LIN Peng: MANGROVE RESEARCH PAPERS(Ⅳ)
(1997--1999)

红树林研究论文集

（第四集）

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厦门大学出版社
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作者简介

林鹏教授，1931年12月18日生，福建省龙岩市人，1955年毕业于厦门大学生物系植物学专业，先后任助教、讲师、副教授，现为厦门大学教授,博士生导师,还兼任中国生态学会理事、常务理事、全国红树林生态学研究学组执委会主席,福建省生态学会名誉理事长、福建省科学技术协会第二、三、四届委员和国家教委首届环境科学教学指导委员会委员、第二届副主任，国际红树林生态系统学会（ISME）理事。

林鹏教授主要从事植物生态学和群落学、环境生物学和红树林生态学研究，曾在国内外发表论文270篇，专著有《植物群落学》（1986）、《福建植被》（1990）、《武夷山研究－森林生态系统（I）》（1998）、《南药栽培》（1980）、《红树林》（1984，中文版；1988，英文版）、《红树林研究论文集，第一集（1980-1989）》(1990)、《红树林研究论文集，第二集（1990-1992）》(1993)、《红树林研究论文集，第三集（1993-1996）》(1999)、《中国红树林环境生态和经济利用》（1995）和《中国红树林生态系》（1997,中文版；1999，英文版）。

Brief Introduction of the Author

Professor Lin Peng, a known researcher of mangroves in China, was born on December18, 1931 in Longyan, Fujian, China. He graduated from Xiamen University in 1955 and now is a professor and Ph. D. supervisor in Xiamen University. He is also Director and Standing Committee Director of the Chinese Society of Ecology, Chairman of Mangrove Ecological Research Organization in China, Honor president of Fujian Society of Ecology, Member of the 2nd, 3rd and 4th Committee of Science & Technology Association of Fujian Province, Member of the 1st Committee and Deputy Chairman of the 2nd Committee of the Environmental Science Teaching Instruction Committee of China National Education Commission(1990-2000), Member of the Council of "International Society for Mangrove Ecosystems"(ISME).

Professor Lin is mainly engaged in researches on Plant ecology, Phytocoenology, Environmental biology and Mangrove ecology. He has published "Phytocoenology"(1986),"Fujian Vegetation"(1990),"Plantation of Southern Herb Medicine"(1980), "Wuyishan Research Series-Forest Ecosystem (I)"(1998), "Mangrove Vegetation"(1984, in Chinese; 1988, in English), "Mangrove Research Papers (I) (1980-1989)" (1990), "Mangrove Research Papers (II) (1990-1992)"(1993), "Mangrove Research Papers (III)(1993-1996) "(1999), "Environmental Ecology and Economic Utilization of Mangrove in China"(1995), "Mangrove Ecosystem in China"(1997, in Chinese; 1999, in English), and published over 270 papers in China and abroad.

▲ 第二届国际红树林生物学和浅水群落学术会议后与秘书长蒙哥马利教授一起考察红树林（巴布亚新几内亚，1980）

▲ 第四届红树林生态系统学会会后考察印尼红树林保护区(雅加达，1999)

▲ 国际红树林生态系统学会（ISME）成立授牌仪式后摄影留念（1990年）

▲ 福建九龙江口引种无瓣海桑4年达4.5米以上

内 容 简 介

本书是一部有关红树林研究的学术论文专集（第四集），汇集了林鹏教授及其领导下的厦门大学红树林研究组三年来（1997－1999）发表的论文44篇。全书包括红树林的物流能流、生理生态学、污染生态学、生物多样性、红树植物形态学以及红树林与全球变化等六个部分。

本书可供大专院校生物系、海洋系、环科系、林学系以及水产学院师生参考，也可供有关科技人员阅读。

序　言

红树林是热带海岸潮间带的木本植物群落，由于温暖洋流的影响，有的可分布到亚热带；有的受潮汐影响，也可分布于河口海岸和水陆交叠的地方。因此，红树植物具有每日浸润的潮间带生长的真红树和只有高洪潮方可浸润的高潮带以上的两栖性的半红树植物。如今大多数生态学家认为红树林有6个主要作用：1. 通过网罗碎屑的方式促进土壤的形成，抵抗潮汐和洪水的冲击，保护堤岸；2. 过滤陆地迳流和内陆带出的有机物质和污染物；3. 为许多海洋动物（包括渔业、水产生物）提供栖息和觅食的理想生境；4. 是为近海生产力提供有机碎屑的主要生产者；5. 植物本身的生产物，包括木材、薪炭、食物、药材和其它化工原料等；6. 红树林是可以进行社会教育和旅游的自然和人文景观。开展红树林研究不仅有重要的理论意义，还有现实的经济意义。

本书是继《红树林研究论文集》（1980－1989）和第二集（1990－1992）、第三集（1993－1996）之后的续集。全书共分为六个部分：第一部分收集论文4篇，论述红树植物的生物量、物质流和能量流等；第二部分收集论文14篇，论述红树植物的某些生理生态学特性，如红树植物抗寒、抗盐特性和蒸腾作用等；第三部分收集论文4篇，论述红树林的污染生态学；第四部分收集论文11篇，论述红树林中的鸟类、底栖动物、微生物和藻类的分布特征及红树林群落生态资源等；第五部分收集论文6篇，论述红树植物的形态学特性；第六部分收集论文5篇，论述红树林在全球变化中的作用。

全书收集的44篇三年来（1997－1999）正式发表和国内外学术会议论文，是作者及其领导下的厦门大学红树林科研组的集体成果之一。本书可供国内外有关学者参阅，并作为进一步开展此项工作的前导。本书编汇过程中得到李振基、刘俊杰等同志的帮助，谨此致谢。此书献给我敬爱的老师汪德耀教授，是他支持我步入红树林的林地，并感谢他的谆谆教诲。

书中不足之处，敬请读者指正。

林　鹏

2000年1月1日于厦门大学

Foreword

Mangroves are woody plant communities in the intertidal zone of tropical coast influenced by warm ocean currents; some species can grow in subtropical coast, river estuary, coast and land where seawater can reach. Therefore, mangrove species can be divided into true mangrove plants which only grow in intertidal zone where the tide can reach daily and semi-mangrove plants which are amphibious plants or grow in uppertidal zone that may be immersed only by spring tide. Today, most ecologists have recognized 6 major roles of mangrove swamps: (1) mangroves help the formation of soil sediment by trapping debris, protect embankment against tide and flood; (2) mangroves can filter land runoff and remove terrestrial organic matters and pollutants; (3) mangroves serve as feeding ground and living habitats for many marine animals including fishes and other aquaculture organisms; (4) mangroves are major producers of detritus contributing to offshore productivity; (5) mangrove plants can be used as timber, firewood, food, medicine and other raw chemical materials;(6) mangroves provide humane and natural landscapes for social education and tourism. Researches in mangroves have important significance in theory and economics.

This book is a continuation of the first collection (1980-1989), the second collection (1990-1992) and the third collection (1993-1996). It is divided into six parts as follows: in part I there are 4 papers which study the biomass, matter cycling and energy flow of the main mangrove communities; in part II there are 14 papers which discuss some physiological ecological characteristics of mangroves, such as cold-resistance, salt-resistance, transpiration, and so on; in part III there are 4 papers which focus on pollution ecology of mangroves; in part IV there are 11 papers on mangrove resources, community characteristics, and distribution characteristics of the birds, benthos, microbes and macroalgae in mangrove areas; in part V there are 6 papers which discuss morphology of mangroves; in part VI there are 5 papers about the role of mangrove in the global changes.

The 44 papers in this volume consist of author's papers published and papers in symposium at home and abroad from 1993 to 1996. It is one of collective achievements by the mangrove research group of Xiamen University guided by the author. The book primarily intends to serve as a source of information for scholars at home and abroad and preceding work for further researches in this field.

The author is thankful to Prof. Dr. Li Zhenji, Mr. Liu Junjie for their helps in the compilation of this book. The book is dedicated to my dear teacher Prof. Wang Deyao for his earnest teachings. He helped me enter the field of mangroves in 1950s.

Criticism and suggestion for this book will be highly appreciated.

LIN Peng

Department of Biology, Xiamen University, China

January 1, 2000

目　录

CONTENT

一、红树林的能流、物流

PART I. MANGROVE MATTER AND ENERGY FLOW

Dynamics of element contents during the development of hypocotyles and leaves of certain mangrove species

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Abstract

The changes in the contents of chlorine, sodium, potassium, calcium, magnesium and ash have been investigated during the development of the leaves of eight mangrove species: *Kandelia candel* Druce, *Bruguiera gymnorrhiza* Lamk., *B. sexangula* Poir., *Rhizophora stylosa* Griff., *R. apiculata* Blume, *Ceriops tagal* C.B. Rob., *Aegiceras corniculatum* Blanco and *Avicennia marina* Vierh., and the viviparous hypocotyles of *K. candel*, *B. gymnorrhiza* and *B. sexangula* in China. With the in situ viviparous development of hypocotyle, contents of chlorine, sodium, potassium, calcium, magnesium and ash in the hypocotyle decreased, indicating that the development of hypocotyle is not a salt-accumulating process, but a desalinating process. With the development of the leaves from young to old, the content of potassium decreased, while calcium and magnesium increased both in salt-secretors and salt-nonsecretors. Sodium, chlorine and ash increased in salt-nonsecretors and decreased in salt-secretors. Eliminating excessive salt by loss of old leaves that are rich in salt is one of the characteristics by which salt-nonsecretors adapt themselves to saline environments. Potassium can be reabsorbed from senescing leaves and reused for the growth of new organs.

Keywords: Mangroves; Leaf; Hypocotyle; Vivipary; Element dynamic

1. Introduction

Mangroves are special intertidal woody communities, common in tropical and subtropical coastal environments. They are important not only in protecting coasts from erosion by fierce tides but also in promoting the diversity of marine organisms and

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fishery by contributing a quantity of food and providing favorable habitats for animals (Teas, 1979; Lin, 1988; Fan, 1993).

Mangrove swamps are rich in salts. When the roots absorb nutrients and water, they will inevitably absorb certain amount of salts. The absorbed salts enter leaves through transpiration flow. Excessive accumulation of salts in the plant tissues is toxic and must be largely excluded. According to the patterns by which mangrove species adapt themselves to saline environments, all mangrove species can be divided into two groups: those that do secrete salt (secretors) and those that do not secrete salt (nonsecretors) (Lin, 1988; Teas, 1979). In salt secretors, such as *Avicennia marina* and *Aegiceras corniculatum*, salt is only partially excluded at roots, and the absorbed salt is primarily excreted metabolically via salt glands on the leaves. Nonsecretors, such as *Kandelia candel* and *Ceriops tagal*, lack salt glands. Salt exclusion here is mainly by a special barrier in the roots that obstructs excessive salt absorption (Tomlinson, 1986). The additional mechanism for salt elimination may be by the shedding of old leaves (Teas, 1979).

Mangroves, especially the species of Rhizophoraceae, possess distinctive vivipary. The seed germinates within the fruit while still attached to the mother tree, forming a stick-like or spindle-like viviparous seedling (hypocotyle). The seedling drops off and floats in the saline water until it lodges in shallow water. Then roots sprout and penetrate into mud that is rich in salts. Thus, a young tree takes place, It is believed that the adaptation of the hypocotyle to salt forms when it is still attached to the tree by absorbing salt from the tree continuously (Jin and Fang, 1958; Joshi et al., 1972; Lin, 1988). Depending on whether or not the seedling sprouts inside or out of the pericarp, vivipary is divided into two types: cryptovivipary and exposed vivipary (Lin, 1988). The seedlings of species such as *K. candel*, *Bruguiera* gymnorrhiza and *B. sexangula* sprout out of pericarps after seeds germinate, and this kind of vivipary is called exposed vivipary. Most of the species of Rhizophoraceae exhibit exposed vivipary. Nevertheless, the seeds of species such as *Aegiceras corniculatum* and *Avicennia marina* remain inside the pericarps after germinating, and this kind of vivipary is called cryptovivipary.

In this paper, we made an attempt to record the accumulation of Cl, Na, K, Ca, Mg and ash in the hypocotyles at different developing stages of three typical exposed viviparous mangroves (*K. candel*, *B. gymnorrhiza* and *B. sexangula*), and in the leaves at different developing stages of eight species of mangroves in China (*K. candel* Druce, *B. gymnorrhiza* Lamk., *B. sexangula* Poir., *Rhizophora stylosa* Griff., *R. apiculata* Blume, *Ceriops tagal* C.B. Rob., *Aegiceras corniculatum* Blanco and *Avicennia marina* Vierh.).

2. Materials and methods

2.1. Materials

The samples of *K. candel*, *Aegiceras corniculatum* and *Avicennia marina* were collected from the mangrove forest at Jiulong River Estuary (24° 29′ N), Fujian, China, and the samples of *B. sexangula*, *B. gymnorrhiza*, *Rhizophora stylosa*, *R. apiculata* and *Ceriops tagal* were collected from the mangrove forest at Dongzhai Harbor (19° 54′ N), Hainan Island, China. The characteristics of the mangrove communities have been reported by Lin and Lu (1985); Lin et al. (1987). At each site, 40 trees of each species, that were similar in height and living conditions were chosen and two shoots were selected randomly from the upper crown of each chosen tree for leaf, flower, fruit and hypocotyle sampling. The different stages of development of hypocotyles were demarcated and are shown in Fig. 1. The last grade was mature hypocotyle. Persistent pericarps were separated from hypocotyles. The development stages of leaves were demarcated into three stages: young leaf (the first pair of immature leaves of the shoots), mature leaf (the third pair of developmentally matured leaves) and yellow leaf (turning yellow from senescence). The sampling numbers of each component, respectively, were 160 for each species, and the samples were mixed extensively according to the component. Water samples of the habitats were sampled at high tide at the same time. All samples were taken to the laboratory immediately, cleaned with distilled water and blotted dry, dried at 80°C, ground and stored for chemical analyses. The water content of the samples was determined too.

2.2. Methods for analyses

Subsamples were digested using HNO_3–$HClO_4$, and K, Na, Ca and Mg content was determined using Model WFX-IB atomic absorption spectrophotometers (Analytical Instruments, Beijing, China). Cl determination was by the method of Chapman and Pratt (1961). Ash content was determined by an ashing method (550°C, 4 h). The Cl content of the sea water was determined by $AgNO_3$ titration (Chen, 1965). The Cl concentration in the tissue saps was calculated as follows (Zheng and Lin, 1992):

$$M = R \cdot C \cdot 10^6 / G$$

Where M is the Cl concentration in the tissue sap (mmol/l), R is the ratio of dry matter

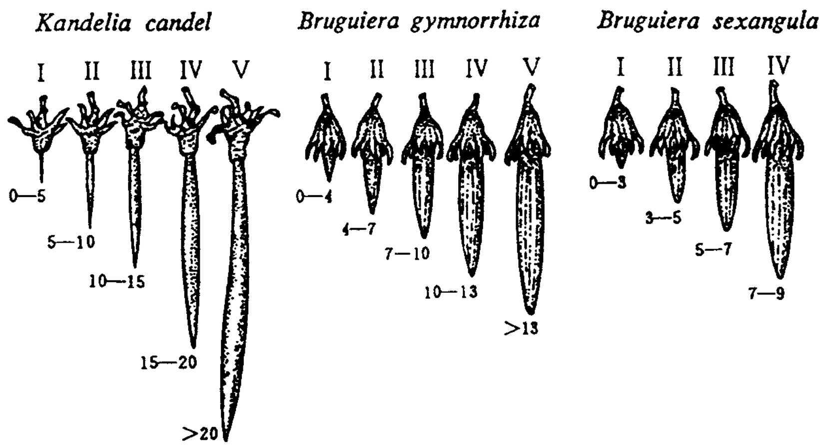

Fig. 1. Division of the developmental stages of viviparous hypocotyles of mangrove species (in cm).