NEW SPECIES 2023

THE FRESHWATER FISH SPECIES DESCRIBED IN 2023

IUCN SSC FFSG

CALIFORNIA ACADEMY OF SCIENCES

Shoal

Lake Zug, Switzerland

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SHOAL would like to thank collaborators Arthur de Lima, Jayasimhan Praveenraj, Larry M. Page, Leandro Melo de Sousa, Lucia Rapp Py-Daniel, Murilo Nogueira de Lima Pastana, Ole Seehausen, Oliver Selz, Rajeev Raghavan, Ray C. Schmidt and Tao Luo.

Furthermore, we wish to thank Jon Fong and Richard van der Laan from the California Academy of Sciences and Eschmeyer's Catalog of Fishes for their support in providing the full list of freshwater fish species described in 2023.

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Cover image: © Jia-Jun Zhou

SHOAL is the global initiative to halt extinctions and recover populations of the most threatened freshwater species around the world. It is hosted by Synchronicity Earth and Re:wild.
Learn more about their work at shoalconservation.org.

The IUCN SSC FFSG has a mission of achieving conservation and sustainable use of freshwater fishes and their habitats through generating and disseminating sound scientific knowledge, creating widespread awareness of their values and influencing decision making processes at all levels.

Eschmeyer's Catalog of Fishes database was begun in the 1980s at the California Academy of Sciences by Bill Eschmeyer. It is the primary resource for current knowledge on the kinds of fishes, and is updated continuously as new species are described[1].

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FOREWORD:
Mike Baltzer

New Species 2023 marks the third of SHOAL's annual *New Species* reports. As ever, the publication is designed to raise much needed awareness of the incredible diversity found in Earth's freshwaters, celebrate the researchers and taxonomists who work so hard to discover and describe species and, through that process, increase the hopes and chances that conservation attention may be directed to protecting and saving more species and habitats.

In late 2023, the IUCN Red List of Threatened Species released their first global assessment of freshwater fish species. The findings, while unsurprising to those working in freshwater species conservation, were damning: 25% of freshwater fish species are now known to be threatened with extinction, which confirms them as one of the most at risk vertebrate groups. Awareness-raising is a critical part of the work needed to give these species a chance of survival, and it's our hope and expectation that *New Species* reports will go some way to driving a greater appreciation for freshwater fish.

One of the more incredible stories in this edition is the seven whitefish species that were described in 2023 from three Swiss lakes. It's perhaps difficult to believe that in the 21st century so many fish species can be discovered from Central Europe. Species that fishers have known about for centuries have, incredibly, eluded description until now. And these findings are by no means a one-off: the researchers told SHOAL there will be many more freshwater fish species described from Swiss lakes over the coming years!

We hope you enjoy reading about each of these and the other fascinating species highlighted in the report.

Mike Baltzer
Execxutive Director, SHOAL

SUMMARY

243 *FRESHWATER FISH SPECIES DESCRIBED IN* 2023

201 *IN* 2022

212 *IN* 2021

This third edition of SHOAL's annual *New Species* reports has a distinctly subterranean feel, with three of the highlighted species being discovered from underground caves and aquifers. Research into subterranean fish has really intensified over the past few years, with an increasing number of species that make their homes underground being discovered and described, with China and India both being cavefish biodiversity hotspots. Researchers Dr. Tao Luo and Dr. Rajeev Raghavan have done extensive work in the countries, including describing species that are included in this report.

This year's cover star, the magnificent longhorn cavefish, sports a unicorn horn-like protrusion jutting from the back of its head. Nobody yet knows for certain what the 'horn' is for, but it certainly gives the species some style points! Turn to p.8 to learn about this fascinating fish, described by Luo and team.

Readers of *New Species 2022* may remember the story of the Pathala eel loach, which was discovered after it washed into somebody's bathroom as they were taking their morning shower: the team are at it again, with more subterranean discoveries that were brought to light as a result of extensive community engagement. Turn to p.30 to learn about *Horaglanis populi*, named 'of the people' as a nod to the local communities that have been instrumental in discovering these mysterious creatures.

The world's largest cavefish, the Indian cave mahseer, was also described in 2023 after being discovered in caves in Northeast India by Indo-European cave explorers. Turn to p.22 to discover how this giant of the subterranean world has most likely not come across many humans throughout its existence, and is so relaxed around them that it feeds directly from people's hands.

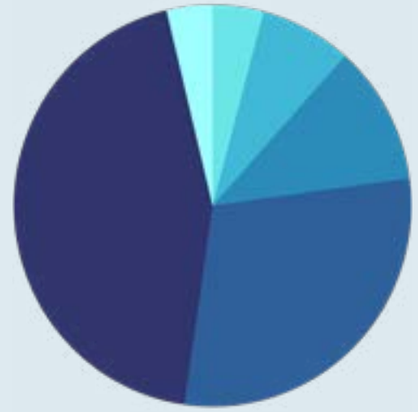
This 2023 edition also features seven whitefish species that were discovered from lakes in Switzerland. It is surprising to learn there are new discoveries being made in Central European lakes. Until recently, researchers and taxonomists thought that fish diversity in the region had been mapped years ago, meaning people tended to go further afield to conduct their work. This is now changing, led in part by the work of Prof. Ole Seehausen.

The numbers of freshwater fish species described from Europe has climbed considerably over the past three years: in 2021 there was only one from the region, in 2022 there were eight, and in 2023 there were an incredible 18! Amazingly, the researchers on the Swiss whitefish species, Prof. Seehausen and Dr. Oliver Selz, told SHOAL that there are many other species of freshwater fish that will be described from Central Europe over the coming years. SHOAL will keep you updated about these findings in future New Species reports. Turn to p.14 to find out more.

There have been more freshwater species described since the turn of the century than at any other equivalent timespan in history. And, with improvements in technology and increased research into the area, the numbers are trending upwards. There is still so much for us to learn about the remarkable diversity found in Earth's freshwaters. It is vital that we mobilise urgent conservation action towards them to ensure they thrive into the future.

Titus Phiri collecting *Labeotropheus* in Lake Malawi, 2020 © Michael J. Pauers

GEOGRAPHIC SPREAD



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GOING UNDERGROUND: SUBTERRANEAN HIGHLIGHTS

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Indian cave mahseer p.22

Horaglanis populi p.30

LONGHORN CAVEFISH

Latin name: *Sinocyclocheilus longicornus*
Researchers: Luo, Xu, Wu, Zhou & Zhou[1]
Location: Pearl River Basin, Guizhou Province, China
Highlight: Has a mysterious, horn-like structure protruding from its head.

Sinocyclocheilus is a genus of 76 species of freshwater fish that are endemic to China. Most of the species are distributed in the karst areas in the southwest of the country. Almost all members of the genus live in or around caves and most of these have adaptations typical of cavefish such as a lack of scales, lack of pigmentation and reduced eyes[2].

Sinocyclocheilus longicornus is the most recently discovered of these 76 species. Individuals have, like most cavefish species, no pigment and so appear white and pink. They grow to around 14cm long – tip of snout to end of caudal fin – and have a prominent horn-like structure on the back of their head, the function of which is currently unclear.

Tao Luo from the School of Karst Sciences, Guizhou Normal University, Guiyang, China, is the lead researcher on the paper describing *Sinocyclocheilus longicornus*. He told SHOAL that Jiajun Zhou, senior engineer at Zhejiang Forest Resource Monitoring Centre, Hangzhou, China, masters student Xingliang Wang, and himself, with the financial support of Prof. Jiang Zhou, "discovered the species by questioning local residents during a cave fish biodiversity survey near the county of Panzhou City, Guizhou Province, China, on 1 May 2022".

During one of the daily chats that the research team had with local residents, they learned of a white fish in a cave found in a cornfield. That same day, the three researchers made their way to the smooth-surfaced, near vertical, cave entrance. Luo said, "It's very difficult to enter this cave. It is found at the lowest point in the area – the surrounding topography is funnel-shaped – and all the water collects in this area. The entrance to the cave faces downward, is nearly vertical and very smooth, and requires a descent of about five meters.

Despite the dangers, they descended into the cave with no protection and found their first white fish in the first pool of water they entered. Knowing the *Sinocyclocheilus* genera well, they were confident they had discovered a species unknown to science – a confidence vindicated once an individual had been brought back to the lab and described by Cheng Xu and Tao Luo.

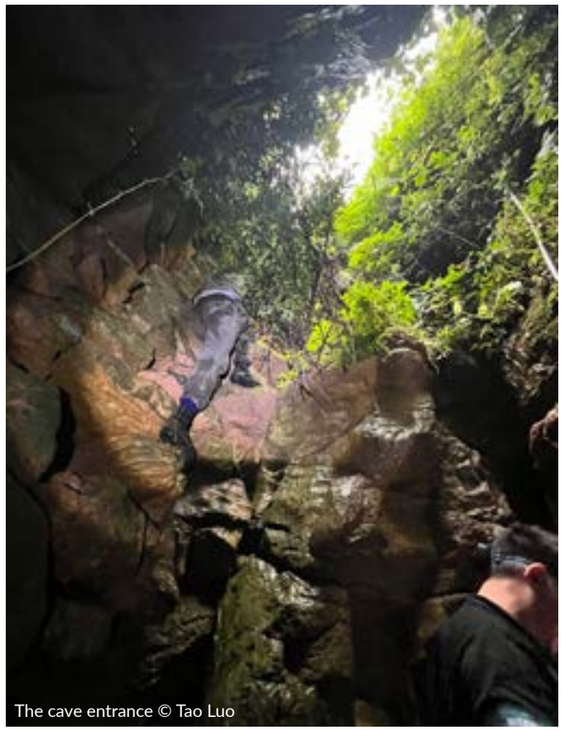

© Jia-Jun Zhou

Currently, the role of the horn-like protrusion on *Sinocyclocheilus longicornus* is unknown. Luo said, "We have two hypotheses. We hypothesise that it is related to the perception of water flow and is used to protect the brain, because the large amount of rainfall in the karst region, which collects in underground rivers, may have caused these fishes to touch the rock walls on a regular basis. The second is that it may be related to secondary sexual characteristics. But", he added, "these need to be confirmed by a lot of work".

The researchers have conducted 12 surveys of the cave over the past three years. Luo is pessimistic about longhorn cavefish populations, and the threats facing them: "The population numbers are in very bad shape, and with the combination of the 12 surveys, we speculate that it could be around 60-100 individuals. We found large amounts of plastic waste inside the cave and in the surrounding area. This domestic waste and pesticide use by local residents are the main factors threatening the life of this species. With its unique phenotype, *Sinocyclocheilus longicornus* may also be the target of some trafficking, and the future expansion of urbanisation may also lead to the disappearance of the species' habitat as the only habitat is located near Panzhou City".

In the near future, the research team will complete the process of sequencing the entire genome of the species and exploring at the genomic level the history of the genes and population dynamics that control the "horns", as well as the genomic mechanisms of adaptation to cave life.

"In the future", Luo added, "what we would like to do most is to complete the captive breeding of the species in order to deal with the possibility of extinction".


The cave entrance © Tao Luo


© Jia-Jun Zhou

GOLDFIN TETRA

Latin name: *Moenkhausia guaruba*
Researchers: de Lima, Vita, Dutra, Ohara & Pastana[3]
Location: Rio Tapajós basin, Pará, Brazil
Highlight: Described from a paradisiac waterfall on a military base in the Amazon.

In the far northwest of the Brazilian state of Pará, deep in the Amazon rainforest, lies the massive Campo de Provas Brigadeiro Velloso, a military base operated by the Brazilian Air Force. A perimeter fence runs for 653 km, keeping intruders out of the 21,588 km² area and, as a result, ensuring the lush biodiversity within the military confines is well protected.

For those that know where to look, gold can be found within those secure borders – schools of shimmering goldfin tetras flashing under a paridisiac waterfall deep inside the secured area.

Murilo Nogueira de Lima Pastana, fish curator at the Museum of Zoology of the University of São Paulo and researcher Arthur de Lima, a PhD candidate at the University of São Paulo had come across specimens of this species from the Museum of Zoology of the University of São Paulo, which were collected in the early 2000s. They knew they looked different from the descriptions of any other species, but they had no idea what the species would look like alive, as the brilliant gold colouration had dulled through the formalin preservation process. Pastana said, "We knew we had something that looked odd, that didn't fit previous descriptions, but we didn't know if it was a new species and we didn't know what it would look like alive".

Pastana planned the field trip to Campo de Provas Brigadeiro Velloso to try find this species and a handful of others, including tetras, plecos, *Corydoras*, and *Apistogramma*. He explained how difficult it is to reach the type locality: "Before even going to the field, we had access permissions with the military. It took maybe six months of exchanging emails with military people to gain access. And the area is very remote – we had to fly three or four hours to the closest state capital, then drive north into the Amazon for 12 hours. There is a small gate

in the middle of nowhere – the closest village could be two to three hours from there".

Once at the waterfall though, the fish was easy to catch using seine nets and gill nets. And, Pastana told SHOAL, "As soon as got it, we knew straight away we had something new and different".

The team brought 32 individuals back to the lab, where de Lima worked on the taxonomic process of describing the tetra as a new species, which the team named 'guaruba' after *Guaruba guarouba*, the golden parakeet – a beautiful golden-yellow parrot native to the same region of the Brazilian Amazon.


© Murilo Nogueira de Lima Pastana

The waters where the golden tetra was discovered are crystal clear. Clear water fishes often prioritise their vision to navigate and find prey and, as the bright yellow is highly visible in the water, Pastana and de Lima believe the golden tetra's intense bright colouration is a way for individuals to easily recognise other individuals of the same species.


Type locality © Murilo Nogueira de Lima Pastana


Part of the species' range © Murilo Nogueira de Lima Pastana

The golden tetra is one of the largest – if not the largest – species in the *Moenkhausia* genus, which has almost 100 species.

Pastana and de Lima predict the population is likely to be robust and stable. Pastana said, "It's good that the species is found in a military area, as it's preserved and controlled. The area is well taken care of".

There is also a heightened chance of finding intense biodiversity in protected areas of the Amazon. De Lima said, "There is a clear correlation between how well preserved and remote the area is and how likely it is to discover new species".

There could be potential threats to the golden tetra. On Google Earth, it is clear to see a sharp line cutting through the rainforest, showing the demarcation of logging areas outside the protected military zone, and the anthropogenic disturbance is likely to affect many of the fish species found outside the protected zone. Much of the Brazilian Amazon also faces possible threats from logging, cattle ranching, and mining.

For now, fortunately, the golden tetra seems safe.

Pastana has now been involved in describing 12 new species. When asked what pushes him to continue discovering and describing species, he said, "Every species is utterly unique. We don't need to put these species in a museum to appreciate their uniqueness and ability to tell a story. Each species is its own work of art, and that's why we want to discover them and protect them all – they are all part of a magnificent artwork".

De Lima added, "Every time something new is described, it adds to the total source of information of that area. The knowledge we've been creating goes well beneath the applications most people see. Taxonomy is unique".


© Murilo Nogueira de Lima Pastana

PEACH BLOSSOM MINNOW

Latin name: *Zacco tiaoxiensis*
Researchers: Zhang, Zhou & Yang[4]
Location: Hangzhou, Zhejiang Province, China
Highlight: : Discovered in a megacity of more than 10 million people.

For over two decades, a programme to clean up the the Chinese megacity of Hangzhou has benefitted an extensive network of waterways that crisscross the metropolis. A team of more than 50 volunteer, non-government river stewards, including lawyers and environmental activists, conduct regular check-ups and work closely with government river chiefs to monitor ecosystem health.

In that time, Hangzhou's rivers and creeks have improved considerably, changing from polluted, dirty and degraded waters, to clean systems swimming with biodiversity.

It is rare for a new species to be discovered in a city as large as Hangzhou. And the discovery of the peach blossom minnow by Zhou Jiajun from the Zhejiang Monitoring Centre of Forest Resources was a direct result of the city's authorities cleaning up their act when it comes to freshwaters.

Zhou said, "There used to be mines and industry by the river, so parents asked us not to go in the river. But now the water is clear!"

The peach blossom minnow, nicknamed as such by local people impressed by the vivid yellow-orange specks and stripes across the species' back, is found in clear and shallow streams with gentle currents and small pebbles or gravel substrates. It feeds on bugs, insects and crustaceans, and has only ever been found in the Tiaoxi Creek basin, which spans Hangzhou's Yuhang district and Huzhou's Deqing county.

The discovery of *Zacco tiaoxiensis* is the fifth species in the *Zacco* genus – a name which derives from the Japanese 'Zako', meaning 'course fish'.


© Zhou Jiajun

REDTAIL GARRA

Latin name: *Garra panitvongi*
Researchers: Tangjitjaroen, Randall, Tongnunui, Boyd & Page[5]
Location: Ataran River drainage, Salween River Basin, Thailand and Myanmar
Highlight: : Popular in the aquarium trade since at least the early 2000s, but unknown to science until now.

With their flame red tails, the redtail garra has been a popular aquarium fish for decades, yet finding information about their biology has proven difficult, as the species has only recently been described to science[6].

Larry Page, curator at the Florida Museum of Natural History, found a few redtail garra on a fieldwork expedition to the Ataran River, on the border between Thailand and Myanmar. The type locality is remote, and takes several hours to reach from the nearest city – Sangklaburi – along gravel and dirt roads. The small, isolated range is part of the reason the species has been relatively unknown in the wild while being readily available in many aquarium stores.

Page said, "When we first collected specimens, we thought it must be widespread in Myanmar because of its popularity in the aquarium trade," Page said. "But it turns out it's not. It's only in the Ataran River Basin".

The recent description adds to the 200 species in the *Garra* genus. Although the genus is one of the most widespread globally, research on their natural history is lacking.

"There's surprisingly little information on their natural history," Page said. "Most of them live in fast-moving water, and they have a disk-like structure formed from a modification of the lower lip, which they use as an adhesive pad to cling to rocks and maintain their position in the water column as they feed."

Two of the features that stand out about the redtail garra are the bright tail that gives the species its name, and the hardened tubercles on its snout which, according to Page, have various functions in fish, "including stimulation of the female when spawning," though this is usually a characteristic of species in which only the male has tubercles.

"Another function," Page added, "possibly relevant here, is defending territories, i.e., using tubercles as mammals use horns. Given the presence of tubercles on both sexes, this could mean defending feeding areas".

These functions are only speculation, and more research needs to be done on the species' behaviour to get a more comprehensive picture.


© Zachary Randall, Florida Museum of Natural History

SWISS WHITEFISH SPECIES

Latin name: *Coregonus intermundia, C.litoralis, C.muelleri, C.suspensus, C. sarnensis, C.supersum and C.obliterus*
Researchers: Selz, Oliver M. & Seehausen, Ole[7]
Location: Lakes Lucerne, Sarnen, and Zug, Switzerland
Highlight: : Seven whitefish species described in 2023 alone in Central Europe.

In Switzerland, a complex of cold, deep, nutrient-poor mountain lakes connect via a river network. This unique aquatic system doesn't occur anywhere else in Central Europe and, after the retreat of the ice after the last ice age, many of the lakes have become refuges for cold-water specialised fish, such as whitefish.

These Swiss lakes once harboured approximately 34 endemic species of whitefish native to 17 lakes. Due to anthropogenic eutrophication of lakes in the middle of the 20th century, one third of this diversity has been lost (Vonlanthen et al. 2012; Hudson et al. 2013; Alexander et al. 2017b).

However, recent work by evolutionary ecologist Prof. Ole Seehausen and researcher Dr. Oliver Selz has uncovered 11 new *Coregonus* whitefish species, including seven described from three lakes in 2023 alone.

C. intermundia, C.litoralis, C.muelleri and *C.suspensus* were described from Lake Lucerne, *C. sarnensis* was described from Lake Sarnen, and *C.supersum* and *C.obliterus* were described from Lake Zug.

How is it possible there are still numerous species being discovered from Central Europe? In part, it comes down to the fact that some of them can be difficult to tell apart. Selz, a former evolutionary biologist at Eawag, Switzerland, and current scientific advisor for the Swiss federal government for the environment, said, "While some species are easily distinguished, others can be very difficult to distinguish for scientists, fishermen and fishery authorities. For these species, you need molecular genetics to find out they are genetically distinct, as their differences in morphology, ecology and behaviour can be subtle".

The Swiss whitefish are well known in Switzerland and have been a popular food fish there for hundreds of years. The Swiss generic name of 'brotfisch', translating as 'breadfish', shows how interwoven with local culture they have been.

A good observer, as fishermen often are, can distinguish some of the Swiss *Coregonus* species with the naked eye. This has resulted in many local names for different and sometimes the same species of whitefish. Accordingly, taxonomic descriptions of some of the species were published a long time ago. Some, but not all, of the newly described species are more difficult to distinguish, meaning there has been far more diversity swimming through the Swiss lakes system than previously thought.

And it doesn't end at the whitefish. According to Seehausen, a professor at the institute of Ecology & Evolution (IEE), University of Bern, "There are new species in other groups of fish. It was initially hard to believe: loaches, minnows, sculpins – totally distinct species that are evolutionary much older [than the *Coregonus*]. Comparatively little has been done by taxonomists on the fish in Europe for a very long time. It may be because students are taught that it is very unlikely there will be new species discovered in Europe, but this is changing in recent years".

This emerging knowledge on the Swiss whitefish has been a long time in the making. Seehausen started working on this group when he moved to the country in 2004. He said, "I started working on whitefish about 20 years ago. I knew that little evolutionary and systematic work had been done. We mapped out the diversity like I had done with African cichlids [earlier in his career and ongoing]. About 10 years into the programme, I realised I had to describe them. It took about 15 years to start working on the taxonomy formally. Oli [Selz] was trained by me in evolutionary biology of cichlid fish and then did a post doc in taxonomy of whitefish".

So do the species have robust populations, and are they still at risk from anthropogenic eutrophication and other threats? Seehausen said, "It depends, is the short answer, on the lake and the species. But none of the species have a big distribution and all should be considered vulnerable".

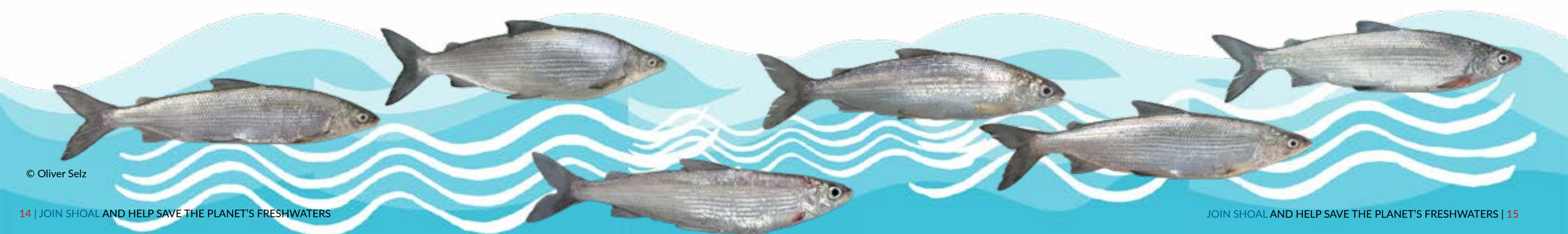
Some of the lakes still have very high phosphorus levels due to historically untreated wastewater (before wastewater plants equipped with phosphorus removal were built starting in the 1960's), the use of certain laundry powders (which have been banned in Switzerland since 1986) and agriculture run-off (which is the main problem today). These lakes still have issues with eutrophication. Seehausen said, "When lakes become eutrophic and polluted, the oxygen in deeper waters gets depleted. The deep water adapted whitefish species don't go straight to extinction but start hybridising with other species in the habitat of the other more shallow-living species, where oxygen is still sufficient. Pollution and eutrophication drove the rates of extinction in this system".

The changing climate is also a threat. The lakes cool down more slowly in the milder winters, meaning there is less mixing of water between the different depth layers in the lakes, which leads to the oxygen reserves in the deeper parts not replenishing every winter as they had in the past.

There is also a threat from the invasive quagga mussel. According to Selz, "they currently occur in a few lakes in Switzerland and will most likely cause strong changes to the ecosystems.

"Lake Constance' whitefish species have experienced a strong decline in abundance over the last years, coinciding with the occurrence and increase in quagga mussel and pelagic stickleback. The situation was considered so serious for the whitefish that a three-year commercial and recreational fishery ban on whitefish started this year. Some cantonal authorities bordering lakes that so far do not contain quagga mussels have implemented regulations to contain transmissions into these lakes. These regulations ensure that the hulls, bilges and motors of boats are washed before they can be slipped into a different lake".

In future *New Species* editions, expect many more species in Central Europe described by Seehausen and team!



© Oliver Selz

LIMAAKUM BADIS

Latin name: *Badis limaakumi*
Researchers: Jayasimhan Praveenraj[8]
Location: Nagaland, Northeast India
Highlight: : Named after the person who discovered it – an uncommon practice – to help raise more support for biodiversity in India's remote northeast.

The Limaakum badis is a new addition to the 26 species in the *Badis* genus of freshwater fish, which can be found throughout Pakistan, India, Nepal, Bhutan, Bangladesh, Thailand & Myanmar

It was discovered in Nagaland, a remote region of Northeast India, in 2020 by Limaakum, an assistant professor and head of the zoology department, Fazl Ali College, Nagaland.

Praveenraj Jayasimhan, a scientist at ICAR-Central Island Agricultural Research Institute and author of the study, started collaborating with Limaakum in 2019. He told SHOAL that, "Limaakum goes into the field and catches fishes and investigates bycatch from local fishers. And that is how we discover new species. Nagaland is very rarely explored and there is a high chance there are many species there that have yet to be described".

Badis are said to be 'chameleon-like', as they can change their colouration based on environmental factors. Jayasimhan said, "they have chromatophores inside the scales which reflect light or migrate as per the mood of the fish, the water quality, if there is any aggression, or during spawning and breeding".

The species should be described based on the original colour at capture, rather than using a dead or preserved specimens. Jayasimhan said, "Females will usually be dull, with a greyish blue colour. Males are brighter and more beautiful, and become more so during breeding to attract females. They display blueish to pale yellowish body colour, with some reddish vertical stripes on the body. When I first received a photo of the dead specimen, it was black or greenish grey, so it was difficult to describe the colours for the description".

It is uncommon for species to be named after the person who discovered it. Jayasimhan said, "People

in Nagland India are poorly recognised and I wanted to honour Limaakum for doing so much work to discover it. Honouring him will lead to more support for biodiversity in the northeast".

Jayasimhan predicts that, due to the species' beautiful colouration, it is likely to have high value as an ornamental fish. He isn't concerned this may lead to overharvesting issues. "There are currently no ornamental fish exported from Nagaland as there is no connectivity to major cities. The species is abundant right now, and local people serve the fish as a food – they make a curry from it using bamboo shoots. The trade won't cause any problems to the population".

In an interview with the Nagaland Tribune in 2023, Limaakum said, "Initially, we thought that it was just some other *Badis* species like *Badis assamensis* or *Badis badis*, but when I reared some live fishes in an aquarium, they changed their colour and the colouration turned out to be quite different from other related species"[9].

He added that the species' habitat, "features an abundant invertebrate community and… is a unique and fragile ecosystem that supports a rich diversity of life, including not only the newly discovered fish but also various other species like amphibians, reptiles and mammals".

Jayasimhan told SHOAL that, "destructive fishing methods such as poisoning the river is common in the northeast. That has to be avoided to ensure the biodiversity there can thrive".


Part of the species' range © Limaakum


© Limaakum

GOING UNDERGROUND: THE 'GHOSTS BENEATH OUR FEET'

New Species 2023 has a distinctly subterranean feel, with three of the 11 species sections featuring fish from the unseen world beneath our feet.

It's no wonder: subterranean fish are some of the most bizarre and fascinating creatures in ichthyology and, with increasing research efforts on them, they are being discovered and described in ever greater numbers.

SHOAL spoke with Tao Luo, the lead researcher involved in the description of the longhorn cavefish (p.8), and Rajeev Raghavan, who has played a major role in the descriptions of many of India's subterranean fish, including the Indian cave mahseer (p.22) and *Horaglanis populi* (p.30). Each of them shone some fascinating insights into this burgeoning field.

Tao Luo, School of Karst Sciences, Guizhou Normal University, Guiyang, China:

SHOAL: Have there been many subterranean fish discoveries in China?

TL: China is a biodiversity hotspot for cave fishes, concentrated in southwestern China, including Guizhou, Guangxi, Yunnan, Chongqing, Hunan and Hubei provinces. According to our recent inventory, there are 184 species of cave fishes in China, dominated by *Sinocyclocheilus* and Nemacheilidae.

SHOAL: Have you been involved in the discovery or describing of other subterranean fish species other than *Sinocyclocheilus longicornus*?

TL: I have been involved in cave fish surveys since 2016, focusing on Guizhou Province, China. After nearly five years of professional study and practice, *Sinocyclocheilus longicornus* was discovered in 2021 and first published in 2023. In 2023 I described a total of six species, including four species of the genus *Triplophysa*, namely *Triplophysa cehengensis, Triplophysa rongduensis, Triplophysa panzhouensis, Triplophysa anlongensis*[10]; the first cave fish of Balitora, *Balitora anlongensis*[11]; and *Oreonectes damingshanensis*[12]. In addition, I have reconstructed the phylogeny of Chinese cave loaches using mitochondrial genomes and multinucleated genes, revised the phylogeny of *Heminoemacheilus*, *Oreonectes*, *Yunnanilus*, *Paranemachilus*, and *Troglonectes*, and created a new genus *Karstsinnectes*[13]. We revealed the phylogeny, origin and evolution of *Sinocyclocheilus* in 2022[14]. I am also involved in the description of new species of cave fishes and recently two new species are about to be published.

SHOAL: What do you find exciting about subterranean fish?

TL: Cave ecosystems are the least known and the most vulnerable, and the organisms that live in them are very susceptible to impacts. However, we know very little about the diversity of cave organisms, especially cave fishes, due to the inaccessibility of caves and the complex subterranean environment. Therefore, the study of cave fish diversity will not only increase our understanding of the Earth's biodiversity, but will also contribute to the development of relevant conservation actions. In addition, since the development of caves is related to orogeny and paleoclimate, when enough cave fish species are obtained, the evolutionary history of cave fish can be reconstructed by the same biogeographic method to reflect how the past has influenced the formation and distribution of cave fish. This is what I am most interested in and working on. Of course, adaptation to cave environments is also an interesting scientific study.

Tao Luo and colleagues from the School of Karst Sciences, Guizhou Normal University, outside the cave where the longhorn cavefish was discovered © Tao Luo

Rajeev Raghavan, assistant professor, Kerala University of Fisheries and Ocean Studies, India:

Rajeev Raghavan © Rajeev Raghavan

SHOAL: Why is there such a significant increase in subterranean fishes being discovered in India?

RR: I think the major reasons are increased research efforts and increased awareness. Over the last few years, there has been a strong focus on groundwater and subterranean biodiversity research in India, especially in southern peninsular India. Local communities who encountered strange fishes in their wells for years and discarded them thinking they are not of much use, or after misidentifying them as earthworms or other creatures, have now realised their uniqueness. They now work closely with researchers, resulting in a successful citizen science initiative, and helping discover several new species. Researchers now have access to many more specimens than they ever had, helping in understanding distribution of the species, as well as intraspecific variations in morphology and genetics.

SHOAL: What originally led you to put so much attention towards subterranean fishes?

RR: The fact that there are so many unique species in the groundwater systems about which we know very little, and that these groundwater systems and associated habitats are facing severe anthropogenic threats, meaning many species could go extinct before they are even described. It was the excitement of working on a field of ichthyology in India which has been largely ignored.

SHOAL: How did you and the team set about engaging local residents?

RR: Mainly through community-level awareness programmes, as well as one-to-one meetings with members of households owning a dug-out well. There was no single, straightforward approach. We continue to adapt, and our strategies evolve as we learn more about the fish, the landscape and the people.

SHOAL: What has the response been from the local communities?

RR: It has been excellent. Working with local communities around the laterite landscape of the region has been a rewarding experience for our team. Local communities who didn't care about these fish at all have suddenly started to become curious and interested in the life underground and the significance of these species. Many times, they have taken extra effort to maintain fish that they accidentally encountered whilst cleaning their wells, until our research team got to their localities.

SHOAL: How often do residents get in touch with you to let you know about fish they've found?

RR: Two or three years ago, it was once every few months. This has now increased to at least once, sometimes even twice a week. More people have now become aware of these fish, and our work to unravel the biodiversity of groundwater systems.

SHOAL: How often are these 'new' species?

RR: Every other fish that we encounter in the groundwater and subterranean systems are likely to be 'new'. Very little exploration and research has been undertaken in these 'inaccessible' systems, and we don't really know the magnitude of biodiversity. I would say that there could be at least a dozen (if not more) new species awaiting discovery in the groundwater systems of India.

SHOAL: What excited you about subterranean fish?

RR: No doubt they are some of the coolest fish I have come across in my career. They are 'underwater ghosts' – many species are white, pale, without eyes and fins. Apart from their strange morphology, these fish also have strange habits. They seldom eat, and starve for days and weeks at a stretch without any changes to their captive behaviour and survival. Most importantly, these fish have an interesting evolutionary history: they are ancient fish that can tell us the history of the world.

Rajeev Raghavan © Rajeev Raghavan

INDIAN CAVE MAHSEER

Latin name: *Neolissochilus pnar*
Researchers: Dahanukar N, Sundar RL, Rangad D, Proudlove G, Raghavan R[15]
Location: Caves in the Jaintia Hills of Meghalaya, Northeast India
Highlight: The world's largest known cavefish.

In 2019, a group of Indo-European cavers were exploring limestone cave systems of Meghalaya, Northeast India as part of an expedition to map the subterranean landscape of the region. Deep inside a large, vertically-walled cave where even experienced cavers with the right equipment can only reach after an entire week of moving through tunnels and crawling through cracks, the team found a big pool with a school of large, white-coloured fish.

The cavers approached the fish and were surprised when they came and ate cookies directly from their hands. They noticed the larger individuals had no eyes at all, though the smaller, likely youngers ones did.

The cavers weren't ichthyologists, but realised the species was likely to be interesting to researchers focusing on India's subterranean fish species. One of the members of the expedition team, Dr. Daniel Harries from Herriot-Watt University, Edinburgh sent media footage of the species to Dr. Rajeev Raghavan, assistant professor at the Kerala University of Fisheries and Ocean Studies, who immediately recognised the species as looking similar to the mighty mahseer species of the *Tor* and *Neolissochilus* genera.

Raghavan knew there were no known cave mahseers in India and, as the fish were found in a region that overlaps with the golden mahseer, he thought it could be a similar species.

According to Raghavan, "We published a short account of this finding in 2020, that there was this cave-dwelling mahseer superficially resembling the golden mahseer (*Tor putitora*), but the lack of specimens for detailed studies meant that it couldn't be given a scientific name. Taking a precautionary approach, we took it as a cave variant of the golden mahseer".

It was only in 2021, when more specimens of the fish were available for detailed studies that they could confirm it was not a golden mahseer variant, but an undescribed species of the sister-genus *Neolissochilus*. The researchers carried out an integrative taxonomic study based on detailed examination of the morphology, as well as the genetic structure to confirm that the fish was in fact a new species.

With scant food resources in many of the world's caves, most cavefish species are small, with a standard length of less than 130 mm and a mean size of just 85.5 mm. The largest Indian cave mahseer individual observed in the cave exceeded 400 mm in standard length, making it the largest known individual of any subterranean fish in the world (Harries et al. 2019).

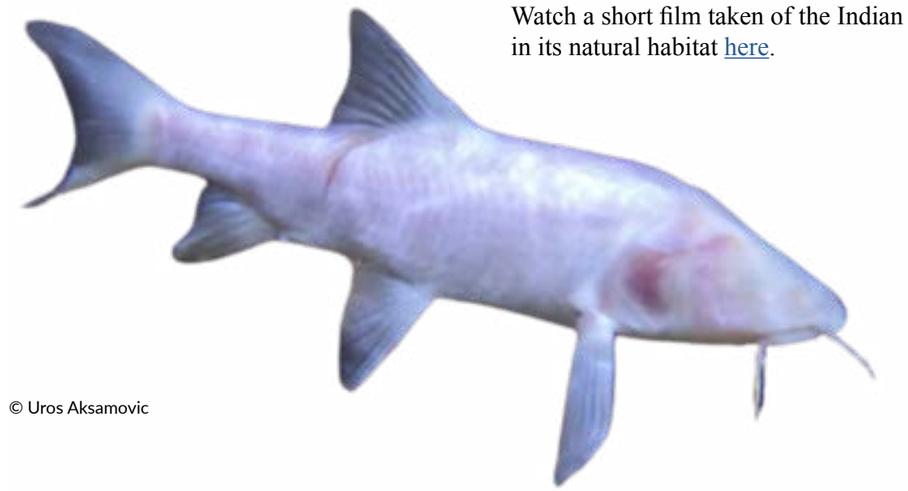
It is thought that the fish feed off nutrients and food materials that wash into the caves during the rainy season, as with other cavefish, though Raghavan believes part of the reason this species has grown so much larger than other subterranean species is a likely ability to feed off invertebrates that can also wash into the caves when it rains heavily. He believes that the monsoon months are the period when most of the growth occurs in the fish, when they are actively feeding on the materials that enter the caves through the torrents. Raghavan said, "They have teeth and look carnivorous like any other mahseer on land".

During the dry months, they forage for any remaining food reserves, and it was during this dry period that undisturbed fish would readily approach and 'mouth' any object placed in the water. While cookie crumbs wouldn't exactly be a natural food source for the fish, Raghavan explained that the lack of enough food resources in the caves was a reason why they were comfortable eating the crumbs sprinkled on the water surface by the cavers.

The researchers currently have no clues about the species' population or distribution. There is extensive limestone mining that happens in the mountains surrounding the fish's range – potentially not exactly in the cave where the holotype was discovered – but the larger area is threatened, which may affect populations in the future.

'Pnar' are an Indigenous tribal community of people who live in the species range. Many of them work as helpers in the caving expeditions and, according to Raghavan, they have probably known about these fish for 100 years, before scientists documented them. We named the species to honour these Indigenous peoples".

Watch a short film taken of the Indian cave mahsser in its natural habitat here.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FRODO'S SUCKERMOUTH CATFISH

Latin name: *Chiloglanis frodobagginsi*
Researchers: Ray C. Schmidt, Pedro H. N. Bragança, John P. Friel, Frank Pezold, Denis Tweddle, Henry L. Bart Jr.[16]
Location: Upper Niger River, West Africa
Highlight: Named after the long-journeying J. R. R. Tolkien character from Lord Of The Rings, Frodo Baggins.

A diminutive character that made an 'unexpected journey': Ray C. Schmidt recognised Frodo's suckermouth catfish as sharing some qualities with the famous J. R. R. Tolkien character from Lord Of The Rings, and named the species after the legendary Hobbit.

Roughly 3,000 miles (4,800 km) separate *Chiloglanis frodobagginsi* in the upper Niger River drainage and *C. micropogon*, the sister species, found in the Congo River basin. It is unclear whether these species are descended from a more widespread species, or the result of dispersal from the Congo River basin into the Niger River drainage, via the Benue River, and then up to the headwaters of the Niger River. This was an incredible journey for such a small fish that doesn't seem to swim well.

© Sandra Raredon

Ray Schmidt, assistant professor at Randolph-Macon College, research associate at the Smithsonian, and lead author on the paper describing Frodo's suckermouth catfish, told SHOAL that, "These fishes were first collected probably in the 1940s and 1950s by a fellow named Jacques Daget, and he noted how similar they were to fishes collected in the Congo, which he thought was strange. He sent them to Max Poll at the Royal Museum for Central Africa in Tervuren, who said they were somewhat different from those he collected in the Congo but not enough to warrant recognising them as a distinct species".

In 2013, Schmidt collected more specimens, from which he was able to obtain some tissue samples. He said, "They were not easy to find. For a long period of time, people thought there was only one or two species of *Chiloglanis* in the Upper Guinean Forests. I noticed that the different species were in different habitats, some by tree roots, others in gravel in the middle of the stream. We found the *C. frodobagginsi* in the middle of the rivers over the gravel. It took a little while to get them, and they are not super abundant. Because of their suckermouths, it can be very difficult to catch them with nets. You have to be looking for these things to catch them".

© Sandra Raredon

Knowing about the species since 2013, Schmidt had plenty of time to think of what name to give it. "I thought it was so interesting that this little fish could get all the way from the Congo to the Upper Niger. How was that possible? I thought, what are some good names for small travellers? I was thinking of Gulliver's travels, but thought, 'ah, I should name it after a Hobbit!'".

Frodo's suckermouth catfish is likely restricted to the Upper Niger River in Guinea and Mali. There are, according to Schmidt, "likely quite a few populations, say 20 or 30, and if you lose one it's not going to wipe out the species. But in Guinea, there's a lot of ore mining, and associated activities, that will negatively affect the streams. The species is likely threatened, as there's a limited amount of habitat they occupy".

The species' diet is likely to be the same as other *Chiloglanis* species, i.e. the organisms within the periphyton that they scrape off the rocks and woody debris. As with many catfishes and all *Chiloglanis* species, stepping on these fish or grabbing one in hand can produce painful stings when the dorsal and pectoral spines puncture the skin and the venom gland cells surrounding the spines are ruptured, allowing venom to enter the wound" (Wright, 2009).

Researchers currently know very little about the species' ecology or reproduction. Schmidt said, "This is true for African freshwater fishes in general, which is a real problem. We know nothing about them, so we know nothing about what, for instance, a dam will do to the species. People, non-scientists, take for granted that we just know things, but the key is that we don't know. We have no idea what's happening in these African freshwaters for the most part. We're in this race to figure out what's there before it goes away. It's really challenging. In African freshwaters, there are so many new things that need to be described and conserved, but this can only happen if we continue to sample and monitor these environments".

Mafou River © John Friel

RAONI'S OPAL SPOTTED PLECO

Latin name: *Scobinancistrus raonii*
Researchers: Chaves, de Oliveira, Gonçalves, Sousa & Rapp Py-Daniel[17]
Location: Xingu River basin, Brazil
Highlight: Likely to be classed as Endangered due to anthropogenic threats from the Belo Monte dam.

Raoni's opal spotted pleco, also known as 'tubarão' ('shark') and 'arábia´ by local communities in the Xingu River, has been known as L82 in the aquarium trade since the 1990s. It is only known from a limited distribution area, on a stretch of river in the middle Xingu River, Pará State, approximately 300km long.

Lucia Rapp Py-Daniel, an ichthyologist at the National Institute for Amazonian Research in Manaus, Brazil, has been collecting fish in the Xingu River for over three decades. There is a list of a dozen fish species collected from the region that are yet to be formally described. Rapp Py-Daniel told SHOAL, "We have a list of new species to be described, but we have constraints of time, number of specimens available, and so on. In this particular case, we had the opportunity to have recent collected specimens and tissues for molecular analysis".

The body of the Raoni's opal spotted pleco is covered by large yellow spots over a dark background – likely a camouflage for the fish in its preferred habitat of encrusted gravel on conglomerate rock. The maximum recorded size is 20 cm, and it has a bulky body with armour-like plates on its head and sides.

Rapp Py-Daniel considers the armour plating to be, "quite efficient, especially for medium to large size loricariids, [and] the plates are certainly a protection against many kinds of fishes". But adds that, "Raoni's opal spotted pleco is a small species, and many loricariids are the prey of caiman, turtles, stingrays, birds, big catfishes and otters".

The species is named in honour of Cacique Raoni Metuktire of the Kayapó people. Raoni is an Indigenous leader in the Xingu River Basin and has been very active in the struggle to preserve the Amazon rainforest and Indigenous peoples for more than 40 years. Raoni has publicly expressed his grave concerns about dam projects in the Xingu River Basin since the 1980s, and participated in global tours, including with the musician Sting, to raise awareness of the issues the dams would bring to his people, the river, and the local ecology. According to Rapp Py-Daniel, "It was clear that Belo Monte, and other dams planned before Belo Monte, were going to be an ecological disaster. Raoni was a visionary to anticipate how the Rio Xingu would suffer with this kind of construction".

© Leandro Melo De Sousa

The pleco's range is in an area under a strong anthropogenic impact from the Belo Monte dam and, with water flow reduction and exposition of rocks of the extensive running waters of the Volta Grande do Xingu due to the deviation of the main channel of the Rio Xingu, the researchers estimate a loss of 45% of the original area. Furthermore, in the upstream portion of the Pimental Dam, including the vicinity of Altamira city, the river was transformed into a large and deep reservoir, causing an additional reduction of 21% of the original range of the pleco. Based in the decline of quality of habitat, area of occupancy, threats from dams, and consequently reduction of the population, Raoni's opal spotted pleco could qualify for the Endangered category under the IUCN (2022) standards .

There is also, according to Rapp Py-Daniel, "the impact of the artificially controlled water level of Xingu to produce electricity that interferes directly in the maintenance of a very complex ecosystem that sustains animal communities and the forest. All this impacts directly on the fishermen and Indigenous peoples that live and depend on Xingu natural resources". She added, the impacts "are still far from being completely understood".

There are currently many conservation initiatives and studies in the region to try get a clearer picture of how the fish communities are impacted by the region's anthropogenic pressures.

Rapp Py-Daniel added, "It is important to create this awareness about the fish diversity in Rio Xingu, as well as other rivers in the Amazon. Taxonomy takes a long time to finish and demands a lot of hard work. But without taxonomy and knowledge about morphology, we cannot distinguish or understand how many species we have, how they differ, how they evolve in certain areas, why they developed certain morphological features, and so on. This huge diversity exists and the sooner we know it, the better we are able to preserve it."

LABEOTROPHEUS SPECIES

Latin names: *Labeotropheus alticodia, L.aurantinfra, L.candipygia, L.chirangali, L.obscurus,* and *L.rubidorsalis*
Researchers: Pauers, Michael J., and Phiri, Titus B[18]
Location: Lake Malawi, Africa
Highlight: The latest additions to the most diverse vertebrate family on Earth.

Cichlids are one of Earth's marvels. They are the planet's single most diverse family of vertebrates, and constitute a remarkable one in ten of all fish species[19]. In lakes Malawi, Tanganyika and Victoria alone, there are approximately 2,300 cichlid species that, according to Axel Meyer, professor of zoology and evolutionary biology at the University of Konstanz, 'display every rainbow hue and range

© Michael J. Pauers

from about an inch to three feet in length'. They have evolved adaptations to eating every conceivable food source in their environment and 'represent a textbook example of what biologists term as adaptive radiation—the phenomenon whereby one lineage spawns numerous species that evolve specialisations to an array of ecological roles'.

The Rift Valley Lakes cichlids evolved at an astonishing speed, 'within the past 15,000 to 10,000 years—an eyeblink in geologic terms'. In Meyer's words, 'As we explore the genetic underpinnings of the extraordinary success of this group of fishes, we are glimpsing the very cogs and wheels of evolution—insights that will help researchers decode the origins of all manner of species'[20].

Until 2023, there were five recognised *Labeotropheus* species. The work of Michael J. Pauers, professor of zoology, University of

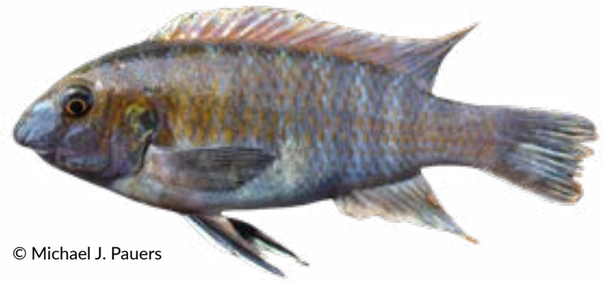
Wisconsin-Milwaukee, and adjunct curator of fishes and research fellow, Milwaukee Public Museum, and Titus B. Phiri, deputy director of fisheries at Malawi's Department of Fisheries has increased that number to 11, with the additional six species all coming from Lake Malawi.

For some time it was thought there were only two *Labeotropheus* species: one with a slender body (*L. trewavasae*), and one with a deeper, more robust body (*L. fuelleborni*), despite extensive evidence suggesting the existence of numerous other species in the genus (Ribbink et al., 1983a, 1983b; Pauers, 2010). While recent efforts have added three additional species (*L. chlorosiglos* and *L. simoneae*, Pauers, 2016; *L. artatorostris*, Pauers, 2017), the presence in the lake of other uniquely coloured *Labeotropheus* populations suggested to Pauers that there could be more species in the genus.

© Michael J. Pauers

Pauers and Phiri conducted two expeditions to Lake Malawi, one in 2018 and another in 2020, to try find out if their suspicions of more *Labeotropheus* species were well-founded. Pauers told SHOAL: "What Titus and I have done is gone to visit some of the locations where *Labeotropheus* can be found, because [the genus] is often overlooked and ignored.

We looked at some of these documented sub-species or colour morphs and did the nitty gritty taxonomy work to show they are indeed distinct species".



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In most cases, it is the colour pattern of the males that is the most obvious identifier of them being separate species (though the meristic differences, that is, the number of quantitative features such as teeth, scales etc, and genetic work has validated Pauers and Phiri's hypotheses). Pauers said, "Female *Labeotropheus* are very sensitive to male colour pattern and that got me thinking that if they're different colours, it's a good sign they're separate species.

Describing new species is not without its controversies, and there have been some critiques about Pauers and Phiri's work. Ad Konings, an ichthyologist well-known for his research on African rift lake cichlids, wrote an opinion piece about Pauers previous work on describing *L.chlorosiglos* and *L.simoneae*, stating that this was nothing more than 'splitting out of context'. Konings wrote that, 'If the "new" species only has a different male coloration but largely overlaps in morphology, it would very likely be classified as a geographical variant'[21].

For decades scientists have debated how to delineate species, with many holding opposing views. Pauers says that, "Any species that were proposed are hypotheses, and anybody is able to examine the species which I've deposited in museums around the world and come to their own conclusions. We've done genetic work on these, and they are all genetically distinct species. We have good morphological and chromatic evidence for these species".

The fact is that defining geographical variation in the Rift Valley Lake cichlids is notoriously difficult, and there is often a great deal of debate when new species are described. Technically, the six new *Labeotropheus* are different species, as they have been formally recorded in Eschmeyer's Catalog of Fishes, the authoritative reference for taxonomic fish names. Each of them adds to the incredible diversity within Lake Malawi, and the debate is a reflection of how complex the evolution of species is.

Population sizes of these six *Labeotropheus* species are currently unknown. Phiri was involved in the IUCN Red List meeting for Lake Malawi, and three of the *Labeotropheus* species described before 2023 were declared Least Concern. "But," Pauers warns, "because the species are so localised, it seems to me that they are likely threatened to some degree". For species found in the north of the lake, there is a lot of mining activity that goes on and, depressingly, a petroleum deposit has been discovered underneath Lake Malawi and it's been proposed to put an oil rig in the lake". Fortunately, for the time being at least, Malawi and neighbouring Tanzania are not cooperating with each other on this, which is preventing the oil from being drilled.

As the work of Pauers and Phiri has shown, no matter your opinion on the species concept, there is still much to be discovered about the rich freshwater fish diversity of Lake Malawi. Conservation action for the freshwater fauna of the lake and further study should be a top priority, especially efforts to stop plans to drill for oil in the lake.

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HORAGLANIS POPULI

Researchers: Rajeev Raghavan, Remya L. Sundar, C.P. Arjun, Ralf Britz, Neelesh Dahanukar[22]
Location: Lateritic aquifers in the towns of Malapally, Edanadu, and Chengannur, and the nearby village of Thiruvanvandoor, Kerala, India
Highlight: Named after 'the people', in honour of the local communities who have been key in discovering and describing subterranean fish species in southwest India.

In the *New Species 2022* report, SHOAL covered the story of the Pathala eel loach (*Pangio pathala*), which was discovered after a specimen washed into Mr Abraham's shower in the small town of Chengannur, Kerala. Mr Abraham knew the species could be important, as Dr. Rajeev Raghavan, assistant professor at the Kerala University of Fisheries and Ocean Studies (KUFOS) and colleagues had worked closely with local communities to engage them in the burgeoning and fascinating field of subterranean fish species.

The story of a new species washing into somebody's shower captured people's imagination around the world, and was picked up by major news outlets including the BBC, The Independent, and India Today after Hollywood actor Leonardo diCaprio posted a picture of the loach on his Instagram account.

In 2023, Raghavan and his team again discovered and described subterranean fishes, including the Indian cave mahseer (see p.22), and *Horaglanis populi*, named after the local communities that have been key to many of these discoveries ('populi' translates from the Latin to 'of the people').

The first species of aquifer-dwelling catfish was described in 1950, from Kottayam in Kerala. Over the next 50 years, there were fewer than 10 location records, and two additional species, one described in the 1990s, and the third one in the 2000s. It was only when Raghavan started the citizen science work in 2017 that there was an organised, systematic programme to understand these fish, and in the few years since, there have been hundreds of specimens from all over Kerala.

Raghavan told SHOAL, "All of these subterranean specimens have come from the common public – it would be impossible for me to go and catch them like you would do for a river or lake fish. We have to wait for the right moment when the fish decides to appear in a dug-out well, an overhead tank, or pop up in a wetland. Unless we have the support of the local communities, we would never be able to get any of these – it is the key and the solution to all of this.

"We have probably engaged several hundred communities, all along the length and breadth of Kerala. We have a network of 300-500 people on WhatsApp groups who provide information about finding specimens. One of the things we do is to let the local media know about collecting fish in the communities, and we've realised local newspapers enjoy publishing stories about a rare fish being discovered in their village. People like being famous – the one to find these strange fish. That is an added incentive".

Horaglanis populi, like all four species in the *Horaglanis* genus, is blind, pigmentless, blood-red in colouration, and endemic to Kerala. They are tiny – less than 3.5 cm long – and not one of the 300 individuals Raghavan's team collected had any traces of food in their stomachs. Raghavan said, "Even if I kept one alive in my tank in the lab, it wouldn't feed for months but would have no difference in their activity patterns. We give them artemia (micro crustaceans), worms etc but they rarely eat. We think they have an extremely low metabolism".

The threats to the species are the same as for the Pathala eel loach: unmanaged groundwater extraction, developmental activities, pollution, chemical run-off, indiscriminate laterite mining and culling of these fish misidentifying them to be worms or other toxic organisms.

From the photos Raghavan's team have been sent, there could be more undescribed species. "But," Raghavan cautioned, "these need to be confirmed using integrative taxonomy including advanced genetic approaches".

© Rajeev Raghavan

NOTABLE MENTIONS

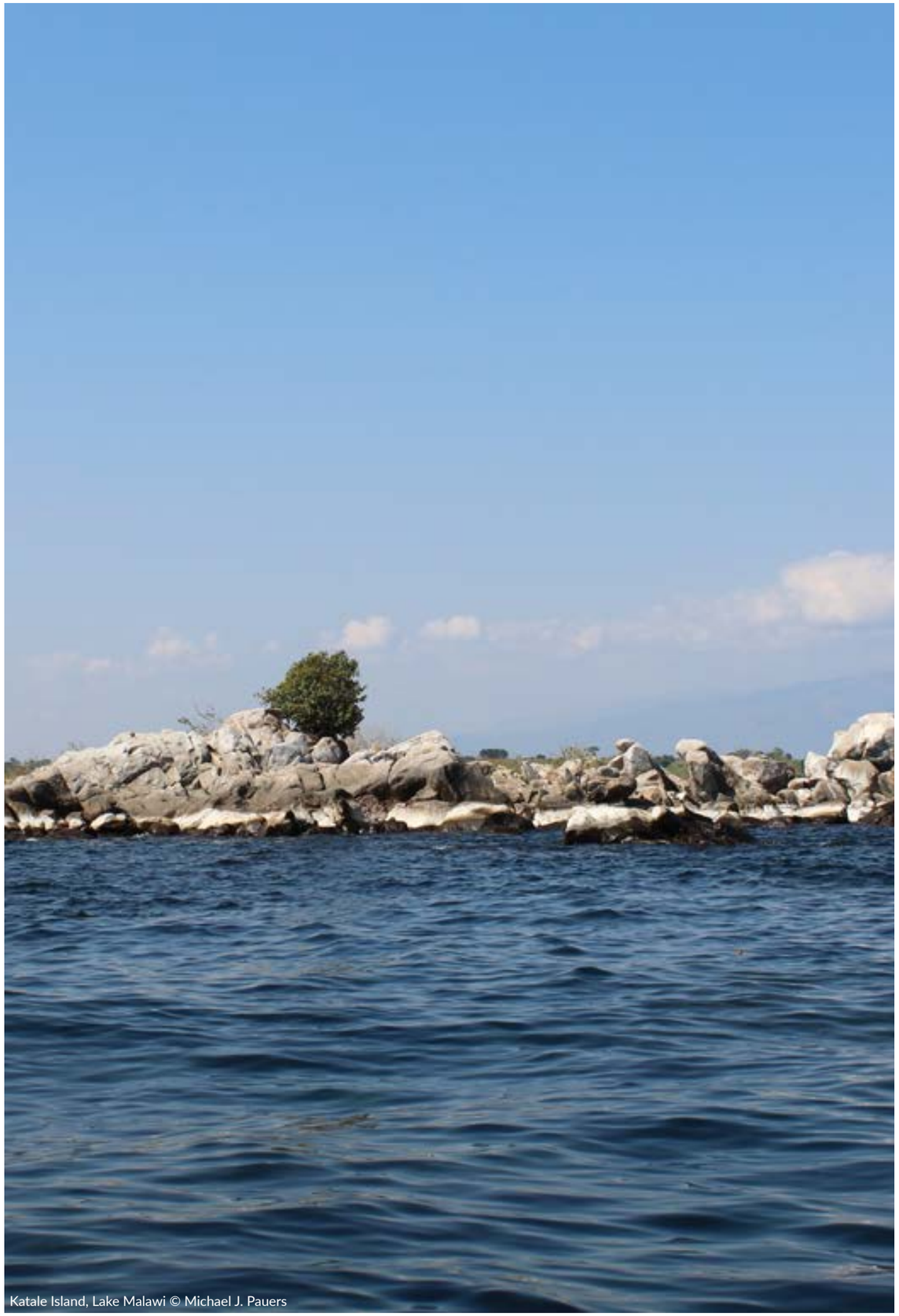
Rivulus gomesi and *Rivuls paradiseus,* Huber, J.H. & Vargas, D.A. & Vermeulen, Frans. (2023). TWO NEW RIVULUS SP-abstract.
- Two attractive killifish species discovered in Colombia.

Phenacostethus sikat, Lynne R. Parenti, Daniel N. Lumbantobing and Haryono. 2023. Description of A New Species of *Phenacostethus* (Atheriniformes: Phallostethidae) endemic to Kalimantan Selatan, Indonesian Borneo, reveals Deep mtCOI Divergence among Miniature Species. Raffles. Bull. Zool. 71; 553–571.
- Males have sex organ protruding from their head.

Bujurquina mabelae, Careaga M, Miranda G, Carvajal-Vallejos FM. "Description of two new species of Bujurquina (Teleostei: Cichlidae) from the Bolivian Amazon." Neotrop Ichthyol. 2023; 21(2):e220093.
- New dwarf cichlids described from Río San Pedro, Río Mamoré drainage, Amazon basin, Bolivia.

Schistura ataranensis, Dvořák, Tomáš & Bohlen, Joerg & Kottelat, Maurice & Šlechtová, Vendula. (2023). Revision of the Schistura cincticauda species group (Teleostei, Nemacheilidae) using molecular and morphological markers. Scientific Reports. 13. 10.1038/s41598-023-42852-1.
- Brightly coloured and beautiful. Already popular in the aquarium trade.

Hypsolebias lulai, Ramos, Telton & Nielsen, Dalton & Abrantes, Yuri & Lira, Fabio & Lustosa-Costa, Silvia. (2023). A new species of cloud fish of the genus *Hypsolebias* from Northeast Brazil (Cyprinodontiformes: Rivulidae). Neotropical Ichthyology. 21. 10.1590/1982-0224-2023-0068.
- A new species of cloud fish described from a temporary pool in the rio Trairi basin, Rio Grande do Norte State, Brazil.



Katale Island, Lake Malawi © Michael J. Pauers

FULL LIST

Achondrostoma asturicense
Achondrostoma garzonorum
Achondrostoma numantinum
Aliteranodon bucinus
Aliteranodon filimbi
Aliteranodon ndoano
Aliteranodon rostratus
Amazonichthys camelierae
Amazonichthys lu
Ambassis octava
Anablepsoides falconi
Anablepsoides katukina
Ancistrus yanesha
Aphyosemion lorai
Argolebias guarani
Astyanax apiaka
Astyanax caroni
Astyanax cuyuni
Astyanax garuttii
Astyanax leoni
Australoheros ricani
Australoherosmboapari
Awaous (Awaous) motla
Badis limaakumi
Balitora anlongensis
Barbus oscensis
Barilius kamjongensis
Betta andrei
Brachyalestes jackiae
Bryconamericus abalio
Bryconamericus lambayequensis
Bryconamericus parapetiensis
Bujurquina beniensis
Bujurquina mabelae
Bujurquina omagua
Butis abdoui
Butis audebertae
Butis huberti
Cabdio occidentalis
Cambeva biseriata
Cambeva chrysornata
Cambeva guaratuba
Cambeva piraquara
Cambeva podostemophila
Cambeva tourensis
Cambeva ventropapillata
Characidium fleurdelis
Cheilonimata minuta
Chiloglanis fortuitus
Chiloglanis frodobagginsi
Cobitis almadae
Cobitis atlantica
Cobitis mellaria
Coregonus intermundia
Coregonus litoralis
Coregonus muelleri
Coregonus obliterus
Coregonus sarnensis
Coregonus supersum
Coregonus suspensus
Corydoras colossus
Corydoras maclurei
Creagrutus cimitarraensis
Creagrutus convencionensis
Creagrutus corredori
Creagrutus embera
Creagrutus florianensis
Creagrutus narvaezi
Crenicichla ama
Crenicichla aravera
Diplomystes arratiae
Diplomystes habitae
Eigenmannia catira
Etheostoma rupestre piersoni
Etheostoma rupestre uphapeense
Etheostoma xanthovum
Euchiloglanis nami
Farlowella wuyjugu
Formosania immaculata
Garra alticauda
Garra chingaiensis
Garra irangensis
Garra laishrami
Garra lungongza
Garra minibarbata
Garra panitvongi
Garra tezuensis
Glyptothorax heokheei
Glyptothorax irroratus
Glyptothorax lairamkhullensis
Glyptothorax motbungensis
Glyptothorax primusplicae
Glyptothorax prionotos
Glyptothorax sardashtensis
Glyptothorax siangensis
Glyptothorax vatandousti
Glyptothorax viridis
Gobio multipunctatus
Gobiomorphus dinae
Gobiomorphus mataraerore
Haplochromis aureus
Haplochromis pelagicus
Hemibrycon chaparensis
Hemibrycon convencionensis
Hemibrycon lorethae
Hemibrycon mamorensis
Hemibrycon megantoniensis
Homatula tigris
Horaglanis populi
Hypostomus lamberti
Hypseleotris ebneri
Hypseleotris garawudjirri
Hypseleotris maranda
Hypseleotris wunduwala
Hypsolebias bonita
Hypsolebias gongobira
Hypsolebias lulai
Imparfinis lepturus
Imparfinis robustus
Ituglanis crispim
Kneria luansaensis
Kneria maxi
Knodus borari
Knodus ytuanama
Labeo manasseeae
Labeo mbimbii
Labeotropheus alticodia
Labeotropheus aurantinfra
Labeotropheus candipygia
Labeotropheus chirangali
Labeotropheus obscurus
Labeotropheus rubidorsalis
Laimosemion anitae
Lasiancistrus wiwa
Leporinus oliveirai
Leptobotia paucipinna
Leptobotia rotundilobus
Lethrinops chilingali
Liobagrus geumgangensis
Listrura gyrinura
Listrura urussanga
Loricaria nimairaco
Melanotaenia jakora
Metriaclima melissa
Microdous amblyrhynchos
Microphis nicoleae
Moema beltramonorum
Moenkhausia guaruba
Moenkhausia iris
Myloplus animacula
Mystus celator
Nannocharax chochamandai
Nemacheilus pullus
Neolissochilus pnar
Oncorhynchus mykiss calisulat
Ophichthys terricolus
Ophiocara gigas
Ophiocara macrostoma
Oreonectes damingshanensis
Oryzias loxolepis
Oxynoemacheilus marmaraensis
Oxynoemacheilus melenicus
Oxynoemacheilus sakaryaensis
Pantanodon propinquus
Paracanthocobitis putaoensis
Parauchenoglanis zebratus
Pethia chakpiensis
Phalloceros maldonadoi
Phenacogaster lucenae
Phenacostethus sikat
Phoxinus abanticus
Physoschistura mango
Ponticola alasanicus
Poptella fortispina
Priocharax marupiara
Priocharax toledopizae
Prodontocharax aquilaepinnae
Profundulus emilioi
Profundulus rei
Pseudolaguvia permaris
Rhadinoloricaria papillosa
Rhinichthys gabrielino
Rhinichthys klamathensis achomawi
Rhinichthys klamathensis goyatoka
Rhinichthys nevadensis caldera
Rhinotridens chromocaudatus
Rhyacoglanis beninei
Rhyacoglanis varii
Rineloricaria cachivera
Rineloricaria nudipectoris
Rivulus gomesi
Rivulus paradiseus
Rivulus sladkowskii
Sabanejewia maeotica
Salariopsis burcuae
Salariopsis renatorum
Salmo duhani
Schistura ataranensis
Schistura hartli
Schistura kuehnei
Schistura myaekanbawensis
Schistura palma
Schistura peninsulae
Schizodon paucisquamis
Scleronema (Scleronema) carijo
Scobinancistrus raonii
Sinocyclocheilus longicornus
Sinocyclocheilus xingyiensis
Squalius gaditanus
Squalius tartessicus
Sternopygus sarae
Sturisoma careirensia
Sturisoma defranciscoi
Sturisoma ghazziae
Sturisoma rapppydanielae
Trichomycterus (Cryptocambeva) garbei
Trichomycterus (Cryptocambeva) listruroides
Trichomycterus (Cryptocambeva) saturatus
Trichomycterus (Cryptocambeva) uberabensis
Trichomycterus (Paracambeva) adautoleitei
Trichomycterus (Paracambeva) coelhorum
Trichomycterus ardilai
Trichomycterus brigadeirensis
Trichomycterus caparaoensis
Trichomycterus caratinguensis
Trichomycterus castelensis
Trichomycterus espinhacensis
Trichomycterus gambitaensis
Trichomycterus puna
Trichomycterus zapatocaensis
Tridens chicomendesi
Tridens vitreus
Triplophysa anlongensis
Triplophysa cehengensis
Triplophysa panzhouensis
Triplophysa rongduensis
Troglonectes canlinensis
Turcinoemacheilus ansari
Turcinoemacheilus christofferi
Turcinoemacheilus ekmekciae
Turcinoemacheilus moghbeli
Zacco tiaoxiensis

REFERENCES

1.Xu C, Luo T, Zhou J-J, Wu L, Zhao X-R, Yang H-F, Xiao N, Zhou J (2023) Sinocyclocheilus longicornus (Cypriniformes, Cyprinidae), a new species of microphthalmic hypogean fish from Guizhou, Southwest China. ZooKeys 1141: 1-28. https://doi.org/10.3897/zookeys.1141.91501

2. https://www.sci.news/biology/sinocyclocheilus-longicornus-11592.html

3. Lima, Arthur De, Vita, George, Dutra, Guilherme M., Ohara, William M. & Pastana, Murilo N. L., 2023, A new Moenkhausia (Characiformes: Characidae) from rio Braço Norte, rio Tapajós basin, with comments on the fish endemism of Serra do Cachimbo plateau, Zootaxa 5330 (4), pp. 586-596

4. ZHANG Yan, ZHOU Jiajun, YANG Jinquan. 2023. A New Species of Genus Zacco from Southern China (Cypriniformes: Cyprinidae). Journal of Shanghai Ocean University. 32(3); 544-552.

5. ZHANG Yan, ZHOU Jiajun, YANG Jinquan. 2023. A New Species of Genus Zacco from Southern China (Cypriniformes: Cyprinidae). Journal of Shanghai Ocean University. 32(3); 544-552.

6. https://news.mongabay.com/2023/07/popular-aquarium-fish-from-thailand-and-myanmar-is-new-to-science-species/

7. Selz, Oliver M. & Seehausen, Ole, 2023, A taxonomic revision of ten whitefish species from the lakes Lucerne, Sarnen, Sempach and Zug, Switzerland, with descriptions of seven new species (Teleostei, Coregonidae), ZooKeys 1144, pp. 95-169

8. Praveenraj J. Badis limaakumi, a new species of badid fish from Nagaland, Northeast India (Teleostei: Percomorpha: Badidae). Zootaxa. 2023 Sep 27;5351(3):371-379. doi: 10.11646/zootaxa.5351.3.5. PMID: 38221482.

9. https://nagalandtribune.in/badis-limaakumi-new-fish-species-discovered-in-nagaland-by-renowned-zoologist-limaakum/

10. Luo T, Mao M-L, Lan C-T, Song L-X, Zhao X-R, Yu J, Wang X-L, Xiao N, Zhou J-J, Zhou J (2023) Four new hypogean species of the genus Triplophysa (Osteichthyes, Cypriniformes, Nemacheilidae) from Guizhou Province, Southwest China, based on molecular and morphological data. ZooKeys 1185: 43-81. https://doi.org/10.3897/zookeys.1185.105499

11. Luo T, Chen Z-X, Zhao X-R, Yu J, Lan C-T, Zhou J-J, Xiao N, Zhou J (2023) Balitora anlongensis, the first cavefish species of the genus Balitora (Teleostei, Balitoridae) from Guizhou Province, southwest China. ZooKeys 1185: 21-42. https://doi.org/10.3897/zookeys.1185.108545

12. Yu J, Luo T, Lan C-T, Zhou J-J, Deng H-Q, Xiao N, Zhou J (2023) Oreonectes damingshanensis (Cypriniformes, Nemacheilidae), a new species of stream fish from Guangxi, Southwest China. ZooKeys 1180: 81-104. https://doi.org/10.3897/zookeys.1180.104645

13. Tao Luo, Qin Yang, Li Wu, Ya-Li Wang, Jia-Jun Zhou, Huai-Qing Deng, Ning Xiao, Jiang Zhou. Phylogenetic relationships of Nemacheilidae cavefish (Heminoemacheilus, Oreonectes, Yunnanilus, Paranemachilus, and Troglonectes) revealed by analysis of mitochondrial genome and seven nuclear genes. Zoological Research, 2023, 44(4): 693-697. doi: 10.24272/j.issn.2095-8137.2022.266

14. Wen H, Luo T, Wang Y et al. (2022). Molecular phylogeny and historical biogeography of the cave fish genus Sinocyclocheilus (Cypriniformes: Cyprinidae) in southwest China. Integrative Zoology 17, 311–25.

15. Dahanukar, Neelesh & Sundar, Remya & Rangad, Duwaki & Proudlove, Graham & Raghavan, Rajeev. (2023). The world's largest cave fish from Meghalaya, Northeast India, is a new species, Neolissochilus pnar (Cyprinidae, Torinae). Vertebrate Zoology. 73. 141-152. 10.3897/vz.73.e101011.

16. Ray C. Schmidt, Pedro H. N. Bragança, John P. Friel, Frank Pezold, Denis Tweddle, Henry L. Bart Jr. "Two New Species of Suckermouth Catfishes (Mochokidae: Chiloglanis) from Upper Guinean Forest Streams in West Africa," Ichthyology & Herpetology, 111(3), 376-389, (31 July 2023)

17. Chaves, M. S., Oliveira, R. R., Gonçalves, A. P., Sousa, L. M., & Py-Daniel, L. H. R.. (2023). A new species of armored catfish of the genus Scobinancistrus (Loricariidae: Hypostominae) from the Xingu River basin, Brazil. Neotropical Ichthyology, 21(3), e230038. https://doi.org/10.1590/1982-0224-2023-0038

18. Pauers, Michael & Titus, Phiri. (2023). Six New Species of Labeotropheus (Cichliformes: Cichlidae) from the Malaŵian Shore of Lake Malaŵi, Africa. Ichthyology & Herpetology. 111. 10.1643/i2021055.

19. https://youtu.be/O4Gm62x6NWg

20. https://www.scientificamerican.com/article/the-extraordinary-evolution-of-cichlid-fishes/#:~:text=To%20get%20a%20clearer%20picture,250%20species%20from%20older%20cichlid

21. https://cichlidae.com/section.php?id=292

22. Raghavan, Rajeev & Sundar, Remya & C.P., Arjun & Britz, Ralf & Dahanukar, Neelesh. (2023). Evolution in the dark: Unexpected genetic diversity and morphological stasis in the blind, aquifer-dwelling catfish Horaglanis. Vertebrate Zoology. 73. 57-74. 10.3897/vz.73.e98367.

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