Creeping Water Primrose (*Ludwigia hexapetala*) and *Culex*: An Invasion of the Laguna de Santa Rosa Wetlands

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INTRODUCTION

The Laguna de Santa Rosa (the Laguna) is an extensive wetland ecosystem located in Sonoma County that consists of a main channel fourteen-miles in length and a 7,000-acre floodplain. The Laguna has a mosaic of seasonal wetlands and vernal pools, is the largest freshwater marsh in Northern California, and drains a watershed of 160,000 acres including five cities. The Laguna ecosystem has been invaded by an alien aquatic plant *Ludwigia hexapetala* (Hooker & Arnott) Zardini, Gu & Raven, commonly known as creeping water primrose. *L. hexapetala* has completely covered an approximate three-mile section of the Laguna main channel and a large portion of the Laguna floodplain totaling approximately 1,452 acres.

In summer 2002, the Marin/Sonoma Mosquito & Vector Control District (MSMVCD) received multiple service requests for abundant mosquito problems from private property owners living in the Laguna floodplain. Adult mosquito surveillance conducted at the edge of the Laguna riparian corridor using Faye traps, indicated *Culex erythrothorax* Dyar and *Culiseta particeps* (Adams) were present in large numbers. Operations staff cut their way through dense riparian corridor to reach the Laguna main channel to sample larval populations. In the main channel it was observed that *Ludwigia* was at 100% cover and standing 5.5 feet off of the water surface. It was also observed that when the *Ludwigia* was disturbed, *C. erythrothorax* mosquitoes emerged in large numbers. The suspicion was *Ludwigia* was providing habitat for *Cx. erythrothorax* larvae and adults.

ACCESS

Access into the Laguna through the dense stand of *Ludwigia* was especially difficult and problematic (Figure 1). MSMVCD operations staff tested several different types of equipment in the Laguna to gain access. Argo Conquest® and Argo Centaur® amphibious vehicles were useful in portions of the Laguna with moderate *Ludwigia* density, shallow water, and minimal sediment. When sediment was deep or the Argos floated, the vehicles were very difficult to maneuver and would get stuck.

Kayaks were useful for accessing areas in the Laguna with moderate to dense *Ludwigia*. In areas with the densest *Ludwigia* canopy cover and root masses, the kayaks were physically exhausting to propel and maneuver.

In late summer of 2003 MSMVCD purchased an airboat (Diamondback Airboats, Cocoa, FL.). Throughout the fall and winter 2003/2004 the airboat enabled MSMVCD staff to access previously unreachable areas of the Laguna (Figure 2). The airboat has potential to be useful as a surveillance platform, as well as a vehicle for larvaciding in the Laguna and several other wetlands in Marin and Sonoma County.

Figure 1. Marin/Sonoma Mosquito & Vector Control Operations staff wading through *Ludwigia* to access the Laguna de Santa Rosa.

SURVEILLANCE

Larval mosquito surveillance within the *Ludwigia* was difficult, frustrating, and at times dangerous. To wade through *Ludwigia* canopy cover, intertwined root masses, and thick sediment was physically challenging and exhausting. Moving through *Ludwigia* was dangerous in deep water and when negotiating numerous submerged obstacles.

Obtaining larval dip samples through *Ludwigia* root masses was problematic and time consuming. Disturbed *Ludwigia* roots sent shock waves across the water surface 10 to 20 feet in every direction and forcing a dipper through the root mass was difficult to impossible. Bio-Quip® mosquito larval traps, placed throughout the Laguna, were unsuccessful in attracting and capturing mosquito larvae in *Ludwigia*. Given the difficulty of sampling larvae from the Laguna, dry ice baited-Faye traps were the most efficient and effective means of sampling mosquito populations. Pyramid style

Figure 2. Marin/Sonoma Mosquito & Vector Control District's airboat traveling in the main channel of the Laguna de Santa Rosa over *Ludwigia*.

emergence traps (Walton et. al. 1999) placed in dense *Ludwigia* were unsuccessful in capturing emerging adult mosquitoes.

Larval and adult mosquito surveillance results showed an abundance of *Cx. erythrothorax*, *Culex pipiens* Linnaeus, *Culex tarsalis* Coquillett, and *Cs. particeps* were being produced in the *Ludwigia* habitat within the Laguna. The presence of *C. pipiens* was surprising to MSMVCD staff and suggested poor water quality in the Laguna.

LARVACIDING

Applying larvacide to the Laguna was an issue that underwent lengthy discussion and consideration amongst MSMVCD staff. Difficult access to the Laguna, limited success with equipment, safety concern, potential penetration and effectiveness of larvacides in the *Ludwigia* habitat, and cost effectiveness of larvacide application were all issues that were deliberated. It was decided that on August 12, 2003 MSMVCD would larvacide the Laguna by helicopter.

Methoprene:

Methoprene (Altosid XRG®) was the larvacide used for the first helicopter treatment of the Laguna. The XRG formulation was selected for its granular properties to penetrate dense stands of *Ludwigia*. It was also selected for its potential to provide long-term twenty-one day control.

MSMVCD treated 102 acres in the Laguna with XRG at the label rate of 20 lb./acre. A total of 2,040 lb. of XRG was applied to the Laguna, at a cost of $170/ acre with a total cost of $17,340, excluding helicopter time.

Turkey sized (12.0 in. x 16.5 in.) roasting tins were placed below the *Ludwigia* canopy in several locations within the treatment area to evaluate XRG penetration of *Ludwigia*. Results showed all roasting tins contained large numbers of XRG granules. Post treatment observations indicated XRG granules did not adhere to *Ludwigia* canopy or roots.

A small number (approximately 150) of pupae were sampled post treatment and brought back to the laboratory for observation. There were pupae in the lab that died or hatched as abnormal adults, however, there were also pupae that hatched as normal adults. Healthy pupae and a continuous abundance of adult mosquitoes were also observed in the field after the XRG treatment. Three weeks post treatment Faye trap results indicated an increase in adult mosquito populations within the treated area.

Bacillus sphaericus (Vectolex CG):

The XRG treatment of the Laguna did not result in the desired level of mosquito control. MSMVCD management realized that the mosquito breeding cycle in the Laguna needed to be broken quickly. Pressure was also being placed by the media and the public to break the mosquito breeding cycle in the Laguna in fear of the potential arrival of West Nile virus. MSMVCD management decided on a second larvacide application to the Laguna by helicopter using Vectolex CG® (CG). CG, like XRG, was selected because of its granular properties to penetrate dense *Ludwigia* canopy and root structures. CG with *Bacillus sphaericus* as the active ingredient also provided potential for rapid control and for the bacteria to recycle in the mosquito populations in the Laguna, thus, providing long-term control. MSMVCD treated 112 acres in the Laguna at the label rate of 20 lb./acre. A total of 2,240 lb. of CG was applied at a cost $85/ acre with a total cost of $9,520.

Glue boards (5.0 in. x 10.5 in.) were placed above and below the *Ludwigia* canopy to evaluate CG penetration. Post-treatment results showed a thirty percent difference in the amount of CG granules in glue boards at the top of the canopy compared to glue boards at the bottom of the canopy. Post-treatment it was observed that CG granules had adhered to *Ludwigia* leaves and stems (Figure 3). The helicopter pilot flew over the treatment area for a second

Figure 3. Vectolex CG® adhering to a *Ludwigia* leaf.

time, as low as possible, and used rotor wash to shake CG granules from the *Ludwigia* to the water surface. Field observations indicated that this method worked quite well.

Two plots (10.0 ft. x 10.0 ft.) were established prior to the CG application to evaluate pre- and post-treatment larval abundance. Plot one showed an average of sixteen larvae per dip pre-treatment and zero larvae per dip post-treatment for twenty-five dips. Plot two showed an average of three larvae per dip pre-treatment and zero larvae per dip post-treatment for twenty-five dips. A set of Argo tracks existed in the treatment area with *Ludwigia* pushed below the surface of the water. Prior to the CG treatment, larvae could be readily dipped in the Argo tracks and observed by the thousands. After the CG treatment larvae could not be dipped nor observed in the Argo tracks. The CG application provided mosquito control in the Laguna for a three-week period and to the end of the mosquito-breeding season.

The situation in the Laguna de Santa Rosa is troubling from a mosquito control as well as, an ecological standpoint. The invasion of the Laguna by *Ludwigia* is a symptom of a much larger problem. The MSMVCD has sponsored an internship with Sonoma State University to study the growth dynamics, abundance, and potential control measures for *Ludwigia*. The Sonoma State intern is also studying water quality in the Laguna. The MSMVCD is also a member of the *Ludwigia* Task Force that is charged with developing a management and restoration plan for the Laguna system.

Acknowledgements

The Marin/Sonoma Mosquito & Vector Control District thanks Stephanie Whitman of Valent Biosciences and Dennis Candito of Fennimore Chemicals for their help and expertise.

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