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硕士学位论文

**中国鲎栖息的沙质潮间带基于大型底栖动
物的生态监测与评价**

**Ecological monitoring and assessing based on benthic
macrofauna in sandy intertidal zone where Chinese
horseshoe crab habitating**

李国强

指导教师姓名: 蔡立哲 教授

专业名称: 环境科学

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摘要

近年来, 中国鲎(*Tachypleus tridentatus*)资源由于人类捕捞、海岸工程等影响急剧减少。底栖动物活动性小、地区性强, 可以较好地反映底质的受扰动状况, 在海洋环境的生物学指标中有重要意义。

平潭岛鲎保护区、诏安湾城洲岛、北海西背岭和竹林盐场砂质潮间带大型底栖动物未见系统监测, 本研究按国标规范地对这些潮间带的大型底栖动物进行了定量和定性监测, 并运用大型底栖动物物种数、栖息密度、生物量、功能群、生物指数和丰度生物量比较法, 评价了中国鲎栖息的砂质潮间带的生态环境状况, 目的在于探索中国鲎资源减少的原因, 同时为中国鲎保护提供科学依据。主要研究成果如下:

(1) 2015年8月和2016年5月、8月在平潭岛山岐澳和坛南湾砂质潮间带定量采集获得大型底栖动物91种, 多毛类是最主要的类群, 为43种。定量和定性采集均未发现中国鲎。山岐澳和坛南湾砂质潮间带大型底栖动物三个季度的平均栖息密度为 3162 ind. m^{-2} , 平均生物量为 140.78 g m^{-2} 。在功能类群方面, 肉食者物种数最多, 为29种, 植食者获得的物种数最少, 仅有9种。

(2) 2013年11月(秋季)和2014年5月(春季)在诏安湾城洲岛砂质潮间带定量采集获得大型底栖动物34种, 其中多毛类最多, 为17种。定量和定性采集均未发现中国鲎。诏安湾城洲岛砂质潮间带两个季度的大型底栖动物平均栖息密度为 202 ind. m^{-2} , 平均生物量是 2.40 g m^{-2} 。从功能群看, 肉食者是主要的功能群类型, 为14种; 其次是杂食者和植食者, 其物种数分别为10种、5种; 碎屑食者位居第四, 其物种数为4种; 浮游生物食者获得的物种数最少, 仅有1种。

(3) 2016年8月(夏季)在北海西背岭和竹林盐场砂质潮间带定量采集获得大型底栖动物37种, 其中多毛类13种, 腹足类7种, 双壳类5种, 甲壳类10种, 刺胞动物和纽形动物各1种。定量采集未发现中国鲎, 定性采集发现了6只中国鲎。夏季北海西背岭和竹林盐场砂质潮间带大型底栖动物栖息密度为 383 ind. m^{-2} 。栖息密度组成以多毛类占优势, 其次是双壳类, 腹足类的栖息密度最低。夏季北海西背岭和竹林盐场砂质潮间带大型底栖动物生物量为 101.08 g m^{-2} , 双壳类在生物量组成中占优势, 其次是甲壳类, 多毛类最低。从功能群来看, 植

食者者是主要的功能群类型，杂食者物种数最少，仅有 3 种。

(4) 夏季平潭岛山歧澳砂质潮间带大型底栖动物多样性指数(H')和均匀度指数(J)平均值高于坛南湾，而春季相反。2013 年秋季和 2014 年春季诏安湾城洲岛砂质潮间带大型底栖动物种类多样性指数平均值比另外两个研究区域更低，为 0.971。2016 年夏季在北海西背岭砂质潮间带大型底栖动物种类多样性指数小于竹林盐场砂质潮间带的，但丰度指数(d)是西背岭的高于竹林盐场的。

(5) 多样性指数平均值表明平潭岛鲨保护区、城洲岛和北海砂质潮间带分别受中度、严重和轻度扰动。海洋生物指数(AMBI)和多变量海洋生物指数(M-AMBI)指数平均值表明平潭岛鲨保护区、城洲岛和北海砂质潮间带均受轻度扰动。可见，AMBI 和 M-AMBI 的评价结果在砂质潮间带较一致，而多样性指数的评价结果不一致。

关键词：中国鲨；大型底栖动物；生态监测；生态评价；砂质潮间带

Abstract

In recent years, due to excessive human fishing, coastal engineering and other human activities, *Tachypleus tridentatus* resources reduced dramatically. Benthic macrofauna has the advantages of wide distribution, relatively stable living habits, and it can reflect the disturbance of the sediment, so it has great significance in the method of biological index to evaluate the marine environment.

In this study, Benthic macrofauna monitoring was carried out in the sandy intertidal zone of three research areas, and macrofaunal species, density, biomass, functional group, biological index and Abundance Biomass Comparison were used to evaluate the ecological environment of sandy intertidal zone in research areas. The aim was to explore the reasons for the reduction of horseshoe crab in China and the results can provide a scientific basis for the protection of horseshoe crab. The main research results are as follows:

1. Ninety-one species of benthic macrofauna were obtained in the horseshoe crab reserve of Pingtan Island. Polychaetes had a majority in the collection of benthic macrofauna, including 43 species, but horseshoe crab was not collected. The average density of benthic macrofauna in Pingtan area was 3162 ind. m⁻², the average biomass of benthic macrofauna was 140.78 g m⁻². Carnivores group was the main benthic macrofaunal functional group in Pingtan research area, with 29 species, and Phytophagous group had the least number of species, only 9 species. The sediments had a great influence on the distribution of macrobenthic functional groups.

2. Thirty-four species of benthic macrofauna were identified in the sandy intertidal of Zhaoan Island. The number of polychaetes was the highest with 17 species, but horseshoe crab was not collected. The monthly average density of benthic macrofauna in Zhaoan research area was 202 ind. m⁻², and the monthly average biomass of benthic macrofauna was 2.40 g m⁻². Carnivorous group was the main benthic macrofaunal functional group in Zhaoan research area, with 29 species; followed by

Omnivores group (10), Phytophagous group (5), Detritivorous group (4), and Planktophagous group has the least number of species, just only 1 species.

3. Thirty-seven species of benthic macrofauna were identified in the horseshoe crab habitat of Beihai. Among them, 13 species belonged to Polychaeta, 7 species belonged to Gastropoda, 5 species belonged to Bivalvia and 10 species belonged to Crustacean, moreover, 6 horseshoe crabs were collected in qualitative sampling. The monthly average density of benthic macrofauna in Beihai research area was 383 ind. m^{-2} , The density of the polychaetes was dominant, *Ceratonereis marmorata* is the dominant species of the West Ridge; followed by bivalves, gastropods has the lowest average density. The monthly average biomass of benthic macrofauna was 101.08 g m^{-2} , followed by Crustaceans, polychaetes has the least density of benthic macrofauna. Phytophagous group was the main benthic macrofaunal functional group in Beihai research area, and Omnivores group has the least number of species, only 3 species.

4. The diversity index and evenness index of benthic macrofauna in the sandy intertidal zone of Pingtan Island in summer were higher than those in Tannan Bay, but the spring was opposite. The average diversity index of benthic macrofauna in the intertidal zone of Zhaoan Bay in Autumn 2013 and Spring 2014 was low (0.971). In the summer of 2016, the diversity index of benthic macrofauna in the sandy tidal zone of Xibei Saltern was lower than that in another sandy intertidal zone, but the abundance index (d) was higher than that in another sandy intertidal zone.

5. The average of the diversity index indicates that the sandy intertidal zone of Pingtan Island, Chengzhou Island and Beihai are respectively moderate, severe and mildly disturbed. The values of AMBI and M-AMBI indicate that the sandy intertidal zone of Pingtan Island, Chengzhou Island and Beihai are slightly disturbed. It can be seen that the results of AMBI and M-AMBI are consistent in the sandy intertidal zone, while the results of the diversity index are inconsistent with the above results.

Key Words: Horseshoe crab; Benthic macrofauna; Ecological monitoring; Ecological evaluation; Sandy intertidal zone

第一章 前言

中国鲎(*Tachypleus tridentatus*)又称中华鲎、三棘鲎、三刺鲎、东方鲎、小海鲎、两公婆,分布于中国长江口以南的海域,是中国国家二级保护动物。中国鲎也分布于印度尼西亚、日本、马来西亚、菲律宾和越南的海域。素有“活化石”之称的中国鲎不仅有着很高的科研价值和经济价值,同时还具有一定的文化价值[陈章波等, 2015]。近年来,由于水质的恶化、鲎栖息地被破坏以及狂捕滥杀行为活动加剧,造成厦门海域中国鲎资源大量减少,甚至已经难觅其踪[陈秋明, 2009]。归结中国鲎资源减少最主要的原因是人类活动造成的一系列后果[翁朝红等, 2012]。

海洋底栖动物(marine zoobenthos)是生活史的全部或大部分时间生活于海洋沉积物以及海水中物体(包括生物体和非生物体)内部或表面的动物[蔡立哲, 2015]。根据通过筛网孔径的大小,可将底栖动物分为:(a)大型底栖动物(macrofauna):不能通过 500 μm 孔径筛网的动物;(b)小型底栖动物(meiofauna):能通过 500 μm 孔径筛网但不能通过 42 μm (深海为 31 μm)孔径筛网的动物;(c)微型底栖动物(microfauna):能通过 42 μm 孔径筛网的动物,如原生生物界的原生动物[蔡立哲, 2006; 李新正, 2011]。

1.1 国内外砂质潮间带大型底栖动物研究概况

1.1.1 国外砂质潮间带大型底栖动物研究进展

国外关于潮间带海洋底栖动物的研究记载开始的较早,最早始于 18 世纪英国皇家学会组织的“挑战者”环球调查,之后海洋底栖生物调查全面兴起,但有关沙滩潮间带生态的研究仍然比较少。

大型底栖动物在砂质潮间带的区域划分十分明显[Mclachlan & Jaramillo, 1995],这可能是栖息于该地区的某些优势种对底质和气候做出的响应[Mclachlan, 1983; Mclachlan *et al.*, 1993; Mclachlan & Jaramillo, 1995]。Narayanan (1986)研究发现希腊卡瓦拉蒂岛(Kavaratti)礁沙滩潮间带中潮带多毛类尖锥虫属最为丰

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