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Distribution of Alien and Cryptogenic Ascidians along the Southern Coasts of Indian Peninsula

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Abstract: The Indian peninsular is dotted with 12 major ports and a number of minor ports serving as gateway for non-indigenous marine organisms. Taxonomical studies on ascidians in India have been expanded but there is a lack of information about the distributions of alien ascidians. Hence the present study was aimed to know the distribution of alien ascidians at 11 stations in the east and west coasts of Indian peninsular. A maximum of 34 non-indigenous ascidians out of 41 species have been reported in the present study. They all belong to diverse families with maximum representation from Didemnidae. All eight native ascidian species are exclusively colonial. Among the 34 alien ascidians, 26 species are listed as cryptogenic of which two are established-cryptogenic (*Herdmania pallida* and *Lissoclinum fragile*). Eight species are invasive with two established-invasive species such as *Phallusia nigra* and *Didemnum candidum*. The highest ascidian diversity was noticed in Tuticorin (south east coast) and Kadiapattanam (south west coast).

Key words: Alien ascidian % Distribution % Ecology % Indian peninsular % Spatial scale

INTRODUCTION

Increased monitoring efforts over the past 15 to 20 years have found that nonindigenous species are conspicuous components of marine communities throughout the world [1-3]. There is growing awareness that, several nonindigenous species of colonial and solitary ascidians, Prochordate members of the Phylum Chordata (Subphylum Tunicata; Class Ascidiacea), have been found across widely separated geographical locations [4-9]. Invasive species are thought to be among the most important causes for decline of native species [10].

Ascidian can be strong spatial competitors and once they become established often experience population explosion that can develop into dense stands or mats that over grow and cover available surfaces. These effects have caused great concern to many aquaculture growers worldwide because they can lead to increased labour costs and affect the quality and quantity of cultured organisms [11]. Following habitat destruction, alien invasions are the most important threat to loss of biodiversity [12]. Cryptogenic species are species with no definite evidence of their native or introduced status [13]. Invasive species is defined as introduced species which, can spread away from their area of initial introduction through the production of fertile offspring without any reference to impact [14]. Established species occur with self-sustaining populations in their new habitat [15].

The Indian coast, being dotted with 12 major ports and a number of minor ports is susceptible for bioinvasions and hence warrants a close watch. Little information exists from marine ecosystems of India regarding the presence and distribution of alien and cryptogenic ascidians. A comparison of the pre-2000 ascidian survey data in Indian waters with that of the post-2000 period showed that more than 300 species of ascidians including more than 170 new species were reported in the later period [16-19] and the total number of ascidians increased to more than 400. This clearly indicates that taxonomical studies on ascidians in India have been expanded. However, distributional information of alien ascidians is lacking. Some information is available on the impact of ascidians as marine fouling species [20-22] but these ascidians were not categorized into either alien or native species. *Styela bicolor, Phallusia nigra*

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and *Eusynstyela tincta* could have been translocated into Indian waters from other parts of the world and also between coastal locations of India [23]. It is reported that 6% of the total 205 non-indigenous taxa introduced into Indian seas in the post-1960 period were represented by ascidians [24]. The first report on alien ascidians in India [25] revealed that out of 33 species, 31 were alien ascidians in Vizhinjam Bay (south west coast of India). The occurrence of 18 alien ascidians in Tuticorin coast (North Break Waters) was also reported [26]. In this context, the present study focuses on distribution of non-indigenous ascidians in southern coasts of Indian peninsula.

MATERIALS AND METHODS

Eleven stations were sampled along the Indian peninsular during 2003-2004 (Figure 1) covering Tuticorin, Tiruchendur, Manapad, Uvary, Koodankulam, Kaniyakumari, Pozhikarai, Azhickal, Muttom, Kadiapattanam and Colechel (Table 1).

Intertidal sites were visited at low tides and a variety of collection methods were used to obtain the organisms. At the marina in Tuticorin, organisms were collected using hand tools to remove materials from bumper tires, docks and marina floats. SCUBA divers sampled the marina to remove materials from the undersides of floating docks.

Table 1: Locations and descriptions of ascidian sampling sites during 2002-2003

Sites sampled for ascidians	# Assigned	Latitude	Longitude	Site substrates
Tuticorin	1	8°45'7"N	78°12'37"E	Marina installations, small rocks and stones in the intertidal regions, sea grasses and hull of barges
Tiruchendur	2	8°29'10"N	78°7'3"E	Boulders, rocks and stones in the intertidal regions
Manapad	3	8°22'22"N	78°3'58"E	Shore line and trawl collections
Uvary	4	8°17'14"N	77°53'49"E	Embedded rocks, shore line and trawl collections
Koodankulam	5	8°10'2"N	77°42'39"E	Shore line
Kaniyakumari	6	8°5'47"N	77°32'17"E	Boulders and rocks
Pozhikarai	7	8°6'25"N	77°24'8"E	Chank bed, Molluscan shells and trawl collections
Azhickal	8	8°7'23"N	77°20'30"E	Chank bed and mussel beds
Muttom	9	8°7'14"N	77°18'44"E	Boulders and rocks
Kadiapattanam	10	8°7'47"N	77°18'18"E	Mussel bed, rocks and shore line
Colechel	11	8°9'46"N	77°15'44"E	Port installations

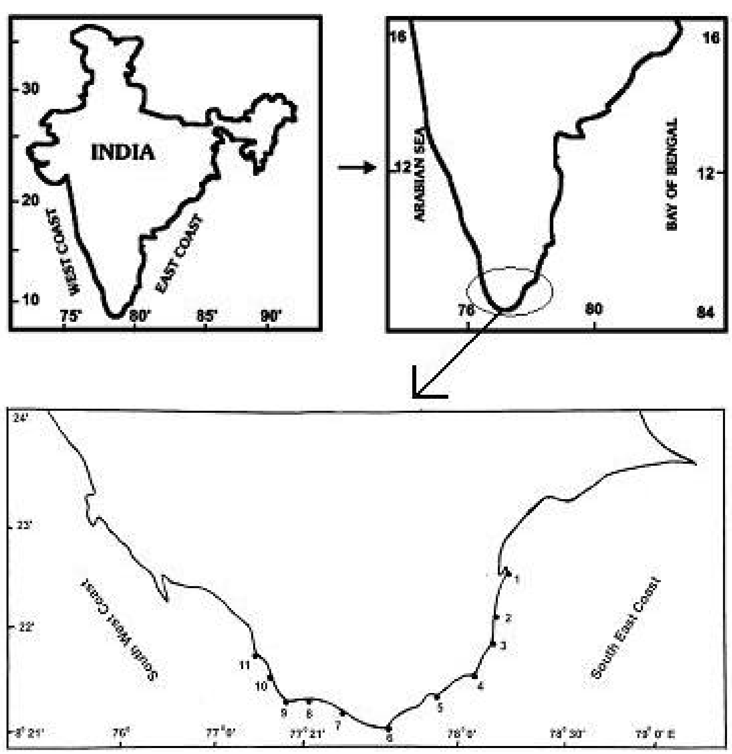

Fig. 1: Map showing the 11 sampling stations

Specimens were carefully dislodged from their surfaces using a sharp fishing knife. In case of large colonial ascidians, a sample of that colony (ie a wedge from the centre or taking whole lobe or branch of the colony if there are many) was taken. At some stations trawl collections were also made. Ascidians attached with sponges, coral pieces, sea grasses and molluscans which were accidentally caught during deep fishing were collected form the fishing nets.

All the specimens were narcotized with menthol crystals for up to 3 hours for colonial and five or more hours for large solitary specimens and were fixed quickly by adding to it one of 40% formaldehyde to the 9 parts represented by the specimen to which we have added enough sea water to cover it. The specimens were sorted and identified to species or the lowest practicable taxon, with dissection and/or compound microscopes using various taxonomic keys and references [27-39].

Since historical records of Indian ascidian species are scarce, the invasive status of all ascidian species encountered was decided based on published geographic records, by exhaustively literature search for all publications which included distributional information.

RESULTS

All 41 ascidians found during the survey at the 11 different stations along the Indian peninsular are shown in Table 2. Out of 41, *Polyclinum madrasensis* Sebestian, 1952, *P. indicum* Sebestian, 1954, *Eudistoma lakshmiani* Renganathan, 1964, *Ecteinascidia krishnani* Renganathan, 1985, *Diplosoma swamiensis* Renganathan, 1986, *Distaplia nathensis* Meenakshi, 1997 and *Ecteinascidia venui* Meenakshi, 1997 are native to Indian waters and are exclusively colonial belong to five diverse families. These seven species are found in Tuticorin station (south east coast).

Table 2: List of ascidian species per sampling site

		Stations										
Species	Status	1	2	3	4	5	6	7	8	9	10	11
Phlebobranchia												
Perophoridae												
Perophora formosana Oka, 1931	Cryptogenic	x										
Ecteinascidia krishnani Renganathan, 1985	Native	x										
E. venui Meenakshi, 1997	Native	x										
Ascidiidae												
Phallusia arabica Savigny, 1816	Cryptogenic	x										
P. nigra Savigny, 1816	Established/Invasive	x										
P. polytrema (Herdman, 1906)	Cryptogenic	x										
Ascidia gemmata Sluiter, 1895	Cryptogenic	x										
A. sydneiensis Stimpson, 1855	Invasive	x										
Stolidobranchia												
Styelidae												
Botryllinae												
Botryllus schlloseri (Pallas, 1766)	Invasive	x										
B. chevalense Herdman, 1906	Cryptogenic	x										
Polyzoinae												
Symplegma oceania Tokioka, 1961	Cryptogenic	x										x
Eusynstyela tincta Van Name, 1902	Invasive	x										
Styelinae												
Styela bicolor Sluiter, 1887	Cryptogenic			x								
Styela canopus Savigny, 1816	Invasive								x			
Pyuridae												
Microcosmus curvus Tokioka, 1954	Cryptogenic	x										
M. exasperatus Heller, 1878	Invasive			x							x	
M. helleri Herdman, 1881	Cryptogenic										x	
M. propinquus Herdman, 1881	Cryptogenic										x	
M. squamiger Micahelson, 1927	Invasive										x	
M. stoloniferus Kott, 1952	Cryptogenic										x	
Herdmania pallida Savigny, 1816	Established/Cryptogenic	x	x	x	x	x		x			x	x
Pyura lanka Herdman, 1906	Cryptogenic								x			
Molgulidae												
Molgula ficus (Macdonald, 1859)	Cryptogenic								x			

Table 2: Continued

Aplousobranchia												
Holozoidae												
Distaplia nathensis Meenakshi, 1997	Native	x										
Polycitoridae												
Eudistoma lakshmiani Renganathan, 1986	Native	x										
E. laysani (Sluiter, 1990)	Cryptogenic										x	
E. viride Tokioka (1985)	Cryptogenic	x										
Polyclinidae												
Polyclinum madrasensis Sebestian, 1952	Native	x										
P. indicum Sebestian, 1954	Native	x										
Didemnidae												
Trididemnum clinides Kott, 1977	Cryptogenic	x							x			
Leptoclinides madara Tokioka, 1953	Cryptogenic		x						x			x
L. rufus (Sluiter, 1909)	Cryptogenic	x	x						x			
Didemnum candidum Savigny, 1816	Established / Invasive	x		x	x	x					x	x
D. moseleyi Herdman, 1866	Cryptogenic							x				
D. psammathodes Sluiter, 1895	Cryptogenic	x			x							
D. nekozita Tokioka, 1967	Cryptogenic	x			x				x		x	x
Polysyncraton lithostratum (Brewin, 1956)	Cryptogenic	x						x	x		x	x
Diplosoma similis Sluiter, 1909	Cryptogenic	x			x							
Diplosoma swamiensis Renganathan, 1986	Native	x										
Lissoclinum bistratum (Sluiter, 1905)	Cryptogenic										x	
Lisoclinum fragile Van Name, 1902	Established/Cryptogenic	x		x		x		x				
Total		28	3	5	5	3	0	4	8	0	11	6

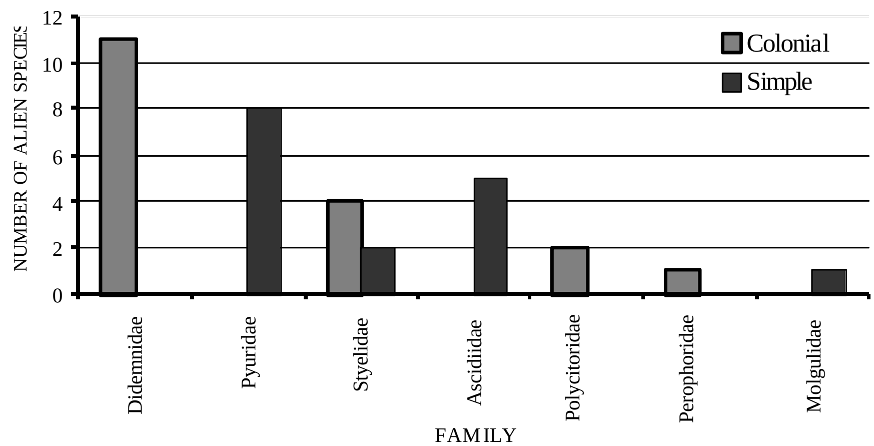

Fig. 2: Number of alien species of selected ascidians families during this study

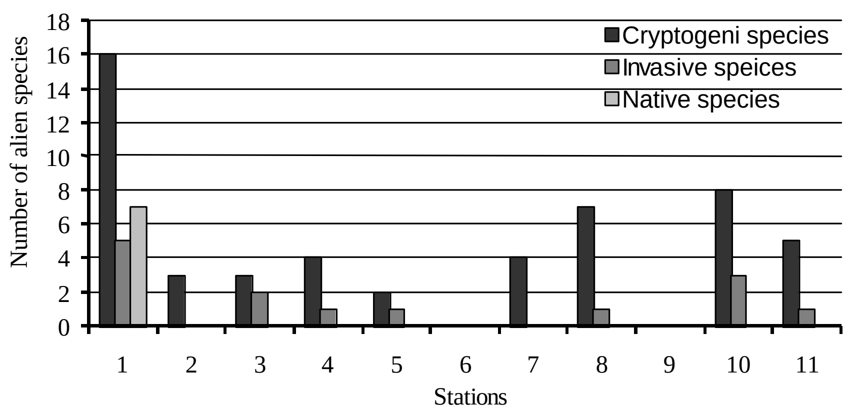

Fig. 3: Number of alien species of ascidians at different staions the peninsular India. For location of sampling sites see Fig 1

In total of 34 non native ascidians 26 are cryptogenic and 8 are invasive. These cryptogenic species belong to diverse families (Fig. 2) with maximum representation from Didemnidae (10 taxa), followed by Pyuridae (6), Styelidae and Ascidiidae (3 each), Polycitoridae (2), Perophoridae and Molgulidae (1 each). The largest group is Aplousobranchia with 12 species. Stolidobranchia are also well represented with 10 species. The minimum number of species (4) is represented by Phlebobranchia.

Of 26 cryptogenic ascidians, two are listed as established-cryptogenic ascidians (*Herdmania pallida* and *Lissoclinum fragile*) and of the eight invasive ascidians, two are established-invasive ascidians (*Phallusia nigra* and *Didemnum candidum*).

Distribution of non Indigenous *Ascidians:* The distribution of non indigenous ascidians in the study areas is depicted in Figure 3. The most ascidian rich site was Tuticorin (south east coast) with a maximum of 16 cryptogenic and 5 invasive ascidians. All the seven native species found during the study were also observed in this station. The second richest site with 8 cryptogenic and three invasive ascidians is Kadiapattanam (south west coast). Station 8 has a relatively high number of cryptogenic (7) and one invasive ascidians and station 11 had the highest share of colonial ascidians with 5 cryptogenic and one invasive. Stations 3 and 4 recorded 4 cryptogenic and one invasive ascidian each while 4 and 3 exclusively cryptogenic species were noticed at station 7 and 2 respectively. Station 5 recorded 2 cryptogenic and one invasive ascidian. An absence of ascidians was observed in two stations, Kanyakumari and Muttom.

DISCUSSION

The Indian peninsular, including the Gulf of Mannar, a hot spot for mega biodiversity along the south east coast and Arabian Sea, a highly fertile and productive sea along the south west coast, is the most extensively and longest studied marine system in India. The present study has been an intensive program conducted along the Indian peninsular and documented 41 ascidian species.

A total of 34 ascidians have possibly been introduced into Indian waters from distant locations. There are some uncertain species as their origin and status as non-indigenous species remains unclear. Various levels of evidence suggest that these species of uncertain status may simply be widespread cosmopolitan species [40]. Other evidence suggests that these species are cryptogenic. In the present study, 26 species have uncertain status and they may be introduced or cryptogenic and are still under investigation. Among the 26 cryptogenic ascidians, two ascidians, *H. pallida* and *L. fragile* are established-cryptogenic. Eight invasive ascidians are recorded with *P. nigra* and *D. candidum* as established-invasive ascidians. The success of an introduction relies as much on the biological characteristics of the species as on the host environment [41]. *H. pallida* [42] and *L. fragile* [43] whose invasion status are unclear, were reported for the first time in Indian waters whereas, *P. nigra* and *D. candidum* were reported from the Tuticorin coast [44]. They are established species because the recruitment of these species occurred continuously throughout the year independent of human activity [45].

The presence of large numbers of cryptogenic ascidians in the Tuticorin may be explained by the existence of the availability of suitable hard substrate provided by harbour installations, designs that often result in the retention of locally-produced propagules [46] and the traffic of boats with hull fouling, which is considered a major vector of exotic ascidians [47-49]. Given the ubiquity of exotic species in ports and marinas and the fact that ports and marinas are becoming increasingly numerous as human populations expand along coastal areas [50], it is unsurprising that floating docks have been sites for many experimental studies investigating exotic ascidians [51, 52].

An invader may enter an environment that has been intensely altered by anthropogenic disturbance. These disturbances can create a mismatch between traits of the native species and the environmental conditions to which they have long adopted, a phenomenon termed Selection Regime Modification (SRM) [53]. The SRM mechanism predicts that highly disturbed environments will have a greater abundance of exotic species and that the impact of invading species as native species will be greater in other environments. The second richest site, Kadiapattanam, is found to contain many rocks, stones in different sizes and shapes and this site contains large mussel beds also which afforded good substratum for attachment of ascidians larvae [44, 54].The wide distribution and dominance of the Didemnidae species in all habitats may be justified by the fact that the *Didemnum* species are considered a strong competitor with the ability to rapidly colonize a substrate [55] and it prefers hard substrate, like dock pilings, over soft sediments [56].

In comparison, the south east coast was found to contain the maximum of both native and non native ascidians. The east side of the Indian peninsular is more protected while the western side is more exposed to waves and currents. Since intense hydrodynamics [57], sedimentary dynamics, availability of food, current intensity and wave exposure [58] can limit the occurrence of more sensitive ascidians and may explain the differences in species compositions between two sides of the Indian peninsular.

Advances in shipping resulted in more frequent intracoastal traffic by fishing vessels and ocean-going pleasure boats. Fishing vessels and pleasure craft are generally not as rigorously maintained as commercial vessels, with the result that a variety of fouling organisms may settle and grow on the hull. Once in a new location, fouling organisms may successfully produce motile larvae that spread. In the present study, Pyuridae species (except *M. curvus*) seem to show their western distribution limit in the south west coast. However, these species have already been reported further west in Vizhinjam bay, a minor port [25]. The distribution of all these invasive species at the south west coast stations as observed in the present study may be due to periodical transport of fishing vessels to and from Vizhinjam bay for seasonal fishing.

H. pallida and *D. candidum* were the most commonly found ascidians during this study. Both the species are reported in Tuticorin (south east) and Vizhinjam bay (south west). These species may also colonize the stations along the south east and south west from Tuticorin and Vizhinjam bay respectively the provision of maritime and other installations associated with commercial harbours and other anthropogenic activities provide additional habitats for ascidian species [59]. Ship hulls support the spread of exotic species which settle in harbour [60].

Virtually all ports and bays of India have at least some non-indigenous marine species that have arrived from other parts of the globe. There is no doubt that the pace of introductions has increased in the past 20 years [23]. It is clear that global maritime commerce will continue to be an important source of introductions. It is important to more carefully assess the impact of secondary introductions from initial introductions to other locations, particularly at the west coast.

The Gulf of Mannar and the Arabian Sea are hydrographically and biogeochemically different. Therefore, if species from one port bordering the Gulf of Mannar, are carried to another one on the west coast of India, the transportable organism may be successfully introduced to the western side. Such species may pose an ecological risk to biota in the recipient coast. Therefore, it is important to study the effects of possibly bioinvasions between ports which will also help to modify and strengthen strategies on ecological conservation.

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