Pomacea insularum **System:** Freshwater

Kingdom	Phylum	Class	Order	Family
Animalia	Mollusca	Gastropoda	Architaenioglossa	Ampullariidae

Common name	island apple snail (English), channeled apple snail (English)
Synonym	
Similar species	*Pomacea canaliculata, Pomacea bridgesi, Pomacea haustrum, Pomacea paludosa*
Summary	Wetlands are among the world's most productive environments and provide tremendous ecological services. Apple snails (*Pomacea* spp.) are nonindigenous gastropods in many parts of the world and are important consumers of aquatic plants in shallow wetland habitats. They have fast growth rates and have a large reproductive potential, facilitating their invasion success.

RED LIST

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Species Description

Apple snails are globular in shape and normally banded brown, black, and yellowish-tan. Color patterns are extremely variable; albino and gold color variations exist (R. Howells Pers. Comm., as cited in Benson 2010). Apple snails (*Pomacea*) may reach the size of apples (Joshi & Sebastian 2006, as cited in Youens & Burks 2008) with island apple snails growing up to 150 mm in length (R. Howells Pers. Comm., as cited in Benson 2010). They lay egg masses in a large bright pink cluster (Barnes *et al*. 2008).

Notes

Burlakova *et al*. (2010) report that apple snails (*Pomacea*) are pre-adapted to exploit ephemeral agricultural habitats. They are aquatic but possess features that allow a semi-terrestrial mode of existence (Andrews 1965a, Keawjam 1986, as cited in Burlakova *et al*. 2010). They possess a ctenidium for underwater respiration, and also have a lung for aerial gas exchange. They also have calcareous eggs that are deposited out of water and are resistant to desiccation. Their capacity for long-term aestivation is another feature that makes species in this group major pests in periodically dewatered, wetland rice and taro agriculture systems (Cowie 2002, as cited in Burlakova *et al*. 2010). All of these features suggest an evolutionary history that produced strategies for taking advantage of unpredictable environments, like floodplains.

Burlakova *et al*. (2009) found a significant negative correlation between snail size and consumption of the control plant (lettuce)a per mass basis, supporting other work that small snails can have a larger impact on plants. Because smaller sized island apple snails will consume macrophytes at a higher mass-specific rate than the larger snails, controlling the younger life stages is most important for protecting aquatic vegetation. However, because larger snails will consume more biomass on an individual basis, it is important to know the size structure and the density of snails to estimate their likely impact (Burlakova *et al*. 2009).

Lifecycle Stages

Island apple snails display unusual reproductive behavior: in order to oviposit the females climb out of the water and lay eggs in clutches on emergent or terrestrial structures (Howells *et al*. 2006, Barnes *et al*. 2008, as cited in Burks *et al*. 2010). Egg clutches are laid on different structures such as emergent plants, trees, concrete pillars, and sewer cisterns (Burks *et al*. 2010). Female island apple snails placed a higher than expected number of clutches on man-made objects, suggesting that *P. insularum* can adjust to new ecosystems and will use almost any dry emergent surface as an oviposition site when needed (Burks *et al*. 2010). Eggs are laid on emergent structures because the eggs of apple snails (*Pomacea*) require air exposure to develop. Exposure to water decreases hatching efficiency of apple snail clutches (M. K. Trawick Unpub. Data, Turner 1998, Pizani *et al*. 2005, Horn *et al*. 2008, as cited in Burks *et al*. 2010). The life stage transition from egg to hatchling represents a critical step in the establishment and spread of exotic island apple snail populations (Barnes *et al*. 2008, as cited in Burks *et al*. 2010). As the clutches dry out development of hatchling snails (neonates) continues; the neonate stage lasts for one to three weeks, depending on the temperature and other environmental constraints (Howells *et al*. 2006, as cited in Burks *et al*. 2010). Snails may live over three years (Estebenet & Cazzangia 1992, as cited in Burlakova *et al*. 2010).

Uses

It is unclear whether the island apple snail may serve as a biocontrol agent for regionally invasive aquatic plants in Florida, United States, such as *Hydrilla verticillata* (Ajith Kumara *et al*. 1999, in Baker *et al*. 2010). Baker *et al*. (2010) concluded that *P. insularum* cannot be relied upon as a biological control agent for nonindigenous plants and may heavily impact native macrophytes. Their results (see *Nutrition*) suggest that in natural ecosystems, with both native and nonindigenous plants, *P. insularum* cannot be relied upon to control nonindigenous macrophytes and may instead consume native aquatic plants.

Habitat Description

Apple snails (*Pomacea*) generally inhabit slow-moving or stagnant waters in lowland swamps, marshes, irrigation canals, streams, ponds, lakes and rivers, and thus are pre-adapted for living in habitats where aquatic crop plants are grown such as rice and taro (Andrews 1965b, Keawjam 1986, Louda & McKaye 1982, Cowie 2002, in Burlakova *et al*. 2010). The island apple snail occurs in lotic (moving water) habitats in their native range (Hylton-Scott 1958, Bachmann 1960, as cited in Burlakova *et al*. 2009). It presents a threat to shallow freshwater aquatic environments where it has been introduced. Burks *et al*. (2010) found that wetlands and shallow lakes surrounded by large emergent macrophytes, particularly wild taro, likely provide ideal oviposition sites for the island apple snail and possibly facilitate invasion into new aquatic ecosystems. Karatayev *et al*. (2009) suggest that it is a higher tolerance to low winter temperatures that has allowed the island apple snail to colonise more waterbodies than other invasive snails in Texas, United States.

Reproduction

Pomacea snails are dioecious, have internal fertilization, very high fecundities and produce eggs that hatch two to four weeks after oviposition (Cowie 2002, in Burlakova *et al*. 2010). High fecundity serves as the\nmost successful indication of mollusc invasive potential (Keller *et al*. 2007, as cited in Barnes *et al*. 2008) and average size of a *P. insularum* clutch greatly exceeds that of a *P. canaliculata* clutch. The island apple snail has an average clutch size of approximately 2000 eggs (mean=2064 eggs; Barnes *et al*. 2008). While clutch size provides an idea of potential fecundity hatching efficiency yields a better estimation of realised fecundity, which makes up one component of propagule pressure that favors the establishment of exotic species (Lockwood *et al*. 2005, as cited in Burks *et al*. 2010). Barnes *et al*. (2008) found clutches exhibited average field and laboratory hatching efficiencies of around 70 and 30%, respectively. Field clutches hatched by Burks *eta al*. 2010 reflected laboratory hatching efficiencies of 30% found in Barnes *et al*. (2008). While this is relatively low one single female island apple snail is likely to produce many clutches during one reproductive season (contributing greater than one clutch per week over an extended growing season in the southeastern United States) (Barnes *et al*. 2008).

Nutrition

Apple snails readily consume vascular plants in contrast to periphyton resources commonly associated with aquatic snails (Burlakova *et al*. 2008, Qiu & Kwong 2009, as cited in Burkes *et al*. 2010). The island apple snail is likely to pose the greatest threat to native submersed macrophytes, which generally have a lower cellulose and lignin content and a higher protein content, and are easier to access by snails (Burlakova *et al*. 2009).
Feeding studies reviewed by Howells *et al*. (2006, as cited in Baker *et al*. 2010) suggest that *P. insularum* feeds on a wide range of submerged and emergent plants; *Elodea canadensis* is avoided by either *P. canaliculata* or *P. insularum* (taxonomy of the snails used in these studies was not certain) (Rawlings *et al*. 2007). Gettys *et al*. (2008) found *P. insularum* preferred *H. verticillata*, *Najas gaudalupensis*, and a freshwater alga *Chara*, while *Myriophyllum aquaticum* was consumed only when no other food was available and *Egeria densa* was not consumed at all (as cited in Baker *et al*. 2010). An absolute selectivity (yes/no) study by Howells (2002) found that no macrophyte species was rejected, although neither *E. densa* nor *E. canadensis* were tested (as cited in Baker *et al*. 2010). Baker *et al*. (2010) conducted a quantitative assessment of the potential impacts of *P. insularum* by evaluating consumption rates as well as feeding preferences on 22 common aquatic macrophytes in Florida, including eight nonindigenous species. The most heavily consumed plants were two native species: *Limnobium spongia* and *Chara* sp.. Nonindigenous *Panicum repens*, *H. verticillata* and *Ceratophyllum demersum* and native *Sagittaria latifolia*, *N. guadalupensis* and *Vallisneria americana* were also heavily consumed. Nonindigenous *Eichhornia crassipes* was consumed at a relatively low rate while nonindigenous *Colocasia esculenta* and *Pistia stratiotes* were not consumed at detectable levels. Burlakova *et al*. (2009) quantified the feeding rate of the island apple snail for three species of invasive macrophytes and 13 species of native macrophytes that are important for wetland restoration and health. They found that the submersed macrophytes, *C. demersum* and *Ruppia maritima*, were consumed at a significantly higher rate than emergent plants. The tissues of submersed macrophytes contain small amounts of lignin and often have higher protein concentrations than emergent plants; vontrary to submersed plants, emergent macrophytes have heavy cell walls and very thick cuticles (Wetzel 1975, as cited in Burlakova *et al*. 2009). Additionally, submersed flora are more accessible to snails and thus more likely to suffer greater damage. The emergent species that were found to be consumed at moderate rates (*Canna glauca*, *Hymenocallis liriosme*, *Panicum hemitomon*, *S. graminea*, and *S. lancifolia*) had broad, succulent leaves and stems allowing easy consumption.

General Impacts
Aquatic plants stabilise and are dominant primary producers in wetland ecosystems, creating structurally diverse habitats and offering refuge to invertebrates and fish, as well as playing a key role in nutrient cycling (Mitsch & Gosselink 1993, Barbier *et al*. 1996, Burlakova *et al*. 2009). Herbivory by exotic gastropods can influence the structure of macrophyte communities and affect nutrient and energy fluxes in wetlands (Burlakova *et al*. 2009). Exotic gastropods may also exclude native snails, introduce parasites and threaten endangered species.
Economic impact: The ability of snails to escape population control and explode in ephemeral habitats could drive the types of impacts seen in agricultural crops (Burlakova *et al*. 2010). Several *Pomacea* species have become serious agricultural pests of wetland crops (Cowie 1995 2002, Naylor 1996, in Baker *et al*. 2010). In Hawaii taro represents a valued resource threatened by the island apple snail (Van Dyke 2009c, as cited in Burks *et al*. 2010). Apple snails are significant agricultural pests of rice and taro in South East Asia, Japan, the Dominican Republic, Hawaii, and the Philippines (Cowie 2002, Ranamukhaarachchi & Wickramasinghe 2006, as cited in Burlakova *et al*. 2009). In Texas, farmers are facing increased maintenance costs for levees in fields with large populations of *P. insularum* due to constant burrowing by the snails (Burlakova Unpub. Data. 2009). The main food for island apples snail in rice fields in Texas was ducksalad and other rice weeds, and farmers reported that the snails were very efficient at clearing the fields from the weeds (Burlakova *et al*. 2009). However in general these invaders are pests (Joshi & Sebastian 2006, in Baker *et al*. 2010).
Ecosystem change: Aquatic plants are the most important components of wetland structure, therefore, herbivores can have profound impacts on community and ecosystem structure in these systems (Sheldon 1987, Lodge 1991, Lodge *et al*. 1998, Van Donk 1998, as cited in Burlakova *et al*. 2009). Nonindigenous apple snails represent a significant threat to wetland ecosystems (Carlsson *et al*. 2004, Carlsson & Lacoursiere 2005, Carlsson 2006, in Baker *et al*. 2010). In experiments conducted by Burlakova *et al*. (2009) *P. insularum* consumed substantial amounts of seven of 13 species that are important for wetland restoration. In some invaded wetlands *P. canaliculata* and/or *P. insularum* (as per Rawlings *et al*. 2007) have been associated with a shift from macrophyte-dominated communities to phytoplankton-dominated communities (Carlsson *et al*. 2004, in Baker *et al*. 2010).
The ecosystem impacts of *P. insularum* in Florida have not yet been resolved (Gettys *et al*. 2008, in Baker *et al*. 2010; Rawlings *et al*. 2007). Cattau *et al*. (2010) found that the island apple snail significantly affects the foraging behavior and activity pattern of the endangered Everglades snail kite (*Rostrhamus sociabilis plumbeus*) in Florida. Populations of the native Florida apple snail *P. paludosa* could be negatively impacted by the island apple snail (Connor *et al*. 2008).
Human health: Apple snails are an intermediate host for the rat lungworm (*Angiostrongylus cantonensis*) a nematode that can cause meningitis in humans (Carter *et al*. 2009).
Interaction with other invasive species: Burks *et al*. (2010) studied oviposition trends of the island apple snail and found that snails laid more clutches on wild taro (*Colocasia esculenta*) than expected by the exotic plant’s availability.

Management Info
Regulations aimed at controlling the spread of apple snails must target the entire genus *Pomacea* and perhaps the entire family if they are to be effective (Hayes *et al*. 2008).
In contrast to Southeastern Asia, at present, there is no documented agricultural damage in Texas from *P. insularum* (Burlakova *et al*. 2009). Agricultural practices common in Texas could explain this difference. Recent studies have concluded that the magnitude of crop damage depends on the technique used to grow rice (Teo 2003, Wada 1999, Sanico *et al*. 2002, Wada 2006, in Burlakova *et al*. 2009). Snail damage to rice seedlings is correlated with the depth of water on the field, and damage decreases as seedling age increases. Increasing seedling age from two to five weeks resulted in significant reductions in snail damage (Sanico *et al*. 2002, as cited in Burlakova *et al*. 2009). Limited moisture conditions immobilise and prevent the snail from causing severe damage even at high densities. Dry direct seeding, which uses a minimal amount of water in the early stages of growth, minimizes snail damage as compared to other methods (Teo 2003, as cited in Burlakova *et al*. 2009). Wada (1999, as cited in Burlakova *et al*. 2009) found that draining after sowing greatly reduces snail damage, and three weeks of drainage can almost prevent all damage due to snails.
Education and awareness: Even though the aquarium industry is one of the five major sources for introduction of all aquatic invaders it has received relatively little attention from scientists and policy makers (Padilla & Williams 2004, Ruiz *et al*. 1997, as cited in Karatayev *et al*. 2009). Karatayev *et al*. (2009) highlight the importance of this vector and the need for special attention from the scientific community as well as policy makers and managers. Measures are needed both in terms of regulation and public education to reduce the negative consequences of future introductions and the spread of exotic species.
Integrated Management: Understanding of the trends in the abundance of clutches on different plant species such as wild taro (*C. esculenta*) may yield important information about island apple snail establishment patterns (Byers 2002, as cited in Burks *et al*. 2010). However Burks *et al*. (2010) do not suggest that the presence of an avoided or less-preferred plant would limit suitable oviposition sites for the island apple snail. Recent management plans for wetland habitats suggest that egg mortality resulting from failed hatching (presumably due to laying on surfaces subject to water stress) may reduce egg supply of this invasive snail (Van Dyke 2009b, as cited in Burks *et al*. 2010). Researchers have not yet found a plant or substrate that will effectively deter *P. insularum* oviposition (Burks *et al*. 2010). On the other hand Burlakova *et al*. (2009) recommend restoring wetland areas (where island apple snails are present) by planting emergent flora with a low risk of damage from apple snails due to low palatability: island apple snail consumption was lowest for *Thalia dealbata*, *Spartina alterniflora*, *Typha latifolia*, and *Scirpus californicus*.

Pathway
The island apple snail was most likely introduced through activities associated with the aquarium and ornamental trade (Murray 1971 1975, Fullington 1978, Neck 1984, Howells 2001a, Howells *et al*. 2006, as cited in Karatayev *et al*. 2009).

Principal source: Baker, Patrick; Zimmanck, Frank; Baker, Shirley M., 2010. Feeding rates of an introduced freshwater gastropod *Pomacea insularum* on native and nonindigenous aquatic plants in Florida. Journal of Molluscan Studies. 76(Part 2). MAY 2010. 138-143.
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Summary: The island apple snail (*Pomacea insularum* (d Orbigny, 1839)) is a South American snail that became naturalized in Florida waterways in the mid-1970s and has recently spread throughout much of the state. Food Consumption by this herbivorous Snail was determined in 10-day feeding trials at temperatures of 15 to 35 degrees C. Optimum feeding of the exotic submerged plant Hydrilla verticillata (L.f.) Royle (hydrilla) occurred over a wide temperature range (20 to 35 degrees C). However, Snail growth was greatest at temperatures of 20 to 30 degrees C. Free choice plant preference Studies were conducted to determine feeding preferences for native and exotic Submerged plants. One exotic and two native species (H. verticillata, Najas guadalupensis (Spreng.) Magnus (southern naiad) and Chara sp. (stonewort), respectively) were highly preferred by island apple snails, followed by the two native Species potamogeton illinoensis Morong. (Illinois pondweed) and Vallisneria americana Michx. (tapegrass). Leaves of the exotic species Myriophyllum aquaticum (Vell.) Verdc. (parrotsfeather) were eaten after the more preferred plants were consumed and no significant feeding was noted on the exotic species Egeria densa Planch. (Brazilian elodea). While island apple snails have distinct preferences for certain submerged plants, they consumed both native and exotic species, which may significantly affect growth of certain species and will likely change species composition of Submerged plant communities in Florida wherever they are common.
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