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DISTRIBUTION AND AFFINITIES OF THE SPONGE FAUNA OF THE INDIAN REGION

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ABSTRACT

The 'Indian Region' as defined here covers an area bounded by Long 60°E and 100°E with its southern limit fixed at Lat. 10°S The general distribution of 481 species of sponges of the Indian Region, in widely separated zoogerographic areas such as the Atlantic Ocean, Mediterranean Sea, Red Sea, Australian region, Pacific Ocean, the Antaractic and Arctic Oceans is discussed and faunistic inter-relationship of the above regions is assessed. Studies revealed that 35.4% of the Indian Region's Demospongean species are common to the Australian region, 21.1% to Pacific Ocean, 20.4% to Red Sea and 18.3% to the Atlantic, while the relationship with the remaining zoogeographic areas given above is negligible The Hexactinellid and Calcareous species also have more or less similar pattern of distribution as that of Demospongiae

INTRODUCTION

THE RICHNESS of the sponge fauna of the Indian Region is well known from the works of Annandale (1915, 1915 a, 1915 b), Bowerbank (1873), Burton (1928, 1930, 1937, 1959), Burton and Rao (1932), Carter (1880, 1881, 1887), Dendy (1887, 1889, 1905, 1916 a, 1921), Dendy and Burton (1926), Kumar (1925), Rao (1941) and Thomas (1968, 1985). From the above list special mention may be made of the works of Dendy (1905) as it provides a comprehensive account, together with the geographic distribution, of the then known 215 species of Ceylon (Sri Lanka). This list was supplemented by Thomas (1968, 1985) and at present 275 valid species are known to inhabit the Gulf of Mannar, Palk Bay and the seas around Sri Lanka.

The Hexactinellida of the Indian Ocean is a group which had received considerable attention is the past. The works of Schulze (1895, 1896, 1902, 1904), Dendy (1916), Levi (1964) and Burton (1959) have made considerable advancement in the biogeography of this group directly. Ijima (1927) published a list of 'recognisably known' species of Hexactinellida after making a critical study of all species hitherto known from the Indian Ocean.

Burton (1963), in his iconoclastic work on the classification of calcareous sponges, has extensively synonymised the then known species, attributing a remarkably wide degree of variability to each species. With the broad limits of variability so established, Burton(1963) reduced the number of existing genera from 54 to 22 and the number of species from more than 500 to 47. No doubt, this has made a drastic cut in the number of species everywhere while considerably widening the distribution. The number of calcareous species from the Indian Region, as now understood, comprises a total of 10 wide spread species.

The present account deals with the distribution and affinities of a total of 481 valid species from the 'Indian Region'. The 'Indian Region', as defined here, covers an area bounded by Long. 60° E and 100°E with its southern limit fixed at Lat. 10°S.

Orderwise total number of species together with the percentage (in parentheses) of various species known from the Indian Region is given below for 8 widely separated zoogeographic

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areas, such as the Atlantic Ocean (AO), Mediterranean Sea (MS), Red Sea (RS), Indian Region (IR), Australian region (AR), Pacific Ocean (PO), Antarctic (ANT) and Arctic (ARC). The Australian region included here is the same as the Indo-Australian region of the Challenger Reports – Area No. IV in the Plate (Table 1).

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The 481 valid species represented in the Indian Region may be accounted in the following manner:

TABLE 1. *Distribution of Indian region sponges in other zoogeographic areas (The number of species is given for each region along with the percentage it forms out of the total number of Indian region species)*

Class/Order	AO*	MED	RS	IR	AR	PO	ANT	ARC
Class Demospongiae								
Ord. Keratosida	8(28.6)	9(32.2)	11(39.2)	28	15(53.6)	11(39.2)	1(3.6)	—
Ord. Haplosclerida	11(17.2)	6(9.4)	18(28.1)	64	26(40.6)	12(18.7)	5(7.8)	2(3.1)
Ord. Poecilosclerida	19(16.7)	7(6.1)	16(14.0)	114	39(34.2)	11(9.6)	—	—
Ord. Halichondrida	6(11.5)	3(5.8)	9(17.3)	52	12(23.0)	7(13.4)	1(1.9)	1(1.9)
Ord. Hadromerida	18(28.6)	11(17.5)	16(25.4)	63	24(38.1)	18(28.6)	1(1.6)	2(3.2)
Ord. Epipolasida	5(21.7)	1(4.3)	7(30.4)	23	10(43.5)	7(30.4)	—	—
Ord. Choristida	3(5.2)	—	6(10.3)	58	14(24.1)	15(25.9)	1(1.7)	1(1.7)
Ord. Carnosida	8(28.0)	7(24.0)	4(16.0)	25	11(44.0)	9(36.0)	2(8.0)	2(8.0)
Total	78(18.3)	44(10.3)	87(20.4)	427	151(35.4)	90(21.1)	11(2.6)	8(1.8)
Class Hexactinellida								
Ord. Amphidiscophora	—	—	—	24	1 (4.1)	1(4.1)	—	—
Ord. Hexasterophora	4(20.0)	—	—	20	5(25.0)	3(15.0)	—	—
Total	4(9.1)	—	—	44	6(13.6)	4(9.1)	—	—
Class Calcarea								
Fam. Homocoelidae	1	1	1	1	1	1	—	1
Fam. Heterocoelidae	5(55.5)	4(44.4)	5(55.5)	9	8(88.8)	8(88.8)	1(11.1)	5(55.5)
Total	6(60.0)	5(50.0)	6(60.0)	10	9(90.0)	9(90.0)	1(10.0)	6(60.0

*AO=Atlantic Ocean, MED = Mediterranean Sea, RS = Red Sea, IR = Indian Region, AR=Australian region, PO=Pacific Ocean, ANT=Antartic, ARC=Arctic and — = Absent.

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Demospongiae – 427 species or 88.8%
Hexactinellida – 44 species or 9.1%
Calcarea – 10 species or 2.1%

Out of the 427 species of Demospongiae represented in the region, 198 are known only from this region, i.e., from the type locality and the original description while others are widely distributed in the Indian Ocean and have been reported by several workers. Thus, out of the 198 species, 129 fall under the former category

and are known only from any one of the following type localities:- (a) Gulf of Mannar, (b) Ceylon (Sri Lanka), (c) Mergui Archipelago, (d) Okhamandal (Gujarat Coast), (e) Ganjam Coast, (f) Maldives, (g) Nicobar, (h) Waltair (Visakhapatnam) and (i) Palk Bay (some type localities of minor importance have been left out). The others *i.e.*, 69 species, are rather wide spread and have been recorded from different parts of the Indian Ocean.

Out of the 44 species of Hexactinellida 36 are known only from the Indian Region. All these species are wide spread in deeper parts. Species of the Order Hexasterophora are distributed in the Australian Region by 5 species (25%), in Atlantic Ocean by 4 species (20%) and in the Pacific by 3 species (15%). Species of the Order Amphidiscophora, on the contrary, are poorly represented in other zoogeographic realms; one each from Australian region and Pacific Ocean. The calcareous species occurring in the Indian Region are widely distributed and are encountered from littoral zone to greater depths.

The close relationship of the sponge fauna of the Indian Seas with that of the Australian region, Red Sea and the Pacific Ocean is well known. The Pearl Oyster Reports prepared after an exhaustive survey of the pearl banks of Ceylon (Sri Lanka) in the beginning of the present century have added considerably to our knowledge on the origin, distribution and past history of the various groups of animals of the Indain coasts. These collections have added about 1500 species of marine animals to the Indian Ocean list. This kind of a relationship is seen not only in the case of sponges but with every group dealt with in this report. Prof. Herdman's collection of sponges from the pearl banks, which were later worked out by Dendy (1905), comprised a total of 146 species inclusive of 77 species new to science. From the rest, *i.e.*, 69 species, no less than 47 species showed very close affinity with species of Australian region. Based on these findings Dendy (1905) included the Ceylon area under the Indo-Australian region, considerably widening the scope of this term from what Ridley and Dendy (1887) used while fixing the geographic limits of 'Challenger' collections. Ridley and Dendy (1887) noted that the Indo-Australian area is the most prolific with regard to the distribution of sponges. This may, according to Dendy (1905), be attributed to the suitable habitats afforded by the broken coast-lines of the land masses between the two continents. Row (1911), based on the observations he made on the sponges collected by Mr. Cyril Crossland (1904-1905) from Sudanese Red Sea, widened the Indo-Australian area to embrace the whole of African shores from Suez to the Cape of Good Hope and divided this area into two by the 65th meridian, though not without some reluctance, because of the relatively scanty knowledge on the sponge fauna of East Africa. Since then several works dealing with the sponge fauna of East Africa either directly or indirectly have appeared, and in this context mention may be made of the works of Burton (1926, 1929) on the Myxospongida, Astrotetraxonida, and 'Lithistidae' collected by the South African Marine Survey, Burton (1931, 1933, 1933a, 1936) on the sponges of South Africa, Levi (1963) on the Poecilosclerideaan sponges of South Africa, Thomas (1979, 1979a) on the sponges of Inhaca Island, Mambone and Paradise Islands, Burton (1959) and Thomas (1976) on the sponges of Zanzibar Island and Thomas (1976a) on sponges of Kenya. Sponge fauna of Madagascar has been subjected to thorough studies in the past, in which the works of Bosraug (1913), Levi (1956, 1964), Vacelet (1967a), 1967b), Vacelet and Vasseur (1965) and Vacelet, Vasseur and Levi (1976) are worth mentioning.

Our knowledge on the sponge fauna of the western Indian Ocean has considerably been enhanced by the collection made by the

Expeditions such as the 'John Murray' (1933–34) and 'Sealark' (1905). The reports subsequently published, besides revealing the general distribution, have thrown considerable light on the sponge fauna of specific areas such as South African coast, Gulf of Aden, Amirante, Sayade Malha, Solomon, Praslin, Providence, Mauritius etc. Burton (1995) based on the material obtained during the 'John Murray' Expedition and other earlier works, listed 315 species from the Indian Ocean. Some other on Aldabra sponges. An area-wise analysis of the sponge fauna dealt with in some of the major works mentioned above, as also some from specific areas such as the Red Sea, Gulf papers dealing directly with the Island fauna include those of Thomas (1973, 1981) on the sponges of Seychelles Bank and Levi (1961) of Mannar and Palk Bay, are furnished in Tables 2 and 3. The zoogeographic areas selected here are the same as those included in Table 1.

TABLE 2 *Zoogeographic inter-relationship of the sponge fauna of Indian Ocean as reported by earlier workers: In Percentage and Number*

Author/Year	Locality	AO	MED	RS	IO	AR	PO	ANT	ARC
Thomas, 1968	Indian Seas	19.0(24)	11.0(14)	34.4(43)	(125)	60.0(75)	28.0(35)	4.0(5)	1.6(2)
Thomas, 1985	Gulf of Mannar & Palk Bay	18.5(51)	11.3(31)	25.0(69)	(275)	42.9(118)	22.0(61)	2.5(7)	1.5(4)
Thomas, 1980	Minicoy Is.	26.8(11)	17.0(7)	46.3(19)	(41)	80.4(33)	46.3(19)	—	4.8(2)
Burton, 1959	Western Indian Ocean	16.9(34)	5.9(12)	22.8(46)	(201)	33.8(68)	17.9(36)	1.9(4)	1.9(4)
Dendy, 1916a	Western Indian Ocean	16.0(4)	4.0(1)	28.0(7)	(25)	40.0(10)	24.0(6)	—	—
Dendy, 1921	Western Indian Ocean	18.4(23)	8.8(11)	12.8(16)	(125)	19.2(24)	5.6(7)	4.8(6)	2.4(3)
Thomas, 1973	Seychelles Bank	27.4(20)	19.1(14)	39.7(29)	(73)	54.9(40)	31.5(23)	1.1(1)	2.6(2)
Levi, 1961	Aldabra Is.	2.3(1)	2.3(1)	32.5(14)	(43)	39.5(17)	13.9(6)	—	—
Vacelet & Vasseur 1965	Madagascar	18.6(8)	11.6(5)	39.5(17)	(43)	51.1(22)	30.2(13)	2.3(1)	4.6(2)
Vacelet, Vasseur and Levi, 1976	Madagascar	13.0(18)	10.6(15)	21.7(30)	(138)	37.9(55)	18.8(26)	0.7(1)	1.4(2)
Thomas, 1979a	Mambone & Paradise I	34.6(9)	26.9(7)	38.5(10)	(26)	46.1(12)	34.6(9)	—	—
Thomas, 1979	Inhaca Is.	30.7(12)	28.2(11)	53.8(21)	(39)	71.8(28)	46.1(18)	2.5(1)	7.7(3)
Burton, 1959	South Arabian coast*	13.4(12)	3.3(3)	15.7(14)	(89)	37.0(33)	20.2(18)	2.2(2)	1.1(1)
Burton, 1959	Zanzibar*	6.6(3)	2.2(1)	11.0(5)	(45)	37.0(17)	5.4(7)	—	2.2(1)
Burton, 1959	Gulf of Aden*	12.7(6)	4.2(2)	25.4(12)	(47)	36.0(17)	14.8(7)	—	—

*Based on Burton, 1959: species were analysed separately for each Station
Zoogeographic areas as in Table 1
Number of species is given in parentheses

TABLE 3 *Zoogeographic inter-relationship of the sponge fauna of red Sea as reported by earlier workers: In Percentage and Number*

Author/Year	Locality	AO	MED	RS	IO	AR	PO	ANT	ARC
Row, 1911	Red Sea	13.6(10)	17.8(13)	(73)	26.0(19)	16.0(12)	5.4(4)	—	—
Levi, 1958	Red Sea	9.4(5)	11.3(6)	(53)	50.9(27)	33.9(18)	20.7(11)	—	—

Zoogeographic areas as in Table 1
Number of species is given in parentheses

The above Table clearly indicates that the faunal inter-relationship exhibited by the sponges of the 'Indian Region' is in full agreement with that of the Indian Ocean. There are slight variations in its affinity when each zoogeographic realm is considered separately, but the general pattern remains more or less the same.

It is evident from Tables 1 and 2 that, next to the Australian region, the sponges of the Indian Region has much in common with that of the Red Sea. Keller (1889, 1891) has recorded 88 species from the Red Sea. Topsent (1892, 1893) added another 13 species to the list. Since then the number has been on the increase and with the publication by Row (1911) it reached a total of 187. Out of 73 species recorded by Row (1911) 26% (or 19 species) were common to both the Red Sea and the Indian Ocean (Table 3).

The relationship of the Red Sea sponge fauna with that of the east coast of Africa is very difficult to assess. Earlier workers like Keller (1891) and Crossland* opined that the faunas of these two areas are very closely related. The results of the present analysis indicate a more or less similar picture: 39.7 % were common to the Seychelles Bank (Thomas, 1973), 39.5% to Madagascar (Vacelet and Vasseur, 1965), 53.8% to Inhaca Island (Thomas, 1979), 38.5% to Mambone and Paradise Islands (Thomas, 1979 a), 32.5% to Aldabra Island (Levi, 1961). The results of both 'John Murray' and 'Sealark' expeditions, on the contrary, gave a quite different relationship; of the former's record, only 22.8% and of the latter's only 12.8% were common to western Indian Ocean. But when sponges collected by the 'John Murray' Expedition (Burton, 1959) were tabulated Station-wise by the present author a more or less similar conclusion was arrived at from two of its Stations (*i.e.* for South Arabian Coast, 15.7% and for Zanzibar area, 11.0%) while for the third Station (i.e., for the Gulf of Aden) it was higher (25.4%). Among the other areas investigated Minicoy (Lakshadweep) has the maximum percentage (46.3) of commonness with the Red Sea (Thomas, 1980) while the sponge fauna of the Gulf of Mannar and Palk Bay registered only 25%.

Next to the Red Sea the sponge fauna of the Indian Region has more in common with that of the Pacific Ocean, for most of the species distributed in both the Indian and Australian regions are widely distributed Indo-Pacific too. But here also, as seen in the case of Red Sea and Indian Ocean, the fauna shows greater preference to some areas than the other. Areas like Minicoy Island, Inhaca Island, Madagascar, Paradise Island and Seychelles Bank have closer affinities (46.3%, 46.1%, 30.2%, 34.6% 31.5% respectively) while the similarity with areas like the Gulf of Mannar, western Indian Ocean, Aldabra Island, south Arabian Coast, Zanzibar and the Gulf of Aden is negligible (22.0%, 17.9%(13.9%, 20.2%, 5.4% and 14.8% respectively).

The relationship of the Indian Region sponge fauna with that of the Atlantic Ocean is seen not only in the number of species but also with regard to the distribution of some genera and orders. The Orders that have more common are Haplosclerida, Poecilosclerida, Hadromerida and Carnosida (Table 1). Species that are distributed exclusively in these two areas are:- *Holoplocamia elegans* (R & D), *Cyamon vickersi* (Bow), *Myxilla arenaria* Dendy, *Basectyon tenuis* (R & D), *Microciona prolifera* (Ell. & Sol), *Eurypon clavatum* (Bow.) *Bubaris vermiculata* (Bow.), *Timea stelligera* (Carter), *Dotona pulchella* Carter, *Geodia perarmata* Bow., *Pachastrella parasitica* Carter, *Sphincterella annulata* (Carter), and *Rhabdodictyon delicatum* Schmidt.

A more or less similar relationship is seen in the case of Australian and Atlantic species also. Lendenfeld (1889) could record many species of Keratose sponges common to these

two areas. Burton (1932) also came to the same conclusion and according to him this is not because of convergence, but of common origin. Species common to Indian Region, Australian region and the Atlantic Ocean, together with their locality of collection in the Atlantic are presented below.

Verongia lacunosa (Lamarck)	- Jamaica
V. crassa (Hyatt)	- West Indies
Haliclona expansa (Thiele)	- North Atlantic
Oceanapia fistulosa (Bowerbank)	- ?
Desmapsamma anchorata (Carter)	- Curacoa, Jamaica
Toxemna tubulata (Dendy)	- Florida (?)
Radiella sarsii (Rid. & Dendy)	- Azores
Sarostegia occulata Topsent	- Atlantic

This sort of close relationship between the Indo-Australian and the Atlantic species, especially of the West Indies, has been discussed by several workers. Alcock* (1899) published a chart showing a direct conneciton by an inland basin extending east-west from Mexico to the Arabian Sea indicating the supposed relation of land and water masses in the Tertiary times. Alcock put forward this theory to show the origin of the fish fauna of India from a "teritiary extended Mediterranean stretching across the present mid Atlantic to the West Indies." Apart from animals the algae distributed in these regions also show considerable relationship in general. Murray.* (1893) suggested that "they must have been mingled periodically round the Cape of Good Hope during epochs when the climate of the Cape was considerably warmer than it is at present day." Svedelius* (1906) considered it much more probable that the explanation of resemblances pointed out by Murray between the algae of West Indies and those of Indian and Pacific Oceans must be looked for in the historical development of land connection between North and South Americas which shows that the whole of Caribbean Sea was once a bay of the Pacific, rather than in the assumption of a connection via the Cape of Good Hope at a time when the external conditions for tropical algae were more favourable than at present.

Burton (1930 a, 1932) stressed the importance of ocean currents in relation to the distribution of sponges. The Indian Ocean at its north and west is bounded by the continents of Asia and Africa respectively, and at its south by the cold waters of the West Wind Drift which is an impassable barrier for most marine animals. The barrier between the Indian Ocean and South Atlantic lies along the junction of Bengula Current directed northwards and Agulhas current flowing southwards. There is considerable difference between the faunas occuring to the east and west of this line. Some of the waters of the Agulhas Current does pass westward around the Cape of Good Hope, as a result of which the larvae may be swept around to the west side of Africa. Larvae, when introduced once into the current system of the south Atlantic, can follow the anti clock-wise pattern prevailing in the south Atlantic, A good part of the South Equatorial Current is directed to the north by the north-east coast of south America. Most of its water enters the Caribbean Sea and eventually flows through the Strait of Florida. The distribution of the various species in the north Atlantic, hence, follows the route of the major water currents prevailing there, and this is evident from the number of species distributed there.

Though theoretically possible this has several limitations. Burton himself pointed out that the apparent migration from Australia to the West Indies was quite evident in species of the groups such as Keratosids and Clavulids only. Burton was also not sure whether only the larvae of these groups were fit for such a long migration and not their adults. Since the length of larval life is not clearly understood in many cases it may not be correct to conclude

along these lines. The other factors, such as the tolerance of larvae to changes in pressure, temperature, nature of substratum etc., must also be studied in detail to arrive at any plausible conclusion.

The faunistic relationship between the Atlantic and the Mediterranean is a well established one. Sars* (1879) found that about 68% of the Scandinavian molluscs also live in the Mediterranean. Similar figures for some of the other important groups of Scandinavian animals were obtained from the Mediterranean by Nordgaard* (1915) who concluded that 60% of the Norwegian fauna is distributed in the Mediterranean also. Burton (1930a), analysing the sponges collected from Norway by A.M. Norman, also came to a more or less similar conclusion. Extra-Norwegian distribution of Norwegian sponges include about 33 species in the Atlantic coast of Africa, 45 in Azores, 38 in the Mediterranean and 7 in the West Indies. As an explanation he stated that "the main ocean current is from the Atlantic to the Mediterranean via. the Strait of Gibralter; yet Norway and the Mediterranean have 38 species in common." All the species common to the Azores or to the Atlantic coast of Europe "have been carried into the Mediterranean from these localities by the main Atlantic Drift, that is that Norway and the Mediterranean can only have species in common because these species have been derived from a common source and not beeause there has been a reciprocal migration. This continuous drift across the Atlantic via. the Azores to the Mediterranean also explains why the faunas of the West Indies, Azores and the Mediterranean have so much in common."

The present study reveals that out of 78 species distributed in the Atlantic, 15 (19%) are distributed in the Mediterranean. Species common to the Atlantic and the Mediterranean are: *Hyattella intestinalis* (Lam), *Ircinia variabilis* (Schmidt), *Haliclona rosea* (Bow.) *Adocia simulans* (Bow.), *Sigmadocia fibulata* (Schmidt), *Acarnus tortilis* Topsent, *Acanthacarnus souriei* Levi, *Raspailia viminalis* Schmidt, *Biemna annexa* (Schmidt), *Rhabdoploca curvistellifera* (Carter), *Timea stellata* (Bow.), *Cliona quadrata* Hancock, *Jaspis johnstoni* (Schmidt), *Pachastrella monilifera* Schmidt and *Plakina monolopha* Schulze

Species from the Indian Region which are distributed in the Mediterranean but not in the Atlantic are: *Cacospongia mollior* Schmidt, *Cacospongia scalaris* Schmidt, *Fasciospongia cavernosa* (Schmidt), *Thoosa hancocki* Topsent, *Halina plicata* (Schmidt), *Corticium candelabrum* Schmidt and *Plankina trilopha* Schulze.

The sponge fauna of the Mediterranean possibly originated mainly from the Atlantic. Burton, based on his studies on the sponge fauna of West Africa, came to the conclusion that "there would appear to be a static population of sponges common to the Mediterranean and west central African region which has received migrants from north and to a less extent from the west."

The effect of Suez Canal on the migration of sponges from the Red Sea to the Mediterranean or vice versa is negligible. Burton (1926a) based on the material collected by the Cambridge Expedition to the Suez Canal showed that "the migration of sponges into the canal has been almost entirely from the Red Sea." Of a total of 25 species occurring in the Suez Canal, 14 migrated from the Red Sea and 2 from the Mediterranean. Munro Fox* (1929) also came to the same conclusion and he attributed this to the prevailing current conditions. The flow of water through the Suez Canal is greatly complicated as it passes through the Bitter Lake, the botton of which consists of layers of salt. In October–December the salinity of the surface over Bitter Lake is as high as 50 ppt, and at the bottom about 55 ppt.

In the southern part of the canal, up to Bitter Lake region, there are strong tidal currents whereas the central and northern parts lack such currents. The sea level is higher at Suez than at Port Said except in July–September and hence the flow is directed from Red Sea to the Mediterranean in all seasons except in July–September when it is reversed. The transport of larvae, hence, is in northerly direction for about ten months and for the rest of the period, in southerely direction. Except fishes which have the ability to swim at will, the other groups have the same pattern of migration (Ekman* 1935). Such migrants from the Red Sea are usually seen in Port Said or along the coast of Egypt, Israel and Syria as a result of the eastward flow prevalent in the Mediterranean. The Red Sea, which is an adjacent sea of the Indian Ocean, exercises an influence similar to that of the Mediterranean water in the Atlantic, communicate with the Gulf of Aden through the Straits of Bab-el-Mandeb. An inflow of the Gulf of Aden water is effected at the surface through the major part of the year. In winter the surface layers are carried to the Red Sea and at greater depths the highly saline Red Sea water flows out. In summer the surface flow is reversed and at intermediate depths water from Gulf of Aden flows in. This type of a circulation may explain the predominance of Indian Ocean elements in the fauna of the Red Sea.

Species which are observed in the Arctic and Antarctic are more or less cosmopolitan in their distribution. Species like *Haliclona oculata* Lin. and *Plakina monolopha* Schulze are well known European species and these might have followed a line of distribution extending southwards along the west coast of Europe and Africa around the southern extremity of Africa, through the southern ocean to Australia and New Zealand. According to Burton (1934) this line can continue to the Antarctic in two ways: 1) through the southern ocean and 2) from Australia and New Zealand. Judging from the distribution pattern of the above mentioned species the latter course of dispersal appears to be a more plausible one. The distribution pattern of these two species, according to Burton (1934) is an exception to that of the majority of Arctic shallow-water species which seldom extend beyond Lat. 40°N on each side of the continent. An altogether different line of distribution is ollowed by the deep-sea sponges, and this is exemplified by *Stylocordyla borealis* (Loven). This species takes an entirely different course through the east coast of north and south America and through the southern seas, across the south Atlantic and to the Antarctic.

References

*Alcock, A. 1899. A. descriptive catalogue of the deep-sea fishes in the Indian Museum collected by the Royal Indian Marine Survey Ship *'Investigator.'* Calcutta. 222 pp.

Annandale, N. 1915. Fauna of Chilka Lake. Sponges. *Mem. Indian Mus.*, **5**: 23-54.

———— 1915a. Indian boring sponges of the family Clionidae, *Rec. Indian Mus.*, **11**: 1-24.

———— 1915 b. Some sponges parasitic on Clionidae with further notes on that family. *Ibid.*, **11**: 457-478.

Bosraug, E. 1913. Die Tetractinelliden. *Retse Ostafrika A Voeltzkow*, **3**: 231-251.

Bowerbank, J. S. 1873. Report on a collection of sponges found at Ceylon by E.W.H. Holdsworth, Esq. *Proc. zool. Soc. Lond.*, pp. 25-32.

Burton, M. 1926. Descriptions of South African sponges collected in the South African Marine Survey, Pt. I. Myxospongida and Astrotetraxonida. *Fish. Mar. Biol. Survey South Africa. Spec. Rep.*, **4**: 1-29.

———— 1926a. Sponges. In: *Zoological Results of the Suez Canal Expedition. Trans. zool. Soc. Lond.*, **1**: 71-83.

———— 1928. Report on some deep-sea sponges collected by the R.I.M.S. *Investigator*. Pt. II. *Rec. Indian Mus.*, **30**: 109-135.

———— 1929. Descriptions of South African Sponges collected in the South African Marine Survey, Pt. II. The 'Lithistidae' *Fish. Mar. Biol. Survey South Africa. Spec. Rep.*, **7**: 1-12.

———— 1930 Additions to the sponge fauna of the Gulf of Mannar. *Ann. Mag. nat. Hist.*, **5** (10): 655-676.

———— 1930 a. Norwegian sponges from the Norman Collection. *Proc. Zool. Soc. Lond.*, pp. 487-546

BURTON, M 1931. On a collection of marine sponges mostly from the Natal Coast. *Ann. Natal. Mus*, **6** (3): 337-358.

———— 1932. Sponges. *Discovery Rep.*, **6**: 237-392.

———— 1933. Report on a small collection of sponges from Still Bay, South Africa. *Ann. Mag. nat. Hist*, **11** (10): 235-244.

———— 1933 a. Four new species of sponges from Natal. *Ann, Natal Mus.*, **7**: 249-254,

———— 1934. Sponges. In: Great Barrier Reef Expedition (1928–29) Scientific Reports. *Brit. Mus. nat Hist.*, **4** (14): 513:614

———— 1936. Notes on sponges from South Africa, with descriptions of new species. *Ann. Mag. nat. Hist.*, **17** (10): 141-147.

———— 1937. Supplement to the littoral fauna of Krusadai Island. *Bull. Madras Govt. Mus.*, **1** (2) Pt. 4: 1-58.

———— 1959. Sponges, Sci. Rep. *John Murray Expedition* (1933–34). *Brit. Mus. nat. Hist.*, **10** (5): 151-281.

———— 1963. *A revision of the classification of the calcareous sponges.* Trustees of the British Museum (Natural History), 693 pp.

BURTON, M AND H.S. RAO 1932. Report on the shallow-water marine sponges in the collection of the Indian Museum. *Rec. Indian Mus.*, **34**: 299-356.

CARTER, H. J. 1880. Report on specimens dredged up from the Gulf of Mannar and presented to the Liverpool Free Museum by Capt. W. H. Cawne Warren. *Ann. Mag. nat. Hist.*, **5** (5): 437-457; **5** (6): 35-61, 129-156.

———— 1881. Supplementary report on specimens dredged up from the Gulf of Mannar, together with others from the sea in the vicinity of the Basse Rocks and from Bass' Straits respectively, presented to the Liverpool Free Museum by Capt. W. H. Cawne Warren. *Ibid.*, **7** (5): 361-385.

CARTER, H. J. 1887. Report on marine sponges, chiefly from King Island in the Mergui Archipelago, collected for the Trustees of the Indian Museum, Calcutta by Dr. John Anderson. *J. Linn. Soc. Lond.*, **21**: 61-84.

DENDY, A. 1887. The sponge fauna of Madras. A report on a collection of sponges obtained in the neighbourhood of Madras by Edgar Thurston. *Ann. Mag. nat. Hist*, **20** (5): 153-164.

———— 1889. Report on a second collection of sponges from the Gulf of Mannar. *Ibid*, **3** (6): 73-99.

———— 1905. Report on the sponges collected by Prof. Herdman at Ceylon in 1902. *Rep. Govt. Ceylon Pearl Oyster Fish. Gulf Mannar. Suppl.* **18**: 57-246

———— 1916. Report on the Hexactinellid sponges (Triaxonida) collected by H.M.S. 'Sealark' in the Indian Ocean. *Trans. Linn. Soc. Lond.*, **17**: 211-224

———— 1916 a Report on the Homosclerophora and Astrotetraxonida collected by H M S 'Sealark' in the Indian Ocean. *Ibid.*, **17**: 225-271.

———— 1921. Report on Sigmatotetraxonida collected by H.M.S. 'Sealark' in the Indian Ocean. *Ibid.*, **18**: 1-164.

DENDY, A. AND M. BURTON 1926. Report on some deep sea sponges from the Indian Museum collected by R.I.M.S. *Investigator*. 1. Hexactinellida and Tetraxonida (Pars). *Rec. Indian Mus.*, **28**: 225-248.

IJIMA, I. 1927. The Hexactinellida of Siboga Expedition. *Siboga Exped.*, **4**: 1-383.

KELLER, C. 1889. Die spongienfauna des rothen Meeres. *Z. wiss. Zool.*, **48**: 311-405.

———— 1891. Die spongienfauna des rothen Meeres. *Ibid.*, **52**: 294-368.

KUMAR, D. A. 1925. Report on some Tetraxonid sponges in the collection of the Indian Museum, Calcutta. *Rec. Indian Mus.*, **27**: 211-229.

LEVI, C. 1956. Spongiaires des cotes de Madagascar. *Mem. Inst. sci. Madagascar*, Ser. A, **10**: 1-23.

———— 1958. Spongiaires de mer Rouge. *Result. scient. Comp. Calypso*, 3: 1-46.

———— 1961. Les Spongiaires de L'ile Aldabra. *Result. scient. Comp. Calypso*, **5** (2): 3-32.

———— 1963. Spongiares D'Afrique du Sud (I) Poecilosclerides. *Trans. R. Soc. S. Afr.*, **37** (1): 1-72.

————1964. Spongiaires du Canal de Mozambique. *Bull. Mus. natn. Hist. nat. Paris*, Ser. 2, **36** (3): 384-395.

LENDENFELD R. VON. 1889. *A monograph of the horny sponges*, London, 1-936.

MUNRO FOX*. 1926. Cambridge Expedition to the Suez Canal, General. *Trans. Zool. Soc. Lond.*, **22**: 6.

MURRAY, G.* 1893. A comparison of the marine flora of the warmer Atlantic, Indian Ocean and the Cape of Good Hope. *Phycological Memoirs*, **2**: 65-70.

RAO, H. S. 1941. Indian and Ceylon sponges of the Naturhistoriska Riksmuseet, Stockholm, collected by K. Fristedt. *Rec. Indian Mus.*, **43**; 417-469.

RIDLEY, S.O. AND A. DENDY 1887. Report on Monaxonida collected by H.M.S. 'Challenger' during the years 1873–1876. *Rep. Sci. Res. Challenger. Zool.*, **20**: 1-275.

Row, R.W.H. 1911. Report on the sponges collected by Mr. Cyril Crossland in 1904–1905. Pt. 2. *J. Linn. Soc.*, **31** (208): 287-400.

Schulze, F. E. 1895. Hexactinelliden des Indischen Oceanes. 1. Die Hyalonematiden. *Abh. K. Preuss. Akad. Wiss. Berlin*, 1894: 1-60.

———— 1896. Hexactinelliden des Indischen Oceanes. 2. Die Hexasterophora. *Ibid.*, pp. 1-92.

———— 1900. Hexactinelliden des Indischen Oceanes. *Ibid.*, pp. 1-46.

———— 1902. An account of the Indian Triaxonida collected by the Royal Indian Marine Survey Ship 'Investigator.' Translated into English by R. von Lendenfeld. *Trustees of Indian Museum, Calcutta*, pp. 1-113.

———— 1904. Die Hexactinellida. *Wiss. Ergebn dt. Tiefsee-Exped. "Valdivia"* 1898–1899, **4**: 1-265.

*Svedelius, N. 1906. Ecological and systematic studies of Ceylonese species of *Caulerpa*. *Ceylon. Mar. biol. Rep.* 4.

Thomas, P. A. 1968b. Studies on sponges. *Ph.D. Thesis. University of Kerala.*

———— 1973. Marine Demospongiae of Mahe Island in the Seychelles Bank (Indian Ocean). *Mus. Roy. L'Afr. Cent.*, **203**: 1-98.

———— 1976. Marine Demospongiae of Zanzibar Island. *J. mar. biol. Ass. India.*, **18** (3): 448-460.

———— 1976 a. Marine Demospongiae of Ras Iwatine (Kenya). *Ibid.*, **18** (3): 642-649.

———— 1979. Studies on sponges of the Mozambique Channel. I. –Sponges of Inhaca Island. *Mus. Roy. L'Afr. Cent.*, **227**: 1-45.

———— 1979 a. Studies on sponges of the Mozambique Channel. II.–Sponges of Mambone and Paradise Islands. *Ibid.*, **227**: 49-73.

———— 1979 b. Demospongiae of Minicoy Island (Indian Ocean) Part I Orders Keratosida and Haplosclerida, *J. mar. biol. Ass. India*, **21** (1 & 2): 10-16

———— 1980. Demospongiae of Minicoy Island (Indian Ocean) Part II Order Poecilosclerida. *Ibid.*, **22** (1 & 2): 1-7.

———— 1980 a. Demospongiae of Minicoy Island (Indian Ocean). Part 3 Orders Halichondrida, Hadromerida, Epipolasida and Choristida. *Ibid.*, **22** (1 & 2): 8-20.

———— 1981. A second collection of marine Demospongiae from Mahe Island in the Seychelles Bank (Indian Ocean). *Mus. Roy. L'Afr. Cent.*, **233**: 1-54.

———— 1985. Demospongiae of the Gulf of Mannar and Palk Bay. In: P. S. B. R. James (Ed.) *Recent Advances in Marine Biology*. Today and Tomorrow Printers, New Delhi, pp. 205-365.

Topsent, E 1892. Eponges de la mer Rouge. *Mem. Soc. zool. Fr.*, pp. 21-29.

———— 1893. Note sur quelques eponges du Golfe de Tajoura. *Bull. Soc. zool. Fr.*, **18**: 177-182.

Vacelet, J. 1967 a. Descriptions d'eponges pharetronides actuelles des' tunnels obscurs sous-recifaux de Tulear (Madagascar). *Rec. Trav. Sta. mar. Endoume*, 6:37-62.

———— 1967 b. Quelques Eponges Pharetronides *et* "Silico-calcaires" des grottes sous-marines obscures. *Ibid.*, **58** (42): 121-132.

Vacelet, J. and P. Vasseur 1965. Spongiaires des grottes et surplombs des recifs de Tulear (Madascar). *Ibid.*, Suppl. **4**: 71-123.

———— 1971. Eponges des recifs coralliens de Tulear (Madagascar). *Tethys*, Suppl., **1**: 51-126.

Vacelet, J., P. Vasseur and C. Levi 1976. Spongiaires de la pente externe des recifs corallines de Tulear (sud-ouest de Madagascar). *Mem. Mus. nat. Hist. nat., A.* **49**: 1-116.

*Not referred to in original