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THE STATUS OF THE APPLE SNAIL, *PILA SCUTATA* (GASTROPODA: AMPULLARIIDAE) IN SINGAPORE

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ABSTRACT. — *Pila scutata* was the largest freshwater snail found in Singapore before the arrival of the introduced *Pomacea canaliculata* in the late 1980s. Its population appears to have declined over the past two decades, seemingly coinciding with the spread of *Pomacea*. The main aim of this article is to assess the status of *Pila scutata* in Singapore. Its past and present occurrence in Singapore is recorded, and threats faced by the snail are discussed.

KEY WORDS. — Ampullariidae, *Pila scutata*, apple snail, Singapore

INTRODUCTION

Freshwater snails of the family Ampullariidae, collectively known as apple snails, are widely distributed along the tropical latitudes (Dillon, 2006), and are the largest living freshwater snails in the world (Perera & Walls, 1996). Most species are readily recognised by their large rotund shell, and the presence of 'two pairs of tentacles' on their head (the shorter pair is actually labial palps projecting from the sides of their mouth). Currently two ampullariid genera are found in Singapore, the Old World *Pila*, and the introduced *Pomacea*, which originates from the Americas.

Pila scutata (Mousson, 1848) is regarded as indigenous to Singapore (Ng, 1991; Chan, 1996; Tan et al., 2012). This species is often mentioned as *Pila conica* (Wood, 1828) in the literature (see Low et al., 2013). It has been recorded from Indonesia, Peninsular Malaysia, Borneo, Vietnam, Cambodia, Laos, and the Philippines, with a doubtful presence in Thailand (van Benthem Jutting, 1956; Brandt, 1974; Keawjam, 1986; Giboda et al., 1991; Vermeulen & Maassen, 2003; JICA, 2007). Up to the 1960s and 1970s, it was widely eaten locally and in neighbouring Malaysia, and was also fed to farmed pigs (Ponniah, 1962; Lim et al., 1978). The species was also introduced as a food item to Hawaii in the 1960s, where it is now established (as *Pila conica* in Cowie, 1998). It has also been introduced to Guam and Palau (as *Pila conica* in Cowie & Hayes, 2012).

The introduced *Pomacea canaliculata* (Lamarck, 1822) is among the 100 of the world's most invasive species (Lowe et al., 2000), and typically regarded as a pest in countries where it has been introduced—damaging crops and threatening native ecosystems (Naylor, 1996; Cowie, 2002; Carlsson et al., 2004). Recent studies have revealed that some species that have been identified as *Pomacea canaliculata*, may in fact be *Pomacea maculata* (see Hayes et al., 2008, 2012). As the identity of the *Pomacea* species established in Singapore has not been positively ascertained, the most often used name for the invasive apple snail regionally and locally, *Pomacea canaliculata*, is here used in the broad sense for convenience. *Pomacea canaliculata* has been established in Singapore for at least two decades (Ng, 1991; Ng et al., 1993; Tan & Tan, 2003). There is little information on the circumstance of its initial introduction, but the aquarium trade is believed to be responsible (Ng, 1991; Yeo & Chia, 2010). Today, it can be found in high numbers in most reservoirs and their tributaries, and in many ponds and canals throughout Singapore.

Although there have been accounts of native *Pila* species being replaced by the introduced *Pomacea canaliculata*, most have relied on anecdotal accounts (Halwart, 1994). In Singapore, *Pila scutata* populations and numbers have been diminishing progressively, coinciding with the arrival of *Pomacea canaliculata* more than two decades ago (Fig. 1; see also Chan, 1996; Tan & Yeo, 2010; Tan et al., 2012). The article aims to provide an update of the status and distribution of the species in Singapore.

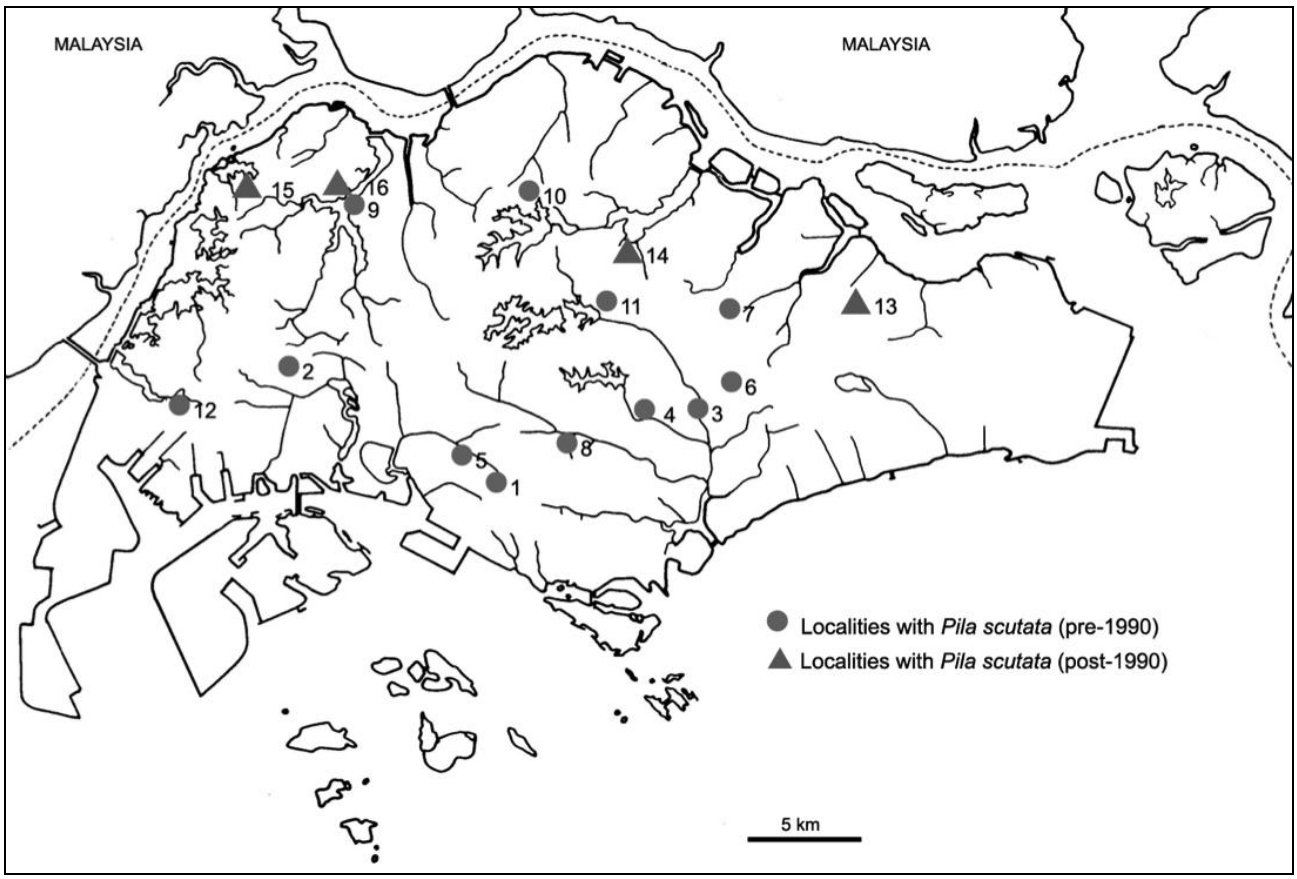

Fig. 1. Approximate localities where *Pila scutata* have been recorded pre- and post-1990 (after first record of *Pomacea canaliculata*). Localities: 1. Buona Vista ponds; 2. Jurong Road ponds; 3. Braddell Road; 4. Sungei Whampoa; 5. Clementi Road ponds; 6. Potong Pasir ponds; 7. Yio Chu Kang Road; 8. Former University of Singapore; 9, 16. Kranji Reservoir; 10. Upper Seletar Reservoir; 11. Lower Peirce Reservoir; 12. Tengeh Reservoir; 13. Sungei Tampines; 14. Lower Seletar Reservoir; 15. Sarimbun Reservoir.

MATERIAL AND METHODS

Specimens of *Pila scutata* deposited in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research (RMBR) at the National University of Singapore were examined. Specimens are cited as follows—locality of collection: catalogue number, date of collection. Published and unpublished reports of the species are also listed, with the locality, habitat, or distribution remarks of the species in parentheses.

SPECIES ACCOUNT

Pila scutata (Mousson, 1848)
(Fig. 2)

Diagnosis. — *Pila scutata* is relatively small for the genus, attaining shell height of about 50 mm although specimens seen are usually considerably smaller. Shell colour is usually dark olive-green or brown with darker spiral bands, but this is often obscured by brownish stains on shells of living snails. The umbilicus of *Pila scutata* is obsolete, and unlike *Pomacea canaliculata*, there are no channels at its suture. Its operculum is solid and calcareous.

Materials examined. — Buona Vista pond: ZRC1989.398–1989.399, 20 Nov.1957; ZRC1989.389–1989.397, 11 Nov.1958. Jurong Road, 11th mile: ZRC1989.452–1989.453, 20 Jul.1960. Jurong Road, pond: ZRC1989.433–1989.437 and ZRC1989.446–1989.451, 23 May 1962; ZRC1989.438–1989.445, 28 May 1962. Jurong Road, 17¾th mile: ZRC1989.425–1989.432, 28 May 1962; Braddell Road, Sungei Kallang: ZRC1989.403, 16 May 1962. MacRitchie Reservoir, Sungei Whampoa: ZRC1989.404–1989.407, 16 May 1962. Clementi Road, ditches: ZRC1989.417–1989.419, 21 May 1962. Clementi Road, pond: ZRC1989.420–1989.422, 21 May 1962; ZRC1989.423–1989.432, — Kian Teck Road: ZRC1989.1949, 23 Jun.1962. Potong Pasir: ZRC1989.379–1989.385, 27 Jun.1962; ZRC1989.1947, 2 Jul.1962. Yio Chu Kang Road, 8th mile: ZRC1989.408–414, 25 Aug.1962. University of Malaya, Botany Department tank: ZRC1989.386–1989.388, 25 May 1962. University Malaya, pond: ZRC1989.466, 15 May 1962. North Buona Vista Road: ZRC1989.467–1989.481, 21 May 1962. Seletar Reservoir: ZRC1989.400–1989.402, 4 Feb.1981; ZRC1990.17176–1990.17177, 6 Dec.1990. Kranji Reservoir: ZRC1991.20053–1991.20066,

31 Aug.1988; ZRC1990.843–1990.851, 2 Sep.1988; ZRC.MOL.6, 7 Jul.2002. Institute of Education: ZRC1990.16215–1990.16223, 10 Sep.1988. Lower Peirce Reservoir Road: ZRC1990.15654–1990.15671, 21 Jul.1990. Lower Peirce Reservoir: ZRC1990.674, 29 Nov.1990. Tengeh Reservoir: ZRC1990.17452–1990.17456, 26 Dec.1990. Pasir Ris Drive 1, canal: ZRC.MOL.5, 13 May 2002. Tampines Eco Green Park: ZRC.MOL.3132, 2 Jul.2011. Lower Seletar Close, canal under Lentor Ave: ZRC.MOL.3135, Oct.2010. Kranji Reservoir: ZRC.MOL.3094, 2009.

Records in literature. — Nevill, 1884: 5 (as *Ampullaria conica* var. *borneensis*, Singapore). Ghosh, 1929: 393 (as *Pila conica*, along Kim Keat Road in Singapore). Johnson, 1973: 116, 120 (found in weed-free and polluted habitats, including fishponds). Khoo et al., 1977: 10 (Seletar Reservoir, common). Ng, 1991: 129 (Singapore). Wee, 1992: 71 (Lower Peirce Reservoir, common). Ng et al., 1993: 22–23 (Singapore). Chou et al., 1994: 73 (as *Pila conica*, Singapore). Chan, 1996: 185–186 (rare). Perera & Walls, 1996: 82 (as *Pila conica*, Singapore). Goh et al., 2002: 103–104 (common in rural ponds and drains). Taylor, 2003: 123 (13 Dec.1985, ditch from Seletar Reservoir, 100 m west of Upper Thompson Road). Clements et al., 2006: 144 (collected from an estuarine reservoir and a monsoon canal). Tan & Woo, 2010: 27 (Singapore). Tan et al., 2012: 126–127 (rare, found in rural ditches and tributaries of reservoirs). Low et al., 2013 (Singapore).

Other records. — D. S. Johnson, undated, unpublished manuscript (very common in developed areas; fishponds, water hyacinth ponds, drainage canals and similar habitats). A. J. Ponniah, 1962, unpublished thesis (University pond; Botany Department tank; North Buona Vista Road, pond; Clementi Road, pond; Jurong Road 10½th mile, ponds; Jurong Road 13½th mile, ditch; Jurong Road 17½th mile, pond; Lorong Buang Kok, ditch; Jalan Kuala Simpang, ditch). Z. L. Xu et al., 1989, unpublished report (River Valley High at West Coast Road, pond; Institute of Education at Bukit Timah Road, puddles in field). G. R. Clements, 2002, unpublished report (Kranji Reservoir; Pasir Ris Drive 1, canal). Pers. obs. (BBC Far Eastern Relay Station, Turut Track: 2003). Pers. obs. (Lorong Tawas, Dragon Kiln Village: Jan.2005). Pers. obs. (Sarimbun Reservoir: 9 Dec.2009; 18 May 2010). Pers. obs. (Kranji marshes, off Kranji Reservoir: 23 Dec.2011).

Ecology. — *Pila scutata* appears to favour shady, sheltered places, often found among vegetation. The main diet of *Pila scutata* consists of vascular water plants, including partially decayed plant matter (Berry, 1963; Palmieri et al., 1979). The eggs are white, and are laid in clusters; each estimated to contain about a hundred or more eggs (see Fig. 3). Egg clusters are deposited above the waterline, usually in depressions in the damp soil, and in sheltered spots under vegetation.

Fig. 2. *Pila scutata* from Neo Tiew Lane 2, shell height 27 mm. (Photograph by: Ng Ting Hui).

Fig. 3. An egg cluster of *Pila scutata*, laid in a depression in the soil among leaf litter, along the banks of a reservoir. Each egg is about 3 mm in diameter. (Photograph by: Ng Ting Hui).

DISCUSSION

Pila scutata was formerly widespread and common in ponds and ditches in Singapore (e.g., Ponniah, 1962; Johnson, 1973; Xu et al., 1989; H. E. Ng, pers. comm.). However, surveys in the 2000s revealed that the species was only extant in a small number of localities (Clements et al., 2006; unpublished data). Although Goh et al. (2002) mentioned that the species was still common in rural areas, they likely relied on older records. Recent records from Kranji Reservoir and Tampines Eco Garden were of single empty shells, while populations have not been recorded in recent years from the localities that were sampled prior to 2009. Habitat loss and wide-scale canalisation of open country streams have been proposed as a reason for the decline of *Pila scutata* in Singapore (Ng et al., 1993; Chan, 1996). Many localities where *Pila scutata* was previously found no longer exist. For example, the ponds in Buona Vista, Jurong Road and Clementi Road have disappeared when these areas were developed for housing and other purposes (see Fig. 1; Housing Development Board, 2011). Although reservoirs have been suggested to be important for the conservation of freshwater molluscs (Clements et al., 2006), the granite-lined banks of many reservoirs do not benefit *Pila scutata*, which prefer shaded, natural banks.

Nonetheless, land use change alone does not seem to explain the decline of *Pila scutata*. This is because suitable habitats for *Pila scutata* still exist around Singapore. While many areas have been modified over the past few decades, some waterways around Singapore are currently being converted into a more natural state (as opposed to concrete canals) for aesthetic and recreational purposes (Lee et al., 2010). These efforts have resulted in canals with natural banks lined with aquatic macrophytes, reminiscent of open country streams of the past, and seem ideal habitats for the molluscs. However, these new habitats are being rapidly colonised by *Pomacea canaliculata* (pers. obs.), while *Pila scutata* appears to have been replaced by the introduced *Pomacea canaliculata* in areas where they were once common (e.g., Sungei Seletar). The species is also known to be tolerant of pollution as it used to thrive in degraded habitats like fish and septic ponds (Ponniah, 1962; Johnson, 1973).

Thus, a more plausible theory for the disappearing numbers of *Pila scutata* is because of competition from the confamilial *Pomacea canaliculata*, although opinions regarding this have varied (see Ng et al., 1993; Chan, 1996; Tan et al., 2012). The decline in *Pila scutata* does appear to have coincided with the introduction and spread of *Pomacea canaliculata*—from the late 1980s onwards. The increasing rarity of *Pila scutata* has followed the rising number of *Pomacea* populations throughout the island. The introduced species was first collected from a tributary of Kranji Reservoir in 1988, but is now found in most reservoirs and many canals and ponds.

The displacement of native apple snail species has been reported in regions where *Pomacea canaliculata* have been introduced (e.g., Halwart, 1994; Thaewnon-ngiw et al., 2004; Marwoto et al., 2011). Empirical evidence for this is

lacking, but a population of native *Pila polita* that existed in a Javan marsh in the 1970s was found to have been completely replaced by *Pomacea canaliculata* by 2011 (Marwoto et al., 2011). In Hawaii, where *Pila scutata* and *Pomacea canaliculata* have been introduced, *Pila scutata* was only found on a single island where *Pomacea canaliculata* was absent (Cowie et al., 2007). It is possible that *Pila scutata* failed to establish in other islands owing to competition from *Pomacea canaliculata*, which is widespread throughout the Hawaiian Islands (Cowie et al., 2007). The biology of *Pomacea canaliculata*, including its faster growth, higher reproductive capacity, and ferocious appetite for aquatic macrophytes, contributes to its invasion success (Cowie, 2002; Estoy et al., 2002; Carlsson et al., 2004; Morrison & Hay, 2011). *Pomacea canaliculata* has also been documented to prey on other snails and their eggs (Cowie, 2002), and could possibly feed on juveniles or eggs of *Pila scutata*. If it is indeed being outcompeted, the few localities where *Pila scutata* is still extant (e.g., Sarimbun Reservoir and Kranji marshes) may not be ideal for the long-term survival of the species, as these areas are also occupied by *Pomacea canaliculata*.

Despite its current scarcity, *Pila scutata* used to be a common human commensal, being found in disturbed habitats in Peninsular Malaysia and Singapore in the 1960s, and Johnson never found the species in undisturbed areas (Johnson, 1973, unpublished data). Its popularity as a food item in the past either meant that it was naturally abundant and widespread in its native distribution (Lim et al., 1978), or that it was widespread because it was commonly introduced by humans (as was the case of its introduction to Hawaii [Cowie, 1998]). As a species associated with humans, the true native distribution of *Pila scutata* is difficult to determine, especially with a paucity of historical data. It is however generally accepted to be indigenous to Singapore (e.g., Ng, 1991; Chan, 1996; Tan et al., 2012).

Nonetheless, the species was undeniably common in the past, and has now become rare in Singapore. The current status of *Pila scutata* in neighbouring Malaysia remains unknown. *Pomacea canaliculata* has been the focus of studies in this region mainly owing to its status as an agricultural pest (Teo, 2004; Marwoto, 2010). The lack of baseline population data and ecological studies on ampullariids native to this region may be obscuring our comprehension of the true extent of the invasiveness of *Pomacea canaliculata*. Further work to fill these knowledge gaps are urgently needed to discover the biological impacts of this invasive species in Southeast Asia, and to avoid any potential ecological disaster from going unnoticed.

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