

# 红树林科普手册

MANGROVE SCIENCE EDUCATION BROCHURES



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## 1. 什么是红树林? What are mangroves?

红树林，指生长在热带与亚热带地区海岸潮间带滩涂的木本植物群落。这些独特的植物在潮间带茁壮成长，沿着海岸线、河岸和河口，形成一条绿色护岸长城。红树林在维护生物多样性、支持海洋生物和保护海岸线免受侵蚀和风暴潮方面发挥着至关重要的作用。

Mangroves are coastal ecosystems found in tropical and subtropical regions, consisting of salt-tolerant trees and shrubs. These unique plants thrive in intertidal zones, where land meets the sea, such as along coastlines, riverbanks, and estuaries. Mangroves play a crucial role in maintaining biodiversity, supporting marine life, and protecting coastlines from erosion and storm surges.

红树林分布在124个国家，如泰国、印度尼西亚、巴西、澳大利亚、尼日利亚和印度，它们对当地生态系统和人类社会都至关重要。然而，它们受到森林砍伐、沿海开发和污染等威胁。

Mangrove forests are found in 124 countries like Thailand, Indonesia, Brazil, Australia, Nigeria and India, and they are vital for both local ecosystems and human communities. However, they are threatened by deforestation, coastal development, and pollution.



红树林的世界分布图 图源: <https://pica.zhimg.com/>  
World distribution of mangrove forests  
Source: <https://pica.zhimg.com/>

红树林看上去明明是绿色的，可为什么会被称为“红树林”呢？

Why are mangrove forests called "red forests" in China when they look green?

红树林的名称主要与它的树干有关。树皮富含丹宁，当树皮被剥开时，丹宁与空气氧化反应会显示为红色。

The name is mainly associated with their trunks, which are rich in tannins, which show up as a red color when the bark is peeled back and the tannins react with air oxidation.



## 1.1 真红树和半红树

### True mangrove plants and semi-Mangrove plants

真红树植物指生长在潮间带滩涂的木本植物，它们在陆地环境不能繁殖。中国有真红树植物 25 种。

True mangrove plants are woody plants that grow on intertidal mudflats, and they cannot reproduce in the terrestrial environment. There are 25 species of true mangrove plants in China.



半红树植物可以在潮间带也能在陆地生长和繁殖。半红树植物一般在涨大潮时才偶尔被海水浸到，它们没有适应潮间带生活的专一性形态特征（比如没有发达的气生根）。中国有半红树植物 12 种。

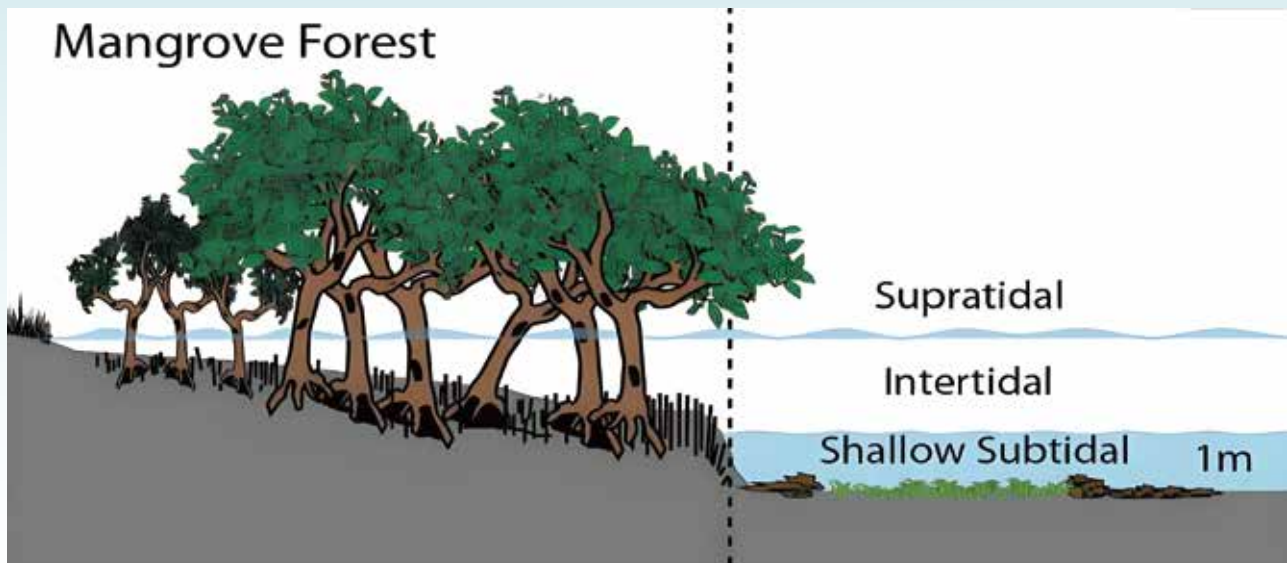
Semi-mangrove plants can grow and reproduce in the intertidal zone and on land. Semi-mangrove plants are generally only occasionally immersed in seawater during high tides, and they do not have specialized morphological traits adapted to intertidal life (e.g. no well-developed aerial roots). There are 12 species of semi-mangrove plants in China.



半红树植物 海芒果（有毒）  
Semi-mangrove plant- *Cerbera manghas*  
(poisonous)

## 1.2 红树林生长环境的特点 Characteristics of mangrove habitat

(1) 被海水周期性淹没 周期性的潮水使红树林每天有一半的时间被海水淹没，一半的时间露出海面。  
Periodic inundation by sea water Cyclical tides cause the mangroves to be submerged by the sea half of the day and exposed half of the day.



红树林生态系统潮间带图示图源: Intertidal zone diagram of the mangrove ecosystem  
picture-source: <https://natureweb.co/intertidal-zones/>

(2) 在“很咸”的环境中 红树林长期被含盐量较高的海水浸淹，土壤中也较多的盐分。  
In a “very salty” environment Mangrove forests have long been flooded by salty seawater and have high levels of salt in the soil.

(3) 缺氧的环境 红树多数生长在透气性差的淤泥环境中，且长期被海水浸淹。  
In an oxygen-deprived environment Most mangroves grow in poorly aerated silt environments and are permanently inundated by seawater.





(4) 贫瘠的地方 红树植物的凋落物由于缺氧，分解的速度较慢，土壤中支持植物生长的氮、磷等养分含量不高。

Barren places Apoplasts of mangrove plants decompose slowly due to lack of oxygen, and the soil is not high in nutrients such as nitrogen and phosphorus that support plant growth.



(5) 种子容易被海浪冲走 从树上掉落的种子容易被海浪冲走，难以生根发芽。

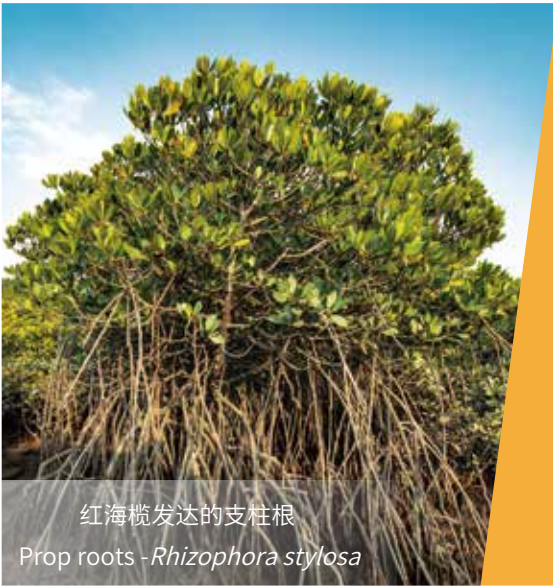
Seeds are easily washed away by the waves Seeds that fall from trees are easily washed away by the waves, making it difficult for them to take root.

## 1.3 红树林的生存绝技 Survival Strategies of Mangroves

【发达的根系】 A well-developed root system

红树林生长在环境多变的潮间带，每天要接受涨潮和退潮的考验，为了能扎根海边，红树林演化出了发达的根系。发达的根系不仅有助于红树林抵抗海浪，诺大的根系面积也有助于其呼吸。

Mangrove forests grow in the intertidal zone where the environment is so varied that they are subjected to high and low tides every day. In order to be able to take root in the sea, mangrove forests have evolved a well-developed root system. A well-developed root system not only helps mangroves resist waves, but the large root area also helps them breathe.



红海榄发达的支柱根  
Prop roots - *Rhizophora stylosa*

走进红树林，你会发现各种各样的根，比较典型的形态包括：

Walk into a mangrove forest and you'll find a wide variety of roots, the typical forms include:

支柱根：支柱根从主干或侧枝斜向下伸出，扎入土中。支柱根的数量少则十几条，多则上百条。发达的支柱根让人有时难以判断哪个是主干。

Prop roots: Prop roots projecting obliquely downward from the main stem or lateral branches and dig into the earth. The number of strut roots in a single mangrove tree can as many as hundreds. Makes it hard to tell which is the main stem.

膝状根（呼吸根）：水平生长的根每隔一段就向上生长露出土壤表面，形成表面分布有许多皮孔的膝盖状呼吸根。  
Kneeroots(Pneumatophores): Horizontally growing roots are exposed to the soil surface at intervals, forming a knee root with many lenticels distributed over the surface.



木榄发达的膝状根  
Knee roots- *Bruguiera gymnorhiza* (Linn.) Sav.



海漆发达的表面根  
Surface roots- *Excoecaria agallocha*

表面根：表面根通常是扎入土壤的根正常加粗后突出地表的的结果。表面根相比其他往上生长的根系对水淹的适应能力较弱，所以长表面根的红树多生长在受潮水影响较少的高潮区。

Surface roots: Roots in the soil grow thicker and are exposed to the surface, forming surface roots. Surface roots are not as resistant to seawater submersion as other types of roots. That's why most mangroves with surface roots grow in areas with higher tide levels.





银叶树发达的板状根

Plank buttresses root-*Heritiera littoralis*

板状根：板状根有两种类型，有一种是从树干基部及其附近的根向外向上生长，形成比较平直的板状根（如秋茄和银叶树），另一种是表面根发育到一定程度就形成板状根（如木果楠）

Plank buttresses roots: There are two types, one where the roots grow outward and upward from the base of the trunk and its vicinity to form a relatively straight, platelike root, and the other where the surface roots develop to a certain extent to form a platelike root.



白骨壤发达的呼吸根

Air root-*Avicennia marina*

呼吸根：水平生长的根每隔一段会长露出表面的垂直分支，增加红树的呼吸面积，使得该种红树成为耐淹的植物。

Air root (Pneumatophores): Roots growing horizontally will grow vertical branches at intervals that expose the surface, increasing the respiratory area of mangroves makes the species a flood-tolerant plant.



【皮孔】

红树植物的树干和根的表面通常有许多疙瘩，起到类似鼻孔的功能，可以吸收氧气和排出废物。

【Lenticel】

Mangrove plants usually have many bumps on the surface of their trunks and roots, which serve a nostril-like function to absorb oxygen and expel waste.

【抗盐保水】

红树的根系有很强的过滤盐分的功能，部分红树物种的滤盐效率能高达 99%。红树植物还可以利用落叶的方式将多余的盐分集中在老叶子上。生活在热带和亚热带的高盐度海水中限制了红树植物对水的吸收。红树的保水能力体现在拥有较厚的叶子，叶子表皮有厚厚的一层角质，气孔通常藏在叶背或表皮下。

【Resistant to salt and water retention】

The root system of mangroves has a strong ability to filter out salt, with some mangrove species achieving up to 99% salt filtration efficiency. Mangrove plants can also utilize leaf drop to concentrate excess salts on older leaves. Mangrove plants live in highly saline seawater in the tropics and subtropics, which limits their uptake of water. Mangrove's ability to retain water is reflected in having thicker leaves with a thick layer of cuticle on the epidermis. Stomata are usually hidden on the back of the leaf or under the epidermis.





树皮中富含的丹宁与空气氧化变成红色 图源：《红树林生态修复手册》

Tannins rich in bark turn red with air oxidation. Figure source:

《Mangrove Ecological Restoration Handbook》

【富含丹宁】

【Rich in tannins】

红树植物富含单宁，单宁苦涩，能避免或减少海洋动物的直接啃食。单宁还是一种广谱抗菌剂，增强红树植物的抗病力和抗海水腐蚀能力。

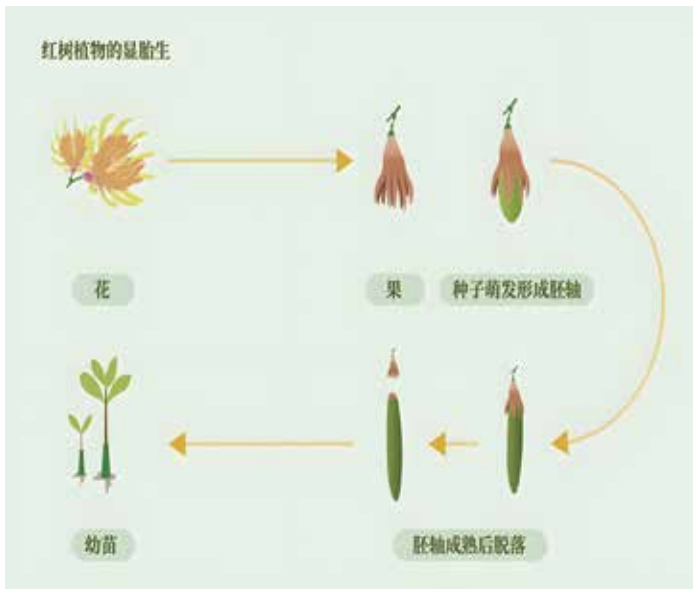
Mangrove plants are rich in tannins, which are bitter and astringent and prevent or minimize direct nibbling on the plants by marine animals. Tannins is also a broad-spectrum antimicrobial agent that enhances the mangrove plant's resistance to disease and seawater corrosion.

【胎生】

【Vivipary】

许多红树植物都是胎生的，种子仍附着在母树上便开始发芽。胚轴连续突破种皮和果皮形成显胎生小苗，如果胚轴只突破种皮不突破果皮的称为隐胎生苗。等胎生小苗长得足够强壮便开始脱离母体，落到滩涂上，有的随地生长，有的开始随波逐流寻找适宜的生境。由于生长在复杂的潮间带环境中，从母体落下的胎生小苗最终的成活率不到万分之五。

Many mangrove plants are viviparous. Their seeds germinate while still attached to the parent tree. Viviparous seedlings are formed when the cotyl continuously breaks through the seed coat and the pericarp. If the cotyl only breaks through the seed coat and does not break through the pericarp, it becomes a cryptic viviparous seedling. When the viviparous seedlings grow strong enough, they begin to break away from the mother and fall to the beach. Some grow everywhere, and some start to drift with the tide to find suitable habitats. Due to the complex intertidal environment, the survival rate of the viviparous seedlings falling from the mother is less than 5 per 10,000.



图源《红树林生态修复手册》

Figure source: 《Mangrove Ecological Restoration Handbook》

### 【胎生苗的“光休眠”现象】

红树林生长的环境不缺水，为什么有的胎生苗生根，有的不生根呢？广西海洋科学院广西红树林研究中心的范航清老师团队在一次研究中偶然发现，红树的小苗有“光休眠”现象，控制他们是否生根的“开关”是光。当胎生苗根端的光照强度大于一定值时胎生苗不生根，在大海中漂流的胎生苗不生根或少生根可以保存营养和能量，漂得更远，提高生存概率。一旦胎生苗被推到岸边，根端与土壤接触而遮光，胎生苗则开始生根发芽。

### 【" Light dormancy "phenomenon of viviparous seedlings】

Mangroves grow in an environment where there is no water shortage. Why do some viviparous seedlings take root and some do not? Fan Hangqing, a researcher at the Guangxi Mangrove Research Center of the Guangxi Academy of Marine Sciences, accidentally found in a study that young mangrove seedlings have a phenomenon of "light dormansion", and the "switch" that controls whether they take root is light. When the light intensity at the root end of the viviparous seedling is greater than a certain value, the viviparous seedling will not take root, and the viviparous seedling drifting in the sea will not take root or take little root, which can save nutrition and energy, float farther and improve the survival probability. Once the viviparous seedlings are pushed to the shore and the root end is in contact with the soil to block the light, the viviparous seedlings begin to take root and germinate.



## 2. 中国的红树林 Mangroves in China

### 2.1 中国红树林的分布 Distribution of mangroves in China

中国的红树林主要集中在广东、广西、福建、海南、浙江、台湾、香港和澳门8个省区。其中，红树林自然分布在7个省区，而在浙江省南部引进了红树林。天然红树林的分布范围从北至福建省福鼎县的沙城湾(北纬27°20)，南至海南省三亚市的榆林港(北纬18°09)。但人工引种的北部界限是浙江省乐清县(北纬28°25)

广西是中国红树林的重要分布区，红树林面积约占全国的32.7%，仅次于广东省，位居全国第二。广西分布有12种真红树植物（含两种外来种），有8种半红树植物。广西分布面积较大的树种是白骨壤、秋茄和桐花树，三者的面积加起来占广西红树面积的80%以上。

China's mangroves are mainly concentrated in eight provinces and regions: Guangdong, Guangxi, Fujian, Hainan, Zhejiang, Taiwan, Hong Kong and Macao. Among them, mangroves are naturally distributed in seven provinces and regions except Zhejiang Province, where mangroves have been introduced. The distribution of natural mangroves ranges from north to Shacheng Bay in Fuding County, Fujian province (27°20 N latitude) and south to Yulin Port in Sanya City, Hainan Province (18°09 N latitude). But the northern limit of artificial introduction is Yueqing county in Zhejiang province (28°25 N).

Guangxi is an important distribution area of mangrove forests in China, accounting for 32.7% of the country's total area, second only to Guangdong Province. There are 12 species of true mangrove plants (including two exotic species) and 8 species of semi-mangrove plants distributed in Guangxi. The tree species with large distribution area in Guangxi are *Avicennia marina*, *Kandelia obovata*, *Aegiceras Corniculatum*, which together account for more than 80% of the area of mangrove in Guangxi.

## 2.2 湿地公园常见植红树植物

### Mangrove species in Beihai National Wetland Park



白骨壤 grey mangrove *Avicennia marina*



白骨壤-花 flower



白骨壤-果 fruit



白骨壤-根 root





中国连片面积最大的红海榄林-广西山口红树林生态自然保护区  
The largest contiguous area of the *Rhizophora stylosa* forest in China

## 红海榄树 tree



红海榄-果 fruit



红海榄-花flower



红海榄-根 root





木榄 large-leafed orange mangrove *Bruguiera gymnorhiza*



木榄-花 flower



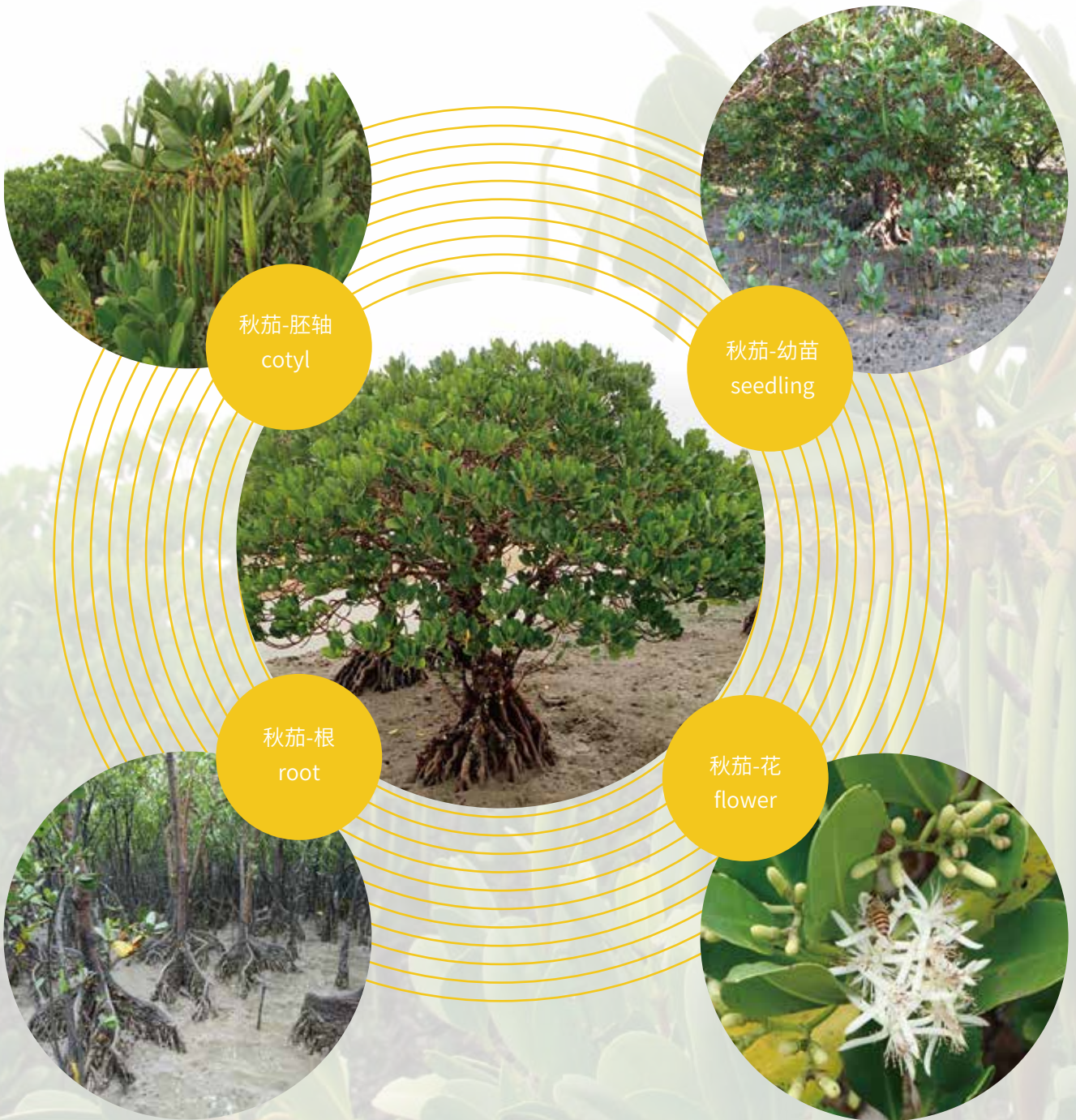
木榄-胚轴 cotyl



木榄-根 root



秋茄 *water pen Kandelia obovata*



秋茄-胚轴  
cotyl

秋茄-幼苗  
seedling

秋茄-根  
root

秋茄-花  
flower



桐花树 black mangrove *Aegiceras corniculatum*



桐花 树 tree



桐花树-根 root



桐花树-花 flower



桐花树-果 fruit



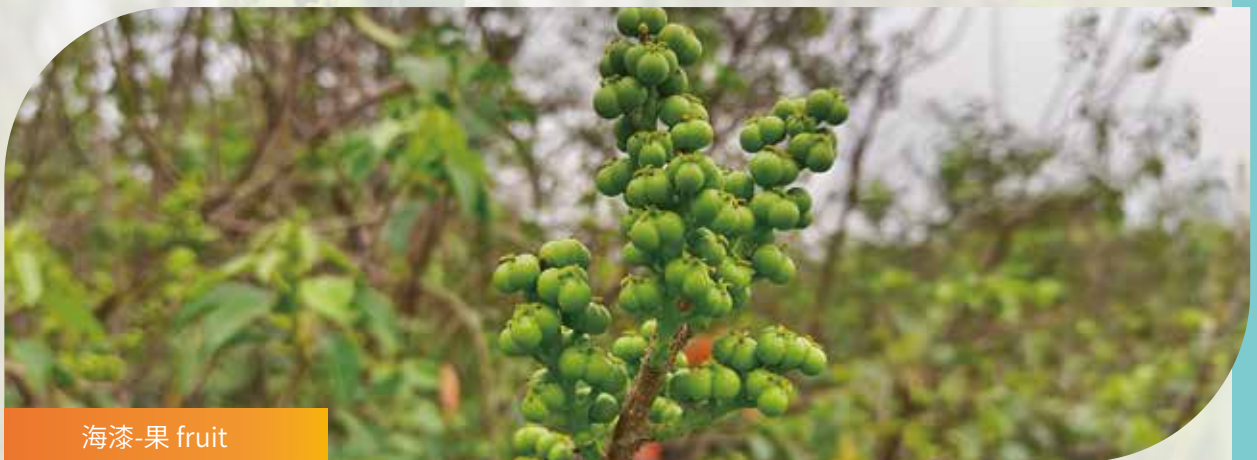
桐花树-苗 seedling



海漆 milky mangrove *Excoecaria agallocha*



海漆-树 tree



海漆-果 fruit



海漆-根 root



卤蕨 golden leather fern *Acrostichum aureum*



卤蕨 Fern



卤蕨-孢子囊 sporangium

老鼠筋 *Acanthus ilicifolius*



老鼠筋-树 tree



老鼠筋-花 flower



老鼠筋-果 fruit



榄李 white-flowered black mangrove *Lumnitzera racemosa*



榄李-树 tree

以上图片来自：广西北海滨海国家湿地公园管理处、广西科学院科学教育与传播中心、广西海洋科学院广西红树林研究中心  
The above photos are from: BEIHAI COASTAL NATIONAL WETLAND PARK; Science Education and Promotion Center, GXAS; Guangxi Academy of Marine Sciences Guangxi Mangrove Research Center.racemosa

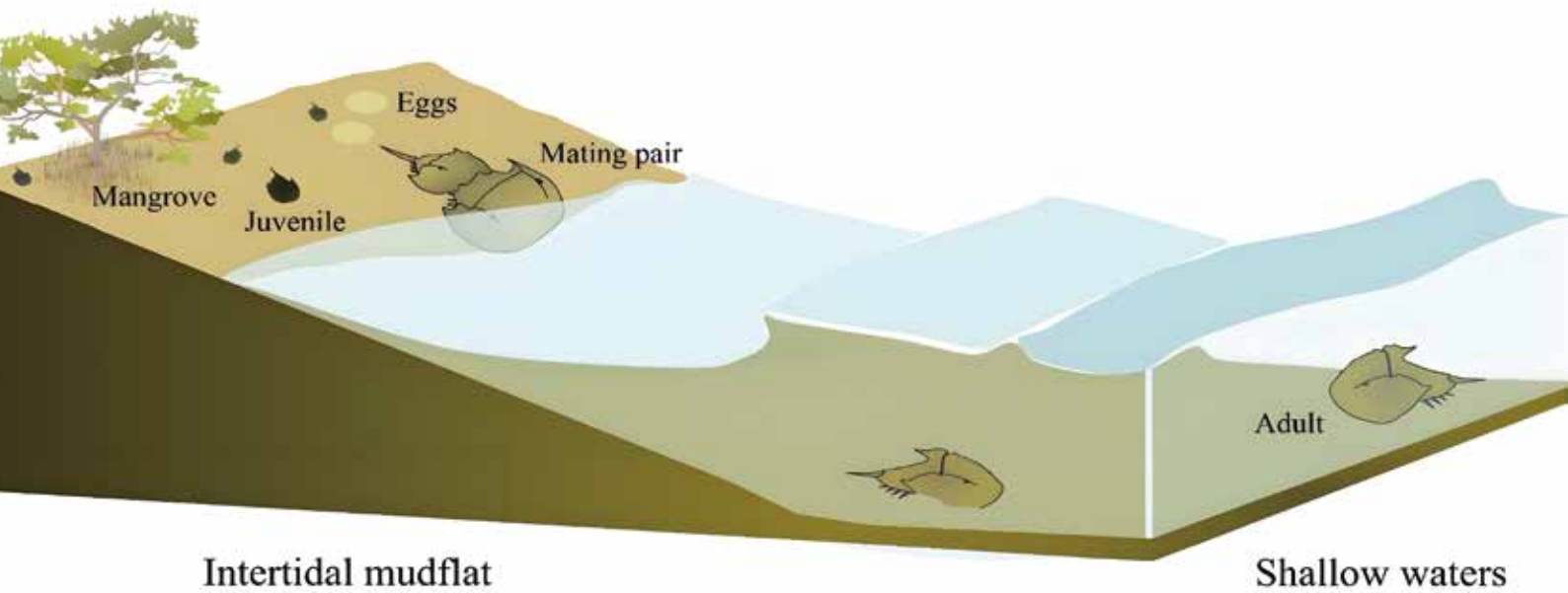


榄李-果fruit



榄李-花 flower

### 3. 红树林里的“明星”——中国鲎 The "star" among the mangroves -- the Chinese Horseshoe Crab



中国鲎的生活史 图源：网络  
Life history of Chinese Horseshoe Crab

全世界有4种鲎，中国有两种鲎，分别是中国鲎和圆尾蝎鲎。中国鲎是体型最大的一种鲎，它是中国的国家二级保护动物，广西北部湾是中国鲎分布的核心区。每年4-10月，是它们繁殖的季节，雄鲎会抱在雌鲎后面，成双成对地游到滩涂上产卵，渔民以为它们会相伴一生，将它们称为“夫妻鱼”。

There are four kinds of horseshoe crab around the world. China has two kinds of horseshoe crab, were Chinese Horseshoe Crab (*Tachypleus tridentatus* and Round Scorpion Horseshoe Crab (*Carcinosvorpius rotundicauda*) . Chinese Horseshoe Crab is one of the largest Horseshoe crab, and is one of China's National Protected Animal. Guangxi Beibu Gulf is it's core area of the distribution. From April to October every year, it is the breeding season. The male horseshoe crab will hug the female and swim to the beach to lay eggs. Fishermen think that they will be together for a lifetime, and call them "couple fish".



## 圆尾蝎鲎

### Round Scorpion Horseshoe Crab

圆尾蝎鲎也是中国的国家二级保护动物，在四种鲎中，它的体型最小，成年时只有成人的巴掌大。它们喜欢生活在盐度较低的河口。它的体内含有河豚毒素，人误食可致死。

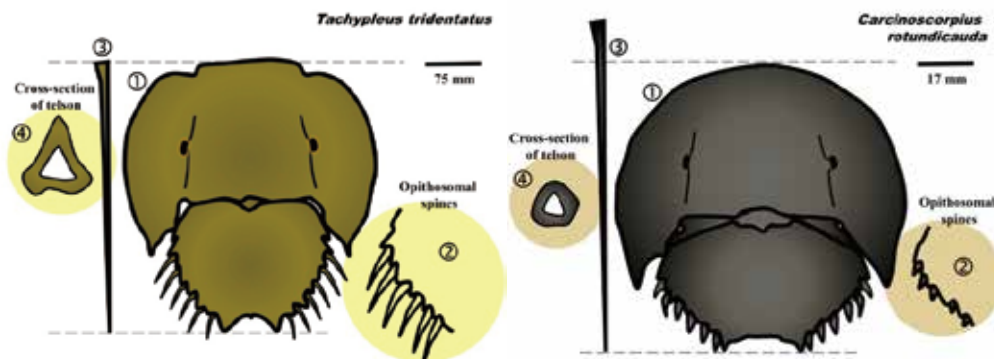
Round Scorpion Horseshoe Crab is also a second-class China's National Protected Animal. Among the four species, it is the smallest. It is only about the size of an adult's palm when it reaches adulthood. They prefer to live in estuaries with low salinity. It contains tetrodotoxin, which can be fatal if ingested.

如何区分中国鲎和圆尾蝎鲎呢？

How can you tell the difference between the Chinese Horseshoe Crab and the Round Scorpion Horseshoe Crab?

中国鲎的尾剑横切面近似三角形，圆尾蝎鲎的尾剑切面近似圆形。

Chinese Horseshoe Crab's tail sword cross-sections approximate triangle,  
Round Scorpion Horseshoe Crab's tail sword edge approximate circle.



## 4. 舌尖上的红树林饮食—红树林的馈赠 Dietary contributions from the mangrove ecosystem: A Gift from Nature

中国红树林里的传统食用种类近 100 种，沿海的人民靠海吃海，使用红树丰富的生物资源制作出了许多特色美食，其中比较有代表性的包括：

There are nearly 100 kinds of traditional mangrove food in China. Coastal people rely on the sea to live, and use the rich biological resources from mangroves to make many special foods, among which some representative ones include:

物质Substances	美食图Dish
 <p data-bbox="379 890 628 955">白骨壤果实 gray mangrove fruit</p>	 <p data-bbox="995 890 1225 955">车螺焖榄钱 Lanqian with clam</p>

刚摘下的榄钱丹宁含量较高不能直接食用，需要进行简单处理才能售卖。车螺焖榄钱是沿海食客最爱的食物之一。但如果白骨壤的果实采摘过度会影响红树林的生态修复。

The high tannin content of just picked olive can not be eaten directly, and it needs to be treated briefly before it can be sold. Braised olive money with conch is one of the favorite foods of coastal diners. But the ecological restoration of the mangroves will be affected if the fruits of the soil are picked too much.

物质Substances	美食图Dish
 <p data-bbox="379 1677 612 1742">红树林的花 Mangrove Flowers</p>	 <p data-bbox="975 1677 1182 1742">红树蜂蜜 Mangrove honey</p>

红树的花是蜜蜂的优质蜜源，蜜蜂采蜜的过程也会帮助红树的花朵授粉，提高红树林自身繁育的能力。

Mangrove flowers are a good source of honey for bees, and the process of honey gathering by bees also helps the mangrove flowers pollinate, improving the mangrove's ability to reproduce itself.





物质Substances	美食图Dish
 <p data-bbox="443 648 564 707">青蟹 Blue Crab</p>	 <p data-bbox="1015 648 1136 707">青蟹 Blue Crab</p>
<p data-bbox="288 761 1302 836">河口红树林是青蟹最好的生长地，一些研究人员甚至还认为“没有红树林就没有螃蟹”。</p> <p data-bbox="288 847 1302 922">Estuarine mangroves are the best breeding grounds for green crabs, and some researchers even argue that "without mangroves, there would be no crabs."</p>	

物质Substances	美食图Dish
 <p data-bbox="384 1386 608 1444">短指和尚蟹 Soldier Crab crab</p>	 <p data-bbox="987 1386 1190 1444">沙蟹汁 Sand Crab Juice</p>
<p data-bbox="296 1483 1286 1558">沙蟹汁是广西有名的特色美食，它用活的短趾和尚蟹捣制而成。用沙蟹汁炒的菜开胃解腻。</p> <p data-bbox="288 1565 1286 1683">Sand crab juice is a famous specialty food in Guangxi, made by pounding live short toed monk crabs. Stir fried dishes with sand crab juice are appetizing and relieve greasiness.</p>	

物质Substances	美食图Dish
 <p data-bbox="349 659 660 720">可口革囊星虫 Phascolosoma esculenta</p>	 <p data-bbox="892 659 1305 720">泥丁粥/泥丁汤 Mudding porridge/mudding soup</p>
<p data-bbox="311 758 1299 838">用可口革囊星虫熬制的粥清甜可口，是许多游客到北海必点的美食。可口革囊星虫目前已有人工养殖，但养殖规模不大。</p> <p data-bbox="311 847 1299 965">Sweet and delicious, the porridge made with the delicious germinal worm is a must-order food for many tourists to Beihai. At present, it has been cultured artificially, but the breeding scale is not large.</p>	

物质Substances	美食图Dish
 <p data-bbox="427 1397 576 1457">青蛤 Green Clam</p>	 <p data-bbox="1002 1397 1214 1457">青蛤汤 Green clam soup</p>
<p data-bbox="303 1485 1318 1565">青蛤肉味鲜美，营养丰富，含有人体所需的多种维生素和微量元素，是中国沿海人民喜爱的一种经济贝类。</p> <p data-bbox="298 1569 1318 1688">Green clam meat is delicious and nutritious, containing a variety of vitamins and trace elements needed by the human body, and is a kind of economic shellfish favored by people in China's coastal areas.</p>	



物质Substances	美食图Dish
 <p data-bbox="432 648 619 707">褶牡蛎 Pleated Oyster</p>	 <p data-bbox="1007 648 1209 707">海蛎煎蛋 Oyster omelette</p>
<p data-bbox="323 739 1318 814">褶牡蛎有“海洋牛奶”之称，每 100 克肉含蛋白质 11.3 克。但褶牡蛎多的地方红树林不易生长，是判定滩涂是否适合红树林生长的一个重要指示物。</p> <p data-bbox="323 825 1318 987">Known as the "milk of the sea", pleated oysters contain 11.3g of protein per 100g of meat. However, mangrove forests are not easy to grow in areas where pleated oysters are abundant, which is an important indicator to determine whether the tidal flats are suitable for mangrove growth.</p>	

物质Substances	美食图Dish
 <p data-bbox="464 1397 587 1461">石磺 Shihuang</p>	 <p data-bbox="1007 1397 1273 1461">石磺小炒 Shihuang stir fry soup</p>
<p data-bbox="336 1494 1334 1580">石磺有很高的营养价值和较强的滋补功能，是沿海地区民间流传的能治哮喘、消除疲劳的补品。</p> <p data-bbox="336 1601 1334 1677">Shihuang has high nutritional value and strong nourishing function, and is a folk remedy in coastal areas that can treat asthma and eliminate fatigue.</p>	

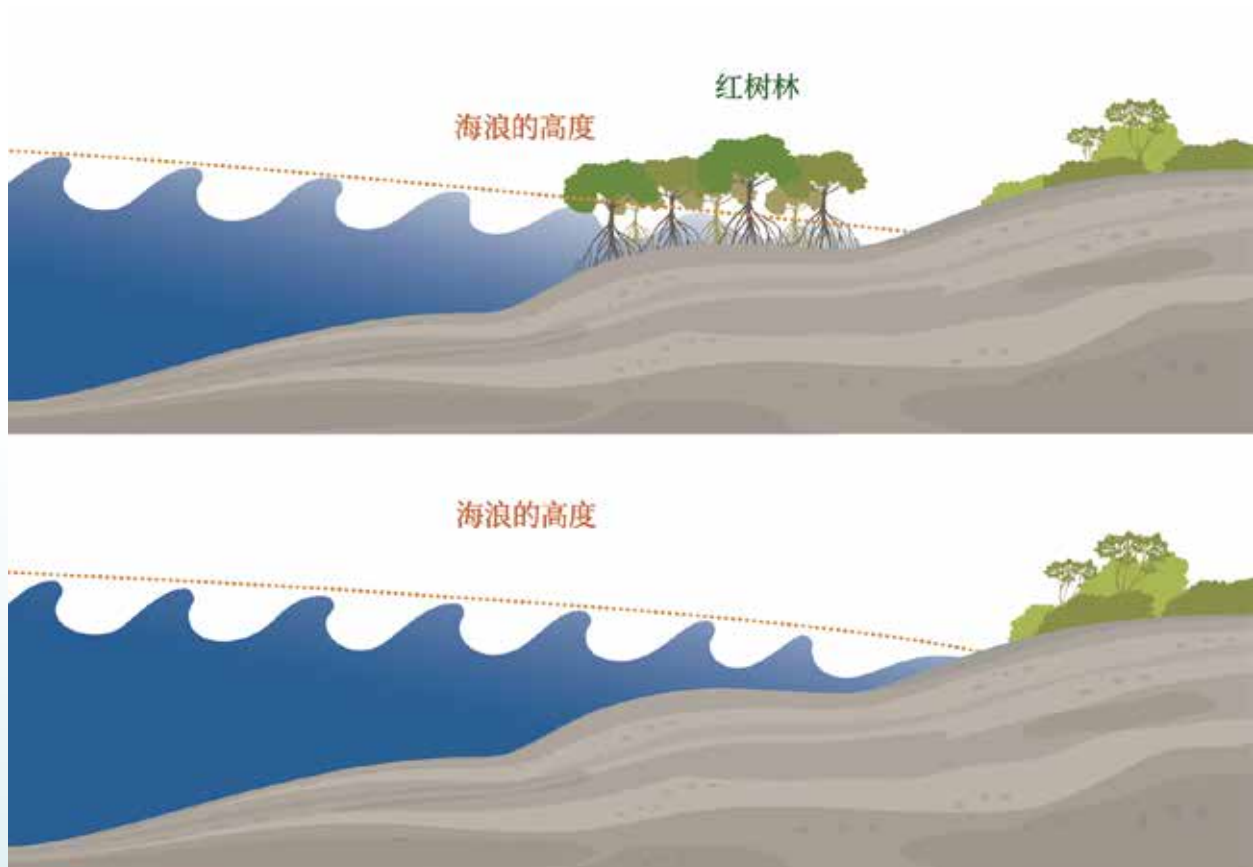
## 5.红树林的作用 Significance and function of mangroves

### 【消浪护岸】

红树植物枝干繁茂根系发达，通过“消浪、缓流、促淤、固土”功能在海岸形成一道密实的天然屏障，实现其良好的防浪护堤作用。

### 【 Wave prevention and shore protection 】

Mangrove plants luxuriant branches and developed roots, through the "wave reduction, slow flow, silt promotion, soil consolidation" function in the coast to form a dense natural barrier, to achieve its good anti-wave berm role.



红树林抵御海浪的作用 图源《红树林生态修复手册》

Mangrove's anti-wave function map Source: Mangrove Ecological



### 【维护海洋生物多样性】

中国的红树林湿地共记录已经超 3000 种生物。红树林凋落地上的花、果实、树叶、枝条及地下部死亡的根经过微生物的分解，为底栖生物提供了丰富的有机碎屑食物，红树林发达的呼吸根和树干为潮间带生物提供了多样的栖息地和安全的庇护所。

### [Maintaining Marine Biodiversity]

More than 3,000 species have been recorded in China's mangrove wetlands. The flowers, fruits, leaves, branches and dead roots on the ground of mangrove litter are decomposed by microorganisms and provide abundant organic detritus food for benthic organisms. The developed breathing roots and trunks of mangrove provide diverse habitats and safe shelters for intertidal organisms. reduction, slow flow, silt promotion, soil consolidation" function in the coast to form a dense natural barrier, to achieve its good anti-wave berm role.



图源：《红树林科普手册》

Ecological Restoration Manual

### 【净化】

海洋的污染主要来源于陆地，红树林生长于海洋与陆地之间。红树林湿地通过土壤 - 植物 - 微生物复合生态系统的物理、化学和生物共同作用能够持续净化水质、庇护生物。

#### [Purification]

The pollution of the sea mainly comes from the land, and mangroves grow between the sea and the land. Mangrove wetlands can continuously purify water and shelter organisms through the physical, chemical and biological interaction of the soil-plant-microbial complex ecosystem.

### 【固碳储碳】

热带原生红树林储碳能力是同面积亚马孙雨林的 6 倍。中国的科学家研究表明，从福建到海南东海岸的红树林每年固碳量达 7.2 吨 / 公顷。红树林土壤能成为储碳的主要场所是因为其根系发达，其地下部分的重量占整个植物总重量的 60% 左右，新陈代谢的根系直接成为土壤储碳，并被海岸沉积的淤泥不断埋到深处。

#### 【 Carbon Sequestration and storage 】

The carbon storage capacity of tropical native mangroves is six times that of the Amazon rainforest. Chinese scientists have shown that mangroves on the east coast from Fujian to Hainan sequestration 7.2 tons of carbon per hectare per year. Mangrove soil can be a major carbon store because of its well-developed root system, which accounts for about 60 percent of the total plant weight. The metabolized root system directly stores carbon in the soil and is continuously buried deep by the silt deposited by the coast.

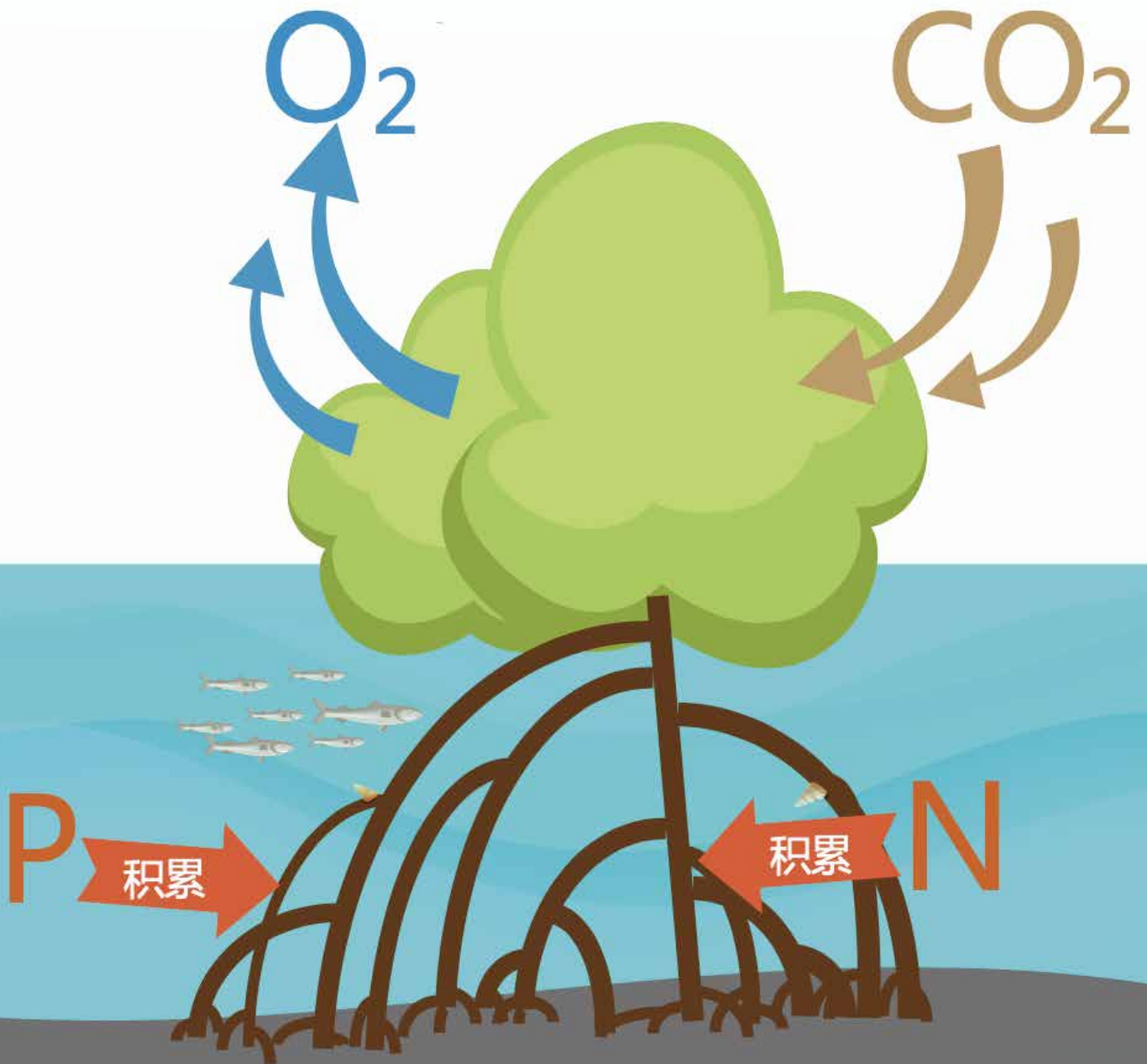


【海洋药物宝库】

现代化学研究发现，红树植物种含有大量与治疗人类重大疾病（比如艾滋病、心血管疾病）有关的化合物。

[Marine Treasure House of Medicine]

Modern chemical research has found that mangrove plants contain a large number of compounds related to the treatment of major human diseases (such as AIDS, cardiovascular disease).



图源：《红树林科普手册》

Ecological Restoration Manual

## 6.红树林遭受的威胁 Threats to mangroves

### 6.1自然因素 Natural Factors

1、病虫害威胁。广西红树林群落结构单一，纯林的比例很高，昆虫多样性远低于陆岸森林，克制害虫的天敌种类偏少，容易引发大规模虫害。广西近十多年来红树林害虫几乎年年发生。

Pest and disease threats. The mangrove community structure in Guangxi is simple, the proportion of pure forest is high, the insect diversity is much lower than that of onshore forest, and the natural enemies to control pests are few, which is easy to cause large-scale insect pests. In recent ten years, mangrove insect pests have occurred almost every year in Guangxi.



以白骨壤果实为食物的昆虫幼虫

Insect larvae that feed on white soil fruits

2、污损生物威胁。藤壶、牡蛎、浒苔是威胁红树林的主要海洋污损生物类群。藤壶和牡蛎的吸附力很强，大量吸附在树苗的茎干上，阻碍幼苗的代谢，是近年来红树林造林失败的主要原因之一。浒苔缠绕红树影响其光合作用，还增加了潮水对树苗的冲击。

Fouling biological threats. Barnacles, oysters and enteromorpha are the main Marine fouling species threatening mangroves. The adsorption capacity of barnacles and oysters is very strong, and a large number of them adsorb on the stems of saplings, hindering the metabolism of seedlings, which is one of the main reasons for the failure of mangrove forestation in recent years. Enteromorpha entwining mangrove trees affects their photosynthesis, and also increases the impact of the tide on the saplings.





藤壶造成红树苗损伤

Barnacles caused damage to the mangroves saplings

3、外来物种威胁。互花米草的大规模快速扩散，压缩了红树林的恢复空间，单一的互花米草区域对生物多样性和生态环境造成严重危害。

Threat of invasive species. The rapid spread of *Spartina alterniflora* on a large scale has compressed the restoration space of mangroves, and a single *S. alterniflora* area has caused serious harm to biodiversity and ecological environment.



互花米草大规模扩散

*S. alterniflora* spread on a large scale

4、环境胁迫。在全球气候变暖、海平面上升的大背景下，红树林直接面临着海平面上升带来的风暴潮、海岸侵蚀、海水入侵、土壤盐渍化和咸潮等海洋灾害的威胁，其分布范围有向陆岸退缩的趋势。

Environmental stress. Under the background of global warming and sea level rise, mangroves are directly facing the threat of Marine disasters caused by sea level rise, such as storm surge, coastal erosion, seawater intrusion, soil salinization and salt tide, and their distribution range has a tendency to retreat to the land coast.



被冻的红树苗

Frozen mangroves saplings

## 6.2 人为因素 Human factor

1、沿海开发建设导致红树林面积缩减。根据遥感监测，在1960~2010年期间，因养殖塘和盐田建设破坏红树林2978.9公顷，是广西红树林面积减少的最主要因素。近年来，工程建设占用红树林以及非法采砂已逐渐成为红树林面积缩减的主要因素。

Coastal development and construction have reduced the area of mangroves. According to remote sensing monitoring, from 1960 to 2010, 2,978.9 hectares of mangroves were destroyed due to the construction of breeding ponds and salt fields, which was the main factor in the decrease of mangrove area in Guangxi. In recent years, construction occupation of mangroves and illegal sand mining have gradually become the main factors for the reduction of mangrove area.



2、围填海活动造成红树林区水动力条件改变。由于围填海作业引起潮流流向改变、流速下降，加之外源性高岭土和悬浮物的淤积，红树植物受低氧胁迫、光合作用受阻，导致红树林退化、死亡。

Reclamation activities caused the change of hydrodynamic conditions in mangrove forest area. Due to the change of tidal flow direction and the decrease of flow velocity caused by reclamation and the deposition of exogenous kaolin and suspended matter, mangrove plants were subjected to low oxygen stress and blocked photosynthesis, which led to the degradation and death of mangrove forests.

3、过度利用导致红树林生态系统生物多样性下降。巨大的海产品需求以及沿海群众维持生计的需要，使得红树林区滩涂挖捕、围网、放养家鸭、捕鸟等破坏性活动长期得不到有效遏制。强烈的人为干扰导致红树林矮化、过度稀疏化及生物多样性的大幅度下降。

Overuse has led to a decline in biodiversity in mangrove ecosystems. The huge demand for seafood and the needs of coastal people to maintain their livelihoods have made it impossible to effectively curb destructive activities such as beach digging, purse netting, stocking domestic ducks and bird hunting in mangrove forests for a long time. Strong human disturbance leads to mangrove dwarfing, over-thinning and a significant decline in biodiversity.

4、海区污染引发红树林敌害生物泛滥。入海河流、陆基海水养殖、临海工业、种植业、畜禽养殖、船舶排放等导致的海区污染是红树林敌害生物爆发的重要诱因。2010 年以来，曾经在放养家鸭的共同作用下，引起蛀木生物团水虱爆发，导致北部湾局部地区成熟红树林连片死亡。

Marine pollution has led to the proliferation of mangrove pests. Marine pollution caused by rivers entering the sea, land-based mariculture, coastal industry, planting industry, livestock and poultry breeding, and ship discharge is an important cause of mangrove pest outbreak. Since 2010, the combined action of domestic ducks has caused an outbreak of water lice, a wood-eating organism, resulting in the death of mature mangroves in some areas of the Beibu Gulf.

5、海堤建设阻断红树林响应气候变化的迁移。红树林生长对水淹时间和水深有严格要求，在全球海平面上升的大背景下，堤前红树林没有后撤之路，总体上将逐渐衰退。

The construction of seawalls blocks mangrove migration in response to climate change. Mangrove growth has strict requirements on the time and depth of flooding. Under the backdrop of global sea level rise, mangroves in front of the embankment have no way to retreat and will gradually decline.

## 7. 红树林保护与修复 Mangrove Protection and Restoration

通过将红树植物繁殖体/幼苗引入退化的红树林区域，或者通过改善原有红树林的生境条件，使其可以形成稳定的红树林生态系统并具有与原生红树林生态系统相似的生态功能和服务。

广西海洋科学院红树林中心开展的红树林生态修复的工作内容包括生态本底调查、退化诊断、修复目标设定、修复方式确定、修复方案编制、修复工程实施、跟踪监测、修复效果评估和适应性管理等。其中最关键的修复方案包括：

- (1) 威胁因素消除，包括但不限于敌害生物、污染防控、人类工程建设和生产活动等；
- (2) 生境要素的修复，包括水动力条件、地形地貌、底质环境等；
- (3) 人工植被修复，包括种植区域规划、物种选择、种植方式确定、种植计划制定等；
- (4) 跟踪监测。

By reintroducing mangrove plant propagules/seedlings into degraded mangroves or by improving the habitat conditions of the original mangrove forests, stable mangrove ecosystems can be formed with ecological functions and services similar to those of the native mangrove ecosystems.

The mangrove ecological restoration work carried out by Mangrove Research Center of Guangxi Academy of Marine Sciences includes ecological background investigation, degradation diagnosis, restoration target setting, restoration method determination, restoration plan preparation, restoration project implementation, tracking and monitoring, restoration effect assessment and adaptive management. The most critical remediation programs include:

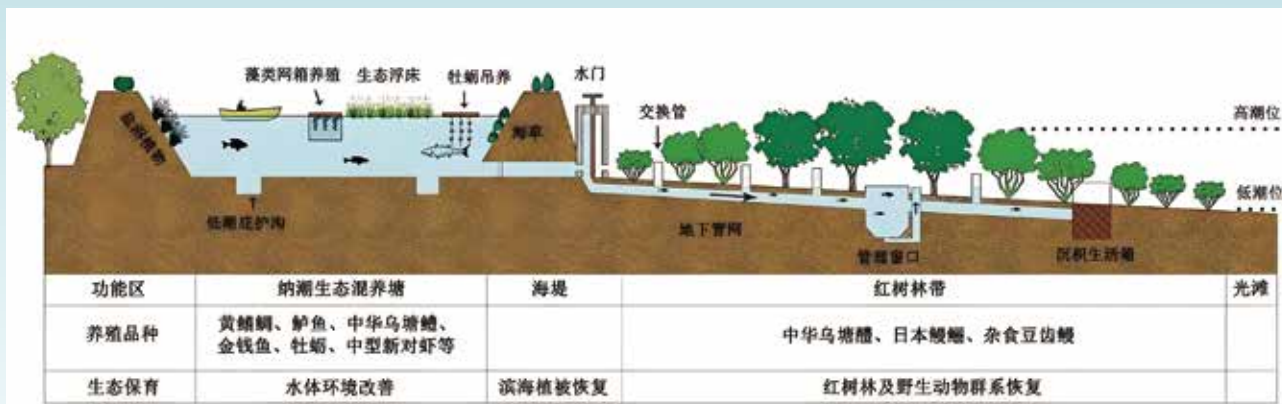
- (1) elimination of threat factors, including but not limited to enemy organisms, pollution prevention and control, human engineering construction and production activities;
- (2) Restoration of habitat elements, including hydrodynamic conditions, landforms, and bottom environment;
- (3) Artificial vegetation restoration, including planting area planning, species selection, planting method determination, planting plan formulation, etc.;
- (4) Tracking and monitoring.

## 8. 红树林生态养殖系统 Ecological aquaculture system

广西红树林研究中心原创了“地理管道红树林原位生态养殖系统”，在全球首次实现不砍不围红树林进行生态养殖的目标，实现了滩涂地下部培育鱼类，地上部生长红树林，滩涂表层保育和增殖软体动物。

Guangxi Mangrove Research Center created the original "in-situ ecological aquaculture System of mangrove with Buried pipeline", which is the first time in the world to achieve the goal of ecological culture of mangrove without cutting down or encircling. It has realized the cultivation of fish under the beach, the growth of mangrove on the ground, and the conservation and proliferation of mollusks on the surface of the beach.





图源：广西红树林研究中心

藻类网箱养殖 生态浮床 牡蛎吊养 水门 交换管 高潮位  
 盐沼植物 低潮庇护沟 水下管网 管理窗口 沉淀生活箱 低潮位  
 功能区 纳潮生态混养塘 海堤 红树林带  
 养殖品种 黄鳍鲷 鲈鱼 中华乌塘鳢 金钱鱼 牡蛎 中型新对虾 日本鳗鲡 杂食豆齿鳗  
 生态保育 水体环境改善 滨海植被恢复 红树林及野生动物群系恢复

Algae cage culture、Ecological floating bed、Oyster rearing、Water gate  
 Exchange tube、High water level  
 Salt marsh plant、Low tide shelter trench、Underwater pipe network  
 Management window、Settling tank、Low water level  
 Functional domain、Tidal pond、seawall、Mangrove belt  
 Cultured variety、Yellow fin bream、Perch、Odontobutis sinensis  
 spadefish、oyster、Medium new prawn、*Anguilla japonica*、*Psammodon  
 omnivore*  
 Ecological conservation  
 Improvement of water environment  
 Coastal vegetation restoration  
 Restoration of mangroves and wildlife fauna

