

Developmental instability
in macrophytes, *Elodea canadensis* and *Ceratophyllum demersum* from the
Muskegon Watershed,
Michigan

Jim Montante¹
Mary Tracy-Bee²
Tamara Avellon¹
R.A. Hough¹

¹Wayne State University, Detroit, MI 48202

²University of Detroit Mercy, Detroit, MI 48219

Abstract

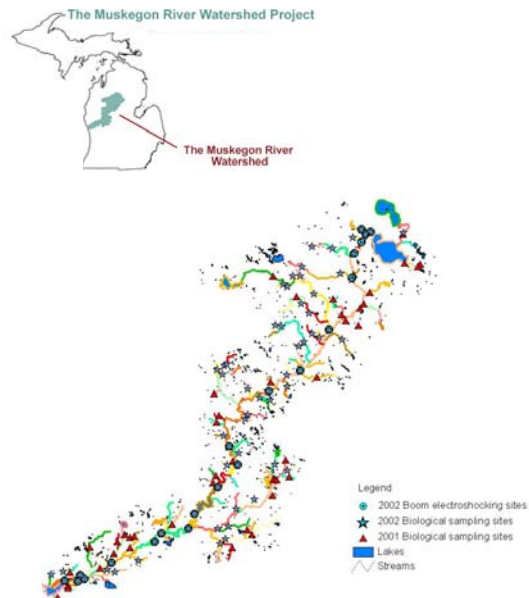
We assessed the health of two species of macrophytes at 48 sites in the Muskegon River watershed, Michigan, within which sites vary in the level of chemical toxicity and other stressors. We used developmental instability (DI) as a marker of environmental stress, an approach that is based on quantifying deviations from normal symmetry in healthy populations of organisms, in this case the radial symmetry of leaf whorls. DI was assessed as within-whorl and within-plant variance of leaf length, width, and area in *Elodea canadensis*, and as within-whorl and within-plant variance of leaflet length to first bifurcation, leaflet width, and leaflet length in distal bifurcations in *Ceratophyllum demersum*.

Significant differences between sites were found in all parameters, with several sites showing higher DI in two or more parameters, in most cases correlating with known locations of pollution and with other indicators of stress. The results support the efficacy of the DI technique in identifying localities that may contain significant toxic pollution or other stressors.

Developmental Instability

- We used developmental instability (DI) as a marker of environmental stress, an approach that is based on quantifying deviations from the typical level of **bilateral symmetry** or **within-whorl variance** present in healthy populations of these macrophytes.
- DI refers to deviations from the normal symmetry in an organism that result from stress during development.
- DI is assessed by the level and occurrence of asymmetries or variance of specified morphological traits.
- Fluctuating asymmetry, an example of a DI parameter, is a measure of the difference between left and right sides in a bilaterally symmetrical organism.
- DI has been positively correlated to exposure to various stressors.

Location of the Study



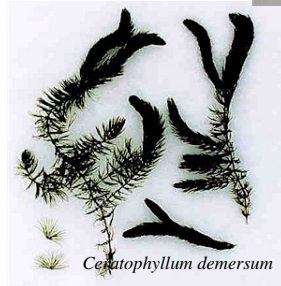
Macrophytes

We assessed developmental instability (DI) in:

- *Elodea canadensis* at 33 sites and



Elodea canadensis



Ceratophyllum demersum

- *Ceratophyllum demersum* at 34 sites throughout the watershed.

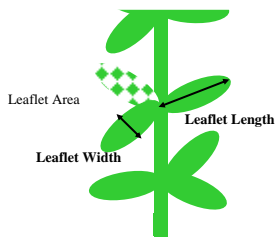
Elodea canadensis and *Ceratophyllum demersum* are submersed aquatic macrophytes with leaves occurring in whorls along the stem of the plant.

Methods

- Fifty two plants were collected from each site and returned to the lab for analyses
- Five consecutive mature whorls of each macrophytes were excised, scanned, and measured using an image analysis system, CIAS.
- Data were compared using a non-parametric Kruskal-Wallis and post-hoc Kruskal-Wallis Z test to detect any significant differences between sites. Non-parametric statistics were employed as data did not exhibit homogeneity of variance.



DI parameters



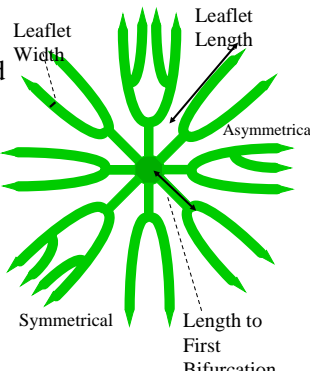
Leaflet Area
Leaflet Length
Leaflet Width

In *Elodea*, DI was measured as the within-whorl plant variance of:

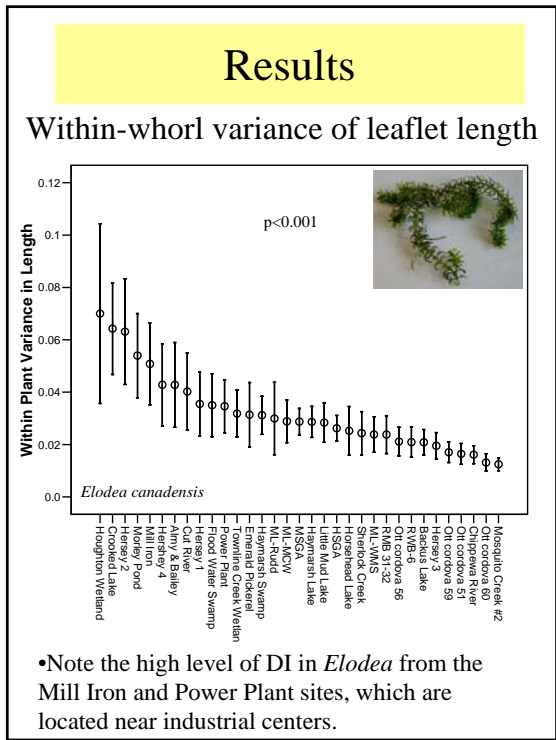
- Leaflet length
- Leaflet width
- Leaflet area

In *Ceratophyllum*, DI was measured as the within-whorl:

- Variance of distance to the first bifurcation
- Fluctuating asymmetry of
 - Leaflet length
 - Leaflet width



Leaflet Width
Leaflet Length
Asymmetrical
Symmetrical
Length to First Bifurcation



Conclusion

- Elevated levels of DI in both species appear to be associated with known stressed sites.
- Specifically, we found elevated levels of DI in *Ceratophyllum* at the Hershey 4 site, and in *Elodea* at the Crooked Lake site. Both of these locations are listed as clean-up sites under Michigan Act 451 due to creosote contamination.
- The results support the efficacy of the DI technique in identifying localities that may contain significant toxic pollution or other stressors.