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The New Finfish Genetic Resource Discoveries from Indian Waters – Need for Enhancing Taxonomy Capacity

TK Teena Jayakumar[1], KK Bineesh[2], TT Ajith Kumar[1] and Kuldeep K Lal[1]
[1]*ICAR-National Bureau of Fish Genetic Resources, Lucknow-226002, Uttar Pradesh, India*
[2]*Zoological Survey of India, Marine Biology Regional Centre, Chennai-600028, Tamil Nadu, India*

India is rich in diversified biological resources and ranks among the top ten species-rich nations with four global biodiversity hotspots. Indian fish fauna is highly diverse and explorations and germplasm inventories of ichthyo-diversity are being updated with several new discoveries. However, both geographical and taxonomic knowledge gaps exist, as many regions especially the far-flung and inaccessible pockets are either under- or unexplored, and many taxonomic groups remain poorly studied. During the last two decades, much information on fishes from the Indian regions have been generated and added to the catalogue of Indian fishes due to the advent of integrated taxonomical approach. Increasing number of new species every year, shows that much more of the diversity yet remains to be discovered and documented. Continuous extensive surveys and explorations are warranted in areas such as deep-sea habitats, islands, subterranean regions, caves and hill streams for unravelling the hidden diversity.

Introduction

India has rich and diverse fishery resources, shares four of the mega biodiversity hotspots, ranging from hill streams to deep seas. Of the 36,272 (Fricke *et al*., 2022) fish species reported from the world, India supports about 3,496 species owing to 9.6% of the total fish diversity (Banerjee *et al*., 2022). During the last two decades, about 7,957 fish species have been added to the world's ichthyofaunal catalogue, with the annual increase of 397 new species (Fricke *et al*., 2022). In India during the last 11 years, an average of 24 new species per year were described (Fig. 1). The recent Indian discoveries of new fish species is reported by Jayakumar *et al*., 2021 and Banerjee *et al*., 2022. In the Indian context, intensive systematic studies on fishes, often supplemented by molecular-based phylogenetic works, have prompted the revision of several taxa and still many groups of fishes are expanding with newly described species, with a net increase in new fish species. Nevertheless, the increase in species discoveries of each year suggests that there are still many more new taxa to be discovered from the diverse habitats of fresh and marine waters of India.

Freshwater Fish Diversity

Native freshwater fishes of India are recognized under 40 fish families of 12 orders, comprising 858 species belonging to 167 genera (Gopi *et al*., 2017). Among the Indian freshwater fishes, four families such as Cyprinidae, Nemacheilidae, Sisoridae and Bagridae are most species-rich with 50 or more species, containing approximately 70% of the total species. The Ganga-Brahmaputra system exhibits among the highest richness of large-bodied freshwater fishes (freshwater mega-fauna) in the world and supports unique and threatened species. The Western Ghats, a global biodiversity hotspot, alone host 288 fish species of which 118 are endemic. The Eastern Himalaya, another biodiversity hotspot, contains exceptional freshwater biodiversity and ecosystems that are of vital importance to local and regional livelihoods. According to the conservation status of freshwater species (IUCN, 2016), 148 species are in threatened category (13 Critically Endangered, 63 Endangered and 72 Vulnerable), while 36 species are Near Threatened, which is likely to slip in to threatened category if proper conservation measures are not taken.

Recent ichthyological explorations on subterranean caves, caverns, lava tubes and phreatic spaces resulted in the discovery of many new species. Habitats, such as deep burrows, ant hill and other similar underground biogenic structures of several burrowing and cryptobiotic animals are encompassed in the subterranean category. These subterranean spaces are poorly explored as regards to biodiversity mapping. The main limitations includes lack of easy access to these underground spaces, prevalence of darkness with high humidity, and the fear of unknown and uncertain things and/or

**Author for Correspondence: Email-teenajayakumar@gmail.com*

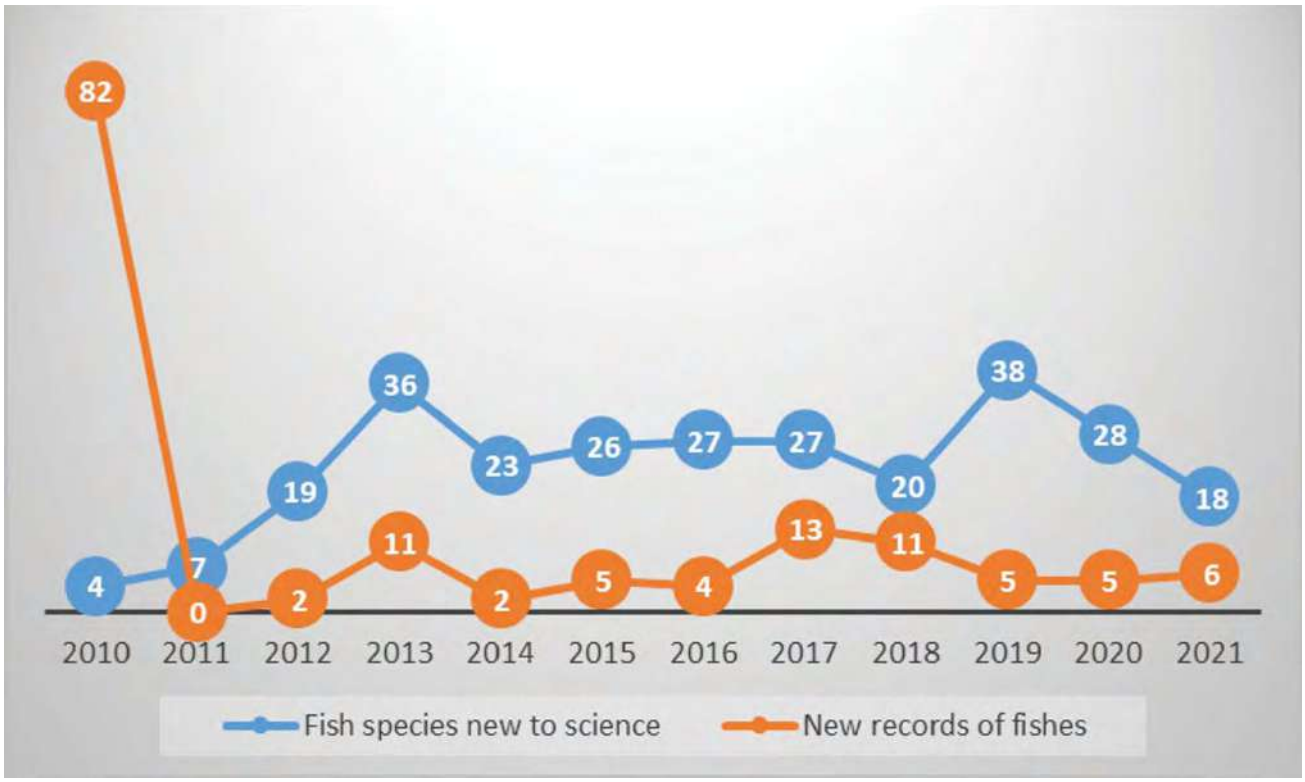

Fig. 1. New species and new records of fishes described in India from 2010-2021 (Source: Animal discoveries 2010-2021, Zoological Survey of India)

events. In India, so far, limited concerted efforts have been made to survey the already known subterranean habitats. Few species described, includes *Nemacheilus evezardi* and *Horaglanis krishnai*. Recently the "living fossil" Gollum snakehead, *Aenigmachanna gollum* was discovered from subterranean waters in the Western Ghats– Sri Lanka, one of the most significant global biodiversity hotspots. This fish was a serendipitous discovery when several individuals were washed out of their aquifer habitat into paddy fields during the 2018 Kerala floods. Western Ghats which has exceptionally high level of biological diversity and endemism is recognized as one of the world's eight 'hottest hotspots' of biological diversity. The exploratory surveys in the area has led to the discovery of new families such as Kryptoglanidae and Aenigmachannidae, new genera such as *Sahyadria, Aenigmanachanna,* and *Waikhomia* and various new species in the genera*; Dawkinsia, Pethia, Pangio, Balitora, Mystus, Badis, Amblyceps, Channa* and *Pseudolaguvia.*

Similarly, North East India with unique topography, varied watershed pattern and physiography is enriched with diversified fish fauna. This region is augmented with 422 species belonging to 39 families and 12 orders (Goswami *et al*., 2012). A recent expedition in caves of Meghalaya, has led to the discovery of world's largest cave fish, a yet-to-be described species of mahseer which is nearly five times the average length (8.5 cm) of all known subterranean fishes till date. Other discoveries include catfishes, cyprinids and loaches such as *Garra simbalbaraensis* from Simbalbara river Himachal Pradesh, *Glyptothorax gopii*, *Neolissochilus kaladanensis*, *Cabdio crassus* and *Laubuka parafasciata*, from river Kalandan, *Rita bacalu* from river Godavari and *Pangasius silasi* from river Krishna. A new species of blind freshwater eel *Rakthamichtys mumba* was discovered from a 40-foot deep well in Mumbai. Similarly, a new species of swamp eel, *Monopterus rongsaw* was discovered from swampy regions of Meghalaya, which was a serendipitous 'by-catch'. The Northeast India is far less studied than the Western Ghats. The uniqueness of northeast India and the Eastern Himalayas is becoming apparent with increased research.

Marine Fish Diversity

The geographic territory of India is an integral part of Central Indian Ocean Region, consisting of three distinct marine zones such as Arabian Sea, Bay of Bengal and Indian Ocean. India has vast marine resources in the form of coastline (over 8,000 km), exclusive economic zone (EEZ, 2.02 million km^2) and various ecosystems including estuaries, coral reefs, mangroves, lagoons, rocky, marshes and sandy areas. Of the overall fish diversity known from India, the marine fishes make up 75.6 percent, containing 2,443 species belonging to 230 families of 40 orders (Gopi and Mishra, 2015). The order Perciformes is the most species-rich group of Indian marine fishes having a total of 1,367 species accounting for 56.0% of the total marine fish species recorded. Among the fish diversity-rich areas in the marine waters of India, Andaman and Nicobar archipelago exhibits the highest number of species with 1,431, followed by the east coast of India with 1,121 species and the west coast with 1,071 species (Gopi and Mishra, 2015). The coral islands of Lakshadweep exhibit a moderate diversity with 753 species. According to the IUCN (2014), 50 species are threatened (6 of them critically endangered, 7 endangered and 37 vulnerable), while 45 are near-threatened. Despite the large number of fishes listed as critically Endangered and Endangered, only 10 Elasmobranchs, seahorses and pipefishes and one grouper are listed in Schedule I of the Wildlife (Protection) Act, 1972 of the Government of India. Marine fish diversity is in ever-increasing danger with depletion of resources.

Diversity of species associated with coral reefs and associated habitats of India is still unknown. Few recent discoveries of pelagic and reef fishes includes, *Dussmieria modakandai*, *Nemipterus andamanenesis*, *Pempheris sarayu*, *Hoplolatilus andamanenesis*, *Pteropsaron indicum*, *Stolephorus tamiliensis* and *S. hindustanenesis*. Though eels are important components of aquatic ecosystems and have fascinated biologists with mysteries of their ecology for centuries, information concerning species diversity, geographic distribution and biology of eels are highly limited in India. As most of the marine eels do not possess economic value, they have been landed as by-catch in trawl landings and are used as ingredients for poultry feeds leading to the concealment of these groups from taxonomic assessment resulting in biodiversity loss. Recent research on Anguilliformes has resulted in description of few new species like; *Rhynchoconger smithi, Cirrhimuraena indica, Ophichthus chennaiensis, Gymnothorax aurocephalus, G. odishi, Xyrias anjaalai, Ariosoma melanospilos, A. indicum, A. maurostigma* and *A. albimaculatum*.

The fishes dwelling in deep-reef and upper-slope areas are underexplored and new unusual discoveries above the species level can be found. Midwater fishes are pelagic, which spend their entire life off the bottom are often widespread such as lanternfishes (Myctophidae). But only fewer studies are carried out in these groups. Deep-living mid-water species that do not migrate to shallow waters are less known than those that can be caught near the surface at night. More new taxa are expected as deep-ocean trawling continues, but the increase in new taxa is correlated with sampling effort.

The diversity of deep-sea Chondrichthyans species along the Indian coast are poorly known, and considered to be higher than thought earlier. Despite the rich deep-sea chondrichthyans diversity, only two new species of sharks *Mustelus manglorensis* and *Planonasus indicus* have been described from Indian EEZ in the past decade. The exploratory surveys by FORV *Sagar Sampada* have brought out many rare deep-sea Chondrichthyans that were collected beyond 200-1100 m depth of Indian EEZ during 2008-2019. While extensive explorations have been made, there are still many species known from single type specimens (eg. Broadnose catshark, *Apristurus investigatoris*, Prickly skate, *Fenestra jamamillidens* and Travancore skate, *Dipturus johannisdavisi*).

Studies on the taxonomy of deep-sea fishes from Indian EEZ have resulted in some distribution extension and description of few species new to science (eg. *Chelidoperca maculicauda*, *Glossanodon macrocephalus, Epigonus indicus* and *Eptatretus wadgensis*). There are many taxonomic issues contributing to the confusion in the alpha taxonomy of many families of deep-sea fishes such as Ophidiidae, Chlorophthalmidae, Synodontidae, Myctophidae, Lophiidae, Centrophoridae, Rajidae etc. Despite scarce studies conducted on deep sea resources of this region in the past, a complete documentation is still lacking.

Molecular Approaches in Taxonomy

The identification of fish species is traditionally based on morphological, meristic and anatomical characters. However, the astounding diversity in size, shape and their morphological plasticity makes the fish and their developmental stages difficult to identify with morphological features alone. Molecular studies are

increasing in fish taxonomy for higher resolution and complementing morphological characterization. These studies are useful in discovering new species that, after investigation, may have demonstrable morphological differences. Accurate identification of fishes is very important, especially in the case of morphologically similar or cryptic species, for fisheries management, biodiversity, and population studies. The analysis involving DNA sequences and quantitative morphometric and meristic comparisons have added a new dimension in taxonomic research and also forensic identification.

Major Challenges

Global taxonomy initiative under CBD recognise the lack of taxonomic capacity among nations and considers it important for the effective mainstreaming of aquatic genetic resources. In India, both geographical and taxonomic knowledge gaps exist, as many regions especially the distant and difficult terrains are under- or unexplored, while many taxonomic groups remain poorly studied or have conflicts. Many species might undergo unrecognised extinctions in the absence of targeted efforts. The taxonomic knowledge gaps existing are limitations in achieving the relevant objectives of CBD and policy making. Explorations and germplasm inventories of fish biodiversity in the aquatic water bodies of India are being progressively updated and analysed with several new discoveries. Some of the major reasons for taxonomic impediment are follows;

Inaccessible historic type specimens: Most of the type specimens of fishes are deposited in international museums. The lack of access to the type specimens housed elsewhere is a crucial constraint in carrying out taxonomic works in India. The type specimens' studies aid the differentiation and credible comparison. Though, the online available resources from some museums and original descriptions are useful, this cannot fully replace the information obtained from examining the type specimen.

Lower publication value of taxonomy: The taxonomic journals are mostly niche specific and rate lower on Impact Factors and Citation Indexes. This stifles the original taxonomic research. Moreover, most of the taxonomic information about our biodiversity occurs in the form of scattered and inaccessible publications.

Shortage of trained manpower: The taxonomic crisis is worsened by a sharp decline in expertise and resources. The number of field taxonomists who is doing survey, studying the natural habitat and identifying and classifying species from the real nature is fast dwindling in the country.

Lack of job opportunities: Taxonomists lack adequate job opportunities. No specific recruitment of field taxonomists is made in the universities and research institutions. Dangerous 'demise' of taxonomy reflects the failure of fellow biologists and policy makers to support taxonomic expertise and resources.

Thrust Areas and Way Forward

There is need for building the institutional and individual taxonomic capacity, through academic curricula combining the morphological and molecular taxonomy tools. The training and education in integrative taxonomy will add to skills, job opportunities and teaching value of such trained personals. A network of taxonomic institutions, individual taxonomists and repositories should be developed in a collaborative manner. Recognition of the institutions as centres of excellence in taxonomic research, repositories under section 39 of biological diversity act 2002 is need of the hour. For accurate generic and species determinations, it is essential to study specimens from across political boundaries and continents and hence, easy facilitations under the BDA 2002 is necessary for exchange of preserved specimens. It is generally accepted among the scientific community that the types are the property of science and should be made available to *bonafide* researchers throughout the world. The efforts to conserve biodiversity will be easier if we know the basic units that are species and their relationships. Taxonomy provides discovery and identification of these units, which is the foundation for all studies on biodiversity. Thus, India, one of the 17 mega-diverse nation in the world, has to overcome taxonomic impediments for the growth of biodiversity science, conservation planning and policy making.

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