COOPERATIVE EXTENSION | UNIVERSITY OF HAWAI'I AT MANOA COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES

On Farm Management of Rat Lung Worm Disease

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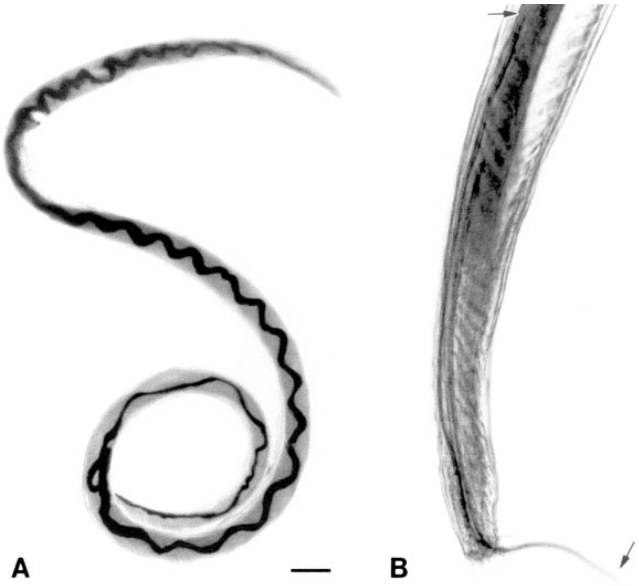
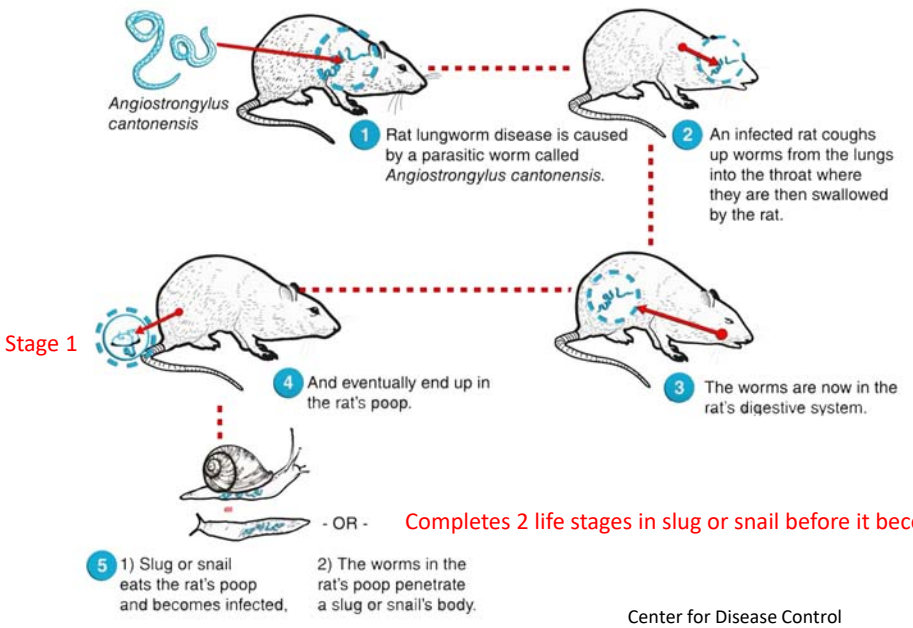
Rat Lung Worm Disease

- 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)



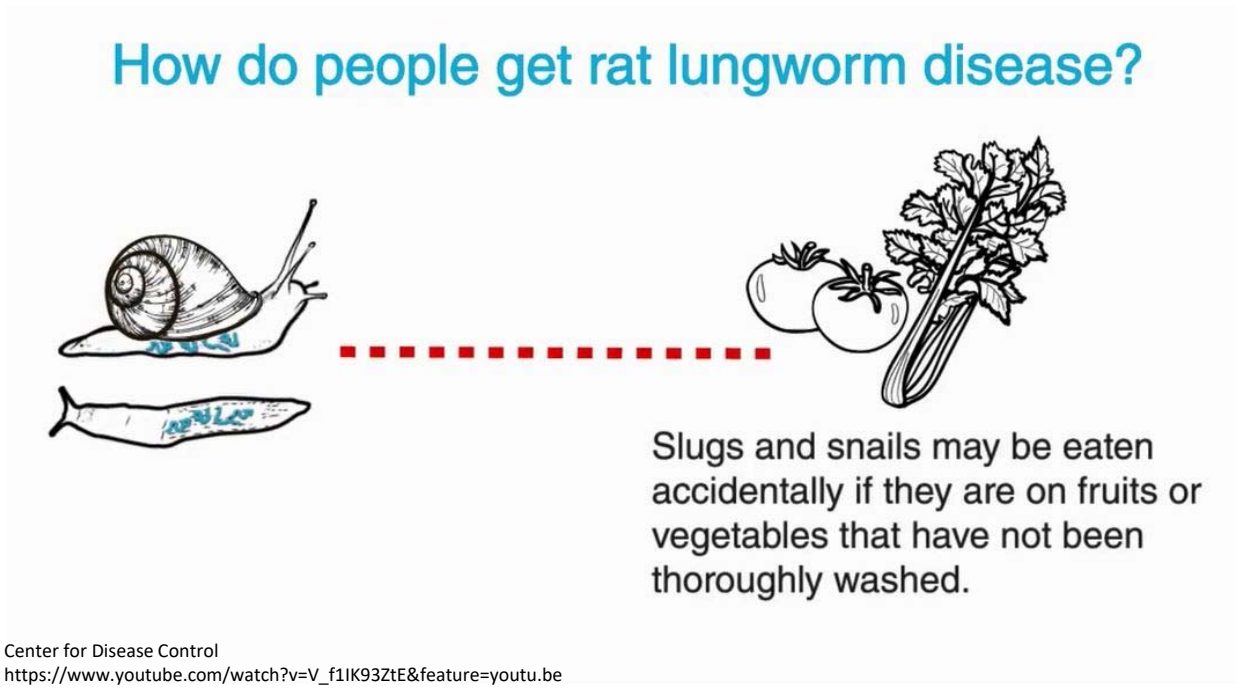
Lindo, J. F., Waugh, C., Hall, J., Cunningham-Myrie, C., Ashley, D., Eberhard, M. L....Robinson, R. D. (2002). Enzootic Angiostrongylus cantonensis in Rats and Snails after an Outbreak of Human Eosinophilic Meningitis, Jamaica. *Emerging Infectious Diseases*, *8*(3), 324-326. https://dx.doi.org/10.3201/eid0803.010316.



Stage 1

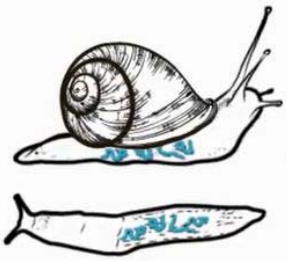
Completes 2 life stages in slug or snail before it becomes infectious to humans

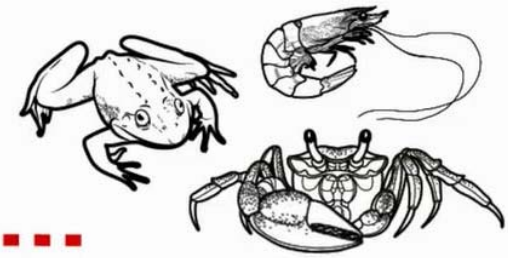
Center for Disease Control
https://www.youtube.com/watch?v=V_f1IK93ZtE&feature=youtu.be



Center for Disease Control
https://www.youtube.com/watch?v=V_f1IK93ZtE&feature=youtu.be

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.

Center for Disease Control
https://www.youtube.com/watch?v=V_f1IK93ZtE&feature=youtu.be

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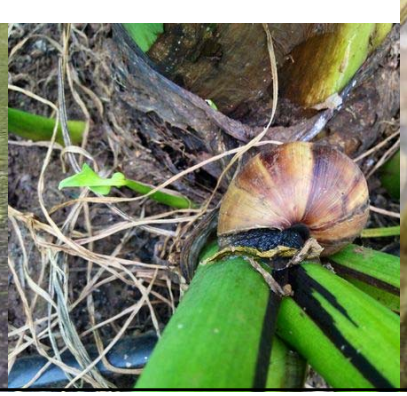
Importance of Control-Ag

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



PC: Scot Nelson

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Importance of Control-Human Concern

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

CNN Health • Food | Fitness | Wellness | Parenting | Vital Signs Live TV U.S. Edition

Infant hospitalized for rare brain parasite in Hawaii

By Victoria Larned, CNN

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AND ENTER TO WIN CONTESTS

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

July 2018

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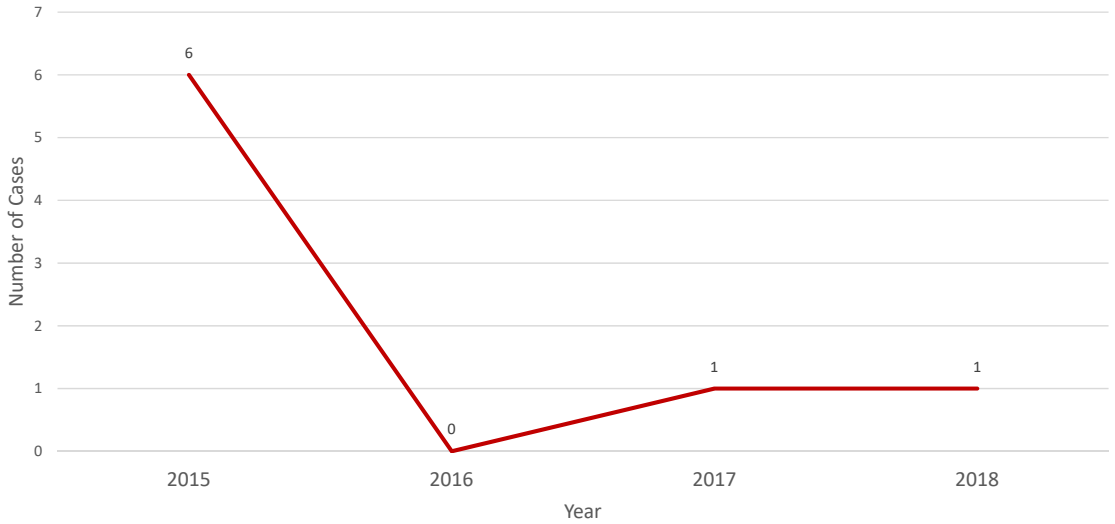
Confirmed Cases of RLW on Oahu



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

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Search

Campuses Admissions UH System

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.

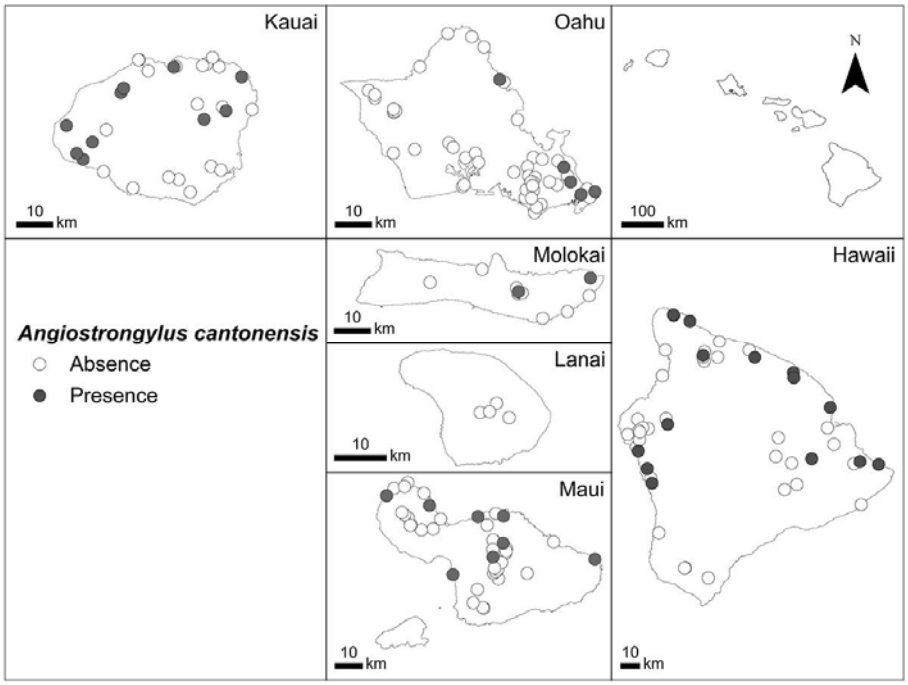
Rat lungworm is a parasitic nematode with a complicated life cycle, part of which requires living inside snails and slugs. Human infection by this parasite is considered an emerging infectious disease. The range and incidence of the disease are expanding throughout the tropics and subtropics, including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

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



Kim, J., Wong, T., Curry, P., Yeung, N., Hayes, K., & Cowie, R. (2018). Modelling the distribution in Hawaii of Angiostrongylus cantonensis (rat lungworm) in its gastropod hosts. *Parasitology*, 1-8. doi:10.1017/S0031182018001026

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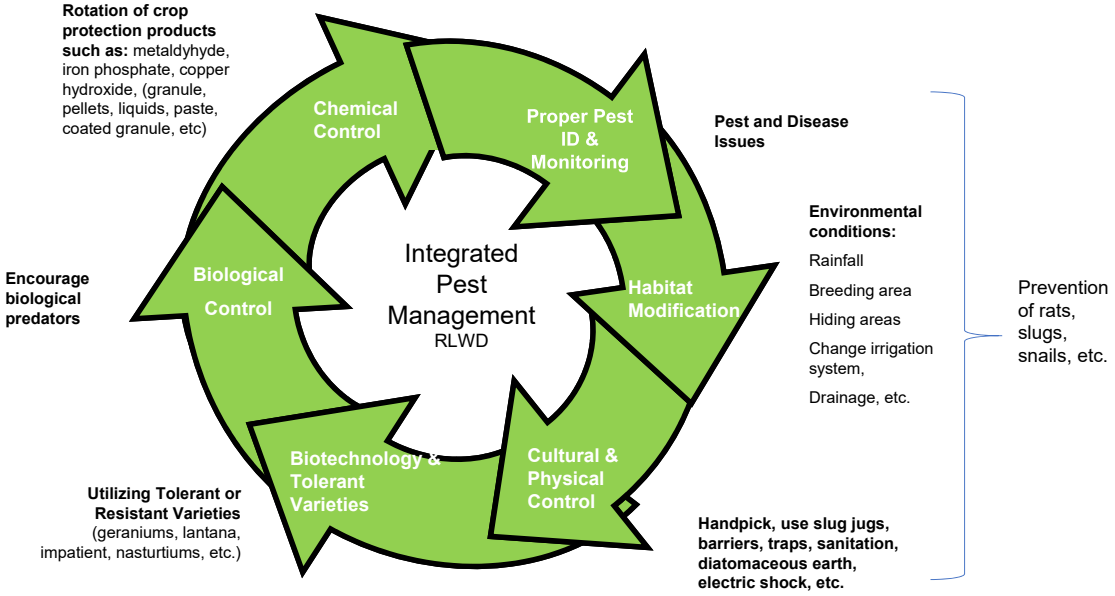

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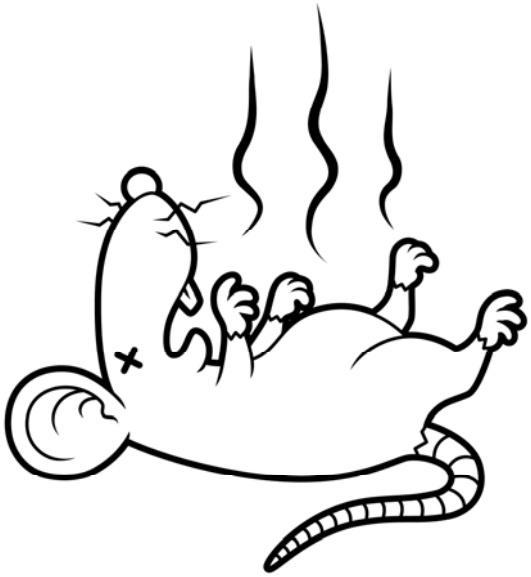
Management of Rats

- 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



Reference: Dr. William Pitt, USDA APHIS Wildlife Services. National Wildlife Research Center
Michael Carberry, DOH (communication)

Baited, placed along wall

Live traps

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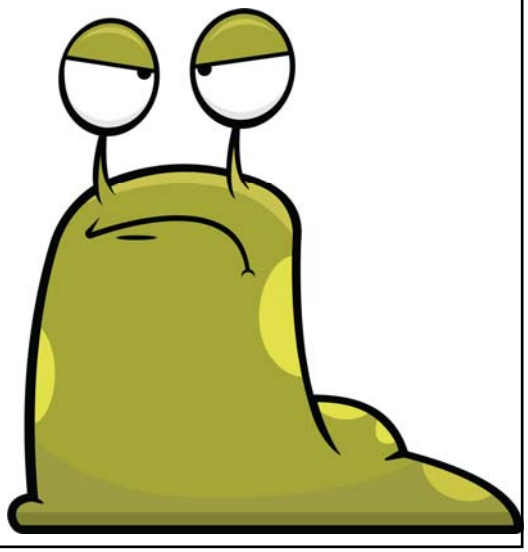
Management of Slugs and Snails

- 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)



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Methods of Commercial Control

- Chemical Controls
  - Metaldyhyde (affects mucus production)
  - Iron Phosphate (stops feeding)
  - Sodium Ferric (affects ability to produce O2)
  - 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

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Traps
(Medium level of suppression)

Deterrents
(Low level of suppression)

Baits
(High level of suppression)

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UNIVERSITY OF HAWAI'I MASTER GARDENER

Department of Agriculture
STATE OF HAWAII

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
- 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

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

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

COOPERATIVE EXTENSION | UNIVERSITY OF HAWAI'I AT MANOA COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES

Literature Review- Metaldyhyde

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 Lanikaula Street Hilo, HI 96720, USA

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

Product	% mortality[a] *V. plebeia*		*V. cubensis*	
Deadline Granules	81.2 a	±3.2	83.5 a	±3.3
Deadline Bullets	76.3 ab	±1.0	65.8 ab	±1.0
Snail and Slug AG Pelleted Bait	62.4 abc	±0.7	60.1 abc	±0.2
Metaldehyde Methiocarb Granules 2-1	60.3 abc	±0.9	33.3 bcde	±2.1
Ortho Bug-Geta Snail and Slug Pellets	57.5 abc	±0.1	41.0 bcd	±2.3
RCO Slug and Snail Pellets	55.1 abcd	±2.0	44.9 bcd	±0.3
RCO Slug and Snail Pellets (rain resistant)	48.2 bcde	±2.0	39.5 bcde	±1.3
Durham Metaldehyde Granules 7.5	47.9 bcde	±1.4	63.0 ab	±0.8
Durham Metaldehyde Granules 3.5	47.2 bcde	±0.1	28.4 cde	±0.7
Corry's Slug and Snail Pellets	42.4 cdef	±0.2	44.9 bcd	±1.0
Deadline One Last Meal for Slugs and Snails	40.5 cdef	±0.8	29.9 cde	±1.3
Corry's Slug, Snail and Insect Killer	38.1 cdefg	±0.2	27.4 de	±0.1
Ortho Bug-Geta Plus Snail, Slug and Insect Granules	34.6 cdefg	±0.5	11.8 e	±2.2
Corry's Slug and Snail Death	25.9 defgh	±3.9	42.7 bcd	±1.2
Ortho Slug-Geta Snail and Slug Bait	20.3 efgh	±1.9	35.9 bcde	±4.7
Deadline 40	18.0 fgh	±0.1	17.7 de	±0.1
Corry's Liquid Slug and Snail Control	13.6 gh	±2.0	17.5 de	±2.3
Corry's Liquid Slug, Snail and Insect Killer	6.8 hi	±2.7	16.8 de	±1.0
Control	0.0 i	±0.0	0.0 f	±0.0

[a]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, $k = 100$.

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.

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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 detaile.
(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	
If swallowed:	• Call a poison control center or doctor immediately for treatment advice. • Have a person sip a glass of water if able to swallow. • Do not induce vomiting unless told to do so by a poison control center or doctor. • Do not give anything by mouth to an unconscious person.
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.
If on skin or clothing:	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.

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 US

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

Net Weight:
As Marked on Container

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Los Angeles, CA 90023 U.S.A
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AMVAC

DEADLINE® M-Ps®

Mini-Pellets!

ONE LAST MEAL FOR SLUGS & SNAILS

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) [1]	25	7	35	7

[1]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.

Case Study:
Apple Snail eaten as escargot

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Literature Review- Iron Phosphate

- Organic lettuce trial, using the randomized block design (4)
- Trial 1, 2, 3: Iron phosphate (Ferramol)/ Metaldyhyde (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	*P. hermaphrodita*	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 ($P \leq 0.05$).

Gengotti, S ; Censi, D and Curto, G (2008) Evaluation of active ingredients and nematodes against slugs and snails on organic lettuce. Poster presented at Cultivating the Future Based on Science: 2nd Conference of the International Society of Organic Agriculture Research ISOFAR, Modena, Italy, June 18-20, 2008. Four randomized block trial

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Literature Review- Iron Phosphate

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

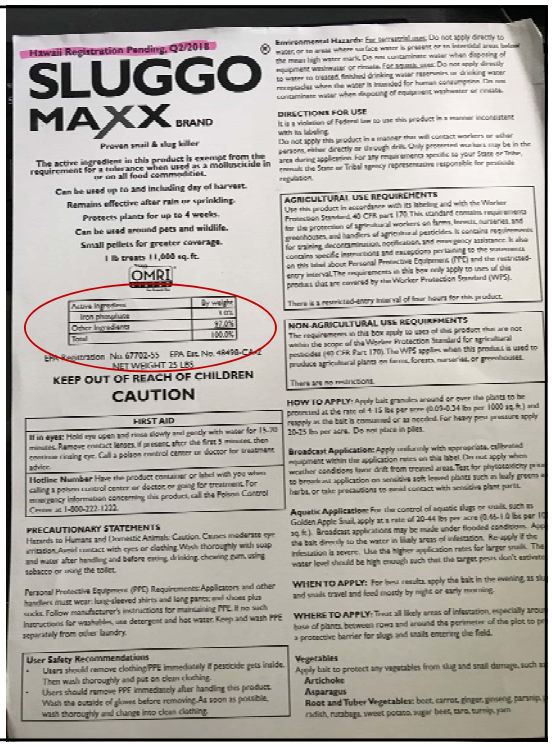
	Treatment	Trial 3 (25-Oct-04) 5 DAT_2				Trial 4 (21-Sep-07) 16 DAT			
		dead slugs (%)		leaf eroded surface (%)		dead slugs (%)		leaf eroded surface (%)	
1	untreated	12.9	c	20.6	a	17.2	a	24.2	a
2	metaldehyde	32.5	b	2.1	b	100	b	0.3	c
3	iron phosphate	86.8	a	0.6	b	89.7	b	6.3	b

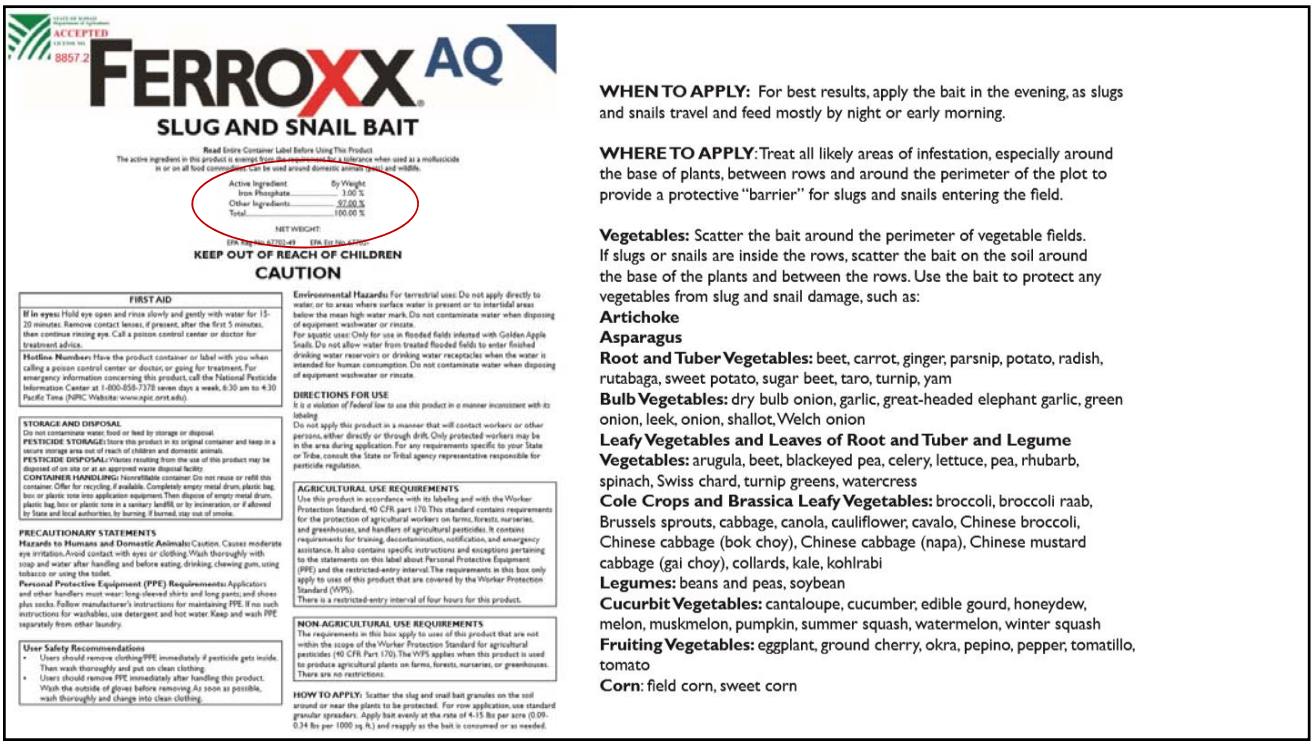
Means marked by different letters on the same column are statistically different according to LSD test ($P \leq 0.05$).

Gengotti, S ; Censi, D and Curto, G (2008) Evaluation of active ingredients and nematodes against slugs and snails on organic lettuce. Poster presented at Cultivating the Future Based on Science: 2nd Conference of the International Society of Organic Agriculture Research ISOFAR, Modena, Italy, June 18-20, 2008. Four randomized block trial

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

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

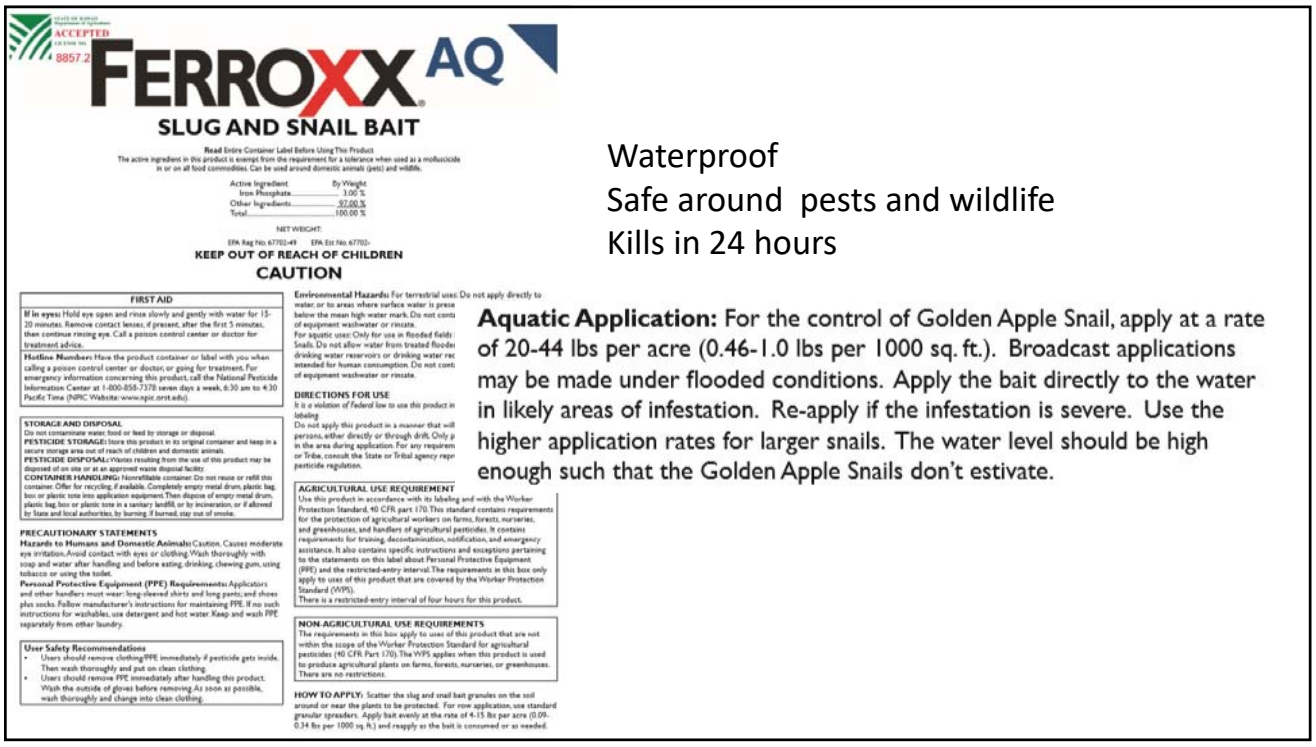




WHEN TO APPLY: For best results, apply the bait in the evening, as slugs and snails travel and feed mostly by night or early morning.

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



FERROXX AQ

SLUG AND SNAIL BAIT

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. 67702-49 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).

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 prese below the mean high water mark. Do not conta of equipment washwater or rinsate.
For aquatic uses: Only for use in flooded fields Snails. Do not allow water from treated flooded drinking water reservoirs or drinking water re intended for human consumption. Do not cont of equipment washwater or rinsate.

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 p in the area during application. For any requirem or Tribe, consult the State or Tribal agency repr 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.

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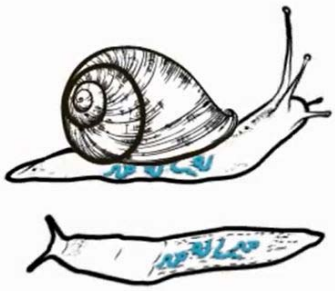
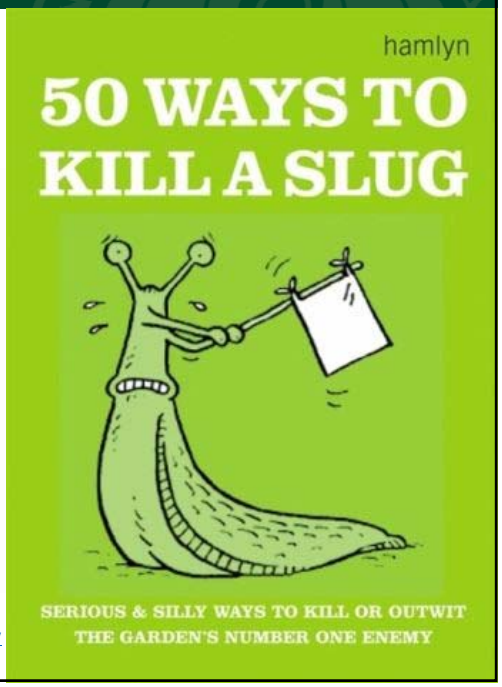
Repel vs. Suppress

Angiostrongylus cantonensis





Images:
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

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.

2017 University of Hawai'i, Sea Grant College Program
Photos: Rob Hollingsworth, USDA/ARS Hilo, HI

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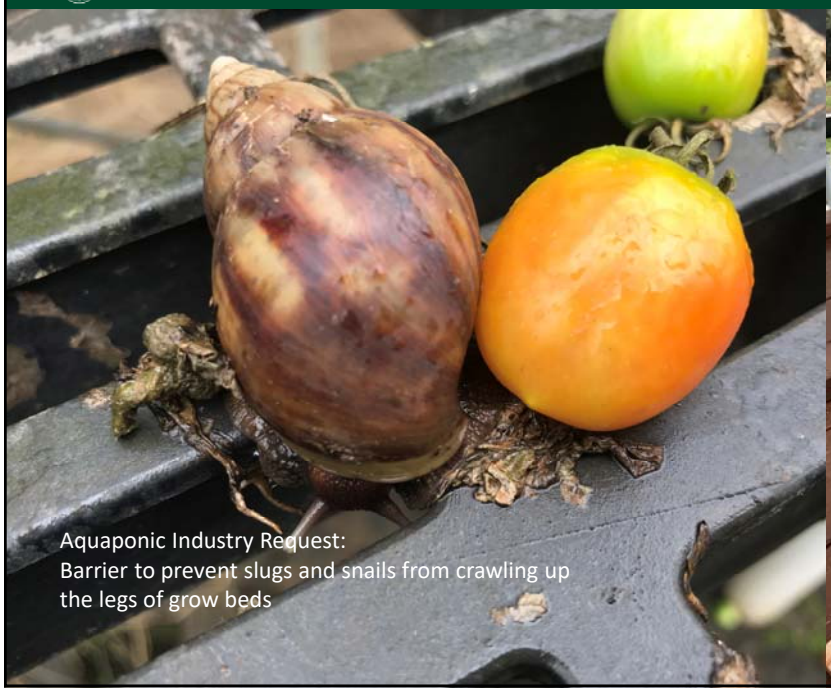

Aquaponic Industry Request:
Barrier to prevent slugs and snails from crawling up the legs of grow beds

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Literature Search-Barrier Study

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

Barrier	Mean number crossing barrier	
	V. cubensis[a]	*V. plebeia*[a]
Copper	3.0 b ± 2.6[b]	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

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

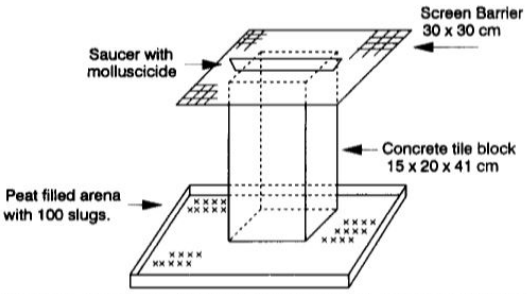

Figure 1. Schematic diagram of the method used in evaluating screen barriers for efficacy against *V. plebeia* and *V. cubensis*

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.

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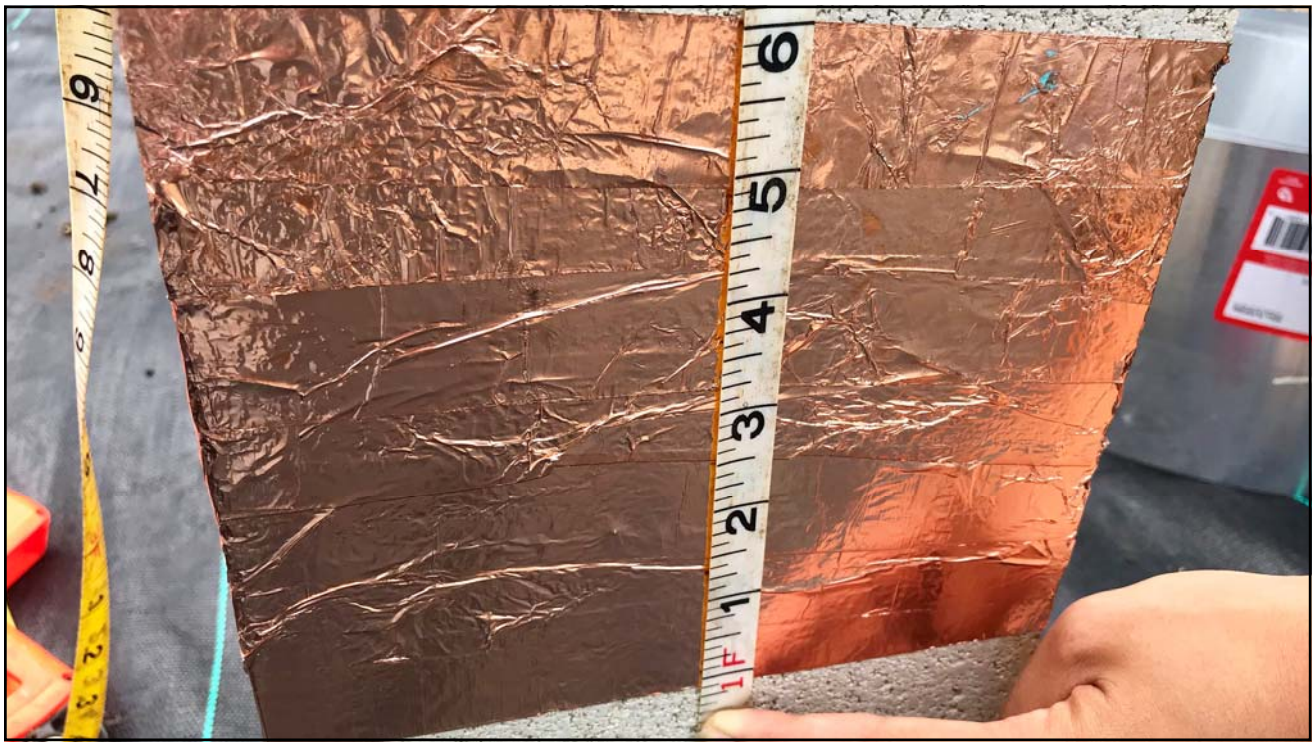
Literature Review-Barrier Study

- 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



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

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Thompson Masonry Water Seal

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Plastic
Moving towards hydrophobic coatings
Private company consult in May 2018

Coated Cement Block

Coated Wood Post

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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.

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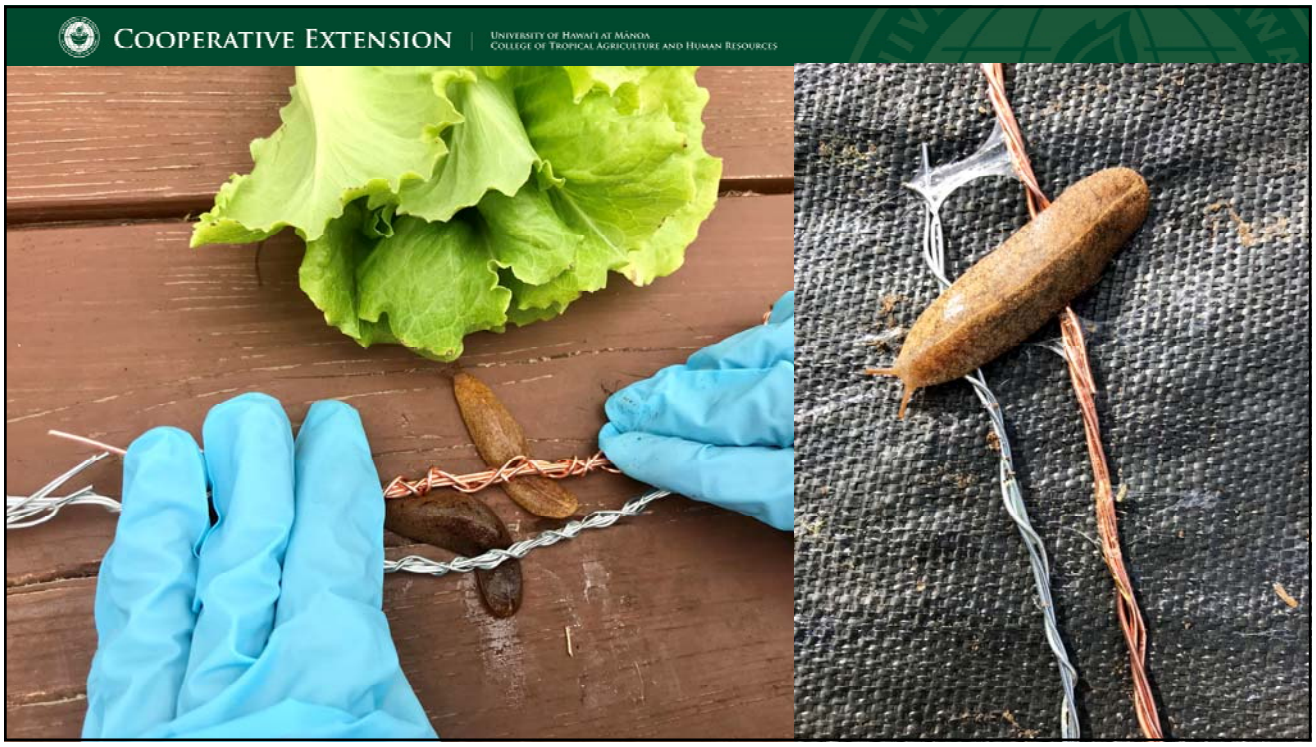

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Schools to test, develop electric anti-slug strips

Goal is to help prevent growth of rat lungworm cases

LOCAL NEWS

JUL 15, 2018

CHRIS SUGIDONO
Staff Writer
csugidono@mauinews.com

SHARE TWEET

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

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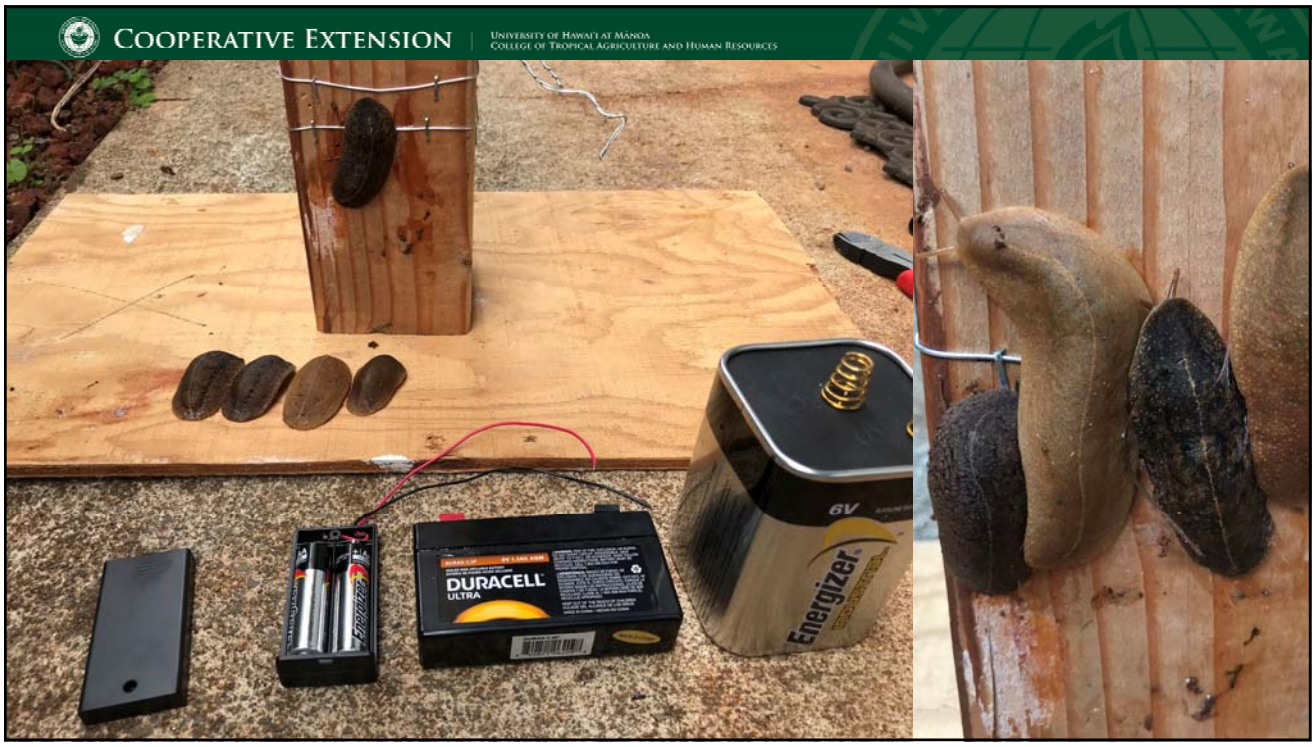
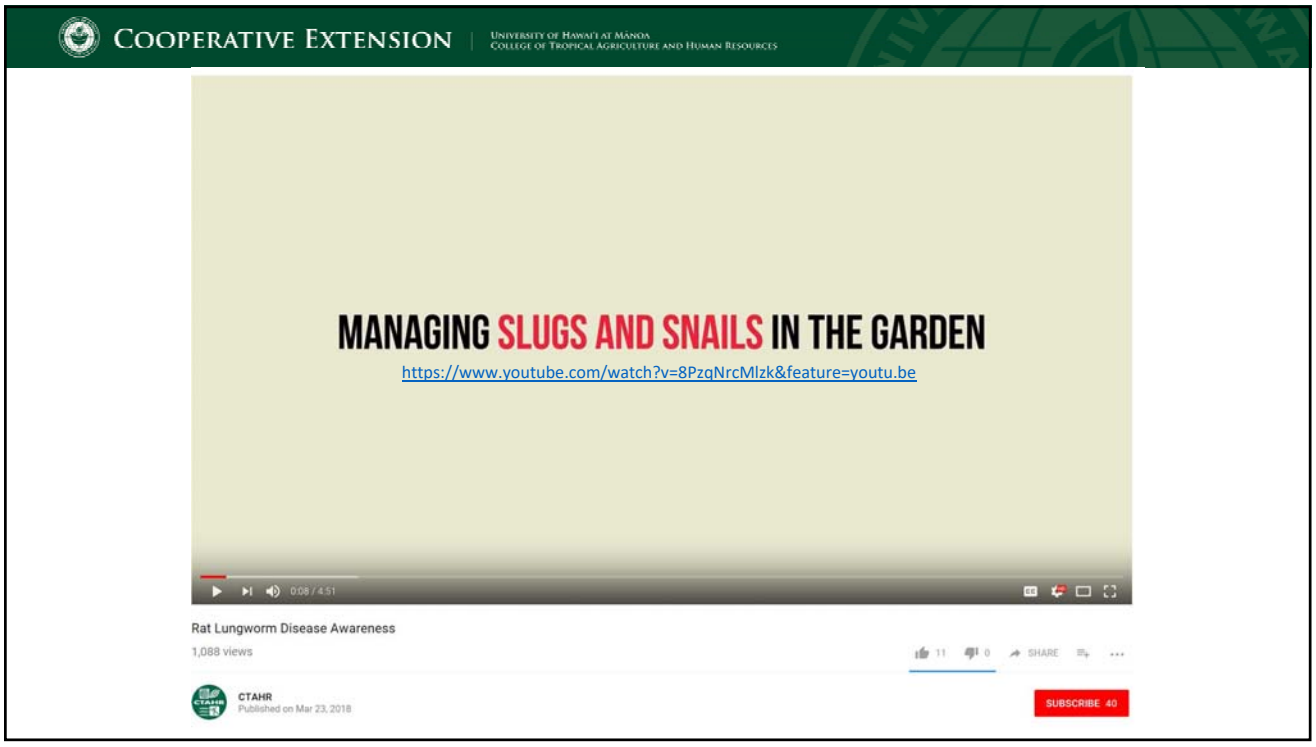


http://manoa.hawaii.edu/ctahr/farmfoodsafety/rat-lungworm/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MANAGING SLUGS AND SNAILS IN THE GARDEN
https://www.youtube.com/watch?v=8PzqNrcMlzk&feature=youtu.be
0:08 / 4:51
Rat Lungworm Disease Awareness
1,088 views
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