



SINGAPORE

Invasive Alien Species in Singapore: A Review

Singapore has a long history of introduction of foreign plants and animals. The Island's location at the centre of major air and shipping routes has inevitably resulted in the accidental or deliberate introduction of numerous plant and animal species, not to mention micro-organisms and fungi (Ng *et.al* 1993).

For plants, more than half of the introduced species are from tropical America, followed by Asia, and then, Africa and Australia. However, among plant groups, the focus of past investigations has been on the seed plants. Only now do we have information about alien pteridophytes and exotic mosses (e.g., *Ochrobryum kuzianum* and *Pterigonidium pulchellum*) that have become established in Singapore.

For the animals, we have good knowledge about non-indigenous mammals, birds, reptiles, amphibians, freshwater fishes and decapod crustaceans. Apart from rats, few non-native mammals have established themselves in Singapore. This is in contrast to a total of 72 species of non-native birds now known to be residents in Singapore (Lim & Gardner 1997). Majority of naturalized birds in Singapore originated from the Asian subcontinent; the rest are from Australia and Africa.

Many are cage escapees that have adapted to the now largely urban environment of Singapore.

Naturalized reptiles as a result of the pet trade include the red eared terrapin (*Trachemys scripta*) from North America (Anonymous 2002), striped keelback (*Xenochrophis vittatus*) from Indonesia, and changeable lizard (*Calotes versicolor*) from Indochina (K.K.P. Lim, pers. comm.).

The painted bullfrog (*Kaloula pulchra*) from Indochina and the American bullfrog (*Rana catesbeiana*) from the USA are now common in residential areas and reservoirs, respectively. Similarly, the majority of the alien freshwater fishes in resident in Singapore are a result of the ornamental fish trade. Examples are *Liposarcus pardalis*, *Poecilia sphenops*, *Gambusia affinis*, *Oreochromis mossambicus*, *Etroplus suratensis*. These are either escapees or were introduced recently for mosquito control. Of a total of 58 non-indigenous teleost fish species recorded from Singapore thus far (K.K.P. Lim pers.comm.), about half are from Asia, while species from Central and South America comprise 33% of the total number of exotic species.

The remaining species consist mainly of African cichlids. Two species of freshwater prawns (*Macrobrachium lanchesteri* from Thailand and *M. nipponense* from East Asia) are now established in freshwater streams in Singapore, but again, their impact on native inhabitants has not been fully



Changeable lizard

Dr. Martin Williams



American bullfrog

www.nps.gov



eebweb.arizona.edu

Bivalve

elucidated. Other significant invertebrate groups such as protozoa, platyhelminthes, nematodes and insects remain poorly documented and their presence (or absence) is not immediately known.

In the estuarine environment, two exotic bivalve species have established themselves. The Caribbean bivalve, *Mytilopsis sallei* (Dreissenidae), is found in large numbers mostly along the walls of tidal monsoon canals, forming mats of several kilometres long in some cases (Tan & Morton, submitted). This bivalve is closely related to the notorious Asian zebra mussel, *Dreissena polymorpha*, which has invaded and caused havoc in waterways in the North American continent. Not surprisingly, *Mytilopsis* has already established itself in various Asian ports including Japan, Taiwan, Hongkong, Thailand, Fiji, Darwin and India.

In Singapore, *Mytilopsis* occurs together with native byssate bivalves, *Isognomon ehippium* (Isognomonidae) and *Musculista senhousia* (Mytilidae), which are common in mangroves but have found the monsoon canals to be suitable habitats as well. Note however that *Mytilopsis* is rare in the mangroves, and it remains to be seen if this bivalve can be classified as "invasive" as defined in this review. The other exotic bivalve is the Indian mussel *Brachidontes striatulus* (Mytilidae), which although not as widespread as *Mytilopsis*, is also found in monsoon canals (Morton and Tan, submitted). It is quite likely that the two bivalves have travelled to Singapore either as adults attached to ships' hulls, or as larvae in ballast water.

However, not all exotic species that became adapted to or naturalized in Singapore are invasive or threaten the survival of local counterparts. Observations suggest that a great majority cannot even survive outside of human intervention. Of about more than 2000 introduced plant species grown in Singapore, about 136 species have become natu-

ralized on their own capability (Corlett 1988). Only a small fraction such as *Adiatum latifolium*, *Clidemia hirta*, *Spathodea campanulata*, *Dioscorea sansibarensis* and *Thunbergia grandiflora*, have been reported or observed to actually invade the primary and old secondary forests, and/or inhibit the regeneration of secondary forest (Turner & Tan 1992). The explanation has been attributed to the fact that many of the introduced species are sun-loving plants and require a nutrient rich soil for their establishment and expansion. Apparently, in Singapore, many local forest plant species have evolved over the millennia to become well adapted to the closed tropical forest condition and, therefore, are resistant to foreign aggression, as long as the remaining forest or original vegetation is not disturbed further by human activities (Teo *et al.*, submitted). In other words, it would appear that the continuous human disturbances facilitate the local spread of invasive alien plant species.

Interestingly, Ng (1993) made a similar conclusion on the assessment of the invasiveness of introduced fresh water fishes and prawns in Singapore as a result of the aquarium trade in recent years. These introduced species have not affected significantly the fauna in pristine forested streams. Of a total of 58 exotic fish species known to occur in Singapore, about 22 species have established populations in the wild. The likely reason for the poor penetration of exotic species into native habitats is that more than 80% of the native species are forest species. They are adapted to living in acid water that is characteristic of the pristine water system inside forest, whereas the introduced ones, thus far, were found to prefer more neutral and harder waters. In fact, their assessment showed that more than 50% of the indigenous fauna have become extinct today due to forest clearance instead.

The poor performance of invasive plant and animal species in Singapore at present does not mean that serious cases of invasive weeds and pests will not occur in the future. Perpetual alertness and constant monitoring are needed to prevent the problem from becoming an environmental crisis. This is particularly relevant in the case of micro-organisms, which have direct relevance for ballast water management. ■

*Excerpts from the paper of the same title presented by **Benito C. Tan** of the Department of Biological Sciences (DBS) and **Tan Koh-Siang** of the Tropical Marine Science Institute (TMSI), both of the National University of Singapore, during the workshop on "The Prevention and Management of Invasive Alien Species: Forging Cooperation through South and Southeast Asia" held from 14-16 August 2002 in Bangkok, Thailand.