

Final report for Hawai'i Invasive Species Council

Reducing rat lungworm disease through an education and research partnership with K-12 schools in Hawai'i

Abstract: Hawai'i's remote location makes food security an important issue. The state estimates it imports 85-90% of its food, making it vulnerable to natural disasters and world events should there be a disruption in the shipping and the food supply. In 2012 the *Increased Food Security and Food Self-sufficiency Strategy* was prepared by Hawai'i state agencies with the objective of increasing the amount of locally grown food consumed by residents. State-wide efforts to promote the Grow Local, Eat Local movement are reflected in the growing number of residential gardens, small farms, farmers' markets, school and youth garden projects, and the passage of the Farm to School Bill. However, only recently have efforts to educate farmers, food handlers, and consumers about rat lungworm disease and the need for disease prevention and host control been similarly supported. In collaboration with schools on Hawaii Island, the University of Hawaii, Daniel K. Inouye College of Pharmacy's Hawaii Island Rat Lungworm Working Group worked with K-12 students and teachers involved in school garden projects to develop a comprehensive plan for a written integrated pest management plan for control of slugs and snails for use in school and youth garden projects and accompanying curriculum relating to rat lungworm disease. The integrated pest management plan uses those practices that are least harmful to human and environmental health and requires data collection that can aid state agencies to better understand intermediate host population patterns and efficacy of control efforts for those organisms. Participating schools play an important role for early detection of unwanted invasive slugs and snails, especially those that are effective intermediate hosts of the rat lungworm parasite. Written lessons related to the rat lungworm parasite and disease prevention are aligned with standards used by the Hawai'i State Department of Education and include Next Generation Science, technology, engineering, art, and Common Core Math. Resources developed were trialed in schools. The curriculum design is place-based, an educational approach that is included in Hawai'i's efforts to improve education through the integration of the "*Every Student Succeeds Act* of 2015." The lessons meet the targeted vision focus areas and support global learner outcomes. The written management plan, protocol for data collection, an evolving identification photo file of common slugs and snails found in Hawai'i, as well as lessons relating to the rat lungworm, the biology and control of host animals, the disease and disease prevention, are available to all schools and the public as online files. The project is supported by the Hawai'i Farm to School Hui and island school garden networks and funds are being sought for implementation and development of additional support materials. Adoption of this management project by the many school and youth garden projects in areas of RLWD has the potential to significantly increase community awareness and encourage public control efforts, potentially reducing disease risk statewide. Further support for this broad-reaching and visionary project will be needed.

Narrative: There is a growing need for public education related to rat lungworm disease (RLWD) prevention and for a campaign that calls the public to join in a concerted effort to control the hosts of the rat lungworm (RLW) parasite. RLWD cases have occurred on Oahu, Maui, Kauai, and Hawaii Island, and serious human infections over the past 15 years have resulted in long-term neurological damage, disability, coma, and death. Until very recently, with the exception of efforts by the Hawai'i Island Rat Lungworm Working Group (RLWG) at the University of Hawai'i (UHH) Daniel K. Inouye College of Pharmacy (DKICP), there has been no concerted effort made by any county, state or federal agency to raise public awareness of RLWD or to develop a campaign to encourage the control hosts of *Angiostrongylus cantonensis* the RLW. Without a statewide campaign for education and control, the RLW parasite and its hosts could pose a direct threat to food safety and security in Hawaii.

The idea of incorporating RLW education into the K-12 school system as a part of a STEM (science, technology, engineering, math) curriculum was first agreed upon at the 2011 International Rat Lungworm Workshop in Honolulu, Hawai'i. The workshop was organized by Dr. Robert Cowie (UHH Manoa), and was supported by the USDA National Institute of Food and Agriculture. Workshop participants hailed from China, Thailand, Taiwan, Brazil, Jamaica, the U.S. Commonwealth of the Northern Mariana Islands, and the United States. Of those representing the U.S. were included members of the Hawai'i Dept. of Health, the U.S. Center for Disease Control, and the University of Hawai'i at Hilo and Manoa. A prioritized list of objectives and top needs was developed by workshop participants. It was agreed that public education was a priority and one pathway for providing education for hard-to-reach, rural communities was to involve children ages 7-14 in the effort by developing STEM curriculum for RLWD (Cowie, 2013).

The RLWG at the UHH DKICP was created in 2012 by Dr. Susan Jarvi with the intention of addressing gaps in RLWD research and education in Hawaii. In 2013 this group published an educational activity book titled "The Mystery of Rat Lungworm Disease," which provides basic information on the rat lungworm parasite lifecycle and steps to prevent disease. The book is based on the Hawaii Science Standards for the 2nd grade level and was developed in collaboration with teachers from four local public schools. Over 12,000 copies have been distributed to school children, educators, medical clinics, and other educational entities in Hawaii. This book can be downloaded from the website of Dr. Susan Jarvi at the DKICP. http://pharmacy.uhh.hawaii.edu/rlw/documents/RLWD_activity_book.pdf

While geared toward 2nd grade, it can be and has been used at multiple grade levels.

To build on this education project the Hawai'i Island RLW Working Group next began to address the need for control programs for RLW hosts and for advanced lessons at higher grade levels, which incorporated STEAM (science, technology, engineering, arts, math) subjects in the study

of RLWD and training students to become educators who assist with RLWD education in their communities. Under the leadership of graduate student Kathleen Howe, a project was conducted during the 2015-2016 school year with five partner public charter schools located on the windward side of Hawai'i Island where most cases of RLWD have originated and which were involved with the Hawai'i Island School Garden Network. An integrated pest management (IPM) plan was trialed during this project as were various topics of interest and importance required to understand this complex issue. The school garden projects serve as an excellent avenue for RLWD education, and this education is important for student safety and to maintain public confidence and continued support of Hawai'i's school garden programs.

The Hawai'i Farm to School Hui oversees the school garden networks that are established on each of the main Hawaiian Island complexes. School gardens provide excellent settings for students to explore the varied aspects related to growing food. This can include the inter/intra-related biology of a food system, the relationship of food with health, and how socio-cultural influences and natural elements affect agriculture. These networks provide unique avenues through which the issue of RLWD can be addressed. Factual information can be shared with students who can then share the information with their community in a statewide effort to prevent infection and advocate for control of the hosts of the rat lungworm parasite. While the situation of the rat lungworm parasite in Hawai'i is unfortunate there is a positive side. This complex issue provides excellent opportunities for academically engaging and challenging learning opportunities, student-centered learning, socio-civil involvement, and a program that provides a template for place-based education. Funding acquired from the Hawai'i Invasive Species Council allowed for the concepts explored in the 2015-2016 pilot project to be developed into written lessons for grades 5-8.

Specific aims:

- 1) Develop a written Integrated Pest Management Plan for the control of non-native slugs and snails for Hawaii School Garden Projects.
- 2) Develop written educational STEAM (science, technology, engineering, art, math) lesson plans that are aligned with Hawai'i Dept. of Education (HDOE) standards and are related to the rat lungworm and disease prevention.
- 3) Engage K-12 students and teachers to become community educators for RLWD prevention.
- 4) Develop a citizen science project wherein students collect data relating to non-native and invasive slug and snail populations and efficacy of control efforts in school garden projects. This data can assist in better understanding and controlling the situation with the rat lungworm parasite in Hawaii.

Methodology: The Integrated Pest Management plan for control of non-native and invasive slugs, snails, and flatworms uses the least toxic methods for control of pests and includes the

careful consideration of available pest control methods including biological, chemical, and cultural practices. The management practices should be dynamic and should involve monitoring systems to continuously evaluate population levels for decision making and adaptive management (Flint & van den Bosch 1981). The IPM plan used at each of the schools was adopted from the University of California Statewide Integrated Pest Management Program guidelines for snails and slugs, which recommends the use of cultural practices (removing materials where they can hide), traps (providing specific shelters for them to hide under), hand picking, barriers (copper, Bordeaux mixture, ashes or other abrasives), natural enemies (predacious snails and domesticated fowl such as ducks, chickens), and baits. We recommend the use of shelters as part of the control plan. Shelters provide the opportunity to identify, monitor, and remove populations and are not intrusive nor do they involve the use of chemicals, an important factor to consider in school gardens where children are present. Safety measures and disposal of slug, snails and flatworms is discussed as part of the management plan as is the importance of data collection to allow tracking of results.

The curriculum is place-based in design and integrates the six key pedagogies used in the environment-based education (EBE) model created by the State Education and Environment Roundtable called EIC® (Environment as an Integrating Context for Learning) (Lieberman 2013). These pedagogies are:

- Integrated interdisciplinary instruction that breaks traditional boundaries between disciplines
- Community-based investigations as learning experiences that offer both minds-on and hands-on experiences through service-learning opportunities
- Collaborative instruction so teachers, parents, students, and community members can together connect instruction and learning
- Learner-centered, constructivist approaches adapted to the needs and unique abilities of individual students
- Combinations of independent and cooperative learning
- Local natural and community surroundings as the “context” for connecting these proved pedagogies.

Place-based education is a practice supported in Hawaii and is included in the state’s efforts to improve education through the integration of *Every Student Succeeds Act* of 2015, which supports “Future-focused, empowered school communities that inspire leadership, creativity and innovation in a healthy and safe learning environment.” The “Global” learner outcomes include: complex thinker, effective communicator, self-directed learner, community contributor, quality producer, effective and ethical user of technology, and innovative creator.

<https://governor.hawaii.gov/wp-content/uploads/2016/09/Gov-ESSA-Team-BLUEPRINT-OUTLINE-rough-draft-2-August-27-2016.pdf>.

The lesson plans were developed through a combination of research, hands on activities for slug/snail control in school gardens, and from many classroom visits and presentations for students at the grades 5-8 level. While we encourage school garden teachers to use the IPM plan and lessons, the lessons are also intended to be used by the classroom teacher. The garden is the laboratory and activities that occur in the garden should be connected to classroom activities and subject standards.

Results:

Thirty classroom visits were conducted and drafts of the lessons were presented between September 2017 and January 2018 with schools on Hawai'i Island. Seventeen teachers and their classes participated in presentations of the IPM plan and lesson developed for RLWD education. Classroom visits were primarily for grades 5-8, however requests for classroom visits were received from lower and upper grades as well. There appears to be a great interest in this subject by teachers and students. A presentation of the project was given to classroom teachers attending the Hawai'i Environmental Education Association Pilina Program Teacher Training. An overview of the IPM plan and lessons was presented to members of the Hawai'i Farm to School Hui on Oahu in Fall of 2017 and interest in supporting this project is ongoing with the Hui. Five public educational presentations on RLWD and this HISC-funded project were given at community meetings. A high school video and film class filmed classroom RLWD presentations and are in the process of editing those videos which will accompany some of the lessons. Na Leo TV, a local production studio located in Hilo, produced an educational video in collaboration with the Jarvi lab, which discusses the many aspects of RLWD including intermediate host control. The video is available to schools and the public at:

<https://www.youtube.com/watch?v=CbkLLur6KYo&t=300s>

The IPM plan for control of slugs and snails in school gardens, 11 lesson plans, a master data sheet, and an evolving identification file of common, non-native slugs and snails found in school gardens are available at this website: <http://pharmacy.uhh.hawaii.edu/rlw/lessonplans.php> PowerPoint and video files are to be added to accompany the lessons. There is an overview file that briefly describes the subject matter of each lesson. Some lessons are more appropriate for the grades 5-6 level and some are more appropriate for the grades 7-8 level. Each of the lessons begins with suggested standards that can be addressed which include Next Generation Science, Common Core Math, and Hawaii DOE standards. Following the standards, the learning objectives are stated. The objectives are followed by a reading for understanding section and the lesson concludes with suggested student learning activities. The lessons are intended to aid students to achieve the specific benchmarks and general learner outcomes required at the grade 5/6 and 7/8 levels. The lessons that have been developed are in PDF form and are available for download. The lessons address the following subjects identified as important to understanding RLWD in Hawaii:

0. Overview of the lessons
<http://pharmacy.uhh.hawaii.edu/rlw/documents/0.Overview%20of%20the%20IPM%20plan%20and%20curriculum.pdf>
1. *Angiostrongylus cantonensis* the rat lungworm in a global context.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/1.Global%20spread%20of%20rat%20lungworm%20disease.pdf>
2. Integrated Pest Management for control of slugs and snails in school gardens.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/2.%20Integrated%20pest%20management%20for%20slug%20and%20snail%20control%20for%20school%20gardens.pdf>
3. The rat lungworm lifecycle.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/3.The%20rat%20lungworm%20life%20cycle.pdf>
4. Classification.
http://pharmacy.uhh.hawaii.edu/rlw/documents/4.Taxonomy_Classification%20lesson.pdf
5. Slug and snail biology.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/5.Slug%20and%20Snail%20Biology.pdf>
6. Data collection.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/6.Data%20collection.pdf>
7. Paratenic and accidental hosts.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/7.Paratenic%20and%20Accidental%20hosts.pdf>
8. Native snails of Hawai'i and the story of failed bio-control.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/8.Native%20Hawaiian%20snails.pdf>
9. Reporting using ArcGIS online.
<http://pharmacy.uhh.hawaii.edu/rlw/documents/9.Reporting-%20Using%20ArcGIS%20online.pdf>
10. Rat lungworm disease symptoms and treatment.

[http://pharmacy.uhh.hawaii.edu/rlw/documents/10.Angiostrongyliasis%20 %20rat%20lungworm%20disease.pdf](http://pharmacy.uhh.hawaii.edu/rlw/documents/10.Angiostrongyliasis%20%20rat%20lungworm%20disease.pdf)

11. Rat lungworm disease prevention.

<http://pharmacy.uhh.hawaii.edu/rlw/documents/11.Disease%20Prevention.pdf>

12. Master data sheet

<http://pharmacy.uhh.hawaii.edu/rlw/documents/12.Master%20Data%20Sheet.pdf>

13. Evolving gastropod photo identification file

<http://pharmacy.uhh.hawaii.edu/rlw/documents/13.Invasive%20gastropods%20ID%20photos.pdf>

The identification file has photographs of more commonly found, non-native and invasive gastropod species. This file is intended to be added to by schools as students identify species found in their school garden or community.

Student and teacher reception for this project has been excellent. At many schools visited the students and or teachers were aware of family or community members who have contracted this disease. All students expressed great interest in sharing the information. As many families on Hawai'i Island rely on rainwater catchment for their household water supply, and as there is a potential for disease transmission via water, this program is crucial for educating the public as to how to prevent infection. Students used critical thinking, creative problem solving, and communication skills when designing control methods and education outreach materials. Feedback from teachers was positive (see auxiliary file).

Significance of the project: Our project collaborates with established partners and supports the statewide adoption of IPM for invasive mollusk control in school garden projects while engaging students as citizen scientists and community educators. The project aids in educating the public of the health risks of RLWD and assists agencies with slug and snail population data and early detection of important carriers of the RLW parasite. The issue of rat lungworm disease in Hawai'i is serious in that it affects health, tourism, and agriculture. We believe that the Hawai'i Island RLW Working Group and the Hawai'i Farm to School Hui, along with each of the island school garden networks, the core organizations and state and federal members, and teachers and K-12 students, are in a great position to help in the following three, crucial areas: 1) provide education to the public for prevention; 2) encourage the public in a statewide, host control program for slug, snail, and rat control; 3) help collect data to track invasive and non-native slug and snail populations and infection levels statewide.

A concerted effort is needed to reduce the infection potential of host animals if we are to reduce human cases of disease and restore public faith in local agriculture. Use of the established

school garden network is an ideal avenue through which to share information and work on solutions for this problem. The information that can be disseminated and integrated within a community by thoughtful and educated young people exceeds what sound bites and pamphlets can achieve. It also grows a generation that is aware of the problem with this parasite in Hawai'i and the actions that are necessary to reduce infection levels in host organisms and for disease prevention. The IPM and RLW-related lesson plans created provide the framework for a model program for Hawai'i. The potential benefits of this program are great, not just for Hawai'i but also for other states, territories, commonwealths, and the approximate 30 countries where the RLW parasite is established. As the parasite range is expected to expand with climate change, this is a timely effort. Further funding is necessary to provide teacher training workshops, collect teacher feedback, create workbooks and assessments, and review and disseminate materials.

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