

CHAPTER 23

REARING TERRESTRIAL GASTROPODA

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23.1 INTRODUCTION

Many species of land snails are relatively easy to keep in captivity; their requirements are simple, they do not take up much space nor do they require constant care. One may keep land snails in captivity for any length of time depending on one's intentions and resources. Short-term captivity lasting a few days may allow one to perform certain activities easily that may be difficult to carry out in the field. For example, photography of live snails, examinations of external anatomy, observations of snail behavior in response to external stimuli, and determination of food preferences are the types of work that may be performed with captive snails in short periods.

Some projects may require captive breeding and maintenance of large numbers of snails for many years. For example, one may want to know if two species will hybridize, or how various conditions will influence the phenotypic characteristics of shells. Depending upon how quickly the captive snails reproduce and their offspring grow, such studies may take several years to complete. One could even collect rare or endangered snail species (with proper permits), captive-breed them, and release their offspring to the wild.

At first glance, the apparent diversity of methods in the literature may give the impression that everyone who has successfully raised land snails has a different protocol. True, there is no ideal container for keeping snails, or a single perfect food that will satisfy all species. However, everyone who intends to establish a healthy colony must satisfy

the basic requirements of snails, but the details of how one accomplishes this task will depend on one's intentions, resources, ingenuity, and the species of snails.

23.2 A SURVEY OF THE LITERATURE

For some of the common North American snails, there is plenty of (but, probably not enough) published information dealing with captive rearing, but for most of the species that never have been kept in captivity, there is almost no information. Often, one may find information on how to raise a particular species in a paper dealing primarily with some other aspect of that species, for example, its genetics. Therefore, before bringing snails indoors, it is advisable to conduct a careful literature search to find out if anything on the captive breeding of that particular species has been published. Keep in mind that the data gathered while raising an infrequently studied species, if done and presented properly, could become a useful contribution to the scientific literature.

The following is an annotated list of some of the publications dealing with raising land snails. Krull (1937) gave directions for establishing a terrarium suitable for large species, such as *Mesodon thyroidus* (Say, 1816). Archer (1937) gave detailed instructions for converting an aquarium or a flowerpot into a snail terrarium. Carmichael (1937) presented methods for rearing slugs, including handling instructions for their eggs and juveniles. Kingston (1966) raised 18 species of North American snails, including slugs, and gave practical advice for maintaining these snails and

their eggs. Grimm (1974) discussed and offered solutions for the various problems encountered when raising snails. Gray *et al.* (1985) provided information on the captive rearing of several species of North American snails, including slugs. Cowie and Cain (1983) presented information especially useful for the captive maintenance of European land snails.

23.3 SHORT TERM MAINTENANCE OF LAND SNAILS

Snails collected dormant during a dry or a cold season may take several hours to become fully active after having been wetted down or warmed up. Therefore, if time is limited, it is best to start a project with snails that are already active in the field. If an active snail is brought indoors soon after collection and placed in a suitable container, for example, a tray, and left undisturbed, it will soon start exploring its new environment.

Occasionally, the tray and the snail should be gently sprayed with water to prevent the snail from getting too dry and thus withdrawing into its shell. Because slugs lack a protective shell, when they get too dry, they stop moving and eventually shrivel and die at that spot. To prevent slugs from getting dry either keep them in a humid environment or occasionally spray them with water or keep them on a moist substrate, like wet paper towel. Incandescent lights should be placed a safe distance away to prevent the snails from overheating; cooler fluorescent lamps are a better choice for indoor observations.

If you intend to keep the snails for only a few hours, you may not need to feed them. Nevertheless, a piece of carrot or a flake of fish food may naturally immobilize a hungry snail thereby allowing it to be photographed easily or examined under a stereomicroscope. If the intent is to keep the snails for a few days, place them in a secure container lined with moist paper towel or damp soil (a few centimeters thick) and provide them with food (see below). At the end of the work, make every effort to return the snails to the wild, most preferably to the same location where they were collected.

23.4 REARING NORTH AMERICAN WOODLAND SNAILS

Some species of land snails that normally reproduce by outcrossing can also produce offspring without mating, for example *Neohelix albolabris* (Say, 1817) (McCracken and Brussard 1980). However, it is not known if a robust clone can be established from such offspring. Therefore, to build a long-term colony it may be best to start with several individuals to avoid the appearance of phenotypic abnormalities in the offspring produced from the mating of closely related individuals.

23.4.1 Containers. Many different types of containers may be successfully used to keep snails. Plastic or glass containers with clear lids or sides are ideal, because snails can be observed without disturbing them. Fish aquaria may be adapted for snails (Archer 1937). The lid of the container should be tight enough to prevent the snails from escaping, but not airtight. Large snails, such as *Neohelix*, can easily push open loosely closed lightweight lids, and yet if too many of them are kept in airtight containers, they may suffocate. Small ventilation holes may be punched in the lids of containers or netting may be used as a cover. Obviously, such ventilation openings must be small enough to prevent the escape of snails, especially the juveniles. Fit the size of the container to the size and the number of snails; if you put a one-millimeter snail in an aquarium full of soil, you may never be able to find the snail again. In addition, for some species, overcrowding may negatively influence growth and reproduction (Cowie and Cain 1983, Pearce 1997). Small snails may be kept in petri dishes (Mapes and Krull 1951), and the petri dishes then may be placed in larger plastic containers to retain moisture. Trial and error will help you develop a system that will produce the best results.

23.4.2 Substrate. Excess moisture can kill snails. This is especially true for the foul liquid that accumulates when plant material with a high water content, such as lettuce leaves, rots. Therefore, if the intent is to keep snails for longer than a day or two, use a substrate in their containers to absorb excess liquids. Paper towels may be used for this

purpose, but after a while the paper itself starts to decompose or develop mold. Soil and leaf litter from the snails' habitat is a natural alternative. Soil absorbs and retains moisture. If the container begins to dry out, some species will bury themselves in the soil, in an attempt to slow their water loss. Many species bury their eggs in soil. Moreover, snails eat decomposing leaves and damp soil, which thereby serve as a backup food source for when one is away or too busy to tend to the snails.

Forest soil, including leaf litter, often contains mites and nematodes that are potentially harmful to captive snails (see the section on snail health below, Chapter 23.5). Heating soil and litter in shallow pans in an oven at about 50°C (120°F) until dry can kill mites and nematodes. Soil can be sterilized by heating at 250°F for 2 hours (USDA 2001). Soil may be heated at higher temperatures, but beware that dry leaves may start to burn at temperatures above 230°C (450°F). Alternately, to avoid the trouble of transporting and heating large quantities of forest soil (and needlessly destroying many inhabitants of the soil in the process), consider using store-bought soil. The best general-purpose substrate for use in snail containers is commercial potting soil manufactured by composting of wood. Composting naturally takes place at raised temperatures, killing many potentially nuisance organisms.

In time, the soil and the sides of a container are covered with snail mucus, to which snail excreta and other debris adhere. Occasionally replace the soil and clean the containers under tap water. Snail mucus may be removed with household bleach (Pearce 1997).

23.4.3 Food. Table 23.1 lists food items fed to several species of native and introduced North American land snails, including some that do not normally live in the woods. Grimm (1974) recommended additional foods to supplement snails' diets, especially during reproductive periods: potatoes, turnips, radishes, wheat germ, porridge, boiled egg yolk, and bananas. Dry oats have always been recommended for snails (Krull 1937). However, uneaten oats should be promptly removed, because fungi quickly grow on moist oats. Aquarium fish

food is also accepted by many species of snails (Table 23.1). Cowie and Cain (1983) fed their snails a mixture of dry skim milk, breakfast cereal, and calcium carbonate. Various fruits, including grapes and apples, may also be fed to snails.

Carnivorous species, for example, *Haplotrema concavum* (Say, 1821), should be given live prey of appropriate sizes (Table 23.1), although some carnivores, for example, *Rumina decollata* (Linnaeus, 1758) can be raised on lettuce only (Table 23.1). Snails need calcium to make their shells and the shells of their eggs. In the wild, they get calcium from their food, the shells of other snails, and calcium containing rocks and soil. Although captive snails get some calcium from the foods they eat (even lettuce has minute quantities of calcium), their diet should be supplemented. Calcium carbonate may be supplied in the form of limestone or marble rocks, cuttlefish bones, empty mollusk shells, eggshells, or any other suitable source. A favorite is powdered limestone, which is cheaply available in gardening supply stores and easily applied from a saltshaker. Powdered limestone will also help prevent the pH of the soil from getting too acidic.

Start out by placing small quantities of food in the snails' containers. If it is quickly eaten, increase the amount. Too much food may spoil before it is eaten and create an unhealthy condition. Place the snails directly on the fresh food. If they have become dormant since last checked, spray them with water, which may quickly revive them. Each time the snails are fed, sprinkle some limestone powder on the food and soil. Excess limestone is not harmful.

As many field collectors have learned, land snails will eat paper. This should not be surprising since paper is mostly cellulose, a main ingredient of the natural diets of many species. Grimm (1974) suggested feeding snails various types of paper products (cardboard, newspaper, etc.). However, since the composition of most inks are a trade secret, you might prefer using paper without printing on it. This removes any potential risk to the snails from the ink.

Table 23.1. Foods for rearing some North American land snails: in addition to a source of calcium.

Species	Food
Native species	
Forest snails	leaf litter, lettuce, cabbage, oatmeal, bran, leaves of <i>Ailanthus glandulosa</i> (Archer 1937, Kingston 1966, Grimm 1974)
<i>Neohelix</i> spp.	lettuce, carrots, cucumbers, mushrooms, spinach, oats, fish food (Vail 1978, McCracken and Brussard 1980, Emberton 1994, Örstan, unpublished)
<i>Mesodon</i> spp.	lettuce, oats, fish food (Emberton 1994, Pearce 1997)
<i>Triodopsis</i> spp.	lettuce, carrots, fish food (Gray <i>et al.</i> 1985, Örstan, unpublished)
<i>Deroceras</i> spp.	lettuce, carrots, leached maple leaves, oatmeal, leaves of <i>Ailanthus</i> sp. (Kingston 1966, Gray <i>et al.</i> 1985)
<i>Discus cronkhitei</i> (Newcomb, 1865)	lettuce (Gray <i>et al.</i> 1985)
<i>Vallonia</i> spp.	leaf litter (Gray <i>et al.</i> 1985)
<i>Zonitoides arboreus</i> (Say, 1816)	leaf litter (Gray <i>et al.</i> 1985)
<i>Anguispira</i> spp.	lettuce, oatmeal, dried maple leaves, fish food, carrots (Elwell and Ulmer 1971, Pearce 1997, Örstan, unpublished)
<i>Haplotrema concavum</i> (Say, 1821)	<i>Succinea ovalis</i> Say, 1817, <i>Zonitoides arboreus</i> (Say, 1816), <i>Discus catskillensis</i> (Pilsbry, 1896), <i>Ventridens suppressus</i> (Say, 1829), <i>Allopeas gracilis</i> (Hutton, 1834), <i>Anguispira</i> spp. (including eggs), young of <i>Mesodon thyroidus</i> (Say, 1816), <i>Neohelix albolabris</i> (Say, 1817), and <i>Helix aspersa</i> Müller, 1774 (Pearce and Gaertner 1996, Atkinson and Balaban 1997, Örstan, unpublished)
<i>Cochlicopa lubrica</i> (Müller, 1774)	leaves of <i>Ailanthus</i> (Mapes and Krull 1951)
Introduced species	
<i>Limax flavus</i> Linnaeus, 1758	bread, potatoes, sweet potatoes, various leafy vegetables, turnips, milk (Carmichael 1937)
<i>Rumina</i> spp.	lettuce, oats, fish food, carrots, beets, <i>Helix aspersa</i> Müller, 1774 (Batts 1957, Dundee 1970, Fisher 1974, Örstan, unpublished)
<i>Oxychilus draparnaudi</i> (Beck, 1837)	<i>Stenotrema fraternum</i> (Say, 1824), <i>Webbhelix multilineata</i> (Say, 1821), <i>Anguispira alternata</i> (Say, 1816), cucumbers (Frest and Rhodes 1982)
<i>Allopeas gracilis</i> (Hutton, 1834)	lettuce, fish food (Örstan, unpublished)
Edible species (<i>Helix</i> , <i>Cepaea</i> , <i>Otala</i> , etc.)	vegetables, fruits, cereals, legumes, garden plants, skim milk powder (Cowie and Cain 1983, Thompson and Cheney 1996)

23.4.4 Moisture, temperature, and light. Dry soil (or other suitable substrates) placed in a snail container should be wetted by spraying it with water. To minimize the growth of fungus and potentially harmful mites and nematodes (see below), avoid

continuous high humidity inside the containers. Shelled snails will usually survive if their containers are dried out for brief periods. Slugs however will die if their containers dry out for even a brief period (Kingston 1966).

For snails to remain active year round, keep them within an acceptable temperature range. The limits of this range may be species specific. Most U.S. forest species will remain active within 10-25°C (50-80°F). If kept for a long period at temperatures below 10°C, snails are likely to become dormant until the temperature rises. Also, at low temperatures, the development of eggs will be delayed. However, exactly what a given snail will do under certain conditions is difficult to predict, since many external physical conditions and individual genotypic variations will influence behavior and physiology. In the woods in Maryland on a rainy January day when the temperature was slightly above freezing, I found under the leaf litter five live, but dormant *Neohelix albolabris* with apertures sealed with dried mucus. Nearby was one *Mesodon thyroideus* sticking to the underside of a leaf with its foot partially out of its shell. Some forest species survive freezing (Riddle and Miller 1988) and some such as *Anguispira alternata* (Say, 1816) (Elwell and Ulmer 1971) may need a cold-induced dormant period before reproducing. Familiarization with published literature will be useful in maintaining the proper conditions for the good of the snails.

Elevated temperatures are more likely to kill snails than are low temperatures (Grimm 1974). Although in areas with long, dry summers (for example, in the Mediterranean countries) many species aestivate (and survive) in the sun for many months, the elevated temperature inside a container of active snails on a window sill exposed to the sun on a summer day is most likely to kill the snails. Thus, the maxim is that cool is better than hot. In addition, the intensity and duration of light exposure may influence snails' activity and reproduction. The easiest way to regulate the duration of light exposure (photoperiod) is to keep the snail containers away from direct sunlight and on or near a north-facing windowsill.

23.4.5 Maintenance of eggs and juveniles. It is best to remove the juveniles and the eggs from the containers of adults and keep them in separate containers (Carmichael 1937, Kingston 1966, Vail 1978, McCracken and Brussard 1980). Otherwise, the small juveniles may be inadvertently thrown

away when removing old food or replacing the substrate. Occasionally adults may consume the eggs (Grimm 1974). Young hatchlings are also known to eat conspecific eggs (Vail 1978, Atkinson and Balaban 1997, Desbuquois *et al.* 2000). However, it would be difficult and unnecessary to attempt to prevent this behavior. You may find the eggs, usually buried in soil in groups, by gently mixing the soil with a small spatula.

Eggs may be incubated in damp soil, or on damp paper towels in petri dishes, or in other small containers. Avoid getting the eggs too dry or too wet for prolonged periods. Empty transparent pill bottles make good incubators for eggs. Eggs placed on damp pieces of paper towel (or several layers of toilet paper) and sealed inside pill bottles may not require further care until they hatch. For accurate control of temperature, bottles with eggs may be partially immersed in temperature-controlled water baths. Keep the newly hatched snails in small containers where they may be easily found. Transfer them to larger containers as they grow.

23.5 SNAIL HEALTH

If snails are kept under proper physical conditions and given adequate food, most of them will be, as far as a human observer can tell, healthy. Occasionally, snail containers may be infested with nematodes, mites, or protozoans (Arias and Crowell 1963, Kingston 1966, Grimm 1974, Gray *et al.* 1985). In the wild, the numbers of such organisms are controlled by various environmental factors, which may be modified in their favor in an artificial setting, resulting in their populations increasing dramatically. These organisms are usually smaller than a millimeter and the examination of the soil from a snail container under a stereomicroscope or with a magnifying glass may be necessary to detect them.

There are several species of mites (Fain 2004) and nematodes (Morand *et al.* 2004) that are parasitic in land snails. Although a few nematodes or mites may not harm the snails, under optimum conditions, the numbers of these animals may reach tremendous amounts. When that happens, snails

are overwhelmed and usually become dormant and although the large ones may survive, the small snails, particularly the juveniles, soon die. In heavily infested cultures, one may find otherwise empty snail shells with numerous nematodes or mites inside.

If a snail container is heavily infested with nematodes or mites, there is no practical way to get rid of them. The infestations usually return, even after washing the snails from infested containers in tap water, picking them clean under a stereomicroscope, and then placing them in new containers with fresh material. In all likelihood, some of the nematodes and the mites remain inside the shells or on the snails' bodies. Therefore, the best cure is prevention from the outset. As discussed above, either use composted potting soil or heat-treated forest soil. If one doubts the cleanliness of commercial soil, it too should be heated before use.

Before placing newly collected snails in their containers, wash and clean their shells with an old toothbrush under tap water. Small shells may be cleaned by briefly dipping them in a small container of water. Also, if the snails are fed lettuce or other leafy vegetables, make sure the vegetables are free from mud that may harbor nematodes. To prevent any unwanted organisms from feeding on rotting leftover food, promptly remove it. Do not mix the snails from infested containers with those from uninfested containers.

Some of my snail containers have also been infested with very small flies and their larvae, and these were difficult to eliminate (see also Gray *et al.* 1985). Although neither the flies nor their larvae seemed to be harming the snails, they were nevertheless a nuisance, requiring frequent changes of containers. The recommendations given above to prevent nematode and mite infestations also should help prevent the fly infestations.

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