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Community collocation of four submerged macrophytes on two kinds of sediments in Lake Taihu, China

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ABSTRACT

To explore a method for rapid restoration and artificial regulation of submerged macrophytes in large-scale restoration of eutrophic lakes, the succession and the biodiversity changes of four communities composed of four native, common submerged macrophytes, *Hydrilla verticillata*, *Potamogeton malaianus*, *Vallisneria spiralis* and *Najas marina*, on two kinds of sediments were investigated. Under low light intensity (reduced by 99%), the plant biomass changed with seasonal changes, plant competition, and environmental stress. The competitive capability for light differed in the four species due to different shoot height and tiller number. After 405 days of transplantation, *H. verticillata* became dominant in all communities. The biomass of *H. verticillata*, with strong ability to endure low water light environment, accounted for more than 90% of the total community biomass, and *P. malaianus* had only weak growth, while *V. spiralis* and *N. marina* almost disappeared. Based on livability and biomass of submerged macrophytes on two sediment types, brown clay sediment appeared to be more favorable for the settlement of the plants, while fertile sludge sediment was suitable for vegetative growth. In conclusion, the improvement of habitats and the selection of appropriate plant species are of the greatest importance for ecological restoration of the aquatic ecosystem.

1. Introduction

With the rapid growth of economic and social development but delayed environmental protection measures, most of the lakes in China are suffering from eutrophication. In order to cope with the continued decline in water quality of the lakes, the Chinese government established a National High-Tech Research and Development Program on ecological restoration of Lake Taihu, which serves as the source of drinking water for more than 20 million people in east China. To rebuild a healthy lake, ecosystem recovery – especially that of aquatic submersed macrophytes – is very important because of their multiple ecological functions, such as improving the self-purification capacity of a lake ecosystem (Moss, 1990; Yang, 1996; Wu et al., 2003; Knight et al., 2003), serving as food source for invertebrate and vertebrate aquatic animals (Lamberti and Moore, 1984; Maceina et al., 1991), and forming a reasonable ecological structure (Carpenter et al., 1998; Kornijow and Moss, 1998; Mitsch et al., 2005). Hence, efficient restoration of the aquatic submerged macrophytes in a eutrophic lake is both a major technique and an important research topic.

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Table 1 – Mean and standard deviation (in parentheses) of shoot height (cm), root length (cm), tiller number and wet weight (g) of the submerged macrophytes used in the experiment

Species	Shoot height	Root length	Tiller number	Wet weight
H. verticillata	16.2 (1.62)	13.8 (4.44)	2.3 (1.08)	1.42
P. malaianus	10.1 (1.87)	3.7 (2.35)	1.0 (0.00)	0.54
V. spiralis	9.4 (1.00)	7.8 (1.69)	1.0 (0.00)	1.24
N. marina	14.8 (2.03)	8.8 (5.92)	1.1 (0.22)	2.88

Many factors can influence the re-growth and succession of submerged macrophytes, such as sediment characteristics, nutrient limitation, light availability, plant growth type, and so on (Chapin, 1980; Fitter, 1986; Hough et al., 1989; Henry and Amoros, 1996; Wigand et al., 1997; Van et al., 1999; Rooney and Kalff, 2000; Irfanullah and Moss, 2004; Liu et al., 2004). However, most previous research has been focused on one or two factors under controlled conditions, and the researchers rarely made a comprehensive investigation. To our knowledge, no research has been conducted on the proper recovery condition for the dominant submerged macrophytes in lakes of China.

The aims of this research can be specified as (1) to investigate the influence of the sediments on community succession and plant growth of submerged macrophytes; (2) to explore the mechanism in submerged macrophyte community succession; (3) to offer a principle for the restoration and artificial regulation of submerged macrophytes in large-scale restoration of eutrophic lakes.

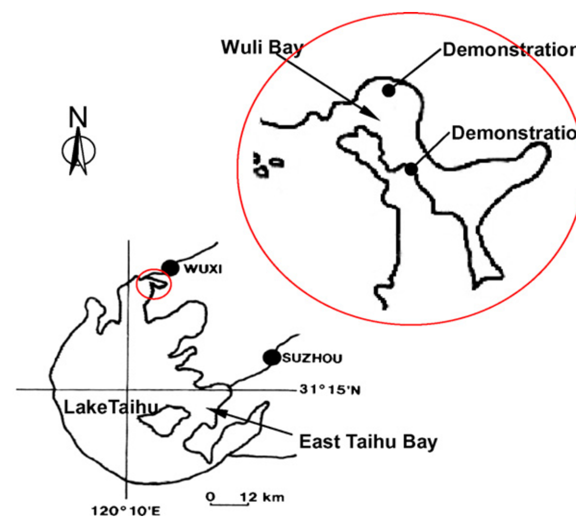

Fig. 1 – Sampling sites in Wuli Bay and East Taihu Bay.

2. Materials and methods

2.1. Materials

The test for submerged macrophytes which are native species included *H. verticillata*, *P. malaianus*, *V. spiralis*, and *N. marina*. All the species came from Wuli Bay and East Taihu Bay, two bays of Lake Taihu in Jiangsu Province of China. Following selection of homogeneous individuals of each species with the same growth status and then cutting off old branches, individuals with new branches and leaves were prepared for transplantation. Background information of the submerged macrophytes in this study is shown in Table 1.

2.2. Experimental design

Four communities were designed, each constituted of all four species of the submerged macrophytes with one species as the dominant species and the other three species as subordinate species. Of a total of forty individuals in each community, dominant species accounted for twenty-two individuals (a proportion of 55%) while the other three subsidiary species had eighteen individuals (a proportion of 45%), with six individuals for each of subsidiary species.

Recent main engineering tasks conducted in Wuli Bay have included dismantling the former fish pond and remerging the pond with the lake body. There were two kinds of sediments in this ecological restoration demonstration project site. One was the brown clay sediment formed after removing the sediment in the former fish pond, then filling it with soils from the bank of the pond. The other one was a kind of fertile sludge sediment which was left after partial dredging of the lake. These two kinds of sediments were tested for the designed communities. The brown clay sediment was taken from the open water zone of demonstration area B of Wuli Bay and the fertile sludge sediment was taken from demonstration area D of Wuli Bay (Fig. 1). The characteristics of the sediments are listed in Tables 2 and 3.

On September 2, 2004, the sediments were dug out and put into plastic containers after thorough mixing. The containers have an inner dimension of 73 cm × 53 cm × 59 cm and thus a cubage of 200 L. A 12-cm-deep layer of the sediment was prepared in each container. All the containers were then moved into a greenhouse covered with shade net, in order to sim-

Table 2 – Contents of organic matter (OM) (%), total nitrogen (TN) (%), total phosphorous (TP) (%) and some heavy metals (mg kg^{-1} dry soil) of the sediments at the beginning of the experiment

Sediment type	OM	TN	TP	As	Cd	Cr	Cu	Hg	Pb
Brown clay	0.272	0.034	0.048	2048	1.26	282.3	19.16	<0.1	75.8
Fertile sludge	2.294	0.147	0.080	165	1.32	86.3	23.96	<0.1	27.8