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Note

Stake net fishery in the Chettuva Estuary, south-western coast of India

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Abstract

The stake net landing in the Chettuva Estuary was studied for two years from October 2019-September 2021 on the basis of the data and samples collected fortnightly from five stations along the estuary. A total of 123 species of finfish and shellfish belonging to 98 genera, 56 families and 29 orders were recorded during the study. The average monthly landing by stake net was estimated as 51.86 t and the catch was minimal during August and maximum in March. Seasonally, 38.65% of the catch was recorded during the pre-monsoon season, followed by 35.02% during the post-monsoon and the remaining 26.33% caught during the monsoon season. Shrimps dominated the total landings in all the months and stations, with an average contribution of 58.72%, followed by 35.79% by fishes and 5.49% by crabs. The mean catch per unit effort in the Chettuva Estuary was estimated to be 24.69 kg and the catch rates of shrimps, crabs and fishes were 14.13, 1.66 and 8.89 kg, respectively. The trend in the catch rate for both shrimps and total resources remained the same for all the stations as well as for all the months, indicating the importance of shrimp catch in the fishery by stake nets in the Chettuva Estuary. The modal length classes observed for these species indicated that majority of them were juveniles. The exploitation of juveniles, especially of shrimps, by stake nets in this estuary is a matter of concern; hence, increasing the cod end mesh size of the nets operating in the Chettuva Estuary is recommended for resource sustainability.

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The estuarine fishery resources of Kerala are of high magnitude and support a rich fishery. The fauna comprises both marine and a few freshwater species that can tolerate variations in salinity in addition to the truly estuarine species, as the species move to or from the sea during spawning. Kerala is blessed with several estuaries and these water bodies are considered good nursery grounds for different species of finfishes and shellfishes. The backwaters in Kerala form habitats for more than 200 resident and migratory fish and shellfish species and fishing activities in these backwaters provide livelihoods to approximately 200,000 fishers and full-time employment to more than 50,000 fishermen (Bijoy Nandan, 2008). With respect to the importance of estuaries, several studies on fishery resources in different estuaries have been conducted (Harikrishnan *et al*., 2011; Bijoy Nandan *et al*., 2012; Regi and Bijukumar, 2012; Rejna *et al*., 2015; Remya and Amina, 2018; Muthupandi *et al*., 2020; Amrutha and Talwar, 2021; Kumar *et al*., 2023a,b; Swetha *et al.*, 2023; Geethalakshmi *et al.,* 2024). Different types of fishing gear are in operation in estuaries. Among the different gear operated, stake nets were found to contribute a maximum of 28.39% to the total landings in selected backwaters along the south-western coast of India (CIFRI, 2005) and a contribution of up to 57% by stake nets in total landings was recorded in Cochin backwaters (Kurup *et al*., 1993). Uskelwar *et al.* (2017) reported that stake net fisheries constitute one of the prominent traditional fisheries practiced along the estuarine villages of Ratnagiri, whereas stake nets and Chinese dip nets together constitute only 8% of finfish landings in the

Ashtamudi Estuary (Kumar *et al*., 2023a). However, Kumar *et al*. (2023a) did not consider the shrimp landings in this estuary, which constitute the major component of stake net fisheries. Marine debris in the stake net fisheries of Vembanad Lake was assessed by Shylaja *et al.* (2018) and anthropogenic impacts on the stake net fishery of the Thevara-Venduruthy region were studied by Leya *et al.* (2015). The Chettuva backwater is located between the Engandiyur Panchayat and the Kadappuram Panchayat of Thrissur District in Kerala. The backwaters start at Enamakkal Lake and empties to Arabian Sea. This estuary is bestowed with good coverage of mangroves and associated bioresources. Some studies have been carried out on the fishery resources of this estuary by a few researchers (George *et al*., 2002; CIFRI, 2005; Laxmilatha *et al*., 2006; Jayachandran *et al*., 2008; CMFRI, 2012; Sreedevi *et al*., 2014; Swapana *et al*., 2016; Vinitha *et al*., 2016; Vivekanand *et al*., 2016). Among the different fishing gear that operate in the Chettuva Estuary, stake net landings contribute the most to the fishery (CIFRI, 2005). It is an age-old practice in this area, and no reports are available on a detailed investigation of stake net fisheries in this estuary. Hence, an attempt is made here to study the qualitative and quantitative aspects of stake net landings in the Chettuva Estuary.

Stake nets locally known as "Oonnuvala" are traditional fishing gear that are operated with the help of stakes or poles fixed across the water body. It is a conical net with different mesh sizes for different portions, with the largest mesh size at the mouth area, and it gradually decreases towards the cod end. In the Chettuva Estuary, traditional stake nets with a total length of 22 m and a cod end mesh size of 8 mm are usually used. The total length of net is divided into cod end region (5.45 m), middle portion (14.55 m), top region (1 m) and extreme top part (1 m). The nets are spaced at a distance of 6 m at each station. The stake net fishery is influenced by tides and when the water starts receding during the start of low tide, the stake nets are erected, and the fishery resources that enter the nets are collected. During the present study, catch and effort data for shrimps, crabs and fishes were collected fortnightly from five stations, *viz.* Azhipadu (Station 1), Thanthapadu (Station 2), Mukkom (Station 3), Kanakkampadu (Station 4) and near Chettuva bridge (Station 5) during the period from October 2019 to September 2021 (Fig. 1).

Among the stations, station 1 (Azhipadu) is located near the barmouth and subsequent stations are located upstream. The distance between Azhipadu and Thanthapadu is 1.10 km, Mukkom is located 870 m away from Thanthapadu, Kanakkampadu is 503 m away from Mukkom and Chettuva bridge station is located 710 m far from Kanakkampadu. From the catch and effort (number of nets/units operated) data collected from each station, the catch per unit effort (CPUE) of different fishery resources was calculated, and month-wise and station-wise values were estimated. The total catch was calculated on the basis of the number of fishing days in each month. The data collected for 24 months were averaged to 12 months for proper interpretation of the data. For the seasonal studies, October-January was considered the post-monsoon period, February-May was considered the pre-monsoon period, and June-September the monsoon period. Samples of fishery resources were collected on a fortnightly basis from different stations, the collected samples were identified (Fischer and Bianchi, 1984; Smith and Heemstra, 1986; Munro, 2000) and length measurements of each species were recorded to determine the modal length class of the landed species.

The catch per unit effort of total resources, shrimps, crabs and fishes collected for 24 months were taken for analysis. One-way ANOVA and *post hoc* tests were carried out to examine the monthly, seasonal and stationwise variations between these entities.

A total of 123 species of finfish and shellfish were recorded from stake net landings in the Chettuva Estuary during the study period in addition to jellyfish. These 123 species belong to 98 genera, 56 families and 29 orders. The list of species of fishes, crustaceans and mollusks landed by stake nets along with their modal length classes, families and IUCN status are given in Table 1.

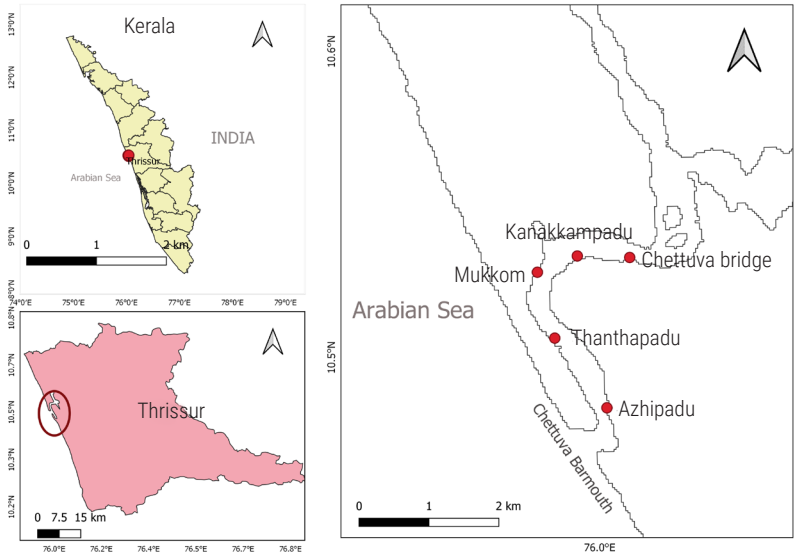

Fig. 1. Map showing the locations of the sampling stations

The 123 species included 104 species of fishes belonging to 49 families, 14 species of crustaceans (4 families) and 5 species of mollusks (3 families). In terms of IUCN status, *Cynoglossus macrostomus*, which belongs to the vulnerable category, is included in this list. Jyothilal *et al*. (2015) recorded 48 species of fishes (33 families), 12 species of crustaceans (4 families) and 5 species of mollusks (4 families) in the stake net catch of Ashtamudi Lake. The lower number of fishes recorded from Ashtamudi Lake may be due to the lower frequency and number of observations than those reported in the present study. Amrutha and Talwar (2021) reported 20 finfishes and 6 shellfishes in coastal set bagnets operating in the Hooghly Matlah Estuary in an experimental study conducted for four months. In another study, Jayawardane and Perera (2003) recorded only 41 species of finfish and crustaceans in stake nets from Negombo Lagoon, Sri Lanka. Ali *et al.* (2013) recorded 95 species of finfishes and shell fishes from stake nets operating in intertidal areas in Kuwait and reported that 40% of the catches were juveniles.

The majority of species recorded were juveniles, as evidenced by the modal length class observed, which may be due to the very small mesh size of the cod end of the net used. The exploitation of juveniles by stake nets has also been recorded in Cochin backwaters (Nandakumar, 2004), the Ashtamudi Estuary (Jyothilal *et al*., 2015, Kumar *et al*., 2023a), Pulicat Lake (Muthupandi *et al*., 2020) and the Hooghly Matlah Estuary (Amrutha and Talwar, 2021). The modal lengths of *Metapenaeus dobsoni* recorded by Jayawardane and Perera (2003) and during the present study were 4.3 and 4.5 cm, respectively.

The annual landings by stake nets in the Chettuva Estuary were estimated to be 622.32 t, which included shrimps, crabs and fishes.

Table 1. List of species, modal length classes, families and IUCN status of the finfishes and shellfishes recorded during the study period

Species	Modal length class (cm)	Family	IUCN Status
Acanthurus mata (Cuvier, 1829)	3.1-4	Acanthuridae	LC
Ambassis gymnocephalus (Lacepède, 1802)	5.1-6	Ambassidae	LC
Nemapteryx caelata (Valenciennes, 1840)	3.1-4	Ariidae	NE
Arius subrostratus Valenciennes, 1840	6.1-8	Ariidae	NE
Atherinomorus lacunosus (Forster, 1801)	6.1-8	Atherinidae	LC
Colletteichthys dussumieri (Valenciennes 1837)	3.1- 4	Batrachoididae	LC
Colletteichthys flavipinnis Greenfield, Bineesh and Akhilesh, 2012	4.1-5	Batrachoididae	LC
Strongylura strongylura van Hasselt, 1823	17.1-19	Belonidae	NE
Tylosurus crocodilus (Peron and Lesueur 1821)	23- 23.5	Belonidae	LC
Bothus Rafinesque, 1810	12.1-13	Bothidae	
Bregmaceros mcclellandi Thompson, 1840	4.1- 6	Bregmacerotidae	NE
Alepes kleinii (Bloch, 1793)	6.1-8	Carangidae	LC
Alepes djedaba (Forsskal, 1775)	10.1-11	Carangidae	LC
Atule mate (Cuvier, 1833)	9.1-10	Carangidae	LC
Carangoides ferdau (Forsskal, 1775)	6.1-7	Carangidae	LC
Caranx heberi (Bennett, 1830)	8.1-9	Carangidae	LC
Caranx hippos (Linnaeus, 1766)	8.1-9	Carangidae	LC
Caranx ignobilis (Forsskal, 1775)	8.1-9	Carangidae	LC
Elagatis bipinnulata (Quoy and Gaimard, 1825)	7.1-8	Carangidae	LC
Gnathanodon speciosus (Forsskal, 1775)	6.1-8	Carangidae	LC
Megalaspis cordyla (Linnaeus, 1758)	6.1-7	Carangidae	LC
Parastromateus niger (Bloch, 1795)	1- 2	Carangidae	LC
Scomberoides tol (Cuvier, 1832)	5.5-7.5	Carangidae	LC
Trachinotus blochii (Lacepede, 1801)	11.1-12	Carangidae	LC
Etroplus suratensis (Bloch, 1790)	6.1-6.5	Cichlidae	LC
Anodontostoma chacunda (Hamilton, 1822)	6.1-8	Clupeidae	LC
Dussumieria acuta Valenciennes, 1847	4- 4.5	Clupeidae	LC
Escualosa thoracata (Valenciennes, 1847)	4.1- 5	Clupeidae	LC
Nematalosa nasus (Bloch, 1795)	8.1-10	Clupeidae	LC
Sardinella albella (Valenciennes, 1847)	4.1-5	Clupeidae	LC
Sardinella fimbriata (Valenciennes, 1847)	6.1-7	Clupeidae	LC
Sardinella gibbosa (Bleeker, 1849)	4.1-5	Clupeidae	LC
Conger sp. Bosc, 1817	30.1-32	Congridae	
Ariosoma anago (Temminck and Schlegel, 1846)	20.1-20.5	Congridae	DD
Cynoglossus macrostomus Norman, 1928	6.1-7	Cynoglossidae	VU
Drepane longimana (Bloch and Schneider, 1801)	3.1-4	Drepaneidae	NE

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Drepane punctata (Linnaeus, 1758)	6.1-7	Drepaneidae	LC
Echeneis naucrates Linnaeus, 1758	33.1-33.5	Echeneidae	LC
Encrasicholina devisi (Whitley, 1940)	5.1-6	Engraulidae	NE
Stolephorus commersonnii Lacepède, 1803	4.1- 5	Engraulidae	LC
Thryssa malabarica (Bloch, 1795)	5.1 - 6	Engraulidae	DD
Thryssa mystax (Bloch and Schneider, 1801)	6.1-7	Engraulidae	LC
Thryssa setirostris (Broussonet, 1782)	8.1-10	Engraulidae	LC
Platax Cuvier 1816	3.5-4.5	Ephippidae	
Gerres filamentosus Cuvier, 1829	7.1-9	Gerreidae	LC
Gerres limbatus Cuvier, 1830	7.5-8.5	Gerreidae	LC
Glossogobius giuris (Hamilton, 1822)	4.1- 5	Gobiidae	LC
Taenioides cirratus (Blyth, 1860)	10.1 - 11	Gobiidae	DD
Trypauchen vagina (Bloch and Schneider, 1801)	9.1-11	Gobiidae	LC
Hemiramphus sp. Cuvier, 1816	7.1-9	Hemiramphidae	
Hyporhamphus quoyi (Valenciennes, 1847)	25.1-25.5	Hemiramphidae	LC
Lactarius lactarius (Bloch and Schneider, 1801)	4.1-5	Lactariidae	NE
Deveximentum insidiator (Bloch 1787)	4.1-5	Leiognathidae	DD
Equulites elongatus (Günther, 1874)	3.1- 5	Leiognathidae	LC
Equulites lineolatus (Valenciennes, 1835)	5.1-5.5	Leiognathidae	NE
Eubleekeria splendens (Cuvier, 1829)	5.1-6	Leiognathidae	LC
Karalla daura (Cuvier, 1829)	4.1-5	Leiognathidae	LC
Karalla dussumieri (Valenciennes, 1835)	7.1-8	Leiognathidae	LC
Leiognathus brevirostris (Valenciennes, 1835)	6.1-7	Leiognathidae	NE
Leiognathus equula (Forsskal, 1775)	9.1-9.5	Leiognathidae	LC
Leiognathus ruconius (Hamilton, 1822)	4.1-5	Leiognathidae	NE
Nuchequula blochii (Valenciennes, 1835)	5.1-7	Leiognathidae	NE
Lobotes surinamensis (Bloch, 1790)	5.5-7.5	Lobotidae	LC
Lutjanus argentimaculatus (Forsskal, 1775)	8.1-8.5	Lutjanidae	LC
Chelon sp. Artedi 1793	16.1-16.5	Mugilidae	
Mugil cephalus Linnaeus, 1758	9.1-9.5	Mugilidae	LC
Upeneus sp. Cuvier, 1829	6.1- 6.5	Mullidae	
Muraenesox cinereus (Forsskal, 1775)	50.1-50.5	Muraenesocidae	LC
Strophidon sathete (Hamilton, 1822)	56.1- 58	Muraenidae	LC
Scolopsis vosmeri (Bloch, 1792)	8.1-8.5	Nemipteridae	LC
Pisodonophis boro (Hamilton, 1822)	56.1- 58	Ophichthidae	LC
Pseudorhombus javanicus (Bleeker, 1853)	2.1- 3	Paralichthyidae	LC
Pempheris sp. Cuvier, 1829	8.1-8.5	Pempheridae	
Grammoplites scaber (Linnaeus, 1758)	24.1-24.5	Platycephalidae	NE
Platycephalus sp. Bloch, 1795	5.1- 6	Platycephalidae	
Plotosus lineatus (Thunberg, 1787)	22.1- 23	Plotosidae	LC
Abudefduf sp. Forsskal, 1775	6.1-6.5	Pomacentridae	
Opisthopterus tardoore (Cuvier, 1829)	5.1-7	Pristigasteridae	LC
Pellona ditchela Valenciennes, 1847	8.1-8.5	Pristigasteridae	LC
Scatophagus argus (Linnaeus, 1766)	5.1-6	Scatophagidae	LC
Johnius carutta Bloch, 1793	11.1-12	Sciaenidae	LC
Johnius glaucus (Day, 1876)	7.1-8	Sciaenidae	NE
Kathala axillaris (Cuvier, 1830)	7.1-8	Sciaenidae	LC
Nibea maculata (Bloch and Schneider, 1801)	5.1-5.5	Sciaenidae	LC
Otolithes ruber (Bloch and Schneider, 1801)	6.1-7	Sciaenidae	LC
Pennahia aneus (Bloch, 1793)	4.1-5	Sciaenidae	LC
Rastrelliger kanagurta (Cuvier, 1816)	10.1- 10.5	Scombridae	LC
Siganus canaliculatus (Park, 1797)	2.1-4	Siganidae	LC
Siganus javus (Linnaeus, 1766)	3.1-4	Siganidae	LC
Sillago sihama (Forsskal, 1775)	4.1-6	Sillaginidae	LC

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Solea ovata Richardson, 1846	3.1-4	Soleidae	LC
Sphyraena jello Cuvier, 1829	23.1- 23.5	Sphyraenidae	LC
Sphyraena obtusata Cuvier, 1829	10.1-10.5	Sphyraenidae	LC
Pampus argenteus (Euphrasen, 1788)	4.1-5	Stromateidae	NE
Saurida sp. Valenciennes 1850	7.1-7.5	Synodontidae	
Pelates quadrilineatus (Bloch, 1790)	4.5-5.5	Terapontidae	NE
Terapon jarbua (Forsskal, 1775)	6.1-7	Terapontidae	LC
Terapon puta Cuvier, 1829	4.1-5	Terapontidae	NE
Terapon theraps Cuvier, 1829	5-5.5	Terapontidae	LC
Arothron sp. Müller, 1841	6.5-7.5	Tetraodontidae	
Lagocephalus inermis (Temminck and Schlegel, 1850)	8.1-10	Tetraodontidae	LC
Tripodichthys blochii (Bleeker, 1852)	4.5-6.5	Tetraodontidae	LC
Triacanthus biaculeatus (Bloch, 1786)	9.1- 10	Triacanthidae	LC
Trichiurus lepturus Linnaeus, 1758	24.1-26	Trichiuridae	LC
Macrobrachium rosenbergii (de Man, 1879)	7.1-8	Palaemonidae	LC
Penaeus indicus Milne-Edwards, 1837	7.1-8	Penaeidae	NE
Penaeus monodon Fabricius, 1798	7.1-9	Penaeidae	NE
Penaeus semisulcatus de Haan, 1844	7.1-9	Penaeidae	NE
Penaeus canaliculatus (Olivier, 1811)	10.1- 10.5	Penaeidae	NE
Metapenaeus dobsoni (Miers, 1878)	4.1-5	Penaeidae	NE
Metapenaeus monoceros (Fabricius, 1798)	6.1-7	Penaeidae	NE
Parapenaeopsis stylifera (H. Milne Edwards, 1837	5.1-6	Penaeidae	NE
Portunus pelagicus (Linnaeus, 1758)	3.1-4	Portunidae	NE
Portunus sanguinolentus (Herbst, 1783)	3.1-4	Portunidae	NE
Charybdis feriatus (Linnaeus, 1758)	1.1-3	Portunidae	NE
Charybdis lucifera (Fabricius, 1798)	4.1 -5	Portunidae	NE
Charybdis natator (Herbst, 1794)	5.1- 6	Portunidae	NE
Miyakella nepa (Latreille in Latreille, Le Peletier, Serville and Guerin, 1828)	7.1-9	Squillidae	NE
Uroteuthis (Photololigo) *duvaucelii* (d'Orbigny [in Ferussac and d'Orbigny], 1835)	4.1-6	Loliginidae	DD
Loliolus hardwickei (Gray, 1849)	3.1-4	Loliginidae	DD
Perna viridis (Linnaeus, 1758)	2- 2.1	Mytilidae	NE
Sepia sp. Linnaeus, 1758	2.1- 3	Sepiidae	
Sepiella inermis (Van Hasselt, 1835)	2.1-4	Sepiidae	DD

LC – Least Concern, DD – Data Deficient, VU – Vulnerable, NE – Not Evaluated

In another study, CIFRI (2005) recorded the total annual landings by stake nets as 510.3 t in this estuary, which is lower than that of the present study, which may be due to the lower number of fishing days during that study, which was only 12 days, whereas the average number of fishing days during the present study was 21 days. The mean catch per net per day in the Chettuva Estuary was estimated to be 24.69 kg. Studies on the CPUE of different categories, *viz*. shrimps, crabs and fishes were 14.13, 1.66 and 8.89 kg, respectively.

The monthly average landings during the present study were estimated as 51.860 t per month. The landings (Fig. 2) varied from 27821 kg in August to 78640 kg in March. A maximum of 12.64% of the total annual landings were observed during March, followed by 10.98% in June, 10.62% in October and 10.59% in May and the other months contributed less than 10%. In Vembanad Lake, Kurup *et al.* (1993) recorded the highest landings by stake nets in January and the lowest in July, which is comparable with the findings of the present study; however, slight variations observed may be due to the vastness and environmental interactions associated with the Thanneermukkom salinity barrier in the Vembanad Lake ecosystem.

The catch rate of fishery resources varied from 13.29 kg in August to 30.29 kg in March (Fig. 3). The monthly variations in the CPUE of the shrimps and total resources followed the same trend and shrimps formed the major component of stake net landings in the Chettuva Estuary. A range of 7.5-18.1 was recorded as the average CPUE (kg unit^{-1} day^{-1}) of stake net landings in different backwaters along the south-western coast of India (CIFRI, 2005), which is lower than that recorded during the present study. These low values may be due to the difference in sampling, as the studies conducted in different backwaters along the south-western coast of India were based on a quarterly survey. Moreover, fishermen were found to operate the nets more than once for a few days every month and the duration of fishing was approximately three hours, which may also have contributed to the higher CPUE during the present study. In another study, Jayawardane and Perera (2003) reported a mean catch rate of total resources as 24.7 kg per operation from Negombo Lagoon in Sri Lanka while studying the artisanal stake net fishery, which is in agreement with the findings of the present study, but the catch rate reported by these authors for shrimp (20.23 kg) was slightly higher than that reported in the present study, which may be due to differences in the types of ecosystems. However,

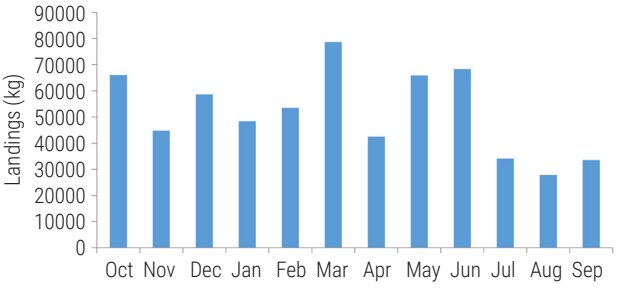

Fig. 2. Month-wise landings by stake nets in the Chettuva Estuary

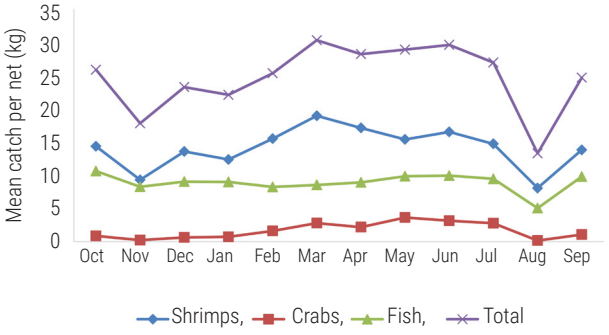

Fig. 3. Month-wise CPUE of stake net landings in the Chettuva Estuary

Kobitha and Wickramarathe (2023) reported CPUE of 8-14 kg for the stake nets operating in Navanthurai Lagoon in northern Sri Lanka. An average catch rate of 62 kg unit^{-1} day^{-1} was recorded by Ali *et al*. (2013) from intertidal fixed stake nets operating along the Kuwait coast in Kuwait Bay, which is much higher than that reported in the present study, as these two findings are from different types of ecosystems.

Results of ANOVA carried out between months with respect to total resources, shrimps and fishes indicated that the variations in catch rates were significant ($p<0.05$). *Post hoc* tests were carried out, and the catch rates of total resources, shrimps and fishes between months were derived.

Post hoc tests between months revealed that the months for which significant variations ($p<0.05$) observed were almost the same for both total resources and shrimps. Additionally, the variations in the catch rates of total resources, shrimps and fishes between August and all other months were found to be significant ($p<0.05$).

Season-wise studies on landings indicated a maximum of 38.65% during the pre-monsoon season, followed by 35.02% during the post-monsoon season and production was minimal during the monsoon season. The minimum landings during the monsoon season may be due to heavy rainfall associated with turbulent freshwater discharge followed by damage to the erected poles and subsequent abandonment of fishing operations. While studying the exploited fishery resources of the Azhikode Estuary, Harikrishnan *et al*. (2011) reported the highest landings during the pre-monsoon period, followed by the post-monsoon period, and the lowest landings occurred during the monsoon period, which is in agreement with the present study. The pre-monsoon season, as the peak season, has also been recorded by other researchers (Nandakumar, 2004; Boopendranath and Shahul, 2010) while studying the stake net fishery in Vembanad Lake.

There was a significant difference between seasons in the catch rates of total resources and shrimps, as indicated by one-way ANOVA ($p<0.05$), but the variation in the case of fishes was not significant. A *post hoc* test using catch rates of total resources and shrimps indicated that the variations between the post-monsoon and pre-monsoon seasons as well as between the pre-monsoon and monsoon seasons were significant ($p<0.05$), but those between the post-monsoon and monsoon seasons were not significant.

Catch composition clearly indicated dominance of shrimps in all the months (Fig. 4). Among the total landings, an average of 58.72% were shrimps, followed by 35.79% by fishes and a minimum of 5.49% by crabs during the study period. Jyothilal *et al*. (2015) reported that shrimps contributed more than 60% of the total catch, followed by fishes (32%) in stake nets operating in Ashtamudi Lake, which also agrees with the present observations. Geethalakshmi *et al*. (2024) reported huge landings of shrimps constituting 65% in stake net fishery of Vembanad Lake.

Among shrimps, *M. dobsoni* (63.76%), *M. monoceros* (25.91%) and *P. indicus* (10.32%) and among fishes, silverbellies (30.74%), *Ambassis gymnocephalus* (23.89%), anchovies (17.89%) and catfish (13.65%) were the major components. In the stake net catch of the Ashtamudi Estuary, penaeids contributed 93% of shrimps (Jyothilal *et al*., 2015) and the major fish groups recorded were leiognathids, anchovies, catfishes and mullets (Kumar *et al*., 2023a), which is comparable with the findings of the present study. Jayawardane and Perera (2003) reported that shrimps, anchovies and silverbellies were the most important groups among the total stake net landings in Negombo Lagoon, Sri Lanka. While studying the shrimp fishery by stake nets in Cochin backwaters, Nandakumar (2004) also recorded *M. dobsoni* as the dominant species and *M. dobsoni, P. indicus* and *M. monoceros* as contributors to the shrimp fishery, and the maximum shrimp catch was recorded in February, with a minimum during July-August. Boopendranath and Hameed (2010) also observed *M. dobsoni* as the dominant component of the stake net catch and *M. dobsoni, M. monoceros* and *P. indicus* as major components in Vembanad Lake. The dominance of *M. dobsoni* in stake net fisheries was also noted by Jyothilal *et al*. (2015) in the Ashtamudi Estuary.

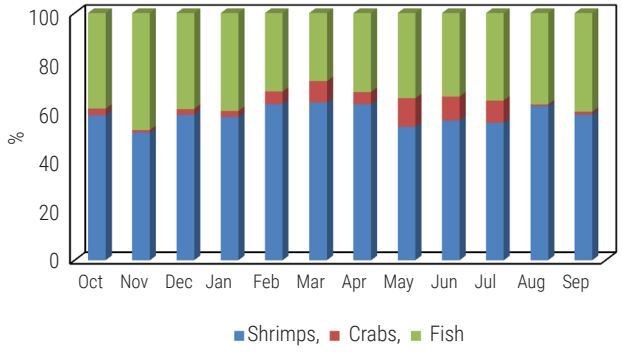

Fig. 4. Month-wise catch composition of stake net landings

Fig. 5 reveals that the catch rates in all the months were maximum for *M. dobsoni* followed by *M. monoceros* and *P. indicus*. The mean catch per net per day for *M. dobsoni, M. monoceros* and *P. indicus* were 8.81, 3.60 and 1.72 kg, respectively. The higher catch per net per day for *M. dobsoni* followed by that for *M. monoceros* and *P. indicus*, was also reported by Boopendranath and Hameed (2010) while analysing the stake net fishery in Vembanad Lake.

Station-wise studies indicated wide variations in landings (Fig. 6), which was mainly due to the variations in fishing effort at different stations. The average numbers of nets (units) operated per day at stations 1, 2 3, 4 and 5 were 10, 14, 18, 18 and 33, respectively. Thus, a maximum production of 40% was contributed by Station 5, whereas it was minimal at Station 1.

The station-wise catch rates of different groups of fishery resources landed by stake nets were estimated and the values for the total resources were found to vary from 18.84 kg at station 4 to 28.74 kg at station 1. The trend in catch rates for both shrimps and total resources remained the same for all the stations, indicating the importance of shrimp catch on the fishery by stake nets in the Chettuva Estuary. Additionally, the catch rates were found to fluctuate at alternate stations in the case of total resources and shrimps, but they did not show much variation between stations in the case of fishes and crabs. The catch rate of shrimps was the highest at station 5 (17.42 kg), followed by station 1 (17.23 kg) and it was the lowest at station 4 (8.65 kg); this variation can be attributed to the magnitude of tides.

The species composition and catch rates in comparison with those of total shrimps at different stations are given in Fig. 7. Among shrimps, the catch rate was the highest for *M. dobsoni* at all the stations studied, and the same was the lowest for *P. indicus*. The catch rate of *M. dobsoni* varied from 5.21 kg at station 4 to 11.49 kg at station 5. The highest CPUE for *M. dobsoni* among shrimps was reported earlier by Nandakumar (2004), who studied the shrimp fishery of Cochin backwaters with stake nets.

One-way ANOVA of the catch rates of total resources, shrimps and fishes between different stations was carried out to determine the significant variations between stations. Results revealed that the variations with respect to total resources and shrimps were significant ($p<0.05$), but the variations in the case of fishes were not significant. *Post hoc* comparisons of the catch rates of

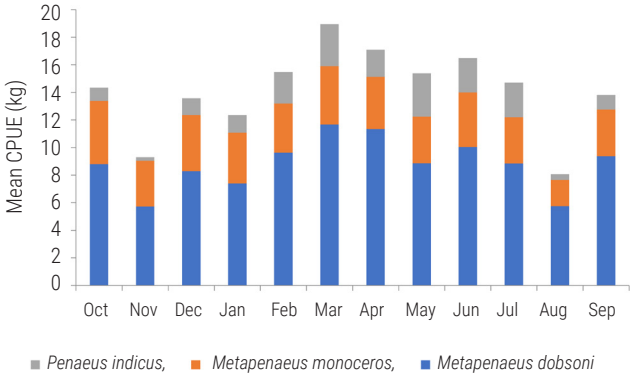

Fig. 5. Species-specific catch rates of shrimps in different months in stake net landings

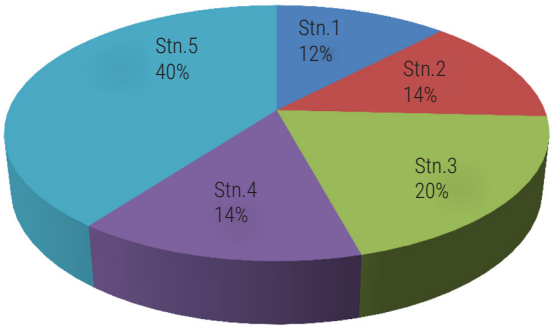

Fig. 6. Station-wise landings by stake nets in the Chettuva Estuary

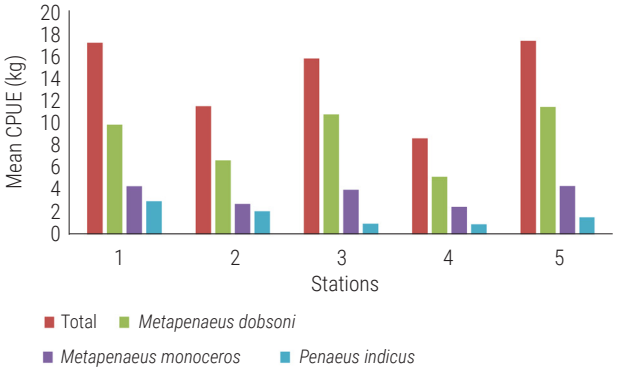

Fig. 7. Species-wise catch rates of shrimps at different stations in stake net landings

total resources and shrimps between stations were derived. The results of *post hoc* tests indicated significant variations ($p<0.05$) between similar stations in terms of catch rates of total resources and shrimps, except between Stations 2 and 3, where significant variations were observed for shrimps only. The variations in catch rates between stations may be attributed to fluctuations in tidal amplitude.

The study indicates that considerable quantities of fishery resources, especially shrimps, are being landed by stake nets in the Chettuva Estuary and the majority of them are juveniles, as evidenced by the modal length class observations. These juveniles of fishes and shrimps trapped in the net have no commercial value and they are mostly sun dried or discarded, thereby depleting the stock of the resources. Since estuaries and backwaters act as the backbone of marine fisheries, this indiscriminate exploitation of juveniles is a serious issue and have to be properly addressed. While studying the stake net fishery in the backwaters of Kerala, Thomas *et al*. (2008) reported that the sizes of the three main species of shrimps, *viz. M. dobsoni, M. monoceros* and *P. indicus* caught by stakenets are smaller than the size at first maturity and they opined that the fishing gear in its present form is harmful to fishery resources. The exploitation of juveniles by stake nets has also been reported previously by many workers (Vijayan *et al*, 2000; Vimalraj *et al*., 2014; Jyothilal *et al*., 2015; Muthupandi *et al*., 2020; Kumar *et al*., 2023a). The exploitation of juveniles is mainly due to the small cod end mesh size of the stake nets used. In the present study, the cod end

mesh size was 8 mm and Kurup *et al*. (1993) reported that 90% of the stake nets operating in Cochin backwaters have a cod end mesh size of less than 13 mm, of which 47% are less than 8 mm. Kumar *et al*. (2023 a) observed a cod end mesh size range of 12-16 mm in stake nets operating in the Ashtamudi Estuary. While studying non-selective fishing gear in the Hooghly Matlah Estuary in West Bengal, Ramesan *et al*. (2009) reported that bagnets used by artisanal fishermen have a cod end mesh size of 10 mm and according to Ramesan (2019), non-selective and destructive estuarine set bagnets are restricted or banned in various places in West Bengal, as they capture the post--larvae and juveniles of various aquatic organisms. While studying the fisheries and environmental assessment of different backwaters on the south-western coast of India, CIFRI (2005) recommended an urgent need to restrict the mesh size of the stake net along with that of other gear to ensure sufficient time for the growth of young ones, and they suggested a minimum mesh size of 18 mm. Thomas *et al*. (2008) carried out a detailed study on the size of *M. dobsoni, M. monoceros* and *P. indicus* landed by stake nets operating with different cod end mesh sizes and proposed an optimum mesh size of 24 mm to minimise the fishing mortality of juvenile shrimps. In the present study, *M. dobsoni, M. monoceros* and *P. indicus* were also found to contribute to the shrimp fishery and since shrimps formed the major share of the stake net landings in this estuary, increasing the cod-end mesh size for the stake nets is recommended to minimise the adverse effects on the stocks of the fishery resources. As estuaries are considered nursery grounds for many finfishes and shellfishes, effective management measures must be taken for resource sustainability. However, conservation measures must be implemented through a democratic process by creating awareness and considering the views of fishermen and other stakeholders so that the measures can be successfully implemented.

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