互花米草入侵对红树林区蟹的分布和食物来源的影响

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Effects of Exotic *Spartina alterniflora* on Distribution and Diet of Crab in Mangroves

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摘要

本论文调查了福建云霄漳江口国家级红树林自然保护区红树林林缘、白骨壤群落、秋茄群落和短叶茳芏群落四个生境(以下合称红树林区)蟹的种类、密度和生物量及其季节变化，并通过比较互花米草群落与红树林林缘、白骨壤群落、秋茄群落及短叶茳芏群落中蟹的种类、密度和生物量差异揭示互花米草入侵对红树林区蟹的分布的影响。此外，运用稳定同位素技术分析了红树林林缘、白骨壤群落、秋茄群落和短叶茳芏群落蟹的食物来源，并通过比较互花米草群落与红树林林缘、白骨壤群落、秋茄群落和短叶茳芏群落中蟹的 $\delta^{13}C$ 值和 $\delta^{15}N$ 值揭示了互花米草入侵对红树林区蟹的食物来源的影响。主要结果如下：

1. 在采样地点共发现蟹类 4 科 12 种，以方蟹科为主。招潮蟹主要分布在林外，方蟹科中相手蟹主要分布在林内。长足长方蟹也是常见种之一，既可分布在林外又可分布在林内。
2. 红树林区不同季节蟹的密度和生物量差异显著。各生境蟹的密度和生物量均在 2 月份和 5 月份较低，8 月份达到最大（林缘除外）。不同生境蟹的密度和生物量也存在显著差异。蟹的生物量在短叶茳芏群落中最高，白骨壤群落和秋茄群落中蟹的密度和生物量没有差异(5 月份除外)($P>0.05$)。由于滩涂养殖和人为干扰严重，红树林林缘蟹的密度和生物量季节变化较大。
3. 互花米草群落中蟹的多样性指数季节平均值高于红树林林缘和短叶茳芏群落，低于白骨壤群落和秋茄群落。互花米草群落中蟹的密度和生物量季节平均值低于红树林林缘、白骨壤群落和秋茄群落，但是差异不显著($P>0.05$)。互花米草群落中蟹的生物量随季节变化，8 月份互花米草群落中蟹的生物量最低，且显著低于红树林林缘、白骨壤群落和秋茄群落($P<0.01$)。互花米草群落中蟹的密度和生物量季节平均值显著低于短叶茳芏群落($P<0.05$)。相关性分析表明蟹的生物量与沉积物沙质含量及有机质含量呈显著正相关($P<0.05$)；而蟹的密度与植物叶片含水量呈显著正相关($P<0.01$)，与植物叶片 C/N 值呈显著负相关($P<0.05$)。
4. 红树林区各生境蟹的食物来源不同。稳定碳和氮同位素分析显示 8 月红

树林林缘的蟹主要以浒苔和沉积物为食，白骨壤群落和秋茄群落中蟹主要以红树植物根部大型藻类为食，红树植物叶对其食性贡献较小。Isosource 分析表明红树植物根部大型藻类、红树植物叶和沉积物对褶痕相手蟹食性的贡献大小分别为 76%~80%、14%~16%和 4%~8%。短叶茳芏群落中蟹主要以短叶茳芏叶为食，Two source-mixing model 分析表明短叶茳芏叶对无齿相手蟹的食性贡献率达到 84.2%。

5. 互花米草入侵改变了红树林区蟹的碳源和营养级位置。互花米草群落中蟹的 $\delta^{13}C$ 值(-13.34‰)显著高于红树林林缘、白骨壤群落和秋茄群落中蟹的 $\delta^{13}C$ 值($P<0.01$)，与短叶茳芏群落中蟹的 $\delta^{13}C$ 值相比无显著差异($P>0.05$)。互花米草群落中蟹的营养级最高(2.8)，且与林缘、白骨壤群落和秋茄群落中蟹的营养级都存在显著差异($P<0.05$)，还与短叶茳芏群落中蟹的营养级存在极显著差异($P<0.01$)。

关键词：红树林；蟹；互花米草；稳定同位素；漳江口

Abstract

This study was designed to understand how the exotic *Spartina alterniflora* invasions influence crabs' species, biomass and food composition. The study was carried out at Zhangjiang Estuary of Fujian, China. Five habitats were chosen, including Mangrove fringe, monospecific forest of *Avicennia marina*, monospecific forest of *Kandelia obovata*, *Cyperus malaccensis* and *Spartina alterniflora* monoculture. Species and biomass of crabs were investigated seasonally through November, 2008 to August, 2009 and $\delta^{13}C$ and $\delta^{15}N$ values of mangrove leaves, sediment and muscle tissues of crabs were determined. The main results were shown as follows.

1. At Zhangjiang Estuary, 12 species of crabs belong to 4 Families were recorded during fielding investigation. Sesarminae crabs were the major subfamily. Most Fiddler crabs live on mudflat and Sesarminae crabs prefer inhabiting under canopy. *Metaplax longipes* (Grapsidae) was also a common species in the area, and distributed both on mudflat and under canopy.
2. There were significant differences in the density and biomass of crabs among four seasons in each mangrove habitat. The density and biomass of crab in February and May were lower than November, the highest was in August (except Mangrove fringe). The density and biomass of crab in each season were also significantly different among the mangrove habitats. The biomass of crab in the *C. malaccensis* community were the highest, significantly higher than that in other mangrove habitats; no significant difference was observed in the density and biomass of crab between *A. marina* and *K. obovata* community($p>0.05$)(except in May). The density and biomass of crab at Mangrove fringe change greatly with the season due to mudflat aquaculture and man-made interference.
3. The seasonal average biodiversity index of *S. alterniflora* community was higher than those of Mangrvoe fringe and *C. malaccensis* and lower than those of *A. marina* and *S. alterniflora* community. Although *S. alterniflora* community had

the lower seasonal average density and biomass of crab than those of Mangrove fringe, *A. marina* and *K. obovata* community, repectively, there were no significant difference between them (P>0.05). The biomass of crab in *S. alterniflora* community changed greatly with the season. Among four seasons, the biomass of crab in August was the lowest, and was significantly lower than those of Mangrove fringe, *A. marina* and *K. obovata* community, repectively (P>0.01). The seasonal average density and biaomass of crab in *S. alterniflora* community was significantly lower than that in *C. malaccensis* community (P<0.05). Pearson correlation analysis shows biomass of crab has a significantly positive correlation with sand and organic matter content of sediment (P<0.05). Density of crab has a significantly positive correlation with water content (P<0.05) and negative correlation with C/N value of of plant leaves (P<0.01).

4. Based on analysis on $\delta^{13}C$ and $\delta^{15}N$ values of crab muscle tissues, we found differences in diets of crab in different sites. Crab in Mangrove fringe mainly eat macroalgae (*Enteromorpha prolifra*). The major food for crab in *A. marina* community and *K. obovata* community was probably macroalgae, while the contribution of mangrove leaves is limited. Isosource analysis demonstrated that the contribution of mangrove leaves, macroalgae and sediment to the diet of *Sesarma plicata* was about 76%~80%, 14%~16% and 4%~8%, respectively. *C. malaccensis* leaves were the major food of crab in *C. malaccensis* community. The contribution of *C. malaccensis* leaves to the diet of *Sesarma dehahni* was about 84.2% through Two source-mixing model analysis.
5. *Spartina* invasions were observed to cause the change in the food sources and trophic position of the native crab. The average $\delta^{13}C$ value of crab was significantly higher than those in other three habitats (Mangrove fringe, *A. marina* and *K. obovata* community) (P<0.01). No significant difference was observed in the average $\delta^{13}C$ value of *Sesarma plicata* between *C. malaccensis* and *S. alterniflora* community (P>0.05). The crab's trophic position in *S. alterniflora* community was the highest (2.8), significantly higher than that in each mangrove habitat (P<0.05).

Key words: mangrove, crab, *Spartina alterniflora*, stable isotope, Zhangjiang Estuary

第一章　前言

红树林是生长在热带、亚热带海湾河口潮间带的木本植物群落(Chapman, 1976; Tomlinson, 1986; 林鹏, 1997)。红树林生态系统具有巨大的初级生产力，并且可以为该系统内的消费者提供良好的栖息、繁衍地以及丰富的食物来源(王文卿和王瑁, 2007; Lee, 2008; Nagelkerken et al., 2008)。蟹是底栖生物中的优势动物类群(Jones, 1984; Hutchings & Saenger, 1987; Macintosh, 1988)，对红树林生态系统的结构和功能起着重要作用(Lee, 1998)。蟹的作用主要包括以下四个方面：第一，蟹能有效处理落叶，滞留大部分的初级生产力而防止落叶随着潮水的涨落大量输出(Lee, 1995)。澳大利亚东北部热带地区方蟹(*Sesarma messa*)能处理 28%红树林落叶(Robertson, 1986)；Emmerson 等(1992)发现 *Sesarma meinerti* 消费的落叶占林内落叶总量的 44%；sesarmids 可以去除林内落叶总量的 79-95%(Robertson & Daniel, 1989; Skov, 2001)；而泰国南部红树林相手蟹能处理 100%的落叶(Poovachiranon & Tantichodok, 1991)。第二，落叶经过蟹处理后，其中 68%随着粪便排出(Camilleri, 1989)，这有助于提高凋落物的转化率，加快有机物质的释放和循环，为碎屑食物链中的消费者提供大量的食物。第三，蟹和其它的碎屑取食者可以作为更高营养级动物的食物来源，部分种类还具有重要的经济价值，比如锯缘青蟹 (Beever et al., 1979)。 第四，蟹还具有干扰活动、消费繁殖体、促进植物生长等重要功能(Botto & Iribarne, 2000; Smith, et al., 1991; Bertness, 1985)。Smith 等(1991)通过了解蟹的干扰活动对红树林生态系统土壤化学性质和植物生长的影响，表明蟹是澳大利亚红树林生态系统中的关键类群之一。

1.1 红树林区蟹的种类和分布

目前对红树林区蟹的研究主要集中在两方面：蟹的分布及其影响蟹分布的因素和食性。Snelling(1959)、Kinne(1963) 和 Barnes(1967)认为盐度是决定蟹类在河口环境中分布的重要因子。而 Seiple(1979)对北卡罗纳州波弗特海地区两种相手蟹的研究发现盐度并不影响它们的分布，而沉积物特征才是影响相手蟹分布的主要因素。Frusher 等(1994)发现渗透调节能力和沉积物特征对蟹的分布影响不大，并推测可能还受到种内竞争和捕食的影响。