



Short Communication

The First Record of the Non-Native West African Lungfish, *Protopterus annectens* (Owen, 1839), in Poyang Lake, China

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ABSTRACT

The West African lungfish, *Protopterus annectens* (Owen, 1839), is native to western, central, eastern and southern Africa. This species has been recently introduced to many countries and regions through the ornamental fish trade. Two individuals of West African lungfish were captured in August 2019 and we observed about twenty individuals occurred in the Poyang Lake, the largest freshwater lake in China. This is the first report of West African lungfish recorded in a natural ecosystem in China. Poyang Lake is an important region for agriculture and aquaculture in China but also has a high representation of natural biodiversity. Due to the influence of some large water conservancy projects and extreme climatic conditions, Poyang Lake has experienced severe drought in recent years. West African lungfish might be well tolerant to a seasonal drought environment and might pose threat to the native biodiversity of Poyang Lake due to its abilities of predation and tolerate to drought. More monitoring and management of West African lungfish should be conducted in Poyang Lake to protect its native biodiversity from this non-native fish.

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Authors' Contribution

JW, WX, DX, XG contributed in the investigation of the research work, methodology, formal analysis, software, data curation, writing the original draft of the manuscript, review, editing, and visualization. JW, WX and QW contributed in the statistical analyses, software, formal analysis, writing review, editing type face, and data curation. JW and WX have contributed in review and editing of the manuscript, visualization and validation. JW and QW contributed to conceptualization, methodology, resources, supervision, project administration, funding acquisition, and review and editing of the manuscript. All authors reviewed and approved the manuscript.

Key words

Invasive species, Freshwater fish, Yangtze River, Wetlands, Ecological impacts

Non-native species are well known to be one of the major threats to global biodiversity (Pyšek and Richardson, 2010). Freshwater ecosystems are particularly susceptible to non-native species and are more vulnerable to the establishment of non-indigenous species than are marine and terrestrial ecosystems (Strayer, 2010). In freshwater ecosystems, fishes are the most frequently introduced animal group throughout the world (Gozlan *et al.*, 2010). Aquaculture has long been considered to be

the most important pathway of introduction for non-native fishes (Naylor *et al.*, 2001). Recently, some research has shown that ornamental fish used in aquaria have become another significant source and means of entry for exotics (Xiong *et al.*, 2015a, 2017a).

A great number of non-native species have been introduced in China and the invasion rate of these non-native species is very high (Xiong *et al.*, 2015a, 2017a; Wang *et al.*, 2016). Most feral populations of non-native freshwater fish species were introduced for use in aquaculture. Of the 53 non-native freshwater fish species with successfully established feral populations in China, only eight species (*Lepisosteus oculatus*, *Notopterus notopterus*, *Carassius auratus*, *Hypostomus plecostomus*, *Pterygoplichthys multiradiatus*, *Parachromis managuensis*, *Scortum barcoo*, and *Macquaria ambigua*) were introduced as ornamental species for aquaria or outdoor ponds (Xiong *et al.*, 2015a), with most ornamental fishes being introduced from Africa, South America and

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Southeast Asia (Chan *et al.*, 2019). There is little regulation of non-native ornamental species in China (Wang *et al.*, 2016). Inevitably, non-native ornamental fish might have relative high risk of escaping and establishing populations in the wild when the environment is suitable (Xiong *et al.*, 2015a, 2017a).

The Yangtze River is a biodiversity hotspot and its protection should be a priority (Olson and Dinerstein, 1998). Recently, we reported that the Yangtze River has experienced a very high rate of invasion by non-native aquatic species (Xiong *et al.*, 2018a) including numerous ornamental fishes (Xiong *et al.*, 2018a). Poyang Lake Basin, located in the center of the Yangtze River watershed, has a water surface area of 4000 km² and the basin encompasses 162000 km² (Mei *et al.*, 2015). It is one of the most important regions for agriculture and aquaculture in China (Wang *et al.*, 2020). Therefore, monitoring and management of non-native aquatic species in the Yangtze River or the Poyang Lake is particularly important, with local government and some environmental organizations paying great attention to non-native species in Poyang Lake (Xiong *et al.*, 2018a; Wang *et al.*, 2020).

West African lungfish, *Protopterus annectens* (Owen, 1839), is an air-breathing freshwater fish that can survive long periods of droughts, allowing it to establish the new non-native population in Poyang Lake, located in an area that is experiencing a severe and ongoing drought (Holden and Reed, 1972; Xiong *et al.*, 2023). This species has been brought into a few countries for aquaculture (Walakira *et al.*, 2014) and also introduced as an ornamental fish for aquaria or outdoor ponds (Xiong *et al.*, 2015a). It is a predator that feeds on mollusks, insects, crustaceans, worms and small fishes (Dankwa *et al.*, 1999).

This is the first report and a new record of West African lungfish in Poyang Lake, the largest freshwater lake in the China (Fig. 1).



Fig. 1. The West African lungfish (*Protopterus annectens*). Photo by Jinming Wu.

Materials and methods

Fish sampling in Poyang Lake was conducted quarterly between January 2010 to October 2019. We implemented 40 surveys in Poyang Lake using dip nets (0.5 m in diameter,

mesh size 1 mm), gill nets (20 × 10 m, mesh-size 5 mm) and electroshocking (CWB-2000 P, 12V, 250 Hz). In wetlands, fish sampled by two individuals using a dip net about 15 min. In lake periphery and bays, fish sampled by gillnet with about 12 h (from 18:00 to 6:00). In wetlands and lake periphery, fish sampled by electroshock fishing techniques about 15 min. For a detailed description of our sampling methods see Xiong *et al.* (2015b, 2017b). The fish sampled were identified according to morphology, and West African lungfish were identified with Kottelat *et al.* (1993) and Lessutthichawal (2005). We caught a small patch of pectoral fin and stored in 95% alcohol, mitochondrial COI genes were sequenced in two individuals of fish sample specimens collected from Poyang Lake and base pairs were collected, molecular sequencing (COI) were conducted in laboratory (Valdez-Moreno *et al.*, 2009).

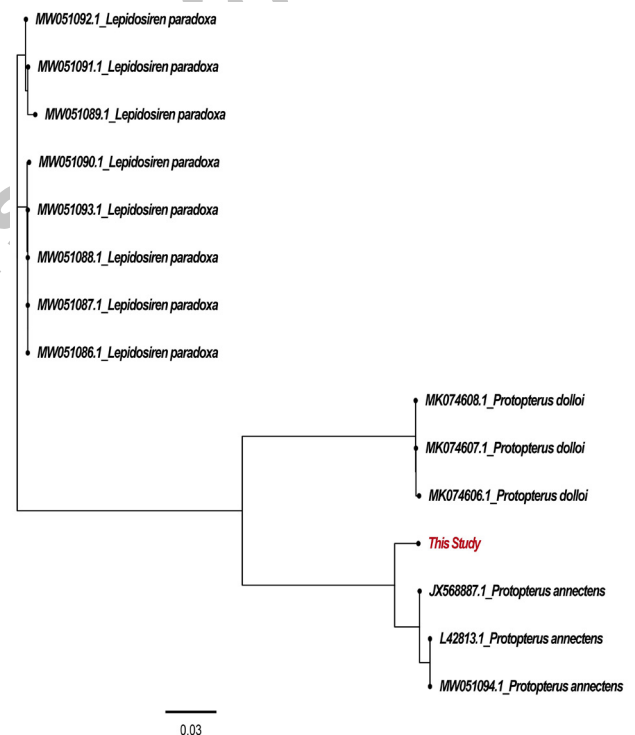


Fig. 2. Neighbor-joining tree for mitochondrial COI fragments for West African lungfish *Protopterus annectens*.

Results

Two West African lungfish were collected in Poyang county (N28.925457, E116.382135). It has an elongate body, filamentous paired fins, and external gills located behind the gill slits and above the pectoral fins (Fig. 1). The morphometric and meristic characteristics of our specimens are shown in Table I. The molecular sequences were checked and matched 100% on NCBI database (Fig. 2).

Table I. Features of *Protopterus annectens* in August 2019 in the Poyang Lake.

No	TL(mm)	SL(mm)	BW(g)
1	210	195	19.52
2	175	160	15.03

TL, total length; SL, standard length; BW, body weight.

This collection is the first record of the species in a natural environment in China. During our survey in 2018 and 2019, about twenty individuals (about 500mm total length) of this species were observed in the weedy littoral areas of the lake preying on small endemic and endangered fishes, such as *Pseudorasbora elongata*, *Luciobrama macrocephalus* and *Oryzias latipes*, which were listed in the China Species Red List (Wang and Xie, 2004). Frequent catches (one to four individuals caught in a month) of West African lungfish (about 20-700 mm total length) in Poyang Lake were mentioned by some local fishermen in the past three years (personal communication with local fisherman).

Discussion

Some researchers have investigated fish biodiversity in Poyang Lake, the West African lungfish was not reported from Poyang Lake until 2015 (Huang *et al.*, 2013; Zeng, 2014). This non-native fish was likely introduced between 2015 and 2019, and could potentially establish a feral population in Poyang Lake.

China is threatened by aquatic non-native species, with a great number of non-native fishes introduced for use in the ornamental fish trade (Xiong *et al.*, 2015a, 2017a; Wang *et al.*, 2016). Non-native species are one of the greatest threats to Chinese freshwater biodiversity (Xiong *et al.*, 2018b, 2019), particularly in the Yangtze River watershed.

Although West African lungfish have been introduced into China for many years in the ornamental fish trade (Xiong *et al.*, 2015a), there have been no previous reports of its having escaped and established populations elsewhere in China (Xiong *et al.*, 2015a). Recently, we observed this species being sold in some aquarium stores of big cities around Poyang Lake such as Nanchang and Jiujiang. Non-native ornamental fish often dive in sewage pipes and eventually escape into natural waterbodies by unintentionally escaped (Bueno *et al.*, 2021). Thus, this study is the first record that West African lungfish occurred in the wild environment of China.

The Poyang Lake is an important region of Chinese freshwater fish biodiversity (Huang *et al.*, 2013), including over 200 fish species, of which 131 are endemic (Huang *et*

al., 2013). Many native fishes are threatened by the loss of wetland habitat caused by some large water conservancy projects (such as the Three Gorges Dam, the Gezhou Dam), drought, and global warming (Mei *et al.*, 2015; Liu *et al.*, 2020). West African lungfish can survive for long periods in dry environments by encasing their bodies in a thin layer of slime (Okeyo, 1998), which possibly enables the species to survive and successfully invade in the drought-prone environment of the Poyang Lake (Okeyo, 1998). West African lungfish prey on small fish, crustaceans, insects, mollusks and plants (Dankwa *et al.*, 1999). In field investigations, we observed that West African lungfish are active predators on native locally endangered fish, such as *Oryzias latipes* (Wang and Xie, 2004). Therefore, we appeal to local government, fishermen and environmental protection organizations to work together to mitigate the potential risk of West African lungfish.

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IRB approval

The Tab of Animal Experimental Ethical Inspection of Laboratory Animal Centre, Yangtze River Fisheries Research Institute, Chinese Academy of Fishery Sciences approved the study.

Ethical approval

This research was conducted in accordance with ethics committee procedures of animal experiments.

Sampling and field studies

All necessary permits for sampling and observational field studies have been obtained by the authors from the competent authorities and are mentioned in the acknowledgements, if applicable.

Data availability

All data generated or analyzed during this study are included in this article.

Statement of conflict of interest

The authors have declared no conflict of interest.

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