Aliens from Aquariums

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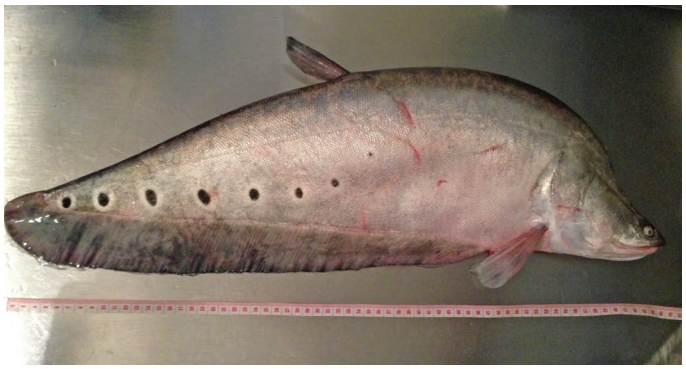
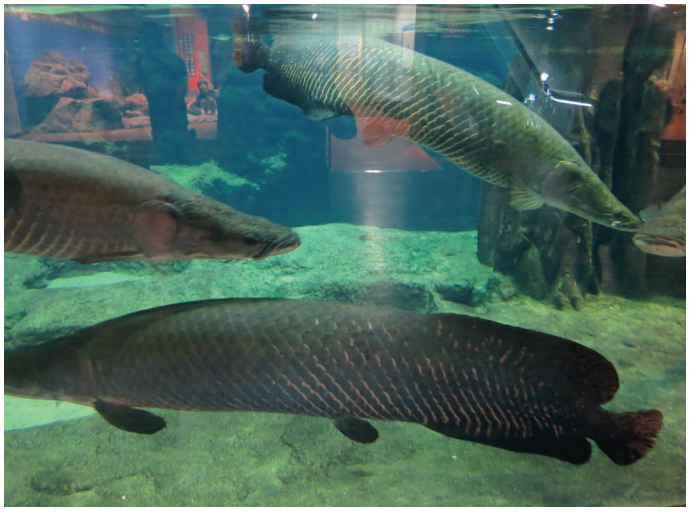
The Philippines is one of the centers of global fish diversity due to its archipelagic shape and tropical position, providing a wide array of ecosystems to sustain a massive assortment of fish species. This diversity is a vital resource for the country because fish provide income, nutrition and international export from the fishing nation (Alima and Patricio 2010). Although rapid population increase leading to pollution, combined with global climate change, have caused extensive damage to inland and coastal aquatic habitats, the alarming increase in proliferation of invasive alien fish species (IAFS) is fast becoming a threat to endemic and indigenous wildlife in national waters (Joshi 2006). There are many pathways for the spread of IAFS and an understudied branch of their proliferation is the escape of ornamental fish into native waters.



The spotted knifefish Chitala ornata *can consume 7 kg of fish and shellfish per day, wrecking aquafarms and nurseries in Laguna de Bay, Philippines. Photo: J.A. Ragaza.*



Arapaima (Arapaima gigas)*, native to South America, is one of the largest freshwater fishes in the world. Photo: J.A. Ragaza.*

What are Alien Fish and What is Their Impact?

"Alien" fish are non-native species that are introduced into marine or freshwater systems deliberately or accidentally for biological control, commerce, food production, sport or ornamentation (Guerrero 2014). In over a century, more than 60 species have been introduced into Philippine waters and have become a mainstay in the majority of the major streams and rivers of the country, thriving with their own wild populations (Joshi 2006, Guerrero 2014). Most of these species are hardy and quick to adapt, having the ability to thrive in local areas that are not part of their natural distribution range. The magnitude of damage from these species is difficult to quantify, owing to multifactorial impacts on an array of colonized habitats (Nghiem *et al*. 2013). Exotic species reproduce and establish themselves quickly in new habitats, altering the natural animal and plant composition of these ecosystems.

These alterations raise ecological, economic, evolutionary and health concerns:

- IAFS can cause alterations in native fish populations, contributing to the production loss of commercial fish species through predation. IAFS are also implicated as a leading cause of displacement of native fishes, occupying open niches vulnerable ecosystems, causing competitive exclusion, and eventually leading to up to 48 percent of fish extinctions (Harrison and Stiassny 1999, MacKinnon 2002, Ricciardi 2004, Clavero and Garcia-Berthou 2006).
- IAFS may cause biotic homogenization – the interbreeding or hybridization with locally compatible fish species that leads to a loss of their biological distinctiveness or identity at functional, genetic and taxonomic levels. This leads to the loss of "pure" native species that often lose to more aggressive hybrids that may have increased bio-invasive potential (Huxel 1999, Mooney and Cleland 2001, Oldgen and Rooney 2006). Biodiversity losses are greater in freshwater ecosystems than in terrestrial environments (Jenkins 2003).
- IAFS may carry new and exotic diseases (Pickrell 2004). Some diseases such as viral hemorrhagic septicemia that causes bleeding and damage to vital organs of fish has been documented to be transmitted through IAFS and affect fish populations (Browser 2017). Certain species such as the freshwater snail *Biomphalaria straminea* can be vectors of disease such as schistosomiasis (Ferrari and Hoffman 1992).
- IAFS may cause habitat degradation and skew food production that are necessary for economically important fishes in aquatic habitats by changing nutrient dynamics (Hermoso *et al.* 2011, Capps and Flecker 2013). This leads to less food and nutrients available for fish and other species in the environment.
- Some species such as from the genus *Pterygoplichthys*, more commonly known as janitor fish, cause damage to riverbanks and fishing implements of commercial fishermen, affecting their livelihoods (Huballa *et al.* 2008, Guerrero 2014).
- Invasive species may influence and shape evolution; it has been previously believed that evolution takes a long time (Hulme and Roux 2016) but studying IAFS shows that they can alter evolutionary pathways of native fish due to various ecological selection pressures

(CONTINUED ON PAGE 60)

and that these alterations can occur over much shorter time intervals (Mooney and Cleland 2001, MacKinnon 2002, Huey *et al*. 2005).

The consequences of uncontrolled IAFS population increase and spread in the Philippines has the potential to be economically deleterious. The Philippine fishing and aquaculture industry provided 1.8 percent of the national gross domestic product in 2012 and employed 1 million people in 2010, producing US$ 1.2 million worth of fish and fishery products for export in 2013 (FAO 2014). Data on the economic impact of IAFS introductions is not comprehensive or complete, limited to unconsolidated reports (Joshi 2006, Guerrero 2014). Damages are not only due to losses of commercially important fish species; the hidden consequences on the environment are also a major concern because, once established, IAFS are almost impossible to completely eradicate (Gozlan *et al*. 2010).

Peacock bass Cichla ocellaris *caught on a fish farm in Laguna, Philippines. Photo: Bettina Salvador.*

The Philippine Freshwater IAFS Scenario

According to reports by Juliano *et al*. (1989), Joshi (2006) and Guerrero (2014), 62 freshwater fish species have been introduced into local waters since 1905 for a variety of purposes, including aquaculture, ornamental, recreational, and biological control. Of these introductions, ten can be classified as invasive and an additional four have the potential to be invasive (Table 1).

One of the easily observed trends is that 11 of 14 invasive and potentially invasive species were introduced directly for ornamental purposes, without much record of the year of introduction, pointing in the direction of their accidental release into Philippine waters. This is not unexpected because almost one-third of the top 100 worst invasive species in the world listed by the International Union

TABLE 1. Invasive and potentially invasive freshwater fish species in the Philippines (Guerrero 2014).

SPECIES	*ORIGIN*	*YEAR*	*STATUS*
Invasive			
Channa striata mudfish	Malaysia	1908	C, EN, W
Channa micropeltes giant snakehead	Thailand	U	O, EN, W
Chitala ornata clown featherback	Thailand	U	O, EN
Clarias batrachusa Asiatic catfish	Thailand	1972	C, EN, W
Monopterus albus rice paddy eel	Malaysia	U	C, EN, W
Parachromis managuensis jaguar guapote	Central America	U	O, EN, W
Pterygoplichthys disjunctivus vermiculated sailfin catfish	South America	U	O, EN, W
Pterygoplichthys pardalis Amazon sailfin catfish	South America	U	O, EN, W
Sarotherodon melanotheron black-chinned tilapia	U	U	O, EN, W
Clarias batrachus Asiatic catfish	Thailand	1972	C, EN, W
Potentially Invasive			
Arapaima gigas arapaima	South America	U	O, EN
Chitala chitala clown knifefish	Thailand	U	O, EN, W
Cichla occularis peacock bass	Central America	U	O, EN
Pygocentrus nattereri red-bellied piranha	South America	U	O, EN

C-cultured O-ornamental EN-natural breeding W-found in wild U-unknown

Walking catfish Clarias batrachus are easily captured from various inland waters of Central Luzon, Philippines. Photo: Joebelle Mercado Ramirez.

Jaguar cichlid Parachromis managuensis *captured as a fingerling from Taal Lake, Batangas, Philippines and kept as an indoor pet. Photo: Zomesh A. Maini.*

for Conservation of Nature are from aquarium or ornamental releases (Lowe *et al*. 2000). The glaring prevalence of aquarium fish as the greatest number of local IAFS necessitates an inquiry of the degree of involvement of the Philippines in ornamental fish trade.

Is Ornamental Fish/Aquarium Trade the Culprit?

One of the primary reasons for ornamental IAFS is the thriving and unregulated aquarium trade industry with consequent and unwanted species invasions from increased commercial activities. The ornamental and aquarium trade represents a large reservoir of invasive species with around 115 invasive freshwater fishes introduced globally (Mendoza *et al*. 2015).

Despite the risks, the Food and Agriculture Organization (FAO) promotes the ornamental fish sector for development in terms of poverty alleviation and marine preservation in rural communities (Padilla and Williams 2004). This is mirrored in the Philippines by promotional activities of the Bureau of Fisheries and Aquatic Resources (BFAR) from as early as 2005, being part of its short-term plan to reduce imports and increase exports of high-value ornamentals using backyard fishpond and tank aquaculture methods (PhilStar Global 2005). The business is lucrative, with ornamentals fetching prices of US$ 395/kg, in comparison to Nile tilapia that sells for US$ 1.58/kg (PDI 2017).

Ornamental fish farming is on the list of sustainable development and trends in Philippine aquaculture (Lopez 2006) and this trend continues. Until recently, BFAR has been providing broodstock and training for those interested in ornamental fish farming (PDI 2017). Stemming from good intentions at augmenting the income of lower and middle-class families, the lack of strict implementation of rules regarding the rearing and trade of ornamental fish may be a possible route of infestation of local waters. Actual reports of Philippine exotic IAFS trade prevalence are very limited, despite numerous sales in several small-scale aquarium shops in Manila.

The interest in ornamental fish export is not without reason. From 1976 to 2007, the number of countries involved in the ornamental fish trade has been increasing, and according to FAO data, export volume value increased from US$ 21.5 million in 1976 to US$ 315 million in 2007 (Monticini 2010). Asia exports about US$ 162 million worth of ornamental fish species, comprising 51 percent of the global ornamental fish trade. The Philippines alone exports about US$ 7.4 million worth of ornamental species, with a 2.3 percent global export share as of 2007 (Monticini 2010). The sheer number of fish transported from one region to the other, including exports from and to the Philippines may be another possible venue for accidental release of IAFS when proper monitoring is scarce. This may be increasingly true for small backyard farms and aquarium shops without proper aquaculture risk management strategies. However, the extent of IAFS invasion in the Philippines, occupying discrete bodies of water, points to several drivers for their territorial expansion.

Pathways for Invasion by Ornamentals

The two major pathways for IAFS ornamental colonization of waters are intended or accidental introduction. Freshwater fishes are some of the most heavily introduced aquatic animals globally (Gozlan 2008). Direct introduction maybe through attempted breeding in freshwater catchments; broodstock rearing in open, inland waters; and introduction into lentic and lotic systems. Despite the demand for fish and fish products varying from country to country, global societal demands for ornamentals may account for up to 21 percent of all intended introductions (Gozlan 2008). In the Philippines, information on the history of intended introductions is scarce, except those primarily intended for food production and recreation (Joshi 2006), with minimal knowledge of possible ecological impacts of their introduction (Guerrero 2014).

Although only a few species that escape have the potential to be invasive (Keller *et al*. 2007), there is a growing concern for impacts of ornamental fish introduction due to a lack of data on the full environmental and economic cost of ornamental escapees (Padilla and Williams 2016). The costs of production losses are difficult to quantify because accurate estimates of losses of commercially important fishes are difficult to measure. Although there are minimal records on the accidental release and dispersal of fishes worldwide (Copp *et al*. 2005), ornamental fish have the greatest potential to be introduced into freshwater ecosystems (Duggan *et al*. 2006). The dumping of ornamentals into new waters is a major route of IAFS reaching new ecosystems (Magalhães and Jacobi 2013). Fragile aquatic habitats are most hit by IAFS travelling via the aquarium trade (Knight 2010).

One major accidental route of IAFS dispersal that needs further study in the Philippines is the impact of the 15-16 typhoons the country experiences annually (FAO 2014). Typhoons may cause flooding that can facilitate the escape of ornamentals from backyard aquaculture farms and contained bodies of water, such as in the case of ornamental knifefish *C. ornata*. This knifefish was believed to have been introduced into Laguna de Bay two years after the massive flooding caused by Typhoon Ondoy in 2009 (Guerrero 2014). The common or leopard

(CONTINUED ON PAGE 62)

Red-bellied piranha Pygocentrus nattereri *sold under-the-table at a local petshop in Manila, Philippines. Photo: Z.A. Maini.*

pleco *Pterogoplichthys pardalis*, introduced with permission from BFAR, is also thought to have been accidentally released in the same manner, through inundation of fishponds that emptied into Laguna de Bay, now being reported as far as Agusan marsh in the southern part of the Philippines in Mindanao (Hubilla *et al*. 2008, Guerrero 2014). Similar situations have happened in the west, with hurricanes and flooding dispersing aggressive invasive species (Rathke 2012).

The Road Beyond

Despite established risk assessment technologies in various countries, adoption has been affected by notions that assessment data is far from perfect and may reduce economic benefit from countries adopting strict enforcement (Keller *et al*. 2007). This highlights tension between commercial interests, responsible farming and culture, and potential risk involved in the intended and accidental release of IAFS.

In the Philippines, the Philippine Fisheries Code of 1998 (RA 8550) and the Fisheries Administrative Order No. 221 of 2003, along with membership in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) have aimed at bio-safety regulation of fish and fishery products but have failed at the prevention of proliferation of IAFS in various locations in the country. The principal problem lies in the enforcement of existing laws, with small aquaculture farms and ornamental and aquarium shops operating illegally or without sanctions, to the extent that the country is considered to be the center of illegal tropical and aquarium fish trade (Alave 2012).

Although the prevalence of IAFS in the Philippines cannot be ignored, a balance must be struck in developing small-scale ornamental aquaculture farms that can augment income and bolster the economy. Around 77 percent of introduced freshwater species in the Philippines are classified as beneficial and far outweigh losses sustained from IAFS (Guerrero 2014). One of the simplest methods of reducing the national susceptibility to IAFS proliferation is to augment the current manpower presently performing operations for various government agencies. With 35 major piers and 122 smaller ports, the government lacks the ability to have regular and meaningful monitoring to prevent smuggling and unlicensed breeding of ornamental IAFS. This problem is further exacerbated by the country's archipelagic nature, increasing the challenge of coordination, transport and monitoring.

Current strategies to mitigate the damage of these local IAFS include their use as food for human consumption after safety checks (*C. micropeltes*, *P. managuensis*), as fishmeal (*C. ornata*, *P. disjunctivus*), as ornamentation (*P. pardalis*), and as an export commodity (*M. albus*) (Huballa *et al*. 2008, Guerrero 2014, Abarra *et al*. 2017). Based on observation and informal reports, even if some of these fish are being sold in rural wet-markets, such as *C. ornata*, there is difficulty in mainstreaming the species as a palatable alternative protein source for human consumption. Utilization for fish feed is a viable option but is limited due to the lack of studies on IAFS as nutritional sources for aquaculture. Although there may be some attempts at using IAFS as potential alternative feedstuffs for commercially important fish (Abarra *et al*. 2017), studies are few and far between, suggesting a prolonged time if ever these do gain acceptance in local and international markets.

Although these are good attempts at utilizing IAFS, stricter measures for the screening of potential invasive aliens must be performed to minimize their threat and impact on the local aquatic environment. Responsible rearing of IAFS could benefit the Philippine economy, considering that ornamental fishes have been in the top ten fisheries export products of the country in terms of value for the last two decades (Philstar Global 2009). Combining the natural tropical climate, abundant freshwater resources and government institutions that deal with aquatic fish research and monitoring, the country may be poised for success – only if it is able to balance the risks against potential benefits and to provide support to train breeders of aliens in aquariums on best practices to avoid potential environmental damage.

Notes

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