NONINDIGENOUS FRESHWATER ORGANISMS

Vectors, Biology, and Impacts

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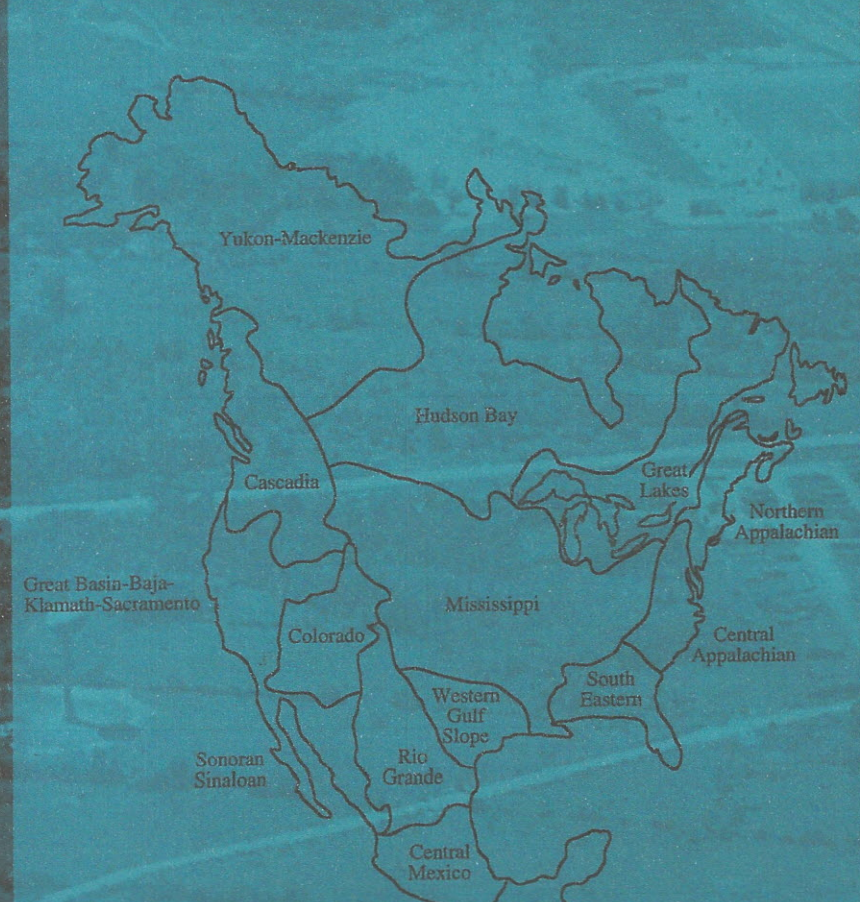

21 Introduction of Molluscs through the Import for Live Food

Gerald L. Mackie

INTRODUCTION

Of the 22 species of molluscs that have been introduced, five appear to have been brought in for their value as food. Four of these are gastropods. The only molluscan bivalve that has been introduced for its value as food is *Corbicula fluminea*. It is discussed extensively in Chapter 22 by McMahon. As one might expect of species imported for their food value, all are relatively large. Most of the species have had either little or no impact or some socioeconomic benefit.

Each species introduced through this vector was examined for the following ten attributes, when known:

1. species characteristics
2. mode of life and habitat
3. most common dispersal mechanisms
4. morphological, behavioral, and physiological adaptations to their habitats
5. predators
6. parasites
7. reproductive potential and life cycle
8. food and feeding habits
9. ecological and/or socioeconomic impact potential
10. a summary of control measures used if the species is a biofouler.

Thorough description of the above attributes is given by the author in Chapter 15 of this book.

DETAILED REVIEW OF MOLLUSCS INTRODUCED TO NORTH AMERICA AS LIVE FOOD

CLASS: GASTROPODA

Subclass: Prosobranchia

Shells small to large; dextral; operculum present with either concentric, paucispiral, or multispiral growth lines; respiration by gills; mostly dioecious, except for Valvatidae.

Family: Pilidae (Ampulariidae)
Mostly amphibious snails with large globose or subglobose shells. Mantle cavity divided into two compartments, the left containing a gill for extracting dissolved oxygen from water and the right serving as a lung for air breathing.

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Pomacea bridgesi (Spiketop Applesnail)

Introduced into Florida from Brazil, apparently in the early 1960s (Clench 1966). Little is known about its ecology, but it is probably similar to other pomaceans, such as *P. urceus* (Burky 1974). Pomaceans are well known for their amphibious nature. The mantle cavity is divided into two chambers, the left one containing a ctenidium and the right one being modified as a gas-filled lung (Burky 1974). During the dry season, the snail burrows into the mud and respires by extending a long siphon from its left side to admit air into the pulmonary chamber. The ctenidium is used when immersed in water.

FIGURE 21.1 *Pomacea bridgesi*, or spiketop applesnail.

Species characteristics: Shell less than 50 mm high, whorls strongly shouldered, body whorl rather narrow with a broadly oval aperture. The operculum is large, broadly oval, and with concentric lines of growth.

Mode of life and habitat: Ampullariids are so large that most vegetation will not support them. Usually they are found living on the sediment feeding on epipsammic algae and detritus. Like all pomaceans, *P. bridgesi* is amphibious and has a lung for respiring while in the atmosphere and a ctenidium for respiring while submerged. The species prefers slow-moving, warm water and is common in the eulittoral zones of lakes, ponds, and rivers, many of which dry up for part of the year.

Dispersal mechanisms: Probably relies on humans for dispersal of adults, but birds and mammals may disperse juvenile and younger stages.

Adaptations: Its possession of both a gill and a lung enables the species to survive long periods of drought and is well adapted to life in temporary aquatic habitats. Life in temporary aquatic habitats is rare in prosobranchs but common in pulmonates which have other mechanisms to survive the dry periods.

Predators: Humans are the main predator of adult snails, but birds apparently feed on the juveniles and smaller specimens.

Parasites: Many gastropods are intermediate hosts of trematode worms, and it is possible that *P. bridgesi* is among these. Although there has been no reports of parasites that cause disease in humans, the species may have the same potential as *P. canaliculata* (see below) to cause leptospirosis and meningoencephalitis in humans.

Reproductive potential and life cycle: The species is dioecious and like all pomaceans, it oviposits its shelled eggs on land. The newly hatched snails seek water when born or, like the adults, burrow into the mud for several months until water reappears.

Food and feeding habits: The species apparently feeds mostly on algae and detritus in the sediments, but they probably feed on leaf tissue of macrophytes as well. Sand and grit are eaten as well and used as triturating agents to grind the food in the gizzard-like part of the stomach. See *P. canaliculata* for other details.

Impact potential: Little is known about the ecological impact of the *Pomacea bridgesi* in North America, but any impacts would probably include competition with other amphibious snails living in warm waters.

Control: None, since there is no evidence to suggest that the species requires immediate control.

Pomacea canaliculata (canaliculate applesnail)

Introduced into Hawaii in the late 1980s, the species was introduced either by the aquarium trade or as a food; it is currently being sold in Hawaii as escargot (Wayne Kobayashi, Department of Agriculture, State of Hawaii, pers. commun.). Apparently the species has been reported in Florida but appears not to have caused the same concerns as in Hawaii (Terry Bills, National Biological Service, National Fisheries Research Center, La Crosse, WI, pers. commun.).

Species characteristics: Shell subglobose in shape, very large, base of aperture being canaliculate.

Mode of life and habitat: The species has the same amphibious adaptations as other pomaceans and lives in tropical climates in rivers, streams and ponds, many of which are temporary aquatic habitats. The snail can burrow into the mud and survive for several months without water.

Dispersal mechanisms: The species appears to rely mainly on humans as its dispersal agent. It is possible that young snails are dispersed by waterfowl and mammals, but adults are probably too large to be dispersed by any animal except humans.

Adaptations: It can be transported great distances out of water because it has physiological adaptations to survive long periods of drought. Like all pomaceans, the species is amphibious and has a lung for respiring while in the atmosphere and a ctenidium for respiring while submerged. It has well developed anal glands for eliminating calcium and iron salts and purines that probably accumulate during estivation and intermittent feeding (Andrews 1965).

Predators: Mainly humans, who eat them as escargots.

Parasites: Like *P. bridgesi, P. canaliculata* is not commonly reported as an intermediate host of digean trematodes, or other parasites for that matter. However, the species has the potential to cause a bacterial disease called leptospirosis in humans. Some snails carry *Leptospira* bacteria that are thin, helical cells with bent or hooked ends. Infection usually results in fever in humans. The species is also a potential carrier of the rat lungworm, *Angiostrongylus cantonensis*, a nematode parasite that causes meningoencephalitis in humans (Wayne Kobayashi, pers. commun. and brochure, "Apple Snail (*Pomacea canaliculata*)," Department of Agriculture, State of Hawaii).

Reproductive potential and life cycle: The species is dioecious, females laying bright, pink egg clusters on plants and other objects. Mating occurs and fertilization is internal. Very little else is known about its reproductive potential and life cycle. Andrews (1964) described the functional anatomy and histology of the reproductive system of *P. canaliculata*, but little is known about the reproductive biology of ampulariids in general. The only significant studies have been for *P. urceus* by Burky (1974) and Lum-Kong and Kenny (1989). In that species, the reproductive cycle is annual; spawning begins at the end of the rainy season, eggs hatch and develop during the dry season while the adult aestivates, the total development period being 22–30 days, and the fecundity ranges from 21 to 200 eggs/female.

Food and feeding habits: The gut of most pilids is specialized for a macrophagous diet, usually of aquatic angiosperms. *Pomacea canaliculata* feeds on large pieces of leaves of *Pistia* (water lettuce) and *Vallisneria* (eel grass), using sand and grit as triturating agents to grind the plant material against the gastric shield in its gizzard (Andrews 1965). The crop is essentially a storage organ in pilids. The leaf is grasped between the sensory palps on each side of the mouth, then perforated by its radular teeth and large pieces are torn off by action of the jaws (Andrews 1965). Digestion is extracellular, occurring in the stomach where plant cellulose is reduced to a broth by amylase supplied by salivary glands (Andrews 1965). In Hawaiian marshes the species feeds voraciously on rice plants and taro (Wayne Kobayashi, pers. commun. and brochure, "Apple Snail (*Pomacea canaliculata*)," Department of Agriculture, State of Hawaii).

Impact potential: In addition to its potential to carry the bacterial and nematode diseases described above, the species is a voracious feeder on rice plants and taro leaves and threatens to destroy a $2 million taro industry in Hawaii (Wayne Kobayashi, pers. commun. and brochure, "Apple Snail (*Pomacea canaliculata*)," Department of Agriculture, State of Hawaii).

Control: Molluscicides appear to be the most promising control agents.

Family: Viviparidae

Operculum with concentric lines of growth. Sexes separate, some parthenogenetic. Males with modified right tentacle, which serves as a copulatory organ. Ovoviparous, giving birth to young crawling snails.

Cipangopaludina chinensis malleatus (Chinese mystery snail)

The species is more widely introduced than Cipangopaludina japonicus, and occurs in western (California, Arizona, Colorado), eastern (Florida north to Ontario, Quebec, and Nova Scotia, Canada), and most central states, while the latter has been recorded only from Massachusetts, Michigan, and Oklahoma (Burch 1989). Both species are large and were introduced by the Chinese for their food value.

Species characteristics: Shell large, up to about 70 mm high. About 7 whorls, the body whorl inflated, nuclear whorl small, flattened to truncated. Periostracum greenish to brownish, smooth and glossy on upper whorls, lower whorls less glossy and with distinct malleations. Growth rest lines very prominent.

Mode of life and habitat: The species appears to prefer shallow waters with muddy or sandy bottoms containing some organic material. Large populations are often found in beach areas with considerable leaf litter. They occur in large rivers or in streams of order 3 or larger but in pools or eddy areas. Clarke (1980) also reports the species in ponds and marshes.

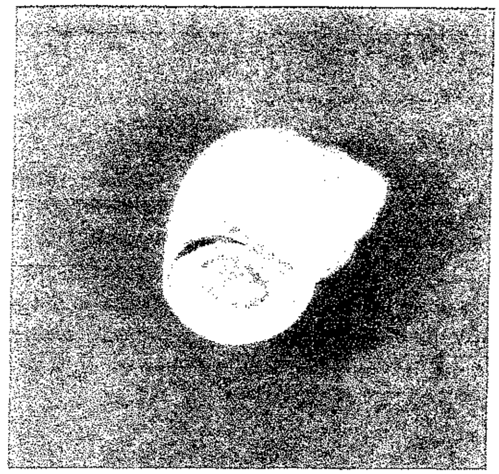

FIGURE 21.2 *Cipangopaludina chinensis malleatus*, or Chinese mystery snail.

Dispersal mechanisms: Waterfowl and aquatic mammals (otters, muskrats) probably disperse the species among adjacent water bodies. Because of its size, the species is a favorite aquarium animal and may be dispersed accidentally by aquarium enthusiasts.

Adaptations: The species appears to have no unique physiological adaptations.

Predators: Besides humans, who eat them as escargot, waterfowl and aquatic mammals also probably feed on the species.

Parasites: Olson (1974) and Cheng (1973) state that *C. c. malleatus* (as *Viviparus malleatus*) is an intermediate and final host of the aspidogaster, *Aspidogaster conchiola*. The snails become infected by eating embryonated eggs, and the entire life cycle of the parasite occurs in the snail. The most common definitive host of *A. conchiola* is unionid clams, which filter from the water embryonated eggs that have been passed in the faeces by the snail. Turtles may serve as a temporary host (Olsen 1974).

Reproductive potential and life cycle: Like all viviparids, sexes are separate and the species is ovoviparous, the eggs hatching within the uterus and retained for several months. Parthenogenesis is common in many viviparids and may also be present to some degree in *Cipangopaludina chinensis malleatus*.

***Food and feeding habits*:** Herbivore and detritivore, grazing on algae, bacteria, fungi, and other material attached to sand, rocks, and leaf litter. Feeding is probably similar to species of *Viviparus* in which a ctenidial ciliary feeding mechanism is used. Food particles are collected on elongated ctenidial filaments and the floor of the mantle cavity and are then passed to a ciliated food groove on the floor of the mantle cavity, which direct the food particles to the mouth (Cook 1949).

Impact potential: Probably none. In fact, the species has some positive socioeconomic value, still being sold as food in Chinese markets in San Francisco (Hanna 1966). The species is also cultured by Orientals, and more recently by North American entrepreneurs for escargot.

Control: None, since there is no evidence to suggest that the species requires immediate control, especially since its reproductive potential is very low.

Cipangopaludina japonicus (Japanese mystery snail)

The species was probably introduced by the Chinese about 1892 when they were first found in a Chinese vegetable store in San Francisco (Hanna 1966). Both *Cipangopaludina* species occur sporadically but are abundant when they do occur. Nothing is known about the ecological impact of either species, but competition with other common viviparids like *Campeloma* and *Viviparus* species is possible. Like *C. c. malleatus*, *C. japonicus* has a positive socioeconomic value, being sold as food in Chinese markets in San Francisco (Hanna 1966). The biological and ecological attributes of both species summarized below are based mostly on descriptions in Jokinen (1983) and Clarke (1980).

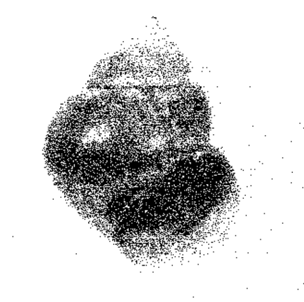

FIGURE 21.3 *Cipangopaludina japonicus*, or Japanese mystery snail.

Species characteristics: Shell not as inflated and with a more acute spire than *C. c. malleatus*. Most whorls have a low carina or acute shoulder, but malleations are absent.

Mode of life and habitat: Like *C. c. malleatus*, the species appears to prefer shallow waters with muddy or sandy bottoms containing some organic material like leaf litter. They occur in large rivers in pools and eddy areas.

Dispersal mechanisms: Like *C. c. malleatus*, the species probably relies on birds and mammals (otters, muskrats) to disperse the species among adjacent water bodies. The species is also a favorite aquarium animal and may be dispersed accidentally by aquarium enthusiasts.

Adaptations: *Cipangopaludina japonicus* also appears to have no unique physiological adaptations. Apparently, the species cannot tolerate low oxygen levels, because winterkill has been reported for the species in Lake Erie by Wolfert and Hiltunen (1968).
Predators: As with *C. c. malleatus*, humans who eat the species as escargot are as much a predator as waterfowl and aquatic mammals.

Parasites: The species is probably intermediate host to aspidogastrids and to sporocysts, rediae and cercariae of some digean trematodes.

Reproductive potential and life cycle: Sexes are separate and the species is ovoviparous, the eggs hatching within the uterus and retained for several months. Parthenogenesis may also be present in *Cipangopaludina japonicus.*

Food and feeding habits: Like *C. c. malleatus*, the species is a herbivore and detritivore, grazing on algae, bacteria, fungi, and other material attached to sand, rocks, and leaf litter. See notes for *C. c. malleatus* regarding feeding mechanisms.

Impact potential: As with *C. c. malleatus*, there is probably little or no ecological impact potential. In fact, the species has some positive socioeconomic value, being cultured by Orientals, and more recently by North American entrepreneurs for escargot.

Control: None, since there is no evidence to suggest that the species requires immediate control, especially since its reproductive potential is very low.

Class: Bivalvia

Family: Corbiculidae
Corbicula fluminea was also introduced for its food value, but the species is discussed by McMahon in Chapter 21 of this Section.

SUMMARY OF IMPACT POTENTIAL OF SPECIES INTRODUCED FOR THEIR FOOD VALUE

Since *Corbicula fluminea* is discussed in detail by McMahon, only the remaining four species are discussed below.

Species With Little or No Ecological Impact

Most species introduced for their food value will have little or no obvious impacts on the ecology of aquatic ecosystems. Although most freshwater molluscs are intermediate hosts of numerous species of trematodes, whose definitive hosts are mostly fish or waterfowl and occasionally humans, there are few studies that have assessed the added impact of exotic molluscs with their trematodes on the definitive hosts. It is not anticipated that the exotic species of molluscs will add significantly to the infestation of definitive hosts that are already infected by trematodes of native species of molluscs. All exotic species introduced for their food value will have to compete with their native counterparts for food and space, but very few are known to have replaced native species. Rather, they seem to have added to the diversity of molluscan fauna. Included in this group are

Cipangopaludina chinensis malleatus
Cipangopaludina japonicus

In summary, two of the four species introduced for their food value appear to be of little or no potential ecological risk.

Species of Potential Socioeconomic Benefit

Species known to have some beneficial uses (given in parentheses) include

Cipangopaludina chinensis malleatus (as food, especially for immigrants)
Cipangopaludina japonicus (as food, especially for immigrants)

Pomacea bridgesi (as food, especially for immigrants, and escargot)
Pomacea canaliculata (as food, especially for immigrants, and escargot)

In summary, all four of the exotic species have been demonstrated to have some beneficial use as escargot for humans.

Species of Potential Ecological and/or Socioeconomic Harm

The only potentially harmful socioeconomic impacts from molluscs introduced for their food value are (i) Vectors of Human Parasites, and (ii) Agricultural Impacts. The ecological impacts of molluscs introduced for their food value are poorly understood and, as stated above, appear so far to be minimal.

Socioeconomic Impacts

(i) Vectors of Human Parasites:

Species known to act as intermediate hosts of parasites harmful to man include (parasites given in parentheses)

Pomacea canaliculata (rat lungworm, Angiostrongylus cantonensis, causes a form of meningitis in man)

(ii) Agricultural Impacts

Pomacea canaliculata is known to cause crop damage and should be eliminated in watersheds used for irrigating agricultural crops of taro or rice.

SUMMARY

Table 21.1 summarizes the country of origin, date of entry, first documented location in North America and their reported impact(s), when known, for molluscs introduced for their food value.

TABLE 21.1
Summary of Species Introduced for their Food Value and their Origin, Date of Entry, First Documented Location in North America, and Reported Impact(s), When Known

Species	Origin	Date	First Location	Impact(s)
Pomacea bridgesi	Brasil	early 1960s	Florida	None reported to date
Pomacea canaliculata	South America	late 1980s	Hawaii	Carrier of bacterial and nematode diseases; potential to destroy rice and taro crops
Cipangopaludina chinensis malleatus	China	1890s	California	None reported to date
Cipangopaludina japonicus	China	1892	San Fransisco	None reported to date

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