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Duckweed biomarkers for identifying toxic water contaminants?

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Abstract

Surface or ground waters can be contaminated with numerous toxic substances. The duckweeds *Lemna minor* and *Lemna gibba* are widely used for assaying waterborne toxicity to higher plants in terms of growth inhibition and photosynthetic pigment reduction. These tests cannot, however, in themselves determine the nature of the agents responsible for toxicity. Morphological, developmental, physiological, biochemical, and genetic responses of duckweeds to exposure to toxic water contaminants constitute biomarkers of toxic effect. In principle, the very detection of these biomarkers should enable the contaminants having elicited them (and being responsible for the toxicity) to be identified. However, in practice, this is severely compromised by insufficient specificity of biomarkers for their corresponding toxicants and by the lack of documentation of biomarker/toxin relationships. The present contribution illustrates the difficulties of using known water contaminant-related duckweed biomarkers to identify toxins, and discusses possibilities for achieving this goal.

Keywords Water contaminants · Toxicity testing · Duckweeds · *Lemna minor* · *Lemna gibba* · Biomarkers · Toxicant identification

Introduction

Municipal, agricultural, and industrial activities release numerous contaminants into surface or ground waters that can be harmful to organisms living in or exposed to these waters. Defined species of aquatic bacteria, invertebrates, fish, and lower and higher plants are used to test for waterborne toxicity at the various organizational levels of aquatic life. Among the aquatic higher plants, two species of the floating macrophyte family Lemnaceae, or duckweeds—*Lemna minor* and *Lemna gibba* (see Fig. 1)—are widely used for standardized toxicity testing (Mkandawire et al. 2014; Ziegler et al. 2016). These tests identify toxicity in terms of an overall deleterious effect on the duckweed. This is usually expressed in terms of the inhibition of growth as evidenced by the number, area, and/or weight of the leaf-like fronds and/or the reduction of the content of the photosynthetic pigments (the pre-requisite for growth). This is well exemplified in the investigation of the phytotoxicity of 10 heavy metals on *L. minor* (Naumann et al. 2007), although other endpoints such as root length (Gopalapillai et al. 2014) and root re-growth (Park et al. 2013) have also been suggested.

The standardized tests and other procedures approximating them have been—and continue to be—useful in determining the toxicity of all types of water contaminants to aquatic higher plants, including nutrients, metals, and numerous organic compounds. The identification of the toxicity of water contaminants is closely associated with the goal of the remediation of contaminated waters, i.e., the removal of contaminants to restore the suitability of the water for safe human use and consumption and for the support of aquatic life. Duckweeds are also admirably suited for this purpose, and their remediative value is enhanced by the manifold uses to which the biomass of the duckweeds growing on contaminated waters can be put (Ziegler et al. 2017).

Although standardized tests with duckweeds demonstrate the overall toxicity of water contaminants to aquatic higher

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