NATURALIZATION AND EXTIRPATION OF WATER HYACINTH (*EICHHORNIA CRASSIPES*, PONTEDERIACEAE) IN SOUTHWESTERN ARKANSAS, U.S.A.

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ABSTRACT

Southern Arkansas appears to be at the edge of the potential range for naturalization of the water hyacinth, *Eichhornia crassipes* (Martius) Solms, due to the cold intolerance exhibited by the plant. A population discovered growing in DeGray Lake, Clark County, Arkansas, was examined from 2002–2003 to determine whether the population could survive after the freezes common during winter. The population was of particular interest because it had become rooted and remained submerged with higher lake levels during the surface freezes of winter. Rosettes that fragmented from the population established new growth during the next growing season, but fluctuating lake levels eventually stranded this growth and caused extirpation of the population.

RESUMEN

Arkansas meridional parece estar en la frontera del rango potencial para la naturalización del jacinto de agua, *Eichhornia crassipes* (Martius) Solms, debido a la intolerancia al frío exhibida por la planta. Una población se descubrió creciendo en el Lago DeGray, Condado de Clark, Arkansas, se examinó entre 2002–2003 para determinar si la población podría sobrevivir después de las heladas comunes durante el invierno. La población era de interés particular porque había llegado a arraigar y quedaba sumergida con los niveles más altos de lago durante las congelaciones de la superficie en invierno. Rosetas que se fragmentaron de la población tuvieron crecimiento nuevo en la siguiente estación de crecimiento, pero los niveles fluctuantes del lago desfavorecieron finalmente este crecimiento y causaron la extinción de la población.

INTRODUCTION

Eichhornia crassipes (Martius) Solms (water hyacinth) is one of two naturalized species of *Eichhornia* found in the United States (Horn 2002; Wunderlin 1998). Water hyacinth is native to tropical South America, specifically Amazonia (Barrett & Forno 1982). Water hyacinth now occurs in over 50 countries across five continents (Barrett 1989). It is believed that *Eichhornia* was introduced into the United States at a Centennial Exposition at New Orleans in 1884 (Penfund & Earle 1948). It is one of the most aggressive aquatic weeds in the tropics, doubling its population as quickly as every 11–18 days (Penfund & Earle 1948). Further, *Eichhornia* is known to produce physiological changes to the aquatic environment (Center & Spencer 1981; Fitzsimmons & Velljos 1986; Penfund & Earle 1948; Ultsch 1973). Seed production in temperate regions is usually only about one-half of that in the tropics, primarily because of differences in levels of insect visitation (Barrett 1980).

Eichhornia crassipes is only marginally cold hardy and is completely destroyed when the rhizome is exposed to temperatures at or below -5°C for 12 or more hours (Penfund & Earle 1948). Water hyacinth should not reliably establish in areas where these temperature conditions occur annually. In southwestern Arkansas, air temperatures reach this level for several days during most winters, which likely would limit the yearly regrowth of populations of *Eichhornia*.

However, a population of *Eichhornia crassipes* was discovered in a cove of DeGray Lake, Clark County, Arkansas on 28 January 2002. Living rosettes with broken stolons were discovered along the north shoreline, and a search to reveal the source of these usually floating plants led to the discovery of the population submerged in the lake waters. We followed the fate of this population, to determine whether the submerged condition would allow survival through the winter due to protection from freezing. It was presumed that the typically clear water would allow adequate photosynthesis to carry the population until the next growing season.

METHODS

The source of the original established population was not known. Upon further search, the only locality found supporting plants was the initial discovery along the north shore of the cove. Prevailing winds from the south presumably pushed floating rosettes into the north shore of the cove and effected establishment at the site. We assumed that the population was established during the previous summer. Numerous old inflorescences were discovered still attached to the rosettes of the population.

We returned to the site on several occasions during 2002 to determine the fate of the population. Water temperature (surface and at one meter) and depth of the population was measured when possible.

During 2002, several rosettes collected from the field site were grown in the lab and in a small plastic outdoor pond to determine whether the plants would flower and produce viable seed. With the onset of winter 2003, a few of these rosettes were planted in pots and submerged to determine whether such overwintering plants would produce break-away rosettes that would establish a new population during spring.

RESULTS

The submerged lake population on 28 January 2002 had rosettes of 15–20 cm width. The water depth at the location of the deepest specimens (the water in the cove was perpetually clear, allowing us to see the plants) was 90 and 107 cm, but most rosettes were located at a depth of 80–85 cm. The widest portion of the population (about 1 m wide) was located toward the head of the cove, where the slope of the substrate was more gradual and the water was shallow, but most of the population occurred in a strip about 1/2 m wide by 80 m long along the contour of the shoreline. Samples of the rosettes showed old inflorescences.

Plants toward the head of the cove exhibited morphology more typical of floating rosettes, but most other specimens had small floats and an upright elongate central or main stem. Temperature at the surface on 28 January was 12°C, and at one meter was 10°C.

On 15 February, the population looked as it had previously, but the lake had risen about 25 cm so that most plants were at a depth of 105–110 cm. Sediments occasionally produced by wave action were deposited as a film over the population, although sampled plants still were green. Many plants had become separated from the submerged mat and were floating near shore. Temperature was 9°C at the surface and 8°C at one meter.

On 24 April, water depth had increased again, making the rosettes impossible to see. Several rosettes that had separated and floated now were rooting into the sediments along the elevated shoreline, and 10 of these were marked to follow their survival. Several green rosettes were trapped among debris at the head of the cove, protected from waves created by boaters. Also, eight rosettes were found in the last 15 m of the cove along the southern shoreline. Temperature was 23°C at the surface and 21°C at one meter.

By 9 May, water depth had increased again, placing the population at an estimated 1.5–2 m depth. The plants rooted into the sediments and marked during the previous trip now were submerged and not relocated. Along the shoreline, we counted about 40 rosettes that recently had broken free of the original population, many at the head of the cove. One of these was partially buried in the wet sandy soil about 1.5 m from water. Most of these stranded rosettes were small (3–10 cm width), but had new growth and new roots were evident. Temperature was 23°C both at the surface and at one meter.

On 12 June, the highest water level we observed kept the original population, if still alive, submerged beyond visibility. Wind action had placed all floating rosettes (the 40 observed on 9 May) along the shore near the head of the cove. These plants now were larger (8–20 cm width), had new growth, and included clusters with side branches. The specimen partially buried in the sand on the previous date was not relocated, and all plants found were floating with the exception of a few stranded at the head of the cove by wave action. Temperature was 31°C at the surface and 29°C at one meter.

On 18 July, depth of the lake had decreased about 3/4 m and the water was very clear, but the original population of *Eichhornia* had disappeared. Only 18 rosettes of the 40 were surviving. These were found in 8 clusters all near the head of the cove in muddy to sandy areas covered by organic debris and in almost constant shade. The roots of these plants had become anchored in sediments, and now had rosettes up to 30 cm in diameter and side branches with upright leaves with small bladders. These plants were in wet soil located 5–9 m from the water of the lake. Temperature was 29.5°C at the surface and 29°C at one meter.

On 9 August, the few remaining exposed plants were drying and dying back, with the healthiest three clusters located 5, 5, and 22 m from the lake in the sandy soil of the head of the cove. Rains fell before 6 September, which apparently rejuvenated the plants and permitted new growth of leaves. Additional rain fell before a 20 September visit, and had resulted in continued new growth.

On 7 January 2003, the site was revisited with the expectation that the frost of 25 November would have killed the remaining plants that had been isolated in exposed locations along the cove. Of the last 18 rosettes, only two were relocated – dead and submerged under 20 cm of water.

In the small pond experiment, the rosettes proliferated and filled the pond during the summer, and produced numerous inflorescences from 6 August through September. However, all surface plants were killed with the first frost. The frost killed only exposed portions of 5 otherwise submerged plants. The remaining portions of these 5 plants remained green until early spring, then died. No new rosettes were able to break away, surface, and proliferate during the next spring. Seeds left in the pond and those used in greenhouse experiments failed to germinate within one year, and no germination of seeds has been discovered at the field location. It is important to note that the seeds used in our experiments were not intentionally scarified to promote laboratory germination.

DISCUSSION

A population of *Eichhornia crassipes* became established in DeGray Lake, at a northern latitude presumably marginal for this cold-intolerant plant to overwinter outdoors. The original established population survived through periods of freezing because the root system anchored the plants, not allowing them to float as the level of water in the lake rose during winter. Although the original population did not survive the entire winter, rosettes that periodically broke free and floated survived if they surfaced after the last freeze.

The higher level of water during spring deposited these surviving rosettes higher up the bank than the original population. Some survived and grew during the next season, but they became exposed and isolated from the lake as water levels dropped during summer. Because none of the originally submerged plants were observed after 18 July, none was present for future re-establishment.

From the available data, we believe that the original population was established during the summer of 2001 when the lake level was near its seasonal low. Plants grew along the shoreline, held there by the winds, and became anchored by their roots. Any plants that grew across the deeper water of the cove, and were not held by the roots as the water level rose, would have died with freezing air temperatures. This scenario would have left the observed 80 m long, 0.5–1 m wide population that followed the contour of the shoreline. This portion of the original population actually survived the winter by being submerged, and re-established and grew the following spring. However, fluctuating lake levels led to the extirpation of the population that had established.

Penfund and Earle (1948) unexpectedly observed that *Eichhornia crassipes* plants died while submerged during the winter. They felt that protection from the freezing surface temperatures would protect the plants, but argued that a lack of oxygen might have explained the death of their submerged population. Because even clear water filters light, we argue that insufficient light to the submerged plants might have precluded adequate photosynthesis. Further, water saturates with much less oxygen and carbon dioxide than is available in air, which likely contributed to the observed death of the rooted population in our study.

Eichhornia crassipes has a means of survival when a rooted population becomes inundated. Penfund and Earle (1948) found that 10 days after submergence, *E. crassipes* begins to produce an abscission layer across the rhizome just below the lowest living leaves, forms new roots just above the abscission layer, and floats to the surface. Those new rosettes could continue the existence of the population if surface conditions were within the range of tolerance.

Seedlings of *E. crassipes* can survive submergence via the same mechanism (Penfund & Earle 1948; Robertson & Thein 1932). Seeds of *E. crassipes* only germinate when exposed to air, and thus seeds that germinate on areas where water has receded could become rooted and attached into the soil substrate, and subsequently submerged if the water level of the lake rises. We did not observe seedling development in our field or lab studies, so we found no evidence that re-establishment would occur by those means at our site.

We believe that this species would be able to survive at our site if the seasonal high and low water levels were less different, or if the relative timing of lake fluctuation and freezes afforded protection. Thus, submerged plants would have a greater chance of surviving longer into the winter and spring, and separating rosettes would not meet high water and be placed too far away from the lake to undergo the rapid growth possible during summer. The present conditions appear to help prevent the long-term establishment of this exotic plant at this site.

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