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Diversity and distribution of marine crab, their importance, threats, and conservation in different sites of Thoothukudi coastal areas

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Abstract
As of 2023, in the world, more than 242,000 marine species have been documented. An average of 2,332 new species per year is being described. There are 45,000 species of crabs living in the world, and 990 species of crabs in the Indian Ocean. Crabs are an excellent environmental indicator. Many crabs feed on detritus, algae, and decaying organic matter and protecting the ecosystem. Crabs decompose dead organisms in the ocean and help to accumulate waste and recycle marine water. Crabs are very useful in the field of medicine. Their economic importance underscores the need for effective management and conservation efforts to ensure the survival of crab populations and their habitats, and increasing climate change has resulted in the decline of crab populations in the ocean. In this study two sites are surveyed, namely Vellapatti and Harbour Beach. Totally eighteen species belonging to twelve genera and seven families to recorded in this study. The crabs are faced with various threats from overexploitation, habitat degradation, pollution, invasive species, and climate change. This study indicates the diversity and conservation of crabs on the coast of the Thoothukudi district.

Keywords: Overexploitation, conservation, pollution, decompose

Introduction
The Ocean is the body of salt water that covers approximately 70.8% of the Earth. Ocean water contains dissolved gases, including oxygen, carbon dioxide and nitrogen. The ocean provides many benefits to humans, such as ecosystem services, access to seafood and other marine resources. The Ocean is known to be the habitat of over 2,30,000 species but many holds considerably more-perhaps over 2 million species. Crustaceans are a group of Invertebrate animals consisting of some 45,000 species distributed worldwide. It is a large, diverse group of mainly aquatic Arthropods including Shrimps, Prawns, Crabs, Lobsters and Crayfish. It is a form of decapods crustaceans belongs to the class Malacostraca. It can be found all oceans and also in fresh water. Some crabs are live in land, mud, mangroves area.

Crustaceans are the important of macro benthic fauna as especially the infra order Brachyura. Brachyuran crabs comprise about 700 genera and 5000 to 10,000 species worldwide and due to their great abundance of biomass and community structure (Ng PLK *et al.*, 2008) [1]. In Indian mangroves 138 brachyuran crab species were reported Kathiresan and Qasim (2005) [2]. Realizing the importance, a few numbers of works pertaining to habitat distribution and diversity of brachyuran crabs in mangroves of east and west coasts of India has been carried out (Ajmal Khan *et al.*, 2005, Soundarapandian *et al.*, 2008, Satheeshkumar 2012) [3-5].

Crustaceans are highly valuable commodities by virtue of their pivotal role in the seafood industry of the world. Many of the crabs are commercially important as a food source for people. Brachyuran crabs are a diverse group of crustaceans alive today. Crabs are one of the important faunal communities serving as a good food source to human beings in the marine and brackish water ecosystems. Crabs are one of the ecologically important faunal communities in the marine ecosystem. They are filter feeders, sand cleaners, mud, plant and carrion feeders, predators, commensals and parasites. Crabs were not only valuable food items, but also have good nutritional and medicinal value. The crab meat contains rich amounts of protein, vitamin A and D, minerals, glycogen and essential amino acids. Crustacean's shells such as crab contain natural ingredients, and its principal components are chitin (20-30 %), protein (30-40 %), calcium carbonate salts (30-50 %) and antioxidant compounds such as selenium and carotenoids (astaxanthin, astatine, and canthaxanthin). The hemolymph of crabs also used in the production of certain drugs and in devices used in medical care (Cho *et al.*, 1998) [6].

The crab meat also has medicinal properties to cure asthma and chronic fevers (Raja, 1981) [7]. About 990 species of brachyuran crabs have been observed in the littoral and deep-sea regions all along the Indian coast (Kathirvel, 2008) [8]. Out of 990 species recorded from Indian waters, 32 species attain large sizes and are edible. Twelve edible species come under three families such as *Calippidae*, *Portunidae* and *Grapsidae*. The edible species are *Portunus pelagicus, P sangunolentus, Charybdis feriatus, C. lucifera, C. annulate, C. narrator, Scylla tranquebarica, S. serrata, Matuta lunaris, Sesarma retragonum* and *Varuna litterata.* Of these, *Portunidae* includes the commercially important marine species such as *P. sanguinolentus, P. pelagicus, C. feritatus, C. annulata, C. narrator, S. tranquebarica* and *S. serrata.*

Crab shell has been introduced as one of the traditional remedies for the treatment and prevention of cancer, and its extract has effective inhibitory effects on breast cancer cell line (MCF7) (Rezakhani *et al.*, 2014) [9] and prostate cancer cell line (LN Cap) (Rezakhani *et al.*, 2017) [10]. Selenium is an essential part of the human diet and is found in crab shell. It inhibits tumor cell progress and it has protective effects against cancer (Brozmanova *et al.*, 2010) [11]. Also, selenium has antioxidant and anti-inflammatory effects and can be effective in diabetes owing to its role in oxidative stress. Studies on diabetes in mice have shown that selenium protects mitochondria from oxidative stress (Akhuemokhan *et al.*, 2013) [12] and plays an important role in the metabolism of vitamin E. It is essential for the normal function of pancreas (Tabar, 2012) [13].

Current drugs used for the treatment of diabetes are associated with several side effects such as hypoglycemia, weight gain, gastro intestinal disorders, peripheral edema and impaired liver function (Mallare *et al.*, 2005) [14]. The revealed a rich and diverse brachyuran crab fauna along the Chennai coast, which is notable compared to other urban regions in India. However, this diversity is unevenly distributed among different habitats, suggesting varying vulnerability to human activities such as pollution, land reclamation, and overfishing. The dominance of the family Portunidae, characterized by its high species richness, underscores the ecological importance of swimming crabs in the marine ecosystem of Chennai. Despite their importance and vulnerability, comprehensive and updated information on brachyuran crabs along the Chennai Coast remains scarce. Therefore, there is an urgent need for systematic and extensive surveys covering different habitats and depths. Such efforts would provide insights into the status, patterns, and trends of brachyuran crab diversity and distribution in Chennai, as well as identify the key factors influencing them (Jayanthi Jayaprakash *et al.*, 2024) [15].

Coastal regions are ecologically important, but face numerous problems, including urbanization, coastal erosion, loss of marine species, and climate change. Pollutants of domestic and industrial origin threaten the quality of freshwater and ocean water. Various types of pollution in ocean and inland water bodies have been observed, such as sewage, thermal, heavy metal, oil, acid, radioactive, industrial, and air pollution. These toxic pollutants affect the fauna and flora of natural ecosystems (Jayanthi Jayaprakash *et al.*, 2024) [15].

Importance of Crabs

Crabs are important to the environment, to the food chain, and to human health. They are an excellent environmental indicator. Crab is packed with protein, which is important for building and maintaining muscle. It also contains high levels of omega-3 fatty acids, vitamins B12, and selenium. These nutrients play vital roles in improving general health while helping prevent a variety of chronic conditions. Crab larvae form a significant part of plankton communities, especially in coastal and reef areas, and are a vital part of complex food chains. It also helps clean the ocean floor by eating plants and animals. Crabs are one of the main decomposers in the marine ecosystem. Chitin can be extracted from the crab and used in products like adhesives, cosmetics, photographic emulsions, and anticoagulants.

Crabs are economically important because they are a delicacy, a source of protein, and are used in scientific research, aquaculture, and more. In Food, Crabs are a delicacy in many cultures and are a good source of protein. Some of the most valuable crabs include the blue crab, Dungeness crab, and king crab. Mud crabs are a seafood delicacy with high flesh content and are in high demand worldwide. In Aquaculture**,** Crabs are cultivated for food and ornamental purposes. Mud crab farming is developing in India, particularly in the states of AP, Kerala, West Bengal, and Odisha. In Scientific research**,** Crabs are used as biological models to study physiological mechanisms, fertilization, regeneration, and cell association. Crabs are also used to test the tolerance levels of aquatic fauna. From another point of view, Crabs are used in ethno-medicine to treat diseases such as whooping cough, bronchitis, pneumonia, and more. Crabs are also used in medicinal liquor and crab curry. The main objective of the present study is, to identify and record the distribution of different crab species, male and female sex ratio crabs, and to understand the ecological and economic importance of crabs in different stations of the Thoothukudi Coast in Tamil Nadu.

Materials and Methods

Field visit and Study area

The field visit was conducted from September 2024 to November 2024 at Vellapatti (Latitudes 8.856938o, Longitudes 78.166804o), and Harbour beach (Latitudes 8.741244º, Longitudes 78.168364º) (Figure 1) and interact with local fishermen based on the primary study result we have choose selecting based on the timing and season. Hand picking method, gill net and trawl net are used to catches carb of different regions and collect all the date like number of species, along with the number of individuals in a species, male and female were noted in the study area. Using this data Diversity index studies calculate using "Biodiversity past 4.03" statistical software.

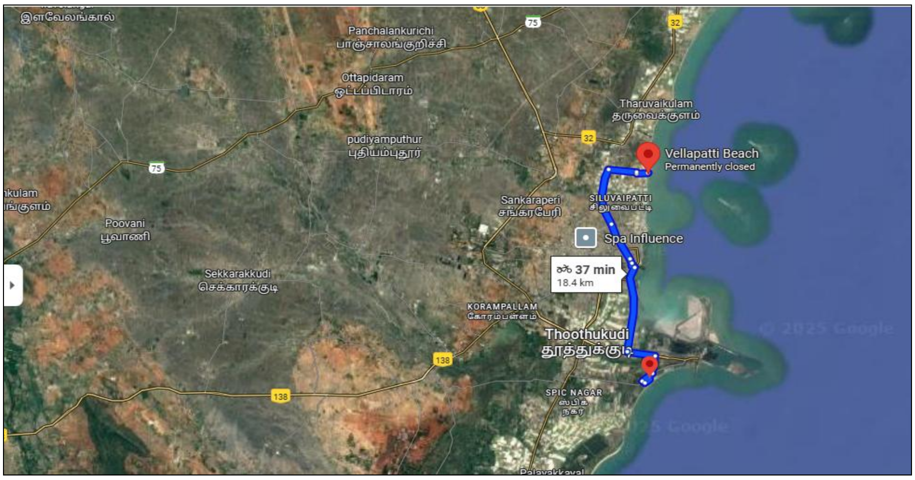

Fig 1: Map showing the location of the study area

Crab Identification

Crab species were identified using a database website and survey, which provided information on the distribution and photographs of crab species. (Crab Database. - Available: shttps://www.crabdatabase.info/en). Taxonomy and scientific names of all brachyuran crabs were verified and referenced from research articles, the WoRMS website and the crab database (WoRMS - World Register of Marine Species).

Result and Discussion

As a result of this study, a total of 18 species were identified, namely *Arenaeus cribrarius, Ashtoret lunaris, Atergatus integerrimus, Calappa bilineata, Charybdis feriatus, Charybdis helleri, Charybdis lucifera, Charybdis natator, Dardanus hessii, Dardanus lagopodes, Halimede ochtodes, Matuta planipes, Menippe rumphii, Monomia gladiater, Portunus pelagicus, Portunus reticulates, Portunus sanguinolentus* and *Scylla serrata*. Of these, fourteen species are found in both Vellapatti and Harbour Beach.

The Vellapatti station is a non-polluted area and is home to sixteen species. *Ashtoret lunaris* and *Halimede ochtodes* species are present in Vellapatti Station and absent from Harbour Beach Station. The harbour beach station is a polluted area in the nearby Thermal power plant, SPIC industrial complex, where sixteen species are found. *Charybdis feriatus* and Dardanus hessii species are present in harbour beach station and absent from the Vellapatti Station (Table1 and Figure 2).

Table 1: Diversity and Distribution of Coastal Crabs in two different stations

S. No	Species Name	Family	Station V	Station H
1	*Arenaeus cribrarius* (Lamarck, 1818)	Portunidae	√	√
2	*Ashtoret lunaris* (Forskal, 1775)	Matutidae	√	
3	*Atergatus integerrimus* (Lamarck, 1818)	Xanthidae	√	√
4	*Calappa bilineata* (Ng, Lai & Aungtonya, 2002)	Calappidae	√	√
5	*Charybdis feriatus* (Linnaeus, 1758)	Portunidae		√
6	*Charybdis helleri* (A. Milne- Edwards, 1867)	Portunidae	√	√
7	*Charybdis lucifera* (Fabricius, 1798)	Portunidae	√	√
8	*Charybdis natator* (Herbst, 1794)	Portunidae	√	√
9	*Dardanus hessii* (Miers, 1884)	Diogenidae		√
10	*Dardanus lagopodes* (Forskal, 1775)	Diogenidae	√	√
11	*Halimede ochtodes* (Herbst, 1783)	Gelenidae	√	
12	*Matuta planipes* (Fabricius, 1798)	Matutidae	√	√
13	*Menippe rumphii* (Fabricius, 1798)	Menippidae	√	√
14	*Monomia gladiater* (Fabricius, 1798)	Portunidae	√	√
15	*Portunus pelagicus* (Linnaeus, 1758)	Portunidae	√	√
16	*Portunus reticulatus* (Weber, 1795)	Portunidae	√	√
17	*Portunus sanguinolentus* (Herbst, 1783)	Portunidae	√	√
18	*Scylla serrata* (Forskal, 1775)	Portunidae	√	√

Note: Station V- Vellapatti, Station H - Harbour beach

A. cribrarius | *A. lunaris* | *A. integerrimus* | *D. logopodes*

C. bilineata | *C. feriatus* | *C. helleri* | *H. ochtodes*

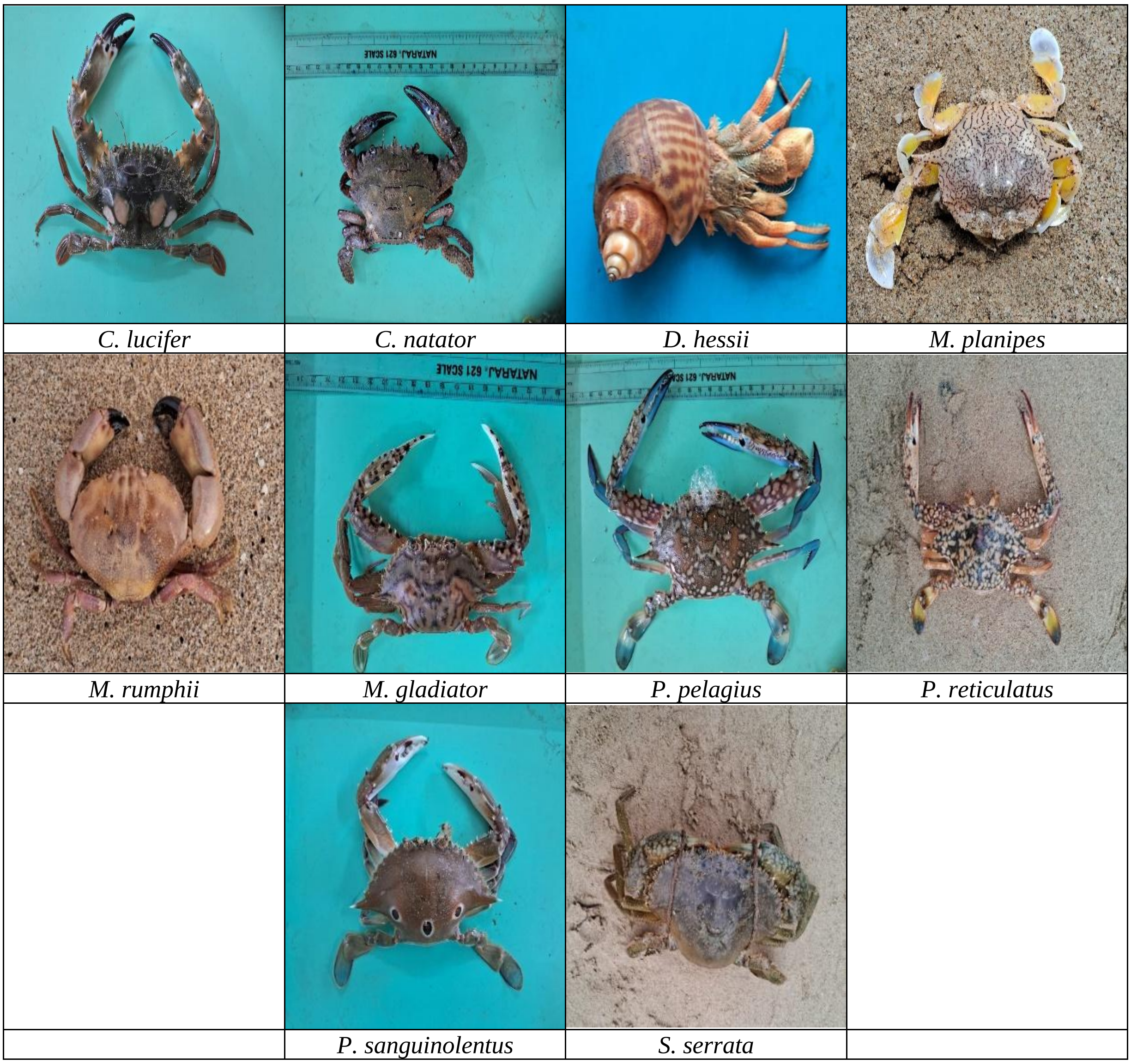

Fig 2: Distribution of carb species along both coastal study areas

A total of 18 species has been identified in the order Malacostraca, belonging to 7 families (Portunidae, Matutidae, Xanthidae, Calappidae, Diogenidae, Gelenidae, and Menippidae) and 12 genera (*Arenaeus, Ashtoret, Atergatus, Calappa, Charybdis, Dardanus, Halimede, Matuta, Menippe, Monomia, Portunus, and Scylla*), which were recorded in different stations in Thoothukudi coastal areas.

The Portunidae family includes 5 groups: *Arenaeus, Charybdis, Monomia, Portunus,* and *Scylla,* which have a total of 10 types: *Arenaeus cribarius, Charybdis feriatus, Charybdis helleri, Charybdis lucifera, Charybdis natator, Monomia gladiator, Portunus pelagicus, Portunus reticulatus, Portunus sanguinolentus,* and *Scylla serrata*. The Matutidae family comprises two groups: Ashtoret and Matuta, which have a total of two types: *Ashtoret lunaris* and *Matuta planipes.* The Xanthidae family includes one group: Atergatus, which has a total of one type: *Atergatus integerrimus.*

The Calappidae, Gelenidae, and Diogenidae families found one species, Calappa, Halimede, Menippidae, which have a total of one species *Calappa bilineata, Halimede ochtodes*, and *Menippe rumphiiare* found respectively. Dardanus, which has a total of 2 species, namely *Dardanus hessii* and *Dardanus lagopodes* (Table.2).

Table 2: Taxonomic classification of marine Brachyuran Crabs

<table>
<tr><th>S. No</th><th>Species name</th><th>Kingdom</th><th>Phylum</th><th>Class</th><th>Order</th><th>Family</th></tr>
<tr><td>1</td><td>A. cribrarius</td><td>Animalia</td><td>Arthropoda</td><td rowspan="8">Malacostraca</td><td rowspan="8">Decapoda</td><td>Portunidae</td></tr>
<tr><td>2</td><td>A. lunaris</td><td>Animalia</td><td>Arthropoda</td><td>Matutidae</td></tr>
<tr><td>3</td><td>A. integerrimus</td><td>Animalia</td><td>Arthropoda</td><td>Xanthidae</td></tr>
<tr><td>4</td><td>C. bilineata</td><td>Animalia</td><td>Arthropoda</td><td>Calappidae</td></tr>
<tr><td>5</td><td>C. feriatus</td><td>Animalia</td><td>Arthropoda</td><td rowspan="4">Portunidae</td></tr>
<tr><td>6</td><td>C. helleri</td><td>Animalia</td><td>Arthropoda</td></tr>
<tr><td>7</td><td>C. lucifera</td><td>Animalia</td><td>Arthropoda</td></tr>
<tr><td>8</td><td>C. natator</td><td>Animalia</td><td>Arthropoda</td></tr>
</table>

9	*D. hessii*	Animalia	Arthropoda			Diogenidae
10	*D. lagopodes*	Animalia	Arthropoda			Diogenidae
11	*H. ochtodes*	Animalia	Arthropoda			Gelenidae
12	*M. planipes*	Animalia	Arthropoda			Matutidae
13	*M. rumphii*	Animalia	Arthropoda			Menippidae
14	*M. gladiater*	Animalia	Arthropoda			Portunidae
15	*P. pelagicus*	Animalia	Arthropoda			
16	*P. reticulatus*	Animalia	Arthropoda			
17	*P. sanguinolentus*	Animalia	Arthropoda			
18	*S. serrata*	Animalia	Arthropoda			

Among them, *Portunus pelagicus* is the highly dominant species of the station in Vellapatti, and the highly recessive species of the station is *Charybdis feriatus* (Figure 3). Then, *Portunus sanguinolentus* is the highly dominant species of the station in Harbour Beach, and the highly recessive species of the station is *Halimede ochtodes* (Figure 4). They have the most abundant species of the Portunus family in both stations. The station-wise percentile coverage of crab's results showed that the Vellapatti station is *Portunus pelagicus* (Figure 5), and the Harbor Beach station is *Portunus sanguinolentus* (Figure 6).

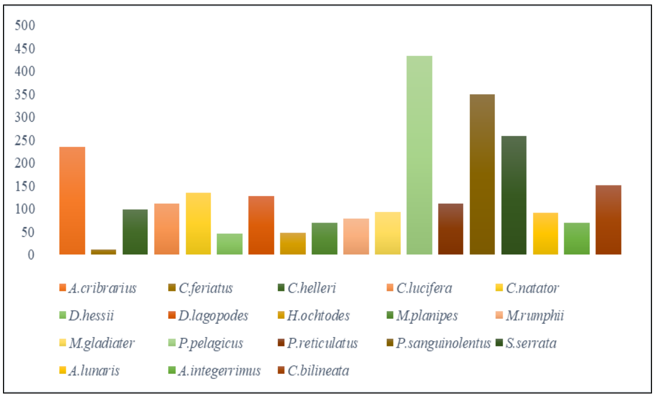

Fig 4: Species-wise distribution of crabs in Vellapatti

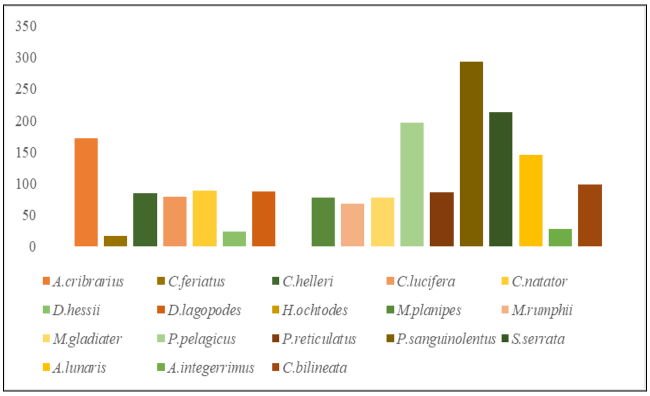

Fig 5: Species-wise distribution of crabs in Harbour Beach

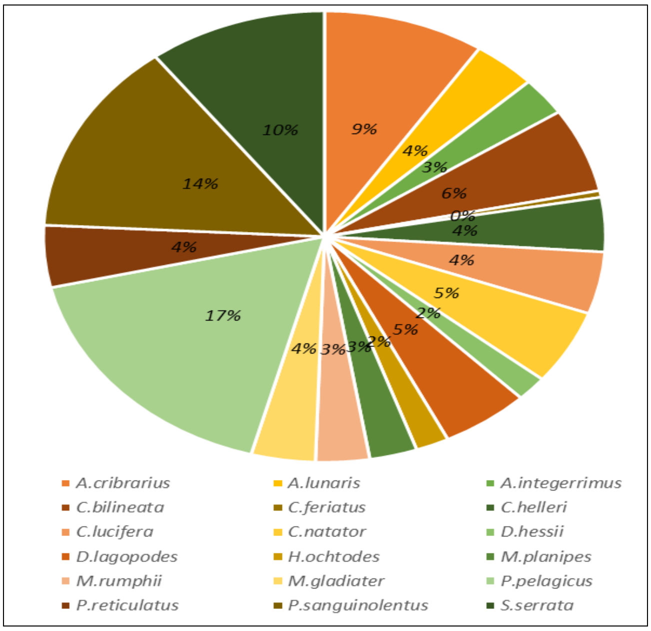

Fig 6: Station-wise percentile coverage of Crabs at Vellapatti

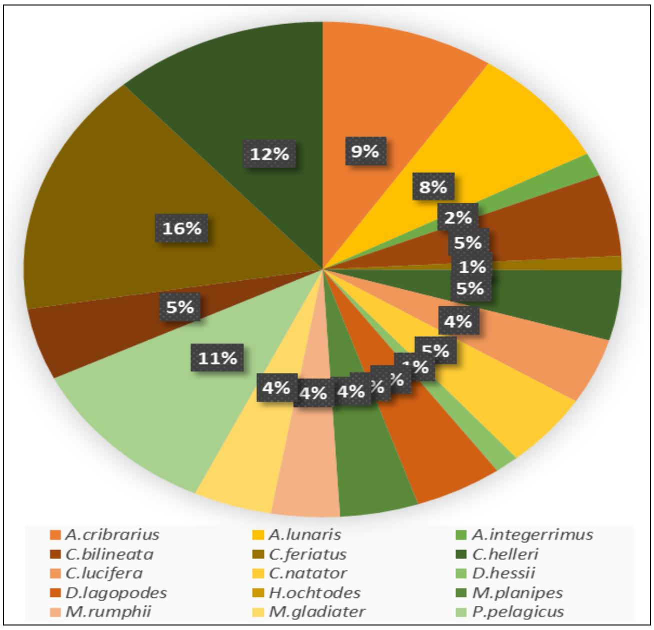

Fig 7: Station-wise percentile coverage of Crabs at Harbour Beach

Table 3: Station -wise crab diversity Index

Index	Vellapatti	Harbour Beach
Shannon - Wiener evenness (H')	2.633	2.622
Simpsons Diversity richness (D)	0.9116	0.9148
Evenness_e^H/S	0.773	0.8095
Margalef	2.171	2.129
Berger_Parker	0.1716	0.1624
Standard Deviation (SD)	110.698	76.6854
Standard Error (SE)	26.0917	18.0749

The Shannon- Wiener diversity index (H') revealed that the Vella Patti and Harbour Beach stations are evenly distributed like 2.633 and 2.622. The Simpsons Diversity richness (D) revealed that the Vellapatti and Harbour Beach stations are evenly distributed like 0.9116 and 0.9148. The Evenness e^H/S revealed that the lowest index was 0.773 in Vellapatti and the highest index was 0.8095 in Harbour Beach (Table. 3).

A total number of 990 species of marine brachyuran crabs belonging to 281 genera and 36 families were recorded in Indian waters by Kathirvel (2008) [8]. Tamil Nadu coast, one of the states in India, has 404 species of crabs belonging to 26 families and 152 genera (Kathirvel, 2008) [8]. Recently, Varadharajan (2012) [16] reported 79 crab species coming under 21 families of crabs in the Palk Strait. Maximum percentages of crab catches are landed from the Gulf of Mannar, Palk Bay, Nagapattinam, and Puducherry landings of the Tamil Nadu coast in India (Rao *et al*., 1973) [17].

As a result of this study, a total of 18 species were identified. The study highlights that the most important to rich and diverse brachyuran crabs. The Portunidae family is a highly dominant species. They have the most abundant species of the Portunus family in both stations. There are 10 species of crabs belongs to the Portunidae family. Xanthidae, Calappidae, Menippidae, and Gelinidae are single-species families present in limited quantities. The dominance of the family Portunidae, characterized by its high species richness, underscores the ecological importance of swimming crabs in the marine ecosystem. Less diverse families, such as Calappidae, Leucosiidae, and Ocypodidae, alongside single-species families, highlight the diverse ecological niches occupied by brachyuran crabs in this region (Jayanthi Jayaprakash *et al.*, 2024) [15]. There are totally 60 crab species were recorded in different stations, which were represented by 10 families and 24 genera. Maximum crab species recorded in the present study belonged to the family Portunidae rather than other families (Vidhya *et al*., 2017) [18].

The conservation measures for catching young, undersized, and berried crabs should be done by educating the fishermen through audio visual adds. Sea ranching should be promoted for over-exploited species. fixing the legal minimum size and protection of ovigerous crabs (V Vidhya *et al*., 2017) [18].

Conservation

A single female crab can produce up to eight million eggs in one mating season; therefore, minimizing their capture is crucial. *Berried crabs* (those carrying eggs) should be released if they are caught. Juveniles and undersized crabs were not captured. Fishing of crabs should be strictly banned during the peak breeding season. Awareness should be created among the local people and fishermen regarding the depletion of crab populations. Extension programs for crab conservation should be implemented through the media. Wastewater released into these complex areas should be treated thoroughly before being released into natural waters. To maintain this population, sea ranching of commercially important crab species should be practiced.

Conclusion

Crabs feed on detritus, algae, and decaying organic matter and protecting the ecosystem. Crabs decompose dead organisms in the ocean and help to accumulate waste and recycle marine water. Their economic importance underscores the need for effective management and conservation efforts to ensure the survival of the crab population and their habitats. Increasing climate change has resulted in the decline of crab populations in the ocean. The crabs are faced with various threats from overexploitation, habitat degradation, pollution, invasive species and climate change.

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