CORAL REEFS IN INDIA

K. Venkataraman
National Biodiversity Authority
Chennai - 600 041

ABSTRACT

Coral reefs are one of the most ancient and dynamic ecosystems of India. The coral reefs not only provide a sanctuary to a myriad of marine life but also play a key role in protecting the coastline from erosion. In addition, people living along the 8000 km long coastal stretch of our country depend on coral reefs for their livelihood. India is centrally placed within the warm tropical region of the Indian Ocean and exhibits extensive coral reefs throughout its marine territories. In India, all the three major reef types (atoll, fringing and barrier) occur, and the region includes some of the most diverse, extensive and least disturbed reef areas of the Indian Ocean, many of which are among the least scientifically known. Pillai recorded a total of 199 species divided among 37 genera, from India, which includes both hermatypic and ahermatypic corals recorded by him from the four major coral reefs of India. The present study includes 15 families, 60 genera and 208 species of Scleractinia (only reef building, hermatypic corals) from the four major reefs of India such as Gulf of Kachchh (36 species, 20 genera), Lakshadweep (91 species, 34 genera), Gulf of Mannar and Palk Bay (82 species, 27 genera), Andaman and Nicobar Islands (177 species, 57 genera). The Scleractinia corals of India have rich diversity as compared to the other reefs of the tropical world. Among the four major reef areas of India, Andaman and Nicobar Islands are found to be very rich and Gulf of Kachchh is poor in species diversity. Lakshadweep Islands have more number of species than the Gulf of Mannar. There are 18 families reported from the world, of which 15 are represented in India. This diversity is almost the same when compared biogeographically to all reefs in the world. However, of the 111 genera reported from the world, India has only 60, which is slightly less when compared to Indo-Pacific centre of diversity (82 genera). Of the 793 species of reef forming shallow water corals reported from the world, India has 208+ species (it is expected to increase up to 400 when intensive studies are carried out), which is far less when compared to 581 species reported from the neighbouring Indo-Pacific centre of diversity. Among the 208 species reported in the present account, the family Acroporidae has the maximum number of species (74 species, which is 34% of scleractinian fauna of India). Probably during the coming years many more new records on the scleractinian fauna of the coral reefs of India are expected to emerge.

INTRODUCTION

Reef-building corals (= hard or stony or hermatypic) are among the most important contributors to the reef structure. As per the recent global estimate, shallow coral reefs occupy 2, 84,300 sq km. This estimate is about half the size of Madagascar, 1.2 % of the world's continental shelf area and only 0.09 percent of the total area of the world's oceans. Coral reefs are scarce, but critically important resource. They provide shelter, food and protection for a diverse array of marine plants and animals. Efforts to quantify the total numbers of species, which are found on reefs, remain largely restricted to wild extrapolations and estimates. As many as 100,000 species may have been named and described worldwide from reefs, but the total number inhabiting the world's reefs may be anything between half and 2 million, perhaps more. Large portions of the world's coral reefs occur within the Indian Ocean. The total area of coral reefs in India is estimated to be 2,379 sq km (D.O.D and S.A.C., 1997), which is less than one percent of all the coral reef areas in the world.

Out of 25 families and 1574 species of scleractinians (hard corals), 12 families, 110 genera and 686 species are ahermatypic/azooxanthellate corals reported from the world, of which 12 families, 71 genera, 227 species are reported from Indian Ocean by various researchers. The most diverse region of the world for coral reefs is centered on the Philippines, Indonesia, Malaysia and Papua New Guinea, with between 500 and 600 species of coral in each of these countries. Unfortunately these are also some of the most threatened coral reefs of the world. There are 208+ species of hard corals recorded within four major coral reefs of India *viz.* Gulf of Mannar, Gulf of Kachchh (= Kutch), Lakshadweep and Andaman and Nicobar Islands, and as research continues, many more are expected to be discovered in the coming years. For example, a recent GCRMN Coral genera identification Training (December 1999) yielded 13 new records from Andaman (New Wandoor area, unpublished data) and the GOI/UNDP/GEF diving mission yielded 234 species of which 110 are new records to India (Turner *et al.*, 2001). Still serious studies are required to complete the inventorisation in the remote areas of the Andaman and Nicobar Islands as well as other reef areas of Indian main land. The coral assemblages of Indian reefs are of great interest to evolution and biogeography because they stem from a blend of widespread Indo-pacific species and species unique to the Indian Ocean and local waters.

During 1969, Pillai published a series of six papers on the coral species of Gulf of Mannar followed by distribution of corals in Minicoy Atoll, Lakshadweep (Pillai, 1971). Pillai (1971, a, b, 1972, 1973, 1974, 1975, 1977) contributed on composition, distribution, coral resources and human effects on corals of Gulf of Mannar. Later, Pillai (1977, 1978, 1983) published a series of account on the corals of Andaman and Nicobar Islands with the impetus gained from the earlier works on the collection of Andaman and Nicobar Islands jointly with Scheer (Scheer and Pillai, 1974). His work with Patel in 1988 on the Scleractinian corals from the Gulf of Kachchh is the only work from that region. Only a very few stray papers were published on the Coral reefs of India, their conservation and management (Pillai, 1967-1996; Venkataraman, 2003; Venkataraman *et al.*, 2003). Excepting the taxonomic studies of Pillai, there is no other contribution on

corals due to reasons unknown. The present paper deals with the status and biodiversity of coral reef ecosystems of India.

CORAL REEFS IN INDIA

All the three major reef types occur in India (atoll, fringing and barrier) (Fig 1). Within these habitats some of the most diverse, extensive and least disturbed reefs exist in and around the Indian subcontinent. To this day, many of these reefs are largely unstudied. The mainland coast of India has two widely separated areas containing reefs: the Gulf of Kachchh in the northwest, which has some of the most northerly reefs in the world, and Palk Bay and Gulf of Mannar in the southeast. In addition to these, there are patches of reef growth on the West Coast, for example, coral reefs at Malvan. The Andaman and Nicobar Islands have fringing reefs around many islands, and a long barrier reef (329 km) on the west coast. Little is known about these reefs, which may be the most diverse and pristine reefs in India. The Lakshadweep also has extensive reefs but these are also poorly explored.

Indian subcontinent with its coastline extending over 8,000 km and subtropical climatic conditions has very few coral reef areas when compared to other regions of the world. In India, the reefs are distributed along the east and west coasts at restricted places. However, all the major reef types are represented. Fringing reefs are found in Gulf of Mannar and Palk Bay. Platform reefs are seen along the Gulf of Kachchh. Patchy reefs are present near Ratnagiri and Malvan coasts. Fringing and barrier reefs are found in Andaman and Nicobar Islands. Atoll reefs are found in Lakshadweep. The absence of reef in Bay of Bengal (North East Coast) is attributed to the immense quantity of freshwater and silt brought by the rivers such as Ganga, Krishna and Godavari. Satellite imagery (Space Application Centre, Ahmedabad) shows scattered patches of corals in the intertidal areas and occasionally at subtidal depths along the West Coast of India, notably at Ratnagiri, Malvan and Rede Port.

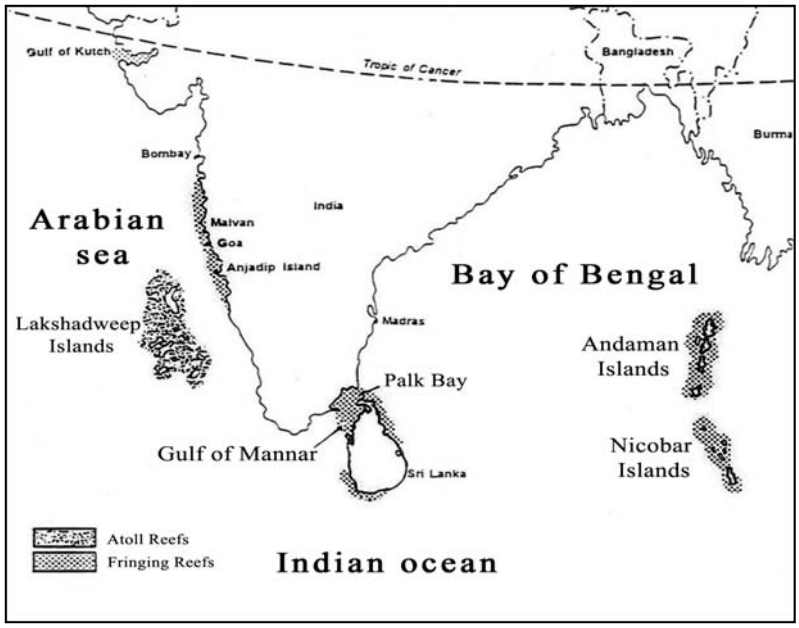


Fig. 1 Major coral reef areas in India

The mainland coast of India has the Gulf of Kachchh in the Northwest (Gujarat State) and Palk Bay and the Gulf of Mannar in the southeast (Tamil Nadu State). Other than these important off shore island groups of India, the Andaman and Nicobar in the Bay of Bengal and Lakshadweep in the Arabian Sea also have extensive reef growth. The total area of coral reefs in India is estimated to be 2,375 sq km (D.O.D. and S.A.C., 1997).

BIOLOGICAL DIVERSITY OF CORAL REEFS

The diversity of coral reefs greatly exceeds that of any other marine environment. Reefs are home to more species than any other ecosystem in the sea. The total number of reef species in the world is still unknown, but up to 3,000 species can be found together on a single reef in South East Asia and over 1,000 on a single Caribbean reef. Coral reefs harbor rich biodiversity. Of the roughly 1.86 million plant and animal species described, 2,74,000 are thought to be marine and more than half of these are tropical. At present, there are thought to be 93,000 described species of coral reef plants and animals. Almost 66,000 of these are macroscopic invertebrates. Till today, no comprehensive all-taxa biodiversity inventory has been conducted on a coral reef, but it is obvious that when this is done, the total biodiversity would be extremely high.

SCLERACTINIAN CORALS

The richest reefs, with the greatest diversity of plants and animals are in the region bound by Indonesia, Malaysia, the Philippines and southern Japan. Of the 793 or so reef corals that are known in the world, 600 are found in this region; over 400 are found in the Philippines and Japan, and about 350 in Indonesia, and there are probably many more to be discovered here. Up to 200 corals may occur on a single reef in South East Asia (Veron, 2000). This high diversity extends equally to other reef associates and is partly because of the greatest area of reefs found here and partly because of its geological history. When the sea level was lower, the region comprised of three separate basins, within each of which numerous species evolved. The coral reefs of India exhibit extraordinary biodiversity. Until 1998, it was thought that the diversity of corals including hermatypic and ahermatypic corals amounts to 245 only. The Government of India and UNDP GEF field mission (2001 diving studies) reported a total of 234 species of scleractinian corals from Andaman group of Islands of which 111 are supposed to be new records to India (on verification with other studies only 94 species are found to be new records and this also includes some non-scleractinian corals) (Turner *et al.* 2001). Also the underwater field mission revealed that the coral reefs of the Andaman Islands are globally significant in terms of coral reef diversity. The reefs around the islands were more diverse coral species than expected and less impacted than the other reefs of Indian Ocean region. The diversity is also comparable with numbers of coal reef species in the Philippines, Indonesia and Papua New Guinea, which are areas considered to be the world centers of coral diversity. The Andaman Islands have around 80% of the global maximum for coral diversity, suggesting a final count could reach 400 species of coral. Other major coral reefs in India such as moderately diverse Lakshadweep and high diverse Gulf of Mannar have 100+ species each, excepting Gulf of Kachchh where the diversity is minimum (36 species, Venkataraman *et al*., 2003).

THE SCLERACTINIAN FAUNA OF INDIA

Pillai (1983) recorded a total of 199 species divided among 37 genera, from India, which includes Lakshadweep (31 genera, 78 species), the Gulf of Kachchh (24 genera, 37 species), Palk Bay and the Gulf of Mannar (37 genera, 94 species) and Andaman and Nicobar Islands (59 genera, 135 species). This account includes both hermatypic and ahermatypic corals recorded by him from the four major coral reefs of India.

The present study includes 15 families, 60 genera and 208 species of Scleractinia (reef building and hermatypic corals) from four major reefs of India such as Gulf of Kachchh (36 species, 20 genera), Lakshadweep (91 species, 34 genera), Gulf of Mannar and Palk Bay (82 species 27 genera), Andaman and Nicobar Islands (177 species, 57 genera). Venkataraman *et al.* (2003) reported 15 families, 60 genera and 208 species from India, of which, 36 are from Gulf of Kachchh, 91 species from Lakshadweep, 82 species from Palk Bay and Gulf of Mannar and 177 species from Andaman and Nicobar.

DIVERSITY OF CORALS IN THE FOUR MAJOR CORAL REEFS OF INDIA

The Scleractinia corals of India have rich diversity as compared to the other reefs of the tropical world. A total of 208 species have been dealt in this book, which includes 15 families and 60 genera (Venkataraman *et al*., 2003). Among the four major reef areas of India, Andaman and Nicobar Islands are found to be very rich and Gulf of Kachchh is poor in species diversity. Lakshadweep has more number of coral species than the Gulf of Mannar (Table 1).

Table 1. Distribution of total number of families, genera and species of Scleractinian corals in the four major coral reefs of India.

	Gulf of Kachchh	***Lakshad weep***	**Palk Bay and Gulf of Mannar**	**Andaman and Nicobar Islands**	**Total**
Families	8	12	13	15	15
Genera	20	34	27	57	60
Species	36	91	82	177	208

Gulf of Kachchh:

The diversity of scleractinian corals in this region is very poor when compared to all the other three major regions of India (Fig. 2). Families such as Asterocoeniidae, Pocilloporidae, Euphyllidae, Oculinidae, Agariciidae, Fungiidae and Trachyphylliidae are totally absent. Among the 60 genera recorded in India only 20 are reported so far. *Acropora humils* reported earlier is not found in the recent studies. *Montipora venosa, Cosinaria monile, Hydnophora excesa, Turninaria petata, Goniastrea pectinata, Platygyra sinensis, Cyphastrea serialia, Porites compressa* and *Goniopora stutchburyi* are some of the common species found in all the islands of Gulf of Kachchh. Species such as *Siderastrea savignayana* and *Acanthastrea hillae* are reported only from Gulf of Kachchh.

Lakshadweep Islands:

There are 12 families, 34 genera and 91 species reported from these islands (Fig. 2). Families such as Astrocoeniidae, Pectiniidae and Trachyphylliidae are absent. Among the 60 genera recorded in India only 34 are reported so far. Species such as *Acropora humilis, A. muricata (= A. formosa), A. intermedia, A. hyacinthus, Pocillopora verrucosa, Euphyllia glabrescens, Galaxea fascicularis, Psammocora contigua, P. haimeana, Pavona maldivensis, P. clavus, Fungia danai, Podobacia crustacea, Hydnophora microconos, Favites abdita, Goniastrea retiformis, Platygyra daedalea, P. sinensis, Leptastrea bottae, Porites solida, P. lichen* and *P. minicoensis* are common in these islands. Species such as *Montipora spongiosa, Acropora abrotanoides, A. hemprichi, Psammocora haimeana, Acanthastrea echinata, Porites rus* and *Alveopora superficialis* are reported only from Lakshadweep.

Gulf of Mannar and Palk Bay:

13 families, 27 genera and 82 species are reported from this area (Fig. 2). Families such as Euphyllidae and Trachyphylliidae are absent. Among the 60 genera recorded in India, only 28 are reported so far. Species such as *Montipora monasteriata, M. informis, M. spumosa, M. turgescens, M. venosa, M. verrucosa, M. digitata, M. millepora, M. manauliensis, Acropora digitifera, A. secale, A. intermedia, Pocillopora verrucosa, Porites mannarensis, P. exserta* and *Goniopora stutchburyi* are common in these islands. Species such as *Montipora millepora, M. jonesi, M. manauliensis, M. edwardsi, M. exserta, Acropora rudis, A. valenciennesi, A. microphthalma, Porites exserta and Porites mannarensis* are reported only from Gulf of Mannar and Palk Bay.

Andaman and Nicobar Islands:

There are 15 families, 57 genera 177 species reported from these islands (Fig. 2). All the fifteen families are represented. Out of 60 genera reported from India, *Siderastrea, Coscinaraea* and *Acanthastrea* are not included in the present account. However, *Acanthastrea* and *Coscinaraea* are reported in one of the recent studies. Hence, *Siderastrea* is the only genus not found in Andaman and Nicobar Islands. There are 85 species reported in the present account, which are not found in other reefs of India.

All India:

The follwing are the 20 species reported from all the four major coral reefs of India. They are *Montipora foliosa, M. turgescens, M. venosa, M. hispida, Acropora humilis, Turbinaria mesenterina, Symphyllia radians, Favia stelligera, F. pallida, F. favus, F. speciosa, Favites halicora, F. complanata, Goniastrea pectinata, Platygyra daedalea, P. sinensis, Leptastrea purpurea, Cyphastrea microphthalma, Porites lutea and Porites lichen.*

ENDEMIC CORAL SPECIES IN INDIA

Unlike terrestrial animals, fewer marine animals are endemic or restricted to a small area –the result of their larvae floating freely in the oceans. The exceptions are species that do not have floating larvae or have larvae that float in the currents for a very short time around isolated reefs or in semi-enclosed seas. Although most coral species are very wide–ranging, thirty one corals are endemic to Indonesian-Philippines center of diversity which is supposed to be the first in the endemism (5% of the total number of species of corals, *i.e.,* 581), twenty one species in the Caribbean and Gulf of Mexico (37% of the total number of species), 18 species in Red Sea (6% of the total number of species) and at least six are endemic to India (3% of the total number of species *i.e.*,208) (*Montipora jonesi* Pillai 1969*; Montipora manauliensis* Pillai 1969; *Porites exserta* Pillai 1969; *Porites mannarensis* Pillai 1969; *Porites minicoensis* Pillai, 1969; *Alveopora superficialis* Pillai and Scheer, 1976) and probably many more to be discovered.

DEEPWATER CORALS OF INDIA

Deep-sea corals are members of the Class of animals called Anthozoa, which among creatures, include sea anemones, stony corals, soft corals and sea pens. Deep-sea coral reefs, live in the cold, dark waters of the oceans but, like shallow water tropical coral reefs, they have a distinct, diverse and sometimes highly endemic associated animal community. Deep-sea reefs are large buildup of stony corals forming a complex three dimensional skeletal framework which occur in waters between 200m and 1,500m deep often on continental slopes, submarine plateaus, ridges and seamounts. These coral frameworks contain many sub-habitats occupied by other species of marine animals and plants. Deep-sea coral reefs can be very large and magnificent; the biggest is over 40 km long and 2-3 km wide. The deep-sea reefs are important because they host communities of associated animals that are distinct from the surrounding deep sea and which have a high species diversity and sometimes a high level of endemism which is still not known. Deep-water reefs also host the early life-stages of many deep-sea animals including juvenile fish of commercial value. Some species of commercially valuable deep-sea fish, such as redfish, are associated with deep –sea coral reefs as adults. Deep-sea corals may provide historical clues to climate change and may also be the source of important drugs from the sea. Our knowledge about the distribution of deep-water reefs in India and Indian Ocean is very poor and largely based on detailed studies of a few species in limited geographic areas (Table 2).

Table 2 : List of ahermatypic and azooxanthellate deep water corals recorded from the four major coral reefs in India

Sl. No.	Species	*Lakshad weep*	Gulf of Kachchh	Gulf of Mannar & Palk Bay	Andaman and Nicobar
Family : **CARYOPHYLLIDAE** Grey, 1847					
Genus *Caryophyllia* Lamark, 1801					
1.	*C. clavus* Scacchi	•			•
2.	*C. arcuata* M. Edwards & Haime	•			•
3.	*C. acanthocyathus grayi* M. Edwards & Haime				•
Genus *Deltocyathus* M. Edwardsa nd Haime, 1848					
4.	*D. andamanensis* Alcock				•
Genus *Paracyathus* M. Edwards & Haime					
5.	*P. indicus* Duncan				•
6.	*P. profundus* Duncan			•	
7.	*P. stokesi* M. Edwards & Haime		•	•	•
Genus *Polycyathus* Duncan, 1889					
8.	*P. verrilli* Duncan		•	•	•
9.	*P. andamanensis*				•
Genus Heterocyathus M. Edwards and Haime, 1848					
10.	*H. aequicostatus* M. Edwards & Haime			•	•
Genus *Stephanocyathus* Seguenza, 1864					
11.	*S. nobilis* (Moseley)	•			
Family **FLABELLIDAE** Boume, 1905					
Genus *Flabellum* Lesson, 1831					
12.	*F. pavonium* Alcock	•			
Genus Placotrocus M. Edwards and Haime, 1848					
13.	*P. levis* M. Edwards and Haime				•
Family **RHIZANGIIDAE** Orbingny, 1851					
Genus *Culicia* Dana, 1846					
14.	*C. rubeola* (Quoy and Gaimard, 1833)			•	•

Sl. No.	Species	*Lakshadweep*	Gulf of Kachchh	Gulf of Mannar & Palk Bay	Andaman and Nicobar
Genus *Cladangia* M. Edwards and Haime, 1851					
15.	*C. exusta* Luetken, 1872			•	
Family **DENDROPHYLLIDAE Gray, 1847**					
Genus *Balanophyllia* S. Wood, 1844					
16.	*B. affinis* (Semper)			•	
17.	*B. imperialis* Kent				•
18.	*B. scabra* Alcock				•
Genus *Endopsamia* M. Edwards and Haime, 1848					
19.	*E. philippinensis* M. Edwards and Haime			•	
Genus *Heteropsammia* M. Edwards and Haime, 1848					
20.	*H. michelini* M. Edwards and Haime			•	•
Genus *Tubastrea* Lesson, 1829					
21.	*T. aurea* (Quoy and Gaimars)		•	•	•
Genus *Dendrophyllia* Blainville, 1830					
22.	*D. coarctata* Duncan			•	
23.	*D. arbuscula* V. der Horst				•
24.	*D. micranthus* (Ehrenberg)			•	
25.	*D. indica* Pillai			•	
Genus *Endopsammia* Micheloti					
26.	*E. amphelioides* (Alcock)				•
27.	*E. marenzelleri* Zibrowius				•
Total		**4**	**3**	**13**	**18**

DIVERSITY CHARACTERISTICS OF THE SHALLOW WATER SCLERACTINIAN FAUNA OF INDIA

There are 18 families reported from the world of which 15 are represented in India. This diversity is almost the same when compared biogeographically to all reefs in the world. However, of the 111 genera reported from the world (Veron, 2000) India has only 60, which is slightly less when compared to Indo-Pacific centre of diversity (82 genera) (Indonesia, Malaysia and Philippines). Of the 793 species reported from the world, India has 208+ species (it is expected to increase up to 400 when intensive studies are carried out), which is far less when compared to 581 species reported from the neighbouring Indo-Pacific centre of diversity. This emphasizes more intensive studies on the inventorization of scleractinian fauna of India.

Among the 208 species reported in the present account, the family Acroporidae has the maximum number of species (70 species, which is 34% of scleractinian fauna of India). Next to Acroporidae, the family with maximum number of species, are Faviidae with 36 species and 17% and Fungiidae with 22 species and 11% of total coral species of India. Families such as Astrocoeniidae, Euphyllidae, Oculinidae, Pectiniidae, Merulinidae, Dendrophylliidae, and Trachyphylliidae have less number of species recorded when compared to other families.

The number of species and genera of each family is compared with the world fauna (Fig. 3). The diversity of scleractinian fauna of India is only 30% when compared to the total coral species of the world (700 in the case of present study). However, when individual families are compared to world, India has unique species in the family Trachyphylliidae due to monospecific genera *Trachyphyllia*. Other monospecific genera represented in India are *Physogyra, Pseudosiderastrea, Gardineroseris, Coeloseris, Scapophyllia, Cynarina, Oulastrea and Diploastrea* (Fig. 3).

Fig. 2. Comparison of number of species occurring in four major coral reefs of India.

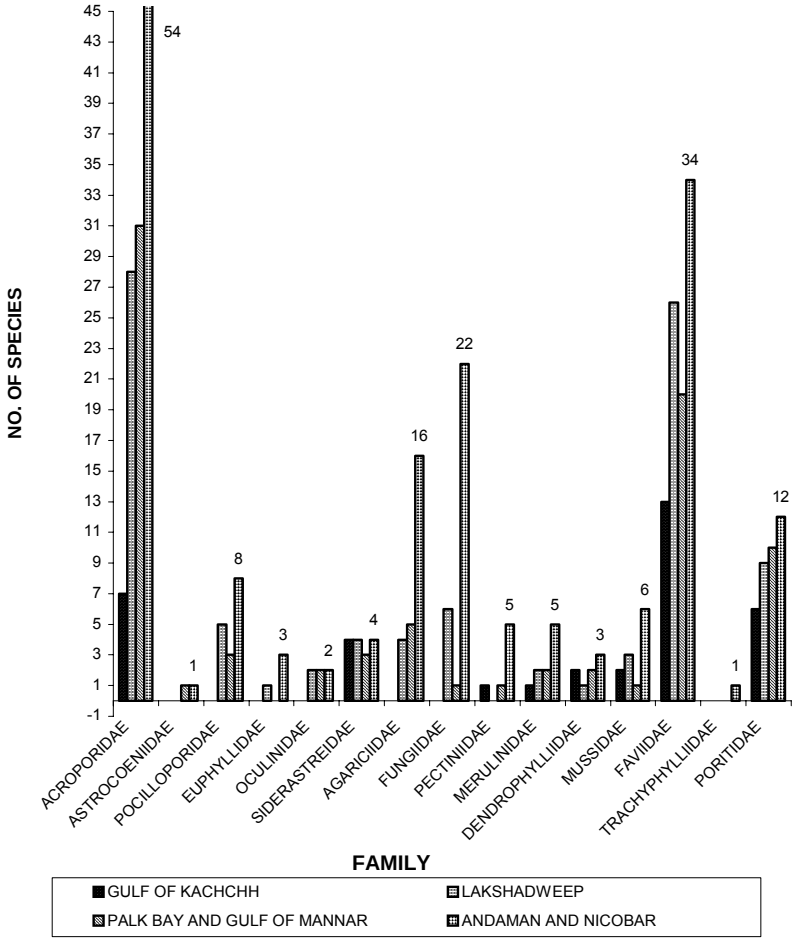
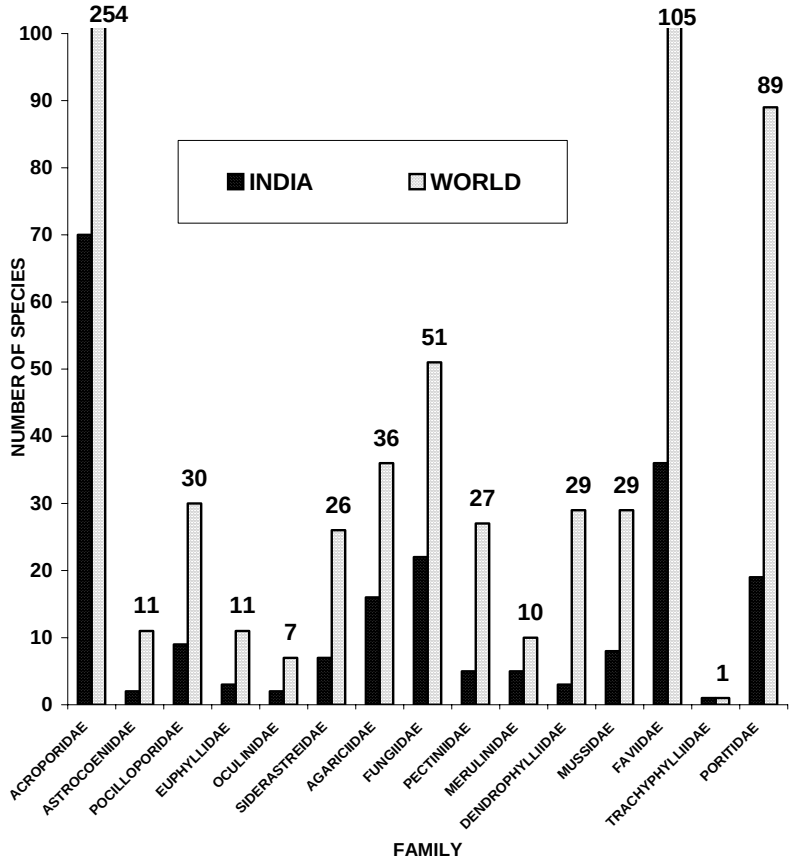


Fig. 3. Comparison of number of species in the world and India in relation to family.



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