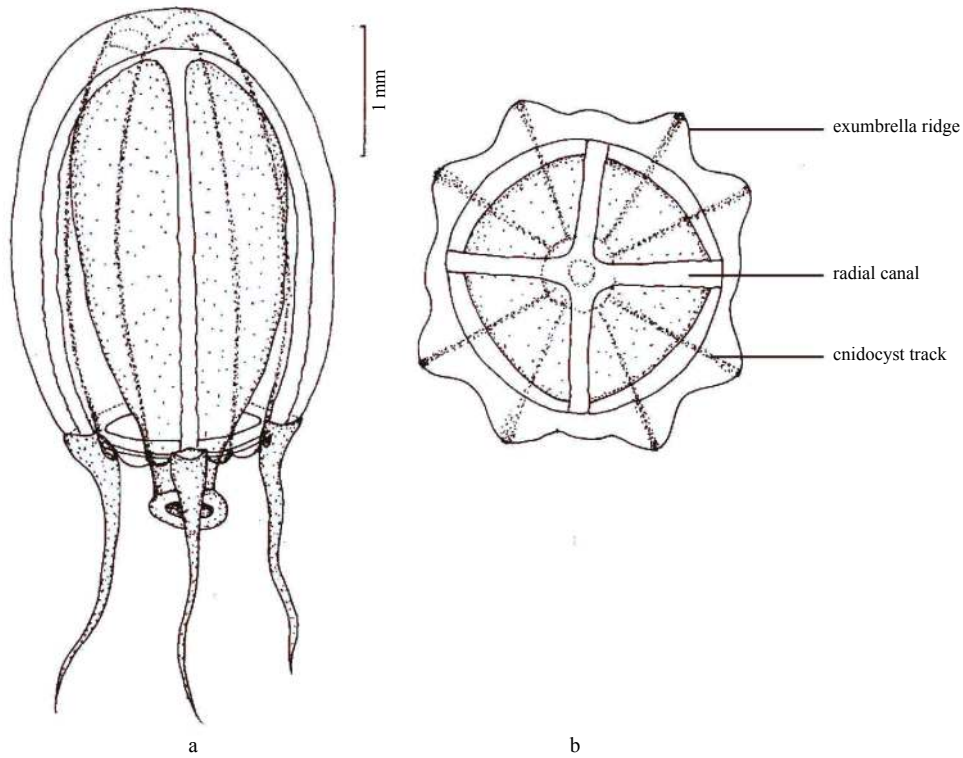


Fig. 3. New taxa *Ectopleura elongate* sp. nov. (modified after Lin et al., 2010). a. The lateral view and b. the dorsal view.

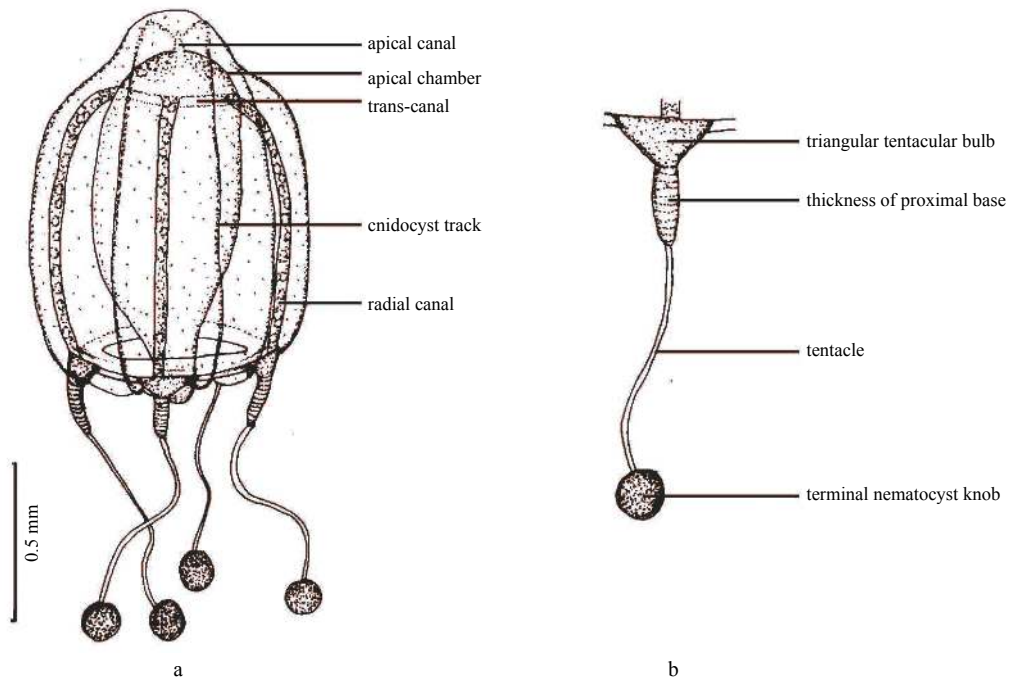


Fig. 4. New taxa *Ectopleura triangularis* sp. nov. (modified after Lin et al., 2010). a. The lateral view and b. the enlargement of tentacle.

search and protection of biodiversity is generally started with species recognizing largely guided by achievement of catalogue and illustration obtained by phyletic classification of species, geographical distribution analysis and quantitative statistics through *in situ* investigation data accumulation and literature learning. During this study, information of qualitative phyletic classification in the West Pacific Ocean and its marginal seas

(0°–45°N, 105°–152°E) could be of high relevance to studies on biodiversity and biogeography of marine mesozooplankton, especially for monographs contributed to make an overall and systematic conclusion on the species of marine life in China after 2008. The major conclusions are:

(1) Totally, there were 2 657 species with 686 genera of 206 families of marine mesozooplankton group identified and com-

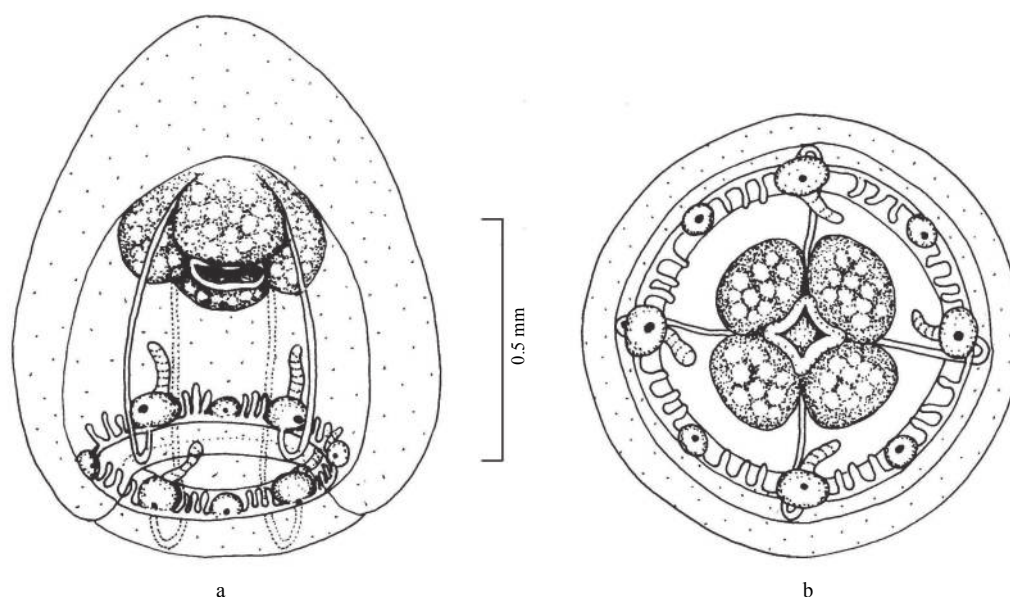


Fig. 5. New taxa *Halitiarella nudibulbus* Xu, Huang et Guo, sp. nov. (modified after Xu et al., 2010). a. The lateral view and b. the oval view.

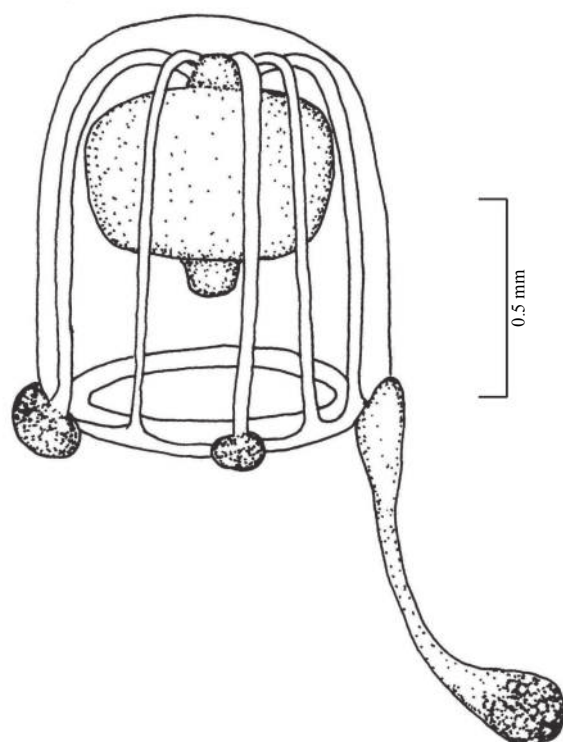


Fig. 6. New taxa *Octovannuccia zhangjinbiaoi* Xu, Huang et Lin, sp. nov. (modified after Xu et al., 2010).

piled in the West Pacific Ocean and its marginal seas.

(2) The major species including dominants of each group, combined with 5 new taxa established were enumerated in comparison to monographs of marine mesozooplankton in China before 2008.

(3) An amount of 806 species are expanded with an increase of 43.5% on the basis of 1 852 species recorded before 2008, in-

cluding 1.4% increase from tropical sea around equator, 4.0% from the frigid waters in high latitude region, and 3.0% of bathypelagic-associated waters.

(4) Taxonomy of mesozooplankton species diversity can effectively promote the study on marine mesozooplankton ecology, which was summarized into five major areas of future prospects enhanced in China.

Acknowledgements

The authors thank Tang Senming from Hong Kong University for fruitful discussion and for helping to revise the manuscript, Xu Zhaoli from the East China Sea Fisheries Research Institute for major mesozooplankton phyletic classification, Guo Donghui from Xiamen University for Medusozoa taxonomy work, Hwang Jiangshiou from Taiwan Ocean University and Liu Zhensheng of the Second Institute of Oceanography for Copepoda taxonomy work. The authors also thank the crew of six research assistants, Xiang Peng, Chen Xiaoying, Ye Youyin, Sun Rouxin, Zhou Qianqian and Wang Yanguo for their work in systematics and species catalogue.

References

- Allen G R. 2002. Indo-Pacific coral-reef fishes as indicators of conservation hotspots. In: Proceedings of the Ninth International Coral Reef Symposium, Bali, Indonesia, 2: 23–27
- Allen G R. 2007. Conservation hotspots of biodiversity and endemism for Indo-Pacific coral reef fishes. *Aquatic Conservation Marine and Freshwater Ecosystems*, 18(5): 541–556
- Barnes R D. 1989. Diversity of organisms: how much do we know. *Integrative and Comparative Biology*, 29(3): 1075–1084
- Bouillon J, Claereboudt M, Seghers G. 1986. Hydromeduses de la baie de Hansa (Mer de Bismarck; Papouasie Nouvelle-Guinée). Répartition, conditions climatiques et hydrologiques. *Indo-Malayan Zoology*, 3: 105–153
- Bouillon J, Gravili C, Pagès F, et al. 2006. An Introduction to Hydrozoa. *Muséum national d'Histoire Naturelle, Paris*, 194: 1–591
- Briggs J C. 2005. The marine East Indies: diversity and speciation. *Journal of Biogeography*, 32(9): 1517–1522, doi: [10.1111/j](https://doi.org/10.1111/j)

[jbi.2005.32.issue-9](#)

- Cai Bingji. 1989. Distribution of Mysidacea in western Taiwan Strait. *Journal of Oceanography in Taiwan Strait* (in Chinese), 11(2): 127–131
- Chen Ruixiang. 1982a. The distribution of plankton Ostracoda in the west coast of the Taiwan Strait. *Haiyang Xuebao* (in Chinese), 4(5): 617–626
- Chen Ruixiang. 1982b. The plankton Ostracoda in the coast of the East China Sea. *Marine Science Bulletin* (in Chinese), 1(6): 45–57
- Chen Boyun. 1985. The distribution of planktonic Copepods in the South China Sea. *Marine Science Bulletin* (in Chinese), 4(4): 45–50
- Chen Ruixiang, Lin Jinghong. 1993. The composition between abundance and diversity of Ostracoda in the Northeast East China Sea and in the source area of the Kuroshio. In: Su JL, ed. *Collected Papers on Kuroshio Survey and Study V* (in Chinese). Beijing: China Ocean Press, 436–449
- Chen Ruixiang, Lin Jinghong, Dai Yanyu, et al. 2000. A study on the richness and diversity of zooplankton in Sea South and East of Taiwan Island. In: Chao Jiping, ed. *Oceanography in China: the Research of the Subtropical Circle in the Northwest Pacific II* (in Chinese). Beijing: China Ocean Press, 135–143
- Chen Yaqu, Xu Zhaoli, Zhao Wenwu. 2003. Study on ecology of meso-small pelagic Copepods in the Southern Yellow Sea and the East China Sea III. Dominant species. *Journal of Fisheries of China* (in Chinese), 27(S1): 16–22
- Chen Qingchao, Yin Jiangqiang, Zhang Guxian. 1983. The planktonic Ostracoda in the north and center of the South China Sea. In: *South China Sea Institute of Oceanography, CAS, eds. Collection of Papers on Marine Biology in the South China Sea* (in Chinese). Beijing: China Ocean Press, 82–132
- Chihara M, Murano M. 1997. An illustrated guide to marine plankton in Japan. Tokyo, Japan: Tokai University Press, 1–1574
- Chiu Shuyuan. 1996. On the geographical distribution and life habits of the Ctenophores of the world. In: Chiu Shuyuan, ed. *Collected Papers on Marine Biology by Professor Chiu Shuyuan* (in Chinese). Xiamen: Xiamen University Press, 83–96
- Dai Yanyu. 1989. Distribution of pelagic Molluscs in western Taiwan Strait. *Journal of Oceanography in Taiwan Strait* (in Chinese), 8(1): 54–59
- Dai Yanyu. 1995. Primary study of the ecology about Pteropods and Heteropoda in the center of the South China Sea. *Haiyang Xuebao* (in Chinese), 17(6): 111–116
- Dai Yanyu. 1996. Study on the ecological of Chaetognatha in the center of the South China sea. *Haiyang Xuebao* (in Chinese), 18(4): 131–136
- Dai Yanyu. 2006. Study on the ecological characteristics of Chaetognatha in waters of southern Huanghai Sea and East China Sea: I. The characteristics of quantitative distribution. *Haiyang Xuebao* (in Chinese), 28(6): 106–111
- Dai Yanyu, Chen Ruixiang, Lin Jinghong, et al. 2000. Ecological characteristics on zooplankton in the subtropical circulation system. In: Chao Jiping, ed. *Oceanography in China: The Research of the Subtropical Circle in the Northwest Pacific II* (in Chinese). Beijing: China Ocean Press, 201–208
- Davis C C. 1955. *The Marine and Freshwater Plankton*. Michigan: Michigan State University Press, 1–562
- De Aguiar M A M, Baranger M, Baptestini E M, et al. 2009. Global patterns of speciation and diversity. *Nature*, 460(7253): 384–387, doi: [10.1038/nature08168](#)
- Gao Shan, Hu Xiaozhong, Chen Zigui, et al. 2009. Characterization of marine microplankton communities of Qingdao coastal areas using randomly amplified polymorphic DNA (RAPD). *Acta Oceanologica Sinica*, 28(1): 55–61
- Gaston K J. 2000. Global patterns in biodiversity. *Nature*, 405(6783): 220–227, doi: [10.1038/35012228](#)
- Gorokhova E, Engström-Öst J. 2009. Toxin concentration in *Nodularia spumigena* is modulated by mesozooplankton grazers. *Journal of Plankton Research*, 31(10): 1235–1247, doi: [10.1093/plankt/fbp060](#)
- Hays G C, Richardson A J, Robinson C. 2005. Climate change and marine plankton. *Trends in Ecology & Evolution*, 20(6): 337–344
- Hobday A J, Okey T A, Pdoczanska E S, et al. 2006. Impacts of climate change on Australian marine life: Part-C-Literature Reviews. Report to the Australian Greenhouse Office. Canberra, Australia: Australian Greenhouse Office, 1–165
- Hsiao S H, Lee C Y, Shih C T, et al. 2004. Calanoid Copepods of the Kuroshio Current east of Taiwan, with notes on the presence of *Calanus jashnovi* Huslemann, 1994. *Zoological Studies*, 43(2): 323–331
- Hu Jian, Xu Zhaoli, Zhu Dedi. 2008. Seasonal changes of ecological characteristics of pelagic mollusc in Yangtze River Estuary. *Journal of Fishery Sciences of China* (in Chinese), 15(6): 976–983
- Huang Zongguo. 1994. *Marine Species and Their Distributions in China Seas* (in Chinese). Beijing: China Ocean Press, 1–898
- Huang Zongguo. 2008. *Marine Species and Their Distribution in China* (in Chinese). Beijing: China Ocean Press, 1–1191
- Huang Zongguo, Lin Mao. 2012. *The Living Species and Their Illustrations in China's Seas-12 Volumes* (in Chinese). Beijing: Science Press, 1–6310
- Huang Fengpeng, Meng Fang, Liu Dongyan, et al. 2000. Distribution of Copepoda in the Kuroshio region in the Northern East China Sea. *Journal of Oceanography of Huanghai and Bohai Seas* (in Chinese), 18(3): 61–65
- Jensen K R. 2006. Biogeography of the Sacoglossa (Mollusca, Opisthobranchia). *Bonner Zoologische Beiträge*, 55: 255–281
- Kramp P L. 1959. The Hydromedusae of the Atlantic ocean and adjacent waters. *Dana Report*, 46: 1–283
- Kramp P L. 1961. Synopsis of the medusae of the world. *Journal of the Marine Biological Association of the United Kingdom*, 40: 1–469
- Kramp P L. 1968. The hydromedusae of the pacific and Indian Oceans. *Dana Report*, 72: 1–200
- Kubota S. 2003. A list of medusae of Anthomedusae and Leptomedusae (Cnidaria, Hydrozoa) in Japan. *Nankiseibutu*, 45(1): 27–32
- Kubota S, Gravili C. 2007. A list of Hydromedusae (excluding Siphonophora, Milleporidae and Actinulidae) in Japan. *Nankiseibutu*, 49: 189–204
- Li Qingliang. 1992. Distribution and composition of the Chaetognatha in the Kuroshio Region of the East China Sea in the spring of 1989. In: Su Jilan, ed. *Collected Papers on Kuroshio Survey and Study: IV* (in Chinese). Beijing: China Ocean Press, 197–202
- Li Qingliang. 1993. A preliminary discussion on the seasonal changes and distribution of Chaetognatha in the Kuroshio Region of the East China Sea and its adjacent waters. In: Su Jilan, ed. *Collected Papers on Kuroshio Survey and Study: V* (in Chinese). Beijing: China Ocean Press, 136–146
- Li Chunhou, Jia Xiaoping, Cai Wengui. 2004. Diversity of marine zooplankton in the north of South China Sea. *Journal of Fishery Sciences of China* (in Chinese), 11(2): 139–146
- Li Qingliang, Meng Fan. 1990. Species composition and distribution of Chaetognatha in Kuroshio region and adjacent waters. In: Su Jilan, ed. *Collected Papers on Kuroshio Survey and Study: II* (in Chinese). Beijing: China Ocean Press, 99–106
- Lin Mao. 1988. The primary study of Thaliacea in the west coast of the Taiwan Strait. *Marine Science Bulletin* (in Chinese), 7: 66–71
- Lin Mao. 1992. The primary study of the Siphonophora in the center of the South China Sea. *Haiyang Xuebao* (in Chinese), 14(2): 99–105
- Lin Yuhui, Lian Guangshan. 1988. Ecology of planktonic copepods in the Taiwan Strait. *Journal of Oceanography in Taiwan Strait* (in

- Chinese), 7(3): 248–255
- Lin Mao, Lin Rongcheng. 2006. Seasonal abundance and distribution of pelagic tunicates (Chordata: Thaliacea) in the central South China Sea. *Acta Oceanologica Sinica*, 25(3): 148–156
- Lin Jinghong, Lin Mao, Dai Yanyu, et al. 2000. Distribution of zooplankton in the subtropical circulation system East of Taiwan Island in winter. In: Chao Jiping, ed. *Oceanography in China: The Research of the Subtropical Circle in the Northwest Pacific: II* (in Chinese). Beijing: China Ocean Press, 195–200
- Lin Mao, Xu Zhenzu, Huang Jiaqi, et al. 2010. Two new species of Ectopleura from the Taiwan Strait, China (Cnidaria, Hydroid-omedusae). *Acta Oceanologica Sinica*, 29(2): 58–61, doi: [10.1007/s13131-010-0022-2](https://doi.org/10.1007/s13131-010-0022-2)
- Lin Mao, Zhang Jinbiao. 1989. The ecology study of the Hydromedusae and Ctenophora in the west of the Taiwan Strait. *Haiyang Xuebao* (in Chinese), 11(5): 621–628
- Lin Mao, Zhang Jinbiao. 1993. Concentration belt of the Siphonophora and Thaliacea and their relation with the boundary of water masses in the middle of the East China Sea. In: Su Jilan, ed. *Collected Papers on Kuroshio Survey and Study: V* (in Chinese). Beijing: China Ocean Press, 452–459
- Liu Ruiyu. 2008. Checklist of Marine Biota of China Seas (in Chinese). Beijing: Science Press, 1–1267
- Liu Zhenshen, Du Mingmin, Zhang Jing. 2013. International research advances in marine zooplankton. *Haiyang Xuebao* (in Chinese), 35(4): 1–10
- Longhurst A R. 2007. *Ecological Geography of the Sea*. Amsterdam: Elsevier, 1–542
- Ma Keping. 1993. On the concept of biodiversity. *Biodiversity Science* (in Chinese), 1(1): 20–22, doi: [10.17520/biods.1993005](https://doi.org/10.17520/biods.1993005)
- Ma Zhaodang, Meng Fan. 1992. The distribution characteristics of Euphausiacea in the North and the Kuroshio region of the East China Sea. In: Su Jilan, ed. *Collected Papers on Kuroshio Survey and Study: IV* (in Chinese). Beijing: China Ocean Press, 191–196
- Ma Zhaodang, Meng Fan. 1993. An ecological study on the Lucifer in the East China Sea and the adjacent waters of Kuroshio on the South of Japan. In: Su Jilan, ed. *Collected Papers on Kuroshio Survey and Study: V*. (in Chinese). Beijing: China Ocean Press, 122–135
- May R M. 1992. How many species inhabit the earth?. *Scientific American*, 267(4): 39–42
- Ohtsuka S. 1984. Calanoid Copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the Middle Honshu, Japan: I. Arietellidae. *Publications of the Seto Marine Biological Laboratory*, 29(4–6): 359–365
- Ohtsuka S. 1985. Calanoid Copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the Middle Honshu, Japan: II. Arietellidae. *Publications of the Seto Marine Biological Laboratory*, 30(4–6): 287–306
- Ohtsuka S. 1992. Calanoid Copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the middle Honshu, Japan: IV. Pseudocyclopiidae. *Publications of the Seto Marine Biological Laboratory*, 35(4–5): 295–301
- Ohtsuka S, Hiromi J. 1987. Calanoid copepods collected from the near-bottom in Tanabe Bay on the Pacific coast of the Middle Honshu, Japan: III. Stephidae. *Publications of the Seto Marine Biological Laboratory*, 32(4–6): 219–232
- Park T S. 1968. Calanoid copepods from the central North Pacific Ocean. *Fishery Bulletin*, 66(8): 527–572
- Peterson C R, Allen C R, Holling C S. 1998. Ecological resilience, biodiversity, and scale. *Ecosystem*, 1(1): 6–18, doi: [10.1007/s100219900002](https://doi.org/10.1007/s100219900002)
- Pousen E M. 1962. Ostracoda-myodocopa: Part I. Cypridiniformes cypridinidae. Vol 57. Copenhagen: Carlsberg Found, 1–250
- Pousen E M. 1965. Ostracoda-myodocopa: PART II: cypridiniformes-rutidermatidae, sarsiellidae and asteropidae. Vol 65. Copenhagen: Carlsberg Found, 1–484
- Pousen E M. 1969. Ostracoda-myodocopa: Part III. Cypridiniformes-thaumatocypridae and halopridae. Dana Report, 75: 1–99
- Pousen E M. 1973. Ostracoda-myodocopa: Part IV. Cypridiniformes-halopridae conchoecinae. Dana Report, 84: 1–224
- Soussi A, Souissi S, Devreker D, et al. 2010. Occurrence of intersexuality in a laboratory culture of the copepod *Eurytemora affinis* from the Seine Estuary (France). *Marine Biology*, 157(4): 851–861, doi: [10.1007/s00227-009-1368-x](https://doi.org/10.1007/s00227-009-1368-x)
- State Bureau of Technical Supervise. 2007. GB/T12736.6–2007 The specification for oceanographic survey-marine biological survey (in Chinese). Beijing: China Standard Press, 30–35
- Tittensor D P, Mora C, Jetz W, et al. 2010. Global patterns and predictors of marine biodiversity across taxa. *Nature*, 466(7310): 1098–1101, doi: [10.1038/nature09329](https://doi.org/10.1038/nature09329)
- Voronina N M. 1998. Comparative abundance and distribution of major filter-feeders in the Antarctic pelagic zone. *Journal of Marine Systems*, 17(1–4): 375–390
- Wägele H, Klusmann-Kolb A, Kuhlmann M, et al. 2011. The taxonomist - an endangered race. A practical proposal for its survival. *Frontiers in Zoology*, 8: 25, doi: [10.1186/1742-9994-8-25](https://doi.org/10.1186/1742-9994-8-25)
- Wang C S. 1991. On the distribution of Chaetognatha in the waters South and East of Japan in the Autumn of 1986. In: Su Jilan, ed. *Collected Papers on Kuroshio Survey and Study: III* (in Chinese). Beijing: China Ocean Press, 325–334
- Wang Rong, Zou Tao, Wang Ke. 2003. The Yellow Sea cold bottom water—an overwintering site for *Calanus Sinicus* (Copepoda, Crustacea). *Journal of Plankton Research*, 25(2): 169–183, doi: [10.1093/plankt/25.2.169](https://doi.org/10.1093/plankt/25.2.169)
- Wiebe P H, Allison M D. 2015. Bringing dark data into the light: A case study of the recovery of Northwestern Atlantic zooplankton data collected in the 1970s and 1980s. *Geo Res J*, 6: 195–201, doi: [10.1016/j.grj.2015.03.001](https://doi.org/10.1016/j.grj.2015.03.001)
- Wong C K, Chan A L C, Chen Q C. 1993. Planktonic copepods of Tolo Harbour, Hong Kong. *Crustaceana*, 64(1): 76–84, doi: [10.1163/156854093X00081](https://doi.org/10.1163/156854093X00081)
- Xu Zhaoli. 2005. Species composition and diversity of Pteropods in the East China Sea. *Biodiversity Science* (in Chinese), 13(2): 168–173, doi: [10.1360/biodiv.040118](https://doi.org/10.1360/biodiv.040118)
- Xu Zhaoli. 2011. The past and the future of zooplankton diversity studies in China seas. *Biodiversity Science* (in Chinese), 19(6): 635–645
- Xu Zhaoli, Chen Yaqu. 2005. The dominant species of Euphausiids in the East China Sea and their ecological adaptability. *Acta Oceanologica Sinica* (in Chinese), 25(9): 2227–2233
- Xu Zhaoli, Cui Xuesen, Chen Weizhong. 2004. Species composition and dominant species study on pelagic Copepods in the East China Sea. *Journal of Fisheries of China* (in Chinese), 28(1): 35–40
- Xu Zhenzu, Huang Jiaqi, Lin Mao, et al. 2010. Description of one new genus and two new species of Anthomedusae from Minnan-Yuedong inshore upwelling area, China (Filifera, Protiaridae; Capitata, Corymorphidae). *Acta Zootaxonomica Sinica*, 35(1): 11–15
- Xu Zhaoli, Lin Mao. 2007. Species composition and diversity of Thaliacea in the East China Sea. *Marine Fisheries Research* (in Chinese), 28(1): 26–32
- Xu Zhaoli, Lin Mao, Zhang Jinbiao. 2006a. Changes in dominant species of Thaliacea in the East China Sea. *Acta Zoologica Sinica* (in Chinese), 52(1): 53–62
- Xu Zhaoli, Yuan Qi, Wang Yunlong. 2006b. Dominant species of pelagic Mysidacea in the East China Sea. *Journal of Fishery Sciences of China* (in Chinese), 13(3): 432–439
- Xu Zhaoli, Zhang Fengying. 2006c. Species distribution and diversity of Appendicularia in the East China Sea. *Journal of Shanghai Fisheries University* (in Chinese), 15(3): 286–291
- Yang Guangming, He Dehua, Wang Chunsheng, et al. 1999. Study on the biological oceanography characteristics of planktonic cope-

- Pods in the waters north of Taiwan Island: II. Community characteristics. *Haiyang Xuebao* (in Chinese), 21(4): 72–80
- Yin Jianqiang, Chen Qingchao, Zhang Gucian, et al. 2006. Spatial and temporal variations of zooplankton composition and quantity distribution in the upper waters around Nansha Islands. *Chinese Science Bulletin*, 51(S1): 154–164
- Zhang Jinbiao. 1979. The primary study of the Hydromedusae in China Sea. *Haiyang Xuebao* (in Chinese), 1(1): 127–137
- Zhang Shuzhen, Chen Qingchao. 1984. An ecological study of the planktonic Copepoda of the South China Sea: I. Quantitative distribution and variation. *Tropic Oceanology* (in Chinese), 3(1): 46–55
- Zhang Guxian, Chen Qingchao. 1991. Euphausiacea study in the South China Sea and adjacent area. In: South China Sea Institute of Oceanography, CAS, ed. *Marine Fauna and Zoogeography of Nansha Island* (in Chinese). Beijing: China Ocean Press, 140–270
- Zhang Jinbiao, Lian Guangshan, Wang Yunlong, et al. 2003. Distribution of Thaliacea (Tunicata) in eastern Taiwan Strait. *Journal of Oceanography in Taiwan Strait* (in Chinese), 22(3): 279–285
- Zhang Jinbiao, Lin Mao. 1997. The ecological geography study of Siphonophora in the South China Sea. *Haiyang Xuebao* (in Chinese), 19(4): 121–131
- Zhang Jinbiao, Xu Zhenzu. 1980. The distribution of Siphonophora in China Sea. *Journal of Xiamen University (Natural Science)* (in Chinese), 19: 100–109