Community structure of Rotifera and eutrophication evaluation of Nansha Mangal-Wetland Park in Guangzhou City

Fei Yu¹, Shuwen He¹, Yu Liu¹,²*, Xin Yao¹ and Qinyu Sun¹

¹School of Environmental Science and Engineering, Sun Yat-Sen University, Guangzhou, Guangdong, 510275, China
²Guangdong Provincial Key Laboratory of Environmental Pollution Control and Remediation Technology, Guangzhou, Guangdong, 510275, China
*Corresponding author’s e-mail: eelyu@mail.sysu.edu.cn

Abstract. The community structure of Rotifera was investigated in four areas, namely the water inlet area (Ia, 1Ψ), Sonneratia apetala area ((Sa, 2Ψ and 3Ψ), Phragmites australis area (Pa, 4Ψ and 5Ψ), and water outlet area (Oa, 6Ψ), in Nansha Mangal-Wetland Park (NMP) in 2017. Indices, such as the dominance index (Y), Shannon Wiener Index (H’), Margalef Index (D), Saprobic index (S), and Brachionus: Trichocerca quotient (Q_BT), were considered. A total of 73 species of Rotifera were identified, and the abundance ranged from 4.5 to 2585.8 ind·L⁻¹ with significant seasonal differences. Brachionus angularis and Asplanchna spp. were the dominant species (Y>0.01). Redundancy analysis (RDA) indicated that CODₘᵦₜ, dissolved oxygen (DO) were the most important factors regulating the community structure of the Rotifera. Evaluation of the results using indexes such as H’ showed large deviations from the results based on physicochemical indicators. The results from Q_BT were not compatible, and the S index was found to be more suitable for water quality evaluation in the NMP. Based on the results, the Sa area was more eutrophic than the Pa area.

1. Introduction

Rotifera is an important component of zooplankton biomass and its food size spectrum [1], and it’s considered to be good bioindicators for water pollution, in particular, eutrophication[2]. Few studies have investigated the relationship between the spatial and temporal variations of Rotifera and the eutrophication levels in mangrove wetlands[3-4].

The community structure of Rotifera and various water quality parameters were investigated in the Guangzhou Nansha Mangal-Wetland Park (NMP) in 2017. Samples from water inlet area, Sonneratia apetala area, Phragmites australis area, and water outlet area were carried out to assess the temporal and spatial variations of Rotifera in relation to the water quality. The aim of this paper is to demonstrate the potential for the use of Rotifera as bioindicators for evaluation of eutrophication in NMP.

2. Materials and methods

2.1. Study area
The Nansha Mangal-Wetland Park (NMP) is the largest wetland park in Guangzhou city, with a surface water area of 200 hectares (ha), and is dominated by artificial mangrove plants, especially *S. apetala* and surrounded by fish ponds.

Investigations were carried out in spring (April 18th), summer (June 28th), autumn (September 22nd), and winter (November 24th) in 2017. Based on the terrain and water quality in the park, samples were taken from water inlet area (*Ia, 1#*), *S. apetala* area (*Sa, 2#* and *3#*), *P. australis* area (*Pa, 4#* and *5#*), and water outlet area (*Oa, 6#*). Shown in Figure 1.

![Figure 1. Six sampling sites in NMP.](image)

2.2. Sample collection and detection
All physic-chemical and biological parameters were sampled and detected according to the National Standards of Surface Water Testing Standards (GB7481-87, GB11892-89) and Water Conservancy Industry Standards of China (SL88-1994).

Rotifera were identified to species level using an optical microscope based on Wang[5] and Zhuge[6]. The abundance of Rotifera (*N*) was calculated as follows: 

\[
N = 1.5A
\]

(1)

Where, *A* is the number of individuals enumerated in the counting chamber under the microscope. The number of rotifers was counted three times.

2.3. Eutrophication evaluation methods

2.3.1. Dominance Index and dominant species. The Dominance Index 

\[
Y = \frac{n_i}{N}
\]

(2)

2.3.2. Diversity Indices and Evenness Index. Three indices have been used for estimating rotifer diversity and evenness, and are described as below:

- Shannon Wiener Index (*H’*):
  \[
  H' = -\sum \left( \frac{n_i}{N} \log_2 \frac{n_i}{N} \right)
  \]
  (3)

- Margalef Index (*D*):
  \[
  D = S - 1 \ln N
  \]
  (4)

- Pielou Evenness Index (*J*):
  \[
  J = \frac{H'}{\ln S_r}
  \]
  (5)

Where, *n* is the number of individuals of *i* rotifer (*i*=1, 2, 3…), and *N* is the total number of rotifers. If *Y>*0.01, this species is considered to be a dominant species. *S* is the total number of species.

2.3.3. Saprobic Index. Saprobic Index(*S*):

\[
S = \frac{\sum m_i \times Y}{\sum Y}
\]

(6)

Where, *m* is the indication value of *i* rotifer, that is, 1 for oligosaprobic taxa, 2 for β- mesosaprobic taxa, 3 for α- mesosaprobic taxa, 4 for polysaprobic taxa; *Y* is the dominance index.
2.3.4. Brachionus: Trichocerca quotient. Brachionus: Trichocerca quotient \( Q_{B/T} \): 
\[ Q_{B/T} = \frac{B}{T} \]  
B and T is the species number of Brachionus and Trichocerca, respectively [7]. The water could be classified as oligotrophic, mesotrophic, or eutrophic when \( Q < 1.0 \), \( 1.0 \leq Q < 2.0 \), \( Q > 2.0 \), respectively.

All data were analyzed using R3.4.4, Excel 2013 and GraphPad Prism 6.02. Figures were processed by using Photoshop CC2015 and Illustrator CC2015.

3. Results and analysis

3.1. Assessment of water quality

Water temperature did not vary greatly between the samples: 32.85±0.63°C in summer, 32.75±0.78°C in autumn, 28.50±0.32°C in spring and 19.15±0.36°C in winter. pH was slightly alkaline (8.00±0.34). The water was slightly brackish, and SD values were below 0.5 m. The DO values indicated that \( Sa \) < \( Pa \) in most samples, as DO was largely consumed by litter decomposition in \( Sa \). The concentrations of \( NH_3-N \) were winter 1.93±0.77mg·L\(^{-1}\) > spring 0.41±0.05mg·L\(^{-1}\) > autumn 0.22±0.04mg·L\(^{-1}\) > summer 0.10±0.03 mg·L\(^{-1}\). The mean value of the concentration of COD\(_{Mn}\) was 3.98~4.62mg·L\(^{-1}\).

The concentration of Chl \( a \) is shown in figure 2; \( Sa \) > \( Pa \) which indicates that \( Sa \) was more eutrophic than \( Pa \).

![Figure 2. Results of evaluation of Chl \( a \) in NMP.](image)

3.2. Community structure of Rotifera

3.2.1. Species composition and abundance. 73 species of Rotifera were identified in NMP. The abundance and dominance of species of Rotifera are shown in Figure 3. The community structure of Rotifera showed significant differences in different waters in each quarter. \( Sa \) > \( Pa \) in spring and summer, however during autumn and winter the opposite was found. Eutrophic indicators such as \( Brachionus \) spp., \( Asplanchna \) spp., and \( Polyarthra \) spp. accounted for a large proportion of the sample, and \( B. \) angularis was the dominant species in NMP (\( Y > 0.01 \)).
3.2.2. The response of Rotifera to water quality. The results of the assessment using each index are shown in Figure 4. The $J$ index significantly underestimated the eutrophication status of water bodies. The results of the $H'$ and $D$ indices also deviated greatly from the results of the assessment using the physicochemical indicators.

Figure 4. Results of indexes and evaluation in NMP.
The $S$ index showed the waters were dominated by $\beta$-$\alpha$ mesosaprobic taxa. Because of the absence of *Trichocerca* spp. in spring and winter, the value of $Q_{BT}$ was assessed in summer (mesotrophic-eutrophic taxa) and autumn (eutrophic taxa). And based on the community structure of Rotifera, the wetland was classified as mesosaprobic.

3.3. **Correlation between abundance of Rotifera with water quality factors**

Redundancy analysis (RDA) was used to analyze the relationship between the community structure of the Rotifera and environmental factors in the NMP. The results are shown in Figure 5. The COD$_{Mn}$, DO, temperature, and salinity were the most important factors in the regulations of the composition and abundance of the Rotifera.

![Figure 5. Redundancy analysis between rotifera and environmental factors in NMP.](image)

4. **Discussion**

Few studies have been undertaken in the Mangal wetlands; Liu (2013) suggested that eutrophication is indicated where rotifer abundance in *S. apetala* waters is $3 \times 10^3$ ind·L$^{-1}$[8], which is higher than the levels observed in this study. In this case, six methods were used to evaluate the water quality, which showed NMP shows evidence of eutrophication and *Sa* was more eutrophic than *Pa*. The variation in the rotifer community was not completely consistent with the microalgae, and the $J$ index significantly underestimated the eutrophication level of the water bodies based on the concentration of Chl $a$. Diversity indices ($H'$, $D$) were similar to the water quality evaluation results in spring but did not adequately reflect the water condition of each sampling point, which was similar to the conclusion of Liu *et al.*[9] in Baiyangdian. The result of $Q_{BT}$ was closest to the results of the assessment by physicochemical and biological factors, but the use of $Q_{BT}$ was somewhat limited as *Trichocerca* and *Brachionus* did not always occur simultaneously. Using saprobic species as indicators seemed to be a
good method; however, saprobic species of Rotifera should be refined in the future to evaluate the trophic state more accurately.

In comparison with other studies in different water bodies, and based on the results of the investigation by Liu[8] in the NMP (see Table 1), the Rotifera abundance in the NMP has increased greatly in recent years, indicating that the levels of eutrophication in the park are getting worse; the level of eutrophication in the NMP was greater than the channel outside the NMP; eutrophication levels were higher in Sa than in Pa, which was consistent with the finding of Liu that S. apetala has the tendency to aggravate the eutrophication level in the offshore area[8].

The NMP is an artificial mangrove park attracting a large number of tourists. Cruise ships pass through the waterway every day resulting in serious disturbance of the surface water layer. The NMP provides habitat for a large number of birds that bring metabolites into the waterway. When the sluice between 1# and 6# is closed, reduced water mobility can increase the accumulation of pollutants. Thus, the wetland plants did not play a role in water purification in NMP.

Table 1. Comparisons of the abundance of rotifera with other studies.

| Study area                   | Sampling sites        | Abundance(ind·L⁻¹) | References |
|------------------------------|-----------------------|--------------------|------------|
| Nansha Mangal-wetland, The 19th Chong | Inlet                  | 40-218             | [8]        |
|                              | Sa                     | 4-6                |            |
|                              | Pa                     | 32-70              |            |
|                              | Outlet                 | 2-6                |            |
| Xi-xi wetland                | Wharf                  | 331                | [10]       |
|                              | Ecological reserve     | 361                |            |
|                              | During dry season      |                    |            |
|                              | Estuary                | 10.0               | [3]        |
| Kaw River (French Guiana)    | Marsh                  | 15.5               |            |
|                              | Tidal creek            | 12.0               |            |
| Pearl River                  | In Guangzhou           |                    |            |
|                              | Estuary                | 737-1123           | [4]        |
|                              | Lake                   | 718-1260           |            |

5. Conclusions
A total of 73 species of Rotifera were identified in the NMP and their abundance ranged from 4.5 to 2585.8 ind·L⁻¹. Most species recorded were Brachionidae, and *Brachionus angularis* was the dominant species (*Y*>0.01).

The results of RDA showed that CODₘᵦ, DO were the most important factors in the regulation of species composition and abundance of Rotifera. The diversity indices (*H', D*) and *J* index did not adequately reflect the water condition at each sampling point. The *Qᵣᵣ* index had limited accuracy. Therefore, the *S* index was found to be more suitable for water quality evaluation in the NMP.

The Sa area was found to be more eutrophic than the Pa area, which indicates that the wetland plants do not play a role in waste purification.

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