APPLICABILITY EVALUATION IN THE PHYSIOLOGICAL ENERGETICS METHOD OF MUSSELS AS A BIOMANIPULATION TOOL

劉, 玉賢

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氏　　名　：　劉　玉　賢

論文題名　：　APPLICABILITY EVALUATION IN THE PHYSIOLOGICAL ENERGETICS METHOD OF MUSSELS AS A BIOMANIPULATION TOOL
（生理エネルギー学的指標によるバイオマニピュレーションツールとしての二枚貝の適用性評価）

区　　分　：　甲

論　文　内　容　の　要　旨

The research goals of the dissertation are directed toward the applicability evaluation in the physiological energetics method of the mussel *Anodonta woodiana* as a biomanipulation tool in Chinese Lake Taihu.

In **Chapter 1**, through literature review and the field investigation, the information of Lake Taihu was obtained. Then the alleviating eutrophication methods applied in practice and deficiency were summarized, furthermore, the research of biomanipulation methods and the application prospect of freshwater mussels were mentioned. Accordingly, the research objectives in this dissertation were proposed as: to clarify the feeding behavior of the mussel *A. woodiana* in freshwater ecosystems, especially on toxic *Microcystis* spp., which are the dominant algal species in Lake Taihu when algae blooming occurs; meanwhile, to evaluate the effect of toxic *Microcystis* spp. on *A. woodiana* in the physiological energetics method - scope for growth (SFG); furthermore, to clarify the interactions of *A. woodiana* and submerged macrophytes. All these results can contribute to our understanding of the integrated ecological role of the mussel *A. woodiana* in the eutrophic lake, in addition the applicability of the mussel *A. woodiana* as a biomanipulation tool in Lake Taihu restoration.

In **Chapter 2**, the physiological evaluation method used in this research, SFG was explained, in which the significance, calculation methods, affecting factors were summarized.

As an important part of SFG, feeding behavior and the affecting factors of mussels were examined and further discussed in **Chapter 3**. The results in this chapter indicated that the filtration rates increased as the increase of algae concentrations till the critical cell density was reached, at which the pseudofaeces were expelled; above the critical cell density, the filtration rates decreased sharply as the algae concentration increased. The mussel *A. woodiana* reached the critical cell density at 4.3×10^7 cells mL^{-1} and 3.4×10^6 cells mL^{-1}, when the temperature was 20℃ and 25℃, respectively in this experiment.

In **Chapter 4**, a comparative study was carried out on the acute physiological responses to variable microalgae diets including toxic microcystins (MCs)-producing cyanobacteria

Microcystis aeruginosa and non-toxic green algae *Scenedesmus obliquus*. The results showed that compared with the green algae *S. obliquus*, the mussel *A. woodiana* has a higher grazing ability on the toxic *M. aeruginosa*; furthermore, the effects of different algae diets on SFG of *A. woodiana* demonstrated that the toxic *M. aeruginosa* may supply 4.5 times more energy for *A. woodiana*'s potential growth than that *S. obliquus* could do.

In **Chapter 5**, the interactions between *A. woodiana* and algae blooming water were examined. The 6-day feeding responses experiment was carried out with naturally blooming pond water and the mussels in the laboratory. The results indicated that toxic *Microcystis* spp. of colony and unicell in natural eutrophic water can be removed greatly by *A. woodiana*; moreover, the toxic *Microcystis* spp. were found to supply about 1.5 times more energy for *A. woodiana*'s potential growth after 6-day exposure, thus the mussels have the strong adaptation ability when they were exposed to toxic natural eutrophic water.

In **Chapter 6**, the mussels demonstrated a strong survival ability during exposure to natural eutrophic water containing high concentrations of MCs for 12 days. In order to clarify the survival mechanisms (feeding selective and detoxification mechanisms), all the conducted experiments from **Chapter 4** to **6** were summarized. A correlation analysis between the diet characters and mussels' physiological rates was performed and the results suggested that (1) filtration selectivity factors - MCs did not restrain the feeding behavior of *A. woodiana*; instead the exorbitant initial diet concentration could inhibit the filtration rates; (2) absorption selectivity factors - probably it is the different digestive enzyme activity in *A. woodiana*'s digestive tract that induced the prefer ingestion of *M. aeruginosa* to green algae cells, indicated by about 3 times higher absorption efficiency of *M. aeruginosa* than that of the green algae cells; (3) the possible detoxification process - in the liver of mussels, through the MCLR-Cys (cysteine conjugates of MCs) formation, MCs could be detoxified and then they were transferred to kidney and were excreted in the form of ammonia. In addition, more MCs were metabolized efficiently rather than accumulated in the liver, thus the MCs toxicity effect in *A. woodiana* did not reveal.

In **Chapter 7**, the experiments were performed with the mussel *A. woodiana* combined with the submerged macrophyte *Vallisneria asiatica* to figure out the interactions between them. The results showed that (1) the beneficial effect associated with mussels culture on the aquatic ecosystem depends on having aerobic sediments and thus mussels stocking density should be in a range named "ecological carrying capacity"; (2) the presence of submerged macrophytes can supply the required aerobic condition for mussels to play the effective role as a biomanipulation tool in the eutrophic freshwaters; (3) for the restoration of submerged macrophytes in the littoral zone, the sediment characteristics, such as composition and grain sizes, as vital factors need to be taken into account; (4) turbidity caused by the wind-induced sediment disturbance can be improved significantly with the existence of mussels, which can benefit the growth of submerged macrophytes and finally increase the possibility of successful restoration.

Finally, in **Chapter 8**, the summary of the thesis and general conclusions were shown. In addition, the integrated ecological restoration method was proposed to be applied in Lake Taihu, through which the algae-dominated turbid state can be pushed into submerged macrophytes-dominated clear state in the lake.