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Research Article

Fish Composition and Efficiency of Stake Nets in Puthenvelikkara Backwaters of Vembanad Lake, Kerala, India

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Abstract

Vembanad lake is the second largest brackish water lake in India and is known for its rich biodiversity. The study investigates the fish diversity, stake net fishing and seasonal variation in species distribution along the Puthenvelikkara backwaters of Vembanad Lake. A total of 30 sampling events using different gears were made during the period from January 2020 to February 2021. Total 2301 individuals were encountered, comprising 54 finfish species and 7 shellfish species from 34 families, 13 orders and 50 genera. Fish abundance peaked during pre-monsoon season, and the lowest were recorded in post monsoon season. *Mugil cephalus, Penaeus indicus, Etroplus maculatus, Etroplus suratensis, Stolephorus indicus, and Ambassis ambassis* were found to be the dominant species in the catch. Stake nets are predominantly utilized to target prawns, which waft with the tides. The Gross Energy Requirement (GER) was calculated to be 5.19 GJ.t fish^{-1}, which is surprisingly excessive for a stationary passively operated gear. The obtained energy efficiency ratio was 0.65, while the energy intensity value was 1.54. The high value of GER of this passively operated, non-motorized gear system is due to the low magnitude of landing by the gears.

Keywords: Fish Composition; Stake Net Fishing; Energy Analysis; Puthenvelikkara

Introduction

Vembanad is one of Kerala's biggest tropical wetland systems, overlaying 2,033 km^2 and bordered with the districts of Alappuzha, Kottayam, and Ernakulam (Kurup., *et al*. 1990) [18]. With a catchment vicinity of 14500 km^2, it is South India's 2nd largest brackish water arrangement. Estuaries, tidal ponds, swamps, mangroves, and a component of the distinctive man-made property have notably improved the vicinity (Ajay, 2021) [1]. The Lake was also designated as a wetland of international significance under the Ramsar Convention in 2002 (GOI 2008) [14] and a critically vulnerable coastal region (Singh, 2016) [25] as a result of its environmental importance as an essential ecosystem service provider and a vital habitat for a diverse range of floura and fauna. The lake connects to the Arabian Sea in two places: Azhikode, which is at least 100 m wide and fairly deep, and Cochin, which is 450 m wide (Ajay, 2021; Ajay and Krishnan AR, 2021; Ajay., *et al.* 2021) [1-3]. The lake has been divided into two zones: a freshwater dominant southern zone and a saltwater dominant northern zone, owing to the construction of the Thanneermukkam barrage. The fragmented mangroves and the backwaters with several interlinking canals have been identified as one of the major nursery grounds of several species of shrimps (Menon, 1951; George,1958) [12,21].

Taking advantage of the rich shrimp resources and the good tidal flux, stake nets have been operated in Vembanad Lake for several decades. The stake net shrimp fishery has been well documented since 1950s which gives a clear picture of the richness of this important coastal ecosystem (Menon and Raman, 1962; George, 1973; Nandakumar, 2004) [13,22,23]. Such bag nets are operated in different estuarine areas especially in Maharashtra and West Bengal (Manisseri and Rao, 2000) [20]. However, threats to this fishery from human activities has not been indicated as a problem in the earlier studies. During the past two decades, the coastal districts of Kerala witnessed high growth in population and urbanization and one of the consequences being the increase in generation of Non-degradable solid waste, of which plastics form a major component. These reach the sea through rivers and estuaries due to improper disposal at its site of origin. Sometimes they are discarded directly into the aquatic ecosystem. Globally, the Occurrence of plastics and similar non-biodegradable litter in different types of habitats were studied (Gall and Thompson, 2015) [11]. Since these persist in the ecosystem in one form or the other for centuries, they are considered as one of the most serious threats to the marine ecosystem (Barnes., *et al*. 2009) [4]. A preliminary study conducted in the northern part of Vemaband Lake to assess the quantity of litter in fishing gears indicated that the stake net fishery is severely impacted by the quantity of litter which gets accumulated in the nets (Kripa., *et al*. 2012) [17].

Materials and Methods

Sampling area

Putenvelikkara is located on the banks of the Periyar River, Chalakudi and Kotapuram lagoons. At Elentikara, the Chalakkudi river flows into the Periyar river. Lagoons are the result of natural forces such as tides. The total area of the Putenvelikkara village is 19.87 km^2 (Figure 1). An ancient belief is that the village was formed as a result of a flood (Veliettam Malayalam), and this belief is confirmed by the discovery of fossils of aquatic organisms in the village (Ajay., *et al.* 2021) [3].

Sampling schedule

From January 2020 to February 2021, monthly/fortnight sampling was conducted in the Puthenvelikkara backwaters of the Vembanad wetlands with the assistance of local fishermen, using various types of nets such as gillnets, cast nets, Chinese dip nets, stake nets, hook and line, and hand picking methods (Ajay., *et al.* 2021) [3]. The design details and energy analysis of the Stake net system used in that area were obtained and represented in accordance with FAO guidelines. Fish of the appropriate size were collected and identified using the FAO catalogue (Thomas., *et al.* 2007) [27]. The table 1 shows the market value of fishes along with its abundance during various seasons.

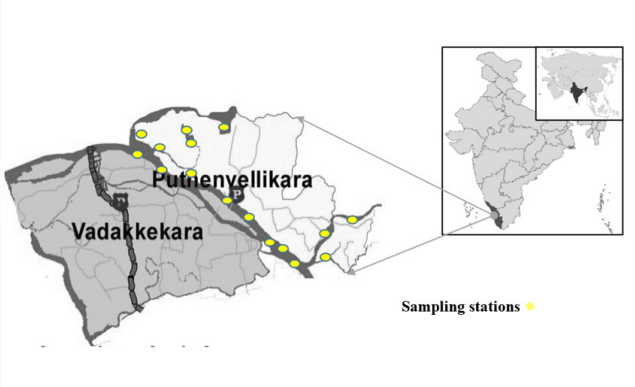

Figure 1: Map showing sampling stations.

Results and Discussion

Fish abundance peaked during pre-monsoon season, and the lowest were recorded in post monsoon season. The dominant species in the catch were *Mugil cephalus, Penaeus indicus, Etroplus maculatus, Etroplus suratensis, Stolephorus indicus,* and *Ambassis ambassis* (Ajay., *et al.* 2021) [3] (Table 1). Out of 37.66% finfishes around 37.50% was from *Etroplus suratensis* followed by Mullets (31.90%), Catfishes (15.40%), *Ambassid* sp. (5.60%), *Scinaeid* sp. (5.20%) and others (4.40%). While among Crustacean resources, *Metapenaeus dobsoni* constitute 62.13% to the fishery followed by *Penaeus indicus* (15.84%), *Metapenaeus monoceros* (11.00%), *Macrobrachium idella* (2.96%), *Scylla serrata* (2.64%), *Macrobrachium rosenbergii* (2.20%), *Penaeus monodon* (1.83%) and others (1.40%).

Stake net fishery along Puthenvelikkara Backwaters

Stake nets are a type of stow net that is used in the artisanal sector around the world (Brandt, 1984) [8]. Filtration is used to catch fish in this passive stationary gear. The organisms that drift with the tide enter the net set against the current, and the catch is collected in the codend as the water filters through the gear. Fish-

Order	Family	Species	Common name	Abundance			Habitat	Max. Length (cm)	Market price Rs./ kg
				Oct to Jan	Feb to May	June to sept			
Perciformes	Pristolepidae	*Pristolepis rubripinnis* Britz Kumar	Leaffish	*	⁂	*	F	13.6	_
	Leiognathidae	*Leiognathus dussumeiri* (Valencienne, 1835)	Dussumier's ponyfish	⁂	*	⁂	BM	14	90- 155
		Leiognathus equulus (Forsskal, 1775)	Common ponyfish	⁂	⁂	⁂	FBM	28	100-150
		Eubleekeria splendens (Cuvier, 1829)	Splendid ponyfish	*	⁂	*	BM	17	90-175
		Photopectoralis bindus (Valenciennes, 1835)	Orangefinned ponyfish	*	⁂	*	BM	11	110- 185
		Leiognathus brevirostris (Valenciennes, 1835)	Shortnose ponyfish	⁂	⁂	⁂	BM	13.5	70- 200
		Deveximentum insidiator (Bloch, 1787)	Pugnose ponyfish	⁂	⁂	*	BM	10.5	135- 220
		Gazza minuta (Bloch 1795)	Silver Bellies	*	⁂	*	BM	14	200-230
	Cichlidae	*Pseudetroplus maculatus* (Bloch, 1795)	Orange chromide	⁂	⁂	*	FB	9.5	100-150
		Etroplus suratensis (Bloch, 1790)	Pearl spot	*	*	⁂	B	40	400-700
		Oreochromis mossambicus (Peters, 1852)	Mozambique Tilapia	⁂			FB	39	150-200
		Oreochromis niloticus (Linnaeus, 1758)	Nile Tilapia	⁂			FB	60	120-200
	Ambassidae	*Ambassis ambassis* (Lacepede, 1802)	Commerson's Glassy	⁂	⁂	⁂	FBM	15	40-75
		Parambassis sp.	Glassfish	⁂	⁂	⁂	FB	17.5	45-80
	Gerridae	*Gerres limbatus* Cuvier, 1830	Saddleback silver biddy	⁂	⁂	⁂	BM	15	50-90
	Carangidae	*Caranx ignobilis* (Forsskål 1775)	Giant trevally	*	⁂	*	BM	170	180- 600
	Glossogobidae	*Glossogobius giuris* (Hamilton, 1822)	Tank goby	⁂	*	⁂	FBM	50	150-175
	Lethrinidae	*Lethrinus* sp.	Emperor fish	*	⁂	*	BM	52	140-400
	Lutjanidae	*Lutjanus argentimaculatus* (Forsskal,1775)	Mangrove red snapper	*	⁂	⁂	FBM	150	150-250
	Scatophagidae	*Scatophagus argus* (Linnaeus, 1766)	Spotted scat	*	⁂	⁂	FBM	38	100-145
	Sillaginidae	*Sillago sihama* (Forsskål 1775)	Silver sillago	*	⁂	*	BM	31	150-350
	Sciaenidae	*Johnius dussumieri* (Cuvier 1830)	Sin croaker	*	⁂	*	BM	40	180-340

Anabantiformes	Anabantidae	*Anabas testudineus* (Bloch 1792)	climbing perch	⁑	*	*	FB	25	125-235
	Channidae	*Channa striata* (Bloch, 1793)	Striped snakehead	⁑	*	⁑	FB	100	345-450
		Channa marulius (Hamilton 1822)	Great snakehead	⁑	*	⁑	F	183	280-400
		Channa punctata (Bloch, 1793	Spotted Snakehead	⁂			FB	31	325-420
	Heteropneustidae	*Heteropneustes fossilis* (Bloch 1794)	Stinging catfish	*	*	⁑	FB	31	450-600
	Nandidae	*Nandus nandus* (Hamilton, 1822)	Gangetic Leaffish	л			FB	20	125-200
Clupeiformes	Clupeidae	*Thryssa malabarica* (Bloch, 1795)	Malabar thryssa	*	*	⁑	BM	17.5	75-110
		Stolephorus indicus (Van Hasselt, 1823)	Indian anchovy	*	*	⁑	BM	15.5	200-330
		Anodontostoma chacunda (Hamilton, 1822)	Chacunda gizzard shad	*	⁑	*	FBM	22	75-110
		Nematalosa nasus (Bloch, 1795)	Bloch's gizzard shad	*	⁑	*	FBM	25.5	90-190
Siluriformes	Mystidae	*Mystus malabaricus* (Jerdon 1849)	Jerdon's Mystus	*	*	⁑	FB	15	80-110
	Ariidae	*Arius maculatus* (Thunberg, 1792)	Spotted sea catfish	*	⁑	*	FBM	80	95-175
	Siluridae	*Ompok malabaricus* (Valenciennes, 1840)	Goan catfish	*	⁑	*	F	51	135-200
	Bagridae	*Horabagrus brachysoma* (Günther, 1864)	Günther's catfish	*	⁑	⁑	FB	45	50-100
Beloniformes	Hyporhamphidae	*Hyporhamphus xanthopterus* (Valenciennes, 1847)	Red-Tipped Half Beak	⁂			FBM	15	150-255
		Hyporhamphus limbatus (Valenciennes 1847)	Congaturi halfbeak	*	⁑	⁑	FBM	35	135-245
	Belonidae	*Xenentodon cancila* (Hamilton 1822)	Freshwater garfish	*	⁑	⁑	FB	40	150-300
Mugiliformes	Mugilidae	*Mugil cephalus* Linnaeus 1758	Flathead grey mullet	*	⁑	*	FBM	100	140-450
		Liza tade (Forsskål, 1775)	Green back mullet	⁑	⁑	⁑	FBM	70	125-400
Pleuronectiformes	Cynoglossidae	*Cynoglossus macrostomus* Norman, 1928	Malabar tonguesole	⁑	⁑	*	FM	30	100-120
	Soleidae	*Brachirus orientalis* (Bloch and Schneider, 1801)	Oriental sole	⁑	*	⁑	FBM	38	250-355

Cypriniformes	Cyprinidae	D*awkinsia filamentosa* (Valenciennes, 1844)	Black-spot barb	*	⁂	⁂	FB	18	Ornamental
		Gibelion catla (Hamilton 1822)	Catla	*	⁂	*	FB	182	
		Puntius sarana (Hamilton, 1822)	Olive barb	⁂	⁂	⁂	FB	42	
		Puntius mahecola (Valenciennes, 1844)	Mahecola barb	*	⁂	⁂	F	8.9	
		Amblypharyngodon melettinus (Valenciennes, 1844)	Attentive Carplet	⁂	⁂	⁂	F	8	
		Labeo dussumieri (Valenciennes, 1842)	Labeo	*	⁂	⁂	F	50	250-320
		Labeo rohita (Hamilton, 1822)	Rohu	⁂			FB	200	240-280
		Puntius amphibius (Valenciennes, 1842)	Scarlet Banded Barb	л			F	20	ornamental
Venerida	Cyrenidae	*Villorita cyprinoides* Gray 1825	Black clam	⁂	⁂	__	FB	__	120-190
Elopiformes	Megalopidae	*Megalops cyprinoides* (Broussonet, 1782)	Indo- pacific tarpon	⁂	⁂	⁂	FBM	150	150-280
Anguilliformes	Anguillidae	*Anguilla bicolor* (McClelland, 1844)	Short-Fin Eel	⁂			FBM	123	275-390
Cyprinodontiformes	Aplocheilidae	*Aplocheilus lineatus* (Valenciennes, 1846)	Striped Panchax	ш			FB	10	ornamental
Decapoda	Penaeidae	*Penaeus indicus* Milne- Edwards, 1837	Indian white prawn	⁂			B	18.4	280-400
		Penaeus monodon Fabricius, 1798	Giant tiger prawn	⁂			B	33.6	350-450
		Metapenaeus monoceros (Fabricius, 1798)	Speckled shrimp	ш			B	15	250-300
	Palaemonidae	*Macrobrachium rosenbergii* (De Man, 1879)	Giant fresh water prawn	ш			FB	34	455-700
		Macrobrachium idella (Hilgendorf, 1898)	Freshwater Prawn	л			F	33	455-700
	Portunidae	*Scylla serrata* (Forsskål, 1775)	Giant Mud Crab	л			B	28	300-750
Habitat: F- Fresh water, B- Brackish water, M- Marine; Monsoon: June–September; Post-monsoon: October–January; Pre-monsoon: February–May; Absence - *, Presence- ⁂, Rarely seen - ⁂, Less seen- л, Moderately seen - ш									

Table 1: Finfish and Shellfish Diversity with Market Trend along the Puthenvelikkara Back waters of Vembanad Lake, Kerala.

ermen use traditional non-motorized canoes for stake installation, gear placement, and catch collection. For operation, canoes ranging in size from 5.5 to 7.6 metres and manned by 2-3 fishermen are used. Manual paddling is used to propel the canoe.

The stake net is a conical bag net composed of numerous cylindrical sections of netting that gradually decrease in diameter from the mouth to the codend. Hridayanathan and Pauly (1993) [15] and Thomas., *et al*. (2007) [27] reported variations in the structure and construction of stake nets used along Kerala's backwaters. Construction features and size have also changed over time, and the designs operating in the area during the period of observation differed in several ways from the descriptions given earlier by Hridayanathan., *et al*. (1990) [16], Pauly (1991) [24], and Hridayanathan and Pauly (1993) [15]. The design of stake nets used in the Puthenvelikkara backwaters is given in figure 2. The gear is constructed with polyamide netting. From mouth to codend, the mesh size shranks from 200 to 60 mm in the three front sections and from 18 to 12 mm in the sections following up to the codend. The codend had a mesh size of 10 mm. In the corresponding sections, the twine size ranged from R635tex for 200 mm meshes to R235tex for 100 mm meshes and R155tex for the rest of the netting. As framing ropes, polypropylene ropes with a diameter of 10 mm were used. The upper and lower frame ropes were 4.5 m long each, and the side frame ropes were 9.0 m long each. Loops were provided at the four corners to allow for the bunching of a few meshes in the adjacent pieces of netting and for tying to the stakes. The gear was built with approximately 12.0 kg of webbing and 1.4 kg of polypropylene rope. Its mouth area was 40.5 m^2.

Prior to the operations, stakes are placed in areas of the fishing grounds where tidal currents are strong. Areca nut tree trunks are commonly used as stakes. In addition to the main stakes, auxiliary stakes of smaller diameter that are obliquely placed as props are tied to the main stake for added strength. To facilitate the operation of several nets, the stakes are installed in series at a distance of 4.5 m. According to Pauly (1991) [24], the stakes are installed by six or seven fishermen working from two canoes.

In the area of operations, the fishing season is open all year. In a lunar month, there are two 10-day fishing periods known as thakkom in vernacular. The first fishing period begins two or three days before the new moon and lasts two to three days after that. The second fishing period occurs around the time of the full moon. During these times, the nets are activated twice a day, once in the morning and once in the afternoon.

Edwardson (1976) [9], Watanabe and Uchida (1984) [30], Endal (1989) [10], Boopendranath (2000) [6], Boopendranath and Hameed (2009) [5] and others have reported on energy analyses of fishing systems. The Gross Energy Requirement (GER) is the total amount of nonrenewable energy consumed in the production of a good or service. The GER is a measure of the intensity with which nonrenewable resources are used. It reflects the amount of non-renewable energy depleted from the earth's inherited store in order to create and make available a good or service (Slesser, 1988) [26]. The GER does not include renewable energies or human energy. The GER in the fish harvesting system up to the point of landing is estimated in this study. The stake net system's energy inputs are estimated to be 2.13 GJ (Table 2).

The traditional plank canoe used for carrying the gear and catch contributed the remaining GER, which was 95 percent made up of fishing gear and stakes. The GER was estimated to be 5.19 $GJ.t\ fish^{-1}$, which was quite high for a stationary passively operated gear. The low magnitude of landings by this gear accounts for the high GER value of a passively operated, non-motorised gear system like stake net. The catch, on the other hand, is made up of high unit value components, which makes the operations economically viable. The energy ratio, also known as the energy efficiency ratio, is the ratio of metabolizable energy produced to non-renewable energy consumed (energy output/energy input). It is commonly used to analyse food production systems (Slesser, 1988) [26]. The amount of energy required to produce one unit of output energy is referred to as energy intensity (energy input/energy output). It is the reciprocal of the energy ratio and equals GER in terms of output energy (Slesser, 1988) [26]. The obtained energy efficiency ratio was 0.65, while the energy intensity value was 1.54.

Boopendranath and Hameed (2009) [5] calculated the GER per tonne of fish landed by non-motorised gill netting operations to be 0.61. The GER value per tonne of fish landed by stake net operations (5.19 GJ) was 8.5 times greater than that of non-motorised gill netting operations. Mammen (1984) [19], Thomas., *et al*. (1999) [28], Vijayan., *et al*. (2000) [29], Thomas., *et al*. (2007) [27] and others have reported a predominance of juveniles in stake net landings. Due to the high GER of stake net operations and the predominance of juveniles in landings, stake net operations in the Vembanad lake must be strictly regulated.

Conclusion

The recorded data on the technical specifications, species diversity and energy utilization of Stake net in the Puthenvelikkara

Component	GJ	Yearly GER, GJ
Operational energy requirement	Nil	
Fishing gear		
Ropes	0.7380	
Netting	0.0820	
Stakes	1.2000	
Subtotal	2.0200	2.0200
Vessel	1.0900	0.1100
Total		2.1300

Table 2: Data on the energy analysis of stake net operation.

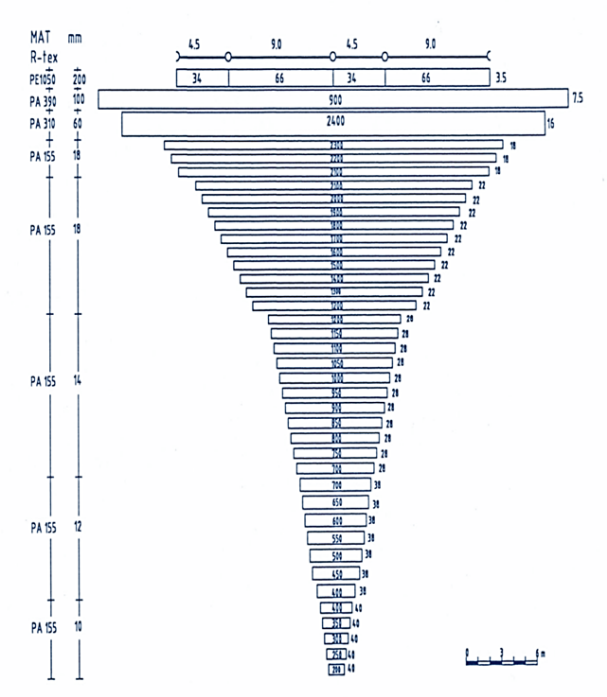

Figure 2: Design of Stake Net.

Backwaters would serve as a base line information for the technological modifications the method may go through in the coming years.

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Conflict of Interest

The authors declare that there are no conflict of interest.

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