



# On Farm Management of Rat Lung Worm Disease

Jari Sugano, Lindsey Okumura, Josh Silva, Jensen Uyeda, Sharon Motomura, Kylie Wong, and  
Lynn Nakamura-Tengan

University of Hawaii at Manoa  
College of Tropical Agriculture and Human Resources



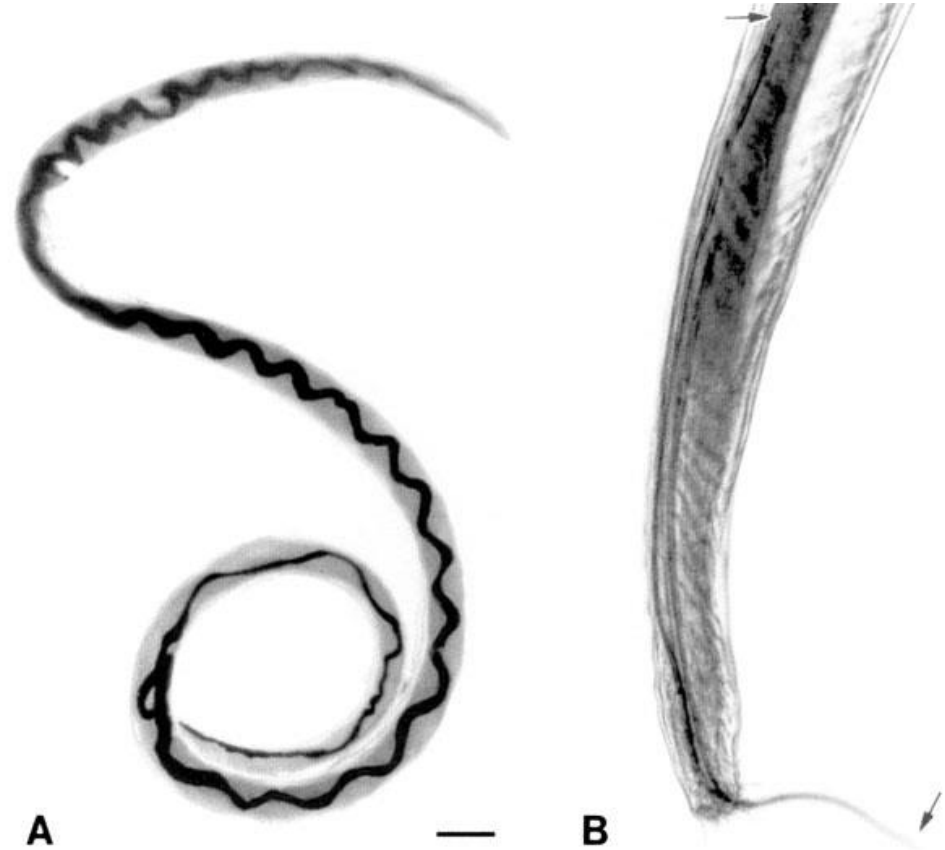
COOPERATIVE EXTENSION

UNIVERSITY OF HAWAII AT MĀNOA  
COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES

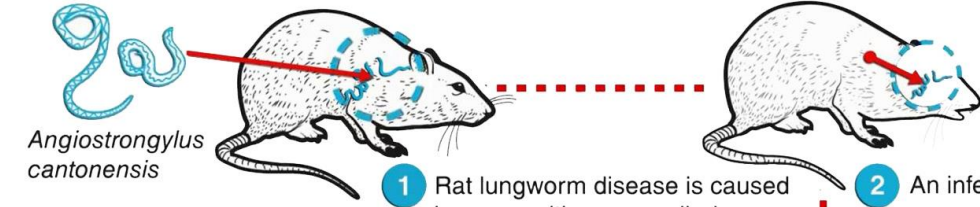


# Rat Lung Worm Disease

- Causes eosinophilic meningitis (angiostrongyliasis)
  - Gastrointestinal and central nervous system disease in humans
- Caused by the parasitic nematode (*Angiostrongylus cantonensis*)
- Infects the lungs of rats which gives it the common name:
  - Rat Lung Worm Disease (RLWD)

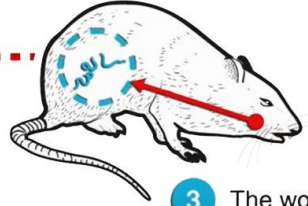


*Angiostrongylus cantonensis*

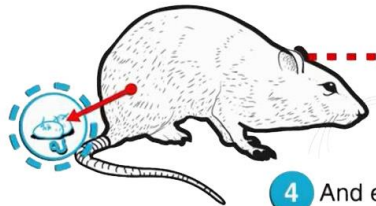


1 Rat lungworm disease is caused by a parasitic worm called *Angiostrongylus cantonensis*.

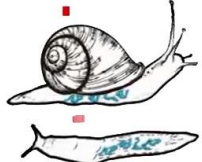
2 An infected rat coughs up worms from the lungs into the throat where they are then swallowed by the rat.



3 The worms are now in the rat's digestive system.



4 And eventually end up in the rat's poop.



- OR -

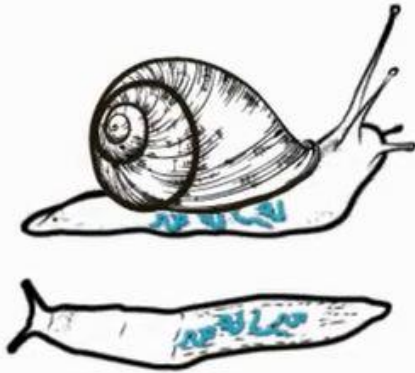
Completes 2 life stages in slug or snail before it becomes infectious to humans

5 1) Slug or snail eats the rat's poop and becomes infected,

2) The worms in the rat's poop penetrate a slug or snail's body.

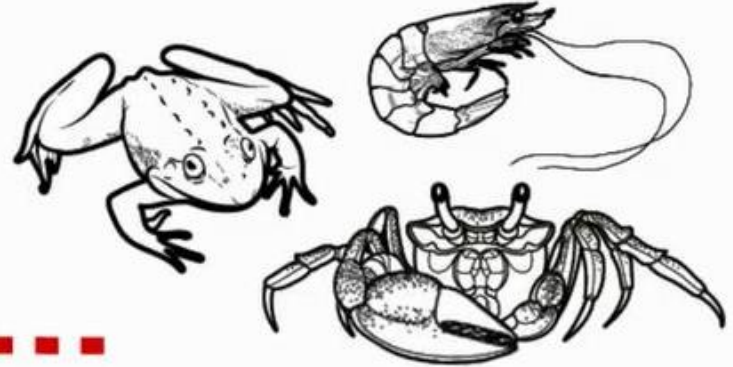
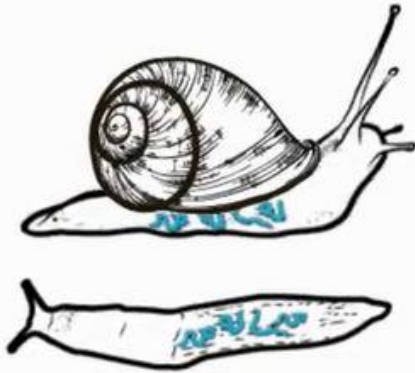
Stage 1

# How do people get rat lungworm disease?



Slugs and snails may be eaten accidentally if they are on fruits or vegetables that have not been thoroughly washed.

# How do people get rat lungworm disease?



Freshwater crabs, shrimp, prawns, or frogs may eat slugs or snails that are infected with worms, then infect people if they are eaten undercooked or raw.



# Importance of Control-Ag

- RLWD vectors are economic problems for fruit and vegetable producers
- They damage seeds, seedlings, tubers, leaves and fruit





# Importance of Control-Human Concern

- **Vectors of *Angiostrongylus cantonensis***
  - Rat Lung Worm Disease
  - Human Eosinophilic Meningitis



Health » Food | Fitness | Wellness | Parenting | Vital Signs

Live TV

U.S. Edition +



## Infant hospitalized for rare brain parasite in Hawaii

By Victoria Larned, CNN

© 2017 CNN. ALL RIGHTS RESERVED. PUBLISHED 03/03/17





# HONOLULU Star Advertiser

May 21, 2018 | 75° | Check Traffic



## Toddler is the first rat lungworm case on Oahu this year

By [Kristen Consillio](#)

Posted on May 19, 2018 12:05 am

The state Department of Health on Friday confirmed that Oahu's first case of rat lungworm disease this year is a toddler from Central Oahu. [Read More](#)





LATEST

MOST VIEWED

NEWS

Next to its solar twins, the sun stands out

BY LISA GROSSMAN

AUGUST 03, 2018

NEWS

Scientists successfully transplant lab-grown lungs into pigs

BY MARIA TEMMING

AUGUST 03, 2018

SCIENCE TICKER

Rat lungworm disease is popping up in the mainland United States

BY LEAH ROSENBAUM

AUGUST 03, 2018

NEWS

The 'language gene' didn't give humans a big leg up in evolution

BY TINA HESMAN SAET

AUGUST 03, 2018

NEWS

Hurricane Maria's death toll in Puerto Rico topped 1,100, a new study says

BY AIMEE CUNNINGHAM

AUGUST 02, 2018

SOCIETY UPDATE

Belly bacteria can shape mood and behavior

NEWS IN BRIEF

Indonesia's pygmies didn't descend from hobbits, DNA analysis suggests

BY BRUCE BOYER

AUGUST 02, 2018

NEWS IN BRIEF

Fossil teeth show how a mass extinction scrambled shark evolution

BY CAROLYN GRAMLING

AUGUST 02, 2018

NEWS HEALTH, ANIMALS, MICROBES

# A medical mystery reveals a new host for the rat lungworm parasite

This disease can be spread by eating centipedes, frogs, snails and other creatures

BY LEAH ROSENBAUM 5:00PM, JULY 30, 2018



**COOK BEFORE EATING** The Chinese red-headed centipede (*Scolopendra subspinipes mutilans*) carries a parasite that can infect humans with rat lungworm disease when eaten raw.

YASUNORI KOIDE

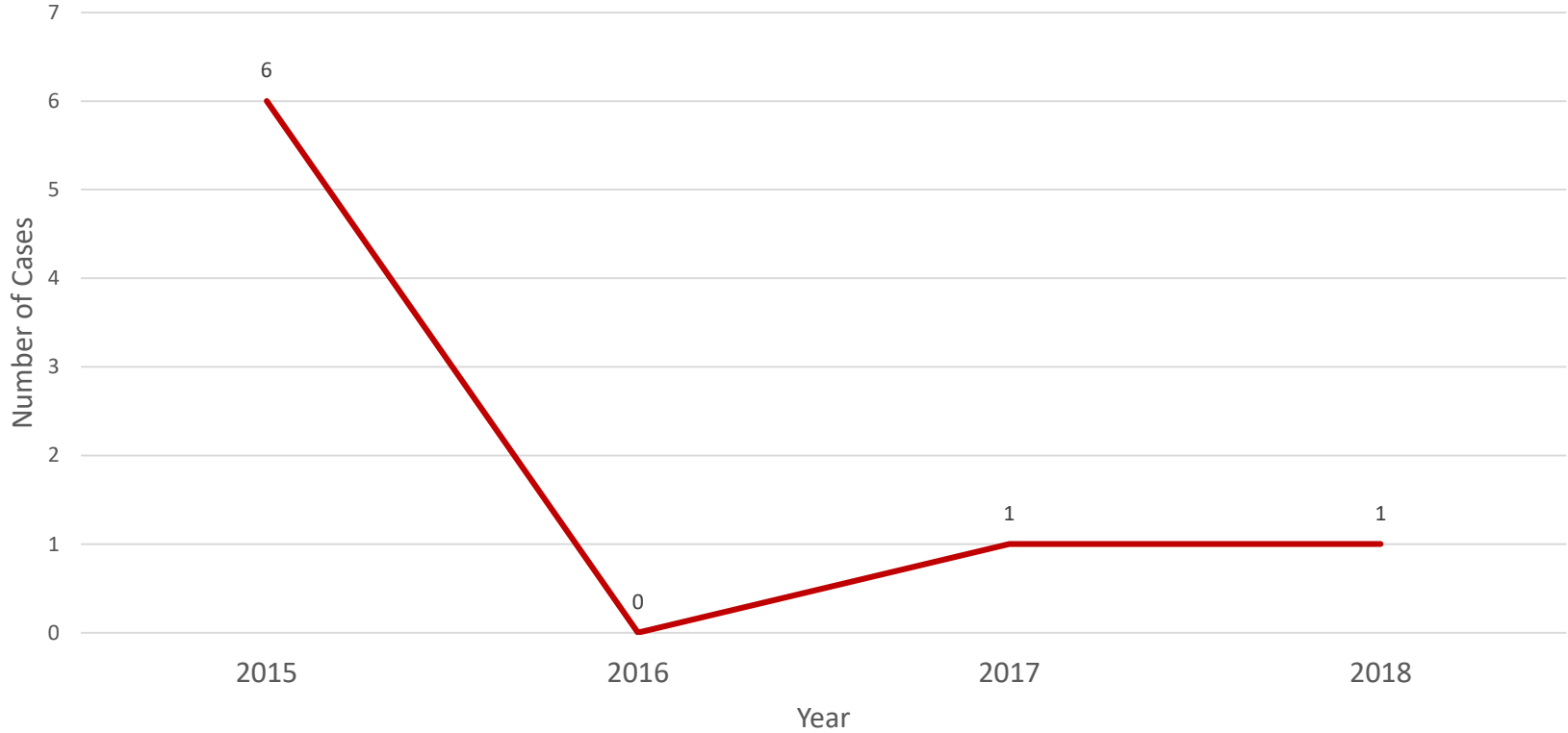
When a 78-year-old woman went to a hospital in Guangzhou, China, in November 2012 complaining of a headache, drowsiness and a stiff neck, doctors initially were puzzled. The patient had meningitis, but no signs of

SPONSOR MESSAGE





# Confirmed Cases of RLW on Oahu



None of these cases have been linked to product from a farm (communication with L. Castro, DOA)



## UH researchers predict distribution of rat lungworm, now and into future

### University of Hawai'i at Mānoa

Contact: [Robert Cowie](#), (808) 541-7121

Research Professor, Pacific Biosciences Research Center

[Diane Chang](#), (808) 956-0391

UH Communications

Posted: Jul 10, 2018

A University of Hawai'i at Mānoa study reveals that *Angiostrongylus cantonensis* or rat lungworm is widespread in the Hawaiian Islands, and its distribution may expand, especially toward higher elevations as the climate warms.

Rat lungworm is a parasitic nematode with a complicated life cycle, part of which requires living inside snails and slugs. Human infection by this parasite is considered an emerging infectious disease. The range and incidence of the disease are expanding throughout the tropics and subtropics, including in the Hawaiian Islands, making this work especially timely.

Using molecular techniques to screen almost 1,300 snails and slugs representing 37 species from almost 200 sites across the Hawaiian Islands, the team determined rat lungworm was present in numerous species of snails and slugs on five of the six largest islands (it may be present on all islands but just not detected). Further, rat lungworm tended to occur in warmer and rainier locations generally, but not exclusively, windward.

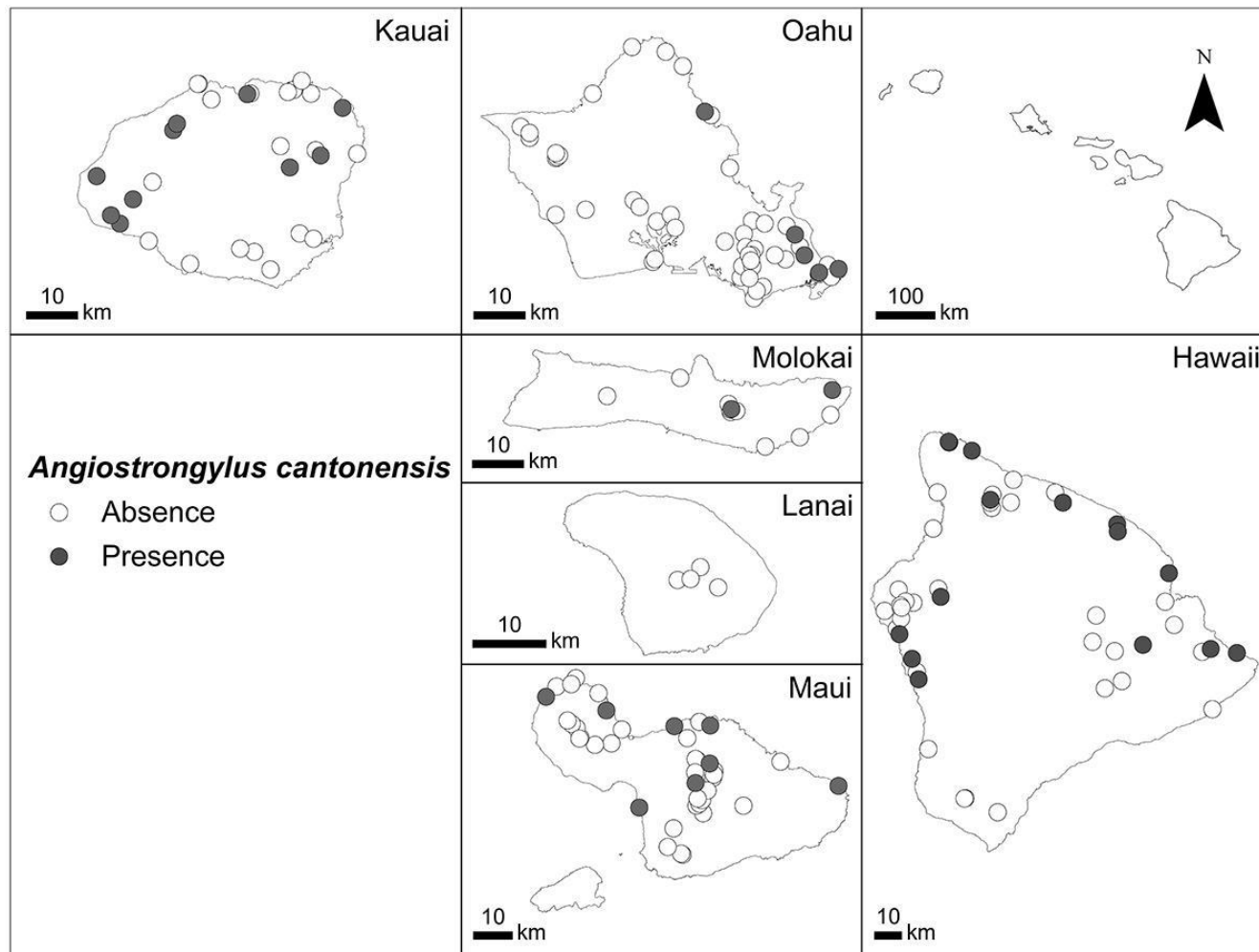
Knowledge of where rat lungworm is or could be across the Hawaiian Islands is important from the perspective of prevention of human and animal infection.

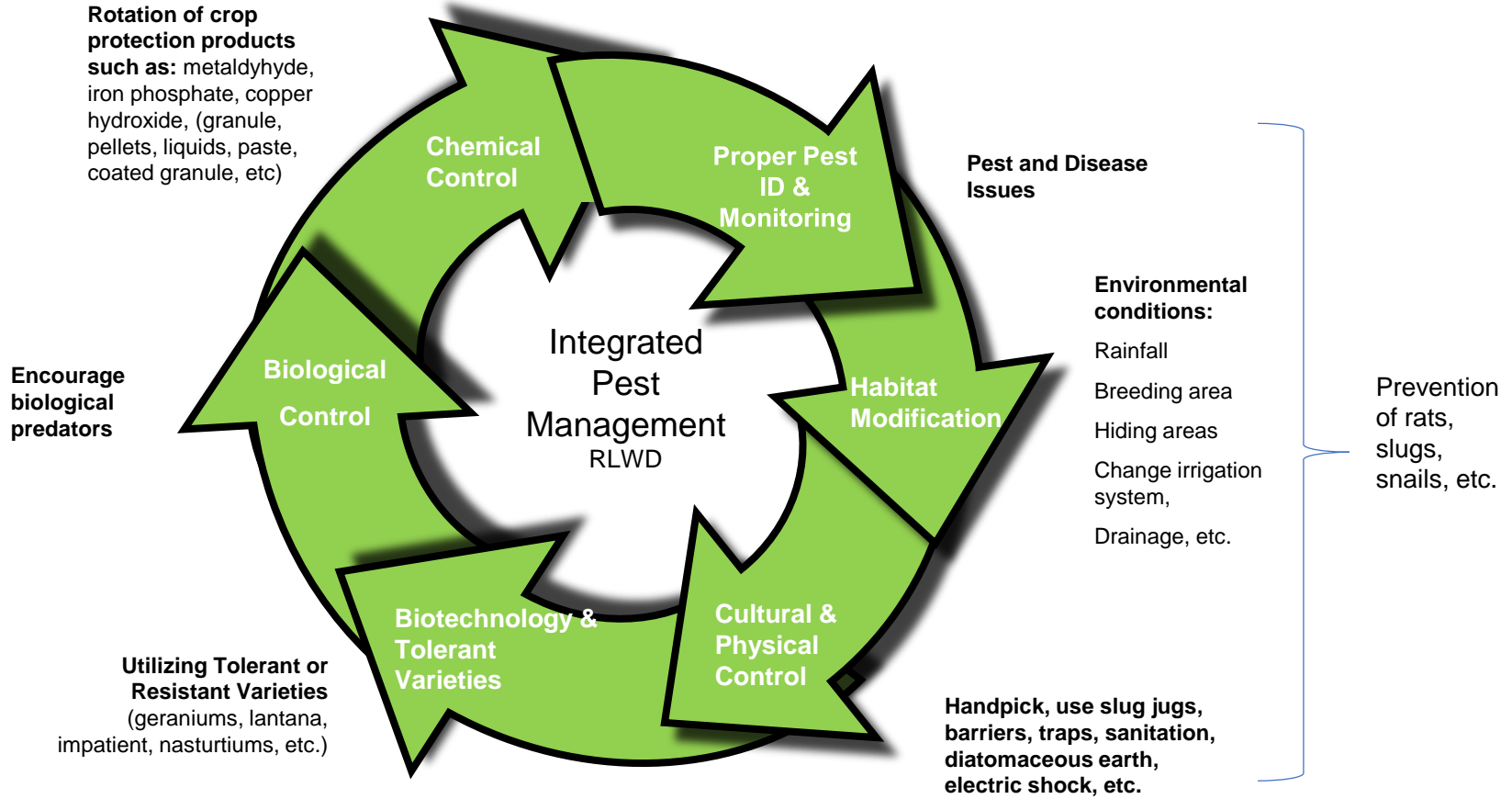
"Local residents and visitors need to know what the risks are. The data will be important to the state Department of Health in targeting epidemiological surveys and interventions," said [Robert Cowie](#), senior author on the study and a research professor at the UH Mānoa Pacific Biosciences



*Lissachatina fulica*, giant African snail. Photo: R. Rollins



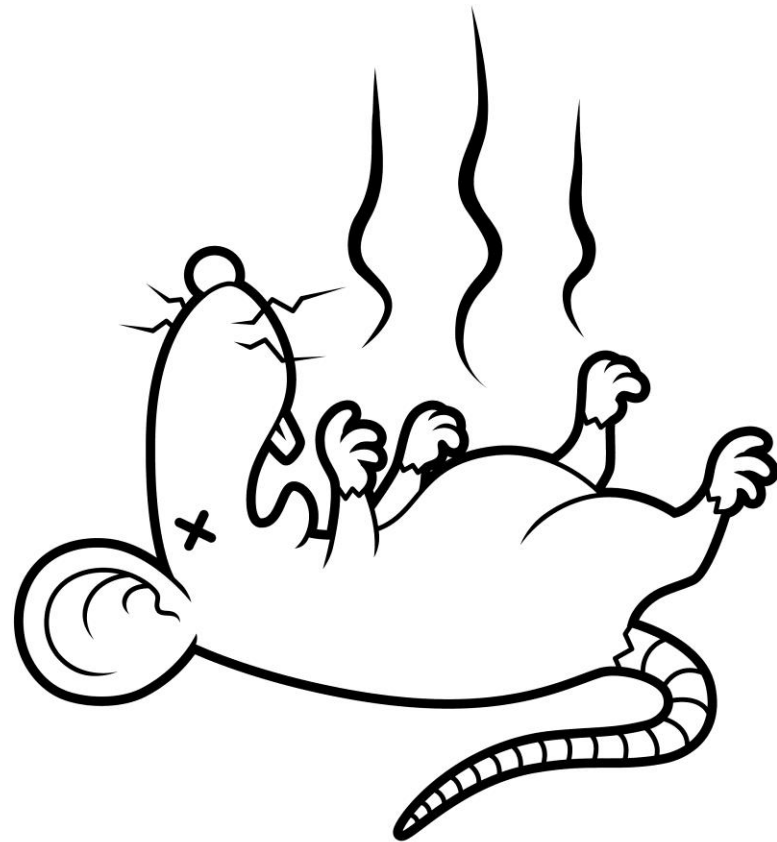






# Management of Rats

- Rat Vectors:
  - Roof rat (*Rattus rattus*)
  - Norway rats (*Rattus norvegicus*)
  - Polynesian rats (*Rattus exulans*)
  - Black rats (*Rattus rattus*)
- House mice (*Mus musculus*) have not been confirmed to be carriers



Baited, placed along wall



Live traps

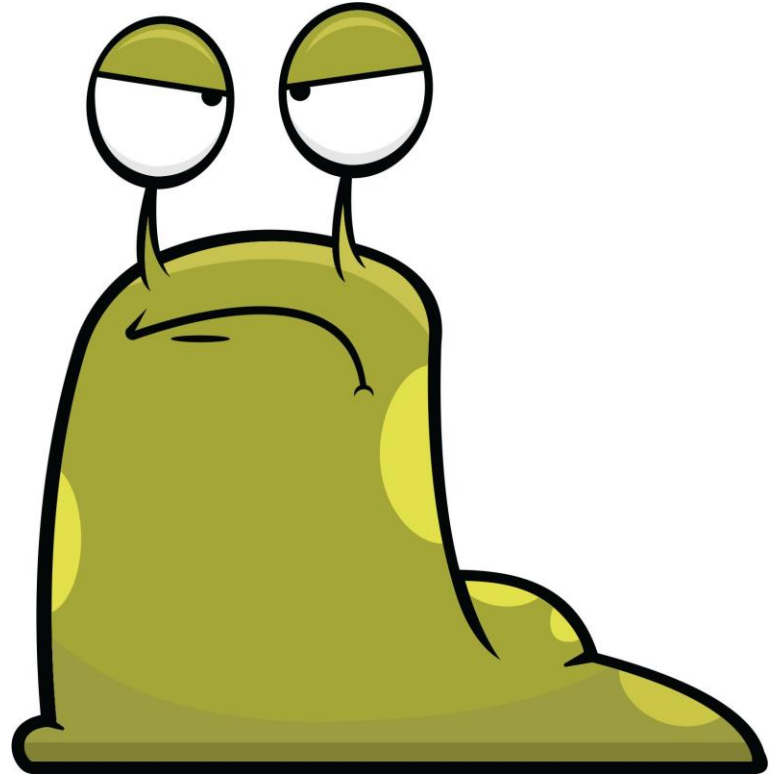






# Management of Slugs and Snails

- Manage the habitat
  - They prefer warm and wet conditions
- Physical controls
  - Barriers (copper (shocks), diatomaceous earth (irritant))
  - Traps (beer, yeast, boards, etc.)
  - Handpicking (dispose in 15% salt solution)





# Methods of Commercial Control

- Chemical Controls
  - Metaldyhyde (affects mucus production)
  - Iron Phosphate (stops feeding)
  - Sodium Ferric (affects ability to produce O<sub>2</sub>)
  - Deltamethrin (pyrethroid)
  - Methiocarb (carbamate, nerve poison)
  - Salt (desiccant)
  - Caffeine (Hollingsworth et al, 2002)
  - Garlic Sprays (Schüder et al. 2003)
  - Hydrated Lime (Laznik & Trdan, 2016)

\*\* Read and follow the label



# Traps

(Medium level of suppression)

**Deterrents**

(Low level of suppression)



**Baits**

(High level of suppression)

Deadline MP  
4% Metaldyhyde

Sluggo  
1% Iron Phosphate





## Slug and Snail Pesticides Registered for Hawai'i Home & Garden Use

**PESTICIDE PRECAUTIONS** All products listed here are labeled in the risk category of CAUTION. Read and follow directions on the manufacturer's label. Check if products are approved for intended use and follow rates of application. THE LABEL IS THE LAW!

If you have questions about pesticides or repellents, please contact your local

- Hawai'i Department of Agriculture (HDOA) Pesticides Branch  
[https://hdoa.hawaii.gov/pi/files/2013/01/Pesticide-Branch-Contacts\\_General-10-16.pdf](https://hdoa.hawaii.gov/pi/files/2013/01/Pesticide-Branch-Contacts_General-10-16.pdf)
- University of Hawai'i Cooperative Extension office at <http://go.hawaii.edu/jhs>

Organic Products (OMRI Listed)				
Company	Product Name	Type of Active Ingredient	% Active Ingredient	EPA Reg. #
BASF	MOTHEREARTH GRANULAR SCATTER BAIT	Boric acid	5.00%	499-515
BAYER ADVANCED	BAYER ADVANCED NATRIA SNAIL & SLUG KILLER BAIT	Iron Phosphate	1.00%	67702-3-72155
BONIDE PRODUCTS	BONIDE BUG & SLUG KILLER	Iron Phosphate Spinosad	0.97% 0.07%	67702-24-4
HAWTHORNE GARDENING	WHITNEY FARMS SLUG & SNAIL KILLER 1	Iron Phosphate	1.00%	67702-3-91161
LAWN & GARDEN PRODUCTS	MONTEREY ANT CONTROL	Iron Phosphate Spinosad	0.97% 0.07%	67702-24-54705
LAWN & GARDEN PRODUCTS	MONTEREY SLUGGO	Iron Phosphate	1.00%	67702-3-54705
LAWN & GARDEN PRODUCTS	SLUGGO PLUS	Iron Phosphate Spinosad	0.97% 0.07%	67702-24-54705
LILLY MILLER	WORRY FREE BRAND BY LILLY MILLER FERRAMOL SLUG & SNAIL BAIT	Iron Phosphate	1.00%	67702-3-33116
MIRACLE-GRO	MIRACLE-GRO NATURE'S CARE SLUG & SNAIL CONTROL	Iron Phosphate	1.00%	67702-3-62355
ORTHO	ORTHO ELEMENTALS SLUG & SNAIL KILLER	Iron Phosphate	1.00%	67702-3-239
SCHULTZ	GARDEN SAFE SLUG & SNAIL BAIT	Iron Phosphate	1.00%	67702-3-39609
SWISS FARMS	WHITNEY FARMS SLUG & SNAIL KILLER	Iron Phosphate	1.00%	67702-3-73327
EP NATURALS	DESECT DIATOMACEOUS EARTH INSECTICIDE	Silicone Dioxide	85.00%	7655-1

Conventional Products				
Company	Product Name	Type of Active Ingredient	% Active Ingredient	
ENSYSTEX II	BORATHOR GRANULAR SCATTER BAIT	Boric acid	5.00%	81824-12
NISUS	NIBAN GRANULAR BAIT	Boric acid	5.00%	64405-2
ROCKWELL LABS	INTICE 10 PERIMETER BAIT	Boric acid	10.00%	73079-6
SENORET	TERRO MULTI-PURPOSE INSECT BAIT	Boric acid	5.00%	64405-2-149
SENORET	TERRO PERIMETER ANT BAIT PLUS	Boric acid	5.00%	64405-2-149
FMC	CYNOFF INSECTICIDE	Cypermethrin	0.15%	279-3259
BAYER ENVIRONMENTAL	DELTADUST INSECTICIDE	Deltamethrin	0.05%	432-772
CONTROL SOLUTIONS	D-FENSE DUST INSECTICIDE	Deltamethrin	0.05%	53883-283
GRANT LABORATORIES	GRANT'S KILLS ANTS MULTI-PURPOSE CARPENTER ANT & TERMITE KILLER DUST	Deltamethrin	0.05%	28293-322-1663
GREEN LIGHT	GREEN LIGHT MANY PURPOSE DUST	Deltamethrin	0.05%	869-237
GREEN LIGHT	GREEN LIGHT MANY PURPOSE DUST 1	Deltamethrin	0.05%	73327-14
SENORET	TERRO ANT DUST	Deltamethrin	0.05%	149-12
SENORET	TERRO FIRE ANT KILLER	Deltamethrin	0.05%	149-12
SWISS FARMS	GREEN LIGHT MANY PURPOSE DUST 1	Deltamethrin	0.05%	73327-14
ZEP	ENFORCER BUGMAX INSECT POWDER	Deltamethrin	0.05%	1021-2617-40849
BAYER ADVANCED	BAYER ADVANCED DUAL ACTION SNAIL & SLUG KILLER BAIT READY-TO-USE	Iron Phosphate	1.00%	67702-3-72155
BONIDE	BONIDE SLUG MAGIC MAKES SLUGS DISAPPEAR	Iron Phosphate	1.00%	67702-3-4
AMBRANDS	AMDRO BUG BAIT	Metaldehyde Carbaryl	2.00% 5.00%	8119-5-73342
AMVAC	DEADLINE ORNAMENTAL	Metaldehyde	4.00%	5481-511
AMVAC	DEADLINE T&O	Metaldehyde	4.00%	5481-511
AMVAC	DURHAM ORNAMENTAL 3.5	Metaldehyde	3.50%	5481-583
AMVAC	DURHAM ORNAMENTAL 7.5	Metaldehyde	7.50%	5481-584
GRO TEC	ELIMINATOR SNAIL & SLUG BAIT II	Metaldehyde	3.25%	8119-11-59144
LILLY MILLER	COOKE PEST GRANULES	Metaldehyde Carbaryl	2.00% 5.00%	8119-5-33116
LILLY MILLER	LILLY MILLER SLUG AND SNAIL BAIT	Metaldehyde	3.25%	8119-11-33116
LILLY MILLER	LILLY MILLER SNAIL & SLUG MINI	Metaldehyde	3.25%	8119-13-33116

# Literature Review- Metaldyhyde



PIE 50261-2194(97)00034-3

Crop Protection Vol. 16, No. 6, pp. 501-506, 1997  
© 1997 Elsevier B.V.  
All rights reserved. Printed in Great Britain  
0029-271X/97/0006-501-06



## Molluscicides and mechanical barriers against slugs, *Vaginula plebeia* Fischer and *Veronicella cubensis* (Pfeiffer) (Stylommatophora: Veronicellidae)

Trent Y. Hata, Arnold H. Hara and Benjamin K.-S. Hu  
Department of Entomology, College of Tropical Agriculture and Human Resources,  
University of Hawaii at Manoa, 461 West Lankaula Street Hilo, HI 96720, USA

Thirteen molluscicides containing metaldehyde, three molluscicides containing metaldehyde plus carbaryl, one molluscicide containing metaldehyde plus methiocarb and one molluscicide containing methiocarb alone were tested for efficacy against the brown slug, *Vaginula plebeia* Fischer, and the two-striped slug, *Veronicella cubensis* (Pfeiffer). With the exception of Corry's Liquid Slug, Snail and Insect Killer against *V. plebeia*, all tested molluscicides caused significant mortalities against both species. Selected molluscicides were further evaluated for persistence under simulated rainfall: Deadline One Last Meal for Slugs and Snails, Deadline 40, Deadline Bullets and Slug and Snail AG Pelleted Bait, all of which contain metaldehyde as the active ingredient, consistently produced high mean percentage mortalities against both species. Efficacy of certain molluscicides decreased steadily with time, whereas efficacy of other molluscicides increased initially before declining. Mold grew on the majority of molluscicides after application. Liquid paste and liquid formulations were more resistant to mold development than pelleted, granule or coated granule formulations. In a separate study, physical barriers composed of copper or fiberglass screens repelled both slug species. © 1997 Elsevier Science Ltd

**Keywords:** *Vaginula plebeia*, *Veronicella cubensis*, copper barriers

### Introduction

The brown slug, *Vaginula plebeia* Fischer, and the two-striped slug, *Veronicella cubensis* (Pfeiffer), were first reported in Hawaii in 1978 and 1985, respectively (HDOA, 1994). Since initial reports, populations of these slugs have significantly increased, resulting in severe damage to many ornamental, vegetable and landscape plants. Of particular concern is the impact on Hawaii's \$US104 million vegetable and floriculture industries (Hawaii Agriculture Statistics Service, 1995). Export shipments of vegetable and floriculture crops have been delayed or rejected by quarantine officials due to the presence of slugs or slug eggs (CDFA, 1993). Several states, including Alabama, Arkansas, Louisiana, Mississippi, Oregon, Tennessee, Virginia and Florida, have imposed strict quarantine regulations to prevent the accidental introduction of mollusks (Pattrella *et al.*, 1985). Nurseries certified by the Hawaii Department of Agriculture to export plants must be slug-free.

of 328 cm (National Oceanic and Atmospheric Administration, personal communication) encouraging high slug populations and short molluscicide activity. Growth of mold on molluscicides may also contribute to reduced efficacy and is a problem in high humidity locations where molluscicides are used repeatedly. An additional concern to ornamental growers is the reduction of quality due to mold growing on the molluscicide placed on the media of potted plants. Several manufacturers incorporate mold inhibitors to retard mold development.

### Materials and methods

Trials were conducted from 18 January 1994 through 22 January 1995 in a fiberglass-covered greenhouse with polypropylene shade cloth sides located at the University of Hawaii at Manoa, Waikeae Agricultural

Table 2. Percentage mortality  $\pm$  SE of *V. plebeia* and *V. cubensis* six days after treatment with molluscicides

Product	% mortality <sup>a</sup>	
	<i>V. plebeia</i>	<i>V. cubensis</i>
Deadline Granules	81.2 a	83.5 a
Deadline Bullets	76.3 ab	65.8 ab
Snail and Slug AG Pelleted Bait	62.4 abc	60.1 abc
Metaldehyde Methiocarb Granules 2-1	60.3 abc	33.3 bcde
Ortho Bug-Geta Snail and Slug Pellets	57.5 abc	41.0 bcd
RCO Slug and Snail Pellets	55.1 abcd	44.9 bcd
RCO Slug and Snail Pellets (rain resistant)	48.2 bcde	39.5 bcde
Durham Metaldehyde Granules 7.5	47.9 bcde	63.0 ab
Durham Metaldehyde Granules 3.5	47.2 bcde	28.4 cde
Corry's Slug and Snail Pellets	42.4 cdef	44.9 bcd
Deadline One Last Meal for Slugs and Snails	40.5 cdef	29.9 cde
Corry's Slug, Snail and Insect Killer	38.1 cdefg	27.4 de
Ortho Bug-Geta Plus Snail, Slug and Insect Granules	34.6 cdefg	11.8 e
Corry's Slug and Snail Death	25.9 defgh	42.7 bcd
Ortho Slug-Geta Snail and Slug Bait	20.3 efgh	35.9 bcde
Deadline 40	18.0 fgh	17.7 de
Corry's Liquid Slug and Snail Control	13.6 gh	17.5 de
Corry's Liquid Slug, Snail and Insect Killer	6.8 hi	16.8 de
Control	0.0 i	0.0 f

<sup>a</sup>Significant by ANOVA ( $P < 0.001$ ). Means followed by the same letter in a column are not significantly different by Waller-Duncan  $k$ -ratio  $t$ -test,  $k = 100$ .



## Deadline® Bullets

NOTIFICATION

AUG 3 1 2011

- Excels at Destroying Slugs and Snails
- Contains a Patented formula! Patent No. 4,961,929
- Long Lasting: Remains effective after rain and watering
- Effective: Excels at attracting and destroying slugs and snails
- Long Lasting: Resistant to rain and watering.
- Not easily dissipated by water
- One Last Meal for Slugs and Snails

**ACTIVE INGREDIENT:**

Metaldehyde (2,4,6,8-Tetramethyl- 1,3,5,7-Tetraoxycyclo-octane)..... 4.0%

**INERT INGREDIENTS:**

..... 96.0%

**TOTAL:**

..... 100.0%

KEEP OUT OF REACH OF CHILDREN

### CAUTION - CUIDADO

Si usted no entiende la etiqueta, busque a alguien para que se la explique a usted en detalle.  
(If you do not understand this label, find someone to explain it to you in detail.)

This pesticide may be fatal to children and dogs, or other pets if eaten. Keep children and pets out of treated areas.

#### FIRST AID

<b>If swallowed:</b>	<ul style="list-style-type: none"> <li>• Call a poison control center or doctor immediately for treatment advice.</li> <li>• Have a person sip a glass of water if able to swallow.</li> <li>• Do not induce vomiting unless told to do so by a poison control center or doctor.</li> <li>• Do not give anything by mouth to an unconscious person.</li> </ul>
<b>If in eyes:</b>	<ul style="list-style-type: none"> <li>• Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.</li> <li>• Call a poison control center or doctor for treatment advice.</li> </ul>
<b>If on skin or clothing:</b>	<ul style="list-style-type: none"> <li>• Take off contaminated clothing.</li> <li>• Rinse skin immediately with plenty of water for 15-20 minutes.</li> <li>• Call a poison control center or doctor for treatment advice.</li> </ul>

#### EMERGENCY INFORMATION

Have the product container or label with you when calling a poison control center or doctor, or going for treatment.  
FOR THE FOLLOWING EMERGENCIES, PHONE 24 HOURS A DAY:

Transportation: CHEMTREC.....1-800-424-9300  
Other: AMVAC.....1-323-264-3910

SEE SIDE/BACK PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS AND DIRECTIONS FOR USE

EPA Reg. No. 5481-507  
EPA Est. No. 64864-WA-01

Net Weight:  
As Marked on Container



4100 E. Washington Blvd.  
Los Angeles, CA 90023 U.S.A.  
1-323-264-3910 • www.amvac-chemical.com



# DEADLINE® MP<sub>s</sub>

Mini-Pellets!

ONE LAST MEAL FOR SLUGS & SNAILS

Deadline® M-Ps Mini-Pellets

Mini-Pellets!  
ONE LAST MEAL FOR SLUGS & SNAILS

**OBJECTIVE**  
KILLS AND DESTROYS slug and snail populations and eliminates their soil nests.  
**LONG LASTING**  
Remains effective after rain and watering. DEADLINE® M-Ps are specially designed to resist moisture and UV radiation.  
Be sure to apply to soil particles exposed to sunlight for best results.

**ACTIVE INGREDIENTS**  
Metaldehyde (2,4,6,8-Tetramethyl-1,3,5,7-Tetraoxycyclo-octane).....4.0%

Crop	Maximum Single Application Rate (lbs. Product/A)	Total number of applications per season	Re-application Interval (days)	Preharvest Interval
Grass (grown for seed)	20	4	21	21
Taro (wetland) <sup>1</sup>	25	7	35	7

<sup>1</sup>Broadcast application to be made under flooded conditions only. Prior to bait application, stop the water flow into and out of the lo'i (paddies) to be treated; water level should be high enough such that apple snails don't estivate. Apply the bait and hold/impound the water for a minimum of 3 days before allowing water to exit the lo'i. Do not apply more than one application per held/impounded water. If the water level in the lo'i becomes too low within the 3 day holding period (due to faster percolation of water through the soil), such that apple snails begin to estivate, allow additional water into the lo'i.



Manufactured by  
**AMVAC**  
4100 E. Washington Blvd.  
Los Angeles, CA 90023 U.S.A.  
11585  
Net Weight  
20150305g



Case Study:  
Apple Snail eaten as escargot









# Literature Review- Iron Phosphate

- Organic lettuce trial, using the randomized block design (4)
- Trial 1, 2, 3: Iron phosphate (Ferramol)/ Metaldehyde (Gastrotox E)

Treatment		Trial 1 (20-Oct-03) 19 DAT						Trial 2 (10-Jun-04) 23 DAT			
		dead slugs (%)		dead snails (%)		leaf eroded surface (%)		dead snails (%)		leaf eroded surface (%)	
1	untreated	23.1	b	0	b	48.7	a	2.5	c	59.4	a
2	metaldehyde	100	a	91.7	a	0.9	b	82.5	a	0.3	c
3	iron phosphate	100	a	66.7	a	0.3	b	62.5	b	1.3	c
4	<i>P. hermaphrodita</i>	25	b	18.2	b	52.3	a	0	c	23.2	b

Means marked by different letters on the same column are statistically different according to LSD test ( $P \leq 0.05$ ).



# Literature Review- Iron Phosphate

- Trial 4: Metaldehyde (Mesurol M plus) / iron phosphate (Ferramol)
- Iron Phosphate was as effective as metaldehyde based formulations in ¾ trials
- Effectiveness of slug mortality was based on formulation type

Treatment		Trial 3 (25-Oct-04) 5 DAT <sub>2</sub>				Trial 4 (21-Sep-07) 16 DAT			
		dead slugs (%)		leaf eroded surface (%)		dead slugs (%)		leaf eroded surface (%)	
1	untreated	12.9	c	20.6	a	17.2	a	24.2	a
2	metaldehyde	32.5	b	2.1	b	100	b	0.3	c
3	iron phosphate	86.8	a	0.6	b	89.7	b	6.3	b

Means marked by different letters on the same column are statistically different according to LSD test ( $P \leq 0.05$ ).

Sluggo  
1% Iron Phosphate –OMRI  
Safe around animals and wildlife

3lgstich\_LPllgstich.qxd 11/6/2012 1:21 PM Page 1



# LEAF LIFE<sup>®</sup>

## SLUGGO<sup>®</sup>

### SNAIL AND SLUG BAIT

---

FOR ORGANIC PRODUCTION

The active ingredient in the product is exempt from the requirement for a tolerance when used as a molluscicide in or on all food commodities.

Can be used around pets and wildlife.

Read Entire Container Label Before Using This Product

ACTIVE INGREDIENT: Iron phosphate	By Wt.	1.0%
OTHER INGREDIENTS:		99.0%
TOTAL		100.0%

**KEEP OUT OF REACH OF CHILDREN**

**CAUTION**

EPA REG. NO. 67702-3-34704  
EPA EST. NO. 67702-DEU-2  
NET WEIGHT 25.0 LBS (11.34 KG)

10/12

MADE IN GERMANY  
FORMULATED FOR  
LOVELAND PRODUCTS, INC.®, P.O. BOX 1286, GREELEY, COLORADO 80632-1286

Sluggo Maxx  
3% Iron Phosphate  
OMRI  
Awaiting registration  
Not waterproof but  
remains effective  
after rainfall



Hawaii Registration Pending, Q2/2018

# SLUGGO<sup>®</sup>

## MAXX<sup>®</sup> BRAND

Proven snail & slug killer

The active ingredient in this product is exempt from the requirement for a tolerance when used as a molluscicide in or on all food commodities.

- Can be used up to and including day of harvest.
- Remains effective after rain or sprinkling.
- Protects plants for up to 4 weeks.
- Can be used around pets and wildlife.
- Small pellets for greater coverage.
- 1 lb treats 11,000 sq. ft.



Active Ingredient	By weight
Iron phosphate	3.0%
Other Ingredients	97.0%
Total	100.0%

EPA Registration No. 67702-55 EPA Est. No. 48498-CA-2  
NET WEIGHT 25 LBS

**KEEP OUT OF REACH OF CHILDREN**  
**CAUTION**

#### FIRST AID

If in eyes: Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

**Hotline Number** Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For emergency information concerning this product, call the Poison Control Center at 1-800-222-1222.

#### PRECAUTIONARY STATEMENTS

**Hazards to Humans and Domestic Animals:** Caution. Causes moderate eye irritation. Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet.

**Personal Protective Equipment (PPE) Requirements:** Applicators and other handlers must wear: long-sleeved shirts and long pants; and shoes plus socks. Follow manufacturer's instructions for maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

#### User Safety Recommendations

- Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Users should remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

**Environmental Hazards:** For terrestrial uses: Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinseate. For aquatic uses: Do not apply directly to water to be treated, finished drinking water reservoirs or drinking water receptacles when the water is intended for human consumption. Do not contaminate water when disposing of equipment washwater or rinseate.

#### DIRECTIONS FOR USE

It is a violation of Federal law to use this product in a manner inconsistent with its labeling. Do not apply this product in a manner that will contact workers or other persons, either directly or through drift. Only protected workers may be in the area during application. For any requirements specific to your State or Tribe, consult the State or Tribal agency representative responsible for pesticide regulation.

#### AGRICULTURAL USE REQUIREMENTS

Use this product in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE) and the restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard (WPS).

There is a restricted-entry interval of four hours for this product.

#### NON-AGRICULTURAL USE REQUIREMENTS

The requirements in this box apply to uses of this product that are not within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses.

There are no restrictions.

**HOW TO APPLY:** Apply bait granules around or over the plants to be protected at the rate of 4-15 lbs per acre (0.09-0.34 lbs per 1000 sq. ft.) and reapply as the bait is consumed or as needed. For heavy pest pressure apply 20-25 lbs per acre. Do not place in piles.

**Broadcast Application:** Apply uniformly with appropriate, calibrated equipment within the application rates on this label. Do not apply when weather conditions favor drift from treated areas. Test for phytotoxicity prior to broadcast application on sensitive soft leaved plants such as leafy greens and herbs, or take precautions to avoid contact with sensitive plant parts.

**Aquatic Application:** For the control of aquatic slugs or snails, such as Golden Apple Snail, apply at a rate of 20-44 lbs per acre (0.46-1.0 lbs per 100 sq. ft.). Broadcast applications may be made under flooded conditions. Apply the bait directly to the water in likely areas of infestation. Re-apply if the infestation is severe. Use the higher application rates for larger snails. The water level should be high enough such that the target pests don't escape.

**WHEN TO APPLY:** For best results, apply the bait in the evening, as slugs and snails travel and feed mostly by night or early morning.

**WHERE TO APPLY:** Treat all likely areas of infestation, especially around base of plants, between rows and around the perimeter of the plot to provide a protective barrier for slugs and snails entering the field.

#### Vegetables

- Apply bait to protect any vegetables from slug and snail damage, such as:
- **Artichoke**
  - **Asparagus**
  - **Root and Tuber Vegetables:** beet, carrot, ginger, ginseng, parsnip, radish, rutabaga, sweet potato, sugar beet, taro, turnip, yam



Read Entire Container Label Before Using This Product  
The active ingredient in this product is exempt from the requirements for a tolerance when used as a molluscicide in or on all food commodities. Can be used around domestic animals, pets, and wildlife.

Active Ingredient	By Weight
Iron Phosphate	3.00 %
Other Ingredients	97.00 %
Total	100.00 %

**NET WEIGHT:**

EPA Reg. No. 47702-49 EPA Est. No. 47702

**KEEP OUT OF REACH OF CHILDREN**

**CAUTION**

**FIRST AID**

**If in eyes:** Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

**Hotline Number:** Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For emergency information concerning this product, call the National Pesticide Information Center at 1-800-858-7378 seven days a week, 6:30 am to 4:30 Pacific Time (NPIC Website: [www.npic.orst.edu](http://www.npic.orst.edu)).

**STORAGE AND DISPOSAL**

Do not contaminate water, food or feed by storage or disposal.  
**PESTICIDE STORAGE:** Store this product in its original container and keep in a secure storage area out of reach of children and domestic animals.  
**PESTICIDE DISPOSAL:** Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.  
**CONTAINER HANDLING:** Nonrefillable container. Do not reuse or refill this container. Offer for recycling, if available. Completely empty metal drum, plastic bag, box or plastic tote into application equipment. Then dispose of empty metal drum, plastic bag, box or plastic tote in a sanitary landfill, or by incineration, or if allowed by State and local authorities, by burning. If burned, stay out of smoke.

**PRECAUTIONARY STATEMENTS**

**Hazards to Humans and Domestic Animals:** Caution. Causes moderate eye irritation. Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet.

**Personal Protective Equipment (PPE) Requirements:** Applicators and other handlers must wear: long-sleeved shirts and long pants; and shoes plus socks. Follow manufacturer's instructions for maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

**User Safety Recommendations**

- Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Users should remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

**Environmental Hazards:** For terrestrial uses: Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when disposing of equipment washwater or rinsate.

For aquatic uses: Only for use in flooded fields infested with Golden Apple Snails. Do not allow water from treated flooded fields to enter finished drinking water reservoirs or drinking water receptacles when the water is intended for human consumption. Do not contaminate water when disposing of equipment washwater or rinsate.

**DIRECTIONS FOR USE**

*It is a violation of Federal law to use this product in a manner inconsistent with its labeling.*

Do not apply this product in a manner that will contact workers or other persons, either directly or through drift. Only protected workers may be in the area during application. For any requirements specific to your State or Tribe, consult the State or Tribal agency representative responsible for pesticide regulation.

**AGRICULTURAL USE REQUIREMENTS**

Use this product in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE) and the restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard (WPS).

There is a restricted-entry interval of four hours for this product.

**NON-AGRICULTURAL USE REQUIREMENTS**

The requirements in this box apply to uses of this product that are not within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses. There are no restrictions.

**HOW TO APPLY:** Scatter the slug and snail bait granules on the soil around or near the plants to be protected. For row application, use standard granular spreaders. Apply bait evenly at the rate of 4-15 lbs per acre (0.09-0.34 lbs per 1000 sq. ft.) and reapply as the bait is consumed or as needed.

**WHEN TO APPLY:** For best results, apply the bait in the evening, as slugs and snails travel and feed mostly by night or early morning.

**WHERE TO APPLY:** Treat all likely areas of infestation, especially around the base of plants, between rows and around the perimeter of the plot to provide a protective "barrier" for slugs and snails entering the field.

**Vegetables:** Scatter the bait around the perimeter of vegetable fields. If slugs or snails are inside the rows, scatter the bait on the soil around the base of the plants and between the rows. Use the bait to protect any vegetables from slug and snail damage, such as:

**Artichoke**

**Asparagus**

**Root and Tuber Vegetables:** beet, carrot, ginger, parsnip, potato, radish, rutabaga, sweet potato, sugar beet, taro, turnip, yam

**Bulb Vegetables:** dry bulb onion, garlic, great-headed elephant garlic, green onion, leek, onion, shallot, Welch onion

**Leafy Vegetables and Leaves of Root and Tuber and Legume**

**Vegetables:** arugula, beet, blackeyed pea, celery, lettuce, pea, rhubarb, spinach, Swiss chard, turnip greens, watercress

**Cole Crops and Brassica Leafy Vegetables:** broccoli, broccoli raab,

Brussels sprouts, cabbage, canola, cauliflower, cavalo, Chinese broccoli, Chinese cabbage (bok choy), Chinese cabbage (napa), Chinese mustard

cabbage (gai choy), collards, kale, kohlrabi

**Legumes:** beans and peas, soybean

**Cucurbit Vegetables:** cantaloupe, cucumber, edible gourd, honeydew, melon, muskmelon, pumpkin, summer squash, watermelon, winter squash

**Fruiting Vegetables:** eggplant, ground cherry, okra, pepino, pepper, tomatillo, tomato

**Corn:** field corn, sweet corn



**Read Entire Container Label Before Using This Product**

The active ingredient in this product is exempt from the requirement for a tolerance when used as a molluscicide in or on all food commodities. Can be used around domestic animals (pets) and wildlife.

Active Ingredient	By Weight
Iron Phosphate.....	3.00 %
Other Ingredients.....	97.00 %
Total.....	100.00 %

**NET WEIGHT:**

EPA Reg No. 67703-49 EPA Est No. 67702-

**KEEP OUT OF REACH OF CHILDREN**

**CAUTION**

**FIRST AID**

**If in eyes:** Hold eye open and rinse slowly and gently with water for 15-20 minutes. Remove contact lenses, if present after the first 5 minutes, then continue rinsing eye. Call a poison control center or doctor for treatment advice.

**Hotline Number:** Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For emergency information concerning this product, call the National Pesticide Information Center at 1-800-858-7378 seven days a week, 6:30 am to 4:30 Pacific Time (NPIC Website: [www.npic.orst.edu](http://www.npic.orst.edu)).

**STORAGE AND DISPOSAL**

Do not contaminate water, food or feed by storage or disposal.  
**PESTICIDE STORAGE:** Store this product in its original container and keep in a secure storage area out of reach of children and domestic animals.  
**PESTICIDE DISPOSAL:** Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.  
**CONTAINER HANDLING:** Nonrefillable container. Do not reuse or refill this container. Offer for recycling, if available. Completely empty metal drum, plastic bag, box or plastic tote into application equipment. Then dispose of empty metal drum, plastic bag, box or plastic tote in a sanitary landfill, or by incineration, or if allowed by State and local authorities, by burning. If burned, stay out of smoke.

**PRECAUTIONARY STATEMENTS**

**Hazards to Humans and Domestic Animals:** Caution. Causes moderate eye irritation. Avoid contact with eyes or clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco or using the toilet.

**Personal Protective Equipment (PPE) Requirements:** Applicators and other handlers must wear: long-sleeved shirts and long pants; and shoes plus socks. Follow manufacturer's instructions for maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

**User Safety Recommendations**

- Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Users should remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

**Environmental Hazards:** For terrestrial uses: Do not apply directly to

water, or to areas where surface water is present below the mean high water mark. Do not contaminate equipment washwater or rinseate.

For aquatic uses: Only for use in flooded fields or Snails. Do not allow water from treated flooded drinking water reservoirs or drinking water rec intended for human consumption. Do not contaminate equipment washwater or rinseate.

**DIRECTIONS FOR USE**

*It is a violation of Federal law to use this product in labeling.*

Do not apply this product in a manner that will persons, either directly or through drift. Only pi in the area during application. For any requirem or Tribe, consult the State or Tribal agency re:pr pesticide regulation.

**AGRICULTURAL USE REQUIREMENT:**

Use this product in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170. This standard contains requirements for the protection of agricultural workers on farms, forests, nurseries, and greenhouses, and handlers of agricultural pesticides. It contains requirements for training, decontamination, notification, and emergency assistance. It also contains specific instructions and exceptions pertaining to the statements on this label about Personal Protective Equipment (PPE) and the restricted-entry interval. The requirements in this box only apply to uses of this product that are covered by the Worker Protection Standard (WPS).

There is a restricted-entry interval of four hours for this product.

**NON-AGRICULTURAL USE REQUIREMENTS**

The requirements in this box apply to uses of this product that are not within the scope of the Worker Protection Standard for agricultural pesticides (40 CFR Part 170). The WPS applies when this product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses. There are no restrictions.

**HOW TO APPLY:** Scatter the slug and snail bait granules on the soil around or near the plants to be protected. For row application, use standard granular spreaders. Apply bait evenly at the rate of 4-15 lbs per acre (0.09-0.34 lbs per 1000 sq. ft.) and reapply as the bait is consumed or as needed.

Waterproof  
Safe around pests and wildlife  
Kills in 24 hours

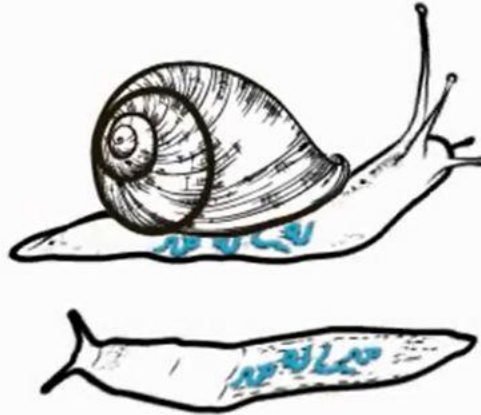
**Aquatic Application:** For the control of Golden Apple Snail, apply at a rate of 20-44 lbs per acre (0.46-1.0 lbs per 1000 sq. ft.). Broadcast applications may be made under flooded conditions. Apply the bait directly to the water in likely areas of infestation. Re-apply if the infestation is severe. Use the higher application rates for larger snails. The water level should be high enough such that the Golden Apple Snails don't estivate.



# Repel vs. Suppress



*Angiostrongylus cantonensis*



hamlyn  
**50 WAYS TO  
KILL A SLUG**



**SERIOUS & SILLY WAYS TO KILL OR OUTWIT  
THE GARDEN'S NUMBER ONE ENEMY**

Images:  
[https://www.buecher.de/shop/garten-pflanzen-natur/50-ways-to-kill-a-slug/ford-sarah/products\\_products/detail/prod\\_id/21498256/](https://www.buecher.de/shop/garten-pflanzen-natur/50-ways-to-kill-a-slug/ford-sarah/products_products/detail/prod_id/21498256/)  
Center for Disease Control: [https://www.youtube.com/watch?v=V\\_f1IK93ZtE&feature=youtu.be](https://www.youtube.com/watch?v=V_f1IK93ZtE&feature=youtu.be)







## Reduce the Risk of Rat Lungworm

# CONTROL SLUGS AND SNAILS



Asian Semi Slugs: the worst carriers

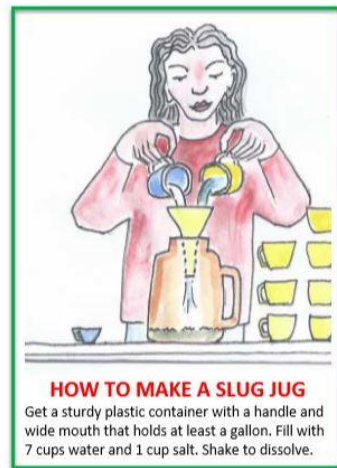


### 1. Remove Hiding Places

- Boards, stones, and rubbish
- Weeds around tree trunks, fallen fruit
- Leafy branches close to the ground

### 2. Handpick- but DON'T TOUCH with Bare Hands

- Rainfall & watering a garden in late afternoon encourages slugs & snails to come out
- Pick them in the evening and/or early morning
- **Wear rubber gloves and use tongs or chopsticks**
- Make a Slug Jug. Drop them in to kill them. Add a little bleach to keep it from smelling bad.
- Leave them in at least 12 hours. Dispose of the dead slugs and solution away from plants, like in a driveway (salt kills plants).
- Do it daily at first, weekly when numbers become lower.
- Don't smash slugs or snails - rat lungworms won't die.



#### HOW TO MAKE A SLUG JUG

Get a sturdy plastic container with a handle and wide mouth that holds at least a gallon. Fill with 7 cups water and 1 cup salt. Shake to dissolve.



### 3. Make Traps

Clear grass and weeds to bare dirt and moisten ground before setting out traps. Use plastic bags, boards held slightly above the ground by a stick, old plates, flower pots, melon rinds and peels. Check them daily, put any caught in the slug jug

### 4. Use Baits

- BAITs ALONE MAY NOT BE EFFECTIVE
- When dry, water before applying bait
- Metaldehyde baits - toxic to pets and children, work well but rain can reduce effectiveness
- Iron phosphate baits - safe for humans and animals, takes a few days to kill slugs and snails.



Aquaponic Industry Request:  
Barrier to prevent slugs and snails from crawling up  
the legs of grow beds





# Literature Search-Barrier Study

Table 6 Efficacy of mechanical barriers against *V. cubensis* and *V. plebeia*

Barrier	Mean number crossing barrier	
	<i>V. cubensis</i> <sup>a</sup>	<i>V. plebeia</i> <sup>a</sup>
Copper	3.0 b ± 2.6 <sup>b</sup>	1.7 b ± 1.5
Fiberglass	4.3 b ± 3.2	5.3 b ± 1.5
Aluminum	19.7 a ± 7.2	11.7 ab ± 10.8
Paperboard	26.3 a ± 2.1	23.0 a ± 1.0

<sup>a</sup>Significant by ANOVA,  $P < 0.01$ . Means followed by different letters in a column are significantly different by Scheffe multiple-comparison procedure.  
<sup>b</sup>Standard deviation.

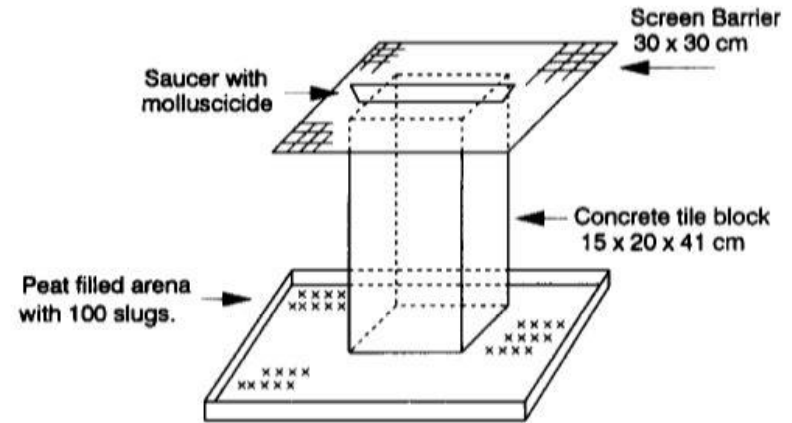


Figure 1. Schematic diagram of the method used in evaluating screen barriers for efficacy against *V. plebeia* and *V. cubensis*

Hata, Trent Y., Arnold H. Hara and Benjamin K.-S. Hu (1997). Molluscicides and mechanical barriers against slugs, (Stylommatophora: Veronicellidae) *Vaginula plebeia* Fischer and *Veronicella cubensis* (Pfeiffer). *Crop Protection*, V.16. no. 6. pg. 501-506.



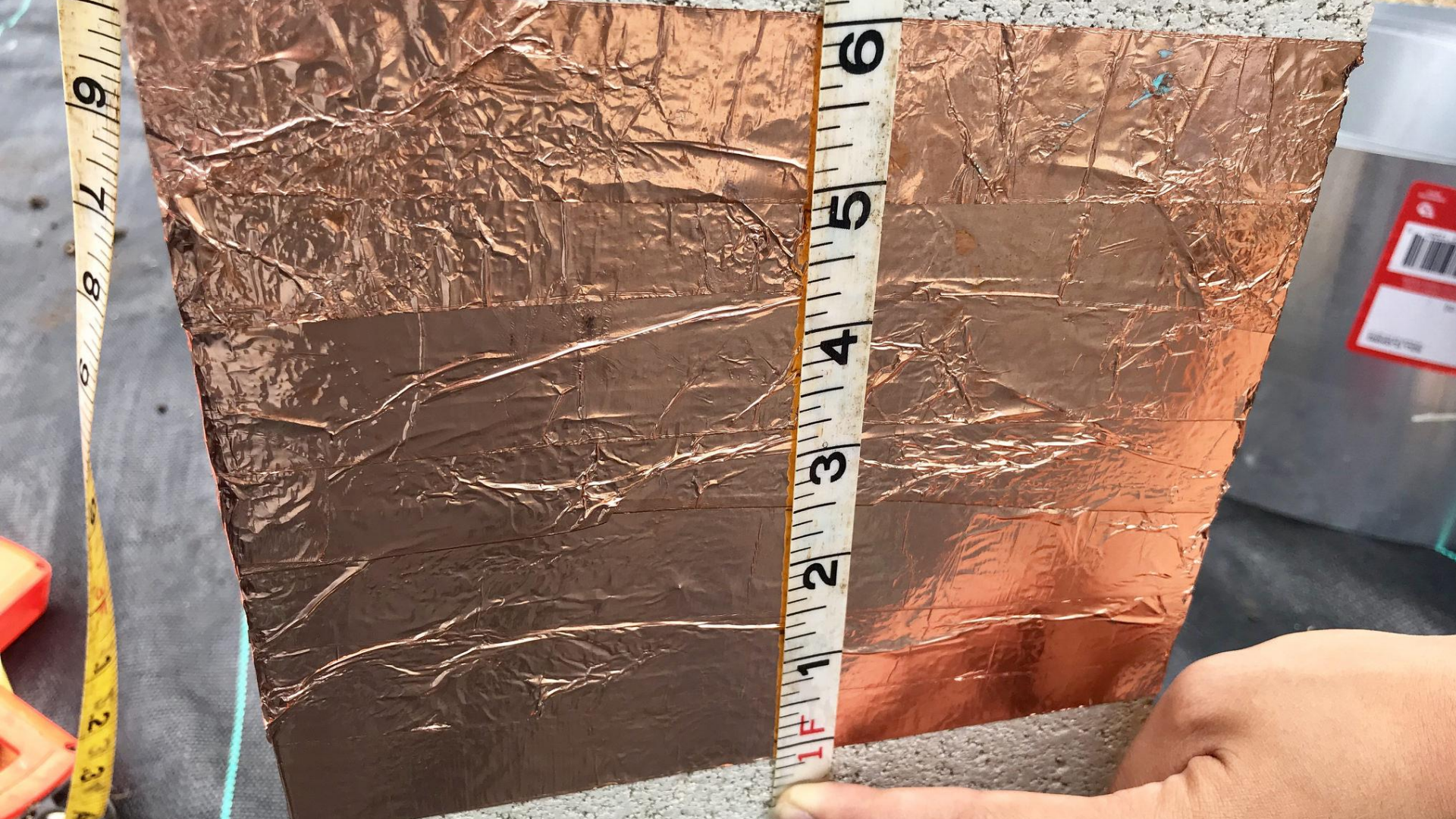
# Literature Review-Barrier Study

- Evaluated cinnamamide, copper ammonium carbonate, garlic, aluminum, copper foil, mulch, urea formaldehyde, kaolin clay mineral, and a proprietary copper matting. (Schüder et al. 2003)
  - Slug barrier: Garlic, urea formaldehyde and copper foil
  - Snail barrier: Urea formaldehyde and copper foil

- Schuder et al. 2003. Barriers, repellents and antifeedants for snail and slug control. *Crop Protection* 22: 1033-1038.
- 20 replicates per treatment

stalled 4/13/18





6

7

8

9

1

2

3

1F

2

3

4

5

6





- 6 weeks of control
- (4/13/18-5/22/18)







15 weeks of control  
(4/13/18-7/27/18)





Copper Mesh  
Not too effective

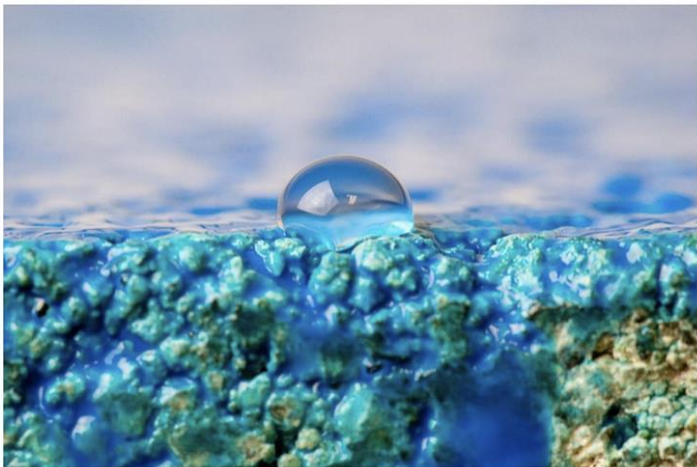




Thompson Masonry Water Seal



Moving towards hydrophobic coatings  
Private company consult in May 2018



**Coated Cement Block**



**Coated Wood Post**



Working with Oceanit Institute





# Literature Review-Barrier Study

- Evaluated wood, ash, sawdust, hydrated lime, and diatomaceous earth (Laznik & Trdan, 2016)
  - **Hydrated lime** had the best contact efficacy on slugs
- Evaluated **caffeine** as its a natural product and classified by the US Food and Drug Administration as a GRAS ('generally recognized as safe')(Hollingsworth et al. 2002)
  - Application of a **2% caffeine solution**: 25% of the slugs remained in the soil after 3.5 hours; after 48 h, all slugs had left the soil and 92% were dead.

- Laznik, Ž.; Trdan, S. (2016). Is a combination of different natural substances suitable for slug (*Arion* spp.) control? Spanish Journal of Agricultural Research, Volume 14, Issue 3, e1004.
- Schüder I, Port G, Bennison J (2004) The behavioural response of slugs and snails to novel molluscicides, irritants and repellents. Pest Manag Sci 60:1171–1177
- Hollingsworth, Robert G.; Armstrong, John W.; and Campbell, Earl, "Caffeine as a repellent for slugs and snails" (2002). USDA National Wildlife Research Center - Staff Publications. Paper 470.



Aquaponic Grower Idea  
Copper wire vs tape





## Schools to test, develop electric anti-slug strips

Goal is to help prevent growth of rat lungworm cases

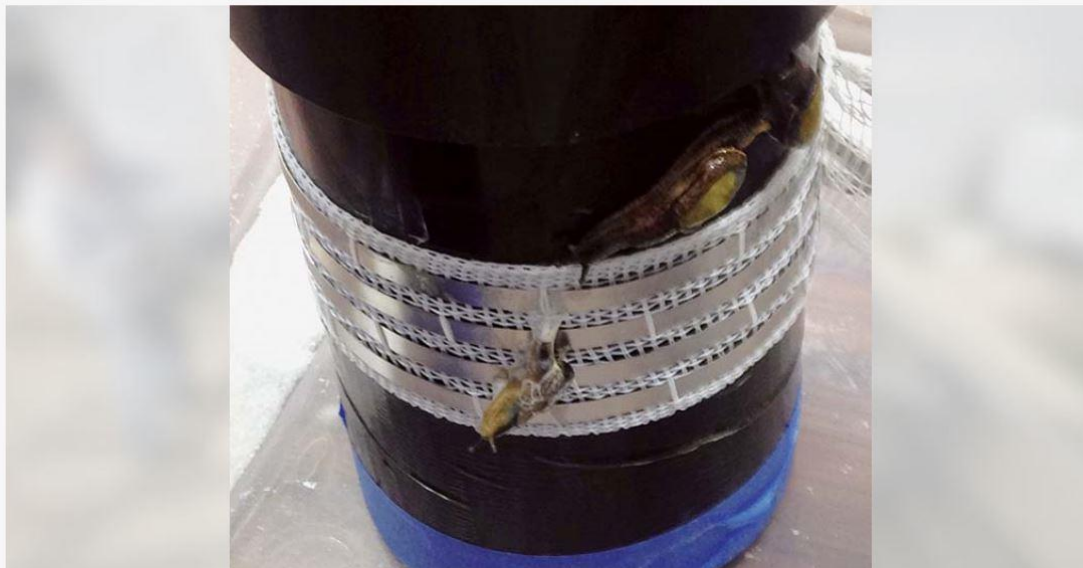
LOCAL NEWS

JUL 15, 2018

CHRIS SUGIDONO

Staff Writer

csugidono@mauinews.com



A dead slug hangs from a makeshift electrical system after crossing circuits powered by a 6-volt battery recently on Maui. Maui District Health Officer Dr. Lorrin Pang built the system in his backyard using electrical fence tape, which could be used by farmers and residents to combat rat lungworm disease. -- LORRIN PANG photo

Four Maui County schools may spend the next school year tinkering with electrical barriers to growing numbers of snails and slugs blamed for a large outbreak of rat lungworm disease statewide last year.

Maui District Health Officer Dr. Lorrin Pang said Friday that he solicited the help of Kamehameha Schools Maui and Hana High and Elementary, Maui High and Kelema Intermediate schools, which are

Make plans now  
to attend

  
**GROWING  
INNOVATIONS**  
NOVEMBER 7-8, 2018  
LAS VEGAS CONVENTION CENTER

REGISTER NOW



MOST READ

Slate takes Neil Pryde pro title

Three design pros discuss creating an...





## CTAHR Farm Food Good Agricultura.

Science-based education for Hawai'i

- HOME: ABOUT US: STEP BY STEP: WRITING YOUR FOOD SAFETY PLAN: GETTING YOUR 3R
- TOOLS & RESOURCES: GAP OUTREACH MATERIALS: RAT LUNGWORM: CONTACT US:

### Rat Lungworm:

#### News & Other Videos

Information for Growers, General Public and Home Gardeners  
Scientific Research Articles & Other Useful Extension Publications  
Resourceful Agencies and Organizations

#### News & Other Videos

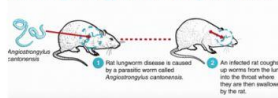
Video transcripts are available for YouTube clips.

To access, open the YouTube video of choice. Click on the 3 horizontal dots "open transcript".



Rat Lungworm Disease Awareness, by University of Hawai'i CTAHR Cooperative Extension, UH Hilo DKICP, Hawai'i Department of Ag.

#### What is angiostrongyliasis or rat lungworm disease



What is Rat Lungworm (Angiostrongylus) Disease? By the Centers for Disease Control (CDC) and the Department of Health and Human Services (DHHS).

#### Terrestrial Gastropod Molluscs as (Crop) Pests in Hawaii

Gene Moore  
NewLeaf North America

#### Control Rodents and Reduce Rodent-Borne Disease Risks

Action is the foundational key to all success.  
-Pablo Picasso



College of Tropical Agriculture and Human Resources  
University of Hawaii at Mānoa

Food Safety and Technology  
Jan. 2010  
FST-39

## Best On-Farm Food Safety Practices: Reducing Risks Associated with Rat Lungworm Infection and Human Eosinophilic Meningitis

James R. Hollyer,<sup>1</sup> Vanessa A. Troegner,<sup>1</sup> Robert H. Cowie,<sup>2</sup> Robert G. Hollingsworth,<sup>3</sup> Lynn C. Nakamura-Tengan,<sup>4</sup> Luisa F. Castro,<sup>2</sup> and Arlene E. Buchholz<sup>4</sup>

<sup>1</sup>CTAHR Agricultural Development in the American Pacific Project, <sup>2</sup>Pacific Biosciences Research Center, UH Mānoa, <sup>3</sup>USDA-ARS Pacific Basin Agricultural Research Center—Tropical Crops and Commodities, <sup>4</sup>CTAHR Department of Human Nutrition, Food and Animal Sciences, <sup>5</sup>CTAHR Department of Natural Resources and Environmental Management, <sup>6</sup>Office of Public Health Studies, UH Mānoa

Recent cases of eosinophilic meningitis have drawn attention to a foodborne parasitic infection that occurs in Hawai'i, the Pacific Islands, southern and eastern Asia, and elsewhere. In late 2008, the Hawai'i Department of Health reported that four people on the island of Hawai'i were diagnosed with eosinophilic meningitis, secondary to rat lungworm infection. They may have been infected after eating fresh produce grown in the region that was contaminated with snails or slugs infected with the parasite *Angiostrongylus cantonensis*. Hawai'i also

This information is primarily for commercial growers so that they can reduce the risk factors for rat lungworm contamination of their produce. The medical information presented is based on current medical knowledge and science-based literature, and it is not intended to be a substitute for a medical evaluation by a licensed professional. This publication may be updated as new knowledge is made available. For current medical findings, please consult the Centers for Disease Control and Prevention website, [www.cdc.gov](http://www.cdc.gov).

experienced a cluster of five infections by this pathogen from November 2004 to January 2005 (Hochberg et al. 2007). According to the Hawai'i Department of Health, reports of severe infections are uncommon. However, anecdotal evidence from a group of workshop attendees in the Puna district on Hawai'i in January 2009 put the incidence rate much higher. Although reporting appears to lag behind actual disease incidence rate, the threat to residents and visitors is low. Due to the possible severity of the symptoms, it is important to practice preventive measures in your home garden or commercial farm, as well as in your kitchen.

Despite the recent cases reported in Hawai'i, the worldwide incidence of rat lungworm infection (angiostrongyliasis) and the associated clinical illness (eosinophilic meningitis) is relatively low. Since 1945, there have been fewer than 3000 documented cases worldwide, with most of them occurring in Thailand and China (Wang et al. 2008). Usually, the infection is self-limiting, and the patient's clinical signs resolve without treatment. Depending on the person, the amount of time it takes to fully recover varies. Under normal circumstances, people recover from eosinophilic meningitis without

Disease Summary
<i>Disease agent:</i> <i>Angiostrongylus cantonensis</i>
<i>Common name:</i> rat lungworm disease
<i>Medical name:</i> human eosinophilic meningitis
<i>Definitive hosts:</i> rats
<i>Intermediate hosts:</i> slugs and snails
<i>Accidental hosts:</i> humans and other mammals
<i>Paratenic hosts:</i> frogs, prawns and other freshwater crustaceans, lizards, and planarian worms
<i>Incubation time:</i> usually 1–3 weeks, but may range from one day to more than 6 weeks.
<i>Clinical signs of eosinophilic meningitis:</i> headache, stiff neck, numbness, tingling or pain of the skin (paraesthesia), fever, nausea and vomiting, blurred vision (diplopia), weakness, joint pain, and neurologic abnormalities. More severe signs can include hyporeflexia or paralysis of the legs, bowel and bladder dysfunction, seizures, coma, and (rarely) death. It is also possible to be asymptomatic.

Published by the College of Tropical Agriculture and Human Resources (CTAHR) and issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Andrew G. Hays, Director, Cooperative Extension Service (CTAHR), University of Hawaii at Mānoa, Honolulu, Hawaii 96822. An equal opportunity/affirmative action institution providing programs and services to the people of Hawaii without regard to race, sex, age, religion, color, national origin, ancestry, disability, marital status, arrest and court record, sexual orientation, or status as a covered veteran. CTAHR publications can be found on the Web site <http://www.ctahr.hawaii.edu/ResPub>.

<http://manoa.hawaii.edu/ctahr/farmfoodsafety/rat-lungworm/>

Reducing Risks Associated with Rat Lungworm Infection

FST-39 — Jan. 2010

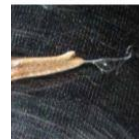
may be harmful if you see, there might be and snail management overall pest management you follow will depend if farmer or a home grower or an organic grower. strolling slugs and snails (components and may be step.

#### Prevention is your key to success

Preventing snails and slugs from reaching your production areas or your home garden takes a multi-pronged approach.

Slugs and snails are mainly active at night. The main reason is that they quickly become dehydrated if they come out during the day. This is especially true for slugs. The best way to reduce your slug and snail population is to limit the number of moist places the slugs and snails can hide in during the day. This means removing unne-

#### and paratenic hosts—create a management plan to eliminate them



i-slug or



Giant African snails, and damage from their feeding (These are small ones—they can be about twice the size; photo: Scott Neilson)



nder water



The Cuban slug comes in many colors.

(About actual size; photo: Robert Cowie)



# MANAGING SLUGS AND SNAILS IN THE GARDEN

<https://www.youtube.com/watch?v=8PzqNrcMlzk&feature=youtu.be>



Rat Lungworm Disease Awareness

1,088 views

👍 11    🗨️ 0    ➦ SHARE    ⌵    ⋮



CTAHR  
Published on Mar 23, 2018

SUBSCRIBE 40

Support Eating Local  
Heighten confidence in locally grown products



The background features a repeating pattern of concentric circles in a light beige color. At the bottom of the image, there are several teal-colored shapes, including large, irregular blobs and smaller circles, resembling water splashes or bubbles.

**WASH  
WHAT YOU  
EAT**



# Contact Information

Jari S.K. Sugano

University of Hawaii at Manoa

College of Tropical Agriculture and Human Resources

Department of Plant and Environmental Protection Sciences

Wahiawa Extension Office

[suganoj@ctahr.hawaii.edu](mailto:suganoj@ctahr.hawaii.edu)

622-4185



**COOPERATIVE EXTENSION**

UNIVERSITY OF HAWAII AT MANOA  
COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES