Factors contributing to geographic distribution of three *Marsilea* spp.

影响三種田字草地理分佈的因子探討

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**Introduction**

*Marsilea*, an amphibious fern, is distributed in tropical and warm temperate zones of all continents. The objective of this study was to investigate factors contributing to the geographic distribution of *M. crenata*, *M. quadrifolia*, and *M. schelpiana*. After examining the climate data and their morphological difference (Fig. 1), we propose that light, water and temperature might be the main factors contributing to the distribution pattern of the three *Marsilea* spp. To test the hypothesis, we compared the morphological traits and photosynthetic performance of the three species grown under different treatment.

**Fig. 1** The outer appearance of the three *Marsilea* spp. and the climate patterns of their habitats.

**Results**

I. Responses to different growth light intensity

![Image](image1)

**Fig. 2** The response of CO₂ assimilation rate to the light intensity of photosynthetic active radiation (PAR) (a) and assimilation quantum use efficiency (the initial slope of A-PAR curve) (b) of three Marsilea spp. (mean ± S.E., n=6).

![Image](image2)

**Fig. 3** Leaf lobing degree [-1- (leaf area/potential leaf area)] (a), and specific leaf area (dry mass/leaf area) (b) of three Marsilea spp. grown different light intensity (mean ± S.E., n=6).

- *M. schelpiana* had the highest photosynthetic rate and leaflet lobing degree under full light, however, the greatest reductions under shade. It indicates the species is adapted to high light environment.
- In response to shade, the three species increased their SLA to intercept more light. In addition, *M. schelpiana* also showed reduction in lobing degree of its leaflets.

II. The effect of soil water availability

![Image](image3)

**Fig. 4** The response of PSⅡ quantum yield (a), trichome density (b) and leaf area (c) to leaf water potential of three Marsilea spp. grown under different watering regimes (mean ± S.E., n=6).

![Image](image4)

**Fig. 5** The cross-section of leaf (400x) and petiole (100x) of three Marsilea spp. grown under high(HW) and low(LW) watering regimes.

- Results of photosynthetic performance revealed that *M. quadrifolia* is more resistant while *M. crenata* is more susceptible to reduction in water availability.
- Trichome density was increased in *M. quadrifolia* under low water availability, which may help reducing transpirational water loss.
- The three species had different degree of adjustment in the internal structure in response to reduction in water availability.

III. PSⅡ quantum use efficiency in response to short-term change in leaf temperature

![Image](image5)

**Fig. 6** The response of PSⅡ quantum yield to leaf temperature. (mean ± S.E., n=5).

- *M. quadrifolia* had the highest optimal temperature (T⁰) and the widest range of temperature tolerance, and *M. crenata* the lowest and the narrowest.

**Table 1** A summary of result from Fig. 6

<table>
<thead>
<tr>
<th>Species</th>
<th>T⁰ (°C)</th>
<th>50%-100% Tₕₑ (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>M. crenata</em></td>
<td>30</td>
<td>19.4-40.7</td>
</tr>
<tr>
<td><em>M. quadrifolia</em></td>
<td>36.5</td>
<td>17.9-55.4</td>
</tr>
<tr>
<td><em>M. schelpiana</em></td>
<td>32.2</td>
<td>18.7-45.0</td>
</tr>
</tbody>
</table>

**Conclusion**

Among the three species, *M. quadrifolia* is the most resistant to drought and extreme temperature, *M. crenata* the worst. *M. schelpiana* is adapted to high light environment, and its lobing leaflets can help avoiding extreme high temperature.

The responses of three species match the light intensity and water availability of their habitat. It indicates that two environmental factors (light, and water)contribute to the geographic distribution of these three species. In addition, the three species had developed different adjustments to cope with the variation in light intensity and water availability of their habitats.