"Using household products to control Crown-of-Thorns outbreaks"

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1. Outcomes

A field trip was conducted in February/March 2015, with 66 station days for the principal investigator and two assistants. 213 *Acanthaster planci* were collected, 92 from reefs directly around Lizard Island, and 121 from reef 14-133 (30 kilometres from LIRS). These were used in three main experiments; 1) development of a one-shot injection method using vinegar (acetic acid), 2) ensuring safety of vinegar injections on other marine organisms in a transmission experiment and 3) pilot trials of citric acid as a alternative injection chemical.

One-shot injection using vinegar:
72 *A. planci* were injected with various concentrations and volumes of either food grade vinegar (4% stated acetic acid content), diluted acetic acid (2 and 8%, i.e. half and double the concentration of store bought vinegar) or seawater (control). This resulted in six treatment categories; 1) 15mL retail vinegar diluted to 50% with freshwater, 2) 15 ml 2% acetic acid, 3) 15 ml 8% acetic acid, 4) 20 ml retail vinegar 5) 25 ml retail vinegar 6) seawater control. All treatments used a single injection (16 gauge stainless steel needle) of vinegar or acetic acid at the base of the arm. Immobility, when the starfish has lost turgor and is unable to move and feed (i.e. 'functionally dead'), can occur hours or days before complete death, when all podia have ceased moving. In this study, I therefore measured the effectiveness of vinegar using three measures: 1) time to immobility, 2) time to death and 3) proportion dead overall.

A single injection of 20 or 25 mL of undiluted vinegar resulted in 100% mortality of *A. planci* in less than 48 hours (47 and 41 hours respectively, Figure 2). Furthermore, individuals were rendered immobile in less than 24 hours. A one shot injection of regular household vinegar therefore has comparable efficiency to that of oxbile or sodium bisulphate. There were no mortalities in the control starfish, injected with seawater only. The remaining treatment categories had less than 100% mortality in 48 hours and are therefore not suitable to be used in control efforts.

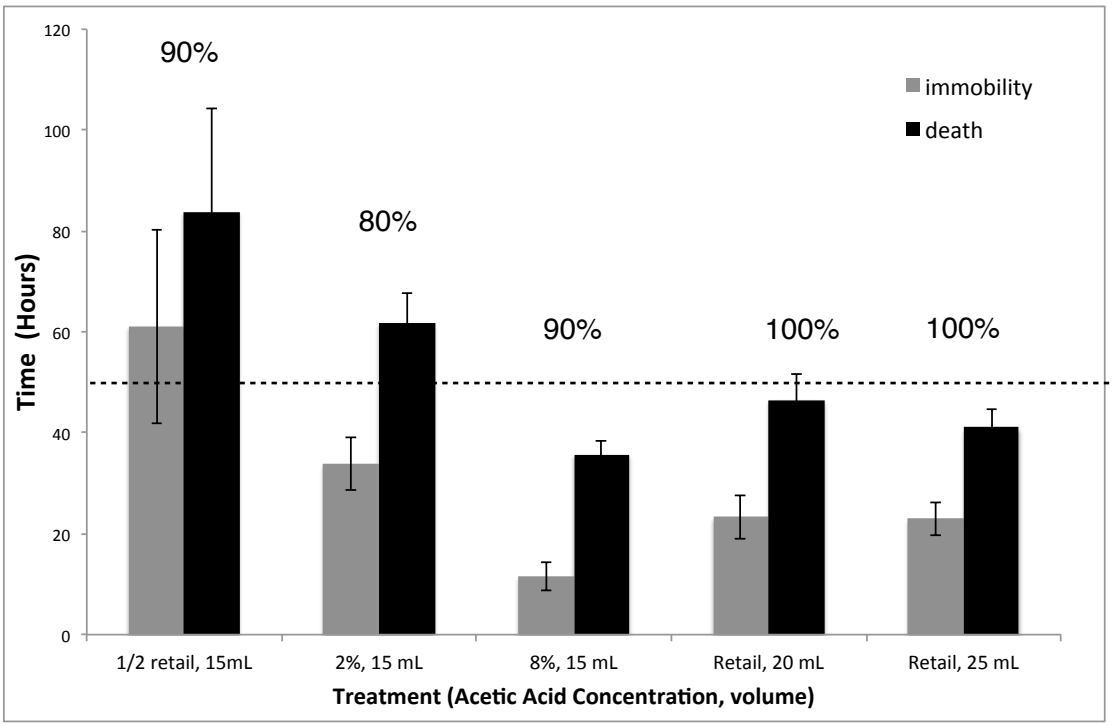

Figure 2: Time to immobility (grey bars) and death (black) of *A. planci* injected with vinegar. Percentages above each treatment represent overall mortality, while the dotted line marks 48 hours post-injection.

Transmission Trials:
An experiment was set up to test the safety of injected *A. planci* to other marine organisms. Two 300L tanks were set up with a sandy bottom and flow through seawater. The control tank housed healthy (un-injected) *A. planci* while the treatment tank contained two injected individuals at all times. Injected *A. planci* were replaced after 3 days, and remains siphoned out of the tanks. 32 different species of marine organisms were collected around LIRS and sequentially placed in either treatment, so that each species was subjected to each treatment for a minimum of seven days. Replicate organisms from most major reef families of fish, invertebrates and corals were used. Animals were monitored for signs of stress or disease and returned to the reef at the conclusion of the experiment.

Three coral colonies were smothered in sand overnight by triggerfish, and were subsequently replaced. Several species were observed interacting with and consuming injected *A. planci*, however there were no signs of stress or disease in any organisms caused by exposure to injected COTS during the experimental period.

Citric Acid:
A pilot study testing the efficiency of citric acid as a control method for *A. planci* was undertaken by Alexander Buck, as a minor research project for the Masters by coursework at James Cook University. The project is supervised by Lisa Bostrom-Einarsson and Dr. Naomi Gardiner (JCU).

60 A. planci were injected with a range of concentrations and dilutions of citric acid, and injected at either 1, 2 or 4 injection sites. Five treatments resulted in 100% mortality (Figure 3). Of these five, one treatment resulted in immobility and mortality rates comparable to vinegar and oxbile (120g/L, 20 ml split over four injection sites). Four treatments rendered the starfish immobile (no longer moving, incapable of feeding) in less than 48 hours (Figure 3).

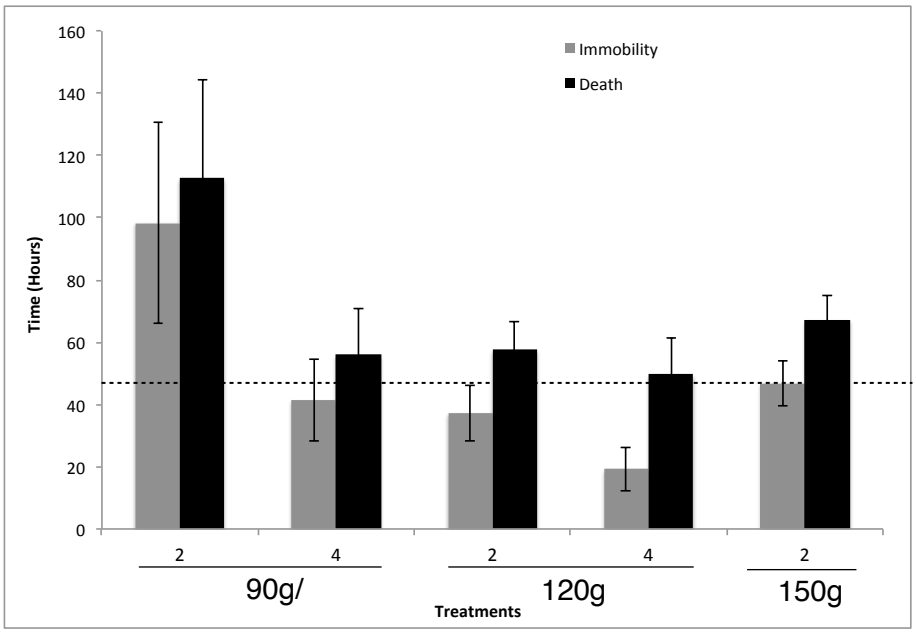

Figure 3: Time to immobility (grey bars) and death (black) of *A. planci* injected with citric acid. Only treatments that resulted in 100% mortality are included in the figure, the dotted line marks 48 hours post-injection.

Samples:
12 A. planci were injected with either vinegar or citric acid (6 of each chemical), and samples taken at regular intervals post-injection for histological analysis at James Cook University. These samples are predicted to be analysed by June 2015.

2. Significance

The use of household products to control outbreaks of *A. planci* provides a low-cost alternative to oxbile that is safe to other marine organisms. While bile salt solutions may still be the preferred method for large scale control efforts run by commercial/government operators, the availability, safety and ease of use of vinegar makes it an ideal methods for smaller scale control efforts. This is particularly true in remote locations and developing nations, where access to oxbile and speciality equipment is limited.

This project has demonstrated that injecting vinegar has the same efficiency, both in terms of mortality rates and time to death, as oxbile. While vinegar requires double the injected volume to oxbile, it can be administered using the same guns as the previously used sodium bisulphate (fitted with a 16G needle). Furthermore, not including cost of equipment (which is similar for both products), injections using vinegar are approximately half the price of oxbile injections (vinegar: 1.2 cent /COTS, oxbile 2.1 cent. Calculations based on 10ml 8g/L oxbile at a cost of $257.4 per kilo, versus 20 ml vinegar at $1.20 per 2L bottle).