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Zebra mussel (*Dreissena polymorpha* Pallas, 1771): the invasive bioindicator for freshwater quality?

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Abstract. In this short review we aim to discuss the advantages and disadvantages of using zebra mussel (*Dreissena polymorpha* Pallas, 1771) for the purposes of freshwater monitoring.

Key-words: zebra mussel, water, pollution.

Introduction

The main focus of aquatic toxicology studies has usually been the measurement of toxicant levels in the organism (body burden) and the observation of various correlated physiological end-points, such as body weight or survival rate in response to toxicant exposure (Broeg *et al.* 2005). In addition, according to Brinke (2017) a current aim is to combine endpoints at different levels of biological organization, molecular to individual, to gain a better vision of molecular toxicity pathways.

Bivalves have been used as bioidicators because they have several advantages in biomonitoring programs that allow to describe them as sentinel species, which as stated by Bervoets *et al.* (2005) are: they are filter-feeders, which are directly in contact with contaminated waters or sediments, and can accumulate pollutants to higher concentrations; they are also sessile, making possible a spatial and temporal assessment of polluted waters.

In this regard, the popularity of *Mytilus* spp. as environmental sentinels stems from their biological and ecological characteristics, which make them virtually ideal for pollution monitoring. Blue mussels are sessile (provide location-specific information), they are medium-sized (one individual may provide enough tissue material for chemical analysis), they form (often large) mussel beds in shallow waters from where they easily can be collected, and as they are hardy creatures they are easy to keep in culture, making them suitable for ecotoxicological laboratory exposure studies. Furthermore, blue mussels are widely used as seafood as they are present in temperate seas all around the globe (Goldberg, 1975). Therefore, *M. edulis* and *M. galloprovincialis* are already established bioindicators, which have been successfully applied in various laboratory experiments and monitoring programs with transplanted mussels, which started in early 1970s.

As there is no commonly accepted bioindicator species for freshwater aquatic ecosystems, one possible species, which recently has been considered to be the counterpart of *Mytilus* spp. in ecotoxicological studies is zebra mussel (*Dreissena polymorpha* Pallas, 1771) (Binelli *et al.*, 2015).

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Discussion

As we confirmed above, indicator species, such as macroinvertebrates are by far the most commonly used and convenient group for different observations compared to fish (Connell *et al.*, 1999). Among freshwater macroinvertebrates, zebra mussel is considered a reliable bioindicator species according to Sures *et al.* (1997). What is more, zebra mussel has been identified as an interesting non-model species for freshwater quality due to its abundance, wide distribution, sessile lifestyle, its filtering activity, which leads to high potential for pollutant accumulation, and also because it resists to variations in the external conditions (Louis *et al.*, 2020; Prud'homme *et al.*, 2020; Hani *et al.*, 2021; Baratange *et al.*, 2022).

However, we should emphasize that *D. polymorpha* as a highly invasive bivalve species, endemic for the Ponto-Caspian region, has successfully colonized a wide range of ecosystems throughout Europe and North America where it became common over wide areas. Moreover, this Dreissenid species has successfully colonized Western Europe and North America freshwater systems, engendering significant changes in ecosystems mainly by biofouling and impacting phytoplankton biomass (Cuhel & Aguilar, 2013; Bódis *et al.*, 2014; Patoka *et al.*, 2021). This makes zebra mussel challenging to use, especially in field studies with transplants, but it can be successfully applied in laboratory experiments according to many studies, including our own (Faria *et al.*, 2014; Parolini *et al.*, 2015; Kerambrun *et al.*, 2016; Yancheva *et al.*, 2017; Evariste *et al.*, 2018; Yancheva *et al.*, 2021). Besides, we consider that its relatively small size might be a serious shortcoming in terms of the multi-biomarker approach. Nonetheless, we agree with Baratange *et al.* (2022) that the physiology of *D. polymorpha* remains poorly known yet, limiting its efficient use in biomonitoring and ecotoxicology.

Conclusions

We strongly support the idea that a research priority is to gain a better understanding of the molecular toxicity pathways of pollutants in this promising model. Hence, the knowledge of zebra mussel's responses in complex exposure scenarios will be undoubtedly improved.

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