Preliminary Field Efficacy of Anthraquinone Repellent to Reduce Drip Irrigation Line Damage by Cottontail Rabbits

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ABSTRACT: Unmanaged cottontail rabbit populations can cause significant damage to drip irrigation tubing. Common integrated pest management strategies to reduce damage include trapping, exclusion, and repellent use. Trapping and exclusion, while effective at managing cottontail rabbits, are impractical when applied to large scale habitat restoration projects. To evaluate repellent use under these conditions, we conducted a preliminary conditioned avoidance field trial using anthraquinone applied to drip irrigation tubing installed in a riparian habitat undergoing restoration in Silverado, CA. The postingestive repellent, anthraquinone, was selected due to prior laboratory research indicating its effectiveness in inducing conditioned avoidance feeding behaviors in cottontail rabbits. Following a complete repair of the irrigation system, alternating sections of the irrigation tubing were treated. After the first treatment, there was an estimated 50.0% reduction in damaged tubing between the treated and control sections. An estimated 0.18% of the total tubing surveyed was damaged after the second treatment. Between the first and second treatments, we observed an estimated 99.5% decrease in total damaged tubing. Our results suggest that anthraquinone may be successful in reducing cottontail rabbit damage by inducing conditioned avoidance to drip irrigation line. As a preliminary study, these findings are promising and warrant future field trials to validate the use of anthraquinone as a repellant to reduce damage by cottontail rabbits.

KEY WORDS: anthraquinone, cottontail rabbit, drip irrigation, habitat restoration, repellent, *Sylvilagus audubonii*, wildlife damage

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INTRODUCTION

The desert cottontail rabbit (*Sylvilagus audubonii*) can be an economically significant pest in irrigated landscapes and nurseries in Southern California. Rabbits will depredate vulnerable nursery stock as well as damage irrigation tubing which not only causes immediate economic damage of equipment but increases risk of plant mortality in the landscape due to water stress. Rabbit damage is characterized by 45-degree-angle cuts (Ellis et al. 2006). Cuts to irrigation tubing made by rabbit incisors are easily identifiable on 3.175 mm and 6.35 mm (1/8 and 1/4 in) micro irrigation tubing due to generally complete breaks in the tubing. Rabbit damage to drip irrigation tubing can be more difficult to identify on 12.7 mm (1/2 in) poly submain tubing specifically when bites occur adjacent to one another, however, the 45-degree-angle of the cut can still be observed. The Irvine Ranch Conservancy estimated damage by cottontail rabbits to drip irrigation was in excess of $6,000 at the Lower Silverado Canyon restoration site in 2018. Damage to plants from water stress due to irrigation damage at the restoration site was also observed.

Lower Silverado Canyon is in the foothills of the Santa Ana Mountains in Southern California (33.744, -117.657) and is owned by Orange County Parks. Habitat restoration in Lower Silverado Canyon was initiated by the Irvine Ranch Conservancy (IRC) in 2013 and is currently in its sixth year of management. The project was funded by Orange County Transportation Authority under the Measure M Freeway Mitigation project and was part of IRC's long-term, landscape-scale, approach to restoring the historic Irvine Ranch. Specifically, this site provided habitat linkages from the Cleveland National Forest to portions of Santiago Canyon and the Santa Ana River watershed. Lower Silverado Canyon was heavily disturbed throughout the last 50 years; historic disturbances included gravel mining operations until the 1980's, grazing, and invasive species. Thus, active restoration was necessary to re-establish native habitat in this portion of the creek. Active restoration included 28.5 total acres of various target riparian scrub habitat types. Additionally, IRC performed targeted invasive species control over the surrounding 328 acres that comprise the subwatershed.

The primary approach to installing native habitat was large-scale container planting (over 13,000 plants) established with a drip irrigation system. Supplemental seeding was also carried out. Irrigation is extremely important in riparian habitat restoration in order to establish perennial shrubs and trees, especially in Southern California due to climate with variable rainfall and periodic droughts. Drip irrigation was chosen in order to facilitate deep watering over a large area. This method of irrigation allows shrubs and trees to grow roots deep into the water table which may help with plant survival over time.

Common recommended management measures for cottontail damage to drip irrigation include exclusion,

trapping, and repellents. Typically, damage by non-burrowing vertebrate pests is best avoided through exclusionary measures such as fencing or burial of the irrigation tubing (Salmon and Gorenzel 2010). Subsurface irrigation, however, is not ideal in restoration settings as burial would make location and removal of the irrigation tubing after the establishment period arduous. Fencing was also not considered a practical control measure due to the study site being a riparian habitat. Trapping, while also effective, was not considered to be economically efficient or ethical in an unbounded wilderness area. Due to the unique nature of the study site, repellents were chosen as the primary method for cottontail rabbit control even though repellents have often been less effective than exclusion or trapping methods.

Anthraquinone was chosen to be the repellent trialed at the restoration site as it has previously been shown in laboratory studies to be effective in developing conditioned taste aversion in cottontail rabbits (Werner et al. 2016, Baldwin et al. 2018). Conditioned taste aversion is a process by which a negative experience resulting from a consumed substance causes an individual to avoid future interactions with the substance based on the taste and odor cues alone. Unfortunately, the window of repellency and dose response is highly variable and substance-, species-, and sex-dependent. Careful efficacy testing must be conducted to establish repellency for each new species considered for management (Hansen et al. 2016). Anthraquinone has been registered federally as a seed coat avian repellent and as an avian repellent for use at airports (Werner et al. 2016). At the time of this study, anthraquinone was not registered for use as a repellent in California. Reducing cottontail damage to irrigation tubing by anthraquinone application appears to be a novel use case for the postingestive repellent.

METHODS

Prior to conducting the study, 400 m of irrigation tubing at the restoration site was surveyed for damage and repaired. Of this area, 300 m was selected from three lines and divided equally into 150 m treated and untreated sections. This was done by alternating the anthraquinone treatment and the control in 30 m sections. An anthraquinone-based repellent with a concentration of 18.6% from Arkion® Life Sciences was applied by hand, using brushes, to the designated treatment sections. Applications of anthraquinone repellent were applied two weeks apart. The irrigation tubing was assessed for damage between the first and second treatment and again eight weeks after the second application. Damaged sections were removed between applications so that they could be assessed more thoroughly using a simple pressure testing apparatus consisting of a garden hose connected to a valve with a hose barb. Sections were fitted, clamped, measured, and then pressurized so leaks could be counted. Individual leaks were only counted between the first and second applications due to budget constraints. After the second application, only the total length of damaged tubing was recorded. All assessments recorded damaged tubing length removed from the site. The first application occurred on August 28, 2018, followed by the second application on September 9, 2018. Unfortunately, due to an unexpected rain event the evening following the second application, the treatment was completely washed away. The second treatment was reapplied on September 12, 2018. On November 11, 2018, the lines were surveyed a final time, repaired, and the trial was concluded.

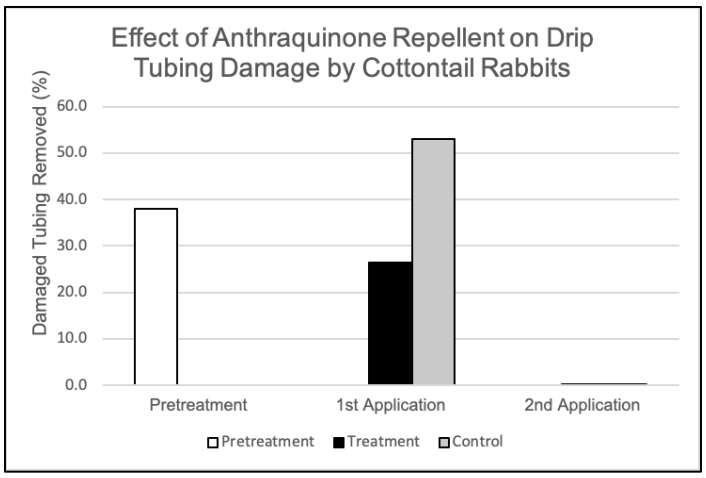

Figure 1. Percent of irrigation tubing damaged by cottontail rabbits before the first application, after the first application and eight weeks after the second application.

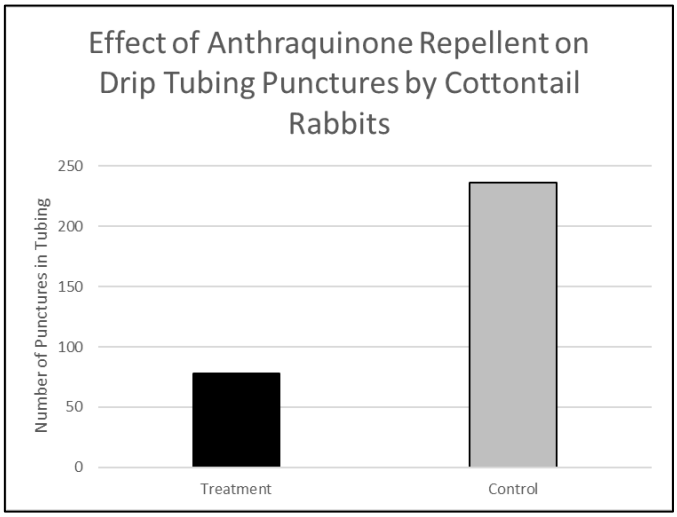

Figure 2. Number of punctures in the irrigation tubing by cottontail rabbits after the first treatment. The treatment and control sections each totaled 150 m in length.

RESULTS

After the first treatment, there was an estimated 50.0% reduction in damaged tubing between the treated and control sections as shown by Figure 1. An estimated 0.18% of the total tubing surveyed between both control and treated sections was damaged after the second treatment. Between the first and second treatments, we observed an estimated 99.5% decrease in all study site irrigation tubing. A 66% reduction in quantity of punctures was observed between the treatment and control areas of the study after the first application as shown by Figure 2.

DISCUSSION

We did not expect to observe both our treatment and control areas to have significantly reduced damage after the second treatment. Our observed reduction in the damage of both control and treatment areas suggests that anthraquinone may be successful in reducing cottontail rabbit damage by inducing conditioned avoidance to drip irrigation line. However, due to funding limitations we were not able to collect the same information as the first treatment during the second treatment resulting in limited options for statistical analyses between treatments. Furthermore, the absence of cottontail rabbit population monitoring during the study limits our ability to conclude that the reduction in damage of untreated drip irrigation tubing observed was a result of conditioned avoidance and not a decrease in population. The robustness of our study could have been increased by conducting population studies before, during, and after treatments as well as increasing our monitoring window after the second treatment to assess treatment effectiveness over time. While we believe our study produced acceptable results for our stakeholders, it was observed that the product did not adhere well to the drip tubing during the experiment. A product reformulation or other novel application method should be investigated in future research to increase product adhesion. As a preliminary study, these limited findings are promising and warrant future field trials to validate the use of anthraquinone as a repellant to reduce damage by cottontail rabbits.

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