



Niches of plant populations in mangrove reserve of Qi'ao Island, Pearl River Estuary

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ABSTRACT

Thirty-two 10 × 10 m² quadrats were set up in four mangrove communities for the study of the niches of nine plants with horizontal and vertical resource sequences in Dawei Bay, Qi'ao Island, Zhuhai City. Generally, species diversities of natural mangroves were higher than those of plantations. The diversities decreased along sequence of substrate layer, shrub layer and tree layer in natural mangroves; and were highest on the shrub layer in plantations. At the horizontal resource sequence, the niche breadth varied 0.132–0.896 ($B_{(sw)}$) and 0.120–0.693 ($B_{(L)}$). The niche breadth of *Acanthus ilicifolius* and *Aegiceras corniculatum* were the highest and that of *Spartina alterniflora* was the lowest. At the vertical resource sequence, the niche breadth varied 0–0.400 ($B_{(sw)}$) and 0.333–0.747 ($B_{(L)}$). All the niche breadth values were the lowest except those of *A. ilicifolius* and *A. corniculatum*. The niche similarity of the populations varied 0–0.746 and 0–1.000 at the horizontal and vertical resource sequences, respectively. *A. ilicifolius* and *A. corniculatum* had niche overlap with all plants at the horizontal resource sequence, while the introduced *Sonneratia caseolaris* and *Sonneratia apetala* had no such overlapping between six and five plants in the community, respectively. At the vertical resource sequence, *A. ilicifolius* and *A. corniculatum* had niche overlapping with all the populations. The more niche overlapping existed among the other populations. The results indicated that, currently, the mangrove plantation in Qi'ao Island had a simplex structure and composition of species. The status of plant populations' niche was determined by the species selected and structure of afforestation. It is suggested to create forest gaps artificially and introduce *Kandelia obovata* saplings to reverse its current status of lower niche breadth, facilitate natural regeneration and spreading of *A. corniculatum* and *A. ilicifolius*, and accelerate the restoration process of natural mangrove. Simultaneously, the species matching and planting methods of mix stands should be emphasized in the future.

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1. Introduction

In 1968, Levins was the first one who defined the niche breadth with individual distribution patterns; later, Schoener calculated the overlapping level of different population with community similarities as “niche overlapping”. The niche research can evaluate the inner-species or inter-species relationship, and the status of population in the community. It can be used to study the biodiversity distribution patterns, mechanism and succession. Mangroves are the unique vegetations colonizing tropical and subtropical intertidal flats with ecological significance. The natural mangrove communities' dynamics and successional patterns were well characterized and forecasted by some researchers [1,2]. The southern

China is adjacent to the South China Sea. In a long period, the South China Sea was considered as the biodiversity focus globally, which had large area of natural mangroves [3]. In recent years, with the reinforcement of consideration on mangrove significance by people, large scale of mangrove afforestation and introduction were performed along the coastline of southern China. Currently, the niche researches on forests in southern China are related to terrestrial natural forests [4], natural mangroves [2]. However, with large scale of mangrove afforestation, there were few researches on population niches of mangrove plantation. The plant population niches of alien mangrove plantations are still to be summarized.

Zhuhai City is located in the southwest of Pearl River Estuary, bordering the South China Sea with large area of tidal flats. Until 1985, the area of mangrove exceeded 1400 ha in Zhuhai City. However, the mangrove remained only 102 ha up to 2001 due to reclamation, agricultural and industrial rapid development at the end of last century [5]. Further, the remaining mangrove was low in biodiversity and inadequate in ecological function. Recently, the mangrove restoration engineering was performed effectively in Zhuhai

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City. Over 400 ha of mangrove was reforested in Qi'ao Island with the introduced rapid growth species, i.e. *Sonneratia apetala* and *Sonneratia caseolaris*. The Qi'ao Island, where typical artificial mangrove wetland ecosystem was established gradually, became one of the hot-spots of mangrove plantations along the southern China coast. Through more than eight-year natural succession, the co-existence pattern of alien–native species, and plantation–natural mangrove formed in Qi'ao Island. The current mangrove research in Qi'ao Island is mainly focusing on remote sensing analysis of wetland dynamics [6], regeneration and distribution of population in plantation [7], control of *Spartina alterniflora* [8]. There is no systematic description on the population niche of mangrove plantation. Hence, the certain research performed in Qi'ao Island can provide significant reference to the forecast of mangrove plantations' dynamics, reconstruction of plantations, and mangrove ecological restoration.

2. Methods

2.1. Study site

Qi'ao Island is located in the western side of the Pearl River Estuary. The Provincial Nature Reserve, with total area of 5093.0 ha was established in 2004. Its geographical location is 23°40'–22°27'38" N, 113°36'40"–113°39'15" E. Historically, there were over 200 ha of mangrove existing in the Island. Because of economic development, 196.7 ha of mangrove was removed by reclamation during 1957–1993. Until 1999, only 32.0 ha natural mangrove remained at Dawei Bay. The Zhuhai Municipality took high consideration on mangrove conservation and restoration, and disbursed 1.2 million Yuan annually for mangrove restoration since 1999. The area of mangrove wetland was up to 533.33 ha at Dawei Bay in 2004.

Table 1
General feature of the quadrats set in the mangrove of Qi'ao Island.

Quadrat code	Mangrove communities	Age (year)	Tidal zone
1–8	a. <i>S. caseolaris</i> plantation	6	Medium
9–16	b. <i>S. apetala</i> plantation	6	Medium
17–24	c. <i>K. obovata</i> natural forest	>30	High
25–32	d. <i>A. corniculatum</i> secondary shrubbery	15–20	High

Table 2
Abundance of plants in different communities in the mangrove reserve of Qi'ao Island*.

Resource states	a-T**	a-S	a-R	b-T	b-S	b-R	c-T	c-S	c-R	d-T	d-S	d-R
<i>Sonneratia caseolaris</i>	106	0	0	0	0	0	0	0	0	0	0	0
<i>S. apetala</i>	0	0	0	127	0	0	0	0	0	0	0	0
<i>Kandelia obovata</i>	0	0	0	0	0	0	134	0	0	0	0	0
<i>Aegiceras corniculatum</i>	2	2	0	7	5	2	11	8	0	58	16	0
<i>Acanthus ilicifolius</i>	0	8	7	0	22	34	0	11	6	8	24	11
<i>Derris trifoliata</i>	0	0	0	0	0	1	0	0	5	0	0	4
<i>Acrostichum aureum</i>	0	0	0	0	0	0	0	0	8	0	0	0
<i>Phragmites karka</i>	0	0	0	0	0	0	0	0	0	0	0	68
<i>Spartina alterniflora</i>	0	0	0	0	0	0	0	0	0	0	0	5
H Shannon–Wiener Index	0.092	0.500	0	0.205	0.479	0.333	0.269	0.681	1.080	0.369	0.673	0.763
E Evenness	0.133	0.722	0	0.296	0.691	0.303	0.387	0.982	0.983	0.533	0.971	0.550

* Unit: individual.

** a–d stands for those communities as Table 1. T, tree layer; S, shrub layer; R, substrate layer.

2.2. Field sampling

The field sampling was performed at Dawei Bay, where the mangrove was well-preserved and the most area of plantation existed. The natural mangrove occupying on the backward high-tide zone flats was well-preserved with more than 30 years. The mangrove plantation occupying the middle mid-tide zone flats, where was occupied by *S. alterniflora* previously. Since 1999, *S. caseolaris* and *S. apetala* were planted to restrain the growth of *S. alterniflora*. At present, the plantations bloomed and fruited mostly at the early stage of succession. In July 2007, thirty two 10 × 10 m² quadrats were settled in four mangrove communities (Table 1), including 16 natural forest ones and 16 plantation ones. In each quadrat, the species, number and basal diameter of all the individuals which basal diameter exceeds 2.0 cm were recorded and measured. One 5 × 5 m² and 1 × 1 m² quadrats were also set at the third quadrat, respectively, to record the plant species, and their number and height.

2.3. Data analysis

The species diversities of different layers are calculated as Shannon–Wiener Index (*H*) and Evenness Index (*E*) [9]. The population niches are calculated with the resource of states of quadrats and layers. The niche breadth refers to the breadth of resource utilization of mangroves at horizontal and vertical states, and is calculated as Shannon–Wiener Index (*B*_(sw)) and Levins Niche Breadth (*B*_(L)). The percentage of niche similarity refers to the similarity of resource utilization between two populations (*C*_{ih}) [10].

3. Results

3.1. Summary of the mangrove communities

Totally, nine plants were recorded in thirty-two quadrats, among which five at tree layer, two at shrub layer, and six at substrate layer (Table 2). At the horizontal resource state, the number of species was five in *Kandelia obovata* (*Ko*) natural forest and *A. corniculatum* (*Ac*) secondary shrubbery. Those of *S. apetala* (*Sa*) and *S. caseolaris* (*Sc*) plantations were four and three, respectively. Generally, it was low in species diversity in different communities. At the vertical resource state, there were two species for all the communities at tree layer. *Ac* occurred at the tree layers in all com-

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