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A dataset of fishes in and around Inle Lake, an ancient lake of Myanmar, with DNA barcoding, photo images and CT/3D models

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Abstract

Background

Inle (Inlay) Lake, an ancient lake of Southeast Asia, is located at the eastern part of Myanmar, surrounded by the Shan Mountains. Detailed information on fish fauna in and around the lake has long been unknown, although its outstanding endemism was reported a century ago.
New information

Based on the fish specimens collected from markets, rivers, swamps, ponds and ditches around Inle Lake as well as from the lake itself from 2014 to 2016, we recorded a total of 948 occurrence data (2120 individuals), belonging to 10 orders, 19 families, 39 genera and 49 species. Amongst them, 13 species of 12 genera are endemic or nearly endemic to the lake system and 17 species of 16 genera are suggested as non-native. The data are all accessible from the document “A dataset of Inle Lake fish fauna and its distribution (http://ipt.pensoft.net/resource.do?r=inle_fish_2014-16)”, as well as DNA barcoding data (mitochondrial COI) for all species being available from the DDBJ/EMBL/GenBank (Accession numbers: LC189568–LC190411). Live photographs of almost all the individuals and CT/3D model data of several specimens are also available at the graphical fish biodiversity database (http://ffish.asia/INLE2016; http://ffish.asia/INLE2016-3D). The information can benefit the clarification, public concern and conservation of the fish biodiversity in the region.

Keywords

Myanmar; Shan State; Inle Lake; freshwater fishes; endemic species; alien; GBIF; mitochondrial DNA; COI; CT scan; 3D model

Introduction

Inle Lake is located on the southwestern part of Shan State, which is the easternmost state of Myanmar. The lake is surrounded by Shan Hills, which isolate it from the neighbouring aquatic habitats. The lake harbours several endemic fish species (Annandale 1918). However, the detailed information of fish fauna of this region has long been unknown since Annandale (1918), while several studies reported the concerns for settlement of non-native species and decline of endemic/native species (Musikasinthorn 1998, Su and Jassby 2000, Davies et al. 2004, Oo 2010). This project aimed to elucidate the current status of fish fauna of the lake, especially focusing on survival of endemic/native species and settlement of non-native species. In addition, DNA sequences (mitochondrial COI), photo images and CT/3D models were published online in the public interest of biodiversity.

Project description

Title: Current status, origin and conservation of endemic fishes in an ancient lake, Inle Lake.
**Personnel:** Katsutoshi Watanabe (Project director, fieldwork and DNA barcoding), Prachya Musikasinthorn (fieldwork, fish identification, photographs and specimens management), Yuichi Kano (fieldwork, photographs and database management), Akihisa Iwata (fieldwork and fish identification), Shoko Matsui (DNA barcoding), Ryoichi Tabata (DNA barcoding), Sein Tun (management and local information), LKC Yun (fieldwork and local information), Seint Seint Win (fieldwork and local information) and Taksehi Yamasaki (CT scanning).

**Study area description:** Inle Lake is located on the Southwestern part of Shan State, which is the easternmost state in Myanmar. The lake is surrounded by Shan Hills and harbours several endemic fish species. The surveys were carried out in the lake and its surroundings from 23 September 2014 until 2 July 2016. In addition, local markets were also investigated for fishes caught in the study area.

**Design description:** This study focused on fish fauna of Inle Lake, a representative ancient lake in mainland Southeast Asia. Until now, the lake has not been investigated for nearly a century (Annandale 1918). In our study, we focused on the condition of endemic species as the environments have been drastically changed (Su and Jassby 2000) and alien species recently settled in the lake (Davies et al. 2004, Oo 2010). As information about the fish species of Inle Lake is quite limited, almost all the specimens were photographed and the photo data were deposited in an online fish database (Kano et al. 2013) (http://ffish.asia/INLE2016). CT/3D models for several specimens were also made and are available from the database (http://ffish.asia/INLE2016-3D). The main bodies were retained as formalin samples for voucher specimens and deposited at Kasetsart University, Thailand. In addition, a small piece of tissue (mainly from the right pectoral or pelvic fin) was excised, preserved in 99% alcohol and stored at Kyoto University to facilitate the study of molecular biology and genetics. The DNA sequences (mitochondrial COI) information was deposited at the DDBJ/EMBL/GenBank (Accession numbers: LC189568–LC190411).

**Funding:** JSPS (The Japan Society for the Promotion of Science) KAKENHI Grant Number JP26304007.

**Sampling methods**

**Sampling description:** The fish samples were either collected from 43 wild habitats as well as from one fish cage in the lake or purchased at 24 local markets (Fig. 1). The fishes were collected by hand-nets, throwing nets, traps and/or purchased from fishermen. In the markets, we avoided purchasing the obvious cultured fishes from other areas (especially from Yangon and Mandalay), such as *Wallago* spp. and *Pangasianodon hypophthalmus*, by checking with the seller.
Quality control: All the scientific names of fish samples were validated by the updated fish checklist in the Catalogue of Fishes, California Academy of Sciences (http://www.calacademy.org/scientists/projects/catalog-of-fishes), Kottelat (2013) and/or Nelson et al. (2016). For order level classification of the family Ambassidae, we followed Hastings et al. (2014). Most of the specimens were photographed in a fresh state (Kano and Nakajima 2014) and then the formalin specimens and its tissue samples were catalogued and deposited at the Research Laboratory of Ichthyology, Department of Fishery Biology, Faculty of Fisheries, Kasetsart University, Bangkok, Thailand (RLIKU) and Kyoto University, Kyoto, Japan, respectively. All the samples were assigned the IDs which were associated with the records of location (latitude, longitude and region name), the dates, methods, accession numbers of DNA sequences, etc.

Step description: Step 1: Sampling locality and date were recorded.

Step 2: Specimens were given IDs, photographed, fin-clipped and roughly classified on site.

Step 3: Specimens were fixed in 10% formalin solution for two or more weeks. Subsequently, they were cleaned with water and preserved in 75% ethanol.

Step 4: Specimens were shipped back to the lab for correct species identification.
Taxonomic coverage

Description: Annandale (1918), Akihito and Meguro (1975), Roberts (1986), Kottelat (1990), Talwar and Jhingran (1991), Fang (1997), Roberts (1997), Musikasinthorn (1998), Roberts (1998), Kottelat and Witte (1999), Ng et al. (1999), Kottelat (2001), Fang (2003), Kottelat (2003), Roberts (2007), Ng and Kottelat (2008), Fang et al. (2009), Matsumoto et al. (2009), Britz (2010), Havird and Page (2010), Jiang et al. (2012), Kottelat (2012), Kottelat et al. (2012), Pethiyagoda et al. (2012), Kottelat (2013), Hastings et al. (2014), Ratmuangkhwang et al. (2014) and Nelson et al. (2016) were used as a taxonomic reference for this work. The coverage of this dataset includes Subclass Actinopterygii. The orders are Cypriniformes (26 species), Anabantiformes (5), Siluriformes (5), Synbranchiformes (5), Cyprinodontiformes (2), Perciformes (2), Beloniformes (1), Cichliformes (1), Gobiiformes (1) and Osteoglossiformes (1) (Fig. 2). The families are Cyprinidae (20), Nemacheilidae (4), Ambassidae (2), Channidae (2), Clariidae (2), Mastacembelidae (2), Osphronemidae (2), Poeciliidae (2), Sisoridae (2), Synbranchidae (2), Anabantidae (1), Adrianichthyidae (1), Balitoridae (1), Chaudhuriidae (1), Cichlidae (1), Cobitidae (1), Gobiidae (1), Heteropneustidae (1) and Notopteridae (1) (Fig. 3).
### Taxa included:

| Rank            | Scientific Name     | Common Name                                      |
|-----------------|---------------------|--------------------------------------------------|
| kingdom         | Animalia            | Animals                                          |
| phylum          | Chordata            | Chordates                                        |
| subphylum       | Craniata            | Vertebrates and hagfishes                        |
| class           | Osteichthyes        | Bony fishes and tetrapods                        |
| subclass        | Actinopterygii      | Ray-finned fishes                                |
| order           | Anabantiformes      | Labyrinth fishes                                 |
| order           | Beloniformes        | Needlefishes                                     |
| order           | Cichliformes        | Cichlids and convict blennies                    |
| order           | Cypriniformes       | Carps, loaches, minnows and relatives            |
| order           | Cyprinodontiformes  | Killifishes                                      |
| order           | Gobiformes          | Gobies                                           |
| order           | Osteoglossiformes   | Bonytongues                                      |
| order           | Perciformes         | Perches                                          |
| order           | Siluriformes        | Catfishes                                        |
| order           | Synbranchiformes    | Swamp eels                                       |
| family          | Anabantidae         | Climbing gouramies                               |
| family          | Adrianichthyidae    | Adrianichthyids                                  |
| family          | Ambassidae          | Asiatic glassfishes                              |
| family          | Balitoridae         | Hillstream loaches                               |
| family          | Channidae           | Snakeheads                                       |
| family          | Chaudhuriidae       | Earthworm eels                                   |
| family          | Cichlidae           | Cichlids                                         |
| family          | Claridae            | Airbreathing catfishes                           |
| family          | Cobitidae           | True loaches                                     |
| family          | Cyprinidae          | Cyprinids                                        |
| family          | Gobidae             | Gobies                                           |
| family          | Heteropneustidae    | Airsac catfishes                                 |
| family          | Mastacembelidae     | Spiny eels                                       |
| family          | Nemacheilidae       | Stone loaches                                    |
| Family                        | Genus/Species                        | Description                                      |
|-------------------------------|--------------------------------------|--------------------------------------------------|
| Notopteridae                  | Knifefishes                          |                                                  |
| Osphronemidae                 | Gouramies and fighting fishes        |                                                  |
| Poeciliidae                   | Livebearers                          |                                                  |
| Sisoridae                     | Sisorid catfishes                    |                                                  |
| Synbranchidae                 | Swamp eels                           |                                                  |
| Anabas testudineus (Bloch 1792)| Climbing gourami                     |                                                  |
| Balitora sp.                  | A species of balitorid loach         |                                                  |
| Barbomynus gonionotus (Bleeker 1849) | Silver barb                           |                                                  |
| Celestichthys erythromicron (Annandale 1918) | A species of Celestichthys minnow     |                                                  |
| Channa harcourtbutleri (Annandale 1918) | Inle snakehead                       |                                                  |
| Channa striata (Bloch 1793)   | Striped snakehead                    |                                                  |
| Chaudhuria caudata Annandale 1918 | Inle swamp eel                       |                                                  |
| Clarias gariepinus (Burchell 1822) | African sharptooth catfish          |                                                  |
| Clarias cf. batrachus (Linnaeus 1758) | Walking catfish                      |                                                  |
| Ctenopharyngodon idella (Valenciennes 1844) | Grass carp                           |                                                  |
| Cyprinus intha Annandale 1918 | Inle carp                            |                                                  |
| Cyprinus rubrofuscus Lacepède 1803 | Common carp                          |                                                  |
| Devario kakhienensis (Anderson 1879) | A species of Devario minnow          |                                                  |
| Devario sp.                   | A species of Devario minnow          |                                                  |
| Esomus danrica (Hamilton 1822) | Flying barb                          |                                                  |
| Gambusia affinis (Baird & Girard 1853) | Western mosquitofish                |                                                  |
| Garra gravelyi (Annandale 1919) | Burmese Garra                        |                                                  |
| Glossogobius cf. giuris (Hamilton 1822) | A species of Glossogobius goby       |                                                  |
| Glyptothorax granosus Jiang, Ng, Yang & Chen 2012 | A species of sisorid catfish      |                                                  |
| Glyptothorax rugimentum Ng & Kottelat 2008 | A species of sisorid catfish      |                                                  |
| Gymnostomus horai (Bânârescu 1986) | A species of Gymnostomus minnow     |                                                  |
| Heteropneustes fossilis (Bloch 1794) | Stinging catfish                     |                                                  |
| Inlecypris auropurpureus (Annandale 1918) | A species of Inlecypris minnow      |                                                  |
| Labeo rohita (Hamilton 1822)  | Rohu                                 |                                                  |
| Lepidocephalichthys berdmorei (Blyth 1860) | A species of cobitid loach          |                                                  |
| Mastacembelus audiocellatus (Boulenger 1893) | A species of spiny eel              |                                                  |
| species                                      | Common Name                                      |
|----------------------------------------------|--------------------------------------------------|
| *Mastacembelus oatesii* Boulenger 1893       | A species of spiny eel                           |
| *Microrasbora rubescens* Annandale 1918      | Red dwarf rasbora                               |
| *Monopterus cuchia* (Hamilton 1822)          | Gangetic mud eel                                 |
| *Monopterus javanensis* Lacepède 1800        | Asian swamp eel                                  |
| *Neolissochilus nigrovittatus* (Boulenger 1893) | A species of *Neolissochilus* barb              |
| *Notopterus notopterus* (Pallas 1769)         | Bronze featherback                              |
| *Oreochromis niloticus* (Linnaeus 1758)      | Nile tilapia                                     |
| *Oryzias uwai* Roberts 1998                  | A species of rice fish                           |
| *Parambassis lala* (Hamilton 1822)           | A species of Asiatic glassfish                   |
| *Parambassis ranga* (Hamilton 1822)          | A species of Asiatic glassfish                   |
| *Pethia stoliczkana* (Day 1870)              | Stoliczka’s barb                                 |
| *Petruichthys brevis* (Boulenger 1893)       | A species of nemacheilid loach                  |
| *Physoschistura rivulicola* (Hora 1929)       | A species of nemacheilid loach                  |
| *Physoschistura shanensis* (Hora 1929)        | A species of nemacheilid loach                  |
| *Poecilia reticulata* Peters 1859            | Guppy                                            |
| *Poropuntius schanicus* (Boulenger 1893)     | A species of *Poropuntius* barb                 |
| *Puntius sophore* (Hamilton 1822)            | Spotfin swamp barb                               |
| *Puntius cf. sophore* (Hamilton 1822)        | A species of *Puntius* barb                     |
| *Sawbiwa resplendens* Annandale 1918         | Burmese rammy nose                              |
| *Schistura sp.*                              | A species of nemacheilid loach                  |
| *Systomus cf. rubripinnis* (Valenciennes 1842) | A species of *Systomus* barb                   |
| *Trichogaster labiosa* Day 1877              | Thick-lipped gourami                            |
| *Trichopodus pectoralis* Regan 1910          | Snakeskin gourami                               |

**Temporal coverage**

**Notes:** 23 September 2014 – 2 July 2016.

**Usage rights**

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Data resources

Data package title: A Dataset of Inle Lake Fish Fauna and Its Distribution

Resource link: http://ipt.pensoft.net/resource.do?r=inle_fish_2014-16

Number of data sets: 1

Additional information

Endemic, native and non-native or status uncertain

Inle Lake has an outstanding endemic fish fauna while non-native species have established in and around the lake. Thus, the species were discriminated by endemic, native (but not endemic), non-native and unknown as shown in Fig. 4. In addition, two endemic species reported in Annandale (1918) were not ascertained in this survey: the two species seemed to be very rare or already extinct from the studied area.

Endemic: Celestichthys erythromicron; Channa harcourtbutleri; Cyprinus intha; Gymnostomus horai; Inleocypris auropurpureus; Mastacembelus caudiocellatus; Mastacembelus oatesii; Microrasbora rubescens; Neolissochilus nigrovittatus; Petruichthys brevis; Physoschistura shanensis; Poropuntius schanicus; Sawbwa resplendens.

Native (but not endemic): Anabas testudineus; Channa striata; Chaudhuria caudata; Clarias cf. batrachus; Devario kakhienensis; Garra gravelyi; Glyptothorax granosus; Glyptothorax rugimentum; Lepidocephalichthys berdmorei; Monopterus cuchia; Monopterus javanensis; Notopterus notopterus; Pethia stoliczkana; Physoschistura rivulicola; Systemus cf. rubripinnis.

Figure 4.
Distribution of the endemic, native, non-native and uncertain species in the studied area.
**Non-native:** Barbonymus gonionotus; Clarias gariepinus; Ctenopharyngodon idella; Cyprinus rubrofuscus; Esomus danrica; Gambusia affinis; Glossogobius cf. giuris; Heteropneustes fossilis; Labeo rohita; Oreochromis niloticus; Oryzias uwai; Parambassis lala; Parambassis ranga; Poecilia reticulata; Puntius sophore; Trichogaster labiosa; Trichopodus pectoralis.

**Unknown:** Balitora sp.; Devario sp.; Puntius cf. sophore; Schistura sp.

**Endemic species unascertained:** Systomus compressiformis; Silurus burmanensis.

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