

Slug Control Efforts in Hawaii

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Pestiferous Snails and Slugs in Hawaii



Two-striped slug, *Veronicella cubensis*



Brown slug, *Vaginulus plebeius*



Tornatellides sp., a native cone spiral shell snail on foliage <math><1/4</math> inch in length



Zonitoides arboreus, an alien flat spiral shell snail on foliage and roots of plants. <math><1/4</math> inch



Giant African Snail, *Achatina fulica*

**Two-striped slug,
*Veronicella cubensis***



**Brown slug,
*Vaginulus plebeius***



- *These slugs were first reported in Hawaii in 1978-1985.
- *Extensive damage to ornamental, vegetable and landscape plants.
- *High rainfall (133 in per year) encouraged high slug populations.
- *No effective natural enemy has been identified.
- *Hawaii has a rich native snail fauna.

Endangered Hawaiian Tree Snails

*Victim of forest depletion, shell collection, canivorous snails.

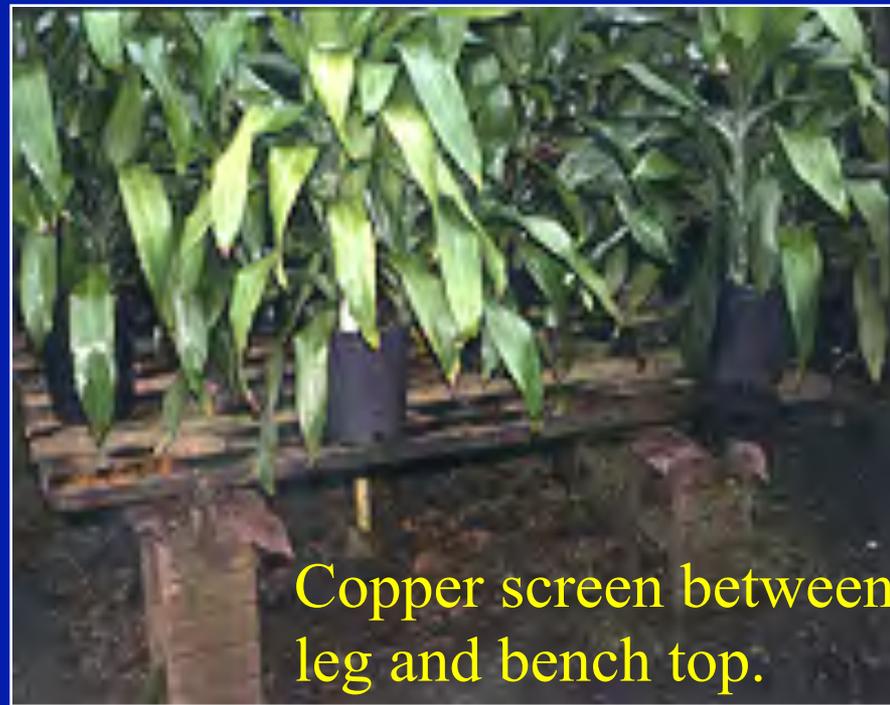
*Twenty-two of 41 species are already extinct.

Achatinella sp.



Biology of Slugs

- * Adults are hermaphroditic (possess both male and female sex organs). After mating both may lay eggs.
- * Egg mass average about 50 eggs, and hatch in 14-30 days depending on species and temperature.
- * Juveniles reach sexual maturity in 3-5 months and may take 2 years to fully grown.
- * Copper is know to be repellent and toxic to slugs. Used as a mechanical barrier in nurseries.
- * Slugs are effectively controlled with slug bait with metaldehyde as the toxicant (Deadline, Corry' s etc.)



Efficacy of Molluscicides

- **Almost all molluscicides available today have metaldehyde as the active ingredient.**
- **Formulation and bait attractancy determine efficacy.**
- **Major formulation types include:**
 - **Granule (Deadline granules)**
 - **Coated Granule (Durham Granules)**
 - **Pellet (Deadline Bullets, Deadline Mini-Pellets)**
 - **Paste (Deadline 40)**
 - **Liquid (Deadline One Last Meal)**

Evaluation of Molluscicides (with & without simulated rainfall)

- Each molluscicide evaluated was applied at the recommended rate to one sq. ft² cages, constructed of a wood frame, aluminum screen bottom, and a Plexiglas cover.
- Cage contained potting mix (1" thick), lettuce and a slug shelter.
- Rainfall was simulated daily using overhead irrigation (500 ml).
- At daily intervals, 10 slugs were added to one of eight cages which was then covered to prevent further watering.
- Mortality assessed 1, 3, and 6 DAT.





Dead slugs - Deadline

Two-striped slug, *Veronicella cubensis*

Treatment		w/o rainfall	w/ rainfall*
Deadline Granules	(G)	83.5	44.3
Deadline Bullets	(P)	65.8	44.3
Deadline OLM	(L)	29.9	39.3
Deadline 40	(LP)	17.7	37.7
Snail & Slug AG	(P)	60.1	36.7
RCO Slug & Snail	(P)	44.9	33.3
Corry's Liquid Control	(L)	17.5	25.7
Metalddehyde Methiocarb	(CG)	33.3	16.5
Durham 3.5 Granules	(CG)	28.4	8.4
Corry's S/S Insect Killer	(P)	27.4	8.3
Corry's S/S Insect Killer	(L)	16.8	6.1
Ortho Bug-Geta	(P)	41.0	3.2

*Subjected to 500 ml of simulated rainfall daily for 8 days.

*Mortality observed 6 days after treatment.

Brown slug, *Vaginulus plebeius*

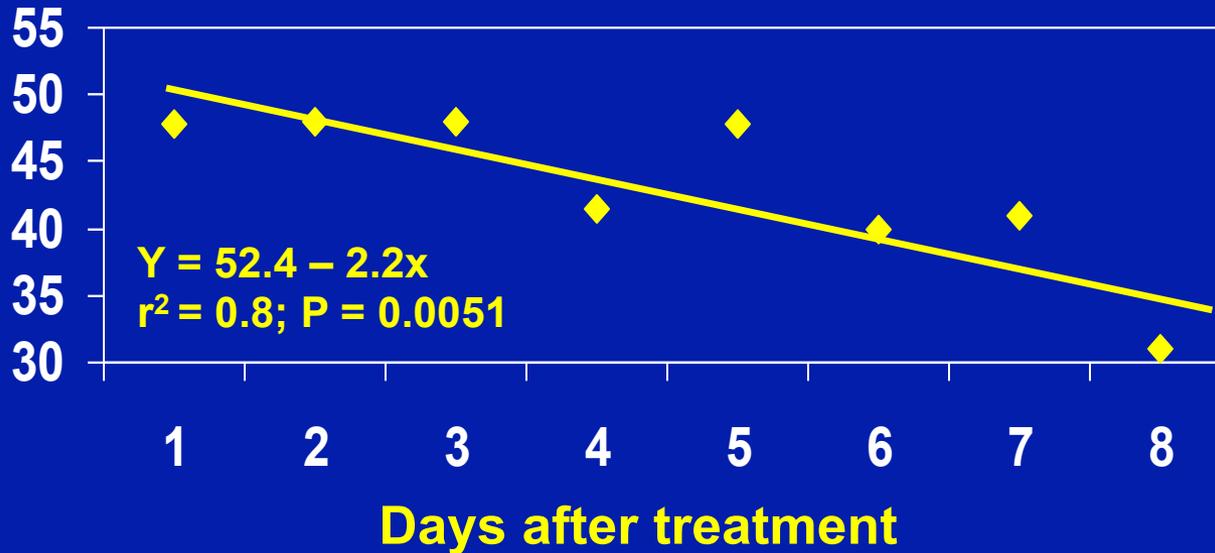
Treatment		w/o rainfall	w/ rainfall*
Deadline OLM	(L)	40.5	47.8
Snail & Slug AG	(P)	62.4	47.5
Deadline 40	(LP)	18.0	46.6
Deadline Bullets	(P)	76.3	45.6
RCO Slug & Snail	(P)	55.1	42.2
Corry's Liquid Control	(L)	13.6	37.4
Deadline Granules	(G)	81.2	32.1
Ortho Bug-Geta	(P)	57.5	23.9
Corry's S/S Insect Killer	(P)	38.1	21.5
Metaldehyde Methiocarb	(G)	60.3	21.0
Corry's S/S Insect Killer	(L)	6.8	17.6
Durham 3.5	(CG)	47.2	15.6
Durham 7.5	(CG)	47.9	14.8
Ortho Bug-Geta Plus	(P)	34.6	10.1

*Subjected to 500 ml of simulated rainfall daily for 8 days; Mortality 6 DAT.

Deadline Bullets Pelleted Formulation

Brown slug

Mortality
(arcsine)



Subjected to simulated rainfall of 500 ml for 8 Days.

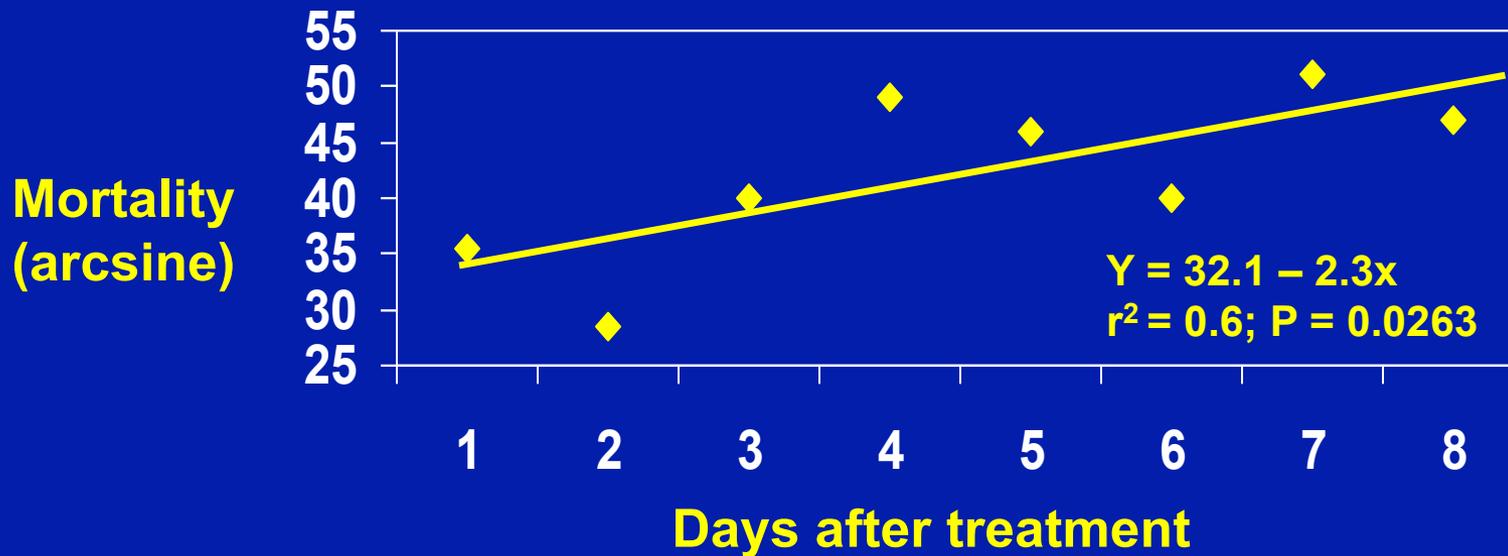


Pellets crumbled and deteriorated after initial swelling with moisture.

Deadline 40

Liquid Paste Formulation

Brown slug

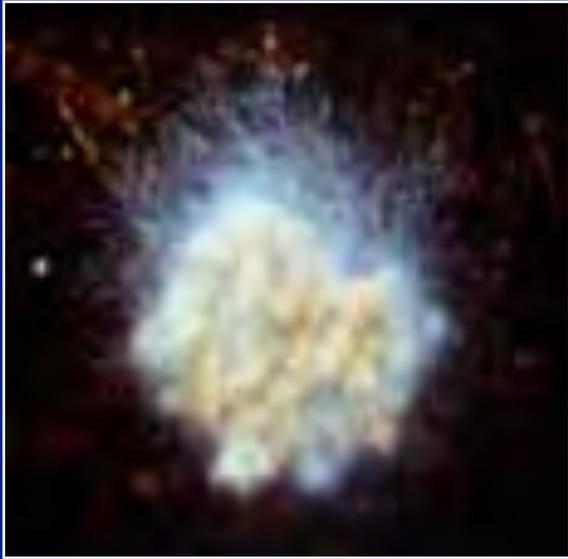


Subjected to simulated rainfall of 500 ml for 8 Days.



Liquid and liquid paste formulations diffused with rainfall increasing effectiveness.

Moldy Slug Bait



Mold development is a problem in areas with high rainfall/humidity.

- **Liquid and paste formulations were more resistant to mold development than pelleted, granule or coated granule formulations.**

Advantages and disadvantages

➤ Paste and Liquid formulations

- + Increase in effectiveness with rainfall
- + Resistant to mold development
- Poor initial kill
- Application labor intensive

➤ Pelleted formulations

- + High initial kill
- + Easy broadcast application with good coverage
- Decrease in effectiveness with rainfall
- Very susceptible to mold development

Efficacy of Other Snail and Slug Products

*Methiocarb – also effective western flower thrips,
aphids, mites, bird repellent

Mesuro1 Pro 2% bait- Gowan

Mesuro1 75-W 75% spray – Gowan

*Iron Phosphate – fertilizer ingredient from Germany

Lawn and Garden Products, Inc.

Sluggo Bait 1% (Monterey)

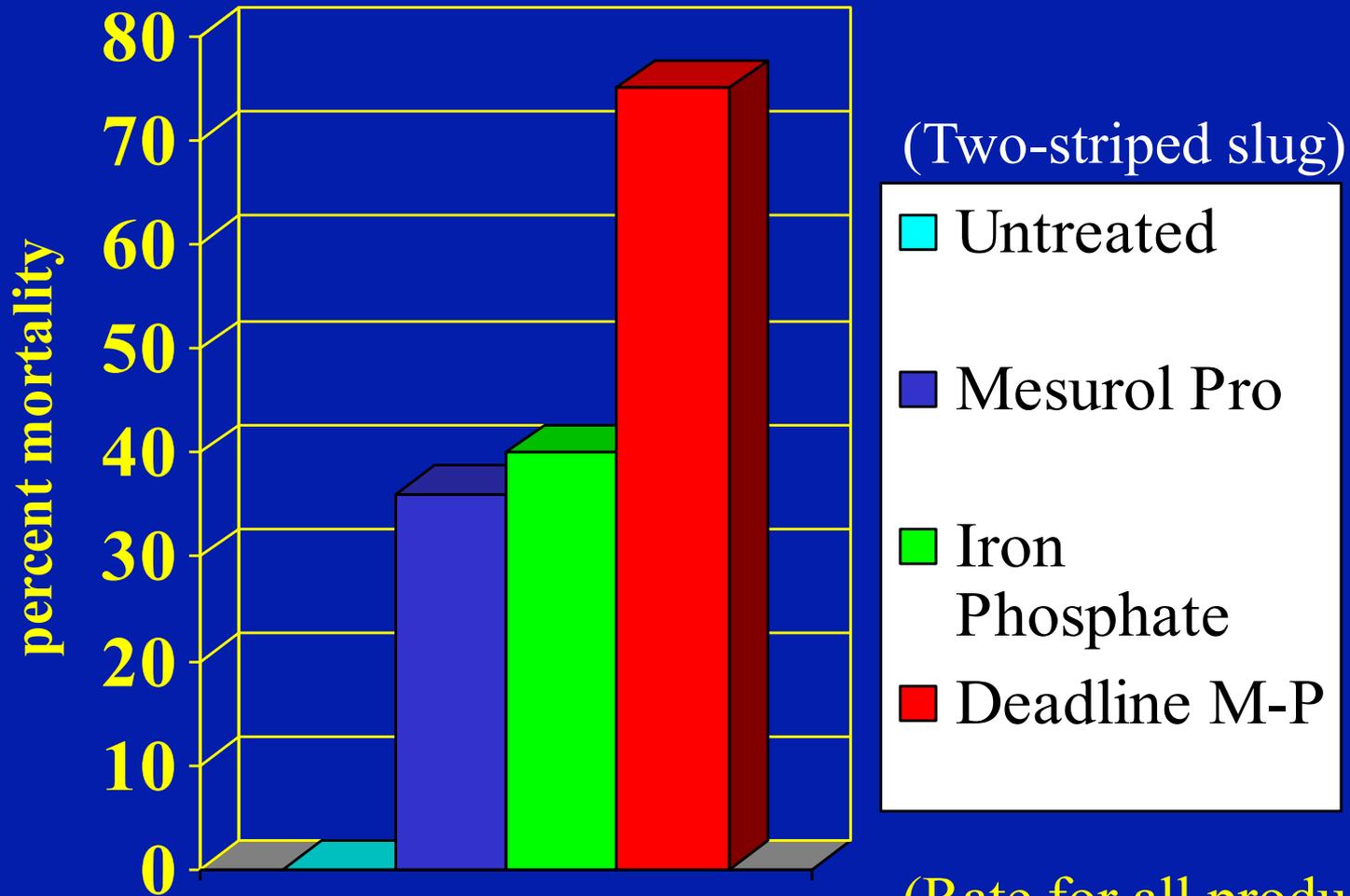
Worry Free Slug and Snail Bait 1%

*Metaldehyde –most common molluscicide

Deadline M-Ps (minipellets) 4%

Efficacy of Slug & Snail Baits

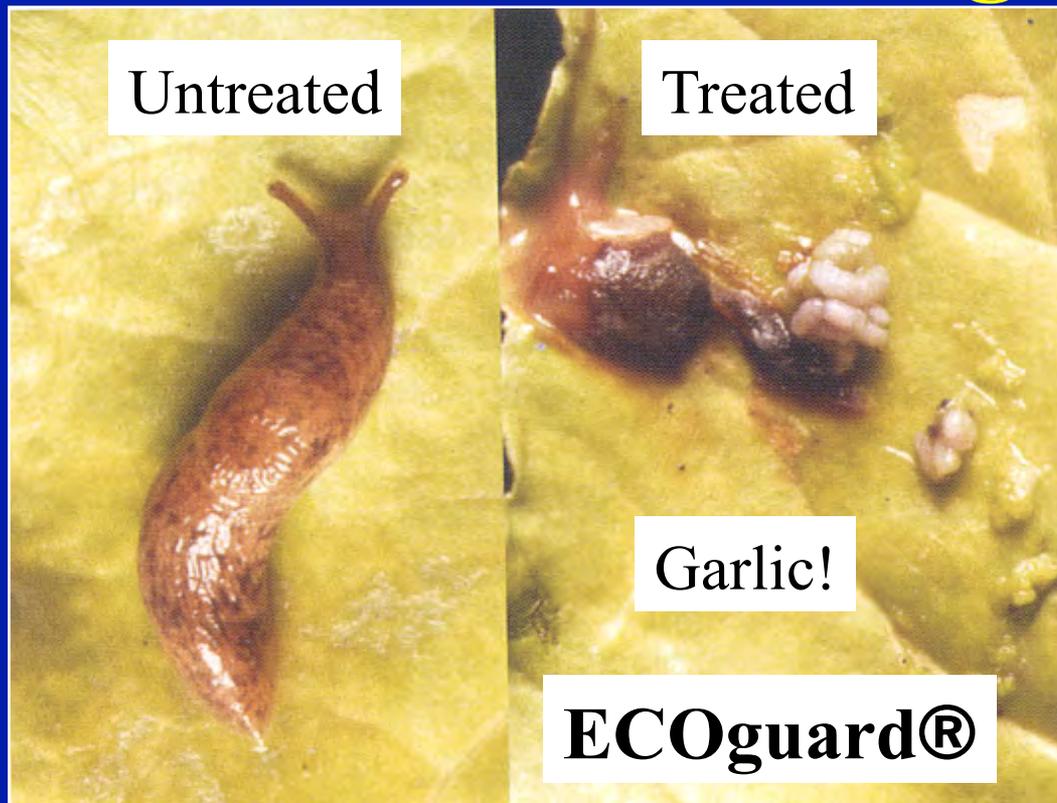
(No simulated rainfall)



8 days after treatment

(Rate for all products at
1.0 lb per 1000 sq. ft)

What Killed This Slug?



*Commercial garlic based pesticide developed by in United Kingdom by ECOspray Ltd.

*Encouraging results in southern Spain for whitefly control in greenhouse crops.

Promising Products for Slug Control???

*Garlic

a.i. = allicin, effective repellent
2.5 to 5% solution

*Ureaformaldehyde

a nitrogen fertilizer formulated as a pellet.
6% solution

*Cinnamamide

a cinnamic acid derivative. antifeedant;
repellent
1% solution

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

Copper screen barriers used at a certified nursery



Effectiveness of Barriers



	Number of slugs	
	<i>V. plebeius</i>	<i>V. cubensis</i>
Copper	1.7 b	3.0 b
Fiberglass*	5.3 b	4.3 b
Aluminum	11.7 ab	19.7 a
Paper board	23.0 a	26.3 a

*Effectiveness of fiberglass was due to the collapse of the screen with the weight of the foraging slug.

Copper Hydroxide against Slugs

- *Copper hydroxide [Cu(OH)₂] is usually used a fungicide (Kocide; Champ).
- *Formulated as a root growth regulator by incorporating the copper hydroxide into latex paint on the inner surface of pots, grow bags & groundcovers.
- *Inhibits root development, prevents root-bounding and promotes fibrous root growth.
- *Also provides weed control.
- *Discovered to be highly effective in repelling slugs.
- *For more information on Spinout (Griffin Corp.) go to:
<http://www.nurserysupplies.com/products/products.htm>



Liquid Flowable

A.I.

Copper Hydroxide* 7.1%

Inert 92.9%

*Metallic copper equivalent 4.6%



Spin out coated pot trial

Treatment	\bar{x} + SD slugs / pot
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1 DAT

Spin Out	1.0a ± 0.9 ^{***}
Control	15.0b ± 5.2

4 DAT

Spin Out	0.0 ± 0.0
Control	24.1 ± 10.4

8 DAT

Spin Out	0.1a ± 0.3 ^{**}
Control	16.9b ± 9.1

Significant by t test (**, ***, $P \leq 0.01, 0.0001$, respectively).

Spinout on root mealybugs and palm rooting.



- *Root matting on bottom of pot increased root mealybug infestations.
- *Spinout (copper hydroxide) significantly prevented root matting, therefore minimizing root mealybug infestations.

Control Strategies for Slugs

- *PHYSICAL - copper barriers.
- *CHEMICAL - baits, sprays (Slugfest), copper hydroxide, garlic.
- *CULTURAL - sanitation; remove rotting leaves.
- *MECHANICAL- harvest every morning with a fork or chopsticks.
- *BIOLOGICAL - predacious snail, Euglandina; flatworms, nematodes, but these will also affect native snails.

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