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专论与综述

能量标签技术及其在红树林生态系统能流研究中的应用

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摘要 传统上认为红树林输出的有机质产生巨大的能流，支持了巨大的河口和近岸水域生态系统的次级生产。但能量标签技术的研究结果却显示红树林输出的有机质的作用并没有如此巨大。用红树碎屑难消化特性来解释此现象，此外数学模型模拟分析发现潮汐的稀释作用也可以解释这种现象。但这两者都不能解释，在其他初级生产者稀少时，红树材输出的有机质可以被大量利用的现象。在有红树林的河口和近海岸水域生态系统中，藻类等非红树初级生产者具有比红树植物更高的初级生产力,而且更容易被动物获得和消化。可以认为是藻类等巨大初级生产力的竞争作用导致红树初级生产在消费者组织中很难被发现，如此上面提到的难题就能得到很好的解决。此外能量标签技术检测出的是红树的初级生产在消费者组织中的相对比率，不是绝对数量值，从此角度看，能量标签技术的结果与传统观点不是矛盾而是互相补充的关系。由此推测红树的初级生产应该还是被消费者所利用，只是它们在消费者初级营养来源组成中占的比例并不大，但其绝对数量并不少。这与传统观点认为的红树的初级生产被大量利用，支撑了具有巨大的次级生产稍有不同。此外，能量标签技术在红树林生态系统中的适用性尚未检验；计算食物组成的数学工具不是很完善；实验设计上考虑的不够全面；对定量研究有一定的影响。

关键词 稳定性同位素 13C 能量输出 消费者 初级生产

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Energy signature technology and its application on energy flux in mangrove ecosystems: a review and outlook

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Abstract A central view of tropical estuarine ecology is that export of organic matter from mangroves represents a major energy pathway and support much of the secondary production of estuaries and nearshore waters. Nevertheless, recent results, especially those obtained using energy signature technology, contradict this paradigm. Overall, most studies found a limited role of mangrove detritus in estuarine food webs. Usually only animals collected inside mangrove swamps or in mangrove-lined waterways have depleted carbon isotopic signatures characteristic of mangrove detritus. These findings are explicable by the difficulty in assimilation of mangrove carbon and the dilution effect of the tides. These factors, however, cannot explain the heavy use of mangroves in estuarine habitats when other primary production sources are scarce.Algae and other primary production sources (e.g. seagrass) have much higher productivity than mangrove in estuaries and nearshore waters, and are easy to obtain and digest. So these alternative carbon sources and the complicated food web structure mask the nutrition role of mangroves. If this hypothesis is true then it could offer an explanation for the observation that mangrove litter is heavily used by consumers when other primary production sources are scarce, a phenomenon that cannot be explained by the difficulty in assimilation or tidal dilution. Energy signature technology addresses the relative contribution of mangroves to the consumer's carbon sources, not the biomass in numbers. Energy signature technology addresses the relative proportion of the assimilated carbon from mangrove to all the consumer carbon, not the biomass in numbers. The traditional view is that mangrove primary production supports large consumer biomass but not the relative proportion. With that in mind energy signature technology is not inconsistent with the traditional view but is complementary. We hypothesize that all of mangrove litter production is used by aquatic consumers. The mode of the use is, however, not in terms of dominance in the consumer(s tissue but small contributions to many in

dividuals.One blemish of past isotopic studies is that none has directly tested the applicability of th e approach to food web links between consumer and mangrove. Another blemish is that what isot opic data indicated was the proportion of the assimilated carbon from mangrove to all the consum er carbon, not its importance. For example algae could get into food webs directly through consu mption by all kinds of fishes but mangrove litter must be consumed by crabs first and then perhap s by fish. So in fish tissue there will be much less carbon from mangrove than from algae if the initi al primary production in terms of carbon mass of mangrove and algae is equal. Because the carbo n mass of mangrove is much reduced after crab digestion and absorption. Digestion and absorptio n will affect the importance of different carbon sources too, but this issue has been ignored in pas t studies. The study of energy flux in mangrove ecosystems only focused on particulate organic ma tter but has ignored dissolved organic carbon (DOC), which is the dominant form of carbon expo rted from mangroves. N and P export is also important.It is apparent that mangrove litter is not th e main source of primary production fuelling the food chains in estuaries and nearshore waters. Is otope signature technology is not yet a perfect tool for studying these trophic linkages, but the imp erfection is in the details.

Key words stable isotope; ^{13}C ; energy export; mangrove; consumer; primary pr oduction

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