The Rice Apple Snail in Spain: a review

Ravindra C. Joshi* and Xavier Vélez Parera**

Pomacea insularum eating Soft-stemmed Rush Juncus effusus. Credit Jess Van Dyke, Snail Busters, LLC, Bugwood.org (CC 3.0)

Introduction

The freshwater Rice Apple Snail (*Pomacea* spp.) is endemic to South America. It was introduced to Asia (Hayes et al., 2008) as a potential food source and for commercial aquaculture but these attempts were not successful. Unused specimens were discarded into and rapidly spread to aquatic habitats (Joshi, 2005a; Joshi, 2005b; Joshi, 2007; Halwart et al., 2006), and their release led them to become a major pest in wetland agriculture, most particularly in rice (Hickel et al., 2012) (Figures 1 & 2). The Rice Apple Snail is one of the world's 100 worst invasive alien species (GISD, 2017). The invasiveness is related to its inherent characteristics: a high reproductive rate, adaptability to harsh environmental conditions, ability to invade diverse habitats through multiple pathways, a wide host range and voracious appetite and an ability to compete with the native snails and native fauna species (Joshi, 2007).

The snail has also been a popular aquarium pet because of its size which can grow to as big as an apple. Its release into the Ebro Delta in Spain has been linked to Promotora Bama and Global Acuatic Tecnologies, an exotic animal importer, which bred the snails at a facility in the village of L'Aldea on the north side of the delta. The presence of this snail was first confirmed in Spain in 2009 (Figure 3). The earliest data on rice cultivation in the Ebro Delta date back to as early as 1697. At present rice is cultivated on 21,000 hectares of land along the river bank producing over 90,000 tons of quality rice annually.

According to Lopez et al. (2010), bright reddish egg masses first appeared on vegetation along a small canal at the Delta in August 2009. The specimens fall within the morphological variability and their mitochondrial DNA variation matches that of *Pomacea insularum*. This was the first instance of an invasion of apple snail in Europe. At that time, the population had reached densities of 1kg/sq. m. By early September the spread of the apple snail had colonized half of the interconnected canals in the northern half of the delta as well as the main river channel.

The snail spread to over 9,500 hectares within a five-month period, populating the river bed and infesting the rice irrigation networks (Joshi, 2015). The Ebro Delta is now threatened by this invasive species with devastating effects on rice harvests. The alarming rate of spread prompted the Catalan government to launch immediate containment measures and since 2010, it has invested €350m in efforts to prevent further damage (Joshi, 2015).

The Rice Apple Snail can grow and breed year-round as long as there is sufficient water. The number of eggs per clutch averages 260, (ranging from 12 to

* Technical Advisor on Rice Apple Snail to Deltamed (Asociación de Deltas del Mediterráneo), Visiting Professor, Pampanga State Agricultural University, Philippines and Visiting Adjunct Professor of Agriculture, University of the South Pacific, Fiji. Email: rcjoshi4@gmail.com

** Regenerative Agri & Aqua Culture Expert, Resonance Academy & Organic Agriculture, Barcelona, Spain. Email: x5v2p3@gmail.com

Figure 1. Rice Apple Snails in the water canal, Terres de l'Ebre, El Lligallo del Gànguil, Spain. (Credit Xavier Vélez Parera).

Figure 2. Rice Apple Snails in the rice field, Terres de l'Ebre, El Lligallo del Gànguil, Spain. (Credit. Xavier Vélez Parera).

Figure 3. Rice Apple Snail's damage distribution in Ebro Delta, Spain, 2016. (Source: Google maps, Accessed 12 December 2016).

1000). The interval between successive hatches has been reported to be from 5 to 14 days. This period varies greatly and development is highly dependent on its environment. An average annual output is about 4,400 eggs per individual snail.

Fully grown females are larger than males. The foot is oval with a square-ish anterior edge. The tentacles are long and tapering, highly extensible with large but short eye stalks at their outer bases. The eggs are spherical, calcareous, deep pink-red to lighter orange pink becoming paler as the calcium hardens, and eventually whitish pink just before hatching. They are laid above water on emergent vegetation and other firm substrates (Figure 4).

Mortality is high at water temperature above 32-35°C. It can survive 5-20 days at 0°C, two days at -3°C and six hours at -6°C. Activity almost stops below 10°C. *P. insularum* grows rapidly because it can feed on numerous plant species. In general, its best known natural enemies are vertebrates. In its non-native range, this snail is eaten by a large number of predators including invertebrates, fish, birds and mammals (Yusa, 2006).

Figure 4. Rice apple snails eggmasses on rice tillers, Terres de l'Ebre, El Lligallo del Gànguil, Spain. (Credit Mr. Xavier Vélez Parera).

The snail has a fully functional lung for aerial respiration and a gill for aquatic breathing (Berthold, 1991) allowing it to survive in poorly oxygenated waters. Another important physical feature that aids survival in ephemeral habitats, such as rice fields and wetlands, is the operculum or shell door that enables the snail to retire into its shell and firmly close it. This discourages predators and allows the snail to hibernate, buried in the mud, within the protective moisture of its shell for periods of several months when its habitat dries out (Oya et al., 1987).

Damage and control measures

Farms at the Ebro delta produce about 138m kg of rice each year and about 10,000 hectares of rice farms are affected by the snail. The snail represents one of the worst gastropod crop pests of the present time (http://neurice.eu/about/apple-snail/?lang=ca). The control measures adopted by the Catalan government were included a survey in 2010. This advised that attention be focused on managing the pest in the rice fields rather than in the rivers. Physical barriers such as nets and traps were installed. Snails and eggs were manually removed and chemical treatments, including pesticides, lime and seawater were applied. In addition, prior to rice planting, fields were levelled to maintain a shallow depth of water during the early growth stage of the rice plants. These methods resulted to about 80% snail mortality.

Five years after the first inspection a returned visit evaluated the situation to assess the efficacy of the methods employed. Farmers on the south side of the delta that had adopted and diligently observed the strategies recommended in 2010 had successfully managed to control the snails and consequently, the damage to the rice plants was insignificant. One farmer practiced dry ploughing which exposes the snails hiding in the soil to the sun. No live snail was found even after digging through the soil. In contrast, those on the north side of the delta, the rice fields had unusually high densities of egg masses and live snails of various age structures. Missing rice plants, as a result of the rice apple snail feeding, were apparent on many hectares of farms.

Another control measure tried was flooding the fields with sea water which the farmers observed as 100% effective in controlling the snail infestation.

However, the salinity has caused 30% loss of rice productivity, not to mention the additional labour and cost of flooding. Other measures include: collection and destruction of the snail including its eggs, burning of rice stubbles in highly infested fields, installation of barrier traps throughout the irrigation networks, installation of floating barriers in the river to avoid invasion of the river habitat from the flood plain at the left side of the delta, placement of fixed barriers adjacent to the riverbank to prevent the spread of the snail by creeping through counter currents, modification of the water inlets and outlets of the rice fields, and mandatory proper cleaning of harvesters and agricultural machinery before crossing the river. Plant molluscicides such as saponins are widely used in the country. Saponin (natural extract of Camellia seeds) treatments are authorized for the Catalan government each year. For one hectare of rice field it costs about €200 for the Saponin product plus the labour cost for the application. There is concerted effort by agencies involved in agriculture including funding agencies and scientific communities in the control of this pest.

Aside from the damage done to agriculture, the snail could push already fragile ecosystems into irreversible decline as it had done in Thailand and other countries in Southeast Asia. Because it is so voracious, there is a high risk to biodiversity and the survival of endangered species. The flooding of rice fields with sea water, have made them no longer good habitats for birds. Ecosystem services such as the availability of fresh, good quality water could also suffer, thereby reducing the availability of plants and fish as food, and making recreation activities less attractive due to diminished bird and fish population and growth of algal bloom. The Apple Snail devours macrophytes, aquatic plants that play key role in nutrient cycling that act as natural biofilter to ensure minimum water quality in freshwater ecosystems. Maintaining an abundant and rich macrophyte species is essential in preserving the self-cleaning characteristics of rivers and wetlands (http://www.efsa.europa.eu/en/press/news/140218a). The Rice Apple Snail also serves as host to disease-causing trematodes and nematodes, including the endoparasite rat lungworm (*Angiostrongylus cantonensis*) which causes the disease Eosinophilic meningoencephalitis in humans; and intestinal fluke (*Echinostoma ilocanum*) (CABI, 2014). In ecological terms, a major change in food webs and biomass distribution is occurring in the agricultural areas (Lopez et al., 2010).

In addition to the advice, communication tools such as posters with information on proper management would help to educate the community and to encourage concerted efforts in managing the problem of rice apple snails. Field research to better understand the population dynamics of the snails could generate more information about this pest (Joshi, 2015). Moreover, the people could be encouraged to use the snail as food, and as biological weeding agent in transplanted rice, only in those areas where the snail has already distributed widely and is thus is difficult to eradicate (Joshi, 2005c).

Conclusion

P. insularum remains a problem in the Ebro Delta due to its biological and ecological characteristics. With the efforts being done by the Catalan government and the assistance of international organizations and funding agencies, the eradication of the Rice Apple Snail is not impossible. Continuous hand picking, trapping, destruction of egg masses, in addition to existing control measures, may take a long time but will eventually keep the pest at non-damaging levels. Its potential as food and weed control agent, as what is done in other countries, can also be tried.

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See also

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