Angiostrongylus cantonensis, Rat lungworm (RLW) in East Maui

By Chad Meyer, MD
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Fortunately dengue virus did not become established in east Maui as a result of the 2001 dengue fever outbreak. Effective interventions included community responses to decrease mosquito breeding sites, and a vigorous campaign by local public health personnel and resources from CDC Atlanta and Puerto Rico. It is also worth noting that dengue fever outbreaks generally occur in crowded urban settings and that rural conditions in east Maui were in our favor.

RL Worm is different. It is a zoonotic disease - a biologic process maintained in animal populations, but with the potential for “spill over” into human outbreaks. The zoonotic cycle associated with rat lung worm involves a roundworm parasite (Angiostrongylus), a definitive host (a rat species), and an intermediate host (snail species). Once this zoonotic cycle is established in an area, it is extremely difficult, if not impossible to eradicate. This is the current situation in East Maui and parts of Hawaii Island; efforts instead should focus on effective control directed at reducing population densities of rats and snails, and their contact with humans.

The current RLW outbreak has several basic components:
Snails, rats, roundworms.

Additionally, human activities have driven the evolving emerging disease epidemic. Snails have been exported from native habitats as new food items (escargot) and aquarium pets. Some have claimed that the the Giant African Snail (first reported in China 1931) was responsible for introducing RLW into southern China. Regardless of its origin, RLW infected rats from southern China and SE Asia have spread the worm via cargo ships throughout the Pacific basin and beyond.

“Angio-stron-g-ylys” is a roundworm - other members of this phylum include the parasites ascaris, hookworm, pinworm, filaria (human filariasis), Dirofilaria (dog heartworm), and Trichinella (trichinosis from undercooked pork), as well as thousands of marine, freshwater, and terrestrial species. The complete Angiostrongylus life cycle requires five larval molts (two in the snail and three in the rat).

Adult male and female worms inhabit and reproduce in the rat’s pulmonary arteries. The eggs hatch into L1 larvae move through the air sacks (alveoli) in the lung, then ascend the wind pipe (trachea) and enter the esophagus; from here they passage the intestine and are excreted in rat poop. Snails become infected when passing through rat feces, and additional molts (L2 and L3) occur in the snail. The L3 larvae in the snail are infectious for rats, and for dog, cats, and many other species including humans. It is important to note this is the only larval stage infectious for humans. In the zoonotic cycle, a rat eats the snail and the L3 larvae move from the rat intestine and via blood circulation take up residence in the brain where L4 and L5 molts occur.

After L5 the worm is now a mature adult (male or female) and becomes established in the rat’s pulmonary artery - reproduction and eggs follow, and the cycle is complete - the rat, subject to repeated snail exposures and reinfection cycles will excrete larvae infective for slugs (not animals and humans) for the rest of its life. Persons infected with Angiostrongylus do not excrete L5 larvae in stools and person to person transmission does not occur. Humans, like dogs, cats, and many other mammals (exception rodents) are called “dead end hosts” because the worm fails to complete its life cycle. Infection stops in the brain - rare or no infection in the pulmonary artery, no intestinal infection, no way of passing on the parasite. Important, to note, the RLW parasite cannot be passed on from person to person, or from an infected dog or cat.

Snails

David Baldwin’s collection of Hawaiian snails in the late 1800’s contained 1144 land snails. Later counts put the number at 750, still a remarkable example of radial evolution. Four species of introduced snails have displaced native snails and are predominantly responsible for recent Hawaiian outbreaks of RLW disease. Consider the following time line.

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Outbreaks of RLW disease on Hawaii Island and Maui have both followed introduction of Parmarion, suggesting this is driving recent human infection. The semislug Parmarion has unique behavior that is important to understand and incorporate in control. Where the apple snail inhabits taro fields, and the cuban snail frequents home gardens, Parmarion is “peri-domestic.” It will invade trash containers, climb house walls, get into pet food left outdoors, and climb on decks and balconies in search of food. It is also described as “polyphagous,” has a wide diet. In addition, studies on Hawaii Island have shown 75% Parmarion samples positive for RLW compared to 25% for the cuban snail, and it also appears to have higher concentrations of the worm, or “worm burden.” All of this makes Parmarion a highly “efficient vector” for RLW, and danger for infection.

Rats

Rats frequently become infected with RLW. Field studies on Hawaii Island showed greater than 90% of rat populations infected, and having high levels of parasites in their rat. Rats commonly have multiple snail exposure, potentially becoming infected at the same time. As a consequence rats are called “amplifier hosts,”—greatly increasing the risk of disease spread, and need to be part of intervention strategies.

Human Infection

Most human infections occur when a whole snail is eaten - either by accident or drunken or drugged rats, or even by people preferring their snails raw. Juvenile forms of Parmarion can have high parasite loads and be infectious. In addition to being small, they can be translucent and difficult to spot. Please refer to a compendium infecting for life. As a consequence rats are called “amplifier hosts,” —greatly increasing the risk of disease spread, and need to be part of intervention strategies.

Complete elimination of this snail is unlikely, but effective control measures can greatly reduce its numbers and reduce risk of contact.

Snails have been relocated into non-native environments worldwide—intentionally as new food sources (escargot), as aquarium pets. Unique species characteristics drive their impact in non-native locations. Apple snails prefer slow moving fresh water. Their introduction has dramatically affected crops yields in rice and taro cultivation. They have been a nuisance for our taro farms since 1989. A comprehensive review of their introduction, effects on wet taro, and attempts at control are available online.

Rats

Rats prefer domestic areas, including trash containers, walls and drain pipes, catchment systems, outdoor animal foods, and fruits left on decks and railings. Environmental steps around homes can greatly reduce Parmarion contacts — don’t leave pet food containers outdoors, particularly at night when rats are active, avoid storing produce and foods in containers in a chubb.

3. A small survey should demonstrate areas where Parmarion is becoming established. Prioritizing efforts directed at these areas may serve to contain further geographic spread.

4. Validation studies are urgently needed to confirm Aichi’s 1967 work which showed a 24 hour freeze effectively killed Angiostrongylus infective L3 stage larvae. Freezing as a readily available, simple intervention would greatly enhance food safety.

5. Water storage and catchment tank safety

A comprehensive discussion is too lengthy for this article and needs to be addressed separately. The following components need to be addressed. Catchment systems need to be designed and maintained in order to assure safe potable water. The Rat Lung Worm catchment systems need to be designed and maintained in order to prevent human exposure to the parasite, and that allow us to continue growing our crops. Snails are an essential part of the zoonotic cycle of rats and a number of species of snails. Instead of elimination, we need to develop effective interventions that prevent human exposure to the parasite, and that allow us to continue growing our crops.

6. Agricultural interventions

As a farming and gardening community we need to work out how best to control snails - what field modifications work best, are easiest to maintain, and economical. Everything is up for study for what works best in east Maui’s tropical habitat - dry border areas around garden plots, the use of lime and copper in perimeter areas, drip irrigation, home gardens using potted plants on garden tables (copper strips around the table legs to prevent snail ascent), animal predators - chickens, ducks, baited traps for both snails and rats (simple placement in PVC piping prevents harm to birds and domestic animals).

7. Safe food selection

We should include determining which types of foods are safest and least affected by snails - for example, onion, leeks, oregano and arugula seem to be outside the snail menu, and can be incorporated into healthy, nutritious salads. Many garden and commercial agricultural products may be grown in snail-free environments and be easily inspected. Foods found to be a poi are rendered safe by heat and pressure used in processing taro.

8. Collaboration and investigation studies

East Maui needs to collaborate with Hawaii Island communities that have been attempting interventions since 2005. They have developed public health initiatives that demonstrate what we can draw on. The U of H Hil Hilo School of Public Health has developed lab based studies using quantitative PCR molecular diagnostics that we can use for testing infection rates in snails and rats. They also have similar testing for human blood which would enable us to do “sero prevalence studies” from east Maui. This would involve blood sampling from Maui risk groups, checking for Angiostrongylus antibodies. The information would provide better understanding of risk (farmers and gardeners), and of the number of “mildly infected” - if it exists.

The east Maui community has a remarkable resource pool - farmers, gardeners, educators, communicators, and researchers. Controlling RLW will be challenging, but it is our kuleana to effectively respond. For generations Indigenous Hawaiian farmers were effective scientists. They closely observed the aina, held it with respect as a sacred gift, tested growing practices, selected plants for eating and medicine. Our generation must do the same: