

Control of the Coqui Frog, *Eleutherodactylus coqui*, (Anura: Leptodactylidae) in Plant Nurseries

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ABSTRACT

The coqui frog, *Eleutherodactylus coqui*, is considered an interisland, interstate and international quarantine pest on potted plants. Potted plants infested with coqui frogs from Puerto Rico were the suspected pathway for coqui frogs in Hawaii. Chemical and non-chemical disinfection treatments were developed against the coqui frogs. Citric acid was effective against all stages of the coqui frog but phytotoxic to potted plants, including orchids, ferns and chrysanthemums. To prevent phytotoxicity, citric acid treated plants must be rinsed with water one hour after treatment, but rinsing was found to reduce the effectiveness against eggs. Natural pyrethrins plus the synergist, piperonyl butoxide (pbo), were found to be effective against juveniles and adults, but most formulated pyrethrin/pbo products (at maximum labeled rate) required two applications up to 12 hours apart to prevent recovery from paralysis. Heat treatments in the form of hot water dip, drench and shower were highly effective against all stages of the coqui frog at 113 °F for 5 min. Other quarantine pests, including ants, caterpillars, mealybugs, scale insects, snails and slugs are also effectively controlled by heat treatments. Extensive tests have demonstrated that most tropical flowers and foliage can tolerate heat treatments as high as 120 °F. Plants that are sensitive to heat treatments may be conditioned at lower temperatures to increase heat tolerance. A physical insect screen barrier surrounding a greenhouse was found effective in excluding coqui frogs, providing coqui-free production of potted plants.

HEAT TREATMENTS



Hot Water Dip and Shower



Vapor Heat Chamber

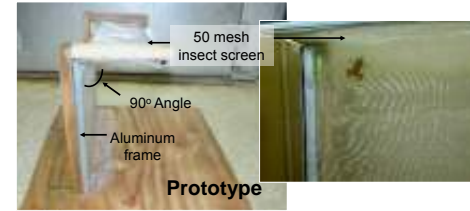
(Courtesy of Diamond Head Papaya Co. Keesau, HI)



Hot Water Dip (eggs)

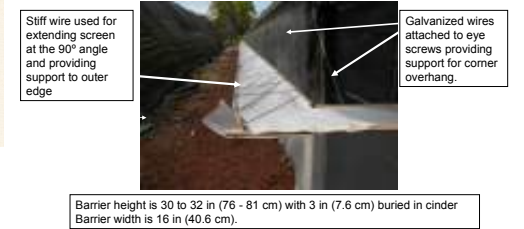
PHYSICAL BARRIERS

Anti-Gravity Coqui Frog Barrier



Prototype

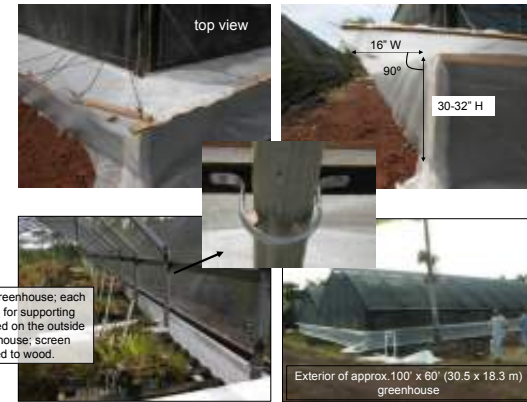
Nursery Applications



Stiff wire used for extending screen at the 90° angle and providing support to outer edge

Galvanized wires attached to eye screws providing support for corner overhang

Barrier height is 30 to 32 in (76 - 81 cm) with 3 in (7.6 cm) buried in cinder
Barrier width is 16 in (40.6 cm).



top view

16" W

90°

30-32" H

Interior of greenhouse; each post used for supporting wood located on the outside of greenhouse; screen stapled to wood.

Exterior of approx. 100' x 60' (30.5 x 18.3 m) greenhouse

CHEMICAL CONTROL

MATERIALS AND METHODS

Pyrethrins, Citric acid, Sodium bicarbonate, Sodium carbonate (Fig. 1)

- Pyronyl (6% pyrethrins/ 60% piperonyl butoxide) treatments:
Label rate 16 oz / 100 gal (n=15)
1.125 x label rate 18 oz / 100 gal (n=6)
1.25 x label rate 20 oz / 100 gal (n=6)
1.375 x label rate 22 oz / 100 gal (n=6)
1.5 x label rate 24 oz / 100 gal (n=30)

- Citric Acid (5%) (n=20)
- Sodium bicarbonate (8 lb / 100 gal) (n=3)
- Sodium carbonate (3%) (n=5)

A mixed population of frogs (M, F, adult, juvenile) housed in either a plastic terrarium (10.5 x 8 x 7.5"; 26.7 x 20.3 x 19.0 cm) or 5-gal (18.9 l) glass aquarium lined with moss were directly contacted with the treatment solution applied with an atomizer (30 ml/rt), observed for 12 hr for mortality and recovery, and then treated with a second application at the same rate, and observed for 12 hr longer.

Citric Acid (with and without rinsing), Hydrated Lime, Pyrethrins, Citric Acid + Pyrethrins (Table 1, Fig. 2)

- Citric acid 16% (1.3 lb/gal) or 8% (0.65 lb/gal)
- Citric acid (16%), rinsed off 1 h after application
- Citric acid (8%) + Pyrethrins (16 oz/gal)
- Pyrethrins (16 oz/gal)
- Hydrated lime (50 or 25 lbs/100gal)

Coqui frog eggs (4-5 d old) from the same cluster were divided into two equal-sized masses, cleared of any unfertilized eggs. One egg mass was subjected to treatment and the other half was not treated. Treatments were applied as a fine mist spray over egg masses (1.5 ml). Each treatment was replicated 10 times. Eggs were allowed to air dry, placed in a plastic Petri dish lined with a paper towel moistened with tap water, and kept at room temp (25 °C, 75% r.h.). Observations were taken every 3 days until all of the viable eggs hatched and data on egg hatch were recorded.

FIGURE 2. COQUI FROG EGGS TREATED WITH CITRIC ACID, PYRETHRINS OR HYDRATED LIME

6 days after treatment

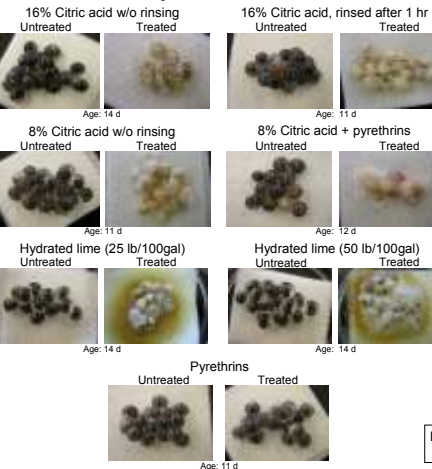


FIGURE 1. EFFICACY OF VARIOUS CHEMICALS ON COQUI FROGS

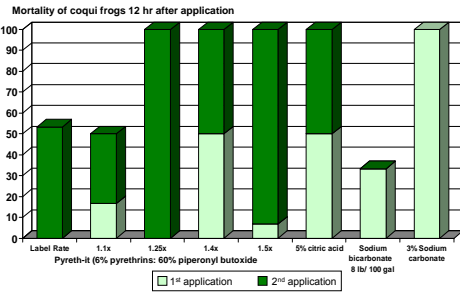


TABLE 1. EFFECTS OF VARIOUS CHEMICAL TREATMENTS ON THE HATCHING RATE OF COQUI FROGS

TREATMENT	NO. EGGS TREATED / AGE AT TRT	% HATCH / % REPS w/ SOME DEGREE OF HATCH
8% CITRIC ACID (no rinse)	158 / 4 - 11 d	0.0a ± 0.0 / 0
8% CITRIC ACID + PYRETHRINS	123 / 4 - 11 d	0.0a ± 0.0 / 0
16% CITRIC ACID (no rinse)	147 / 4 - 8 d	0.5ab ± 0.2 / 20
16% CITRIC ACID (rinsed after 1 h)	160 / 4 - 8 d	15.1b ± 1.6 / 60
HYDRATED LIME (25 lb / 100 gal)	127 / 4 - 10 d	0.0a ± 0.0 / 0
HYDRATED LIME (50 lb / 100 gal)	145 / 4 - 10 d	0.0a ± 0.0 / 0
PYRETHRINS (label rate)	172 / 5 - 12 d	92.5c ± 1.8 / 100
CONTROL (untreated)	991 / 4 - 12 d	See footnote ¹ / 100

¹Treatments had an average of 15.5 ± 5.4 eggs per replicate. Abbott's formula was used to correct data for overall control mortality (2.4%).

²Hatching percentages were significant by ANOVA (P < 0.0005); values were arcsine-transformed prior to ANOVA. Values followed by different letters were different (family error rate P < 0.05) by Tukey's multiple comparison procedure.

MATERIALS AND METHODS

Vapor Heat (Table 2)

The chamber (capacity 20 pallets, 6 ft (1.8 m) height) temperature was raised from ambient temperature to 113 °F (45 °C) (>90% r.h.) and held for 10, 15, 30 or 45 min. Ramp time up to the target temperature was an additional 15 min. Egg clutches of various ages were held in plastic terrariums (10.5 x 8 x 7.5"; 26.7 x 20.3 x 19.0 cm) and placed in the chamber. Eggs were observed for 14 d until hatching.

Hot Water Dipping (Fig. 3)

Water in a 106-l stainless steel tank was heated by immersion circulators to maintain a constant tank temperature. Coqui frog eggs were collected from laboratory pairs; clusters were halved - one half was treated and the other half served as control. Treatments were immersion in hot water at 43 °C or 45 °C (109 and 113 °C, respectively) for durations in 1-min intervals up to 5 min, and for durations of 1, 1.5, 1.75, and 2 min. Eggs were contained in modified 150 x 20 mm polystyrene petri dishes sealed with masking tape. A 10 cm diameter hole was cut both on the cover and bottom of the dish, screened with silk organza (74 µm pore) and sealed with hot glue. Immediately after treatment, the eggs were immersed in ambient temperature (23 °C) water for 2 min. Controls were immersed in ambient water for the longest treatment duration + 2 min. Mortality was determined by lack of development and ultimately failure to hatch. Treatment mortality was corrected for lack of hatching among controls then logit transformed and subjected to linear regression.

TABLE 2. HATCHING RATE OF *E. coqui* EGGS TREATED WITH VAPOR HEAT

TREATMENT	% HATCHING / NO. OF CLUTCHES
10 min at 45 °C	0 / 7
15 min at 45 °C	0 / 7
30 min at 45 °C	0 / 7
45 min at 45 °C	0 / 7
Ramp time only (15 min)	100 / 58
Untreated	100 / 51

Age of eggs at time of treatment did not appear to be a factor in hatching rate. Placing the eggs into the vapor heat chamber and allowing the temperature to reach 45 °C (15 min) had the same effect as the control, causing no mortality.

FIGURE 3. LINEAR REGRESSION OF HATCH OF COQUI FROG EGGS AFTER HOT WATER IMMERSION AT 43 AND 45 °C

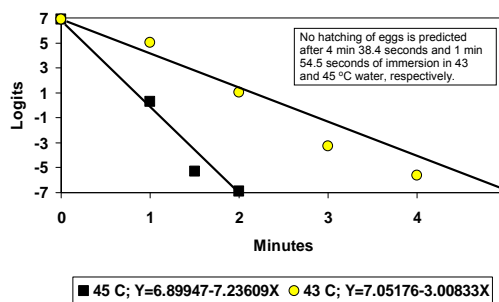


TABLE 3. THERMAL TOLERANCE OF POTTED PLANTS TO HEAT TREATMENTS FATAL TO COQUI FROGS AND EGGS

TOLERANT	Palms:	Chrysanthemum	Miracle berry
Phoenix	Aglaonema	Dieffenbachia	Mock orange
Areca	Anthurium:	Dracaena	Mulberry
Triangle	'Kalapana'	<i>Dracaena warneckeii</i>	Passion fruit
Fishtail	'Marian Seefurth'	<i>Dracaena fragrans</i>	Philodendron
Sago	'Masunaka'	Dwarf apple banana	Streptocarpus
Rhapis	'Lady Jane'	False heather	Synonium
Parlor	Calathea	Gardenia	Ti plant
Kentia	Citrus (<i>only tender, emerging growth burned</i>)	Guava	
		Maiden hair fern	
HEAT SENSITIVE	Dendrobium orchid (<i>Flowers faded; lesions on leaves</i>)	Epidendrum orchid (<i>Lesions on some leaves</i>)	

TABLE 4. EFFICACY OF CITRIC ACID, HYDRATED LIME, PYRETHRINS, COLD & HOT WATER AGAINST COQUI FROGS

TREATMENT	EFFECTIVE ON		SAFE ON PLANTS
	EGGS	JUVENILES AND ADULTS	
Citric Acid* (16%)	Yes	Yes	No / Yes with rinse** except for orchids
Hydrated Lime* (50 lb / 100 gal)	Yes	Yes	Yes; persistent white residue, not marketable
Pyrethrins* (24oz/100gal)	No	No, paralysis only; 2 applications fatal	Yes
Pyrethrins (24oz/100gal) + citric acid (8%)	Yes	Yes	Yes, most plants except orchids
Hot Water 113 °F (45 °C), 5 min***	Yes	Yes	Yes, most tropical plants and orchids
Vapor Heat 113 °F (45 °C) >90% r.h., 15 min (45 min w/ ramping time)	Yes	Yes	Yes; except certain orchids
Cold Air 36-38 °F (2.2-3.3 °C), 6 hours	No	No	No
Ambient Water 82 °F (27.8 °C), 20 min submersion	-	No (30 min)	Yes

*Citric acid, pyrethrins and hydrated lime must have direct contact with frogs for effectiveness.

**Rinsing eggs with water after citric acid application reduces effectiveness by 15%.

***unpublished data Kraus, F., 2000, DLNR / DOFAW.