Effects of Physical and Chemical Factors on Zooplankton in Tropical Shallow Urban Lakes

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Abstract. Zooplankton played an important role in freshwater ecosystem. Its distribution was influenced not only by biological factors such as fish and aquatic plants, but also by physical and chemical factors such as water temperature, chlorophyll and pH. By analyzing the relationship between zooplankton and physical and chemical factors in urban lakes of Lingnan, the results showed that water temperature was one of the important factors affecting the distribution of zooplankton which had half of the species and dominant species being tropical or subtropical. The abundance of zooplankton was positively correlated with the chlorophyll content in the water, positively correlated with the suspended matter content, and negatively correlated with the transparency and pH. The study was helpful in providing support for the ecological restoration of tropical shallow water urban lakes.

1. Introduction
Zooplankton was distributed in the whole water area which took dissolved or granular organic matter, algae and bacteria as food. Most of zooplankton was easy to be eaten and digested by fish. Zooplankton distribution was mainly affected by food, predation, temperature, light, pH, water flow and other factors. Zooplankton had different living habits, such as true plankton, facultative plankton, periphyton and benthic plankton. In the open water area of the lake, zooplankton was basically true plankton[1]. The periphyton and benthic plankton generally couldn’t compete with floating types in the open water area of the still water body, and they were easy to be preyed on by predatory rotifers and copepods. The species diversity of coastal zone was generally higher than that of open water area, but the types were mainly periphyton, benthic and facultative plankton[2]. The special life style of zooplankton to drift with the current made them very sensitive to the changes of various hydrological factors. The changes of species distribution and quantity were always related to certain hydrological conditions. The seasonal and long-term changes caused by environmental impact also forced zooplankton to present different degrees of response.

2. Impact of water temperature on zooplankton
During the sampling period of zooplankton in urban lakes of Lingnan, the water temperature measured at various points was between 26.5 °C and 32.30 °C, and the average water temperature was (30.12 ± 1.25) °C. Water temperature was an extremely important environmental factor affecting the growth, development, community composition and quantity change of zooplankton, and an important factor affecting the horizontal distribution of zooplankton[3]. With the difference of temperature range and average temperature, the distribution of zooplankton was also different. Among the rotifers detected in this sampling, the three genera of Lecane, Brachionus and Trichocerca, which were mainly distributed in tropical and subtropical areas, accounted for 49% of the rotifer species detected in Lingnan area,
and the dominant species were also mostly from these genera. In addition, the species and abundance of Cladocera in Lingnan urban lakes were small and low. The abundance of Cladocera was between 0.80 and 30.00 ind·L⁻¹, and the average abundance was only (5.89±0.97) ind·L⁻¹, which might be affected by water temperature to some extent, except for the pressure of fish predation. Studies had shown that temperature affected the body length, age, number of age, reproduction rate and mortality of Cladocera. The physiologically limited temperature of crustacean zooplankton had been widely reported, for example, the lowest temperature threshold of Ceradaphnia cornuta was between 10-15°C[4]. The seasonal fluctuation of Cladocera species was significantly affected by water temperature. With the rise of water temperature, the time of individual development was shortened, and the amount of reproduction was increased. Therefore, the sudden occurrence of Cladocera could be observed in the warm season, but the higher water temperature was not suitable for growth. In Kasumigaura lake, it was pointed out that in addition to the higher pressure of fish, the higher water temperature in summer might inhibit the emergence of Daphnia, because the high temperature above 25°C reduced the feeding efficiency of many Daphnia species, thus controlling their population existence[5]. In addition, in natural water, the increased water temperature could intensify the inhibition of toxic cyanobacteria on daphnid population[6].

3. Relationship between chlorophyll content and zooplankton

In the sampling of zooplankton in Lingnan urban lakes, there was a significant positive correlation between the total abundance of zooplankton and the content of chlorophyll (r=0.426, P<0.01), among which there was a significant positive correlation between the abundance of rotifer and the content of chlorophyll (r=0.534, P<0.01). There was no significant correlation between the contents of chlorophyll and the abundance of Cladocera, and neither was there with Copepoda and nauplius. Most species of zooplankton were algophagous, including phytoplankton, bacteria and organic debris as food. Therefore, in the water body rich in phytoplankton, there were more filter feeding zooplankton. In the multivariate analysis of the relationship between plankton, it found that the density and biomass of zooplankton in Wuhan East Lake were determined by the content of chlorophyll a, and the order of correlation with chlorophyll a was rotifer, copepod and protozoa[7]. Generally speaking, in a wide range of temperate and tropical lakes, with the increase of nutrition, the density of zooplankton also rose, and sometimes the density of small species also rose[8].

![Figure 1. The correlation analysis of zooplankton abundance and content of Chl.a in urban lakes of Lingnan](image)

There was a significant positive correlation between the abundance of rotifers and the content of chlorophyll in urban lakes of Lingnan, but the relationship between the abundance of Cladocera and the content of chlorophyll was not obvious. It was possible that most phytoplankton were dominated by blue-green algae, which was not conducive to the feeding of Cladocera and other large zooplankton.
In general, the higher food density in the eutrophic lake would lead to the higher abundance of Cladocera, while Calanoida was at a disadvantage. On the contrary, the results of the study in South America's Valencia Lake showed that copepods (Mesocyclops crassus, Notodiaptomus venezolanus) and rotifers (Brachionus calyciforus, Keratella americana) were absolutely dominant, while the number of Cladocera was very low[9]. Lake eutrophication was accompanied by the emergence and growth of cyanobacteria. When the concentration of nutrients in the water increased, the abundance of bacteria went up as well, which correspondingly boosted the density of efficient bacterial herders or small omnivorous species. However, the high concentration of cyanobacteria was not only low nutrition, but also hindered the large-scale individual’s filter feeding organs and consumed a lot of energy. Therefore, in the eutrophic lake riched in cyanobacteria, the species of grazing micro algae were dominant in spring, while in summer, when the "water bloom" of cyanobacteria occurred, the species that mainly fed on bacteria and organic debris were dominant. Although Cladocera, Copepoda and rotifer could consume a small population of algae in the tropical eutrophic lake, when the density of macroalgae reached a certain size, it would inhibit the population density of Cladocera. Because large Cladocera was sensitive to external interference, when there were adverse external factors, small Cladocera and rotifer would become relatively important, and then became the dominant group of water body.

4. Relationship between zooplankton abundance and SS, SD, pH

The correlation analysis of zooplankton abundance and suspended matter content, transparency, pH and other indicators in Lingnan urban lakes showed that the total abundance and suspended matter content (r=0.404, P<0.01) was significantly positively correlated, and negatively correlated with transparency (r =-0.242), pH (r =-0.237). The abundance of rotifer, Cladocera and Copepoda was positively correlated with the content of suspended matter. The content of suspended matter, including plankton, bacteria, organic debris and inorganic particles, was the main food source of zooplankton. Therefore, the abundance of zooplankton was positively correlated with it. The pH value of water also had an impact on zooplankton. Some previous studies have showed that the density of rotifers was positive correlation with pH[10], however it was mainly negative here, potentially having something to do with the increasingly serious eutrophication of urban lakes, whose water bodies were mostly alkaline (7.81±0.65), some of which being as high as 9.00, which was not conducive to the distribution of some zooplankton species. According to the different pH value of water environment, rotifers were divided into alkaline water type, facultative type and acid water type, and most of them were facultative type. Many of Lepadella, Lecane, Monostyla, Cephalodella, Diceranophorus and Trichocerca adapted to acid water. It was believed that Cladocera was also affected by pH value, which was closely related to metabolism, reproduction, development and other life activities of Cladocera. Some species were only suitable for acidic waters, such as Chydorus sphaericus that the optimal pH value for development was 5.0, but most Cladocera generally had a suitable pH range.

| Abundance(ind·L⁻¹) | SS(mg·L⁻¹) | SD(m) | pH  |
|-------------------|-------------|-------|-----|
| Rotifer           | 0.353*      | -0.297*| -0.248 |
| Cladocera         | 0.168       | 0.006 | -0.186 |
| Copepoda          | 0.472**     | -0.144 | -0.153 |
| Nauplius          | 0.292*      | 0.057 | -0.053 |
| Total             | 0.404**     | -0.242 | -0.237 |

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

5. Conclusion

During the sampling period, the water temperature of city lakes in Lingnan was between 26.5 °C and
32.30 °C, and the average water temperature was (30.12±1.25)°C. The results showed that the species composition and abundance of rotifers were dominated by Brachionus, Trichocerca and Lecane, which were distributed in tropical and subtropical areas. The low abundance of Cladocera was also affected by the water temperature. Water temperature was an important factor affecting the horizontal distribution of zooplankton.

There was a significant positive correlation between the total abundance of zooplankton and the content of chlorophyll (r=0.426, P<0.01), among which there was a significant positive correlation between the abundance of rotifer and the content of chlorophyll (r=0.534, P<0.01), the correlation between Cladocera and chlorophyll content was not obvious which needed to be further studied. The total abundance of zooplankton was positively correlated with the content of suspended matter, and negatively correlated with transparency and pH. It should be paid more attention to the situation that the small Cladocera and rotifer were the main zooplankton in the tropical shallow water urban lakes.

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