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Authors: Tan, Siong Kiat, and Clements, Gopalasamy Reuben

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Short communication

Limicolaria flammea (Müller, 1774), another potentially invasive African land snail in tropical Asia

Siong Kiat Tan[1*] and Gopalasamy Reuben Clements[2,3]

[1]Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore, Block S6, Science Drive 2, #03-01, Singapore 117546, Republic of Singapore

[2] School of Marine and Tropical Biology, James Cook University, Cairns, Queensland, Australia

[3] Center for Malaysian Indigenous Studies, Universiti Malaya, Malaysia.

[*] Corresponding author, E-mail: dbstsk@nus.edu.sg

Abstract

The pulmonate land snail, *Limicolaria flammea* (Müller, 1774), is native to West Africa and its invasive potential is hitherto unknown. We report this species in Asia, specifically on the tropical island of Singapore. The presence of this alien species is of grave concern because its congener (*L. aurora*) has invaded the French West Indies and the confamilial giant African land snail (*Achatina fulica*) has colonized the globe to an extent where it is regarded as one of the world's worst 100 invasive alien species. In order to curb the spread of *L. flammea* into the native forests in Singapore, local authorities should start employing mechanical eradication methods (e.g., handpicking). We hypothesize that *L. flammea* arrived together with an exotic plant species, whose identity and import origin must be determined urgently to prevent the spread of this species into the rest of tropical Asia.

Keywords: Achatinid, Africa, mollusc, Singapore, Southeast Asia, terrestrial

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Introduction

Biological invasions involving non-marine molluscs are known to be detrimental to native biodiversity, natural ecosystems, and human health [1-4]. As such, the arrival of an Achatinid land snail in Asia warrants urgent conservation attention, especially if we want to avoid another biological invasion on a scale similar to that of the giant African land snail (*Achatina fulica* Bowdich, 1822), which is now considered by IUCN to be one of the world's 100 worst invasive alien species [5]. From its native range of East Africa or Madagascar, *A. fulica* was transplanted accidentally or deliberately by humans halfway around the globe, including Asia [1, 6-7]. In comparison, the ability of its smaller confamilial relatives from the genus *Limicolaria* to rapidly colonize countries abroad is not well known. Thus far, only *L. aurora* (Jay, 1839) has been documented beyond its native range, in Martinique (French West Indies) where it is considered a pest that can cause economic losses by damaging a variety of crop plants [8]. Here, we report the spread and establishment of its African congener, *L. flammea* (Müller, 1774), in Singapore. Apart from mapping its local distribution, we discuss the conservation implications of its establishment and management interventions to minimize its spread.

Methods

The Republic of Singapore (103º 50′ E, 1º 20′ N) is an island (685.4 km^2) located off the southern tip of Peninsular Malaysia (Fig. 1). Empty shells of *L. flammea* were first noticed in early 2006 during routine mollusc surveys at Tuas, southwestern Singapore (Fig. 1a). Checks in the literature and local land snail reference collection in the Raffles Museum of Biodiversity Research revealed no prior record of this species. The *Limicolaria* specimens were identified using Crowley and Pain [9] and by O. C. Oke (pers. comm. via S. Y. Chan, July 2008). In December 2006, the presence of more shells (many recently dead with rotting animal flesh) was noted near the first site. In mid-2007, more intensive surveys were carried out in the Tuas area to search for live individuals.

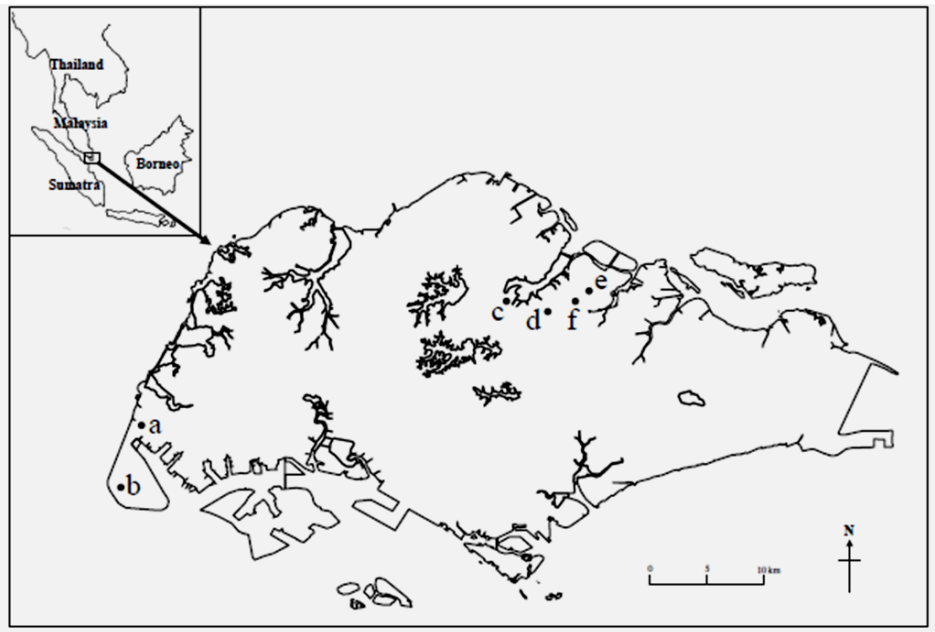

Fig. 1. Map of Singapore showing the known distribution of *Limicolaria flammea* in Singapore in sequential order of discovery: a) Tuas; b) Tuas South; c) Lentor Avenue; d) Yio Chu Kang Road; e) Seletar Aerospace Drive; and f) Seletar West Farmway.

Results

Live individuals of *L*. *flammea* were found for the first time in Tuas South (Fig. 1b; about 6 km from the first site), which was a newly developed industrial area with little traffic and few human activities. Live individuals of *L. flammea* were found beneath dead leaves, underneath fallen fronds of wayside palm trees (*Washingtonia robusta*) native to Mexico, and under vegetation thickets along the pavement. A total of 72 individuals of different sizes and stages of maturity were recorded within a 50 x 50 cm quadrat placed at the spot with the highest snail density. Since the initial discoveries at Tuas in 2006 and 2007, additional surveys at four out of 10 sites (Fig. 1c,d,e,f) yielded live *L. flammea* individuals.

Fig. 2. Adult animal of *Limicolaria flammea* from Seletar West Farmway, Singapore. PHOTO CREDIT: S. K. Tan

Discussion

It was not possible to determine the initial site of establishment for *Limicolaria flammea* in Singapore given our fortuitous (and timely) discovery of this species. Individuals of this alien species were initially found in disturbed areas (e.g., wayside vegetation in industrial areas and plant nurseries), but they do not appear confined to such habitats – several individuals have actually been observed in secondary forests. During a night survey at one site, many *L. flammea* individuals were seen actively foraging among long grass at forest edges. Only a few empty shells were found despite a concerted search during a day trip to the same area – this suggests that the snails are predominantly nocturnal. At the moment, distribution of *L. flammea* in Singapore seems patchy (Fig. 1), but we believe that the species is more widespread. To the untrained eye, *L. flammea* could be mistaken for juveniles of *A. fulica*, a species already well established in this region, and the absence of reports could be attributed to the lack of awareness of *L. flammea*'s presence.

There is paucity of information on the biology and ecology of *L. flammea* in the wild. In laboratory conditions, the snails start laying eggs at 5 months old and clutches of up to 56 eggs are produced [10-11]. *L. flammea* fed readily on potato, apple, lettuce, and carrot in laboratory experiments [12], and it is likely that the snails are unselective phytophagous snails as reported for its congeners. For example, *L. zebra* and *L. numidica* were reported as pests in palm plantations and even colonized interplanted leguminous crops [13]. Mead and Palcy [8] reported many crop plants attacked by *L. aurora* in Martinique, where the snails are an invasive species; these plants included yam, pepper, bean, cucumber, okra, and sweet potato, all of which are grown in many tropical countries. Many *Limicolaria* spp. occur in

abundance in plantations, cultivated land, forest edges, and modified forest, and are also found on outskirts of settlements and farms [14]. Oil palm and cocoa plantations are also mentioned as suitable habitat for *L. flammea* in Nigeria [15-16]. Based on these accounts, the spread of *L. flammea* is potentially damaging to the multi-billion dollar horticultural industry in Singapore, as well as a major threat to agricultural productivity in neighboring countries such as Malaysia and Indonesia.

To date, we have not been able to conclusively determine the origin of this exotic species' introduction. The most plausible explanation would be that the snails (or eggs) were stowaways on exotic plants, since trade is a major pathway [17-18], particularly in a country such as Singapore where major air and shipping routes intersect. We hypothesize that *L. flammea* arrived together with an exotic plant, given the initial detection of these species in built-up areas with newly planted exotic trees. *Washingtonia robusta*, the exotic Mexican palm that individuals of *L. flammea* were first found with, is commercially available in Singapore. Our hypothesis is not unrealistic as more than 400 species of vascular plants in Singapore are native to tropical Africa, of which 259 species are known to be cultivated locally (K. Y. Chong unpublished data).

Fig. 3. Top row, *Limicolaria flammea*. Bottom row, *Achatina fulica*. Scale bar (white): 1 cm.
PHOTO CREDIT: S. K. Tan

Implications for conservation

Biological invasions involving non-marine molluscs are known to be detrimental to native biodiversity and natural ecosystems, but studies alerting to potential invasions are rarely published. We argue that this trend should change. In one of the first documentations of the alien apple snail, *Pomacea canaliculata*, in Singapore, Ng et al. [19], the invader was not considered to be a threat to the native apple snail, *Pila scutata*. Today however, in less than two decades, the native snail is on the verge of local extinction with the alien species implicated [20]. Although there is no evidence of adverse interactions between *L. flammea* and other native taxa, we recommend that the local spread of this species should be curbed using mechanical eradication methods (e.g., handpicking) based on the precautionary principle.

Identifying the exotic plant that transported *L. flammea* should be the priority task in order to enable local customs authorities to regulate its import and adopt appropriate quarantine measures. In fact, we have sent letters to the National Parks Board and Agro-food and Veterinary Authority in Singapore to inform them of this need. Knowledge of the plant's import origin is also important in order to alert authorities of that exporting country to verify the presence of *L. flammea* in the import sources. It is worrying that the congener (i.e., *L. aurora*) of *L. flammea* is considered as potentially more damaging than the globally invasive *A. fulica* [8, 18], which spread from Singapore, to China, Taiwan, and Indonesia, then further on to Hong Kong, Japan, Micronesia, Hawaii, and possibly the Philippines [1, 6-7]. Hence, dissemination of information regarding the establishment of *L. flammea* in Singapore to arrest its spread is of utmost priority. If our suggested preventive and control measures are not implemented, the ecological and economic damages caused by *L. flammea* in tropical Asia could be costly, and eradication almost impossible.

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