

# The biodiversity of Indian Ocean benthos and taxonomic impediment: the way forward

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**Abstract:** The Indian Ocean is the third largest ocean in the world, mostly surrounded by a rim of developing countries and island States. From a wide geographical perspective, most of the major ocean area is under-sampled, particularly the oceanic areas, and therefore the biological diversity is still incompletely described for most ecosystems. The poor documentation of diversity notwithstanding, marine biological diversity is changing, especially in the recent past due to broad-scale human activities. However, our ability to evaluate the scale and ultimate consequences to life in the sea of a plethora of anthropogenic effects is limited by our inadequate knowledge of marine biodiversity. Among the continental nations, the most comprehensive account of coastal and marine biodiversity is available from India, represented by about 15,042 marine species, with records from majority of animal phyla. Studies shows that majority of the groups representing marine benthos are rather underestimates, which is primarily due to the lack of taxonomic expertise, especially in lower marine phyla. Further, many of the ecosystems in Indian Ocean, especially the sea mounts are poorly surveyed for marine biodiversity. Similarly, the deep sea biodiversity of Indian Ocean also remains poorly investigated.

**Keywords.** Indian Ocean, Biodiversity, taxonomic impediment

## 1. Introduction

Biodiversity, which include diversity of genomes, species and ecosystems, forms the foundation for understanding and predicting how human and natural effects can change ocean ecosystems. About one sixth of the world's 1.5 million described species are marine, however it is estimated that marine life represents some two thirds of the world's biodiversity. For example, of the 32 or so invertebrate phyla, 31 occur in the oceans, 15 in freshwater habitats and 10 on land. It has also been suggested that the unexplored deep-sea (representing about 60% of Earth's surface) could hold tens of millions of undiscovered species (Pain, 1996) and recent estimates suggest that deep-sea diversity is much higher than in any other marine habitat, perhaps rivaling tropical rainforests in total species numbers. The marine biodiversity is well reflected in the benthic environment and the unique adaptations maintained by them play critical role in maintaining ecosystem structure and functioning. Benthic animals have an intimate relationship with the substratum and the components, texture and chemical attributes of the sediment has a regulatory effect on the species that can live in any particular area. The benthos also play an important role in maintenance of trophic dynamics of ocean, and the highly specialised benthos sensitive to environment disturbances, therefore, are extensively used as biological indicators to monitor changes in water and sediment (Brandt et al., 2007). As the largest and least studied ecosystem in the planet deep sea biodiversity also remains poorly documented. Further, the geological structures such as canyons, seamounts, reefs, hydrothermal vents and faults support greater biodiversity of benthos, specifically microbes, due to the structural uniqueness and complexity (Brandt et al., 2007).

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ocean area is under-sampled, particularly the oceanic areas, and therefore the biological diversity is still incompletely described for most ecosystems (Ruwa and Rice, 2016). The poor documentation of diversity notwithstanding, marine biological diversity is changing, especially in the recent past due to broad-scale human activities (UNESCO, 2017). However, our ability to evaluate the scale and ultimate consequences to life in the sea of a plethora of anthropogenic effects is limited by our inadequate knowledge of marine biodiversity. According to Wafar et al. (2011), among the continental nations, the most comprehensive account of coastal and marine biodiversity is available from India, represented by about 15,042 marine species, with records from majority of animal phyla. However, the data on species diversity presented in Wafar et al. (2011) shows that majority of the groups representing marine benthos are rather underestimates, which is primarily due to the lack of taxonomic expertise, especially in lower marine phyla. Further, many of the ecosystems in Indian Ocean, especially the sea mounts are poorly surveyed for marine biodiversity (Ingole and Koslow, 2005). Similarly, the deep sea biodiversity of Indian Ocean also remains poorly investigated.

The deep Indian Ocean is composed of a variety of habitat types, including abyssal plains, oxygenated slopes and basins, seamounts, and trenches. The geomorphological features of the Indian Ocean include mid-ocean ridges, abyssal plains and few deep-sea trenches. Although the Indian Ocean has relatively few seamounts and islands, it contains numerous submarine plateaus and rises. Satellite altimetry data indicate that the Indian Ocean has an intermediate number of generally small to moderate-sized seamounts, mostly associated with its ridge systems. The fauna of Indian Ocean seamounts remains virtually unexplored. The deep-sea benthic habitats are often studied with advanced technologies and there are limitations in many of the Indian Ocean countries to initiate such works on a large scale. Taxonomic impediment, which essentially characterised by acute shortage of taxonomic expertise world over, uneven distribution of global taxonomic resources (reference collections and literature), scarcity of monographic and revisionary studies and low proportion of good and standard taxonomic description of species (Dar et al., 2012) is very much effervescent in India, especially with regard to marine biodiversity. This paper examines the status of knowledge on marine biodiversity of India in the backdrop of taxonomic impediment and forwards a few suggestions to overcome the impediment.

## **2. State of taxonomic knowledge**

The state of taxonomic, biological and ecological knowledge regarding marine methods of Indian coast is relatively poor, with more species recorded from shallow coastal waters. The available knowledge on benthos biodiversity varies with location, habitat and taxa. The data on marine biodiversity recorded from Indian coast is far from complete (Wafar et al. 2011), The yet not fully explored ecosystems coupled with absence of authentic and curated biodiversity database in Indian coast, further characterised by the taxonomic impediment (decreasing taxonomy expertise and ageing of taxonomists) would not only weaken resilience of the ecosystems, but severely hamper the proposals to manage biodiversity and conservation initiatives. Though recent explorations have brought to light extensive range of ecosystems, specifically methane seeps and seamounts in Indian Ocean, absence of large-scale taxonomic efforts coupled with taxonomic impediment limit species identifications. The available databases are not comparable as there are limited numbers of specifically directed taxonomic surveys. The state of taxonomic, biological and ecological knowledge regarding marine invertebrates is

relatively poor from the Indian coast. It is most comprehensive in shallow coastal waters and least known in deeper waters. Knowledge varies with location, habitat and taxonomic group. There are large gaps in our understanding of even the relatively well-studied macrofaunal groups while many taxa are very poorly known to virtually completely unstudied. There are very few experts on marine invertebrates in India, despite the diversity of the fauna. Little funding is available for taxonomy research, and many proposals submitted by experts are often rejected considering it as "basic" and not "cutting edge" science! The lack of biological information often necessitates the use of exemplars (often from the ecologically unrelated areas, especially from the temperate areas) when attempting to extrapolate biological features or predict ecological outcomes.

The available knowledge is not readily accessible, the few guidebooks dealing with only a small fraction of the common species and most of the literature is in relatively obscure scientific publications. For most groups there is not even and up to date, authoritative list of species available. Though the intertidal fauna and fauna of shallowwater coral reef diversity is relatively well documented, most parts of the Indian marine environment are poorly sampled or unsampled for invertebrates, especially the deep-sea, offshore islands, seamounts and banks. Even the new species records (Animal Discoveries) published by Zoological Survey of India every year records very lesser number of deep sea invertebrates (especially the interstitial fauna, meiofauna), and the documentation is highly skewed towards terrestrial fauna, especially towards insects (as is the case with number of scientists in ZSI, with specialisation in entomology). The majority of data relating to marine invertebrates resides in museum collections. Major biodiversity surveys done by research vessels in India or the biological samples from other cruises remain poorly catalogued, especially with regard to invertebrates, primarily because of lack of skilled manpower in taxonomy and absence of networking to get the things documented. There is a need to synthesise existing data and collate biological data with physical/oceanographic data.

### **3. Impediments**

There is a serious lack of resources in the provision of taxonomic studies and services and analyses of research funding from various agencies in India reveal that very little amount has been allocated for taxonomic research, especially towards marine benthos. The number of taxonomists working on marine invertebrates in museums, research institutions and universities has declined over the last few decades and many experienced taxonomists are approaching retirement. The analyses of curricula in many universities further reveal that courses related to taxonomy and systematics are limited to graduate level. Only few keys and guides are available to identify India's marine invertebrates and those available are restricted to only a few groups. Besides this checklists are not available for many groups and the existing ones are often not taxonomically curated and updated. There are very few specialists in India, especially in marine invertebrates and several significant groups have no specialists (specifically minor phyla). There is a serious lack of information about dynamics of ecosystems, including their composition, natural variability, and biological processes within them etc., which often hamper management and conservation options, besides modelling studies aimed at resilience of the system. The high cost and high demand on the very limited facilities, especially research vessels available makes it almost impossible for most "basic" offshore and deep-sea research work to be undertaken, specifically aimed at creating a stronger benchmark data on biodiversity. Knowledge sharing and

access to information are key issues that need to be addressed as quickly as possible by the facilitation of programs that will increase public access through the production of printed and web-based information. Most of the data bases are not fully accessible or accessible only for a few experts. Some international programs such as The Global Biodiversity Information Facility (GBIF) are global in scope but the amount of data on benthos from Indian waters is proportionately less. Museums are struggling to maintain reasonable curatorial standards and do not have the resources to database their collections. Though digitisation process has been initiated by many repositories in India, the data base is not accessible for all the taxonomists and for the benefit of biodiversity science; it should be available to the global community to promote research. There is a need for prioritisation of taxonomic research based on gap areas and to avoid huge amount of ‘duplication’ of work done in various organisation. University, museum and other relevant institutional libraries, are continually forced to make cuts in journal and book acquisitions so it is often difficult to obtain specialist literature. The lack of knowledge on biodiversity of marine taxa, especially invertebrates, has its own consequences. For example, the oceans around the world are severely impacted by habitat degradation, over exploitation and climate change. The magnetite of such impacts cannot be immediately assessed due to the lack of data on spatio-temporal variation to biodiversity, and dynamics of such variation. The global climate changes are affecting deep-sea ecosystems, both directly (causing shifts in bottom-water temperature, oxygen concentration and pH) and indirectly (through changes in surface oceans’ productivity and in the consequent export of organic matter to the seafloor) (Birchenough et al., 2015; Danovaro et al., 2017). Loss of components of the invertebrate fauna may lead to losses of processes and functions with the eventual possible collapse of the ecosystems. Managing marine ecosystems will be largely guesswork without better knowledge. The objective of an adequate conservation policy for marine biodiversity cannot be realised without a much better knowledge of the components of that diversity, its habitats and biological requirements. The benthos is also affected by the impact of fishing (especially bottom trawling) and such information is also lacking from Indian coast. Due to the difficulty of dealing with the conservation of all threatened organisms as part of benthos on a species basis, there is a need to focus on protecting and managing identified threatened systems at a variety of scales, from assemblages and communities (including habitats) through to larger scales such as “ecosystems”, bioregions, etc.

#### **4. Addressing Taxonomic Impediment**

There is a need for an overarching Ocean Policy for India, which takes into account filling the knowledge gap in taxonomy and marine biodiversity, besides looking at addressing the issue of taxonomic impediment. The taxon approach for conserving marine biodiversity is generally neither a practical nor cost effective strategy for the great majority of taxa. However, the conservation strategies would fail in the absence of biodiversity data, which makes addressing taxonomic impediment urgency in India. There exists large gaps in our knowledge base, especially on marine invertebrates, even in the dominant larger invertebrate groups such as Annelida, Crustacea, Mollusca and Echinodermata, and very large parts of Indian waters (including the EEZ) that remain unsampled. One of the essential requirements in this front is to promote basic taxonomic research on marine benthos, with adequate funding, especially in those currently poorly known groups. The biodiversity baselines need to be determined by surveys and inventories, along with identification of areas of high diversity and endemism. Such studies should be complemented by basic ecology studies to realise the ecosystem functions and ecological linkages of benthos. To assess the genetic diversity associated with specific habitats

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modern techniques such as metabarcoding may be adopted. Specific studies are required to examine the effects of anthropogenic changes in ecosystems (e.g., increased nutrients, reduced freshwater runoff, effects of global warming etc.), especially in bays, estuaries and shallow coastal waters. In India marine research infrastructure is generally inadequate. To maximise the range of research outcomes, the research vessels of limited number of research organisations in India should be more accessible to scientists from universities specifically for doing biodiversity and taxonomy studies. Biodiversity surveys should be undertaken in such vessels with taxonomists specialised in various taxa in order to reduce the expenditure incurred. Outcomes from individual cruises should be maximised by ensuring that sampling and other activities are of benefit to as wide a range of scientists and research areas as possible.

The issue of taxonomic impediment needs to be addressed with a well-defined futuristic plan, aimed at identifying the priorities for the country in biodiversity documentation and conservation. The research and survey organisations should have one expert for each taxonomic group in the common pool, and ‘generalist’ taxonomists may be made ‘specialists’ by appropriate training abroad. Other ways to circumvent the shortage of taxonomists include launching of more coordinated taxonomy projects involving taxonomists of multiple organisations, promoting collaborative research with experienced organisations elsewhere in the world, and through promoting parataxonomists/citizen scientists involved in the process (though it has several limitations with regard to deep sea benthos studies). The listing of threatened species is not practical for many marine invertebrates, especially those associated with benthos, where high heterogeneity and poor knowledge do not generally provide sufficient data to assess their status according to current IUCN or similar criteria. In this context, the agencies should prioritise knowledge gaps with regard to the diversity of benthos, and prepare action plans to prepare inventories. Few areas that need immediate attention are sea mounts, methane seep areas and deep sea benthos. With regard to conservation actions, fishing and climate change are the major possible threats to marine benthos. Trawling is identified as a serious threat to the benthic epifauna of coastal and offshore (Continental Shelf and Slope, seamounts, banks etc.) areas, and therefore restricting the usage of damaging gears and restricting access to critical biodiversity-rich habitats would become investable for management. Further, environmental impact statements concerning mining activities should give greater attention to impacts on the benthos likely to be affected. Presently, most of India’s recent initiatives in overcoming taxonomic impediment remains poorly implemented due to lack of coordination and vision. For example, the AICOPTAX initiated by the Ministry of Environment and Forests (MoEF), remains in low pace due to limitations in setting research priorities and funding (Dar et al., 2012). Some other initiatives in this direction include Department of Biotechnology’s Indian Bioresources Information Network (IBIN), National Biodiversity Authority’s Indian Biodiversity Information System (IBIS), and National Chemical Laboratory’s INDFAUNA.

## **5. Education and Community Involvement**

There is an urgent need to develop public awareness programs regarding the need to conserve marine biodiversity, and the nature and consequences of threats to the marine environment. This could be achieved by an increase in content on benthos and their importance for our well-being, in school curricula and university courses. There is also a need for the development of tools and material that will assist in highlighting marine conservation issues and marine benthos in educational arenas. There is also a need for training of teachers and teacher trainees in issues

*Chapter 5: The biodiversity of Indian Ocean benthos and taxonomic impediment: the way forward*

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relating to marine biodiversity, marine benthos and their conservation. There is a need for networking for promotion of research on benthos and therefore a national benthological society, with representative members including taxonomists in all taxa, would be a starting point to coordinate awareness activities and to influence policy making.

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