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Suppression of the Invasive Plant Watermeal (*Wolffia columbiana*) by Interfering with Floatation

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ABSTRACT

After research which identified waxy cuticular pits as organs of floatation in Watermeal (*Wolffia columbiana*), this study examined the use of detergents for control by disruption of floatation. In addition to disruption of floatation, treatment with the detergent Tween 20 dramatically increased the infection of plants by natural fungi. Most *Wolffia* plants grown under conditions similar to natural conditions formed clumps, sank and died within 5 days when exposed to 0.1% Tween 20 by a combined mechanism of chemical and biological control. This study describes a method for control of Watermeal which depends on enabling natural fungi to opportunistically attack these plants, once their floatation is disrupted by low concentrations of relatively non-toxic detergents. This method may be developed to use low toxicity detergents as a method of control for floating nuisance plants in urban environments.

Key words: *Wolffia columbiana*, invasive, watermeal, detergent, biological control

INTRODUCTION

Eutrophication is a destructive process that is often seen in lakes overtaken by residential development and associated increases in fertilization, erosion of tributaries and the erection of engineering works that prevent efficient flushing (Nixon, 1995). Members of the Lemnaceae (duckweeds), including Watermeal (*Wolffia* sp.) have long been recognized as important members of aquatic plant communities and a perennial unsolved problem of water plant management (Alexander *et al*., 2008; Les *et al*., 2002) and are common members of eutrophic systems (Santamaria, 2002; Frédéric *et al*., 2006). Most Watermeal reproduction is vegetative (Frédéric *et al*., 2006; Cayuela *et al*., 2007) with an average *in vitro* doubling time of approximately 17 days (Bernard *et al*., 1990), allowing for rapid and invasive growth. Therefore, duckweeds periodically form large continuous mats on the surface of ponds and lakes which prevent penetration of light to lower levels. This causes death and decay of plants lower in the water, accelerating eutrophication and production of nuisance gases. Godfrey Lake in New Jersey is formed from a freshwater stream and reed bed system that has been separated from salt marshes by two causeways (Fig. 1). This lake is part of a residential district and is periodically covered by a mat of waterweeds, predominantly the watermeal *Wolffia columbiana*.

Watermeal are very simple angiosperms with few gross anatomical features. Although, some varieties have been studied as model plants, few physiological details relevant to its natural habitat or ecological interactions are known. Distribution by floating is a key feature of watermeal ecology and White and Wise (1998) have suggested that flotation is achieved by a mechanism involving

surface tension interactions between cuticle and pond water. However, this recent study has identified waxy cuticular pits which underlay adaxial stomata as organs of floatation in *Wolffia columbiana*.

Control of watermeal may be achieved using herbicides such as Fluridone (Kay, 1991), however, restrictions and strong public opinion in urban environments may make the use of such chemicals difficult. Observations by Kay (1991) suggested the surfactant rather than the expected active compound in herbicide preparations may play a role on suppression of the watermeal *W. columbiana* and to confirm this using low toxicity detergents for control by disruption of floatation. Tween 20 is amenable to remediation and therefore suitable for use in the inland waterways of New Jersey.

MATERIALS AND METHODS

Chemical and physical parameters in Godfrey Lake, New Jersey, were measured by wading into the lake and using an automatic chemical analysis device i.e., a YSI 6600 EDS data sonde equipped with multiple sensors. Measurements of water temperature, salinity, dissolved oxygen and pH were made along two transects (Fig. 1). The sensor was placed at the transect points defined in Fig. 1, the physical parameters water temperature, salinity, dissolved oxygen and pH were measured, then the sensor moved to the next transect point and measurement repeated. Samples of *W. columbiana* were collected from Godfrey Lake during May 2008 and used to initiate tank colonies in the Monmouth University Laboratory. Plants from tanks were then transferred to a series of 25 mL conical flasks containing Godfrey Lake water under 19 μE m^{-2} sec^{-1} from fluorescent lamps which approximated environmental conditions. Dilute Tween 20 was added to flasks in order to create the

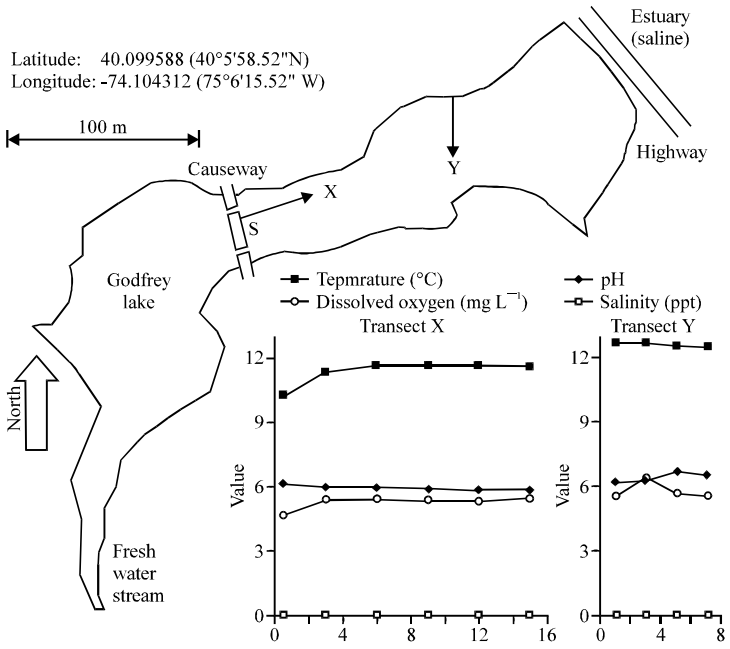

Fig. 1: The location and environmental parameters of Godfrey Lake. The Lake is well mixed as shown by two transects with measurements for temperature (°C), pH, dissolved oxygen (mg L^{-1}) and salinity (ppt)

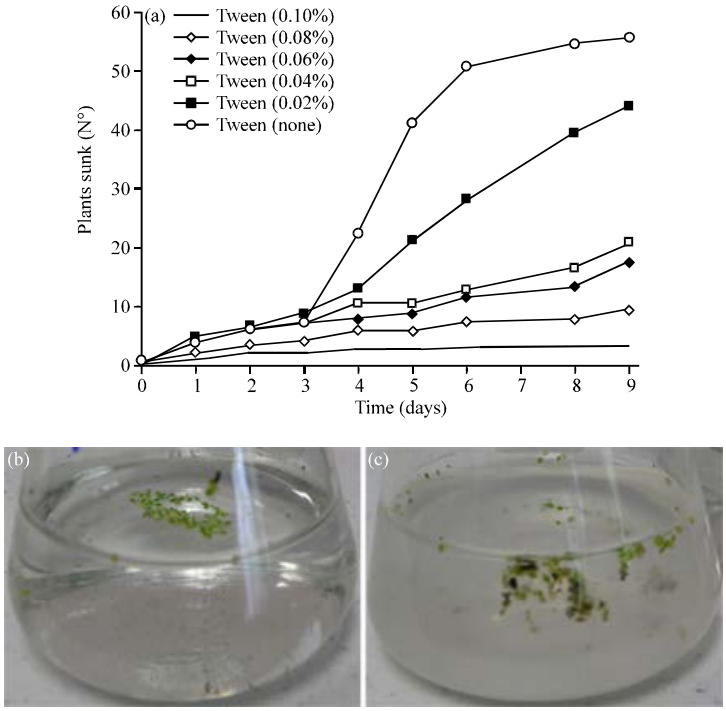

Fig. 2: (a) *W. columbiana* were incubated in 25 mL Godfrey Lake water supplemented with small amounts of the detergent Tween 20. Natural shaded daylight (19 μE m^{-2} sec^{-1}) was used and sunk plants counted periodically. Treatments were in quintuplicate, i.e. a total of thirty flasks were used, then averages calculated. (b) Typical flask of *W. columbiana* in plain Godfrey Lake water. Most are healthy and floating. (c) Typical flask of *W. columbiana* in Godfrey Lake water plus 0.1% v/v Tween 20. By day five most are beneath the meniscus and entangled in hyphae

range of concentrations from 0 to 0.1% v/v Tween 20 in quintuplicate as described in Fig. 2. Volume was made up to 25 mL using Godfrey Lake water and a uniform amount of *W. columbiana* added by spooning with a disposable spatula i.e., 1 cm^2 of floating plant material. Incubation was continued with periodic inspection and numbers of *W. columbiana* were counted as they sank (Fig. 2a-c).

RESULTS AND DISCUSSION

Many herbicide preparations contain detergents to dissolve hydrophobic components and wet plants to ensure efficient absorption of active compounds from a soapy solution that contacts all parts of plants (Showell, 2005). It is assumed that the herbicide is the effective compound and that the water or detergent plays only the minor role of increasing efficiency of herbicide delivery. However, aquatic plants occupy a special situation not usually considered in the formulation of herbicide preparations. Aquatic plants may sink then decay and are particularly dependent on surface tension to keep in contact with the atmosphere, making them vulnerable to detergents, which reduce surface tension (Kay, 1991).

Chemical and physical characterization of Godfrey Lake shows that it is a typical Pine Barrens lake with low salinity and pH suitable for rapid growth of *Wolffia columbiana* (Fig. 1). Treatment

of Watermeal with Tween 20 confirmed that detergents accelerate watermeal sinking (Fig. 2a). In addition, an unexpected result was seen. Water fungi which were previously commensal proliferated and watermeal plants were entangled in clumps as they submerged (Fig. 2b, c). These fungi were stained with Methylene blue and examined under bright field microscopy. No spores but septa were seen in hyphae that invaded plant tissue. It is assumed that detergents compromised the protective cuticle and allowed opportunistic fungi to flourish at the expense of these plants. This effect was seen for concentrations of Tween 20 from 0.04 to 0.01% v/v but was marked for 0.08% v/v and 0.10% v/v Tween 20 where counting of individual plants became difficult after 4 days (Fig. 2a).

Many of the herbicides currently used to control duckweed are harmful to people (Michel *et al*., 2004). In contrast, some detergents have comparatively low toxicity (Desalva, 1982). This phenomenon may be further developed as a method of control for floating nuisance plants in urban environments; even the United States Food and Drug Administration has granted generally regarded as safe status to several detergents such as stearic acid (USFDA, 2009). The procedure depends on altering the interactions of watermeal with other species, in particular water fungi, by compromising their defensive cuticle. Wetting and clump formation is promoted and watermeal are weighted down then sink. Once sunk, watermeal will not shade other plants and may be subject to the decay processes they would otherwise inflict on others.

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John Tiedemann is an inspiration to us all.

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