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A study on communities with *Potamogeton malaianus* MIQ. in Poyang Lake Nature Reserve of People's Republic of China

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ABSTRACT: Due to its unique environmental and geological traits, Poyang Lake Nature Reserve in China was chosen for studying the characteristics of a *Potamogeton* community. The results were as follows: (1) two emergent and four submerged macrophytes were identified in the *Potamogeton malaianus* community, in which four growth forms (herbids, magnopotamids, parvopotamids, vallisneriids) were classified. *Potamogeton malaianus* and *Vallisneria spiralis* L. possessed the highest (100%) frequency and the former also had the maximum dominance. (2) The horizontal structure of the community proved to be uniform rather than any zonation. *Potamogeton* was clumped in its distribution with three pattern scales: 100 cm^2, 400 cm^2, and 6400 cm^2. (3) Vertical structure of the *Potamogeton* community appeared rather simple. Only one layer (submerged strata) could be distinguished in most community stands. (4) The biomass of the community was nearly equal to the sum of the biomasses of *Potamogeton* and *Vallisneria* and the maximum biomass of the *Potamogeton* community appeared to be 309.43g.dw.m^{-2} in the September of the given period.

KEYWORDS: Community Structure; Biomass; Nature Reserve; *Potamogeton malaianus* MIQ., aquatic macrophyte; Poyang Lake; China

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Introduction

The genus *Potamogeton* L. in Potamogetonaceae was putatively treated to be one of the ancestral groups in monocot and one of the main aquatic plants on the world (SUN 1992). Among the worldwide *Potamogeton* species, *Potamogeton malaianus* MIQ. has been proven to be exclusively distributed in the East and Southeastern Asian, including the Indonesian Archipelago and some Pacific Islands (WIEGLEB & KADONO 1988). Since its frequent occurrence in lakes, ditches and rivers, and adaptation to water quantity, *Potamogeton malaianus*, was posed to be a well definedly material for understanding the adaptability to certain ecological circumstances and vegetational processes. Recently the biology of *Potamogeton malaianus* has been researched, including life history, growth and development, reproductive strategy, etc. (e.g., GUAN & al. 1987a,b; WIEGLEB & KADONO 1989a, b; WIEGLEB & Brux 1991; CUI & al. 1999, 2000).

In the People's Republic of China, *Potamogeton malaianus* was counted as one of the dominant aquatic macrophyte species and frequently abundant in some sections of waters. However, no intensive studies of this species have been carried out so far (PU & LI 1999). Thus, in this paper we circumscribed the Poyang Lake Nature Reserve, employed *Potamogeton malaianus* as study material in order to reveal the characteristics of the community, including species composition, horizontal and vertical structures and dynamics of the community.

Methods

Study areas

Poyang Lake in Jiangxi Province, the largest freshwater lake in China, is situated halfway downstream of the Yangtze River (115°49´-116°046´E; 28°11´-29°51´N). A seasonally shallow lake characteristic of flow-through, Poyang Lake is well known for its unique environmental and geological traits referred as "surface while flooding and line while ebbing". Poyang Lake Nature Reserve was designated at the southwest part of Poyang Lake, containing nine constituent sub-lakes and included in the "international important wetland list". The Natural Reserve is representative of typical vegetation of Poyang Lake.

In this project, we employed the Poyang Lake Natural Reserve as the study site for investigating aquatic macrophytes, especially *Potamogeton malaianus*. Herein, we chose the Meixi Lake (116°03´E; 29°13´N), a constituent lake of the Nature Reserve, for further studies involving community structure since *Potamogeton malaianus* mainly occurred in the Meixi Lake (ZHU & ZHANG 1997).

Community structure

The sampling station was located in Meixi Lake, a homogeneous community of *Potamogeton malaianus*. We surveyed and determined the community structure of *Potamogeton malaianus* during its life expectancy four times in 1999, 16th June (I), 27th August (II), 24th September (III) and 23rd October (IV), respectively. While sampling, we replicated ten quadrats, collected all the aquatic macrophytes with roots using a sampling iron clip of 20×20 cm^2 at the area of 500 m^2, carefully rinsed and removed epiphytes, then identified and determined the number of macrophytes. During these processes, we constantly recorded the water depth, and orientated the sampling sites with GPS so that the investigating scope was surrounded in the same 500 m^2 coverage during separate periods. Regarding the analysis of the community structure, we weighed every macrophyte with an electronic balance (precision: 0.1g) as soon as we obtained the collections; the weight was defined as fresh weight (w_f). Then we transported the sorted materials to the laboratory in polyethylene bags. Here we dried the samples to constant weight in an oven at 80±1°C and measured their respective weights (dry weight: w_d) by using an electronic balance (precisions: 0.0001g). With the obtained data, we then analyzed the production structure of the *Potamogeton malaianus* community by the stratified clip technique (KIMURA 1976).

Concerning the distribution of individuals within *Potamogeton malaianus* population, we employed the adjacent grid quadrate method (YANG 1983). In a rectangular sampling area of 320 × 80 cm^2, we defined the basic unit as a 10 × 10 cm^2 and/or 10 × 20 cm^2 grid, dug to 15 cm depth, and counted the winter buds of *Potamogeton malaianus* in every basic unit in December, 1999 (as the lake bottom was exposed to the air, the winter buds were treated as the individuals of *Potamogeton malaianus*).

Data analysis

From the data, we determined the relative frequency and biomass of all macrophytes, and counted the dominant value by the following equation (CHEN 1980):

Dominant Value =[(Relative Frequency + Relative Biomass)/2] × 100%.

When dealing with the growth-form of all aquatic macrophytes, we adopted the HUTCHINSON growth-form system (HUTCHINSON 1975). Subsequently it becomes the quantitative growth form spectrum:

$$\text{Some growth-form ratio} = \frac{\text{Adding to all dominant value of the growth-forms}}{\text{100(Total dominant value in the studied community)}} \times 100\%$$

As for the distribution pattern of individuals within the *Potamogeton malaianus* population, we displayed it by the correcting variation analysis method (GREIG-SMITH 1983; CHAPMAN 1976) for the quantitative description of the characteristics of horizontal distribution in the given community.

Results and discussion

Species composition

In the Meixi Lake, we found two emergent and four submerged macrophytes in the *Potamogeton malaianus* community. The related parameters were presented in Tab.1, which showed *Potamogeton malaianus*, *Vallisneria spiralis* L. and *Hydrilla verticillata* (L. f.) Royle as commonly distributed while the rest were definitely rare. The distribution pattern implied that dynamics of frequency distribution of the species was closely related to their growth habits and growth environments (LI & CHENG 1999). Close relationships were also referred

Tab.1 Species composition, growth-forms and dominant values in *Potamogeton malaianus* MIQ. community.

Species	Growth-forms	Frequency				Dominant Values			
		I	II	III	IV	I	II	III	IV
Potamogeton malaianus MIQ.	Magnopotamids	100	100	100	100	43.40	46.36	51.48	52.59
Vallisneria spiralis L.	Vallisneriids	100	100	100	100	41.80	36.14	35.75	37.26
Hydrilla verticillata (L.f) ROYLE	Parvopotamids	20	50	50	40	5.52	12.86	10.70	10.15
Potamogeton pectinatus L.	Parvopotamids	20	20	10		4.65	4.46	2.14	
Callitriche stagnalis L.	Herbids	10				2.09			
Cardamine lyrata BUNGE	Herbids	10				2.56			

between the dynamics of dominance of the main species and their growth habits and environments. The dominant value of *Potamogeton malaianus* increased in accord with the simultaneous increase in biomass. This consistency possibly resulted from the tolerance of *Potamogeton malaianus* to various ecological factors, such as stormy waves, water quality, water depth, substrate, etc. The dominant value of *Vallisneria spiralis* was proven to be minimal in September. We believe the higher water limited the growth of *Vallisneria spiralis* from July to the middle of August. Afterward the vegetative propagules quickly expanded with the following decrease of water depth, so the dominance of *Vallisneria spiralis* accordingly increased. Regarding the dominance in the community, its maximal value was designated in August. Though *Hydrilla verticillata* started flowering and bearing, and then declining and falling in August, the resulting seeds germinated shortly and the daughter shoots grew up at nearly the same time. This coexistence of progenitors and their offspring in the month contributed to the maximum dominance to a great degree. Subsequently, the dominance tended to reduce due to the disappearance of declining individuals.

In terms of the hierarchies of HUTCHINSON (1975) and DEN HARTOG & VAN DER VELDE (1988), we identified four growth forms in the *Potamogeton malaianus* community (Tab.1, Fig.1), namely, herbids, magnopotamids, parvopotamids and vallisneriids. Magnopotamids, the dominant growth form in the community, appeared maximal in October, while the rest minimal during the same month. The main reason for this was influenced by the growth habit of the main species

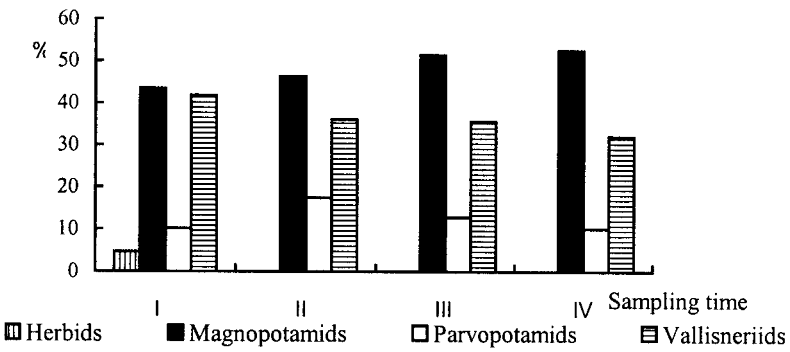

Fig. 1 Quantitative growth form spectrum in *Potamogeton malaianus* community.

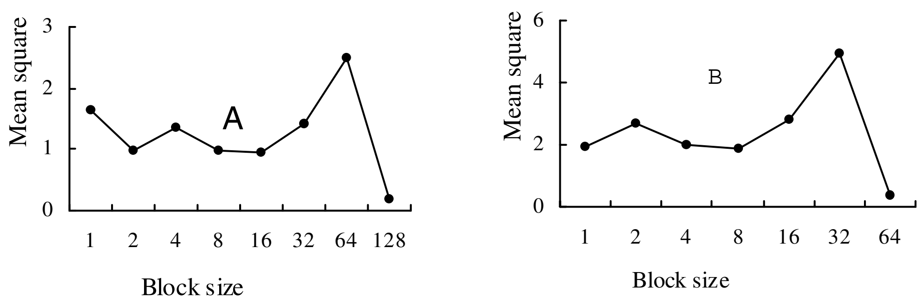

Fig. 2 Distribution pattern of *Potamogeton malaianus.* A - Basic unit: 10×10 cm^2; B - Basic unit: 10×20 cm^2.

on the variance of growth form ratio. Since the studied community was located at a nature reserve, there was no interference from humans at all. Therefore, the specialized growth forms of every component species generally represented their own growth habits in nature.

Horizontal structure

In the Meixi Lake, species of *Potamogeton malaianus* covered the whole lake without external interference since it was capable of tolerating the wide range of adverse environments. In the March, the propagules of *Potamogeton malaianus* first germinated at the watery center, then *Potamogeton malaianus* dispersed continuously to the surrounding lakeshore with the increase of water depth. *Vallisneria spiralis* and *Hydrilla verticillata* germinated following *Potamogeton malaianus*, expanded and eventually grew to become “forest under water”. At the level of population, the horizontal distribution of the community was considered to be comparatively uniform without obvious zonation due to the environmental homogeneity in Meixi Lake. However, we observed that *Potamogeton malaianus* communities were located along the boat routes in some lakes (CUI & al. 1999). The observations indicated the zonal distribution pattern of the *Potamogeton malaianus* population in a community developed from the interaction of growth habit and living environment.

In Fig. 2A, the distributional pattern of *Potamogeton malaianus* shows, peaks at blocks of 1, 4, and 64, representative of 100 cm^2, 400 cm^2 and 6400 cm^2 block areas. While in Fig. 2B, the peaks at blocks of 2 and 32, correspond to block areas of 400 cm^2 and, 6400 cm^2, respectively. The data revealed the clumped distribution pattern of *Potamogeton malaianus*. Since *Potamogeton malaianus* reproduces mainly through vegetative reproduction of stoloniferous horizontal shoots (WIEGLEB & BRUX 1991), we noticed the offshoot type was defined as sympodial branching. When the buds on the underground shoots grew up to the lake bottom, the auxilary bud horizontally extended forward to become new underground rhizomes. In the areas with thin substrates, the underground roots and stems gathered into one layer and twisted together so densely that restricted the extendable space for their own growth. In such situations, the shoots grew up to the lake bottom. In the thick substrate areas, however, the complexes of horizontal shoots were stratified into multiple layers under lake bottom, where the deeper shoots frequently extended laterally before their upward growth. Resultantly, during our survey within 20×20 cm^2 quadrats with thick substrates, we observed the stoloniferous horizontal shoots extended beyond the restricted scale under the lake bottom. Therefore, we speculated that the distribution pattern of *Potamogeton malaianus* in the Meixi Lake community at the three separate scales as follows: the pattern of the blocks with 100 cm^2 and 400 cm^2 resulted from the offshoot of underground shoots at the thin-substrate areas while that of the block with 6400 cm^2 from the lateral spread of the deeper shoots at the thick substrate sites.

Vertical structure

In the *Potamogeton malaianus* community, we observed that there appeared vertically only a submerged vegetation layer on most occasions. Hyperhydates, fragmentarily dispersed in the community, failed to develop into an entire vegetation layer. Actually, we identified small communities at the bottom of the projected community. The formation of the small communities involved in the terrain variances of the lake bottom and the water rapid. *Potamogeton malaianus* clustered as the main species in the above layer of the community, whose mature shoots generally reached to the water surface and then crept along the water surface. The average length of the mature shoots was measured to be 5-7m, maximum to 9m. While at the lower layer in the community, the presence of *Vallisneria spiralis* commonly appeared to be a small community dominated by this species.

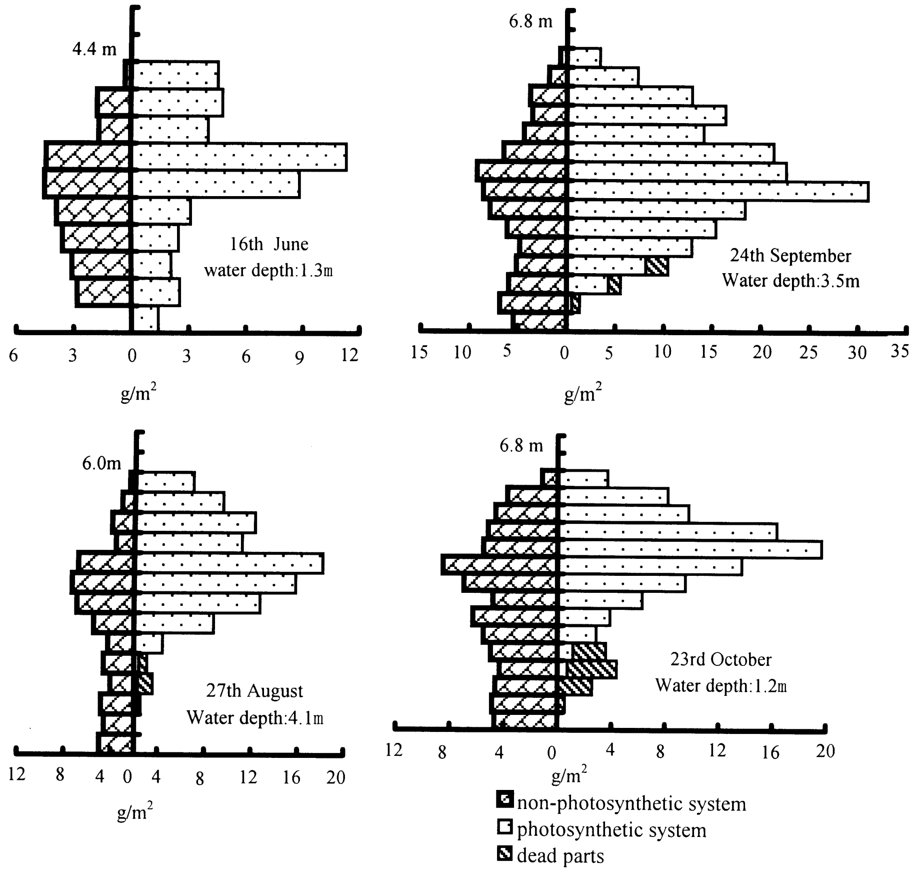

Fig. 3 Dynamic of production structure of *Potamogeton malaianus* community.

Considering its simple elements, herein we attempted to quantitatively analyze the vertical structure of the *Potamogeton malaianus* community in terms of the vertical quota of above-ground vegetative production. Equipped with a stratified clip (KIMURA 1976), we determined the dynamics of the production structure of *Potamogeton malaianus* (Fig. 3). In the community, the photosynthetic systems (leaves) were mainly located near the surface of water in June, September and October. This special position favored the absorption of light. Meanwhile, the non-photosynthetic systems (stems and others) on the water surface accounted for a slightly greater percentage than those submerged. This distributional trait involved in the sharp variance of water depth and the great flow rate of water that resulted in the shoots creeping on the water surface to grow stronger. The data obtained on16th June displayed the biomass quota of the new shoots of *Potamogeton malaianus*. With their vegetative growth, the location center of photosynthetic systems gradually moved up along the entities and the lower leaves abscised continuously. The information obtained on 27th August showed the biomass of photosynthetic systems and non-photosynthetic systems accumulated largely in the body of water. That of the former still kept the tendency upward movement while that of the latter was redistributed uniformly. In the graph of 24th September, the peaks of photosynthetic systems and non-photosynthetic systems were both designated and the biomass of non-photosynthetic systems was redistributed more uniformly. Nevertheless, the location center of photosynthetic systems in the graph of 24th September was comparatively lower than that of 27th August. The decrease of water depth ranging from August to September in the community possibly accounted for the downward movement of photosynthetic systems. Up to 23rd October, the self-thinning process reduced the biomass of photosynthetic systems and non-photosynthetic systems while both the location centers peaked among the four specialized months.

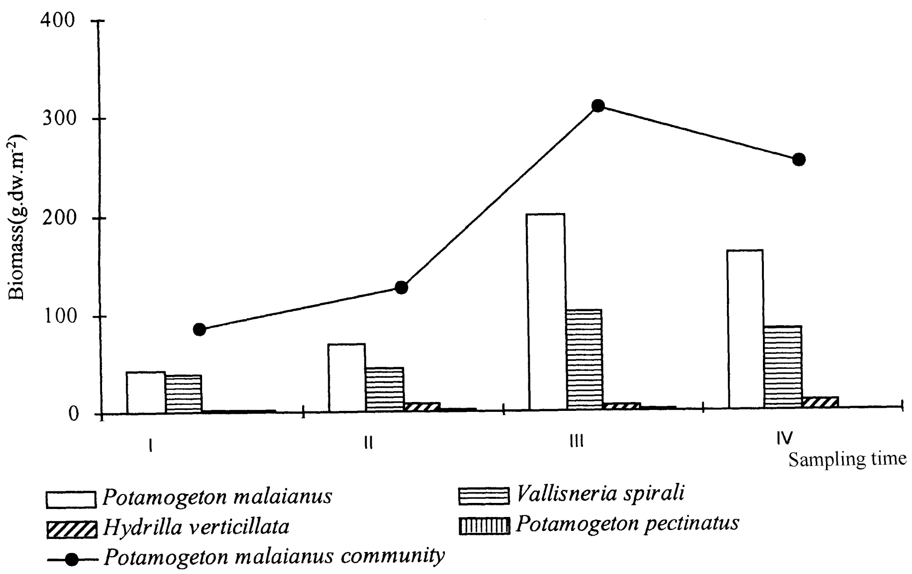

Fig.4 Biomass dynamic of *Potamogeton malaianus* community.

Biomass dynamic of the *Potamogeton malaianus* community

The dynamics of biomass of the four submerged macrophytes in the community, namely, *Potamogeton malaianus*, *Vallisneria spiralis*, *Hydrilla verticillata*, and *Potamogeton pectinatus* are presented in Fig. 4. The biomass of *Potamogeton malaianus* kept increasing from June to September when it reached its greatest value (199.5 g.dw.m^{-2}), which differed from the control dynamic obtained from laboratory cultivation (unpublished data). The maximum biomass in September maybe resulted from the sufficient absorption of light and newly developed shoots, and the subsequent decrease of biomass was the result of self-thinning. The biomass of *Vallisneria spiralis* also reached its maximum in September (approximately 102.2g.dw.m^{-2}) and underwent the same tendency of biomass variance as *Potamogeton malaianus.* As for *Hydrilla verticillata*, its biomass variance appeared to be a certain negative relationship with that of *Potamogeton malaianus* during September and October. One cause existed in their mutual counteractions. As *Potamogeton pectinatus* was fragmentally dispersed in the community, the biomass always appeared to be such a small quantity that no biomass value was counted in October. Resultantly, the biomass of the *Potamogeton malaianus* community was nearly equal to the sum of the biomass of *Potamogeton malaianus* and *Vallisneria spiralis*. Therefore, the maximum biomass of the *Potamogeton malaianus* community appeared to be 309.43g.dw.m^{-2} in September during the given period.

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