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New Pest Response Guidelines

Giant African Snails: Snail Pests in the Family Achatinidae

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Snail Pests in the Family Achatinidae

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Snail Pests in the Family Achatinidae

Contents

1 Introduction

Snail Pests in the Family Achatinidae

Program Safety

Important

Consumption of snails and slugs, or of vegetables and fruits contaminated by snails and slugs, may lead to infection by pathogens that are easily transmitted by these pests. Wear rubber or latex gloves when handling mollusks, associated soil, excrement or other materials that may have come in contact with the snails. Immediately after removing protective gloves, thoroughly wash hands with hot soapy water and rinse well. Consult a physician if, after handling snails and slugs, you experience symptoms resembling forms of meningitis, including headache, stiff neck, tingling or painful feelings in the skin, low-grade fever, nausea, and vomiting. These symptoms could indicate an infection by *Angiostrongylus cantonensis*, a parasite carried by snails and slugs**.** Additional diseases are carried by snails and slugs.

Safety of the public and program personnel has the highest priority. Safety officers and supervisors must enforce on-the-job safety procedures. Follow all safety precautions outlined in the USDA Emergency Programs Manual, Section 9. In addition, observe the following precautions while working with snails (CDC 2004):

- Always wear disposable gloves when handling live or dead snails, slime, or other snail products
- Always wear disposable gloves when handling food plants that mollusks have fed upon
- Wash your hands with hot, soapy water immediately after removing gloves
- Do not eat mollusk products or contaminated vegetables and fruit, especially if raw or undercooked
- Collect and dispose of shells in an approved landfill, to prevent their use as breeding sites by disease-carrying mosquitoes
- Health personnel should remain alert for the appearance of new diseases in snail-infested areas

Purpose

Use *New Pest Response Guidelines. Giant African Snails: Snail Pests in the Family Achatinidae* as a guide when designing a program to detect, monitor, control, contain, or eradicate an infestation of achatinids. If these pests are detected in the U.S., PPQ personnel will produce a

site-specific action plan based on the New Pest Response Guidelines and the most recent findings. We hope that state agriculture department personnel and others concerned with developing local survey or control programs for this pest may find this document useful.

PPQ develops each through discussion, consultation, or agreement with staff at Animal and Plant Health Inspection Service (APHIS), Agricultural Research Service (ARS), and with university advisors.

Pest Status

The species reported are plant pests or show promise of being plant pests. Most achatinids feed on a wide variety of plants and may utilize new hosts in a new environment. This report focuses on the control of several species of achatinids. All of the achatinids have a potential for entry and establishment in the U.S. and thus all are of equal concern. Commerce and intentional spread by mankind appear to be the most likely pathways for introduction of this pest.

Disclaimers and Document Comprehension

This document is not intended to be complete and exhaustive. It provides a foundation, based on the literature available, to assist further work. Some key articles were not available at the time of writing, and not all specialists and members of the research community were consulted for their advice. For the most current information on this pest, consult with local agricultural experts, including personnel from Cooperative Extension Service, state Departments of Agriculture and USDA. Conduct your own literature search. Search web sites frequently, since material is updated periodically.

Commercial Suppliers or Products

References to commercial suppliers or products should not be construed as an endorsement of the company or product by the U.S. Department of Agriculture.

Contacts

When an emergency program for achatinids has been implemented, its success depends on the cooperation, assistance, and understanding of other involved groups. The appropriate liaison and information officers should distribute news of program progress and developments to interested groups, including:

- Other federal, state, county, and municipal agricultural officials
- Grower groups (such as specific commodity or industry groups)
- Commercial interests
- Academic entities with agricultural interests
- Land-grant universities and Cooperative Extension Services
- State and local law enforcement officials
- Public health agencies
- Foreign agricultural interests
- National, state and local news media, and
- The public

Initiating an Emergency Pest Response Program

An emergency pest response program or incident response consists of detection and delimitation, and may be followed by programs in regulation, containment, eradication and/or control.

If a newly detected exotic or imminent pest threat does not have a current New Pest Response Guidelines document for reference, the New Pest Advisory Group (NPAG) evaluates the pest. After assessing the risk to U.S. plant health and consulting with experts and regulatory personnel, NPAG makes a recommendation to PPQ management for a course of action.

Follow this sequence when initiating an emergency pest response program:

1. A new or reintroduced pest is discovered and reported.
2. The pest is examined and pre-identified by regional or area identifier (See “Identification” on page 3-1).
3. Pest identity is confirmed by national taxonomic authority (See “Identification” on page 3-1).
4. New Pest Response Guidelines are consulted or NPAG is assembled to evaluate the pest.

5. Depending on the urgency, official notifications are made to the National Plant Board, cooperators, or trading partners.
6. A delimiting survey is conducted at sight of detection (See "Delimiting Survey" on page 4-1).
7. A Incident Assessment Team may be sent to evaluate the site.
8. A recommendation is made, based on the assessment of surveys, other data, and recommendations of the Incident Assessment Team and/or an NPAG, as follows (See "Regulatory Procedures" on page 5-1 and See "Public Education" on page 6-1):
   - ❖ Take no action
   - ❖ Regulate the pest
   - ❖ Contain the pest
   - ❖ Suppress the pest
   - ❖ Eradicate the pest
9. State Departments of Agriculture are consulted.
10. If appropriate, a control strategy is selected.
11. A PPQ Deputy Administrator authorizes a response.
12. A command post is selected and the Incident Command System is implemented.
13. Further detection surveys are conducted (See "Survey Procedures" on page 4-1).
14. Field identification procedures are standardized (See "Identification" on page 3-1).
15. Data reporting is standardized.
16. Environmental assessments are completed as necessary.
17. Treatment is applied for required pest generational time (See "Public Education" on page 6-1).
18. Environmental monitoring is conducted if appropriate.
19. Pest monitoring surveys are conducted to evaluate program success (See "Survey Procedures" on page 4-1 and See "Public Education" on page 6-1).
20. Programs are designed for eradication, containment or long-term control of the pest (See "Public Education" on page 6-1).

Support for Program Decision Making

The USDA/APHIS/PPQ Center for Plant Health, Science and Technology provides technical support to emergency pest response program directors concerning risk assessments, survey methods, control strategies, regulatory treatments, and other aspects of pest response programs.

2 Pest Information

Snail Pests in the Family Achatinidae

Classification

Phylum—Mollusca
Class—Gastropoda
Order—Pulmonata
Family—Achatinidae

Achatinidae is the name of a family of giant snails that are native to Africa. Commerce and intentional spread by mankind appear to be the most likely pathways for introduction of this pest to the U.S. This report focuses on the control of several species of achatinids that are pests of plants. Achatinids have a potential for entry and establishment in the U.S. and thus all are of equal concern. In this report, each snail is referred to by its species name (Table 2-1 below).

Snail terminology is confusing, because scientists and the media often use the name "giant African snail" to refer to any large land snail. Scientifically, the common name "giant African snail" is applicable to *Achatina fulica*. The emphasis on *A. fulica* in this report reflects its predominance as well as the abundance of literature focused on this species.

TABLE 2-1 Quarantine significant giant terrestrial snails originating in Africa. All snails in the family Achatinidae have a potential for entry and establishment in the U.S.

Scientific name	Common names
Achatina achatina (Linné 1758)	giant African snail, escargot Géant, Achatine, giant Ghana tiger snail
Achatina fulica Bowdich 1822	giant African snail, escargot Géant, Achatine, Caramujo
Archachatina marginata (Swainson 1821)	giant African snail, Achatine, banana rasp snail
Limicolaria aurora (Jay 1839)	escargot géant d'Afrique

Spread of Achatinids

Abbott (1949) documented the movement of *A. fulica* out of Africa and around the world, fearing its spread across the U.S. (Figure 2-1 below).

Achatinids in the U.S.

Achatina fulica first appeared in the U.S. in gardens in San Pedro, California in the late 1940s (Abbott 1949). Inspectors in California found thousands of *A. fulica* moving up the wharf area of San Pedro and quickly eradicated them, preventing their establishment in California (Mead 1949 and 1961; Hanna 1966).

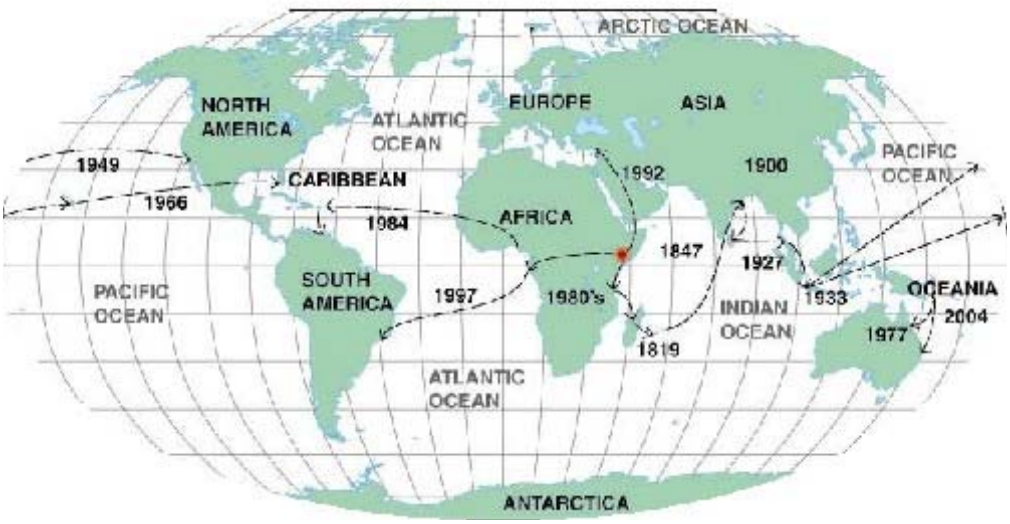

FIGURE 2-1 Dissemination of achatinid snails from Africa since 1804. Revised from Raut and Barker (2002) and Abbott (1949) by USDA/APHIS/ Legislative and Public Affairs.

Despite subsequent infestations, achatinids have not become established in the U.S. Inspectors in California, Oregon, Louisiana, Texas and Maryland intercepted many specimens brought in by the return of war material from snail infested areas. In 1949, 1950, and 1951, there were six, eight, and twelve interceptions, respectively, at California ports. Between 1948 and 1958, snails were intercepted fifty times in California. The number of interceptions decreased after war material ceased being imported. Since then, snails have been found in Arizona, Florida, the midwest and eastern US, and Puerto Rico.

A regulatory incident occurred in Arizona in 1958 (Mead 1959). A young boy, traveling with his family from Hawaii to California, packed *A. fulica* snails in a suitcase. The family later drove to the east coast. On the way, they left the snails at a wild animal farm in Arizona. When

the owner of the farm included the snails in advertising, he learned that they were serious pests. State quarantine agents destroyed the snails. A period of two weeks had passed and the snails had little time to reproduce.

Achatina fulica became established temporarily in Florida in the late 1960's. A boy, returning from Hawaii in 1966, brought three snails into Florida. His grandmother released them in her garden. In 1969, the Florida Division of Plant Industry was alerted to the infestations and began a survey and eradication program. By 1973, over 18,000 snails were destroyed, a testimony to the reproductive powers of *A. fulica*. After an absence of two years, inspectors declared it eradicated.

In 2004, USDA inspectors discovered the importation of *A. fulica* by the pet store trade and educational institutions. Inspectors initiated a control program in April. By the time the program ended in late September, 6,700 snails were found in nine states and Puerto Rico. Wisconsin was the center of the infestation. One snail was found in both New Jersey and in Puerto Rico, and 3,139 were found in Ohio, where *A. fulica* was used as an educational tool for school children. Fortunately, the snail did not establish itself in the natural environment. The last confiscation occurred at a residence on September 28, 2004, in West Olive, Michigan.

Movement from Africa

From Africa, *A. fulica* also spread west. It arrived on the West African coastline in the 1980's. In Ghana, it displaced the native snail *Achatina achatina* (Asamoah 1999). Travelers have carried *A. fulica* even further west. Within a short period after its introduction, *A. fulica* achieved dominance in the achatinid community in the Ivory Coast and in Ghana and became a significant crop pest (Raut & Barker 2002).

In 1984, *A. fulica*, *A. marginata* and *L. aurora* from Africa reached the Caribbean (Mead & Palcy 1992, 1993; Robinson 1997). Raut & Barker (2002) claim that *A. fulica* moved to the Caribbean via Florida.

Achatina fulica spread to several Caribbean Islands. It was found in Brazil in 1997, and has spread throughout most of that nation. Coltro (1997) and Paiva (2004) predict that it will spread to South and Central America. In the Pacific Ocean, *A. fulica* has continued to spread among the islands. It was found in Gordonville, Australia in 1977, and in Currumbin, Queensland in 2004. Both infestations were eradicated.

Achatina fulica has also spread throughout Asia, to islands in the Pacific and Indian Oceans, and to the West Indies.

Impact And Host Range

Achatinids are a potential threat to a wide variety of crops, including vegetable, field, oil, ornamental and fruit crops (see "Food Plants" on page C-1). The following are examples of losses attributed to *A. fulica*:

One million dollars—A six-year campaign to eradicate achatinids from Florida ended in 1975 at a cost of one million dollars (Simberloff 1996). Economists estimated that, if the infestation of this pest in 1969 had remained undetected, annual losses would have reached 11 million dollars (in 1969 dollars) (Smith & Fowler 2003).

Tropical food crops—In 1994, this snail threatened production of the basic food crops of Western Samoa, including bananas and coconuts (CIA 1996).

Infestation in South America—In Brazil, infestation of this snail resulted in displacement of small agricultural producers to cities, lessened availability of food, greater food prices, and the importation of food (Paiva 2004).

Damage to shade and native plants—Snails can have profound effects on plant communities, including endangered plant species. The effects are comparable to infestations of insects and rodents (Speiser 2001). Snails are generally not host specific.

Labor and materials—Costs for labor and materials associated with snail control are costly.

Nutrient cycling—Under conditions of heavy infestations, large volumes of plant material pass through the snail gut, altering nutrient cycles.

Plant pathogens—Transmission of plant pathogens, including *Phytophthora palmivora* (in black pepper, betel pepper, coconut, papaya), *Phytophthora colocasiae* (in taro), and *Phytophthora parasitica* (in eggplant and tangerine).

Human pathogens— *Achatina fulica* is a vector of *Angiostrongylus cantonensis* (Nematoda) (Chen 1935) causing eosinophilic meningitis (or cerebral angiostrongyliasis) in humans. The spread of the disease has been correlated with the spread of *A. fulica* (Cowie, 2004). Achatinids carry other diseases that affect humans and animals (Raut & Barker 2002).

Obstruction of roadways and walkways—The snails frequently reach such great numbers that they cover roadways and walkways.

Native snails—Native snail populations are likely to be affected by control efforts aimed at the invasive species (Cowie 2004).

Tourism—Degradation of habitat caused by snail feeding and feces may have an impact on local tourism.

Ecological Range

Achatinids are native to tropical and subtropical Africa south of the Sahara (Pilsbry 1919). *Achatina fulica* is the most adaptable species, which accounts for its success throughout the world. This species is abundant as far north as 30° latitude. Temperature, moisture and availability of calcium restrict its range. The exact ecological range is unknown. Expect to find *A. fulica* in environments that meet the following requirements:

- A minimum temperature of 34°
- Subtropical rainfall, and
- Available calcium and soil pH of 7.0-8.0

Smith and Fowler (2003) predicted a potential distribution of *A. fulica* in the continental United States of up to 38° Latitude, including most of the southern states, up to Maryland in the east, through Texas to California in the west, and north to Washington and the climate of the Pacific northwest (Figure 2-2 below.

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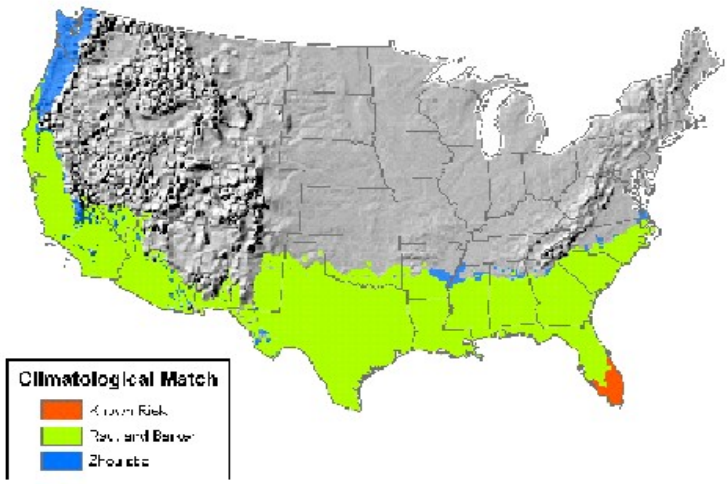

FIGURE 2-2 Potential distribution of *Achatina fulica* in the continental U.S. Adapted from Zhou et al (1998), Raut and Barker (2002) and Mead (1973).

Biology

Achatinids require calcium for proper formation of the shell and for successful reproduction. Achatinids obtain calcium from many sources in their environment. Calcium carbonate can be found in alkaline soils. Plants also provide a store of calcium silicates where free calcium is not readily abundant in the soil. In large populations, snails ingest the shells of live and dead snails to obtain minerals.

Species in the family Achatinidae differ with respect to development, reproductive behavior, size, and temperature and moisture requirements.

Achatina fulica Bowdich 1822

This species is highly adaptable to a wide range of environments, modifying its life cycle to suit local conditions. It is one of the greatest threats to agriculture and the environment worldwide due to its reproductive capacity, destructiveness to plants, threat to human health, and large size. *Achatina fulica* prefers environments that are rich in calcium carbonate, such as limestone, marl, and developed areas with an abundance of cement or concrete.

Snails reach sexual maturity in less than one year. The average life span is 3-5 years, but individuals may reach the age of 9 years. Adults have both male and female sexual organs, but reciprocal copulation is required to produce viable eggs. The male organs mature at the age of 5-12 months; the female organs mature later (Robinson 2002; South Pacific Commission 1993).

This snail stores sperm, and is able to lay fertilized eggs repeatedly after just a single mating (Robinson 2002). Mating lasts from 3 to 6 hours, but may last as long as 24 hours. Individuals may lay viable eggs for up to 382 days after mating.

Snails begin laying eggs at 5 to 6 months. Individuals produce from 10 to more than 400 eggs, 8 to 20 days after mating. Under optimum conditions, 300 to 1000 eggs in 3 to 4 batches may be laid each year. Snails deposit eggs in cool, moist soil and under objects on the ground. In the tropics, eggs hatch after 11 days. The juveniles eat their egg shells before seeking other food including unhatched eggs and organic detritus. They burrow and remain underground for 5-15 days.

Upon emergence, juveniles remain fairly close to the nest for a few weeks. They establish a home range within two months, feeding primarily on plants and returning home before dawn. Larger snails continue to feed on plant material, but may become detritus feeders as they age.

This species is nocturnal, but may become active at twilight if the day is overcast and the soil is moist and warm. The snail is extremely sensitive to high rates of evaporation. Under moisture stress, it becomes inactive and begins aestivating within 24 hours. However, aestivation can occur independent of moisture. Scientists believe that aestivation may be cyclic. Snails may aestivate as they cling to objects, aiding in their inadvertent spread to new areas on cargo, vehicles or machinery.

During unfavorable periods, the snail buries itself 10 to 15 cm (4 to 6 inches) deep in soft soil and may become inactive for up to a year, losing 60% of its weight. Physiological changes in blood and certain organs occur before and during the period of inactivity. This species can reproduce in areas that are too dry for other large snails (Hardouin et al. 1995) (Snail Draft Generic Action Plan, 1986; modified by IICA, 2002; Srivastava, 1985).

Achatina achatina (Linné 1758)

Achatina achatina matures within 24 months. At maturity, it averages 13.4 times its size at hatching. The average life span is 5 to 6 years. It is hermaphroditic, but cross-fertilization occurs. Mating occurs at night and can last for up to 12 hours.

Achatina achatina breeds during the rainy season of the year in tropical climates. At that time, decaying vegetable matter is abundant and high humid conditions as well as high temperatures persist for long periods in the tropical forests. In vitro clutch size varies from 35 to 305 eggs; the average is 167.7 eggs per clutch.

Eggs are small (about 5 mm), spherical and whitish. Like *A. fulica*, *A. achatina* lays hundreds of eggs below the surface of the substrate. Cold weather will inhibit egg laying in the first year; snails lay few eggs in their last year.

Before laying, the snail makes a burrow or egg chamber. Eggs are laid in the burrow and covered with loose soil. If loose soil is unavailable, the snail lays the eggs on the soil surface.

Hatchlings of *A. achatina* and *A. fulica* are identical, resembling many other species for the first few weeks. Distinctive markings begin to appear after a few months. At hatching, the average length of the shell of *A. achatina* is 6.9mm; average body weight is 0.10 grams. Hatchling snails tend to aggregate in groups for the first few days and eat only soft food and their eggshells. While young, they bury themselves deep in the soil by day with their shells often totally covered. They grow rapidly but variably for the first six months, and aestivate if dry weather occurs during that time. They resume rapid growth after favorable, humid conditions return. Unlike *A. fulica*, adults of *A. achatina* remain on the soil surface during the day and retract their

fleshy parts into their shells. *Achatina achatina* is nocturnal, emerging from hiding places early in the evening. They alternate time spent feeding, resting and exploring, spending most of their time at the latter two.

In Ghana, Duah and Monney (1999) collected 48,467 *A. achatina* in 1 ¼ acres over a 10-day period during the rainy season. Analysis of the gut and feces of specimens confirmed that this species is nonselective. The food found in abundance in its feces included dropped leaves, dropped fruits, decomposed leaf litter, okra, yam leaves and the ripe fruits of *Ficus anomani* (Okafor 1989, Hodasi 1975,1979).

Archachatina marginata (Swainson 1821)

This species was introduced into Martinique in the 1980s, but it did not become established. *Archachatina marginata* matures and stops growing within one year. Its average life span is 3 to 5 years; some individuals may live as long as 10 years. It is hermaphroditic but has been observed in coitus.

This species forms smooth walled, oval egg chambers in soil 4-6 inches below the surface. It lays from 1-40 eggs per clutch, averaging 8.6 eggs per clutch. Eggs are laid on the surface if soil is compacted. The large eggs are lemon-yellow or speckled with dark blotches but whiten with age. This species has been reported to lay its eggs in trees (Lange 1950).

Most eggs will hatch over a period of 24-36 hours after an incubation period of 35 to 41 days in very damp soil maintained at 23°. Because the eggs and hatchlings are so much bigger than those of *Achatina* spp., they are easy to distinguish. The juveniles remain underground for 7-14 days (Palcy & Mead 1993; Goodman 1998; Ashby 2004).

Limicolaria aurora (Jay 1839)

This species was probably introduced to Martinique by African immigrants some time before 1989. They reached considerable numbers in 1989 at the start of the rainy season and attacked yam, bean, pepper, cucumbers, okra, sweet potato, and Jerusalem artichoke. This species damaged palm fruits and leguminous cover crops in Cameroon, Africa. Such behavior suggests that *L. aurora* may prove to be a greater pest than *A. fulica* or *A. marginata* (Mead & Palcy 1992; Spence 1938).

This species is able to reproduce in areas that are too dry for *A. achatina* or *A. marginata* (Hardouin et al. 1995). Some *Limicolaria* spp. survive in cold, mountainous climates and may be regarded as temperate. Other *Limicolaria* spp. thrive in modified forests, at forest edges and in plantations. In open habitats, *Limicolaria* spp. spend long periods of time deep in the soil, favor cultivated land and are found on the outskirts of settlements and farms (Raut & Barker 2002).

Behavior of Achatinids

Achatinids are active in the early morning, late afternoon and on cloudy, damp, or rainy days. They prefer damp, shady places and avoid direct sunlight. They are commonly found in and around human dwellings, in open woodlands, parks, gardens, cemeteries, hedgerows, borders of marshes and similar habitats. They climb trees and walls. They will often move to protected sites prior to the outbreak of a storm (Raut & Ghose 1984).

Achatinids are nocturnal. During the day, they retreat into their shells. Common daytime retreats include:

- Loose soil
- Under bricks, rocks, fallen logs, plant mats, decaying leaves
- In or on plants, trees and heavy vegetation, or
- Under air conditioners, houses or discarded containers

3 Identification

Snail Pests in the Family Achatinidae

Introduction

Accurate identification of these pests is pivotal to assessing their potential risk, developing a survey strategy, and determining the level and manner of control. The protection of non-target snails is equally important. Some native snails are beneficial, or may be protected by local, state or federal laws.

Snails are carriers of pathogens that may infect humans. See "Introduction" on page 1-1 if you plan to handle snails.

Verification

Qualified local personnel may perform pre-identification and screening of suspected snails. Before survey and control activities are initiated in the U.S., a USDA/APHIS/PPQ/National Identification Service-recognized authority must verify the presence of Achatinids. To verify identification of snail specimens, contact NIS personnel specializing in malacology at the following address:

Dr. David Robinson
USDA National Malacology Specialist
Academy of Natural Sciences
1900 Ben Franklin Parkway
Philadelphia, PA 19103
Phone: 215-299-1175
Email: robinson@ansp.org
Fax: 215-567-7229

Identification

Use this section as a guide to identification of these pests.

Identification of Quarantine-significant Snails

Snail Anatomy

The body of a snail has two pairs of tentacles: a short, lower pair that are sensitive to touch and chemical signals; and one long, upper pair with eye spots at the tips (Schotman 1989 and USDA 1960). The body is moist, slimy and rubbery. Body coloration varies with species. The foot sole is flat, with coarse tubercles most evident on the sides and upper surface of the extended body.

Shell characters that are important for identification include the columella, whorls, sutures, transverse striae, parietal wall, apex, and lip (Figure 3-1 and Figure 3-2 below).

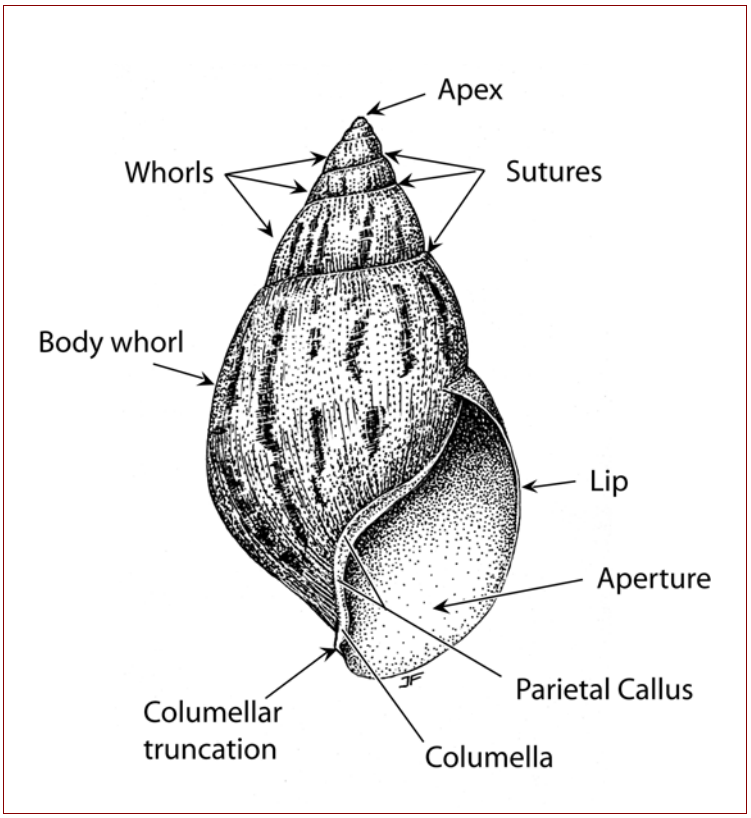

FIGURE 3-1 Anatomy of an achatinid snail; image courtesy of Joel Floyd, USDA/ APHIS/PPQ/PDMP/Planning and Preparedness

FIGURE 3-2 Comparison of shell size, shape and markings of (from left to right) *Achatina fulica*, *Achatina achatina*, *Archachatina marginata* and *Limicolaria aurora*

Achatina fulica Bowdich 1822

Eggs—Use the following criteria to identify eggs of *Achatina fulica*:

- Color is yellowish-white to yellow (Figure 3-3 and Figure 3-4 below)
- Shape is oval
- Size is approximately ¼ inch long X 0.16 inch wide (Goel and Srivastava 1985)

FIGURE 3-3 Eggs of *Achatina fulica*

FIGURE 3-4 Egg shell and juvenile of *Achatina fulica*

Juveniles—Use the following criteria to identify juveniles of *Achatina fulica*:

- Columella is truncated (Figure 3-5 and Figure 3-6 below)

Juveniles are similar to adults, but have a thinner, translucent shell which is more brittle. Upon emergence, the juvenile shell is approximately 1/6 inch long (Denmark and Poucher 1969).

FIGURE 3-5 Shells of immature (left) and adult (right) stages of *Achatina fulica;* reproduced by permission from M. Overton, "The Tarantula's Burrow," http://arachnophiliac.co.uk/burrow/home.htm (accessed March 8, 2005) © All rights reserved

FIGURE 3-6 Shell of immature *Achatina fulica*

Adults—Use the following criteria to identify adults of *Achatina fulica*:

- Columella is truncated (Figure 3-1 above; Figure 3-7 and Figure 3-8 below)
- Columella and the parietal callus are white or bluish-white with no trace of pink (Bequaert 1950)
- Shell size may be up to 8 inches in length and almost 5 inches in maximum diameter (Bequaert 1950)
- Shell has seven to nine whorls and rarely as many as ten whorls (Bequaert 1950)
- Shell color is reddish-brown with light yellowish, vertical (axial) streaks; or, light coffee colored
- Protoconch is not bulbous
- Body coloration can be either mottled brown or more rarely a pale cream color

The truncated columella is evident throughout the lifespan of the snail. The columella is generally concave. Snails with a lesser concaved columella tend to be somewhat twisted. Snails with a broader shell tend to have a more concave columella (Bequaert 1950). In calcium-rich areas the shells of the adults tend to be thicker and opaque.

The outline of the shell may vary somewhat, even within the same colony, from slender to moderately obese. Shells of broader specimens with the same number of whorls tend to be shorter in length. The shell is generally conically spired and distinctly narrowed but barely drawn out at the apex (Bequaert 1950). The whorls are rounded with moderately impressed sutures between the whorls. The aperture is relatively short (Bequaert 1950) and has an ovate-lunate shape (Burch 1960). The lip is sharp, convex, thin and evenly curved (Bequaert 1950) into a regular semi-ellipse. The shell surface is relatively smooth, with faint axial growth lines.

Though shell coloration may be variable due to environmental conditions and diet (Schotman 1989 and USDA 1960), generally it is reddish-brown with light yellowish, vertical (axial) streaks (Schotman 1989 and USDA 1960). The two shell colors are not distinct from each other and are somewhat streaked or smudged in appearance. Another shell color variation resembles a light coffee color. The colors fade with age in the earliest whorls appearing lighter or less intense (Schotman 1989 and USDA 1960), becoming darker and more vibrant nearest the body whorl. Body coloration can be either mottled brown or, rarely, a pale cream color. The foot sole is flat.

FIGURE 3-7 Adults of *Achatina fulica*

FIGURE 3-8 Shell of adult *Achatina fulica*

Achatina achatina (Linné 1758)

Eggs—No criteria are available (Figure 3-9 below).

FIGURE 3-9 Eggs of *Achatina achatina;* reproduced by permission from S. Peterson, "Welcome to BugWeb," http://www.bugweb.dk/index.html (accessed March 8, 2005) © All rights reserved

Juveniles—No criteria are available (Figure 3-10 below.

FIGURE 3-10 Juveniles of *Achatina achatina;* reproduced by permission from S. Peterson, "Welcome to BugWeb," http://www.bugweb.dk/index.html (accessed March 8, 2005) © All rights reserved

Adults—Use the following criteria to identify adults of *Achatina achatina*:

- Columella is truncated as in *Achatina fulica* (Figure 3-11 below)
- Columella and parietal wall always a vinaceous red color (Bequaert 1950)
- Shell with spiral sculpture, particularly close to the suture, crossing the axial growth lines, resulting in a somewhat reticulated surface
- No more than seven to eight whorls (Bequaert 1950)
- Protoconch is **not** bulbous

FIGURE 3-11 Adult shell of *Achatina achatina*

Archachatina marginata (Swainson 1821)

Eggs—No criteria are available (Figure 3-12 below).

FIGURE 3-12 Eggs of *Achatina fulica* (right) and *Archachatina marginata* (left); reproduced by permission from Annette Goodman, "The Giant African Land Snail Site," http://www.geocities.com/Heartland/Valley/6210/ (accessed March 8, 2005) © All rights reserved

Juveniles—No criteria are available.

Adults—Use the following criteria to identify adults of *Archachatina marginata*:

- Columella is truncated (Figure 3-13 and Figure 3-14 below)
- Parietal wall and outer lip are white or bluish (Bequaert 1950), although some subspecies may have an apricot-yellow or wine red columella and parietal wall
- Shell size is very large, reaching a maximum length 8 ¼ inches and a maximum diameter of 5 inches

- Protoconch is very large and bulbous

FIGURE 3-13 Adult shell of *Archachatina marginata*

FIGURE 3-14 Adult and eggs of *Archachatina marginata;* photograph courtesy of Brian Sullivan, USDA/APHIS/PPQ

Limicolaria aurora (Jay 1839)

Eggs—No criteria are available (Figure 3-15 below).

FIGURE 3-15 Eggs of *Limicolaria aurora*

Juveniles—Use the following criteria to identify juveniles of *Limicolaria aurora*:

- Shell size is approximately the same as *Achatina fulica*

Adults—Use the following criteria to identify adults of *Limicolaria aurora*:

- Columella is complete, connecting with the lip (Figure 3-1 above and Figure 3-16 below)
- Shell color is cream with reddish-brown patterns that resemble flames
- Shell with growth striae which give it a slightly wrinkled appearance (Crowley & Pain 1970)
- Shell size is smaller than *Achatina fulica*, reaching a maximum of 2 1/3 inches in height and 1 inch in diameter
- Shell has a maximum of 9 to 9½ convex whorls
- Shell shape is oblong-ovate

FIGURE 3-16 Adult of *Limicolaria aurora* (streaked color form)

Identification of Quarantine-insignificant Snails

Euglandina rosea (Spiraxidae) and *Orthalicus* spp. (Orthalicidae) have been mistaken for *Achatina fulica*. These native species do not require quarantine action. Find *E. rosea* in the southeastern U. S., from North Carolina to Florida, and west to Texas. Scientists introduced this carnivorous species to the Hawaiian Islands and elsewhere in the Pacific as part of an ill-conceived biological control program aimed at *A. fulica*. The introduction had little to no effect on the target snail, while decimating populations of native wild snails (Robinson 2003).

Euglandina rosea (Férussac 1821)

Use the following characters to identify adults of *Euglandina rosea:*

- Columella is truncated
- Shell shape is oblong, tapered, nearly bullet-shaped and variable (Figure 3-17 below)

- Shell colors range from rosy pink to light peach with white to beige growth lines
- Shell size up to 3 inches in height and 1.1 inches in maximum diameter (Robinson 2003)
- Shell with 6-9 convex whorls
- Shell with minimally depressed sutures (Pilsbry 1946; Robinson 2003)
- Aperture nearly twice as long as wide with a pink interior, extending to nearly ½ or more of the shell's length having a truncated, concave columella

The apex is blunt. The *bullata* form, with a more inflated aperture and shorter spire, is common in southern states including Louisiana, Mississippi, and North Carolina (Robinson 2003). The shells of the juveniles appear smooth and shiny becoming slightly rougher or more roughly striated in appearance toward maturity.

FIGURE 3-17 Typical form (left) and *bullata* form (right) of *Euglandina rosea*

Orthalicus spp.

Some *Orthalicus* spp. are endangered or threatened (Robinson 2003). Native species do not require quarantine action. In North America, *Orthalicus* spp. are found only in the warmer areas of south Florida.

Orthalicus spp. have been confused with immature *Achatina fulica* due to their similar color patterns and shape. However, *Orthalicus* spp. lack a truncated columella (Figure 3-18 below). The columella connects smoothly with the lip. They tend not to be as large as *A. fulica* of the same age, with some species reaching only 2¾ inches in height and 1½ inches maximum width (Robinson 2002). Adult *Orthalicus* spp. may be brightly colored with spiral stripes and axial

bands. The lip will be black or dark brown (Pilsbry 1899). The aperture has blackish bands and streaks on a lighter background (Pilsbry 1899).

FIGURE 3-18 Shells of *Orthalicus* spp.

Collection, Preparation and Submission of Specimens

When collecting, preserving or submitting snails, follow the procedures outlined below and in the PPQ/Airport and Maritime Operations Manual.

Important

Safeguard and contain all suspect snails, eggs, and infested soil to eliminate the pest risk. Your goal is to contain the snail to minimize spread, sale or removal. Juvenile snails may be as small as their egg shells and may escape through holes of the same size.

Labeling

Gather as much information as possible during the initial detection. This may be the only time when a potential violator cooperates sufficiently to substantiate claims. Label samples with the following information:

- Specific location
- Global positioning system coordinates, if available
- Plant host or substrate
- Type of property
- Date of sampling
- Survey method used to obtain the sample
- Name of the sampler
- Temperature and habitat
- Sample number if applicable

Local quarantine procedures

Follow local quarantine procedures, which may include:

- Issuing an Emergency Action Notification Form (PPQ Form 523)
- Issuing a "stop order" normally issued by the state agriculture department
- Sealing the container to prevent removal or escape and/or
- Relocating or safeguarding the container used to house the snails, until identification is verified

Be sure to use approved PPQ guidelines when attempting to safeguard suspected pests. If you are in doubt consult with your supervisor.

Submitting Specimens for Identification

Follow the procedures outlined in the PPQ/Manual for Agricultural Clearance. Include a completed PPQ Form 391 (Specimens for Determination) marked "Urgent".

A national authority recognized by PPQ/National Identification Service must verify the identity of achatinids. To verify identification of snail specimens, contact NIS personnel specializing in malacology at the following address:

Dr. David Robinson
USDA National Malacology Specialist
Academy of Natural Sciences
1900 Ben Franklin Parkway
Philadelphia, PA 19103
Phone: 215-299-1175
Fax: 215-567-7229
Email: robinson@ansp.org

Identification by Digital Imaging

Digital imaging allows for quick identification of pests. Take three or more digital images from various angles, similar to Figures 3-1 through 3-5. Images should clearly reflect the color patterns, size, and shape of shells of various life stages. Include a clear view of the columella. Include images of living and dead snails.

Send digital images to the USDA National Malacology Specialist at the email address above. Include a completed PPQ Form 391 (Specimens for Determination) marked "Urgent", along with the following information:

- Collection number
- Type of blitz or program name

- Property or type of conveyance (i.e., warehouse, market, nursery, rail, barge, weigh station checkpoint, farm, private residence, school)
- Complete address of location of snail
- Your current telephone number

4

Snail Pests in the Family Achatinidae

Survey Procedures

Introduction

Use a survey to determine the extent and means of pest spread, or to identify pest-free areas. Before initiating survey and control activities in the U.S., a national authority recognized by USDA/APHIS/PPQ/ National Identification Service must verify the identity of achatinids. To verify identification of snail specimens, contact NIS personnel (see "Verification" on page 3-1).

Use three types of survey to determine the presence and distribution of achatinids: detection, delimiting, and monitoring surveys.

Detection Survey

Use a detection survey to detect the presence of achatinids. Visual inspection is the most effective method of survey for achatinids. Survey activity should focus on sites that pose the highest risk.

Identify high-risk sites

Use the information gathered in traceback and traceforward investigations to identify the potential pathways of snail introduction. Once high-risk sites are identified, determine the survey sites.

Estimate size of survey

At high-risk sites, estimate the size of the field survey. Consider natural dispersal and human-aided dispersal. Interview landowners, local residents and workers, and examine import records and bills of lading to help determine a specific point of release or introduction. Estimate the furthest natural dispersal of the pest from the point of introduction.

Delimiting Survey

Once a positive detection of an achatinid is confirmed, use a delimiting survey to gather sufficient information about the pest population to assist in planning a strategy for containment, suppression or eradication. As with the detection survey, site selection and survey methods for delimitation survey will need to consider environmental factors and local conditions.

Use the delimiting survey decision table (Table 4-1 below) and the survey scheme (Figure 4-1 below) as a guide when conducting a delimiting survey.

TABLE 4-1 Delimiting survey decision table for achatinids

If snails are found in this environment:	Then conduct a survey in this zone:	And examine the following properties:
Urban	Core zone	All properties
	Protection zone	50% of all properties
	Public outreach zone	None
Rural	Core zone	All acreage
	Protection zone	50% of all acreage
	Public outreach zone	None

To allocate survey resources, establish the following zones of activity: core, protection, and public outreach.

Core zone

The core is at the center of a confirmed infestation. Many positive detections will make the core zone larger. If a detection is significantly distant, the establishment of a second core zone may be warranted. Within the core zone, follow these procedures:

- Determine the radius of the core by estimating the rate of natural dispersal
- Conduct a field survey of all properties
- Contact 100% of residents, businesses, and landowners
- Initiate educational activities as described in "Public Education" on page 6-1

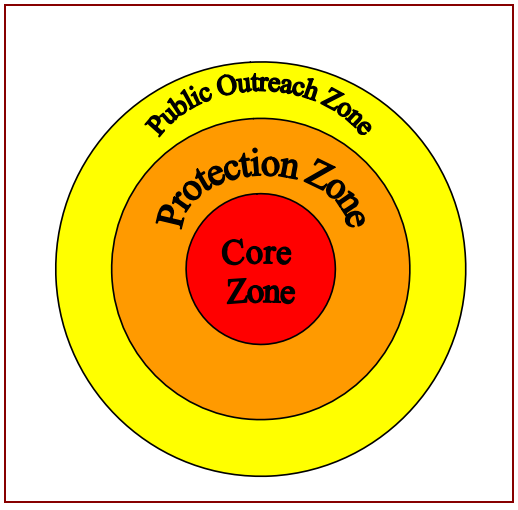

FIGURE 4-1 Survey scheme for achatinids

Protection zone

The protection zone is outside of the core zone, but within the potential natural dispersal range of the snail. Within the protection zone, follow these procedures:

- Survey 50% of the most high-risk sites
- Focus surveys on waterways, riparian zones, and other areas that might serve as “corridors” for dispersal outside of the estimated core zone
- Contact 100% of residents, businesses and landowners

Public outreach zone

The public outreach zone is outside of the natural dispersal range of the snail. Within the public outreach zone, follow these procedures:

- Contact 100% of residents and landowners
- Provide informational brochures, photographs, contact numbers to every resident, business

Monitoring Survey

The purpose of a monitoring survey is to evaluate the effectiveness of an action taken to contain, suppress or eradicate the pest. Use the delimiting rate for trap placement and visual surveying.

Backtracking

Use backtracking to locate the source of an introduction after achatinids have been detected. By identifying the source, other potential infestations may be identified through traceforward investigations. Backtracking investigations may also provide clues to the estimated time and exact location of a specific introduction.

For interception on imported commodities, obtain all related documentation on shipping, origin, consignee, destination, and frequency of shipments. For interceptions within the U.S., interview those involved to determine the source of the snails. If the source is unknown, continue questioning local residents, schools, businesses. Follow-up by investigating local pet stores, science suppliers, pet hobby groups, pet swap meets, and internet traders. Investigate leads that may indicate further distribution.

Population Dynamics

Estimate Population Density

Follow these steps to estimate the population density of an infestation:

Step 1 Determine the number of snails at the site

Step 2 Determine the total area of the site or property

Step 3 Divide the number of snails by the total area of the site

Determine Rate of Dispersal

Under ideal conditions—high humidity, high precipitation, abundant hosts, and high population density—juvenile *A. fulica* may naturally disperse at an estimated rate of 125 meters per month (Tomiyama and Nakane 1993). Use this rate, and information gathered during investigations, to define a core zone:

Step 1 Determine the point of introduction.

Step 2 Estimate the number of months since the introduction.

Step 3 Multiply the number of months by 125 meters. The answer equals the radius of the core zone.

EXAMPLE: A survey report was completed on October 15th. The snail was reportedly released around April 1. Six and one-half months X 125 meters equals 812.5 meters or one-half mile. The radius of the core zone is one-half mile.

Consider factors such as temperature, precipitation, available hosts, and physical substrate (see "Behavior of Achatinids" on **page 2-9** and Visual Inspection below). Exclude periods of dry weather. Include those months that experienced humid and wet conditions. Waterways located in the survey area should extend the survey range, since vegetated riparian zones could support snail populations, and eggs are easily transported on waterways.

Visual Inspection

Visual inspection is the best method to use when looking for snails. Consider the following when conducting a visual inspection:

Intensity

Maintain standardization by conducting a time-controlled survey. For each site, track the number of surveyors and time as "survey hours". A minimum "survey-hour" standard should be required for each

property to be surveyed. The size of the properties and acreages will influence the minimum standard. In addition, the schedule and time allocated for survey will vary based on local conditions and resources.

Seasonality

Conduct detection surveys on an ongoing basis, with repeated visits at the beginning, during, and/or just after the rainy season. Keep in mind that *Achatina fulica* remains active at a range of 9° – 29° C (48° - 84 °F). *Achatina fulica* begins hibernating at 2° C (35°F), and begins aestivation at 30° C (86 °F).

Time of Sampling

Plan surveys for early morning and overcast days. Achatinids are active on warm nights, early mornings, and overcast and rainy days. To maintain a consistent sampling time, conduct surveys in the early morning. On overcast days, conduct additional surveys throughout the day.

Micro habitats

During the day, find snails in the following moist micro habitats:

- Near heavily vegetated areas
- Under or near rocks and boulders
- Under discarded wooden boards and planks, fallen trees, logs, and branches
- In damp leaf litter, compost piles, and rubbish heaps
- Under flower pots and planters
- On rock walls, cement pilings, broken concrete, or grave markers
- In gardens and fields where plants have been damaged by feeding snails and slugs
- At the base of the plants, under leaves, or in the “heart” of compact plants, such as lettuce or cabbage.

Search for Evidence

While conducting a survey, look for clues that suggest the presence of snails:

- Chewing damage to plants (**Figure 4-2**, **Figure 4-3** and **Figure 4-4** below)
- Eggs, juveniles and adults (see “Identification” on **page 3-1**)
- Empty snail shells
- Mucus and slime trails
- Large, ribbon-like feces

- An increase in rat population densities in an area

FIGURE 4-2 Damage to leaves of *Dieffenbachia* spp. caused by *Achatina fulica;* photograph courtesy of Department of Plant Industry, Florida

FIGURE 4-3 Damage to leaves of *Heliconia* spp. caused by *Achatina fulica*; photograph courtesy of Department of Plant Industry, Florida

FIGURE 4-4 Damage to leaves of *Sanchezia nobilis* caused by *Achatina fulica;* photograph courtesy of Department of Plant Industry, Florida

Trapping

Use traps to supplement a visual inspection, if time and resources allow. Use commercial brands of slug bait to attract snails; however, due to the slow-acting effects of the molluscicide, these baits alone are not effective in trapping snails. Beer-baited pitfall traps are less effective.

Create snail refuges to attract snails where natural cover is scarce. Install the refuges the day before a survey is scheduled, then check them daily for snails. Snail refuges can be constructed from plywood boards, raised 2" above the ground. Or, strategically place sources of calcium carbonate (such as limestone or concrete), or piles of compost or plant debris.

5

Snail Pests in the Family Achatinidae

Regulatory Procedures

Instructions to Officers

Regulatory actions are required until these pests are eradicated. Officers must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles. Understanding the instructions and procedures is essential when explaining procedures to persons interested in moving articles affected by the quarantine and regulations. Only authorized treatments may be used in accordance with labeling restrictions.

Find instructions for regulatory treatments in the PPQ Treatment Manual.

Issuing an Emergency Action Notification

An Emergency Action Notification may be issued pending positive identification and/or further instruction from the USDA, APHIS, PPQ Deputy Administrator.

If necessary, the deputy administrator will issue a letter directing PPQ field offices to initiate a specific emergency action under the Plant Protection Act until emergency regulations can be published in the *Federal Register*.

The Plant Protection Act of 2000 provides for authority for emergency quarantine action. This provision is for interstate regulatory action only. Intrastate regulatory action is provided under state authority. However, if the secretary of agriculture determines that an extraordinary emergency exists and that the measures taken by the state are inadequate, USDA can take intrastate regulatory action provided that the governor of the state has been consulted and a notice has been published in the *Federal Register*. If intrastate action cannot or will not be taken by a state, PPQ may find it necessary to quarantine an entire state.

PPQ works in conjunction with state departments of agriculture to conduct surveys, enforce regulations, and take control actions. PPQ employees must have permission of the property owner before accessing private property. Under certain situations during a declared extraordinary emergency or if a warrant is obtained, PPQ may enter private property without owner permission. PPQ prefers to work with the state to facilitate access when permission is denied, however each state government has varying authorities regarding accessing private

property. A General Memorandum of Understanding (MOU) exists between PPQ and each state that specifies various areas where PPQ and the state department of agriculture cooperate. For clarification, check with your State Plant Health Director (SPHD) or State Plant Regulatory Official (SPRO) in the affected state.

Regulated Articles

The following regulated articles may present a risk of dissemination of snails or snail eggs:

Plant Material

- Food plants (see "Food Plants" on **page C-1**) in the regulated area
- Crops harvested from quarantine areas
- Crops harvested from high-risk crops
- Potted plants rooted in soil or media (Plants may be removed and washed with pressure sprays to facilitate visual inspections. Plants that pass inspection can be repotted in sterile media, certified, and sold or shipped.)
- Compost
- Forest products (leaves, needles, wood, mushrooms)
- Vegetation used as packing material
- Nursery stock
- Sod

Soil and Building Materials

- Bricks, blocks and tiles
- Compost
- Concrete
- Soil from the infested area
- Sand
- Sod
- Stone, gravel, and rocks

Miscellaneous Items

Regulated articles may include any product, article, or means of conveyance, of any character whatsoever, when it is determined by an inspector that they present a hazard of spread of snails and the person in possession thereof has been notified. Miscellaneous items may include the following:

- Discarded household or yard items
- Containers
- Manure
- Used equipment

Quarantine Actions

Use the decision table (Table 5-1 below) to determine the need for quarantine action.

TABLE 5-1 Decision table for quarantine action

IF:	THEN:	AND:
Inactive stages (eggs) of achatinids are collected in an area	Take no action	
One or more active stages of achatinids are collected in an area	Establish a quarantine area. Issue an Emergency Action Notification (PPQ Form 523) requiring treatment or other approved handling procedures to all growers, handlers, movers, or processors of regulated articles, including soil and sod removal/supply firms and firms or agencies which handle vehicles, within a minimum distance of 1 mile	Once an area of infestation is delimited, all establishments within a half mile buffer around the area will be considered regulated

Regulated Establishments

Field personnel will attempt to detect these pests within the regulated area at all establishments where regulated articles are sold, grown, handled, moved, or processed. Establishments may include the following:

- Airports
- Landfill sites
- Processing plants
- Vehicle depots
- Sod and soil firms
- Farmers' produce and flea markets
- Nurseries

- Flower shops
- Any other establishments that handle regulated articles

Surveys may be set up at establishments deemed to be at risk by project personnel. Set and service two traps, baited with a molluscicide, or equivalent per establishment (see "Trapping" on page 4-7). Service traps daily if catches of snails are great, or every week if trap catches are few.

Property Survey

Set traps on properties in the regulated area on which finds have been made when snails are active. This includes periods of rainfall, after rains, or on properties where watering or irrigation will keep the snails active.

Use of Pesticides

The PPQ Treatment Manual and this document identify authorized pesticides, and describe methods, rates of application, and special application instructions (see "Control Procedures" on page 7-1). Concurrence by PPQ is necessary before using any other pesticide or procedure for regulatory purposes.

Approved Treatments for Regulatory Articles

Approved regulatory treatments for these pests are determined by program management and/or a Technical Advisory Committee in conjunction with the Center for Plant Health, Science, and Technology (CPHST). Find directions for utilizing the treatments in the PPQ Treatment Manual. Apply the following approved treatments before removing regulated articles from a quarantine area:

Cold Treatment

Application of cold temperatures lethal to a target snail (below the biological threshold or for a time period beyond the snail's ability to endure). May be used alone or in combination with fumigation.

Fumigation/Cold Treatment

Application of an approved fumigant in conjunction with cold treatment procedures.

Fumigation/Vacuum

Application of an approved fumigant in conjunction with vacuum procedures.

Sanitation

Removal and destruction of leaves, flowers, stems, stalks, rotting or fallen fruit, vegetables, and other food plant material.

Soil Treatment

An approved molluscicide applied to the soil within the drip line of food plants. Hold plants for one week after treatment before certifying for movement after reinspection.

Principal Activities

The degree of regulatory activity required depends, among many other factors, on the degree of the infestation. For example, it may not be necessary to safeguard vegetable stands throughout the regulated area if they are engaged in local retail activity only and the infestation is limited. However, if the infestation is great, mandatory checks of passenger baggage (i.e., for host material) at airports and road patrols and roadblocks may be necessary.

Regulatory Inspection for Snails

Make a thorough inspection of all material and personal household effects prior to movement from a known snail area to any designation. Because of the tendency of snails to hide, inspect the interior as well as the exterior of containers, when likely entry holes are noted. The smaller snails resemble ordinary pebbles, in color markings as well as size; therefore, a significant infestation could be overlooked on a superficial inspection of contaminated articles. The presence of snails may be indicated by a faint slime trail.

Boxes, particularly when they have been in contact with soil, offer a number of havens for snails—bottom runners (some of which are hollow), life hook slots, and holes in weathered boxes. Closely examine all sides of each likely item, noting any cracks, crevices, or other areas not readily observable. Fork lifts will frequently be required in order to inspect bottoms of boxes, crates, and the heavier articles.

Steel cylinders present good hiding places—under the screw cap and adhering to the pallets of which the cylinders are often fastened. Pipes of all types are especially attractive to snails since caps or plugs are seldom feasible.

In the case of half-tracks, cranes, and other heave equipment, steam or water-jet cleaning is recommended in lieu of or in addition to examination. In the examination of ships before loading, attention should be given to the bottom of holds and ledgers around the sides.

Hold bulkheads near the engine room, being warmer, are favored snail sites. Snail-free cargo should never be loaded until holds have been thoroughly inspected and found or made snail-free.

Additional Factors Involving Movement

Equipment (fork-lifts, tractor-trailers, trucks, and rail cars) and materials (pallets, dunnage, and tarpaulins) utilized in the storage and transportation of noninfested supplies must be snail-free. When not in use, equipment and materials should be returned to snail-free areas. Equipment and materials that are utilized to handle or transport snail-infested supplies should not be utilized to transport snail-free cargo unless it has been fumigated.

To prevent the contamination of military or commercial cargo carried during the movement of supplies from one location to another, limit shipments to snail-free cargo.

Household movement

Establish adequate procedures to prevent snail "stowaways" in personal household effects of military and civilian personnel. Packing should be accomplished indoors or in a place equally secure from snails. Lawn furniture, garden hoses and tools, sporting goods (boats, motors, etc.), bicycles, motor scooters, and utility trailers that are allowed to remain outdoors must be fumigated before packing for shipment from snail infested areas.

Household furniture and packing materials should never be placed on the ground or lawns while being prepared or packed for shipment.

Yard and landscape maintenance

Such companies may need to be under compliance agreement if their activities present a risk of dissemination of snails or snail eggs in the course of their normal work. After training of workers, compliance agreements can be implemented detailing the conditions and precautions companies and their employees must adhere to safeguarding the movement of potentially infected plant materials, machinery, vehicles, or tools.

Storage of Supplies and Equipment

Snail-free storage areas

Only snail-free supplies, equipment, or vehicles should be stored in warehouses or permitted access to snail-free storage areas. Infested, uninspected, or untreated items should never be mixed with snail-free cargo in storage or in transit.

Snail-free storage areas should be established at those installations where large quantities of items are stored in open areas. The snail-free area will serve two purposes:

- Incoming snail-free items can be stored to prevent infestation, and

- Uninspected or untreated items that are scheduled to be moved can be decontaminated several weeks before the scheduled shipping date and placed in the snail-free area

Protect snail-free areas by laying down a 1" wide strip of common table salt (sodium chloride) or lime (finely ground, such as quicklime) as a barrier around the snail-free area. This must, however, be renewed when disrupted or when rain washes it away, if outside.

Control vegetation in open fields bordering storage areas, taking particular care along fence rows or other such areas where snails may congregate. Fields may be plowed twice a year, especially in late autumn. If the topsoil is thin or erosion is a problem, use a soil disc or cultipacker instead.

Transporters and heavy equipment including buses, trains, trucks, bulldozers, etc., when not in use **must be** stored in snail-free areas to prevent infestation. Containers have been a major source of snail interceptions at the ports of entry in the past. They must not be stored or allowed to remain on the open ground. Cargoes or household effects infested with snails should never be packed in containers for shipment.

Interior storage

Supplies, equipment, and vehicles coming in from outside the regulated area should be stored in warehouses. Land snails do not normally enter buildings to estivate, therefore, enclosed structures provide the greatest protection against infestation.

Exterior storage

If warehouses are not available, utilize paved open storage. However, such areas must be protected by a sound, aggressive, and continuous snail control program. Areas covered with asphalt or concrete provide the most suitable and lasting types of ground cover for storage areas, and less maintenance will be required.

However, in the event neither warehousing nor paved areas are available for supply storage, it will be necessary to construct an area of suitable storage. Concrete or asphalt is preferred, but crushed stone may be utilized. A layer of crushed stone six inches or more deep should be laid on the soil, the depth will depend on the soil conditions.

Apply an herbicide immediately prior to laying the stone. The crushed stone should be well compacted. Placing an impermeable barrier over the soil in the storage area will eliminate the food and also break an important link in the snail's reproductive cycle. Use glyphosate (Roundup ™) to remove the vegetation from a strip (20 to 25 feet wide) around the perimeter of this area. Remove the top soil from the same area.

Apply the herbicide glyphosate (Roundup ™) to the strip as follows:

Step 1 Review "Laws Pertaining to Pesticide Use" on page 7-1.

Step 2 For each acre, prepare a solution of 16.9 fluid ounces of Roundup™and 10 gallons of water.

Step 3 Apply the solution as a spray to all vegetation in the designated perimeter.

Ground maintenance equipment

Equipment utilized in ground maintenance work must not be parked, stored, or left idle in snail infested areas. Clean and return equipment to a protected storage area at the end of each work day to prevent further spread of the snails.

Principal Activities

Principal activities for conducting a regulatory program to contain snails include the following:

1. Advise regulated industry(ies) of required treatment procedures.
2. Supervise, monitor, and certify commodity treatments of commercial lots of regulated articles.
3. Make regulatory visits to:
   - ❖ Security and airline personnel
   - ❖ Soil and sod firms
   - ❖ Vegetable stands
   - ❖ Flower stands
   - ❖ Local growers, packers, and processing plants
   - ❖ Farmer's associations, produce markets, and flea markets
   - ❖ Local vehicle and maintenance depots, vehicle fleet operators
   - ❖ Local building contractors
   - ❖ Local vehicle dealers, garages, service stations
   - ❖ Truck and trailer rental firms
   - ❖ Commercial haulers of regulated articles
   - ❖ Public transportation
   - ❖ Post offices
4. Visiting warehouses, canneries and other processing and storage establishments.
5. Monitor the movement of waste material to and from landfills to ensure adequate disposal of regulated articles.
6. Monitor the movement of regulated articles through major airports and other transportation centers.

7. Observe major highways and quarantine boundaries for movement of host materials.

Removing Areas from Quarantine

Project managers identify and remove areas from quarantine requirements after the snail is declared eradicated from those areas.

Eradication is achieved when sufficient time, equal to two years, has passed since the last specimen recovery. At a minimum, one year must elapse after control activities have ceased. APHIS will publish a Notice of Quarantine Revocation in the *Federal Register* when areas are removed from quarantine requirements.

6 Public Education

Snail Pests in the Family Achatinidae

Introduction

Public education plays a key role in the early detection and eradication of achatinids. Trade is a major risk pathway for the movement and redistribution of achatinids. Interceptions are strongly associated with both unintentional movement (on soil, cut flowers, herbs and vegetables), and intentional movement and smuggling (for consumption or the pet trade)—especially from African nations.

Public education is extremely important in controlling and regulating the human-aided movement of achatinids from infested areas. In addition, public education can aid in identifying new infestations, and in estimating the size of survey areas. Public education may provide clues helpful in identifying the source of the infestation.

Once identification of achatinids has been confirmed by a specialist, initiate a public education campaign utilizing the following resources:

- Media (newspaper, television and radio)
- Contact with local Cooperative Extension Service personnel
- Contact with local horticultural and agricultural groups
- Contact with city government officials
- PPQ brochures
- Flyers and pamphlets distributed in infested communities
- Public meetings
- Involvement of schools, community groups, and volunteer organizations
- Neighborhood liaisons

Hand-picking of snails, and site clean-up to remove snail refuges, are simple yet effective tasks for communities experiencing an outbreak of this pest.

Legislative and Public Affairs

Contact with news media sources must be coordinated with APHIS Legislative and Public Affairs (LPA).

Positive Response

Response from a member of the public that qualifies as a suspected achatinid report warrants an investigation. Direct questioning of those involved should focus on the distribution, sale or release of suspect snails. Results of the questioning may help estimate and delineate the presence of an infestation in time and space. Should a positive detection be made, detailed questioning may provide important information helpful in defining the survey area.

Fill out a Snail Report Worksheet ("Snail Survey Report Worksheet" on **page B-1**) for each residential or public contact.

7 Control Procedures

Snail Pests in the Family Achatinidae

Introduction

Eradication of achatinids in the continental U.S. is essential. Consider cultural or chemical control measures for eradication—or biological control organisms for control—before beginning a program. Your goal is to eradicate these pests while minimizing environmental effects. Program managers within Plant Protection and Quarantine (PPQ) will provide cooperating states with control plans.

Laws Pertaining to Pesticide Use

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) authorizes the Environmental Protection Agency (EPA) to regulate pesticides. All persons using and applying pesticides should have a general understanding of the laws pertaining to pesticide use and application. The following are provisions of FIFRA that are most pertinent to emergency pest control programs:

- Restricted use pesticides must be applied by a certified applicator
- Use of any pesticide inconsistent with the label is prohibited
- Violations can result in heavy fines and/or imprisonment

States may register pesticides on a limited basis for local needs according to the following Sections:

- Section 18. EPA administrators may exempt federal or state agencies from FIFRA if it is determined that emergency conditions exist that require such exemptions
- Section 24. A state may provide registration for additional uses of federally registered pesticides formulated for distribution and use within that state to meet special local needs in accordance with the purposes of this act

For additional information concerning exemptions, see the Emergency Programs Manual, Section 14. Contact Environmental Services staff to assure that any pesticide being considered as part of an eradication program conforms to pesticide use requirements. Obtain all required environmental documentation before beginning.

Environmental Monitoring

Environmental monitoring is an important consideration in all programs. Contact Environmental Services staff to learn if environmental monitoring is required for the emergency control program of achatinids. Environmental staff may evaluate environmental impact by monitoring the following:

- Water, to detect insecticide levels resulting from direct application, leaching, and runoff
- Soil, to determine insecticide levels and residues
- Foliage, to identify residues
- Non-target organisms before, during and after applications and post treatments, to determine impact of pesticides

Orientation of Control Personnel

Only trained and experienced personnel will be used initially. These personnel will train replacements. A training period of three working days should be sufficient for the orderly transfer of these functions.

Records

Program personnel must maintain records and maps noting the locations of all detections, the number and type of treatments, and the materials and formulations used in each treated area.

Site Assessment

Site assessment is the foundation of snail control. Complete a "Snail Survey Report Worksheet" on **page B-1** prior to treatment. Send completed forms to the state Plant Health Director.

Interview all persons involved with the discovery of the pest for relevant information on site history and property ownership. Contact the identifier to learn more about precautions associated with the species.

Site Visit

Communicate frequently with the person responsible for the site. Keep a log of observations made while evaluating the site. Mark areas of invasive species with flags, ribbon or other devices.

Prepare a status report by answering the following questions:

- Is the terrain sloped or flat?
- Is there a source of calcium carbonate?
- Are water sources nearby?
- What is the property used for?
- Is the area secure?
- Does the area contain debris, trash or other obstacles?
- Does the area contain an overgrowth of weeds and brush?
- Are any “hot zones” close to other properties?
- What is the general condition of the property?
- Are snails climbing weeds, high brush or into trees?

Site classification

Developing a control plan is dependant on the type of property infested. Site access, security, containment, and ownership type may dictate a particular direction in eradication options.

Prepare a concise overview of the infested area. This means recording information about the infested the property, including the following data:

- Location
- Type of property ownership: government, private, commercial, residential or agricultural
- Current and past property uses
- Snail distribution
- Status of security and containment

Site Mapping

Prepare a detailed map of the infested site, pinpointing the location and severity of snail infestations. The map should include as much information as possible, such as acreage, roads, tree lines, water sources, property uses, and global positioning system coordinates.

Defining the Treatment Area

Once a decision has been made to eradicate achatinids, use the decision table (Table 7-1 below) to define the treatment area.

TABLE 7-1 Decision table to define treatment area

IF:	Are detected in an area:	THEN treatment will commence and extend:
1-3 snails of any age	Of one property	100 yards beyond the detection
Eggs	Of one property	200 yards or three properties beyond the infested property
More than 3 snails of any age	Of several or more properties	200 yards or three properties beyond the nearest infested property

Treatment Options

Continue eradication measures for two to four years. After the termination of eradication measures, monitor the success of the program for one to two years.

Treatment may include the application of recommended molluscicides and/or cultural controls. Effective, noninvasive biological control methods are unavailable for control of achatinids. A combination of chemical and cultural controls is the most effective treatment against this group of snail pests.

Formulate a treatment plan addressing specific issues based on the site classification and types of resources needed to complete the treatment.

Consider the following:

- Document all activity in infested area
- Prepare lists of available resources and contacts
- Determine if counter measures are likely to be needed
- Cooperation of property owner
- Widespread or random infestations may warrant treatment zones

Application of Recommended Molluscicides

At the initiation of an eradication program, evaluate all available molluscicides (see "Using Molluscicides" on **page A-1**). Select a molluscicide after considering local conditions, survey results, and efficacy of available products.

Metaldehyde

Metaldehyde is the most widely used active ingredient used in snail baits. It comes in many formulations with various attractant systems. Metaldehyde baits containing 4% metaldehyde are significantly more effective than those products containing only 2% metaldehyde.

Some metaldehyde products are formulated with carbaryl, partly to increase the spectrum of pests controlled to include soil and debris-dwelling insects, spiders, and sowbugs. However, carbaryl is toxic to soil-inhabiting beneficial organisms, such as ground beetles and earthworms.

Deadline® M-Ps™ (Label/MSDS) is a bait treatment that has been very effective in recent years for invasive snail eradication. Deadline® 40 is a liquid formulation of metaldehyde.

Methiocarb

Methiocarb is an organophosphate chemical. Most formulations of methiocarb are classified as "restricted use". Restricted use products may only be applied by a certified pesticide applicator or under the direct supervision of a certified applicator. According to some researchers, methiocarb produces better kill than metaldehyde under wet conditions.

Mesurol® 75-W (Label/MSDS) is formulated as a wettable powder with 75% active ingredient. Mesurol Pro® (Label/MSDS) is a food bait with 2% active ingredient.

Iron Phosphate

Iron phosphate is a relatively new active ingredient for slug and snail food baits. Iron phosphate baits are considered safe for the environment. Unlike metaldehyde and methiocarb products, baits containing iron phosphate are thought to be safe for pets and other non-target animals.

After feeding on baits containing iron phosphate, slugs and snails will cease feeding but will not die until 3-6 days later. For some slug and snail species, there is evidence than iron phosphate baits are less effective than those containing metaldehyde or methiocarb. Use iron phosphate baits on a test basis in areas where the potential harm to non-target organisms is great. First Choice ® Sluggo Slug and Snail Bait (Label/MSDS) is a granular bait containing 1% iron phosphate.

Tips for Applying Molluscicides

Follow these tips when applying molluscicides:

- Spread baits evenly
- Reverse the pattern of application on repeat treatments (spots may be missed during ground application)
- Use colored pellets for greater visibility
- Use granules when visible bait is undesirable
- Avoid bait applications preceding heavy rainfall to prevent rapid breakdown
- Apply baits following rain, irrigation or dew
- Liquid applications may be effective when bait formulas cannot reach target snails
- Place baits under boards or inverted flower pots to extend the life of the bait and reduce the chance that baits are consumed by non-target animals

Application Of Cultural Controls

Use cultural controls to augment the effectiveness of chemical controls. Or, use a combination of cultural methods without chemical controls in non-emergency situations. Some cultural controls—such as draining wetlands—may be subject to obtaining environmental documentation under the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA). Check with the program manager to make sure documentation is in order.

Copper Foil Barrier

Where practical, install strips of copper foil to repel snails and prevent their access to tree foliage or planting beds for several years (**Figure 7-1** below). Snails will not cross the copper foil. Snail Barr® is a copper foil product widely available from suppliers of agricultural products.

FIGURE 7-1 Copper foil wrap on tree trunk; photograph courtesy of Jack Kelley Clark

Bordeaux Mixture

Brush copper sulfate or Bordeaux mixture (10 pounds of copper sulfate, 10 pounds of lime, and 100 gallons of water) on tree trunks to repel snails. Bordeaux mixture will withstand rainy weather better than copper sulfate alone. For more information, see "Resources" on page 11-1.

Soil Barrier

Snails limit their movement onto bare ground. Consequently, a strip of bare earth about 1.5 meters wide around cultivated areas will give some protection. This form of control is made more effective if combined with chemical means of control and regular hand collection of snails.

Hand Collect Snails

Look for snails in areas with abundant calcium carbonate (limestone, marble, etc.). Regular and extensive collection of snails should be carried out in tandem with other control methods. Community cooperation can help to reduce snail numbers significantly, particularly in newly infested areas. Use the following methods to dispose of snails:

- Freeze snails at -10 °C for at least three days
- Immerse snails in boiling water, rubbing alcohol, ethanol, seawater

Disruption of Soil

In open fields, plowing the soil twice yearly will reduce small populations of achatinids. Disking and cultivating will help to reduce snail populations in areas of thin topsoil or where erosion is a problem.

Sanitation

Sanitation is a continual process during an eradication campaign. Destroy snail habitats by clearing underbrush, eliminating refuse piles and loose boards, and checking underneath stones. All infested properties must be cleaned thoroughly to facilitate survey operations and to improve the effectiveness of control treatments.

Removal of trash, litter or debris must be done in such a way as to prevent the spread of an infestation. Equipment used for maintenance, roadwork, etc. should not be parked, stored or left idle in snail infested areas; but cleaned and returned to storage at the end of each work day. Idle equipment should be removed from the infested area, unless protected by barriers or stored inside buildings kept clear of any infestation.

Trapping

Trap snails under boards or flower pots positioned throughout the landscape. Inverted melon rinds also make good traps.

Burn Debris

Collect, pile and burn host material if local ordinances permit.

Apply Herbicides

Use herbicides to control wild and cultivated hosts.

Application Of Biological Control Organisms

Important

USDA/APHIS/PPQ does not currently recommend the use of biological control organisms for control of achatinid snails. The recommendation may change if new research indicates that effective species-specific organisms are available.

Currently, there are no effective, ecologically-safe biological control organisms available for the control of achatinids. However, the introduction of biological control organisms may have helped to lower the population density of established achatinids on Hawaii, Guam and other locations to the extent that they are no longer considered a pest. In contrast, achatinids have persisted at other locations at pest levels for many decades, despite the introduction of biological control organisms (Raut and Barker 2002).

In the future, predators and pathogens of achatinids may have a greater role in a snail control program.

Predators

Predatory flatworms (Platyhelminthes: Turbellaria) include *Geoplana septemlineata* (Figure 7-2 below) and *Platydemus manokwari. P. manokwari* may be responsible for a 95% decrease in population density of achatinids over a four year period in Guam.

FIGURE 7-2 Predatory flatworm (Platyhelminthes: Turbellaria) *Geoplana septemlineata* attacking an achatinid in Hawaii; photograph courtesy of L. Nakahara, Hawaii Department of Agriculture

FIGURE 7-3 Predatory snail *Gonaxis quadrilateralis* attacking an achatinid egg in Hawaii; photograph courtesy of L. Nakahara, Hawaii Department of Agriculture

Predatory snails include *Edentulina affinis*, *Gonaxis quadrilateralis* (**Figure 7-3** above), *Steptaxis kibweziensis* and *Euglandina rosea*, which is native to the Gulf states (**Figure 3-17** earlier). Efforts to use predatory snails for control on the Hawaiian Islands have failed. Furthermore, the introduction of snail predators has resulted in unwanted predation on endemic tree snails.

Predatory insects include ants, beetles in the families Carabidae, Drilidae, and Lampyridae, and flies in the family Muscidae. Some researchers found that predatory insects released in Hawaii and Southeast Asia failed to become established or contribute significantly to snail mortality.

In India, the hermit crabs (Arthropoda) *Coenobita perlatus* and *Birgus latro* (coconut crab) are collected from sea beaches and released in snail-infested locations to prey upon achatinids.

Rats (*Rattus* spp.) feed directly on snails and also infect them with *Angiostrongylus* spp. (see "Program Safety" on **page 1-1**). Scientists have found a direct correlation between greater population densities of rats and lower population densities of achatinids, on some Pacific islands.

Ducks are a natural enemy of achatinids and have been observed to feed on the eggs and juveniles in India.

Pathogens

Aeromonas hydrophila is a species of small, motile, gram-negative, rod-shaped bacteria that is capable of causing a disease in humans, fish, and mollusks. *Aeromonas hydrophila* has been implicated as a causative agent in the decline of achatinids in much of the pests naturalize range. The disease spreads easily among achatinids under

conditions of high temperature and humidity, when their population density is great. The disease is spread through physical contact, eating dead snails, and rasping slime from infected snails. In South Andamans, scientists have spread the disease among snails by spraying their food and habitat with an aqueous extract of diseased snails.

Approved Treatments for Regulated Articles

Approved regulatory treatments for this pest are determined by program management and/or a Technical Advisory Committee in conjunction with the Center for Plant Health, Science, and Technology (CPHST). Find directions for using the treatments in the PPQ Treatment Manual. Use the following approved treatments to move regulated articles out of a quarantine area:

Cold Treatment

Application of cold temperatures lethal to a target snail (below the biological threshold or for a time period beyond the snail's ability to endure). May be used alone or in combination with fumigation.

Fumigation/Cold Treatment

Application of an approved fumigant in conjunction with cold treatment procedures.

Fumigation/Vacuum

Application of an approved fumigant in conjunction with vacuum procedures.

Sanitation

Removal and destruction of leaves, flowers, stems, stalks, rotting or fallen fruit, vegetables, and other food plant material.

Soil Treatment

An approved molluscicide applied to the soil within the drip line of food plants. Hold plants for one week after treatment before certifying for movement after reinspection.

8

Snail Pests in the Family Achatinidae

Environmental Compliance

Overview

Environmental Services (ES) is a unit of APHIS' Policy and Program Development Staff (PPD). ES is responsible for APHIS' compliance with various laws such as the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA). ES manages the preparation of environmental documentation, such as environmental impact statements (EIS), environmental assessments (EA), and categorical exclusions, to aid in program operational decisions. ES also coordinates pesticide registration and approvals for APHIS pest control and eradication programs, ensuring that registrations and approvals meet program use needs and conform to pesticide use requirements.

Regulatory Coordination manages the final preparation of environmental documents and prepares them for publication in the *Federal Register*.

See "Resources" on **page 11-1** for more information.

Disclaimer

All uses of pesticides must be registered or approved by appropriate federal, state, and/or tribal agencies before they can be applied. The information provided on pesticide labels may not reflect all of the actual information, including precautions and instructions for use, which you are required to follow in your specific state or locality.

It is the responsibility of persons intending to use a pesticide to read and abide by the label, including labeling that has been approved for the particular state or locality in which the chemical is to be used, and to comply with all federal, state, tribal, and local laws and regulations relating to the use of the pesticide. APHIS program staffs are responsible for their compliance with applicable environmental regulations.

9

Snail Pests in the Family Achatinidae

Pathways

Introduction

Commerce and intentional spread by mankind appear to be the most likely pathways for introduction of this pest. Species such as *Achatina fulica* were transported accidentally by man during the period of largely European colonization of many areas of the world, and have utilized the increased flotsam of modern human societies as a vehicle (Mead 1961, 1979).

Today, ethnic populations utilizing achatinids as dietary, medicinal, or cultural foodstuffs move live snails with their personal possessions. Most achatinids that PPQ intercepted during the period January 1993 to December 2003 arrived on flights that originated in countries that have established populations of achatinids—countries such as Ghana, Nigeria, and Senegal (Mead 1961, 1979).

Natural Dissemination

Natural spread does not appear to be a significant source for giant African snail. Achatinids are not found on the island of Annobon (Isla de Bioko), which lies less than 40 km off the eastern coast of Equatorial Guinea, suggesting that natural spread over water is extremely limited (Mead 1961, 1979).

The spread of achatinids over land can be correlated with the movement and colonization of new areas by humans. According to Mead (1961, 1979), “There are many factors which favor spread of the giant snail. Chief among these is the human factor—man might justifiably be considered the only effective disseminator.”

Impact of International Flights

During the period January 1993 through December 2003, eighty-nine per cent of all achatinids intercepted by PPQ arrived in the passenger baggage pathway from flights, particularly from Africa and Hawaii (Table 9-1 below).

TABLE 9-1 Achatinids intercepted at ports of entry in the U.S. by Plant Protection and Quarantine (PPQ) during the period January 1993 through December 2003

Port of entry	Achatinids intercepted	
	Total number/ 10 years	Per cent of total
DC: Dulles Airport	23	6
Georgia: Atlanta	15	4
Hawaii: pre-clearance inspection	77	20
Illinois: O'Hare Airport	14	4
Maryland: Baltimore	10	3
Massachusetts: Boston	12	3
New Jersey: Elizabeth Airport	9	2
New York: JFK Airport	173	45
Texas: Dallas airports	10	3
Texas: Houston Airport	9	2
Other airports	36	9
Total	388	101

Source: USDA, Port Information Network, quarantine interception data.

Commerce

During the period January 1993 through December 2003, three per cent of achatinids intercepted by PPQ arrived in association with the containers, cargo, soil, foodstuffs, crating, and tools pathway (Table 9-2 below).

TABLE 9-2 Pathways of arrival of achatinids intercepted by PPQ during the period January 1993 through December 2003

Pathway	Achatinids intercepted	
	Total number/ 10 years	Per cent of total
Baggage	320	89
Cargo	10	3
Plants	27	7
Other	4	1
Total	361	100

Source: USDA, Port Information Network, quarantine interception data.

Pet Industry

Prior to 1997, live snails were seized by PPQ in Arizona, California, Florida and Ohio. For example, in 1992 more than 70 *Archachatina marginata* were seized in Florida. A Tallahassee pet store owner had been selling snails to buyers as far away as Wilmington, NC.

During a blitz conducted by Safeguarding, Intervention, and Trade Compliance (SITC) in April, May, and June 2004, PPQ Officers seized and destroyed 6,719 achatinids in six states and 64 cities (Table 9-3 below). In Ohio, one seizure resulted in 2,500 achatinid snails, which the owner stated were the offspring of one adult.

TABLE 9-3 Seizures of achatinid snails during the period April—June 2004, from pet stores, aquarium owners, and private homes in the U.S. APHIS/ Safeguarding, Intervention and Trade Compliance (SITC) conducted the blitz

Location	Number of cities	Number of interceptions/ 3 months
Illinois	7	98
Indiana	4	300

TABLE 9-3 Seizures of achatinid snails during the period April—June 2004, from pet stores, aquarium owners, and private homes in the U.S. APHIS/ Safeguarding, Intervention and Trade Compliance (SITC) conducted the blitz

Location	Number of cities	Number of interceptions/ 3 months
Michigan	8	1544
New Jersey	1	1
Ohio	4	3,139
Pennsylvania	1	170
Puerto Rico	1	1
Wisconsin	37	1364
West Virginia	1	102
Total	64	6,719

Source: USDOT, Air Travelers entering the US.

Countries of Origin

Seventy-four per cent of the achatinids intercepted from the air passenger pathway originated in African countries, particularly Nigeria and Ghana, and another 20 per cent were intercepted by pre-clearance activities in Hawaii (Table 9-4 below). Achatinids originated in Africa but are now widely distributed throughout the Pacific (see chapter 2).

TABLE 9-4 Origin of species of achatinids intercepted at ports of entry in the U.S. by Plant Protection and Quarantine (PPQ) during the period January 1993—December 2003

	Number of snails intercepted					
Location	***A. achatina***	***A. fulica***	***A. marginata***	***L. aurora***	**Unidentified achatinids**	**Total**
Ghana	76		12			88
Nigeria	73		75			148
Senegal	11					11
Other	22		14			36
Total Africa	182	5	101			288
Honolulu	0	36				36
Lihue	0	35				35

TABLE 9-4 Origin of species of achatinids intercepted at ports of entry in the U.S. by Plant Protection and Quarantine (PPQ) during the period January 1993—December 2003

Location	Number of snails intercepted					
	A. achatina	***A. fulica***	***A. marginata***	***L. aurora***	**Unidentified achatinids**	**Total**
Kailua Kona	0	5				5
Kahului	0	1	0	0		1
Total Hawaii		77				77
Pacific Islands	0	4	0	0		4
Other	6		1	2		9
Total	188	86	102	2	10	388

Source: USDA, Port Information Network, quarantine pest interception data.

Destinations

New York was the final destination for 40 per cent of the achatinids intercepted by PPQ; California intercepted 14 per cent. Twenty-nine other states made up the remainder of the destinations, varying from 1 per cent (most other states) to 6 per cent (Texas) (Table 9-5 below).

TABLE 9-5 Destination of travelers intercepted, with achatinids, at ports of entry in the U.S. by PPQ during the period January 1993—December 2003

Destination	Travelers intercepted with achatinids	
	Total number	**Per cent of total**
California	51	14
Florida	9	2
Georgia	19	5
Illinois	16	4
Maryland	11	3
Massachusetts	10	3
New Jersey	24	7
New York	144	40
Virginia	10	3

TABLE 9-5 Destination of travelers intercepted, with achatinids, at ports of entry in the U.S. by PPQ during the period January 1993—December 2003

Destination	Travelers intercepted with achatinids	
	Total number	**Per cent of total**
Other	44	12
Total	361	99

Source: USDA, Port Information Network, quarantine pest interception data.

10

Snail Pests in the Family Achatinidae

Glossary

APHIS. Animal and Plant Health Inspection Service.

apex. The tip of the spire of a snail shell, at the opposite end from the aperture.

aperture. The mouth or principal opening of the shell, through which the body of the gastropod passes out of the shell.

attractant trap. A trap employing a lure which incites the target snail to come to it and be caught.

barrier. A natural or artificial obstacle to movement.

biometric survey. A survey succeeding the delimiting survey, in which properties are number and letter coded for survey purposes on a rotational basis.

body whorl. The last whorl of a snail shell, from the aperture to the line directly above the aperture on the previous whorl (=ultimate whorl). Normally, it is the largest portion of the shell, and as such, partially encloses the rest of the shell.

buffer zone. The area extending 75 meters (81.9 yd.) beyond the core zone.

collumella. Central column of the shell, around which the shell whorls coil.

commercial production area. An area where host material is grown for sale.

confirmed detection. A positive laboratory identification of a submitted specimens the target snail.

core zone. A minimum distance of 25 meters (27.3 yd.) in all directions of any confirmed target snail infestation.

delimiting survey. A survey to determine the extent of the infestation in an area after the target snail has been detected.

detection. The collection of any life stage of the target snail.

detection survey. A survey conducted in a susceptible area not known to be infested with the target snail.

dry heat. The use of high temperatures as a treatment.

egg survey. The collection and holding of suspect eggs when no hatched snails are available to determine the extent and nature of an infestation.

epicenter. The initial site of an infestation.

epiphragm. A hardened mucous barrier that seals the aperture in most land snails and prevents desiccation during dry spells.

fumigation. The application of an approved fumigant, such as methyl bromide, as a treatment (methyl bromide).

generation. Or life cycle. The period of time for the pest to complete all stages of development predicated on the basis of biological information.

ground spray. Using ground spray equipment to apply molluscicide to the ground, selected resting places or host vegetation in a target snail infested area.

host. A plant species, substrate, debris, or other food reproduction of the target snail.

infestation. The collection of one or more target snails from an area.

infested area. The infested properties or core areas of no less than 25 m (27.3 yd.) on a side each, unless biological factors indicate the need for more or less area.

monitoring. Or evaluation survey. Using interdependent visual and/ or trapping surveys in an area where treatment has been applied to evaluate the effectiveness of the application.

PPQ. Plant Protection and Quarantine.

parietal callus. A layer of shell secreted over the parietal area.

regulated zone. A zone that extends at least 100 meters (109 yd.) in any direction from an infested property. The regulated zone may be extended to include any other nearby regulated areas as seems practical or within 1 km (0.6 mi.

regulatory inspection. Visual examination of host material, containers, and transport.

steam sterilization. The use of live steam as a treatment on selected regulated items.

suture. The line of contact or fusion between one shell whorl and the next.

target snail. The exotic species of snail found to be established in a given area of the United States against which it has been determined to conduct eradication and/or regulatory action.

trap survey. Determining the presence or absence of a pest by the use of traps placed in a predetermined pattern and serviced on a given schedule.

urban area. Or residential area. Noncommercial crop production area containing multiple or single-family dwellings.

USDA. United States Department of Agriculture.

visual survey. Examining hosts, substrate, or hiding places for eggs, adults, or visible damage; either in the field, in regulated establishments, or in monitoring the movement of regulated articles.

11

Snail Pests in the Family Achatinidae

Resources

Pesticide Supplies

Mesurol® Products

Gowan Company
P.O. Box 5569
Yuma, Arizona 85366-5569
Telephone: (800) 883-1844 X 2
http://www.gowanco.com

Deadline® Products

Pace International
1011 Western Ave., Suite 505
Seattle, Washington 98104
(800) 936-6750
http://www.paceint.com

First Choice ® Sluggo Slug and Snail Bait

Western Farm Service, Inc.
P.O. Box 1168
Fresno, California 93711
(559) 436-2800
http://www.westernfarmservice.com

Copper Sulfate and Bordeaux Mixtures

CR Chemical Corp.
4450 Trade Center Blvd., ITC Park
Laredo, Texas 78045
(956) 753-0175
http://www.crchemical.com

Statewide IPM Program
Agriculture and Natural Resources
University of California
Pests in Landscapes and Gardens
Bordeaux Mixture
http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7481.html

Pest Management Supplies

BioQuip Products, Inc.
2321 Gladwick Street
Rancho Dominguez, CA 90220
Telephone (310) 667-8800
http://www.bioquip.com/

Wards Natural Science
PO Box 92912
Rochester, NY 14692-9012
Telephone 800-962-2660
http://www.wardsci.com/

Carolina Biological Supply Co.
2700 York Road
Burlington, NC 27215-3398
Telephone (800)334-5551
http://www.carolina.com/

Hercon Environmental Corporation
PO Box 467 Aberdeen Road
Emigsville PA 17318-0467 USA
Telephone (717) 764-1191
Fax (717) 767-1016
http://www.herconenviron.com/

Cooper Mill Ltd
RR3
Madoc, Ontario K0K 2K0
CANADA
Telephone (613) 473-4847
Fax (613) 473-5080
http://www.coopermill.com

ISCA Technologies, Inc.
P.O. Box 5266
Riverside, CA, 92521
Telephone (909) 686-5008
Fax (815) 346-1722
http://www.iscatech.com/exec/index.htm

Great Lakes IPM, Inc.
10220 Church Road
Vestaburg, Mi 48891-9746
Telephone (989) 268-5693 or (989) 268-5911
Fax (989) 268-5311
http://www.greatlakesipm.com/index.html

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4700 River Road
Riverdale, MD 20737
Telephone (301) 734-7175
http://www.aphis.usda.gov/ppd/es/staff.html

Other

Predicting Pest Development

University of California Statewide Integrated Pest Management Program 2003 (http://www.ipm.ucdavis.edu/WEATHER/ddconcepts.html#Using or http://www.ipm.ucdavis.edu/MODELS/DDU/)

Collecting Local Temperature Data

- National Oceanic and Atmospheric Administration (http://www.noaa.gov/)
- U.S. Department of Commerce (http://www.commerce.gov/)
- Local Cooperative Extension Service
- Private, state, university, or industry sources

12

Snail Pests in the Family Achatinidae

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A

Snail Pests in the Family Achatinidae

Using Molluscicides

General Safety Information

Safety of personnel and the public are of primary importance. Stress safety practices in preprogram planning. Supervisors must enforce on-the-job safety procedures.

Molluscicides vary in toxicity (see "Control Procedures" on **page 7-1**). When used in accordance with label instructions, materials do not constitute a threat to people, bees or wildlife. When handling a molluscicide, follow all precautionary labeling. Specific safety precautions for each molluscicide are listed on the label. In addition, observe any special precautions listed in this or specific manuals.

When applying a molluscicide, consider the potential impact of the pesticide on all components of the total environment, including humans, crops, livestock, wildlife, aquatic life, non-target insect species, and domesticated honey bees. Avoid contamination of lakes, streams, ponds, or watersheds.

Keep molluscicides in closed, properly labeled containers in a dry place. Store them where they will not contaminate food or feed, and where children and animals cannot reach them.

In the case of accidental contact, wash immediately with soap and water. Should clothing become contaminated, wash it before wearing again. Refer to the PPQ Treatment Manual for additional information.

Dispose of empty molluscicide containers in an approved sanitary landfill, by incineration, or by other satisfactory methods approved by the federal Environmental Protection Agency. Make arrangements for disposal of such containers and make sure that all parties directly involved with the program thoroughly understand the arrangements before the actual start of operations. Consult PPQ regional offices and the National Program Planning Staff for pertinent information in states where operations are conducted.

First Aid Suggestions

In case of accidental poisoning or as soon as any person shows symptoms of having been affected by a molluscicide, take the following action:

1. Remove the person to a place where there will be no further contact with the pesticide.
2. Have the person lie down and keep quiet.
3. Call a physician and provide the name and formulation of the molluscicide, and any first aid given.
4. Keep the local Poison Control Center telephone number posted where molluscicides are stored and used. This number is also on the inside front cover of the telephone directory. Call Chemtrex (telephone 800-424-9300) for additional assistance in the event of spills, leaks, fires, exposures, accidents, or other chemical emergencies.

Managing and Monitoring Spills

Supervisors involved in molluscicide applications must have available and be familiar with the "Guidelines for Managing and Monitoring Pesticide Spills," dated March 1981. In addition, make sure that the following molluscicide spill safety equipment is present at all job sites where pesticides are stored or used:

- First Aid Kit – truck kit, GSA 66545-00-664-5312 (or equivalent)
- Fire extinguisher – 5 lb. size for class A, B, C fires
- Portable eye wash kit

Cleanup Equipment

Make sure that the following molluscicide spill cleanup equipment is present at all job sites where pesticides are stored or used:

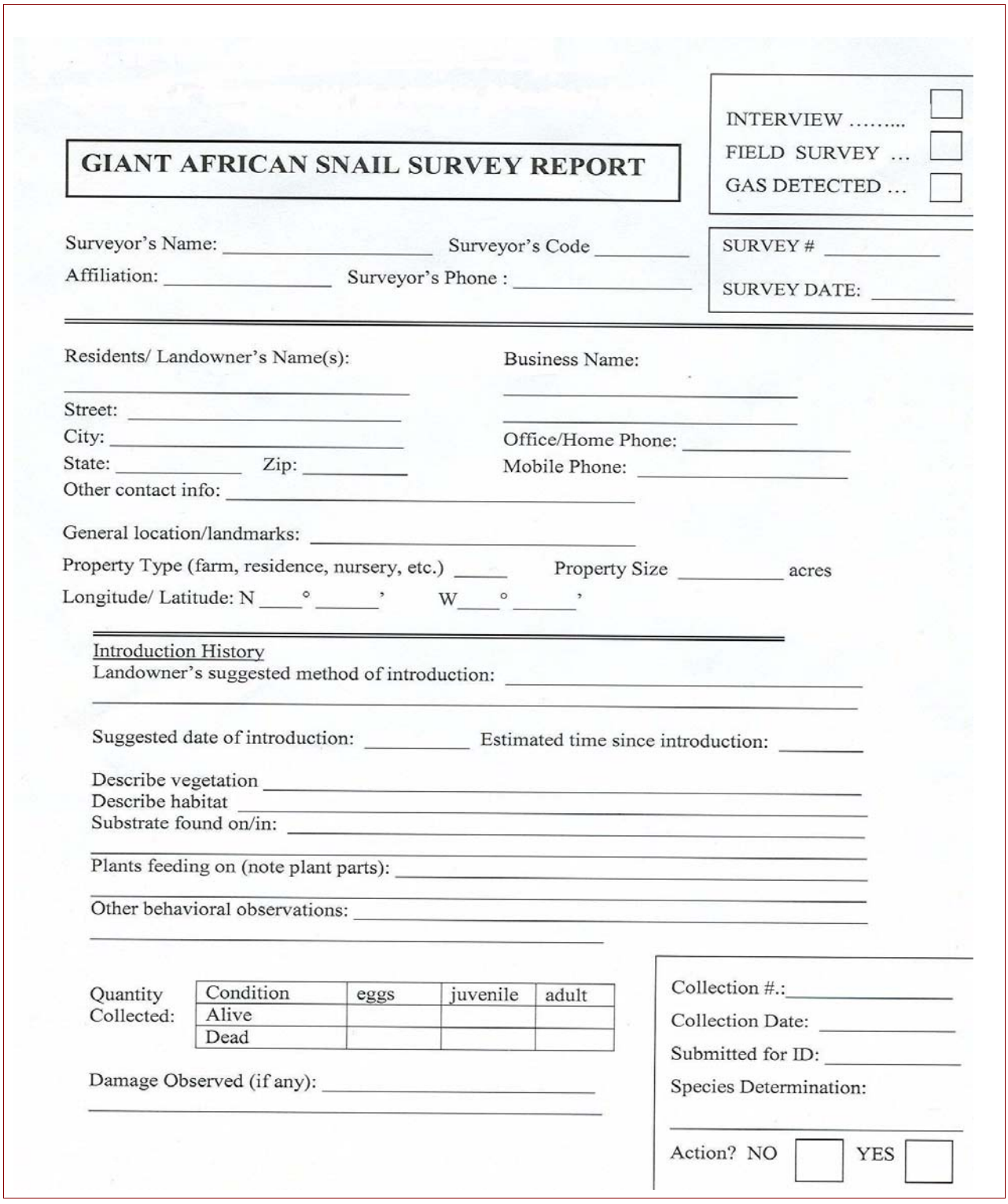
- Absorbent material to absorb liquid spills (sand, sawdust, vermiculite, cat litter, etc.)
- Broom
- Disposable coveralls (4 pairs)
- Dust pan
- Liquid detergent (1 pint bottle) and paper towels
- Plastic bags, large heavy duty, with ties (23)
- Plastic cover or tarpaulin to cover dry spills (10' x 12')
- Portable light source
- Respirators and pesticide cartridges (2 sets)
- Rubber boots (2 pairs)

- Rubber gloves (4 pairs)
- Scrub brushes
- Shovel, square-point, “d” handle
- Water (5 gallons)

B

Snail Pests in the Family Achatinidae

Snail Survey Report Worksheet



GIANT AFRICAN SNAIL SURVEY REPORT

INTERVIEW ……..
FIELD SURVEY …
GAS DETECTED …

Surveyor's Name: _____ Surveyor's Code _____
Affiliation: _____ Surveyor's Phone : _____

SURVEY # _____
SURVEY DATE: _____

Residents/ Landowner's Name(s):
_____
Street: _____
City: _____
State: _____ Zip: _____
Other contact info: _____

Business Name:
_____
_____
Office/Home Phone: _____
Mobile Phone: _____

General location/landmarks: _____
Property Type (farm, residence, nursery, etc.) _____ Property Size _____ acres
Longitude/ Latitude: N ____° _____' W____° _____'

Introduction History
Landowner's suggested method of introduction: _____
_____
Suggested date of introduction: _____ Estimated time since introduction: _____

Describe vegetation _____
Describe habitat _____
Substrate found on/in: _____
_____
Plants feeding on (note plant parts): _____
_____
Other behavioral observations: _____
_____

Quantity Collected:

Condition	eggs	juvenile	adult
Alive			
Dead			

Damage Observed (if any): _____
_____

Collection #.:_____
Collection Date: _____
Submitted for ID: _____
Species Determination:
_____
Action? NO ☐ YES ☐

FIGURE 14-8 Example of snail survey report worksheet

C

Snail Pests in the Family Achatinidae

Food Plants

Achatina achatina

TABLE C-1 Economic food plants of the continental U.S. with potential to become host plants of *Achatina achatina*

Brassica spp.	Cabbage
Carica papaya	Papaya
Citrus sinensis	Sweet orange
Dioscorea alata	Greater yam
Dioscorea esculenta	Lesser yam
Elaeis guineensis	African oil palm
Abelmoschus esculentus	Okra
Ipomoea batatas	Sweet potato
Lactuca sativa	Lettuce
Manihot esculenta	Cassava
Musa sapientum	Banana
Pyrus communis	Pear
Persea gratissima	Avocado

TABLE C-2 Primary (P) and secondary (S) food preferences of *Achatina achatina*

Brassica oleracea	Cabbage	S[14]
Carica papaya	Papaya	P[6,14]
Citrus sinensis	Sweet orange	P[6,14]
Dioscorea alata	Greater yam	P[14]
Elaeis guineensis	Oil palm	P[6,14]
Dioscorea esculenta	Yam	P[14]
Ficus anomani	Fig	P[3]
Hibiscus esculentus	Okra	P[11]
Ipomoea batatas	Sweet potato	S[14]
Lactuca sativa	Lettuce	P[6,14]
Lactuca taraxacifolia	Wild lettuce	P[6]
Manihot esculenta	Cassava	S[14]
Musa sapientum	Banana	P[6]
Persea gratissima	Avocado pear	P[6]
Pyrus communis	Pear	S[14]

Achatina fulica

TABLE C-3 Economic food plants of the continental U.S. with potential to become host plants of *Achatina fulica*

Abelmoschus esculentus	Okra
Amaranthus spp.	Amaranth
Arachis hypogaea	Peanut
Beta vulgaris	Common beet
Bougainvillea spp.	Bougainvillea
Brassica spp.	Cabbage
Cajanus cajan	Pigeon-pea
Camellia sinensis	Tea
Capsicum annuum	Cayenne pepper
Capsicum spp.	Chilli peppers
Carica papaya	Papaya
Catharanthus roseus	Periwinkle
Citrullus lanatus	Watermelon
Citrus spp.	Citrus
Cocos nucifera	Coconut
Crotalaria anagyroides	Crotalaria
Cucumis spp.	Melon, cucumber
Cucurbita pepo	Pumpkin
Cucurbita spp.	Gourds
Daucus carota	Carrot
Dioscorea alata	Greater yam
Epipremnum aureum	Golden pothos
Epipremnum pinnatum	Tongavine
Eugenia spp.	Star apple
Fragaria spp.	Strawberry
Glycine spp.	Beans
Gossypium spp.	Cotton
Hibiscus spp.	Hibiscus
Ipomoea batatas	Sweet potato

TABLE C-3 Economic food plants of the continental U.S. with potential to become host plants of *Achatina fulica*

Lablab purpureus	Hyacinth bean
Lactuca spp.	Lettuce
Lagenaria spp.	Gourd
Luffa spp.	Vegetable sponge
Lycopersicon esculentum	Tomato
Manihot esculenta	Cassava
Monstera deliciosa	Cut-leaf philodendron
Musa spp.	Bananas
Nicotiana spp.	Tobacco
Pachyrhizus erosus	Yam bean
Phaseolus spp.	Bean
Physalis peruviana	Peruvian ground-cherry
Piper nigrum	Pepper
Pisum spp.	Peas
Prunus persica	Tao
Psidium guajava	Guava
Raphanus sativus	Radish
Ricinus communis	Caster
Ruta graveolens	Common rue
Saccharum officinarum	Sugarcane
Sesamum indicum	Sesame
Sinapis arvensis	Charlock mustard
Solanum melongena	Eggplant
Solanum tuberosum	Potato
Symphytum officinale	Comfrey
Trichosanthes dioica	Pointed gourd

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Abelmoschus esculentus	Okra	S[14,19]
Falcataria molucanna	Peacocks plume	P[9,14]
Albizia lebbeck	Woman's tongue	P[14,8]
Albizia spp.	Albizia	P[14]
Allangana lamarcana	Ballabhi-anga	S[15]
Allium cepa	Onion	S[14]
Alocasia indica	Arum	S[14]
Alocasia macrorrhizos	Giant taro	S[14]
Colocasia esculenta	Taro	S[14]
Aloe indica	Aloe	S[14]
Cyathea lunulata	Tree fern	P[9]
Alsophila spp.	Alsophila	P[14]
Alstonia scholaris	Devil tree of India	P[17]
Amaranthus blitum	Purple amaranth	P[14]
Amaranthus gangeticus	Molten fire	P[15]
Amaranthus tricolor	Chinese amaranth	P[14,17]
Amaranthus viridis	Green amaranth	P[14,15]
Amaranthus spp.	Amaranth	P[9]
Amorphophallus campanulatus (=paeoniifolius)	Elephant-Foot Yam	S[15]
Annona muricata	Soursop	P[9,8]
Antigonum lepiotus	Antigonon	S[15]
Alocasia spp.	Elephant ear	S[9]
Arachis hypogaea	Peanut	P[7,9,12,14]
Arctium lappa	Greater burrdock	S[12]
Areca catechu	Betel nut palm	S[14]
Artocarpus altilis	Breadfruit	P[14]
Artocarpus heterophyllus	Jackfruit	P[7,9,14]
Artocarpus spp.	Breadfruit	P[7,9,14]
Asplenium nidus	Bird's nest fern	P[9,14,8]
Averrhoa bilimbi	Blimb	P[9,14]
Averrhoa carambola	Carambola	S[9,14]
Basella alba	Ceylon spinach	P[14]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Basella rubra	Malabar spinach	P[12,15]
Bauhinia accuminata	White dwarf orchard tree	S[14,15]
Bikkia mariannensis		S[8]
Blechum brownei	Browne's blechum	P[8]
Beta vulgaris	Common beet	S[12,17]
Boehmeria nivea	Chinese grass	S[9,12]
Boerhavia diffusa	Boerhavia	P[15]
Bougainvillea speciabilis	Bougainvillea	P[14,15]
Bougainvillea spp.	Bougainvillea	P[9,14,2]
Brassica campestris	Field mustard	S[2]
Brassica oleracea	Kohlrabi	P[7,14]
Brassica oleracea var. acephala	Cabbage	P[12]
Brassica oleracea var. botrytis	Cauliflower	P[7,14,15,2,19]
Brassica oleracea var capitata	Cabbage	P[12,15,2,19]
Brassica oleracea var. italica	Sprouting broccoli	P[12]
Brassica spp.	Cabbage	P[7,9]
Broussonetia papyrifera	Paper mulberry	S[14]
Bryophyllum pinnatum	Air plant	P[9]
Cajanus cajan	Pigeonpea	P[17]
Callicarpa cana		S[8]
Calophyllum inophyllum	Indian laurel	P[9]
Camellia sinensis	Tea	S[12,14]
Canavalia gladiata	Sword jackbean	P[8]
Canna edulis	Arrowroot	P[9]
Canna indica	Canna	P[14,15]
Canna spp.	Canna	P[9,14]
Capparis cordifolia	Maiapilo	S[8]
Capsicum annuum	Cayenne pepper	S[14,19]
Capsicum baccatum	Locoto	S[14]
Capsicum spp.	Chili peppers	S[9,12,14,15]
Carica papaya	Papaya	P[5 7,9,12 14,15,19]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Cassia (=Chamaecrista) mimosoides	Chamaecrista	P[9]
Cassia occidentalis	Septic weed	P[8]
Senna sophera	Kasuandi	S[15]
Catharanthus roseus	Periwinkle	S[14]
Centrosema pubescens	Flor de conchitas	P[9]
Cerbera manghas	Madagascar ordeal bean	S[8]
Cereus hildmannianus	Hedge cactus	S[12]
Cereus spp.	Cactus	S[14]
Cestrum nocturnum	Night Queen	P[17]
Cichorium endivia	Endive	P[12]
Cichorium intybus	Chicory	P[12]
Chrysanthemum spp.	Chrysanthemum	P[15]
Cinnamomum tamala	Indian bay leaf	P[14,15]
Citrullus vulgaris (=lanatus)	Watermelon	P[9,14]
Citrus limon	Lemon	P[7]
Citrus reticulata	Tangerine	P[14]
Citrus sinensis	Sweet Orange	P[14]
Citrus spp.	Citrus	P[9,12,14]
Cleome gyandra	Spiderwisp	S[14]
Clerodendron inerme	Glory bower	S[8]
Clitoria ternatea	Butterfly pea	P[14,15]
Coccinia cordifolia	Coccinea	S[15]
Cocos nucifera	Coconut	S[12]
Coffea arabica	Arabian coffee	S[12,14]
Coffea canephora	Robusta coffee	S[14]
Coffea spp.	Coffee	S[9,14]
Colocasia antiguorum	Arum	S[15]
Colocasia esculenta	Dasheen or taro	S[9,14,8]
Colubrina asiatica	Asian nakedwood	P[8]
Corchorus capsularis	Jute	P[14]
Corchorus spp.	Corchorus	P[15]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Cosmos spp.	Cosmos	P[9,14,15]
Crinum spp.	Crinum lily	P[9,14]
Crotalaria anagyroides	Crotalaria	P[9]
Crotalaria pallida var. obovata	Smooth rattlebox	P[9]
Cucumis melo	Cantaloupe	P[9,14]
Cucumis sativus	Cucumber	P[9,12,14,]
Cucumis spp.	Melon	P[14]
Cucurbita maxima	Winter squash	P[14,15]
Cucurbita pepo	Field pumpkin	P[9,14,19]
Cucurbita spp.	Gourds	P[14]
Dalbergia sissoo	Indian rosewood	S[14]
Daucus carota	Carrot	P[9,12]
Dhalia spp.	Dhalias	S[14,15]
Dieffenbachia seguine	Dumbcane	S[14]
Dioscorea alata	GreaterYam	P[9,14,15]
Dioscorea bulbifera	Air Yam	P[17]
Dioscorea spp.	Yam	P[15]
Dolichos spp.	Beans	P[15]
Dracaena spp.	Dracaena	S[14,2]
Edgaria darjeelingensis	Squash	S[14,15]
Elaeis guineensis	Oil palm	S[9]
Epipremnum aureum	Golden pothos	P[12]
Epipremnum pinnatum	Pothos	S[14]
Eranthemum spp.	Eranthemum	S[2]
Erythrina lithosperma (=subumbrans)	Erythrina	P[9]
Erythrina spp.	Erythrina	P[14]
Eucalyptus deglupta	Indonesian gum	S[14]
Eucalyptus spp.	Australian gum	S[14]
Eugenia spp.	Star apple	S[15]
Euphorbia pulcherrima	Poinsettia	S[15]
Euphorbia trigona	Sandmat	S[9]
Falcataria moluccana	Peacocks plume	P [9,14]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Ficus hispida	Fig	P[14,15]
Ficus tinctoria	Fig	S[8]
Fragaria x ananassa	Strawberry	P[12]
Galinsoga parviflora	Gallant-soldier	S[12]
Gardenia augusta	Gardenia	S[14, 15]
Gazania rigens	Treasure-flower	P[12]
Gliricidia sepium	Madre de Cacao	S[16]
Glycine max	Soybean	P[14]
Glycine spp.	Beans	P[15]
Commelina benghalensis	Tropical day flower	S[15]
Gomphrena globosa	Globe amaranth	S[14]
Gossypium herbaceum	Cotton	P[14,15]
Gossypium spp.	Cotton	P[9,14]
Grewia mariannensis		P[8]
Gynandropis speciosa	The queen's plume	P[9]
Helianthus annuus	Sunflower	S[14,15]
Hevea brasiliensis	Rubber	P[7,9,12,14]
Hernandea ovigera		S[8]
Hibiscus esculentus	Okra	P[9,15]
Hibiscus mutabilis	Dixie rosemallow Land-lily	P/S[14,15]
Hibiscus rosa-sinensis	China rose	P[14,15,2,19]
Hibiscus spp.	Hibiscus	P[9,12,14]
Hemigraphis colorata	Broad leaf flame ivy	P[12]
Impatiens balsamina	Balsam	P[14,15]
Indigofera suffruticosa	Anil de pasto	P[9]
Ipomoea alba	Tropical white morning-glory	P[8]
Ipomoea batatas	Sweet potato	S[9,12,14]
Ipomoea pes-caprae	Beach morning glory	P[9,8]
Pachystachys coccinea	Cardinal's guard	P[12]
Jasminum sambac	Jasmine	S[14,15]
Kakanchoe pinnatum	Kalanchoe	S[14]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Lablab purpureus	Lablab Bean	P[14]
Lactuca indica	Lettuce	P[14,15]
Lactuca sativa	Lettuce	P[9,12,14,]
Lactuca spp.	Lettuce	P[14]
Lagenaria leucantha	Haired gourd	P[9]
Lageneria siceraria	Bottle Gourd	P[14]
Lagenaria vulgaris	Gourd	P[15]
Lagenaria spp.	Gourds	P[14]
Laportea crenulata	Tree nettle	P[9]
Leucaena leucocephala	White leadtree	P[9]
Catharanthus) *rosea*	Madagascar periwinkle	P[17]
Luffa aegyptiaca	Dishcloth gourd	P[5,14,15]
Luffa acutangula	Angled luffa	P[14,15]
Luffa cylindrica	Smooth luffa	P[15,19]
Luffa spp.	Vegetable sponge	P[9,14]
Lycopersicon esculentum	Tomato	S[9,12,14,15]
Manihot esculenta	Cassava	P[7,9,12,14]
Melanolepis multiglandulosa	Alom	P[8]
Mentha repens	Hortela	S[12]
Mimosa invisa (=diplotricha)	Giant false sensitive plant	P[9]
Monstera deliciosa	Split leaf philodendron	S[12]
Montanoa hibiscifolia	Tree daisy	S[9]
Morinda citrifolia	Indian mulberry	P[9,8]
Moringa oleifera	Horseradish tree	S[9,14,15]
Momordica charantia	Balsam apple	P[9,14,15]
Momordica cochinchinensis		P[14,15]
Momordica spp.	Momordica	P[14]
Morus alba	White mulberry	S[14]
Muntingia calabura	Strawberry tree	S[8]
Musa acuminata x balbisiana	French plantain	P[14]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Musa paradisiaca	Plantain	P[7,9,14]
Musa sapientum	Banana	P[15]
Musa spp.	Bananas	P[12,14,2,19]
Nerium spp.	Oleander	S[14, 15]
Nicotiana spp.	Tobacco	S[9]
Ochrosia mariannensis	Lipstick tree	S[8]
Ochrosia oppositifolia	Bwa sousouri	S[8]
Operculina turpethum	St. Thomas lidpod	P[8]
Opuntia spp.	Cholla cactus	S[9,14]
Pachyrhizus erosus	Yam bean	P[17]
Pandanus spp.	Screwpine	S[9,8]
Parkia spp.	Parkia	P[9]
Passiflora foetida	Fetid passionflower	P[8]
Passiflora spp.	Passion flower	P[9,14]
Pauinia cupana	Guarana	P[12]
Pemphis acidula	Small-leafed mangrove	S[8]
Phalaenopsis spp.	Moth orchids	S[9,14]
Vigna radiata	Bean	P[9]
Phaseolus vulgaris	Kidney bean	P[12]
Physalis peruviana	Peruvian groundcherry	P[8]
Piper nigrum	Pepper	P[9,12]
Pipturus albidus	Waimea pipturus	P[9]
Pipturus argenteus	Native mulberry	P[8]
Pisum sativum	Garden pea	S[14]/P[19]
Pisum spp.	Pea	S[14]
Pluchea indica	Pluchea	S[15]
Portulaca grandiflora	Purslane	P[4]
Portulaca oleracea	Little hogweed	P[8]
Portulaca spp.	Nine-O'Clock	P[15]
Prunus persica	Peach	P[7]
Pisidium guaja	Guava	S[15]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Psychotria mariana		S[8]
Pueraria montana var. lobata	Kudzu	P[9]
Raphanus sativus	Radish	P/S[9,1214,15,19]
Tradescentia spathacea	Moses in the cradle	S[2]
Ricinus communis	Castor	P[14,15]
Rosa spp.	Roses	S[9,14,15,2]
Ruta graveolens	Common rue	S[12]
Saccharum officinarum	Sugarcane	S[7,9]
Salvia spp.	Sage	S[16]
Sanchezia nobilis	Sanchezia	P[17]
Sanseveria trifasciata	Snake Plant	S[14]
Scaevola sirecea	Naupaka	P[9]
Sechium edule	Chayote	S[12]
Semibarbula orientalis	Moss	S[15]
Sesamum indicum	Sesame	P[17]
Sinapis arvensis	Charlock mustard	S[12]
Solanum melongena	Eggplant	S[9,12,14]/P[19]
Solanum tuberosum	Potato	S[14]
Spilanthes acmella	Paracress	P[12]
Spinacea oleracea	Garden spinach	P[14,15]
Swietenia mahogoni	Mahogany	S[14]
Symphytum officinale	Common comfrey	S[12]
Synedrella nodiflora	Synadrelia	S[15]
Tabernaemontana divaricata	Pinwheel flower	P[17]
Tagetes erecta	African marigold	P[14]
Tagetes patula	Indian marigold	P[14,15,16,19]
Tagetes spp.	Marigolds	P[14]
Tectaria spp.	Halberd fern	P[8]
Tectona grandis	Teakwood	P[9,14]
Tephrosia candida	White hoarypea	P[9]
Tephrosia vogelii	Vogel's tephrosia	P[9]
Thea sinensis	Tea	S[15]

TABLE C-4 Primary (P) and secondary (S) food preferences of *Achatina fulica*

Theobroma cacao	Cacao	P[7,9,12,14]
Thespesia populnea	Portia tree	P[9,8]
Tradascantia spathacea	Moses in the boat or oysterplant	S[14]
Trema orientale	Oriental trema	S[8]
Trichosanthes anguina	Snake gourd	S[14]
Trichosanthes dioica	Pointed gourd	P[17]
Tridax argentea	Tridex	S[12]
Triticum aestivum	Wheat	P[5]
Vanda spp.	Vanda orchid	S[9,14]
Vanilla spp.	Vanilla	S[14]
Vernonia scandens	Vernonia	S[15]
Vigna marina	Notched cowpea	P[8]
Vigna radiata	Mung bean	P[14,2,19]
Vigna sinensis unguiculata	Blackeyed pea	P[9,14]
Vitis vinifera	Grape	P[17]
Xanthosoma brasiliense	Cakakib	S[9,14]
Xanthosoma maffafa	Golden delicious	P[12]
Zea mays	Corn	S[9,12,15]
Zinnia linearis	Zinnia	S[9,14,15]

Archachatina marginata

TABLE C-5 Economic food plants of the continental U.S. with potential to become host plants of *Archatina marginata*

Amaranthus spp.	Amaranth
Carica papaya	Papaya
Citrus nobilis	Tangor
Citrus spp.	Citrus
Cucumis sativus	Cucumber
Elaeis guineensis	African oil palm
Eupatorium odoratum	Jack-in-the -bush
Laportea aestuans	West Indian woodnettle
Ipmoea batatas	Sweet potato
Ipomoea spp.	Wild Ipomoea
Lactuca spp.	Lettuce
Manihot esculenta	Cassava
Musa paradisiaca	Banana
Physalis angulata	Cutleaf groundcherry
Portulaca oleracea	Purslane
Psidium guajava	Guava
Sorghum bicolor	Sorghum
Talinum triangulare	Waterleaf
Tridax procumbens	Coat-buttons
Zea mays	Corn
Talinum triangulare	Waterleaf

TABLE C-6 Primary (P) and secondary (S) food preferences of *Archachatina marginata*

Acalypha ciliata		S[1]
Ageratum conyzoides	Goat weed	S[1]
Amaranthus hybridus	Red amaranth	P[6]
Amaranthus spinosus	Spiny amaranth	S[1]P[8]
Annona muricata	Soursop	P[1]
Aspilia helianthoides		S[1]
Bryophyllum pinnatum	Air plant	S[1]
Carica papaya	Papaya	P[1,6,14]
Citrus nobilis	Tangor	S[1]
Citrus paradisi	Grapefruit	S[1]
Citrus sinensis	Sweet orange	S[1]
Cleistopholis patens	Otu	P[1]
Cucumis sativus	Cucumber	S[6]
Dacryodes edulis	African pear	S[1]
Elaeis guineensis	Oil palm	S[1,6]
Chromolaena odorata	Jack in the bush	S[1]
Fleurya aestuans	West Indian woodnettle	S[1]
Hevea brasiliensis	Rubber	S[1]
Ipomoea batatas	Sweet potato	P[1]
Ipomoea spp.	Wild ipomea	S[6]
Irvingia gabonensis	Oba	S[1]
Lactuca spp.	Lettuce	S[14]
Manihot esculenta	Cassava	P[1]
Musa paradisiaca	Plantain	P[1,6,14]
Physalis angulata	Wild tomato	S[1]
Portulaca oleracea	Little hogweed	S[1]
Psidium guava	Guava	S[1]
Rauvolfia vomitoria	Poison devils pepper	S[1]
Sorghum bicolor	Sorghum	S[1]
Talinum triangulare	Waterleaf	S[1]
Telfairia occidentalis	Fluted pumpkin	P[6]
Theobroma cacao	Cacao	S[1]

TABLE C-6 Primary (P) and secondary (S) food preferences of *Archachatina marginata*

Treculia africana	African breadfruit	S[1]
Tridax procumbens	Coatbuttons	S[1]
Xanthosoma maffafa	Golden delicious	P[1]
Xylopia aethiopica	Ethiopian pepper	P[1]
Zea mays	Corn	S[1]

Limicolaria aurora

TABLE C-7 Economic food plants of the continental U.S., with potential to become host plants of *Limicolaria aurora*

Abelmoschus esculentus	Okra
Cucumis sativus	Cucumber
Dioscorea spp.	Yam
Elaeis guineensis	African oil palm
Helianthus tuberosus	Jerusalem artichoke
Ipomoea batatas	Sweet potato
Phaseolus vulgaris	Bean
Piper nigrum	Pepper

TABLE C-8 Primary (P) and secondary (S) food preferences of *Limicolaria aurora*

Abelmoschus esculentus	Okra	P[10]
Cucumis sativus	Cucumber	P[10]
Dioscorea spp.	Yam	P[10]
Elaeis guineensis	Oil Palm	S[14]
Gmelina arborea	White teak	S[4]
Helianthus tuberosus	Jerusalem artichoke	P[10]
Hibiscus loculentus		P[13]
Ipomoea batatas	Sweet potato	P[10]
Phaseolus vulgaris	Kidney bean	P[10]
Piper spp.	Pepper	P[10]

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Snail Pests in the Family Achatinidae

Pest Alert 81-35-009

PEST ALERT

United States Department of Agriculture • Animal and Plant Health Inspection Service

Giant African Snails: A Foreign Threat to U.S. Agriculture

"Giant African snail" is the common name used to describe several foreign snail species that could become serious agricultural pests in the United States. The giant African snail *(Achatina fulica)*, the giant Ghana tiger snail *(Achatina achatina)*, and the banana rasp snail *(Archachatina marginata)* are large, terrestrial snails native to Africa.

Figure 1–A mature *Achatina fulica* maneuvers in its environment.

Figure 2–A penny is used to show the size of giant African snail eggs.

The Giant African Snail

Scientists consider *Achatina fulica* to be one of the most damaging land snails in the world. It is known to eat at least 500 different types of plants, including peanut, beans, peas, cucumbers, and melons. If fruits and vegetables are not available, the snails will eat a wide variety of ornamental plants, tree bark, and even paint and stucco on houses.

A. fulica is established throughout the Indo–Pacific basin, including the Hawaiian islands. This mollusk has also been introduced to several Caribbean islands. Giant African snails reached the island of Martinique in 1987 and spread throughout the islands of Basse-Terre and Grande-Terre in Guadeloupe by 1989. They were discovered in St. Martins and Marie-Galante in 1995. By 2000, *A. fulica* infestations were detected on Saint Lucia and Barbados.

In 1966, a Miami, FL, boy smuggled three giant African snails into South Florida upon returning from a trip to Hawaii. His grandmother eventually released the snails into her garden. Seven years later, more than 18,000 adult snails were found, along with thousands of eggs. The Florida State eradication program took 10 years at a cost of $1 million.

Description and Life Cycle

Reaching almost 8 inches (20 cm) in length and 5 inches (13 cm) in maximum diameter, *A. fulica* is one of the world's largest land snails—about the size of an average adult fist. When fully grown, the shell of *A. fulica* consists of seven to nine whorls, with a long and greatly swollen body whorl. The brownish shell with darker brown lengthwise stripes covers at least half the length of the snail.

Each snail contains both female and male reproductive organs. After a single mating, each snail can produce 100 to 500 eggs. These amazing creatures can reproduce several more times without mating again. They can generate clutches of eggs every 2 to 3 months.

Although this species thrives in tropical and subtropical areas, it can survive in cold conditions. In winter in the Northern United States, the snail would just become slow and sluggish, almost hibernating until warmer weather returns.

Distribution

Like other exotic land snails, giant African snails may enter the United States as hitchhikers on imported cargo. However, there have been recent reports of these snails being illegally imported by individuals for classroom exhibits, as pets, or for food.

APHIS 81–35–009 July 2004

FIGURE 16-9 USDA/APHIS Pest Alert 81-35-009; page 1

Figure 3–Giant African snail infestation on the Caribbean island of Saint Lucia.

Figure 4–Shell of an immature giant African snail.

Damage

Giant African snails cause extensive damage to plants in tropical and subtropical agricultural systems as well as the environment. These snails are also known to carry organisms that can cause diseases in humans. These organisms can be transferred by ingesting improperly cooked snail meat or by handling live snails and allowing their mucus to contact human mucous membranes such as those in the eyes, nose, and mouth.

Control

Because several species of this snail family are capable of becoming agricultural pests, they are illegal in the United States. If you have a giant African snail, do not release it into the environment or give it away. Instead, immediately report it to your State department of agriculture or to the U.S. Department of Agriculture, Animal and Plant Health Inspection Service office in your State.

Additional Information

For more information on giant African snails and how to contact your State department of agriculture, please visit the APHIS Web site at <http://www.aphis.usda.gov/lpa/issues/ga_snail/ga_snail.html>.

Photo credits: All images were taken by APHIS malacologist David G. Robinson.

FIGURE 16-10 USDA/APHIS Pest Alert 81-35-009; page 2

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Snail Pests in the Family Achatinidae

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