Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 6
Open Access

Assessment of Crab By-catch and Species Diversity at Fish Landing Sites in the Gulf of Mannar, Tamil Nadu, India

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Cite this paper as: K. Bhanumathi, Ganeshan Petchidurai, G. Sankarapandian, V. Santhana Karthika, M. Sasirekhamani (2024) Assessment of Crab By-catch and Species Diversity at Fish Landing Sites in the Gulf of Mannar, Tamil Nadu, India. Frontiers in Health *Informatics*, *13(6)* 4385-4412

Abstract-

Indian seashores have diverse ecoregions, Tamil Nadu and Puducherry cover nearly 15% of the total coastline of India. The Gulf of Mannar region is one of the most important ecoregions spreading from north Rameswaram to south of Tuticorin, and they are categorized into the four divisions viz. Mandapam group, Keezhakarai group, Vembar group and Tuticorin group. Crabs are a mutual group of crustaceans that belong to the invertebrate animals, and systematic field assessments were conducted to document crab species at the selected fish landing center of the Tuticorin district. Completely sixteen species were noted in the study area, belonging to the seven different families and genera. In the point of family and genus Portunidae family (50 %) and 25 % Charybdis genus is highly occupying the selected studied area center. In the overall study time of all selected areas, grant total of 8774 ±119.23 numbers of crab individuals were recorded, while species-wise wise M. gladiator (1036 ± 6.61) was extremely recorded, which mostly belong to edible (81.25 %) in nature. Simpson, Shannon Weiner evenness, Brillouin, Menhinick, Margalef, and Equitability – J index showed Vellapatti, TF Harbor, and Tharuvaikulam are noted for more diversity (16 species), while the least diversity (3 species) was recorded at Punnaikayal, and some other associated animals are also noted. In focus to month-by-month basis, July was noted highest crab distribution, August had noted highest distribution of crab distribution, and in March, September, January, and February were noted to have high distribution of crab distribution. Results from the current assessment displayed that several decapod species originate from the studied area and consequently, decapod low diversity areas need conservation action to sustain decapod diversity.

Keywords: Crab, Decapoda, Tuticorin,and fish landing centre

1. INTRODUCTION

Coastal regions: The extended seashore of India has diverse ecoregions (Trivedi et al., 2021, Sathish et al., 2023). Tamil Nadu and Puducherry nearly cover 1076 km in length and account for around 15% of the total coastline of India (Nagarajan et al., 2022). Gulf of Mannar region one of the most important ecoregions of India located Tamil Nadu, nearly covers in 10, 500 sq. km, spreading from north Rameswaram to south of Tuticorin. The Gulf of Mannar is the most important first Marine Biosphere Reserve of India. Totally 21 Islands, remarkably present at the Gulf of Manner regions around an area of 623 ha, and they are categorised into the four divisions, viz. Mandapam group, Keezhakarai group, Vembar group and Tuticorin group. In prior findings, the Gulf of Manners region noted 3600 species of flora and fauna. Amid fauna, crabs are one of the most abundant groups and provide a wide range of ecosystem services, like as algal and leaf biomass processing, and are considered vital keystone engineers of this ecosystem (Cannicci et al., 2008).

Crabs are a mutual group of crustaceans that belong to the invertebrate animals in the phylum Arthropoda, subphylum Crustacea, family *Crustacea***,** and order Decapoda (Satheeshkumar, 2011). They have diverse species composition and widespread distribution (Tsang et al., 2014). Nearly 8500 (Karlathil et al., 210) species were noted and ranging their size from tiny pea crabs (a few millimeters across) to 12 feet (Japanese Spider Crabs), able to live nearly 100 years (Tho Le et al., 2018). Crabs be positioned *decapods* (ten-footed, typically have four pairs of legs and one pair of claws) (Akshay and Sanjay, 2018), typically existing a short projecting tail structure at the abdomen area, habitually entirely hidden by the thorax. In Indian cost originate miscellaneous marine crustaceans originate, among these crustacean's crab is placed rank second after shrimp (Anusha and Roopavathy, 2021). In India, the greatest possibilities for the rich are in crab at the coasts of Tamil Nadu, Kerala, and Karnataka, and to a certain extent in Maharastra and Gujarat (Samuel and Soundarapandian, 2009; Anusha and Roopavathy, 2021)

General characteristics of crab: They live in the world's wide oceans, fresh water, as well as in land area habited like sea, estuary, sandy, muddy, and rocky intertidal areas, mangroves, sheltered creeks, algal weeds, tide pools, sand beaches, coral reefs, and other marine areas. Crustaceans reside in all these habitats, from above the high waters to the deep abyssal zones. They generally walk and swim sideways (Karlathil et al., 2010). Littoral crabs are majorly nocturnal in nature; most of them hide under rocks, or dead corals, or in their crevices, or in burrows of soft sediments. Some of them are buried in intertidal mud and sandy beaches, the roots of mangroves, and rocks. Coral reefs have diverse habitats and a good number of holes, crevices, and cavities, which provide sufficient shelter or hideout for crustaceans. All these serve as sufficient reasons for the impressive diversity of crustaceans in coral reef ecosystems. Their fleshy body are usually enclosed in a thick exoskeleton. Crabs periodically shed their shell during a process that takes some amount of water for the purpose of removing old shell, and the new soft-shell turn into hardening within hours and takes two days for full maturation of the shell (Luque et al., 2021). Many other animals with similar names, like hermit crabs, king crabs, porcelain crabs, horseshoe crabs, and crab lice, but they do not belong to the true crab groups. Crab shells' strength and hardiness depend upon the hydration, which correlates to hydrogen bonding within the shell materials (Sayekti et al., 2020).

Crabs are smart animals, learning so many things from their previous mistakes and recollecting that information don't make similar mistakes again. Easily adapt to changing their environment. Crustaceans are extremely valued commodities in the seafood industry worldwide. They play a vital role food source for people as well as many birds, snakes, and predatory fishes, accordingly, crabs play an important role in the food chain (Satheeshkumar, 2012).

They are predacious carnivores and scavengers, and play an important role in detritus formation, recycling of nutrients, and overall dynamics of ecosystems. Crabs are distributed up to 6000 m depth (Ng et al., 2008; Chakravarty et al., 2016). Crabs feed omnivorously on both lower (e.g., fungi, bacteria, detritus, leaves, algae, decaying organic matter, phytoplankton) and higher tropic levels (insects, mollusks, worms, and fish) (Tue et al., 2012; Tho Le et al., 2018). Crabs have often been considered tobe 'keystone species' in mangroves because of their role in carbon

recycling (Ravichandran, 2011).

Commonly, most of them feed a mixed diet of plant and animal matter for their fastest growth and greatest fitness. Marin ecosystems rich in innumerable ecologically faunal communities, among these crabs are most significantly important faunal communities and key engineers of marine ecosystem (estuaries, backwaters, saltwater, lakes, mangroves etc) (Diele et al., 2013) due du their feeding mechanisms like filter feeders, sand cleaners, mud, plant feeders, carrion feeders, predators, commensals and parasites feeders (Vidhya et al., 2017). They act as scavengers in coastal ecosystems (Behera et al., 2021).

Economic importance: In India, commercially, fifteen edible crab species are usually existing, amongst them twelve crab species are economically valued for exportation trade. Protein, lipids, minerals, and vitamins (Akshay and Sanjay, 2018) of Crab offer significant income and employment opportunities for coastal societies. Particularly, the main protein source at developing country coastal regions peoples. Now, commercially export marine crab species in quite a lot of regions of the Indian Exclusive Economic Zone (EEZ), which is the most important source of several employees (Sathiya and Valarmathi, 2019). Crabs are hold good medicinal and pharmaceutical uses, like asthma, malaria, typhoid (Ramakrishna et al., 2010), diarrhoea, dysentery and wound healing, due to the free from cholesterol crab also cure cardiac disorders, as well as crab shells used to manufacturing surgical suture threads (Karlathil et al., 2010).

Beforehand some investigate noted that diversity Brachyuran crabs, mangrove environment (CMFRI, 1969; Sylvester Fredrick and Ravichandran, 2013), Pichavaram mangrove areas (Ajmal Khan et al., 2005), Gulf of Manner (Jeyabaskaran et al., 2007) Parangipettai Coast (John Samuel et al., 2004 and 2009), Chennai coast (Subramanian 2001; Pillai and Thirumilu, 2008), Pondicherry mangrove areas (Satheeshkumar and Khanm, 2011), (Sakthivel and Fernando, 2012), Punnaikayal Mangroves (Vinoth and Rajesh, 2013), Arukkattuthurai Pasipattinam Coast (Varadharajan and Soundarapandian, 2014), Gulf of manner (Vidhya et al., 2017), Nagapattinam Coastal Area (Sathiya and Valarmathi, 2018) Kerala (Apreshgi and Kurian, 2019), Biodiversity of hermit crabs in Odisha (Behera et al., 2021), Chinnangudi Coast (Jeeva Selvasundari and Anupriya, 2022), Poompuhar Fish Landing Site (Sathiya and Valarmathi, 2022),

As a result of above mention findings, crab stocks are in crisis at every coastal area. But recently, very inadequate work has been available linked to crab diversity in the Thoothukudi district. Therefore, it is required to stock assessment of crabs in the coastal areas of Thoothukudi district. The present study aims to contribute to the knowledge of the richness of the brachyuran crabs. Hence, the current study design is to examine the decapod crab diversity at selected marine shores of Tuticorin District, Tamil Nadu, India.

2. MATERIALS AND METHODS

Study area and field visit: Systematic field investigations were conducted according to the approach of Nagarajan et al, (2022) with little modification. Investigations were conducted at low tide and fish landing sites of the southeast coastal area of Tuticorin district, Gulf of Mannar, Tamil Nadu, India, during July, August, September of 2023, January, February, and March of 2024. Four localities (Fish Landig Centre) were selected from the study zone via Vellapatti, Thoothukudi Fishing Harbour (TF Harbour), Tharuvaikulam, and Punnaikayal (Fig. 1). The samples were predominantly collected by handpicking, and data were noted during beachcombing while walking along the coastline and fish landing site (Behera et al., 2021). The collected specific samples were brought to the Kamaraj College (Autonomous), PG and Research Department of Zoology laboratory, and they were rinsed with water to remove adhering debris and separated based on species, and then transferred to 4% formalin. The identification was confirmed based, on photographs, drawings and character description and comparing them with the illustrative keys (Ajmal khan and Ravichandran, 2007) characters like colour, shape, shape of the chelate legs, formation of spines on carapace and other places, structure of walking and swimming legs (Jeeva Selvasundari and Anupriya, 2022). Several species existing in each studied area was also calculated, and their mean and standard Error were measured. Species,

family, and order of crab at the locality with month month-wise level was expressed by mean and standard error or in percentage.

Statistical analyses: To measure the crab diversity data of the selected study area, their diversity index is calculated using the Shannon-Weiner index (H') and Simpson's diversity index (D), and the Evenness index (E) method is calculated using the statistical tool PAST 4.03

$H' \leq 1$ = Low diversity, $1 < H' \leq 3$ = Moderate diversity, $H' \geq 3$ = high diversity

D is usually between 0 and 1. The closer D is to 1, the higher is diversity.

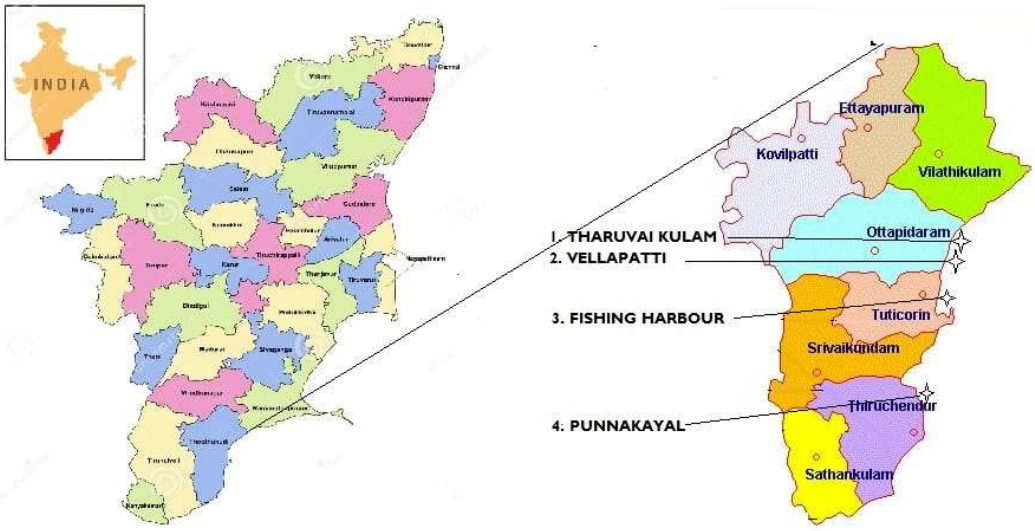
$0 < E \leq 0.5$ = Depressed community, $0.5 < E \leq 0.75$ = Unstable community and $0.75 < E \leq 1$ = Stable community

t- Test & ANOVA : All data were subjected to t – test and one-way ANOVA by SPSS (Version 25), and the output showed characteristic mean plus standard error, and significance was expressed at a 5% level.

Fig. 1, Map showing the location of the selected fish landing centre of Thoothukudi district.

3 RESULT:

Crab distribution in the overall: In the current finding, by-catch assessment of crab species in the fish landing



centre of Thoothukudi district was carried out for six months (July, August, September of 2024, January, February, and March of 2025). A list of various crab species collected and recorded during the study, dated at the designated fish landing centre Thoothukudi district (Vellapatti, TF Harbour, Tharuvaikulam and Punnaikayal) as shown in Fig. 2. Totally sixteen species were recorded, belonging to different families and genera, are exhibited in Table 1 with their species name, family name, common name, and habitat. However, analysis based on the representation of families reveals that the Thoothukudi district fish landing centre exhibited 7 families, among the 16 crab species Portunidae family occupying 50 %, remaining 50 % share with 6 families. Similarly, based on family-wise distribution for locality, *the Portunida* family occupies 50 %, the remaining 50 % is shared with 6 families for Vellapatti, TF Harbour, Tharuvaikulam, but Punnaikayal has only distributed three families (*Calappidae, Portunida,* and *Diogenidae*).

Table 1. Bycatch assessment of crab species at Thoothukudi district fish landing centre with common name, family, and habitat.

Species	Family	Common name	Habited	References
Ashtoret integerrimus	Xanthidae	Red egg crab	Coral reef, under rocks or crevices,	Trivedi et al., 2012

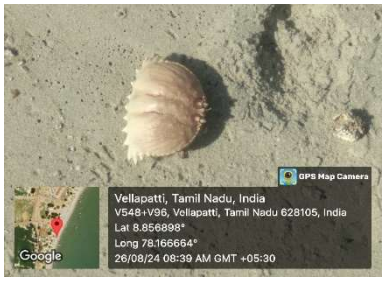
Ashtoret lunaris	Matutidae	Yellow moon crab, spotted moon crab, or box crab, Indian Ocean squid/Indian squid	Sandy and muddy shores, especially near seagrass beds and depth of 15-20 m	Cemal Turan, et al., 2015
Calappa bileneata	Calappidae	Two-striped Box, box crab, or Shame-faced crabs	Tropical and subtropical oceans in the shallow coral reef areas.	Saravanan and Ramamoorthy, 2013
Charybdis helleri	Portunidae	Indo-Pacific Swimming Crab	Littoral zone of coastal waters with depths of up to 30-50 m, rocky bottom areas, and intertidal coral reefs	Dineen et al., 2001
Charybdis lucifera	Portunidae	Yellowish-brown crab	Subtidal on substrates of sand, mud, or rocky reefs, from depths of 5 to 100 meters	Hadi Hamli et al., 2022
Charybdis feriatus	Portunidae	Crucifix Crab.	Subtidal, sublittoral, infralittoral, deep zone of the oceans from the lower limit of the intertidal zone (intertidal) to the shelf edge at about 200 m water depth	Yin Zhang et al., 2018
Charybdis natator	Portunidae	Ridged swimming crab, wrinkled swimming crab, or rock crab	Rocky-sandy substrates or near reefs	Davie, 2010
Dardanus logopodes	Diogenidae	Anemone carrier hermit crab,	Sandy or muddy-bottomed	Jason & John, 2004
Halimede ochtodes	Galenidae	Nodule crab.	Intertidal and subtidal zones like g rocky, cobble, oyster banks, muddy, and mangrove.	Habib et al., 2021
Matita plaipes	Matutidae	Flower Moon Crab	Surf zone of tropical sandy shores, sandy to muddy tidal flats in front of the mangroves	Noor Us Saher et al., 2017
Menippe rumphii	Menippidae	Maroon stone crab,	shallow to intertidal zones, typically found on sandy-muddy substrates, often under rocks.	Marasinghe & Ranatunga, 2018
Monomia gladiator	Portunidae	Red swimming crab or swimming crab	30–100 meters deep with bottoms composed of sand, broken shells, or pebbles	Peter et al., 2008
Portunu sargentatus	Portunidae.	Silver Swimming Crab or Silver Portunus	Subtidal areas with sand or mud substrates with depths of 10 to 219 meters	Amanda et al., 2019

Portunus pelagicus	Portunidae	Blue swimming crab	Sandy or muddy substrate areas near reefs, mangroves, sea grass and algal beds	Zairion et al., 2020
Portunus reticules	Portunidae	Swimming crab, Reticulate Swimming Crab	Sandy and muddy bottoms in shallow waters	Vivek Rohidas Vartak et al., 2018
Scylla serrata	Portunidae	Giant Mud Crab or the Mangrove Crab,	Just offshore on soft muddy bottoms	James et al., 2009

Portunus reticules

Charybdis natator

Charybdis lucifera



Calappa bileneata

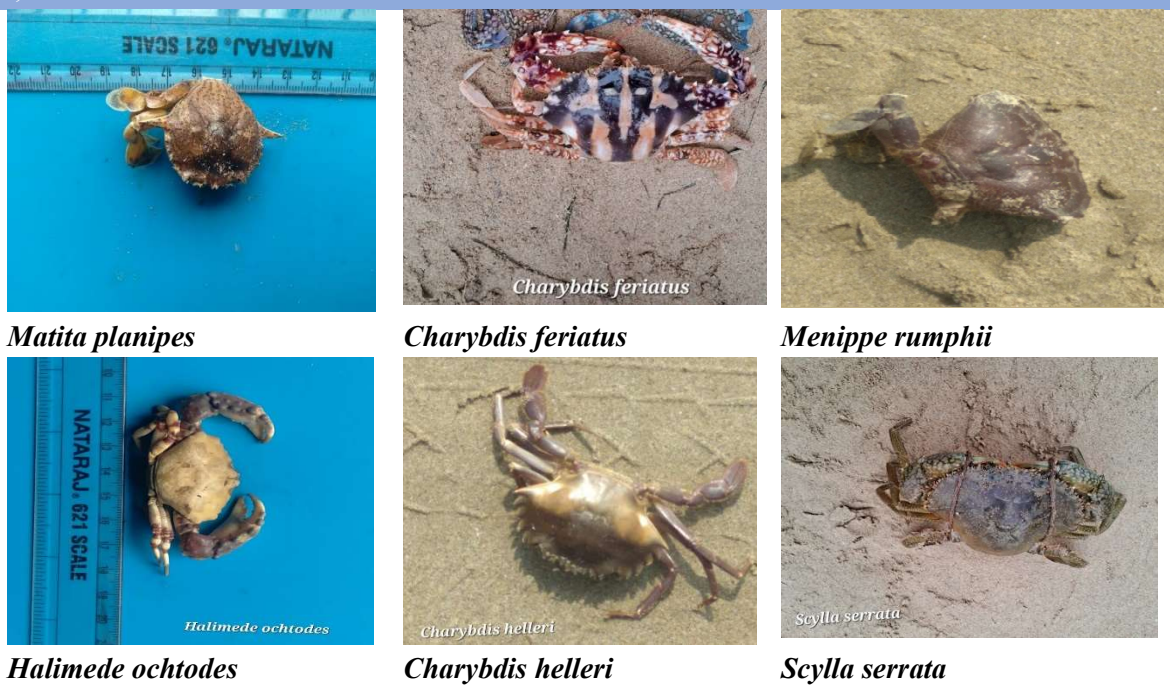
Portunus pelagicus

Atergatis integerrimus

Monomia gladiator

Portunus sanguinolentus

Ashtoret lunaris



Matita planipes ***Charybdis feriatus*** ***Menippe rumphii***

Halimede ochtodes ***Charybdis helleri*** ***Scylla serrata***

Fig. 2. Pictures shown in by bycatch assessment of crab distributions in Thoothukudi district fish landing centre.

Table 2. By Bycatch assessment of crab variety in different fish landing centres of Thoothukudi district and their statistical analysis data.

Species name	Vellapatti	TF Harbour	Tharuvaikulam	Punnaikayal	Total
C. bileneata	148 ± 1.32^{fgA}	116 ± 0.55^{jB}	041 ± 0.40^{nC}	038 ± 0.83^{cD}	0343 ± 3.10^{l}
M. gladiator	444 ± 0.73^{aA}	354 ± 1.42^{dB}	090 ± 1.96^{jD}	148 ± 1.94^{aC}	1036 ± 6.61^{a}
C. natator	351 ± 1.42^{bB}	372 ± 1.36^{cA}	124 ± 2.97^{hC}	075 ± 2.50^{bD}	0922 ± 8.25^{b}
A. lunaris	205 ± 1.43^{dA}	035 ± 0.73^{mC}	076 ± 1.54^{lB}	-	0316 ± 3.70^{m}
P. sargentatus	317 ± 2.43^{cA}	174 ± 3.63^{gB}	124 ± 1.90^{hC}	-	0615 ± 7.96^{g}
P. pelagicus	318 ± 2.10^{cB}	398 ± 1.37^{bA}	173 ± 2.40^{dC}	-	0889 ± 5.87^{c}
C. lucifera	022 ± 0.05^{lC}	355 ± 2.48^{dA}	276 ± 10.6^{bB}	-	0653 ± 13.1^{f}
H. ochtodes	035 ± 0.19^{kC}	022 ± 0.30^{nA}	075 ± 2.83^{lB}	-	0132 ± 3.32
D. logopodes	152 ± 1.02^{eA}	115 ± 1.38^{jB}	047 ± 4.90^{mC}	-	0314 ± 7.30^{mn}
C. helleri	122 ± 0.51^{iC}	221 ± 1.82^{fA}	131 ± 5.83^{gB}	-	0474 ± 8.16^{i}
A. tintegerrimus	152 ± 0.83^{eA}	152 ± 1.50^{iA}	082 ± 0.80^{kB}	-	0386 ± 3.13^{k}
C. feriatus	013 ± 1.39^{mC}	056 ± 2.93^{lB}	229 ± 4.94^{cA}	-	0298 ± 9.80^{p}
S. serrata	212 ± 3.43^{dC}	159 ± 1.30^{hB}	360 ± 7.45^{aA}	-	0731 ± 12.1^{d}
M. plaipes	104 ± 0.42^{jC}	336 ± 1.60^{eA}	140 ± 1.56^{fB}	-	0580 ± 3.58^{h}
M. rumphii	150 ± 3.05^{efB}	101 ± 0.80^{kC}	161 ± 2.00^{eA}	-	0412 ± 5.85^{j}
P. reticules	148 ± 2.08^{fgB}	419 ± 10.3^{aA}	106 ± 5.02^{iC}	-	0673 ± 17.4^{e}
Grant total	2893 ± 22.04^{B}	3385 ± 43.47^{A}	2235 ± 57.10^{C}	261 ± 5.27^{D}	**8774±119.23**
Mean ± S. E	180.81 ± 1.22^{B}	211.56 ± 1.38^{A}	139.68 ± 0.8^{C}	87.00 ± 0.52^{D}	-
Percentage	32.97^{B}	38.57^{A}	25.47^{C}	2.97^{D}	-

t-Test					
t value	5.893	6.089	6.503	2.692	-
P	0.003	0.002	0.001	0.115	-
Lower limited	115.4168	137.5124	93.9048	-52.0452	-
Upper limited	246.2082	285.6126	185.4702	226.0452	-
df	15, 2				

Note: TF Harbour (Thoothukudi Fishing Harbour), Same (^{abcd}) lowercase letter in a column shows significance at 0.05% among the crab species, and upper case (^{ABCD}) letter shows the significance at 0.05% between the localities.

In the point of genus-wise during the studied time, Vellapatti, TF Harbour, Tharuvaikulam are rich in 25 % Charybdis and are followed by 18.75% of *Portunus* and low genus diversity in 6.25 % of *Calappa, Daranus, Atergatis, Menippe, Ashtoret, Halimede, Matita, Monomial,* and *Scylla*. Punnaikayal has very low genus diversity, presenting only *Charybdis, Calappa,* and *Daranus* in a small amount (Table 1). Overall, the past six months of study time in all selected areas, entirely 8774 ±119.23 individuals of crab's individuals are recorded, while species-wise wise *M. gladiator* (1036 ± 6.61) was extremely recorded in the past study time (Table 2).

Locality-wise distribution: Assessment of crab species and numbers was also noted in a locality-wise manner; more number (16) of species were noted at Vellapatti, TF Harbour, and Tharuvaikulam, while the least number (3) of crab species were recorded at Punnaikayal (Table 2). Significantly more individual crab species were noted in *M. gladiato* (444 ± 0.73)*, P. reticules* (419 ± 10.3), *S. serrata* (360 ± 7.45), and *M. gladiato* (148 ± 1.94) at Vellapatti, TF Harbour, Tharuvaikulam, and Punnaikayal, respectively (Table 2). Based on the locality with numbers of crabs (over al total = 8774 ± 119.23), among this significantly more amount (38.57%, N = 3385 ± 43.47, X - 211.56±1.38, t= 5.893, p = 0.002) of crabs were noted at TF Harbour flowed by Vellapatti and Tharuvaikulam, while least number of crabs (2.97%, N= 261 ± 5.27, **x** - 87.00 ± 0.52, p = 0.115, t = 2.692) at Punnaikayal (Table 2).

Diversity index: Diversity index of Simpson -1-D, Shannon - H, Margalef calculation methods uses to quantitative measure that just how many dissimilar types crab species with individuals are distributed, The Shannon Weiner Index (H) range between 0.083 to 2. 2.569, Shannon Weiner Index (H) of Vellapatti, Tharuvaikulam, and TF harbour showed crab are Moderately diversity and Punnaikayal have low diversity (Table 3). Similarly, Simpson (D) diversity index also showed that Vellapatti, Tharuvaikulam, and TF Harbour showed crabs have higher diversity, and Punnaikayal has low diversity, range of Simpson (D) index values between 0.025 to 0.9141 (Table 3). Shannon Weiner's evenness Index result showed crab diversity ranged from 0.5019 to 0.8155. Shannon winner evenness index showed crab community is very stable at Vellapatti, Tharuvaikulam, and TF Harbour, and at Punnaikayal, are crab community is depressed. The Brillouin, Menhinick, Margalef, and Equitability – J index also showed a similar kind of result (Table 3).

Table 3. Diversity index report for by-catch crab dispersal in Thoothukudi district fish landing centre.

Locality /Index	Vellapatti	Tharuvaikulam	TF Harbour	Punnaikayal
Simpson -D	0.9135	0.8949	0.9141	0.025
Shannon – H	2.557	2.429	2.569	0.083
Evenness - e^ H/S	0.8059	0.8103	0.8155	0.5019
Brillouin	2.541	2.407	2.554	2.021
Menhinick	0.2886	0.3202	0.2701	0.7064
Margalef	1.868	1.721	1.837	2.404

Equitability - J	0.9222	0.9203	0.9264	0.7514

Note

H' ≤ 1 = Low diversity, 1 < H' ≤ 3 = Moderate diversity, H' ≥ 3 = high diversity.

D is usually between 0 and 1. The closer D is to 1, the higher is diversity.

0 < E ≤ 0.5 = Depressed community, 0.5 < E ≤ 0.75 = Unstable community and 0.75 < E ≤ 1 = Stable community

Month & Locality-wise distribution: Considering the month and locality basis, for the July month, Vellapatti, Tharuvaikulam, TF harbour, and Punnaikayal, a greater number of *M. gladiator* (89), *C. helleri* (65), *D. logopodes* (89), and *C. lucifera* (32) were rerecorded respectively. Overall, during the July month *D. logopodes* (198) were dominantly available (Fig. 2). Given the month and locality base, all through August dominantly available in *P. reticulatus* (83) and *C. bileneata* (42) at Vellapatti and Punnaikayal, respectively. *M. gladiator* (76 and 87) at Tharuvaikulam and TF Harbour, respectively. Overall, during the August month *D. logopodes* (198) were dominantly obtainable at *C. natator* (206) (Fig. 3). Considering the month and locality basis, for September month Vellapatti, Tharuvaikulam, and TF harbour a greater number of *M. rumphii* (90), *C. natator* (63), and *P. sanguinolentus* (81) respectively; moreover, in Punnaikayal, a greater number of *D. logopodes* and *C. bileneata* (12) were rerecorded. Overall, during the September month *C. natator* (197) were dominantly available (Fig. 4). Given the month and locality base, for January, Vellapatti, Tharuvaikulam, TF harbour, and Punnaikayal were dominantly available for *M. gladiator* (87), *P. pelagicus* (67), *C. natator* (72), *C. bileneata* (20), respectively. In complete during September month *P. pelagicus* (207) were dominantly available (Fig. 5), and a total of 1298 crabs were noted in that month. In the interpretation of month and locality base, for February, Vellapatti, Tharuvaikulam, TF harbour, and Punnaikayal were dominantly existing for *M. gladiator* (90), *P. pelagicus* (76), *M. gladiator* (88), and *C. bileneata* (23) respectively. In complete during February month *P. pelagicus* (218) were dominantly existing (Fig. 6), and wholly 1474 crabs were noted in that month. In reading of month and locality base, for March, Vellapatti, Tharuvaikulam, TF harbour, and Punnaikayal were dominantly existing for *M. gladiator* (88), *P. pelagicus* (69), *M. gladiator* (78), and *C. lucifera* (25) respectively. In complete all through the March month *P. pelagicus* (247) were dominantly existing (Fig. 7), and wholly 1660 crabs were noted in that month.

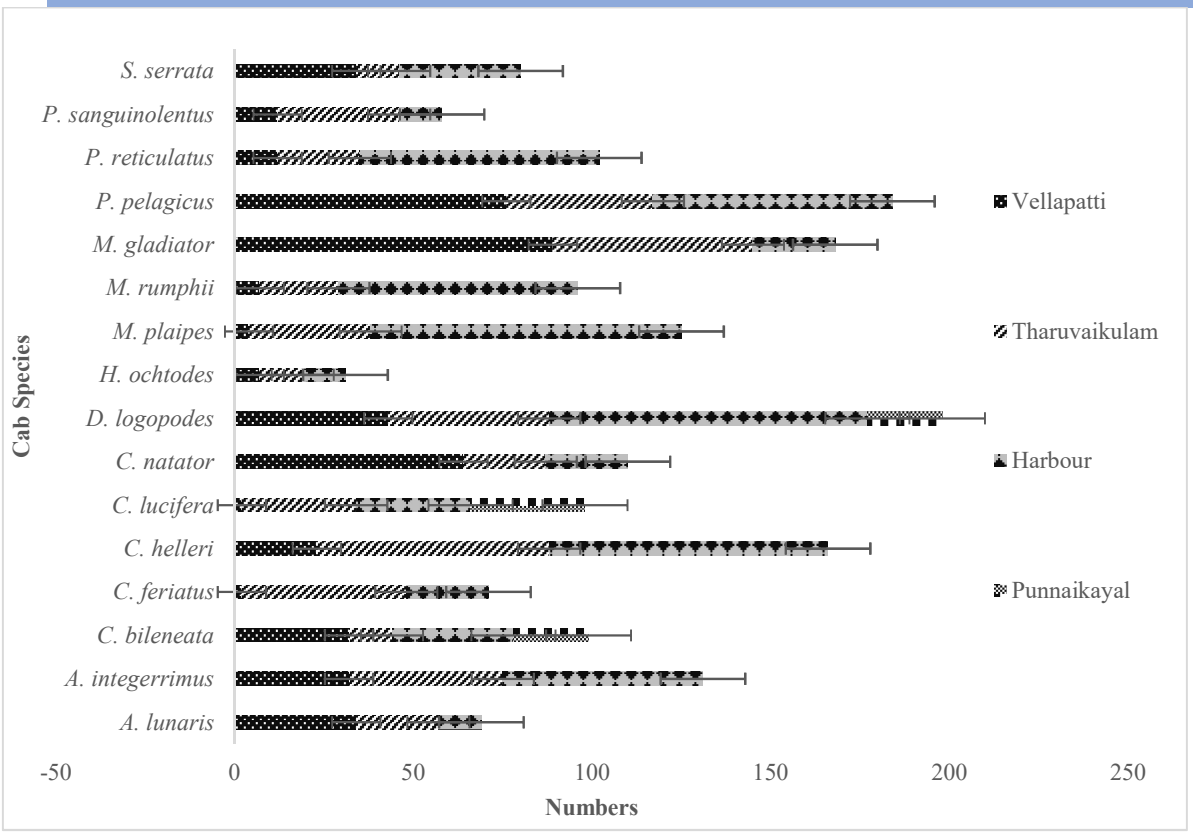


Fig. 2. Bycatch assessment of crab species in July for Thoothukudi district.

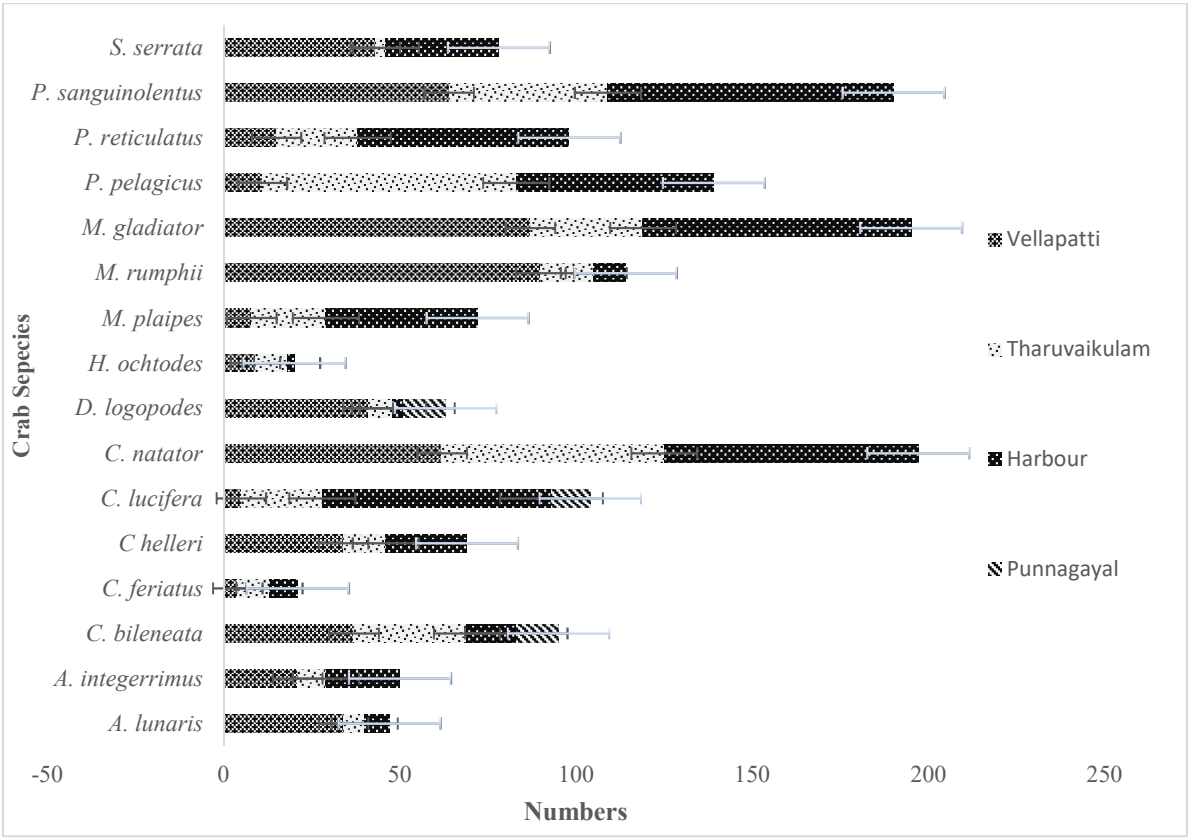


Fig. 3. Bycatch assessment of crab species in September for the Thoothukudi district

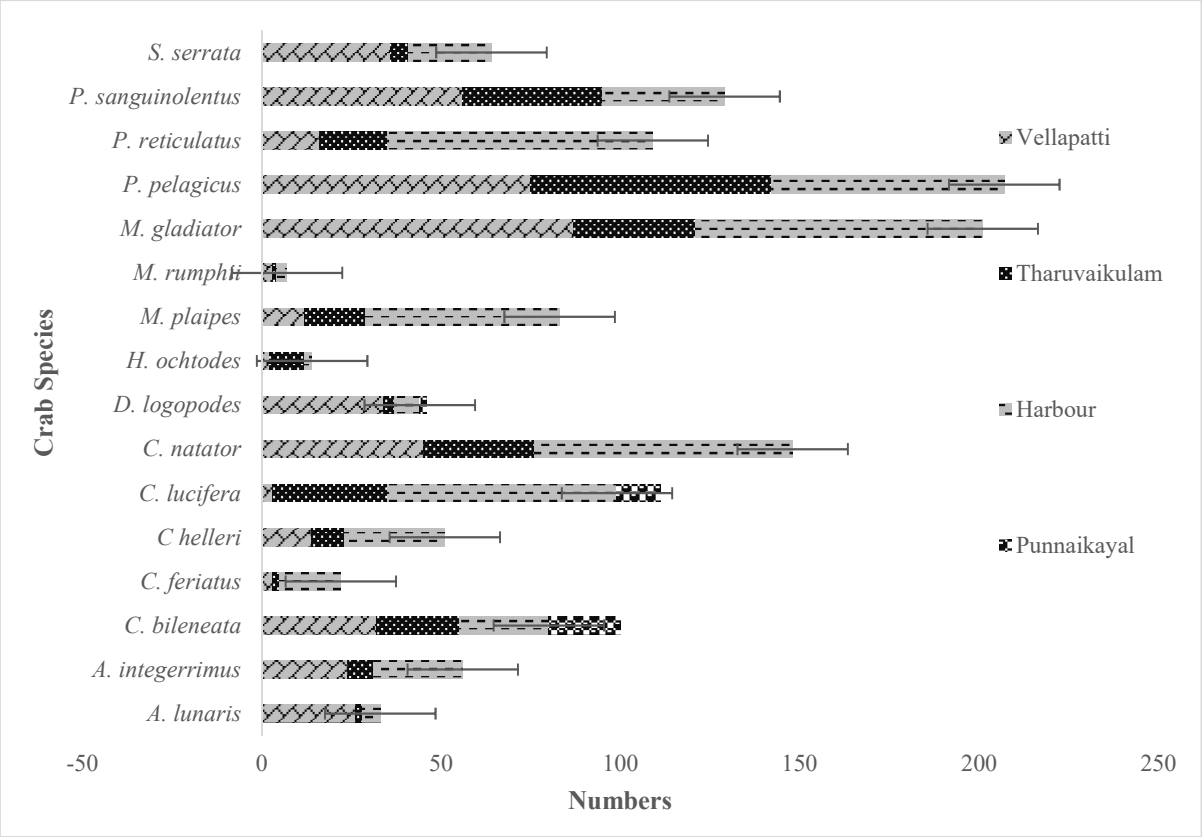


Fig. 4. Bycatch assessment of crab species in January for the Thoothukudi district.

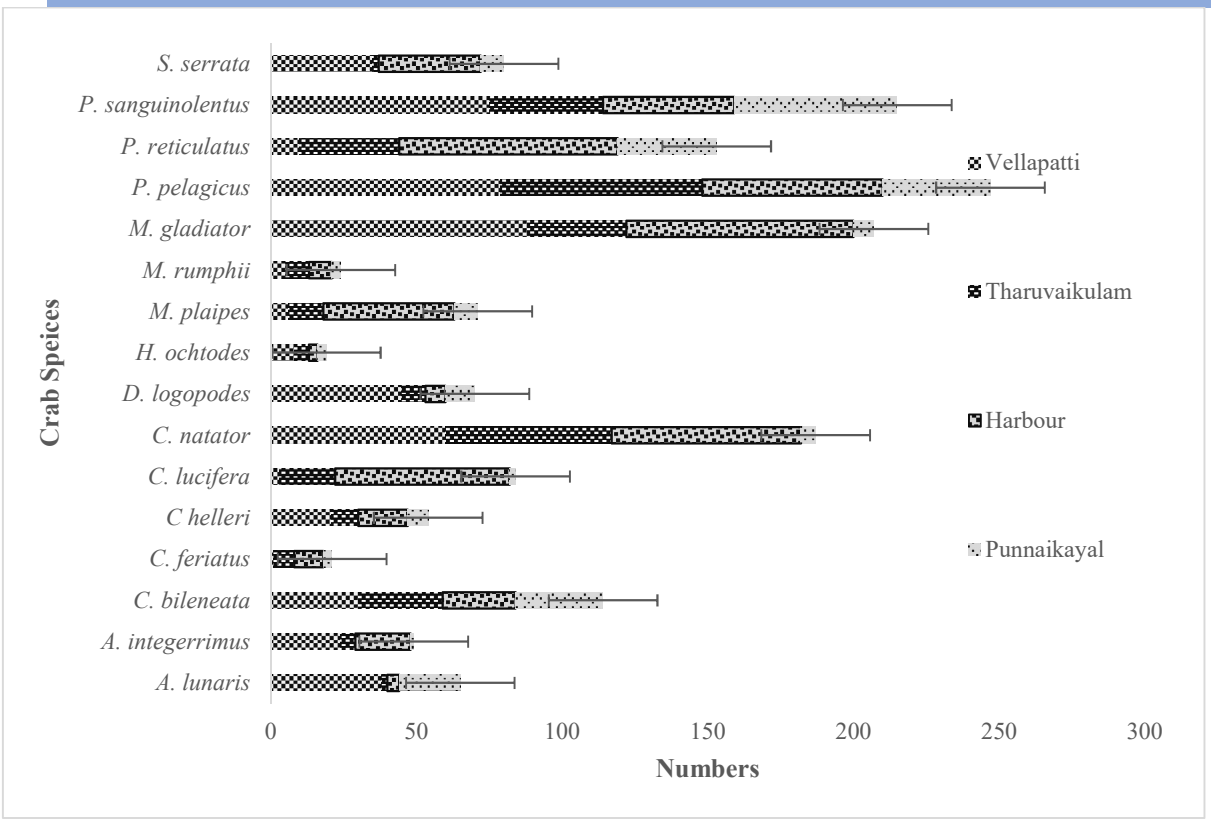


Fig. 5. Bycatch assessment of crab species in March for Thoothukudi district.

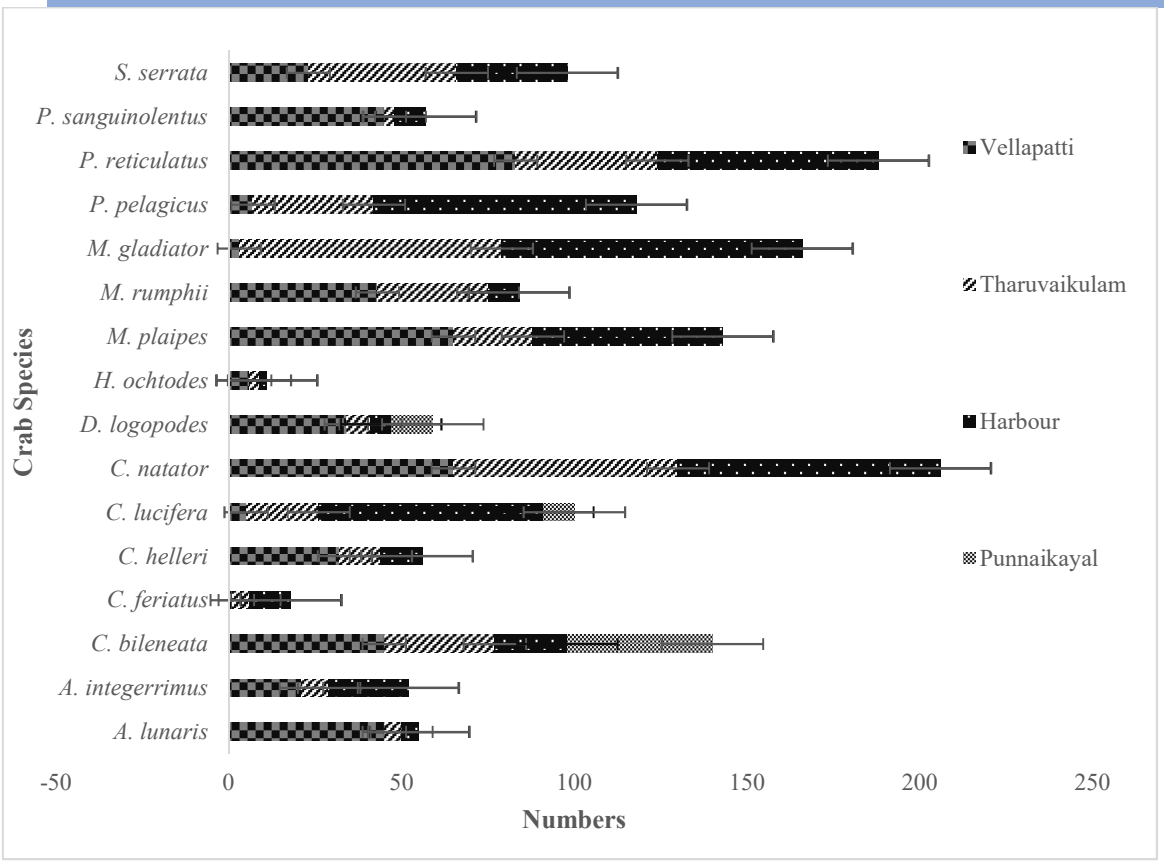


Fig. 6. Bycatch assessment of crab species in August for the Thoothukudi district

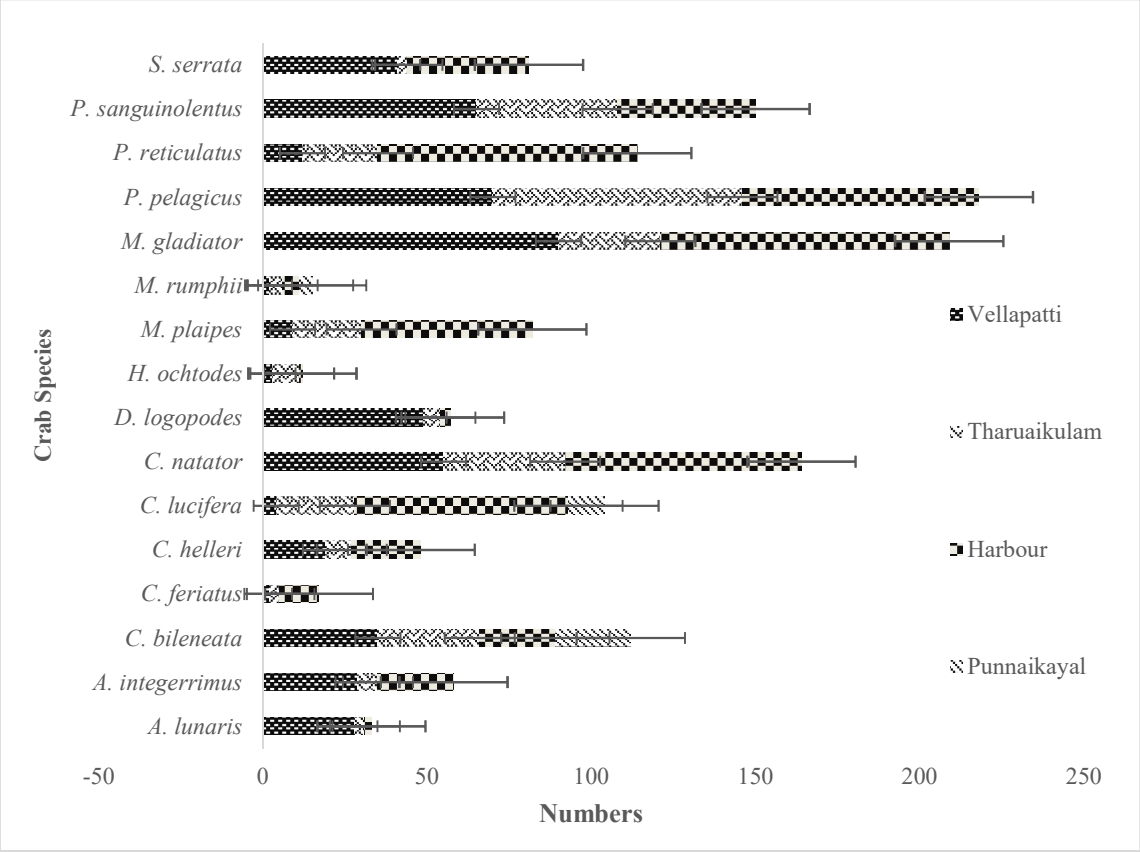


Fig. 7. Bycatch assessment of crab species in February for Thoothukudi district.

Crab distribution for the month-wise at the district level: In an investigation of crab for month-wise distribution at the district level, crab species *Ashtoret lunaris*, *Atergatis integerrimus*, *Charybdis feriatus*, *Charybdis helleri*, *Dardanus logopodes*, and *Halimede ochtodes* are dominantly available in July (Fig. 8 -13), whereas *Calappa bileneata*, *Charybdis natator*, *Matita plaipes*, *Portunus reticules,* and *Scylla serrata* are predominantly available in August (Fig. 14 – 18). Moreover, *Menippe rumphii* (September) (Fig. 19), *Monomia gladiato* (February and March) (Fig. 20), *Portunus sanguinolentus* (March) (Fig. 21), *Portunus pelagicus* (March) (Fig. 22), and *Charybdis lucifera* (January) (Fig. 23), were dominantly recorded at respective months. Overall, July, month was the highest crab distribution, August month a higher distribution, and in March, September, January, and February noted high crab distribution was noted.

By-catch assessment of crab based on profitable purpose (Edible): In the point of edible purpose, by-catch assessments of the report showed Vellapatti fish landing centre predominantly notable for edible crab species (81.25 %) followed by TF Harbour, Tharuvaikulam and Punnaikayal. In over all the Thoothukudi district fish landing centre highly. Non eatable crabs are very ow diversity in study area of Thoothukudi district (Table 4).

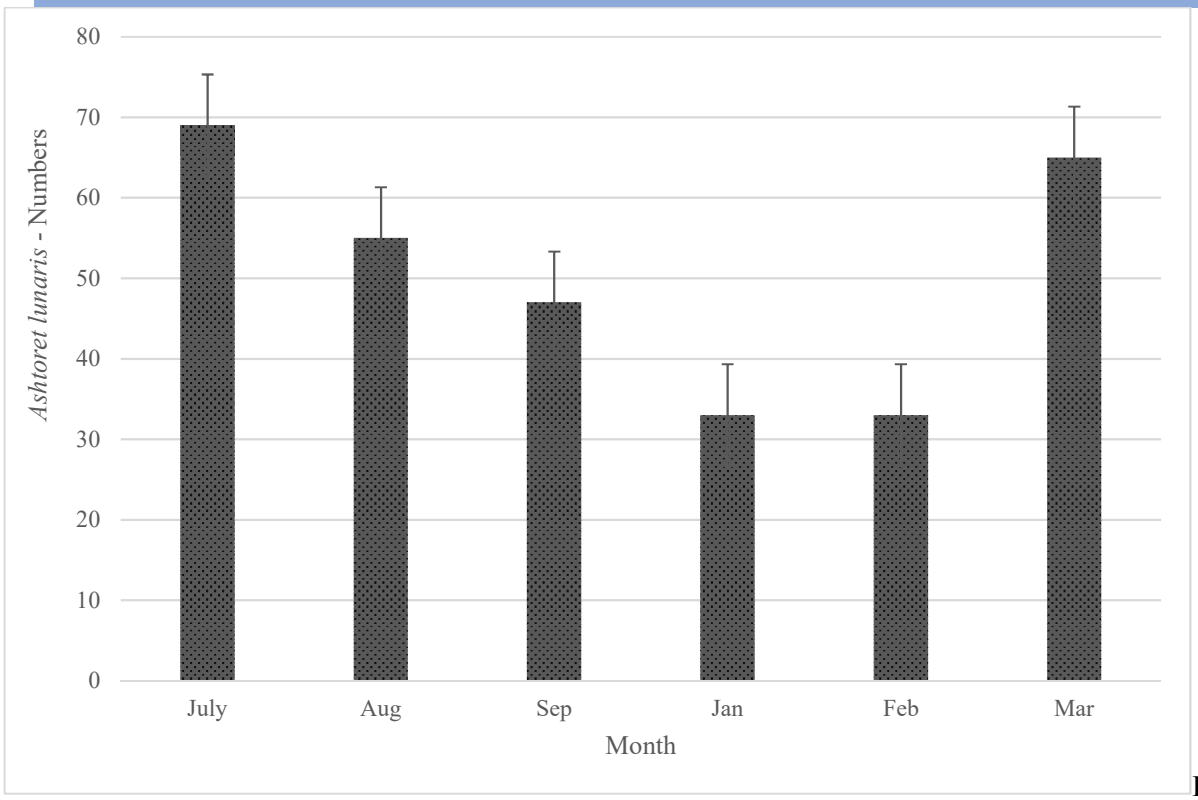


Fig. 8. Bycatch assessment of *Ashtoret lunaris* for the month-wise at the Thoothukudi district level.

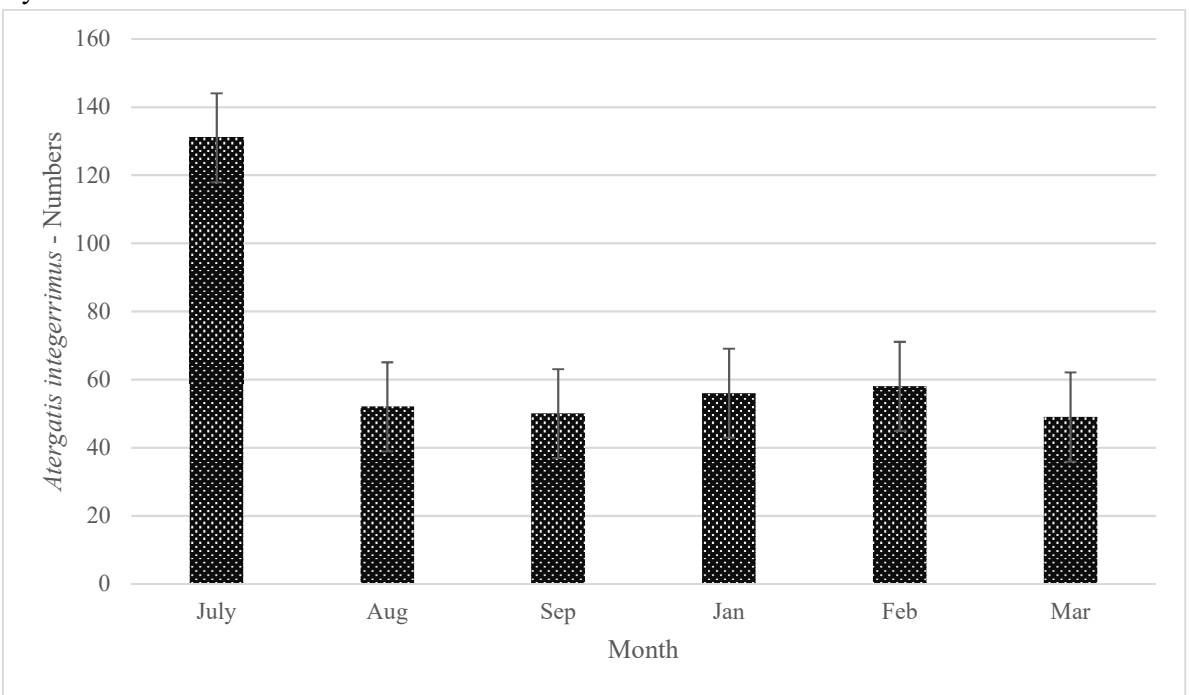


Fig. 9. Bycatch assessment of *Atergatis integerrimus* for the month-wise at the Thoothukudi district level.

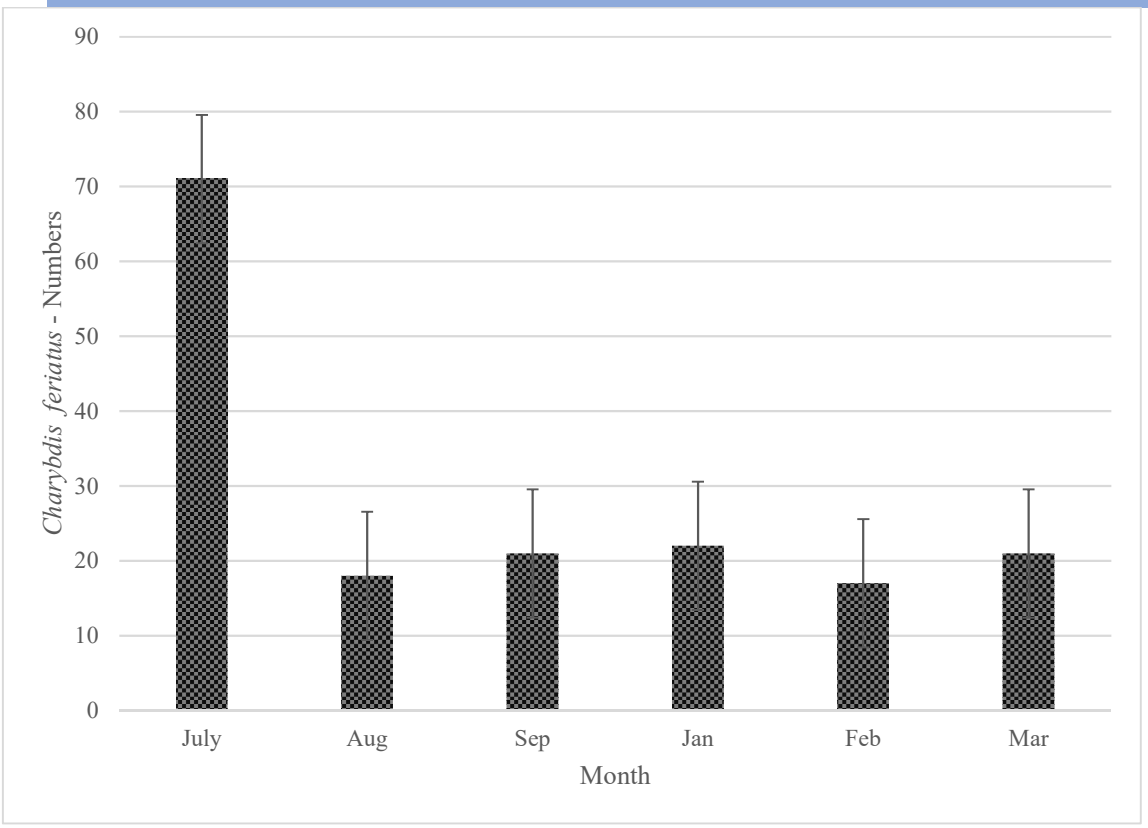


Fig. 10. Bycatch assessment of *Charybdis feriatus* for the month-wise at the Thoothukudi district level.

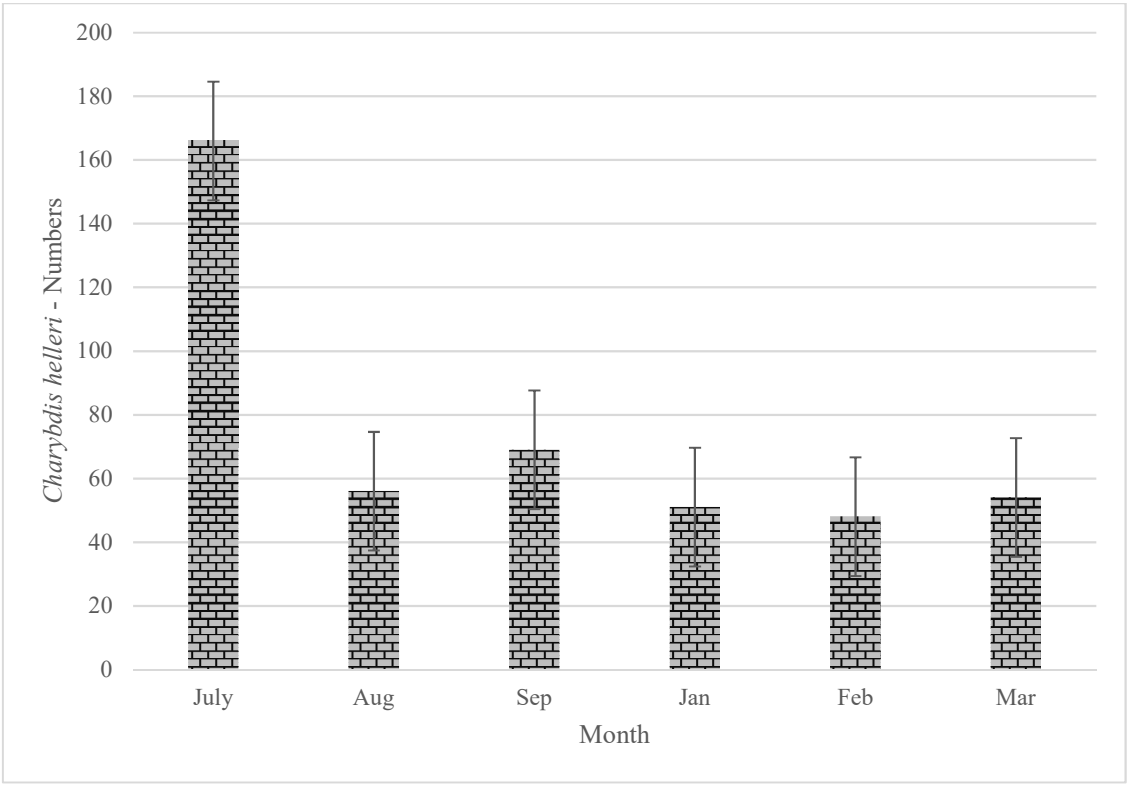


Fig. 11. Bycatch assessment of *Charybdis helleri* for the month-wise at the Thoothukudi district level.

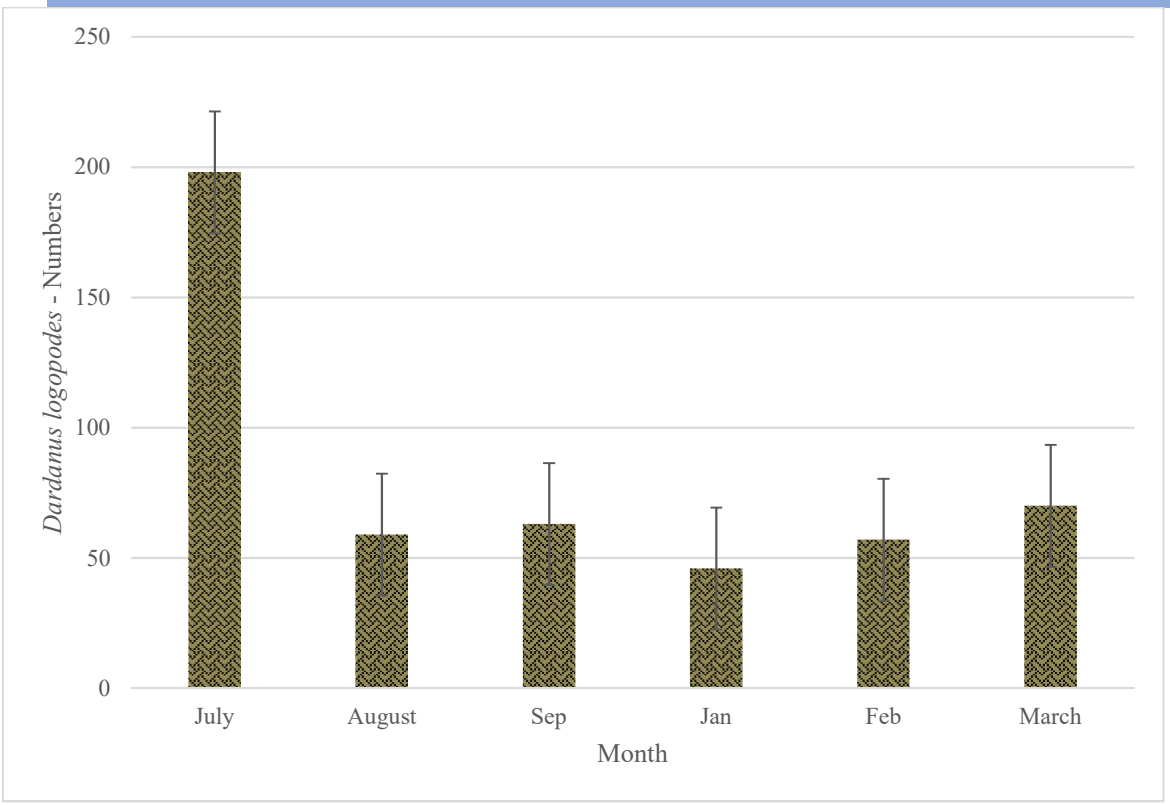


Fig. 12. Bycatch assessment of *Dardanus logopodes* for the month-wise at the Thoothukudi district level.

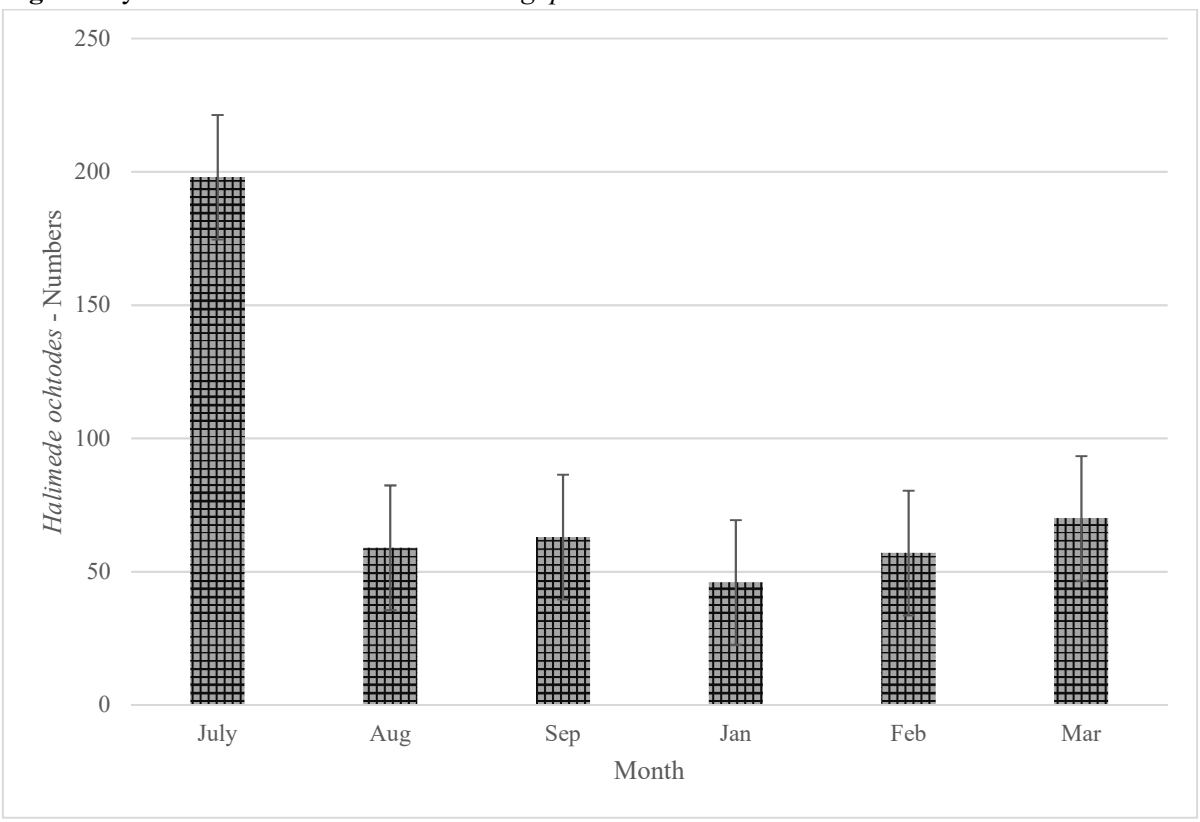


Fig. 13. Bycatch assessment of *Halimede ochtodes* for the month-wise at the Thoothukudi district level.

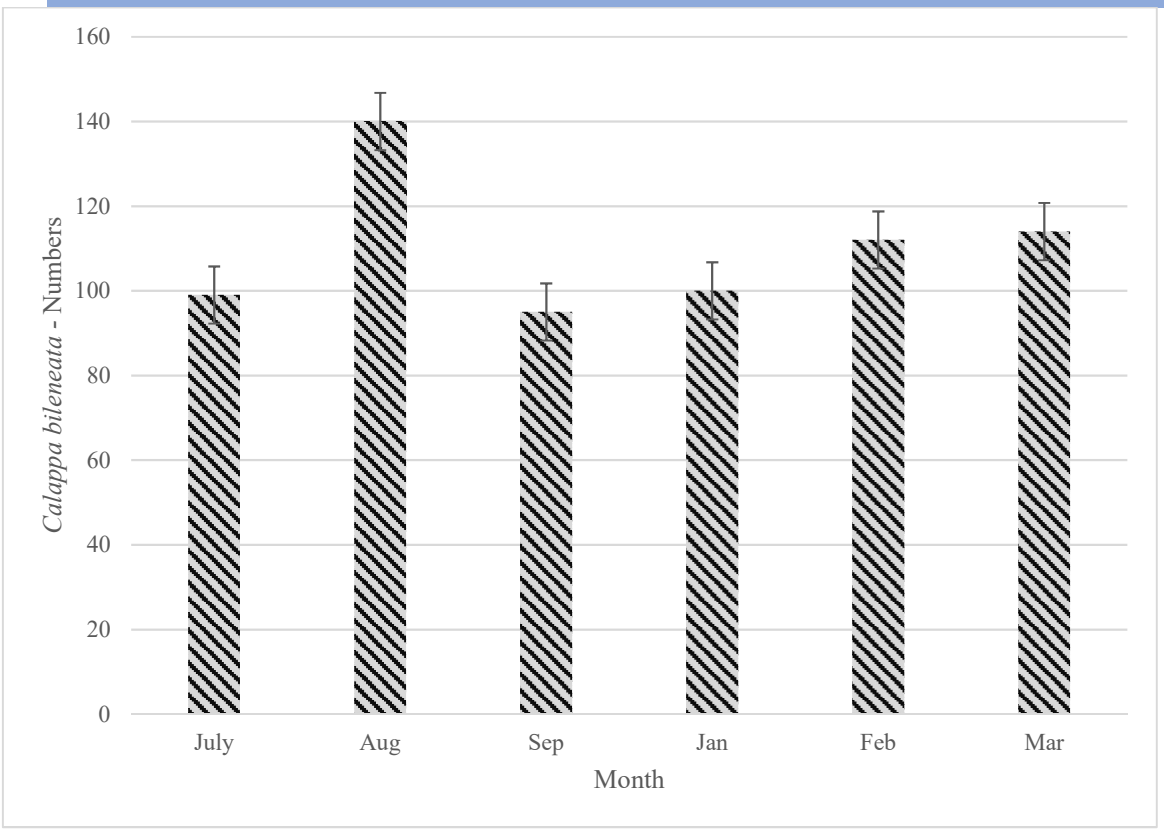


Fig. 14. Bycatch assessment of *Calappa bileneata* for the month-wise at the Thoothukudi district level.

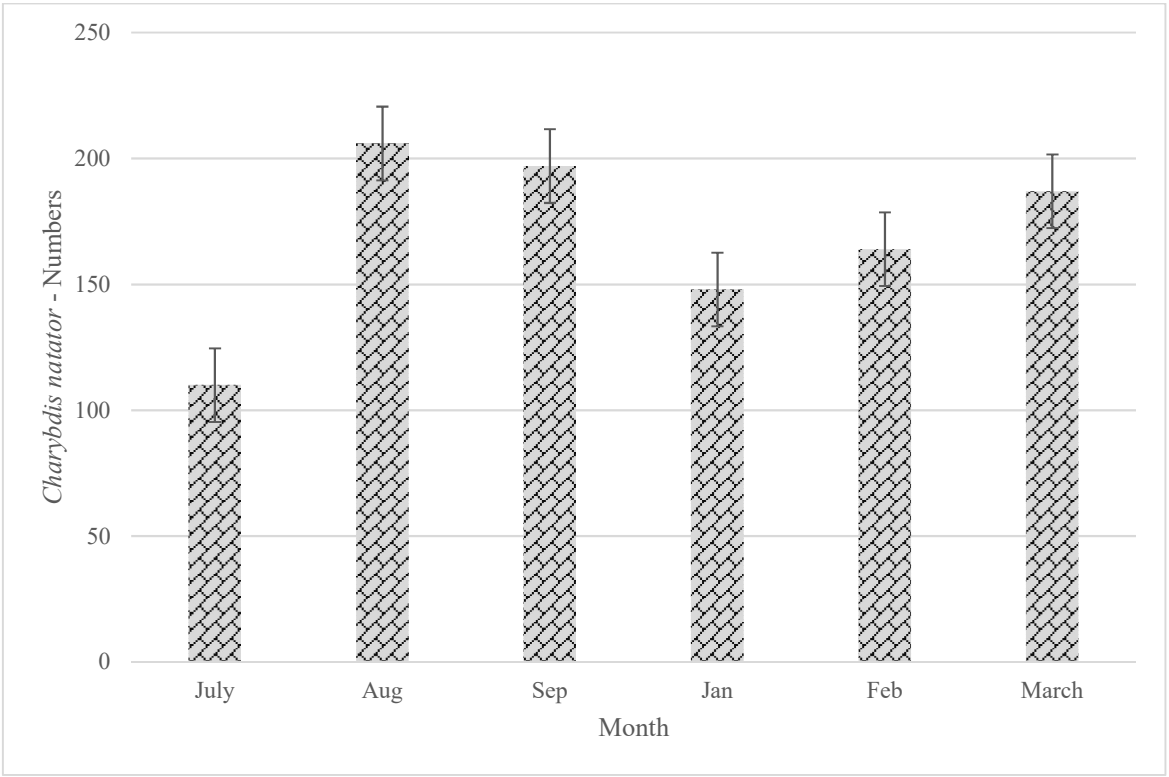


Fig. 15. Bycatch assessment of *Charybdis natator* for the month-wise at the Thoothukudi district level.

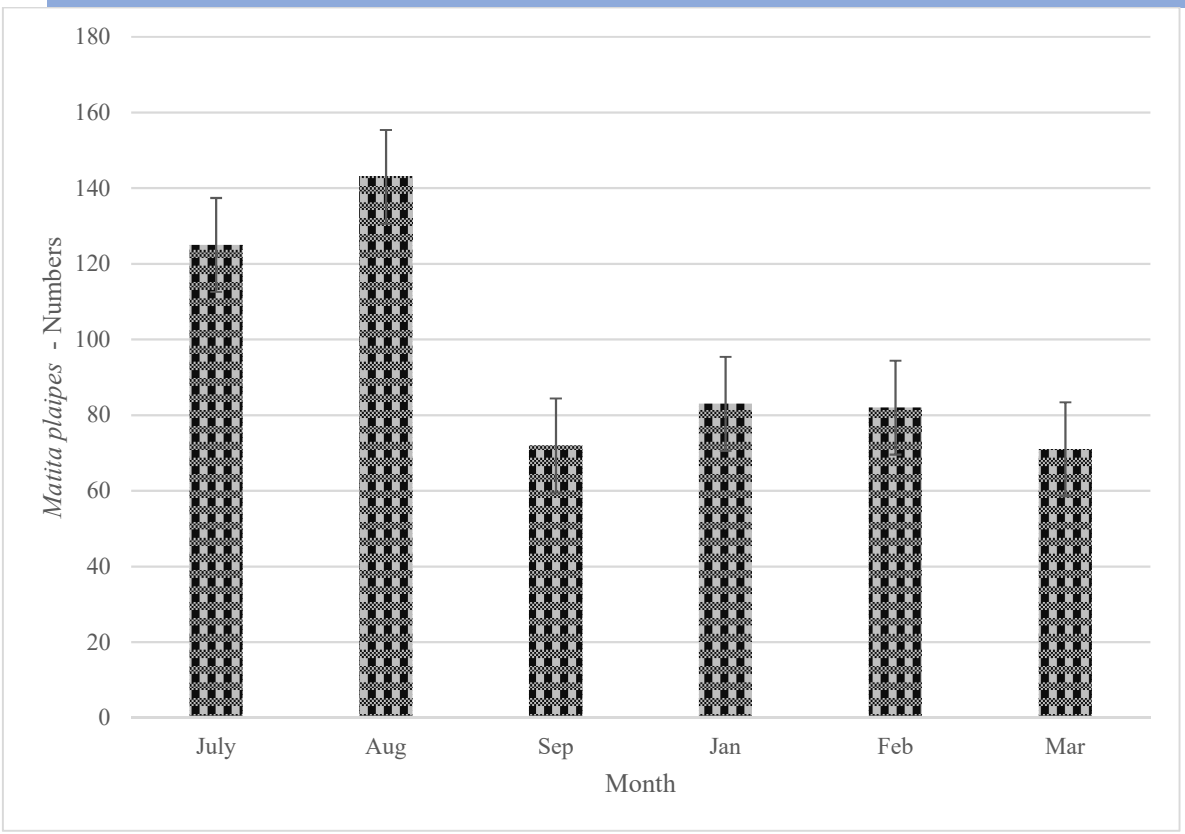


Fig. 16. Bycatch assessment of *Matita plaipes* for the month-wise at the Thoothukudi district level.

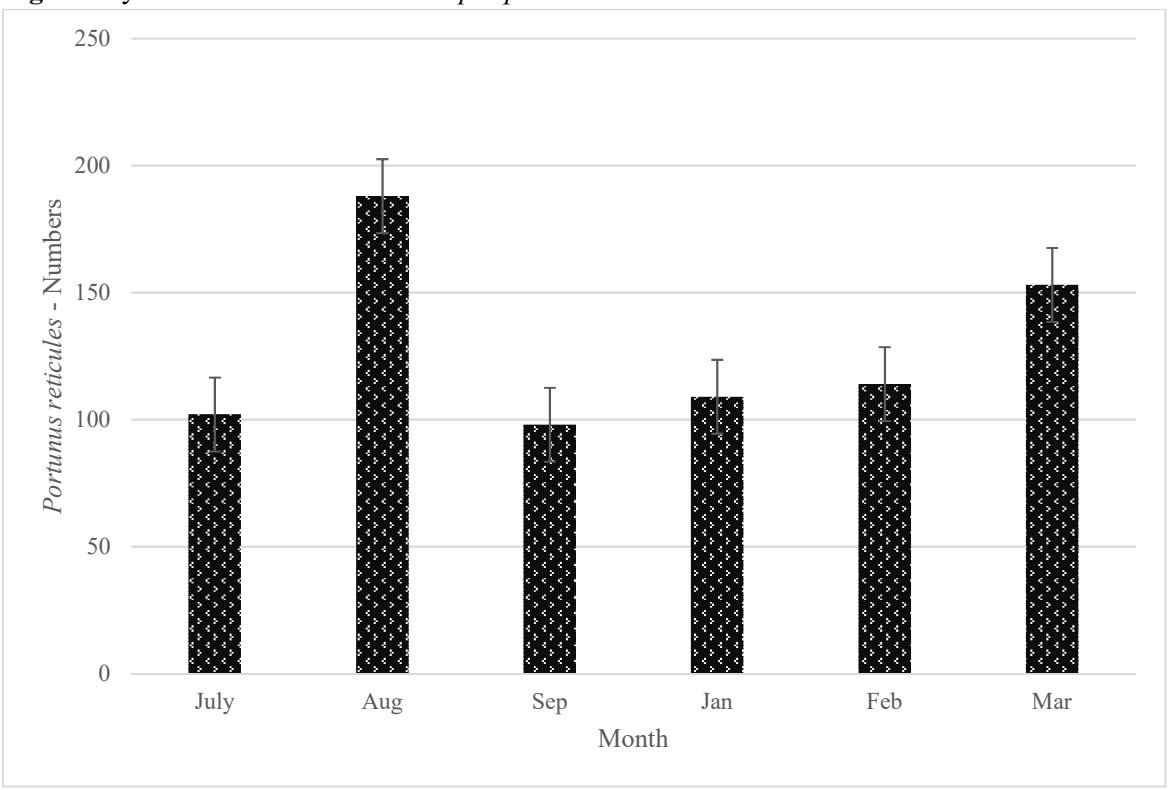


Fig. 17. Bycatch assessment of *Portunus reticules* for the month-wise at the Thoothukudi district level.

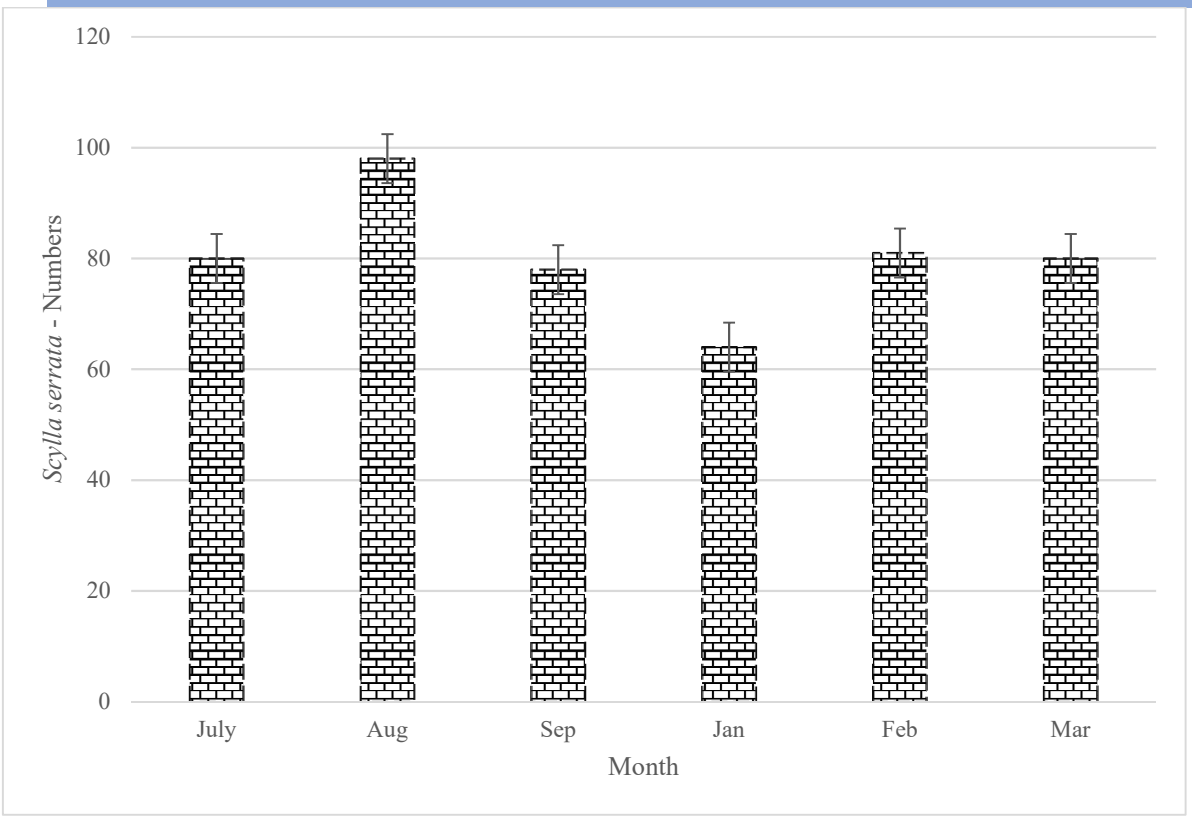


Fig. 18. Bycatch assessment of *Scylla serrata* for the month-wise at the Thoothukudi district level.

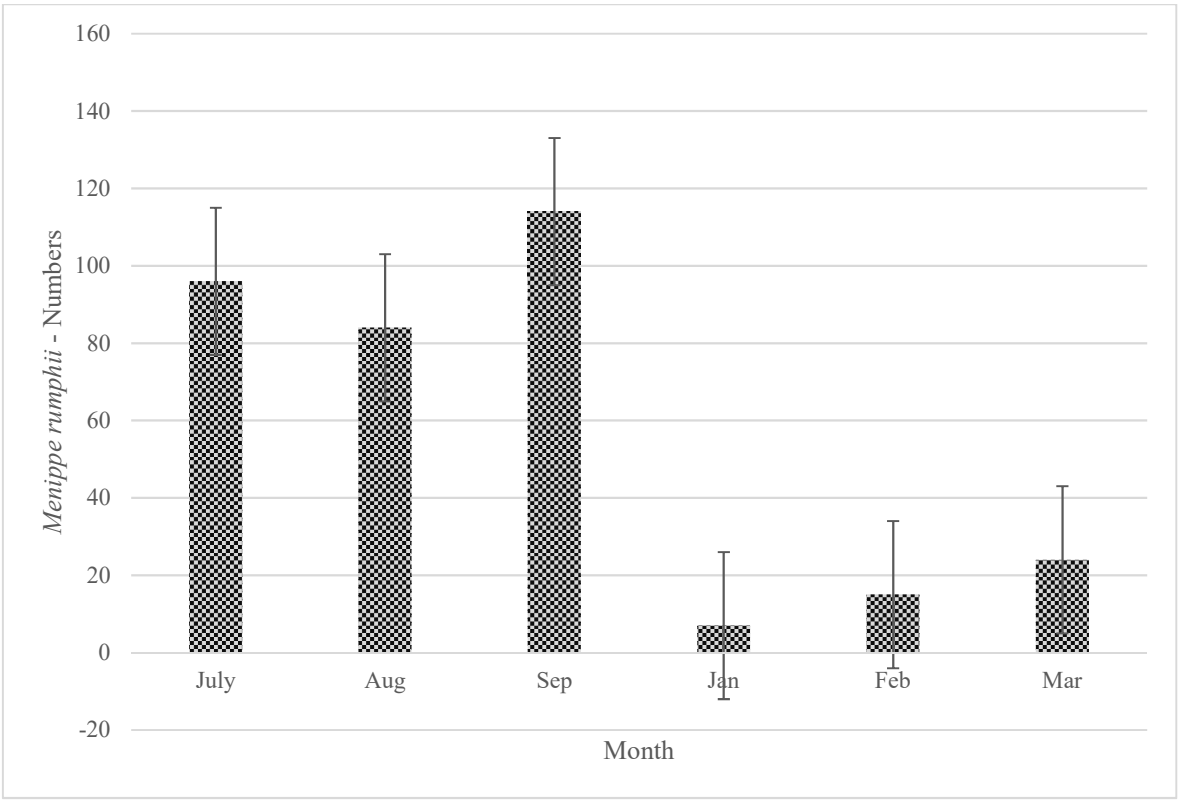


Fig. 19. Bycatch assessment of *Menippe rumphii* for the month-wise at the Thoothukudi district level.

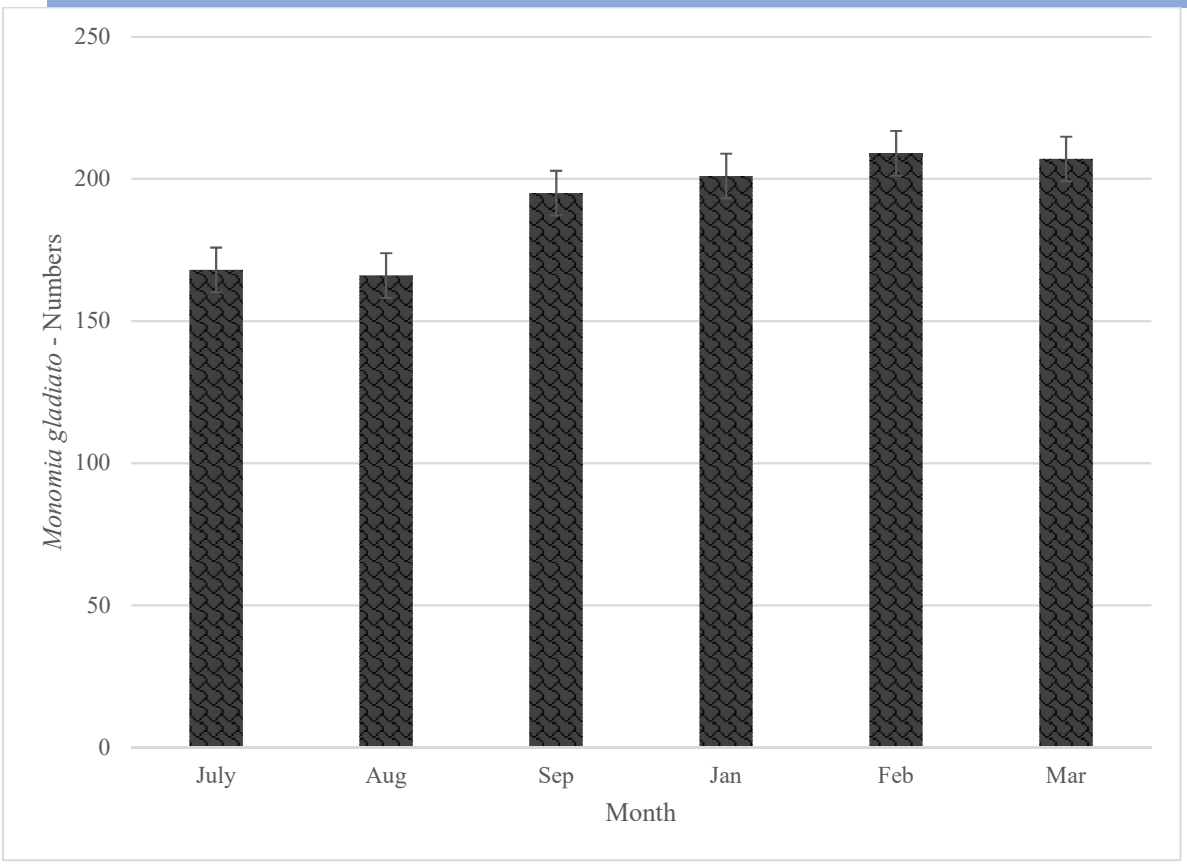


Fig. 20. Bycatch assessment of *Monomia gladiato* for month-wise at the Thoothukudi district level.

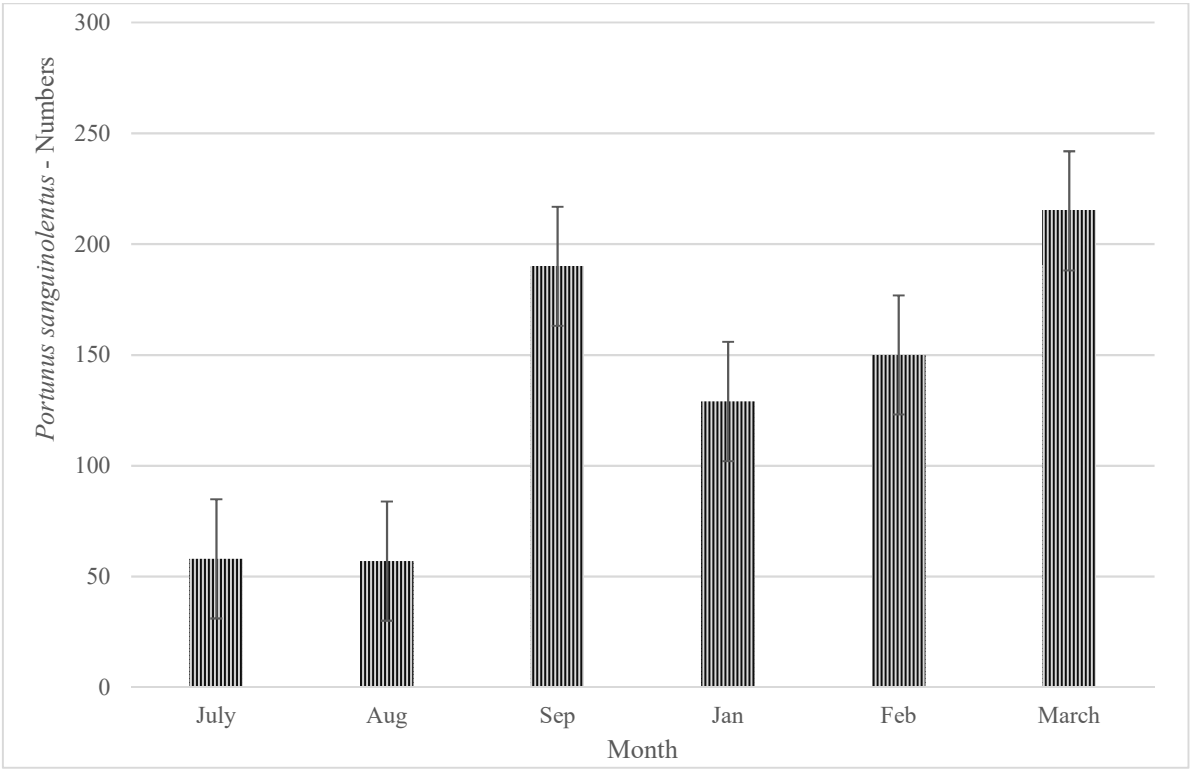


Fig. 21. Bycatch assessment of *Portunus sanguinolentus* for month-wise at the Thoothukudi district level.

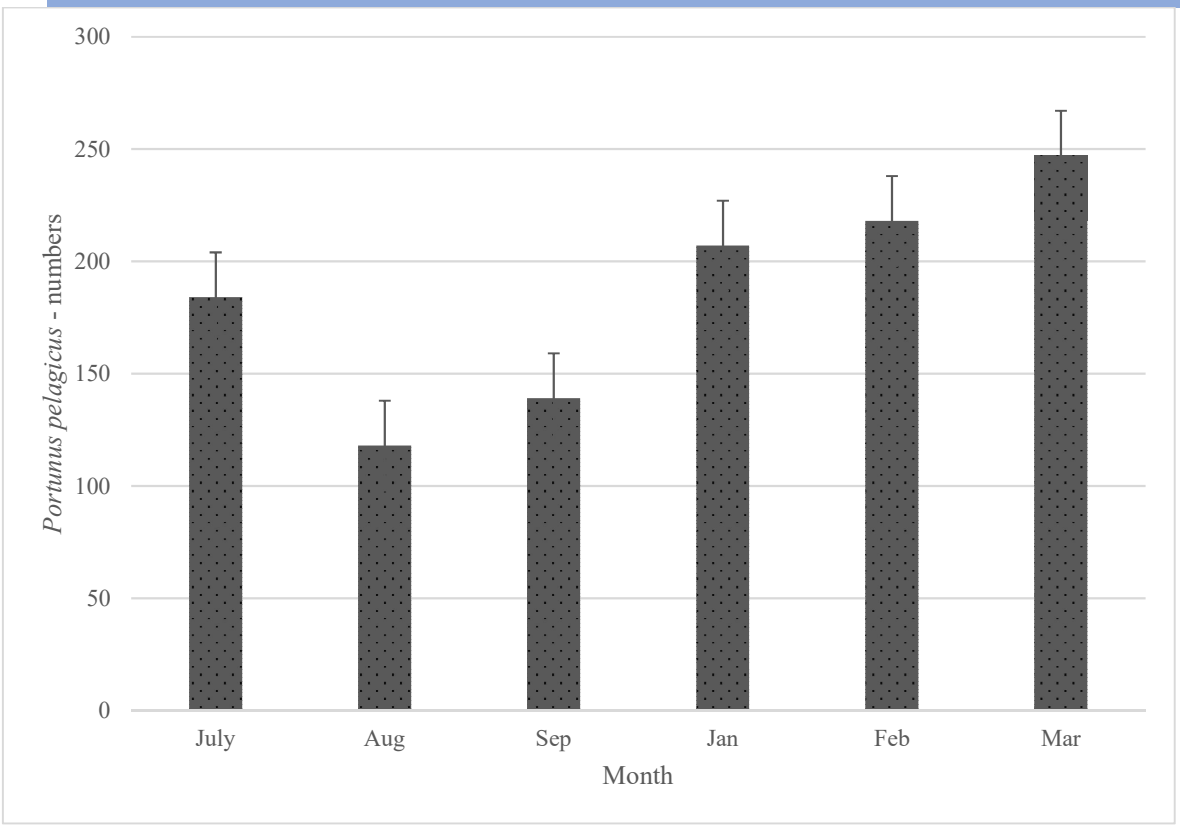


Fig. 22. Bycatch assessment of *Portunus pelagicus* for the month-wise at the Thoothukudi district level.

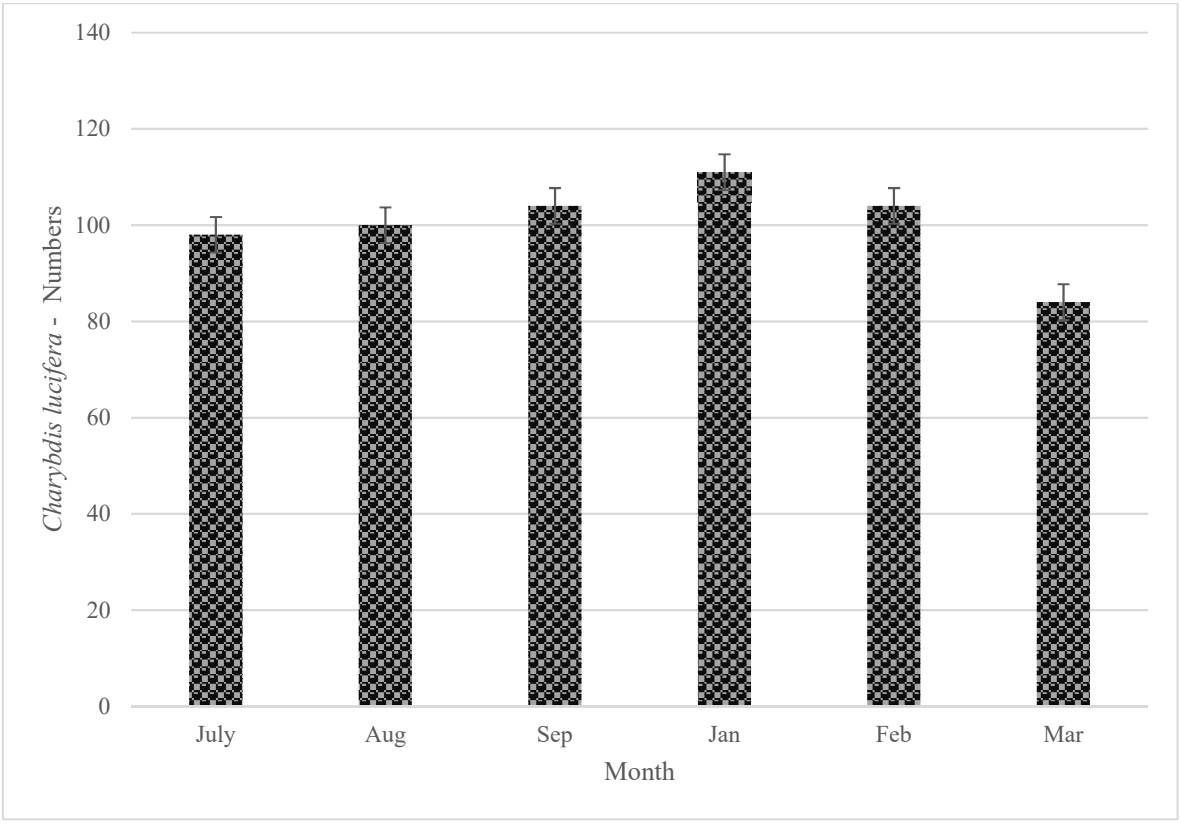


Fig. 23. Bycatch assessment of *Charybdis lucifera* for month-wise at the Thoothukudi district level.

Table 4. Bycatch assessment of crab diversity based on human consumption character for the fish landing centre of Thoothukudi district.

Species	Vellapatti		Harbour		Tharuvaikulam		Pun
	Edible	Non edible	Edible	Non edible	Edible	Non edible	Edi
A. integerrimus	×	√	×	√	×	√	-
A. lunaris	√	×	√	×	√	×	-
C. bileneata	√	×	√	×	√	×	√
C. feriatus	√	×	√	×	√	×	-
C. helleri	√	×	√	×	√	×	-
C. lucifera	√	×	√	×	√	×	√
C. natator	√	×	√	×	√	×	-
D. logopodes	×	√	×	√	×	√	×
H. ochtodes	×	√	×	√	×	√	-
M. gladiator	√	×	√	×	√	×	-
M. plaipes	×	√	×	√	×	√	-
M. rumphii	√	×	√	×	√	×	-
P. pelagicus	√	×	√	×	√	×	-
P. reticules	√	×	√	×	√	×	-
P. sanguinolentus	√	×	√	×	√	×	-
S. serrata	√	×	√	×	√	×	-

Note: √ = Eatable, × = Non eatable, and - = Not available. **4. DISCUSSION**

In this finding of bycatch assessment of crab at selected fish landing centres of Thoothuudi district, Cleary proved that crab is highly distributed in all selected areas except Punnaikayal, but the numbers of species and individuals vary from one area to another area of study. Overall studied place 16 crab species were recorded with different quantities, numbers of species and quantity. Fluctuations of quantity form month to month Aswells as area to area which is correlated to numerus of environmental features like Salinity (Sandilyan et al., 2010; Varadharajan et al., 2013), temperature, vegetation, substratum, physical changes in the substrate composition, food, existence of other animals (Saenger, 2002; Caésar et al., 2005; Pandya and Vachharajani, 2010; Apreshgi and Kurian, 2019), artificial dykes, sandy beaches and mangrove vegetation (Nhuong *et al*., 2004; Tho Le et al., 2018).

Earlier, Kathirvel, (2008), Sathiya and Valarmathi 2018 conducted a similar kind of study at the Tamil Nadu coastal area and Nagapattinam fish landing centre and identified 404 and 12 crab species, respectively. Satheeshkumar, (2012) total of 22 species of brachyuran crabs belonging to 12 genera and 5 families (Satheeshkumar, 2012). Rao et al, (1973), Maharajan et al, (2015) stated that the greatest percentage of crab species are landed at the Gulf of Mannar regions of Tamil Nadu coast in India (Rao et al, 1973; Maharajan et al., 2015). This finding is particularly aimed at documenting bycatch assessment in crabs at Thootukudi district fish landing centre and which is a useful practice to assess the crab species diversity at the study area. The average temperature showed no significant difference between the studied area off Vellapatti, TF Harbour, and Kuam, but Punnaikayal has a slightly higher temperature (Fig. 24). For that reason, when compared to Vellapatti, TF Harbour, and Kuam, the Punnaikayal landing centre has very low carb diversity, which's also confirmed by a study of Aschenbroich et al, (2016).

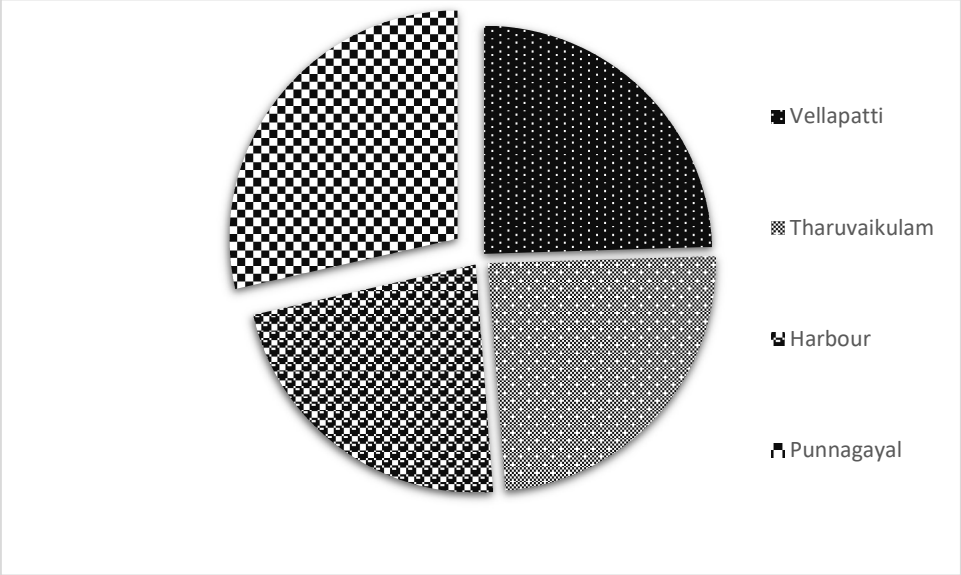


Fig. 24. Average temperature of the selected fish landing centre of Thoothukudi District

Among all biological factors and physical factors, Water salinity plays a vital character in distribution of crab species, in current findings Vellapatti, Harbour and Tharuvaikulam distribute more number crab's species may be due to high water salinity, alternatively due to slightly low salinity of water Punnaikayal are low of distribution of crab's species, in prior finding of Ravichandran, and Kannupandi, (2007) and Aschenbroich et al, (2016) agreed that explanations. On the other hand, the studied area crab's diversity is influenced by the presence of accompanying animals and plants (Caésar et al., 2005; Pandya and Vachharajani, 2010, Apreshgi and Kurian, 2019). Selected sites of Vellapatti, Harbour, and Tharuvaikulam are rich in associated animals and plants, and low numbers of associated animals and plants at Punnaikayal are a supplementary reason for the distribution of crab species in high and low diversity correspondingly (Table 5).

Results from the current findings displayed that a number of decapod species found at selected fish landing centre in Thoothukudi district. Consequently, decapod low diversity areas are need to conservation. Assessment of biodiversity account is monetary aids to promote and justify conservation actions and abate to fishing effort for a certain time.

Table 5. Accompanying animals and plants of the selected fish landing centre of Thoothukudi District.

Associate organisms / Locality	**Vellapatti**	**TF Harbour**	**Tharuvaikulam**	**Punnaikayal**
Star fish	√	√	√	×
Buffer fish	√	√	√	×
Seaweed	√	√	√	√
Corals	√	×	√	×
Sponges	√	×	√	√
Oyster	√	√	×	√
Shell	√	√	×	×
Seagrass	√	√	√	×
Sea archin	×	×	√	×

Note: √ = Present and × = Not available

CONCLUSION

The present investigation will serve as a baseline dataset for decapod distribution. Currently, these Decapoda (crab) are being significantly reduced by various anthropogenic activities. The study results recommended various eco-friendly management plans and programs for the conservation aspect, and suggested reducing ongoing industrial development near the coastal area especially in gulf of Mannar regions. Should be follow to conservation action to sustain decapods diversity.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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