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# FIELD ASSESSMENT OF BAYLUSCIDE TREATMENTS FOR THE CONTROL OF NEW ZEALAND MUDSNAIL *POTAMOPYRGUS ANTIPODARUM* IN A CONCRETE-LINED CANAL

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## ABSTRACT

**Survival of New Zealand mudsnail, *Potamopyrgus antipodarum,* was tested against exposure to Bayluscide$^{R}$ (active ingredient: nicolosamide) in a concrete-lined irrigation canal. Concentrations of niclosamide in water and sediment were monitored in the canal. Test snails in live cages were exposed to niclosamide concentrations of approximately 1 mg/L for eight or 17 hours. The results of this study indicate that almost complete mortality of New Zealand mudsnails is achieved at 1 mg/L for eight hours. No additional mortality was seen in the 17-hour treatments. The half-lives of niclosamide in water and sediment were 1.8 and 1.6 days, respectively.**

## INTRODUCTION

New Zealand mud snails (NZMS), *Potamopyrgus antipodarum,* were first reported in Europe during the 1800s and in North America (Idaho) in 1987. NZMS are parthenogenic livebearers and are typically 4- to 5-mm shell length at adulthood. NZMS quickly colonize habitable waters, and were discovered in California in the Owens River in 2000 and have since spread to creeks and rivers in 18 counties. NZMS have the potential to reach population densities of up to 300,000 per $m^2$ in the western United States (Richards et al. 2001) and disrupt the food chain by displacing native invertebrates (Kerans et al. 2005). Fish populations can decline as a consequence. Their ability to reach high densities suggests that they might have the potential to impede water delivery systems.

The Putah Creek South Canal is a concrete canal that is used to deliver water to agricultural users and domestic water treatment plants. NZMS were first discovered in the canal in 2005 and the population has been variable since. The Solano County Water Agency operates the canal and has funded projects to study possible control methods for the snail. Copper sulfate was tested in the canal as a treatment against NZMS during routine copper sulfate treatments for algae control (Trumbo 2008[1]). NZMS in live cages were exposed weekly for 13 weeks. The high rate of NZMS survival during the treatments

[1] Trumbo, J. 2008. Field assessment of copper sulfate treatments for the control of New Zealand Mudsnail, *Potamopyrgus antipodarum* in the Putah Creek South Canal. California Department of Fish and Game Pesticide Investigations Unit. 4 pages.

suggested that copper sulfate is not an effective treatment at the concentrations used for algae control.

Bayluscide (active ingredient: niclosamide) is a lampricide and molluscicide. Previous work by the California Department of Fish and Game (CDFG) found that when NZMS were exposed to Bayluscide in the laboratory for 4 hours and 8 hours, the 96-h $LC_{50}$ values were 1.726 mg/L and 0.423 mg/L, respectively (California Department of Fish and Game 2007[2]). In laboratory bioassays performed by Montana Fish, Wildlife, and Parks, 100% of NZMS were killed when exposed to 4 mg/L niclosamide for 12 hours[3]. Niclosamide toxicity does not appear related to temperature, however it is more toxic at lower pH values because of increased lipid solubility (Bills and Marking 1976). In order to confirm the effectiveness of Bayluscide for NZMS control in a field setting, a treatment was made in a concrete-lined canal using a concentration of 2 mg/L (as niclosamide). Water and sediment samples were collected to assess the environmental fate and persistence of Bayluscide in the canal environment. Bayluscide has been shown to break down rapidly in natural systems, with half-lives in water and sediment of 0.83 and 3.9 days, respectively (Dawson 2003).

In addition to NZMS, other invasive mollusks have been found recently in the waterways of California. Zebra mussels, *Dreisssena polymorpha,* and quagga mussels, *Dreissena rostriformis bugensis,* also have the potential to clog waterways[4]. Treatment strategies, such as use of Bayluscide, may need to be developed for these organisms as well.

## METHODS

The Allendale Canal in the Solano Irrigation District delivery system was chosen for the field trial of NZMS against Bayluscide. The treatment was performed after the end of irrigation season so that there would be no pesticide exposure to crops. Four sites were chosen to monitor snail survival and concentrations of niclosamide in water and sediment (Table 1 and Fig. 1): a control site upstream of the project (Site C) and three sites in the treatment area (Sites 1 through 3). A fifth site (application Site A) was also used to monitor Bayluscide concentrations in sediment.

NZMS were collected from Putah Creek, counted, sized, and placed in numbered live cages. A total of 50 snails of varying sizes were placed in each cage. Cages were kept at a constant temperature during transport. Cages were placed in outer atria cages and locked shut. Cages (three per site) were weighted and placed in the canal at four different sites C, 1, 2, and 3 prior to Bayluscide treatment.

The Bayluscide application was made on 15 October 2008. The emulsifiable concentrate formulation (20% active ingredient) was applied for 8 hours. Canal flows during the application period were approximately 2 cfs. A total of 14,800 ml (3.9 gallons) was used for the application. At the time of the application, discharge from the canal was blocked.

The intended application method, the use of a float box, was revised after it became clear that a 10-fold dilution of the formulated product did not mix readily with water. This poor mixing resulted in an inability to maintain a constant flow out of the float box. The

[2] California Department of Fish and Game. 2007. Aquatic Toxicology Laboratory Report P-2454. Elk Grove, California.

[3] Don Skaar, Montana Fish, Wildlife, and Parks Department, personal communication.

[4] California Department of Fish and Game http://www.dfg.ca.gov/invasives/quaggamussel

float box method was replaced with the use of single nozzle boom placed across the canal. In order to maintain constant flow, the nozzle was removed allowing the pesticide mix to flow directly out of the hose. After trying several different dilutions, the following dilution and application rate was selected: 30 oz of Bayluscide mixed in 15 gals of water (approximately 1.5%) applied at a drip rate of 440 ml/10 seconds. The drip rate was checked and corrected, if necessary, every 10 minutes. The mixed material was under constant agitation and was applied at a tank pressure of 30 PSI.

Live cages were retrieved from Site 2 after 8 hours of treatment. Live cages at the other two sites and the control site were retrieved 9 hours after the treatment ended (17 hours since the beginning of treatment). Snails were rinsed from the cages into beakers for counting. Snails were considered dead if they were separated from their shells or if they did not move or attach to the beaker for 15 minutes.

Water samples were collected at Sites C, 1, 2, and 3 at 5 and 10 hours after the start of treatment and on Day 1, 2, 5, and 7. Sediment samples were taken at all sites on Days 1, 5, and 7 post-treatment. Samples were analyzed for niclosamide by the CDFG Water Pollution Control Laboratory using LC/MS.

## RESULTS

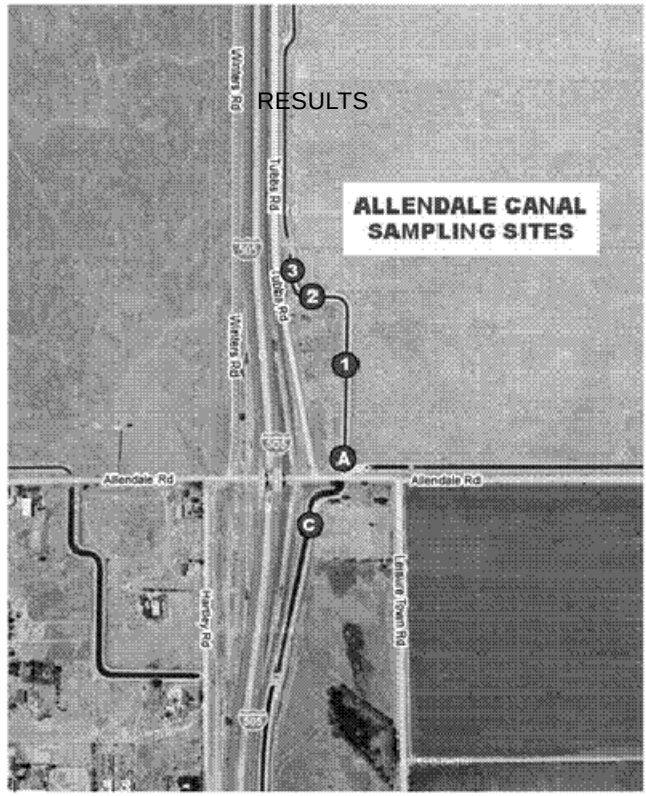


**Figure 1.** Sampling Sites on Allendale Canal. Site C = control site. Site A = application site. Sites 1 – 3 = downstream sites.

Although Bayluscide was applied with an intended concentration of 2 mg/L, the measured concentration was closer to 1 mg/L (Table 2) Niclosamide has a relatively high adsorption coefficient ($k_{oc}$) ranging from 148 to 2,213 (Dawson et al. 1986) and it is likely that it was removed from the water column by adsorption to sediment.

Snail survival was similar at the three sites on the treated canal (Table 1). Eight hours of treatment at approximately 1 mg/L provided nearly 100% mortality of test snails. Snails that survived in the treatment cages showed less movement than snails in the control cages. During the treatment of the Allendale Canal, small unidentified warm-water fish in the treatment area were observed in distress and dying a short time after exposure started. This was expected as fish and snails exhibit similar sensitivity to niclosamide.

After 7 days in water, niclosamide had degraded from approximately 1 mg/L to between 0.01 (Site 4) and 0.11 mg/L (Site 3) (Table 2). It was difficult to determine individual half-lives for the different sites, as there appeared to be additional movement of the chemical downstream for a few days after application. The half-life of niclosamide in water (average of all sites) was 1.8 days. Intralaboratory precision was determined by analyzing laboratory splits. Relative percent difference (RPD) was acceptable (<20%) in four of the five sets of split samples. Accuracy was determined by analyzing laboratory control spikes and matrix spikes. Recovery was acceptable in all four spiked samples (RPD between 70 and 130%).

Sediment half-life averaged 2.6 days for all sites. Not surprisingly, the highest concentration of niclosamide in sediment was at the site of the application (Site 5) (Table 2). Intralaboratory precision was determined by analyzing laboratory splits. RPD was acceptable (<20%) in four of the five sets of splits. Accuracy was determined by analyzing laboratory control spikes and matrix spikes. Recovery was acceptable in all four spiked samples (RPD between 70 and 130%).

**Table 1.** New Zealand Mudsnail Survival (**%**). Site 1 cages were exposed to niclosamide for 8 hours. Other sites were exposed for 17 hours.

| | Snail Survival (%) | | | |
|---|---|---|---|---|
| Cage (50 snails/cage) | Control | Site 1 | Site 2 | Site 3 |
| 1 | 100 | 0 | 4 | 0 |
| 2 | 94 | 0 | 0 | 8 |
| 3 | 100 | 6 | 2 | 0 |
| Average | 98 | 2 | 2 | 3 |

[5] Trumbo, J. 2008. Field assessment of copper sulfate treatments for the control of New Zealand Mudsnail, *Potamopyrgus antipodarum* in the Putah Creek South Canal. California Department of Fish and Game Pesticide Investigations Unit. 4 pages.

**Table 2.** Niclosamide Concentrations in Water and Sediment

| | Water (mg/L) | | | | | | Sediment (mg/g, fresh weight) | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | 5 hours | 10 hours | Day 1 | Day 2 | Day 5 | Day 7 | Day 1 | Day 5 | Day 7 |
| C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0.847 | 1.33 | 1.21 | 0.781 | 0.55 | 0.088 | 1.54 | 0.7 | 0 |
| 2 | 0.396 | 0.913 | 0.968 | 0.792 | 0.385 | 0.11 | 1.45 | 0.72 | 0.07 |
| 3 | 0.099 | 0.451 | 0.77 | 0.869 | 0.528 | 0.01 | 0.26 | 0.57 | 0 |
| A | | | | | | | 1.46 | 1.1 | 0.3 |

## DISCUSSION

Bayluscide was effective at killing NZMS at 1 mg/L for 8 hours in slowly flowing natural water. However, eradication was not complete and higher concentrations could likely be required to accomplish complete eradication. Complete eradication is desirable as survivors can quickly repopulate the habitat, possibly with more resistant individuals. Bayluscide broke down rapidly in water and sediment with half-lives of 1.8 and 2.6 days, respectively. It is likely that a higher flow rate would allow for more complete mixing, and possibly, a higher success rate.

Bayluscide shows promise in the eradication of other invasive invertebrates, such as quagga mussels and zebra mussels. Toxicity values for snails, mussels, and fish are all similar (Table 3). Of the eighteen chemicals tested for effectiveness against zebra mussel by the United States Fish and Wildlife Service, Bayluscide was among the top three most selective (Waller et al. 1993).

Other treatments have been proposed for NZMS control, such as copper sulfate and potassium permanganate. Field trials for copper sulfate control of NZMS were performed last year in the Putah South Canal and the material proved to have little effect on the snails (Trumbo 2008[5]). Potassium permanganate has been used to control invasive mollusks in water supply systems and may also be worth further analysis.

**Table 3. Toxicity values for aquatic organisms to niclosamide.**

| Organism | Genus | Toxicity range (mg/L) |
|---|---|---|
| Snail (48-h) | *Viviparus* | 57 |
| | *Oncomelania* | 64 - 78 |
| Zebra mussel (48-h) | *Dreissena* | 15 - 17 |
| Lamprey (9-h) | *Ichthyomyzon* | 30 - 40 |
| Trout (48-h) | *Oncorrhynchus* | 47 |

[5] Trumbo, J. 2008. Field assessment of copper sulfate treatments for the control of New Zealand Mudsnail, *Potamopyrgus antipodarum* in the Putah Creek South Canal. California Department of Fish and Game Pesticide Investigations Unit. 4 pages.

Future research may be able to identify the minimum effective dosage for niclosamide, as well as its efficacy against other invasive mollusks. Repeated applications should also be tested to provide complete eradication. Subsequent studies should place the test animals in clean water for at least 24 hours to determine if the effects of the treatment are reversible.

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