Ecological Indicators 61 (2016) 865–870

Contents lists available at ScienceDirect

Ecological Indicators

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

An approach to determining homogeneity of body-size spectrum of biofilm-dwelling ciliates for colonization surveys

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ARTICLE INFO

Article history:
Received 13 August 2015
Received in revised form 10 October 2015
Accepted 14 October 2015
Available online 6 November 2015

Keywords:
Biofilm-dwelling ciliates
Body-size spectrum
Body-size distinctness
Homogeneity
Functional ecology
Colonization survey

ABSTRACT

Body-size spectrum, as an inherent function of a community, has been considered as a feasible bioindicator for functional ecological research and global bioassessment. To determine the homogeneity of body-size spectrum of biofilm-dwelling ciliates in colonization surveys, a 1-month baseline study was conducted at two depths of 1 and 3 m in coastal waters of the Yellow Sea, northern China. The temporal variability in body-size spectrum of the ciliate communities represented a decreasing trend at both depths. The average body-size distinctness (Δ_z^+) and variation in body-size distinctness (Λ_z^+), which were proposed based on a trait hierarchy of body-size units, represented a high variability in the young samples (>10 days), but a low in the mature (10–28 days). The paired body-size distinctness measures (Δ_z^+ and Λ_z^+) showed a significant departure between young samples and the mature communities with an expected trait hierarchy of body-size spectrum. These results suggest that the paired body-size distinctness measures may be a useful indicator for determining the homogeneity of body-size spectrum in colonization surveys for biofilm-dwelling ciliates.

1. Introduction

Biofilm-dwelling ciliates are a primary component of a biofilm or a microperiphyton community, and devote great contributions to the functioning of microbial food webs by mediating carbon and energy flux from plankton to the benthos in aquatic ecosystems (Kathol et al., 2009; Norf et al., 2009a,b; Xu et al., 2011, 2012a; Zhang et al., 2012a). Ciliated protozoa have many advantages, such as rapid response to environmental changes, easy sampling and comparisons on spatial and temporal scales, for bioassessment, and thus they have widely been used as a useful bioindicator of water quality in aquatic ecosystems (Morin et al., 2010; Xu et al., 2012b). Furthermore, our previous studies have demonstrated that biofilm-dwelling ciliates have a feasible indication of water quality status in marine ecosystems (Xu et al., 2014a–c, 2015a–d).

Body-size spectrum analysis has been considered as a useful tool to summarize functional structure of a community and to assess ecological quality status (Sheldon et al., 1972; San Martin et al., 2006; Jiang et al., 2012; Xu et al., 2013), since the spatial and temporal variation in such an inherent functioning pattern of a community is sensitive to environmental contamination and anthropogenic impact (Kamenir et al., 2010; Jiang et al., 2012; Xu et al., 2013). So far, several studies on body-size spectrum of a community for discriminating water quality status have been conducted in Jiaozhou Bay of the Yellow Sea, northern China (e.g., Jiang et al., 2012; Xu et al., 2013). However, as regards the use of the body-size diversity measures of a community for determining homogeneity of body-size spectrum of biofilm-dwelling ciliates in colonization surveys, little information was documented.

In this study, we demonstrated a temporal variation in body-size spectrum of biofilm-dwelling ciliates during a 1-month colonization period in coastal waters of the Yellow Sea, northern China (May–June, 2015). Two body-size distinctness measures were proposed based on a hierarchy of body-size ranks. Our objectives of the study were to evaluate the feasibility of the body-size distinctness measures for determining homogeneity of body-size spectrum in a biofilm-dwelling ciliate community.

2. Materials and methods

2.1. Data collection

The sampling station was located in the harbor of the Olympic Sailing Center at Qingdao, northern China (Fig. 1). This is a typical coastal area of the Yellow Sea with an average depth of ~8 m and an

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http://dx.doi.org/10.1016/j.ecolind.2015.10.039
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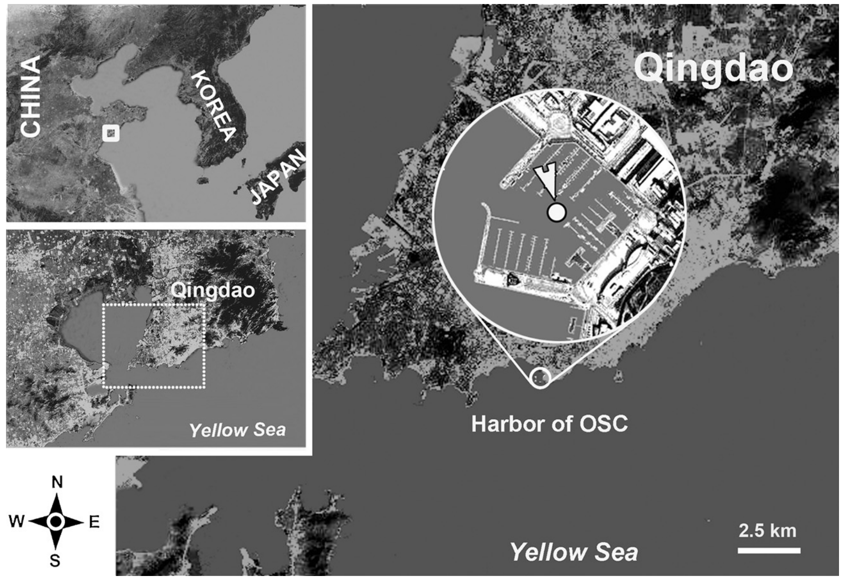

Fig. 1. Sampling station, which was located in the harbor of the Olympic Sailing Center (OSC) at Qingdao, on the Yellow Sea coast of northern China.

average tidal range of 3 m. The glass slide systems were designed, deployed, anchored, and sampled as described by Xu et al. (2011).

A total of 280 microscopy glass slides were used as artificial substrates for collecting the biofilm-dwelling ciliates at two depths of 1 m and 3 m below the water surface. For each depth, a total of seven PVC frames were used to hold a total of 140 slides, 20 of which were randomly collected from each PVC frame at the time interval of 1, 3, 7, 10, 14, 21 and 28 days. From both depths, samples were collected simultaneously (Xu et al., 2011).

Identification and enumeration of the ciliate species were performed following the microscopy methods outlined by Xu et al. (2011). Protargol staining was performed for species identification (Song et al., 2009). Taxonomic classification of ciliates was according to published keys and guides such as Song et al. (2009). The enumeration was conducted in vivo at a 100-fold magnification under an inverted microscope within 24 h after sampling in order to prevent significant changes in species composition (Xu et al., 2012b; Zhang et al., 2012b).

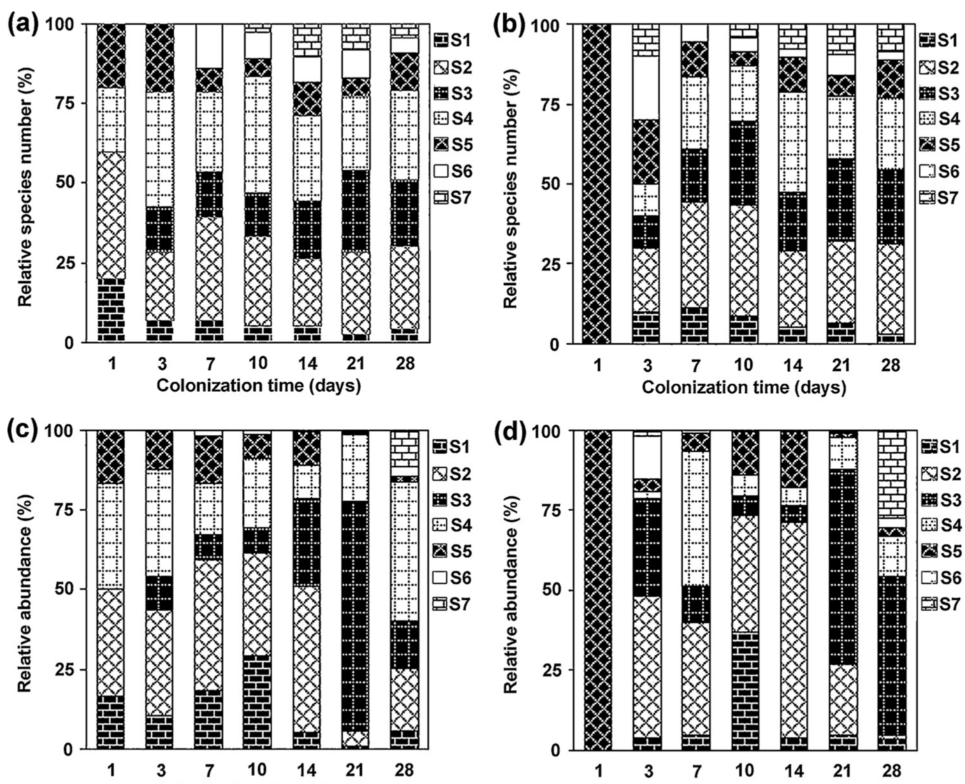

Fig. 2. Temporal variations in relative species number (a, b) and relative abundance (c, d) of each body-size rank of the ciliates at depths of 1 m (a, c) and 3 m (b, d) during the colonization period. S_1–S_7, ranks S_1–S_7 of body sizes.