Aquatic invasive apple snails (*Pomacea* spp.) in Timor-Leste: Current status, spread and management in rice fields

Americo Alves Brito[1], Ravindra C. Joshi[2*], and Soetikno S. Sastroutomo[3]

1. Chief of Plant Protection Department, National Directorate of Agriculture Horticulture and Extension, Ministry of Agriculture and Fisheries, Street: Presidente Nicolao Lobato, Comoro- Dili, Democratic Republic of Timor-Leste.

2. Technical Advisor on Invasive Apple Snails to DELTAMED (Asociación de Deltas del Mediterráneo), Amposta, Spain; Senior Adviser on Invasive Apple Snails, NEURICE Project-Funded by European Commission, Spain; Associate, CABI-SEA, Malaysia; Pacific Coordinator, Tropical Agriculture Association (UK); SAFE-Network Pacific Islands Coordinator; and Visiting Adjunct Professor at the University of the South Pacific, Fiji.

3. ASEANET c/o CABI Southeast Asia, Building A 19, MARDI, Serdang 43400, Selangor, Malaysia.

**Corresponding author: rcjoshi4@gmail.com, ravindra.joshi@usp.ac.fj*

Introduction, history and spread

There is no exact information as to when the freshwater invasive apple snail (*Pomacea* spp.)in the family Ampullariidae, was first introduced into Timor-Leste. Anecdotal evidence indicates that these exotic snails were introduced by Indonesian transmigrates, and they deliberately brought to Timor-Leste for food, because at that time Timor-Leste was still an Indonesian colony. It is locally known as "keong mas, keong murbei, siput murbai. In Indonesia, the studies on snail taxonomy are mainly based on morphological characteristics (Marwoto, 1997; Isnaningsih & Marwoto, 2011). They concluded that there are many variations in size, shell color, and shape of the spire and its aperture shape that can be used to separate four species [*Pomacea canaliculata, Pomacea maculata* (*Pomacea insularum*)*, Pomacea scalaris* and *Pomacea paludosa*] that invaded rice farms in Indonesia (Marwoto *et al,* 2018). Thus, it is likely that species of *Pomacea* in Timor-Leste is likely to be same as that of Indonesia. In literature many *Pomacea spp.* have commonly been referred to as golden apple snails, or GAS, often without clarifying specifically which species, was involved, or indeed simply assuming it to be *Pomacea canaliculata* (Cowie *et al*, 2017). For clarity, this article avoids this ambiguous common name designation. Therefore, it is very difficult at this time to pinpoint the exact pathways, source of introductions, and the number of *Pomacea* species that have been introduced to Timor-Leste, unless preserved specimens are examined using molecular and morphological approaches (Hayes *et al,* 2008).Correctly identifying the invasive species is one of the most fundamental prerequisites when attempting to control it (Joshi *et al,* 2017).

Rice cultivation in Timor-Leste

The land area devoted to rice cultivation each year is 38,000 ha (FAO, 2011). The average land holding by the farmers ranges from 1-3 ha. There are farmers that owns more than 3 ha, but not all of the land is utilized due to limited labor and land preparation costs. The most common rice varieties planted are IR8, IR64, Membramo, Nakroma, PSB RC 80, and Ciheran (Oxfam, 2008). The average rice yields range from 2.5-3 t/ha. The rice production cost incurred by farmers per ha on an average is USD $ 300-500, which includes costs for land processing, tractor rentals, planting, pest control, fertilizers and others. The rice cropping calendar is as follows:

During the main season, rice is planted in lowland areas in December-January in the northern parts and a month or two later on the south coast, and harvest from May to July. During the second rain peak in the south (May-June), farmers plant a second crop of irrigated rice and harvest from August to December (Oxfam, 2008).

Invasive apple snail eggmasses on transplanted rice, Timor-Leste. (Credit: Americo Alves Brito).

Damage by invasive apple snails to rice plants, Timor-Leste. (Credit: Americo Alves Brito).

Rice is established by two methods: Transplanting and direct-seeding. However transplanting is a common method carried-out in areas with irrigation facilities, and also in areas where the water is always available throughout the rice growing season. Irrigation water in many of the irrigated rice areas are available only when river water level from the source has increased to the level of the intake of the irrigation systems (MAFF, 2018). In areas where the water source is lacking and have no irrigation facilities, and dependent on rainfall, then farmers resort to direct-seeding method. If tractors are unavailable, buffaloes puddle the paddies. Otherwise, there is little animal traction in Timor-Leste (Lopes & Nesbitt, 2012). Rice is planted once a year, but there are areas, where farmers are able to plant twice.

The total rice production in Timor-Leste is about 207,500-249,000 t. Harvested rice is bought by the Government, private companies, and NGOs. Depending on the quality of rice, the average price in the local markets ranges from USD $ 0.60 - 0.80/kg. Milled rice are sold in cans with approximately one kilogram. Prices for local rice sold by farmers in the local markets are around USD $ 0.50/kg, and those sold by NGOs are USD $ 1/kg milled rice. The HACELDA company buys rice grains directly from farmers with the basic price of dry grain at the farm level is US $ 0.45 / kg, and after milling is sold at US $ 1/kg. Farmers' estimated revenue (income) in each cropping season/ha is from US$ 800-1000. The Ministry of Agriculture and Fisheries allocates a special budget to buy rice seeds from the seed breeder group, namely the association "Anaprofiku" with a price per kilo of seeds which is US $ 1.50/kg. Such rice seeds are distributed to farmer groups in the territory of Timor-Leste, and are not for consumption.

Impact of invasive apple snails

The first reported damages by *Pomacea* spp. in Timor-Leste on rice was around 1985, in the southern part (Maunfahi and Suai districts), and the western part (Bobonaro district) (Figure 1), with approximately 700 ha, and 80 ha damaged, respectively in both transplanted and direct-seeded rice systems (Figures 2 & 3). However the current data on the extent of spread and damage to rice at the national level is lacking. Thus, there is a urgent need for systematic surveys on the areas invaded, and the rice crop losses.

Control of invasive apple snails

Two active ingredients (a.i.) of synthetic molluscicides (metaldehyde and niclosamide), used in Timor-Leste. All the four molluscicide formulations sold in Timor-Leste are imported from Indonesia. Siputox 5G is a granular formulation with a.i. metaldehyde; while Kencida 500 EC, Keong tox 250 EC, and Nicolasan 250 EC are liquid formulations with a.i. niclosamide (Table 1). In Timor-Leste there are no chemical pesticide manufacturing/formulation companies, thus all molluscicides are imported from Indonesia.

Molluscicides are applied 1-2 times at the time of rice transplanting (Figure 4) or direct-seeding (Figure 5) in each rice planting season, but there are certain areas that do not apply molluscicides because of their non-availability at the

Dead invasive apple snails in field treated with metaldehyde pellets (Siputox 5G), Timor-Leste. Note metaldehyde pellets in black circles. (Credit: Americo Alves Brito).

farmers' level. The price of molluscicides ranges from USD $ 15-17per liter or kg, but farmers get molluscicides from the government assistance program through the Ministry of Agriculture, in areas with heavy snail damage.

Non-chemical methods used by rice farmers are as follows:

- Replanting missing rice plants is normally done by farmers, but transplanting older rice plants is not practiced.
- Several farmers collect snails, and then crush them
- Install screen traps on the water channel into the rice field
- Using the roots of the tuba plant (*Derris* sp.)
- Human consumption of snails is not common in Timor-Leste, though some people eat them
- Feeding ducks with collected snails is practiced by some farmers.

Presently most of the snail management techniques could not be easily adopted by farmers as these are labor-intensive, not economical, not effective to reduce snail numbers at non-damaging levels, and not environment friendly (Joshi, 2007). Thus, new innovative approaches should be developed and promoted to manage the invasive snails, especially in direct-seeded rice fields.

Conclusions

Invasive apple snails (*Pomacea* spp.) were first detected around 2015 in Timor-Leste rice fields, further limiting already low rice yields/ha. Their control has triggered the use of imported synthetic molluscicides. To our knowledge the other negative impacts of this freshwater snail on non-target fauna and flora including human health and the environment are still unknown. Thus, long-term control and containment is needed

Table 1. Molluscicidal formulated products traded in Timor-Leste.

Product Name	Company Name (Supplier)	Ingredient	Package	Price (USD $)	Date & License No.
Siputox 5G	PT TAni MAs Subur	Metaldehyde	250 g	US$ 14	30-April 2014 RI 3491/4-2009/T
Kencida 500EC	PT. Agro Sejahtera Indonesia	Niclosamide	200 ml	US$ 14	12-December2018 RI. 01050120093345
Keong tox 250EC	PT. Santani Sejahtera	Niclosamide	200 ml	US$ 14	4-Januari 2018 RI 01050120083051
Nicolasan 250EC	PT. Bio Agritech Nusantara	Niclosamide	200 ml	US$ 14	15-Januari 2014 RI 3358/12-2008/T

Dead invasive apple snails in direct-seeded rice field treated with metaldehyde (Siputox 5G) pellets, Timor-Leste. Note the colored metaldehyde pellets on the soil surface (Credit: Americo Alves Brito).

to reduce ecological and economic losses. International collaboration with infested countries in ASEAN region is needed for accurate species identification, and for better understanding of invasion biology in order to develop effective ecologically sustainable snail management options.

References

Cowie, RH, KA Hayes, EE Strong, SC Thiengo, 2017. Non-native apple snails: systematics, distribution, invasion history and reasons for introduction. ***In***: Joshi RC, Cowie RH, and Sebastian LS. (eds). *Biology and management of invasive apple snails*. Philippine Rice Research Institute (PhilRice), Maligaya, Science City of Muñoz, Nueva Ecija 3119, Philippines; pp 3-32.

FAO, 2011. FAOSTAT Statistical database of the United Nations Food and Agriculture Organization (FAO), Rome [http://faostat.fao.org/site/291/default].Accessed 05 October 2018.

Hayes KA, Joshi RC, Thiengo SC, Cowie RH, 2008. Out of South America: multiple origins of non native apple snails in Asia. *Diversity and Distributions*, **14**: 701-712.

Isnaningsih NR, Marwoto RM, 2011. Keong hama *Pomacea* di Indonesia: karakter morfologi dan sebarannya (Mollusca, Gastropoda: Ampullariidae). *Berita Biologi* **10**(4), 441-447.

Joshi RC, 2007. Problems with the Management of the Golden Apple Snail *Pomacea canaliculata:* An Important Exotic Pest of Rice in Asia. ***In***: Vreysen MJB, Robinson AS, & Hendrichs J, eds. *Area-Wide Control of Insect Pests*. Springer Verlag, Netherlands; pp 257-264.

Joshi RC, Cowie RH, & Sebastian LS. (eds). 2017. *Biology and management of invasive apple snails*. Philippine Rice Research Institute (PhilRice), Maligaya, Science City of Muñoz, Nueva Ecija 3119. 406 pp.

Lopes M, Nesbitt H, 2012. Improving food security in Timor-Leste with higher yield crop varieties. Paper Presented at the 56th AARES annual conference, Fremantle, Western Australia, February7-10, 2012, 21pp.

Marwoto RM, 1997. Keong mas atau keong murbei (*Pomacea* spp.) di Indonesia. Prosiding III. Seminar Nasional Biologi XV. Universitas Lampung, 953-955.

Marwoto RM, Isnaningsih NR, Joshi RC, 2018. Notes on the invasive apple snail *Pomacea* spp. in Indonesia. *Agriculture for Development*, **35** (In Press).

MAFF, 2018. [http://gov.east-timor.org/MAFF/English/plant_production.htm]. Accessed 05 October 2018.

Oxfam, 2008. Oxfam Australia Timor-Leste Food Security Baseline Survey Report (accessed 5 October 2018): https://www.oxfam.org.nz/sites/default/files/reports/Timor-Leste%20Food-Security-Baseline-Survey.pdf