Marine Pollution Bulletin 107 (2016) 88–91

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Insights into bioassessment of marine pollution using body-size distinctness of planktonic ciliates based on a modified trait hierarchy

Henglong Xu *, Yong Jiang, Guangjian Xu

College of Marine Life Science, Ocean University of China, Qingdao 266003, China

ARTICLE INFO

Article history:
Received 1 March 2016
Received in revised form 30 March 2016
Accepted 8 April 2016
Available online 20 April 2016

Keywords:
Planktonic ciliate
Body-size distinctness
Trait hierarchy
Bioassessment
Marine pollution

ABSTRACT

Based on a modified trait hierarchy of body-size units, the feasibility for bioassessment of water pollution using body-size distinctness of planktonic ciliates was studied in a semi-enclosed bay, northern China. An annual dataset was collected at five sampling stations within a gradient of heavy metal contaminants. Results showed that: (1) in terms of probability density, the body-size spectra of the ciliates represented significant differences among the five stations; (2) bootstrap average analysis demonstrated a spatial variation in body-size rank patterns in response to pollution stress due to heavy metals; and (3) the average body-size distinctness (Δ_z^+) and variation in body-size distinctness (Λ_z^+), based on the modified trait hierarchy, revealed a clear departure pattern from the expected body-size spectra in areas with pollutants. These results suggest that the body-size diversity measures based on the modified trait hierarchy of the ciliates may be used as a potential indicator of marine pollution.

1. Introduction

Ciliated protozoa are primary components of microbiota and play an important role in the functioning of microbial food webs in aquatic ecosystems (Dolan and Coats, 1990; Sime-Ngando et al., 1995; Kchaou et al., 2009; Jiang et al., 2011a, 2011b; Feng et al., 2015). With many advantages, such as short generation time and rapid response to environmental stress, they have been widely used as useful bioindicators of water quality in both freshwater and marine environments (Cairns and Henebry, 1982; Xu et al., 2005; Kchaou et al., 2009; Jiang et al., 2011a, 2011b; Xu et al., 2014, Feng et al., 2015).

As a trait function of a community, body-size distinctness has been considered as a potential bioindicator capable of assessing ecosystem changes due to environmental stress and anthropogenic impact (Jiang et al., 2012; Xu et al., 2016; Xu and Xu, 2016). So far, several studies on body-size distinctness of ciliated protozoa have been carried out mainly for bioassessment of organic pollution or eutrophication (Jiang et al., 2012; Xu et al., 2016; Xu and Xu, 2016). However, with regard to feasibility for assessing pollutions by heavy metals, few works were reported.

In this study, based on modified trait hierarchy of body-size unites, the body-size distinctness of planktonic ciliates was studied in a semi-enclosed bay of the Yellow Sea, northern China during a 1-year cycle. The aims of this study were to determine the feasibility for bioassessment of marine pollution by heavy metals using body-size distinctness of planktonic ciliates based on modified trait resemblance.

2. Materials and methods

2.1. Data collection

Five areas with different pollution stresses were selected as sampling stations in Jiaozhou Bay (Fig. 1). Station A was slightly polluted due to tidal circulation of pollutants from inshore waters; station B was a severely polluted area mainly due to heavy metals (mainly Pb and Zn) from industrial discharges; station C was stressed mainly by mariculture activities and the tidal circulation of inshore waters; station D was heavily polluted due to heavy metal pollutants (mainly Cd and Cu) from industrial discharges; and station E was located at the mouth of this bay, which was far from the sources of pollutants (Liu et al., 2005).

2.2. Sampling and sample processing

Samples were biweekly collected at a depth of 1 m at five stations during a 1-year cycle (June 2007–May 2008). Sample processing, species identification and individual enumeration were carried out as described by Jiang et al. (2011a).

* Corresponding author.
E-mail address: henglongxu@126.com (H. Xu).

http://dx.doi.org/10.1016/j.marpolbul.2016.04.014
0025-326X/

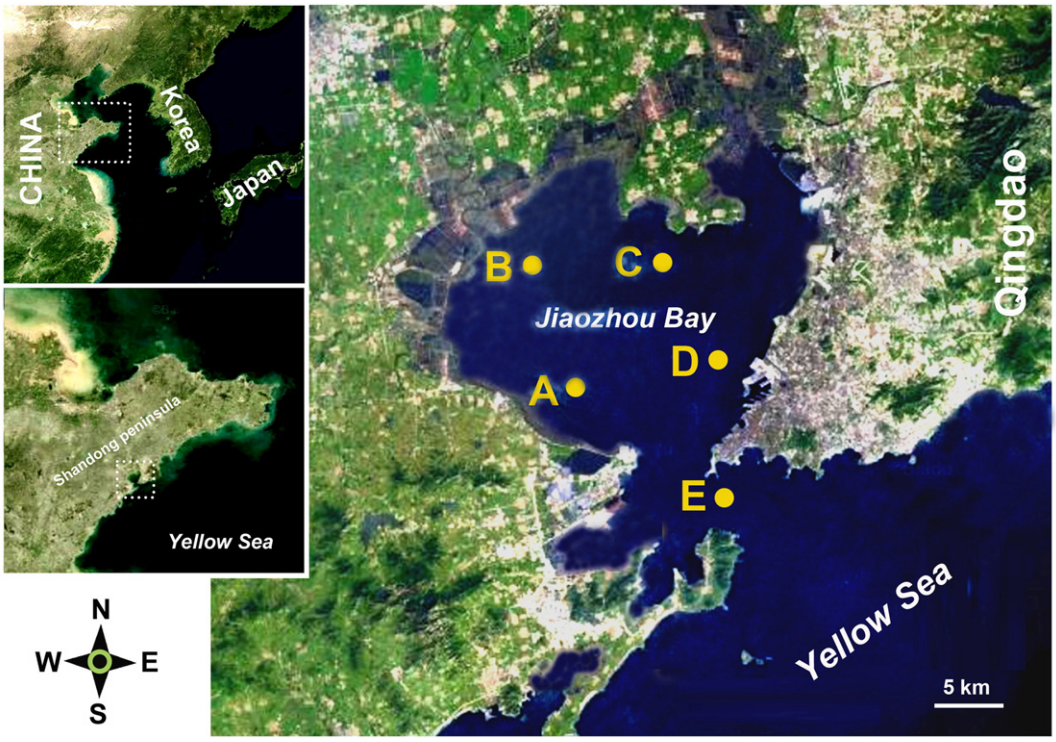

Fig. 1. Map showing the sampling sites in Jiaozhou Bay, north China. A, site A near Huangdao; B, site B near the mouths of Yang and Dagu rivers; C, site C near mariculture area; D, site D near the mouths of Haipo and Licun rivers; E, site E at the mouth linking the bay with Yellow Sea.

Biovolumes of ciliate cells were determined from measurements of their linear dimensions and using volume equations of appropriate geometric shape (Winberg, 1971). Equivalent spherical diameters (ESDs) were used as a body-size unit of the ciliates (Jiang et al., 2012; Xu et al., 2016; Xu and Xu, 2016).

2.3. Data analyses

All multivariate analyses were conducted using PRIMER v7.0.10 and the PERMANOVA + for PRIMER (Clarke and Gorley, 2015; Anderson et al., 2008). The spatial patterns of body-size spectra were summarized

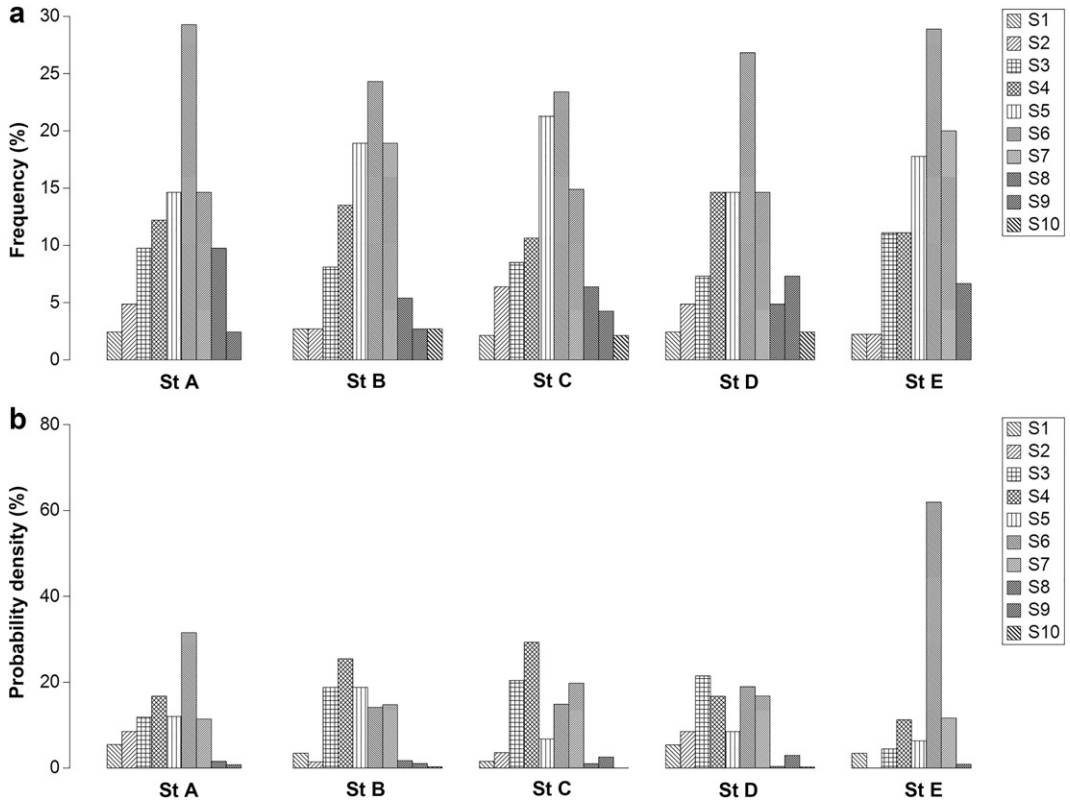

Fig. 2. Spatial pattern in frequency (a) and probability density (b) at a total of 10 body-size ranks of planktonic ciliates in a semi-enclosed bay of the Yellow Sea during the study period.