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INTRUSION OF EXOTIC ASCIDIAN *HERDMANIA MOMUS* (SAVIGNY, 1816) IN THE SOUTHEAST AND WEST COASTS OF INDIA - A CASE STUDY

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ABSTRACT

Peninsular India has great ecological as well as economical values as this region has direct link with various Ports of the world via maritime transport. One of the emerging problems at global level is the intrusion of non-native organisms into new areas that significantly impact on biodiversity of the specific ecosystem. One such invader organism is tunicate/ascidians, fouling the hulls of ship and other objects even on other tunicates. Many ascidians have great potential to invade through a variety of vectors and gradually extending into nearby areas by dispersing their viable progeny. Of all the invaders of ascidians we can single out a simple ascidian, *Herdmania momus* from the Class Ascidiacea of subphylum Urochordata is well recognized non-native species to Indian coastal water. The previous report on this species revealed its abundance, dominance and restricted distribution from the Port areas at 5m depth, where the availability of artificial substrata is more. The present survey shows that, out of 55 stations, a total of 29 stations revealed its presence throughout the study period. It is noteworthy to mention that the introduction of this species into 17 new areas indicate the ongoing invasiveness in Indian waters. A prodigious abundance in the Southeast and west coast signified its ongoing spread among the fishlanding centres too. Whereas, it's sporadic occurrence was noted from majority of the stations including Thoothukudi Port area that signaled the migration of this species to other conducive areas. Therefore, an extensive research is imperative on this group to identify the environmental sensitive areas that would help to monitor the marine environment in future.

Key words: *Herdmania momus,* Ongoing introduction, regressive species.

INTRODUCTION

In the current scenario, "bioinvasion" has been one of the major threats to marine ecosystem as it echoes the significant impact on biodiversity at global level. Increasing global trade, changes in global climate, changes in water current patterns, pollution, acidification, corals bleaching, mining etc., facilitate translocation of number of species beyond their boundaries. Tunicates/ascidians are considered as "silent invaders and fast cultivators" in the marine ecosystem as they invade and spread through mechanical (hulls of ship, boating vessels), physical (waves, tides, water currents etc.,) as well as the biological vectors (molluscs, crab etc.,). The successful mode of recruitment of ascidian is due to active motile juvenile stage in the early part of the life history. Their dispersal from their origin to nearby areas is mainly relies on environmental attributes as well as the vectors. If the environmental variables are suitable after the settlement; they breed well by sexual and asexual modes and later establish in the specific environment. The rate of introductions of non-indigenous ascidians into tropical and temperate waters are escalating annually (Coles *et al.,* 1999 and Lambert, 2002) resulting in homogenization of global biota (Svane and Young, 1989, Carlton and Geller,1993; Hewitt *et al*., 2004; Lambert and Lambert, 2003, Abdul Jaffarali and Sivakumar, 2007 and Tamilselvi *et al*., 2011).

There is growing awareness that many ascidians are highly invasive and can spread rapidly to new habitats (Rocha and Kremer, 2005), causing significant effects on the structure and functions of ecosystem (Lambert, 2001). The simple ascidian *Herdmania momus,* is one such tunicate which has great invasive potential and commonly distributed along the coast of Atlantic Ocean, Indo-west Pacific, Mediterranean and the sub Antarctic regions. The first record of this species in Indian coastal water was reported by Das, (1936) from the sea adjacent to Thoothukudi coast. Later, it was found to occur in artificial substrates such as walls, piers and buoys in Madras (Chennai) coast (Sebastian, 1952) and in Ennur (Das, 1945). After a long four decade period, its distribution was recorded in Thoothukudi Port area (Meenakshi, 1997; Tamilselvi, 2008 and Tamilselvi *et al.,* 2011), Vizhinjam Bay (Abdul Jaffar Ali and Sivakumar, 2007), near Roche Park area and Kayalpattanum (Tamilselvi *et al.,* 2015). Recent investigations reported that the rates of introduction of this species is high in Port areas ((Abdul Jaffarali and Sivakumar, 2007 and Tamilselvi 2008) from where they are oceanically translocated to nearby areas due to environmental stress. As this species comes under regressive in nature and flagship to provide a habitat for a number of organisms, its on-going distribution and role in the specific ecosystem in the southeast and west coast of India is imperative. The data obtained during this study will be useful to identify the sensitized areas and to prepare environmental sensitivity maps for monitoring.

MATERIALS AND METHODS

A survey was conducted from January 2013 to December 2015, covering 55 stations (Fig.1 and Table 1) including two major Port areas such as Thoothukudi and Vizhinjam located in southeast and southwest coasts respectively. Many fish landing centers around these two major Ports were studied. As substratum is one of the factors for its distribution, different types of habitats such as sea - grass beds, coral reefs, intertidal rocky areas, muddy flats and sandy areas were examined. During the visit, a visual inspection of recreational marinas and docks harboured along the study areas was also made. Besides, a questionnaire was also prepared for the fishermen, boat owners and SCUBA divers to get accurate data regarding the availability of *H.momus*, its location, its distribution in varied depth, number, size and predators. As per the availability, abundance was classified as follows: 20-50- High; 5-20-Medium; <5- Low. The adult *H.momus* was identified on the spot by examining the larger size, globular body, position of siphons, nature of test and fouling nature. The immature individuals were scrapped from the hulls of oil jetty and also from the shells of gastropods. They were kept in a jar filled with fresh seawater, narcotized for about 1 hour and preserved in 10% formalin.

Figure 1. shows the distribution of *Herdmania momus* in Southeast and West coast of India.

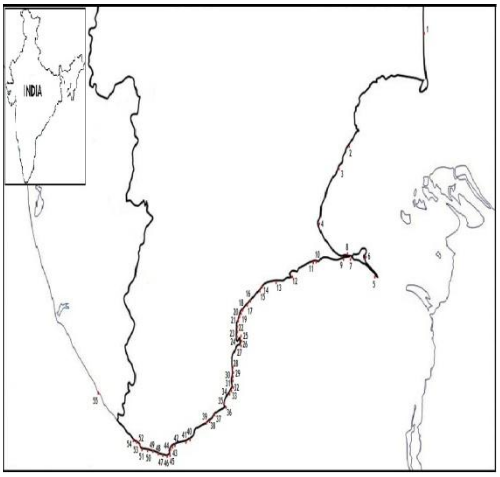

Figure 2. shows the abundance of *Herdmania momus* in Veerapandianpatnam

RESULT AND DISCUSSION

World wide shipping transport among the countries has not only promoted trade but also introduced the biotic resources to various parts of the world via ballast water and hulls of ship. In the present study, a discontinuous distribution of *H. momus* was noted and its occurrence was found in 29 stations including two major Ports such as Thoothukudi and Vizhinjam. These Ports have direct cargo connectivity to major international cargo ports of different countries through sea route. Earlier reports on *H.momus* in Indian coast by Das(1936); Sebastian,(1952); Tamilselvi, (2008); Tamilselvi *et al.,(*2011) revealed the introduction of this species into Indian coastal water through the primary vectors such as hulls of ship and ballast water from its native origin, the Red Sea. Many researchers (Svane and Young, 1989); (Lambert and Lambert, 2003); Hewitt *et al.,*2004; Abdul Jaffarali and Sivakumar, 2007) have strongly supported the fact that shipping activity has introduced ascidians into many Port areas either through ballast water or boat's hulls. Interestingly to note that, in contrary to earlier report of a remarkable occurrence and abundance of this species at 5m depth in Thoothukudi Port (Tamilselvi, 2008) as well as in Vizhinjam Port (Abdul Jaffarali and Sivakumar, 2007), less availability was noted at the former station at the same depth in the consequent study periods, including the present. A moderate difference was noted in terms of biomass between Thoothukudi and Vizhinjam Ports, even though both the areas are enriched with many permanent artificial substrates such as pearl oyster cage, barges, pillars, pebbles, granite stones and other harbour installations. Tamilselvi *et al.,* (2015), reported that the aquatic environment of Thoothukudi Port was found to be vastly disturbed by cumulative anthropogenic pressure such as ever handling of cargo construction and reclamation works, dredging of channels to accommodate the container ships etc. These short term effects might have disrupted the hydrodynamic natures that in turn pose a series threats on settlement and distribution behaviour of *H.momus's* larvae. Ascidian's distribution is influenced by certain physical and chemical variables such as salinity (Vazquez and Young, 2000), hydrodynamics (Holloway and Connell, 2002) and wave exposure (Shenkar and Loya 2008). The present finding has the supportive evidence from the report of Susanna *et al., (*2015), who discussed the significant differences in the distribution of ascidians in accordance with the harbour types and their position. Besides, the widening and deepening of the seafloor in Port areas for accommodating the ship containers might have also altered the topographical, geological, biological, physical and chemical oceanographic parameters. These factors collectively stressed the regressive and sagacious species like *H.momus,* which might have translocated to non-transformed areas in eastward and westward directions.

The availability and abundance of *H.momus* at Vizinjam Port (west coast), was similar to previous report (Abdul Jaffarali and Sivakumar, 2007) and further extension was recorded in stations such as Muttom, Kadiapattanum, Mandaikadu and Colechel. It could be inferred with the productive nature of medium that would maintain the stability and more availability of *H.momus* in west coast. This hypothesis agrees with the report of Madhupradap and Prasannakumar *et al.,* (2001) who recorded higher biological production in Arabian sea as frequent upwelling facilitates to bring higher amount of nutrients to this coast. This eutrophic fertile ground might have provided the feeding as well as breeding place for *H.momus* and established well subsequently as reported by Naranjo *et al*., (1996); Lambert and Lambert (1998, 2003); Lambert (2002) and Mastrototaro and Dappiano (2005).

H. momus is considered as "high probability lessepsian migrant" as its introduction was more in nearby stations of Ports and introduced to majority of the study areas (Figure 2), such as Threshpuram, Near Nehru park, Near Roche park, North Break water, Kayalpattanum Veerapandianpattanum, Alanthalai, Kulesekaranpattanam, Manappadu, Periathalai, Kooduthalai, Uvari and Leepuram. The above mentioned study areas are very close to Thoothukudi Port and interlinked with one another by means of commerce through fishing vessels that might have helped the ongoing introduction and extension of *H.momus* to nearby areas. The present data also confirmed the continuous spreading and settlement of *H.momus* in Indian coast at greater depths in between 15 and > 30 m. The same observation was also made by Shenkar and Loya (2008) in *H.momus* from the Mediterranean sea coast at greater depths (20–30 m) than those occupied by the native Red Sea population and implies that it is the nature of non-indigenous species crossing its initial stages of invasion or species that is continuing to spread. This statement also agrees with the report of Davis and Davis (2007) who recorded the high velocity vessel movements upset the pollution sensitive species and creating space for pollution tolerant species. Also, Sebastian and Kurian (1981) noted that the frequent change of water and continuous supply of plankton were essential to the proper growth of healthy *H.momus* in the culture tank and also noted that the least specialized sense organs in the tadpole stage are considered to be the most primitive and remained as such without any change during the course of evolution. This feature might have unfitted to *H.momus* to lead a successful life in the transformed area that might have provoked to shift to non-transformed areas. It could be correlated with the prolonged effect of natural disaster such as cyclone and tsunami in 2000 and 2004 respectively might have caused the non- availability of food and other factors that are essential to lead a normal life. This hypothesis could be ascertained with Kathal (2005), who reported that the stressed turbidity made an imbalance of O_2 and Co_2 ratio during the post effect of tsunami that in turn affected the distribution of phytoplankton and food chain in Gulf of Mannar marine ecosystem.

The community structure is determined by the physical nature of the habitat and the organisms associated to it. In the present study there were no record of *H.momus* from the fish landing centres such as Velankanni and Sippikulam. Like ascidians, molluscs are one of the principal competitors in macrobenthic community and strongly compete with other sedentary organisms like barnacles, tubiculus organisms etc., The dominant and restricted distribution of bivalve molluscs, *Mytilus* sp., was found in Velankanni and Sippikulum. It could be inferred to the principle of Gause or Law of Competitive Exclusion and according to this principle, two species that have identical ecological niche cannot coexist for long in the same area at the same time. As ascidian's prerequisites such as requirement of energy and material for growth and reproduction are same like that of bivalve molluscs; however in natural environment, ascidians do not exploit their growth potential to the same extent as do bivalves because of the lack of a particle sorting mechanism in ascidians (Armsworthy *et al*, 2001). In this specific environment, the fast growing organisms gradually replaced the slow growing forms (Rajagopal *et al.,* 1990) and over crowding by its number and size.

Generally most of the benthic marine organisms produce secondary metabolites as chemical weapons to protect them against predators. These bioactive chemicals are widely released by a wide range of benthic animals on the surface of the organisms for its protection and survival as exhibited by some bivalve molluscs. Eventhough the solitary *H.momus* having the large globular size body in nature, its smooth exoskeleton cannot compete with the small sized aggregated form of *Mytilus sp.*, as growth proceeds. The hard exoskeleton of the *Mytilus sp.,* might have suppressed the growth of *H.momus* gradually as it occupies more space during growth and release of some metabolites as reported by Hay (1996) who analysed the settling and metamorphosing behaviour of *Herdmania curvata*'s larva and found that these two attributes are inhibited by a number of cohabiting metabolites. It may also be the one of the reasons for inhibiting the settlement and metamorphosis event of larvae of *H.momus* on or nearby to *Mytilus sp.* Examining these two species, the test of *H.momus* provide a substratum for numerous epizoic forms whereas the *Mytilu*s sp., shows antifouling nature. Interestingly to note that the bivalve mussel *Mytilus edulis* is used as biomarker in metal contaminated areas of certain coastal environments (Ake Granmo, 1995) and have the ability to survive in low oxygen areas and prefer high xenobiotics area unlike to *H.momus*. The non-availability of *H.momus* in these two stations can be interrelated with the polluted nature of the study areas as *H.momus* is identified as an ideal flagship species as well as the regressive species that do not prefer transformed areas to live in.

In the present investigation, *H.momus* was not found in nearly 26 stations even though they are intermittently distributed along these stations. It could be compared with the availability of soft substrate in habitats such as sandy beaches, muddy areas, sea grass areas, the areas having large embedded boulders etc., Besides,a countable researchers (Castilla *et al.,* 2002, Carver *et al.,* 2003 and Lambert 2005) also indicated that tunicates are prey for a number of organisms such as starfish, sea urchins, gastropods, and crabs. The coastal areas such as Vellapatti, Inico nagar and

North break water are highly dominated by different species of crabs likewise starfish in Tiruchendur coast that might have predatory effect on *H.momus* to curb its population.

To conclude, as per the report of Galil (2007), *H. momus* is alien to the coastal water of Israel and marked as "critical reevaluation" for its lessepsian introduction. In Indian coastal water, *H.momus* was identified as "productive non-conventional resource" from the marine ecosystem as it possess rich protein, supplementary food source for fishes and human beings, bioindicator to assess the transformed areas and umbrella species for number of organisms (Tamilselvi, 2010 and 2013 and Tamilselvi *et al.*, 2015). Recently, its sporadic distribution and introduction into many new areas stunned the ascidiologist as it echoes the emerging problems at global level. Eventhough this species is considered as socio-economic and environmentally significant species in Indian coastal water, a thorough prolonged investigation on this group is essential to understand its invasiveness, transport vectors, biogeography, lessepsian introduction and its long term effect in the existing areas to safegaurd the biodiversity at global level.

Table 1. shows the habitat/ mode of collection and distribution of *Herdmania momus* in different study areas

S. No.	Stations	Substrata	Collection Method	Coordinates	Availability		
					2013	2014	2015
1	Velankanni	Sandy beach, fishing vessel	Trawl collection	10°68'1385"N, 79°85'3988"E	A	A	A
2	Gopalapattinam	Sandy beach	Trawl collection	9°92'8520"N, 79°15'2856"E	P	P	P
3	Thondi	Sandy beach	Trawl collection	9 °73'7135"N 79 ° 01'8268"E	P	P	P
4	Devipattinam	Sandy beach	Trawl collection	9°48'0429"N 78°89'8169"E	A	A	A
5	Dhanushkodi	Sandy beach	Trawl collection	9°17'7431"N 79°41'4977"E	A	A	A
6	Rameswaram	Calcareous stones	Scrapping, peeling off	9°28'1321"N 79°31'4866"E	A	A	A
7	Pamban	Coral pieces, molluscan shells	Hand Picking	9°28'2087"N 79°19'4992"E	A	A	A
8	Mandapam	Hull of boat, cement blocks	Scrapping,	9°28'5767"N 79°15'8605"E	P	P	P
9	Maraikayar pattinam	Hull of boat, cement blocks	Scrapping,	9°27'1575"N 79°13'2188"E	P	P	P
10	Sethukarai	Sandy beach	Trawl collection	9°24'8086"N 78°84'4811"E	A	A	A
11	Keelakarai	Sandy beach	Trawl collection	9°22'7574"N 78°78'6371"E	A	A	A
12	Valinokkam	Small stones	Scrapping, trawl collection	9°16'2327"N 78°65'1437"E	P	P	P
13	Naripayur	Pipeline	Hand picking	9°11'3982"N 78°41'9909"E	P	P	P
14	Keelavaipar	Embedded rocks	Trawl collection	8°99'5638"N, 78°25'5142"E	A	A	A
15	Sippikulam	Embedded rocks	Trawl collection	8°99'4281"N, 78°25'2815"E	A	A	A
16	Pattanamaruthor	Intertidal rocks	Trawl collection	8°92'2877"N, 78°18'6215"E	A	A	A
17	Tharuvaikulum	Artificial substrates- pillars and pipelines	Trawl collection	8°89'1480"N, 78°17'5385"E	A	A	A
18	Vellappatti	Seagrass	Trawl collection	8°85'7282"N, 78°16'6870"E	A	A	A
19	Threshpuram*	Sandy beach	Trawl collection	8°81'6470"N, 78°16'3559"E	A	A	P
20	Near Nehru park*	granite stones and large boulders	Trawl collection Scrapping,	8°80'6014"N, 78°16'2878"E	A	A	P
21	Old harbour	fishing vessel	Scrapping	8°79'4986"N, 78°16'0628"E	P*	P	P

22	Inigonagar	seagrass bed and granite stones	Trawl collection Hand picking, scrapping	8°79'0135"N, 78°16'1839"E	A	A	A
23	Near Roche park*	seagrass, sandy shore	Trawl collection	8°78'3346"N, 78°16'0070"E	P*	P	p*
24	CMFRI	pearl oyster cages and granite stone	Hand picking, scrapping	8°78'1274"N, 78°15'9883"E	P*	P	P*
25	Hare Island	sandy beach	Trawl collection	8°78'6826"N, 78°19'8275"E	A	A	A
26	North Break water*	chanks	Trawl collection	8°77'2484"N, 78°19'9229"E	A	A	P
27	South Break water	pearl oyster cages, permanent barges, pillars, pebbles, coral reefs and granite stone	Hand picking, scrapping, dislodging whole animal	8°44'53.82"N, 78°12'1577"E	P**	P*	P*
28	Pazhayakayal	Sandy beach	Trawl collection	8°66'7994"N, 78°13'2267"E	A	A	A
29	Punnakayal	Sandy beach	Trawl collection	8°63'6885"N, 78°12'7549"E	A	A	A
30	Kayalpattanum*	Sandy beach	Trawl collection	8°56'2110"N, 78°13'3370"E	P***	P***	P***
31	Veerapandianpattanum*	Sandy beach	Trawl collection	8°53'5586"N, 78°12'4822"E	P	P**	P**
32	Tiruchendur	Sandy beach,large boulders	Trawl collection	8°49'6658"N, 78°13'0037"E	A	A	A
33	Amalipuram	Sandy beach	Trawl collection	8°48'8928"N, 78°12'4603"E	A	A	A
34	Alanthalai*	Sandy beach	Trawl collection	8°48'3427"N, 78°11'9637"E	A	P	P
35	Kulesekaranpattanum*	Sandy beach	Trawl collection	8°39'5628"N, 78°05'9120"E	P*	P**	P***
36	Manappadu*	Sandy beach	Trawl collection	8°37'4239"N, 78°06'7079"E	P	P	P
37	Periathalai*	Sandy beach	Trawl collection	8°33'4694"N, 77°97'5103"E	P	P**	P**
38	Kooduthalai*	Sandy beach	Trawl collection	8°29'8692"N, 77°92'8168"E	A	A	P
39	Uvari*	Sandy beach	Trawl collection	8°27'4837"N, 77°89'0873"E	P	P	P
40	Kudankulam	Sandy beach	Trawl collection	8°16'9895"N, 77°72'2252"E	P	P	P
41	Perumanal	Sandy beach	Trawl collection	8°15'8640"N, 77°64'6214"E	A	A	A

42	Arockiapuram	Molluscan Shells, Sandy shore	Scrapping, Trawl collection	8^{o}12'1573"N, 77^{o}56'0956"E	A	A	A
43	Leepuram*	large boulders, embedded rocks and small stones	Scrapping,	8^{o}11'0692"N, 77^{o}55'7276"E	A	P	P
44	Chinnamuttom	Stones, Embedded rocks and Cement blocks	Scrapping,	8^{o}09'6337"N, 77^{o}56'0944"E	P	P	P
45	Kanyakumari	Embedded rocks	Scrapping,	8^{o}08'6529"N, 77^{o}55'4364"E	A	A	A
46	Kovalam	Sandy shore	Trawl collection	8^{o}08'0358"N, 77^{o}52'4928"E	A	A	A
47	Keezhamanakudi	Sandy shore	Trawl collection	8^{o}08'9681"N, 77^{o}47'8363"E	A	A	A
48	Manakudi	Sandy shore	Trawl collection	8^{o}09'3125"N, 77^{o}45'7260"E	A	A	A
49	Pallam	Embedded rocks	Trawl collection	8^{o}09'8060"N, 77^{o}43'3091"E	A	A	A
50	Periakadu	Sandy shore	Trawl collection	8^{o}10'9549"N, 77^{o}39'1158"E	A	A	A
51	Muttom*	Embedded rocks and Stones	Scrapping,	8^{o}12'4331"N, 77^{o}31'2506"E	P	P	P
52	Kadiapattanum*	Large boulders	Scrapping, peeling off	8^{o}13'1382"N, 77^{o}30'5174"E	P	P	P
53	Mandaikadu*	Sandy shore	Trawl collection	8^{o}16'0924"N, 77^{o}27'8288"E	P	P	P
54	Colechel*	large boulders, cement blocks and hulls of boat	Scrapping, dislodging whole animal	8^{o}17'2412"N, 77^{o}25'0508"E	P	P	P
55	Vizhinjam Bay*	chank beds, barges, hulls of ship, oyster beds, and other harbour installations	Hand picking, dislodging whole animal	8^{o}37'4709"N, 76^{o}98'9474"E	P	P**	P**

P= 5>: P**= 5<20: P***= 20< 50: Stations*- introduced /ongoing spread study areas.

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