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Injuries Caused by the Giant African Snail to Papaya

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Herbivory by the giant African snail (*Achatina fulica*) severely damages a wide range of plants in Hawai'i. Among agricultural crops, papaya (*Carica papaya*) sustains great economic injury. These large, plant-parasitic land snails rasp papaya stem and fruit tissues with bands of stiff, chitinous teeth that move to and fro over a supporting, protrusible radula ("tongue"). This radular tool mechanically scrapes and removes layers of host tissue, conveying this nutrition back into the parasite's gut.

Achatina fulica is the most ecologically damaging land snail, and the Global Invasive Species Database has ranked it among the "100 Worst Alien Invasive Species" (Invasive Species Specialist Group 2012). Its host range includes 500 plant species. Although snails symbolize slow movement (*snail's pace*), the rapidity with which a foraging population can multiply and then decimate crops is disheartening and costly to affected farmers and gardeners.

Here we describe the giant African snail, illustrate its herbivory and damage to papaya, and suggest integrated management practices for effective control of this invasive pest.

Morphology

Achatina fulica carries a narrow, conical shell, half as wide as it is long. The shell of fully grown adults has 7 to 9 ridges, or whorls. It is normally reddish-brown or light coffee-colored with faint yellowish, vertical markings. However, these hues may vary with the snail's environment and diet. The length of the adult shell may exceed 20 cm (8 in), but usually averages between 5 and 10 cm (2 to 4 in). The giant African snail weighs, on average, 32 g (1.1 oz) (Invasive Species Specialist Group 2012).

Giant African snails often cluster together while feeding on papaya stems, increasing the potential for severe injury to the plant.

Reproduction

Giant African snails are obligate-outcrossing hermaphrodites; each snail possesses male and female sex organs but must mate with another snail (Invasive Species Specialist Group 2012). The eggs, measuring 4.5 mm to 5.5 mm in diameter, hatch at temperatures above 15°C. Hatched snails become mature adults in 6 to 12 months and remain fertile for 400 days. A snail lays up to 100 and 500 eggs during the first and second years, respectively. Although the fertility rate declines after the second year, giant African snails may live up to 5 years, yielding a total of up to 1,000 eggs (Raut and Barker 2002).

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Left: *Achatina fulica* feeding on a papaya stem in Hawai'i. Middle: Giant African snails commonly feed on unripe papayas, creating injuries that prevent harvest of the damaged fruits. Right: The snails also feed on fallen fruits, which should be picked up regularly to reduce their food supply.

Diet

Achatina fulica feeds on the stems, leaves, flowers, and/or fruits of a broad range of agriculturally important plants, including the following:

- Banana (*Musa* spp.)
- Bean (*Phaseolus* spp.)
- Breadfruit (*Artocarpus altilis*)
- Cabbage (*Brassica oleracea*, Capitata group)
- Cacao (*Theobroma cacao*)
- Carrot (*Daucus carota* subsp. *sativus*)
- Cauliflower (*Brassica oleracea*, Botrytis group)
- Cassava (*Manihot esculenta*)
- Cotton (*Gossypium hirsutum*)
- Cucumber (*Cucumis sativus*)
- Eggplant (*Solanum melongena*)
- Marigold (*Tagetes patula*)
- Melons (*Cucumis* spp.)
- Noni (*Morinda citrifolia*)
- Okra (*Abelmoschus esculentus*)
- Papaya (*Carica papaya*)
- Peas (*Pisum sativum*)
- Pumpkin (*Cucurbita pepo*)
- Sponge gourd (*Luffa cylindrica*)
- Taro (*Colocasia esculenta*)

The snail also consumes important naturalized and native plants within landscapes, forests, and non-agricultural ecosystems.

Habitats

Achatina fulica inhabits most botanical areas in the warm, humid, tropics and subtropics. The temperature range for the giant African snail lies between 9 and 29°C (48 and 84°F). Air temperatures below 2°C (36°F) induce hibernation and those above 30°C (86°F) induce aestivation (dormancy) (Invasive Species Specialist Group 2012).

This animal moves and feeds nocturnally, but it can also parasitize plants during overcast, rainy weather in Hawai'i. *Achatina fulica* may spend daylight hours buried in the soil or litter to avoid sunlight, which can kill it.

Geographic Range and Distribution

The native range of *A. fulica* is the coastal area of East Africa and its adjacent islands. The snail subsequently spread to infest Morocco, Ghana, Japan, Australia, Southeast Asia, and the American continent.

Among Pacific Islands, the giant African snail occurs in French Polynesia, Samoa, American Samoa, Wallis

Left: The initial symptom of snail feeding on a papaya stem is an abraded surface that turns brown and looks moist. Middle: A papaya stem severely abraded by the feeding of giant African snails. Right: The giant African snail can create holes in papaya stems that, if extensive enough, can cause affected plants to wilt and die.

and Futuna, Tuvalu, New Caledonia, Vanuatu, the Solomon Islands, Papua New Guinea, the Marshall Islands, the Federated States of Micronesia, Palau, Guam, and the Northern Mariana Islands (Cowie 2000).

The giant African snail inhabits all of the main Hawaiian Islands. It was first reported on O'ahu and Maui (1936), then on Kaua'i (1958), Moloka'i (1963), Lana'i (1963–1972), and Hawai'i (1958) (Cowie 2000).

This pest can move a substantial distance under its own power. In the field, *A. fulica* can move 50 m (164 ft) overnight (Global Invasive Species Database 2010). Therefore, new infestations must be controlled quickly, before they colonize new areas.

Damage

Giant African snails cause extensive damage on farms and in natural ecosystems and pose certain risks to society. They affect papaya farming in the following ways:

- loss of crop yield from feeding on papaya fruits;
- death of papaya plants from snails feeding on the fruit-bearing, green portion of the stems;
- increased fruit and stem blight caused by *Phytophthora palmivora* as the snail spreads the pathogen within and among papaya plants in feces and by contact with its body;
- increased farm costs (labor, materials, traps, molluscicides) associated with control of the snails; and
- loss of the opportunity to grow papaya in certain locations due to the crop's susceptibility to the giant African snail.

The habits of *A. fulica* create other problems for humans, environments, and society:

- Altered or damaged natural or native ecosystems occur from snail herbivory.
- Altered nutrient cycling ensues in ecosystems due to the large volumes of plant material that passes through the snail's gut.
- Adverse effects on indigenous snails and slugs (gastropods) arise through competition for resources with *A. fulica*.
- There are indirect adverse effects on indigenous gastropods from snail management practices, such as pesticides or biological control. The use of pesticides against *A. fulica* and biological control with the rosy wolfsnail (*Euglandina rosea*) are examples.
- In Hawai'i, *A. fulica* preys on veronicellid slugs in

at least two sites on the island of O'ahu. *Achatina fulica* also competes with endemic snails on Lana'i, reducing animal biodioversity.

- In urban areas, *A. fulica* is a nuisance to humans. The decaying bodies of dead snails release a foul odor, and masses of crushed snails on roads pose a hazard to drivers, causing cars to skid.
- The calcium carbonate in snail shells neutralizes acidic soils, potentially altering soil properties and the types of plants that can grow in the soil.
- In many Asian, Pacific, and American societies, the giant African snail transmits human parasites and pathogens in slime trails or when infested snails are eaten raw or undercooked. One such pathogen is rat lungworm (*Angiostrongylus cantonensis*), which causes eosinophilic meningoencephalitis in humans.

Management

Eradication of the giant African snail is costly and difficult, even if the target is a new infestation. Large, well-established populations may be virtually impossible to eradicate on Hawai'i farms or within ecosystems that favor the snail's survival. Even effective management of the snail population will cost time, money, and labor. Manage the giant African snail with an integrated approach that combines two or more of the following practices.

Prevention and Avoidance

- Prevent the introduction of *A. fulica* to a new location. Avoid introducing plants, equipment, garden rubbish, building materials, farm vehicles, or soils from infested areas. Inspect agricultural, horticultural, and other commercial products and the containers in which they are shipped for snails and snail eggs. Avoid transporting snails on personal vehicles or in belongings. Do not intentionally introduce *A. fulica* to new locations as pets, as ornaments, for human or animal food, or for any other purpose. Remember, the giant African snail's ability to store sperm enables a population to develop from a single introduced snail.

Physical Barriers

- Erect or install physical barriers to prevent the movement of snails, such as a strip of bare soil around a papaya field, a fence of corrugated tin or metal

Right: A papaya plant in the Puna district of Hawai'i Island that wilted and died due to a severe stem injury caused by the feeding of giant African snails. Middle: Severely damaged papaya plants are cut down by papaya farmers, reducing farm income. Left: As the snails feed, they can also transmit plant pathogens such as *Phytophthora palmivora*, which causes fruit blights and stem cankers.

screen, a fence of security wire mesh, or ditches.
- Use salt or copper foil barriers on the ground.
- Enclose the base of papaya stems in corrugated tin screen, copper foil, or security wire mesh.

Pesticides and Chemicals

- Table 1 lists molluscicides registered for papaya in Hawai‘i as baits, soil applications, or foliar sprays. However, these non-selective products can endanger non-target snails, including endemic snails, and other plants and animals.
- Kerosene and common salt may effectively control *A. fulica*, but these are not registered as agricultural pesticides in Hawai‘i.
- The extract of fruits from *Thevetia peruviana* (be-still tree, yellow oleander) repels *A. fulica* (Raut and Barker 2002).
- Boric acid, iron phosphate, and methiocarb are effective, but are not registered for snail management on papaya in Hawai‘i.

Cultural Practices

- Collect snails and eggs daily (after sunset, if possible) by hand and destroy them.
- Incinerate snails and eggs with a flame.
- Eat the snails only after cooking them thoroughly.
- Use cuttings of *Annona glabra* (alligator apple, bullock’s heart, pond apple) to construct softwood fences as a snail repellant to protect nursery beds (Prasad et al. 2004). Although cultivated in some locations in Hawai‘i, this plant is a high-risk, invasive weed (Pacific Islands Ecosystems at Risk, 1999), so be sure it is not living.
- Clear scrub brush from around a papaya plantation. Remove alternate or unwanted hosts of *A. fulica* from around and within papaya fields.
- Choose a sunny location with low humidity for a papaya farm. *Achatina fulica* is killed by sunlight.
- Remove debris from fields to eliminate shelter or hiding places for the snail. Pick up fallen fruits.

Table 1. Molluscicides registered for use on papaya (*Carica papaya*) in Hawai‘i to control snails.[1]

Product Name (Formulation)	Active Ingredient (%)	Application
Bug-N-Sluggo® (Granular)	Phosphoric acid, iron (3+) salt (1:1) (0.07%)	Bait
Deadline® Bullets (Pelleted/tableted)	Metaldehyde (4%)	Soil
Deadline® M-PS Pellets (Pelleted/tableted)	Metaldehyde (4%)	Soil
Deadline® T&O (Pelleted/tableted)	Metaldehyde (4%)	Soil
Metarex 4% Snail and Slug Bait (Granular)	Metaldehyde (4%)	Bait
Nordox® 75 WG (fungicide) (Water-dispersible granules)	Cuprous oxide (83.9%)	Foliar
Sluggo® Plus (Granular)	Phosphoric acid, iron (3+) salt (1:1) (0.97%); Spinosad (0.07%)	Bait

[1]Follow the label instructions for these pesticides.

A gravid giant African snail can lay 100 eggs at a time. Here, the eggs are on the soil surface at the base of a papaya plant.

Although the rosy wolfsnail (above) feeds on the giant African snail, it is also a predator of endangered, endemic Hawaiian snails.

Traps

Traps set in and around the orchard or home can be effective in reducing snail populations. Here are some common examples and how they work.

- Salt traps: The salt dries and kills them.
- Beer traps: Beer attracts the snails, and the alcohol kills them.
- Tanglefoot® traps: The snail contacts the sticky substance, becomes stuck and dies.
- Tanglefoot® Tangle Guard Paper Tree Wrap: Snails that try to climb papaya stems stick to the paper and die.
- A piece of wood raised about one inch off the ground can be set out to trap snails. They use it for shelter during the day. Check the traps each morning and destroy any snails hiding there.

Biological Control

Snails that predate and feed upon *A. fulica* include *Euglandina rosea*, *Gonaxis kibweziensis*, *Gonaxis quadrilateralis*, *Edentulina ovoidea*, and *Edentulina affinis*. Although biological control may seem attractive, misguided attempts can severely damage non-target, indigenous snails. According to Cowie (2000), "It cannot be stressed enough that these introductions of putative biological control agents against *Achatina fulica* are extremely dangerous from the perspective of the conservation of native snail species. And in any case, there is no good evidence that they can indeed control *A. fulica* populations."

In 1955 the predatory rosy wolfsnail (*Euglandina rosea*) was introduced into Hawai'i to control *A. fulica*, but non-target impacts included the consumption of native snails. The carnivorous snails have not reduced populations of *A. fulica*, but native snail populations have been devastated (Cowie 2000). *Platydemus manokwari*, a turbellarian flat worm, has been used to control the giant African snail in Guam, the Philippines and the Maldives. However, this worm has also been implicated in the decline of native snails (Invasive Species Specialist Group 2012).

Birds such as chickens and ducks eat snails and/or snail eggs and can help to suppress snail populations. However, one should avoid using molluscicides that may harm birds where the birds are used to manage snails.

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