Invasive apple snails (*Pomacea* spp.) in Brunei Darussalam: Current status and management in irrigated transplanted rice fields

Hajah Aidah binti Haji Mohd Hanifah[1], Fuziah binti Haji Hamdan[1], Khairunnisa binti Haji Omar Ali[1], Jormasita binti Jormasie[1], Siti Amaniah binti Haji Awang Besar[1], Masjuwita binti Haji Muhin[1], Fahmi bin Haji Masri[1], Norkhadijah binti Haji Latip[1], Haji Roslan bin Haji Pudin[1], Mohd Faadzel bin Haji Abdul Rahman[1], Nurul Hanisah binti Morni[1], Soetikno S. Sastroutomo[2], and Ravindra C. Joshi[3*]

1. Department of Agriculture and Agrifood, Jalan Muhibbah, Berakas, BB3510, Brunei Darussalam; 2. ASEANET c/o CABI Southeast Asia, Building A 19, MARDI, Serdang 43400, Selangor, Malaysia; 3. Tropical Agriculture Association (UK) Pacific Coordinator; SAFE-Network Pacific Islands Coordinator; 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; and Visiting Adjunct Professor at the University of the South Pacific, Fiji.
**Corresponding author: rcjoshi4@gmail.com*

Invasive apple snail egg masses on vegetation along an irrigation canal, Brunei Agricultural Research Centre, Brunei Darussalam. (Credit: Norkhadijah binti Haji Latip).

History and spread

Freshwater invasive apple snail (*Pomacea* spp.), family Ampullariidae, was first recorded in 2009 at the Wasan Paddy Plantation Area, Brunei Muara District, Brunei Darussalam. However, it was not introduced intentionally with a definite purpose; unlike in other ASEAN countries, where they were deliberately introduced for food aside from the aquarium trade (Cowie et al, 2017). Communities in Brunei Darussalam have never recognised *Pomacea* spp., as a food source, although there are several other snail species which are considered as traditional gastronomies. Two species of Pomacea namely, *Pomacea canaliculata* and *Pomacea maculata* have been recorded from Malaysia (Yahaya et al, 2006; Hayes et al, 2008; Arfan et al, 2014; Yahaya et al, 2017). *P. canaliculata* and *P. maculata* have commonly been referred to as golden apple snails, often without clarifying specifically which species, or if both, were involved, or indeed simply assuming it to be *Pomacea canaliculata* (Cowie et al, 2017). For clarity, this article avoids this ambiguous common name designation.

In Sabah, these snails were first sighted in Keningua in the early 1990s, and in Sarawak they were reported in Ba Kelalan in the Limbang Division in 1997 (Teo & Nur, 2017). Brunei Darussalam is right next to Sabah and surrounded by Sarawak, East Malaysia. Therefore, their accidental introduction is likely from a neighboring country.

The Fourth National Report Convention on Biodiversity, Brunei Darussalam, Forestry Department (2010) simply lists Golden Apple Snail, *(Pomacea canaliculata)* and Black Apple Snail *(Pomacea insularus)*, as invasive alien species, with no details. In addition, the use of common terms “Golden Apple Snail” and “Black Apple Snail”, and “insularum” (junior synonym of *maculata*), incorrectly spelled as “insularus”, which added further confusion to the species identity.

A preliminary checklist of the freshwater gastropods of Brunei Darussalam has been documented by Ng et al, (2015). Based on the examination of one empty Pomacea shell collected along edge of mangrove forest on Pulau Bedukang, they

Dead invasive apple snails in the newly transplanted rice treated with synthetic molluscicide, Wasan Rice Plantation Area, Brunei Darussalam. (Credit: Siti Amaniah binti Haji Awang Besar).

could not verify it as either *Pomacea canaliculata* or *Pomacea maculata* (Ng et al, 2015). Exact species determination based on the shell alone is difficult (Hayes et al, 2012).

Therefore, it is very difficult at this time to pinpoint the exact pathways, source of introductions, and the number of *Pomacea* species that have invaded Brunei Darussalam, unless preserved specimens are examined using molecular and morphological approaches (Hayes et al, 2008). Identification of invasive species is one of the most fundamental needs when attempting to manage them (Joshi et al, 2017).

Rice cultivation in Brunei Darussalam

Rice is cultivated in two types of areas, namely irrigated and non-irrigated (rain fed) areas. Farmers in irrigated areas practice double cropping while farmers in non-irrigated areas produce only one crop per year which is in the main season. The main season spans September to February, whereas the off-season is usually from April to August. In 2016, the total rice cultivation area was 1,013 ha where 427 ha were irrigated, while the remaining 586 ha were rain fed. The majority of the farmers practiced transplanting methods either using mechanical transplanters or manual transplantation. However, there are a few farmers who practice direct-seeding methods either by dibbling, broadcasting or using drum seeders. Since more than half of the area is non-irrigated and depends greatly on rainfall, the rice planting and harvesting months varies within a year with the changing weather conditions. The most common rice varieties planted and their average yield/ha are as follows: MRQ76 – 4mt/ha/season and Laila – 3mt/ha/season in irrigated areas, while in rainfed areas, BDR5 – 2mt/ha and traditional landraces such as Pusu, Adan and Bario – 1mt/ha are used. Total rice production expenses per hectare are about BND 5,476.25 (USD 4,102). An estimated revenue in each cropping season/ha is BND 4,800 (USD 6,384) for the irrigated areas and BND 1,600 (USD 2,128) for the rainfed areas. The Government of Brunei Darussalam through the Department of Agriculture and Agrifood buys the paddy from the farmers at BND 1.60/kg under the Paddy Buyback Scheme. After milling, the rice is sold to the public at BND 1.25/kg.

Impact of invasive apple snails

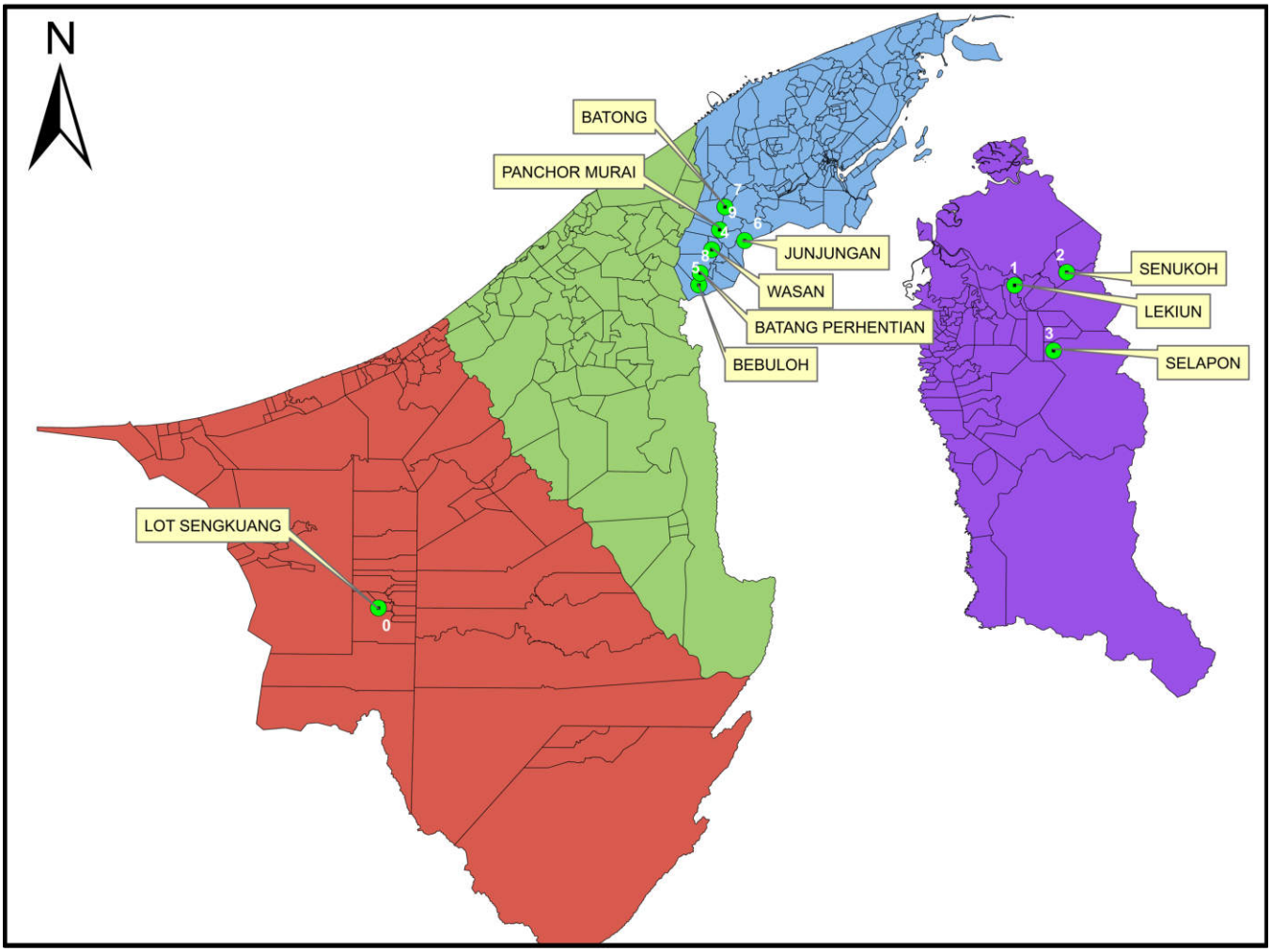
Since its first reported occurrence in Wasan Rice Plantation Area, Brunei Muara District, Brunei Darussalam, there has been no systematic surveys or crop loss analysis to determine the rice areas invaded and destroyed. However, snails are present in all rice fields of four districts and estimated to cause 10-20% damage/ha to newly transplanted rice.

Control of invasive apple snails

The main infested areas are located on the east side of the country, which are mainly irrigated, and where the molluscicides are used. Molluscicides registered in Brunei Darussalam are niclosamide ethanolamine (traded by Bayer Company, Malaysia as Bayluscide in 250g package costing BND 46.00) and metaldehyde (traded by Hwa Hong Trading, Malaysia in 500g package costing BND 1.60-4.50), of which niclosamide is used in rice fields at the rate of 0.315kg/ha, and metaldehyde (Trade names: Siputox, Racun Siput Berbutir), on vegetables and fruit farms at 15-20 kg/ha, but it is likely some rice farmers would have also used metaldehyde in paddy fields. Both molluscicide formulations are sold under Government Incentive Program and the annual estimated average volume was 90.25 kg, based on the Government Agricultural Input Scheme records from 2013-2015. The expenses for crop protection products, are estimated to be BND 400.00/ha, with farmer average spending of about BND 50.00 for molluscicides. Most molluscicides are applied twice per season, during the first month after transplanting, when snails devour young rice seedlings.

Conclusions

Invasive apple snails have spread across both irrigated and rainfed rice areas in Brunei Darussalam since they were first detected in 2009, causing serious crop losses and



Map of rice growing areas in Brunei Darussalam.

increasing reliance on the use of synthetic molluscicides. Aside from direct rice damage, the other negative impacts on non-target fauna and flora including human health and the environment is still unknown. Thus, long-term control and containment is needed 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 integrated approaches.

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