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Short communication

# No impacts of microcystins on wild freshwater snail *Bellamya Aeruginosa* fecundity from a eutrophic lake

Fei Qiao[a], Kun Lei[a], Xuemei Han[a], Zhanliang Wei[a], Xingru Zhao[a], Lihui An[a,*], Gerald A. LeBlanc[b]

[a] State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences, Beijing 100012, China
[b] Department of Biological Sciences, North Carolina State University, Raleigh, NC, 27606, USA

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ABSTRACT

The preliminary investigation at shoreline along Taihu lake with different degrees of eutrophication status found no significant relationship between the microcystin-LR concentrations and the freshwater snail *Bellamya aeruginosa* fecundity or the abundance of wild freshwater snails. To further confirm the impact of eutrophication on the reproductive ability of snails, ecological mesocosm experiments were employed at four sites in Taihu lake during the algal blooming period, and no significant relationship was also found between MC-LR concentrations and snail fecundity. These results implied that eutrophication does not negatively or positive affect snail fecundity in Taihu Lake, a typical eutrophication lake in China.

## 1. Introduction

Eutrophication, characterized by excessive algal growth, has become a global environmental problem in freshwater lakes, ponds and reservoirs, from the Great Lakes of North America to Taihu Lake in China, even in Lake Victoria in Africa (Smith, 2003). Its deleterious consequences on biodiversity are well documented for marine and freshwater bodies (Qin et al., 2013), for it releases various toxins by cyanobacteria, such as microcystins (MCs) which induce extensive damage in aquatic organisms (Zurawell et al., 2005).

Gastropods, inhabiting shallow littoral zones in lakes, are important components of freshwater ecosystems. As a primary consumer in aquatic ecosystems, snails are indispensable for maintaining particular ecological processes. Importantly, gastropods are regarded as sentinel species for evaluating the ecological risk caused by algae toxins (Gerard and Poullain, 2005; Lance et al., 2007). Especially, the toxicological effects of MCs on life-history traits have been observed for gastropod *via* a decrease in survival, growth and fecundity (Gerard and Poullain, 2005). And so, the episodic proliferation of cyanobacteria in a freshwater lake was associated with declines in gastropod communities over a 10-year period (Gerard et al., 2008). Such negative effects on community structure pose a threat to the stability of freshwater ecosystems.

Taihu Lake, a typical eutrophication lake in China, has undergone progressive deterioration due to increasing eutrophication (Liu et al., 2011) which disrupted the lake's ecology, such as the occurrence of the abnormal tentacle bifurcation of freshwater snail *Bellamya Aeruginosa* (Lei et al., 2017). Consequently, the toxicity of bloom-forming in eutrophic lakes might cause the benthic snail population decline, although these snails promote the recovery of eutrophic shallow lake to clear water through stimulating benthic algae (Zhang et al., 2017). Thus, to evaluate the impact of algal bloom on freshwater snail *B. aeruginosa* fecundity, the present study performed the field investigation and ecological mesocosm at shoreline sites along Taihu Lake during the algal bloom season, and it is very easy to evaluate its fecundity by counting the number of embryos in brood for *B. aeruginosa* is ovoviviparous.

## 2. Material and methods

### 2.1. Field sampling

In 2015, 33 shoreline sites along Taihu Lake were investigated using a Surber sampler in an area of about 0.2 $m^2$ (0.5 length × 0.4 width) with three replicates per site (Fig. 1), and *B. aeruginosa* was collected randomly. The number of embryos in the brood pouch was counted using a binocular microscope to assess snail fecundity. At same time, the *Chl-a* and phytoplankton community were also monitored; and about 100 mL surface water was sampled at each site for MCs analysis.

### 2.2. Mesocosm experiments

Adult snails were collected and counted from a good environmental status pond far away Taihu Lake, and then placed into mesocosm randomly (100 females and 50 males each) which was placed at four sites

* Corresponding author at: No. 8, Da-Yang-Fang, An-Wai-Bei-Yuan Road, Chao-yang District, Beijing 100012 China.
*E-mail address:* anlhui@163.com (L. An).

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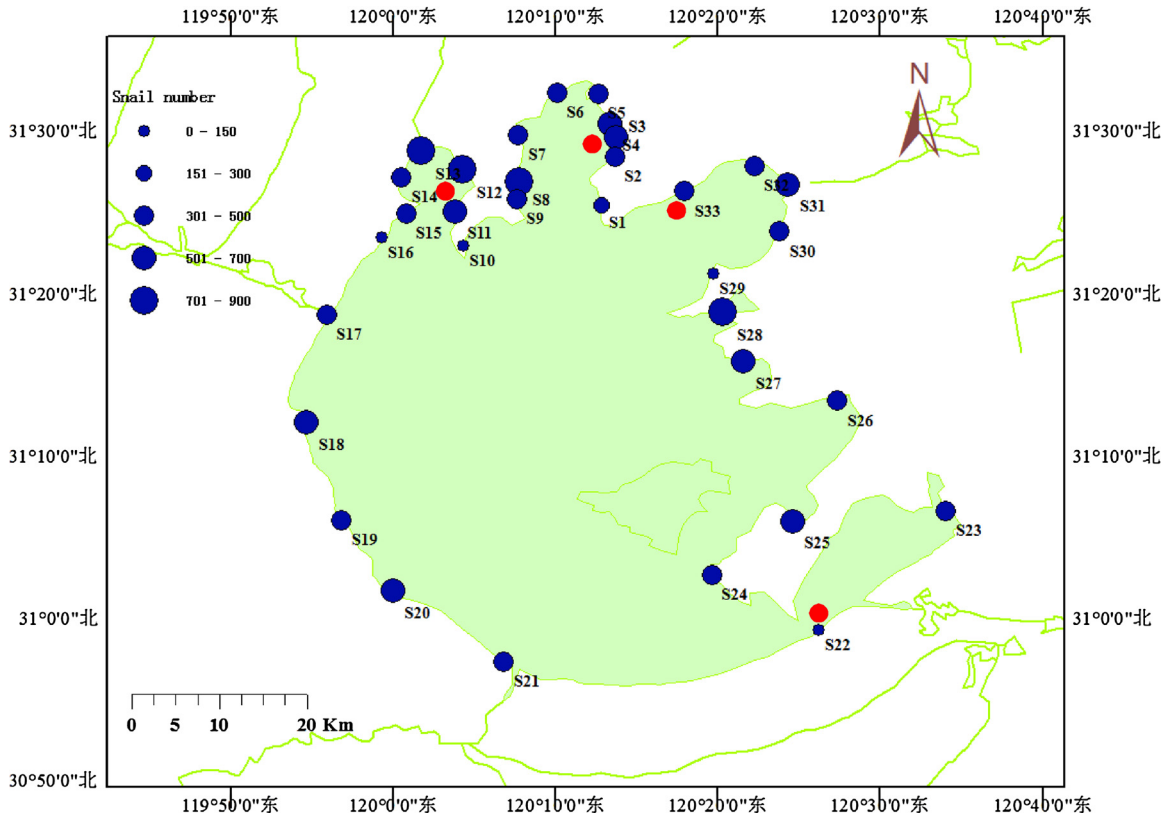


**Fig. 1.** Sampling sites for investigating wild freshwater snails (blue dots) and the mesocosm experiments (red dots) in Taihu Lake, south of China. The sizes of sampling site indicated numbers of snails collected from the sampling sites (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

in SZ, ML, ZS and GH about 2.0 km away from the shoreline (Fig. 1) during the algal bloom period, from May to September in 2016. Monthly samples were taken from each chamber to monitor water quality. At the end of the exposure for four months, the number of embryos in the adult brood pouch was counted to assess the fertility of *B. aeruginosa*.

### 2.3. MC-LR concentration analysis

MC-LR the most toxic compounds produced by cyanobacteria, was analyzed with an ACQUITY ultra performance liquid chromatography-tandem mass spectrometry (UPLC/MS/MS) system (Waters, Milford, USA) equipped with a reversed-phase sorbent column (3 cc Oasis SPE HLB, Waters, USA) on-line using a sequential elution, with a detection limit of 0.2 ng/L (Zhang et al., 2012).

### 2.4. Cyanobacteria identification

Genera and cell numbers were identified under an inverted light microscope, and the biomass was estimated from the approximate geometric volumes of each taxon, with an average of 10～30 individuals for each dominant genus or species based on the assumption.

### 2.5. Data analysis

To compare the data easily for the number of snails collected from each site, the number of embryos in the brood pouch, and the concentration of MC-LR, *Chl-a* and cyanobacterial density, Taihu Lake was divided into six regions (I～VI) based on the geographic location (Table 1). Analysis of variance (ANOVA) using SPSS 13.0 (SPSS Inc., Chicago, IL, USA) was performed to evaluate the differences of these data among regions, and a $p$-value $< 0.05$ was regarded as statistically significant.

## 3. Results and discussion

As a whole, 150–841 individuals with an average of 457 and a total of 15 105 with the average sex ratio of 2.1 were sampled from investigation sites, except for one site (S16) where no living snail was found. At the same time, the phytoplankton community profiles during the field investigation revealed that cyanobacteria, especially the *Microcystis aeruginosa,* was the dominant taxon in most of the sites sampled, with average densities of $50 \times 10^4$ cells/L to $727{,}264 \times 10^4$ cells/L, corresponding to the high biomass ranging from 0.0092～4405.25 mg/L. Interestingly, the highest concentration of MC-LR (18.41 μg/L) which was detected in all of sampling sites with an average concentration of 1.56 ± 4.22 μg/L, corresponding to the maximal biomass production of *M. aeruginosa* (4405.25 mg/L), was also observed at site S16. Furthermore, the Pearson correlation analysis showed that there was a significant positive relationship between the abundance of snails and the concentration of MC-LR ($p < 0.05$), but not the fecundity of snail from these sampling sites ($p > 0.05$), along Taihu Lake, implying that MC-LR had a negative impact on the snail survival, even to cause the snail to die for its high toxicity. This was also reported that the total mollusk abundance was significantly different before and after during the algae bloom period at highly contaminated stations where the MC-LR concentrations were as high as 47.61 μg/L (Gerard et al., 2009). When the sampling sites were divided into six regions based on the geographic location, the average number of embryos per snail in region I (13.21 ± 5.44) was also significantly higher than those in the other regions (II: 8.23 ± 3.85; III: 6.62 ± 2.35; IV: 5.95 ± 2.29; V: 5.68 ± 2.65; VI: 6.31 ± 1.67) ($p < 0.05$), and the concentrations of *Chl-a* were also significantly higher in region II than those in regions IV, V and VI ($p < 0.05$), but no statistical difference