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Population dynamics of accidentally introduced Amazon sailfin catfish, *Pterygoplichthys pardalis* (Siluriformes, Loricariidae) in Pologolla reservoir, Sri Lanka

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Abstract

Many fish species have been introduced either intentionally or accidentally into Asian freshwaters and some species have been disreputed as alien invasive species (AIS) due to their potential threats to the biodiversity. In Polgolla reservoir of Sri Lanka, there is an established population of *Pterigoplichthys pardalis*, which makes a significant negative impact on the commercial fishery targeting exotic cichlid species as this armored catfish damages gillnets of the fishery. In the present study, an attempt was made to investigate population dynamics of *P. pardalis* in Polgolla reservoir with a view to ascertaining possibilities for commercial level exploitation of the fish stock. The fish landing sites in the reservoir were visited 4-6 days a month from May to November 2004 to collect data on species composition of landings and length frequency data of *P. pardalis*. *P. pardalis* accounted for 21% of the landings and von Bertalanffy growth parameters estimated by length-based stock assessment methodologies using FISAT II software were asymptotic total length of 41.3 cm and growth constant of 0.3 yr^{-1}. Total mortality, natural mortality and fishing mortality were 0.76 yr^{-1}, 0.73 yr^{-1} and 0.03 yr^{-1} respectively. Relative yield-per-recruit analysis indicated that there would be a great potential to optimize the fishery by increasing exploitation ratio from the present level of 0.4 to 0.7, while increasing length at first capture from the present level of 17.8 cm to 23 cm. However, as the consumer demand for this species is presently very poor, intensification of the fishery is possible only if market demand for *P. pardalis* is established through value addition by post-harvest technology.

Keywords: AIS, armored catfish, FiSAT, inland fisheries, Loricariidae, *Pterigoplichthys*

Introduction

Despite the rich freshwater biodiversity in tropical Asia, concern over biodiversity conservation is not sufficiently invoked (Dudgeon 2000). Furthermore, introduction of exotic fish species into Asian freshwaters, either intentionally or accidentally, has also posed considerable threats to the freshwater biodiversity in the region (Welcomme 1988). However, some of the exotic species in Asia, most notably *Oreochromis mossambicus* and *O. niloticus*, support profitable fisheries providing cheap animal protein for rural communities (Fernando 1993), and as such, introduction of exotic cichlids to Asia brought about sociologically beneficial impacts in most Asian countries (De Silva et al. 2004). On the other hand, globalization and free trade have provided more opportunities for species to be spread. As a result, despite strong quarantine bars, many fish species are carelessly introduced into countries (Welcomme 1988; De Silva 1989).

In Sri Lanka, range expansion of accidentally introduced exotic fish species, clown knife fish, *Chitala ornata* in the water bodies of the western province has been reported (Kumudinie and Wijeyaratne 2005), and this introduction has taken place through the ornamental fish trade. Amazon sailfin catfish, *Pterygoplichthys pardalis* was recently observed in Polgolla reservoir (7°19′18″N, 80°38′42″E) and its impact on the commercial fishery in the reservoir through entangling in gillnets reducing their catch efficiencies was significant (HPWS, pers. obs.). *P. pardalis* is also found in many inland reservoirs of Sri Lanka such as Kala wewa, Balalu wewa, Kandalama wewa and Usgala Siyambangamuwa wewa (USA, pers. obs.). Although caught in significant proportions of total landings in reservoir fisheries, they are largely discarded by fishers due to poor consumer acceptability. The reservoir fishers regard this as a nuisance species as they get entangled in commercial gillnets from their spines making gillnets less effective for catching target species of cichlids.

Management of reservoir fisheries where there is Amazon sailfin catfish infestation therefore requires reducing population sizes of this species. As it is difficult, if not impossible, to eradicate these invasive species, one of the feasible alternatives is to increase their market value through introduction of postharvest value addition methods. However, no studies have been hitherto reported on any aspect of biology and population dynamics of exotic Amazon sailfin catfish species in Sri Lankan waters. In the present study an attempt is made to investigate population dynamics of *P. pardalis* in Polgolla reservoir using length-based stock assessment methodologies with a view to ascertaining possibilities for commercial level exploitation of the fish stock.

Materials and Methods

The Polgolla Barrage (441 m above mean sea level) has been built across the Mahaweli river at Polgolla in the Central Province of Sri Lanka. The barrage is used to increase the volume of water, for transfer to the hydroelectric power station located 8 km north. Some morphometric and edaphic characteristics of Polgolla reservoir are given in Table 1. There is a small-scale fishery in Polgolla reservoir and the major species caught are exotic cichlid species. *P. pardalis* is caught as a by-catch, but fishers discard them due to poor consumer preference. This species has been brought to Sri Lanka through ornamental fish trade and subsequently introduced accidentally to Sri Lankan freshwaters (Marambe et al. 2011). As the species of the family Loricariidae, collectively known as armored catfish caught in Sri Lankan freshwaters are evidently misidentified (Marambe et al. 2011), in the present study, this species was accurately identified as *P. pardalis* based on the morphological and meristic characteristics (Froese and Pauly 2004; Armbruster 2004) and using taxonomic keys (http://www.auburn.edu/academic/science_math/res_area/loricariid/fish_key/pterygo/pterygo.html).

Table 1. Some morphometric and edaphic characteristics of Polgolla reservoir (Sumanasinghe 2005).

Parameter	Value (range)
Extent at full supply level (ha)	117.4
Storage at full supply level (MCM)	4.1
Temperature °C	27.2 (25.9-28.0)
pH	7.12 (6.45-7.73)
Conductivity (µS cm^{-1})	63.9 (52.0-74.8)
Total alkalinity (mg l^{-1})	25.3 (22.0-29.0)
Hardness (mg l^{-1})	43.0 (36.0-51.0)
Nitrite (mg l^{-1})	0.02 (0.00-0.05)
Nitrate (mg l^{-1})	4.0 (1.0-9.0)
Total phosphorous (mg l^{-1})	0.19 (0.12-0.28)
Dissolved oxygen (mg l^{-1})	6.9 (6.2-7.6)

There were four landing sites in Polgolla reservoir. These landing sites were visited 4-6 days a month from May to November 2004.During the study period there were 12 active fishers working on eight non-mechanized fiberglass out-rigger canoes. Of these, 5-6 boats were operated in each fishing day and on average, there were 25 fishing days per month. During each sampling occasion, all the crafts operated were sampled to collect data on total landing, species composition and length frequency of *P. pardalis* landed. Total length of each specimen was measured to the neared 0.5 cm below its actual length. From the species-wise data of catch per boat, species composition of the landings was determined. Length frequency data of *P. pardalis* were analyzed using FiSAT II (Version 1.2.2) software package (Gayanilo et al. 2005). For this purpose, the step-wise procedure described by Athukorala and Amarasinghe (2010) was adopted. From the von Bertalanffy growth parameters (asymptotic length, L_∞ and growth constant, K), total mortality (Z) was estimated by means of length-converted catch curve method (Gayanilo and Pauly 1997). Pauly's (1980) empirical equation was used to estimate natural mortality (M) considering mean annual habitat temperature as 27°C. From these mortality parameters, fishing mortality (F = Z–M) and exploitation rate (E = F/Z) of *P. pardalis* were estimated. Finally, relative yield-per-recruit (Y'/R) analysis (Beverton and Holt 1966) was performed assuming knife-edge recruitment and selection.

Results

In the commercial fish landing of Polgolla reservoir, nine species were recorded during May-October 2004 (Table 2). Two exotic cichlid species formed 75% of the landings and *P. pardalis* accounted for 21% of the landings. Rest of the landings was formed by six indigenous species.

Table 2. Species composition of fish landings in Polgolla reservoir during May-October 2004.

Species	Percentage contribution
O. mossambicus and *O. niloticus*	75
P. pardalis	21
Others	4
Channa marulius	
Ompok bimaculatus	
Systomus sarana	
Dawkinsia singhala	
Puntius dorsalis	
Tor khudree	

Powell-Wetherall plot of *P. pardalis* in Polgolla reservoir is shown in Figure 1. The growth curve superimposed on length frequency data, length converted catch curve and the plot of probabilities of capture are shown in Figure 2. Natural mortality was estimated to be 0.72 year^{-1}. Estimated growth and mortality parameters and mean length at first capture are given in Table 3. It can be noted that L_∞ and Z/K estimated from Powell-Wetherall method are consistent with those estimated by ELEFAN I and length-converted catch curve methods.

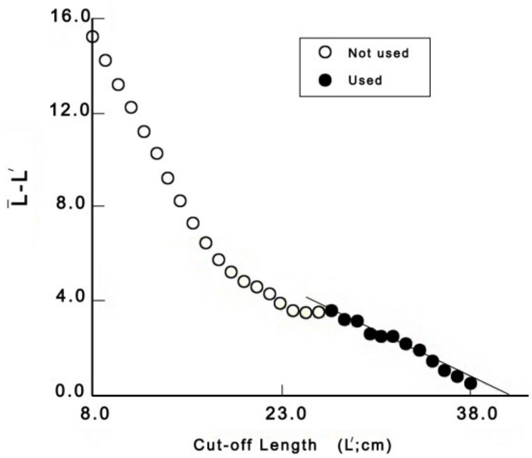

Figure 1. Powell-Wetherall plot of *P. pardalis* in Polgolla reservoir, Sri Lanka.

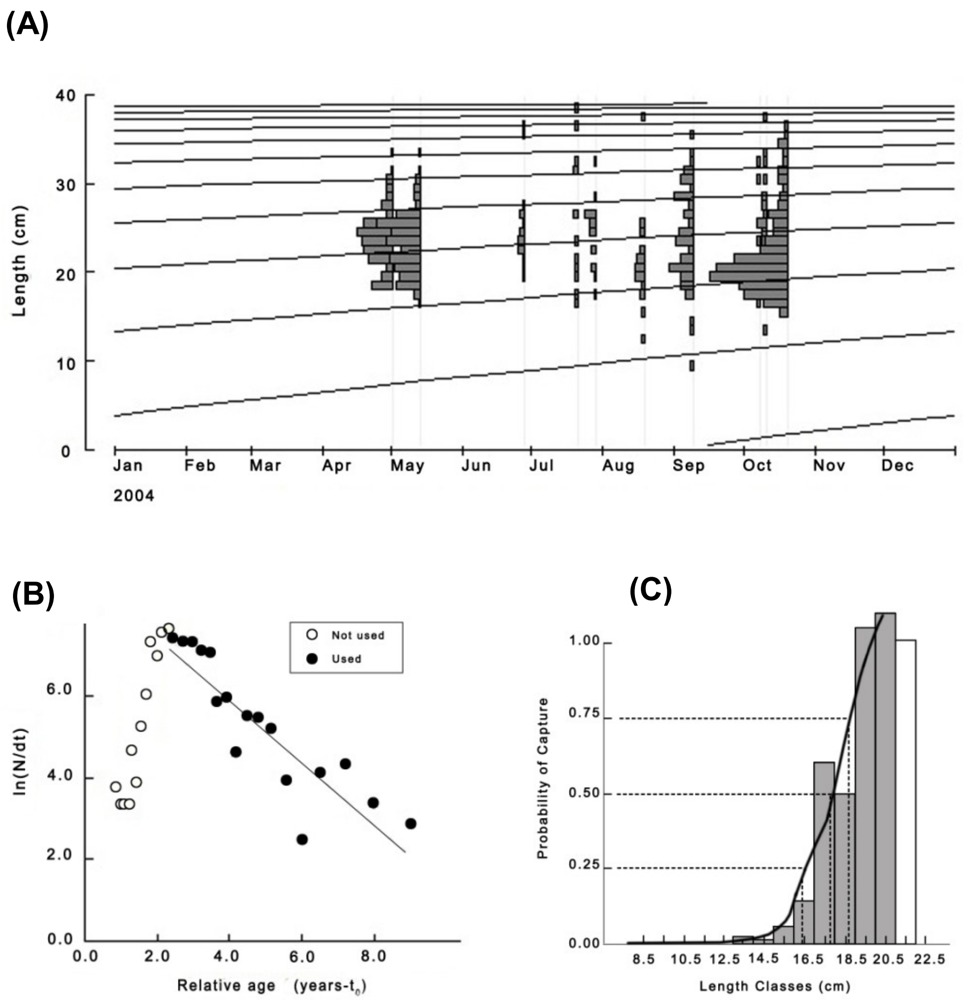

Figure 2. (A) Growth curve superimposed on length frequency data; (B) Length-converted catch curve; and (C) Probabilities of capture of *P. pardalis* in Polgolla reservoir. In B, N is the number of fish in a length class and dt is the time needed to grow through a length class and t_0 is the theoretical age at length zero.

Relative yield- per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) values as a function of exploitation ratio (E) corresponding to estimated length at first capture (L_{50}) of 17.8 cm are shown in Figure 3A. This indicates that the optimal E at this L_{50} is about 0.72, but B'/R tends to decline to a very low level. The Y'/R isopleths is also shown in Figure 3B, which indicates that Y'/R can be significantly increased by increasing E upto about 0.7 while increasing L_{50} upto about 23 cm.

Table 3. Growth and mortality parameters and length at first capture of *P. pardalis* in Polgolla reservoir.

Parameter	Value
Powell-Wetherall method	
Asymptotic length (cm)	41.2
Total mortality/growth constant ratio (Z/K)	2.996
ELEFAN I	
Asymptotic length (cm)	41.3
Growth constant (yr^{-1})	0.30
Total mortality (yr^{-1})	0.76
Natural mortality (yr^{-1})	0.73
Fishing mortality (yr^{-1})	0.03
Exploitation ratio	0.04
Length at first capture (cm)	17.8

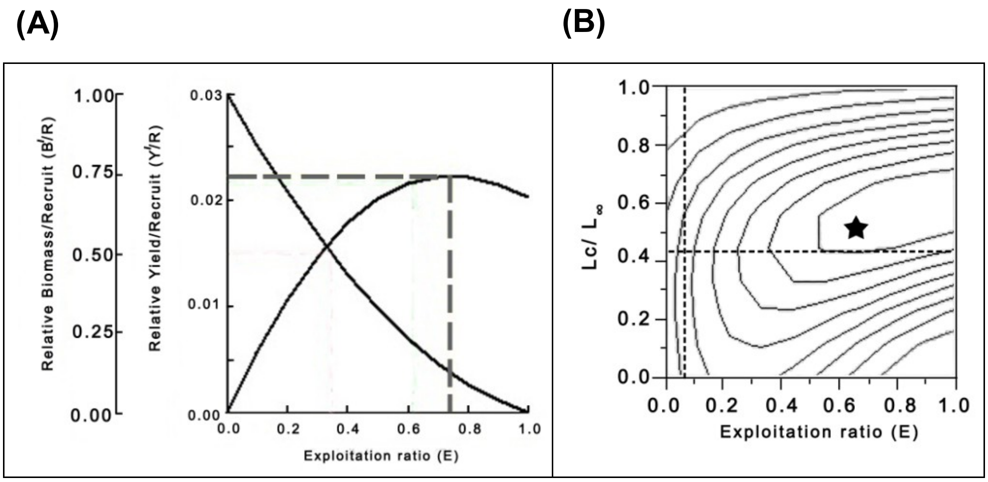

Figure 3. (A) Relative yield-per-recruit (Y'/R) and relative biomass-per-recruit (B'/R) as a function of exploitation rate (E) at the L_{50} of 17.8 cm; and (B) Y'/R isopleths of *P. pardalis* in Polgolla reservoir. In panel (A) maximum Y'/R at the L_{50} of 17.8 cm is indicated as broken lines. In panel (B), L_c ($=L_{50}$) is the length at first capture in cm; L_∞ is the asymptotic total length in cm; vertical and horizontal broken lines indicate present levels of E and L_{50} respectively. Asterisk indicates the optimal level of exploitation where $E \approx 0.7$ and $L_{50} \approx 23$ cm.

Discussion

The armored catfishes are a group of the alien invasive species (AIS) in Sri Lanka, which have essentially been introduced accidentally through ornamental fish industry. There may be more than one species of armored catfish in Sri Lankan waters because juveniles of this group are very popular among ornamental fish hobbyists due to their unique role of cleaning algal and periphyton growth in home aquaria. Due to this special feature, armored catfishes are also known as 'tank cleaner' or 'janitor fish.' Krishnakumar et al. (2009) have stated that a major underlying cause for accelerated biological invasion is the growth and development of world markets under the process of globalization through which intercontinental trade of live flora and fauna has been blown up. In Polgolla reservoir, although contribution of *P. pardalis* to the total commercial fisheries landings was only 21%, its impact on the commercial fishery is very significant because it causes economic losses by damaging commercial gillnets.

Apart from economic losses to the commercial inland fisheries, armored catfishes are known to have significant negative impacts on trophic balance of freshwater aquatic food webs. They feed on benthic algae, periphyton and alter food and substrates available for various aquatic insects. It has also been reported that the non-native *Pterygoplichthys* species in the Chacamax River, Mexico have changed both spatially and temporally, the heterogeneous nutrient fluxes through nitrogen and phosphorous remineralization (Capps and Flecker 2013). As the armored catfishes have become AIS in many inland water bodies of Sri Lanka, there is a need to launch concerted efforts to minimize its damage to the biodiversity and commercial inland fisheries.

However, it is difficult, if not impossible, to eradicate armored catfishes from the inland water bodies where they have already established but it might be possible to control the population increase locally. One of the effective and feasible means of controlling population growth of armored catfish is intensive fishing; but in the absence of ready consumer demand, it is imperative to establish a commercial market for the landings. As such, investigation of population dynamics of armored catfish in different localities is important to find out the likelihood to support commercial scale exploitation. Many studies on armored catfish in Asia are however based on taxonomic aspects (Page and Robins 2006), basic biological aspects such as length-weight relationships and condition factor (Samat et al. 2008), and commentary notes on the impact on biodiversity (Krishnakumar et al. 2009). Present study is therefore useful to support whether *P. pardalis* population in Polgolla reservoir can be commercially exploited.

In the present analysis, although length frequency data were collected from gillnet catches, the estimates of growth and mortality parameters were reliable as there was a fair consistency of the estimates from Powell-Wetherall and ELEFAN methods. As armored catfish were entangled in gillnets from their spines, and as fishers used gillnet of wide range of mesh sizes (7.5-12.4 cm), catch samples were possibly not affected by gillnet selection.

Present analysis has shown that the *P. pardalis* population in Polgolla reservoir is presently underexploited and there is a significant potential for further increase of exploitation level. However, due to poor consumer demand, fishers cannot be motivated to catch more fish. In order to create a market demand for fish postharvest technologies should be developed. In Mexico, using armored catfishes collagen, fish paste for human consumption and fishmeal are produced (Mendoza-Alfaro et al. 2009). As such, it is irrational to treat this AIS as a pest but could be utilized as a potential resource base supporting livelihoods of inland fishers and contributing to food security of the human beings. Furthermore, management efforts involving education and public awareness to inform aquarists, collectors and fishers not to release AIS to environment is also of paramount importance for effective control of their population growth and range expansion.

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