The National Red List of Sri Lanka: Assessment of the Threat Status of the Freshwater Fishes of Sri Lanka 2020

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Figure 1. Many freshwater fish endemic to Sri Lanka are found in wet zone rivers like the above

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Cover: 1st row left to right: Bandula barb (*Pethia bandula*), Filamented barb (*Dawkinsia singhala*); Combtail (*Belontia signata*); 2nd row left to right: Giant danio (*Devario malabaricus*); Mountain labeo (*Labeo fisheri*), Striped dwarf catfish (*Mystus nanus*); 3rd row left to right: Cherry barb (*Puntius titteya*), Pallaides rasbora (*Rasboroides pallidus*), Blotched filamented barb (*Dawkinsia srilankensis*); 4th row left to right: Stone sucker (*Garra ceylonensis*), Cuming's barb (*Pethia cumingii*), Large Silver carplet (*Amblypharyngodon grandisquamis*) (Photo credits: © IUCN/Sampath de A. Goonatilake).

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Executive summary

Chapter 1 provides an introduction and background to the assessment. Sri Lanka has a diverse network of freshwater habitats, comprising both natural and human-made ecosystems. There is a total of 103 river basins forming a dendritic pattern, spreading throughout the entire island. Besides rivers and streams, several other freshwater habitats — such as tanks, flood plains, pools, *villus* and paddy fields — are found in Sri Lanka. These freshwater habitats support a rich aquatic fauna, including freshwater fish.

During the last two decades, studies have shown that the number of freshwater fish species, as well as the number of species endemic to Sri Lanka, have changed significantly. Yet, the global threat assessment of IUCN, International Union for Conservation of Nature, does not reflect clearly the threat status of the freshwater fish species endemic to Sri Lanka.

Therefore, this assessment was undertaken, using the IUCN Global Red List™ criteria (version 3.1), to determine the current threat status of freshwater fish species endemic to Sri Lanka. The completed data from this assessment were used to update the global Red List™ website (www:redlist.org).

This assessment is also needed critically to set conservation priorities for Threatened species.

Chapter 1 traces the history of the study of freshwater fish and describes the studies conducted under three periods: from 1828-1955, 1955- 2012 and 2012 to the present. It notes the first recorded description of a Sri Lankan freshwater fish by Cuvier and Valenciennes. It identifies the most notable local biologist — P.E.P. Deraniyagala — during this period, who also produced the first coloured atlas of freshwater fish.

The contribution towards freshwater fish taxonomy and conservation, during the 1980s, by Ranil Senanayake and Rohan Pethiyagoda, is discussed.

The nomenclature of freshwater fish has been revised extensively during the past two decades. From 2012 to date, work on freshwater fish taxonomy and nomenclature continued with vigour. Biologists such as Batuwita and his co-workers, as well as Sudasinghe and others, have reviewed and made several taxonomic changes to the freshwater fish fauna of Sri Lanka.

In addition, Pethiyagoda in 1991, Goonatilake in 2007, and de Silva et al. in 2015 published books on freshwater fish.

Despite this progress, there are several species that still need taxonomic study for clarification of their status as species.

In 1982, Senanayake and Moyle identified four major ichthyological provinces in Sri Lanka: the Southwestern Province, the Mahaweli Province, the Transition Province and the Dry Zone Province. The highest number of endemic and threatened freshwater fish species is found in

the Southwestern ichthyological province. Several species are only known from a single location — that is, they are point endemics.

The global IUCN Red List™ provides the threat status of 54 species, including 18 endemic species. Of the 18 endemic species, eight species are listed as Threatened species. Except for two species evaluated using Red List criteria version 3.1 in 2007, the rest were assessed using the 1994 version 2.3. This means that 44 endemic species have not been assessed in the Global IUCN Red List™. In addition, more than 20 species endemic to Sri Lanka are not even recognised as valid species in the Red List™ database.

The last national assessment of the threat status of freshwater fish was carried out in 2012, by the Biodiversity Secretariat of the then Ministry of Environment — with inputs from a freshwater expert panel — using Red List™ criteria version 3.1. Ninety-one species, including 50 endemic species were assessed. Of the 50 endemics considered, 45 were listed as Nationally Threatened.

Chapter 2 discusses the methodology used. Ninety-seven freshwater fish species, including 61 species endemic to Sri Lanka were assessed. (Thirty exotic species were not considered.)

This assessment was coordinated by the Sri Lanka Country Office of IUCN, in collaboration with the IUCN Freshwater Biodiversity Unit, IUCN Global Species Programme, and the National Freshwater Fish Expert Panel, appointed by the Biodiversity Secretariat of the then Ministry of Mahaweli Development and Environment.

All available published and unpublished data on the distribution of freshwater fishes of Sri Lanka (369 documents) were compiled and locations mapped and verified, in consultation with the National Freshwater Fish Expert Panel and individual fish experts, to fulfil the requirements of IUCN Species Information Service (SIS) database.

The freshwater fish checklist was updated using the list published in the National Red List (2012), as well as additions from taxonomic reviews, which were published from 2012 to date. This new list was reviewed and adopted at a meeting of the National Freshwater Fish Expert Panel held at the Biodiversity Secretariat.

All available information on the distribution, ecology and population estimates were gathered separately for each species and entered into separate data sheets.

The IUCN Freshwater Biodiversity Unit of the Global Species Programme held a half-day training session on the use of the SIS database for the local officers and compilers. Following this training, information on distribution, ecology, population estimates, and threats were entered into data sheets and sent to the Freshwater Biodiversity Unit for mapping, verification and uploading onto the SIS database.

Ninety-seven fish were assessed based on the IUCN Red List categories and criteria version 3.1 (second edition) (IUCN, 2012) and the most appropriate threat status was assigned to each species.

Chapter 3 details the results from the assessment. A total of 61 endemic species were assessed. Of these, 12 point endemic species were listed as Critically Endangered (CR); 24 range-restricted species were Endangered (EN); and nine species were Vulnerable (VU). In addition, five species were Near Threatened (NT); two were listed as Data Deficient (DD); and the remaining were listed as Least Concern (LC). This means that 74% — nearly three quarters — of the freshwater fish endemic to Sri Lanka were found to be Threatened with extinction.

Thirty-six native species were also assessed and of these, only eight species were listed as Threatened.

Chapter 4 discusses drivers that directly affect freshwater fish in Sri Lanka. Deforestation in catchment areas, as well as removal of stream and riverbank vegetation, is a prime driver of loss that affects freshwater fish in the wet zone. Such deforestation will result in significant changes in water flow regimens. Removal of streamside or riverine vegetation will enhance soil erosion, increase sediment flow into streams and rivers, and will also change water quality and alter stream beds. These changes can impact the breeding and foraging ecology of many freshwater fish species.

River diversion projects for hydropower generation, drinking water, irrigated agriculture and flood mitigation can result in significant alteration of the flow regimens of streams/rivers, and result in changes such as, *inter alia*, reduction of carrying capacity and water quality, as well as changes in water temperature. In addition, these changes in flow regimens can also result in complete removal of micro-habitats. These changes have resulted in the loss and/or displacement of several endemic and Threatened freshwater fish species.

Overexploitation is another driver of species loss. Destructive fishing techniques lead to large-scale mortalities of freshwater fish. In addition, there is a high demand of several endemic species in the aquarium trade. Even though wild capturing is prohibited by law, overexploitation of endemic fish species from the wild for the ornamental fish trade continues; and is considered a major cause for the decline in their populations and, in some cases, local extinctions.

The introduction of exotic species is yet another driver of species loss. Several species introduced into natural habitats have become invasive alien species, directly or indirectly affecting native species. Invasive alien plant species can make most marsh habitats unsuitable for freshwater fish or convert these habitats to woodlands. Others create thick floating mats on the surface of the water, resulting in changes to light and oxygen penetration. Freshwater fish diversity of coastal wetlands — such as the Bellanwila-Attidiya Sanctuary and Muthurajawela Sanctuary — have declined drastically during the last few decades, as a consequence of the rapid spread of invasive alien plants.

More than 30 species of exotic fish have been introduced — both intentionally and accidentally — to freshwater habitats of Sri Lanka. While many of these species were introduced to boost inland fisheries, others were accidentally introduced by the aquarium industry. Some of these species have become invasive in many natural and human-made habitats. They can directly impact freshwater fish either by competing with native species for resources or directly feeding on native species.

Many rivers and minor streams are directly affected by gem mining, especially in the foothills of the wet zone area. Gem mining results in soil erosion and, therefore, tends to increase siltation in streams and rivers, altering water quality, as well as changing the streambed, because of sediment being deposited.

Urbanisation is also a major driver of the loss of freshwater fish. Both major and minor towns are located on the banks of wet zone rivers. Urban areas release very large amounts of wastewater and other pollutants into rivers and this directly impacts freshwater fish species. Urbanisation has also led to the reclamation of lowland marshes and swamps, and this has already led to local extinctions or the drastic reduction of populations of certain species.

Effluents released by industries, as well as wastewater discharged from households, alter the water quality of many water bodies because toxic compounds are accumulated. In addition, many solid waste disposal sites are located near freshwater habitats and this results in the flow of leachate, containing many pollutants such as heavy metals and polycyclic aromatic hydrocarbons.

The catchments of major rivers in the wet zone — such as Kelani, Kalu, Gin and Nilwala Rivers (in which there are several range-restricted, endemic freshwater fish) — are used for agriculture, such as tea, rubber and paddy. Cultivators of these major crops use excessive quantities of pesticides and artificial fertilisers and as a consequence, much of these are washed, with surface runoff, into streams/rivers. These inorganic nutrients are then transported downstream and cause eutrophication when the water is relatively stagnant, and this directly affects the survival of fish species. Many of these pesticides and fertilisers contain heavy metals that tend to bio-accumulate in freshwater food chains.

Climate change can also have a significant influence on the survival of freshwater fish species. It can affect water yield, because high variability in rainfall patterns can cause increased flows or extremely low flows; salinity intrusion, driven by sea level changes, can change the salinity regimen of coastal streams; and increased incidence of natural hazards, such as landslides associated with climate change, can increase the sediment load in streams and rivers. These changes can have significant impacts on the survival of species, and also on species assemblages, as species with a wide tolerance to environmental changes will survive and change the composition of species in water bodies.

Most Threatened, endemic freshwater fish are subject to multiple anthropogenic influences because their habitats lie outside protected areas.

Chapter 5 details current conservation measures to protect freshwater fish and also provides recommendations for the future.

Legal protection provided currently to the freshwater fish of Sri Lanka includes 17 species, which have been protected by law under the Fauna and Flora Protection Ordinance No.22 of 2009; 13 species which are prohibited from export under the Fisheries and Aquatic Resources Act, no 2 of 1996; and another 13 species whose exports is restricted, under the same act.

Approximately 28% of the land area in Sri Lanka has been declared as protected areas and is managed by either the Department of Wildlife Conservation or Forest Department. However,

most of the Threatened, endemic and range-restricted freshwater fish are found in habitats located outside the Protected Area Network and are subject to high human pressure. There have been several local extinctions, and if this trend continues, it may lead to extinction of species as well. Therefore, urgent action is needed to protect these habitats.

The first recommendation provided is that island-wide systematic surveys of the freshwater fish fauna of Sri Lanka are needed urgently. Recent phylogenetic studies have demonstrated that there still are new species to be described and that taxonomic clearances are needed of several already described species. In addition, systematic surveys will document the ecological variables needed for each species of freshwater fish in Sri Lanka. The baseline data generated from such surveys can also be used to make accurate assessments of the threat status of each species, as well as to draw up species conservation plans.

The second recommendation is that population assessments — at least for Critically Endangered Species — should be conducted. During the current global threatened status evaluation process, it was revealed that some nationally threatened species, which have a wide distribution, cannot be listed under any of the IUCN threat categories. However, the opinion of fish experts was that there are several drivers already reducing population sizes of such species. Therefore, there is a critical need to conduct population assessments for — at least — identified species, as this would facilitate the use of more objective criteria (IUCN criteria version 3: A, C, D, E) for assessments, rather than relying completely on geographic range (B), which is the basis of all assessments carried out to date.

The third recommendation is that conservation action plans should be developed for Threatened fish species endemic to Sri Lanka. This assessment revealed there are 12 species of Critically Endangered freshwater fish endemic to Sri Lanka. It is, therefore, important to develop conservation action plans for each of these Critically Endangered, endemic, freshwater fish species.

Site-directed action planning (SDAP) is needed for species inhabiting a defined area and subject to multiple, localised threats linked to the specific area.

Individual species recovery planning (ISRP) is an ideal approach for species whose conservation needs do not overlap significantly with those of other species. Such an action plan should first identify priority species (for example, Critically Endangered species), as well as critical habitats (for example habitats of point endemic species that lie outside the Protected Area Network) of freshwater fish that require immediate conservation action.

Ex-situ conservation feasibility assessment or action planning (ECFA) should be considered for species where *in-situ* conservation alone is unlikely to prevent extinction and to boost dwindling wild populations. The next step after *ex-situ* breeding — translocation or reintroduction programmes — should be planned with the utmost care, to prevent hybridisation and the introduction of disease to the existing wild populations.

Habitat-directed action planning (HDAP) is ideal for species which are dependent on the same habitat type that is subject to a common threat or threats. Therefore, any type of development affecting these habitats must be assessed clearly before approval is granted. Meanwhile, a mechanism must be established to monitor the recommendations provided by the

environmental impact assessments of such projects. Also, a national programme to protect catchments, as well as to enforce river and stream reservations, is another identified need.

Threat-directed action planning (TDAP) will target a group of species affected by a common threat. This type of planning is not dependent on a site or sites but is associated with the process of threat. Threats such as pesticides, invasive alien species and gem mining affect many of Sri Lanka's freshwater fish. All pesticides approved for release in Sri Lanka should be assessed specifically on their impact on non-target organisms and generally, in relation to their damage to the environment. All future intentional release of exotic fishes should be preceded by a risk assessment involving specific safeguards against invasiveness, and at the same time a ban should be imposed on importation of exotic fish species known to be invasive in other countries.

The final recommendation provided is that awareness should be created among local communities. As most freshwater fish species occur in human-dominated landscapes, a conservation model involving local communities in the conservation of freshwater fish *must* be developed, at least for the restricted-range species. Such a programme has been implemented successfully for *Pethia bundula* and has resulted in the curtailing of illegal collection of the fish, and the consequent recovery of the population.

In this assessment, 74% — nearly three quarters — of the freshwater fish endemic to Sri Lanka were found to be threatened with extinction. Most Sri Lanka's freshwater fish are found outside protected areas and are thus affected directly by all the major drivers of biodiversity loss (habitat loss and degradation, overexploitation, pollution, invasive alien species and climate change). The results of the assessment call for exigent and planned conservation actions, at least for those species not only endemic to Sri Lanka, but also threatened by human actions.

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Acronyms

AOO	Area of Occupancy
CR	Critically Endangered
CR (PE)	Critically Endangered (Possibly Extinct)
DD	Data Deficient
E	Endemic
ECFA	*Ex-situ* Conservation Feasibility Assessment or Action Planning
EN	Endangered
EOO	Extent of Occurrence
EW	Extinct in the Wild
EX	Extinct
FARA	Fisheries and Aquatic Resources Act
FBU	Freshwater Biodiversity Unit
FFPO	Fauna and Flora Protection Ordinance
GIS	Geographic Information System
GTS	Global Threat Status
HDAP	Habitat-directed Action Planning
ISRP	Individual Species Recovery Planning
IUCN	International Union for Conservation of Nature
LC	Least Concern
LR:CD	Lower Risk: Conservation Dependent
N	Native
NE	Not Evaluated
NT	Near Threatened
NTS	National Threat Status
SDAP	Site-directed Action Planning
SIS	Species Information Service
SpS	Species Status
TDAP	Threat-directed Action Planning
VU	Vulnerable

Foreword

Many of Sri Lanka's endemic freshwater fish are found in the southwestern part of the island, where human population density is high. The rivers in which these fish are found flow mostly outside protected areas. Hence, these endemic freshwater fish are threatened by deforestation, surface runoff of large quantities of agrochemicals, the release of polluting effluents, gem mining, and the construction of large and small hydropower projects.

Since the last National Red List, there have been several taxonomic revisions of freshwater fish, while new species were identified, and many taxonomic uncertainties clarified. Therefore, there has been considerable change in both the total number and the number of species endemic to Sri Lanka. Yet, IUCN's Global Red List™ had not accommodated these changes.

The Biodiversity Secretariat (BDS) is responsible for assessment, monitoring, and revision of the National Red List, with continuing assistance from different panels of species experts. We gratefully acknowledge the timely support of the Sri Lanka Country Office of IUCN, for obtaining funding from the Asian Development Bank for evaluating the threat status of Sri Lanka's endemic freshwater fish at both the Global and National levels.

We also acknowledge the technical support provided by Sri Lanka Country Office of IUCN, in collaboration with the IUCN Freshwater Biodiversity Unit, IUCN Global Species Programme, as well as that of the National Freshwater Fish Expert Panel, appointed by the BDS.

Under the aegis this project, 97 species of freshwater fish were assessed using the IUCN Red List™ categories and criteria (version 3.1), and each was assigned a threat status. The results of this endeavour have already been uploaded onto the Red List™ website.

However, Red Listing is worthless, unless used as a tool for setting priorities for conservation actions. The Biodiversity Secretariat, in collaboration with the Department of Wildlife Conservation, other state and non-state partners and the Sri Lanka Country Office of IUCN, is proud to have developed and implemented a conservation action plan, in 2008, for the Bandula Barb (*Pethia bandula*), a point-endemic, found naturally only in a very restricted part of a stream that flows through the Galapitamada area of the Kegalle District in Sri Lanka. In the 1990s, there were about 2,000 individuals, but by the turn of the century, there were only 200-300 fish as a consequence of many human activities. Two years after the conservation plan was implemented in 2015, the population was estimated to be 1,500.

The Biodiversity Secretariat, as the responsible government organisation for species conservation, is looking forward to implementing recommended actions of this national threat assessment for freshwater fish, developing conservation action plans for endemic threatened fish species, and setting in motion the recovery of Threatened freshwater fish species. It is hoped that this National Red Listing effort will serve as a springboard for urgently needed conservation actions for Sri Lanka's threatened, endemic freshwater fish.

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Chapter 1: Introduction

Sri Lanka has a diverse network of freshwater habitats, comprising both natural and human-made ecosystems. There is a total of 103 river basins, forming a dendritic pattern and spreading throughout the entire island. The estimated combined length of the principal rivers is approximately 4,500 km. Besides rivers and streams, several other freshwater habitats — such as tanks, flood plains, pools, *villus* and paddy fields — are found in Sri Lanka (Pethiyagoda, 1991). These freshwater habitats support a rich aquatic fauna, of which, freshwater fish are the most studied taxonomic group.

Objective of the report

The following sections will show that the number of freshwater fish species, as well as the number of species endemic to Sri Lanka, have changed significantly over the past two decades. However, IUCN's global threat assessment does not reflect clearly the threat status of the freshwater fish species endemic to Sri Lanka. Therefore, it has become important to re-assess the threat status of Sri Lanka's freshwater fish species — especially those endemic to Sri Lanka — in order to set conservation priorities for Threatened species.

This assessment, therefore, was undertaken to determine the current threat status of freshwater fish species endemic to Sri Lanka, using the IUCN Global Red List™ criteria (version 3.1). Once completed, the data from this assessment will be used to update the global Red List™ website (www:redlist.org).

Taxonomic studies of freshwater fishes of Sri Lanka

The study of freshwater fish dates back to 1828 (Goonatilake, 2012) and studies can be divided into three major periods: from 1828-1955, 1955 to 2012, and 2012 to the present date (Goonatilake, 2012).

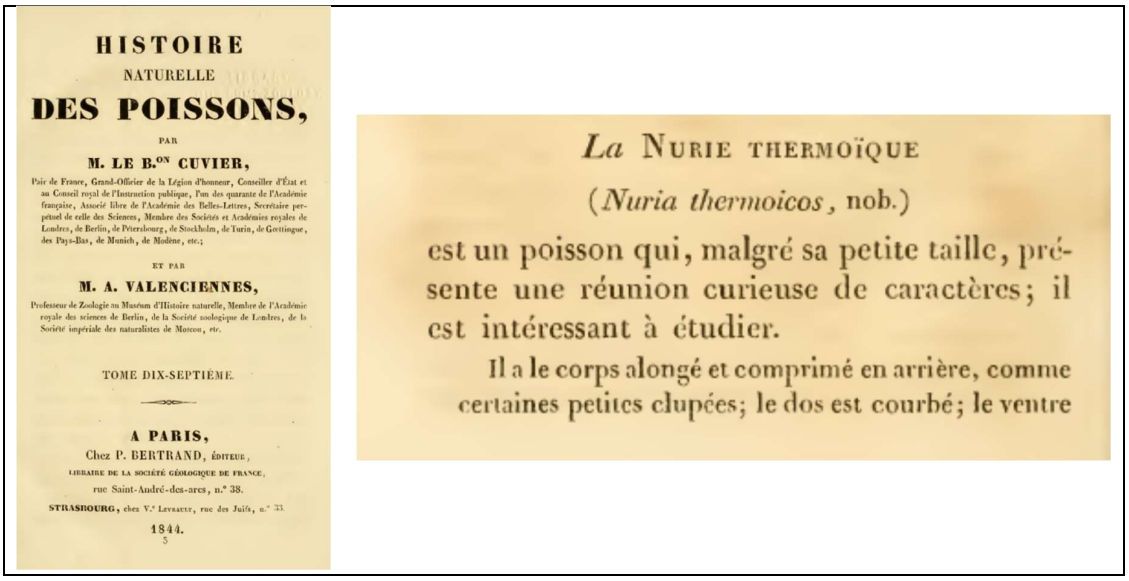
Studies carried out from 1828-1955

The first recorded description of Sri Lankan freshwater fish can be attributed to Georges Cuvier and Achille Valenciennes, who described several species of fish from Sri Lanka, based on a single collection made in 1827 near the Kinniar hot springs, by the French explorer A. Reynaud (Cuvier & Valenciennes, 1828– 49) (Figure 2, Figure 5).

However, the first methodical exploration of the freshwater fish fauna occurred in the early 1860s, when the Dutch ichthyologist P. Bleeker described several new species of freshwater fish, based on a collection made from the Gin River basin (Goonatilake, 2012).

In the early 1900s, Bleeker's work was followed that of a German ichthyologist, George Duncker, who explored several localities, including the Gin river basin; and who compiled the first checklist of Sri Lankan freshwater fish (Duncker, 1912).

In the mid-20th century, local naturalists followed these early efforts of fish exploration by European ichthyologists. The most notable of these was P.E.P. Deraniyagala, who described several new species and produced the first illustrated book on Sri Lankan freshwater fish (Deraniyagala, 1952) (Figure 3, Figure 5). His work was followed by A. S. Mendis in 1954, and I. S. R. Munro in 1955.


HISTOIRE
NATURELLE
DES POISSONS,
PAR
M. LE B.ON CUVIER,
Pair de France, Grand-Officier de la Légion d'honneur, Conseiller d'État et au Conseil royal de l'Instruction publique, l'un des quarante de l'Académie française, Associé libre de l'Académie des Belles-Lettres, Secrétaire perpétuel de celle des Sciences, Membre des Sociétés et Académies royales de Londres, de Berlin, de Pétersbourg, de Stockholm, de Turin, de Gœttingue, des Pays-Bas, de Munich, de Modène, etc.;
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TOME DIX-SEPTIÈME.
A PARIS,
Chez P. BERTRAND, ÉDITEUR,
LIBRAIRE DE LA SOCIÉTÉ GÉOLOGIQUE DE FRANCE,
rue Saint-André-des-arcs, n.° 38.
STRASBOURG, chez V.e Levrault, rue des Juifs, n.° 33.
1844.
5
La Nurie thermoïque
(Nuria thermoicos, nob.)
est un poisson qui, malgré sa petite taille, présente une réunion curieuse de caractères; il est intéressant à étudier.
Il a le corps alongé et comprimé en arrière, comme certaines petites clupées; le dos est courbé; le ventre

Figure 2. Left: The cover page of the original publication by Valenciennes; right: Part of the description of the first Sri Lankan freshwater fish to be described by Valenciennes, 1842, *Nuria thermoicos*[1]

Studies carried out from 1955-2012

During the late 1970s, Ranil Senanayake carried out the first systematic exploration of Sri Lanka's freshwater fish fauna for his doctoral dissertation, and this led to a comprehensive review of the threat status of Sri Lanka's freshwater fishes (Senanayake, 1980; Senanayake and Moyle, 1982) (Figure 5).

His studies were followed by a more extensive survey on freshwater fish carried out by the Wildlife Heritage Trust, which resulted in the discovery of many new species of freshwater fish (Bailey & Gans, 1998; Kottelat & Pethiyagoda, 1991; Meegaskumbura, et al., 2008; Pethiyagoda et al., 2008; Pethiyagoda et al., 2008a; Pethiyagoda et al., 2008b; Pethiyagoda et al., 2008c; Pethiyagoda et al., 2012; Silva et al., 2008; Silva et al., 2011).

[1] Now named *Esomus thermoicos* (English: Flying barb; Sinhala: *Rawul dandiya*; Tamil: No name known)

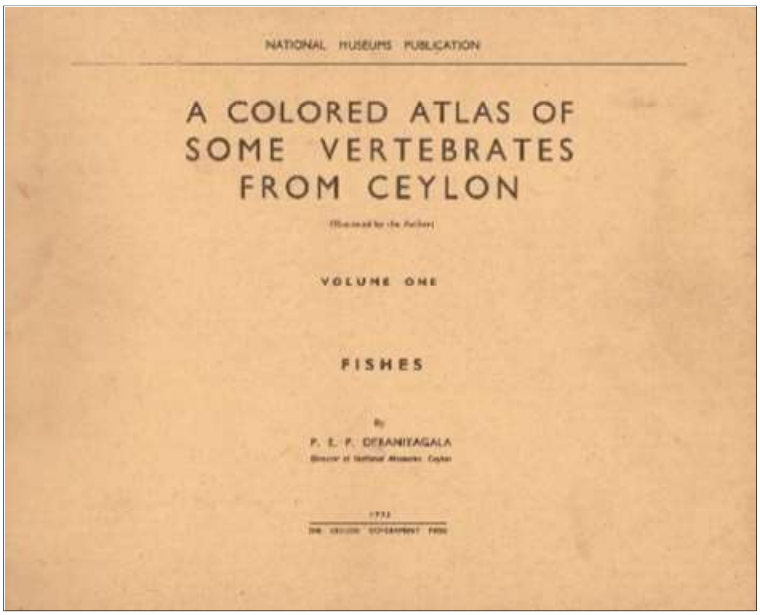

Figure 3. The cover of P.E.P. Deraniyagala's first illustrated book on Sri Lankan freshwater fish

Pethiyagoda (1991) also published an updated, limited edition version of an illustrated book on Sri Lanka's freshwater fishes (Figure 4, Figure 5) and Goonatilake (2007) published, in Sinhala, a field guide.

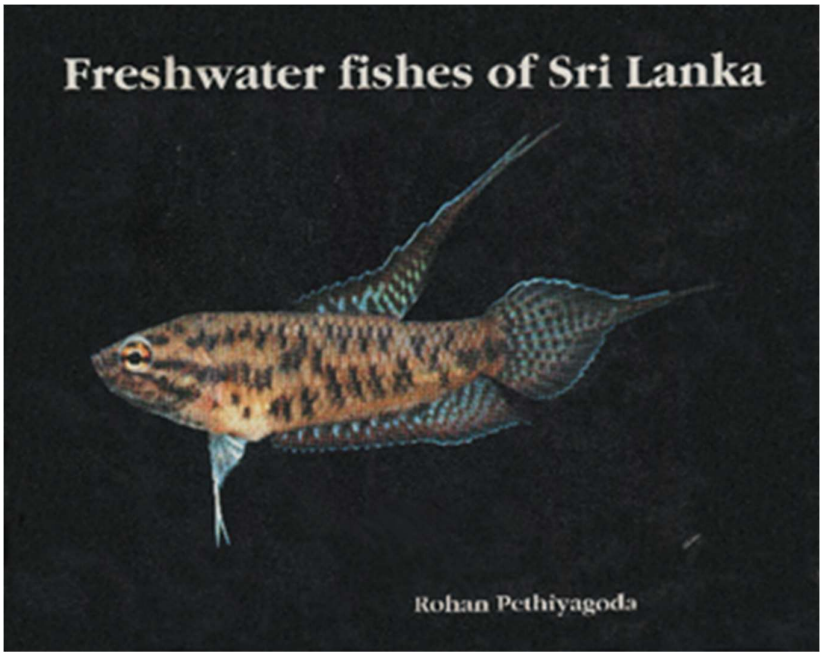

Figure 4. The cover page of Rohan Pethiyagoda's illustrated book on Sri Lanka's Freshwater Fishes, published in 1991

The nomenclature of freshwater fish was also revised extensively during the past two decades. The most recent taxonomic revision was that of the genus *Puntius,* by Pethiyagoda et al. (2012) which has resulted in the splitting of this genus into four genera, namely *Puntius, Pethia, Systomus* and *Dawkinsia*.

Similarly, the revision of the genera *Rasbora* (Silva et al., 2011) and *Danio* (Kevin et al., 2010) resulted in some species of the genus *Rasbora* being placed under the genus *Rasboroides*, and all species of the genus *Danio* now under the genus *Devario* (Miya et al., 2010).

Further, what was formerly named *Chela ceylonensis* was split into four species and placed under the genus *Labuca (*Pethiyagoda et al., 2008a).

In addition, over the past decade, species names of several species were also revised. For example, *Puntius filamentous, Puntius amphibious*, *Macroganthus aral*, and *Labeo porcellus* were renamed *Puntius singhala*, *Puntius kamalika*, *Macrognathus pentophthalmos,* and *Labeo lankae* respectively (Pethiyagoda & Kottelat, 2005; Silva et al., 2008 and Pethiyagoda et al., 2008c; Pethiyagoda, 1994).

Channa marulius is distributed widely throughout India and Sri Lanka. As the Sri Lankan species is significantly different from the Indian species, Musikasinthon (1997) proposed that *Channa marulius ara* be elevated to a full species, *Channa ara* (Deraniyagala, 1945) (Pethiyagoda, 1998).

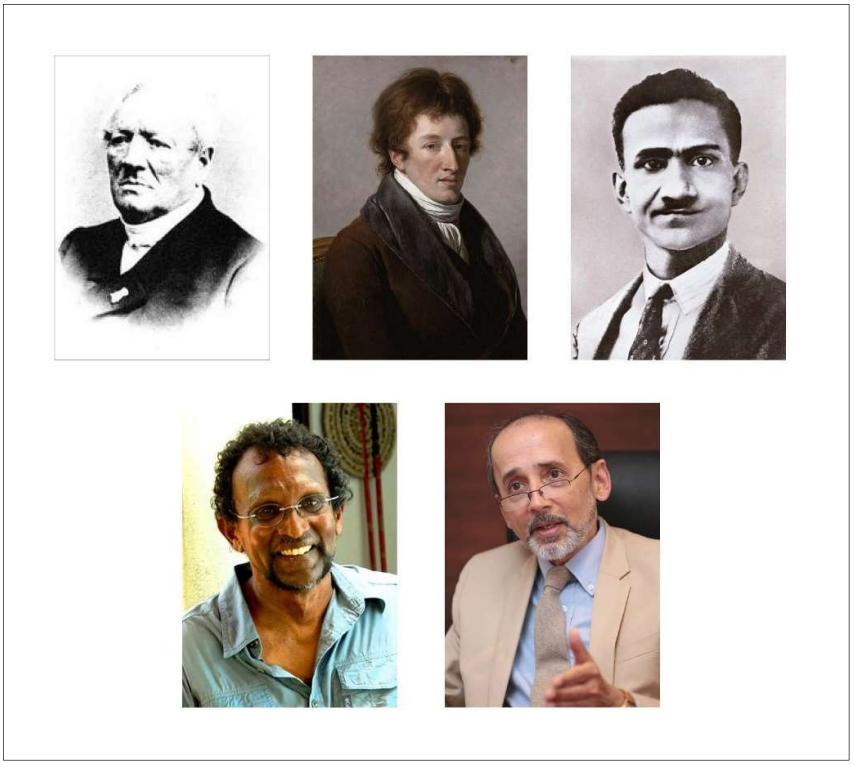

Figure 5. Pioneers of research about Sri Lanka's Freshwater Fish

Top left: Georges Cuvier; middle: Achille Valenciennes; right: P.E.P. Deraniyagala; bottom left: Ranil Senanayake; right: Rohan Pethiyagoda

Studies carried out from 2012 to date

In 2013, Batuwita et al., after reviewing the genus *Rasboroides*, declared *Rasboroides vaterifloris var. pallidus* (Deraniyagala 1958) and *Rasboroides nigromarginatus* (Meinken, 1957) as new species, and another new species (*Rasboroides rohani*) was described from the eastern part of Sinharaja rain forest.

Sudasinghe et al. (2018a), based on a phylogenetic study, demonstrated that *R. nigromarginatus* was a synonym of *R. vaterifloris*, and *R. rohani*, a synonym of *R. pallidus*.

In 2013, Batuwita et al. showed that the Sri Lankan subspecies of *Horadandia atukorali* (Deraniyagala, 1943) *H. a. atukorali*, is distinctly different from the Indian subspecies, *H. a. britoni* and listed them as two valid species, where the Sri Lankan subspecies was named *Horadandia atukorali,* and listed as a species endemic to Sri Lanka.

Batuwita et al. (2017a) carried out another study on the genus *Devario* and the results revealed changes in the species assemblage of this genus. *Devario micronema* (Bleeker, 1863) was declared a synonym of *Devario malabarius* (Jerdon, 1849), while four species, namely *Devario micronema* (Bleeker, 1863), *Devario monticola*, *Devario annnataliae,* and *Devario udenii* were added to the Sri Lankan *Devario* group.

However, Sudasinghe and Pethiyagoda (2019) demonstrated that *Devario udenii* was a synonym of *Devario micronema.* In 2017 and 2018, Sudasinghe described two new species of *Schistura*: *Schistura madhavai* from eastern Sinharaja and *Schistura scripta* from the estates of Homadola and Nakiyadeniya.

In 2015, de Silva et al. published a book on freshwater fishes of Sri Lanka that included all the species described prior to 2015 and also several proposed new species with their locations and included colour photographs. This book also listed 30 naturally occurring exotic species found in the inland waters of Sri Lanka.

Several Indian species names which were applied erroneously to Sri Lankan populations have also been resolved between 2012 to date. These species have now been assigned new names, with the result that all these species are now listed as endemic species. These include *Pethia melanomaculata* (Deraniyagala, 1956) (formerly *Pethia ticto*) (Batuwita et al., 2015a); *Channa kelaartii* (Günther, 1861) (formerly *Channa gachua*) (Conte-Grand et al., 2017); *Mystus zeylanicus* (formerly *Mystus keletius*) (Ng & Pethiyagoda, 2013); and *Mystus nanus* (formerly *Mystus vittatus*) (Sudasinghe et al., 2016). Further, Sudasinghe and Meegaskumbura, (2016) demonstrated that the species *Ompok bimaculatus* (Bloch, 1794) actually comprised two different species *Ompok ceylonensis* (Günther, 1864) and *Ompok argestes,* both of which are endemic to Sri Lanka.

Sudasinghe et al. (2018b), after reviewing the genus *Labeo*, demonstrated that *Labeo* is represented in Sri Lanka by three endemic taxa: *L. heladiva*, *L. fisheri,* and *L. lankae*. *Labeo lankae* was described originally as a subspecies, *Labeo porcellus lankae* (Heckel, 1844) by Deraniyagala (1952) and was later renamed, in 1991, by Pethiyagoda as *L. porcellus* and subsequently as *Labeo lankae* (1994). It was further indicated that the name *Labeo dussumieri* (Valenciennes, 1842) had been mis-applied to the Sri Lankan population and therefore, *Labeo*

dussumieri was renamed *Labeo heladiva* (Sudasinghe et al., 2018b) and declared a species endemic to Sri Lanka.

Sudasinghe et al. (2019), after conducting a phylogenetic study on the species of *Amblypharyngodon* identified that Sri Lanka had only one species: *Amblypharyngodon grandisquammis* (Jordan & Starks, 1917) and removed *Amblypharyngodon melettinus* (Valenciennes, 1844) from the Sri Lankan checklist.

In 2015, Singer and Page changed the genus name of *Acanthocobitis urophthalmus* genus to *Paracanthocobitis.*

Likewise, Kullander et al. (2017) corrected the genus name *Labuca* in to *Laubuka.*

Batuwita et al. (2015b, 2017b) identified *Butis gymnopomus* (Bleeker, 1853) and *Bunaka gyrinoides* (Bleeker, 1853), from Sri Lankan inland waters.

Deraniyagala (1933) noted that a population of *Garra ceylonensis,* which inhabits streams of streams in the Mousakele Estate and Gammaduwa (1,066.8 m), have distinct differences from specimens collected elsewhere and, therefore, ascribed them to a subspecies, *Garra ceylonensis phillipsi.* Pethiyagoda (1991) later declared *Garra phillipsi* as a valid species. Recent genetic analysis of populations of *Garra* inhabiting different tributaries of the Knuckles range of hills (such as Heen Ganga, Kalu Ganga, Sudu Ganga, Kota Ganga) were found to be genetically similar to the rest of populations in other parts of the Mahaweli basin (Sudasinghe, person. comm). However, it is still retained in the list of Sri Lankan freshwater fish, as further phylogenetic studies are needed for complete taxonomic resolution.

The status of two more species — *Systomus timbiri* (Deraniyagala, 1963), and *Puntius layardii* (Günther, 1868) — were identified as valid species, based on phylogenetic studies (Pethiyagoda et al., 2012). However, further taxonomic studies that include field identification, as well ecology and distribution data, are needed to confirm the validity of these two species. In the same study, a new cyprinid species from the Mahaweli basin was identified, and its name proposed as *Systomus "Richmondi."* For this species, further detailed taxonomic studies are needed (Figure 6).

Puntius tetraspilus (Günther, 1868) is listed as a species, but its validity has been queried by Pethiyagoda et al. (2008b, 2012) (as it is known only from a putative holotype). Thus, this species also needs further phylogenetic study (Figure 6).

Esomus thermoicos (Valenciennes, 1842), listed as a species endemic to Sri Lanka, will have to be removed from the Sri Lankan list of endemic fish, as new findings reveal that it is also present in India (Sudasinghe et al., 2019).

Britz et al. (2020) have recognized *Monopterus desilvai* as *Ophichthys desilvai* based on osteological evidence.

Figure 6. A few species known from limited localities, which need further taxonomic research

(Top left: Holotype of *Systomus timbiri* (Deraniyagala, 1963) (Source: Deraniyagala, 1963); top right: Syntype of *Puntius layardi* (Günther, 1868) (Source: Pethiyagoda et al., 2008); bottom left: *Systomus "Richmondi"* from Pallegama, Mahaweli basin (© IUCN/ Sampath de A Goonatilake); bottom right: Putative holotype *Puntius tetraspilus* (Günther, 1868) (Source: Pethiyagoda et al., 2008)

Distribution patterns of the freshwater fishes of Sri Lanka

Based on the distribution patterns of freshwater fish species, four major ichthyological provinces are identified in Sri Lanka (Senanayake *et al*, 1982): the Southwestern Province, the Mahaweli Province, the Transition Province and the Dry Zone Province (Figure 7). The Southwestern Province is demarcated in the south by the Nilwala Ganga and in the north by the Attanagalu Oya and extends across both the first and second peneplains. The highest number of endemic and threatened freshwater fish species is found in the Southwestern ichthyological province. The Mahaweli Province is essentially the drainage basin of the Mahaweli River extending across all three peneplains and supports the second highest number of threatened and endemic freshwater fish species. The Dry Zone and Transition Zone Provinces also support rich freshwater species assemblages. However, in these two provinces are found only the commoner endemic species and a few threatened species. The fish found in the Dry Zone province have a higher affinity to the freshwater fish in the Indian peninsula.

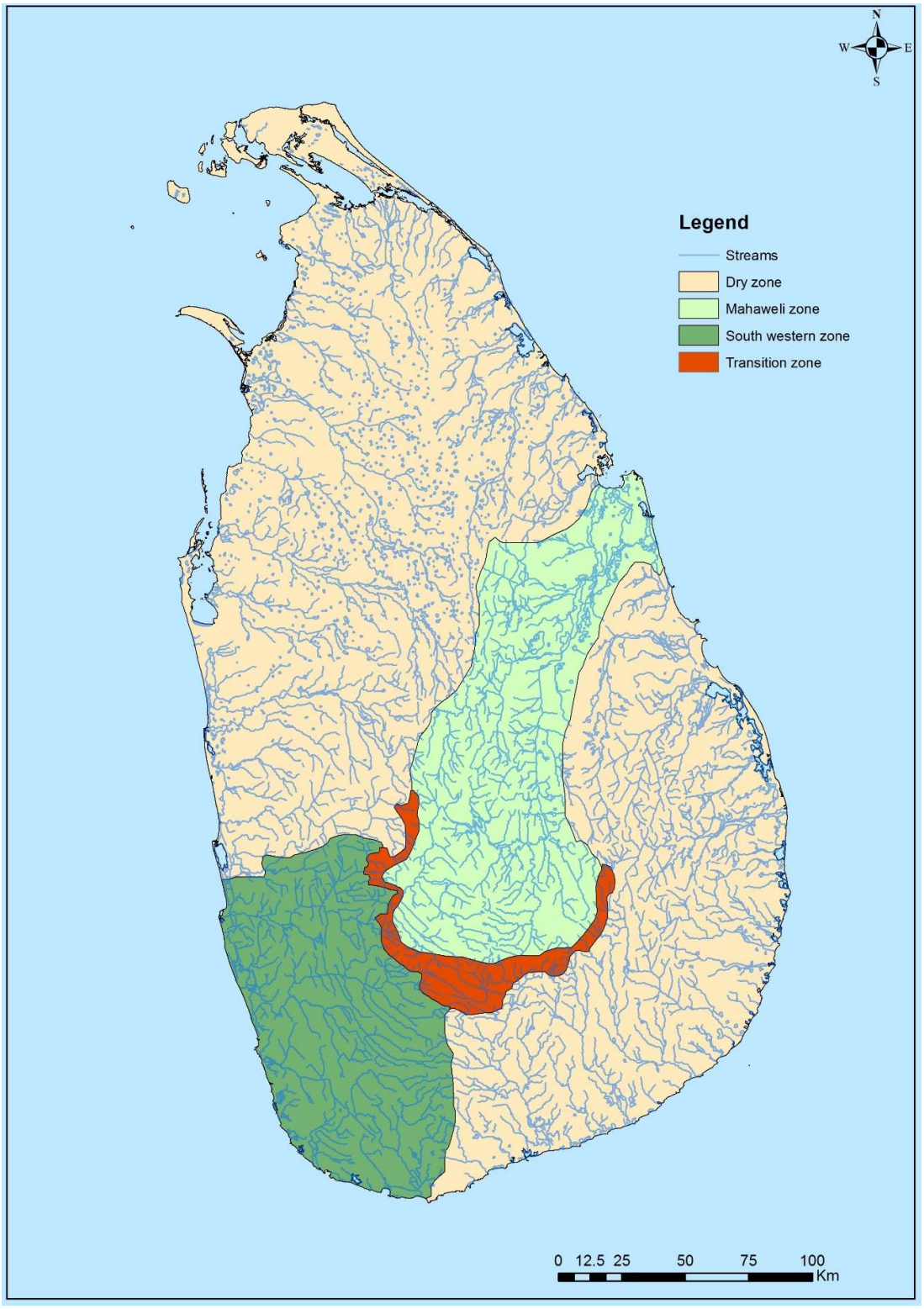

Figure 7. Ichthyological zones of Sri Lanka

(Source: Senanayake and Moyle, 1982)

Several species — such as *Pethia bandula* (Minipura, at Kegalle District) and *Stiphodon martenstyni* and *Rasboroides nigromaginata* (Atweltota near Matugama) — are only known from a single location (that is, they are point endemics). However, species such as *Lepidocephalichthys jonklaasi,* and *Rasbora wilpita*, which were also thought to be restricted to a single river basin — the Nilwala basin — have now been found also in the other river basins.

The Mahaweli Province has several species — such as *Dawkinsia*[2] *srilankensis*, *Systomus*[3] *martenstyni*, *Labeo fisheri*, and *Labuca insularis* — found nowhere else on the island.

Freshwater fish habitats in Sri Lanka

One hundred and three rivers drain from almost entirely from the central hill massif of Sri Lanka, spreading across the entire island (MMDE, 2016a). Tributaries of these rivers eventually form seasonal or shallow streams.

In some of the basins of these rivers there are also flood plains — areas near rivers where excess water is discharged during heavy rains.

Although Sri Lanka has no natural lakes, the dry zone of the island has a unique suite of human-made ancient irrigation reservoirs. There are about 10,000 of the reservoirs (also called tanks from the Portuguese word *tanque*), relics of an ancient hydraulic civilization (MMDE, 2016a). These tanks extend over nearly 60,000 ha (Survey Department, 2007), and provide perennial and seasonal sources of water to many fauna, and habitats to many species such as freshwater fish.

Among these reservoirs are large ones — such as the Senenayake Samudraya — which has a catchment area as large as 99,455 ha.

Irrigation canals supply water from these large reservoirs and are also found commonly in the dry zone.

There are also some 12,000 small tanks and 13,000 anicuts, feeding an extent of about 246,000 ha, also inherited from the past. These small tanks do not exist as discrete units but as a series of tanks that form a cascade. They are called village tank cascade systems (IUCN, 2015).

Also found in the Mahaweli basin are *villus* — similar to ox-bow lakes in other parts of the world — which are natural, saucer-shaped depressions near flood plains. These depressions fill with water during the monsoons. There are more than 38 *villus* extending over an area of 12,800 ha in this basin (Rajakaruna, 2014).

Another type of *villu* — in which ground water percolates to the surface — is found in Wilpattu (Eisenberg & Lockhart, 1972).

[2] Formerly *Puntius*
[3] *Ibid.*

Although Sri Lanka has lost much of its wetlands, there still are marshes, which provide habitats for freshwater fish. Marshes constructed by humans — paddy fields — are also habitats for some freshwater fish.

Example of some of these habitats and species that are found in them are presented in Table 1.

Table 1. Examples of some habitats of freshwater fish, and species found in them

(Source: de Silva et al., 2015)

Habitat	Examples of species found in these habitats
Fast flowing rivers/Streams	*Garra ceylonensis, Dawkinsia singhala, Dawkinsia srilankensis, Laubuka insularis, Rasbora naggsi, Systomus asoka, Sicyopus jonklaasi*
Moderately flowing rivers/Streams	*Laubuka ruhuna, Pethia reval, Puntius kamalika, Puntius kelumi, Puntius thermalis*
Slow flowing river/Streams	*Aplocheilus werneri*, *Paracanthocobitis urophthalma, Belontia signata, Malpulutta kretseri, Lepidocephalichthys jonklaasi, Dawkinsia singhala, Pethia bandula, Puntius titteya, Rasboroides pallidus*
Stagnant/Still water	*Mystus ankutta*, *Clarias brachysoma, Dawkinsia singhala, Pethia reval*
Paddy fields	*Aplocheilus werneri, Horadandia atukorali, Pethia reval, Macrognathus pentophthalmos*
Irrigation canals	*Laubuka lankensis, Mystus zeylanicus, Systomus spilurus, Dawkinsia singhala*
Deep pools/Pools of large rivers	*Tor kuhdree, Walago attu*, *Channa ara*
Tanks	*Amblypharyngodon grandisquamis, Rasbora microcephalus, Systomus spilurus*
Marshes	*Amblypharyngodon grandisquamis, Horadandia atukorali, Ophichthys desilvai, Aplocheilus dayi*

Figure 8. Some habitats of freshwater fish in Sri Lanka

(1st row left: A wet zone river; middle: a dry zone river; right: a stream; 2nd row left: a large reservoir (Minneriya) (© Sriyanie Miththapala); middle: a village tank (Mahakirula) (© Sriyanie Miththapala); right: an irrigation canal; 3rd row left: a flood plain; middle: a wetland; right: a paddy field. All except photographs already credited © IUCN/Sampath de A. Goonatilake)

Global threat status of the freshwater fish species of Sri Lanka

The global IUCN Red List™ provides the threat status of 54 species, which includes 18 endemic species. Out of the 18 endemic species, eight species are listed as threatened species (two as Critically Endangered and six as Endangered). Further, except for *Devario pathirana* and *Labeo fisheri* (evaluated in 2007, using criteria version 3.1), the remaining six species were evaluated using Red List 2.3 version (of 1994). The remaining ten species are listed as the following categories: Least Concern (three), Data deficient (one) or Lower Risk: conservation dependent (six).

Therefore, of the 62 endemic species, 44 have not been assessed in the Global IUCN Red List™ until early 2019. In addition, more than 20 species endemic to Sri Lanka are not even recognised as valid species in the Red List™ Species Information Service (SIS) database. This shows that the freshwater fish fauna of Sri Lanka are both under-represented and mis-represented in the global Red List™. Therefore, there is an urgent need to evaluate and upgrade the threat status of the freshwater fish fauna of Sri Lanka in the IUCN Global Red List™. In addition to these 18 endemic species, 34 native species are also listed in the IUCN Global Red List™ under the categories of Endangered (one), Data Deficient (five), Least Concern (27), or Near Threatened (three) (Table 2). Therefore, the present assessment has assisted the Global IUCN Red List™ team to evaluate and update the status of freshwater fish species endemic to Sri Lanka. The revised threat status of each of Sri Lanka's endemic freshwater fish species was published in mid-December on the Red List™ website (IUCN, 2019).

Table 2. List of Sri Lankan species listed in the IUCN Global Red List (to date November 2019)

Abbreviations used: SpS: Species Status; GTS: Global Threat Status; E: Endemic; N: Native;
CR: Critically Endangered; EN: Endangered; NT: Near Threatened; LR:CD: Low Risk Conservation Dependent; DD: Data Deficient; LC: Least Concern.
No Tamil names are known for these species

	Scientific Name	English Name	Sinhala Name	SpS	GTS
1	*Labeo lankae*	Orange-fin labeo	*Thambalaya*	E	CR
2	*Pethia bandula*	Bandula barb	*Bandula Pothaya*	E	CR
3	*Devario pathirana*	Barred danio	*Pathirana Salaya*	E	EN
4	*Labeo fisheri*	Green Labeo	*Gadeya*	E	EN
5	*Rasbora wilpita*	Wilpita rasbora	*Wilpita Dandiya*	E	EN
6	*Systomus asoka*	Asoka barb	*Asoka Pethiya*	E	EN
7	*Systomus martenstyni*	Martenstyn's barb	*Dumbara Pethiya*	E	EN
8	*Lepidocephalichthys jonklaasi*	Jonklaas' loach	*Pulli Ahirawa*	E	EN

	Scientific Name	English Name	Sinhala Name	SpS	GTS
9	*Tor khudree*	Mahseer	*Lehella*	N	EN
10	*Anguilla bicolor*	Level-finned eel	*Kalu Andha*	N	NT
11	*Anguilla bengalensis*	Long-finned eel	*Pol mal Andha*	N	NT
12	*Wallago attu*	Shark catfish	*Walaya*	N	NT
13	*Oryzias dancena*	Deep-bodied ricefish	*Handi handaya*	N	LC
14	*Oryzias carnaticus*	Spotted ricefish	*Thith handaya*	N	LC
15	*Xenentodon cancila*	Freshwater garfish	*Yonna*	N	LC
16	*Amblypharyngodon grandisquamis*	Large silver carplet	*Gangiliya*	E	LC
17	*Devario malabaricus*	Giant danio	*Dankola Sayala*	N	LC
18	*Esomus thermoicos*	Flying barb	*Revul Dandiya*	N	LC
19	*Labeo heladiva*	Sri lanka labeo	*Hiri Kanaya*	E	LC
20	*Puntius bimaculatus*	Redside barb	*Ipili Kadaya*	N	LC
21	*Puntius dorsalis*	Long-snouted barb	*Bimtholla*	N	LC
22	*Puntius vittatus*	Silver barb	*Bandi Titteya*	N	LC
23	*Rasbora dandia*	Striped rasbora	*Dandiya*	N	LC
24	*Rasbora microcephalus*	Thin-line Rasbora	*Caveri Randiya*	N	LC
25	*Horadandia atukorali*	Horadandia	*Horadandiya*	E	LC
26	*Lepidocephalichthys thermalis*	Common spiny loach	*Thith Ahirawa*	N	LC
27	*Pseudosphromenus cupanus*	Spike-tailed paradisefish	*Pulutta*	N	LC
28	*Channa punctata*	Spotted snakehead	*Mada Kanaya*	N	LC
29	*Channa striata*	Murrel	*Loola*	N	LC
30	*Pseudetroplus maculatus*	Orange chromide	*Ralliya*	N	LC
31	*Etroplus suratensis*	Pearl spot	*Koraliya*	N	LC
32	*Awaous melanocephalus*	Scribbled goby	*Bali Weligouva*	N	LC
33	*Glossogobius giuris*	Bar-eyed goby	*Maha gan weligouva*	N	LC
34	*Redigobius balteatus*	Rhino-horn goby	*Deiri Weligouva*	N	LC
35	*Redigobius bikolanus*	Speckled goby	*Weligouva*	N	LC

	Scientific Name	English Name	Sinhala Name	SpS	GTS
36	*Sicyopterus griseus*	Stone goby	*Gal weligouwa*	N	LC
37	*Sicyopterus lagocephalus*	Red-tailed goby	*Maha Gal weligouwa*	N	LC
38	*Eleotris fusca*	Brown gudgeon	*Puvak badilla*	N	LC
39	*Mystus gulio*	Long-whiskered catfish	*Mana ankutta*	N	LC
40	*Heteropneustes fossilis*	Stinging catfish	*Hunga*	N	LC
41	*Mastacembelus armatus*	Marbled spiny eel	*Gan theliya*	N	LC
42	*Ophisternon bengalense*	Swamp eel	*Potta aandha*	N	LC
43	*Anabas testudineus*	Climbing perch	*Kavaiya*	N	DD
44	*Schismatogobius deraniyagalai*	Redneck goby	*Kata rathu weligouva*	N	DD
45	*Oligolepis acutipennis*	Sharptail goby	*Weligouva*	N	DD
46	*Microphis ocellatus*	Ocellated pipefish	*Punchi athu teliya*	N	DD
47	*Sicyopus jonklaasi*	Lipstick goby	*Thol Rathu Weligouwa*	E	DD
48	*Garra phillipsi*	Phillips' garra	*Gal Panderuwa*	E	DD
49	*Pethia nigrofasciata*	Black ruby barb	*Bulath Hapaya*	E	LR/cd
50	*Puntius titteya*	Cherry barb	*Le Titteya*	E	LR/cd
51	*Belontia signata*	Combtail	*Thalkossa*	E	LR/cd
52	*Malpulutta kretseri*	Ornate paradisefish	*Malpulutta*	E	LR/cd
53	*Systomus pleurotaenia*	Black-lined barb	*Heeta Massa*	E	LR/cd
54	*Paracanthocobitis urophthalma*	Tiger loach	*Pol Ahirawa*	E	LR/cd

National threat status of the freshwater fish species of Sri Lanka

The last national threat status assessment for freshwater fish was carried out in 2012 by the Biodiversity Secretariat, of the then Ministry of Environment, with the involvement of a freshwater expert panel. This assessment was carried out using IUCN Red List™ criteria (version 3.1). The 2012 assessment considered 91 species, including 50 species endemic to Sri Lanka. Of the 50 endemics considered, 45 were listed as Nationally Threatened: two Critically Endangered and Possibly Extinct, 19 Critically Endangered, 19 Endangered and five Vulnerable (MoE, 2012). For endemic species, the National Assessment should also reflect the Global Status.

Table 3. Threat status of the freshwater fish species listed by family according to the 2012 national threatened list

Abbreviations used: CR(PE) - Critically Endangered (possibly Extinct); CR - Critically Endangered; EN - Endangered; VU - Vulnerable; NT - Near Threatened; DD - Data Deficient; LC - Least Concern

No	Family name	Total number of species	Total Endemic species	Global threat categories				NT	DD	LC
				CR (PE)	CR	EN	VU			
1	Adrianichthyidae	2	0	0	0	0	0	0	2	0
2	Aplocheilidae	3	2	0	0	2	0	0	0	1
3	Anabantidae	1	0	0	0	0	0	0	0	1
4	Anguillidae	2	0	0	0	0	0	0	0	2
5	Bagridae	4	1	0	0	1	0	0	0	3
6	Balitoridae	2	2	0	0	1	0	1	0	0
7	Belonidae	1	0	0	0	0	0	1	0	0
8	Belontidae	3	2	0	1	0	0	1	0	1
9	Cichlidae	2	0	0	0	0	0	0	0	2
10	Cobitidae	2	1	0	1	0	0	0	0	1
11	Channidae	5	2	0	0	1	1	0	0	3
12	Claridae	1	1	0	0	0	0	1	0	0
13	Cyprinidae	45	35	0	13	11	4	1	5	11
14	Eleotridae	2	0	0	0	0	0	0	0	2
15	Gobiidae	9	2	1	2	2	0	0	2	0
16	Heteropneustidae	1	0	0	0	0	0	0	0	1
17	Mastacembelidae	2	1	1	0	0	0	0	0	1
18	Siluridae	2	0	0	0	1	0	0	0	1
19	Synbranchidae	2	1	0	2	0	0	0	0	0
	Total count	**91**	**50**	**2**	**19**	**19**	**5**	**5**	**9**	**30**

Chapter 2: Methodology

Ninety-seven freshwater fish species, including 61 species endemic to Sri Lanka, were assessed.

Box 1. Exotic species of freshwater fish

Other than the above indigenous species, there are 30 exotic species that have been introduced to the island. Most of these exotic species have been introduced intentionally to boost inland fisheries, while a few species of aquarium fish have been introduced accidentally into natural water bodies. Of the accidentally introduced exotic species, three have been listed as Nationally Invasive Species.

These exotic species were not considered in this assessment.

This assessment was coordinated by the Sri Lanka Country Office of IUCN, in collaboration with the IUCN Freshwater Biodiversity Unit (FBU), IUCN Global Species Programme and the National Freshwater Fish Expert Panel appointed by the Biodiversity Secretariat, of the then Ministry of Mahaweli Development and Environment.

The methodological approach followed in conducting this assessment was as follows:

Firstly, all available published and unpublished data on the distribution of freshwater fishes of Sri Lanka were compiled, mapped and locations verified, in consultation with the National Freshwater Fish Expert Panel, as well as those individual fish experts who reported distribution data, to fulfil the requirements of IUCN Species Information Service (SIS) database. The relevant data were extracted from 369 references, comprising journal articles, magazines, books, dissertations, project reports, research communications, symposium papers, and unpublished data provided by the National Freshwater Fish Expert Panel (Annex 3).

The freshwater fish checklist was updated using the list published in the National Red List (2012), as well as additions from taxonomic reviews, which were published from 2012 to date. On 19 January 2019, this list was then reviewed and adopted at a meeting of the National Freshwater Fish Expert Panel held at Biodiversity Secretariat.

Secondly, all available information on the distribution, ecology and population estimates were gathered separately for each species and entered into two separate data sheets (Annex 1 and Annex 2).

The IUCN FBU provided access to the SIS and held a half-day training session for local officers and compilers on the use of SIS database. Following this training, information on

distribution, ecology, population estimates and threats were entered into data sheets prepared based on the SIS database format by the project officers (Annex 2). The compiled data sheets were sent to the FBU for mapping, verification and uploading to the SIS database.

Thirdly, all 97 species of freshwater fish were assessed based on the IUCN Red List™ categories and criteria version 3.1 (second edition) (IUCN, 2012) and the most appropriate threat status was assigned to each species.

Box 2. IUCN Red List criteria that have been developed to assess the threat status of a species

There are five (A-E) IUCN Red List criteria that have been developed to assess the threat status of a species (IUCN, 2012). These include:

A. Past, present or future population size reduction
B. Restricted geographic range and fragmentation and continuing decline or extreme fluctuations
C. Small population size and continuing decline
D. Very small or restricted population
E. Quantitative analysis

The present knowledge of the freshwater fish species in Sri Lanka is limited to their distribution, ecology and drivers of change. Population estimates and breeding data are available for less than five species.

Therefore, the present assessment is based primarily on criterion B, as defined in the IUCN Red List Categories and Criteria (IUCN, 2012).

Table 4. A summary of criterion B, and its sub-criteria, which has been used for the determination of the threatened status of freshwater fish species

B. Geographic range in the form of either B1 (extent of occurrence) AND/OR B2 (area of occupancy)			
	Critically Endangered	Endangered	Vulnerable
B1. Extent of occurrence (EOO)	< 100 km²	< 5,000 km²	< 20,000 km²
B2. Area of occupancy (AOO)	< 10 km²	< 500 km²	< 2,000 km²
AND at least 2 of the following 3 conditions:			
(a) Severely fragmented **OR** Number of locations	= 1	≤ 5	≤ 10
(b) Continuing decline observed, estimated, inferred or projected in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** area, extent and/or quality of habitat; **(iv)** number of locations or subpopulations; **(v)** number of mature individuals.			
(c) Extreme fluctuations in any of: **(i)** extent of occurrence; **(ii)** area of occupancy; **(iii)** number of locations or subpopulations; **(iv)** number of mature individuals.			

The SIS database is designed to generate automatically the final categories, once the relevant data have been fed. The final categories assigned to each of the freshwater fish species from the SIS database were discussed at a meeting of the National Freshwater Fish Expert Panel, before arrival at the final decision regarding the threat status to be assigned to each species. Any comments made by the experts were submitted to the FBU for further clarification. The

final data set was sent to Prof. Rajeev Raghavan (South Asia Coordinator of IUCN's Freshwater Fish Specialist Group) for final review. The reviewed data set was then sent to the IUCN Global Red List™ unit through the FBU, and was uploaded in mid-December 2019, to the Global Red List™ website (IUCN, 2019).

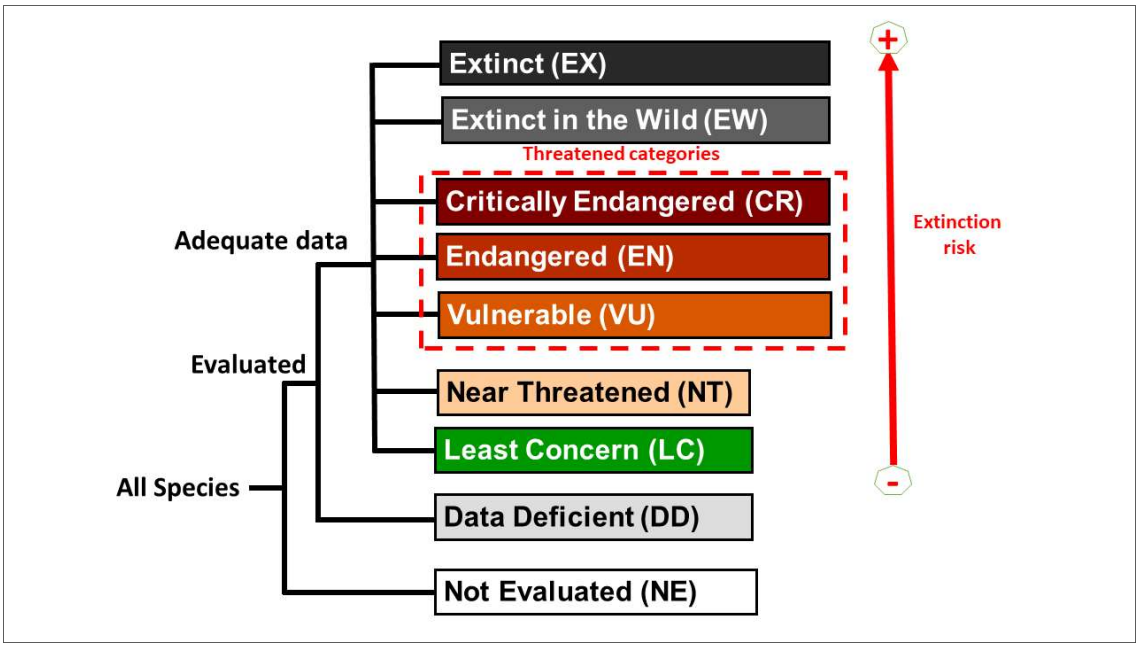

Figure 9. The Red List™ categories

(Source: IUCN, 2012)

'EX: A taxon is Extinct when there is no reasonable doubt that the last individual has died. A taxon is presumed Extinct when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
EW: A taxon is Extinct in the Wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range. A taxon is presumed Extinct in the Wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.
CR: Species that are considered to be facing an extremely high risk of extinction in the wild.
EN: Species that are considered to be facing a very high risk of extinction in the wild.
VU: Species that are considered to be facing a high risk of extinction in the wild.
NT: Species that are considered to be close to qualifying for or is likely to qualify for a threatened category in the near future.
DD: Species that has inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and/or distribution are lacking. Data Deficient is therefore not a category of threat.
LC: A taxon that is widespread and/or abundant and are not at risk of extinction at present are listed under this category.
NE: A taxon is Not Evaluated when it has not yet been evaluated against the criteria' (IUCN, 2012).

Chapter 3: Results

For the national assessment, 61 species of endemic freshwater fish were assessed. However, *Systomus 'Richmondi'* and *Channa ara* were not considered for the global assessment, as their species validity is not yet confirmed.

Of the 61 endemic species assessed, 12 point endemic species were listed as Critically Endangered (CR), 24 range-restricted species were Endangered (EN) and nine species were Vulnerable (VU). A further five species were Near Threatened (NT). Two species that did not have exact distributional data were listed as Data Deficient (DD). The remaining nine species that showed a wide distribution throughout the island were listed as Least Concern (LC).

In addition to endemic species, 36 native species were also assessed and of these, only eight species were listed as Threatened (EN: 6 and VU:2). In addition, five species were listed as Near Threatened and five species as Data Deficient. The remaining 20 species were listed as Least Concern.

A summary of the national threat status of the assessed species, classified by family, is given in Table 5, and the detailed list of assessed species with the assigned threat status of each species is presented in Table 6.

Table 5. National threat status of the assessed freshwater fish species of Sri Lanka classified by family

Abbreviations used:
CR: Critically Endangered; DD: Data Deficient; EN: Endangered; LC: Least Concern; NT: Near Threatened; VU: Vulnerable.

Family name	Total number of species	Total number of Endemic species	Threat Status					
			CR	EN	VU	NT	DD	LC
Aplocheilidae	3	2	0	2	0	0	0	1
Adrianichthyidae	2	0	0	0	0	0	2	0
Anabantidae	1	0	0	0	0	0	0	1
Anguillidae	2	0	0	0	0	2	0	0
Bagridae	4	3	0	1	0	0	0	3
Belonidae	1	0	0	0	1	0	0	0
Channidae	5	3	0	0	2	2	0	1

Family name	Total number of species	Total number of Endemic species	Threat Status					
			CR	EN	VU	NT	DD	LC
Cichlidae	2	0	0	0	0	0	0	2
Claridae	1	1	0	0	0	1	0	0
Cobitidae	2	1	0	1	0	0	0	1
Cyprinidae	47	39	7	17	5	3	2	13
Eleotridae	1	0	0	0	0	0	0	1
Gobiidae	10	2	1	4	0	0	3	2
Heteropneustidae	1	0	0	0	0	0	0	1
Mastacembelidae	2	1	1	0	0	0	0	1
Nemacheilidae	4	4	2	1	0	1	0	0
Osphronemidae	3	2	0	1	1	0	0	1
Siluridae	3	2	0	0	1	1	0	1
Synbranchidae	2	1	1	1	0	0	0	0
Syngnathidae	1	0	0	1	0	0	0	0
Total count	**97**	**61**	**12**	**29**	**10**	**10**	**7**	**29**

Figure 10. Two Critically Endangered freshwater fish endemic to Sri Lanka

(Left*: Malpulutta kretseri*; right: *Devario pathirana* (© Samantha Gunasekera))

Table 6. Threat status of all assessed freshwater fish species of Sri Lanka

Note: Geographical distribution maps for these species are presented in Annex 3. The maps for *Puntius layardi* and *Puntius tetraspilus* are not provided, as these are only known from their type localities, simply listed as Ceylon.

Abbreviations used: NTS: National Threat Status according to the 2012 Red List; EOO: Extent of Occurrence; AOO: Area of Occupancy;
CR(PE): Critically Endangered (possibly extinct); CR: Critically Endangered; DD: Data Deficient; EN: Endangered; LC: Least Concern; NT: Near Threatened; VU: Vulnerable.

There are no known Tamil names.

Family	Species Name	English Name	Sinhala Name	Species Status	2012 NTS	IUCN Sri Lanka		Number of Locations	2020 Threat Status	Criterion/ Criteria
						EOO (km^2)	AOO (km^2)			
Adrianichthyidae	*Oryzias carnaticus*	Deep-bodied ricefish	*Handi handaya*	Native	DD	309	12	2	DD	N/A
Adrianichthyidae	*Oryzias dancena*	Spotted ricefish	*Tit handaya*	Native	DD	238	8	2	DD	N/A
Anabantidae	*Anabas testudineus*	Climbing perch	*Kaavaiya*	Native	LC	50,846	432	22	LC	N/A
Anguillidae	*Anguilla bengalensis*	Long-finned eel	*Pol mal aandha*	Native	LC	36,262	212	15	NT	N/A
Anguillidae	*Anguilla bicolor*	Level-finned eel	*Kalu aandha*	Native	LC	47,358	384	20	NT	N/A
Aplocheilidae	*Aplocheilus dayi*	Day's killifish	*Uda handaya*	Endemic	EN	3,734	212	3	EN	B1ab(iii)+2ab(iii)
Aplocheilidae	*Aplocheilus werneri*	Werner's killifish	*Iri handaya*	Endemic	EN	3,826	168	4	EN	B1ab(iii)+2ab(iii)
Aplocheilidae	*Aplocheilus parvus*	Dwarf panchax	*Kalapu handeya*	Native	LC	60,409	264	22	LC	N/A
Bagridae	*Mystus ankutta*	Yellow dwarf catfish	*Kaha ankuṯṯa*	Endemic	EN	4,768	88	5	EN	B1ab(iii)+2ab(iii)
Bagridae	*Mystus nanus*	Striped dwarf catfish	*Iri ankuṯṯa*	Endemic	LC	44,642	512	21	LC	N/A
Bagridae	*Mystus zeylanicus*	Sri Lanka mystus	*Pat ankuṯṯa*	Endemic	LC	28,368	148	13	LC	N/A
Bagridae	*Mystus gulio*	Long-whiskered catfish	*Māna ankutta*	Native	LC	65,047	244	24	LC	N/A
Belonidae	*Xenentodon cancila*	Freshwater garfish	*Yonna*	Native	NT	5,964	160	8	VU	B1ab(iii)+2ab(iii)
Channidae	*Channa ara*	Giant snakehead	*Gan ara*	Endemic	EN	23,473	172	9	VU	2ab(iii)
Channidae	*Channa kelaartii*	Brown snakehead	*Paradel kanaya*	Endemic	LC	41,305	280	15	NT	N/A
Channidae	*Channa orientalis*	Smooth-breasted snakehead	*Kola kanaya*	Endemic	VU	19,864	420	9	VU	B1ab(iii)+2ab(iii)

Family	Species Name	English Name	Sinhala Name	Species Status	2012 NTS	IUCN Sri Lanka		Number of Locations	2020 Threat Status	Criterion/ Criteria
						EOO (km^2)	AOO (km^2)			
Channidae	*Channa punctata*	Spotted snakehead	*Mada kanaya*	Native	LC	41,485	204	15	NT	N/A
Channidae	*Channa striata*	Murrel	*Loola*	Native	LC	56,401	508	23	LC	N/A
Cichlidae	*Etroplus suratensis*	Green chromide	*Koraliya*	Native	LC	53,163	416	25	LC	N/A
Cichlidae	*Pseudetroplus maculatus*	Orange chromide	*Ralliya*	Native	LC	58,682	296	24	LC	N/A
Clariidae	*Clarias brachysoma*	Walking catfish	*Magura*	Endemic	NT	45,503	476	14	NT	N/A
Cobitidae	*Lepidocephalichthys jonklaasi*	Jonklaas's loach	*Pulli ahirava*	Endemic	CR	2,413	96	4	EN	B1ab(iii)+2ab(iii)
Cobitidae	*Lepidocephalichthys thermalis*	Common spiny loach	*Wairan ahirawa*	Native	LC	56,596	656	26	LC	N/A
Cyprinidae	*Amblypharyngodon grandisquammis*	Large silver carplet	*Soraya*	Endemic	EN	43,686	320	17	LC	N/A
Cyprinidae	*Dawkinsia singhala*	Filamented barb	*Dankola petiya*	Endemic	LC	55,946	896	18	LC	B2ab(ii,iii)
Cyprinidae	*Dawkinsia srilankensis*	Blotched filamented barb	*Mal Petiya*	Endemic	CR	1,737	136	5	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Devario annnataliae*	Natali’s danio	*Natali salaya*	Endemic	NE	20.1	16	1	CR	B1ab(iii)
Cyprinidae	*Devario micronema*	Kitulgala danio	*Kitulgala salaya*	Endemic	NE	602	24	3	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Devario monticola*	Agra danio	*Agrā salaya*	Endemic	NE	12.5	12	1	CR	B1ab(iii)
Cyprinidae	*Devario pathirana*	Barred danio	*Patirana salaya*	Endemic	CR	204	52	1	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Devario malabaricus*	Giant danio	*Dankola sayala*	Native	LC	34,737	852	20	LC	N/A
Cyprinidae	*Esomus thermoicos*	Flying barb	*Revul dandiya*	Native	LC	55,020	452	25	LC	N/A
Cyprinidae	*Garra ceylonensis*	Stone sucker	*Gal pandiya*	Endemic	VU	39,745	792	19	NT	B2ab(ii,iii)
Cyprinidae	*Garra phillipsi*	Phillips' garra	*Gal panduruva*	Endemic	DD	4	4	1	CR	B1ab(iii)+2ab(iii)
Cyprinidae	*Horadandia atukorali*	Hora dandia	*Hora dandiya*	Endemic	VU	17,295	248	8	VU	B1ab(iii)+2ab(iii)
Cyprinidae	*Labeo fisheri*	Mountain labeo	*Gadaya*	Endemic	CR	3,116	252	4	EN	B1ab(i,ii,iii,iv)+2ab (i,ii,iii,iv)
Cyprinidae	*Labeo heladiva*	Sri Lanka labeo	*Hiri kanaya*	Endemic	LC	53,273	428	23	LC	N/A
Cyprinidae	*Labeo lankae*	Orange-fin labeo	*Tambalaya*	Endemic	CR	1,603	36	3	EN	B1ab(iii)+2ab(iii)

Family	Species Name	English Name	Sinhala Name	Species Status	2012 NTS	IUCN Sri Lanka		Number of Locations	2020 Threat Status	Criterion/ Criteria
						EOO (km^2)	AOO (km^2)			
Cyprinidae	*Laubuka insularis*	Knuckles labuca	*Dumbara kara-ædaya*	Endemic	CR	1,688	104	3	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Laubuka lankensis*	Lanka labuca	*Lanka kara-ædaya*	Endemic	VU	32,668	180	14	NT	B2ab(ii,iii)
Cyprinidae	*Laubuka ruhuna*	Southern laubuca	*Ruhunu kara-ædaya*	Endemic	EN	944	68	4	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Laubuka varuna*	Western laubuca	*Varuna kara-ædaya*	Endemic	CR	2,074	96	4	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Pethia bandula*	Bandula barb	*Bandula pothaya*	Endemic	CR	8	8	1	CR	B1ab(iii)+2ab(iii)
Cyprinidae	*Pethia cumingii*	Cuming's barb	*Kaha-varal depulliyā*	Endemic	EN	2,539	144	3	EN	B2ab(iii)
Cyprinidae	*Pethia melanomaculata*	Tic-tac-toe barb	*Depulliya*	Endemic	VU	26,967	200	15	LC	B1a+2ab(ii,iii)
Cyprinidae	*Pethia nigrofasciata*	Black ruby barb	*Bulat hapaya*	Endemic	EN	8,001	472	9	VU	B1ab(iii,v)+2ab(iii, v)
Cyprinidae	*Pethia reval*	Red-fin two-banded carplet	*Ratu-varal depulliya*	Endemic	EN	2,552	144	4	EN	B1ab(iii,v)+2ab(iii, v)
Cyprinidae	*Puntius bimaculatus*	Redside barb	*Ipili-kadaya*	Native	LC	48,470	832	30	LC	N/A
Cyprinidae	*Puntius dorsalis*	Long-snouted barb	*Bim-tolla*	Native	LC	37,145	528	21	LC	N/A
Cyprinidae	*Puntius kamalika*	Kamalika's barb	*Mada-ipilla*	Endemic	EN	3,911	76	5	EN	B1ab(iii,v)+2ab(iii, v)
Cyprinidae	*Puntius kelumi*	Kalum's Long-snouted barb	*Ratu-varal petiya*	Endemic	EN	4,672	176	5	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Puntius layardi*	Layard's barb	*Leyādige petiya*	Endemic	DD	0	0	0	DD	N/A
Cyprinidae	*Puntius tetraspilus*	Long-snouted barb	*Dikhombu petiya*	Endemic	DD	0	0	0	DD	N/A
Cyprinidae	*Puntius thermalis*	Swamp barb	*Kota petiya*	Endemic	LC	46,564	348	20	LC	N/A
Cyprinidae	*Puntius titteya*	Cherry barb	*Le ţittaya*	Endemic	EN	5,815	372	7	VU	B1ab(iii,v)+2ab(iii, v)
Cyprinidae	*Puntius vittatus*	Silver barb	*Bandi titteya*	Native	LC	50,612	524	32	LC	N/A
Cyprinidae	*Rasbora armitagei*	Armitage's rasbora	*Rakwana dandiya*	Endemic	CR	4	4	1	CR	: B1ab(iii)+2ab(iii)
Cyprinidae	*Rasbora dandia*	Striped rasbora	*Kehel dandiya*	Native	LC	53,962	804	21	LC	N/A

Family	Species Name	English Name	Sinhala Name	Species Status	2012 NTS	IUCN Sri Lanka		Number of Locations	2020 Threat Status	Criterion/ Criteria
						EOO (km^2)	AOO (km^2)			
Cyprinidae	*Rasbora microcephalus*	Common rasbora	*Dandiya*	Native	LC	54,005	532	22	LC	N/A
Cyprinidae	*Rasbora naggsi*	Naggsi's rasbora	*Udavalava dandiya*	Endemic	CR	255	24	2	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Rasbora wilpita*	Wilpita rasbora	*Wilpita dandiya*	Endemic	EN	3,629	92	7	VU	B1ab(iii)+2ab(iii)
Cyprinidae	*Rasboroides pallidus*	Pallaides rasbora	*Halmal dandiya*	Endemic	NE	1,552	184	4	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Rasboroides vaterifloris*	Vateria flower rasbora	*Hal Mal dandiya*	Endemic	EN	1,648	108	3	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Systomus pleurotaenia*	Black-lined barb	*Hîta massa*	Endemic	EN	4,753	248	8	VU	B1ab(iii)+2ab(iii)
Cyprinidae	*Systomus asoka*	Asoka barb	*Asoka petiya*	Endemic	CR	97	44	1	CR	B1ab(iii)
Cyprinidae	*Systomus martenstyni*	Martenstyn's barb	*Dumbara petiya*	Endemic	CR	2,410	156	4	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Systomus "Richmondi"*	Redfin olive barb	*Ratu-varal mas petiya*	Endemic	NE	4,890	104	4	EN	B1ab(iii)+2ab(iii)
Cyprinidae	*Systomus spilurus*	Olive barb	*Mas petiya*	Endemic	DD	64,954	544	23	LC	B2b(ii,iii)
Cyprinidae	*Systomus timbiri*	Thimbiri barb	*Thimbiri petiya*	Endemic	DD	4	4	1	CR	B1ab(iii)+2ab(iii)
Cyprinidae	*Tor khudree*	Mahseer	*Lehella*	Native	NT	23,273	364	11	NT	N/A
Eleotridae	*Eleotris fusca*	Brown gudgeon	*Puvak badilla*	Native	LC	38,190	96	3	LC	N/A
Gobiidae	*Sicyopus jonklaasi*	Lipstick goby	*Thol-ratu veligouva*	Endemic	EN	3,544	160	5	EN	B1ab(iii)+2ab(iii)
Gobiidae	*Stiphodon martenstyni*	Martenstyn's goby	*Mārtenstynige veligouva*	Endemic	CR(PE)	4	4	1	CR	B1ab(iii)+2ab(iii)
Gobiidae	*Awaous melanocephalus*	Scribbled goby	*Bali veligouva*	Native	LC	51,718	324	13	LC	N/A
Gobiidae	*Glossogobius giuris*	Bar-eyed goby/ Tank goby	*Maha-gan veligouva*	Native	LC	41,959	388	25	LC	N/A
Gobiidae	*Oligolepis acutipennis*	Sharptail goby	*Veligouva*	Native	DD	585	8	2	DD	N/A
Gobiidae	*Redigobius balteatus*	Rhino-horn goby	*Deiri veligouva*	Native	NE	85	8	2	DD	N/A
Gobiidae	*Redigobius bikolanus*	Speckled goby	*Veligouva*	Native	NE	4	4	1	DD	N/A
Gobiidae	*Schismatogobius deraniyagalai*	Redneck goby	*Kata-rathu veligouva*	Native	EN	1,521	52	4	EN	B1ab(iii)+2ab(iii)
Gobiidae	*Sicyopterus griseus*	Stone goby	*Gal weligouwa*	Native	CR	5,379	48	4	EN	B1ab(iii)

Family	Species Name	English Name	Sinhala Name	Species Status	2012 NTS	IUCN Sri Lanka		Number of Locations	2020 Threat Status	Criterion/ Criteria
						EOO (km^2)	AOO (km^2)			
Gobiidae	*Sicyopterus lagocephalus*	Red-tailed goby	*Maha-gal weligouwa*	Native	CR	1,878	60	5	EN	B1ab(iii)
Heteropneustidae	*Heteropneustes fossilis*	Stinging catfish	*Hunga*	Native	LC	55,608	484	26	LC	N/A
Mastacembelidae	*Macrognathus pentophthalmos*	Sri Lankan spiny eel	*Bata-kola teliya*	Endemic	CR(PE)	4	4	1	CR	B1ab(iii)+2ab(iii)
Mastacembelidae	*Mastacembelus armatus*	Marbled spiny eel	*Gan teliya*	Native	LC	42,526	464	17	LC	N/A
Nemacheilidae	*Paracanthocobitis urophthalma*	Tiger loach	*Pol ahirava*	Endemic	EN	5,048	148	4	EN	B2ab(iii)
Nemacheilidae	*Schistura madhavai*	Rakwana mountain loach	*Rakwāna ahirava*	Endemic	NE	7.97	16	1	CR	B1ab(iii)
Nemacheilidae	*Schistura notostigma*	Banded mountain loach	*Puvak badilla*	Endemic	NT	14,590	588	16	NT	N/A
Nemacheilidae	*Schistura scripta*	Scriptic mountain loach	*Nakiyādeniya ahirava*	Endemic	NE	4	4	1	CR	B1ab(iii)+2ab(iii)
Osphronemidae	*Belontia signata*	Combtail	*Talkossa*	Endemic	NT	15,723	580	9	VU	B1ab(iii)+2ab(iii)
Osphronemidae	*Malpulutta kretseri*	Ornate paradise fish	*Malpuluṭṭa*	Endemic	CR	5,034	92	5	EN	B2ab(iii)
Osphronemidae	*Pseudosphromenus cupanus*	Spike-tailed paradise fish	*Pulutta*	Native	LC	32,214	196	18	LC	N/A
Siluridae	*Ompok argestes*	Wet zone butter catfish	*Valapotta*	Endemic	NE	13,881	256	7	VU	B1ab(iii)+2ab(iii)
Siluridae	*Ompok ceylonensis*	Dry zone butter catfish	*Valapotta*	Endemic	NE	37,341	260	16	LC	N/A
Siluridae	*Wallago attu*	Shark catfish	*Walaya*	Native	EN	41,150	212	14	NT	N/A
Synbranchidae	*Ophichthys desilvai*	De Silva's blind eel	*Dumburu-poṭṭa anda*	Endemic	CR	76.8	12	1	CR	B1ab(iii)
Synbranchidae	*Ophisternon bengalense*	Swamp eel	*Poṭṭa anda*	Native	CR	56	16	1	EN	B1ab(iii)+2ab(iii)
Syngnathidae	*Microphis ocellatus*	Ocellated pipefish	*Punchi ata teliya*	Native	NE	2,173	40	3	EN	B1ab(iii)

Chapter 4: Drivers that directly affect freshwater fish in Sri Lanka

In natural habitats, freshwater fish — especially those endemic to Sri Lanka — have well-defined niche segregation and ecological adaptations that have evolved over centuries. However, many anthropogenic activities — such as deforestation, gem mining, excessive use of agrochemicals, release of pollutants, large and small dams and natural hazards (for example floods, landslides, and changes in climatic weather patterns) — can alter habitat variables and thereby, change the delicate ecological balance, which, in turn, can threaten the long-term survival ability of many species of freshwater fish in Sri Lanka (Amarasinghe, et al., 2006; Pethiyagoda, 1994), especially endemic species, which demonstrate high habitat specificity.

In addition, other human-induced pressures — such as the introduction of exotic fish species, overexploitation by aquarium industry, extraction of fish for food using illegal methods (for example, poisoning and the use of explosives) — are resulting in the significant reduction in the population sizes of native fish.

Fish endemic to Sri Lanka are most abundant and are restricted to rivers and streams in the first peneplain of the wet zone and their habitats are found mostly outside the protected area network. For example, the Critically Endangered *Pethia bandula* is restricted to a single locality in a stream in Galapitamada, which is surrounded by agricultural land (Gunawardena, 1998). Likewise, the habitats of many other point endemic species — such as *Systomus asoka*, *Rasbora armitagei, Ophichthys desilvai* — lie completely outside protected areas and are, therefore, subject to many detrimental human influences (Goonatilake, 2012; De Silva et al., 2015). As a consequence, several are Threatened with extinction.

This chapter explores how some of these drivers have affected Sri Lankan freshwater fish.

Removal of forest cover

Deforestation in catchment areas, as well as removal of stream and riverbank vegetation — mainly for agricultural purposes and development projects — is common in the wet zone. In the lowland areas of the wet zone, small and medium-scale tea plantations are recognised as the major cause of deforestation (Senanayake and Moyle, 1982, de Silva et al., 2015, Goonatilake, person. observation). Such deforestation will result in significant changes in the flow regimens, especially of small streams and rivulets, which tend to have high flows during rainy days and dry out rapidly when there is no rain, because the water regulation function performed by the forest floor is no longer available, once the forest cover is removed and replaced by a different land use type (Senanayake and Moyle, 1982, de Silva et al., 2015, Goonatilake, person. observation).

In addition, deforestation and removal of streamside or riverine vegetation enhances soil erosion and increases the sediment flow into the streams and rivers, and this will result in a change of water quality. In turn, this will alter the streambed, because sediment deposition can impact the breeding and foraging ecology of many freshwater fish species (Hewawasam et al., 2003).

River diversions

River diversion projects for hydropower generation, drinking water, irrigated agriculture and flood mitigation can result in significant alteration of the flow regimen of a stream/river, which, in turn, brings about several changes in these freshwater habitats. For example, the reduction of carrying capacity; reduction in water quality; changes in water temperature; increased predation rates; reduction in the wetted perimeter; and alteration of the stream/river bed.

In addition, these changes in flow regimens can also result in the complete removal of microhabitats. These changes have resulted in the loss and/or displacement of several endemic and Threatened freshwater fish species. For example, the breeding habitat of *Systomus asoka* has been affected by mini-hydropower development (Perera, 2005). The habitats of *Labeo fisheri, Systomus martenstyni, Dawkinsia srilankensis, and Laubuca insularis* have become fragmented because of the construction of large dams such as Pollgolla, Victoria, Randenigala, Rantembe, Moragahakanda, and Kalu Ganga (this assessment). Populations of *Macrognathus aral* and *Labeo lankae*, which were once considered common and widely distributed (Fernando, 1980), have declined drastically within a decade, and mysteriously disappeared from many of their original localities (Pethiyagoda, 1994).

Overexploitation

Destructive fishing techniques — such as the use of *Derris scandens* (a plant that is toxic to fish), dynamite and other chemicals (for example, anti-lice compounds) by local communities — leads to large-scale mortalities of freshwater fish (this assessment, Goonatilake, 2012). A recent study along the Mahaweli river basin has revealed that populations of *Labeo fisheri, Systomus martenstyni,* and *Tor kuhdree* are Threatened mainly because of such illegal fishing activities (IUCN Sri Lanka, 2019).

In the past, labourers employed in the tea plantations used to catch *Garra ceylonensis* for food (Jayaratne and Surasinghe, 2010).

In addition, several endemic species are in high demand in the aquarium trade. Even though wild capturing is prohibited by law, overexploitation of endemic fish species from the wild for the ornamental fish trade still continues and is, therefore, considered a major cause for the decline in their populations and in some instances, local extinctions (Goonatilake, 2012).

Introduction of exotic species

Many exotic plants and animals have been introduced to natural ecosystems, intentionally or accidentally. Some of these have become invasive alien species, affecting native species directly or indirectly. Invasive alien plant species such as *Annona glabra, Eichornia crassipes,* and *Salvinia molesta* can bring about rapid habitat changes that make most marsh habitats unsuitable for freshwater fish (Goonatilake, 2012). *Annona glabra* is spreading rapidly in coastal marshes in the wet zone and this spread results in the conversion of these marsh habitats to woodlands (Bambaradeniya et al., 2002).

Eichornia crassipes and *Salvinia molesta* create thick floating mats on the surface of the water that can result in changes in important ecological processes such as light and oxygen penetration (Howard & Harley, 1997). Freshwater fish diversity of coastal wetlands — such as the Bellanwila-Attidiya Sanctuary and Muthurajawela Sanctuary — have declined drastically during the last few decades as a consequence of the rapid spread of invasive alien plants (Goonatilake, 2012).

More than 30 species of exotic fish have been introduced, both intentionally and accidentally to freshwater habitats of Sri Lanka (de Silva et al., 2015). Many of these species have been introduced to boost inland fisheries. Other species — such as *Pterygoplichthys disjunctivus, Pterygoplichthys pardalis, Chitala ornata and Clarias batrachus* — have been introduced accidentally by the aquarium industry and have become invasive in many natural and human-made habitats (De Silva et al., 2015). These species can directly impact freshwater fish, either by competing with native species for resources (Pethiyagoda, 1999), or directly feeding on native species. For example, predatory fish species such as *Chitala ornata and Clarias batrachus* have been shown to be directly responsible for the reduction of native fish populations in lowland wet zone marshes (Gunawardane, 2002).

Cichlids belonging to genus *Oreochromis* were introduced originally in the 1950s to dry zone tanks and ponds to facilitate inland fisheries (Sugunan, 1997). These cichlids have also successfully established themselves in wet zone stream habitats (De Silva et al., 2015). Because they are prolific breeders and are resilient to a broad range of ecological conditions, these cichlids can pose a serious threat to native species by competing for space and food (De Silva et al., 2015). In addition to these cichlid species, several cyprinid species belonging to genera such as *Labeo, Carassius, Ctenopharyngodon, Cyprinus and Trichopodus* have been introduced as food species. These species can also outcompete native and endemic fish species (Pethiyagoda, 1999, Marambe et al., 2011).

Gem mining

Many rivers and minor streams are affected directly by gem mining — especially in the foothills of the wet zone area. Gem mining results in soil erosion and therefore, tends to increase siltation rate of streams and rivers, causing alteration of water quality, as well as changes in the streambed because of sediment deposition (Goonatilake, 2012, Priyanath, 1999).

Urbanisation

Most urban centres (major and minor towns) are located on the banks of wet zone rivers. The expansion of urban areas leads to the large-scale release of waste-water and other pollutants into rivers and this directly impacts freshwater fish species (Surasinghe et al., 2020). Urbanisation has also led to the reclamation of lowland marshes and swamps, especially in the Western Province and this has led to local extinctions or the drastic reduction of the populations of two species of blind eels (*Ophichthys desilvai* and *Ophisternon bengalense*) (Goonatilake 2000; Fernando & Priyadarshana, 1997). These species were once commonly and widely distributed in lowland marshes in the western part of Sri Lanka (Deraniyagala, 1952).

The release of pollutants

The water quality of many suburban water bodies has undergone drastic changes because of the accumulation of toxic compounds discharged by industries (Goonatilake 2012), or wastewater discharged from households. In addition, many solid waste disposal sites — such as Karadiyana and Kerawalapitiya — are located near freshwater habitats, Bolgoda Environmental Protection Area and Muthurajawela Sanctuary respectively. This results in the flow of leachate, containing many pollutants, such as heavy metals and polycyclic aromatic hydrocarbons (Chandrasiri et al., 2019; Doole and Subramanium, 2016).

Most endemic freshwater species are restricted to major rivers — such as Kelani, Kalu, Gin and Nilwala Rivers — which flow through the wet zone. The catchments of these rivers mostly comprise agricultural land use — such as tea in the upper and middle catchments; tea or rubber in the lower catchments; and paddy in the flood plains. These cultivators use excessive quantities of pesticides and artificial fertilisers and, as a consequence, large quantities of these agrochemicals are washed easily into streams/rivers through surface runoff, because this region experiences heavy, continuous rainfall for a long period of the year (Surasinghe et al., 2020). Such inorganic nutrients are transported downstream and cause eutrophication when the water is relatively stagnant. This directly affects species survival. In addition, many of these pesticides and fertilisers contain heavy metals that tend to bio-accumulate in freshwater food chains.

Climate change

Climate change can also have a significant influence on the survival of freshwater fish species. It can affect several environmental variables of freshwater ecosystems — such as water yield (high variability in rainfall patterns can cause increased flows or extremely low flows); salinity (salinity intrusion driven by sea level changes can change the salinity regimen of coastal streams); sediment load (increased incidence of natural hazards — such as landslides associated with climate change — can increase the sediment load in streams and rivers). For example, a long-term drought can directly affect endemic species — such as *Pethia bandula, Schistura scripta, Rasbora armitagei, Puntius titteya* and *Malpulutta kretseri* — which inhabit small, slow-flowing streams in the upper catchment areas. If these habitats dry during prolonged droughts, point endemics can be eradicated completely. In other examples of

endemic species, a critical sub-population may be wiped out, bringing the species towards the brink of extinction.

In contrast, regular flooding in the lower catchment of the wet zone river basins will affect several freshwater species — such as *Rasboroides pallidus, Rasboroides vaterifloris*, and *Puntius titteya* — which predominantly inhabit clear, slow-flowing streams in the lower catchments of these rivers. For these species, regular flooding can result in the change of habitat variables such as water level, substrate, vegetation and water quality.

Changes in salinity regimens in the lower catchments of the rivers, as a consequence of rising sea levels, can also affect endemic species — such as *Aplocheilus dayi*, and *Horadandia atukorali* — that inhabit marsh habitats located in the flood plains of some rivers.

Figure 11. The threats to the freshwater fish fauna of Sri Lanka

Top left: Riverbank encroachment by hotels; top right: River bed disturbance as a consequence of development projects; middle left: Habitat fragmentation as a consequence of large dams; middle right: Habitat fragmentation as a consequence of mini-hydro weirs; bottom left: River bed disturbance as a consequence of road building; bottom right: Use of traditional fish poisoning. (© IUCN Sri Lanka /Sampath de A Goonatilake)

Chapter 5: Current conservation measures to protect freshwater fish and recommendations for the future

Legal protection provided currently to the freshwater fish fauna of Sri Lanka

Of the 97 species of freshwater fish species in Sri Lanka, 17 species have been protected by law under the Fauna and Flora Protection Ordinance (FFPO) No.22 of 2009, Schedule VI (Table 7). In addition, the export of 13 species is prohibited under the Fisheries and Aquatic Resources Act (FARA), No 2 of 1996 (Table 8), and the export of another 13 species is restricted under the same act (Table 9).

Approximately 28% of the land area in Sri Lanka has been declared as protected areas and managed by either the Department of Wildlife Conservation or the Forest department. However, most threatened, endemic and range-restricted freshwater fish are found in habitats located outside the Protected Area Network. These habitats are subject to high human pressure and as a result the extent and the quality of these habitats are declining rapidly, reducing the carrying capacity of these habitats for freshwater fish. This has resulted in number of local extinctions and if this trend continues, it may lead to extinction of species as well. Therefore, urgent action is needed to protect these habitats; especially their catchment areas that will determine water yield, as well as water quality (Goonatilake, 2012).

Table 7. List of freshwater Fish that are protected under the Fauna and Flora Protection Ordinance No.22 of 2009 SCHEDULE VI

(No Tamil names are known.)

No	Scientific Name	English Name	Sinhala name
Family: Cyprinidae			
1	*Labeo porcellus*[4]	Orange-fin labeo	No name known
2	*Labeo fisheri*	Mountain labeo/ Green labeo	*Gadeya*
3	*Puntius asoka* [5]	Asoka barb	*Asoka pethiya*
4	*Puntius martenstyni*[6]	Martenstyn's barb	*Martenstyn pethiya*

[4] Current valid species name *Labeo lankae*
[5] Current valid genus name *Systomus*
[6] Current valid genus name *Systomus*

No	Scientific Name	English Name	Sinhala name
5	*Puntius srilankensis* [7]	Blotched filamented barb	*Pethiya*
6	*Rasbora wilpita*	Wilpita rasbora	*Wilpita rasbora*
7	*Danio pathirana (Devario pathirana)*[8]	Barred danio	*Pathirana salaya*
8	*Puntius handula*[9]	Bandula barb	*Bandula pethiya*
Family: Cobitidae			
9	*Lepidocephalichthys jonklaasi*	Jonklaas' loach	*Jonklaas Ehirava*
Family: Channidae			
10	*Channa orientalis*	Smooth-breasted snakehead	*Kola Kanaya*
Family: Gobiidae			
11	*Schismatogobius deraniyagalai*	Redneck goby	No name known
12	*Sicyopterus halei* [10]	Red-tailed goby	No name known
13	*Sicyopus jonklaasi*	Lipstick goby	No name known
14	*Stiphodon martenstyni*	Martenstyn's goby	*Martenstynige weligouwa*
Family: Mastacembelidae			
15	*Macrognathus aral* [11]	Lesser spiny eel	*Bata kola theliya*
Family: Synbranchidae			
16	*Ophisternon bengalense*	Bengal eel/Swamp eel	*Potta aandha*
17	*Ophistermon desilvai*[12]	de Silva's blind eel	*Potta aandha*

[7] Current valid species name is *Dawkinsia srilankensis*
[8] Current valid species name is *Devario pathirana*
[9] Current valid species name is *Pethia bandula*
[10] Current valid species name is *Sicyopterus lagocephalus*
[11] Current valid species name is *Macrognathus pentophthalmos*
[12] Current valid species name is *Ophichthys desilvai*

Figure 12. Selected freshwater fish species listed in the FFPO

(1st row left: Orange-fin labeo (*Labeo lankae*) (© IUCN/Naalin Perera); right: Mountain labeo (*Labeo fisheri*) (© IUCN/ Sampath de A. Goonatilake); 2nd row left: Martenstyn's barb (*Systomus martenstyni*) (© IUCN/ Sampath de A. Goonatilake); right: Asoka barb (*Systomus asoka*) (© Galle Conservation Society); 3rd row left: Blotched filamented barb (*Dawkinsia srilankensis*) (© IUCN/ Sampath de A. Goonatilake); right: Bandula barb (*Puntius bandula*) (© IUCN/ Sampath de A. Goonatilake); 4th row left: Smooth-breasted snakehead (*Channa orientalis*) (© IUCN/Sampath de A. Goonatilake); right: de Silva's blind eel (*Ophichthys desilvai*) (© Nadika Hapuarachchi)

Table 8. Sri Lankan freshwater fish species for which export is prohibited under the Fisheries and Aquatic Resources Act

(No Tamil names are known.)

	Freshwater fish species for which export is prohibited		
No	**Scientific name**	**English name**	**Sinhala name**
1	*Labeo fisheri*	Mountain labeo	*Gadeya*
2	*Labeo porcellus* [13]	Orange-fin labeo	*Hiri Kanaya*
3	*Puntius asoka*[14]	Asoka barb	*Ashoka Pethiya*
4	*Puntius martenstyni*[15]	Martenstyn's barb	*Dunbara Pethiya*
5	*Puntius srilankensis*[16]	Blotched filamented barb	*Dankudu Pethiya*
6	*Puntius bandula*[17]	Bandula barb	*Bandula Pethiya*
7	*Rasbora wilpita*	Wilpita rasbora	*Wilpita dandiya*
8	*Malpulutta kretseri*	Ornate paradisefish	*Malpulutta*
9	*Schismatogobius deraniyagalai*	Redneck goby	*Kata-rathu Veligouva*
10	*Sicyopterus halei*[18]	Red-tail goby	*Maha-gal weligouwa*
11	*Sicyopterus jonklaasi*	Lipstick goby	*Thol-ratu veligouva*
12	*Channa orientalis*	Smooth-breasted snakehead	*Kola Kanaya*
13	*Lepidocephalichthys jonklaasi*	Jonklaas' loach	*Jonklaas Ehirava*

Table 9. Sri Lankan freshwater fish species for which export is restricted under the Fisheries and Aquatic Resources Act

(No Tamil names are known.)

Freshwater fish species for which export is restricted			
No	**Scientific name**	**English name**	**Sinhala name**
1	*Danio pathirana*[19]	Barred danio	*Patirana salaya*
2	*Puntius cumingii*[20]	Cuming's barb	*Pothaya*
3	*Puntius nigrofasciata*[21]	Black ruby barb	*Bulath Hapaya*
4	*Puntius titteya*	Cherry barb	*Lay Tittaya*
5	*Rasbora vaterifloris*	Golden rasbora	*Halmal Dandiya*
6	*Clarias brachysoma*	Walking catfish	*Magura*
7	*Belontia signata*	Combtail	*Thalkossa*
8	*Macrognathus aral* [22]	Lesser spiny eel	*Bata Kola Theliya*

[13] Current valid species name is *Labeo lankae*
[14] Current valid genus name is *Systomus*
[15] Current valid genus name is *Systomus*
[16] Current valid genus name is *Dawkinsia*
[17] Current valid species name is *Pethia bandula*
[18] Current valid species name is *Sicyopterus lagocephalus*
[19] Current valid genus name is *Devario*
[20] Current valid genus name is *Pethia*
[21] Current valid species name is *Pethia nigrofasciata*
[22] Current valid species name is *Macrognathus pentophthalmos*

Research gaps, research needs and conservation actions needed

Conducting island-wide systematic surveys of the freshwater fish fauna of Sri Lanka

Recent field surveys, in both the dry and wet zone, as well as phylogenetic studies have demonstrated that there still are new species (for example, *Systomus 'Richmondi'*) to be described (Pethiyagoda et al., 2012). Meanwhile, taxonomic clearances of several already described species (*Systomus timbiri*, *Puntius tetraspilus, Puntius layardi* and *Channa ara*) are also needed urgently. The above will help to identify natural distributions so that valid conservation plans may be prepared.

Therefore, island-wide systematic surveys should be carried out to document the distribution and ecological variables needed for species of freshwater fish in Sri Lanka. The baseline data generated from such surveys can be used to make accurate assessments of the threat status of each species, as well as to formulate species conservation plans. Lack of financial support is the main obstacle for such systematic island-wide surveys. A model already exists in neighbouring India, where they have a dedicated zoological survey to gather baseline data, not only for fish but for other taxonomic groups as well. The National Science Foundation of Sri Lanka had a similar programme in the 1980s. This needs to be revived.

The river basins of the wet zone river have been the focus of most studies of freshwater fish, compared to those of the dry zone (Figure 13). Among the dry zone river basins, the rivers (such as Kirindi Oya, Manik Ganga, Kumbukkan Oya, Heda Oya, Gal Oya, and Maduru Oya) flowing in the southern and eastern coast are less studied (Figure 13). Several unidentified cyprinids have been reported from these river basins (Goonatilake, person. observation). Therefore, there is a need to conduct systematic fish surveys in the dry zone river basins as well.

Conducting population assessments for — at least — Critically Endangered species

During the current global threatened status evaluation process, it was revealed that some of the Threatened species — for example, *Gara ceylonensis* — which has a wide distribution, cannot be listed under any of the IUCN threat categories. However, the opinion of fish experts, who participated in this assessment, was that there are already are several drivers that reduce population size. Therefore, there is a critical need to conduct population assessments for at least identified critical species, as this would facilitate the use more objective criteria (A, C, D, E) for assessments, rather than relying completely on geographic range (B), which is the basis of all assessments done to date.

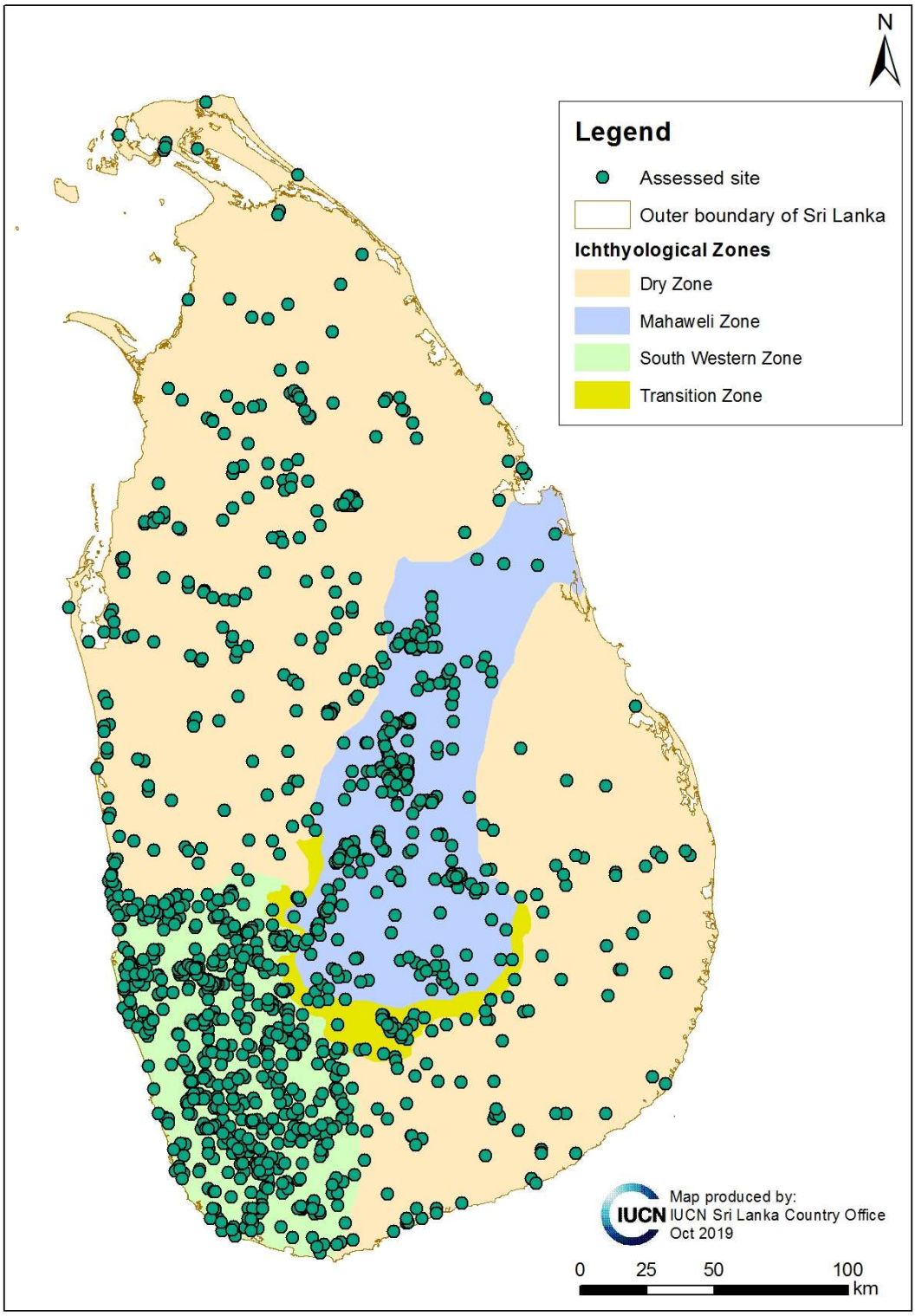

Figure 13. Distribution of studies (161) of freshwater fish in Sri Lanka

Developing conservation action plans for Threatened species endemic to Sri Lanka

Seventy-four percent (43 species) of Sri Lanka's rich endemic freshwater fish are listed as Threatened, as a consequence of several different drivers of loss (Chapter 4, Table 5). Of these, 12 are Critically Endangered.

It is, therefore, important to develop conservation action plans for each of these Critically Endangered, endemic freshwater fish species. Thus, the following actions are recommended to reduce the risk of extinction of these Sri Lankan freshwater fish species.

1. Site-directed action planning (SDAP)

This type of plan is needed for species inhabiting a defined area and subject to multiple, localised threats linked to the specific area. SDAP can support the conservation of species such as *Ophichthys desilvai, Schistura madhavai, Schistura scripta*, *Garra phillipsi* and *Devario monticola* (Figure 14), which are affected directly by disturbance, pollution or other impacts from specific development projects.

2. Individual species recovery planning (ISRP)

ISRP is an ideal approach for species whose conservation needs do not overlap significantly with those of other species. Such action plans should first identify priority species (for example, Critically Endangered species such as *Devario annnataliae, Pethia bandula,* and *Systomus asoka*), as well as critical habitats (for example habitats of point endemic species that lie outside the Protected Area Network) of freshwater fish that require immediate conservation action.

In addition, species-oriented conservation programmes and habitat-oriented conservation programmes should be developed for at least Critically Endangered species. Funding organisations should consider these species as priority species, when consideration of funding of proposals. This should be followed by preparation and implementation of species specific recovery plans.

3. Ex-situ conservation feasibility assessment or action planning (ECFA)

ECFA should be considered for species where *in-situ* conservation alone is unlikely to prevent extinction. *Ex-situ* breeding programmes should also be established with the aim of boosting dwindling wild populations.

The next step after *ex-situ* breeding — translocation or reintroduction programmes — should be planned with the utmost care to prevent hybridisation and the introduction of disease to the existing wild populations.

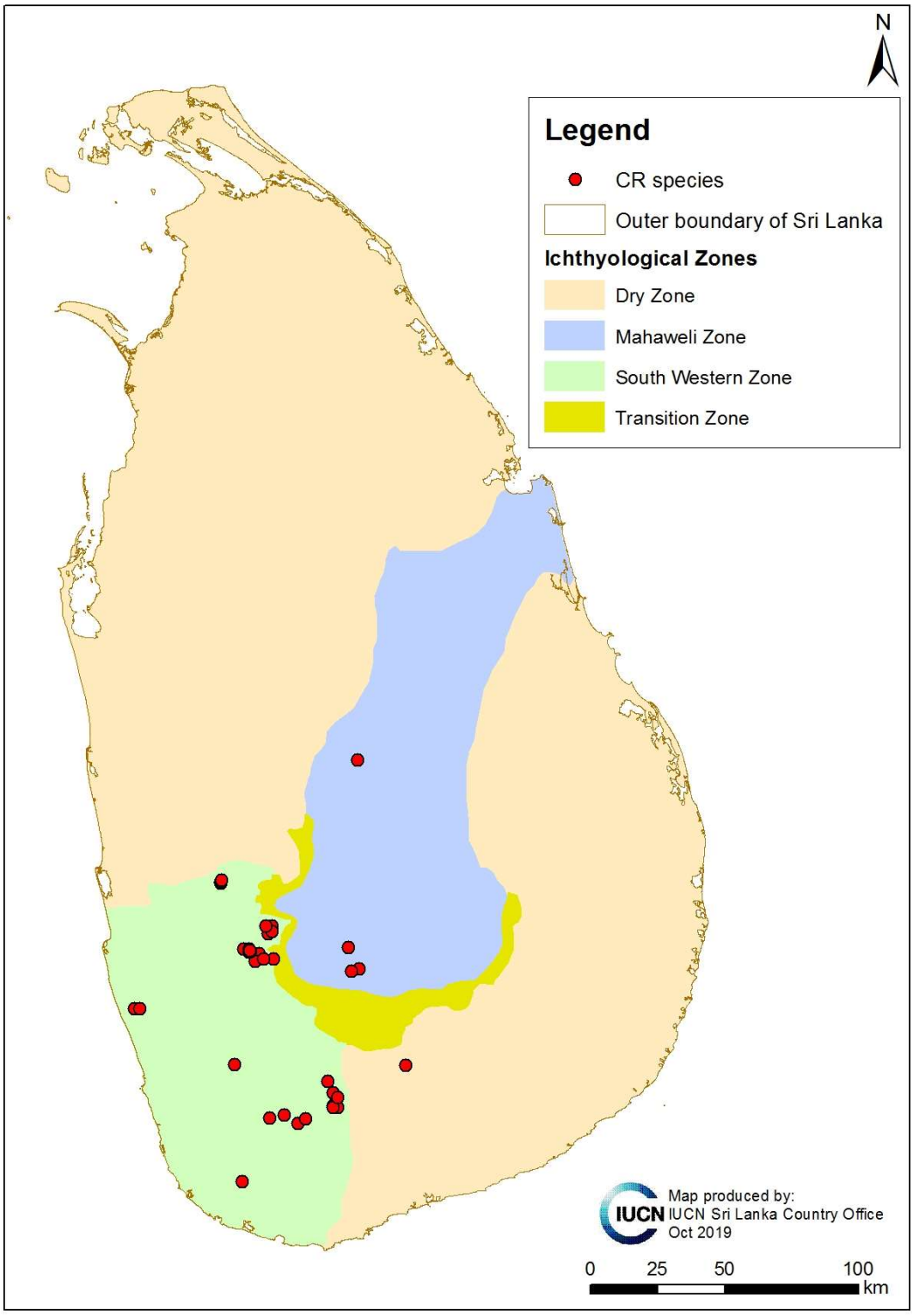

Figure 14. Distribution of Critically Endangered freshwater fish species

So far, several translocations have been attempted in Sri Lanka (for example, *Pethia bandula* and *Devario pathirana*) with the aim of conserving these Threatened species. Some of these translocation programmes have been highly successful, while others have failed to achieve the desired objectives. Therefore, these programmes should be reviewed carefully to document the lessons learned before attempting further translocations. *Ex-situ* breeding programmes can be established with the expertise available in the ornamental fish industry, especially to develop breeding techniques for Threatened species that are difficult to breed in captivity. Special attention must be given for point endemic species such as *Devario annnataliae, Pethia bandula, Systomus asoka, Rasbora armitagei, Schistura scripta* and *Macrognathus pentophthalmos*.

Engaging the ornamental fish experts will require prior establishment and implementation of rigorous legal controls to ensure that populations are bred *ex-situ.*

4. Habitat-directed action planning (HDAP)

HDAP is ideal for species which are dependent on the same habitat type and are subject to a common threat or several threats. Therefore, any type of development affecting these habitats must be assessed clearly before approval is granted. Meanwhile, a mechanism must be established to monitor the recommendations provided by the environmental impact assessments of such projects.

Also, a national programme to protect catchments, as well as to enforce river and stream reservations, are other identified needs, which will benefit not only freshwater fish but also some terrestrial species. HDAP will support conservation of most of the Endangered and Vulnerable species.

5. Threat-directed action planning (TDAP)

This approach will target a group of species affected by a common threat which is not dependent on a site or sites but is associated with the process of threat. Threats such as pesticides, invasive alien species and gem mining affect many of Sri Lanka's freshwater fish.

All pesticides approved for release in Sri Lanka should be assessed specifically on their impact on non-target organisms and generally, in relation to their damage to the environment. The labelling of such products should include information on environmental safeguards.

All future intentional release of exotic fishes should be preceded by a risk assessment involving specific safeguards against invasiveness, and at the same time a ban should be imposed on importation of exotic fish species that are known to be invasive in other countries. This recommendation parallels the National Invasive Alien Species (IAS) Policy of Sri Lanka (2016) — approved by the cabinet of ministers — in which 'an effective risk assessment protocol is in place for prevention of entry of IAS' (MMDE, 2016b).

The implementation of such plans requires large investments and therefore, the possibility of private sector involvement in financing of such recovery plans should also be pursued.

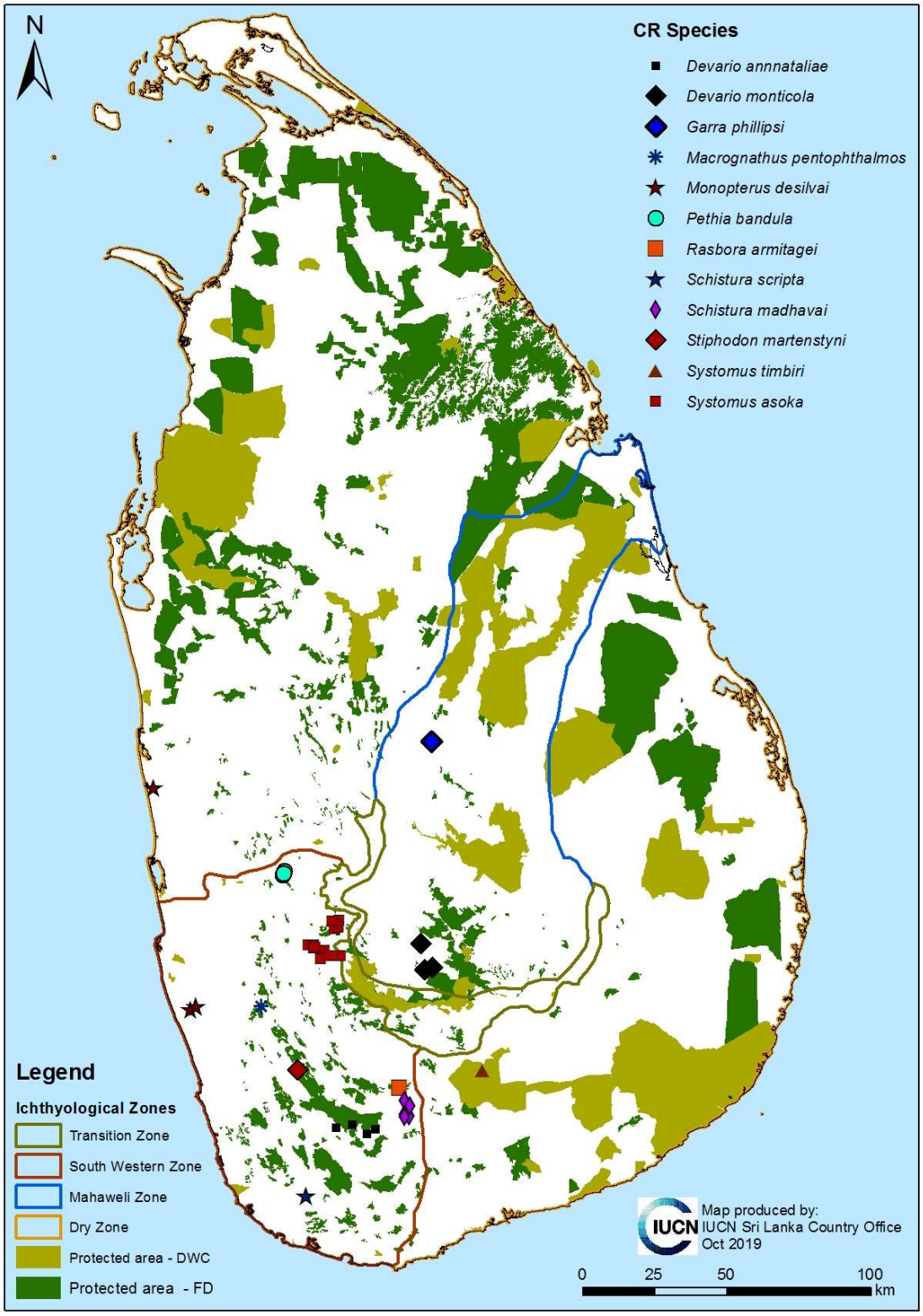

Figure 15. Areas where habitat- and threat-directed action planning are needed

6. *Creating awareness among local communities*

As most of freshwater fish species occur in human-dominated landscapes, a conservation model involving local communities in conservation of freshwater fish must be developed, at least for the restricted-range species.

Such a programme has been implemented successfully for *Pethia bundula* and has resulted in the curtailing of illegal collection of the fish, as a consequent recovery of the population.

Box 3. The Critically Endangered, point-endemic Bandula Barb, as an example of a success story for conservation

The Bandula Barb is a point-endemic species, which is found naturally only in the 2.5 km stretch of stream that flows through the Galapitamada area of the Kegalle District in Sri Lanka. It is a Critically Endangered fish found entirely outside the protected area network of Sri Lanka.

The stream, in which this fish lives, flows through human settlements, as well as paddy fields, rubber plantations and home gardens.

When this species was first identified in 1991, the population was estimated to be around 2,000 individuals (Pethiyagoda 1991). However, within a decade, this population decreased at an alarming rate to 200-300 individuals. The reasons attributed to this decline were illegal collection for the ornamental fish trade, extensive use of agrochemicals in paddy fields and changes in land use (Wickramasinghe 2008).

The Ministry of Environment proposed a resolution called 'Conservation of Bandula Barb in Sri Lanka — resolution 3.117' — as a special conservation effort, passed at the 2004 IUCN World Conservation Congress held in Bangkok. In response to the above resolution, a Conservation Action Plan for the Bandula Barb was developed in 2008 by the Ministry of Environment and some of the initial actions presented therein were implemented by the Ministry itself, including the establishment of a second population of Bandula Barb inside a protected area managed by the Forest Department.

In 2013, the Sri Lanka Office of IUCN initiated a project to implement the Bandula Barb Conservation Action Plan and employed a variety of approaches, including creation of awareness, engagement of youth, deployment of nature-based solutions and participatory community decision-making in conservation activities. IUCN worked with key local stakeholders, including the Hapugoda, Rubbidigala and Alpitiya community-based organizations, C-CAMP-P (a traditional and organic farming organization in Warakapola), the Forest Department and the Department of Wildlife Conservation, to implement this project.

Through the project, the second population of the Bandula Barb was augmented by the introduction of a few more individuals, with permission from the Department of Wildlife Conservation.

A decade after the passing of the resolution 'Conservation of Bandula Barb in Sri Lanka' at the IUCN World Conservation Congress, the Bandula Barb population in 2015 was estimated to be 1,500 individuals.

(Extracted directly, and summarised from MMDE, 2016a)

Conclusions

In this assessment, 74% — nearly three quarters — of the freshwater fish endemic to Sri Lanka were found to be threatened with extinction. Most of Sri Lanka's freshwater fish are found outside protected areas and are thus affected directly by all the major drivers of biodiversity loss (habitat loss and degradation, overexploitation, pollution, invasive alien species and climate change).

This calls for exigent and planned conservation actions, at least for those species not only endemic to Sri Lanka, but also threatened by human actions.

Figure 16. Two endemic species which need conservation attention: (top: the Endangered *Aplocheilus dayi*; bottom: the Vulnerable *Garra ceylonensis*

(The former is found in the Kelani basin, subject to a range of anthropogenic threats; the latter, needing populations assessments to clarify its threat status. © Samantha Gunasekera)

Citations

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Annex 1: Sample data sheet for collecting distribution data

Binomial[23]	Presence[24]	Origin[25]	Seasonal[26]	Compiler	Year	Citation	Dec_Lat[27]	Dec_Long[28]	Spatial Ref	Basis OfRec	Event_Year	Source[29]	Island
Pethia bandula	1	1	1	Sampath de A Goonatilake	2019	IUCN	7.1500000	80.2500000	WGS84	Human Observation	1989	API0036	Sri Lanka
Pethia bandula	1	1	1	Sampath de A Goonatilake	2019	IUCN	7.1400000	80.2363000	WGS84	Human Observation	2007	API0117	Sri Lanka
Pethia bandula	1	1	1	Sampath de A Goonatilake	2019	IUCN	7.1400000	80.2363000	WGS84	Human Observation	2016	CHE00185	Sri Lanka
Pethia bandula	1	1	1	Sampath de A Goonatilake	2019	IUCN	7.1333000	80.2333000	WGS84	Human Observation	2008	CHE00231	Sri Lanka
Pethia bandula	1	1	1	Sampath de A Goonatilake	2019	IUCN	7.1666670	80.2500000	WGS84	Human Observation	2010	CHE0113	Sri Lanka
Pethia bandula	1	1	1	Sampath de A Goonatilake	2019	IUCN	7.1666670	80.2500000	WGS84	Human Observation	2011	CHE00187	Sri Lanka
Pethia bandula	1	1	1	Malka Fernando	2019	IUCN	7.1400000	80.2363000	WGS84	Human Observation	2016	CHE00185	Sri Lanka
Pethia bandula	1	1	1	Malka Fernando	2019	IUCN	7.1666670	80.2500000	WGS84	Human Observation	2011	CHE00187	Sri Lanka

[23] Scientific name (must match the corresponding field in SIS)
[24] Is/was the species in this area
[25] Why/how the species is in this area
[26] What is the seasonal presence of the species in the area
[27] North Latitude
[28] East Longitude
[29] Reference Number

Annex 2: Sample data sheet for collecting ecological and population data

Red List Assessment Questionnaire

(Please complete one questionnaire per taxon, extra sheets may be used)

1. SCIENTIFIC AND COMMON NAMES

1a. Scientific name:

***Labeo fisheri* Jordan & Starks, 1917**

1b. Synonym/s (if there has been a taxonomic change in the last 5 years or if widely used):

Labeo (Morulius) gadeya Deraniyagala, 1929

1c. English Common Name (if known):

Green Labeo; Mountain labeo

1d. Other Common Names (if known and state language):

Gadeya; Kalu gadeya

2. HIGHER TAXONOMY

2a. Kingdom	**2b. Phylum**	**2c. Class**
Animalia	Chordata	Actinopterygii

2c. Order	**2b. Family**
Cypriniformes	Cyprinidae

3. COUNTRY, SUBCOUNTRY AND MARINE AREA OCCURRENCES

3a. Countries			**3b. Sub country units** (if known)		
Country name	**Presence**	**Origin**	**Sub country unit name**	**Presence**	**Origin**
Sri Lanka	Extant	Native	Central Province (Mid and upper Mahaweli basin)	Extant	Native

3c. Marine Areas		
FAO area name or LME	**Presence**	**Origin**
N/A	**N/A**	**N/A**

4. TEXT DOCUMENTATION

4a. Taxonomic Notes

Sudasinghe et al., (2018) reviewed the genus *Labeo* and it has been confirmed both morphologically and phylogenetically that *Labeo fisheri* as a true species.
Anusha et al., (2017) recorded a specimen of *L. fisheri* from the upstream regions of the Tamiraparani River in the southern Peninsular India. However, the meristic counts reported for this specimen differ from those of Sri Lankan *L. fisheri* as follows: 42 (vs. 37–39) lateral-line scales; and 21 (vs. 17–20) circumpeduncular scales. Therefore, the record of *L. fisheri* from India by Anusha et al. (2017) can be considers as a misidentification (Sudasinghe et al., 2018).

4b. Distribution

Endemic to Sri Lanka. *Labeo fisheri*, was considered to be restricted to the upper basin of the Mahaweli River, made up of streams draining through the Knuckles mountain range and the central hills in the vicinity of Kandy, Gampola and Nawalapitiya in the Central province (Deraniyagala, 1952; Pethiyagoda, 1991). Recent studies have recorded *L. fisheri* from the Mid and lower basins of the Mahaweli River as far downstream as Angammedilla near Polonnaruwa (NARA, 2017; Sudasinghe et al., 2018).

4c. Population

It appears that there are several localized populations of *L. fisheri* throughout its range in the Mahaweli River basin. However, large numbers were not recorded in any of these localities (NARA, 2017; Sudasinghe et al., 2018). There are ten large dams constructed along the upper and middle basins of the Mahaweli River, which may have affected the distribution of *L. fisheri*. For example, fishermen in the Polgolla-Digana and Hulu ganga area reported that they rarely catch *L. fisheri* but they used to catch them compared to their catchability 20–30 years ago. Similarly, in Lewella near Kandy, downstream of the Polgolla dam, *L. fisheri* is rarely caught today (IUCN, 2019; NARA, 2017; Sudasinghe 2018), even though it has been reported that the fish could be easily collected in this area in the past (Jordan & Starks 1917; Deraniyagala 1952).

During the NARA survey carried out in 2017, population density of *Labeo fisheri* has been estimated at two locations, namely Moragolla area and Heen Ganga in the upper basin of the Mahaweli river where 158±14 individuals over a 3-km (or 0.31 km^2) stretch and 272±3 individuals over a 1.5 km (0.14 km^2) stretch have been reported respectively. Therefore, the estimated population size per 1 km^2 ranges between 510 and 1942 individuals. Hence, the total estimated population, based on the currently known area of occupancy (35.15 km^2) for this species ranges between 17915 and 68291 individuals.

Current population trE (tick (✓) one box only)	Increasing	
	Decreasing	✓
	Stable	
	Unknown	

4d. Habitats and Ecology

The lowest elevation from which *L. fisheri* is recorded is about 80m MSL at Angammedilla, Polonnaruwa, while the highest elevation is about 750 m MSL, at Inguru oya, above Nawalapitya. The species was recorded from both clear-water streams draining the Knuckles hills, as well as much more turbid waters in the central hills (IUCN, 2019; NARA, 2017; Sudasinghe, et al., 2018). At the Heen Ganga [= river] at Sulugune, adults of *L. fisheri* were observed in > 1m deep rapids, among large rocks and boulders, whereas juveniles and semi-adults were common in shallower regions with a moderate, non-turbulent flow (Sudasinghe, et al., 2018). In Moragolla area adults were recorded from dark crevices in deep rocky pools >16m deep during daytime and it is assumed that the fish moves into shallow areas during dusk in search of food. It was also recorded that *L. fisheri* has a well-

developed swim bladder comprising of two chambers. This obviously bears evidence for its ability for quick diving, surfacing and occupying deep pools (NARA, 2017).

Shirantha (2012) suggests that there is an upstream movement for spawning (like other cyprinids, and that eggs would drift downstream, but this has not been properly documented). Several gravid females (individuals up to 45-60 cm length) were recorded in the Moragolla proposed hydropower project area in March 2017 by the NARA survey team (2017).

De Silva (1989) demonstrated that the fish is herbivorous, mainly feeding on diatoms and algae. Sudasinghe, et al., (2018), has also observed *L. fisheri* feeding on algae on submerged rocks during daytime. However, more recent data has shown that juveniles (up to 8 cm long) are prevalent in shallow (1 to 2 m depth) areas where the rocky substratum supports aquatic plant *Farmeria metzgerioides* (family: Podostemaceae) and patches of sand with river debris (Kumara and Samarawickrama, 2018; NARA, 2017). Most recent study on the food habits of *L. fisheri* was done by Thilakaratne et al., (2018) using specimens collected from the Victoria Reservoir, where they report that the most dominant food types found are algae species such as *Aulacaseira* sp. (29%), *Staurastum* sp. (8%), *Chracoccus* sp. (9%) and diatoms (14%).

It has also been observed that the fish prefers to rest under crevices for extended periods (5–10 minutes) suggesting that individual *L. fisheri* may inhabit limited stretches of the river, apparently maintaining territories. Adult *L. fisheri* were observed to display schooling behaviour with *Puntius dorsalis* (Jerdon), *Systomus martenstyni* (Kottelat & Pethiyagoda) and *Tor khudree* (Sykes) (NARA, 2017; Sudasinghe, et al., 2018).

Elevation in m above sea level	**Upper limit:**	750 m	**Depth in m below sea level**	**Upper limit:**	
	Lower limit:	80 m		**Lower limit:**	

4e. Use and Trade

Locally, this fish is taken as a food fish.

4f. Threats

Green *Labeo* is known to be a fast swimmer where adults show a preference to deep rocky water pools and juveniles occur in shallow slow flowing pools with sandy or rocky substrates. This habitat preference potentially makes them vulnerable to habitat loss and degradation due to construction of large reservoirs (nearly 10 reservoirs during the last 50 yr) within its natural range.

The species occurs in association with aquatic plant *Farmeria metzgerioides* (family: Podostemaceae) that grows on rocky substrates along with freshwater microalgae. These habitats have been adversely affected by human activities and loss in quality and quantity of habitat has been observed (NARA, 2017; Samarawickrama, et al., 2012). The loss of habitat is most severe during the construction of dams that directly damage the habitats due to excess soil erosion that take place during construction work as well as soil erosion resulting due to unplanned land use in the upper catchment.

The effect of reservoir conditions (post construction of large dams) to the species is not known. However, the Green Labeo has not been recorded in any of the major reservoirs of the Mahaweli river during the recent NARA fish surveys (Shirantha person. comm., 2018). However, Thilakaratne et al., (2018), has reported the first confirmed record of *Labeo fisheri* from the Victoria reservoir.

Labeo fisheri was a common edible fish species in middle reaches of the Mahaweli river until the late 1970s. Use of destructive fishing practices such as use of fish poison and blast fishing is a significant threat to the species.

There is a strong possibility that long term population fragmentation due to large dams, qualitative and quantitative reduction of feeding habitats due to larger reservoirs and heavy siltation, competition for space and food by introduced fish species (*Labeo rohita* and *Pterygoplichthys spp*.), and toxic effect to the population due to continuous flush of agrochemicals in to the Mahaweli river system will have a significant impact on the long-term survival of *Labeo fisheri*.

Therefore, it can be concluded that the major threat to *Labeo fisheri* is fragmentation of its population due to large dams. It has separated the population to four major locations and it should be taken into account when evaluating this species.

4g. Conservation Actions

The species is listed as a protected species in the schedule II of the Fauna & Flora Protection Ordinance No. 2 of 1937 (last amendment by Act No. 22 of 2009). It is subject to export controls in the Fisheries Act Schedule I. The species is listed as an Endangered (EN) species in the global Red list (Devi and Boguskaya, 2009) and Critically EngEered (CR) species in the National list of Threatened species (MOE, 2012).

One of the known sites of occurrence, the main Mahaweli river at Waratenna-Hakkinda area in the Kandy District in the Central Province has been declared as an Environmental Protected Area (EPA) targeting the Green Labeo and several other endemic and threatened species under Section 24C of the National Environmental Act (NEA), which enables regulating and prohibiting certain activities in this area under Section 24D of the NEA. This order is officially published in the Gazette Extraordinary No; 2024/06 of 19.06.2017.

5. DATA FOR RED LIST CRITERIA

5a. Data for criterion A: rate of population reduction *(no required data)*

Generation length (please state the unit used). ☐

Time period used for criterion A (tick (✓) one box only) — 10 years ☐ ; 3 generations ☐ ; Time period ☐

Criteria A1 and A2:
% population size reduction over the last 10 yrs or 3 generations: ☐

Data quality: Observed ☐ Estimated ☐ Inferred ☐ Suspected ☐

Are the causes of this reduction understood? (tick (✓) one box only) — Yes ☐ No ☐ Unknown ☐

Have the causes of the reduction now ceased? (tick (✓) one box only) — Yes ☐ No ☐ Unknown ☐

Is the reduction reversible? i.e., is the population now showing signs of recovery? (tick (✓) one box only) — Yes ☐ No ☐ Unknown ☐

Past population reduction rate based on (select any combination)**:**

- Direct observation ☐
- Index of abundance ☐
- Decline in area of occupancy, extent of occurrence, and/or habitat quality ☐
- Actual or potential levels of exploitation ☐
- Effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites ☐

Criterion A3:
% population size reduction over the next 10 yrs or 3 generations (max. 100 years in future)**:** ☐

Data quality: Projected ☐ Suspected ☐

Future population reduction rate based on (select any combination)**:**

- Index of abundance ☐
- Decline in area of occupancy, extent of occurrence, and/or habitat quality ☐
- Actual or potential levels of exploitation ☐
- Effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites ☐

Criterion A4: **% population size reduction over the longer time period of 10 yrs or 3 generations, where some time falls in the past and some is projected in to the future** (max. 100 yrs in future)**:**		**Data quality:**	Observed Estimated Inferred Projected Suspected
Population reduction rate based on (select any combination)**:**	Direct observation Index of abundance Decline in area of occupancy, extent of occurrence, and/or habitat quality Actual or potential levels of exploitation Effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites		

5b. Data for criterion B: restricted range

Criterion B1: Extent of occurrence (EOO) in km²: 3,004			**Criterion B2: Area of occupancy (AOO)** in km²: 160		
See annex 03					
Is the population severely fragmented? (tick (✓) one box only)	Yes ✓ No Unknown	If yes, justify this statement in the population text box (refer to habitat fragmentation AND the dispersal abilities of the taxon).**fragmentation due to large dams (each location can be threatened due to siltation, water pollution due agro-chemicals, competition for food and space due to invasive species).*		**Number of locations:**	**4***
Extent of occurrence	**Continuing decline** ✓ **Extreme fluctuation**	Observed ✓ Inferred Projected			
Area of occupancy	**Continuing decline** ✓ **Extreme fluctuation**	Observed ✓ Inferred Projected			
Area, extent and/or quality of habitat	**Continuing decline** ✓	Observed ✓ Inferred Projected			
Number of locations or subpopulations	**Continuing decline** ✓ **Extreme fluctuation**	Observed ✓ Inferred Projected			
Number of mature individuals	**Continuing decline** ✓ **Extreme fluctuation**	Observed Inferred ✓ Projected			

5c. Data for criterion C: small population size and continuing decline

Population size Number of mature individuals in the global population:	Range between 17,915 – 68,291

Is there continuing decline in the population? (tick one box only)	Yes		**Rate of continuing decline known?** (tick one box only)	Yes	
	No			No	
	Unknown	✓		Unknown	✓

Estimated continuing decline % within 3 years or 1 generation (whichever is the longer time period; max. 100 years in future)**:**	**NK**
Estimated continuing decline % within 5 years or 2 generation (whichever is the longer time period; max. 100 years in future)**:**	**NK**
Estimated continuing decline % within 10 years or 3 generation (whichever is the longer time period; max. 100 years in future)**:**	**NK**

Number of mature individuals in largest subpopulation:	**NK**	**% of mature individuals in largest subpopulation**	**NK**

Extreme fluctuations in number of mature individuals:	Yes	
	No	
	Unknown	✓

5d. Data for criterion D: small population size or restricted range *(no required data)*

Population size Number of mature individuals in the global population:	

Area of occupancy (AOO) in km²:		**Number of locations**:		**Is there a plausible threat that could rapidly push the taxon towards extinction?**	Yes
					No
					Unknown

5e. Data for criterion E: quantitative analysis *(no required data)*

Has a quantitative analysis predicting probability of extinction been carried out? (e.g. Population Viability Analysis)	Yes	
	No	
	Unknown	

Probability (%) of extinction within the next 10 years or 3 generations (use the longer time period; max. 100 years in future)	
Probability (%) of extinction within the next 20 years or 5 generations (use the longer time period; max. 100 years in future)	
Probability (%) of extinction within the next 100 years	

6. RED LIST ASSESSMENT

Assess the taxon using the information and data recorded in section 4 and 5, and following the *IUCN Red List Categories and Criteria: version 3.1.* and current version of the *Guidelines for Using the IUCN Red List Categories and Criteria* for guidance on applying the IUCN criteria.

6a. Red List Category & Criteria

Tick (✓) one of the following Red List categories, For taxa qualifying for a threatened category (CR, EN or VU), record all criteria and subcriteria met. For the NT category, record all criteria and subcriteria nearly met:

	Extinct (EX)	Date last seen in wild (day/month/year)	
	Extinct in the Wild (EW)	Date last seen in wild (day/month/year)	
	Critically Endangered (CR)	Criteria met for CR	
✓	**Endangered (EN)**	Criteria met for EN	EN B1ab (iii) and B2ab (iii)
	Vulnerable (VU)	Criteria met for VU	
	Near Threatened (NT)	Criteria nearly met for NT	
	Least Concern (LC)		
	Data Deficient (DD)		
	Not Evaluated (NE)		

Is this taxon Possibly Extinct? (applies to CR taxa only)

Yes	
No	✓
Unknown	

6b. Rationale for the assessment

The species showed a wide distribution in the Mahaweli river basin and was considered as a common food fish until the implementation of accelerated Mahaweli Development Programme which has resulted in construction of several major dams across Mahaweli river and Many of its tributaries that has contributed to significant level of fragmentation and inundated large segments of the habitat of the fish.

Within about two decades the status of the species changed from common to rare and only six confirmed records were available for the last Global and National assessments which has resulted in the species being listed as a Globally Eangered species as well as a Nationally Critically Endangered Species.

Number of recent studies indicates that *Labeo fisheri* may be more common than originally thought (5 years ago), as surveys in new areas as well as use of reliable observation techniques have confirmed that the species is present in several new areas where the suitable habitat was present.

However, it should be noted that many of these locations support small populations that are highly fragmented due to construction of large dams. The recent studies done along the Kambarawa Oya beyond the upper water level of Moragahakanda Reservoir (from Moragahakanda and Kaluganga reservoirs) did not record the species (IUCN Sri Lanka, 2019) even though it has been reported from this location in the past.. Loggal Oya population was also not observed during the recent studies conducted by NARA (pers com Ramani Shritantha, 2019).

Also number of the known locations is likely to be affected by projects that are planned to be implemented in the future and therefore the decline in habitat and thereby the species will continue to take place.

The major threats which effect the long term survival of *Labeo fisheri* include population fragmentation due to large dams, qualitative and quantitative reduction of feeding habitats due to larger reservoirs and siltation, competition for space and food by the introduced fish species, and finally direct effect to the population due to agrochemical run off from the agriculture lands in the catchment of the Mahaweli river. There is also illegal fishing taking place targeting this species which functions as a significant threat owing to reduced number of species, which should be taken into account in evaluating this species. Above threats were taken into consideration when determining the number of locations for this species (Map 02).

Therefore, it is prudent to maintain its listing at its current status, Endangered even though new information shows that the species is not restricted to the areas that it was presumed to occupy few years ago, and no direct conservation action has been undertaken targeting the species or its habitat other than listing it as a protected species and habitat of a single population (Gatambe) has been declared as an Environmental Protected Area (Gazette Extraordinary No; 2024/06 of 19.06.2017).

This is a range-restricted species, known from 4 locations in Mahaweli River basin in central Sri Lanka. Its extent of occurrence (EOO) is around 3000 km², and area of occupancy (AOO) is 160 km². Its habitat is declining due dam construction and increased sedimentation caused by soil erosion. The species is also threatened by overfishing. Even though part of the species range occurs within protected areas, these threats are likely to continue. Therefore, the species is listed as Endangered.

Assessment Date:

DD	MM	YYYY
29	04	2019

Assessors' Names:

Given Name(s)	Family Name	Email Address	Institution
Sampath	De A Goonatilake	Sampath.goonatilake@iucn.org	IUCN Sri Lanka
Malka	Fernando	sandunimalkafernando@gmail.com	IUCN Sri Lanka
Odatha	Kotagama	odatha27@gmail.com	IUCN Sri Lanka

6c. Changes in Red List status

Check the IUCN Red List web site (www.iucnredlist.org) to find out whether the taxon has previously been assessed.

Has this taxon been assessed for a previous IUCN Red List? Yes ✓ / No / Unknown

If yes, what was the previous assessment? *Labeo fisheri. The IUCN Red List of Threatened Species 2009*

If yes, has the taxon changed category since its last assessment? Yes / No ✓

If no, have the criteria changed? Yes / No

Reason for change in category:

Genuine change
- Recent change
- Change since first assessment

Non-genuine change
- New/better information available ✓
- Taxonomic change
- Incorrect application of criteria previously
- Criteria thresholds changed since previous assessment

Annex 3: Atlas of the geographical distributions of species

The order of species distribution maps presented in this annexe follow that of Table 6.

Maps have not been provided for Layard's barb (*Puntius layardi*) and Long-snouted barb (*Puntius tetraspilus*) as these are only known from their type localities, simply listed as Ceylon.

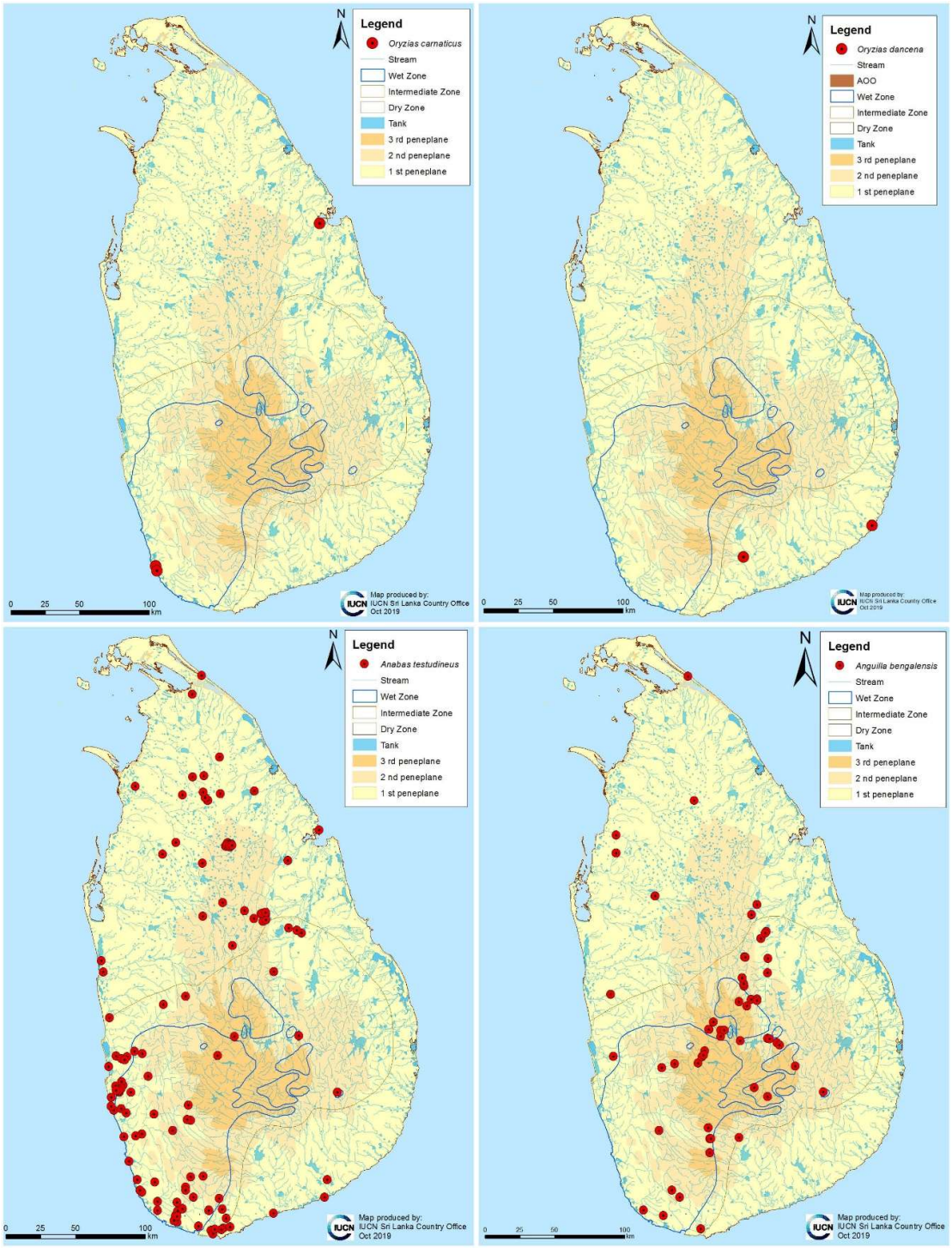

Figure 17. Known locations of top left: *Oryzias carnaticus*; top right: *Oryzias dancena*; bottom left: *Anabas testudineus*; bottom right: *Anguilla bengalensis*

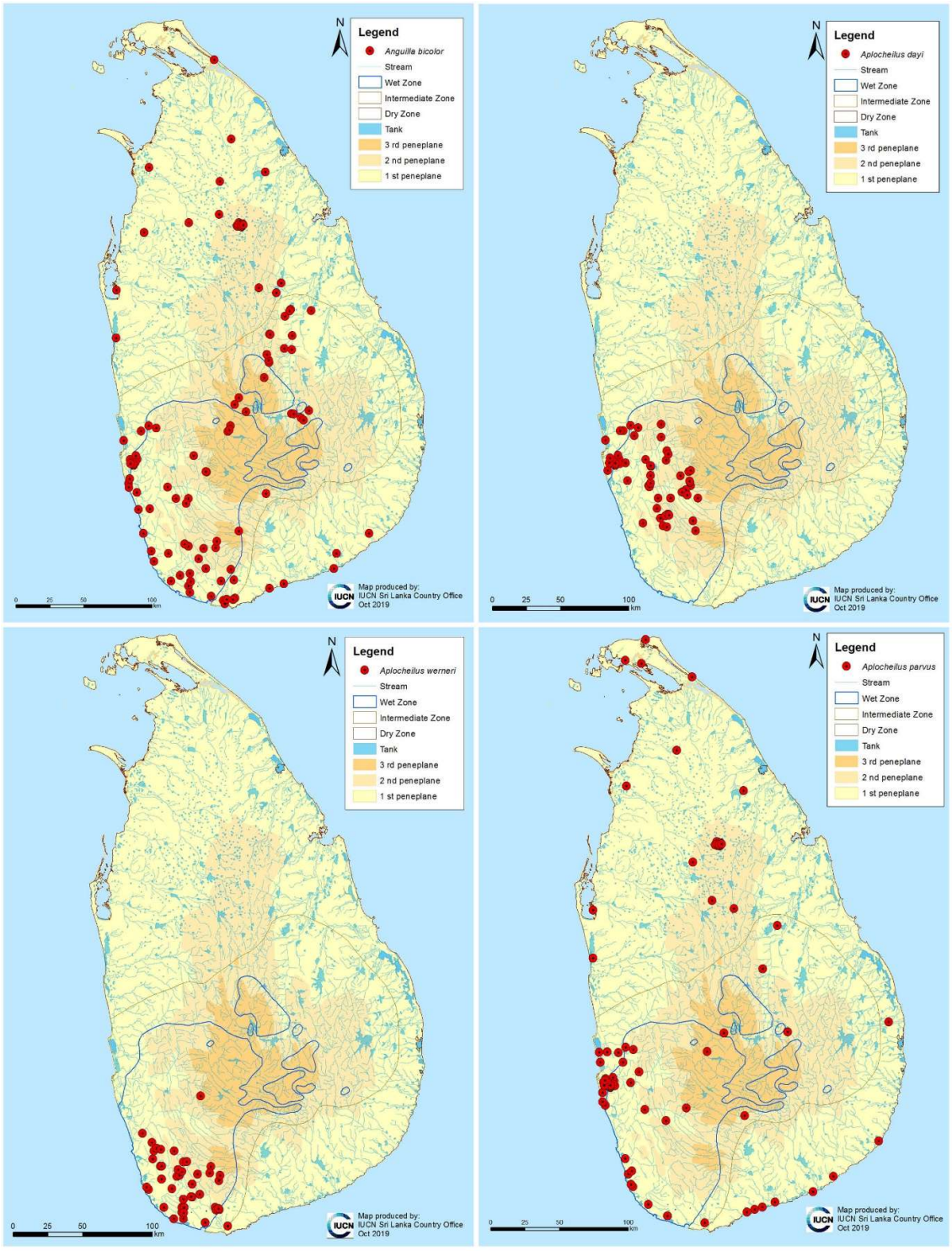

Figure 18. Known locations of top left: *Anguilla bicolor*; top right: *Aplocheilus dayi*; bottom left: *Aplocheilus werneri*; bottom right: *Aplocheilus parvus*

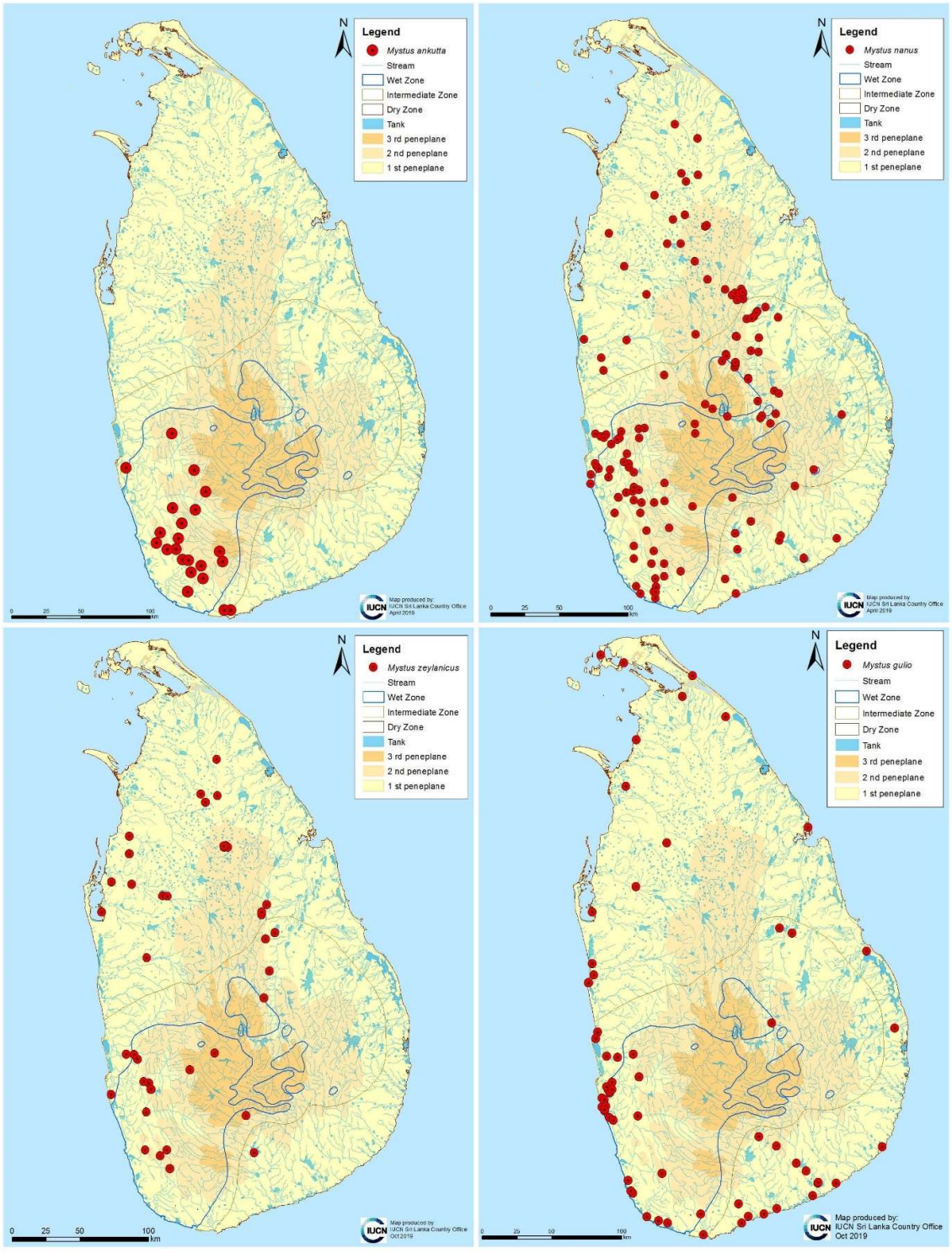

Figure 19. Known locations of top left: *Mystus ankutta*; top right: *Mystus nanus*; bottom left: *Mystus zeylanicus*; bottom right: *Mystus gulio*

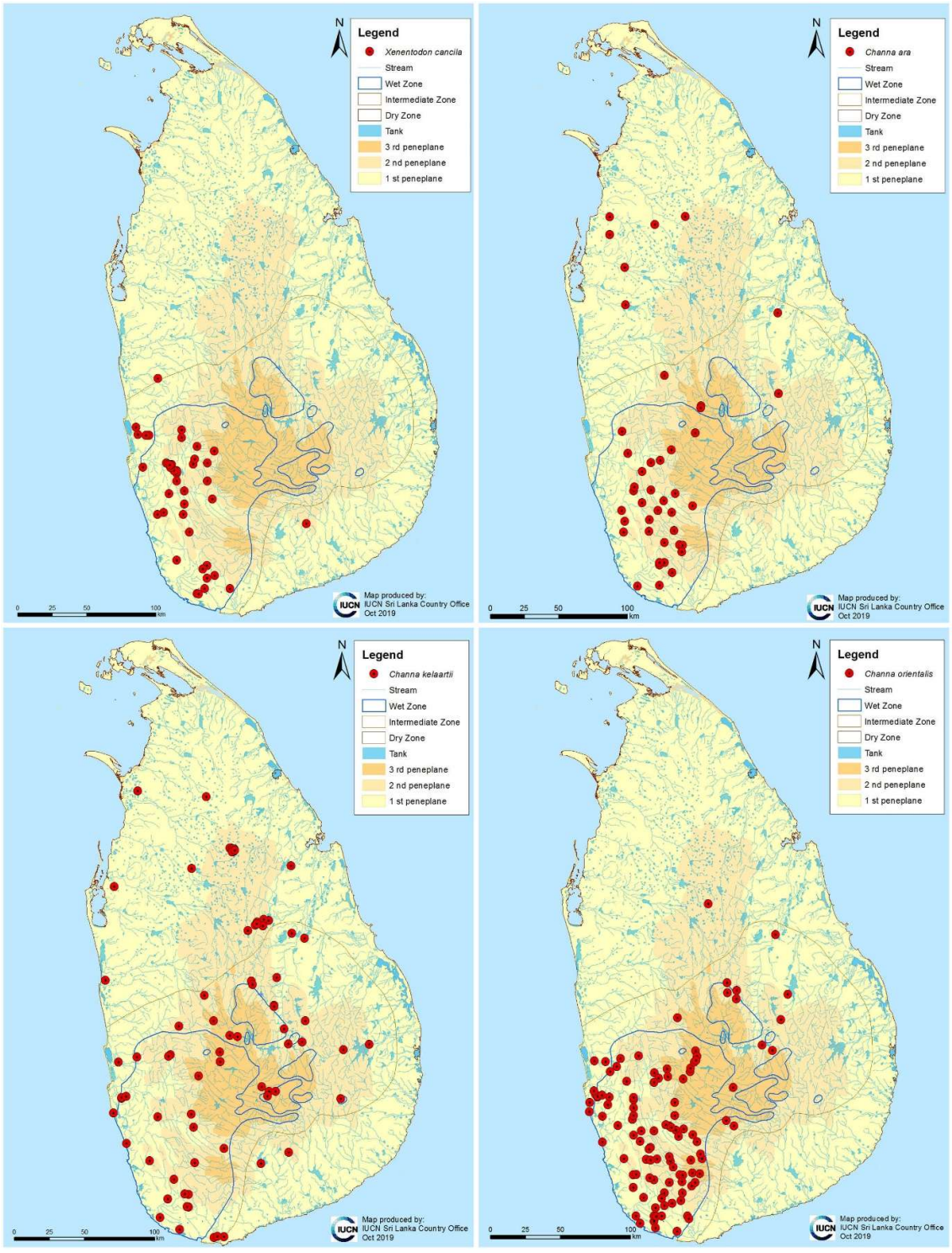

Figure 20. Known locations of top left: *Xenentodon cancila*; top right: *Channa ara*; bottom left: *Channa kelaartii*; bottom right: *Channa orientalis*

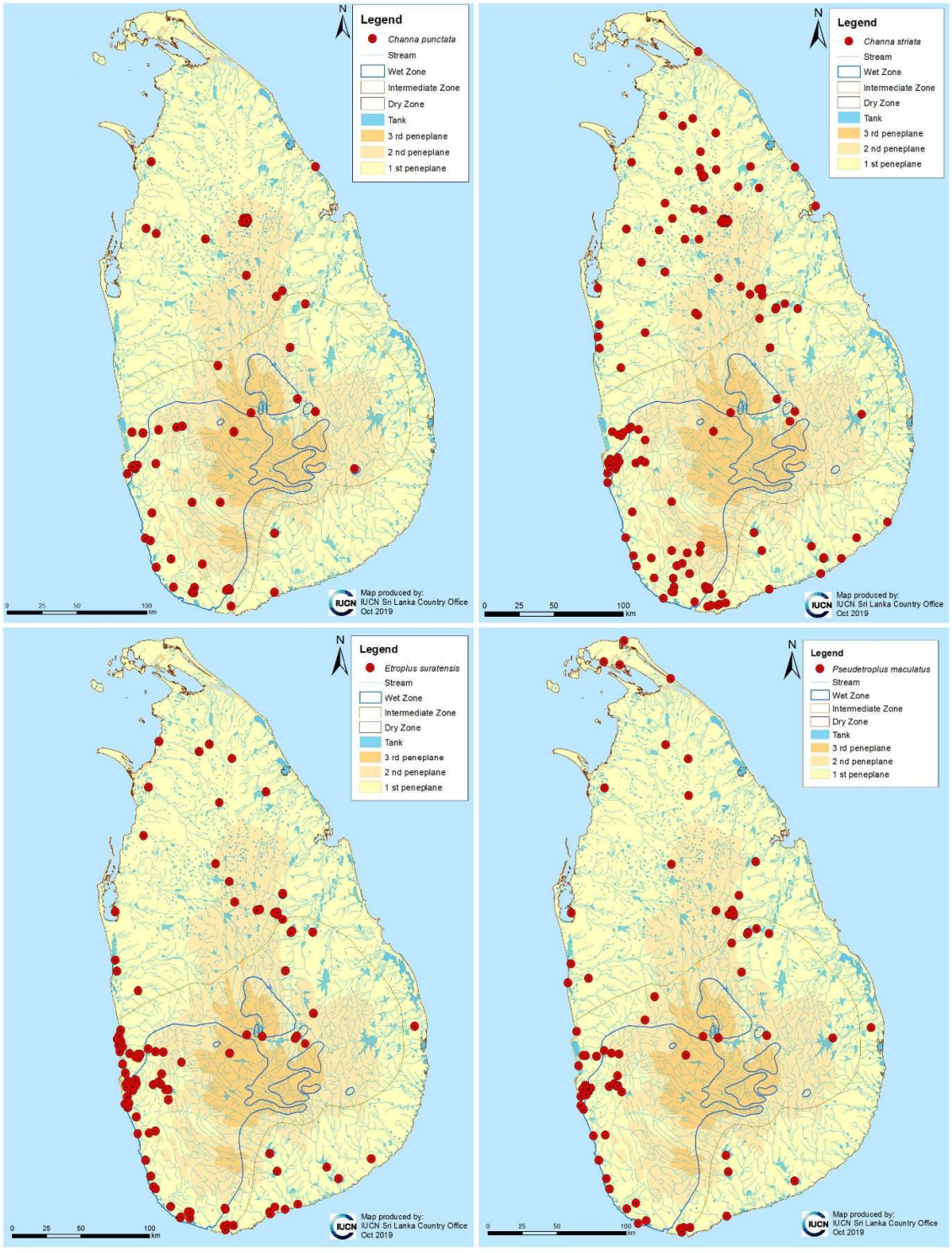

Figure 21. Known locations of top left: *Channa punctata*; top right: *Channa striata*; bottom left: *Etroplus suratensis*; bottom right: *Pseudetroplus maculatus*

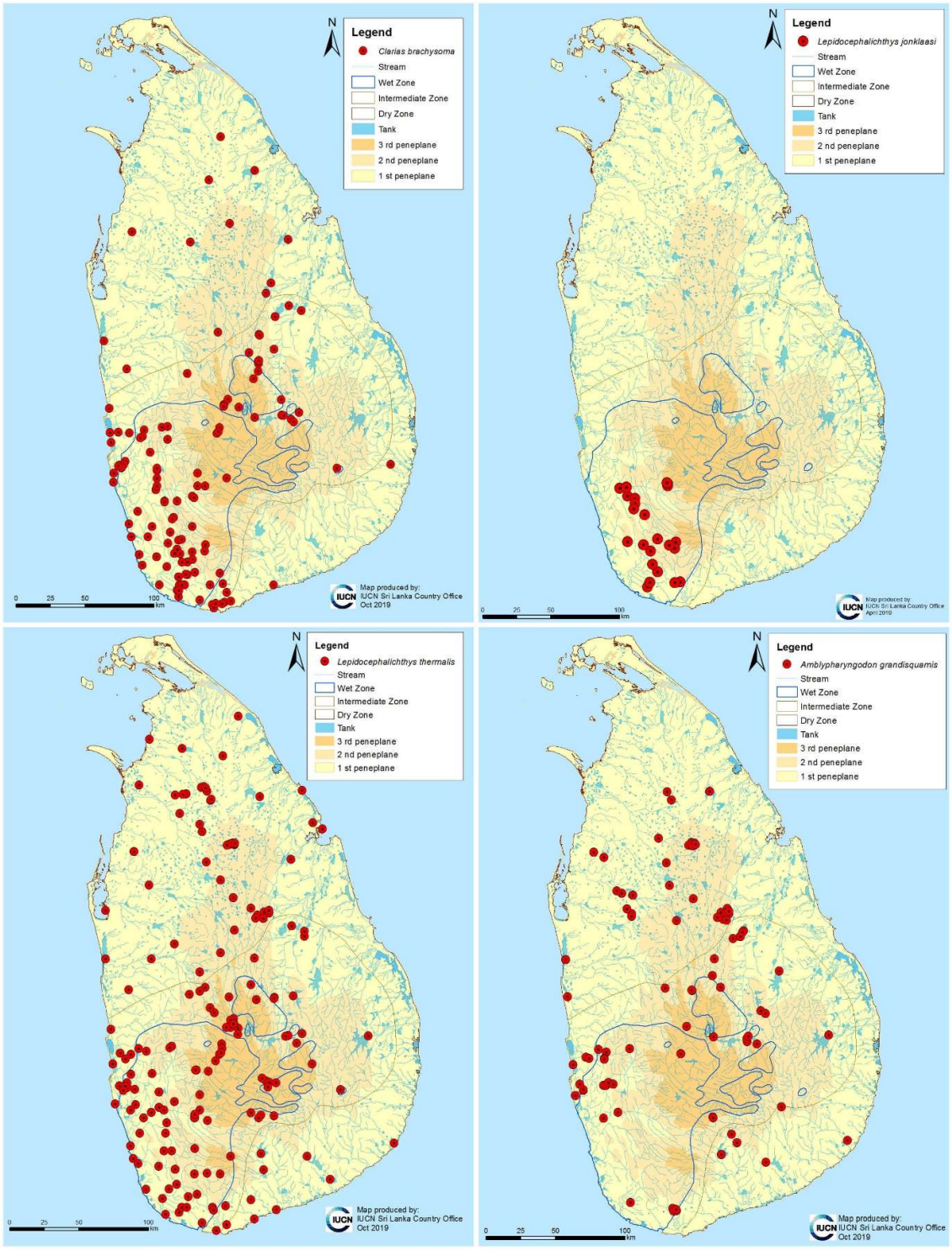

Figure 22. Known locations of top left: *Clarias brachysoma*; top right: *Lepidocephalichthys jonklaasi*; bottom left: *Lepidocephalichthys thermalis*; bottom right: *Amblypharyngodon grandisquammis*

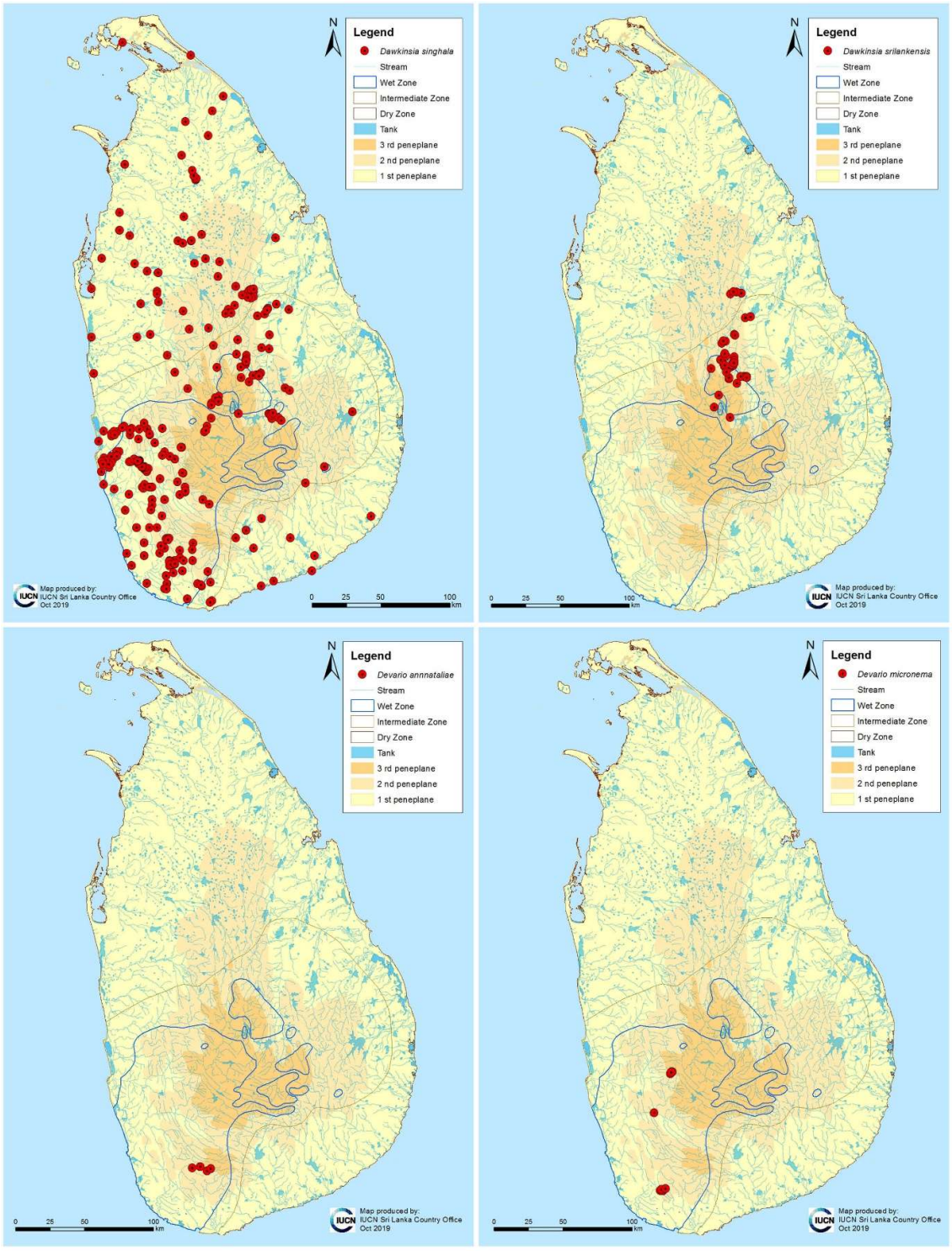

Figure 23. Known locations of top left: *Dawkinsia singhala*; top right: *Dawkinsia srilankensis*; bottom left: *Devario annnataliae*; bottom right: *Devario micronema*

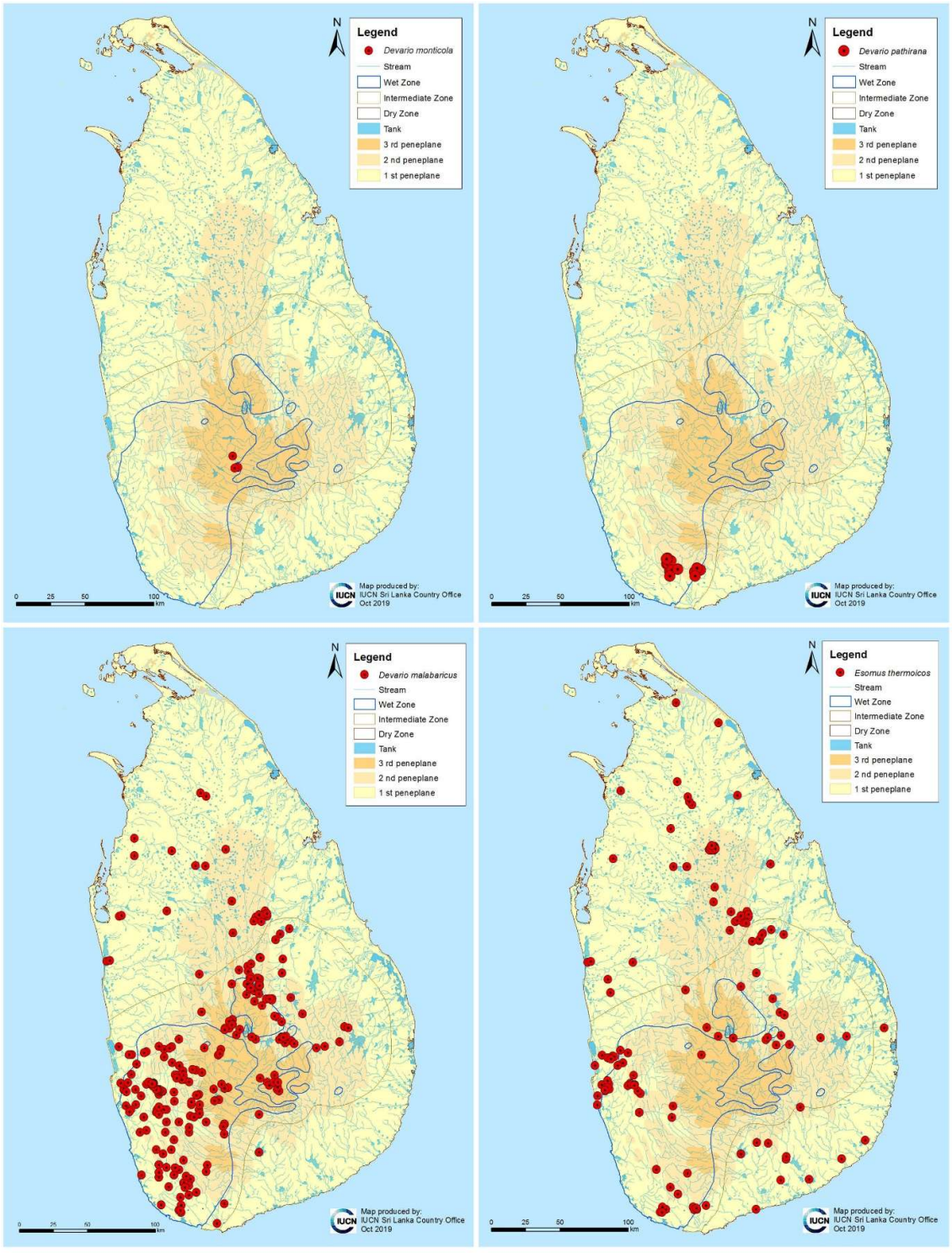

Figure 24. Known locations of top left: *Devario monticola*; top right: *Devario pathirana*; bottom left: *Devario malabaricus*; bottom right: *Esomus thermoicos*

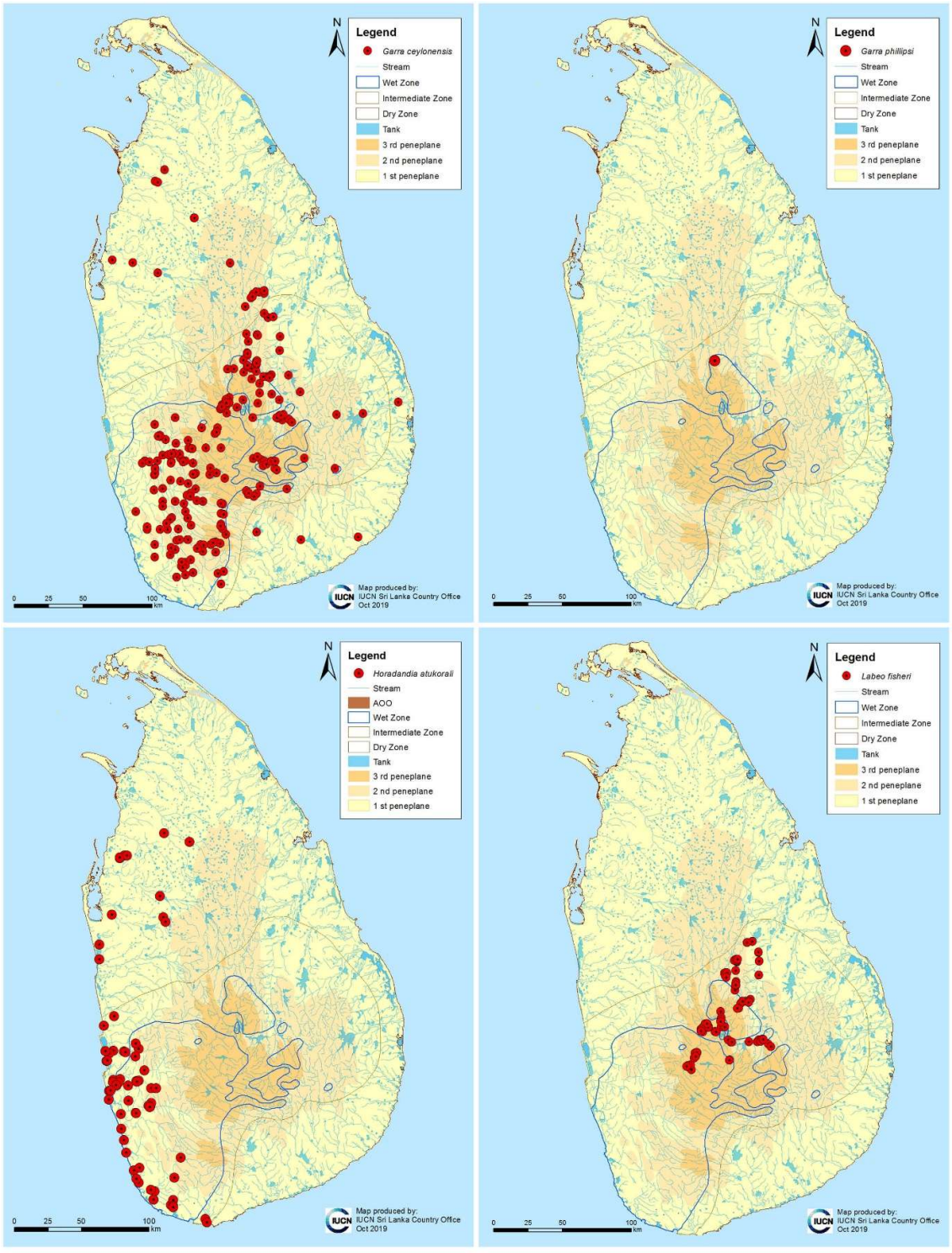

Figure 25. Known locations of top left: *Garra ceylonensis*; top right: *Garra phillipsi*; bottom left: *Horadandia atukorali*; bottom right: *Labeo fisheri*

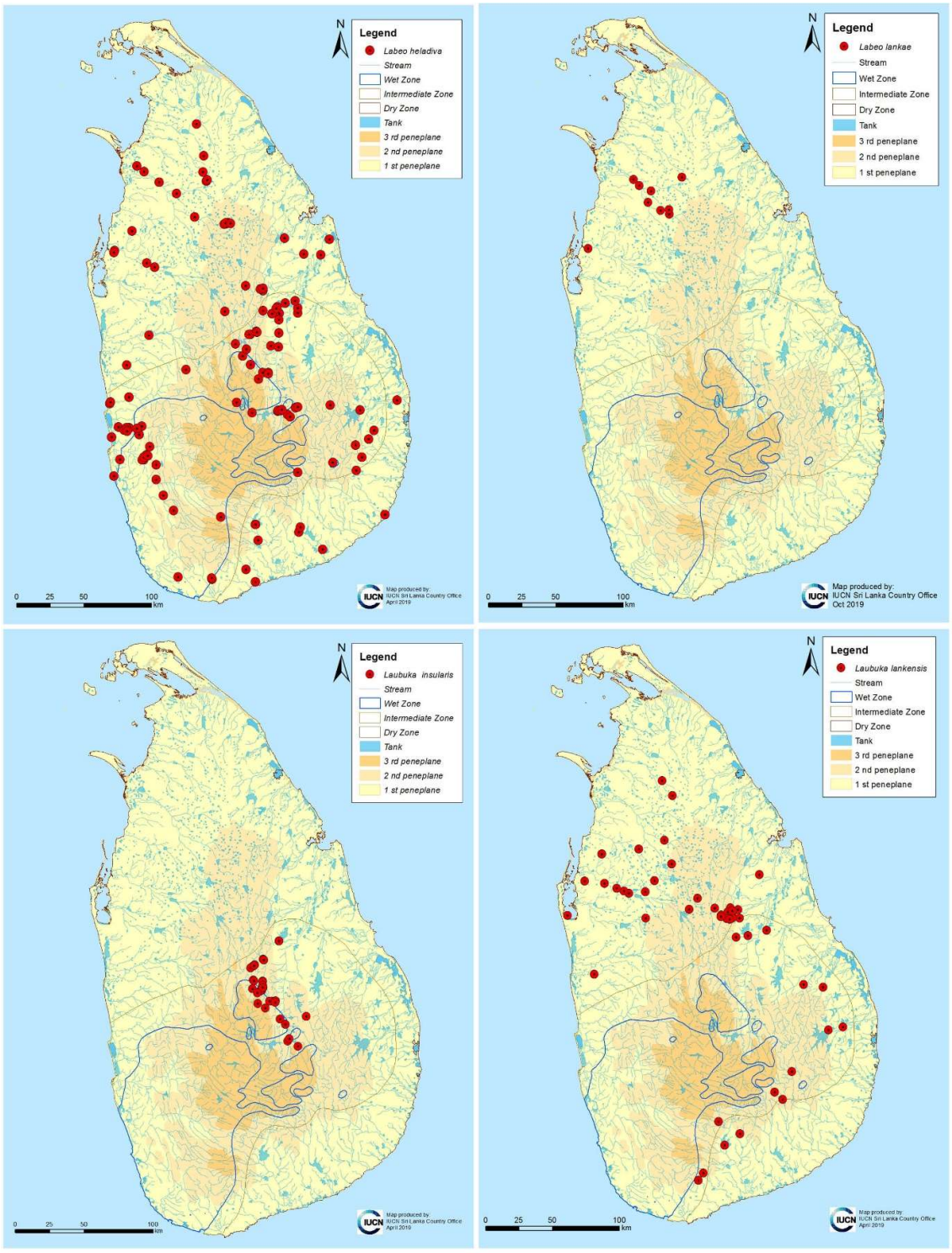

Figure 26. Known locations of top left: *Labeo heladiva*; top right: *Labeo lankae*; bottom left: *Laubuka insularis*; bottom right: *Laubuka lankensis*

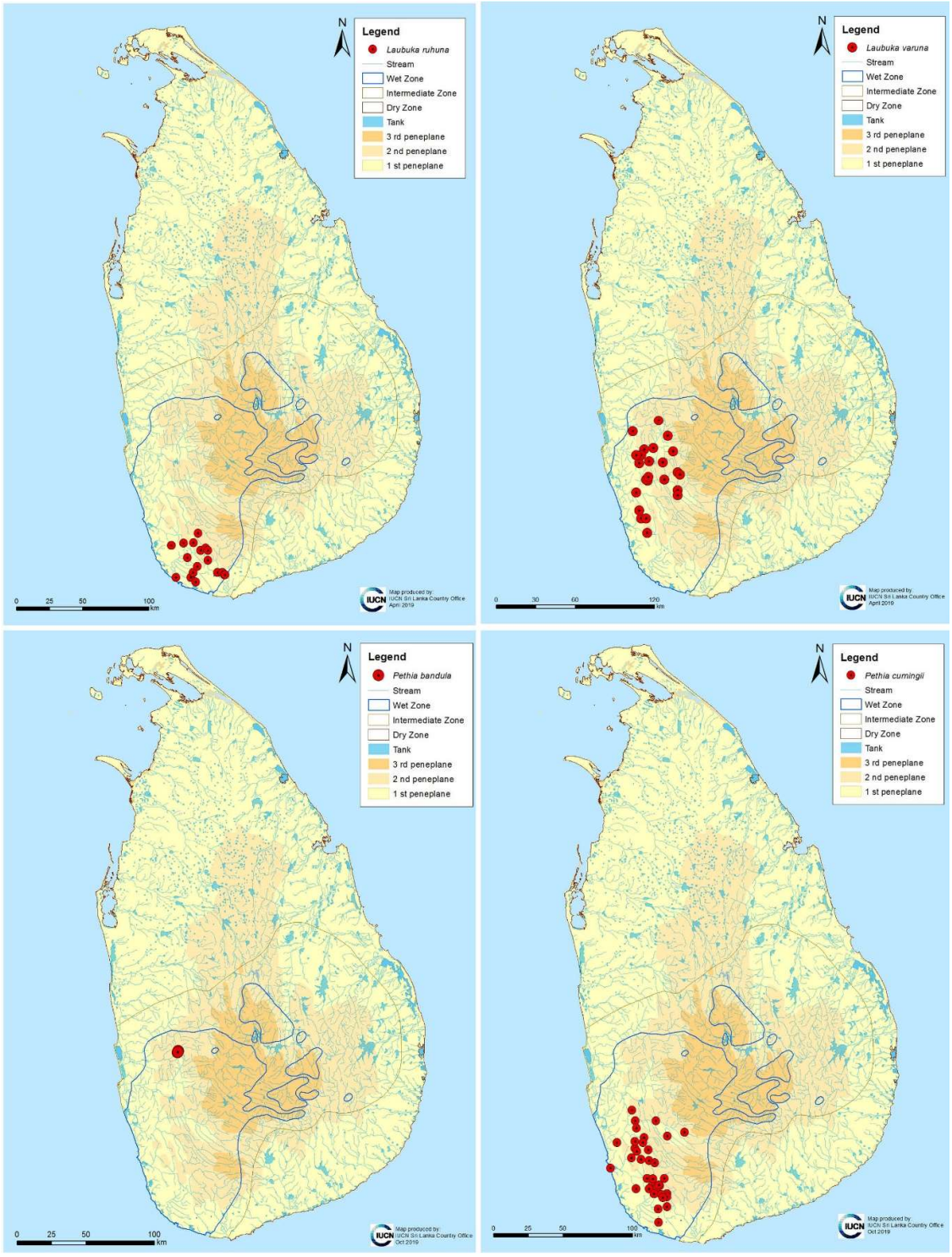

Figure 27. Known locations of top left: *Laubuka ruhuna*; top right: *Laubuka varuna*; bottom left: *Pethia bandula*; bottom right: *Pethia cumingii*

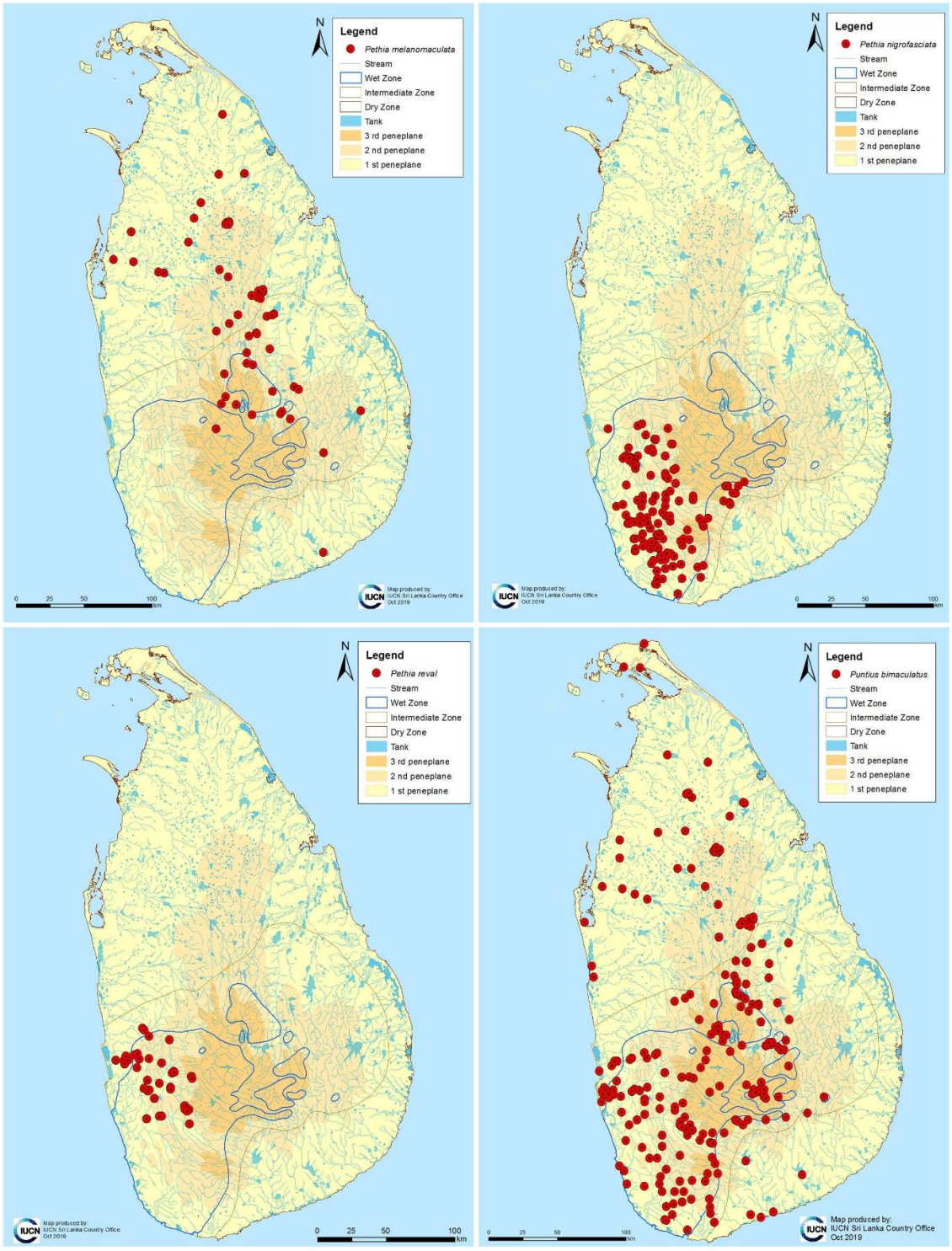

Figure 28. Known locations of top left: *Pethia melanomaculata* ; top right: *Pethia nigrofasciata*; bottom left: *Pethia reval*; bottom right: *Puntius bimaculatus*

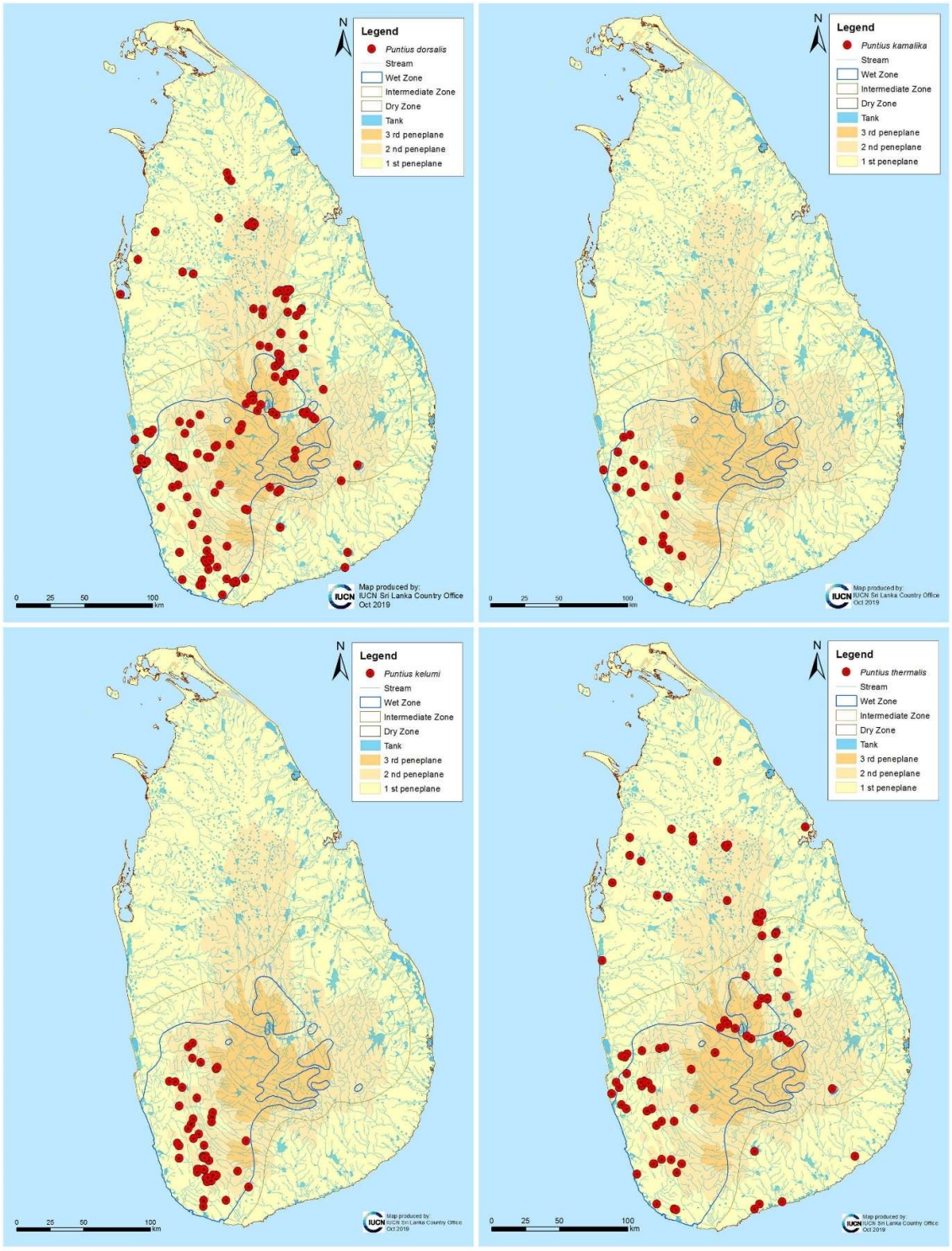

Figure 29. Known locations of top left: *Puntius dorsalis*; top right: *Puntius kamalika*; bottom left: *Puntius kelumi*; bottom right: *Puntius thermalis*

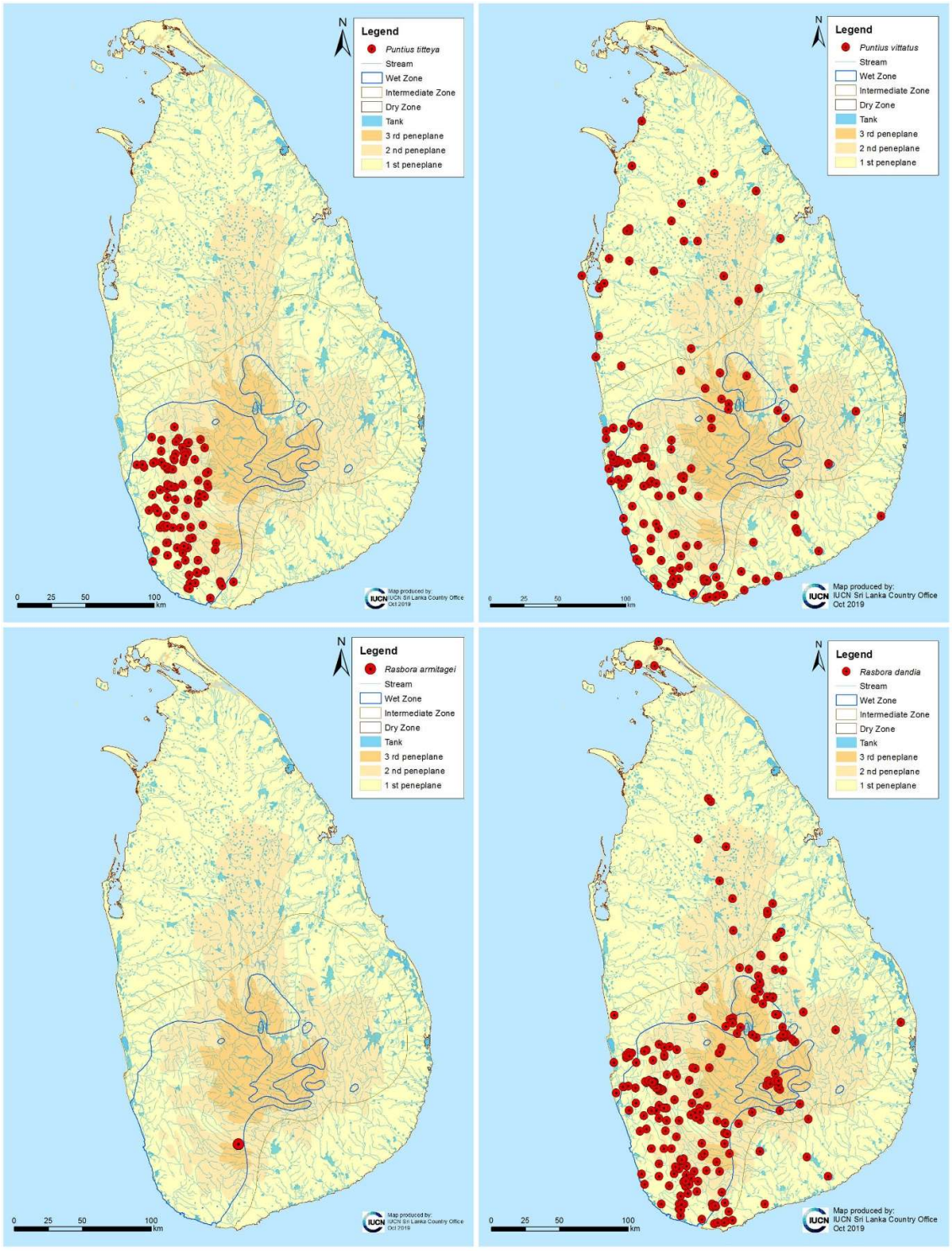

Figure 30. Known locations of top left: *Puntius titteya*; top right: *Puntius vittatus*; bottom left: *Rasbora armitagei*; bottom right: *Rasbora dandia*

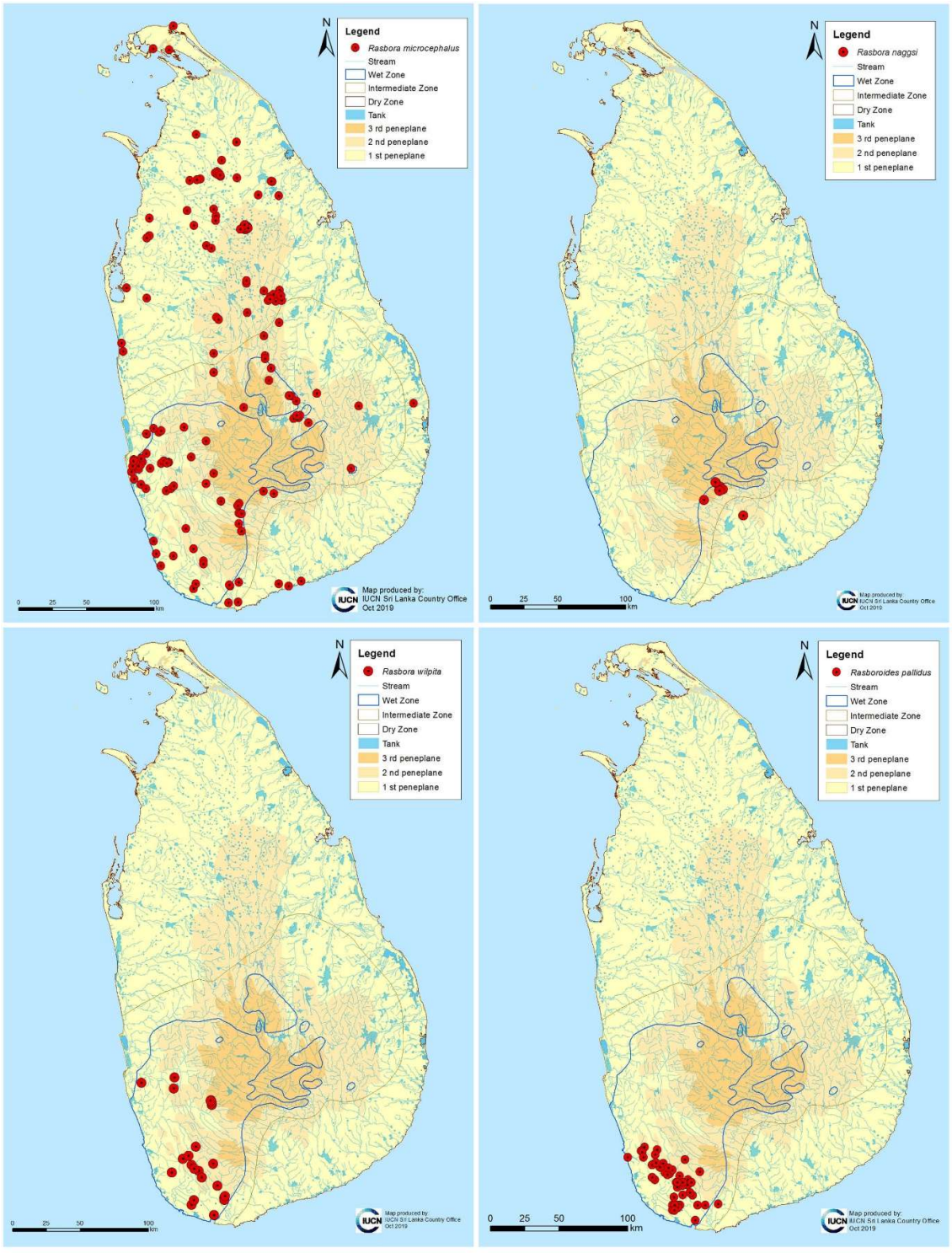

Figure 31. Known locations of top left: *Rasbora microcephalus*; top right: *Rasbora naggsi*; bottom left: *Rasbora wilpita*; bottom right: *Rasboroides pallidus*

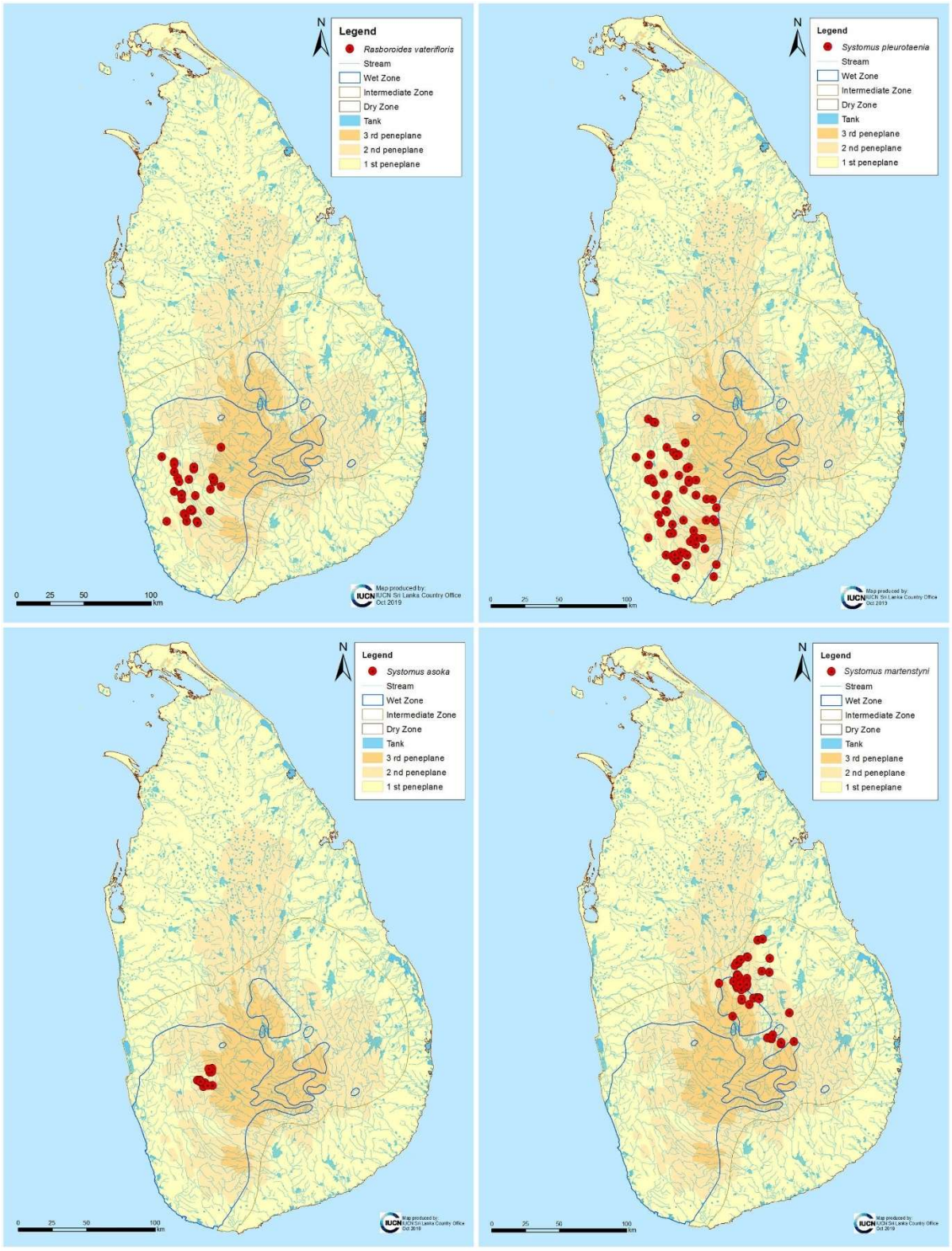

Figure 32. Known locations of top left: *Rasboroides vaterifloris*; top right: *Systomus pleurotaenia*; bottom left: *Systomus asoka*; bottom right: *Systomus martenstyni*

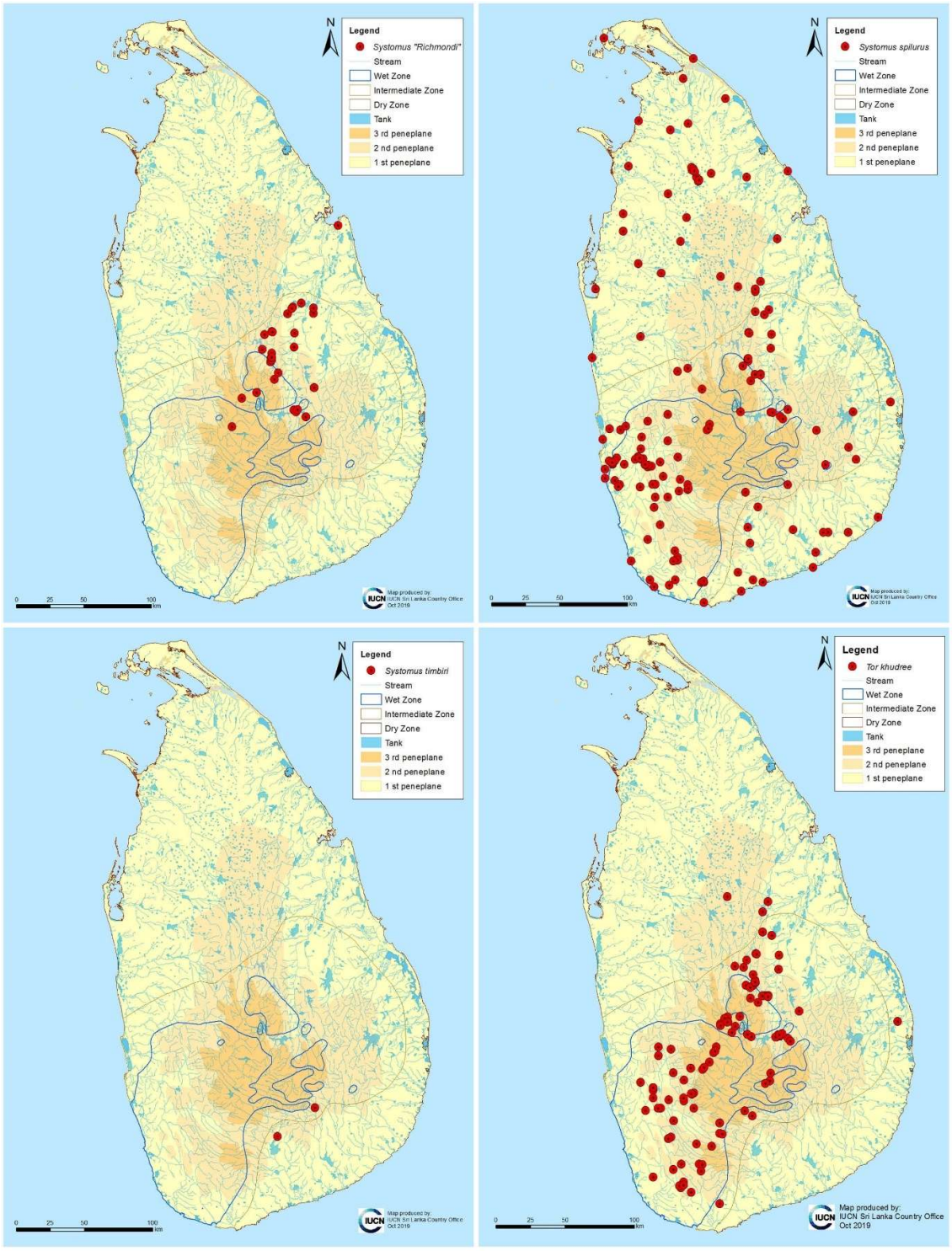

Figure 33. Known locations of top left: *Systomus "Richmondi"*; top right: *Systomus spilurus*; bottom left: *Systomus timbiri*; bottom right: *Tor khudree*

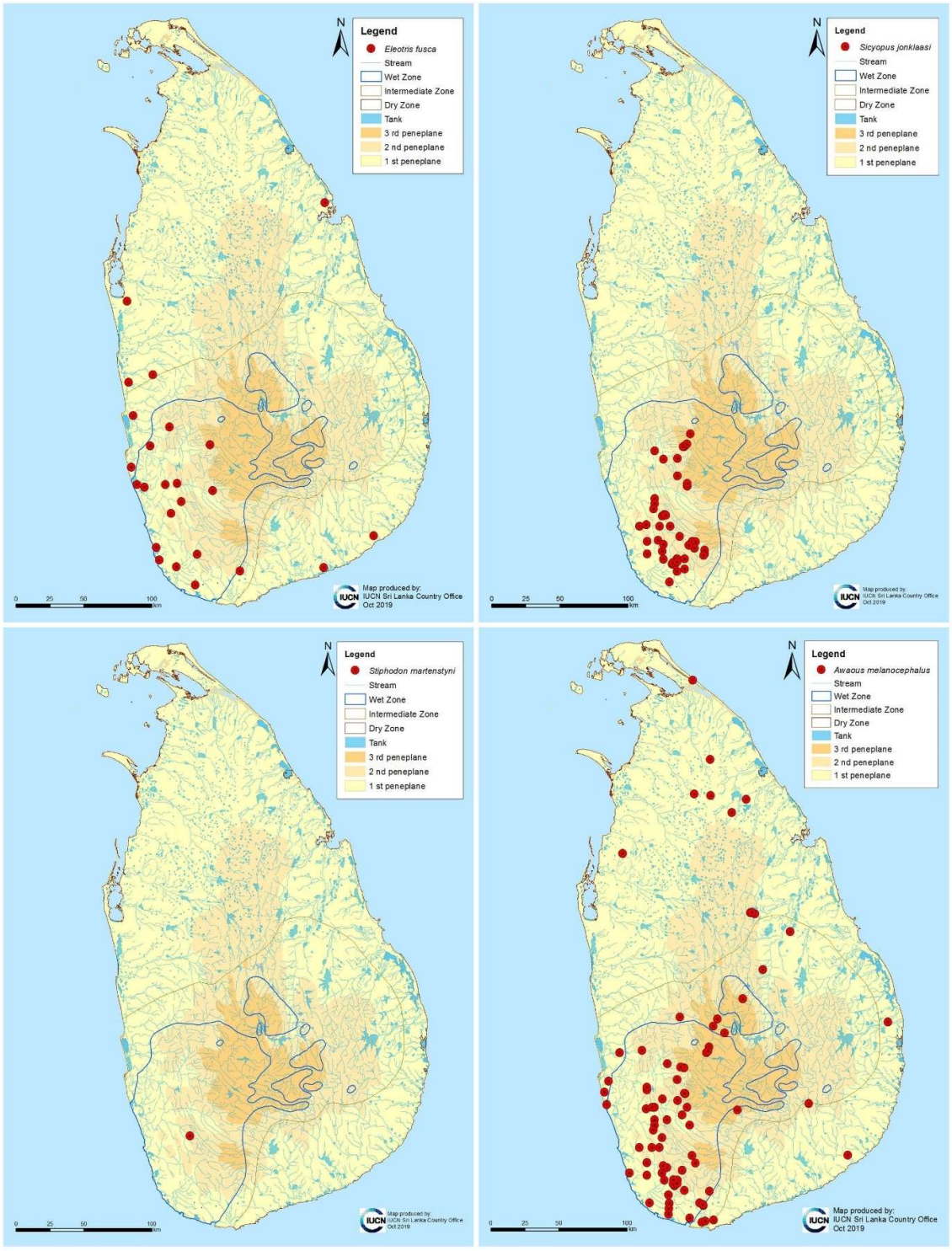

Figure 34. Known locations of top left: *Eleotris fusca*; top right: *Sicyopus jonklaasi*; bottom left: *Stiphodon martenstyni*; bottom right: *Awaous melanocephalus*

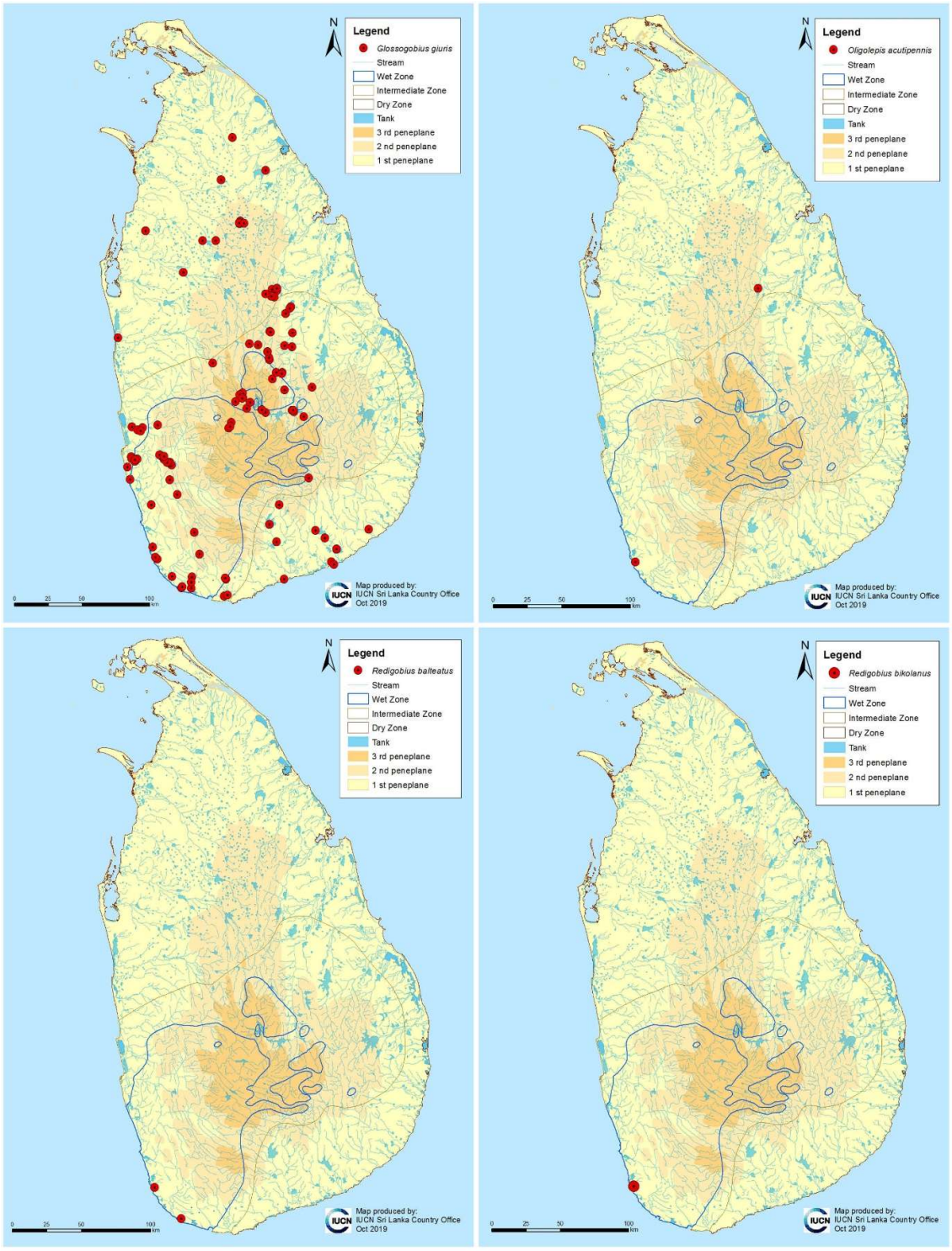

Figure 35. Known locations of top left: *Glossogobius giuris*; top right: *Oligolepis acutipennis*; bottom left: *Redigobius balteatus*; bottom right: *Redigobius bikolanus*

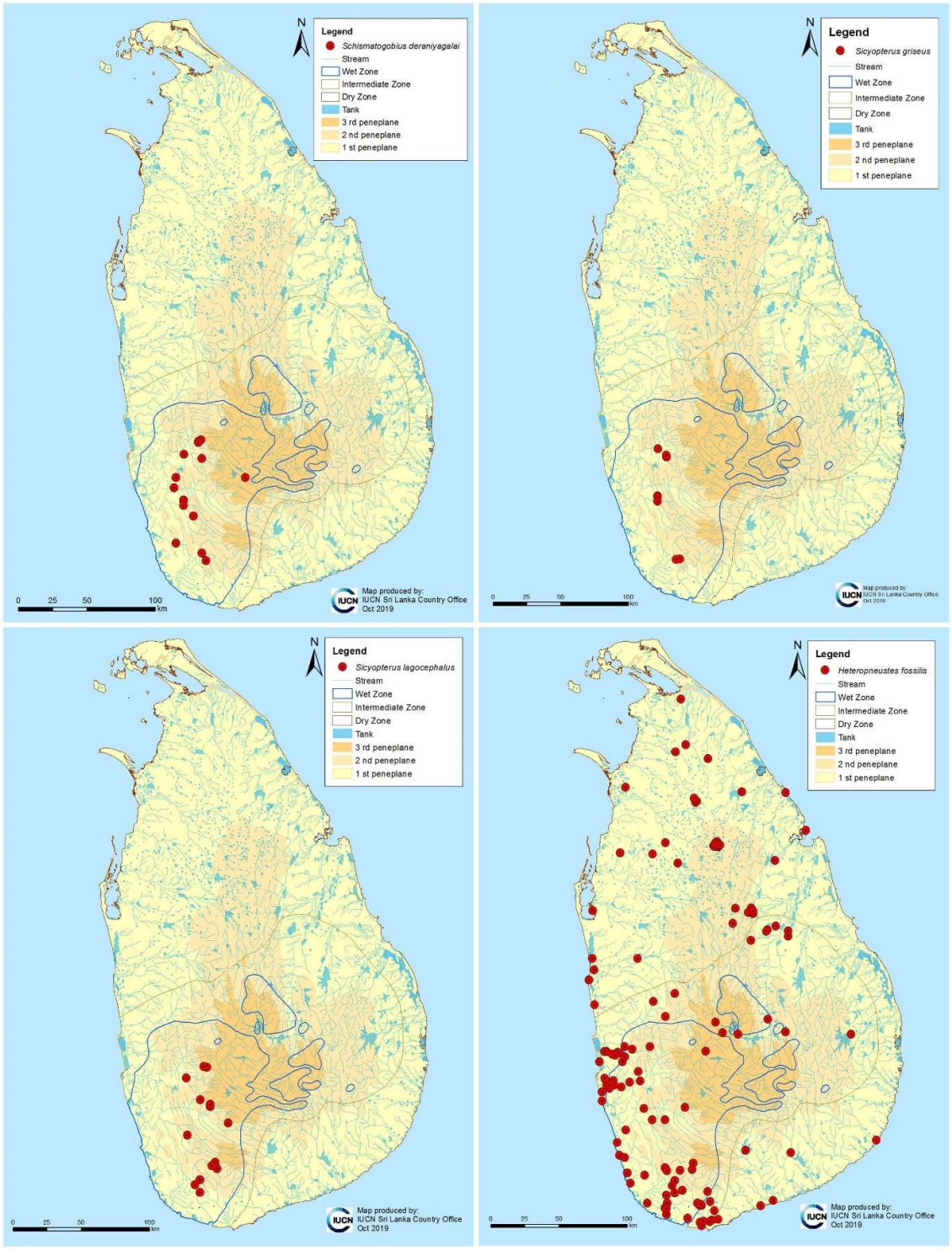

Figure 36. Known locations of top left: *Schismatogobius deraniyagalai*; top right: *Sicyopterus griseus*; bottom left: *Sicyopterus lagocephalus*; bottom right: *Heteropneustes fossilis*

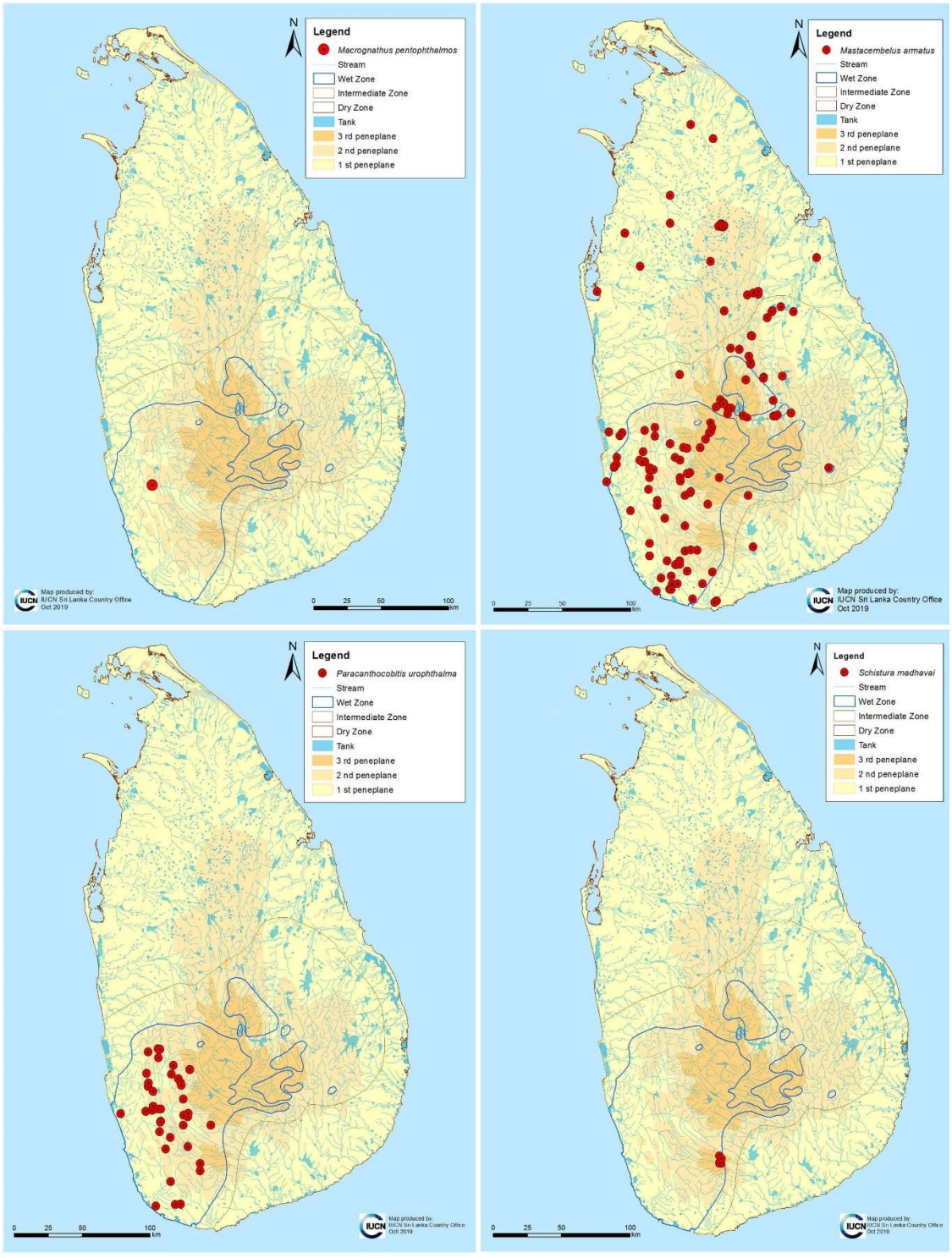

Figure 37. Known locations of top left: *Macrognathus pentophthalmos*; top right: *Mastacembelus armatus*; bottom left: *Paracanthocobitis urophthalma*; bottom right: *Schistura madhavai*

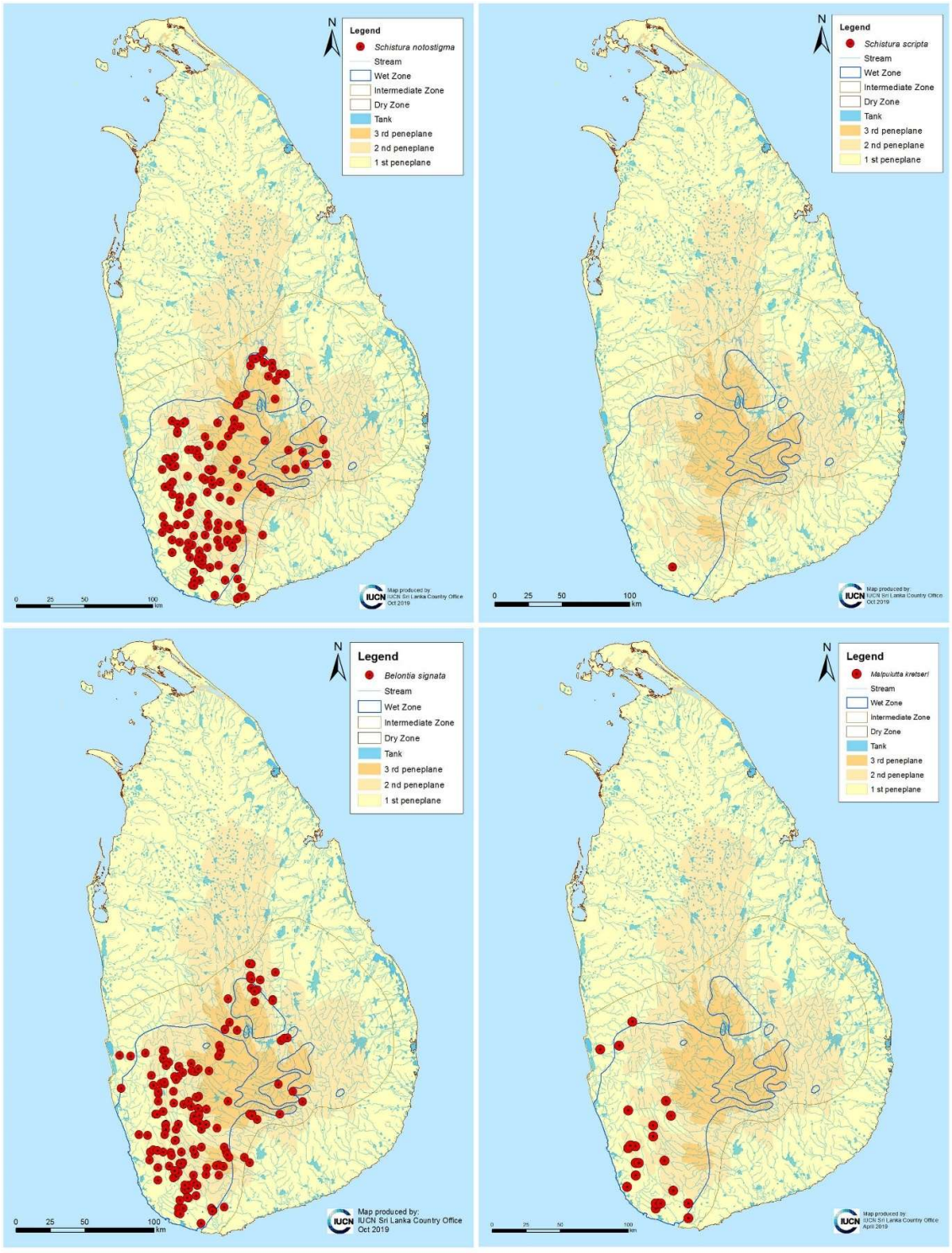

Figure 38. Known locations of top left: *Schistura notostigma*; top right: *Schistura scripta*; bottom left: *Belontia signata*; bottom right: *Malpulutta kretseri*

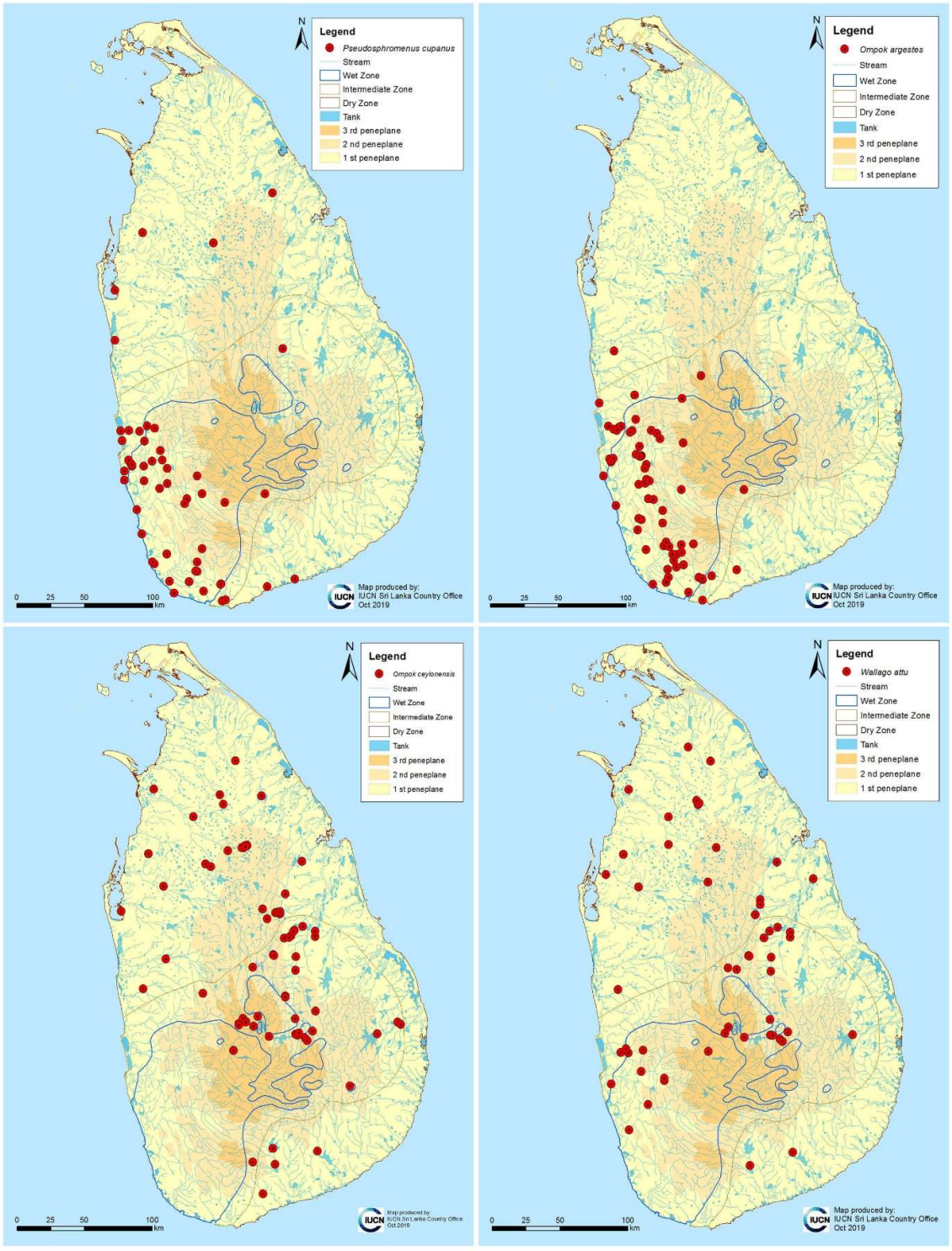

Figure 39. Known locations of top left: *Pseudosphromenus cupanus*; top right: *Ompok argestes*; bottom left: *Ompok ceylonensis* bottom right: *Wallago attu*

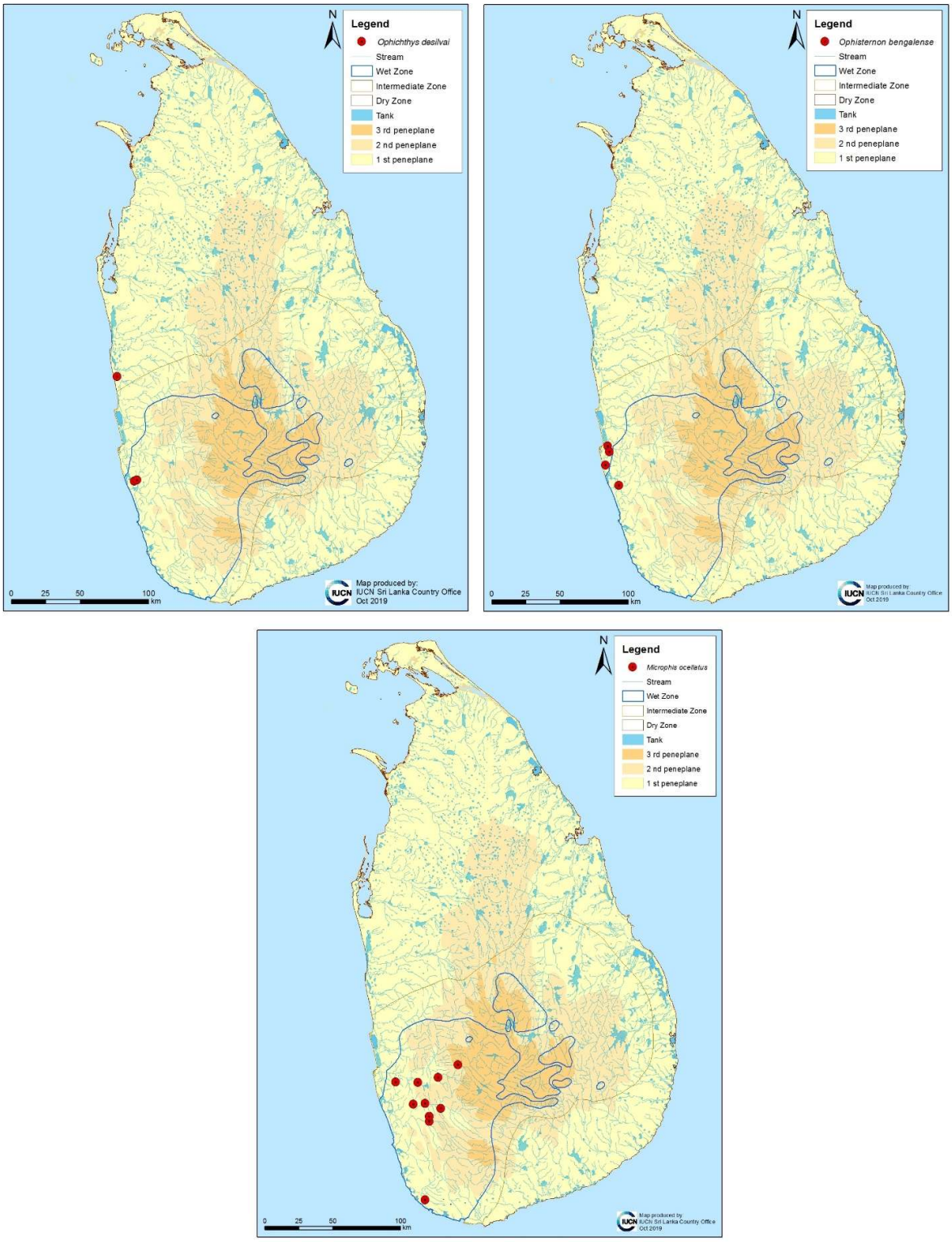

Figure 40. Known locations of top left: *Ophichthys desilvai*; top right: *Ophisternon bengalense*; bottom *Microphis ocellatus*

Annex 4: Bibliography

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IUCN, International Union for Conservation of Nature

IUCN is a membership Union uniquely composed of both government and civil society organisations. It provides public, private and non-governmental organisations with the knowledge and tools that enable human progress, economic development and nature conservation to take place together.

Created in 1948, IUCN is now the world's largest and most diverse environmental network, harnessing the knowledge, resources and reach of more than 1,300 Member organisations and some 16,000 experts. It is a leading provider of conservation data, assessments and analysis. Its broad membership enables IUCN to fill the role of incubator and trusted repository of best practices, tools and international standards.

IUCN provides a neutral space in which diverse stakeholders including governments, NGOs, scientists, businesses, local communities, indigenous peoples organisations and others can work together to forge and implement solutions to environmental challenges and achieve sustainable development.

Working with many partners and supporters, IUCN implements a large and diverse portfolio of conservation projects worldwide. Combining the latest science with the traditional knowledge of local communities, these projects work to reverse habitat loss, restore ecosystems and improve people's well-being.

IUCN has been working in Sri Lanka since 1988.

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***Systomus 'Richmondi': a* species new to Science**