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Integrated control of *Eichhornia crassipes* by using insects and plant pathogens in Mexico

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Abstract

Eichhornia crassipes management by using insects and plant pathogens was carried out in a small reservoir in Mexico. The total reservoir area was 7 ha and the area covered with water hyacinth was around 3 ha. A total of 9800 insects of *Neochetina eichhorniae* and *Neochetina bruchi* were released in the reservoir. One month after insect establishment, two aspersions of *Cercospora piaropi* and *Acremonium zonatum* (fungal plant pathogens) were applied. After 2 months of the described combined biocontrol application, a fresh weight reduction of 29% was observed, as well as a diminution of 59% in the number of plants per square meter. Additional observed results were a 65% reduction in the number of green leaves per plant and 85% reduction in the number of new ramets. In a period of time of 3 months the reservoir was completely free of *E. crassipes*. It is believed that some other conditions contributed to *E. crassipes* control such as the phenological stage of plants and weather conditions.

Keywords: Biological control; *Eichhornia crassipes*; *Neochetina*; *Cercospora piaropi*; *Acremonium zonatum*

1. Introduction

Water hyacinth (*Eichhornia crassipes* (Martius) Solms), with a geographical origin in South America, continues to be one of the most prolific aquatic weeds in the world. In Mexico, more than 40,000 ha of reservoirs, lakes, canals and drains are infested with *E. crassipes*. This weed was probably introduced in Mexico in the early 1900s (Novelo, 1996). Chemical and mechanical control methods have been used to manage *E. crassipes*, but these methods have resulted expensive and unsatisfactory because many repeated applications have been needed (Gutiérrez et al., 1994). *E. crassipes* control difficulties are related to the weed's rapid growth rate and its ability to reinfest via the seed bank or by flood-borne plants. For these reasons, the only long-term and sustainable solution is the application of an integrated approach to *E. crassipes* management in which biological control agents can play a key role.

The host-specific weevils *Neochetina eichhorniae* (Warner) and *Neochetina bruchi* (Hustache) have been used as biological agents for controlling *E. crassipes* (Harley, 1990). *N. eichhorniae* was introduced in Mexico from the US in the late1970s (Bennet, 1984). However, other reports have indicated its presence in some Mexican water bodies as early as 1967 (O'Brien, 1976). Another three *E. crassipes*-specific insects have been observed in Mexico, these are *Sameodes albiguttalis* (Warren), *Cornops aquaticum* (Bruner) and *Orthogalumna terebrantis* (Wallwork), all of them occur naturally in water bodies. Although there is not evidence of their origin source in Mexico, they could have come accompanying the water hyacinth introduction in the past (Gutiérrez López et al., 1996). However, insects alone have not generally caused extensive damage (Perkins, 1978; Center et al., 1982; Martínez et al., 2001) but their effects are enhanced when they are applied in combination with plant pathogens (Charudattan et al., 1976; Galbraith, 1987). Several highly virulent pathogens of *E. crassipes* have been studied as promising candidates for *E. crassipes* control (Charudattan, 1996). Among them, *Cercospora piaropi* and *Acremonium zonatum* have shown a high level

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of virulence and aggressiveness necessary for controlling *E. crassipes* (Martínez and Charudattan, 1998; Martínez and Gutierrez, 2001). This paper describes the use of *N. eichhorniae* and *N. bruchi*, host-specific herbivorous weevil species in combination with indigenous plant pathogens for controlling *E. crassipes*.

2. Materials and methods

2.1. Insects collects

N. bruchi: After obtaining permission from The Mexican Plant Protection Service, 1200 adults of *N. bruchi* were imported from the USDA Aquatic Plant Management Laboratory in Fort Lauderdale, Florida, USA, and put into quarantine (Martínez et al., 2001).

N. eichhorniae: As mentioned before, *N. eichhorniae* is an organism broadly distributed in Mexico, then 2000 adults of *N. eichhorniae* were collected in the Chapala Lake, located at the Northwest of Mexico, to be release in the Cruz Pintada reservoir alongside with *N. bruchi* insects.

2.2. Sanitary inspection

In order to detect possible pathogen infection, due to fungi, bacteria, microsporidia or nematodes, a fresh sample of 100 young adults and larvae of *N. bruchi* and *N. eichhorniae*, coming from the first, second and third generation and obtained in quarantine conditions, were analyzed according to the procedures described by Poinar and Thomas (1984).

2.3. Mass rearing

The just fifth day harvested third generation of *Neochetina* spp. was used for mass production. 80 females and 80 males of *N. bruchi* and *N. eichhorniae* were placed in tanks of 2 m^2 (80 plants of *E. crassipes*/thank). Five days later, the adults were removed. In order to prevent insects' escape, tanks were covered with a greenhouse shade cloth. Each *Neochetina* species was rearing separately. Within 64–75 days afterwards the new insect colony was harvested twice a week. According to the methodology described by Poinar and Thomas (1984), a sample of 100 adults and larvae from each harvest was analyzed to detect pathogens.

A sample of 100 females from each harvest was analyzed to ascertain the population reproductive capacity using a physiological age-grading system (Grodowitz et al., 1997).

2.4. Plant pathogens

In order to identify the indigenous fungal pathogens of water hyacinth that could be used as mycoherbicides, *E. crassipes* plants with disease symptoms were collected during the rainy season in 46 infested sites, from the south and the central part of Mexico (Martínez and Charudattan, 1998). According to their cultural and morphological characteristics, two pathogens were identified as potential biocontrol agents of *E. crassipes*: *Cercospora piaropi* and *A. zonatum*. Following Koch's postulates, isolated strains were tested to establish their pathogenicity and their host range to *E. crassipes* (Martínez and Charudattan, 1998; Martínez and Gutiérrez, 2001).

Mexican indigenous strain of *Cercospora piaropi* (Mx-WH-15.1) and *A. zonatum* (Mx-WH-26), were grown on potato-dextrose broth supplemented with 0.5% yeast extract (Acumedia Manufacturers, Baltimore, USA) in sterilized gas permeable microboxes of clear polypropylene (Combiness, Gent, Belgium). Microboxes were maintained at room temperature (25 ± 2 °C).

2.5. Study area

For the experimental application of insects and plant pathogens, a small reservoir, named Cruz Pintada (Table 1), located in the Morelos State in the central part of Mexico was selected (Fig. 1). The reservoir area is approximately of 7 ha, and *E. crassipes* covered around 3 ha of the flooded area. The study was carried out in agreement with The Mexican Plant Protection Service and involved municipal authorities. Cruz Pintada reservoir was

Table 1
Cruz Pintada Reservoir, Huautla Morelos, México

Main features			
Geographical conditions		Climatic conditions	
Altitude (meters above sea level)	1100	Climate (AwO(w)(e)g)[a]	Tropical warm and moist
Latitude N	18°30′37″	Annual average temperature	24.3 °C
Longitude W	99°01′10″	Annual precipitation	885 mm
		Trophic level	Eutrophic

[a]Köppen climate classification, modified by García (1988).

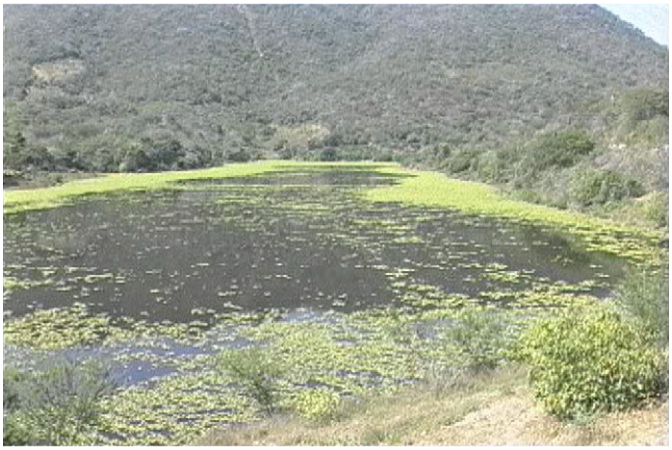

Fig. 1. Cruz Pintada reservoir before biocontrol.