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RESEARCH ARTICLE

Survey of oyster beds of Mulky estuary, south-west coast of India

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Abstract

A survey has been carried out to assess the distribution of oyster beds in the Mulky estuary to inventory the number of oyster beds suitable for oyster exploitation and culture. There were 25 oyster beds in total ranging from 49.17 to 18528.01 m² area. The total area of the oyster beds in the Mulky estuary is 53,488.01 m². Among 25 oyster beds, 19 oyster beds are productive. For the first time, the present investigation reported *C*. *gryphoides* in Mulky estuary. It was found that *S. cucullata* formed beds in the Mulky estuary suitable for exploitation. During the present study, instances of infestation of *C. madrasensis* by the pea crab *Pinnotheres* spp. were also observed. The density of the oysters varied from 35 to 125 No/m². The density of the live and dead oysters varied from 6 to 100 No/m² and 0 to 70 No/m² respectively. The density of oysters was found to be more during pre monsoon months compared to post monsoon months. The percentage prevalence of *S. cucullata* was found higher compared to *C. madrasensis*.

Keywords: Mulky estuary, survey, oysters, oyster beds, key stone species, percentage prevalence.

Introduction

Oysters are ecosystem engineers influencing many ecological processes such as maintenance of biodiversity, population and food web dynamics, nutrient cycling and water quality maintenance (Alexandra *et al*., 2010). They are considered as the keystone species that provide habitat, shelter and food for their associates and are excellent tools for biodiversity restoration in degrading brackish water ecosystems (Sanjeevaraj, 2008). Besides, oyster beds serve as breakwaters to protect adjacent shorelines from erosion (Hosack *et al*., 2007). Oysters form an important component of the intertidal biota of Indian coast. The commercially exploited oyster species in Indian waters are *Crassostrea madrasensis*, *C. gryphoides*, *C. rivularis* and *Saccostrea cucullata* (Rao, 1974). *Crassostrea madrasensis* and *Saccostrea cucullata* occur throughout the Indian coast whereas *C. gryphoides* and *C. rivularis* are restricted to the north-west coastal regions (Mahadevan and Nagappan Nayar, 1987). In Karnataka, Nethravati, Sharavati, Kali, Mulky river estuary and estuaries at Uppunda, Bhatkal, Venkatpur and Kundapur possess oyster beds ranging from 1 ha to 5 ha (Mahadevan, 1987).

The principal factors favorable for the propagation, growth and general welfare of an oyster community are character of bottom, water movements, water temperature, salinity and food. The unfavorable or destructive factors that tend to inhibit the growth and productivity of an oyster community are sedimentation, pollution, competition, disease and predation (Kimbro and Grosholz, 2006; Kimmel and Newell, 2007). The effects of commercial harvesting, storm and erosional activities could account for some oyster bed losses. Boating activities, pollution, excessive sedimentation and extreme turbidity can also cause changes in intertidal oyster beds (Grizzle *et al*., 2002, 2008). Changes in oyster abundance and distribution can be used as indicators of environmental changes. Therefore, it is important to document the currently existing oyster beds so as to enable the future researchers to evaluate future changes to the oyster population. Against these backdrops, a survey has been carried out to assess the distribution of oyster beds in the Mulky estuary to inventory the number of oyster beds suitable for oyster exploitation and culture.

Materials and methods

Study area: The Mulky estuary (Lat. 13º 05¹ N and Long. 74º 46¹ E) is located about 29 km north of Mangalore (13° 4N' 74° 17' E) was selected as the study area for the present investigation. The confluence of the Mulki river (also called as Shambhavi river) and Pavanje river into the Arabian Sea results in the formation of the Mulky estuary. The Mulky river takes its birth in the hill ranges of Padal Gudde in Karkal taluk of Dakishna Kannada (D.K) and after flowing for about 40 kms it empties into the Arabian Sea at Mulky. The Pavangje river which has its origin near Pavanje (D.K) also empties into the Arabian Sea at Mulki after flowing over 12 kms. The estuary is connected to the Arabian sea throughout the year and is subjected to tidal influence to a length of 6.0 km in Mulki river and 6.6 km in Pavanje river (Reddy and Gopala 1982). The estuary has an average depth of 3 m and the tidal range is about 1 m. The bottom of the estuary is mostly a mixture of silt and sand. This is a typical tropical estuary which experiences wide variations in salinity.

During the south-west monsoon period (June to Sep), the estuary is flooded with fresh water influx from the land and the estuarine waters become almost fresh. During this period, the water is very turbid throughout the estuary. During the non-monsoon period, estuarine water comprises mainly of sea water as the freshwater influx is very much reduced. In the present study, survey of oyster beds in Mulky estuary was carried out during Oct 2008.

Inventory of oyster beds and determination of growth of oysters: Oyster beds were located using Global Positioning System (Model: Megallan GPS NAV DLX10). Length and width of each oyster bed were measured using a meter tape. The area of each oyster bed (OB) was calculated based on an oval shape using the following formula: A= [(Length/2) (width/2)] π. Two oyster beds (OB1 and OB2) in the Mulky estuary were selected for study. The total density, density of live and dead oysters at OB1 and OB2 were recorded from Oct 2008 to Apr 2010. The percentage prevalence of *C. madrasensis* and *S. cuculllata* was also recorded. The weight, height and length of oysters at OB1 and OB2 were determined to record the growth of the oysters. The growth of oyster is expressed in terms of increment in weight and shell height.

Results

Distribution of oyster beds in the Mulky estuary is given in Table 1 and Plate 1. The density of the live and dead oysters varied from 6 to 100 No/m² and 0 to 70 No/m² (Fig. 1a and b). Percentage prevalence *C. madrasensis* and *S. cucullata* at OB1 varied from 5-85% and 15-95% (Fig. 2a and b). The percentage prevalence of *C. madrasensis* and *S. cucullata* at OB2 varied from 0-60% and 35-100% (Fig. 2a and b). The average weight, height and length of *C. madrasensis* varied from 18.52 to 69.69 g, 2.91 to 5.23 cm and 3.27 to 6.05 cm (Fig. 3a and b). The average weight, height and length of *S. cucullata* varied from 9.56 to 36.86 g, 2.24 to 5.80 cm and 1.17 to 3.82 cm (Fig. 3a and b).

Discussion

A survey has been carried out to assess the distribution of oyster beds in the Mulky estuary to inventory the number of oyster beds suitable for oyster exploitation and culture. There were a total of 25 oyster beds ranging from 49.17 to 18528.01 m² area. The length of the oyster beds varied from 11.60 to 244.80 m. The width varied from 5 m to 129.40 m. The density of the oysters varied from 35 to 125 No/m². The density of the live and dead oysters varied from 6 to 100 No/m² and 0 to 70 No/m². Among 25 oyster beds, 19 oyster beds are productive in terms of their density per meter square and high number of live oysters per meter square area suitable for oyster exploitation and culture. The present study reported that the total area of the oyster beds in the Mulky estuary is 53,488.01 m². The area of 32556.36 m² having high density oyster populations and 20931.65 m² area having low density oyster populations.

Plate 1. Locations of oyster beds in Mulky estuary.

However, presently two oyster beds which are far from the bar mouth and easy to access are being commercially exploited. From the present study, it was found that most of the productive oyster beds are distributed near the bar mouth region of the estuary where water turbulence, lush growth of mangroves and silty bottom restricted the accessibility. Furthermore, in the Mulky estuary, local fisherwomen are engaged in the oyster exploitation who may not do oyster fishery in the beds located near the bar mouth. Due to this reason, most of the oyster beds in the Mulky estuary are not exploited yet and may be suitable for commercial exploitation and culture. It is very important to inventory the oyster beds in the estuary because changes in oyster abundance and distribution can be used as indicators of environmental changes. Therefore, documentation of the currently existing oyster beds in the Mulky estuary may enable the future researchers to evaluate future changes to the oyster population. Similar survey was carried out in Ishahaya Bay, Japan to assess the distribution of oyster beds that revealed number of oyster beds suitable for oyster exploitation and culture (Jinno, 1998). The survey of North Carolina's oyster beds in 1992 reported 8,327 acres of oyster beds having high-density population and 20,553 acres having low-density population (Jones, 1994). Intertidal benthic community survey revealed the aggregations of oyster beds along intertidal mud banks of Skardon River, Queensland, USA (Grizzle *et al*., 2005). In a survey, more than 70,400 acres of oyster beds were identified in Delware Bay estuary, USA (Grizzle *et al*., 2008). During 1984, in Virginia, USA, a survey was conducted in estuarine waters to locate and map the naturally productive oyster beds. In this survey, 20,000 acres of oyster beds suitable for harvesting were reported (Fullford *et al*., 2007). In a survey by the Chesapeake Bay Programme, fresh oyster beds were found in the Chesapeake Bay suitable for harvesting (Kimmel and Newell, 2007).

Table 1. Location, length, width, area, density, live and dead oysters, percentage live and dead and species of oyster beds in the Mulky estuary during Oct 2008.

S. No.	Latitude	Longitude	Length (m)	Width (m)	Area (m²)	Density (No/m²)	Live (No/m²)	Dead (No/m²)	Live (%)	Dead (%)	Species present
1.	13º 04.648N	74 46.789E	46.10	7.26	262.72	42	22	20	52.38	47.61	*C. madrasensis, S. cucullata*
2.	13º 04.527N	74 46.747E	85.00	27.15	1810.91	120	50	70	41.66	58.33	*C. madrasensis, S. cucullata*
3.	13º 04.497N	74 46.749E	63.20	27.20	1349.44	75	26	50	33.33	66.66	*C. madrasensis, S. cucullata*
4.	13º 04.463N	75 46.762E	30.60	30.60	735.04	125	75	50	60.00	40.00	*C. madrasensis, S. cucullata*
5.	13º 04.420N	74 46.778N	61.20	30.60	1470.08	80	60	20	75	25.00	*C. madrasensis, S. cucullata*
6.	13º 04.386N	74 46.778E	92.80	7.00	509.93	65	25	40	38.46	61.53	*C. madrasensis, S. cucullata*
7.	13º 04.312N	74 46.801E	54.60	7.00	300.02	70	20	50	28.57	71.42	*C. madrasensis, S. cucullata*
8.	13º 04.223N	74 46.833E	43.10	8.00	270.66	35	10	25	28.57	71.42	*C. madrasensis, S. cucullata*
9.	13º 04.245E	74 46.754E	11.60	5.40	49.17	55	30	25	54.54	45.45	*C. madrasensis, S. cucullata*
10.	13º 04.312N	74 46.717E	58.90	5.40	249.67	45	20	25	44.44	55.55	*C. madrasensis, S. cucullata*
11.	13º 04.337N	74 46.699E	91.60	5.00	359.53	46	6	40	13.04	86.95	*C. madrasensis, S. cucullata*
12.	13º 04.378N	74 46.684E	30.60	15.70	377.12	55	30	25	54.54	45.45	*C. madrasensis, S. cucullata*
13.	13º 04.424N	74 46.657E	29.00	8.40	191.22	40	30	10	75	25	*C. madrasensis, S. cucullata, C. gryphoids*
14.	13º 05.080N	74 46.658E	48.00	15.60	587.80	64	60	4	93.75	6.35	*C. madrasensis S. cucullata, C. gryphoids*
15.	13º 05.175N	74 46.569E	44.00	20.00	345.40	70	40	30	57.14	42.85	*C. madrasensis, S. cucullata*
16.	13º 05.195N	74 46.537E	39.60	5.60	174.08	70	10	60	14.28	85.71	*C. madrasensis, S. cucullata*
17.	13º 05.186N	74 46.596E	182.40	129.40	18528.01	35	30	5	85.71	14.28	*C. madrasensis, S. cucullata, C. gryphoids*
18.	13º 05.175N	74 46.615E	67.20	19.40	1023.38	40	40	0	100	0	*C. madrasensis, S. cucullata, C. gryphoids*
19.	13º 05.117N	74 46.671E	150.00	40.00	4710.00	100	100	0	100	0	*C. madrasensis, S. cucullata,, C. gryphoids*
20.	13º 05.176N	74 46.773E	244.80	76.60	14720.06	100	75	25	75	25	*C. madrasensis, S. cucullata, C. gryphoids*
21.	13º 05.207N	74 46.773	133.40	15.00	1570.78	75	25	50	33.33	66.66	*C. madrasensis, S. cucullata, C. gryphoids*
22 (OB1)	13º 05.161N	74 46.763 E	81.40	29.00	1853.07	100	75	25	75	25	*C. madrasensis, S. cucullata*
23.	13º 05.175N	74 46.760E	65.00	8.00	408.20	87	63	24	72.41	27.58	*C. madrasensis, S. cucullata*
24 (OB2)	13º 05.587N	74 46.870E	50.30	9.40	371.16	96	82	14	85.41	14.58	*C. madrasensis, S. cucullata*
25.	13º 05.465N	74 46.820E	102.5	15.70	1263.26	69	53	16	76.81	23.18	*C. madrasensis, S. cucullata*

A survey has been carried out in Caloosahatchee estuary, Florida, USA to assess the status of Eastern oyster, *Crassostrea viriginica* (Aswani *et al*., 2008). This study revealed that the overall status of oysters in this estuary was below restoration. The present study recorded three species of oysters, *Crassostrea madrasensis*, *Saccostrea cucullata* and *Crassostrea gryphoides* in the Mulky estuary. In India, *Crassostrea madrasensis*, *C. rivularis*, *C. gryphoides* and *Saccostrea cucullata* are considered as commercially important (Rao *et al.*, 1983).

It has been reported that *C. rivulais* occurs all along the Gujarat coast and in some regions of Maharashtra coast. *Crassostrea madrasensis* is a major oyster species in India and occurs all along the Indian coasts and Andaman. It is referred as the native oyster of India. The oysters, *C. gryphoides* and *C. rivularis* are restricted to the north-west coast regions of India (Mahadevan, 1987). Joseph and Joseph (1987) reported two species of oysters, *Crassostrea madrasensis* and *Saccostrea cucullata* in the Mulky estuary.

Fig.1a and b. Density of live and dead oysters (No/m²) at OB1 and OB2 in Mulky estuary from Oct 2008 to Apr 2010.

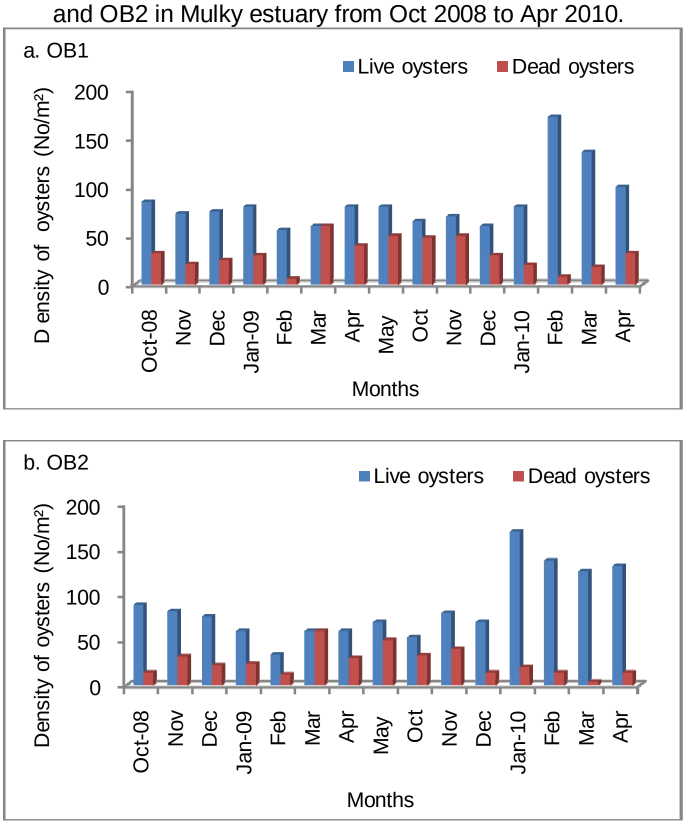


Fig. 2a and b. Percentage prevalence (%) of *C. madrasensis* and *S. cucullata* at OB1 and OB2 in the Mulky estuary during Oct 2008 to Apr 2010.

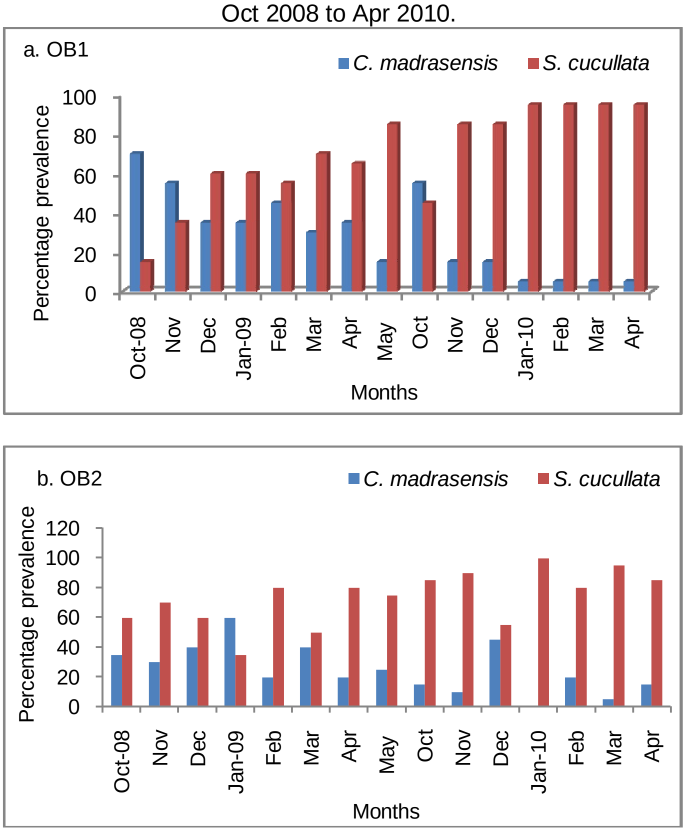
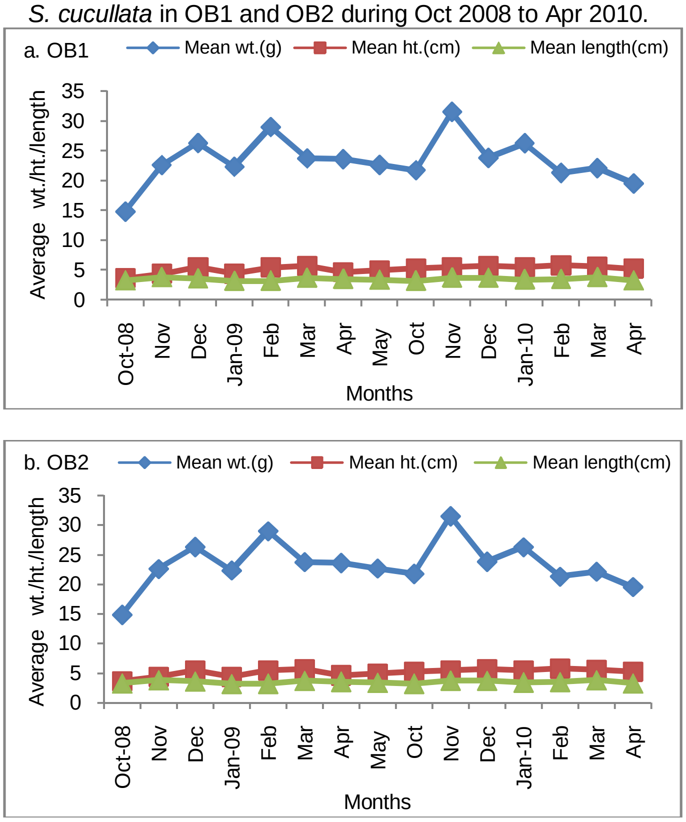


Fig. 3a and b. Monthly average weight, height and length of *S. cucullata* in OB1 and OB2 during Oct 2008 to Apr 2010.



But interestingly, for the first time, the present investigation reported *C. gryphoides* also in the Mulky estuary in some beds near to the bar mouth. But density was very low (1-3 No/m²). However, nowhere in the Mulky estuary, *C. gryphoides* formed bed for exploitation. The reason for the occurrence, restricted distribution and low density of *C. gryphoides* in the Mulky estuary is not clear that may invite further study. It was stated that although *S. cucullata* occurs all along the coast of India, nowhere is it found to form prolific oyster beds unlike the other three species (Mahadevan, 1987). But from the present investigation, it was found that *S. cucullata* formed beds in the Mulky estuary suitable for exploitation. The density of the oysters varied from 35 to 125 No/m². The density of the live and dead oysters varied from 6 to 100 No/m² and 0 to 70 No/m². The density of oysters was found to be more during pre-monsoon months compared to post-monsoon months. This may be due to spawning of oysters during pre monsoon months when the water temperature and salinity were high. Ward *et al*. (2000) reported that the higher water temperature and salinity may induce the spawning in oysters. The percentage prevalence of *S. cucullata* at OB1 and OB2 varied from 15 to 95% and 60 to 100% during Oct 2008 to Apr 2010. These results indicated that the *S. cucullata* formed prolific intertidal beds in Mulky estuary. At OB1, *C. madrasensis* showed decreasing trend over the months and *S. cucullata* showed increasing trend over the months.

This may be due to low rate of recruitment due to delayed or advanced spawning or failure in spawning. The average weight, height and length of *C. madrasensis* varied from 18.52 to 69.69 g, 2.91 to 5.23 cm and 3.27 to 6.05 cm. The average weight, height and length of *S. cucullata* varied from 9.56 to 36.86 g, 2.24 to 5.80 cm and 1.17 to 3.82 cm. These results indicate that the size of *C. madrasensis* was found to be more than *S. cucullata*. This may be due to higher growth rate of *C. madrasensis* compared to *S. cucullata*. In Mulky estuary, bigger individuals of *C. madrasensis* and *S. cucullata* are abundant in subtidal areas compared to intertidal oyster beds. This indicates that the growth rate of oysters is faster in subtidal area. This may be due to greater availability of food and longer feeding time as they are always submerged in the water unlike the oysters of intertidal bed that may expose during tidal cycle. It was also observed that the elevated temperatures of the tropics can produce high oyster growth rates if adequate food is available (Croft, 1998). From this study, it was noticed that some oyster beds near to the river bank are also associated with clam beds. So that oysters and clams may be exploited simultaneously for better economic gain. Apart from the utilization of live oyster meat as food, the dead shells are collected for industrial purposes. Mining of subfossil deposits by lessees carried out in many estuaries like Kali river, Athankarai and Bahuda river yield nearly 15,000 tons of oyster shells annually (Mahadevan, 1987). It was observed that only limited mining of oyster shells have been done in the Mulky estuary in spite of its high potential. Interestingly, for the first time during the present study, three instances of infestation of the oysters by the pea crab *Pinnotheres* spp. were observed in the samples of *C. madrasensis*. The infestation of pea crab in oysters is very rare (Durve, 1964). The pea crab was reported in *S. cucullata* by Awati and Rai (1931) and in *C. gryphoides* by Durve (1964) along Bombay coast.

Conclusion

All inventoried oyster beds in the Mulky estuary may be used for commercial harvesting to uplift the livelihood of local fishers. Oysters are found abundant during pre-monsoon compared to post-monsoon season. The growth was found higher in *C. madrasensis* than that of *S. cuccullata*. Bigger individuals of oysters are abundant in the subtidal regions. Moreover, some oyster beds are also associated with calm beds that may enable fishers to exploit both oysters and clams simultaneously for better economic gain. The occurrence and limited distribution of northwest oyster, *C. gryphoides* invite further study. The pea crab infestation was observed in some oysters. However, changes in oyster abundance and distribution may be used as indicators of environmental changes. Inventory of existing oyster beds in the Mulky estuary may enable future researchers to evaluate future changes to the oyster population. Moreover, some oyster beds are also associated with clam beds that may enable fishers to exploit both oysters and clams simultaneously for better economic gain.

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