

First report on introduced freshwater fishes in the waters of Aceh, Indonesia

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Abstract. There is a paucity of information regarding introduced freshwater fishes in Indonesian waters. Hence, the objective of the present study was to evaluate the distribution of introduced fishes in the waters in the vicinity of Aceh, Indonesia. Fish sampling was conducted in five regions of Aceh at 17 sampling locations from January to June 2008. The samples were evaluated based on the Global Invasive Species Database and current publications and reports. A total of 114 species were recorded during the survey, of which nine were shortlisted as introduced species. Moreover, one additional introduced species, *Atractosteus spatula* (Lacepède), was recorded in April 2011. Overall, ten species of introduced fishes were noted in Aceh waters; of these *Oreochromis mossambicus* (Peters), was the most widely distributed.

Keywords: distribution, threatened, introduced species, endemic, red list

Introduction

The conservation of freshwater fishes is recognized as an important global issue since the number of species that are extinct, endangered, or becoming rare is increasing dramatically as a result of numerous

anthropogenic perturbations (Cowx and Collares-Pereira 2002, Drechsler and Watzold 2004) such as pollution, changes in land use, river management and dam building (McCully 1996), the introduction of exotic species (Lucas and Marmulla 2000), deforestation, and effluent discharges (De Silva et al. 2007). However, the introduction of exotic species is widely considered to be the second most important cause of species extinction after habitat devastation (Vitousek et al. 1997, Simberloff 2003). According to Acosta and Gupta (2005), exotic fishes have been intentionally introduced mainly to enhance fisheries and aquaculture production thus increasing available animal protein sources especially in developing countries. In contrast, fish are most often introduced to support recreational fishery activities in developed countries. Other major reasons include pest control and research activities. Accidental introduction can occur through neighboring waterways that are opened by engineering projects and from vessel ballast water exchange (Sorensen and Hoye 2007).

Aceh Province, Indonesia has many aquatic resources including coastal waters, marshes, rivers and lakes, and even the rain forests of the Leuser and Ulu Masen ecosystems, which act as global lungs. Aquaculture is currently growing rapidly in Aceh to meet increasing market demands and in response to consumer awareness regarding the nutritional advantages of fish protein. In the 1980s and 1990s, aquaculture

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activities in Aceh focused on brackish water aquaculture of, for example, tiger shrimp, *Penaeus monodon* (Fabricius), and milkfish, *Chanos chanos* (Forsskal), with the latter having been cultured extensively traditionally. Unfortunately, the industry collapsed in the late 1990s because of shrimp diseases (*Monodon baculovirus*, MBV) and damage to coastal ponds as a result of the massive tsunami in late 2004. These cultured species have been taken over by freshwater species; unfortunately most of them are introduced fishes.

According to Zambrano et al. (2001) and Davis (2003), the introduction of an exotic species into a delicate aquatic ecosystem can result in serious environmental problems, reduced biodiversity, and economic declines (Sala et al. 2000, Leung et al. 2006, Westphal et al. 2008) or even the extinction of endemic and native species (Lever 1996, Stapp and Hayward 2002). Unfortunately, the causes of population declines are often not assessed until long after an invasion (Strecker 2006).

The diversity of freshwater fishes of Aceh was reported by Muchlisin and Siti-Azizah (2009). However, there is no complete list of introduced species in Aceh waters. Hence, the objectives of the present study were to evaluate the status of introduced freshwater fishes and their distribution in Aceh waters.

Materials and Methods

Study sites

The study was conducted for a duration of six months from January to June 2008 in seventeen locations around Aceh Province, Indonesia. Based on topography and water characteristics, Aceh Province can be divided into five regions as follows (Fig. 1): (1) western Aceh where the topography generally includes marsh lands of black water with high acid contents, irrigation canals, and brackish waters in some areas. It includes the Aceh Jaya, Aceh Barat, and Nagan Raya districts; (2) southern Aceh is characterized by black and rust-colored waters because of the high amounts of total suspended solids during rainy seasons, and the sampling areas are



Figure 1. Map of Aceh Province with regions and main cities denoted.

generally tropical rain forest (Leuser Ecosystem). This region includes the Aceh Selatan district; (3) central Aceh – highland topography with rivers and streams of clear water where the Aceh Tengah and Aceh Tenggara districts are representative of the central region. Moreover, Lake Laut Tawar, which was selected as a habitat model for conservation in this project, is situated in this region; (4) eastern Aceh – with slow-flowing rivers (several influenced by tides) as well as irrigation canals, the eastern region covers the Pidie, Biruen, and Tamiang districts; (5) northern Aceh – represents an area of variable water characteristics such as fast and slow flowing rivers and some of the rivers are influenced by tides. This region is represented by the Banda Aceh and Aceh Besar districts.

Fish sampling

The survey was conducted based on initial reports by local residents. Gillnets (0.75, 1, 2, and 3 inch mesh), hooks, casting nets (1, 2 and 3 inch mesh), and traditional traps (bubu) were used to catch fish samples.

Table 1
List of introduced fishes and their distribution in the waters of Aceh, Indonesia

No.	Family	Species	Southern			Western			Central			Eastern			Northern			Distribu- tion (%)		
			A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		P	Q
1	Lepisosteidae	<i>Atractosteus spatula</i> (Lacepède)	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.88
2	Clariidae	<i>Clarias gariepinus</i> (Burchell)	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	11.76
3	Cyprinidae	<i>Cyprinus carpio</i> L.	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-	+	-	23.53
4	Cyprinidae	<i>Ctenopharyngodon idella</i> (Val.)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	11.76
5	Cichlidae	<i>Oreochromis</i> <i>mossambicus</i> (Peters)	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	29.41
6	Cichlidae	<i>Oreochromis niloticus</i> (L.)	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	23.53
7	Poeciliidae	<i>Apocheilichthys panchax</i> (Hamilton)	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	17.65
8	Loricariidae	<i>Pterygoplichthys pardalis</i> (Castelnau)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.88
9	Poeciliidae	<i>Xiphophorus helleri</i> (Heckel)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	5.88
10	Poeciliidae	<i>Xiphophorus maculatus</i> (Günther)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	5.88

South Region: A – Lembang River, Aceh Selatan; West Region: B – Simpang Dam and irrigated canal, Aceh Barat; C – Meurebo River, Aceh Barat; D – Alue Pedeang River, Aceh Barat; E – Woyla River, Aceh Barat; F – Kuala Tuha, Nagan Raya; G – Nagan River, Nagan Raya; H – Lagean River, Aceh Jaya; Central Region: I – Laut Tawar Lake, Aceh Tengah; J – Alas River, Aceh Tenggara; East Region: K – Aras Napal, Aceh Timur, L – Batee Iliak River, Bitureun; M – Pante Radja canal, Pidie; North Region: N – Sibreh Irrigation canal, Aceh Besar; O – Murtala River Jantho, Aceh Besar; P – Aceh River, Banda Aceh; Q – Cut River, Banda Banda Aceh

The fishes caught were counted, and sub-samples representing each species were cleaned and photographed, and then preserved in 10% formalin in plastic bags. The bags were tagged with catch location, date, and the local name of the fish. These fish samples were transported to the laboratory and identified based on Kottelat et al. (1993), Nelson (1994), Gilbert and Williams (2002), and Vida and Kotai (2006). After identification the samples were transferred to 70% ethanol for long-term preservation.

Evaluation of introduced status and its distribution

After identification and documentation, the status of each fish as an introduced species was determined based on the Global Invasive Species Database (<http://www.issg.org/database/welcome/>). Additional information on the present status of the fishes was also obtained from Fishbase data and scientific publications. The local distribution of each identified species with confirmed taxonomic status was calculated as follows:

Local distribution (%) = $L_i/L_t \times 100$, where, L_i = total number of locations where species i was found and L_t = total number of sampling locations.

Results

A total of 114 species belonging to 69 genera, 41 families, and 12 orders were evaluated for their status. The complete list of freshwater fishes was reported in a previous study (Muchlisin and Siti-Azizah 2009). Of these, nine were identified as introduced species. However, after the survey period (January – June 2008), in April 2011, we found one additional introduced species, the alligator gar fish, *Atractosteus spatula* (Lacepède), in a fish pond in the city of Meulaboh (western region of Aceh). Overall, there were 10 species of introduced fishes recorded in Aceh waters (Table 1).

Among the introduced species, *Oreochromis mosambicus* (Peters), *Oreochromis niloticus* (L.), and

Cyprinus carpio L. were widely distributed. For instance, *O. mossambicus* and *O. niloticus* were found in four regions of Aceh. In addition, the central region had higher numbers of introduced species as compared to other regions, and no introduced species were observed in the southern region of Aceh during the study (Table 1).

Discussion

Wargasasmita (2005) recorded 19 introduced fish species in Indonesian waters. In comparison, 10 introduced species were reported in Aceh Province waters; these included *Clarias gariepinus* (Burchell), *C. carpio*, two species of tilapia – *O. mossambicus* and *O. niloticus*, two species of swordtail – *Xiphophorus hellerii* Heckel and *X. maculatus* (Günther), *Pterygoplichthys pardalis* (Castelnau), *Aplocheilichthys panchax* (Hamilton), *Ctenopharyngodon idella* (Val.), and *A. spatula*.

Alien fish species have been introduced into Aceh waters for decades, but there are no existing data available regarding species or their distribution. This article is the first report on this issue. In a local context, there are also no data available regarding other Indonesian regions for comparisons. However, in general, the total number of introduced species in Indonesia is lower compared to other countries, for example Greece, Singapore, Poland, Austria, and Israel, for example, but higher than Bangladesh (Table 2). This is probably because of the limited indigenous species of high economic value in these countries, which provides an impetus for introducing exotic species into aquaculture to increase national fishery production. Kumar (2000) reported that exotic fishes are introduced globally mainly to improve fisheries production, sport, the ornamental fish trade, and for the bio-control of mosquitoes. Muchlisin (2010) reported that 15 freshwater fish species of higher economic value occurred in Aceh waters.

In April 2011, one specimen of alligator gar fish, *A. spatula*, was caught by a fisher using a hook baited

Table 2
Total number of introduced fish species by country

Country	Total number of introduced species	Authors
Greece	66	Zenetos et al. (2009)
Singapore	54	Ng and Tan (2010)
Poland	40	Nowak et al. (2008)
Austria	27	Rabitsch and Essl (2006)
Israel	27	Roll et al. (2007)
Malaysia	26	Chong et al. 2010
Spain	25	Ribeiro et al. (2008)
India	24	Kumar (2000)
Nepal	23	Gurung (2005)
Indonesia	19	Wargasasmita (2005)
Bangladesh	15	Islam et al. (2003)

with shrimp in a coastal pond in the city of Meulaboh, and the specimen was deposited at the Laboratory of Ichthyology, Syiah Kuala University. This fish was probably released incidentally from the aquarium during the tsunami in December 2004.

Among introduced species, *O. mossambicus*, *O. niloticus*, and *C. carpio* were more widely distributed than were other exotic species. Kottelat et al. (1993) reported that *O. mossambicus*, *O. niloticus*, and *C. gariepinus* were introduced worldwide from Africa for fish consumption and reared in ponds or cages. The tilapia species of *O. mossambicus* and *O. niloticus* have been introduced into 90 and 85 countries, respectively, and from 13 to 15 of these countries have reported ecological problems with them (Casal 2006). In addition, *O. mossambicus* and *C. carpio* have been included in the top hundred of the world's most destructive invasive alien species (GISP 2004).

Many authors are in general agreement that the introduction of alien species has a negative impact on biodiversity. This is a global ecological problem, especially in inland water systems (Wellcomme 1992, Garcia-Berthou and Moreno-Amich 2000) and fisheries production (Sorensen and Hoyer 2007). The indiscriminate introduction of aquatic organisms from one habitat into another poses serious risks and

represents a significant threat to aquatic biodiversity (Wellcomme 1988) since it can cause a decline in or even the extinction of endemic and native species (Lever 1996, Kumar 2000, Macneale et al. 2010). The mechanisms responsible for this include predation (Elvira et al. 1996, Nicola et al. 1996), food competition (Garcia-Berthou 1999, Alcaraz and Garcia-Berthou 2007), habitat alteration and/or the disruption of ecological processes (Garcia-Berthou 2001, Bruton 1995), disturbances in mate recognition (Seehausen et al. 1997), the introduction of new pathogens or diseases (Zenetos et al. 2009) that can have negative consequences on aquaculture and capture fisheries and/or other resources that impact the livelihoods of fisheries communities (FAO 2005), hybridization with native species (Elvira 1995, Almodovar et al. 2006, Nguyen and De Silva 2006, Peh 2010), and ecosystem modification (Zambrano et al. 2001, Peh 2010). In addition, Wellcomme (1988) reported that another negative impact of exotic species was the depletion in the production of commercially important species and substantial costs incurred for control and eradication programs.

There is no historical record on the introduction of *O. mossambicus* into Indonesia. However, this species was first observed in the estuarine zone of the Serang River Blitar, East Java by Mr. Moedjair in 1936/1939, and it was hence given the local name of *mujair*. In Aceh, *O. mossambicus* is believed to have been first introduced in the early 1950s. In Lake Laut Tawar the introduction of *O. mossambicus* was done by Mr. Radja Ilang in 1957/1958 (U. Kasim – personal communication). On the other hand, *O. niloticus* was introduced to Indonesia by the Center for Freshwater Research, Department of Fisheries Republic of Indonesia in 1969 and into Aceh in the 1990s. Both *O. mossambicus* and *O. niloticus* are well established and distributed widely in Aceh waters. These species are omnivorous and are not averse to eating small fishes, and many indigenous Indonesian fish species have disappeared as a consequence. This situation is worsened by the fact that *O. mossambicus*, *O. niloticus*, and *C. carpio* have become some of the most popular pond fishes in Indonesia, including in Aceh, thanks to the ease of rearing

them and their fast growth rates which render them highly economical to culture, and therefore affordable not only to the rich but also to the poor.

To date, there has been no systematic study conducted to evaluate the impact of invasive species in Aceh or even in Indonesia generally. On the other hand, the threat of invasive species continues, and very limited attention is being paid to this issue by both society and the government.

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