Invasion and abundance of reef-inhabiting fishes in the Vellar estuary, southeast coast of India, especially the lionfish *Pterois volitans* Linnaeus

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Invasion of lionfish *Pterois volitans* and other reef fishes in the Vellar estuary, Parangipettai (lat. 11°29′N, long. 79°46′E) southeast coast of India, is a cause of concern as it may affect the local fishing communities and the estuarine ecological conditions. The present study reveals the temporal variations in the abundance of the reef-inhabiting fishes in the different estuarine locations (oyster beds, mangroves and bridge). A total of 184 individuals of lionfish were captured from the three locations during April–September 2011. Different size groups were caught (total length 6.8–17.8 cm) throughout the sampling period and captured individuals were more (*n* = 164) near the mangroves and oyster beds, than those (*n* = 20) found near the man-made structure (bridge). Percentage capture of lionfish was higher during August. Other reef-associated fishes were also recorded and the family Acanthuridae (*n* = 51) was dominant and the remaining taxa were less abundant. Twelve prey taxa were identified through gut content analysis of lionfish that includes penaeids, non-penaeids and teleosts. The dominant taxa were found to be the shrimps, indicating the colonization of lionfish in newer but natural habitat as feeding ground. The human-driven changes may facilitate the successful intrusion of reef fishes in the estuaries.

Keywords: Abundance, invasion, *Pterois volitans*, Vellar estuary.

CORAL reef fishes form one of the most diverse communities of animals in nature. Origin and maintenance of this diversity have evolved a high degree of specialization in morphology and behaviour, most often demonstrated in studies of resource partitioning, particularly space and food. Reef-associated fishes are rather sedentary and maintain territoriality; home-range behavioural patterns are highly developed[1]. Some marine invasions result from natural dispersal mechanisms, but human-mediated sources are appearing to be more established. The relative contribution of anthropogenic dispersal to marine invasions has increased over the past few centuries and may be still increasing[2–5]. In the coral reefs, lionfish have shown to reduce the recruitment of native fishes by nearly 80% (ref. 6) and hence influx of these fishes in the estuarine habitats deserves our attention.

A complete spectrum of the distribution and species composition of fishes with reference to seasonal changes is abundantly available for the shallow coastal, estuarine and brackish waters[7], including the Vellar estuary. The study area is a potential fishing ground and intensively exploited by gill and cast nets. Based on the documentation of reef-inhabiting fishes in the Vellar estuary[8], the present study focuses on the abundance of coral reef-inhabiting fishes from this area with special reference to lionfish (*Pterois volitans*), size variations and habitat specificity.

The Vellar estuary (lat. 11°29′N and long. 79°46′E; Figure 1) on the southeast coast of India, originates from the Shervaryan Hills, Salem district, Tamil Nadu. It joins the Bay of Bengal at Parangipettai, and is said to be a 'true estuary' as there is no complete closure of the mouth. This estuary has been demarcated into marine, gradient, tidal and freshwater zones based on salinity characteristics[9]. It is subjected to semi-diural tides with maximum tidal amplitude of about 1 m. The average depth ranges between 2.3 and 5.0 m. Influence of the neritic water with the estuarine environment promotes a perfect exchange of both biotic and abiotic components and the tidal influence extends over a distance of 16 km upstream of the estuary. It is being subjected not only to alterations in chlorinity, but also to seasonal variations in the amount of freshwater input and consequent circulation of elements between the estuarine system and the neretic waters[10].

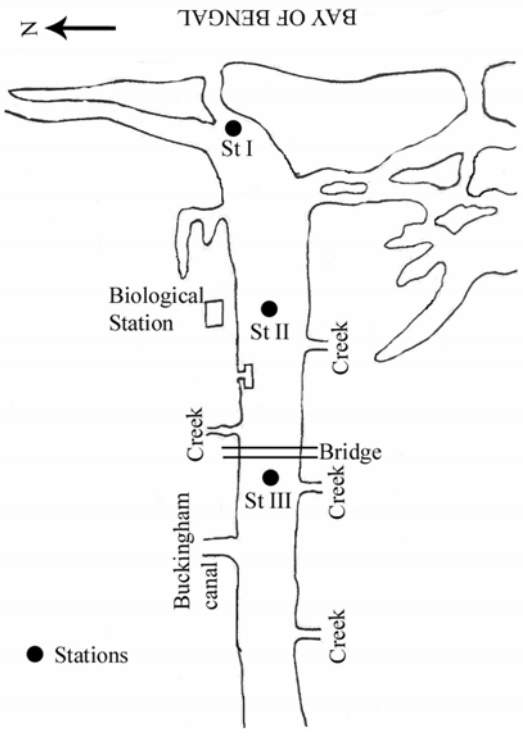

Figure 1. Map showing the study area – Vellar estuary, southeast coast of India.

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Three stations were selected along the Vellar estuary to study the occurrence of lionfish *P. volitans*: Station I – River mouth consists of oyster and mussel beds (lat. 11°29′51.99″N, long. 79°46′35.11″E). Station II – Opposite to the Marine Biological Station with mangroves (CASMB, Annamalai University, Parangipettai) (lat. 11°29′21.20″N, long. 79°46′02.19″E); Station III – Bridge area (lat. 11°29′05.02″N, long. 79°45′37.15″E). The sampling locations were selected using exact coordinates in the form of quadrates (250 × 200 m). Fishing was done for six months (April–September 2011) at the above three locations with the help of local fishermen using cast nets at 1.0–4.0 m depth. Samplings were made for 2 h at each station in the morning (6–8 a.m.) and evening (5–7 p.m.). The number of lionfish captured during the study period was estimated and size distributions were recorded. Temporal variations on percentage capture were calculated. Other reef fishes captured during the study were also counted and considered as a whole. Identification of reef fishes was made with the help of standard literature (FAO and field guides). Further, gut contents of captured lionfish were examined using a microscopic during the survey period. Underwater documentations could not be made due to high turbidity and less transparency of the water column. Water quality parameters like temperature and salinity were also recorded.

A total of 184 individuals of the lionfish, *P. volitans* (Scorpaenidae) were collected from the Vellar estuary during the study period (April–September 2011). The collection covered a total distance of about 0.1–2.3 km from the sea. Most of the lionfish were found to associate with the oyster beds (Station I) and mangroves (Station II) than the man-made structure (Station III). Other reef fishes, which include 18 taxa, were also frequently captured during the sampling period. They belong to the following families: Acanthuridae, Balistidae, Chaetodontidae, Ephippidae, Labridae, Pomacanthidae, Synanceiidae, Antennaridae, Sygnathidae, Diodontidae, Holocentridae and Tetrodontidae. Fishes were captured at various depths ranging from 1.5 to 4.0 m and some fishes were found rarely near the shoreline with < 1.5 m depth. In addition, no lionfish was found > 2.3 km distance away from the sea, where the salinity was < 12‰.

Size distribution of the captured lionfish ranged from 6.8 to 17.8 cm in total length (Figure 2) and variation in size was observed in all the locations. Maximum number of fishes showed a size range of 11–15 cm. Temporal variations in the number of lionfish captured were also noticed: April (n = 13), May (n = 20), June (n = 28), July (n = 37), August (n = 52) and September (n = 34; Figure 3). Lionfish captured during August were higher in number followed by July compared to the other months.

Percentage capture of lionfish from April to September 2011 was calculated (Figure 4). Higher capture percentage was recorded at Station I (river mouth) with 48.37 followed by Station II (mangroves) with 40.76 and a lower capture of 10.87 was recorded at the Station III (near the Bridge).

Detailed information concerning other species of reef fishes and their numbers is as follows: *Acanthurus xanthopterus* (n = 33), *Acanthurus nigrofuscus* (n = 17), *Pseudobalistes flavimarginatus* (n = 5), *Odonus niger* (n = 2), *Heniochus acuminatus* (n = 6), *Chaetodon vagabundus* (n = 4), *Chaetodon decussatus* (n = 13), *Platax orbicularis* (n = 3), *Thalassoma lunare* (n = 1), *Iniistius cyanifrons* (n = 3), *Apolemichthys xanthurus* (n = 1), *Synanceia verucosa* (n = 3), *Antennarius coccineus* (n = 2), *Antennarius indicus* (n = 1), *Phoxocampus tetrophthalmus* (n = 2), *Diodon holocanthus* (n = 1), *Sargocentron rubrum* (n = 3) and *Arothron nigropunctatus* (n = 4; Figure 5, Table 1).

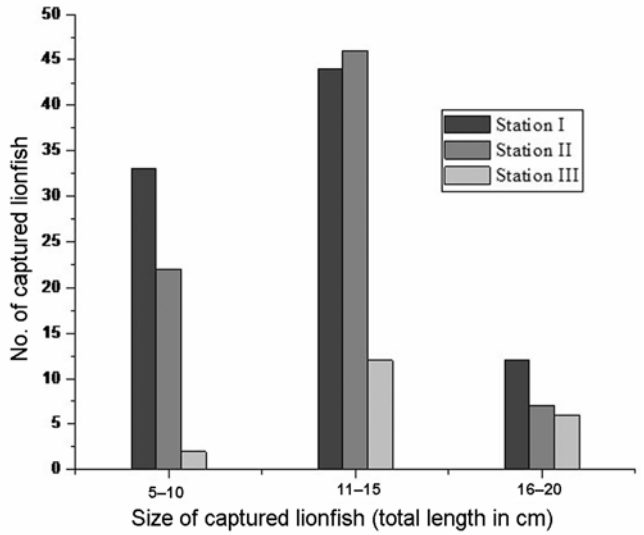

Figure 2. Size distribution of lionfish, *Pterois volitans* captured from the three stations (total length in cm).

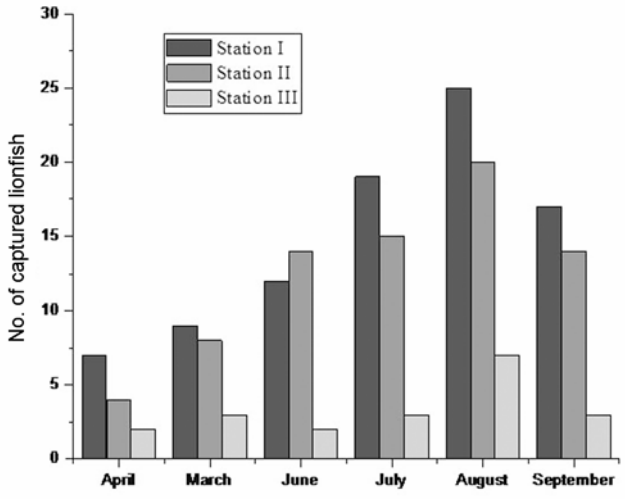

Figure 3. Number of lionfish (*P. volitans*) captured from April to September 2011 at the three stations (n = 184).

Table 1. Coral reef-inhabiting fishes collected from the Vellar estuary, south east coast of India

Scientific name	Common name	Family	Number
Pterois volitans Linnaeus	Red lionfish	Scorpaenidae	184
Acanthurus xanthopterus Valenciennes	Yellowfin surgeon	Acanthuridae	33
Acanthurus nigrofuscus Forsskal	Brown surgeon	Acanthuridae	17
Pseusobalistes flavimarginatus Ruppell	Yellow-margined trigger	Balistidae	5
Odonus niger Ruppell	Blue-toothed trigger	Balistidae	2
Heniochus acuminatus Linnaeus	Longfin Banner fish	Chaetodontidae	6
Chaetodon vagabundus Linnaeus	Vagabond butterfly	Chaetodontidae	4
Chaetodon decussatus Cuvier	Black-finned/Indian Vagabond	Chaetodontidae	13
Platax orbicularis (Linnaeus)	Orbicular Bat fish	Ephippidae	3
Thalassoma lunare Linnaeus	Moon wrasse	Labridae	1
Iniistius cyanifrons Valenciennes	Razor fish	Labridae	3
Apolemichthys xanthurus Bennett	Indian Smoke angel	Pomacanthidae	1
Synanceia verucosa Bloch and Schneider	Stone fish	Synanceiidae	3
Antennarius coccineus Lesson	Scarlet Frogfish	Antennaridae	2
Antennaris indicus Schultz	Indian Frogfish	Antennaridae	1
Phoxocampus tetrophthalmus (Bleeker)	Rock Pipe fish	Sygnathidae	2
Diodon holocanthus Linnaeus	Baloon/Long-spined Porcupine	Diodontidae	1
Sargocentron rubrum Forsskal	Red-coat Squirrel fish	Holocentridae	3
Arothron nigropunctatus Bloch and Schneider	Blackspotted puffer	Tetrodontidae	4

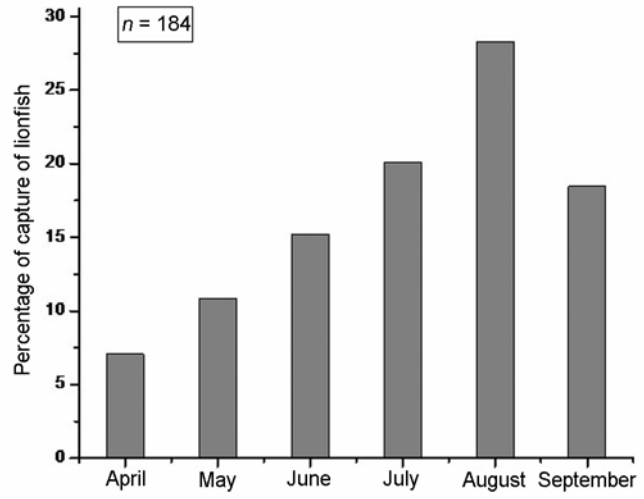

Figure 4. Percentage capture of lionfish (*P. volitans*) from April to September 2011 at the three stations.

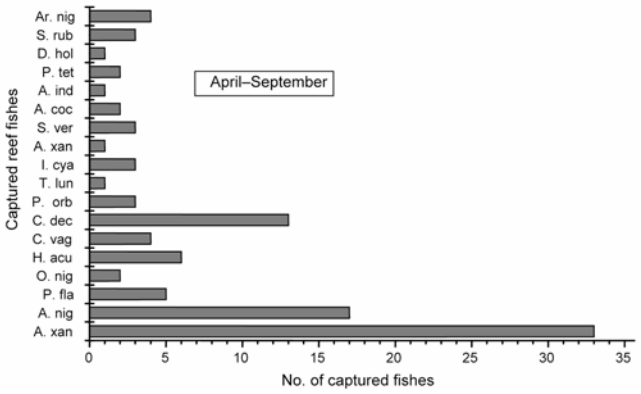

Figure 5. Other species of reef-inhabiting fishes captured during the sampling period: A. xan – *Acanthurus xanthopterus*, A. nig – *Acanthurus nigrofuscus*, P. fla – *Pseudobalistes flavimarginatus*, O. nig – *Odonus niger*, H. acu – *Heniochus acuminatus*, C. vag – *Chaetodon vagabundus*, C. dec – *Chaetodon decussatus*, P. orb – *Platax orbicularis*, T. lun – *Thalassoma lunare*, I. cya – *Iniistius cyanifrons*, A. xan – *Apolemichthys xanthurus*, S. ver – *Synanceia verucosa*, A. coc – *Antennarius coccineus*, A. ind – *Antennarius indicus*, P. tet – *Phoxocampus tetrophthalmus*, D. hol – *Diodon holocanthus*, S. rub – *Sargocentron rubrum* and Ar. nig – *Arothron nigropunctatus.*

Fifty-four individuals of *P. volitans* were sacrificed for gut content analysis at a ratio of three individuals per month per habitat. A total of 12 prey taxa were identified and shrimps dominated the gut compared to other teleosts. The prominent prey items were found to be *Penaeus monodon* and *P. indicus* followed by *Metapenaeus* sp., *A. indicus*, *Macrobrachium* sp. and *Hippolysmata* sp., with some unidentified crabs. The five teleosts were *Mugil cephalus*, *Terapon jarbua*, *Carangoides* sp., *Lutjanus* sp. and *Ophisthopterus* sp.

During the study period, water temperature varied from 24°C to 31°C and salinity ranged from 24 to 34 ppt. Lower salinities were common from mid-September due to the inflow of freshwater, which indicates the onset of the northeast monsoon that is prevalent along the southeast coast of India during October–December of every year. A few individuals of lionfish (n = 7) were also captured in the early October, which is not included in the study.

The present study reports the estuarine invasions of reef-inhabiting fishes at the Vellar estuary, which is just considered as a short-term phenomenon. The distribution of these fishes in the Vellar estuary signifies the rapid range expansion of species of reef-inhabiting fishes. Undoubtedly, invasion of lionfish will have serious effects on the local biodiversity. As lionfish were often found in turbid bays in their native range, estuaries might also become another site of major invasions[11].

The present study was restricted to the summer and pre-monsoon (April–September) period and no observation was made during the peak northeast monsoon (October–December). Salinity of the Vellar estuary may fall even up to 1 ppt or even less during monsoon[12]. Water temperature of up to 34°C was recorded during the summer season with more number of reef fishes, suggesting their thermal tolerance for invasions in the estuary. However, there is no published literature concerning the temperature and salinity tolerance of lionfish for physiological adaptation to the estuarine habitats. Lionfish were caught during the pre-monsoon season (July and August), but later (in September) their number reduced when salinity was low (Figure 3). This suggests that the lower salinity may also have an impact on the distributional range of these fishes. Experiments to determine the temperature and salinity tolerance of lionfish will help define further the potential invasive range of these fishes in the estuarine environment.

Acanthurus xanthopterus ($n = 33$) and *A. nigrofuscus* ($n = 17$) were more abundant compared to other reef-inhabiting fishes near the bridge area (man-made structure), suggesting the utilization of man-made habitats for their invasion. Size of both the species ranged from 7.6 to 18.0 cm. Butterfly fishes (Chaetodontidae) like *C. vagabundus* ($n = 4$), *C. decussatus* ($n = 13$) and bannerfish *H. acuminatus* ($n = 6$) were often captured during the sampling period near the mangrove habitat. Triggerfish (Balistidae), Batfish (Ephippidae), Wrasse (Labridae), Smoke Angel fish (Pomacanthidae) and Rock Pipe fish (Sygnathidae) were rarely captured during the sampling. Total abundance of reef fishes other than lionfish was considered as a whole due to their lesser availability during the study period. The possibility of these invasions might be from Palk Bay, Gulf of Mannar Islands located 170 nautical miles away from the study site, and further long-term studies are required to understand their distribution and invasive ranges in the estuarine habitats.

The successful invasion and survival of lionfish within this estuary describes that these predators may feed frequently on native species, consequently affecting the local fish community[13]. Additionally, release from predation in their invaded range may allow the lionfish to spend more time foraging and less time sheltering from predators[11]. Equivocal effect of introduced fish species on native marine fishes, fisheries and communities, has not been thought of traditionally as an important threat[14]. However, continued presence of lionfish in estuaries may threaten the early life-history stages of a number of commercially, recreationally and ecologically valuable fish species, either through indirect interactions or because of direct predation[15]. To conclude, genetic studies can provide information regarding effective population size and genetic variability of the influx populations. In addition, they may also be able to identify the source region of the native range, which may elucidate the mechanism of introduction[16].

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