

Article

Biodiversity of cultivable molluscan resources from Pulicat Lake, southeast coast of India

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Abstract

The molluscs constitute a natural resource of sizable magnitude in parts of the world. The range of their distribution is extensive in space as in time for it covers terrestrial, marine and freshwater habitats. In Bar mouth, the Shannon-Wiener diversity index ranged from 2.15 to 2.45 showing minimum during October and maximum during May. The Shannon-Wiener index in Karimanal ranged from 2.26 to 2.40 showing minimum during October and maximum during May. The Shannon-Wiener index in Pulicat town ranged from 2.25 to 2.39 showing minimum during October and maximum during September. Among the study areas, Bar mouth showed maximum diversity in Pulicat lake. Now there was no active culture practiced in lake as far as the Molluscan culture is concerned, apart from commercial liming. More studies are needed for conservation and management of this valuable resource. If this ancient heritage of the Pulicat wetland has to be preserved for posterity and its rich biodiversity conserved, this Pulicat Lake must be recognized as a 'Ramsar Site', for international protection, as early as possible. Early detection and rapid response of habitat loss and alteration could prevent the loss of biodiversity.

Keywords biodiversity; molluscs; Pulicat Lake; India.

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1 Introduction

The most level of biological diversity is that found within a species and is known as genetic diversity. The most common usage of diversity is the number of species found in a particular area (Jayakumar et al., 2011; Wu and Zhang, 2012). The biodiversity can also be considered at other levels that of taxonomical organization at the level of the community or ecosystem (Zhang, 2011). The most frequently used quantitative measure of biodiversity is for a given area or a given community. Large scale biodiversity studies are rarely accomplished in marine tropical areas. The need to assess the status of natural marine communities has long been noted. In the tropics, natural communities comprise thousands of species which all play strategic roles in the multiple

ecological and biological processes (Poore and Wilson, 1993). Furthermore, sustainable use of marine and coastal living resources cannot be properly established without an adequate knowledge of biodiversity. Ultimately, monitoring the biodiversity of a large ecosystem will allow a proper evaluation of the effects of natural and anthropogenic factors on species numbers, kinds and distribution.

In India, studies on species diversity are very few (Gravelly, 1942; Satyamurti, 1956; Hornell, 1927, 1941; Appukuttan, 1972, 1980, 1989, 1996, 2008; Narashima 1993; Fred Pinn, 1990; Sakthivel and Fernando, 2002. In India, molluscs fishery comprise mainly by bivalves such as clams, mussels and oysters. Except for the chank and pearl-oyster beds, the most productive of which are concentrated on the south eastern coast, the shell-fish resources of other commercial species of molluscs are generally more plentiful on the west coast (CSIR, 1962b).

Table 1 Some Edible and Cultivable species of bivalves in India.

S. No	Common Name	Scientific Name
1.	Bay clam	<i>Meretrix meretrix</i> (Linn.)
2.	Backwater clam	<i>M. casta</i> (Deshayes)
3.		<i>Katelysia opima</i> (Gmelin)
4.	Black clam	<i>Velorita cyprinoids</i> (Gray)
5.	Cockle clam	<i>Gafrarium tumidum</i> (Roding)
6.		<i>G. divaricatum</i> Gmelin
7.	False cockle	<i>Cardita bicolor</i> Lam.
8.	False clam	<i>Paphia malabarica</i> (Dilwyn)
9.		<i>P. marmorata</i> (Reeve)
10.		<i>P. marmorata</i> (Reeve)
11.		<i>Mesodesma glabratum</i> (Lam)
12.		<i>Macra corbiculoides</i> (Deshayes)
13.	Asiatic cockle	<i>Cardium asiaticum</i> (Bruguere)
14.	Clams	<i>Donax cuneatus</i> Linn
15.		<i>D. scortum</i> Linn.
16.	Green mussel	<i>Perna viridis</i>
17.	Brown mussel	<i>P. indica</i>
18.	Bearded weaving mussel	<i>Modiolus barbatus</i> (Linn)
19.	Estuarine oyster	<i>Crassostrea madrasensis</i>
20.	Rock oyster	<i>C. cucullata</i> (Born)
21.	Disc oyster	<i>C. discoidea</i> (Gould)
22.	Giant oyster	<i>C. gryphoides</i> (Newton & Smith)
23.	Ribbed ark-shell	<i>Acra granosa</i> Linn.
24.	True scallop	<i>Chlamys senatoria</i> Gmelin (Pectinidae)
25.		<i>Sanguinolaria (Soletellina) diphos</i> (Gmelin)
26.		<i>S. (Soletellina) atrata</i> (Deshayes)
27.	Razor-shells	<i>Solen truncatus</i> (Sowerby)
28.		<i>S. brevis</i> (Hanley)
29.	Pearl Oyster	<i>Pinctada fucata</i>
30.		<i>P. margaretifera</i>
31.		<i>P. chemnitzii</i>
32.		<i>P. atropurpurea</i>
33.		<i>P. anomioides</i>
34.		<i>P. sugillata</i>

Bivalves are the second largest class in the Phylum Mollusca (Table 1). It has two shells or valves join together with the help of teeth like structure called hinge and fibrous tissue- ligament. The shells are made up of calcium carbonate. Most of the forms are completely sedentary remaining attached to hard substrata by thread-like byssus of the foot or by one of their shell valves. A few forms burrow into submerged timbers, and commensal and parasitic types are also known. Most commonly utilized bivalves for food include clams (Veneridae), sea-mussels (Mytilidae) and edible oysters (Ostreidae) (CSIR, 1962a). In India eight species of oysters, two species of mussels, 17 species of clams, six species of oysters, four species of giant clams, one species of window-pane oyster are exploited extensively from marine regions. Hence, the present study was undertaken to estimate the cultivable molluscan distribution in Pulicat Lake.

2 Materials and Methods

The molluscs were collected from three stations namely, Bar mouth, Karimanal and Pulicat Town for a period of six month from May 2007 to October 2007. For the quantitative analysis, the molluscs were collected by hand picking in a transect of known area or using a quadrat of known size. At the same time the foulers like mussels and oysters were collected by scrapping those using knives or spatula from a known unit area either using a quadrat. Further the in faunal bivalves were collected by hand digging the subs tram by hand picking in five different places of each sampling stations (Varshney and Ghosh, 1997). The specimens were brought to laboratory, cleaned with brush and identified using appropriate monographs. Data were collected fortnightly, pooled seasonally and this was repeated throughout the study period. Data were subjected to Software tool (Primer Ver. 6.1) for diversity, richness and evenness.

2.1 Data analysis

In the present study, the data on cultivable molluscs from three stations were collected together for seasons and subjected to various univariate methods such as species diversity, species richness and species evenness.

2.2 Shannon - Weiner index

In the present study, the data were analyzed for diversity index (H') using the following Shannon - Weiner's formula (1949):

$$H' = - \sum P_i \log_2 P_i \dots$$

This can be rewritten as

$$H' = 3.3219 (N \log N - \sum n_i - \log n_i) / N$$

where, H' = species diversity in bits of information per individual, n_i = proportions of the samples belonging to the i^{th} species (Number of individuals of the i^{th} species), N = total number of individuals in the collection and, Σ = sum.

2.3 Simpson index (D)

Species richness (S) was calculated using Margalef index (d):

$$D = 1 - C$$

where, $C = \sum P_i^2$, $P_i = n_i/N$.

2.4 Pielou's evenness index (J')

The equitability (J') was computed using the following formula of Pielou (1966):

$$J' = H' / \log_2 S, \text{ or } J' = H' / \ln S$$

where J' = evenness, H' = species diversity in bits of information per individual, S = total number of species.

3 Results

In the present study 6 species (*Meretrix meretrix*, *M. casta*, *Katelsia opima*, *Acra granosa*, *Perna viridis*, *Crassostrea madrasensis*) of Cultivable bivalve molluscs belonging to 4 families (Veneridae, Mytilidae,

Aricidae, Ostreidae) and 5 genus (*Meretrix*, *Katylisia*, *Acra*, *Perna*, *Crassostrea*) were recorded in all three stations in Pulicat Lake.

During the study period about 357 samples were collected in Bar mouth (station-I). Among them *Meretrix meretrix*, *M. casta* and *Crassostrea madrasensis* (18.0%), *Katylisia opima* (17.0%), *Acra granosa* (16.0%), and *Perna viridis* (13.0%). The most abundance species observed is *Meretrix meretrix*, *M. casta* and *Crassostrea madrasensis* and least is *Perna viridis* (Fig. 1).

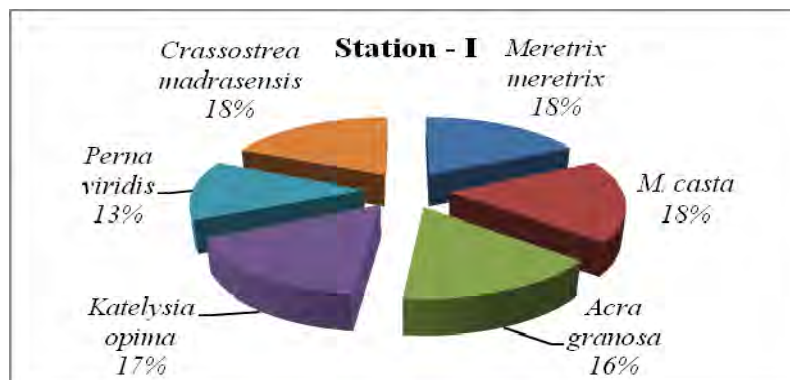


Fig. 1 Species composition of Bar Mouth.

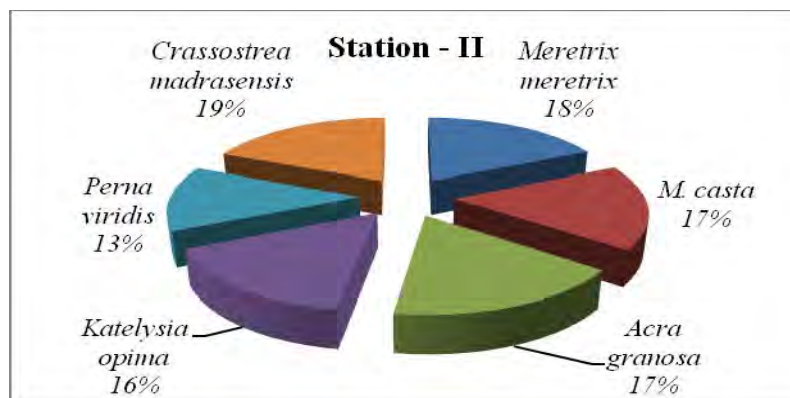


Fig. 2. Species composition of Karimanal.

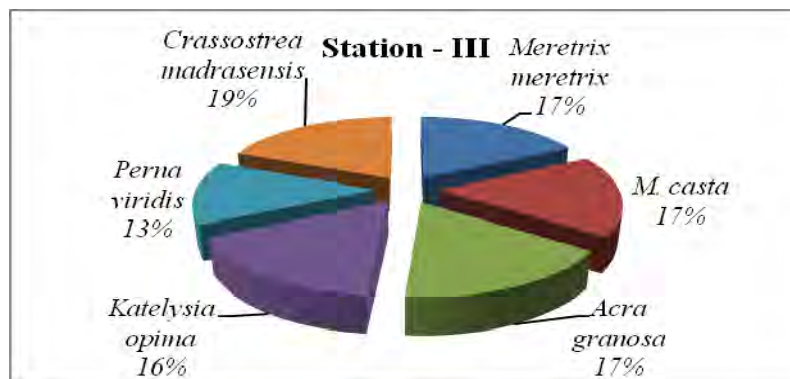


Fig. 3 Species composition of Pulicat Town.

From Karimanal (station-II) 349 samples were collected. Among them *Crassostrea madrasensis* (19.0%), *Meretrix meretrix* (18.0%), *M. casta*, *Acra granosa* (17.0%), *Katelysia opima* (16.0%), and *Perna viridis* (13.0%). The most abundance species observed is *Crassostrea madrasensis* and least is *Perna viridis* (Fig.2).

From Pulicat town (station-III) 292 samples were collected. Among them *Crassostrea madrasensis* (19.0%), *Meretrix meretrix*, *M. casta* and *Acra granosa* (17.0%), *Katelysia opima* (16.0%), and *Perna viridis* (13.0%). The most abundance species observed is *Crassostrea madrasensis* and least is *Perna viridis* (Fig. 3).

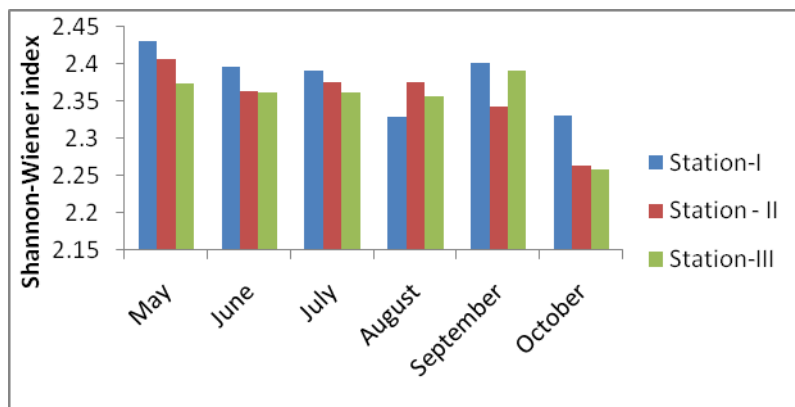


Fig. 4 Diversity index.

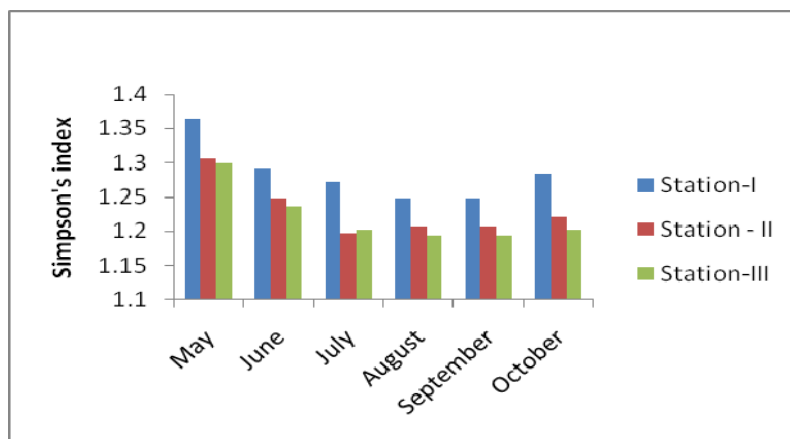


Fig. 5 Richness index.

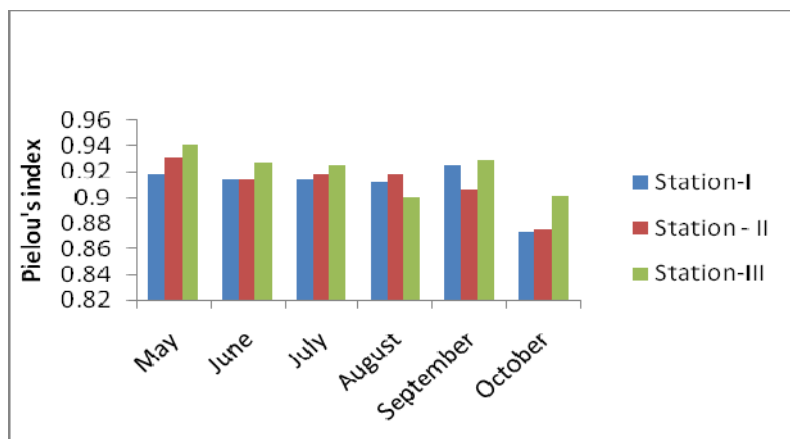


Fig. 6 Evenness index.

In Bar mouth (station-I), the Shannon-Wiener diversity index ranged from 2.15 to 2.45 showing minimum during October and maximum during May. Karimanal (station-II), the Shannon-Wiener index ranged from 2.26 to 2.40 showing minimum during October and maximum during May. Pulicat town (station-III), the Shannon-Wiener index ranged from 2.25 to 2.39 showing minimum during October and maximum during September (Fig. 4). Among the study areas, Bar mouth (station-I) showed maximum diversity in Pulicat Lake.

In Bar mouth (station-I), the Simpson's Richness index ranged from 1.28 to 1.36 showing minimum during October and maximum during May. Karimanal (station-II), the Simpson's Richness index ranged from 1.20 to 1.30 showing minimum during August, September and maximum during May. Pulicat town (station-III), the Simpson's Richness index ranged from 1.19 to 1.29 showing minimum during August, September and maximum during May (Fig. 5).

In Bar mouth (station-I), the Pielou's Evenness index ranged from 0.873 to 0.924 showing minimum during October and maximum during September. Karimanal (station-II), the Pielou's index ranged from 0.875 to 0.930 showing minimum during October and maximum during May. Pulicat town (station-III), the Pielou's index ranged from 0.901 to 0.940 showing minimum during October and maximum during September (Fig. 6).

Perna viridis

Shell large, elongate sub-trigonal with its anterior end pointed, arched and beak-like, dorsal margin of shell angularly convex in the middle, posterior margin broadly rounded, ventral margin slightly concave, valves strongly inflated particularly in the anterior part, surface of shell strongly decussately striated, ligament strong and elongated, shell surface covered by a firm, horny, bright green periostracum. The mussel attaches itself to hard substratum by means of tough, thin, flexible byssus threads secreted by byssus glands present in the byssus cavity and the foot. The body has the visceral mass, with two pairs of gills covered by a pair of mantle lobes which are united dorsally and free ventrally. The gonads extend in to the lobes of the mantle. The mantle is cream colored but during the period of sexual activity it becomes deep reddish orange in color in females. The species occurs all along the east and west coasts of India. On the east coast it occurs generally as stragglers except in harbors. The mussels are abundant at Cochin, Malabar and north of Kerala. In addition to open coasts and harbors the mussels are found in the mouths of estuaries and rivers as they are capable of withstanding wide variations of salinities.

Kingdom	:	Animalia
Phylum	:	Mollusca
Class	:	Bivalvia
Order	:	Mytiloida
Family	:	Mytilidae
Genus	:	<i>Perna</i>
Species	:	<i>viridis</i> (Fig. 7a)

Crassostrea madrasensis

Shell straight, shape irregular, covered by numerous fallacious laminae, left valve deep, right one slightly concave, hinge narrow and elongated, adductor scar sub-central, reniform and dark purple in colour, inner surface of valves white, glossy and smooth, purplish black coloration on the inner margin of the valves. The right and "the left mantle lobes of the oyster enclose a large mantle cavity which is divisible into a lower inhalant chamber and an upper exhalent chamber. In the inhalant chamber are two pairs of gills one each on the right and left sides extending forwards up to the two labial palms between which the mouth is present. In about the middle of the body is the adductor which runs across the two valves of the shell. The digestive

system consists of a narrow oesophagus leading from the mouth, a spacious stomach closely pressed against the ramifications of the digestive gland of either side, a slightly twisted mid gut with a style sac in the oral process, a long intestine partly within the oral process and partly encircling the stomach and a rectum opening into the exhalant chamber by the anus located on the dorsal side of the adductor muscle. Sonapur, deltas of Godavari and Krishna, Gokulapalli, Pulicat, Ennur, Madras, Cuddalore, Athankarai and Kancbanagudinear Mandapam, Kerala coast and Port Blair (Andaman Islands). *Crassostrea madrasensis* is essentially a brackish water oyster. It occurs as thick beds in estuaries, backwaters, ports and harbors and only sporadically on the open coasts. The oysters are found from the intertidal zone to a depth of about 4 m.

a. *Perna viridis*b. *Crassostrea madrasensis*c. *Meretrix meretrix*d. *Meretrix casta*e. *Katelaysia opima*f. *Acra granosa***Fig. 7** Molluscs species.

Kingdom	:	Animalia
Phylum	:	Mollusca
Class	:	Bivalvia
Order	:	Ostreoida
Family	:	Ostreidae
Genus	:	<i>Crassostrea</i>
Species	:	<i>madrasensis</i> (Fig. 7b)

Meretrix meretrix

This is a large clam with a thick shell and grows to a length of about 75 mm. The periostracum is thin, delicate and of grey or straw colour. On the posterior-dorsal margin of the shell a greyish blue or bluish brown band is present. This species is found at the mouths of the majority of estuaries on the east coast especially those of Adyar, Courtalayar, Vellar and Cooum in Tamil Nadu. It is also found in Pulicat Lake and Chilka Lake on the seaward side. In the west coast it is common in Tellicherry coastal area along the Malabar Coast and in river mouths in south Kanara.

Kingdom	:	Animalia
Phylum	:	Mollusca
Class	:	Bivalvia
Order	:	Veneroida
Family	:	Veneridae
Genus	:	<i>Meretrix</i>
Species	:	<i>meretrix</i> (Fig. 7c)

Meretrix casta

This clam can be distinguished from *M. casta* by its more elongated shell. The shell is sub-equilateral, covered with a thin, grayish-yellow periostracum and with or without narrow brown bands radiating from the hinge region. The posterior margin is stained greenish grey. This clam is generally separated as a distinct species. It occurs in great abundance in west coast backwaters. The clams grow to a size of 35-40 mm in length and 25-28 mm in breadth. This clam also is fished indiscriminately. This is one of the important clams of the Kerala State. The flesh is tender and has good flavor. On the Malabar Coast the poorer classes of fishermen search for these clams when the general fishing is dull. Men, women and lads go about in small canoes in the backwaters and when a good fishing area is found they anchor the boat, get down into the shallow water, locate the clams with their feet and dislodge them from loose mud. If the area happens to be a little deeper the fishermen dive and gather the clams.

Kingdom	:	Animalia
Phylum	:	Mollusca
Class	:	Bivalvia
Order	:	Veneroida
Family	:	Veneridae
Genus	:	<i>Meretrix</i>
Species	:	<i>casta</i> (Fig. 7d)

Katelsia opima

In this species the shell is thick, inflated, smooth and of yellowish brown color. The inner surface of the valves is white and the pallial line deeply sinuate. This clam is found in great abundance along the estuaries and backwaters of South India and is called *Vazhukku matti* in Tamil. It is next in importance to *M. casta* on the east coast especially in Adyar estuary. The clam prefers water edge near the river-mouth since it is essentially a marine form. It is found burrowing in quiet shallows as in the mud-flats of Pamban in the Gulf of Mannar and Ratnagiri coast. It has also successfully invaded the estuaries and backwaters where it is found near the river-mouths in Bombay, north kanara and Madras coasts. It is never found up the river-mouths or in the interior of the backwaters where the salinity is low, a striking contrast to *Villorita cyprinoides* and *M. casta*. The life span is about three years. Clams of the size 26-33.8 mm in length are over one year old but not completed second year. Similarly 38.8 to 4.35 mm size represents two year old clams. The first definite indication of sexual maturity is seen in three months old clams when they are 11-12 mm in length. The clams have been found to spawn thrice in their life span. Spawning starts in December when the estuary is in communication with the sea and lasts about a month.

The clam beds are extensive in Adyar river-mouth in the east coast and Batya creek and Kalbadevi creek in Ratnagiri where there is a good fishery. Elsewhere along the east coast and west coast it is found separately along the tidal flats and does not form regular fishery. The clams are fished by fisher-folk along with other clams and the commercial catch does not seem to be composed of any particular size, being there no restriction on size limit in fishery. Fishing is indiscriminate as it exists today.

Kingdom	:	Animalia
Phylum	:	Mollusca
Class	:	Bivalvia
Order	:	Veneroida
Family	:	Veneridae
Genus	:	<i>Katelsia</i>
Species	:	<i>opima</i> (Fig. 7e)

Acra granosa

Marine species common in Palk Bay on the east coast where beds exist on a bottom of dirty muddy sand at depths upto ten metres. But the meat is not appreciated by the fisherfolk and therefore the bivalves are not exploited for the meat. Narasimham (1969) has studied the biology and fishery of *Anadara granosa* which is commercially important on the Kakinada coast. The ark shells are fished from 4 m depth by fishermen who use them almost entirely for manufacture of lime. *A. granosa* grows to a length of 31.5 mm at the end of the first year and 49.5 mm at the end of the second year. The species appears to breed throughout the year in Kakinada Bay with peak spawning activity between January and April. The sandy backwaters of the east coast especially in Pulicat Lake. The meat of this cockle is tough and red and believed to be nutritious. The ark-shells are widely cultivated in Japan but they are not appreciated much by Indian people.

Kingdom	:	Animalia
Phylum	:	Mollusca
Class	:	Bivalvia
Order	:	Arcoida
Family	:	Arcidae
Genus	:	<i>Acra</i>
Species	:	<i>granosa</i> (Fig. 7f)

4 Discussion

Conservation of biological diversity is considered to be one of the major goals for sustainable management of marine renewable resources. The species diversity has a good relationship with species richness and evenness and diversity index is maximum with high number of species and minimum with low number of species (Srinivasan, 1999).

Pulicat lake is rich in biodiversity, having about 500 species of macro fauna includes 168 species of fish, 12 species of penaeid prawns, 36 species of crabs, 19 species of molluscs and 80 species of water birds. The distribution of the molluscan fauna in the Pulicat Lake has been described by Thangavelu and Sanjeeva Raj (1988). The Edible Oyster (*Crassostrea madrasensis*) is the most extensively distributed bivalve in this lake, and in fact, Pulicat Lake is ideally suited for the culture of this oyster. This species of oyster is literally the 'Keystone species in this lake Sanjeeva Raj (2006).

The results of the present study are in accordance with the earlier reports (Srinivasan, 1999). In Pazhayar, an adjacent landing centre, 37 species of gastropods and 14 species of bivalves were recorded among them gastropods *Nassa dorsata* was showed maximum diversity and *Natica albula* showed minimum diversity. In bivalves the maximum diversity was observed in *Paphia textile* and *Donax faba* which exhibited the minimum diversity (Mohanasundaram, 1993). But in the present study remarkable observation were made with *Nassa dorsata*, *Natica albula* and *Paphia textile*. But at the same time *Donax faba* is not recorded throughout the study period. In the present study significant sharing was made with *Murex virgineus* and at the same time meager numbers of bivalve such as *Paphia textile* was noted in station II. These findings are allied with the earlier reports of Mansingh (1994) that have been recorded thirty six species of gastropods and nineteen species of bivalves from coastal line of Cuddalore. Among them *Babylonia spirata* and *Paphia textile* were the most abundant species.

Murugan (1998) has recorded thirty species of gastropods from Cuddalore coast. Among them *Babylonia spirata* is the maximum numbers. But in the present study *Murex virgineus* showed the maximum numbers. In the present study *Murex virgineus* was recorded in maximum numbers since this species is not used by human's consumption.

A total of 32 species of gastropods and bivalves were recorded from Pazhayar and Cuddalore by Sivakumar (2001). Among them gastropods *Turritella attenuata* & *Babylonia spirata* and bivalves such as *Paphia textile*, *Placenta placenta* were the most abundant species respectively. In the present study *Murex virgineus* were present in maximum numbers of diversity and *Babylonia spirata* distributed significantly. But in bivalves *Paphia textile* is least number of diversity and *Placenta placenta* is the maximum number of diversity.

In Mudasalodai (Sakthivel, 2000) observed 75 species of gastropods and 33 species of bivalves were recorded. Among the gastropod diversity *Nassarieu nivea*, *N. dorsata* and bivalves such as *Anadara rhombea* and *Paphia textile* were the most abundance respectively. But in the present study *Nassarieu nivea* and *Nassarieu dorsata* are distributed significantly. In bivalves *Anadara rhombea* was the most abundant species and *Paphia textile* distributed in least numbers. In Nagappattinam 67 species of gastropods and 33 species of bivalves were recorded. Among them *Turritella attenuata*, *Nassa dorsata*, *Anadara rhombea* and *Paphia textile* are the most abundant molluscs. 59 species of gastropods and 11 species of bivalves were recorded in the present study at Mudasalodai, where *Murex virgineus* is most abundant species followed by *Nassa dorsata*. The reason for non availability of some of the shells in the present study is mainly due to the fact that fishermen do not discard these shells as trash, since these shells in the present day are in demand and purchased by shell industrialists. Shells like *Xancus pyrum*, *Cymbium melo* and longer sized *Hemifusus pugilinus* shells and undamaged shells of *Natica* spp. and *Oliva* spp. were not seen in the trash, for they are

demanded by the local shell dealers.

The present study, all three stations in the Pulicat lake the Oysters are showing the dominance among the other cultivable molluscan species. Because it is widely distributed in lake, this lake environment is more suitable for its dominance and also this species is 'Keystone species' of Pulicat lake Sanjeeva Raj (2006). Second abundant cultivable molluscs are Clams and the Mussels are the least abundant in the lake as far as the Biodiversity is concern.

In the present study 6 species (*Meretrix meretrix*, *M. casta*, *Katelysia opima*, *Acra granosa*, *Perna viridis*, *Crassostrea madrasensis*) of Cultivable bivalve molluscs belonging to 4 families (Veneridae, Mytilidae, Aricidae, Ostreidae) and 5 genus (*Meretrix*, *Katelysia*, *Acra*, *Perna*, *Crassostrea*) were recorded in all three stations in Pulicat lake.

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In Bar mouth (station-I), the Shannon-Wiener diversity index ranged from 2.15 to 2.45 showing minimum during October and maximum during May. Karimanal (station-II), the Shannon-Wiener index ranged from 2.26 to 2.40 showing minimum during October and maximum during May. Pulicat town (station-III), the Shannon-Wiener index ranged from 2.25 to 2.39 showing minimum during October and maximum during September.

Bar mouth (station-I), the Simpson's Richness index ranged from 1.28 to 1.36 showing minimum during October and maximum during May. Karimanal (station-II), the Simpson's Richness index ranged from 1.20 to 1.30 showing minimum during August, September and maximum during May. Pulicat town (station-III), the Simpson's Richness index ranged from 1.19 to 1.29 showing minimum during August, September and maximum during May.

Bar mouth (station-I), the Pielou's Evenness index ranged from 0.873 to 0.924 showing minimum during October and maximum during September. Karimanal (station-II), the Pielou's index ranged from 0.875 to 0.930 showing minimum during October and maximum during May. Pulicat town (station-III), the Pielou's index ranged from 0.901 to 0.940 showing minimum during October and maximum during September.

The present study, all three in the Pulicat Lake the *Crassostrea madrasensis* are showing dominance among the other cultivable molluscan species. Because it is widely distributed in Pulicat lake. Environment is more suitable for its dominance and also this species is 'Keystone species' of Pulicat lake Sanjeeva Raj (2006). As far as biodiversity is concern Bar mouth (station-I) is showing higher range and lesser in Pulicat town (station-III) in the Pulicat lake. Pulicat Lake has been so rich in biodiversity and fisheries since ancient time. The recent years, this lake has been subject to a variety of ecological crises, both natural as well as man-made, as result not only the biodiversity but also fishing has been declining so fast.

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