Community Structure and Abundance of Tintinnids in the Bay of Bengal During the Spring

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Received 2012-03-04, Revised 2012-07-13; Accepted 2012-07-19

ABSTRACT

The Bay of Bengal (BoB) locates in eastern part of the northern Indian Ocean, with a unique inter-related oceanographic system due to the monsoon and enormous runoffs’ supply. microbial food web often dominated the stratified Tropical Ocean, while few studies have been taken up to the tintinnids ciliates. Community structure and abundance of tintinnids were investigated in transact 10°N of the BoB during April 23 to May 2 of 2010. Discrete samples (for tintinnids and environment parameter analysis) were collected at various depths of 0, 25, 50, 75, 100, 150 and 200 m at each station. The tintinnids abundance vertically increased from surface water to maximal at the 75 m, decreased thereafter to the 200 m layer. A total of 20 tintinnids species that belong to 16 genera. Undella ostenfedi was dominant species, followed by Eutintinnus fraknoii and Amphorella quadrilineata. Tintinnids abundance was positively correlated to chlorophyll a concentration (p<0.01), indicating the vertical distribution of the tintinnids community was regulated by available food resource.

Keywords: Tintinnids, Abundance, Community Structure, Bay of Bengal

1. INTRODUCTION

Tintinnids ciliates that have a lorica into which the ciliate cell can withdraw, occur in the worldwide oceans (Pierce and Turner, 1993; Dolan, 2000; Dolan et al., 2006). Many studies have provided quantitative data on tintinnids diversity of the world (Verity, 1985; Cariou et al., 1999; Thompson et al., 2004; Zhang et al., 2008). Biogeographic distributions of tintinnids related to hydrographics are well known for several oceanic provinces (Modigh et al., 2003; Thompson et al., 1999). The tintinnids are agreed to present as the tracers of upwelling, oceanic currents and water masses (Pierce and Turner, 1993; Kršinić and Grbec, 2006).

The BoB locates in eastern part of the northern Indian Ocean, with a unique inter-related oceanographic system due to the semi-annually reversed monsoon winds and enormous land-derived runoffs’ supply (Jyothibabu et al., 2008). The BoB was conventionally referred as an oligotrophic water where nutrients (e.g., nitrate and phosphorus) were deplete (Narvekar and Kumar, 2006; Li et al., 2012) and solar radiation was low caused by cloudy days, restricting the phytoplankton growth (Madhupratap et al., 2003; Madhu et al., 2006). Moreover, microbial food web often dominated the stratified Tropical Ocean, microzooplankton may thus play important role in the BoB. Many studies of the BoB have focused on the hydrological features (Gomes et al., 2000), physical circulations (Schott and McCreary, 2001; Shankar et al., 2002) and phytoplankton characters (Li et al., 2012). However, few studies have been taken up to the tintinnids ciliates. In this study, vertical changes in community structure and ab.
2. MATERIALS AND METHODS

The tintinnids samples were collected during the BoB research cruise (April 23 to May 2, 2010), initiated by the South China Sea Institute of Oceanology, Chinese Academy of Science. Samples were collected from six sites along the transect 10°N of the BoB (Fig. 1), after the profiles of environmental factors being obtained as described in details by Li et al. (2012). The water column of the sampling area was severely stratified with the upper mixed layer of ~75 m where the nutrientcline and maximal chlorophyll layers almost located (Li et al., 2012).

At each station, seven discrete tintinnids samples (1L for each) were collected at various depths of 0, 25, 50, 75, 100, 150 and 200 m, using a Rosette sampler fitted with 2.5-L Niskin Bottles. The collected water samples (1L) were fixed with Lugol’s solution (final concentration of 1%). Back in the laboratory, the samples were settled and concentrated to a volume of about 20 mL. To examine tintinnids, the samples were thoroughly mixed and then 3mL was dropped into a count chamber. Lorica of the tintinnids in the chamber was examined and counted under a Nikon stereomicroscope. Species were identified according to the shape of lorica with reference to Kofoid and Campbell (1929; 1939) and Carey (1992).

Pearson correlation analysis was applied to find the tintinnids community in relation to the environmental variables (SPSS 16.0 software).

3. RESULTS

A total of 20 tintinnids species belonging to 16 genera were identified in present study (Table 1). Maximum species number were found at B1 and B5 (10), followed by B4 and B6 (6); only 3 species presented at B3. Surface tintinnids abundance was only a few tens per liter, with the mean value of <40 ind L⁻¹. Vertical distribution of tintinnids abundance coincided well with chl-a concentration (for details in Li et al., 2012), with the mean cell-density gradually increased from surface to DCM layer (except B2), then sharply decreased to the 200 m layers (Fig. 2).

![Fig. 1. Location of sampling site in the Bay of Bengal](image)

### Table 1. Tintinnids species encountered in Bay of Bengal. *Common species (>10% total cells)

| Depth/m | B1                  | B2                  | B3                  | B4                  | B5                  | B6                  |
|---------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 0       | Marshallia aperta,  | Cratereilla retusa  | nd                  | Eutintinnus stramentus | Eutintinnus fraknoi* | Tintinnopsis schotti |
|         | Undella ostenfeld*  |                     |                     | Steenstrupiella gracilis |                      |                     |
|         | Stenosemma inflata  | nd                  | Undella ostenfeld*  | Steenstrupiella gracilis | Eutintinnus fraknoi* |                      |
|         | Eutintinnus stramentus |                     |                     | Undella ostenfeld*  | Eutintinnus fraknoi* |                      |
|         | Marshallia aperta   |                     |                     |                     | Marshallia aperta   |                     |
| 25      | Dadyiella ganymedes | nd                  | Amphorella quadridactyla | Eutintinnus fraknoi* | Amphorella quadridactyla |                      |
|         | Eutintinnus fraknoi* | nd                  | Undella ostenfeld*  | Eutintinnus fraknoi* | Euphhabdona nici     |                     |
|         |                     |                     |                     |                     | Amphorella quadridactyla |                     |
|         |                     |                     |                     |                     | Epirhabdonella niei  |                     |
|         |                     |                     |                     |                     | Propectella clavaredi |                     |
|         |                     |                     |                     |                     | Undella ostenfeld*  |                     |
|         |                     |                     |                     |                     |                      | Ambothrella quadridactyla |
| 35      | Arnorhabdonella sieboldii |                     |                     |                      | Ambothrella quadridactyla |                     |
|         |                     |                     |                     |                     |                      | Eutintinnus fraknoi* |
|         |                     |                     |                     |                     |                      | Salpingella cuneolata |
| 50      | Dicyocysta reticulata |                     |                     |                      | Salpingella cuneolata |                     |
|         | Arnorhabdonella sieboldii |                     |                     |                      |                      | Ormosella bresslau   |
|         |                     |                     |                     |                     |                      | Salpingella attenuata |
| 75      | Arnorhabdonella sieboldii |                     |                     |                      |                      | Eutintinnus fraknoi* |
|         | Arnorhabdonella sieboldii |                     |                     |                      |                      | Salpingella cuneolata |
|         |                     |                     |                     |                     |                      | Ormosella bresslau   |
|         | Arnorhabdonella sieboldii |                     |                     |                      |                      | Salpingella cuneolata |
|         | Arnorhabdonella sieboldii |                     |                     |                      |                      | Ormosella bresslau   |
| 100     | nd                  | Salpingella minutissima | nd                  | nd                  | nd                  | nd                  |
|         |                     |                     |                     |                     |                     |                     |
| 150     | Eutintinnus stramentus | Eutintinnus stramentus | nd                  | nd                  | Salpingella attenuata | nd                  |
|         | Eutintinnus sp.      | Eutintinnus sp.      | nd                  | nd                  |                      |                     |
| 200     | Eutintinnus stramentus | Eutintinnus sp.      | nd                  | nd                  | Steenstrupiella gracilis | nd                  |

nd: no detected
Dominant species showed an obvious spatial difference in the BoB, with *Undella ostenfeldii* found at most sites except B2, followed by *Eutintinnus fraknoii* and *Amphorella quadrilineata*. Tintinnids community structure changed by site, with *Tintinnopsis schotti* dominated the community at B1, *E. fraknoii* at B2, *E. fraknoii* and *Proplectella claparedeii* at B5 and *U. ostenfeldii* at B6. In particular, the tintinnids abundance positively correlated to chl-a concentration (P<0.01) at each sampling layer (Fig. 3).

4. DISCUSSION

The activities of tintinnids such as grazing or excretion are probably much less important than those of the naked oligotrich taxa in marine ecosystems, since they merely account for low proportion (<10% of cell numbers or biomass) of the ciliate community (Dolan and Marrase, 1995; Dolan, 2000). Furthermore, the tintinnids may play a relatively minor role in e.g., carbon flux or nutrient regeneration; however, they are ideal organisms (easily be detected) to mark the changes in species structure or community of microzooplankton (Thompson et al., 1999; Dolan, 2000). Krsinic and Grbec (2006) thus suggested that ingestion of water masses from the Ionian Sea and formation of cyclonic gyre was important in determining the horizontal distributions of tintinnids in the south Adriatic. In this study, tintinnids abundance and integrated Chl-a concentration at B1 was higher than B2. Nevertheless, B1 (low temperature and high salinity) and B2 (high temperature and low salinity) showed differential environment characters (Li et al., 2012). Different environments resulted in different tintinnids compositions, in turns, indicated the responses of that the tintinnids to the environmental changes.

Chl-a concentrations and primary productivity values were low in present study (Li et al., 2012; Liu et al., 2011), as a consequence, tintinnids abundance was relative low (Fig. 2). Due to the weaker wind force and relatively warmer climate that depress the exchanges of the nutritious deeper water with the surface water, the BoB is considered as a region of low biological productivity (Gomes et al., 2000; Kumar et al., 2002; 2007).

Dolan et al. (2002) postulated that the tintinnids diversity reflected the resource diversity more closely than the competitive interactions or predation. The abundance of tintinnids positively correlated to chl-a concentration in present study, this could be explained by their feeding on phytoplankton (especially pico and nanophytoplankton), indicated the phytoplankton biomass regulated the ciliates abundance in the BoB.

5. CONCLUSION

Surface tintinnids abundance was only a few tens per liter and the mean cell-density gradually increased from surface to DCM layer (except B2), then sharply decreased to the 200 m layers. *Undella ostenfeldii* was the dominate species at most site in the BoB. Tintinnids abundance was positively correlated to chlorophyll a concentration,
indicating the vertical distribution of the tintinnids community was regulated by available food resource.

6. ACKNOWLEDGMENT

This research was supported by National Nature Science Foundation of China (41130855). Special Project of the Social Commonwealth Research of the National Science Research Institute (South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences) (No. 2011TS06).

7. REFERENCES

Carey, P.G., 1992. Marine Interstitial Ciliates: An Illustrated Key. 1st Edn., Springer, London, ISBN-10: 0412406101, pp: 368.

Cariou, J.B., J.R. Dolan and S. Dallot, 1999. A preliminary study of tintinnid diversity in the NW Mediterranean Sea. J. Plankton Res., 21: 1065-1075. DOI: 10.1093/plankt/21.6.1065

Dolan, J.R. and C. Marrase, 1995. Planktonic ciliate distribution relative to a deep chlorophyll maximum: Catalan Sea, N.W. Mediterranean, June 1993. Deep Sea Res. Part I: Oceanogr. Res. Papers, 42: 1965-1987. DOI: 10.1016/0967-0637(95)00092-5

Dolan, J.R., 2000. Tintinnid ciliate diversity in the Mediterranean Sea: longitudinal patterns related to water column structure in late spring-early summer. Aquatic Microbiol. Ecol., 22: 69-78. DOI: 10.3354/ame022069

Dolan, J.R., H. Claustre, F. Carlotti, S. Plounevez and T. Moutin, 2002. Microzooplankton diversity: Relationships of tintinnid ciliates with resources, competitors and predators from the Atlantic Coast of Morocco to the Eastern Mediterranean. Deep-Sea Res. Part I: Oceanogr. Res. Papers, 49: 1217-1232. DOI: 10.1016/S0967-0637(02)00213-3

Dolan, J.R., S. Jacquet and J.P. Torreton, 2006. Comparing taxonomic and morphological biodiversity of tintinnids (planktonic ciliates) of New Caledonia. Limnol. Oceanogr., 51: 950-958. DOI: 10.4319/lo.2006.51.2.0950

Gomes, H.R., J.J. Goes and T. Saino, 2000. Influence of physical processes and freshwater discharge on the seasonality of phytoplankton regime in the Bay of Bengal. Continental Shelf Res., 20: 313-330. DOI: 10.1016/S0278-4343(99)00072-2

Jyothibabu, R., N.V. Madhu, P.A. Maheswaran, K.V. Jayalakshmy and K.K.C. Nair et al., 2008. Seasonal variation of microzooplankton (20-200 µm) and its possible implications on the vertical carbon flux in the western Bay of Bengal. Continental Shelf Res., 28: 737-755. DOI: 10.1016/j.csr.2007.12.011

Kofoid, C.A. and A.S. Campbell, 1929. A conspectus of the marine and freshwater ciliata belonging to the suborder Tintinoinea, with descriptions of new species principally from the agassiz expedition to the eastern tropical pacific. University of Califorinia Press, California.

Kofoid, C.A. and A.S. Campbell, 1939. The Ciliata: The Tintinnoinea. 1st Edn., Printed for the Museum, Cambridge, pp: 473.

Krsinic, F. and B. Grbec, 2006. Horizontal distribution of tintinnids in the open waters of the south Adriatic (Eastern Mediterranean). Sci. Mar., 70: 77-88. DOI: 10.3989/scimar.2006.70n177

Kumar, S.P., M. Nuncio, N. Ramaiha, S. Sardesai and J. Narvekar et al., 2007. Eddy-mediated biological productivity in the Bay of Bengal during fall and spring intermonsoons. Deep-Sea Res. Part I: Oceanographic Res. Papers, 154: 1619-1640. DOI: 10.1016/j.dsr.2007.06.002

Kumar, S.P., P.M. Muraleedharan, T.G. Prasad, M. Gauns and N. Ramaiah et al., 2002. Why is the Bay of Bengal less productive during summer monsoon compared to the Arabian Sea? Geophys. Res. Lett., 29: 2235-2235. DOI: 10.1029/2002GL016013

Li, G., Z. Ke, Q. Lin, G. Ni and P. Shen et al., 2012. Longitudinal patterns of spring-intermonsoon phytoplankton biomass, species compositions and size structure in the Bay of Bengal. Acta Oceanol. Sinica, 31: 121-128.

Liu, H.X., Z.X. Ke, X.Y. Song, Y.H. Tan and L.M. Huang et al., 2011. Primary production in the Bay of Bengal during spring intermonsoon period. Acta Ecol. Sinica, 31: 7007-7012.

Madhu, N.V., R. Jyothibabu, P.A. Maheswaran, V.I. Gerson and T.C. Gopalakrishnan et al., 2006. Lack of seasonality in phytoplankton standing stock (chlorophyll a) and production in the western Bay of Bengal. Continental Shelf Res., 26: 1868-1883. DOI: 10.1016/j.csr.2006.06.004

Madhupratap, M., M. Gauns, N. Ramaiah, S.P. Kumar and P.M. Muraleedharan et al., 2003. Biogeochemistry of the Bay of Bengal: Physical, chemical and primary productivity characteristics of the central and western Bay of Bengal during summer monsoon 2001. Deep-Sea Res. Part II: Topical Stud. Oceanography, 50: 881-886. DOI: 10.1016/S0967-0645(02)00611-2
Modigh, M., S. Castaldo, M. Saggiomo and I. Santarpia, 2003. Distribution of tintinnid species from 42°N to 43°S through the Indian Ocean. Hydrobiologia, 503: 251-262.

Narvekar, J. and S.P. Kumar, 2006. Seasonal variability of the mixed layer in the central Bay of Bengal and associated changes in nutrients and chlorophyll. Deep-Sea Res. Part I: Oceanographic Res. Papers, 53: 820-835. DOI: 10.1016/j.dsr.2006.01.012

Pierce, R.W. and J.T. Turner, 1993. Global biogeography of marine tintinnids. Marine Ecol. Prog. Ser., 94: 11-26. DOI: 10.3354/meps094011

Schott, F.A. and J.P. Jr. McCreary, 2001. The monsoon circulation of the Indian Ocean. Progress Oceanogr., 51: 1-123. DOI: 10.1016/S0079-6611(01)00083-0

Shankar, D., P.N. Vinayachandran and A.S. Unnikrishnan, 2002. The monsoon currents in the north Indian Ocean. Progress Oceanogr., 52: 63-120. DOI: 10.1016/S0079-6611(02)00024-1

Thompson, G.A., 2004. Tintinnid diversity trends in the southwestern Atlantic Ocean (29 to 60°S). Aquatic Microbial. Ecol., 35: 93-103. DOI: 10.3354/ame035093

Thompson, G.A., V.A. Alder, D. Boltovskoy and F. Brandini, 1999. Abundance and biogeography of tintinnids (Ciliophora) and associated microzooplankton in the Southwestern Atlantic Ocean. J. Plankton Res., 21: 1265-1298. DOI: 10.1093/plankt/21.7.1265

Verity, P.G., 1985. Grazing, respiration, excretion and growth rates of tintinnids. Limnol. Oceanogr., 30: 1268-1282. DOI: 10.4319/lo.1985.30.6.1268

Zhang, C., W. Zhang, T. Xiao, R. Lu and S. Sun et al., 2008. Meso-scale spatial distribution of large tintinnids in early summer in southern Yellow Sea. Chinese J. Oceanol. Limnol., 26: 81-90.