COMMENTARY

When pets become pests – exotic aquarium fishes and biological invasions in Kerala, India

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One of the major underlying causes for increased biological invasion is the growth and development of world markets[1] facilitated through globalization, and the booming intercontinental trade of live flora and fauna. The vast majority of recent invasions has been attributed to human activities associated with this international trade, which is accelerating the spread of organisms into new regions[2,3]. Global trade in flora and fauna has led to both repeated introductions of popular exotic species in many systems and has aided in secondary releases through their cultivation[4,5]. For example, in the United States, 85% of established non-native woody plant species were introduced through horticultural trade[6], and 26% of non-indigenous freshwater fishes that occur beyond their native range were introduced through the aquarium trade[7].

Over one billion ornamental fish comprising more than 4000 freshwater and 1400 marine species are traded internationally each year[8], making it one of the most important components of the global fish trade. Freshwater species make up 90% of this trade as they are the most popular and widely kept aquarium pets worldwide. Although aquarium fisheries and trade is a multi-million dollar industry that supports thousands of rural people in the developing countries, as well as retailers and hobbyists in developed countries, the industry is also known to be one of the most important, yet poorly studied pathways for biological invasions in aquatic environments[9]. The release and dispersal of aquarium fish have received little attention worldwide[10,11], in spite of the knowledge that one third of the world's worst aquatic invasive species are ornamentals[12]. Aquarium fishes are mainly introduced into recipient waters as a disposal method apparently perceived as more humane than various euthanasia options[13]. The most commonly cited reasons for release of healthy ornamental fish are that owners tire of them, or that, they become too large or prolific for their aquaria[14]. Additional reasons include accidental escape during drainage of water from aquaria[9] and during rains and floods from culture systems.

Aquarium fishkeeping is a popular hobby among many people in Kerala, where the demand for exotic species is maintained by the supply from commercial breeders and farmers operating both within and outside the state. There are around 168 registered aquarium shops operating in the state[15], and many hundreds of unregistered ones. With around 500 breeding units, Kerala is also the third largest ornamental fish-producing state in India[16]. To a large extent, the breeding and rearing of exotic aquarium fish in Kerala are carried out in earthen and cement ponds, cement tanks and plastic lined pools. Many hundreds of species of exotic aquarium fish are bred in such systems and marketed in the state. Despite this extensive trade, release and dispersal of exotic aquarium fish, and its consequences on native species and ecosystems is yet to receive attention in the state.

Eleven species of exotic fish are known to occur in the inland waters of Kerala[17], posing a serious threat to the native biodiversity. Of this, at least four species are popular aquarium pets: *Pterygoplichthys multiradiatus*[18] (algae sucker/sucker cat), *Poecilia reticulata*[19] (guppy), *Trichogaster trichopterus*[20] (three-spot gourami) and *Xiphophorus maculatus*[19] (platy).

P. multiradiatus, an armoured catfish native to the South American drainages, is a popular aquarium pet worldwide and is known commonly as 'algae eater'. *P. multiradiatus* has been recorded from three natural freshwater ponds at Vylathur in Thrissur District[18], and the Chackai Canal of Thiruvananthapuram District[21] in Kerala. Species under the genus *Pterygoplichthys* have been introduced worldwide as a result of the ornamental fish trade. In the Philippines, where they are known as janitor fish, two species have established feral populations in Marikana River and Laguna de Bay, and are considered a threat to the native freshwater fish. *P. multiradiatus* is also known to have established in natural waters of countries as widespread as Puerto Rico, United States of America and Taiwan. They are omnivores, attaining large sizes (up to 500 mm) and exhibiting territorial behaviour. Further, they are capable of tolerating pollution because of their air-breathing ability[22] and are also known to create serious negative impacts on periphyton feeding and bottom spawning fishes. Similar situations may be replicated in water bodies of Kerala, where economically valuable bottom spawners such as *Etroplus suratensis* occur. Grazing on benthic algae and detritus by suckermouth catfish is also known to alter and reduce food, and physical cover available for various aquatic insects[23], thereby affecting the trophic chain. The perennial ponds from where *P. multiradiatus* were collected from Vylathur, are connected to the Canoli canal which is subjected to tidal influx from the adjacent backwaters[18]. Hence, the possible escape and colonization of the sucker catfish in the backwaters and associated natural waters of the region is a cause for grave concern. *P. multiradiatus* has also established a substantial population in Chackai Canal, replacing other herbivorous fishes[21]. Apart from biological interactions, *P. multiradiatus* is also known to cause economic losses to fishermen through damage to fishing gears, especially cast and gill nets[24].

Individuals of guppy, *P. reticulata*, one of the most popular aquarium fishes worldwide were collected from the second order streams of Chalakudy River flowing through tea plantations[19]. Many were found to be brooders, whereas others were early fry, suggesting that *P. reticulata* has already established a self-sustaining population in these waters. Further, guppies have established good populations in natural ditches connecting the main branches of Meenachil River in Aymanam Panchayat in Kottayam District[25] and also in the drainage canals of Ernakulam city, which are connected to various natural water bodies including the Vembanad Lake. Since males of *P. reticulata* mature at two months and females at three months of age, they have every chance of proliferating and becoming a potential pest in the inland waters of Kerala.

Another recent study[20] resulted in the collection of 21 individuals (15 males and 6 females) of the popular aquarium fish, *T. trichopterus* – three spot gourami, from canals that empty into Vembanad Lake – the first report of this species from natural waters of Kerala. The habitat from where *T. trichopterus* was collected was also seen to be infested with *Eichornia crassipes*, a common invasive waterweed. Local fishers also revealed that gourami have been sporadically observed in their catches since the last few years. The length–weight relationship of *T. trichopterus* revealed a positive isometric growth indicating that the species has a good condition in this habitat[20]. Although there is no information on the ecological impacts of the three-spot gourami in its introduced ranges, the species is an opportunistic carnivore having territorial and aggressive behaviour[26] that could potentially prove harmful to native ornamental species such as *Pseudosphronemus cupanus* and *Apolocheilus lineatus*.

The insectivorous feeding habit of platy, *Xiphophorus maculatus* makes them potential competitors for indigenous barbs like *Puntius fasciatus*, *Puntius ticto*, *Puntius vittatus* and Killi fishes like *A. lineatus*, *A. panchax* and *A. dayi*. As in the case of *P. reticulata*, *X. maculatus* also attain sexual maturity after 3–4 months and reproduce easily, becoming potential pests in the near future[19]. *A. lineatus*, which is a popular native ornamental Killi fish species found in Chalakudy River[27], was found to co-exist with *X. maculatus* in the mid and upstream reaches (Rajeev Raghvan, pers. obs.). Platy is already known to have become sympatric with the native melon barb, *Puntius fasciatus* in the first order streams of Chalakudy River[28].

Although not all aquarium fish species released/escape to the wild will survive, nor will all of those that survive be able to reproduce or ultimately become pests. If sufficient numbers of individuals find their way out, they may be able to reproduce[9] and subsequently establish feral populations. The large populations of *P. reticulata* and *T. trichopterus* observed from Chalakudy River and Vembanad Lake are evidences for species that have now established in the new environments. Little information is currently available on the distribution and possible impacts of other exotic aquarium fish species in the region. Much of our understanding on the alien fish invasion in Kerala is through a handful of studies restricted to certain rivers[17,19,20]. Unless follow-up investigations are conducted over subsequent years, the status of many exotic invasions will remain unknown. Multiple discoveries of various life stages over at least two consecutive years could reveal the establishment potential of the species in various river systems. Large populations of *P. reticulata* and *X. maculatus* which have been observed continually over the last few years in Chalakudy River confirm fears of their widespread invasion in this riverine hotspot.

Marketing and trade in exotic aquarium species is significantly related to their occurrence and establishment in the wild. The volume of trade in many species is known to be a significant factor in the probability of their establishment[29]. Fish species sold in high volumes in the aquarium trade are more likely to be sighted in the wild[11,30]. 'Propagule pressure' – still the best explanation of invasion success[31,32] has been used as a basis to understand the dynamics of invasion of many species in different countries[11,33,34]. The four species of exotic fish sighted from the wild (*P. multiradiatus*, *T. trichopterus*, *P. reticulata* and *X. maculatus*) are indeed some of the most popular and intensively marketed ornamental varieties in Kerala, giving credibility to the propagule pressure effect.

Another major risk factor is the rearing of exotic aquarium fishes in open systems such as granite quarries and homestead ponds. Quarry farming of ornamental fish is an emerging activity in Kerala, especially in the central districts[35]. During monsoon, water accumulates in the quarries and the owners lease their sites for ornamental fish culture. A vast majority of such quarries are not protected with fencing/netting, and as a result, individual fish escape into the adjoining natural ecosystem during runover associated with monsoon. Similar problems also exist with homestead ponds culturing exotic aquarium fish. Such culture ponds operate with little or no infrastructure to prevent escape of captive fish during monsoon, when there is considerable flooding.

To make matters even more complicated, India has no legislation on the import or introduction of aquatic organisms[36], nor is there a proper quarantine procedure in place for imported fishes[37]. Although the National Committee for Exotic Species suggested setting up of quarantine facilities for the import of aquarium fishes near the international airports[38] at Mumbai, Chennai and Kolkata as early as 2004, there has been no concerted effort to implement such a policy till date. Exotic species introduced purposefully or accidentally into natural water bodies can adversely affect local fauna through genetic pollution, disease introduction and ecological impacts, such as predation, competition and environmental modification. More precaution is essential while undertaking large-scale breeding programmes of exotic ornamental fish. Effective quarantine measures are required as a precaution to prevent the introduction of pathogens and parasites along with exotic species, and to reduce the resultant economic losses to the country.

Aquarium fish trade is undeniably a vector activity that has a role in the introduction, dispersal and invasion of exotic species. The role of domestic markets and local trade in the dynamics of invasion success needs to be studied in detail as the escape, establishment and spread of exotic aquarium fishes will depend on the developments in domestic markets[33]. In addition, field investigations on eco-biology of the exotic fish species that have established in the wild should be carried out, in an attempt to manage the existing invasive populations. This will allow fisheries researchers and conservation biologists to control any additional dispersal of exotic fish to new ecosystems, and limit the impact that these exotics may have on the native fauna with regard to predation, competition for food and other resources, and also introduction of new pathogens.

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