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Raising Snails

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Contents

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Raising snails.
(Special reference briefs ; 96-05)
1. Snail farming. 2. Edible snails. 3. Snails Computer network resources. 4. Snail farming Bibliography. I. Cheney, Sheldon.
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Return to: Contents

Raising Snails

Introduction

Heliciculture is the process of farming or raising snails. Snail farming on a large-scale basis requires a considerable investment in time, equipment, and resources. Prospective snail farmers should carefully consider these factors, especially if their goal is to supply large quantities to commercial businesses. Anyone who wishes to raise snails should expect to experiment until he finds what works best in his specific situation. Expect a few problems.

Roasted snail shells have been found in archaeological excavations, an indication that snails have been eaten since prehistoric times. In ancient Rome, snails were fattened up in "cochlear" gardens before they were eaten. "A Virginia Farmer" (1) described keeping snails in a cool, moist and shady environment, supplying artificial dew if necessary, containing them on an "island" surrounded by water to prevent escape, supplying vegetation as feed, and fattening them on corn meal. Pliny described the snail garden of Fulvius Hirpinus 2,000 years ago as having separate sections for different species of snails. Hirpinus allegedly fed his snails on meal and wine. (2) [But note, stale beer placed in a shallow dish is a way of killing them. Snails are attracted to the yeast in beer and will crawl into the dish and drown.] The Romans selected the best snails for breeding. "Wall fish" were often eaten in Britain, but were never as popular as on the continent. There, people often ate snails during Lent, and in a few places, they consumed large quantities of snails at Mardi Gras or Carnival, as a foretaste of Lent.

According to some sources, the French imported brown garden snails to California in the 1850's, raising them as the delicacy escargot. Other sources claim that Italian immigrants were the first to bring the snail to the U.S..

U.S. imports of snails were worth more than $4.5 million in 1995 and came from 24 countries. This includes preserved or prepared snails and snails that are live, fresh, chilled, or frozen. Major exporters to the U.S. are France, Indonesia, Greece and China. The U.S. exported live, fresh, chilled, or frozen snails worth $55,000 to 13 countries; most were shipped to Japan, the Netherlands, and the United Kingdom. [See U.S. Imports and Exports. Source: U.S. Department of Commerce. Individual statistics are not available for U.S. exports of prepared or processed snails.

This publication provides a general overview of farming edible terrestrial snails. The authors have used many sources believed to be reliable. Information supplied by some farmers or researchers may conflict with information supplied by others. The information applies to several different species of snails, and not all of it necessarily applies to one particular species.

Return to: Contents

Edible Species

Edible land snails range in size from about one millimeter long to the giant African snails, which occasionally grow up to 312mm (1 foot) in length. "Escargot" most commonly refers to either *Helix aspersa* or to *Helix pomatia*, although other varieties of snails are eaten. *Achatina fulica*, a giant African snail, is sliced and canned and passed off on some consumers as escargot. Terms such as "garden snail" or "common brown garden snail" are rather meaningless since they refer to so many types of snails, but they sometimes mean *H. aspersa*.

- *Helix aspersa* Muller is also known as the French "petit gris," "small grey snail," the "escargot chagrine," or "La Zigrinata." The shell of a mature adult has four to five whorls and measures 30 to 45mm across. It is native to the shores of the Mediterranean and up the coast of Spain and France. It is found on many British Isles, where the Romans introduced it in the first century A.D. (Some references say it dates to the Early Bronze Age.) In the early 1800's the French brought it into California where it has become a serious pest. These snails are now common throughout the U.S. It was introduced into several Eastern and Gulf states even before 1850 and, later introduced into other countries such as South Africa, New Zealand, Mexico, and Argentina. *H. aspersa* has a life span of 2 to 5 years. This species is more

adaptable to different climates and conditions than many snails, and is found in woods, fields, sand dunes, and gardens. This adaptability not only increases *H. aspersa's* range, but it also makes farming *H. aspersa* easier and less risky.

- *Helix pomatia* Linne measures about 45mm across the shell. It also is called the "Roman snail," "apple snail," "lunar," "La Vignaiola," the German "Weinbergschnecke," the French "escargot de Bourgogne" or "Burgundy snail," or "gros blanc." Native over a large part of Europe, it lives in wooded mountains and valleys up to 2,000 meters (6,000 feet) altitude and in vineyards and gardens. The Romans may have introduced it into Britain. Immigrants introduced it into the U.S. in Michigan and Wisconsin. Many prefer *H. pomatia* to *H. aspersa* for its flavor and its larger size, as the "escargot par excellence."

- *Otala lactea* or *Helix lactea* is sometimes called the "vineyard snail," "milk snail," or "Spanish snail." The shell is white with reddish brown spiral bands and measures about 26 to 35mm in diameter. Many think it tastes better than *H. aspersa*.

- *Iberus alonensis*--the Spanish "cabretes" or "xona fina"--measures about 30mm across the shell.

- *Cepaea nemoralis*--*Helix nemoralis*, the "wood snail," or the Spanish "vaqueta,"-- measures about 25mm across the shell. It inhabits Central Europe and was introduced into and inhabits many U.S. states, from Massachusetts to California and from Tennessee to Canada. Its habitat ranges widely from woods to dunes. It mainly eats dead plant material, but it likes nettles and buttercups and will eat dead worms and dead snails.

- *Cepaea hortensis*, or *Helix hortensis*, the "garden snail," measures about 20mm across the shell and has distinct dark stripes. It is native to central and northern Europe. Introduced into Maine, Massachusetts, and New Hampshire in colonial times, it never became established in these states. Its habitat varies like *C. nemoralis*, but *C. hortensis* is found in colder and wetter places than nemoralis. Their smaller size and some people's opinion that snails with striped shells do not taste as good make hortensis and nemoralis less popular.

- *Otala punctata* or *Archelix punctata*, called "vaqueta" in some parts of Spain, measures about 35mm across the shell.

- *Otala vermiculata*--also called *Eobania v.* or *Helix v.*, the "vinyala," "mongeta," or "xona"--measures about 25mm. It is found in Mediterranean countries and was introduced into Louisiana and Texas.

- *Helix lucorum*, sometimes called "escargo turc," measures about 45mm across the shell. It is found in central Italy and from Yugoslavia through the Crimea to Turkey and around the Black Sea.

- *Helix adanensis* comes from around Turkey.

- *Helix aperta* measures about 25mm. Its meat is highly prized. It is native to France, Italy, and Mediterranean countries and has become established in California and Louisiana. Sometimes known as the "burrowing snail," it is found above ground only during rainy weather. In hot, dry weather, it burrows three to six inches into the ground and becomes dormant until rain softens the soil.

- *Theba pisana*--also called the "banded snail"or the "cargol avellanenc"--measures about 20mm and lives on dry, exposed sites, usually near the sea. Native to Sicily, it has been spread to several European countries, including England. This snail is a serious garden pest and is the "white snail" that California once eradicated by using flamethrowers to burn off whole areas. In large numbers, up to 3,000 snails per tree, it can ravage a garden in 24 hours and a citrus or other crop in a couple of nights.

- *Sphincterochila candidisima* or *Leucochroa candidisima*, the "cargol mongeta," or "cargol jueu" measures about 20mm.

- *Achatina fulica*, one of several giant African snails, grows up to 326mm (one foot) long. Its origin is South of the Sahara in East Africa. This snail was purposely introduced into India in 1847. There was an unsuccessful attempt to establish it in Japan in 1925. It has been purposely and accidentally transported to other Pacific locations and was inadvertently released in California after World War II, in Hawaii, and later in North Miami Florida in the 1970's. In many places, it is a serious agricultural pest that causes considerable crop damage. Also, due to its large size, its slime and fecal material create a nuisance as does the odor that occurs when something like poison bait causes large numbers to die. The U.S. has made considerable effort to eradicate Achatina. **The U.S. Department of Agriculture (USDA) bans the importation of, and it is illegal to possess, live giant African snails.**

  "There is no such thing as **the** giant African or West African snail since there are many genera containing numerous species. . . . For instance, the giant snail in Ghana is taken to mean *Achatina Achatina* (Linne), but in Nigeria this might refer to *Arachachatina Marginata* (Swainson), and in East Africa to *Achatina fulica* Bodich. There are, therefore, several giant land snails in Africa, and not just one species." (3)

Return to: Contents

Mating and Egg Laying

Snails are hermaphrodites. Although they have both male and female reproductive organs, they must mate with another snail of the same species before they lay eggs. Some snails may act as males one season and as females the next. Other snails play both roles at once and fertilize each other simultaneously. When the snail is large enough and mature enough, which may take several years, mating occurs in the late spring or early summer after several hours of courtship. Sometimes there is a second mating in summer. (In tropical climates, mating may occur several times a year. In some climates, snails mate around October and may mate a second time 2 weeks later.) After mating, the snail can store sperm received for up to a year, but it usually lays eggs within a few weeks. Snails are sometimes uninterested in mating with another snail of the same species that originated from a considerable distance away. For example, a *H. aspersa* from southern France may reject a *H. aspersa* from northern France.

Snails need soil at least 2 inches deep in which to lay their eggs. For *H. pomatia*, the soil should be at least 3 inches deep. Keep out pests such as ants, earwigs, millipedes, etc. Dry soil is not suitable for the preparation of a nest, nor is soil that is too heavy. In clay soil that becomes hard, reproduction rates may decrease because the snails are unable to bury their eggs and the hatchlings have difficulty emerging from the nest. Hatchability of eggs depends on soil temperature, soil humidity, soil composition, etc. Soil consisting of 20% to 40% organic material is good. Keep the soil 65 F to 80 F, best around 70. Maintain soil moisture of 80%. One researcher removes eggs immediately after they are deposited, counts them, then keeps them on moist cotton until the eggs hatch and the young start to eat. Snails lose substantial weight by laying eggs. Some do not recover. About one-third of the snails will die after the breeding season.

H. pomatia eggs measure about 3mm in diameter and have a calcareous shell and a high yolk content. *H. pomatia* lays the eggs in July or August, 2 to 8 weeks after mating, in holes dug out in the ground. (Data varies widely on how long after mating snails lay eggs.) The snail puts its head into the hole or may crawl in until only the top of the shell is visible; then it deposits eggs from the genital opening just behind the head. It takes the snail 1 to 2 days to lay 30 to 50 eggs. Occasionally, the snail will lay about a dozen more a few weeks later. The snail covers the hole with a mixture of the slime it excretes and dirt. This slime, which the snail excretes to help it crawl and to help preserve the moisture in its soft body, is glycoprotein similar to eggwhite.

Fully-developed baby *H. pomatia* snails hatch about 3 to 4 weeks after the eggs are laid, depending on temperature and humidity. Birds, insects, mice, toads and other predators take a heavy toll on the young snails. The snails eat and grow until the weather turns cold. They then dig a deep hole, sometimes as deep as 1 foot, and seal themselves inside their shell and hibernate for the winter. This is a response to both decreasing temperature and shorter hours of daylight. When the ground warms up in spring, the snail emerges and goes on a binge of replacing lost moisture and eating.

H. aspersa eggs are white, spherical, about 3mm in diameter and are laid 5 days to 3 weeks after mating. (Data varies widely due to differences in climate and regional variations in the snails' habitats.) *H. aspersa* lays an average of 85 eggs in a nest that is 1- to 1 1/2-inches deep. Data varies from 30 to over 120 eggs, but high figures may be from when more than one snail lays eggs in the same nest.

In warm, damp climates, *H. aspersa* may lay eggs as often as once a month from February through October, depending on the weather and region. Mating and egg-laying begin when there are at least 8 hours of daylight and continue until days begin to get shorter. In the United States, longer hours of sunlight that occur when temperatures are still too cold will affect this schedule, but increasing hours of daylight still stimulate egg laying. If warm enough, the eggs hatch in about 2 weeks, or in 4 weeks if cooler. It takes the baby snails several more days to break out of the sealed nest and climb to the surface. In a climate similar to southern California's, *H. aspersa* matures in about 2 years. In central Italy, *H. aspersa* hatches and emerges from the soil almost exclusively in the autumn. If well fed and not overcrowded, those snails that hatch at the start of the season will reach adult size and form a lip at the edge of their shell by the following June. If you manipulate the environment to get more early hatchlings, the size and number of snails that mature the following year will increase. In South Africa, some *H. aspersa* mature in 10 months, and under ideal conditions in a laboratory, some have matured in 6 to 8 months. Most of *H. aspersa's* reproductive activity takes place in the second year of its life.

By contrast, one giant African snail, *Achatina fulica*, lays 100 to 400 elliptical eggs that each measure about 5mm long. Each snail may lay several batches of eggs each year, usually in the wet season. They may lay eggs in holes in the ground like *H. pomatia*, or lay eggs on the surface of a rocky soil, in organic matter, or at the base of plants. In 10 to 30 days, the eggs hatch releasing snails about 4mm long. These snails grow up to 10mm per month. After 6 months, the *Achatina fulica* is about 35mm long and may already be sexually mature. Sexual maturity takes 6 to 16 months, depending on weather and the availability of calcium. This snail lives 5 or 6 years, sometimes as many as 9 years.

Return to: Contents

Growth

Within the same snail population and under the same conditions, some snails will grow faster than others. Some will take twice as long to mature. This may help the species survive bad weather, etc., in the wild. However, a snail farmer should obviously select and keep the largest and fastest maturing snails for breeding stock. Sell the smaller snails. By selecting only the largest, the average size of the snail may increase significantly in only a couple of generations. Most of the differences in growth are probably due to environmental factors including stocking density. However, to whatever extent these differences are genetic, you might as well breed large, fast-growing snails instead of small, slower-growing ones.

Several factors can greatly influence the growth of snails including: population density; stress [snails are sensitive to noise, light, vibration, unsanitary conditions, irregular feedings, being touched, etc.]; feed; temperature and moisture; and the breeding technology used.

H. aspersa requires at least 3% to 4% calcium in the soil (or another source of calcium) for good growth. Most snails need more calcium in the soil than *H. aspersa*. Low calcium intake will slow the growth rate and cause the shell to be thinner. Calcium may be set out in a feeding dish or trough so the snails can eat it at will. Food is only one calcium source. Snails may eat paint or attack walls of buildings seeking calcium, and they also will eat dirt.

A newborn's shell size depends on the egg size since the shell develops from the egg's surface membrane. As the snail grows, the shell is added onto in increments. Eventually the shell will develop a flare or reinforcing lip at its opening. This shows that the snail is now mature; there will be no further shell growth. Growth is measured by shell size, since a snail's body weight varies and fluctuates, even in 100% humidity. The growth rate varies considerably between individuals in each population group. Adult size, which is related to the growth rate, also varies, thus the fastest growers are usually the largest snails. Eggs from larger, healthier snails also tend to grow faster and thus larger.

Dryness inhibits growth and even stops activity. When it becomes too hot and dry in summer, the snail becomes inactive, seals its shell and estivates (becomes dormant) until cooler, moister weather returns. Some snails estivate in groups on tree trunks, posts, or walls. They seal themselves to the surface thus sealing up the shell opening.

Return to: Contents

Farming snails

Successful snail culture requires the correct equipment and supplies, including: snail pens or enclosures; devices for measuring humidity (hygrometer), temperature (thermometer), soil moisture, and light (in foot candles); a weight scale and an instrument to measure snail size; a kit for testing soil contents; and a magnifying glass to see the eggs. You also may need equipment to control the climate (temperature and humidity), to regulate water (e.g., a sprinkler system to keep the snails moist and a drainage system), to provide light and shade, and to kill or keep out pests and predators. Some horticultural systems such as artificial lighting systems and water sprinklers may be adapted for snail culture. You will have better results if you use snails of the same kind and generation. Some recommend putting the hatchlings in another pen.

Four Systems: Snail farms may be outdoors; in buildings with a controlled climate; or in closed systems such as plastic tunnel houses or "greenhouses." In addition, snails may breed and hatch inside in a controlled environment and then (after 6 to 8 weeks) may be placed in outside pens to mature.

Climate: A mild climate (59-75 F) with high humidity (75% to 95%) is best for snail farming, though most varieties can stand a wider range of temperatures. The optimal temperature is 70 F for many varieties. When the temperature falls below 45 F, snails hibernate. Under 54 F the snails are inactive, and under 50 F, all growth stops. When the temperature rises much above 80 F or conditions become too dry, snails estivate. Wind is bad for snails because it speeds up moisture loss, and snails must retain moisture.

Moisture: Snails need damp, not wet, environments. Although snails need moisture, you must drain wet or waterlogged soil to make it suitable for them. Similarly, rainwater must run off promptly. Snails breathe air and may drown in overly wet surroundings. A soil moisture content of 80% of capacity is favorable. In the hours of darkness, air humidity over 80% will promote good snail activity and growth.

Ninety-nine percent of snail activity, including feeding, occurs in the cool, dark nighttime, with peak activity taking place 2 to 3 hours after darkness begins. The cooler temperature stimulates activity, and the nighttime dew helps the snail move easily. They hide in sheltered places during most of the day. If necessary, use misting sprayers, like those used for plant propagation, in dry climates to maintain adequate humidity and moisture levels.

Soil: Use a good medium soil that has neither a lot of sand nor too much clay. Snails are unable to dig into hard, dry clay. Soils with too much sand do not contain enough water. Soil that contains 20% to 40% organic matter is good. The soil should be similar to that of a garden in which green, leafy vegetables thrive. If your snail farm contains plants, keep them wet and properly care for them. Regularly remove any weeds. Neutralize soil that is too acidic with lime to make it suitable (at about pH 7). Besides the pH value of the soil, calcium must be available either from the soil or another readily available source, since snail shells are 97% to 98% calcium carbonate. If in doubt, you can add a little ground limestone. One researcher treats the soil with polyacrylamide at the rate of 12.5cc of a 160-g M.A./one preparation in 250cc of water per kilogram of dry soil. This stabilization treatment helps the soil structure resist washing. This allows regular cleaning without destroying the crumb structure of the soil that is beneficial for egg laying.

Snails dig in soil and ingest it. Good soil favors snail growth and provides some of their nutrition. Lack of access to good soil may cause fragile shells even when the snails have well-balanced feed; the snails growth may lag far behind the growth of other snails on good soil. Snails will often eat feed, then go eat dirt. Sometimes, they will eat only one or the other. This may be one reason that you should not crowd too many snails into too small a pen. The soil, unless frequently changed, will become fouled with mucus and droppings. Chemical changes also may occur in the soil. A mixture of peat, clay, compost, $CaCO_3$ at pH 7 makes a very good soil. Leaf mold at pH 7 works almost as well. Organic matter in the soil seems as important as carbonates. Soils that are richest in exchangeable calcium and magnesium stimulate growth best. Usable carbonates and total calcium are important. Calcium may be added to the soil at the rate of 10 pounds per 100 square feet. Calcium may also be set out in a feeding dish or trough so the snails can eat it at will.

Pens and Enclosures

[Note: The U.S. Animal and Plant Health Inspection Service (APHIS) *Standards for Snail-Rearing Facilities* were revised March 2001 and are available at http://www.aphis.usda.gov/plant_health/permits/downloads/snails_containment_guidelines.pdf.]

Enclosures for snails are usually long and thin instead of square. This allows you to walk around (without harming the snails) and reach in the whole pen. The enclosure may be a trough with sides made of wood, block, fiber cement sheets, or galvanized sheet steel. Cover it with screen or netting. The covering will confine the snails and keep out birds and other predators. Fences or walls are usually 2-feet high plus at least 5 inches into the ground. Fencing made of galvanized metal or hard-plastic sheets helps keep out some predators. A cover will protect against heavy rain. Shade (which may be a fine mesh screen) on warm winter days helps keep the snails dormant. Use 5mm mesh or finer for pen screens or fences. Pens containing baby snails will need a finer mesh.

Snails like hiding places, especially during the warm daytime. For example, purchase plastic soil drainage pipes from the local garden center, split them in two lengthwise, and stack one layer one way and the next layer at a right angle. This will provide shelter and will increase by 50% the

number of snails you can put in the pen.

A sprinkler system will ensure moisture when needed. Turn it on at sunset. If turned on early in the day, the moisture may drive snails out into hot sunshine. Monitor temperature and humidity using a thermometer and a hygrometer.

Although you can use fencing for the enclosure's sides, the bottom, if not the ground or trays of dirt, must be a surface more solid than screening. A snail placed in a wire-mesh-bottom pen will keep crawling, trying to get off the wires and onto solid, more comfortable ground.

Preventing escapes: In an open pen, curve the top of the fences inward in a half circle to confine the vineyard snail. *H. aspersa* will escape from such an open pen, so you could use an electric fence to contain them. [The electric fence top has two or more thin wires that are 2 to 4mm apart. Each wire carries the opposite charge of the wire next to it. Use a battery or transformer to supply 4 to 12 volts to the wire. A snail will get a mild shock and retract when it crawls over a wire and touches a second wire.]

Another technique to confine snails is to bend the fence top inward into a sharp "V" shape with about a 20 angle. The snail's shell will hit the bent-back part of the screen before he can reach up and start crawling on it. This blocks him, and the angled screen automatically compensates for the size of the snail.

Another alternative, especially handy for solid wall enclosures, is to attach to the wall a horizontal piece of screen that projects inward several inches over the enclosure. Make the screen with material like nylon monofilament that is moderately stiff and springy yet easily flexible. On the inside edge of the screen, remove the cross fibers until you've created a fringe several inches wide. As the would-be escapee crawls on the underside of the screen and moves out onto the fringe, his weight pulls several individual fibers down. One by one, another fiber gets away from the snail and springs back up out of reach. Eventually the snail is dangling by a thread. He then falls because the surface area is not big enough to crawl on.

Since snails usually will not cross a copper band, another solution is to top the fence with 3-inch-wide (or wider) copper band. You could bend the band so that part of it faces inward and is parallel to the pen floor. If the band is placed too close to the ground, rain may wash soil against the copper and leave a residue that may enable the snail to cross it. Also, be sure to bury the bottom of the fence deep enough into the ground so that the snails don't dig under it.

Pens with gardens: An alternate method is to make a square pen with a 10-foot-square garden in it. Plant about six crops, e.g., nettles and artichokes, inside the pen. The snails choose what they want to eat. If it has not rained, turn sprinklers on for about 15 minutes at dusk, unless the snails are dormant. A disadvantage to this method is that, if the snails are not mature at the end of the year, it is difficult to replant fresh plant crops in the pens.

Plastic tunnels make cheap, easy snail enclosures, but it is difficult to regulate heat and humidity. The tunnel will be 10 to 20 warmer than the outside, and snails become dormant as the temperature climbs above 80 F.

Indoor pens: With snails raised indoors under controlled conditions, reproduction varies according to the geographic origin of the breeding stock. For example, one researcher found that *H. aspersa* snails from Brittany seem to do better indoors than snails from another region. To breed snails indoors, keep the temperature at 70 F. and the relative humidity at 80% to 90%; some sources say 95%. Another source recommends 75% humidity by day and 95% at night. The Center for Heliciculture once recommended 65-75% humidity during the day and 85-95% at night at 68 F. In any event, avoid humidity higher than 95% (some say 90%) for any length of time. Excessive humidity can kill snails. Optimum temperature and relative humidity depend on several things, including the snail variety and even where breeding stock was gathered. For *H. aspersa*, the optimum temperature for hatching eggs seems to be 68 F at 100% relative humidity. The second best temperature/humidity combination depends on where the snails came from and results can drop drastically to 0% hatching at 62.6 F and 100% humidity. Err on the side of a few degrees warmer or a small percentage dryer. Do not keep the soil wet when the humidity is maintained at 100%, as the eggs will absorb water, swell up, and burst.

Use fluorescent lights to give artificial daylight. Different snails respond differently to day length. The ratio of light to darkness influences activity, feeding, and mating andegg-laying. Eighteen or more hours of light apparently stimulate *H. aspersa* growth, while less than 12 hours inhibit it. Some snail species may associates the long hours of light with the start of summer--the peak growing season. Eighteen hours of daylight also appear optimal for breeding (mating and egg laying), but snails will breed in darkness.

Breeding boxes and cages: Snails can be bred in boxes or cages stacked several units high. Use an automatic sprinkler system to provide moisture. Breeding cages should have a feed trough and a water trough. Plastic trays that are a couple of inches deep are adequate; deeper water troughs increase the chance of snails drowning in them. These trays may be set on a bed of small gravel. Fill small plastic pots, e.g., flower pots about 3 inches deep, with sterilized dirt (or a loamy pH neutral soil) and set them in the gravel to give the snails a place to lay their eggs. Remove and replace each pot after the snails lay eggs. (Set one pot inside another so that you can easily lift one out without shifting the gravel.)

After the snails have laid their eggs, put the pots in a nursery where the eggs will hatch. Keep the young snails in the nursery for about 6 weeks. Then move them to a separate pen as young snails do best if kept with other snails of similar size. Eight hours of daylight is optimal for young snails.

The following is an example of starting *H. pomatia* in boxes: Build wooden boxes measuring 25 by 35cm and 25cm high. Cut a 6cm-diameter hole (to drain excess moisture) in the bottom and cover the hole with plastic screening, well secured. Cover a frame with plastic screening to create the box lid. The lids either must open or be removable. Keep the boxes on shelves so they are easily accessible. Fill the boxes one-third full with loose, uncompacted garden soil baked to kill all organisms (insects, nematodes, bacteria, etc.). [Use soil that does not have fertilizer or chemicals in it.] Partially cover the soil with moss, but leave enough room for the snails to crawl around on the dirt. Sprinkle water on the moss.

Move to boxes (three per box) those snails in the outdoor pen that are starting to make holes in which to lay their eggs. After the snails lay eggs, return them to the outside pen. The soil in the boxes must not dry out. Always keep the moss slightly moist. Too much moisture is dangerous,

however, as the eggs may swell up and burst. The eggs hatch in about 25 days, but the baby snails remain in the egg "shells." They then work their way out of the nest for about 10 additional days before they appear on the moss and on the sides of the box. Snails on the wood sides of the box are in danger of drying out and must be *carefully* removed and put on the moss. Shells are very fragile at this time.

Feed the baby snails tender lettuce leaves (Boston type, but head type is probably just as good.) [This description does not include a water trough, but the authors assume there is one. The snails should have water available.]

Three weeks after the snails appear on the moss, carefully remove the baby snails and put them together in a temporary container. Carefully remove the moss and dirt, watching for any more baby snails. Replace the dirt and moss with fresh (sterilized/baked) dirt and fresh moss. Count and return the snails to the box.

The young snails can be kept over winter in these boxes. Stack the boxes in a cool room protected from frost. The room should never get colder than 32 F nor warmer than 37.4 F. Snails will become active again the following spring when the temperature rises above 41 F. Feed them for 4 weeks. They should now average about 8mm. Move them to a pen, carefully clean and dry the boxes, and prepare the boxes for the new season. *H. pomatia* matures in 18 months to 4 years.

Mixed system: A variation of the method above is to let the snails lay the eggs in the outdoor pen, then carefully transfer the eggs to the boxes. [The other steps are the same.] In the pen, look for snails that have dug holes and are in them laying eggs. The tip of their shell will be visible. Stick a marker in the ground next to the hole. When the snail is finished and leaves, use a garden trowel to dig up the eggs and move them. This task is difficult. The eggs can be both physically damaged and covered with dirt.

Example: Five stages of snail raising

Some who raise *H. aspersa* separate the five stages: reproduction, hatching, young, fattening, and final fattening.

In a typical example, the breeding box has concrete sides, soil with earthworms (to cleanse the soil) on the bottom, vegetation, curved tiles to provide shelter, feeders, and a chicken waterer. Mosquito netting or screening covers the top. These breeding boxes may be outside, or you may get better results when the boxes are inside a greenhouse--as long as the greenhouse does not get too hot or too dry. One researcher reported that in outdoor boxes, each breeder snail had about seven young. In greenhouses, each breeder snail had about 9 to 12 young. The researcher felt that under better weather conditions than those he had that year, each adult breeder snail would have produced 15 young snails.

Fattening pens may be outside or in a greenhouse. High summer temperatures and insufficient moisture cause dwarfing and malformations of some snails. This is more a problem inside greenhouses if the sun overheats the building. A sprinkler system (e.g., a horticultural system or common lawn sprinklers) can supply moisture. Make sure excess water can drain.

Fattening pens may contain 2-foot by 3-foot pieces (or other convenient size) of heavy plastic sheets, hung from boards resting on a rack that lets the tips of the plastic sheets just touch the ground. The plastic sheets are about 4 inches apart. The sheets give the snails a resting and hiding place. Feeders may be located on the rack that supports the plastic sheets.

Put a layer of coarse sand and topsoil with earthworms on the fattening pen's bottom. The worms help clean up the snail droppings.

You can put snails that hatched the previous summer in a chilled room for hibernation over winter. Then, about the 1st of April, (adjusted for your local climate), move them to the final fattening pen. If you have several fattening pens, put the smaller snails in one, medium in another, large in another. Do not exceed one-third pound of *H. aspersa* snails per square foot of pen. Since snails lose weight when they estivate in summer, some growers do not stock pens by weight but by count. For *H. aspersa*, 10 to 12 snails per square foot is about the maximum.

Breeding pens can be set up just like the fattening pens or the fattening pens can be used as breeding pens after you harvest the mature snails. Harvest some snails and leave some to breed.

Cannibalism by Hatchlings

The first snails to hatch eat the shells of their eggs. This gives them needed calcium for their shells. They may then begin eating unhatched eggs. If the snail eggs are kept at the optimum temperature, 68 F (for some varieties), and if none of the eggs lose moisture, most eggs will hatch within 1 to 3 days of each other. Cannibalism also will be low. If hatching extends over a longer period, cannibalism may increase. Some eggs eaten are eggs that were not fertile or did not develop properly, but sometimes, properly developing embryos might be eaten. A high density of "clutches" of egg masses increases the rate of cannibalism, as other nearby egg masses are more likely to be found and eaten. Snail egg has 12 to 20 times the protein of salad. The protein helps the baby snails start developing quickly and be healthier. Snail egg is an excellent starter food for newly hatched snails, but they tend to only eat eggs of their own species.

Gathering snails

Besides farming snails, it is possible to gather them free from artichoke, kiwifruit, avocado, and citrus growers in some areas. The growers might pick the snails for you for a fee. In citrus groves where copper bands have been placed around the tree trunks, the snails will crawl up the tree to feed on the leaves. They will stop when they come to the copper band and will remain there for days. The snails gathered just below the band are easy to pick off.

Snails gathered in the wild to stock a snail farm may have a high mortality rate as they adjust to the new conditions. These snails may have consumed poison baits, agricultural chemicals, or poisonous plants (e.g., nightshade); therefore, you should not immediately use them. Put them in a pen and feed them for at least 3 days to purge their system of any toxins and to give them a chance to die if they have consumed a lethal dose. If they are still healthy after 3 or 4 days, they should be O.K.. Withhold all food, except water, for the last 1 to 2 days.

Feeding

Feeding season is April through October, (or may vary with the local climate), with a "rest period" during the summer. Do not place food in one small clump so that there is not enough room for all the snails to get to it. Snails eat solid food by rasping it away with their tongues. Feeding activity depends on the weather, and snails may not necessarily feed every day. Evening irrigation in dry weather may encourage feeding since the moisture makes it easier for the snails to move about.

Put the breeding snails in the breeding pens in April or early May. Feed until mid June when mating begins and the snails stop feeding. Snails resume eating after they lay eggs. Once snails have laid their eggs, you can remove the adult snails. This leaves more food and less crowding for the hatchlings.

Snails of the same species collected from different regions may have different food preferences. Some foods that snails eat are: Alyssum, fruit and leaves of apple, apricot, artichoke (a favorite), aster, barley, beans, bindweed, California boxwood, almost any cabbage variety, camomile, carnation, carrot, cauliflower, celeriac (root celery), celery, ripe cherries, chive, citrus, clover, cress, cucumbers (a favorite snail food), dandelion, elder, henbane, hibiscus, hollyhock, kale, larkspur, leek, lettuce (liked, and makes good snails), lily, magnolia, mountain ash, mulberry, mums, nasturtium, nettle, nightshade berries, oats, onion greens, pansy, parsley, peach, ripe pears, peas, petunia, phlox, plum, potatoes (raw or cooked), pumpkins, radish, rape, rose, sorrel, spinach, sweet pea, thistle, thornapple, tomatoes (well liked), turnip,wheat, yarrow, zinnia. They will eat sweet lupines, but will reject bitter lupines and other plants with high quinolizidine alkaloids. Snails also avoid plants that produce other defensive chemicals, defensive stem hairs, etc.

Snails usually prefer juicy leaves and vegetables over dry ones. If you feed snails vegetable trimmings, damaged fruit, and cooked potatoes, promptly remove uneaten food as it will quickly spoil. You may supply bran that is wet or sprinkle dry bran over leafy vegetables. The diet may consist of 20% wheat bran while 80% is fruit and vegetable material. Some growers use oats, corn meal, soybean meal, or chicken mash. Laying mash provides calcium, as does crushed oyster shells. Snails also may eat materials such as cardboard (but do not purposely feed it to them); they can eat through shipping cartons and escape. Snails may sometimes eat, within a 24-hour period, food equal to 10%, and occasionally as much as 20%, of their body weight. Active snails deprived of food will lose more than one-third of their weight before they starve to death--a process that takes 8 to 12 weeks. Estivating snails can survive much longer.

Supply calcium at least once a week if it is not available in the soil. It should not contain harmful salts or be so alkaline as to burn the snails. Mix calcium with wet bran or mashed potatoes and serve on a pan; this will keep any leftover food from rotting on the ground.

Some researchers use chicken mash for feed. You can cut a plastic pipe in half lengthwise to make two troughs which can be used as feeders for mash. Mix laying mash (used for egg-producing hens) into the feed to provide calcium for the snails' shells. Commercial chicken feeding mash is around 16% to 17% protein, from fish meal and meat meal, making it good for growing snails. Supplying mash to hatchlings might reduce cannibalism. Two feeds that snails like and that promote good growth are: (A) broiler finisher mash consisting of 7% broiler concentrate, 58% corn, 16% soya, 18% sorghum, 7 % limestone flour (40% Ca); and (B) chicken feed (pellets) for layers consisting of 5% layer concentrate, 10%, corn, 15% soya, 20% sorghum, 44% barley, 6% limestone flour (40%Ca).

Pellets are fine for larger snails, but mash is better for younger ones. Partially crush pellets if you feed them to young snails. Snails do not grow well if rabbit pellets are their primary diet. Snails show a distinct preference for moist feed. Ensure easy access to enough water if you feed snails dry mash.

Be sure to frequently clean the feed and water dishes. The amount of feed a snail eats depends very much on air humidity and on the availability of drinking water. You can serve clean drinking water in a shallow container to reduce the risk of the snail drowning. Some types of chicken waterers may be suitable. Other factors (e.g., temperature, light intensity, food preferences versus food supplied, etc.) also affect feeding. A compromise, until you find the optimum feed, is to feed half green vegetable material and half chicken feed/grain/animal protein.

Young *H. aspersa* readily eats milk powder. Its rapid rate of assimilation promotes rapid growth.

Diseases and Pests

Basic common sense hygiene may prevent the spread of disease or otherwise improve the health and growth rate of snails. For example, remove and replace food daily to prevent spoilage. Earthworms added to the soil will help keep the pen clean.

Parasites, nematodes, trematodes, fungi, and microarthropods may attack snails, and such problems can spread rapidly when snail populations are dense. The bacterium Pseudomonas aeruginosa causes intestinal infections that can spread rapidly in a crowded snail pen.

Watch for predators such as: rats, mice, moles, skunks, weasels, birds, frogs and toads, lizards, walking insects (e.g., some beetle and cricket varieties), some types of flies, centipedes, and even certain cannibalistic snail varieties (such as *Strangesta capillacea*).

Population Density

Population density also affects successful snail production. Pens should contain no more than six to eight fair-sized snails per square foot, or about four large *H. pomatias*; or figure one kilogram per square meter (about .2 pounds of snail per square foot), which automatically compensates for the size of the snails. If you want them to breed, best results will occur with not more than eight snails per square meter (.8 snails per square foot). Some sources say that, for *H. pomatia* to breed, .2 to .4 snails per square foot is the maximum.

Snails tend not to breed when packed too densely or when the slime in the pen accumulates too much. The slime apparently works like a pheromone and suppresses reproduction. On the other hand, snails in groups of about 100 seem to breed better than when only a few snails are confined together. Perhaps they have more potential mates from which to choose. Snails in a densely populated area grow more slowly even when

food is abundant, and they also have a higher mortality rate. These snails then become smaller adults who lay fewer clutches of eggs, have fewer eggs per clutch, and the eggs have a lower hatch rate. Smaller adult snails sell for less. Dwarfing is quite common in snail farming and is attributable mainly to rearing conditions rather than heredity factors. Crowding snails is false economy. A recommended rate for *H. aspersa* is not more than one-third pound per square foot of soil surface for snails that weigh more than 1 gram and not more than .2 pound per square foot for snails that weigh less. (One ounce is about 28 grams.)

Return to: Contents

Shipping

Select only active snails for canning, processing or shipping. An inactive snail may be sick or dying. It is best to ship live snails (laws permitting) while dormant, between late Fall and early March, although it is then difficult to be sure they are "active." Inspect each snail to be sure it looks healthy. Put them in a container packed in ice to keep the temperature near (but not below) freezing to keep the snails dormant. When the weather warms up and the snails are active, they cannot be packed so closely in cartons. As live animals, you must handle them humanely. Some sources say not to ship live snails (*H. pomatia*) after June begins, as they no longer have good flavor. *H. aspersa* has a fragile shell until it matures and forms a lip, so immature snails are not commercially desirable.

Snails tend not to eat during shipping. Do not provide food, as it will spoil and may make the snails sick or die. Purge the snails' digestive tracts to ensure that they are clear of grit or previously-eaten food. Three or 4 days before transporting, put the snails in a separate container without dirt or other kinds of food. Feed the snails cornmeal or bran for several days. As it passes through the digestive tract, it will clean out previously-eaten food. Stop feeding, but continue to supply water. Clean the pens and snails several times a day to keep out mucus and fecal matter.

Shipping cartons must have air holes, preferably screened to prevent escape or injury to the snails. Be careful not to injure snails with wires or staples when closing the carton. Also remember, snails can push upward against a barrier with a force equal to several times their own weight. Enough snails may cause the carton lids to pop off and may even loosen nails.

Return to: Contents

Turning Snails into Escargot

Snails are mature when a lip forms at the opening of their shell. Before they mature, their shells are more easily broken, making them undesirable. For *H. aspersa*, commercial weight is 8 grams or larger.

The nutrient composition of raw snails (per 100 grams of edible portion), according to information from the nutrient databank of France, is:

Energy (kcal): 80.5
Water (g): 79
Protein (g): 16
Available carbohydrates (g): 2
Fibres (g): 0
Fat (g): 1
Magnesium (mg): 250
Calcium (mg): 170
Iron (mg): 3.5
Vitamin C (mg): 0

Snails are washed, steamed, shelled, then washed in a vinegar- (or lemon juice) and water-solution before they are canned. Producing a quality canned product is somewhat tricky, and you must take care to prevent food poisoning. To prepare live snails for cooking, remove the membrane, if any, over the shell opening. Soak the snails in enough water to cover them. (Add 1/2-cup salt or 1/4-cup vinegar for every 50 snails.) Mucus will turn the water white. Change the water several times during the 3- to 4-hour soaking. Rinse several times or under running water until no mucus remains. Put snails in cold water and bring to a boil. Boil about eight minutes, then drain and plunge the snails into cold water. Drain. With a needle or small fork, pick the snails out of their shells. Remove the intestine and cut off all black parts. (Some cooks also cut off the head, tail, and all "cartilage or gristle.") Prepare according to your recipe. An alternate method is: Wash the snails well in clear water. Drop into boiling salt water (to which you may add lemon juice and/or herbs), and cook--about 10-15 minutes--until you can easily remove the snails from their shells. Drain and rinse.

Prepare the giant African snail by breaking away the shell, then cutting the foot away from the rest of the body. The traditional way to remove the slime is to rub wood ashes on the snail, then wash the snail (or part of the snail) under running water, then repeat until no slime remains. You may substitute substances like flour (to which you may add salt and vinegar) for ashes. Cut up the foot into convenient-sized pieces. [You may dehydrate the leftover visceral mass, crush it up with the shell, and mix it in poultry feed to make up 10% of your snail feed.] Another source says put the live snails in boiling water for 30 minutes to kill them and to make removal from the shell easy. During boiling, the snails will release a large quantity of mucus. Data varies, but 28% to 46% of the live weight of Achatina is shell.

Return to: Contents

Restrictions and Regulations

The same snails that some people raise or gather as food also are agricultural pests that cause considerable crop damage. Introduced slug and snail varieties tend to be worse pests than native species, probably due in part to the lack of natural controls. Snail pests attack crops ranging from leafy vegetables to fruits that grow near the ground, such as strawberries and tomatoes, to citrus fruits high up on trees.

The Federal Plant Pest Act defines a plant pest as "any living stage (including active and dormant forms) of insects, mites, nematodes, slugs, **snails**, protozoa, or other invertebrate animals, bacteria, fungi, other parasitic plants or reproductive parts thereof; viruses; or any organisms similar to or allied with any of the foregoing; or any infectious substances, which can directly or indirectly injure or cause disease or damage in or to any plants or parts thereof, or any processed, manufactured, or other products of plants..." The Animal Plant Health and Inspection Service (APHIS) categorizes giant African snails as a "quarantine significant plant pest." The United States does not allow live giant African snails into the country under any circumstances. It is illegal to own or to possess them. APHIS vigorously enforces this regulation and destroys or returns these snails to their country of origin. For more information, see APHIS Permits: Snails and Slugs (http://www.aphis.usda.gov/plant_health/permits/index.shtml), or the National Invasive Species Information Center Species Profile: Giant African Snail (http://www.invasivespeciesinfo.gov/animals/africansnail.shtml).

Since large infestations of snails can do devastating damage, many states have quarantines against nursery products, and other products, from infested states. Further, it is illegal to import snails (or slugs) into the U.S. without permission from the Plant Protection and Quarantine (PPQ) Division, Animal Plant Health and Inspection Service, U.S. Department of Agriculture. For more information, contact Plant Pest Evaluations Toll Free Telephone: 866-524-5421. APHIS also oversees interstate transportation of snails. To import snails into the U.S. and/or move them interstate, download application or apply on-line for an APHIS PPQ 526 Plant Pest Permit at http://www.aphis.usda.gov/permits/ppq_epermits.shtml. To access the on-line permitting system, create a level 2 eAuthentication account at https://eauth.sc.egov.usda.gov/eAuth/selfRegistration/selfRegLevel2Step1.jsp. To complete the level 2 eAuthentication process, contact your nearest local registration authority, which can be found at http://offices.sc.egov.usda.gov/locator/app.

The Food and Drug Administration (FDA) regulates the **canning** of low-acid foods such as snails. According to FDA, "establishments engaged in the manufacture of Low-acid or Acidified Canned Foods (LACF) offered for interstate commerce in the United States are required. . .to register their facility. . .and file scheduled processes for their products with" the FDA. This does not refer to fresh products. For appropriate forms, contact: LACF Registration Coordinator, HFS-618, Food and Drug Administration, Center for Food Safety and Applied Nutrition, 200 C Street, S.W., Washington, D.C. 20204. Telephone: (202) 205-5282. FAX: (202) 205-4758 or (202) 205-4128.

Improper canning of low-acid meats, e.g., snails, involves a risk of botulism. When canning snails for home consumption, carefully follow canning instructions for low-acid meats to prevent food poisoning.

State laws also may apply to imports into certain states and to raising snails in a given state. Your state also may want to inspect and approve your facility. Thus anyone who plans to raise snails also should check with their State's Agriculture Department.

Return to: Contents

U.S. Imports and Exports

General information on importing agricultural products to the U.S. is available at:

- The United States Department of Agriculture, Animal and Plant Health Inspection Service
  Information on Importing and Exporting, http://www.aphis.usda.gov/ppq/permits/plantpest/snails_slugs.html or
  http://www.aphis.usda.gov/import_export/

- Export.Gov offers resources from across the U.S. governement. One is a factsheet titled *How can I obtain information about importing products into the United States?* (http://www.export.gov/exportbasics/eg_main_017477.asp)

- The U.S. Food and Drug Administration, Center for Food Safety and Applied Nutrition provides information about acidified and low-acid canned foods, including regulations; and guidance and compliance resources (http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/AcidifiedLow-AcidCannedFoods/default.htm). Common questions about Establishment Registration and Processing Filing for Acidified and Low-Acid Canned Foods may be found at http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/AcidifiedLow-AcidCannedFoods/
  EstablishmentRegistrationThermalProcessFiling/Instructions/ucm125810.htm

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U.S. Import and Export Statistics

U.S. Census
Import/Export Statistics (http://www.census.gov/econ/overview/index.html#inttrade)
Call (301) 457-2242. Provide the 10-digit subject code. There is a fee if the information is faxed to you. Mailed printouts are free.
http://www.census.gov/foreign-trade/reference/codes/sitc/sitc.txt

U.S. Department of Commerce, Commerce Department Online Services
http://www.commerce.gov/index.htm
* STAT-USA (or go to http://www.stat-usa.gov/)
Select GLOBUS and NTDB

The United States International Trade Commission
http://dataweb.usitc.gov

Select "Interactive Tariff and Trade DataWeb Login"
Create an account. Login in.
Create a New Query/Report. When you create this report, use the "Create a New Commodity List" button in the "Select All Commodities or a Pre-Defined List" section to develop a report that calculates statistics for snails.
The HTS codes are:
0307.60.0000: SNAILS, OTHER THAN SEA SNAILS, LIVE, FRESH, CHILLED, FROZEN, DRIED, SALTED OR IN BRINE
1605.90.5500: SNAILS, OTHER THAN SEA SNAILS, PREPARED OR PRESERVED
The 5-digit SITC code is:
01293 - SNAILS, EXCEPT SEA SNAILS, FRESH CHILLED...

Return to: Contents

Contacts

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URL: http://www.lumache-elici.com/en/

Instituto Internacional De Helicicultura
Cl. Sant Salvador D`Horta, 42 17003-Girona
FAX: 972.20.95.35
Phone: 657.87.11.12
URL: http://www.helicicultura.com/Castellano.htm

Plant Pest Evaluations
Toll free: 866-524-5421
Information on Plant Pest Permits: http://www.aphis.usda.gov/plant_health/permits/index.shtml
Provides information on U.S. regulations for the raising, handling, import or export of snails.

Return to: Contents

References

Electronic References

There are few online documents that focus specifically on snail production. Many documents focus on eradication efforts. However, some information found at these sites also can be useful for rearing snails.

The sites below contain general information, images, and/or diagrams. To locate additional online resources, try the automated searches at the end of this section.

- **Animal Plant Health and Inspection Service (APHIS), Plant Protection and Quarantine (PPQ) Division.** Information on Plant Pest Permits.
  URL: http://www.aphis.usda.gov/ppq/permits/

- **Agriculture Notes: Snails**. (Australia)
  URL:
  http://www.dpi.vic.gov.au/DPI/nreninf.nsf/9e58661e880ba9e44a256c640023eb2e/4663e08f5200b0c3ca256f350007bbca/$FILE/AG0743.pdf

- ***Ventures***, 11950 W. Highland Avenue, Blackwell, OK 74631 USA. Phone: 580-628-4551; FAX: 580-628-2011. E-mail: agventures@aol.com. [NAL CALL No.:DNAL S441.A475]
  URL: http://www.agventures.com
  Published *Snail Farming - Production, Potential and Profitability* and the following articles:
  - Silva, Beth. "Heliculture is Hot and Markets are Many: Snail Farmers Demonstrate That There's More Than One Way to Sell A Snail. Part 1." In: AgVentures, Volume 3, Issue 1, February/March 1999, pages 47-48.
  - Silva, Beth. "Heliculture is Hot and Markets are Many: Snail Farmers Demonstrate That There's More Than One Way to Sell A Snail. Part 2." In: AgVentures, Volume 3, Issue 2, April/May 1999, pages 44-46, and p. 61.
  - Silva, Beth. "The Snail Market A Slow but Sure Opportunity." In: AgVentures, Volume 1, Issue 3, October/November 1997, pages 58-62

- **All About Snails (for kids and teachers)**
  URL: http://www.kiddyhouse.com/Snails/snail.html

- **All You Need to Know About Snails**.
  URL: http://www.escargot.fr/uk/tout.htm

- **Annuaire Environment, Nature, Ecologie**.
  URL: http://www.univers-nature.com/ref/ref_recal.cgi?recmc=escargots

- **Biology of Gastropod Molluscs** (Research, publications, images)
  Ronald Chase (McGill University, Biology Department, Montreal, Quebec, Canada)
  URL: http://biology.mcgill.ca/faculty/chase/

- **Breeding and Growing Snails Commercially in Australia**. By B. Murphy. RIRDC Project No. ARH-1A. RIRDC Publication No. 00/188. Rural Industries Research and Development Corporation, 2001.
  URL: www.rirdc.gov.au/reports/NAP/00-188.htm

- **Centro de Helicicultures Argentinos**. (Spanish)
  URL: www.cedeha.com/intro.htm

- **Concerning History of Snail Cultivation**. (Also includes information on economics of snail cultivation and the types of escargot.)
  URL: http://weichtiere.at/english/gastropoda/index.html

- **Escargot.at. (German)**.
  URL: www.escargot.at

- **Escargot Passion**
  URL: http://escargot.free.fr/eng/index.html (English)
  URL: http://escargot.free.fr/fra/index.html (French)

- **Escargot Peru: Association of Peruvian Helices Culture**.
  URL: http://www.escargotperu.com/

- **Escargots Funcia**
  URL: www.escargot.com.br/eng/index.html

- **Farming Edible Snails - lessons from Italy** By Sonya Begg. Rural Industries Research and Development Corporation (Australia). RIRDC Publication Number: 03/137 RIRDC Project Number: SF1-1A
  https://rirdc.infoservices.com.au/downloads/03-137.pdf

- **Farming Roman Snails**
  URL: http://weichtiere.at/Mollusks/Schnecken/weinberg.html

- **Featured Creatures. Common name: brown garden snail. Scientific name: Helix aspersa Müller (Gastropoda: Pulmonata: Helicidae)**
  URL: http://creatures.ifas.ufl.edu/misc/gastro/brown_garden_snail.htm

- **First Cooperative of Snail Breeders**. (Serbia and Montenegro)
  URL: http://www.prvazadruga.com/e_mi.htm

- **FOSSWeb: Land Snails**. (educational)
  URL: http://www.lawrencehallofscience.org/foss/fossweb/teachers/materials/plantanimal/landsnails.html

- **Free-range Snail Farming in Australia. By Sonya Begg. Rural Industries Research and Development Corporation (Australia).** RIRDC Publication Number: 06/104. RIRDC Project Number: SF1-1A.
  URL: https://rirdc.infoservices.com.au/downloads/06-104.pdf

- **Gastronomic Gastropods.** In: *New Agriculturalist online*, March 1999.
  URL: http://www.new-agri.co.uk/99-3/focuson/focuson3.html

- **Case Study: the Golden Apple Snail**.
  URL: http://www.state.gov/g/oes/ocns/inv/cs/2312.htm

- **Helicicultura: Instito Brasileiro de Helicicultura**.
  URL: www.cedic.org.br/ibh_inst.asp

- **Heliciculture: Books on Snails and Snail Farming**.
  URL: http://www.heliciculture.co.uk/books.asp

- **Heliciculture: Culture of Edible Snails**. British Columbia, Ministry of Agriculture, Food and Fisheries
  URL: http://www.agf.gov.bc.ca/resmgmt/publist/700series/770.000-1.pdf

- **Heliciculture: Snail Farming in the UK**.
  URL: http://www.heliciculture.co.uk/index.asp

- **Helix Aspersa**. (images)
  URL: http://wwwbio200.nsm.buffalo.edu/labs/tutor/Snail/

- **Helix Web**.
  URL: http://www.helix.web.pt/

- **How to manage Pests : Snails and Slugs. U.C. Pest Management Guidelines (Davis, CA)**. (Includes images)
  URL: http://ipm.ucdavis.edu/PMG/PESTNOTES/pn7427.html

- **Index of Snail Families**.
  URL: http://members.tripod.com/arnobrosi/snailfamilies.html

- **Institut fuer Deutsche Schneckenzucht** (Institute for German Heliculture). (German)
  Located in Nersingen, Bavaria, Germany.
  URL: http://www.schneckenzucht.de/

- **Institute d'Helicicultura de Girona**.
  URL: http://www.helicicultura.com/Castellano.htm

- **La Fontaine De Bernn. Snail Farming**.
  URL: http://www.escargot.fr/uk/

- **Land Snails of Pennslyvania.**.
  URL: http://carnegiemnh.org/mollusks/palandsnails/

- **Lista bibliografica y sitios referidos a la cria de Helix aspersa (Bibliography and Sites that reference Helix aspersa)**.
  URL: http://www.zoetecnocampo.com/Documentos/helix/bibliog_escargot.htm

- **The Living World of Molluscs: Gastropods**.
  URL: http://weichtiere.at/english/gastropoda/index.html

- **Man and Mollusc's Data Base of Edible Molluscs**.
  URL: http://www.manandmollusc.net/molluscan_food_files/molluscan_food_terrestrial.html

- **Market Development: Market Brief on Snails**. Overview of the European Community, 1993. International Trad Centre UNCTAD/WTO
  URL: http://www.helixdelsur.com.ar/web/mercadoeuropeo.pdf

- **A Natural History of Terrestrial Snails.**. Laura Klappenbach.
  URL: http://animals.about.com/od/mollusks/ig/World-of-Snails/Snail-1.htm or http://animals.about.com/od/mollusks/ig/World-of-Snails/
  [Select "Continue Gallery"]

- **Pest Management: Snails and Slugs** (University of California)
  URL: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7427.html

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["Snail farming."] "L'achatiniculture."
Hardouin J; Stievenart C; and J. T. C. Codjia.
[Address: Bureau pour l'echange et la distribution de l'information sur le mini-elevage, Unite de zoologie generale et appliquee, Faculte des sciences agronomiques de l'Etat, 2, Passage des Deportes, 5030 Gembloux, Belgium.] *World Animal Review* no. 83 (1995): 29-39. Includes 16 references.
(Language: French; summaries in English and Spanish.)
Abstract: This articles discusses the giant snails of the Achatina, Archachatina, Burtoa and Limicolaria species in Africa. Topics include the current market for snails, breeding, feeding and nutrition, growth, habitats, and pathogens.

146. **NAL Call No.: SF597.S6C5**
[Snail Farming.] L'elevage Des Escargots: Production et Preparation du Petit- Gris.
Chevallier, Henry. Maisons-Alfort: Editions du Point Veterinaire, 1985. 128 pp. Includes references and illustrations.
(Language: French.)
Abstract: Each issue of this bimonthly magazine focuses on a specific aspect of snail farming, e.g., nutrition, housing, breeding, environment, etc. Includes graphs, charts, drawings, etc.

147. **NAL Call No.: 23-N484**
"Snail farming for export--the pace quickens [Culture, markets, New Zealand]."
Pos, H. *New Zealand Farmer* [Auckland: New Zealand Newspapers] 105, no. 11 (June 14, 1984): pp. 99, 101, 102.

148. **NAL Call No.: SB599.B73**
"Snail farming in field pens in Italy."
Elmslie, L. J. In the series analytic: *Slugs and Snails in World Agriculture. Proceedings of a Symposium Organized by the British Crop Protection Council with the Support of the Malacological Society of London, April 10-12, 1989, University of Surrey, Guildford, England*. I. Henderson, ed. British Crop Protection Council Monograph Series, no. 41 (1989): 19-25. Thornton Heath, [England]: British Crop Protection Council, 1989.
Abstract: Discusses culture of edible snails in Italy, particularly the Helix aspersa. Includes information on snail pens and rearing techniques.

149. **NAL Call No.: SB599.B73**
"Snail farming in the United Kingdom."
Runham, N. W. In the series analytic: *Slugs and Snails in World Agriculture. Proceedings of a Symposium Organized by the British Crop Protection Council with the Support of the Malacological Society of London, April 10-12, 1989, University of Surrey, Guildford, England*. I. Henderson, ed. British Crop Protection Council Monograph Series, no. 41 (1989): 49-55. Thornton Heath, [England]: British Crop Protection Council, 1989.

150. **NAL Call No.: SF597.S6S52**
Snail Farming Research: A Collection of Papers Published in Conjunction with the First International Award for Research on Snail Farming Offered by Associazione Nazionale Elicicoltori (A.N.E.), the Italian Snail Farmers Association.
Associazione Nazionale Elicicoltori (Italy). [Scientific Committee of the Italian Snail Farmers Association, trans. and ed.] Cherasco, Italy: Associazione Nazionale Elicicoltori, 1986. 91 pp.

151. **NAL Call No.: SF597.S6S52**
"Snail farming techniques and research problems."
Elmslie, L. J. *Snail Farming Research: A Collection of Papers Published in Conjunction with the First International Award for Research on Snail Farming by The Italian SnailFarmers Association*. [Scientific Committee of the Italian Snail Farmers Association, trans. and ed.] Cherasco, Italy: Associazione Nazionale Elicicoltori, 1986. pp. 84-89. Includes references.
Abstract: Includes information on farming systems; animal housing; pens; loose housing; nutrition and feeding; and stocking-density

152. **["The snail, have a look on the market [in Italy]."] "Chiocciola, un occhio al mercato [in Italia]."**
Nunzi, L. *Terra e Sole (Italy)* 48, no. 610 (June 1993): 307-308.
(Language: Italian.)
Abstract: Describes snail culture in Italy and the Italian market for edible snails. Contains marketing information and data on production, consumption, imports, foreign trade, and wholesale prices.

153. **[Snail Helix Aspersa: Biology, Breeding.] L' Escargot Helix Aspersa: Biologie, Elevage.**
Bonnet, J. C.; Aupinel, P.; and J. L. Vrillon. Paris, France: Institut National de la Recherche Agronomique [Address: Domaine Pluridisciplinaire du Magneraud, 17700 Surgeres, France], 1990. 124 pp. Includes bibliography, glossary, production figures, tables, and 49 graphs.

154. **["Snail husbandry in the Slovak Republic."] "Sucasna situacia v CSFR."**
Euro Helix Co. (Bratislava, CSFR). *Chov Slimakov* v. 1 (December 1990): p. 5.
Abstract: Describes five new snail farms in the Slovak Republic.

155. **NAL Call No.: S441.A475**
The snail market: a slow but sure opportunity.
Silva, B. *AgVentures*. Blackwell, OK : Schatz Pub. Group, c1997-. Oct/Nov 1997. v. 1 (3) p. 58-59, 61-62.
(Language: English)

156. **NAL Call No.: SF597 S6J65**
Snail Production Basics.
Johnson, Richard M; and Richard V. Johnson. Sanger, CA: Frescargot Farms, 1987. 3 pp.
Includes 7 references.
Abstract: Gives a brief overview of the history, biology, and anatomy of snails; describes feeding and nutrition, sanitation and hygiene, preferred environment, and breeding and rearing techniques.

157. **NAL Call No.: SF597.S6J65**
Snail Production Techniques: Raising Terrestrial Snails (Helicidae) Commercially.
Johnson, Richard V. Sanger, CA: Frescargot Farms, Inc., rev. May 1995. 87 pp.
Abstract: This guide discusses snail body systems and body processes; production facilities and equipment; nutritional guidelines for snails; snail processing and preparation; predators, pests, and parasites; snail production management; and snail production troubleshooting. Includes illustrations, references, a glossary, sample application forms, and recipes.

158. **Snail Production Techniques: Raising Terrestrial Snails (Helicidae) Commercially.**
Sanger, CA: Frescargot Farms, Inc., 1995. Video (VHS, 40 minutes.)

159. **"Snail rancher: escargot finding a niche."**
The Associated Press. *St. Louis Post Dispatch*, Five Star Lift ed., November 19, 1995, Business Section, p. 03E.

160. **NAL Call No.: SF597 S6G7**
[Snail Rearing.] La Chiocciola D'allevamento.
Griglione, Natale. In the series: *I Libri Di Vita in Campagna*. Verona: Edizioni L'Informatore Agrario. 1990. 103 pp. Includes references and illustrations. (Language: Italian.)

161. **NAL Call No.: SB599.B73**
"Snail rearing or heliciculture of Helix aspersa Muller."
Daguzan, J. In the series analytic: *Slugs and Snails in World Agriculture. Proceedings of a Symposium Organized by the British Crop Protection Council with the Support of theMalacological Society of London, April 10-12, 1989, University of Surrey, Guildford, England*. I. Henderson, ed. British Crop Protection Council Monograph Series, no. 41 (1989): 3-10. Thornton Heath, [England]: British Crop Protection Council, 1989.

162. **NAL Call No.: SF597.S6V53 1986**
[Snails.] Escargots: Criacao Domestica E Comercial.
Vieira, Marcio Infante. Sao Paulo, Brasil: Nobel, 1986. 4a edition. 131 pp. (Language: Portuguese.)

163. **NAL Call No.: QL430.4 C72**
[Snails.] L'escargot: Zoologie, Symbolique, Imaginaire, Medecine et Gastronomie.
Cranga, Francoise. Dijon: les Editions du bien public, 1991. 183 pp. Includes references.
(Language: French.)

164. **"Snails pace the path to profit; escargot ranchers riding herd to yuppie market."**
Hamilton, Martha M. *The Washington Post*, April 05, 1987, p. h01

165. **NAL Call No.: SF597.S6F72 1983**
[Snails and Snail Culture.] L'escargot et l'heliciculture.
Daguzan, Jacques. [France. Ministere de l'agriculture. Informations techniques des services veterinaires.] Paris: Ministere de l'agriculture, 1983. 207 pp. Includes references, illustrations, graphs, and photos.
(Language: French.)

166. **NAL Call No.: 41.8-V641**
"Snails and snail farming: an introduction for the veterinary profession."
Cooper, J. E.; and C. Knowler. *The Veterinary Record: Journal of the British Veterinary Association* 129, no. 25/26 (December 1991): 541-549. Includes references.
Abstract: Heliciculture increases the likelihood that snail farmers will consult a veterinarian about the health, diet, well-being, or conservation of snails. This article describes the biology, anatomy, and reproductive systems of snails; proper environment; handling and transportation considerations; nutritional requirements; and predators and parasites.

167. **["Snails and snail farming: An introduction for the veterinary profession."] "Lumache e loro allevamento: un nuovo interesse per la professione veterinaria."**
Cooper, J. E.; and C. Knowler. *Selezione Veterinaria (Italy)* 34, no. 1 (January 1993): 91- 92.
(Language: Italian.)

168. **[Snails and its Utilization.] Bekicot Dan Manfaatnya.**
Ungaran (Indonesia): Balai Informasi Pertanian Jawa Tengah, 1988. 36 pp. Includes 8 references; 14 illustrations.
(Language: Indonesian.)
Descriptors: snails; snail-culture; feeds; foods; food-technology; animal-production; mollusca; production

169. **NAL Call No.: S441.A475**
Snails--slow, edible, and highly profitable.
Wiley, M.K. *AgVentures*. Blackwell, OK : Schatz Pub. Group, c1997-. Dec 2001/ Jan 2002. v. 5 (6) p. 14-17.
(Language: English)

170. **"A snail's tale; it's a very different sort of ranching."**
Sietsema, Tom. *The Washington Post*, November 4, 1987, Food Section, p. E01.

171. **NAL Call No.: SF597.S6S52**
"Some aspects of the reproduction of Helix aspersa (Muller)."
Stephanou, D. *Snail Farming Research: A Collection of Papers Published in Conjunction with the First International Award for Research on Snail Farming by The Italian Snail Farmers Association*. [Scientific Committee of the Italian Snail Farmers Association, trans. and ed.] Cherasco, Italy: Associazione Nazionale Elicicoltori, 1986. pp. 34-41. Includes references.
Abstract: Describes culture of Helix aspersa including reproduction, stocking density, hatch success of eggs, and proper environment.

172. **NAL Call No.: 41.8 V6439**
["Some aspects of snail breeding."] "Niektore aspekty chovu slimakov."
Puzder M.; and F. Lesnik. *Veterinarstvi* 42, no. 6 (June 1992): 222-223.
(Language: Slovakian.)
Abstract: This article on raising Helix aspersa includes information on snail biology, age,weight, reproductive performance, environment factors (temperature, humidity), lighting, feeds and feeding, and biology.

173. **"Some facts and updates on edible snails and snail farming."**
Quinones, N. C. *Tigerpaper (FAO)* 21, no. 1 (January-March 1994): 8-14. [FAO Accession No: XF95:347539 (available on Microfiche).]
Abstract: Gives a short background on snails; describes various aspects of snail culture such as feeding habits, feeds, and nutrition; behavior and reproduction; and pens and cages.

174. **NAL Call No.: SF191.W6**
"Some observations on the edible giant land snails of West Africa."
Hodasi, J. K. M. *World Animal Review*, no. 52 (Rome: FAO, 1984): 24-28. Includes references, illustrations, and maps.

175. **NAL Call No.: SF597.S6S52**
"Some observations on the feeding behaviour and food preferences of the giant West African snail Archachatina marginata (Swainson)."
Hodasi, J. K. M. *Snail Farming Research: A Collection of Papers Published in Conjunction with the First International Award for Research on Snail Farming by The Italian Snail Farmers Association*. [Scientific Committee of the Italian Snail Farmers Association, trans. and ed.] Cherasco, Italy: Associazione Nazionale Elicicoltori, 1986. pp. 54-66. Includes references.

176. **"Some really slow 'pokes: Texan corrals snail trade rancher goes high tech to fatten up his tiny herd."**
Bundy, Beverly. *The Arizona Republic*, final ed., October 7, 1995, p. A35.

177. **"Some really slow 'pokes: Texas 'ranch' raises snails."**
Bundy, Beverly. *Phoenix Gazette*, final ed., October 6, 1995, p. A35

178. **["Studies and practical applications on the open breeding of Helix pomatia."] "Studi e applicazioni pratiche sull' allevamento all' aperto di Helix pomatia."**
Cavallo-Passerini, M. G. *Elicicoltura (Italy)*, no. 2 (July 1993): p. 7.
(Language: Italian.)

179. **Strain differences in Helix pomatia L. (Gastropoda: Pulmonata): diapause, digging, growth rate and shell fill.**
Elmslie, L.J. *Journal of Molluscan Studies*. 2001, 67: 1, 121-124. Includes references.
(Language: English)

180. **NAL Call No.: 442.8-B5265**
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Turcek, F. J. *Biologia Bratislava* 25, no. 2 (1970): 103-108.

181. **["Study of the garden snail Helix aspersa M., under artificial rearing conditions."] "Estudio del caracol de jardin Helix aspersa M., bajo condiciones de cria artificial."**
Rebolledo, R.R.; Tapia, P; and L. L. Leonelli. *Simiente (Chile)* [Universidad de la Forontera, Temuco, Chile.] 62, no. 1 (March 1992): 1, 8-13. Includes 6 references.
(Language: Spanish; summaries in English and Spanish.)
Abstract: The feeding habits, food preferences, and behavior of the Helix aspersa was studied in artificial growing conditions over a 3-month period. Chile's potential market for Helix aspersa is discussed.

182. **NAL Call No.: 9.3 SI4**
["Study on selection of the reproducing subjects [of Helix pomatia] by the investigation of embryonic coil diameter."] "Studio sulla selezione dei soggetti riproduttori [di Helix pomatia] mediante l' esame del diametro della spira embrionale."
Griglione, N. *Elicicoltura (Italy)*, no. 2 (July 1993): 4-5. Includes 4 tables.
(Language: Italian.)

183. **NAL Call No.: 23-N484**
"Systems for snail farming."
Pos, H. *New Zealand Farmer* 105, no. 13 (July 12, 1984): 93-94, 96.
Abstract: This article describes four types of snail farming systems.

184. **NAL Call No.: QL750.O3**
"Terpene-based selective herbivory by Helix aspersa (Mollusca) on Thymus vulgaris (Labiatae)."
Linhart, Y.B.; and J. D. Thompson. *Oecologia* [Berlin, W. Germany: Springer International] 102, no. 1 (1995): 126-132.

185. **"USDA to pet store owners: Don't let that escargot! Federal agents are trying to track down 1,000 illegally imported giant African snails."**
Pressley, Sue Anne. *The Washington Post*, final ed., May 23, 1992, pp. F03.

186. **Variability of egg cannibalism in the land snail Helix aspersa in relation to the number of eggs available and the presence of soil.**
Desbuquois, C.; Chevalier, L.; Madec, L. *Journal of Molluscan Studies*. 2000, 66: 2, 273-281. Includes references.
(Language: English)

187. **NAL Call No.: 49-F84**
["Variations in the reproductive capacities of 'Petit-gris' snails, Helix aspersa Muller according to their geographic origin. I. Mating and egg laying."] "Variations des capacites reproductrices de l'escargot 'Petit-gris' Helix aspersa Muller (Mollusque, Gasteropode, Pulmone, Stylommatophore), selon son origine geographique. I. Accouplement et ponte."
Guemene, D.; Daguzan, J. *Annales de Zootechnie* [Paris: Institut National de la Recherche Agronomique] 31, no. 4 (1982): 369-390. Includes references.
(Language: French; summary in English.)

188. **NAL Call No.: 49-F84**
["Variations in the reproductive capacities of 'Petit-gris' snails, Helix aspersa Muller (Mollusca, Gasteropoda, Pulmonata, Stylommatophora) according to their geographic origin. II. Incubation of eggs and hatching of juveniles."] "Variations des capacites reproductrices de l'escargot "Petit-gris" Helix aspersa Muller (Mollusque, Gasteropode, Pulmone, Stylommatophore), selon son origine geographique. II. Incubation des oeufs et eclosion des jeunes."
Guemene, D.; and J. Daguzan. *Annales de Zootechnie* [Paris: Institut National de la Recherche Agronomique] 32, no. 4 (1983): 525-538. Includes references.
(Language: French; summary in English.)

189. **["What healthy snails need. Knowledge and experience of a practicing veterinarian in feeding snails of the species Helix aspersa M., their husbandry and disease occurrence."] "Co potrebuje zdravy hlemyzd'. Poznatky a zkusenosti praktickeho veterinarniho lekare s krmivem pro hlemyzde druhu Helix aspersa M., technologii a vyskytem nemoci."**
Martinkova, I. *Veterinarstvi* 44 (1994): 9, 434.
(Language: Czechoslovakian.)

190. **["The winter coating [in the Helix husbandry]."] "La copertura invernale [nell' allevamento della Helix]."**
Santomaggio, G. *Elicicoltura (Italy)* no. 3, (November 1994): 8-10. Includes 10 tables.
(Language: Italian.)

191. **["Winter preservation of Helix pomatia [housings in the husbandries]."] "Conservazione invernale di Helix pomatia [ricoveri negli allevamenti]."**
Griglione, N. *Elicicoltura (Italy)* no. 3, (November 1994): 4-5. (Language: Italian.)

Notes

1. "Of snails." *Roman Farm Management: The Treatises of Cato and Varro*. Trans. "A Virginia Farmer," from Varro's Rerum Rusticarum, Libri III. New York: The MacMillan Company, 1913. pp. 325-327.

2. Pos, Hans. "Systems for snail farming." *New England Farmer* 105, no. 13 (July 12, 1984).

3. J.K.M. Hodasi, "Some observations on the feeding behaviour and food preferences of the giant West African snail Archachatina marginata (Swainson)," in *Snail Farming Research: A Collection of Papers Published in Conjunction with the First International Award for Research on Snail Farming by The Italian Snail Farmers Association*. [Scientific Committee of the Italian Snail Farmers Association, trans. and ed.] Cherasco, Italy: Associazione Nazionale Elicicoltori, 1986. pp. 54-66.]

Return to: Contents

Metric Conversion Charts

Convert Fahrenheit to Celsius

The formula to convert degrees Fahrenheit (F) to degrees Celsius (C) is: F=(Cx1.8) +32

32° F equals 0° C
50° F equals 10° C
69° F equals 20° C
77° F equals 25° C
86° F equals 30° C

Convert Millimeters to Inches

The formula to convert millimeters to inches is: mm x 0.04 = inches
The formula to convert inches to millimeters is: inches / 0.04 = mm

6 millimeters equals .25 inches
10 millimeters equals .40 inches
13 millimeters equals .5 inches
25 millimeters equals 1 inch

Return to: Contents, Top of document

September 17, 1996
[Revision notes: Additional citations and Web sites added this electronic version, July 2004. An automated literature search feature was added, October 2004. Web sites were updated May 2008]

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