STUDIES ON THE RIVERINE FISHING GEARS OF CENTRAL KERALA

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DOCTOR OF PHILOSOPHY

by

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Dedicated to
my parents

DECLARATION

I, M. Baiju do hereby declare that the thesis entitled "*Studies on Riverine Fishing Gears of Central Kerala*" is an authentic record of research work carried out by me under the supervision and guidance of Dr. C. Hridayanathan, Professor (Rtd.), School of Industrial Fisheries, Cochin University of Science and Technology, Cochin in partial fulfilment of the requirements for the Ph.D. degree in the Faculty of Marine Sciences and that no part of it has previously formed the basis of the award of any degree, diploma, associateship, fellowship or any other similar title of any University or Institution.

Cochin – 16
25.02.2005

M. Baiju

CERTIFICATE

This is to certify that the thesis entitled "*Studies on Riverine Fishing Gears of Central Kerala*" is an authentic record of the research work carried out by Shri. M. Baiju under my supervision and guidance at the School of Industrial Fisheries, Cochin University of Science and Technology, Cochin, in partial fulfilment of the requirements for the degree of Doctor of Philosophy of the Cochin University of Science and Technology, and that no part thereof has been submitted for any other degree.

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Dr. C. Hridayanathan

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Contents

SYMBOLS AND ACRONYMS

◊	mesh
Ø	diameter
dia	Diameter
PA	Polyamide
PP	Poly propylene
PE	Poly ethylene
HDPE	High density poly ethylene
PVC	Poly vinyl chloride
FAO	Food and Agricultural Organisation
FAD	Fish aggregating Devices
HR	Head rope
FR	Foot rope
Multi	Multifilament
Mono	Monofilament

Chapter I

INTRODUCTION

Chapter 1

INTRODUCTION

India is one of the leading nations in the world in inland water resources with vast and varied resources. It is the second largest producer of inland fish, next only to China. India's inland water resources are as diverse as they are plentiful. It is an important source of food and provides employment and sustenance to sizeable section of the society in rural areas. Aquatic resources of inland origin are harvested from rivers, its tributaries, distributaries, natural lakes, bheels, jheels, multipurpose reservoirs, community tanks, household ponds, irrigation canals, water logged paddy fields, burrow pits and innumerable ditches by the sides of rivers, canals, roads and railway tracks. (Varghese, 2002).

During the period 1951-1978, the recorded production gradually increased from 0.218 million t in 1951 to 0.875 million t in 1976. During the corresponding period the total world inland production was 2.9 million t and 10.35 million t. The increase in Indian and global inland fish production over this period was 301 % and 256 %, respectively. By the year 1998, the Indian inland fish production rose to 2.57 million t and global production to 28 million t. It has also been estimated that the inland sector, including the rivers and the reservoirs, has a potential for producing over 4.5 million t, annually. (Varghese, 2002). To achieve this national goal, a scientific understanding of all the water bodies supporting capture fisheries is imperative. (Sheshappa, 2001 and Kamal, 2002)

All the inland resources offer immense scope and potential for developing the capture fisheries. (Jhingran, 1989; Jhingran, 1989a). Indian rivers carry a surface runoff 167.23 million hectare-meter. The different river systems in the country having an estimated linear length of 45,000 km provide traditional source of livelihood to thousands of fishermen and contribute significantly to the inland fish production (Chandra, 1989)

Rivers and reservoirs of India, harbour a rich and varied spectrum exceeding 400 species, which include commercially important fishes such as Indian major carps, mahseer, minor carps, snow trouts, peninsular carps, catfishes, featherbacks, murrels and a number of exotic species.

Riverine capture fishery resources have been showing a declining trend in recent years. Increased sedimentation of riverbed, water abstraction, environmental degradation, marked alteration in the river courses and indiscriminate fishing have been detrimental to the riverine fishery resources. Catches have declined from 1 t. $km^{-1}.yr^{-1}$ in 1958 to 0.3 t. $km^{-1}.yr^{-1}$ in 1995. (Anon, 2002)

Some disturbing trends are already discernible in riverine fisheries of the country, especially Ganga. A host of manmade changes in the riverine habitat due to large scale water abstraction for irrigation, construction of dams and barrages, soil erosion due to deforestation in the catchment areas and water pollution from industrial, agricultural and municipal wastes have all had devastating effects on the fish stocks of Indian rivers. (Kamal, 2002). Excessive withdrawal of water from the river courses for agriculture, domestic and industrial uses leaving inadequate water for comfortable fish life is also a major factor responsible for the depletion of fish germplasm resources (Menon, 1989; Kirchhofer and Hefti, 1996).

The major water resources of Kerala state include rivers, brackish water lakes and reservoirs. Rivers in Kerala has a total water spread of 85,000 ha. Among the 44 rivers flowing through the state only three are flowing eastwards (Bhavani, Kabbini and Pambar) while all others flow westwards and join the Arabian Sea. The total length of rivers and canals in the state is 3092 km. (Anon, 1999). All the rivers in the state together provide a total catchment area of 37884 km^2 (Anon 1995).

According to recent estimate there are about 30 reservoirs in the state spread over an area of 29,635 ha (FAO, 1997). Malampuzha, Sholayar, Neyyar, Kallada, Idukki, Periyar, Bhoothathankettu are some of the major reservoirs of the state. Although the reservoirs support many varieties of fishes like carps, tilapia and catfishes, no attempt have been made till recently to develop them on scientific lines for fish yield optimization. Besides these large reservoirs, many of the small reservoirs of the state like Chulliar, Pothundi, Mangalam, Meenkara and Muthalamada are not being utilized efficiently for the development of reservoir fisheries in the state (Kutty, 1997).

Brackish water area occupying 2,42,800 ha forms an important resource base for augmenting culture fisheries (BOBP, 2001). Around 79% of the brackish water area available in Kerala remains unutilised

(Varghese, 2001). The tanks and ponds present in various parts of the state constitute around 3,300 ha. Potential area for freshwater culture comes to around 1,17,935 ha (Varghese 2001). Kerala also posses 0.243 million ha of wet and marshlands in the form of bheels, oxbow lakes and derelict waters (Anon, 1999)

Inland Fish Production

With rapid overall development of the country and owing to ever-increasing demand of fish as food, the aquatic ecosystems are under constant pressure of man-induced stresses to the detriment of the aquatic flora and fauna (Jhingran 1991, Lal and Pamdey, 1995).

The fish and fisheries play a crucial role in the well being of Kerala's economy. The inland fish production of Kerala was estimated at around 73,900 t against 5,75,500 t from the marine sector (Sudarsan, 2000). The reservoirs are one of the greatest potential fishery resources of Kerala. However, annual production of these reservoirs is estimated at a low of 5-8 $kg.ha^{-1}yr^{-1}$ (Ravikumar, 2000). Out of the thirty reservoirs seventeen remain unutilised as far as fisheries is concerned (FAO, 1997)

The inland fish production in the country has registered a phenomenal increase during the last 5 decades. As against 0.2 million t produced in 1951, the present production of fish (1988) in the country is estimated at 2.2 million t in capture sector. The domestic demand of fish in the country is required to be more than 13 million t (Kamal, 2002a).

The vast riverine resources of the state remains largely unutilized with regard to augmentation of existing stock and introduction of new stocks. Localised efforts in this direction do not have the monitoring facility to keep track of improvements (John *et. al*, 2002). Besides the changing ecology due to construction of dams, siltation from the catchment areas has destroyed the feeding and breeding grounds of many fishes. (Sehgal, 1994)

The fast growing fish species of inland waters include the major carps (rohu, mrigal and catla) mahseers, catfish (*Aorichthys seenghala*, *A. aor, Wallago attu, Silonia silondia*, *Pangasius pangasius*), murrels (*Channa striatus* and *C. marulius*), clupeids (*Hilsa ilisha*) and, at the high altitudes, the schizothoracids. (Jhingran, 1989; Jhingran, 1989a)

A good number of exotic fishes, which were introduced to increase the fish production through aquaculture, have found a firm footing in Indian waters. The grass carps (*Ctenopharyngodon idella*), the silver carps (*Hypophthalmichthys molitrix*), trouts (*Salmo trutta fario, Salmo gairdneri*) and tilapias (*Oreochromis mossambicus*, *O. niloticus*) have been cultured in India with varying degree of success. Among candidate species suggested for the introduction in the country are black carps (*Mylopharyngodon pisceus*), bigheaded carps (*Aristichthys nobilis*), tilapia (*Tilapia zilli*) and channel catfish (*Ictalurus punctatus*). (Jhingran, 1989)

Studies in the rivers and streams of Kerala, part of Western Ghats could bring out the occurrence of about 170 freshwater fish species of which 66 species belong to potential food fish category, while 104 species can be considered as potential ornamental varieties. (Kurup, 2001)

Fishing Gears

Till 18th century fishing gear and fishing methods were not considered in any great detail in fisheries publications. The vast inland fishery resources are far from fully exploited during the first half of the 19th century, due to the inadequacies of the existing fishing gear and methods (Joseph & Narayanan, 1965). French encyclopaedists were the first to give publicity to catching methods (Brandt, 1972). Studies on fishing gear technology can undoubtedly make a considerable contribution to the progress of fisheries in a developing country like India. (Pauly, 1991)

Gulbrandson (1988) has observed that developing countries attached increasing importance on traditional fishing to provide employment and income of fishing community. Willman and Garcia (1985) have observed that artisanal fisheries require small investment in craft and operate gears which are energy saving and requires little inputs and provide food and income to large number of fishing families. Kristjonsson (1968) has observed that the traditional fishing sector has good talent and fishery experience, but lack in entrepreneurship and capital compared to industrial fisheries sector.

Fishery resources of the inland water areas are still exploited by traditional or artisanal fishing methods and gears. Since the fishing opportunities vary at different areas, both as regards species and as regards the nature of the fishing ground, and also because of variations in weather, currents, other environmental factors and local availability of materials and skills, a variety of different types of traditional fishing gear have been developed over the centuries. With the advent of new fishing techniques, many of the fishing techniques that were efficient in the past have become non-remunerative and hence inefficient. Naturally they are being phased out (George, 1995).

The earliest work in this field is that of De (1910) who in his report on the fisheries of Eastern Bengal and Assam has mentioned some of the fishing methods of the river. Hornell (1924), while reviewing the fishing methods of the Ganges, has referred to some of the fishing implements. Job and Pantallu (1958) have reviewed the fish trapping methods of the river system. Hornell (1925) reveals some of the backwater fishing gears in Coromandel coast. Fishing gear and methods of Mysore and Travancore have been described by Bimachar (1942) and Gopinath (1953), respectively. George (1971) has given an account of the inland fishing gears and methods of India. Ahmed (1956), Saxena (1964) and Joseph and Narayanan (1965) have studied respectively the fishing methods and gear of East Pakistan, river Ganges near Allahabad and river Brahmaputra in Assam. The fishing methods in the Nilgiri District of Tamil Nadu were reported by Wilson (1920). Different fishing gear systems are described by Brandt (1972), Kristjonsson (1959), Welcomme (1985) and others.

The distribution of fishing gear in various inland systems is mainly depending upon the topography of the area and behaviour of the fish. In the pond system, cast net, stick-held seine nets, plunge basket, lantern nets, gill nets, traps and hand lines are important. The drift gillnets, fixed gillnets, cast net, different kinds of lines and fish aggregating devices (FAD) are extensively used for fishing in rivers. The important gears used for harvesting freshwater prawns are the fixed push net, stake net, dip net and cast net.

Davis (1958) has divided fishing gear into five types while Klust (1959) has grouped into three, based on the stress and strain developed on the fishing gear while under fishing. A broad classification into active and passive fishing gear were made by Brandt (1984). Nedelec (1982) has classified fishing techniques into 20 groups.

Hornell (1925, 1938, 1950), Panicker (1937), Gopinath (1953), Shetty (1965) and Kurup (1982) have attempted to describe the fishing gears of backwaters of Kerala. However, very little experimental work in riverine fishing techniques had been conducted in Kerala with the objectives of improving overall efficiency of inland gear systems. Hence a detailed study on the design, construction, operation and operational economics of the major fishing gears viz. gillnet, cast net and lines operated in rivers of central Kerala is undertaken in this research work.

A number of diverse physical features such as deep channels, sometimes wide, sometimes narrow, creeks long and winding, often ending blindly, shallow with muddy bottom, covered with grass and weeds, fluctuations in water column, dry season are observed in river systems. Methods have to vary to meet the ingenuity of fishermen is depending with these varied fishing condition is well known. The distribution of fishing gear in various inland systems is mainly depending upon the topography of the area and behaviour of the fish (Sheshappa, 2001a). There are a number of fishing gears used by the local and migrant fishermen in the entire length of the river system. The accessibility of rivers and the ease with which fishing can be carried on here often induce men of other occupations to try their hand at fishing in the slack season of their own calling, or after their ordinary day's work is done.

Studies on inland fishing gears have not received adequate attention in the country. Details regarding structure, construction and operations of many of the gears are yet to be collected.

Riverine Resources of Kerala

There are 41 west flowing rivers, most of them having their source in the Western Ghats and draining into the Arabian Sea (Fig. 1). Some of these rivers have a portion of their catchments in the adjoining states of Karnataka and Tamil Nadu (Table 1). In addition, there are 3 rivers, which also originate from the Western Ghats, but they flow eastwards into the State of Karnataka and Tamil Nadu (Anon, 1995).

Seven rivers located in central Kerala viz., the Bharathapuzha River, the Puzhakkal River, the Keecheri River, the Karuvannur River, the Chalakudy River, the Periyar River and the Muvattupuzha River and their major tributaries were selected for this study (Table 2). The rivers covered a total length of 832 km and catchment area of 14,745 sq.km covering the districts of Malappuram, Palakkad, Thrissur, Ernakulam, Idukki and Kottayam.

The Bharathapuzha River

The Bharathapuzha River, the second longest river of the state (Fig. 2) takes its origin at an elevation of +1964 m above MSL from Anamalai Hills and flows through the districts of Coimbatore, Palghat, Malappuram and Trichur and joins the Arabian Sea near the Ponnani Town (Anon, 1974).

Its main tributaries are the Gayathripuzha, the Kannadipuzha or Chitturpuzha or Amaravathi, the Kalpathipuzha and the Thuthapuzha. The Gayathripuzha, one of the major tributaries, originates from Anamalai Hills. In its downward course, the river touches Kollengode, Nenmara, Alathur, and Wadakkancheri. Koniazhi and Pazhayannur and joins the main river at Manannur. This tributary has four main sub tributaries. *viz.*, i) the Mangalam River ii) the Ayalurpuzha iii) the Vandathipuzha iv) the Meenkara River and v) the Chulliar River.

The Kannadipuzha also starts from the Anamalai Hills, flows through Thathamangalam and Chittur and joins the main river near Parli. Three main streams combine to form this river. They are the Palar, the Aliyar and the Uppar. The Tamil Nadu Government constructs two reservoirs in the upper reaches of the Aliyar.

The Kalpatipuzha is formed by four streams, the Koraiyar, the Varattar, the Walayar and the Malampuzha.

The Koraiyar and Varattar originate from the Anamalai Hills and after their confluence, flow towards west where the Walayar stream joins near Tampalam. The river is thereafter known as the Koraiyar. The Malampuzha River joins the Koraiyar about 10 km downstream. The largest irrigation reservoir existing in the State, the Malampuzha is located on this stream. The Walayar is the second storage reservoir constructed on this tributary.

The Thuthapuzha starts from the Silent Valley Hills and after taking a meandering course, joins the main river about 2 km from the Pallipuram railway station. The important stream which feed this tributary are the Kunthipuzha, the Kanjirapuzha, the Ambankadavu and the Thuppanad puzha. The Kanjiramukku stream is also included in this basin.

The length of the river is 209 km with a catchment area of 6186 sq. km. The area of the basin in spread over 11 taluks from the Western Ghats to the Arabian Sea. About two-third of the drainage area of the basin lies in Kerala State and the balance in Tamil Nadu.

The Keecheri River

The Keecheri River also known as the Wadakkancherry River on the Alurpuzha, (Fig. 3) is one of the smallest rivers in the State and is practically dry during summer. The river originates from Machad Malai at about +365 m elevation in the upper reaches of Talappilly taluk forming part of the Western Ghats. The river flows in a north-westerly direction up to Nelluvayi and then takes a south-westerly course up to Choondal. It then changes its direction and flows south-wards up to Mathukkara where it joins the Kole canals. The Kole canals are linked with the backwaters at Enamakkal with exit into the Arabian Sea at Chettuvai. The only important tributary of the Keecheri River is the Choondal thodu (Anon, 1974). The total length of the river is 51 km. It has a total drainage area of 401 sq. km.

The Puzhakkal River

Draining into the Kole lands of Trichur district, the Puzhakkal River, is formed by the confluence of the Parathodu, the Poomala thodu, the Naduthodu and the Kattachira thodu. The Parathodue and Poomala thodu have their origin in the hills of Killannoor village at an elevation of +150 m. The Naduthode rises from the Manalithara Hills on the south side of Machadmalai at an altitude of +525 m while the Kattachira thodu rises from below +75 m near Mudikotty. The river flows past the northern outskirts of

Trichur town (Fig. 4). It has a length of 29 km and drains an area of 234 sq. km (Anon, 1974).

The Karuvannur River

The river originates from the Western Ghats and is fed by its two main tributaries namely the Manali and the Kurumali (Fig. 5). The Manali originates from Vaniampara Hills at an elevation of +365m. The Chimony and the Muply, the two sub-tributaries of the Kurumali originate from Pumalai at an elevation of +1100m. The pillathodu joins the Kurumali just downstream of the confluence of the Chimony with the Muply. (Anon, 1974)

The Manali River flows westwards up to Mundanchira and then southwards up to Nemmenikara. It then turns towards west and subsequently to the south before joining the Kurumali at the Muply flows west through dense forest and then joins together at Elikode to form the Kurumali River. The Kurumali River flows in a westerly direction till it joins the Manali River to form the Karuvannur River.

The Karuvannur River takes a south-westerly direction up to Panamkulam and then a wersterly course. Just before it joins the backwaters, it bifurcates and one branch flows towards south to join the Periyar and Crangannore while the other branch flows northwards and enters the Arabian Sea at Chettuvai. The Karuvannur River has a length of 48 km and drains an area of 1054 sq. km.

The Chalakudy River

The Chalakudy River is formed by the confluence of five streams, viz., the Parambikulam, the Kuriarkutty, the Sholayar, the Karappara and the Anakkayam, originating from the Anamalai Hills of the Western Ghats (Fig. 6). Of these, the Parambikulam and the Sholayar begin from the Coimbatore district in Tamil Nadu and the Karappara and the Kuriarkutty, from the Palghat district in this State at about +470m above MSL. The Anakayam joins the main river 8 km further down at 365 m above MSL. In the initial course, the river passed through thick forests and its flow is broken by many falls till it reaches the plains at Kanjirappally. The main falls in the river are at Peringalkuttu and Athirapalli. After Kanjirappally, the river takes a tortuous course of 35 km, through picturesque and fertile tracts. The banks are high and dotted with houses and cultivated plots. The river finally empties into the right arm of the Periyar at Elanthikkara in Puthervelika village of Ernakulam district. The river derives its name from Chalakudy town, which is the most important town in the basin (Anon, 1974).

The length of the river is 130 km. The total drainage area of the river is 1704 sq.km. Out of this 1404 sq.km lie in Kerala State and the rest 300 sq.km in Tamil Nadu.

The Periyar River

The Periyar, the longest of all the rivers in Kerala, and also the largest in potential, is formed by several streams, having their origin in the Sivagiri Group of Hills at an elevation of about +1830 m above MSL (Fig. 7). From its origin, the river traverses through an immense cliff of rocks in northerly direction receiving several streamlets in its course. About 48 km downstream, the Mullayar joins the main river at an elevation of +854 m above MSL. The river flows west-wards for 16 km and receives a few streams from either bank. About 11 km downstream, the river passes through a narrow gorge. Thereafter the river changes its course and flows in a north-westerly direction and take a winding path till it reaches Vandiperiyar. The river then passes through another gorge, and below the gorge, the Perumthuri Aar joins the river. From here the river flows in a northerly direction for about 18 km till it is joined by the Cheruthoni Aar, at an elevation of +540 m below the Idukki gorge. Here the river turns and flows almost due north till it is joined by the Perinjankutty Aar at an elevation of +305m. The Periyar continues to flow in a northerly direction and takes its major tributary, the Muthirapuzha Aar, coming from the opposite direction. After the confluence, the main river flows in a west-north-westerly direction and descends by about 244 m within a distance of 15 km. At Kokkaranipara the river spill over a cliff of about 30 m heights. After this, the river flows underneath a large rock and during summer the river disappears for some length. From Karimanal, about 16 km down stream of its confluence with the Muthirapuzha, the Periyar is a navigable for country boats. The Thotti Aar joins the main river from right. Further down, the river is joined by the Idamala Aar. Up to the confluence with Idamala Aar, the river course is through virgin forests. Till Kayattuvakayam, the river falls very gently and thereafter in rapid succession up to Malayattoor. In this reach it receives a few more streams. Lower down of Malayattoor, the river takes a meandering course, and flows very calmly for about 23 km through Kalady and Chowara and reaches Alwaye, where the river bifurcates into the Mangalapuzha branch and the Marthanda Varma branch. Upstream of this point, a branch of the river loops off the main river near Kalady to join the principal branch, the Mangalapuzha branch, near Chengamanadu. The Mangalapuzha branch flows north-west, receives the waters of the loop and is joined by the Chalakudy River at Puthenvelikara. These portions are influenced by tides as the bed level in this reach is below MSL. After receiving the Chalakudy River, the Periyar expands itself into a broad sheet of water at Munambam and finally merges with the Arabian Sea. The other branch (the Marthanda Varma branch) flows in a southerly direction. This branch initially splits up into two and flows through the Industrial Complex in the basin and before draining into the Vembanad lake at Varapuzha, splits up further into several small channels (Anon, 1974).

The length of the river from its origin to its confluence with the Arabian Sea is 244 km. The river has a total drainage area of 5398 sq.km., out of which 5284 sq.km lie within the State and the rest 114 sq.km in Tamil Nadu.

The Muvattupuzha River

The Muvattupuzha River is formed by the confluence of three rivers, the Thodupuzha, the Kaliyar and the Kothamangalam (Fig. 8). The Thodupuzha River originates from the Taragam Kanal Hills at +1094 m above MSL. Flowing down in a westerly direction many rivulets, originating from Mar Malai, Konnkally Mala, Kothakal Modu, Vettikkuria Malai join together and form the Vati Aar. Near Valiakandam camp shed the Nach Aar joins the Vati Aar to form the Kadayathurpuzha, one of the tributaries of the Thodupuzha River. Before its confluence with the Vazhipuzha it takes in the Manipuzha thodu also. The Thodupuzha River flows for a length of 38 km in a north-westerly direction and joins the Kaliyar and Kothamangalam Rivers near Muvattupuzha (Anon, 1974).

The Kaliyar is formed by the confluence of the Kamb Aar and the Toni Aar, the Kannadipuzha flowing from Valiya Parantan Hills joins the Kaliyar at Kannadi. Another stream originating from Venniyar Mudi also joins the main Kaliyar River. The Kaliyar flowing in a westerly direction for about 42 km. joins the Kothamangalam River near Perumattom and the combined river flows for about 2 km before joining the Thodupuzha River.

The Kothamangalam River originates from the Neriamangalam Ranges of the Thodupuzha State Forest. Up to Kothamangalam the river flows in a westerly direction and then turns south-west and joins the Kaliyar.

The Muvattupuzha River, after confluence of the three rivers, flows in a south-westerly direction for about 2 km, then flows in a south-westerly direction about 13 km, again turns south-west and passes through low swampy lands. At Vettikkattumukku it bifurcates into the Murinjapuzha and the Ithipuzha to join the Vembanad lake though a series of channels.

The length of the river is 121 km. The total drainage area of the river is 1554 sq. km. During its course it passes though 45 villages of the Thodupuzha, Muvattupuzha, Vaikom, Kunnathunadu and Kanayannur taluks.

Objectives of the study

A number of fishing methods are employed in the riverine sector for the exploitation of the riverine fishery. Nevertheless, no detailed work has been attempted so far to study the design, construction, operation, distribution, selectivity and economics of different types of gears used in the rivers of Kerala and document them scientifically. Hence to set the foundation for further work, the objectives of the present study consisted of the following:

i) to conduct a comprehensive study of the riverine fishing gears of central Kerala.

ii) to classify and comprehensively document the design, construction, method of operation of important riverine fishing gears operated at present in the rivers of central Kerala.

iii) to study comparative efficiency of major fishing gears and selectivity of gillnet

iv) to study the economics of operation of major inland fishing gears and

v) to study the scope for upgradation and optimisation of gillnet for the judicious exploitation of Kooral (*Hypselobarbus curmuca*), a predominant species, in the rivers of Kerala.

Table 1. RIVERS OF KERALA

No.	Rivers	Length (km)	Catchment area in Kerala (sq. km)	Total Catchment area (sq. km)
1.	Manjeswar	16	90	90
2.	Uppala	50	76	250
3.	Shiriya	67	290	587
4.	Mogral	34	132	132
5.	Chandragiri	105	570	1406
6.	Chittari	25	145	145
7.	Nileswar	46	190	190
8.	Kariangode	64	429	561
9.	Kavvayi	31	143	143
10.	Peruvamba	51	300	300
11.	Ramapuram	19	52	52
12.	Kuppam	82	469	539
13.	Valapattanam	110	1321	1867
14.	Anjarakandy	48	412	412
15.	Tellicherry	28	132	132
16.	Mahe	54	394	394
17.	Kuttiadi	74	583	583
18.	Korapuzha	40	624	624
19.	Kallai	22	96	96
20.	Chaliyar	169	2535	2923
21.	Kadalundi	130	1122	1122
22.	Tirur	48	117	117
23.	Bharathapuzha	209	4400	6186
24.	Keecheri	51	401	401
25.	Puzhakkal	29	234	234
26.	Karuvannur	48	1054	1054
27.	Chalakudy	130	1404	1704
28.	Periyar	244	5284	5398
29.	Muvattupuzha	121	1554	1554
30.	Meenachil	78	1272	1272
31.	Manimala	90	847	847
32.	Pamba	176	2235	2235
33.	Achencoil	128	1484	1484
34.	Pallickal	42	220	220
35.	Kallada	121	1699	1699
36.	Ithikkara	56	642	642
37.	Ayroor	17	66	66
38.	Vamanapuram	88	687	687
39.	Mamom	27	114	114
40.	Karamana	68	702	702
41.	Neyyar	56	497	497
42.	Kabbini	-	1920	2070
43.	Bhavani	-	562	-
44.	Pambar	-	384	-
Total		**3092**	**37884**	**41731**

Chapter II

MATERIALS AND METHODS

Chapter II

MATERIALS AND METHODS

There are a number of fishing gears used by the local and migrant fishermen in the entire length of the river system of Kerala. There have not been any detailed studies carried out so far on the different types of fishing gears and their operation. The present study deals with the different types of fishing gears in the river system of central Kerala with respect to their design, construction, operation, selectivity and operational economics.

Area of Study

Seven rivers from the central Kerala were selected for the study. i.e., Bharathapuzha River, Puzhakkal River, Keecheri River, Karuvannoor River, Chalakudy River, Periyar River and Muvattupuzha River. The Bharathapuzha River and the Periyar River are the longest and widest rivers of Kerala. Puzhakkal and Keecheri rivers were relatively smaller (Table 2). Total length of these rivers is 832 km., catchment area of 14,745 sq.km. and it covers the districts of Malappuram, Palakkad, Thrissur, Ernakulam, Idukki and Kottayam.

The general information regarding the rivers were collected from the publications, journals, papers, etc. of different governmental agencies such as Central Institute of Fisheries Technology, Central Marine Fisheries Research Institute, Central Inland Fisheries Research Institute, Central Water Resource Development and Management, Cochin University of

Science and Technology, Marine Products Export Development Authority, Kerala State Public Works Department, Kerala State Water Authority, Kerala State Fisheries Department, Matsyafed, ADAK, Kerala Agricultural University and non-governmental organizations such as South Indian Federation of Fishermen Societies (SIFFS), Fishermen Welfare Cooperative Societies and Matsya Thozhilaly Kshemanidhi Board.

Based on the preliminary information from the Kerala Public Works Department and Central Water Resource Development and Management a baseline survey was conducted in the rivers of Central Kerala viz., the Bharathapuzha River, the Puzhakkal River, the Keecheri River, the Karuvannoor River, the Chalakudy River, the Periyar River and the Muvattupuzha River to identify the major fishermen colonies in these rivers. The fishermen colonies were scanty and they were concentrated in certain pockets in the entire stretch of the river. Based on the results obtained, a detailed outline for primary survey was generated.

Design, Structure, Operation and Distribution of Riverine Fishing Gear

Based on the primary survey in the entire length of the river systems a number of fishermen colonies were identified for the detailed study of different types of fishing gears. The important fishing grounds, fishing villages and fish landing places (Table 3) in and around these centers were visited for collection of data for this study. Forty eight fishermen colonies were selected for the study covering all rivers of central Kerala. The sample units were selected by random sampling from the different stretches of the rivers. The detailed sampling procedures are given in the respective chapters and sections.

Bharathapuzha River

In Bharathapuzha River eight centres were identified for the data collection from the main river and tributaries. i.e., Mannarkadu, Kumarampathoor, Chittoor, Koduvayoor, Thavanoor, Thirunavaya, Ottappalam and Lakkidi (Fig. 2). The design and technical details of different types of gears used in these areas were collected.

Puzhakkal River

It is a very small river and becomes dry during summer. Hence the fishing is limited to winter season. The fishermen are mainly migratory in nature. Only two centres in this river were identified for the survey viz., Vazhani and Puzhakkal (Fig. 3).

Keecheri River

The Keecheri River also known as the Wadakkancherry River, is one of the smallest rivers in the State and is practically dry during summer. Here also the fishing is only in winter season and the fishermen are mainly migratory. Two centres were identified for the study, i.e. Keecheri and Chettuva (Fig. 4).

Karuvannoor River

Compared to other rivers it is a smaller river. Seven numbers of fishermen colonies were identified in this area. Pottichira, Illikkal, Karuvannoor, Moorkanadu, Pavaratty, Enamavu and Peringottukara (Fig. 5).

Chalakudy River

It is one of the important rivers of Kerala state. Its major areas are in the hilly areas of the forest. Fishing is mainly concentrated in the midstream and down stream areas. Seven centres were identified for this study viz. Ayiroor, Cheruvaloor, Kurumassery, Vettilappara, Poringalkuthu, Muzhikkulam and Pariyaram (Fig. 6).

Periyar River

The Periyar, the longest of all the rivers in Kerala, it has a number of tributaries. A number of fishing gears are operating in this river. Seven centres were identified for the data collection. i.e. Kalady, Bhoothathankettu, Thattekkadu, Paalamittom, Kuttanpuzha, Vettampara and Vadattupara (Fig. 7).

Muvattupuzha River

It is formed by the confluence of the Kothamangalam River, Kaliyar River and Thodupuzha. Fifteen centres were identified in this river i.e., Kolupra, Irumpanam, Kozhippilly, Mrala, Kadumpidy, Moolamattom, Karakunnu, Kanjaar, Muttam, Peruvanmuzhy, Ganapathy, Randaar, Ooramana, Kalampoor and Chembu (Fig. 8).

A thorough survey was conducted in the above centres and the important fishing grounds, fishing villages and landing places (Table 3) in and around these centers. Information was collected about different types of fishing gears used in these areas. Technical specifications of the different types of gears like gillnet, cast net, different types of lines, traps and other miscellaneous gears were collected by direct observation. The costs of gears, maintenance, labour, operational expenditure and earnings were collected from fishermen, through interview with the fishermen and structured questionnaires. Catch composition, method of operation and season of operation for each gear were collected. All these information were crosschecked with the periodic visit to these centres.

Technical details of different types of gears were recorded from each centre during the survey (Miyamoto, 1962). The drawings of different gears were prepared and presented based on the FAO catalogue of Fishing Gear Designs (FAO, 1972; FAO, 1975).

SI system of measurements was followed in this study; meter (m), centimeter (cm) and millimeter (mm) are used for length, width and thickness. Weight is given in kilogram (kg) and gram (g).

Selectivity Studies on Gillnet

Selectivity studies on gillnet for the species *Gonoproktopterus curmuca* was conducted for a period of 12 months. For this study the Kadumpidy, Kolupra and Randar centres of Muvattuupuzha River were selected. Nylon monofilament gillnets of 45mm, 55mm and 65mm with twine thickness 0.16 mm dia were used for the study. All other technical parameters were kept constant. Catch details in respect of each gear and the data on total length, gill girth, maximum girth, girth of entangled area were collected (Sparre *et. al*) at fortnight intervals. The details about the earnings were also noted.

Determination of mesh size

The selection of mesh size is an important factor for designing a gill net. In order to choose the mesh size suitable for exploiting the fish stock, Baranov's (1914, 1948) equation.

$A = kl$ was used

where *A* the size of mesh bar

l average length of fish for which the gear is designed and

k a co-efficient specific for a given species determined empirically.

The coefficient k was found out by (a) length measurement or by (b) girth measurement.

Length measurement

Let us assume that fishing is carried out simultaneously by two gill nets, of different mesh bar a_1 and a_2. The length frequency distribution of catch obtained in the two nets may be prepared and the frequency curve corresponding to these can be drawn on a single graph.

If l_0 represents the length of fish, appearing in equal numbers in both the nets, then the coefficient k was determined by the equation.

$$k = \frac{2a_1a_2}{l_0(a_1 + a_2)}$$

Girth measurement

When a fish is gilled and the fish struggles to escape, its body gets compressed and at the same time the twine of the mesh stretches a little. Therefore the perimeter of a section of body of the fish where it is caught is S_1 always exceeds than the girth at gill covers S_2. But the place of gilling S_1 will be less than maximum girth S_3. The relation between the mesh perimeter and area of cross section where it is caught can be represented by the equation:

$$n_1 = \frac{4a}{s_1}$$

Where a is the mesh bar and this will be different for different species of fish. Obviously if the fish has to be caught firmly, S_1 must be great than S_2 and less than S_3. If the perimeter of the sections of fish body in the place of gilling satisfies inequality ($S_2 < S_1 < S_3$) the fish is held firmly, we can to a certain extent arbitrarily set the value of the relation of the perimeter S_1 to maximum girth S_3, as

$$n_2 = \frac{s_1}{s_3}$$

Then knowing the relation of maximum girth of fish to its length

$$n_3 = \frac{s_3}{l}$$

The coefficient k can be determined by applying the formulae.

$$k = \frac{n_1 n_2 n_3}{4}$$

Hanging Coefficient

The shape and looseness of webbing depends on the coefficient of hanging. From the viewpoint of geometry, the mesh of fishing net is a rhomboid with properties attributed to it.

The hanging ratio E is defined as the length of float line L relative to the stretched length of netting L_0 with N as the number of meshes and L_m, as the mesh size.

$$E = \frac{L}{L_0} = \frac{L}{(NL_m)}$$

To find out the appropriate hanging coefficient for the effective exploitation of the targeted species, *Gonoproktopterus curumuca*, three types of gillnets of PA monofilament of 0.16 mm dia thickness were made with different hanging coefficient, *i.e.* 0.4, 0.5 and 0.6. All other parameters were kept identical. These nets were operated in the Muvattupuzha River. All the experimental operations were conducted at night. A total of 90 operations were made. The number and individual weight of the target species *Gonoproktopterus curumuca* and other species were collected for studying the effect of hanging on catching efficiency.

Economic Analysis

The experiments were conducted in the selected centres of the Muvattupuzha River system. Field surveys were conducted in these centres for one year. The centres were selected by taking into consideration the geographic spread of the rivers, convenience to collect reliable data and geographical distribution of fishermen population. Two stations from the down stream, two stations from mid stream and one station from up stream areas were selected for the study. Twenty percentage of the families from each station were taken for this purpose.

The economic analysis of gillnets and cast net operations were conducted in the above stations. But the family unit selected for each gear was different, because the fishermen are adherent to a particular type of gear.

The basic information such as capital investment on gear and equipment, operational cost, periodic maintenance, labour, etc., were collected using a pre-tested structured questionnaire. The results of the operations were collected by direct observation during visits to the landing centres.

Table 2. Rivers of Central Kerala

No.	Rivers	Length (km)	Catchment area in Kerala (sq. km)	Total Catchment area (sq. km)
1.	Bharathapuzha	209	4400	6186
2.	Keecheri	51	401	401
3.	Puzhakkal	29	234	234
4.	Karuvannur	48	1054	1054
5.	Chalakudy	130	1404	1704
6.	Periyar	244	5284	5398
7.	Muvattupuzha	121	1554	1554
Total		**832**	**14331**	**16531**

Table. 3. Fishermen colonies surveyed

River	Place	River	Place
Bharathapuzha	Chittoor Koduvayoor Kumarampathoor Lakkidi Mannarkadu Ottappalam Thavanoor Thirunavaya	Periyar	Bhoothathankettu Kalady Kuttanpuzha Malayattoor Palamittom Thattekkadu Vadattupara Vettampara
Chalakudy	Ayiroor Cheruvaloor Kurumassery Muzhikkulam Pariyaram Poringalkuthu Vettilappara	Muvattupuzha	Chembu Irumapanam Kadumpidy Kalampoor Kanjar Karakkunnu Kolupra Kothamangalam Moolamattom Mrala Ooramana Peruvanmuzhy Randar Sankirippally (Muttam)
Karuvannoor	Chettuva Eenamavu Illikkal Karuvannoor Moorkanadu Pavaratty Peringottukara Pottichira		
Keecheri river	Chettuva Keecheri	Puzhakkal	Puzhakkal Vazhani

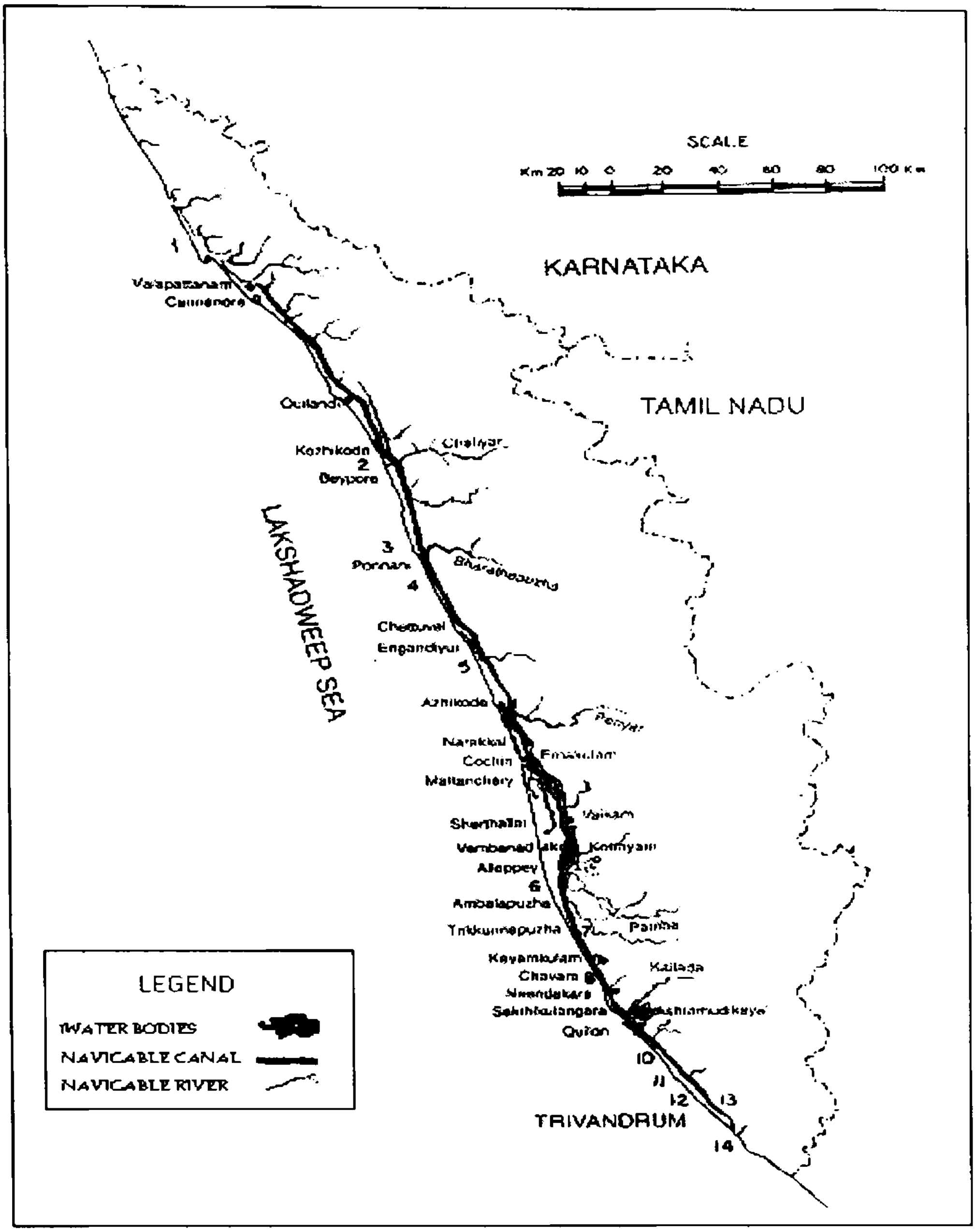


Fig. 1. Rivers of Kerala

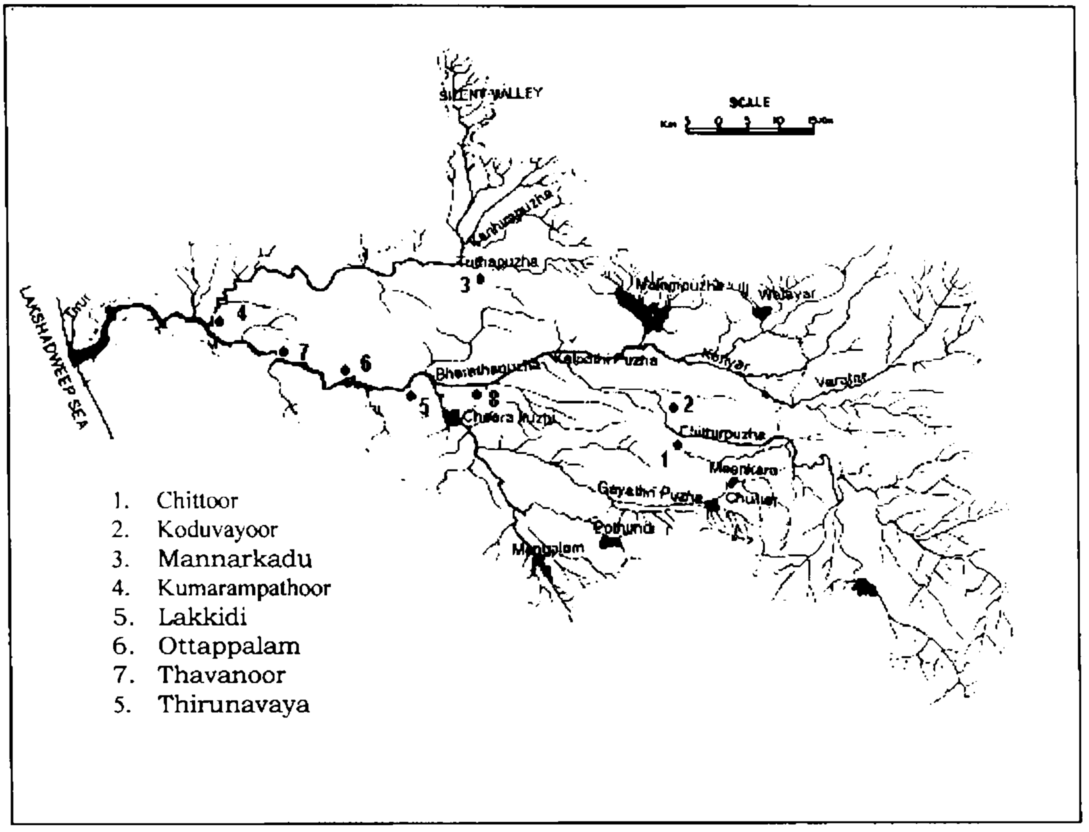


Fig. 2. Selected centres from Bharathapuzha River Basin

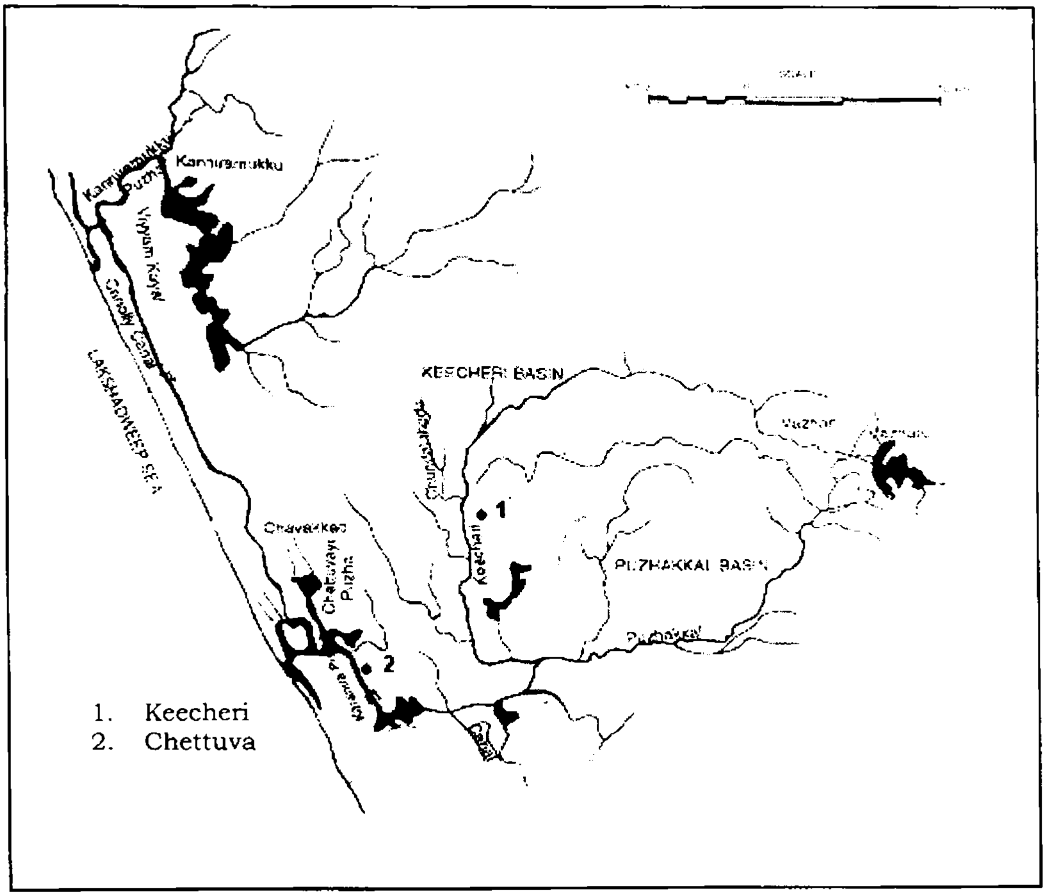


Fig. 3. Selected centres from Keecheri River Basin

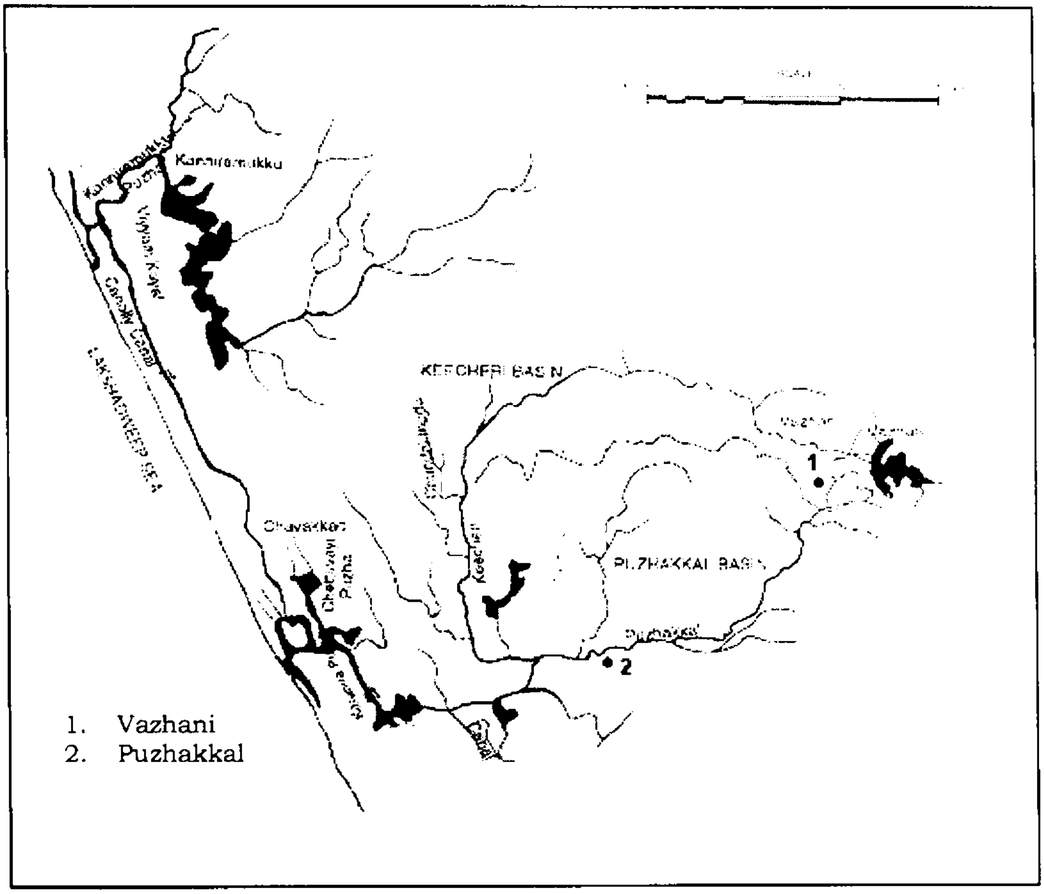


Fig. 4. Selected centres from Puzhakkal River Basin

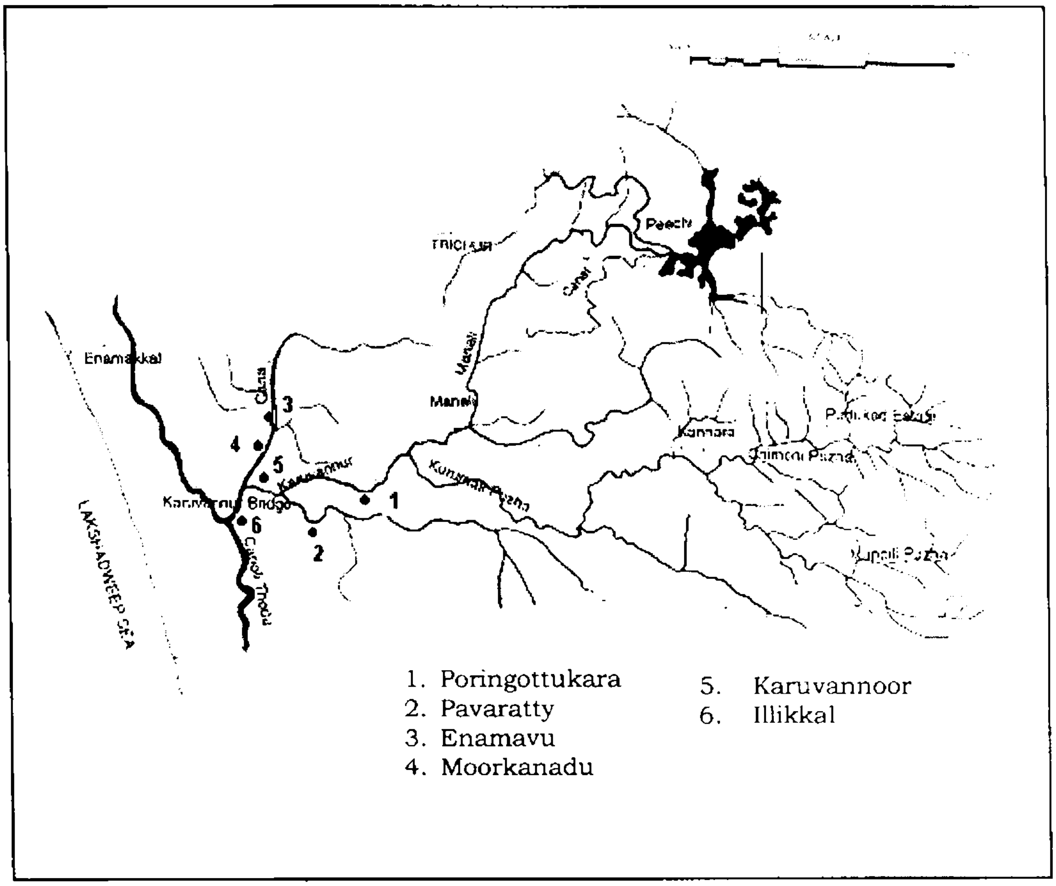


Fig. 5. Selected centres from Karuvannur River Basin

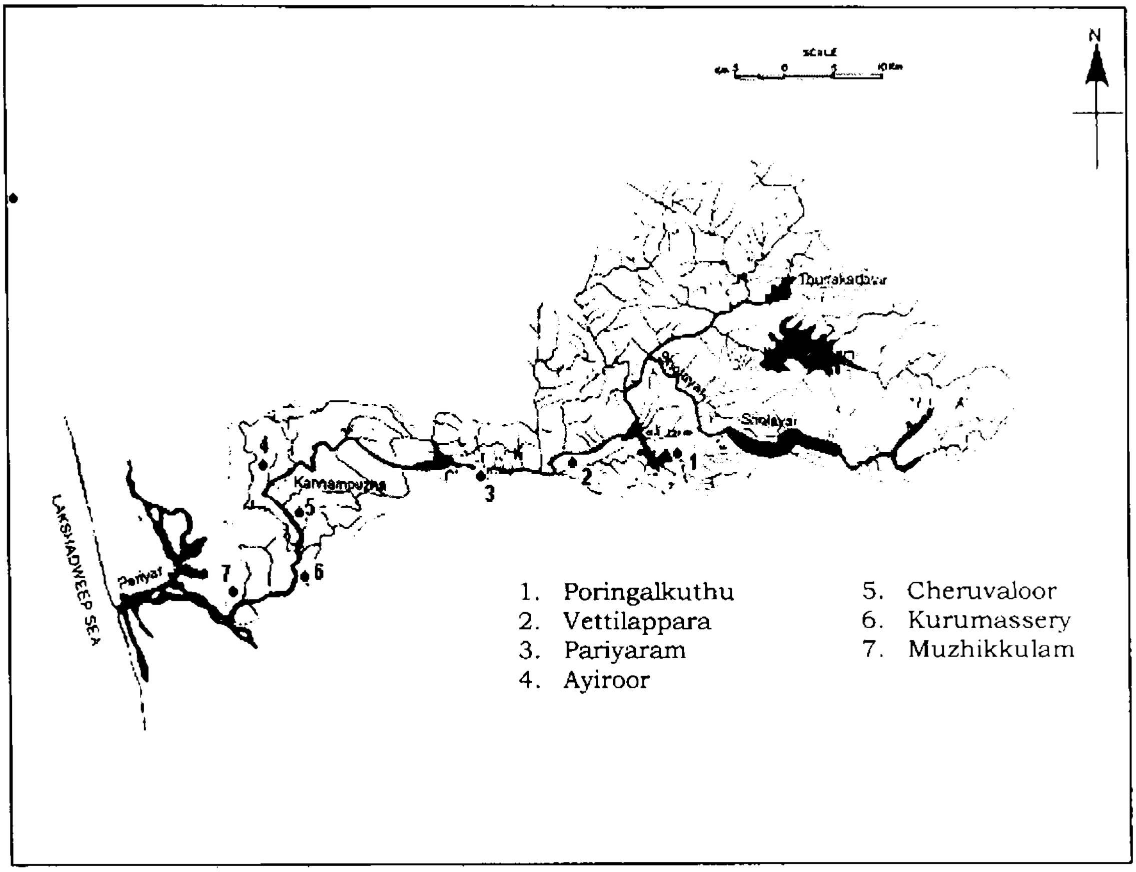


Fig. 6. Selected centres from Chalakudy River Basin

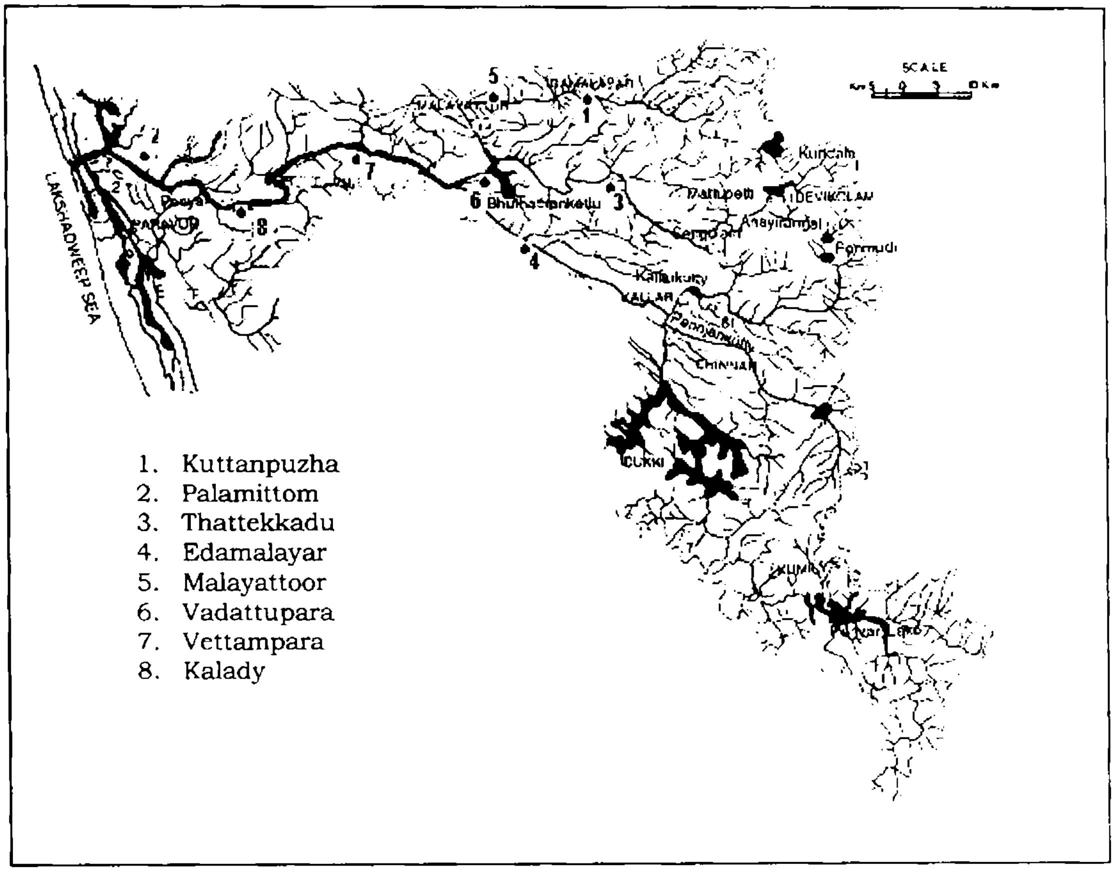


Fig. 7. Selected centres from Periyar River Basin

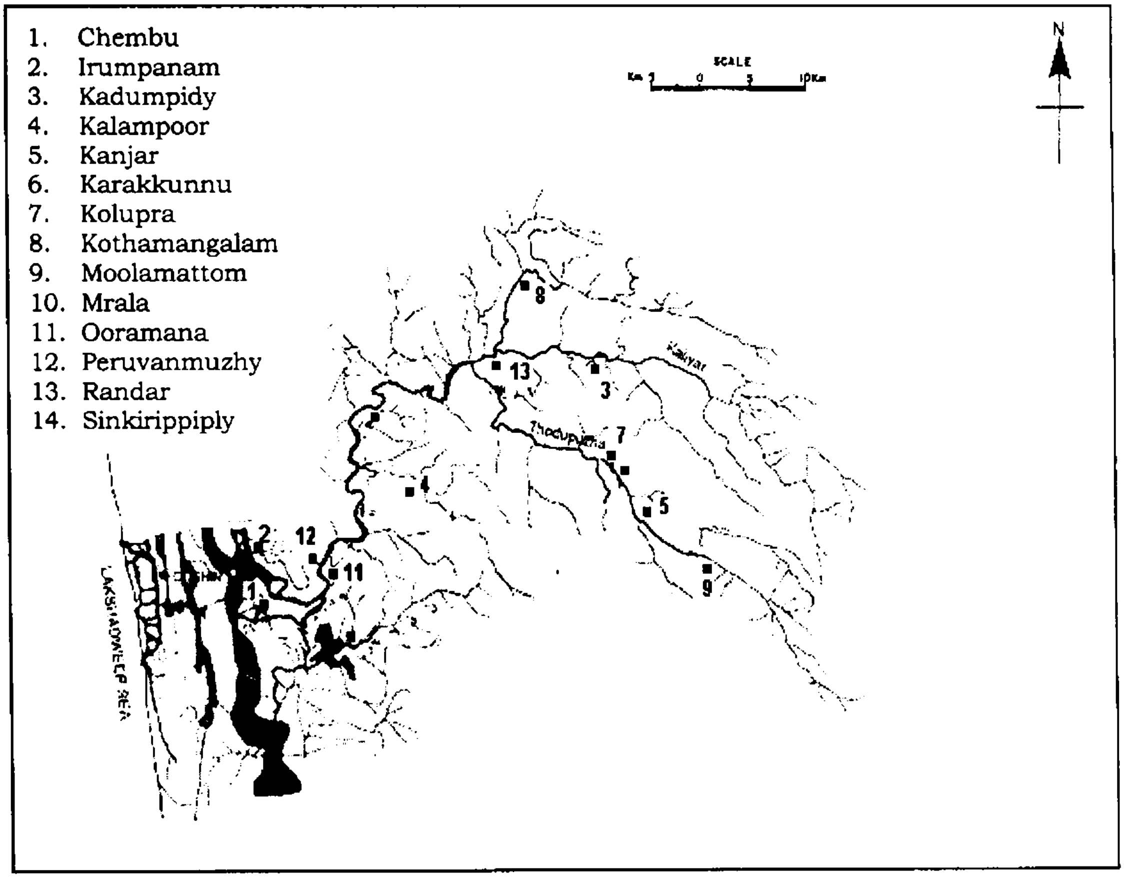


Fig. 8. Selected centres from Muvattupuzha River Basin

Chapter III

GILLNET

Chapter III

GILLNETS

Gill nets are among the simplest and oldest methods of fishing. Twenty percent of the world catch is by gill netting. This gear consisting of a sheet of rectangular webbing, whose upper edge is raised by floats (head rope) and lower edge is weighted by sinkers (foot rope), and with a mesh opening of such a size that fish of the required size group can gill themselves in the netting, are classified as gill nets (Brandt, 1972). The upper and lower edges are strengthened with selvedges of thicker twines of varied depth ranging from one to three meshes. The sides of the main webbing are provided with lines known as breast lines of thicker twines.

In world fisheries, gillnets rank next to trawls and purse seines in terms of total catch (Thomas, 2002). In India, they formed around 25 % of the total catch (Anon, 1988). It is the most important selective and low energy fishing technique practiced by artisanal fishermen.

Gill netting being a low cost fishing method is of special interest for artisanal fisheries. Since only a small crew and a relatively small number of nets are required, this method is widely practiced around the world.

Gill nets form 66% of all fishing gears of Kerala as out of the 55,712 artisanal gears operated in Kerala, 36,552 units are gill nets (SIFFS, 1999)

Gill nets are generally highly selective gear, the advantage that the fishes can be exploited more selectively than any other gear. Optimisation of the mesh size of gillnet for species and size selectivity could support conservation of resources.

Review of Literature

It is believed that the fisherman noticing how some fish got gilled in nets started designing special nets to effect their capture by gilling. The mesh size of gillnet has to be at least marginally smaller than the maximum girth of the fish that is aimed to be caught. Since the fish are mostly caught in mesh bars behind the gills, these nets came to be popularly known as gill nets. It is also quite certain that gill nets could have become effective only after it was possible to manufacture large number of uniform meshes of very fine netting yarn. Due to these reasons, as compared with other fishing gear, gill nets can be presumed to be of a relatively recent origin (Brandt, 1972). The principle behind gill netting has not changed over the years but the equipment and materials have changed. It is widely recognized as an efficient and selective type of gear (Bjoringsoy, 1996). Gillnet is one of the most popular gear among fishermen due to its lower capital investment, simple design, construction and operation. It is one of those fishing methods with a low energy consumption in terms of fuel consumed per kg of fish landed (Brandt, 1984).

Brandt (1964) has classified gill nets into 3 types: set gillnets, floating gillnets and drifting gill nets. Chernphol (1951), Davis (1958), Klust (1959), Satyanarayana and Sadanandan (1962), Andreev (1962), Sainsbury (1971, 1996), Brandt (1959, 1984), SIFFS (1991, 1999) and Luther *et.al.* (1997) also attempted classification of gill nets.

Gill net fishing of different states of India has been described by (George 1971, 1981; Muthiah 1982, Pillai *et.al.* 1991; Koya and Vivekanandan, 1992 Narayanappa *et.al.*, 1993; Kemparaju, 1994; Sivadas, 1994; and Pravin *et.al.*, 1988). Karlsen and Bjarnasson (1987) and Munasinghe (1985) have discussed on the advantages and disadvantages of gill net fishing.

Gill nets of Kerala has been described by few. Hornell (1938) described two typical gill nets of Malabar Coast used for mackerel and sardine. Anon (1951) and Nayar (1958) gave a description of gill nets and their mode of operation. Gill net is the only gear in which the 'mesh' of the gear itself serves the dual function of catching fish and selecting the fish to be caught (Anon, 1994, Thomas, 2000). Jayaprakash (1989) studied the trends in drift gill net fishery of Cochin with special reference to effort, inputs and return during 1986-87 and compared the same with that of 1981 and 1982. Vijayan *et.al.* (1993) studied the changes that have taken place in coastal gill nets of Kerala in three decades from 1958 to 1990. The relative efficiency of gillnet is studied by Thomas *et.al.* (1993).

Gillnet, though relatively passive, is efficient in catching sparsely distributed fish in large water bodies like lakes. It is a highly selective gear and a rule of thumb states that few fish are caught whose length differ from the optimum by more than 20 percent (Baranov, 1948). Hence knowledge of selectivity is needed in managing a commercial gill net fishery, as a proper mesh size aids in obtaining the maximum yield (Kennedy, 1950; Peterson, 1954; Mc Combie, 1961), protecting small fish (Hodgson, 1939; Anon, 1979), and minimizing escapement of injured or dying fishes (Ishida, 1962; Ueno *et. al.* 1965; Thomson *et. al.* 1971). Selection can be defined as the process that causes the probability of capture to vary with characteristics of the fish (Hamley, 1975). The factors listed by Clark (1960), Steinberg (1964), Fridman (1973 and 1986) and Pillai (1989) as most important to gill net selectivity are mesh size, extension and elastic properties of the netting yarn, twine material, shape of the fish including compressibility of its body and pattern of behaviour. Panikkar *et. al.* (1978) conducted selectivity studies with gill nets of three different mesh sizes, twine specifications and hanging coefficients to standardize an optimum net for exploiting the commercial size group of *Hilsa toil* and *Pampus argenteus.*

The selection of the best available material for a specific gear is very important (Klust, 1982; Karlsen, 1989). Nomura (1959, 1961), Mugas (1959), Molin (1959), Zaucha (1964), Shimozaki (1964), Sulochanan *et.al.* (1968), Mathai and George (1972), and Radhalakshmi and Nayar (1973, 1985) discussed the superiority of synthetics over natural fibres. Meenakumari *et.al.* (1993) reported that the major commercial use of polyamide (PA) is in the fabrication of gill nets. The popularity of polyamide (PA) monofilament in gill net was reported by Anon (1951), Vijayan *et.al.*

(1993), Rao *et.al.* (1994) and Pravin and Ramesan (2000). The studies on material substitution is done by Rajan *et. al.*(1991) who proposed the use of PP gillnet, Radhalakshmi *et. al.* (1993), Pillai *et. al.* (1989) and Pillai (1993) who suggested PE gillnet in place of PA.

Studies of Hicklin (1939), Havinga and Deelder (1949), Olsen (1959), Joseph and Sebastian (1964), Sulochanan *et. al.* (1968, 1975), Sreekrishna *et. al.* (1972) and John (1985) were all aimed at determining optimum mesh size for gill nets, with reference to a specific species.

The effect of hanging coefficient of the net on the catch efficiency was studied by many (Baranov, 1948, Riedel, 1963, Miyazaki, 1964, Ishida, 1969; Panikkar *et. al.*, 1978; George 1991 and Samaranayaka *et. al.*, 1997).

George *et. al.* (1975) studied the efficiency and selective action of coloured gill nets in the Gobindasagar reservoir and Narayanappa *et al.* (1977) conducted similar experiments with frame nets in the Hirakud reservoir. Rao *et. al.* (1980) studied the effect of coloured gill nets on the catch of seer, pomfrets, tuna and sharks along the East coast of India. A similar study on the effect of colour of webbing on the efficiency of gill nets for *Hilsa* spp. and pomfrets off Veraval was conducted by Kunjipalu *et. al.* (1984). Matuda and Sannomiya. (1977 & 1978) describes the statistical analysis of the movement of bottom drift gillnet.

Optimum mesh sizes for important commercial species of India were worked out by many authors. Desai and Shrivastasva, 1990, Joseph and Sebastian, 1964; Sreekrishna *et.al.*, 1972; Sulochanan *et.al.*, 1975; Panikkar *et.al.*, 1978; Khan *et.al.*, 1989; Mathai *et.al.*, 1990; Kartha and Rao, 1991; George, 1991; Mathai *et.al.*, 1993; Luther *et.al.*, 1994 and Neethiselvan *et.al.*, 2000).

Selectivity is also affected by the method of fishing by gillnet (Treschev, 1963). As different sizes of fish may occupy different habitats, the sizes caught may depend on the location and depth of fishing (Parrish, 1963). Progressive accumulation of catch in the gill net decreases the efficiency of the net, eventually reaching a saturation level when no further increase in catch is possible (Baranov, 1948; Kennedy, 1951). Observation on the lunar and tidal influences on gill nets have been made by Mathai *et al* (1971) and Pati (1981).

Even though the awareness of the basic property of gill nets viz., selectivity existed as early as in 19th century (Collins, 1882), its scientific study started much later (Baranov, 1914). Baranov (1948) proposed the basic mathematical models for gillnet selectivity.

Economic analysis evaluated the productivity of different fishing inputs in gill net fishing systems, by comparison of the technical efficiency among fishing gears and fishing grounds and by assessment of the economic efficiency of input use. The difference in catch can arise from inputs such as size and power of crafts, size of nets, fishing effort in terms of crew and time and management skills of fishermen (Jayantha and Amarasinghe, 1998; Tokrishna *et.al.* (1985); Yater 1982 and Shibu (1999). Khaled (1985) compared the productivity of drift nets and seine nets in the riverine fishery of Bangladesh. Balan *et.al.* (1989) assessed the impact of motorisation on production, productivity and earning of fishermen in the motorized, non-motorised and mechanized gill net sector of Kerala.

The economics of operation of gill nets in India was studied by many (Nobel and Narayanan Kutty 1978; Kurien and Willmann, 1982; Silas *et.al.*, 1984; Sehera and Kharbari, 1989; Panikkar *et.al.*, 1990, 1993; Dutta and Dan 1992; Iyer 1993, Luther *et.al.*, 1997 and Thomas 2001).

Mesh size assumes considerable importance as it has a direct bearing on the size composition of the catch. Baranov (1948) interpreted gill net capture as a mechanical process that depends only on the relative geometry of the mesh and the fish, and propond that since all meshes are geometrically similar and all fish of the same species are also geometrically similar, the selectivity curves for different mesh sizes must be similar. Thus, a given net with a given mesh size can successfully catch fish of a certain size only, which are optimal for the net. With increasing deviation of the fish size from the optimum, the number of fish retained in the net decreases (Fridman, 1973).

Regardless of the fact that there are many common features in the operation of set and drift nets, the principles of calculating the rigging differ considerably. In set nets the total buoyancy of the floats is proportional to the weight of the nets and rigging in water, while the total weight of sinkers is proportional to the buoyancy of the floats. In the case of drift nets, the type of net movement is taken into account. Hence, for nets floating without touching the bottom, the buoyancy must be at least twice the weight of nets, ropes and sinkers. Here the sinkers are used only to accelerate the sinking rate of the bottom of the net and is approximately equal to the weight of the net in water. The required net shapes and tension in a drift net moving along the bottom is obtained by controlling ratio of the buoyant forces to the ballast and changing the pressure of the lead line on the bottom (Fridman, 1973).

Miyazaki (1964), based on experiments with drift nets opined that for merely getting the fish into the meshes a hanging coefficient of 0.70 is adequate, but to entangle them, the hanging coefficient should be between 0.60 and 0.50 or less and if both gilling and entangling is desired at the same time, a hanging coefficient of 0.60 is appropriate. Khan *et al.* (1985) conducted comparative fishing experiments with frame nets and has indicated that the net with hanging coefficient of 0.4 to be more effective than 0.5 for *Catla catla.*

Studies on the freshwater fishes of Kerala mainly were undertaken in the river systems of Northern Kerala (Hora & Law, 1941; Raj, 1941; Silas

1951; Remadevi and Indra, 1986; Basha & Easa 1995; Menon 1993; Vairavel *et. al.* 1998; Biju *et. al.* 1999.

Gonoproktopterus sp. was earlier referred as Barbus and Puntius by Day (1865). Menon and Remadevi (1995) treated this genus as *Hypselobarbus* (Bleeker). Genus *Gonoproktopterus* is represented by seven species (Jayaram, 1999), viz. *G. curumuca* (Ham. Buch.), *G. Dubius* (Day), *G. kolus* (Sykes), *G. lithopidos* (Day). *G. micropogon micropogon* (Val), *G. micropogon periyarensis* (Raj) and *G. thomassi* (|Day).

G. curumuca is more abundantly distributed than all other species in the rivers of Kerala. (Euphrasia and Kurup, 2000). The distribution of this species in Travancore is described by Pillai (1929); John (1936); Periyar Lake and stream system by Chacko, (1948); Arun, (1998), and Ranjeet *et.al.* (2002), Achenkoil by Jero, (1994); Chaliyar River by Shaji & Easa, (1997); Chalakudy River by Shaji & Easa, (1997); Bharathapuzha, Chalakudy, Periyar, Kabini, Valapattanam, Bhavani by Biju *et.al.* (2000); Malampuzha, Idukki, Periyar by Shaji and Easa (2001).

Mesh regulations are recommended for the conservation and judicious exploitation of fisheries. Consequent on the introduction of mechanized fishery, the problem of indiscriminate fishing has become all the more important. Studies of Hodgson (1939), Baranov (1948), Holt (1957), Olsen (1959), Nomura (1961), Joseph and Sebastian (1964), Sulochanan, *et.al.* (1968, 1975), Sreekrishna *et.al.* (1972) Panikkar *et.al.* (1978) on gill nets are aimed at minimizing indiscriminate fishing.

The comparative technical and economic performance of different fishing systems in different parts of world have been discussed by many (Yater, (1982); Librero *et.al.*, (1985); Panayotou *et. al.*, (1985); Tokrishna *et. al.*, (1985); Fredericks and Nair, (1985); Khaled, (1985) and Jayantha and Amarasinghe, (1998)). In the Indian context, techno-economic aspects of purse seine were studied by Verghese (1994), Mukundan and Hakkim (1980), Panikkar *et. al.* (1993), Iyer *et. al*, (1985), Devaraj and Smitha (1988), John (1996), and Shibu (1999) investigated the economics of trawling.

A few economic tudies have been made on fishing operations in marine sector (Yahaya and Wells, 1980; Kurien and Willmann, 1982; Unnithan *et.al.* 1985; Sathiadhas and Panikkar, 1988; Sadananthan *et.al.* 1988 and Dutta *et.al.* 1989). However, no systematic study has been carried out to assess the economics of operations of the gears in the riverine sector of Kerala in spite of their efficiency, employment potential and importance.

Objectives

Gillnetting is one of the important methods employed for the exploitation of the riverine fishery. Nevertheless, no detailed work has been attempted so far to study the complete design details of the different types of gill nets used in the rivers of Kerala. Hence to set the foundation for further work, the objectives of the present study consisted of the following:

i) a comprehensive study of the riverine gillnets of central Kerala.

ii) to reclassify and comprehensively document the design, construction, method of operation of gillnets operated at present in the rivers of central Kerala.

iii) to study selectivity of selected gillnets in the rivers of central Kerala.

iv) to study the economics of operation of gillnets in the selected stations

v) to study the scope for upgradation and optimization of gillnet for the judicious exploitation of Kooral (*Hypselobarbus curmuca*), a predominant species, in the rivers of Kerala.

The study was conducted with a view to provide an insight on the present scenario of gill net fishing in rivers of Kerala.

3.1. Structure and operations of gillnets

3.1.1. Materials and methods

The study required data of primary and secondary nature. The secondary data was collected from the publications/data base of research organization, administrative departments and non-Governmental organizations. The Central Institute of Fisheries Technology, Central Marine Fisheries Research Institute, Central Inland Capture Fisheries Research Institute, Kerala State Fisheries Department, Kerala State Public Works Department, Central Water Resource Development and Management, Matsyafed, South Indian Federation of Fishermen Societies were important agencies were sources for secondary data, used for the study.

Preliminary information about the course of river (Anon, 1995), was taken for the base level survey in the rivers of central Kerala, Bharathapuzha, Puzhakkal, Keecheri, Karuvannur, Chalakudy, Periyar and Muvattupuzha rivers. Preliminary surveys were conducted at various fishing centers of rivers to document the different types of gears that are operated in the river.

Based on the pilot survey 49 fishing centers were selected from these rivers. The location of the centres surveyed is given in Table 3 and in Fig. 2 to 7. Eight centres from Bharathapuzha River (Fig. 2), seven centres from Chalakudy River (Fig. 6), eight centres from Karuvannoor

River (Fig. 5), two centres from Keecheri River (Fig. 3), fourteen centres from Muvattupuzha River (Fig. 8), eight centres from Periyar River (Fig. 7) and two centres from Puzhakkal River (Fig. 4) were selected.

The design details of different types of gillnets were collected during the survey (Miyamoto 1962). Method of operation, time and season of operation and the craft used for the operation and number of fishermen engaged in the operation were collected. Direct observations were made to collect details of method of operations, fishing areas, fishing time, season and catch details.

A thorough study were conducted regarding the different types of gillnet operated in the above centres. As a result a total 295 gillnets were surveyed from 48 centres in different rivers of central Kerala, out of which 86 gears were from the Bharathapuzha River, 55 from the Chalakudy River, 32 from the Karuvannur River, 4 from the Keecheri River, 60 from the Muvattupuzha River, 54 from the Periyar River and 4 from the Puzhakkal River. The results of this survey were taken as a basis for the present study.

Technical details of different types of fishing gears are collected and documented based on the FAO catalogue (FAO, 1972; FAO, 1975). All the parameters like materials, mesh size, twine diameter, number of mesh in length, number of mesh in depth, hanging coefficient, and details of selvedge, head rope, foot rope, float and sinkers and the cost of materials were collected.

Species-wise catch composition from different fishing gears, area of operation, and total catch were recorded during fort-night surveys.

The design details of the different types of gears are presented as per conventions followed in FAO Catalogue (FAO, 1972; FAO, 1975). SI system is followed for the length, width, thickness and diameter specification of the gear.

Selectivity Studies

The selectivity studies of the gillnet for the species *Hypselobarbus curmuca* were conducted at the Muvattupuzha River system. The station were fixed on basis of the availability the selected species and suitability of area for operation. Fortnightly data were collected for one year for this study and 45 mm, 55 mm and 65 mm mesh sizes were used for the mesh selectivity studies in these centres. For the effective capture of the species *Hypselobarbus curmuca* comparative analysis of gillnets with different hanging coefficient of 0.4, 0.5 and 0.6 were conducted and data collected for 30 operations. The detailed methodology is discussed in the sections on gillnet selectivity.

Economic analysis

In Muvattupuzha River system five centres namely Piravam, Randar, Kadumpidy, Kolupra and Kanjar were selected for the economic studies on operation of gillnets. Details about the operational cost, catch, season and earnings from each station were collected at fortnightly intervals for a period from August 2001 to September 2002. The detailed methodology is discussed in the respective sections.

3.1.2. Results and Discussion

Based on the data collected, different types of gillnet present in the riverine systems of Central Kerala are classified into three types, drift gillnet, set gillnet and encircling net (Fig. 9). The set net and drift net are again divided in to two: with footrope and without footrope. Table 5 shows the different types of gillnet present in the different riverine sectors of central Kerala.

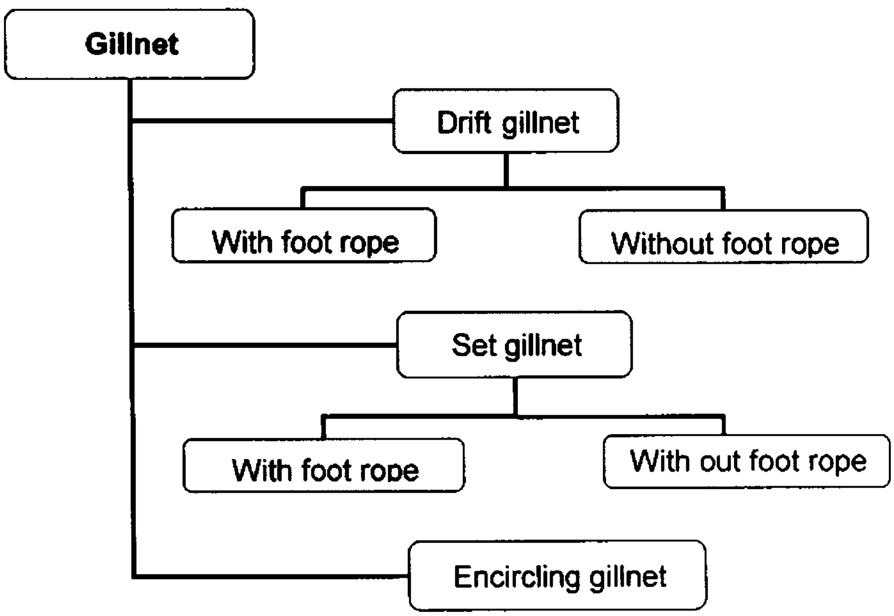


Fig. 9. Classification of gillnet

In drift gillnet one end of the net is fixed into the neighbouring object like root of trees or small shrubs or anchored and the other ends kept free. There are of two types: gillnet with footrope and without footrope.

In set gill net both ends of the net are fixed into the neighbouring object like root of trees or small shrubs or anchored. Sometimes the gear is set across the river. These are of two types: with footrope and without footrope.

Andhra vala

Structure

The Andhravala is a popular type of gillnet in riverine sector of Kerala. It has its origin from Andhra Pradesh and hence known as *Andhravala* or *Andhranet*. It is made of PA monofilament of 0.16 mm dia. and rarely of 0.23 mm monofilament. Each unit has 1000-2000 meshes in length and 19-30 meshes depth. The mesh size varies from 35 to 65 mm., 35 mm being the most common. The unique feature of this gear is its special type of float and sinkers. The detailed specification of this gear is given in Table 6. The study revealed that *Andhravala* are prevalent in many areas of the Kerala particularly in Muvattupuzha River, Periyar River and Chalakudy River.. Design of a typical *Andhranet* is given in Fig. 10.

In all the centers of the river surveyed, the *Andhranet* is exclusively made of PA monofilament with varying diameter between 0.16 to 0.23 mm. Selvedge made of PA multifilament of 210Dx2x2 and 210Dx2x3 (upper and lower) are used in all gears. Only one case is reported in Kolupra areas, which is without any lower or upper selvedge. PP ropes are used as head rope and footrope. Different types of PP ropes are used in different areas. Two numbers of 1.5 mm twines or one number of 2.5 mm twines or a combination of 210Dx6x3 PA multifilament and one number of 1.5 mm PP twines are used as head rope and footrope. A special type of float is used in *Andhranet*. 'Peely' stem pieces of a plant (*Ochlandra* sp.), which is locally available in the river banks is used as float. The length of these pieces varies from 5 to 7 cm and it is attached to the float line between 4 meshes. The major problem with this float is that it absorbs water and loses its buoyancy after 1-2 hours of operation. A special type of sinkers, made of clay is used in this gear. The sinkers are dumbbell shaped with size of 2.5 to 4.0 cm. in length and attached between 4 meshes. It also absorbs water thereby increasing the weight during operation. The mud sinkers are cheaper compared to lead sinkers. Hanging coefficient varies from 0.48 to 0.56. In most cases depth of the gear is 19 meshes and in certain areas the depth of the gear increases up to 30 meshes. The fleet length of 30 m is very common and it increases up to 40 m in some areas.

Operation

This gear is used as drift gillnet or set gillnet. It is operated from *Coracle* (Kotta) by fishermen from Andhra Pradesh. *Kotta* is a special type of circular craft made of bamboo. (Fig. 33). Dugout canoes or plank built canoes of length 5.4 to 5.9 m are commonly used in rivers. The gear is also operated with out any craft in many areas, and in such places old rubber tubes of car or mini lorry tubes are used as craft.

In most of the areas only one person is required to operate the gear. On reaching the fishing ground the gear is paid out from the craft and placed in the water as drift or set net according to the flow of the river. When it is operated as set net, the gear is only operated as surface set. In such times both ends of the gear is attached to the root and branches of the trees on the river banks. This gear is operated throughout the year and mainly operated in the night or early morning. The gear is hauled in every 1 to 2 hours. When the availability of fish is less, the fishermen place the gear in the evening and haul it early morning in the next day. The catch mainly comprise of *Etroplus* sp., *Puntius* sp., and *Gonoproktopterus* sp.

Pandi vala

Structure

It is a modified form of Andhranet. Most of the specifications are common in Pandivala and Andhranet. The gear is made of PA monofilament of different thickness (0.16 to 0.23 mm). The float and sinkers are the same as that of Andhravala. On the basis of selvedge this gear is divided into three groups. In the first group the selvedge are absent, which is the unique feature of this group. The mesh size is 35 mm with twine size of 0.16 mm dia. The length of the gear varies from 1300 to 1500 meshes and the depth is 19 meshes. The head rope and footrope is made by using double PP twines of 1.5 mm thickness. In Kolupra area a combination of 1.5 mm PP and 210Dx2x3 PA multifilament is used as footrope. The length of this group is 30 m and the hanging coefficient varies from 0.57 to 0.66. Small pieces of 40 to 50 mm long peely (*Ochlandra* sp.) is used as floats. The floats are attached in every 4 to 5 meshes and a total of 325 to 375 numbers of floats are used in a single net. Dumbbell shaped mud sinkers are used as weight. The number of sinkers varies from 325 to 375. The sinkers are kept in every four meshes (Table 7).

In the second category of Pandivala the gear is made of PA monofilament diameter 0.16 to 0.23 mm. The length of the gear varies from 1000 to 1700 meshes and depth varies from 19 to 30 meshes. The unique feature of this gear is that it has both upper and lower selvedge. These selvedges are made of PA multifilament of 210Dx2x2 or 210Dx2x3, which are 0.5 to 1.0 mesh in depth.

The head rope and footrope is made using double PP twines of 1.5 mm thickness. In Kolupra and Kanjar area a combination of 1.5 mm PP and 210Dx2x3 PA multifilament is used as footrope. The length of the gear is 30 m and hanging coefficient varies from 0.50 to 0.55. The float and sinkers are same as that of the above gear.

The third group of pandivala has only the upper selvedge. The gear is made of PA monofilament of 35 mm mesh size and of 0.16 to 0.23 mm twine thickness. The length of the gear is 1200 to1500 meshes and depth varies from 19 to 50 meshes. The upper selvedge is made of PA multifilament of 210Dx2x2 or 210Dx2x3 of 0.5 to 1 mesh in depth. The head rope and footrope is made of two numbers of PP twines of 1.5 mm thickness. In Muttam area, a combination of PA 210Dx2x3 and PE twine of 1.5 mm dia is used as footrope. The length of the gear is 30 m with hanging coefficient of 0.45 to 0.50. Peely (*Ochlandra* sp.) of 40 mm pieces are used as floats and mud sinkers are used as weight. The floats and sinkers are kept in every four mesh like the above gear. Design of a typical Pandivala is given in Fig. 11.

Operation

Only one fisherman operates the gear. In most cases plank built canoes of length 5.4 to 5.9 m are used as craft, old rubber tubes were used in some areas. The fishermen reach the fishing ground and set the gear in set net or drift net method same as that of Andhranet. In certain areas both upper and lower selvedge are absent in this gear. Floats and sinkers are used as in *Andhranet*.

Operation is mainly in the night or early morning. The catch mainly comprise of *Etroplus* sp., *Puntius* sp., and *Gonoproktopterus* sp.

Podi vala

Structure

The present investigation indicates that the Podivala or Podikannivala is operated mainly in Peruvanmuzhy, Ooraman areas of Muvattupuzha River system.

Podivala is made of PA multifilament webbings of 210Dx1x2. The gear is called as Podivala, because very small mesh is used in this gear. The mesh size varies from 30 to 35 mm. The length of the gear varies from 1500 to 2500 meshes and depth is 50 meshes. The upper selvedge is made of PA multifilament of 210Dx2x3 of 0.5 mesh in depth. The lower selvedge is absent. Polypropylene twine of 2.5 mm dia is used as head rope and jute twine of 3 mm is used as footrope. The length of the head rope varies from 35 to 45 m. Compressed PVC floats of 60 x 20 and 50 x 20 are very commonly used. Sinkers are absent. The floats are kept in every 1.0 m. in the head rope. The jute footrope is acting as sinkers. Hanging coefficient varies from 0.60 to 0.67. Design of a typical Podivala is given in Fig. 12 and the technical details are given in Table 8.

Operation

Only one fishermen is engaged in the operation of Podivala. The gear is operated mainly during the night. The fishermen set the gear in the evening and collect the catch early in the morning.

One end of the gear is attached to the neighbouring tree roots or rock pieces and the other end become free. Bottom selvedge is absent in this gear. The footrope is made of jute twine. Sinkers are absent in this gear. The foot rope itself acts as sinkers. Fishermen operating the gear without a craft. The catch includes small miscellaneous fishes like *Puntius* sp., *Peneas* sp., etc.

Kuruva vala

Structure

The present study indicates that the Kuruva vala is very common in areas like Cheruvaloor, Kadumpidy, Ooramana, Peruvanmuzhy and Karakunnu. This gear is specifically targeted for Kuruva (*Puntius* spp.).

In most of the areas the gear is made of 0.16 to 0.23 mm dia. PA monofilament and in areas like Cheruvaloor and Ooramana it is made of PA multifilament of 210Dx1x2. The mesh size varies from 40 to 55 mm in PA monofilament gears and 50 to 60 mm in PA multifilament gears. (Table 9). The upper selvedge is made of PA 210Dx2x3 or PA 210Dx3x2 in monofilament gears and PA 210Dx2x3 in multifilament gears. In Karakunnu and Ooramana areas both selvedges are absent. In monofilament gears the head rope is made of 2.5 to 3 mm polypropylene twine. In multifilament gears polypropylene twine of 2.5 mm or 210Dx6x2 polyamide twine (2 nos.) is used as head rope. Footrope is made of polypropylene twine, jute and old PA webbings. PVC floats are very common in this type of gears. PVC discoid floats are very common compared to PVC apple floats. In Karakunnu areas pieces of old rubber slippers are very common. Lead is commonly used as sinkers. Steel rings are used as sinkers in Peruvanmuzhy areas and rock pieces are used in Ooramana areas. Rolled lead sheets are used as sinkers in areas like Cheruvaloor. Hanging coefficient varies from 0.60 to 0.65 in multifilament gears and 0.56 to 0.62 in monofilament gears. Design of a typical Kuruva vala is given in Fig. 13 & 14.

Operation

Only one fisherman is engaged in the operation of Kuruva vala. After reaching the fishing ground the fishermen release the gear and keep it as set net in most cases. In certain areas, however, it is used as drift gillnet. This gear is operated through out the year. It is operated during day and night. The fisher hauled the gear every 1 to 2 hours according to the availability of fish. The craft used for this operation were plank built canoes of length varies from 5.2 to 5.7 m.

Karimeen vala

Structure

Karimeen vala is very common in all rivers of central Kerala. It is commercially very important gear. As the name indicates the gear is used for capturing Karimeen (*Etroplus* sp.) It is reported by Kurup and Samuel (1985) as a drift net, Brandt (1972) grouped this as an encircling gear.

Nylon multifilament of 210Dx1x2, 210Dx1x3 webbing is very common in Karimeen vala. In Peruvanmuzhy old PA monofilament of 0.23 mm dia gear is used as Karimeen vala. (Table 10). Webbing of mesh size of 55 mm is used in Karimeen vala except in one area, where 50 mm mesh webbing is used. The upper selvedge is made of PA multifilament of 210Dx2x3 and 210Dx3x2 in all areas. Lower selvedge is absent. Head rope is made of 2.5 to 3.0 mm dia PP or PE twines. Footrope is absent in most cases. Different types of thermocole and PVC floats are used as buoyant material. PVC floats of 50x10, 50x20 and 60x20 mm are very common. Locally available materials like rock, stone, etc, of 100 to 300 g are used as sinkers. In Peruvanmuzhy areas, iron rings of 80 mm dia. are used as sinkers. Hanging coefficient varies from 0.45 to 0.63. Designs of a typical Karimeen vala are given in Fig. 15 & 16.

Operation

On reaching the fishing ground the fishermen very carefully releases the gear after fixing the sinkers in to water. One end of the gear is fixed to any nearby objects and the other end is left free. The gear is hauled up every 1 hour. Plank built canoes of length of 5.2 to 5.9 m were the craft used by the fishermen. The catch mainly consists of Karimeen, *Etroplus suratensis.* In addition to the target species small and medium sized fishes are also caught.

Thadamvali

In Chembu area a variation of Karimeen vala known as Thadamvali is used. It has only a slight difference between the Karimeen vala. The depth of this type of gear is little more, 100 meshes, compared to Karimeen vala. The footrope is made of coir ropes (Table 11).

The operation of the gear is as same as that of Karimeen vala.

Vazhutha vala

Structure

It is a type of gillnet mainly used for catching the species Vazhutha/Pullan (*Labeo dussumieri*) in the rivers of central Kerala.

The study reveals that the gear is made of PA monofilament webbing of mesh size 75 mm and twine size of 0.16 - 0.23 mm dia. The gear is 700 to 1100 meshes in length and 25 to 50 meshes in depth. The upper selvedge is made of 210Dx2x3 PA multifilament of mesh size 100 mm and lower selvedges are absent. (Table 12). The head rope is of 2.5 to 3.0 mm polypropylene of 35 to 45 m in length and footrope is of 2.0 to 2.5 mm polypropylene. In Ooramana areas 3.0 mm jute twine is used as footrope. 35 - 45 numbers of PVC floats are used in this gear. Rock pieces are used as sinkers. Special types of steel rings are used as sinkers in Ooramana areas. Hanging coefficient varies from 0.55 to 0.67. Design of a typical Vazhutha vala is given in Fig. 17.

Operation

The operation is mainly conducted during night. The fishermen set the gear in the evening and haul up early in the morning. In post monsoon period, the fishermen haul up the gear every 2 hours. Plank built canoes of length of 5.2 to 5.7 m were the craft used by the fishermen. The catch comprises mainly Vazhutha (*Labeo dussumieri*). In addition to it other large and medium sized fishes are also caught.

Vaala vala

Structure

Vaala vala is a type of gillnet mainly used for catching Vaala (*Wallagu attu*). Vaala vala is found in different areas selected for the present study. Cheruvaloor, Kadumpidy, Kalady, Kurumassery, Randar, Mrala, Peruvanmuzhy and Pottichira.

Mesh size varies from 80 to 110 mm. Nylon multifilament webbings of 210Dx1x2 are used in Cheruvaloor areas and PA monofilament webbings of 0.20, 0.23 and 0.32 are used in other areas (Table 13).

In Cheruvaloor and Ooramana areas 210Dx1x2 PA multifilament of 100 to 110 mm mesh size is used as Vaala vala. The upper and lower selvedges are made of 210Dx2x3 PA multifilament. Two numbers of PA multifilament 210Dx8x3 or 210Dx9x3 are used as head rope. Polypropylene twine of 2 mm dia or jute of 5 mm dia is used as footrope. Thermocole pieces, 28-35 numbers, are used as floats. Rolled lead sheets or stones are used as sinkers. Galvanised iron rings of 180 mm dia. are used as sinkers in Ooraman areas in addition to the usual stones. Hanging coefficient varies from 0.60 to 0.61.

Nylon monofilament of 0.23 and 0.32 mm twine size with 80 to110 mm mesh are used as webbing in PA monofilament gear. Nylon multifilament of 210Dx2x3 and 210Dx3x2 are used as upper selvedge. In Kalady and Randar upper selvedge is absent. The lower selvedge is present only in Kurumassery and Mrala, and it is made of 210Dx2x3 PA multifilament. Thermocole and PVC are used as floats. In Kurumassery floats are absent. In these areas the head rope is tightened to the root and twigs of the nearby trees in the river banks. Stones, mud, lead, etc. are used as sinkers. In Peruvanmuzhy areas steel rings of 120 mm dia, 200 g weight is used as sinkers. In Randar, old twisted PA webbings are used as footrope.

The hanging coefficient of the gear varies from 0.38 to 0.61. Design of a typical Vaala vala is given in Fig. 18 & 19.

Operation

Operation of gear is mainly during night. Plank built canoes or dug out canoes of 5.0 to 5.4 m length were used as craft. The fishermen set the gear in the late evening and haul the gear early in the morning.

The catch comprises the species Vaala (*Wallagu attu)* and other large and medium sized fishes.

Chemmeen vala

Structure

Chemmen vala is mainly seen in the down stream areas of the rivers. It is made of PA monofilament of 0.16 mm dia. The mesh size is 30 mm with 3000 meshes in length and 50 meshes in depth. (Table 14). The upper and lower selvedges are present and it is made of PA multifilament 210Dx2x3. Head rope is of 45 m length polypropylene of 3 mm dia. Twenty two numbers of thermocole pieces are used as floats. Twisted old PA webbings are used as footrope. Sinkers are absent. The foot rope itself act as sinkers. The hanging coefficient is 0.50. Design of a typical Chemmeen vala is given in Fig. 20.

Operation

It is a seasonal fishing gear mainly operated in the monsoon and post monsoon period. It is operated during day and night. Dug out canoes and plank built canoes of 5.4 to 5.9 m length are used as craft.

The catch comprises of *Penaeus indicus* and *Metapenaeus monocerus* in addition to this small sized fishes, which are also caught in the gear.

Njarampu vala

Structure

Njarampu vala is found only in Irumpanam areas. It is mainly used as an encircling gear for collection of fishes from FADs.

The gear is made of PA multifilament webbing of 40 mm mesh size. The material is 210Dx2x3 polyamide multifilament. (Table 15). The upper and lower selvedges are absent. Head rope is of 3 mm PP and footrope is composed of a combination of 210Dx2x3 polyamide multifilament and 1 mm PP. Floats composed of PVC discoid and dumbbell shaped concrete pieces are used as sinkers. Hanging coefficient is 0.58. Design of a typical Njarampu vala is given in Fig. 21.

Operation

This gear is mainly operated as encircling gear around FADs. Cashew nut trees (*Anacardium occidentele*) or branches of bamboos

(*Dendrocalamus* sp.) was mainly used for the construction of FADs.. The length of these branches varied (2.0 to 3.0 m) according to the depth of the water column. These branches were fixing in the mud in the bottom parts of the river in an area of 15 to 25 m dia. After fixing the FADs, the fishermen wait for 20 to 30 days for aggregating the fishes. The submerged bundles of twigs or branches of trees make attractive hiding places for fishes. The movement of water in this area is little less compared to other areas of the water body and as a result a number of fishes aggregate in this area.

The fishermen laid down the gear around the FADs. Then the footrope tightened to the river bottom. After that branches and leaves of the plants are removed from the FAD. Then disturbances are made inside the gear and as a result the frightened fishes get gilled or entangled in the gear. Plank built canoes of 5.4 m are used for this purpose. The catch comprises mainly *Etroplus* sp., *Oreochromis mossambicus*, cat fishes, etc.

Neettu vala

Structure

The neetu vala is mainly composed of PA monofilament of 0.16 to 0.23 mm dia. One case is noted where the gear is made of PA multifilament of 210Dx1x3. (Table 16). The upper selvedge of 210Dx2x3, 210Dx3x2 is present in all cases except the multifilament gear. In most of the gears the lower selvedge is absent. Thermocole and PVC floats are commonly used in this type of gear. In one case there are no floats provided and the locally available materials such as stone, brick pieces, tiles and lead are used as sinkers. Hanging coefficient varies from 0.40 to 0.63. Design of a typical Neettu vala is given in Fig. 22. Neettu vala is found in Ayiroor, Kurumassery and Vettilappara areas.

Operation

Generally, only one fisherman is engaged in the operation of the gear. However, during monsoon season two fishermen are engaged in the operation of the gear. Plank built canoes of 3.6 to 5.2 m length are the common crafts from which the gear is operated. The gear operated during day and night according to the availability of the catch. It is operated as both set net and drift net. In certain gears the floats are absent and in such cases the both ends of the gear are fixed on the neighbouring objects in the opposite river banks.

Mani vala

Structure

Mani vala was found only in Bharathapuzha River system. It has a length of 2400 to 5000 meshes and a depth of 100 meshes. It is called as Mani vala because lead sinkers locally called as 'mani' are used as weight.

The Mani vala is made of 210Dx1x2 polyamide multifilament of 20 mm to 35 mm mesh size. (Table 17). Upper and lower selvedges are present in Mani vala. It is made of 210Dx2x3 polyamide multifilament. Head rope is of 6mm coir rope and footrope of 2 to 4 numbers of polyamide multifilament of 210Dx4x3. Floats of PVC discoid shape are using in Mani vala and sinkers are of lead. Hanging coefficient is 0.60. Design of a typical Mani vala is given in Fig. 23.

Operation

Two fishermen engaged in the operation of this gear during rainy season. Plank built canoes of length of 5.0 to 5.4 m were the craft used by the fishermen. and the catch includes small sized fishes like *Puntius* sp. and *Gonoproktopterus* sp.

Chala vala

Structure

Chala vala is found in down stream areas of Chalakudy River and Karuvannur River. This is the old Chala vala used by marine fishermen for catching Chala (*Sardinella* sp.).

It is made of PA monofilament of 0.16 mm dia and mesh size is of 30 mm. The size the gear is 2200 meshes in length and 100 meshes in width. (Table 18). The upper and lower selvedges are made of 210Dx2x3 PA multifilament. The head rope is made of a combination of PA multifilament of 210Dx6x3 and 1.5 mm PP twines. The footrope is made of 3 mm PP twine. Floats of PVC apple type are using in Chala vala and the commonly used sinkers are made of mud. The hanging coefficient is 0.61. Design of a typical Chala vala is given in Fig. 24.

Operation

The chala vala is operated by a single fisherman. It is mainly used as drift net and plank built canoes of length 5.7 to 5.9 m are the common craft used for this gear. After reaching the fishing ground the fishermen carefully released the gear. After socking for 1 to 2 hours the gear is hauled up and to collect the catch. According to the intensity of catch the set time of the gear is varied. The catch comprised of small and medium sized fishes like *Puntius* spp., *Etroplus* sp., *Channas* spp. etc..

Vidu vala

Structure

The gillnet present in the Chittoor areas of Palakkad district is commonly called as Vidu vala. It is exclusively made of PA monofilament. The mesh size varies from 35 to 60 mm. (Table 19). In all the gears the upper and lower selvedges are present and it is made of PA multifilament 210Dx2x3. In Vidu vala the head rope is made of PA multifilament 210Dx6x3. Footrope is of 2.5 mm polypropylene. Thermocole pieces are used as floats and rolled lead sheets are used as sinkers. Hanging coefficient varied from 0.56 to 0.57 mm. Design of a typical Vidu vala is given in Fig. 25.

Operation

This gear is operated throughout the year. Mainly it is operated in the day time. Rubber tubes (Fig. 32) are used as craft during the operation of the gear. Only one fisherman is engaged in the operation of the gear.

On reaching the fishing ground, the fishermen released the gear as drift net. In every 30 to 60 minutes the fishermen collect the catch. During pre monsoon period the gear is hauled in every 1 to 2 hours. The gilled fishes are removed from the gear and thrown over to the river banks or the whole gear is taken to the banks to collect the fish.

The catch comprises *Etroplus* sp., *Oreochromis mossambicus*, etc.

Paachil

Structure

This type of gear is prevalent in the midstream areas of the Bharathapuzha River. The gear is made of PA multifilament webbing of 210Dx1x2 and 210Dx1x3 webbing. The mesh size varies from 35 to 75 mm. (Table 20). The upper and lower selvedge is made of 210Dx2x3 PA multifilament. Two numbers of polypropylene (1 mm dia) is used as head rope. 2 mm polypropylene is used as footrope. Pieces of rubber slippers are used as floats. Rock pieces are used as sinkers and in some cases sinkers are absent. Hanging coefficient varies from 0.47 to 0.50. Design of a typical Paachil is given in Fig. 26.

Operation

On reaching the fishing ground the fishermen release the gear. The speciality of this gear is that pieces of old rubber slippers are used as floats and stones are used as sinkers. This gear is mainly used as drift gear. One end of the gear is fixed to the craft or the neighbouring objects and other end is left free. Small plank built canoes of length of 3.6 to 4.6 m were the craft used for the operation of this gear.

The catch mainly comprised of *Etroplus* sp., *Puntius* sp., *Oreochromis mossambicus*, and *Hyporhampus* sp.

Kaara vala

Structure

Kaara vala is found in down stream areas and this gear is mainly aimed to fish *Penaeus monodon* (Tiger prawn) locally called Kara and hence its name as Kaara vala. The gear is 1300 to 2000 meshes in length and 50 meshes in depth. This gear is described earlier by Pauly (1991).

It consists of only PA monofilament of 0.16 to 0.23 mm dia. The mesh size is 55 mm. (Table 21). Polyamide multifilament of specification 210Dx3x2 selvedges are present in some gears. Head rope consists of 2.5 to 3 mm polypropylene twine and 3 mm PE twines. Old twisted PA webbings are used as footrope and in certain cases footrope is absent. Disc shaped PVC are commonly used and in certain cases pieces of rubber slippers are popular as floats. Stone is used as sinkers. The gear consists of PA old webbing as footrope and such cases gears didn't have any sinkers. Hanging coefficient varies from 0.45 to 0.56. Design of a typical Kaara vala is given in Fig. 27.

Operation

It is operated mainly in night time during monsoon and post monsoon season.

Plank built canoes of length 5.2 to 5.4 m were the craft used for this gear. The catch comprises *Penaeus monodon* in addition to it small and medium sized fishes are caught.

Kannadi vala

Structure

It is exclusively made of PA monofilament of 0.16 to 0.23 mm dia. The length of the gear varies from 1200 to 2000 meshes in length and 50 to 100 meshes in depth. The mesh size varies from 20 to 75 mm. (Table 22). The upper selvedge is made of 210Dx2x3 to 210Dx3x3 PA multifilament. The lower selvedge is absent in all cases. In Cheruvaloor areas the head rope is made of PP 2.5 to 3 mm dia. and in Pottichira areas it is made of 210Dx20x3 PA multifilament. The footrope is made of polypropylene and polyethylene twine of 2 to 2.5 mm dia. Floats of PVC apple type are using in this type of gears. The locally available materials such as bricks, tile pieces etc. are used as sinkers and lead sinkers are using in certain areas.

Hanging coefficient varies from 0.41 to 0.63. Design of a typical Kannadi vala is given in Fig. 28. It is found only in Cheruvaloor and Pottichira areas.

Operation

In Cheruvaloor areas, two fishermen are engaged in operation of the fishing gear from plank built canoes of length 5.2 to 5.9 m. On reaching the fishing ground one of the fisherman released the gear very carefully, while that time the other man navigated the craft. The gear is hauled in every 1 hour during monsoon and post monsoon period. In night fishing during pre monsoon period the fishermen release the gear in the late evening and haul up it early in the morning. The catch comprises large and medium sized fishes.

Visaly vala

Structure

The Visaly vala is widely operated in the upstream and midstream areas of Periyar and Muvattupuzha River system. It is a collective name for the gillnet. Because the monofilament is too transparent, it is called as Vaisaly net.

The Visaly vala is exclusively made of PA monofilament of 0.16 to 0.32 mm thickness. The mesh size varies from 30 to 140 mm according to the fishes to be caught. (Table 23). All the gears have upper and lower selvedges of PA multifilament of specification 210Dx2x3 and 210Dx3x2. But in Thattekkadu in certain Visaly gears have only upper selvedge. Head rope is mainly made of PP (3 mm) and PE (2.5 to 3 mm) and footrope is of PE (2.5)and Jute (8 mm). Floats are of PVC and thermocole and sinkers are of stone. Hanging coefficient varies from 0.43 to 0.52. Design of a typical Visaly vala is given in Fig. 29.

Operation

In most of the areas, only one fisherman is engaged in the operation of the gear. The gear is mainly used as drift net. Operation is done during day and night. In day fishing the fishermen started the operation early in the morning and finished the operation by 10 to 11'0 clock. When the operation is in the night, the fishermen shot the gear late in the evening and hauled the gear early in the morning. During monsoon and post monsoon time, the gear is hauled in every 1 to 2 h. In other seasons, the gear is shot in the late evening and hauled early in the morning. Plank built canoes of length of 5.0 to 6.1 m were used for the operation of this gear.

A wide range of mesh sizes from 30 to 140 mm is used in this gear and the catch varies according to the mesh size used in the gear. The catch comprises *Etroplus* sp., *Puntius* sp., *Oreochromis mossambicus*, and *Hyporhampus* sp.

Thandadi vala

Structure

In the riverine systems the gillnets are collectively called as Thandadi vala. These gears are aimed for catching different types of fishes.

Thandadi vala is very common in most of the riverine areas under study viz., Palamittton, Pariyaram, Pavaratty, Perigottukara, Poringalkuthu, Pottichira, Thavanoor, Thirunavaya, Malayattoor, Mannarkadu, Moorkanadu, Muzhikkulam, Ottappalam, Kothamangalam, Kumarampathoor, Eenamavu. Lakkidi, Bhoothathankettu, Cheruvaloor, Chettuva, Illikkal, Karuvannur, Koduvayoor and Kolupra.

Two types of Thandadi vala are used in the above areas viz. nylon monofilament gears and multifilament gears.

Nylon monofilament gear

Nylon monofilament webbing of 0.16 to 0.23 mm dia is used the construction of monofilament Thandadi vala. The mesh size varied from 30 to 90 mm. The upper selvedge is made of PA multifilament of twine size 210Dx2x3 or 210Dx3x2. The lower selvedge is made of PA multifilament of twine size 210Dx2x3 or 210Dx3x2. In certain cases lower selvedge is absent. Head rope is made of polypropylene twine of 2.5 to 3 mm dia or PE twine of 3 mm dia or PA multifilament twine of 210Dx12x3 or 210Dx20x3. Footrope is made of 2.5 mm dia PP twine or 2.5 to 3 mm dia

PE or PA multifilament of twine size 210Dx12x3. In a number of areas where the gears are operated footrope is absent. In Thirunavaya and Kolupra areas, coir ropes are used as footropes in certain gears and in such cases the sinkers are absent. Commonly used floats are constructed of PVC and thermocole. Among PVC floats the apple shaped and discoid types are common. Bamboo pieces of 50-75 mm length are used as floats in gears of Mannarkadu areas. In some regions floats are absent. The commonly available materials such as lead, stone, brick, tiles and concrete are used as sinkers. The rolled sinker sheets are used as sinkers in some areas. Specially prepared dumbbell shaped mud sinkers are common in areas like Mannarkadu, Kumarampathoor, etc. Hanging coefficient varied from 0.42 to 0.66.

Nylon multifilament gear

Multifilament of specification 210Dx1x2, 210Dx1x3 or 210Dx2x3 are used as webbing. The mesh size varied from 55 to 110 mm. The upper selvedge is made of PA multifilament of specification 210Dx2x2, 210Dx2x3, 210Dx3x2 or 210Dx3x3. The lower selvedge is absent. In Thavanoor, Bhoothathankettu areas both upper and lower selvedges are absent. Head rope is made up of PE twine 3 mm dia or PA multifilament of twine specification 210Dx20x3. Footrope is absent. In Poringalkuthu areas, pieces of *Saccharum spontaneum* (a locally available plant stem) is used as floats. In Kothamangalam areas pieces of rubber slippers are used as floats in some gears. PVC floats of apple and discoid type are very common and lead, stone, rock, are used for sinkers. Hanging coefficient varied from 0.41 to 0.63. Design of a typical Thandadi vala is given in Fig. 30.

Operation

One fisherman is generally engaged in the operation of this gear. In monsoon and post monsoon period two or three fishermen are engaged in the operation of the gear.

The gear is operated during day and night. The gear is generally shot late in the evening and hauled early in the morning. Different types of crafts are used in different areas. Plank built canoes of length 5.0 to 5.9 m are very common. Fishing without craft is also common in some areas.

Catch varies from gear to gear because of the mesh size variation of the gear from 30 to 100 mm. Catch comprises *Etroplus* sp., *Puntius* sp., *Oreochromis mossambicus*, and *Hyporhampus* sp

Odakku vala

Structure

Odakku vala is a collective name of gillnets in most of the riverine sector. It is generally not targeted at particular species. There is a wide range of mesh sizes is used in the riverine waters of Kerala. According to the variation of mesh size and twine size, it is used for capture different species of fish.

In most of the areas, the Odakku vala is made of PA monofilament. In very few areas like Irumpanam, Kalady, Kalampoor, Moolamattom and Kurumassery, gears made of polyamide multifilament are also seen along with monofilament gears. In PA monofilament Odakku vala, a wide range of mesh sizes from 25mm to 110 mm are used in different areas according to the target species. In PA multifilament Odakku vala, the mesh size varied from 50 to110 mm. The twine size ranged from 0.16 to 0.32 mm dia in polyamide monofilament gear and 210Dx1x2 and 210Dx1x3 twines were used for polyamide multifilament gear. Generally PA multifilament of 210Dx2x2, 210Dx2x3, 210Dx3x2 and 210Dx3x3 is used as selvedge. The most commonly used one is 210Dx2x3. In areas like Kalampoor, Moolamattom, Kalady, Paimattom, Karakkunnu, Thirunavaya, Randar and Ganapathy, some gears didn't have selvedge and in areas like Moolamattom, Palamittom, Irumpanam, Kurumassery, Thirunavaya, Thavanoor and Kurumassery, some gears had only upper selvedge. Polypropylene and polyethylene twine of size 2.5 to 3.0 mm dia are the commonly used material for head ropes. In addition, PA multifilament twine of 210Dx6x3, 210Dx9x3, and 210Dx12x3 and 210Dx20x3 are used in areas like Thirunavaya and Kurumassery. PP twines of 2 to 3 mm dia and PE twines of varies from 2.5 to 3 mm dia were used as footrope. In addition to these, 5 mm thickness jute rope is used in Kalampoor and Kalady areas. Old PA webbings (twisted) is used in Irumpanam, Randar and Kadumpidy areas. Braided PE of 3mm dia is used as footrope in

Karuvannur areas. In Moolamattom, Kalady, Palamittom Vadattupara and Thavanoor some gears didn't have the footrope. The commonly used floats are PVC (Apple and disc-shaped). Thermocole floats are also seen in areas like Kalady, Thavanoor, Thirunavaya, Vazhani and Chettuva. In areas like Karakkunnu and Randar pieces of rubber slippers are also used as floats. In Moolamattom area, 'peely' (*Ochlandra* sp.) of plant origin is used in certain gears as floats. In Moolamattom and Palamittom areas some gears didn't have any floats. In such cases the gear is attached to the twigs and roots of the neighbouring trees during operation. Commonly used sinkers are pieces of stone, tiles, rock and lead. Mud sinkers are very common in Kurumassery areas. During the operation, the mud sinkers absorbs water and it leads to the increase of weight in footrope. In areas like Irumpanam and Randar sinkers are absent. Hanging coefficient varied from 0.4 to 0.63. Design of a typical Odakku vala is given in Fig. 31.

Operation

Only one fisherman is engaged in the operation of this gear. In monsoon and post monsoon period two or three fishermen are engaged in the operation of the gear.

The gear is operated during day and night. If the availability of fish is less the fishermen operate the gear only during night. The gear is shot late in the evening and hauled early in the morning. Different types of crafts are used in different areas. Plank built canoes of length 5.0 to 5.9 m are very common. In some areas rubber tubes are used as craft (Fig. 32). Fishing without craft is also practiced in some areas.

Species constituting the catch varied from gear due to significant variation in the mesh sizes used (25 mm to 100 mm. Species caught generally are *Etroplus* sp., *Puntius* sp., *Oreochromis mossambicus*, *Wallagu attu*, and *Hyporhampus* sp.

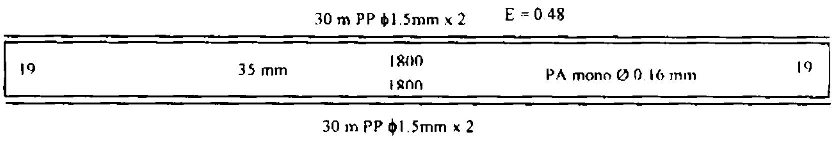
Table 5. Distribution of gillnets in rivers of central Kerala

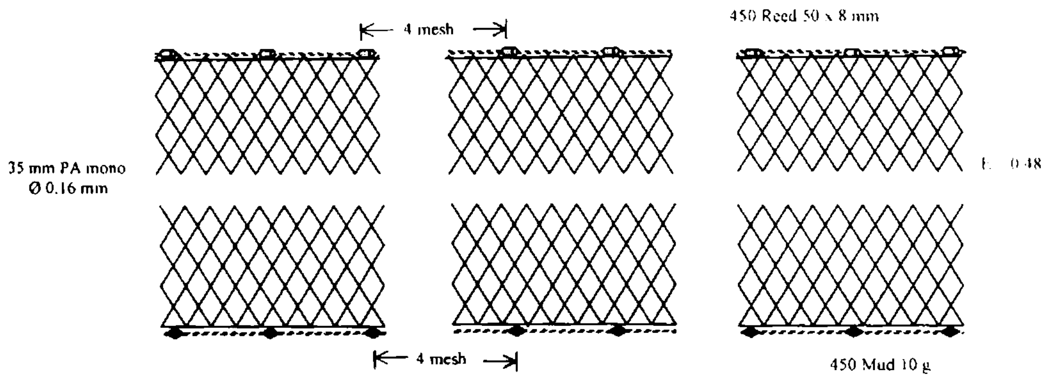
Local Name	Bharathapuzha River	Chalakudy River	Karuvannur River	Keecheri River	Muvattupuzha River	Periyar River	Puzhakkal River	**Total**
Andhra vala		1			3	1		5
Chala vala		1						1
Chemmeen vala					1			1
Kannadi vala		4	3					7
Karimeen Vala				1	4	2		7
Kuruva vala		1			4			5
Mani vala	3							3
Neettu vala		17						17
Njarampu vala					1			1
Odakku vala	19	13		3	20	24	4	79
Paachil	2							2
Pandi vala					8			8
Podi vala					2			2
Thandadi vala	60	15	28		4	17		124
Vaisaly vala					4	8		8
Vazhutha vala					2			2
Vidu vala	2							2
Vaala vala		3	1		5	1		10
Kaara vala					2	1		3
Total	**86**	**55**	**32**	**4**	**60**	**54**	**4**	**295**

Table 6. Specifications of *Andhra vala*

Gillnet Local name : Andhra vala	Main species: *Etroplus* sp., *Puntius* sp. and *Gonoproktopterus* sp.	
Specifications	Category I [1]	Category II [2]
Material	PA Monofilament	PA Monofilament
Mesh size (mm)	35	35-65
Twine size (mm)	0.16 mm ϕ	0.16-0.23 mm ϕ
Length in mesh (No.)	1800	1000-2000
Depth in mesh (No.)	19	19-30
Selvedge Top	Nil	0.5-1.0
Material	Nil	PA Multifilament
Mesh size (mm)	Nil	50-60
Twine size	Nil	210Dx2x2, 210Dx2x3
Selvedge Bottom	Nil	0.5-1.0
Material	Nil	PA Multifilament
Mesh size (mm)	Nil	50-65
Twine size	Nil	210Dx2x3
HR		
Material	PP	PP/PP&PA Multifilament
Twine size	1.5 mm x 2	1.5 mx2/2.5mm/210Dx6x3&1.5mm
Length (m)	30	30-40
FR		
Material	PP	PP
Twine size	1.5mm x2	2.5mm/3mm/210Dx2x3&1mm
Length (m)	30	30-40
Hanging Coefficient	0.48	0.50-0.56
Float		
Material	Peely	Peely
Size (length/mm)	50	50
No. of floats	450	250-500
Distance between floats	4 meshes	4 meshes
Sinkers		
Material	Mud	Mud
No. of sinkers	450	250-500
Distance between sinkers	4 meshes	4 meshes
Size (mm)	35 mm	35 mm
Shape	Dumbbell	Dumbbell

1. Gillnets without selvedges
2. Gillnets with selvedges





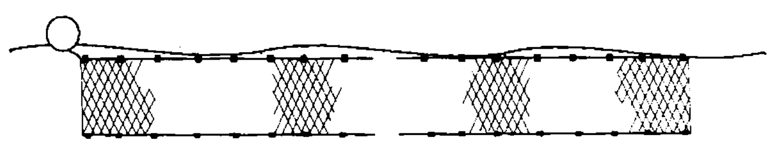


Fig. 10. ***Andhra vala***

Table 7. Specifications of *Pandi vala*

Gillnet Local name : Pandivala		Main sps. : *Etroplus* sp., *Puntius* sp. and *Gonoproktopterus* sp.	
Specifications	Category I [1]	Category II [2]	Category III [3]
Material	PA Monofilament	PA Monofilament	PA Monofilament
Mesh size (mm)	35	35	35-60
Twine size (mm)	0.16 mm ϕ	0.16-0.23 mm ϕ	0.16-0.20 mm ϕ
Length in mesh (No.)	1300-1500	1200-1500	1000-1700
Depth in mesh (No.)	19	19-50	19-30
Selvedge Top	Nil	0.5-1.0	0.5-1.0
Material	Nil	PA Multifilament	PA Multifilament
Mesh size (mm)	Nil	55-55	55-60
Twine size	Nil	210Dx2x2, 210Dx2x3	210Dx2x2, 210Dx2x3
Selvedge Bottom	Nil	Nil	0.5-1.0
Material	Nil	Nil	PA Multifilament
Mesh size (mm)	Nil	Nil	55-60
Twine size	Nil	Nil	210Dx2x2, 210Dx2x3
HR	PP	PP	PP
Twine size	1.5 x 2	1.5x2	1.5x2
Length (m)	30	30	30
FR	PP/PA&PP	PP/PA&PP	PP/PA&PP
Twine size	1.5x2, 210Dx2x3&1.5	1.5x2, 210Dx2x3&1.5	1.5x2, 210Dx2x3&1.5
Length (m)	30	30	30
Hanging Coefficient	0.57-0.66	0.45-0.50	0.50-0.55
Float	Peely	Peely	Peely
Size (mm)	40	40	40
No. of floats	325-375	300	250-500
Distance between floats	4 meshes	4 meshes	4 meshes
Sinkers	Mud	Mud	Mud
No. of sinkers	325-375	300	250-500
Distance between sinkers	4 meshes	4 meshes	4 meshes
Size	35 mm	35 mm	35 mm
Shape	Dumbbell	Dumbbell	Dumbbell

1. Gillnets without selvedges
2. Gillnets with top selvedge
3. Gillnet with top and bottom selvedges

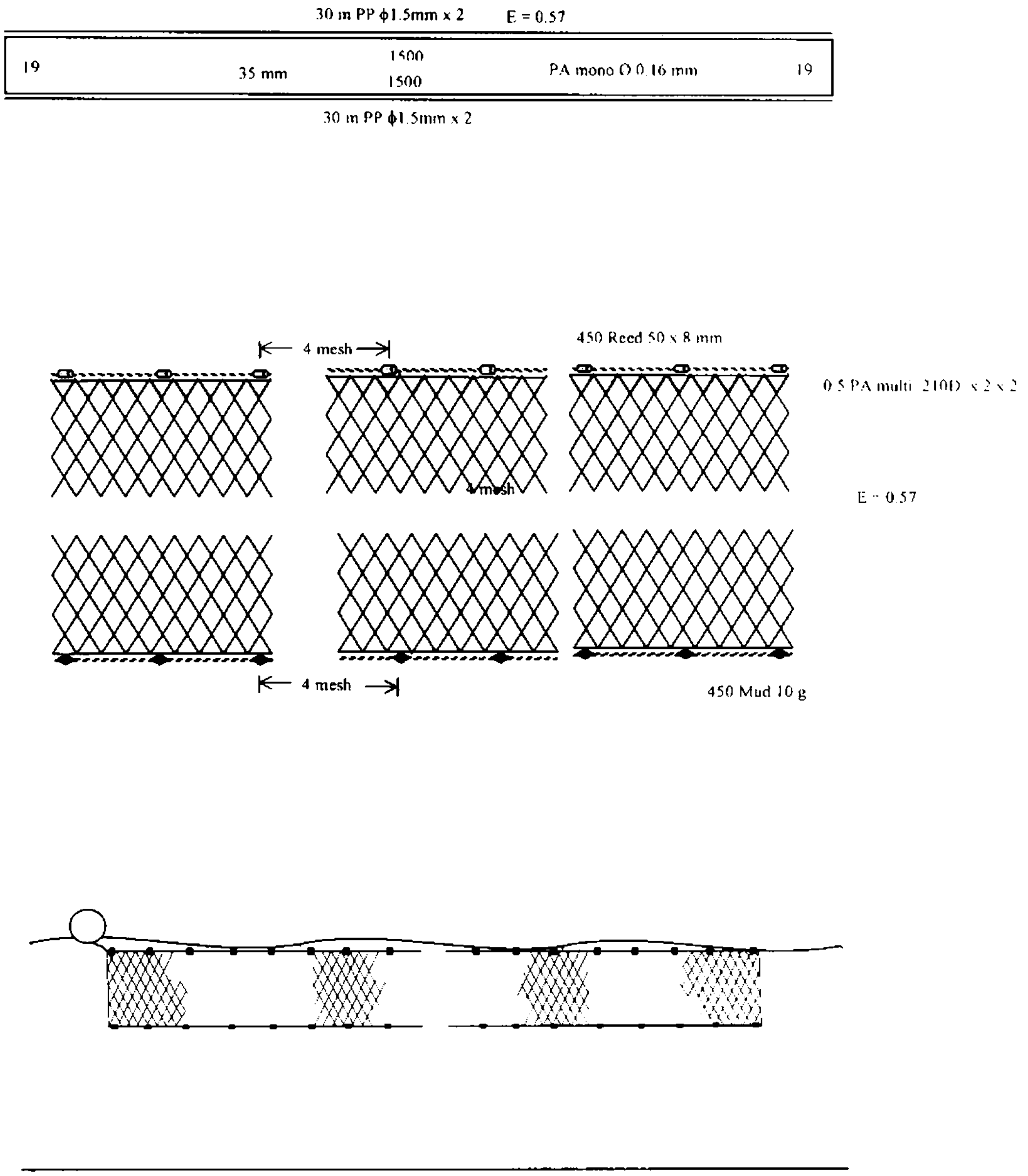


Fig. 11. ***Pandi vala***

Table 8. Specifications of *Podi vala*

Gillnet Local name : Podivala	Main sps. : *Puntius* sp. and Prawn
Material	PA Multifilament
Mesh size (mm)	30-35
Twine size (mm)	210Dx1x2
Length in mesh (No.)	1500-2500
Depth in mesh (No.)	50
Selvedge Top	0.5
Material	PA Multifilament
Mesh size (mm)	55
Twine size	210Dx2x3
Selvedge Bottom	Nil
Material	Nil
Mesh size (mm)	Nil
Twine size	Nil
HR	PP
Twine size (mm ϕ)	2.5
Length (m)	45
FR	Jute
Twine size(mm ϕ)	4.0
Length (m)	35-45
Hanging Coefficient	0.60-0.67
Float	PVC
Size (mm)	50x20x60x20
No. of floats	35-45
Distance between floats	1.0 m
Sinkers	Nil

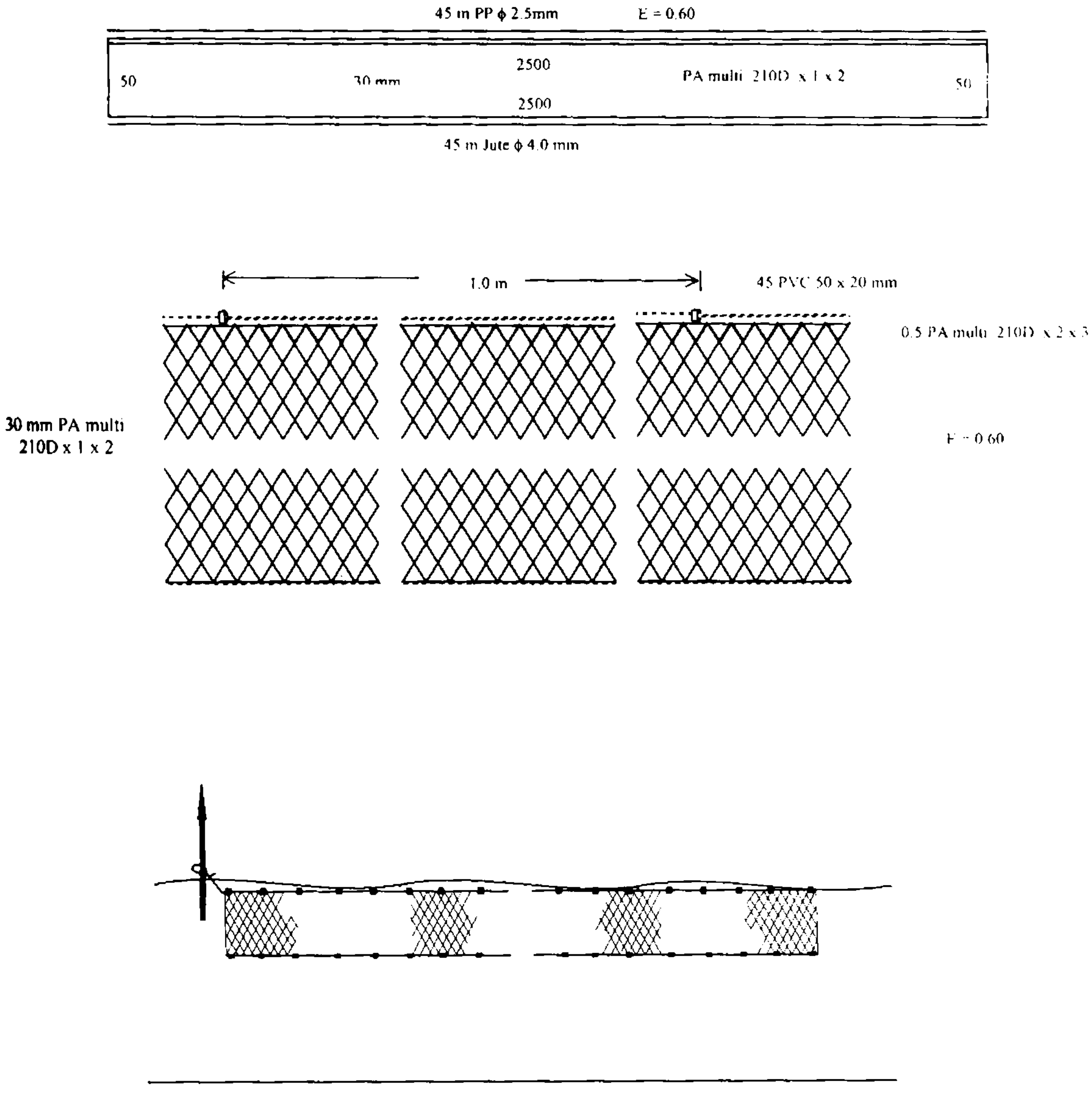


Fig. 12. *Podi vala*

Table 9. Specifications of *Kuruva vala*

Gillnet Main sp. : *Puntius* sp.

Local name : Kuruvavala

Specifications	Category I [1]		Category II [2]	Category III [3]
Material	PA Monofilament	PA Multifilament	PA Monofilament	PA Multifilament
Mesh size (mm)	55	50-60	40-50	50-60
Twine size	0.23 mm ϕ	210Dx1x2	0.16-0.23 mm ϕ	210Dx1x2
Length in mesh (No.)	1600	900-1200	1300-2000	900 -1200
Depth in mesh (No.)	50	50	50-65	50
Selvedge Top	1	1	0.5-1.0	Nil
Material	PA Multifilament	PA Multifilament	PA Multifilament	Nil
Mesh size (mm)	55	50	55	Nil
Twine size	210Dx3x2	210Dx2x3	210Dx2x3-210Dx3x2	Nil
Selvedge Bottom	1	0.5	Nil	Nil
Material	PA Multifilament	PA Multifilament	Nil	Nil
Mesh size (mm)	55 mm	50	Nil	Nil
Twine size	210Dx3x2	210Dx2x3	Nil	Nil
HR	PP	PA Multifilament	PP	PP
Twine size	2.5 mm	210Dx6x3x2	2.5-3.0 mm	2.5
Length (m)	50	30-35	40-45	30-35
FR	Old PA webbings	PP	PP	Jute
Twine size	12.0 mm ϕ	2.0 mm ϕ	2.5-3.0 mm ϕ	3.0 mm ϕ
Length (m)	50	30-35	40-45	30-35
Hanging Coefficient	0.57	0.50-0.70	0.56-0.62	0.50-0.70
Float	PVC compressed	PVC Apple	PVC/Pieces of RS	PVC
Size (mm)	60 x 20	50 x 10	50 x 20	60 x 20
No. of floats	31	30	28-45	35
Distance between floats	1.6 m	1 m	1.0-1.5 m	1 m
Sinkers	Pb	Pb sheet	Steel ring/Pb	Pb
No. of sinkers	125	34	45/80	35
Distance between sinkers	40 cm	15 mesh	50-100 cm	1.0 m
Size	20 g	25 mm	100g-200 g	100-150 g
Shape	Dumbbell	Cylinder	ring/dumbbell	Dumbbell

1. Gillnets with top and bottom selvedges
2. Gillnets with top selvedge
3. Gillnet without selvedges

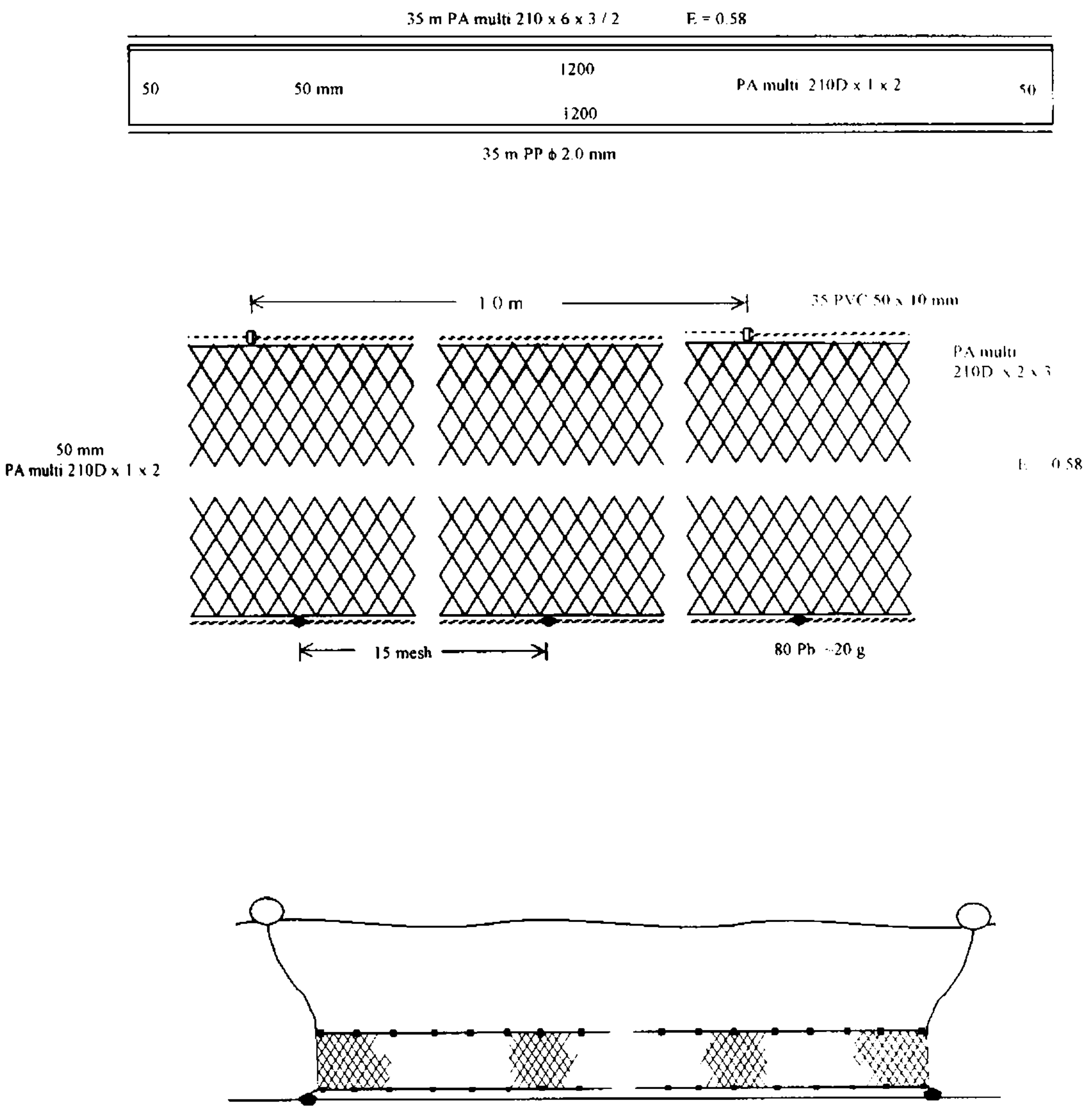


Fig. 13. ***Kuruva vala***
PA Multifilament

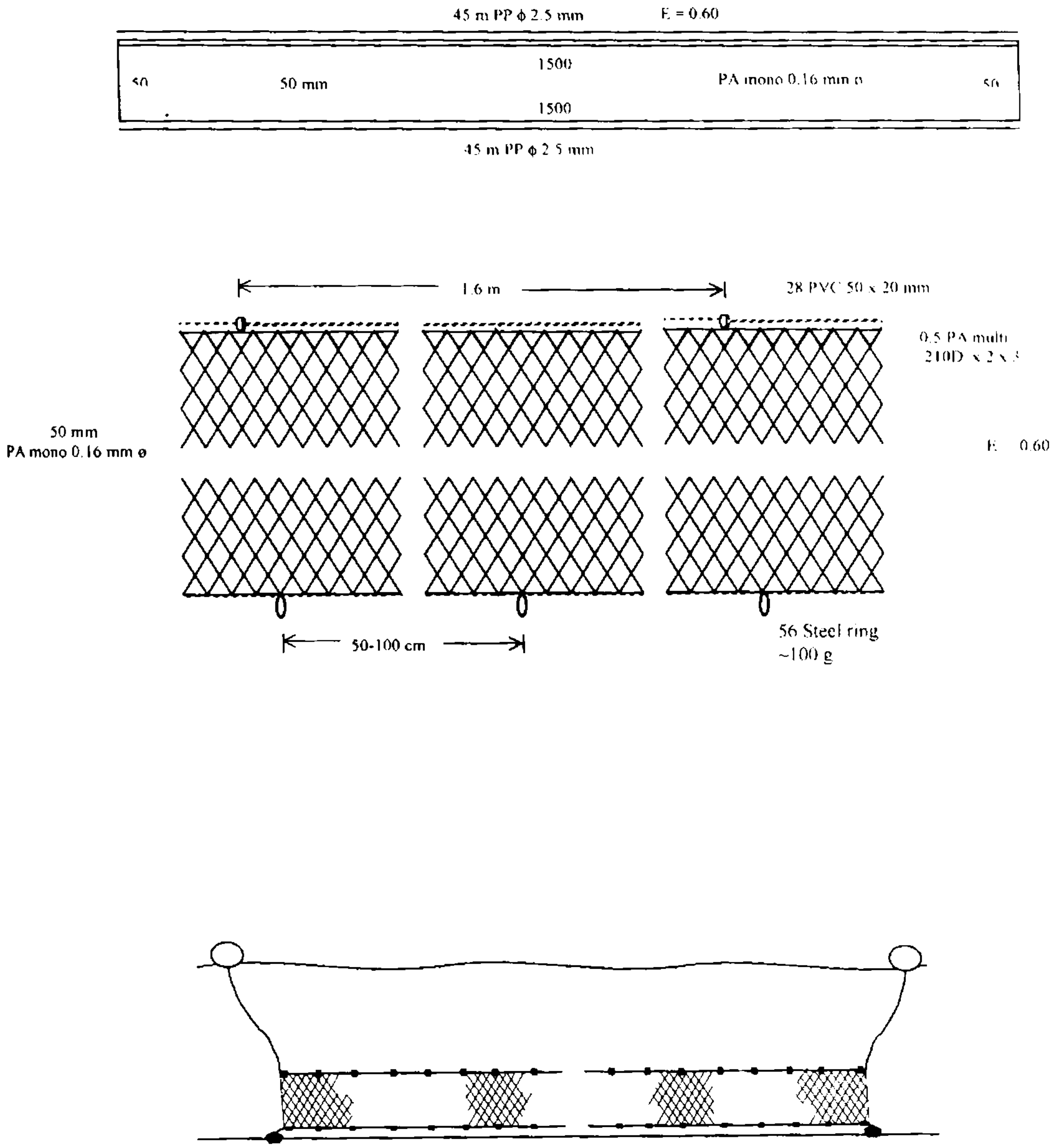


Fig. 14. ***Kuruva vala***
PA Monofilament

Table 10. Specifications of *Karimeen vala*

Gillnet Local name : Karimeen vala	Main sp. : *Etroplus* sp.	
Specifications	Category I [1]	Category II [2]
Material	PA Monofilament	PA Multifilament
Mesh size (mm)	50-55	55
Twine size	0.16-0.23 mm ϕ	210Dx1x2-210Dx1x3
Length in mesh (No.)	1500	1300-1800
Depth in mesh (No.)	50	50
Selvedge Top	1	1
Material	PA Multifilament	PA Multifilament
Mesh size (mm)	55	55-60
Twine size	210Dx3x2	210Dx2x3-210Dx3x2
Selvedge Bottom	Nil	Nil
Material	Nil	Nil
Mesh size (mm)	Nil	Nil
Twine size	Nil	Nil
HR	PP	PP/PE
Twine size (mm ϕ)	3	2.5-3.0
Length (m)	45	45-55
FR	Nil	Nil
Twine size (mm ϕ)	Nil	Nil
Length (m)	Nil	Nil
Hanging Coefficient	0.54-60	0.45-0.63
Float	PVC compressed	PVC/Thermocole
Size (mm)	50 x 20	50x10/60x20/50x30x30
No. of floats	45	22-39
Distance between floats	1.0 m	1.1-2.1 m
Sinkers	Steel ring	Stone
No. of sinkers	45	20-60
Distance between sinkers	1.0 m	1.5-2.0 m
Size	80 mm ϕ	100-300 g
Shape	ring	Irregular

1. Gillnets with monofilament webbing.
2. Gillnets with multifilament webbing.

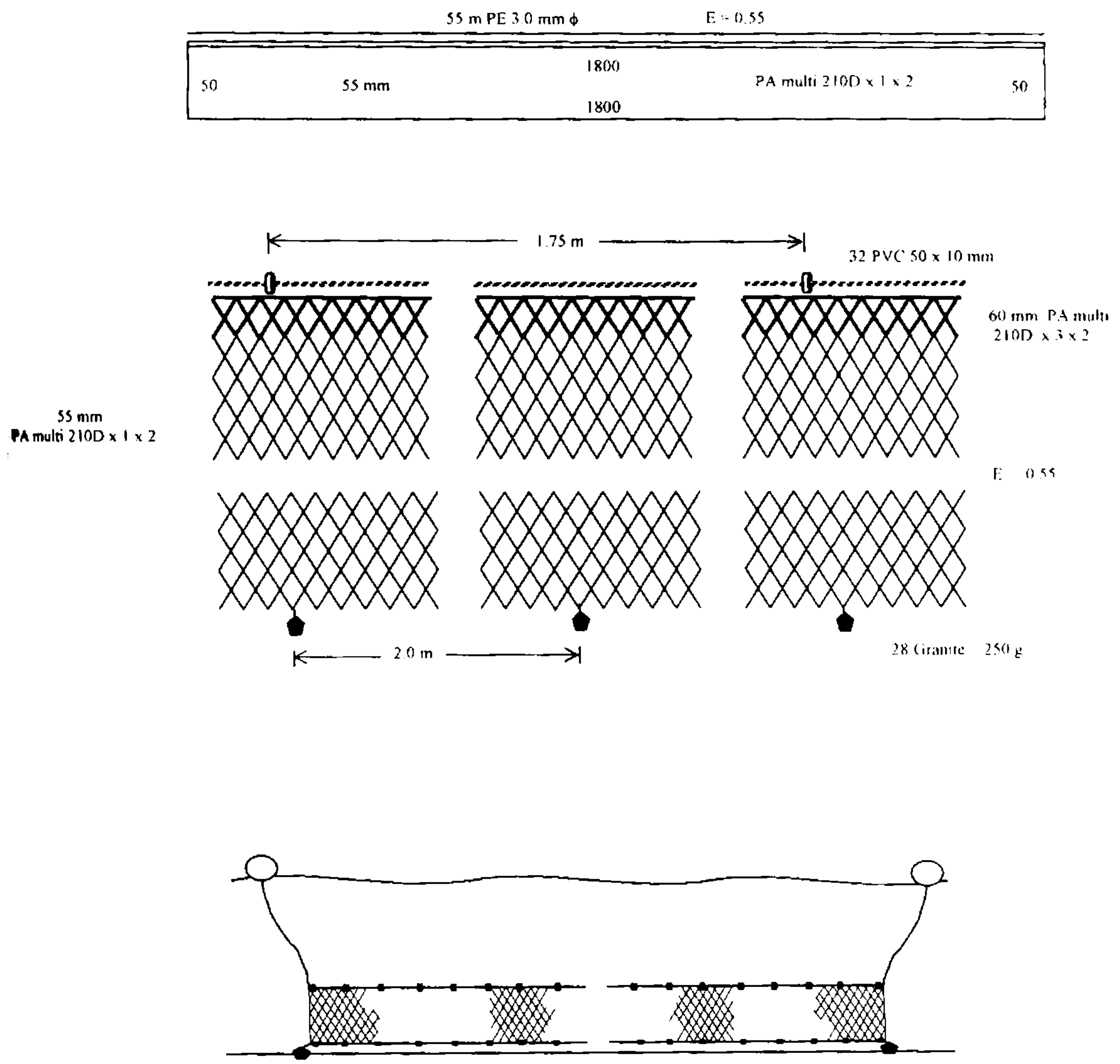


Fig. 15. *Karimeen vala PA multifilament*

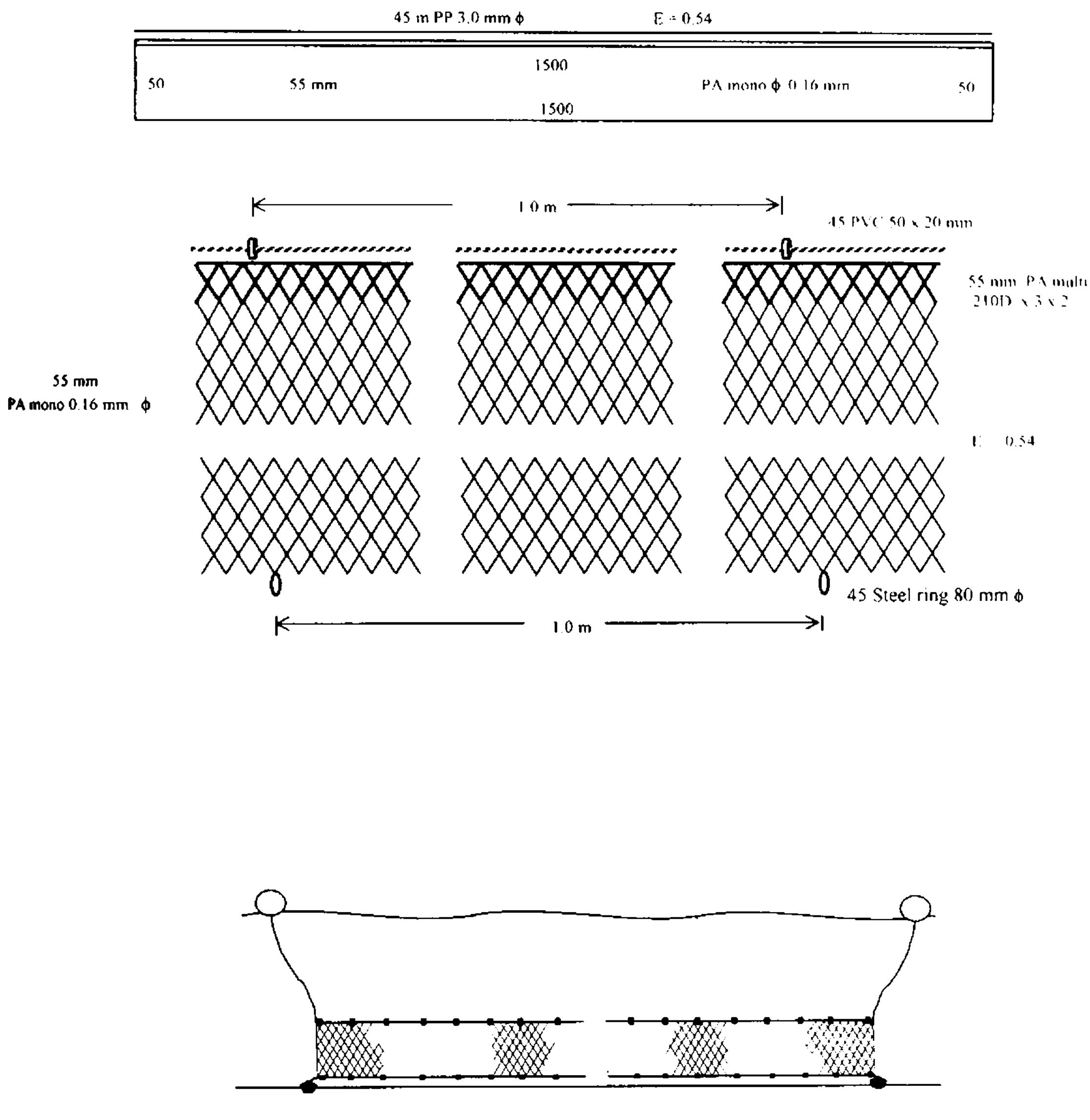


Fig. 16. ***Karimeen vala***
PA Monofilament

Table 11. Specifications of *Thandadi vala*

Gillnet	Main sp. : *Etroplus* sp.
Local name : Karimeen vala/Thadmvali	
Material	PA Multifilament
Mesh size (mm)	55
Twine size	210Dx1x3
Length in mesh (No.)	1500
Depth in mesh (No.)	50-100
Selvedge Top	2
Material	PA Multifilament
Mesh size (mm)	60
Twine size	210Dx2x3
Selvedge Bottom	Nil
Material	Nil
Mesh size (mm)	Nil
Twine size	Nil
HR	PP
Twine size	3.0 mm ϕ
Length (m)	45
FR	Coir ropes
Twine size	8.0 mm ϕ
Length (m)	45
Hanging Coefficient	0.55
Float	Thermocole
Size (mm)	50 x 30 x 30
No. of floats	10
Distance between floats	5
Sinkers	Rock pieces
No. of sinkers	18
Distance between sinkers	2.5 m
Size	150 g
Shape	irregular

Table 12. Specifications of *Vazhutha vala*

Gillnet	Main sp. : *Labeo* sp.
Local name : Vazhuthavala	
Material	PA Monofilament
Mesh size (mm)	75
Twine size	0.16-0.23 mm ϕ
Length in mesh (No.)	700-1100
Depth in mesh (No.)	25-50
Selvedge Top	0.5
Material	PA Multifilament
Mesh size (mm)	100
Twine size	210Dx2x3
Selvedge Bottom	Nil
Material	Nil
Mesh size (mm)	Nil
Twine size	Nil
HR	PP
Twine size	2.5-3.0 mm ϕ
Length (m)	35-45
FR	Jute/PP
Twine size	2.0-3.0 mm ϕ
Length (m)	35-45
Hanging Coefficient	0.55-0.67
Float	PVC
Size (mm)	70 x 20
No. of floats	35-45
Distance between floats	1.0 m
Sinkers	Rock/Steel ring
No. of sinkers	16-45
Distance between sinkers	1.0-2.25 m
Size	100-200 g
Shape	irregular/ring (80 mm dia)

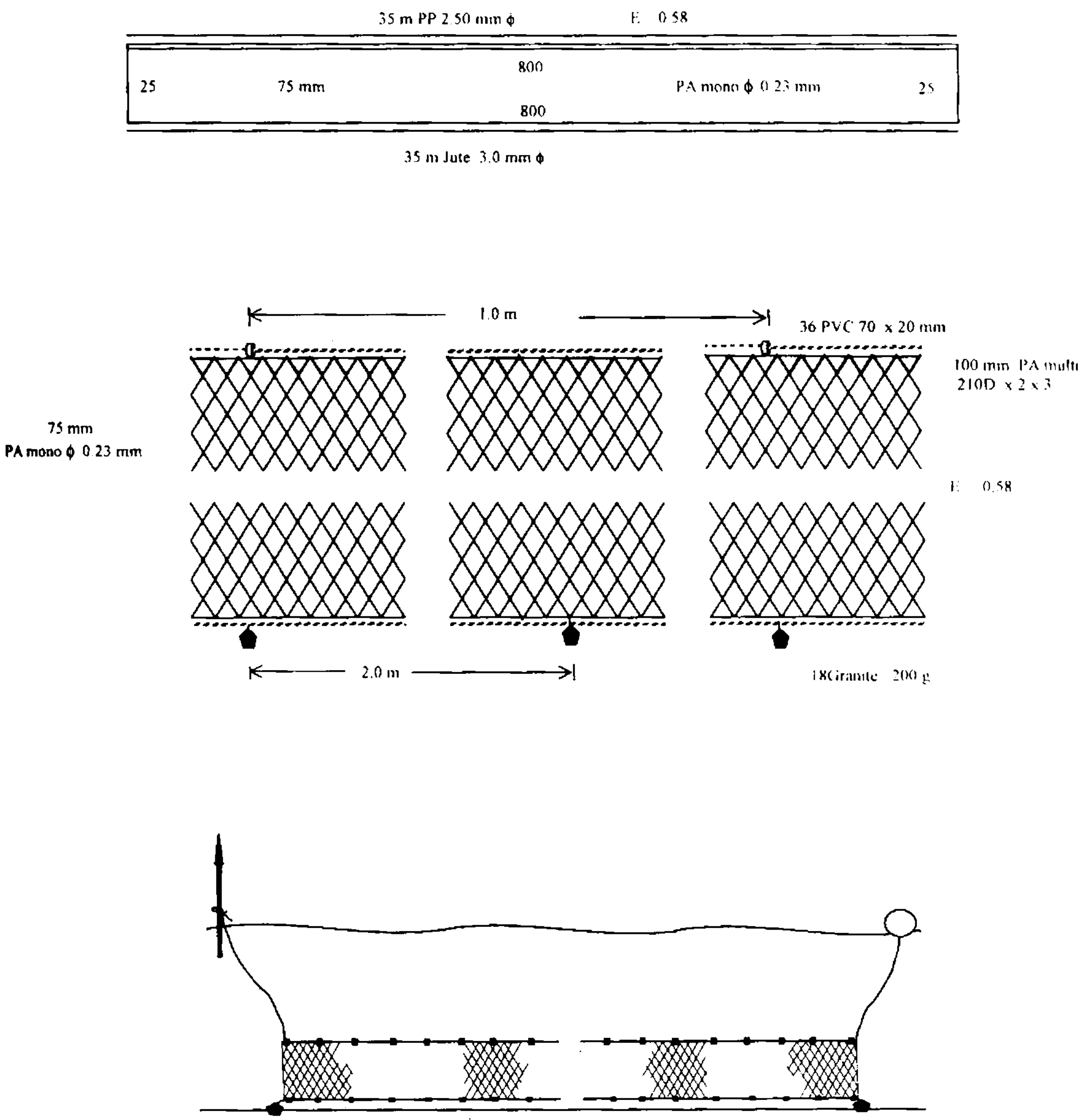


Fig. 17. *Vazhutha vala*
PA Monofilament

Table 13. Specifications of *Vala vala*

Gillnet Local name : Vala vala		Main sp. : *Wallagu attu*	
Specifications	Category I [1]		Category II [2]
Material	PA Multifilament	PA Monofilament	PA Monofilament
Mesh size (mm)	100-110	80-85	90-110
Twine size	210Dx1x2	0.23-0.32 mm ϕ	0.23-0.32 mm ϕ
Length in mesh (No.)	500-600	800-1000	800-1200
Depth in mesh (No.)	15-20	20-25	15-25
Selvedge Top	1	0.5-1.0	0.5-1.0
Material	PA Multifilament	PA Multifilament	PA Multifilament
Mesh size (mm)	100-110	100	90-100
Twine size	210Dx2x3	210Dx2x3	210Dx2x3, 210Dx3x2
Selvedge Bottom	0.5	0.5-1.0	Nil
Material	PA Multifilament	PA Multifilament	Nil
Mesh size (mm)	100-110	100	Nil
Twine size	210Dx2x3	210Dx2x3	Nil
HR	PA Multifilament	PP/PA Multi&PP	PP/PA Multifilament
Twine size	210Dx8x3x2, 210Dx9x3x2	2.5mm ϕ, 210Dx6x3&1.8	2.5-3.0mm ϕ / 210Dx20x3
Length (m)	30-40	30-40	40-50
FR	PP/Jute	PP	PP/PE/Old PA webbing
Twine size	2.0/5.0 mm	2.0-3.0 mm	2.5-3.0mm/12.0 mm
Length (m)	30-40	30-40	40-50
Hanging Coefficient	0.60-0.61	0.38-0.50	0.46-0.51
Float	Thermocole	Nil/PVC	PVC/Thermocole
Size (mm)	80 x 40 x 40	Nil/70x20 & 50x20	70/80x20, 80x40x40
No. of floats	28-35	20	22-45
Distance between floats	110 cm	1.5	100-210 cm
Sinkers	Pb sheet/Stone/GI rings	Mud/Pb	Stone/Steel ring
No. of sinkers	18-34	40-150	13-30
Distance between sinkers	60-225 cm	20-100 cm	1.5-2.5 m
Size	40-350 g	40 x 25/40 mm	200-350 g
Shape	Dumbbell/Irregular	Dumbbell	irregular/ring

1. Gillnets with top and bottom selvedges
2. Gillnets with top selvedge

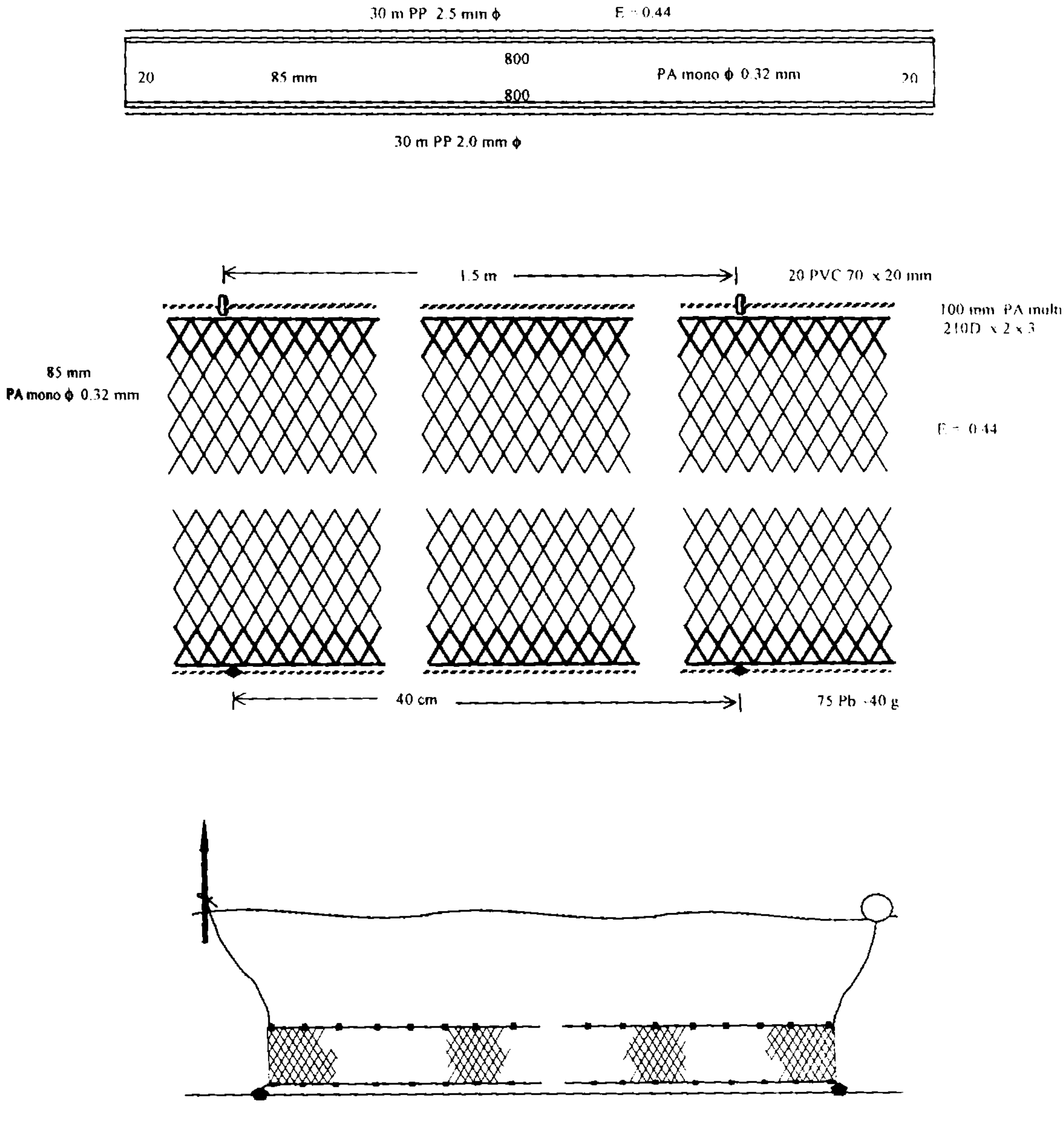


Fig. 18. ***Vala vala***
PA monofilament

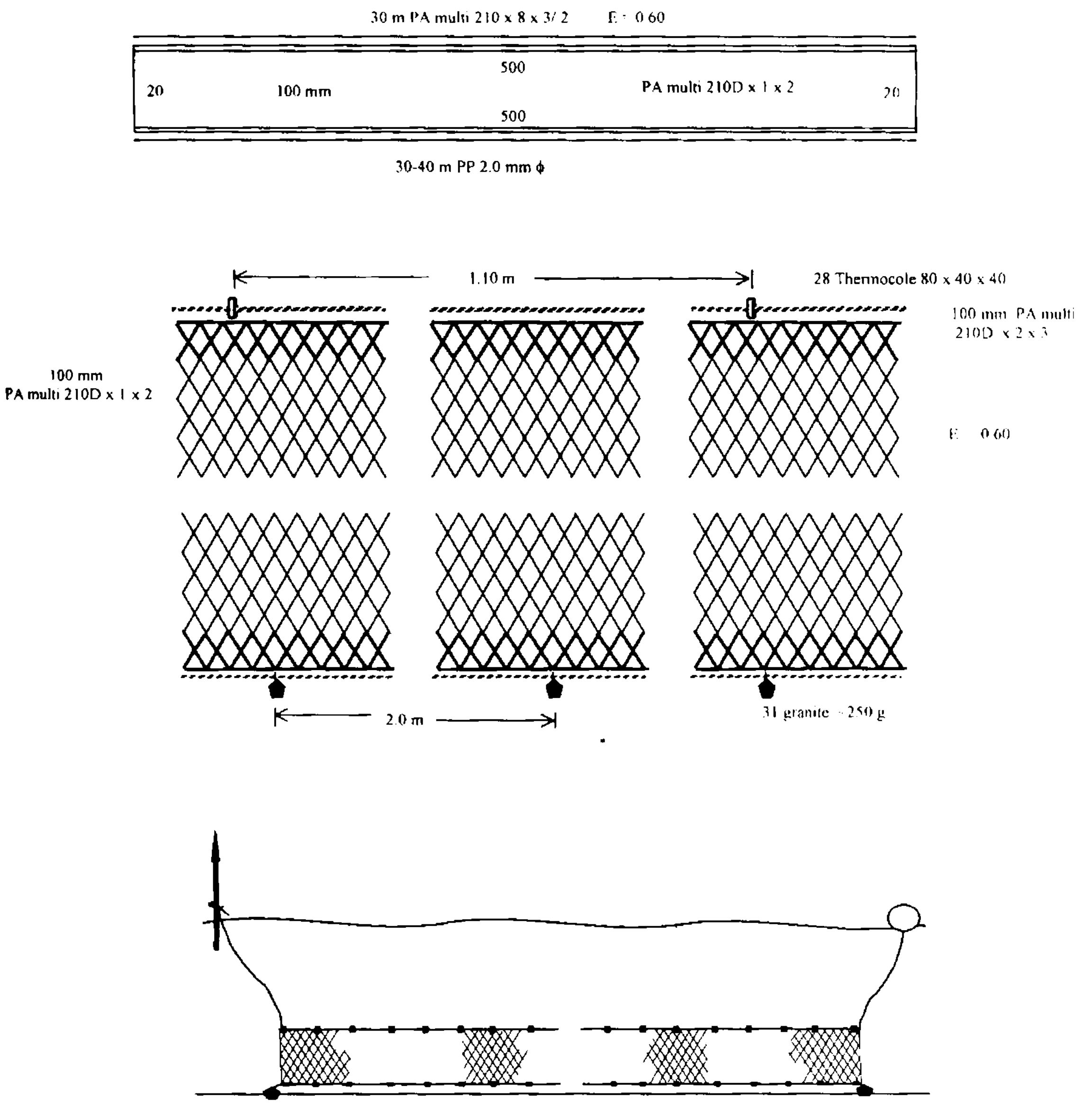


Fig. 19. ***Vala vala***
PA multifilament

Table 14. Specifications of *Chemmeen vala*

Gillnet Local name : Chemmeen vala	Main sp. : Prawn
Material	PA Monofilament
Mesh size (mm)	30
Twine size	0.16 mm ϕ
Length in mesh (No.)	3000
Depth in mesh (No.)	50
Selvedge Top	0.5
Material	PA Multifilament
Mesh size (mm)	50
Twine size	210Dx2x3
Selvedge Bottom	0.5
Material	PA Multifilament
Mesh size (mm)	50
Twine size	210Dx2x3
HR	PP
Twine size	3.0 mm ϕ
Length (m)	45
FR	Old PA webbings (twisted)
Twine size	12.0 mm ϕ
Length (m)	45
Hanging Coefficient	0.50
Float	Thermocole
Size (mm)	50 x 30 x 30
No. of floats	22
Distance between floats	2.15
Sinkers	FR also act as wt.

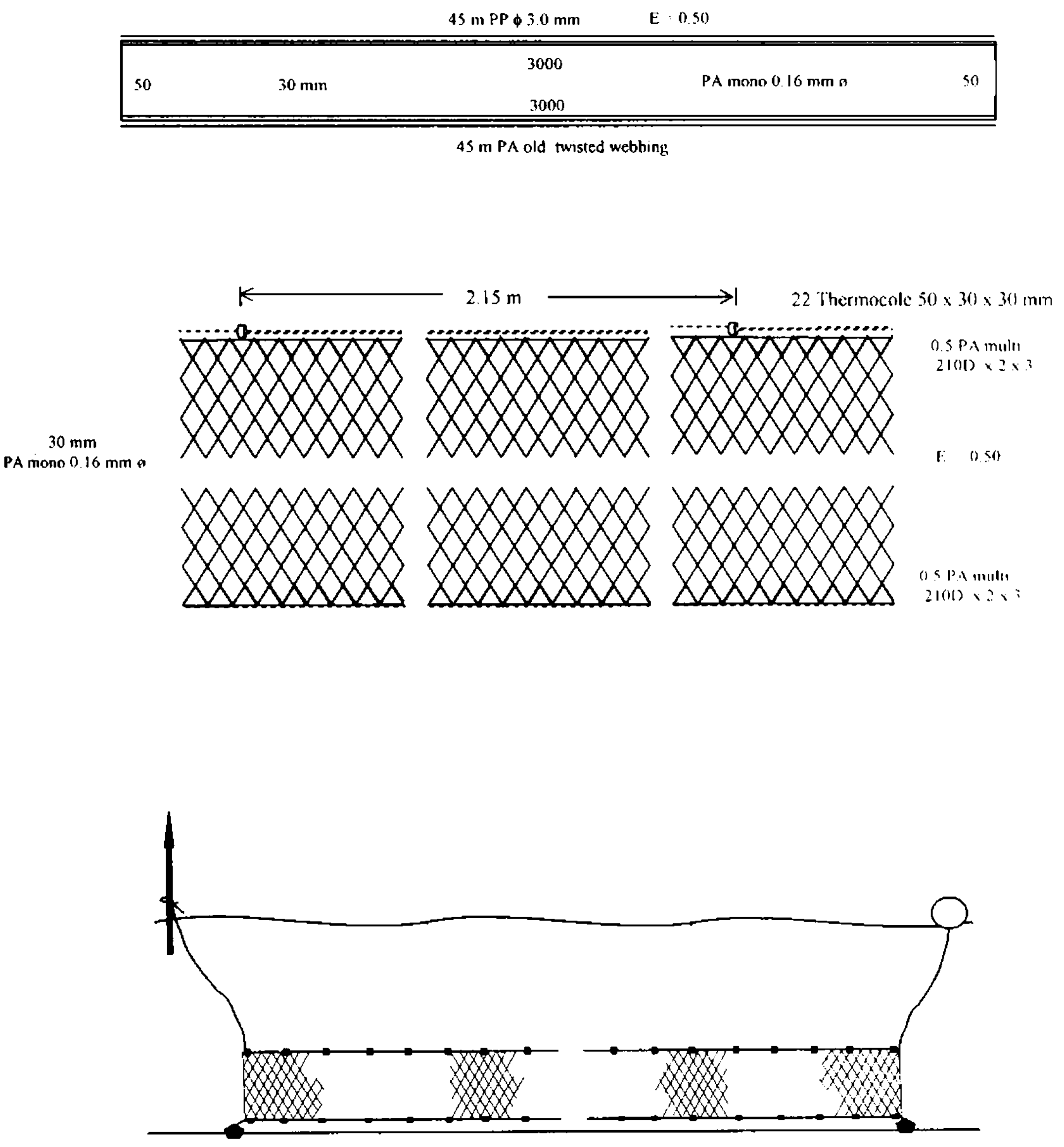


Fig. 20. ***Chemmeen vala***
PA Monofilament

Table 15. Specifications of *Njarampu vala*

Gillnet Local name :Njarampuvala	Main sp. : *Etroplus*
Material	PA Multifilament
Mesh size (mm)	40
Twine size	210Dx2x3
Length in mesh (No.)	1800
Depth in mesh (No.)	100
Selvedge Top	Nil
Material	Nil
Mesh size (mm)	Nil
Twine size	Nil
Selvedge Bottom	Nil
Material	Nil
Mesh size (mm)	Nil
Twine size	Nil
HR	PP
Twine size	3 mm ϕ
Length (m)	35
FR	PA&PP
Twine size	210Dx2x3&1.0 mm ϕ
Length (m)	35
Hanging Coefficient	0.48
Float	PVC
Size (mm)	50 x 20
No. of floats	22
Distance between floats	1.6 m
Sinkers	Concrete
No. of sinkers	117
Distance between sinkers	30 cm
Size	40x15, 100g
Shape	Dumbbell

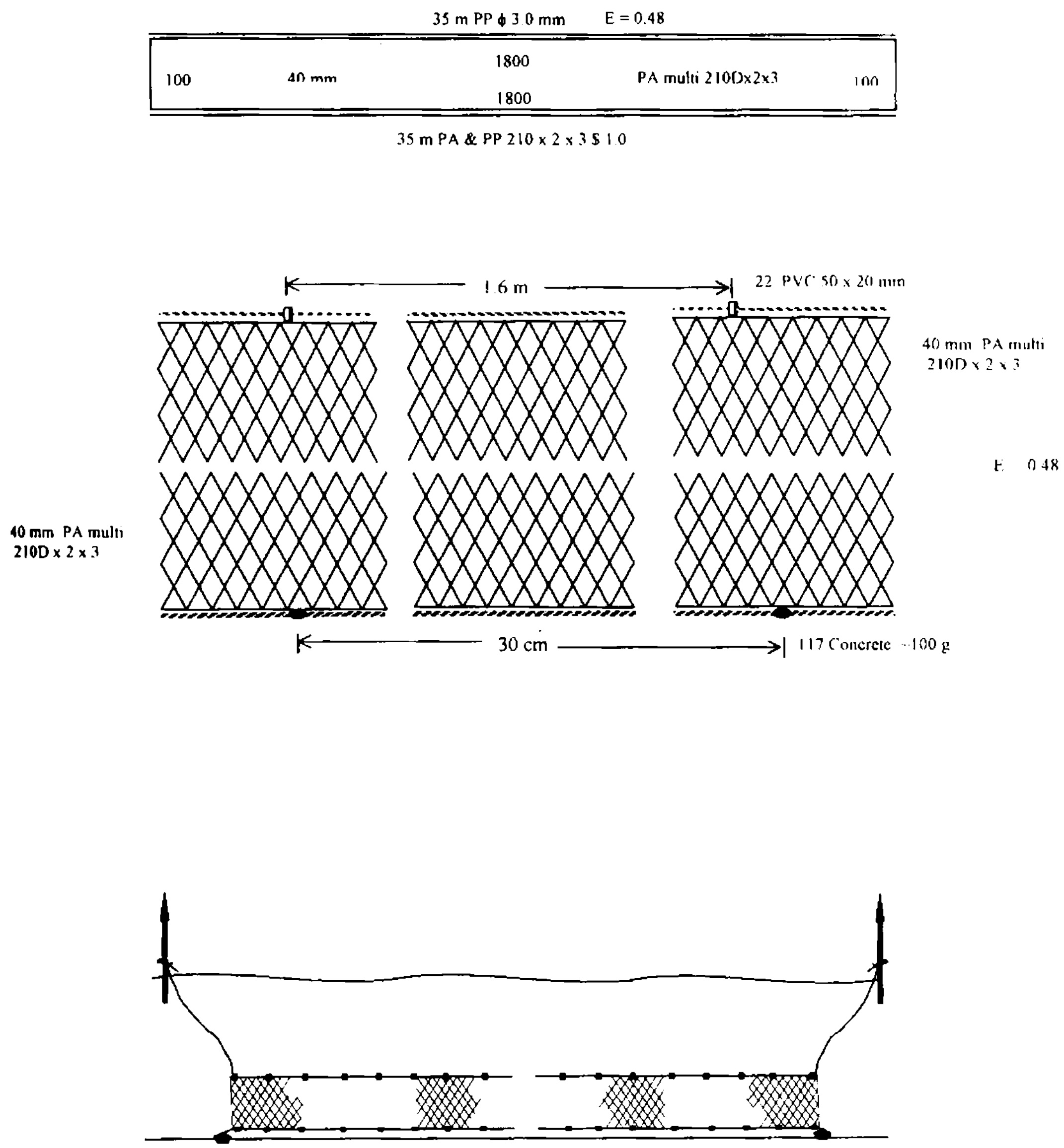


Fig. 21. ***Njarampu vala***

Table 16. Specifications of *Neettu vala*

Gillnet Local name : Neettuvala	Main spp. : *Etroplus* sp., and *Puntius* sp.	
Specifications	Category I [1]	Category II [2]
Material	PA Monofilament	PA Monofilament
Mesh size (mm)	35-90	40-100
Twine size	0.16-0.23 mm ϕ	0.16-0.23 mm ϕ
Length in mesh (No.)	850-1500	1000-1800
Depth in mesh (No.)	20-100	20-100
Selvedge Top	0.5-1.0	0.5-1.0
Material	PA Multifilament	PA Multifilament
Mesh size (mm)	55-90	40-100
Twine size	210Dx2x3, 210Dx3x2	210Dx2x3, 210Dx3x2, 210Dx3x3
Selvedge Bottom	Nil	Nil
Material	Nil	Nil
Mesh size (mm)	Nil	Nil
Twine size	Nil	Nil
HR	PP/PE/PA	PP
Twine size	2.0-3.0 mm ϕ, 210Dx12x3, 210Dx9x3x2	2.5-3.0 mm ϕ
Length (m)	30-40	35-50
FR	PP/PE/PA	Nil
Twine size	2.0-2.5 mm ϕ, 210Dx12x3	Nil
Length (m)	30-40	40-50
Hanging Coefficient	0.42-0.59	0.40-0.63
Float	PVC/Thermocole/Nil	Thermocole
Size (mm)	Different size	Different size
No. of floats	23-38	25-38
Distance between floats	1.0-1.6	100-170 cm
Sinkers	Pb/rock/tile/stone	Stone/Bricks
No. of sinkers	16-80	16-30
Distance between sinkers	50-250cm	1.5-2.5 m
Size	20-300 g	100-300 g
Shape	dumbbell/irregular	irregular

1. Gillnets with foot rope
2. Gillnets without foot rope

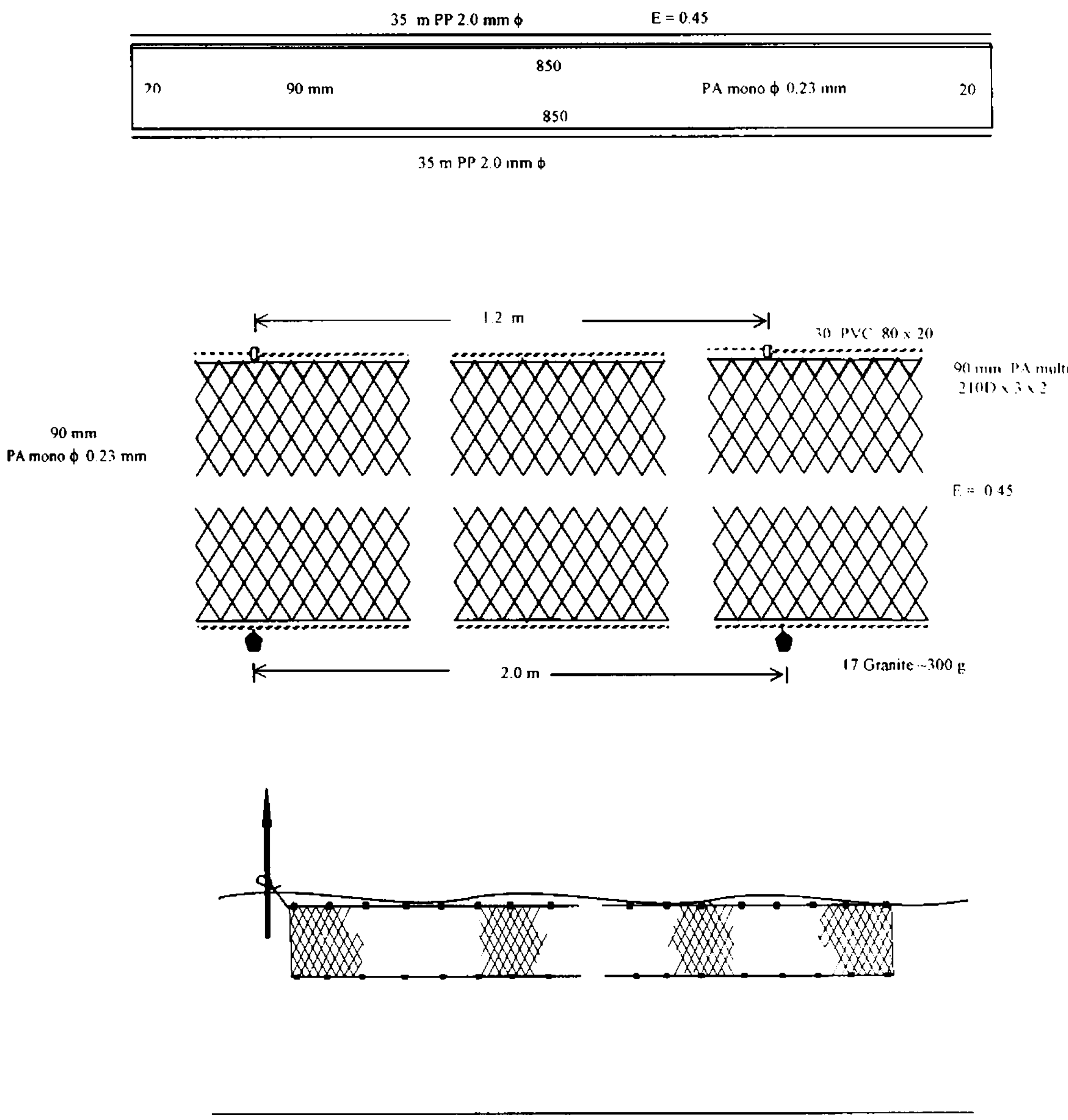


Fig. 22. ***Neettu vala***

Table 17. Specifications of *Mani vala*

Gillnet Local name : Manivala	Main spp. : Puntius sp. and Gonoproktopterus sp.
Material	PA Multifilament
Mesh size (mm)	20-35
Twine size	210Dx1x2
Length in mesh (No.)	2400-5000
Depth in mesh (No.)	100
Selvedge Top	0.5
Material	PA Multifilament
Mesh size (mm)	50
Twine size	210Dx2x3
Selvedge Bottom	0.5
Material	PA Multifilament
Mesh size (mm)	50
Twine size	210Dx2x3
HR	Coir
Twine size	6 cm ϕ
Length (m)	50-60
FR	PA Multifilament
Twine size	210Dx4x3x2/3
Length (m)	50-60
Hanging Coefficient	0.59-0..60
Float	PVC
Size (mm)	50x10/50x20
No. of floats	29-37
Distance between floats	1.6-1.8
Sinkers	Pb
No. of sinkers	330-480
Distance between sinkers	125-150mm
Size	25-45 mm
Shape	Dumbbell

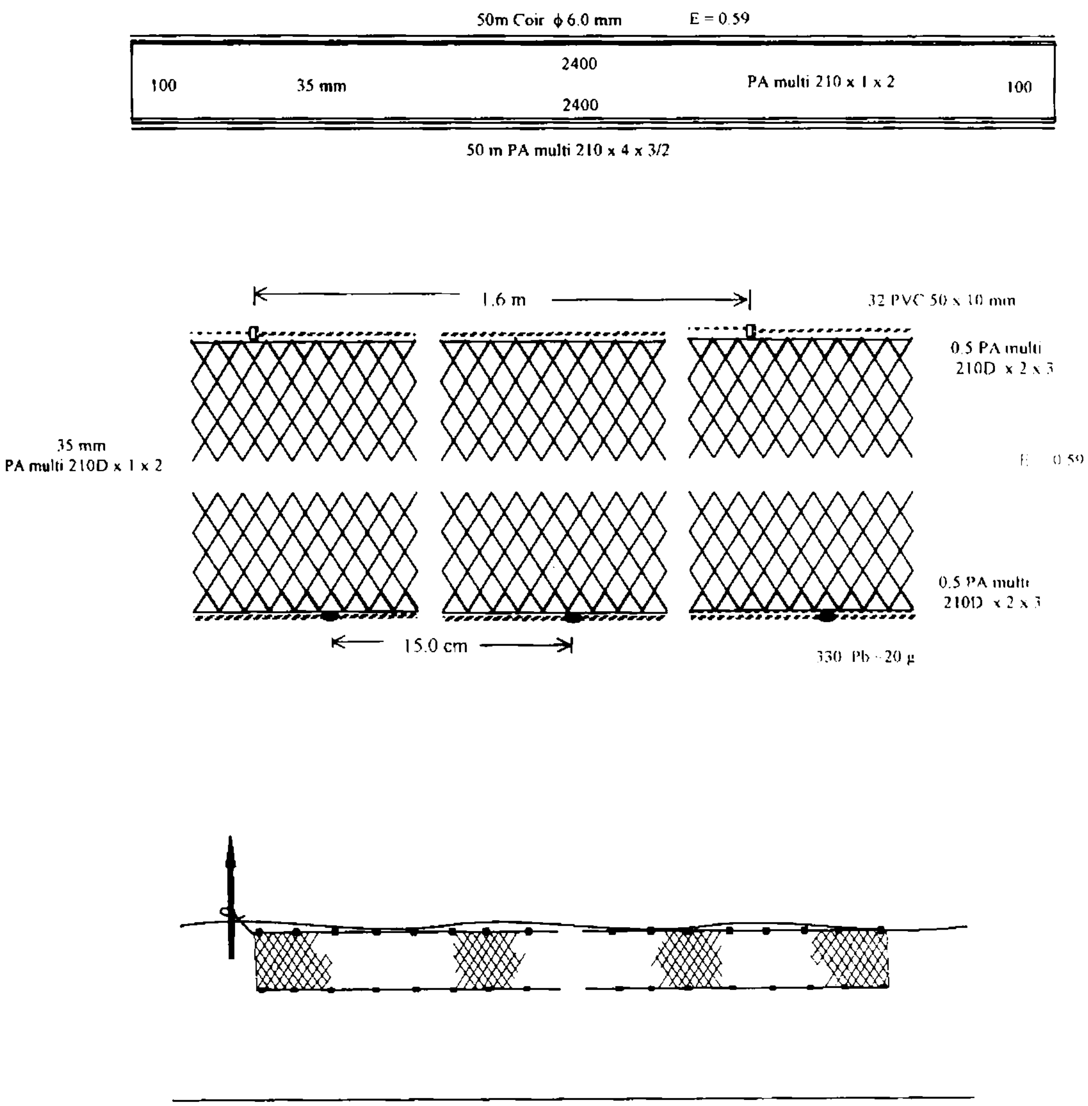


Fig. 23. ***Mani vala***

Table 18. Specifications of *Chala vala*

Gillnet Local name : Chalavala	Main sp. : Misc. fish
Material	PA Monofilament
Mesh size (mm)	30
Twine size	0.16 mm
Length in mesh (No.)	2200
Depth in mesh (No.)	100
Selvedge Top	1
Material	PA Multifilament
Mesh size (mm)	40
Twine size	210Dx2x3
Selvedge Bottom	1
Material	PA Multifilament
Mesh size (mm)	40
Twine size	210Dx2x3
HR	PA Multi&PP
Twine size	210Dx6x3&1.5 mm
Length (m)	40
FR	PP
Twine size	3.0 mm ϕ
Length (m)	40
Hanging Coefficient	0.61
Float	PVC Apple
Size (mm)	50 x 10
No. of floats	29
Distance between floats	1.5 m
Sinkers	Mud
No. of sinkers	67
Distance between sinkers	60 cm
Size	40 x 25
Shape	Dumbbell

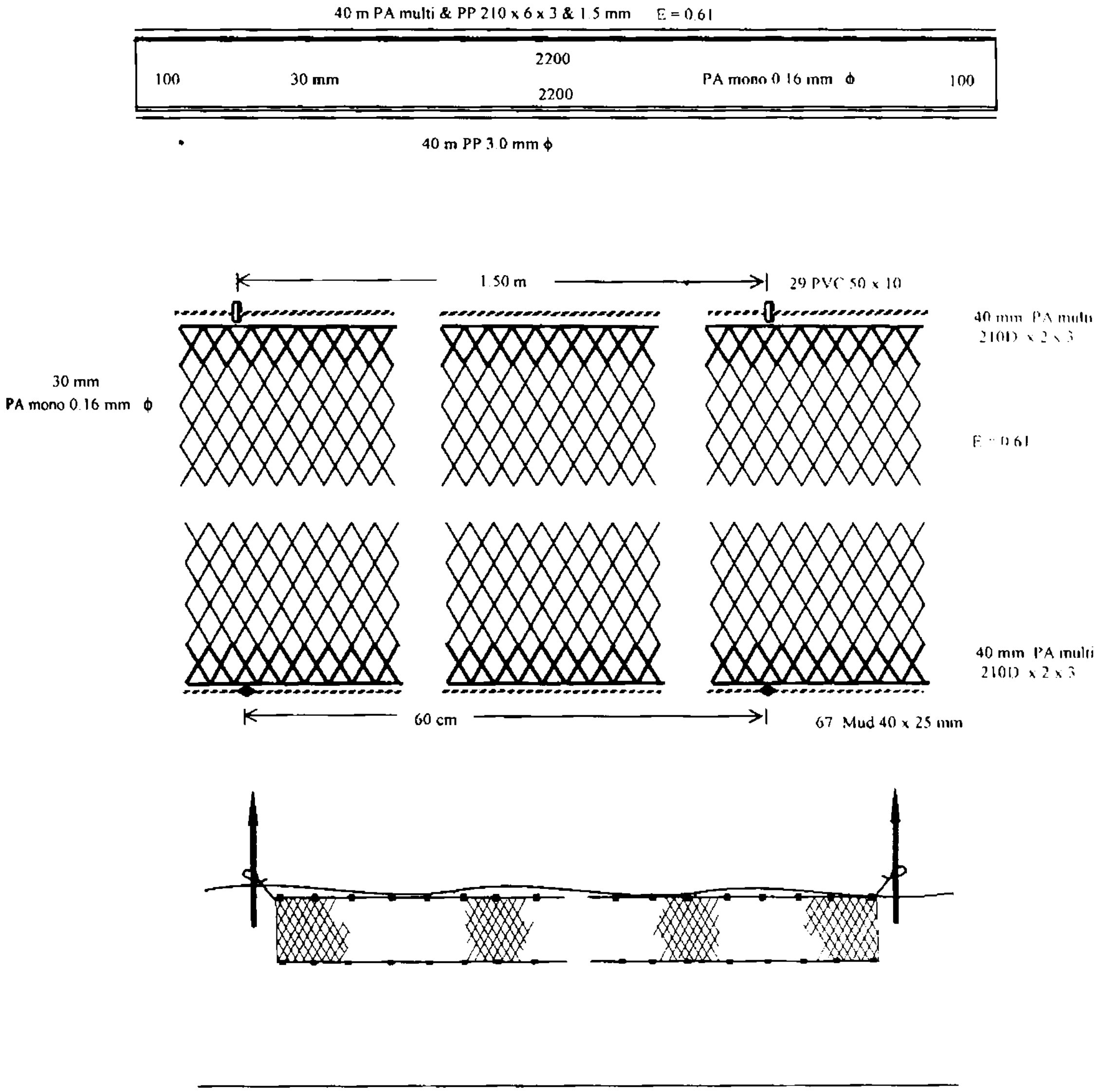


Fig. 24. ***Chala vala***

Table 19. Specifications of *Vidu vala*

Gillnet Local name : Viduvala	Main sp. : *Etroplus* sp. and *Oreochromis* spp.
Material	PA Monofilament
Mesh size (mm)	35-60
Twine size	0.23 mm ϕ
Length in mesh (No.)	1200-2000
Depth in mesh (No.)	50
Selvedge Top	1
Material	PA Multifilament
Mesh size (mm)	60
Twine size	210Dx2x3
Selvedge Bottom	1
Material	PA Multifilament
Mesh size (mm)	60
Twine size	210Dx2x3
HR	PA Multifilament
Twine size	210Dx6x3x1/2
Length (m)	40
FR	PP
Twine size	2.5 mm ϕ
Length (m)	40
Hanging Coefficient	0.55.57
Float	Thermocole
Size (mm)	50x25x30/75x50x50
No. of floats	31
Distance between floats	1.3 m
Sinkers	Pb sheet
No. of sinkers	200
Distance between sinkers	20 cm
Size	25 mm
Shape	Dumbbell

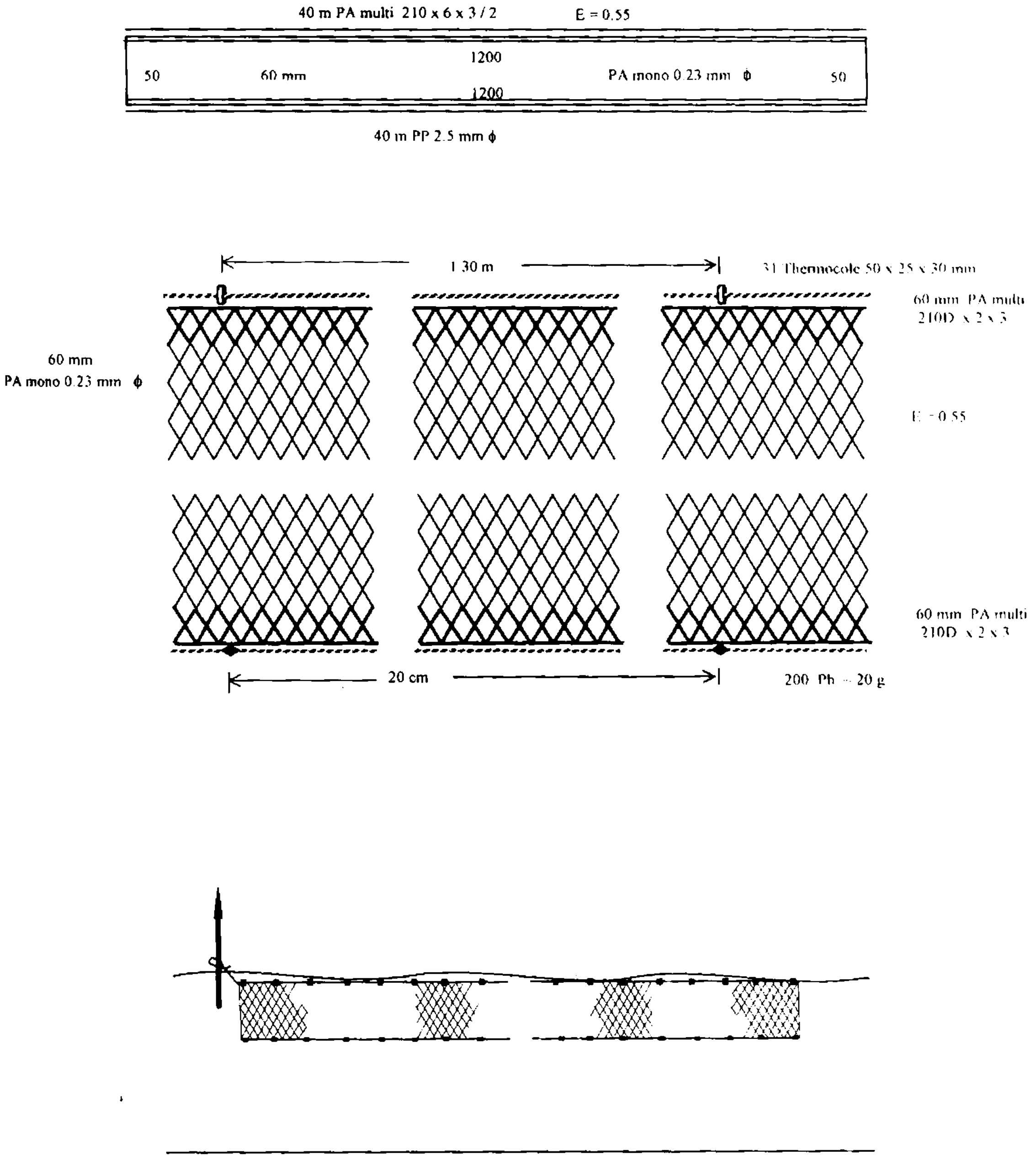


Fig. 25. ***Viduvala***

Table 20. Specifications of *Paachil*

Gillnet Local name : Paachil	Main spp. : *Etroplus* sp. and *Puntius* sp.
Material	PA Multifilament
Mesh size (mm)	35-75
Twine size	210Dx1x2, 210Dx1x3
Length in mesh (No.)	1000-2000
Depth in mesh (No.)	25-100
Selvedge Top	1
Material	PA Multifilament
Mesh size (mm)	55-75
Twine size	210Dx2x3
Selvedge Bottom	1
Material	PA Multifilament
Mesh size (mm)	55-75
Twine size	210Dx2x3
HR	PP
Twine size	2 mm ϕ
Length (m)	35
FR	PP
Twine size	2 mm ϕ
Length (m)	35
Hanging Coefficient	0.46-0.50
Float	Rubber slipper pieces
Size (mm)	Irregular
No. of floats	25
Distance between floats	1.4 m
Sinkers	Nil

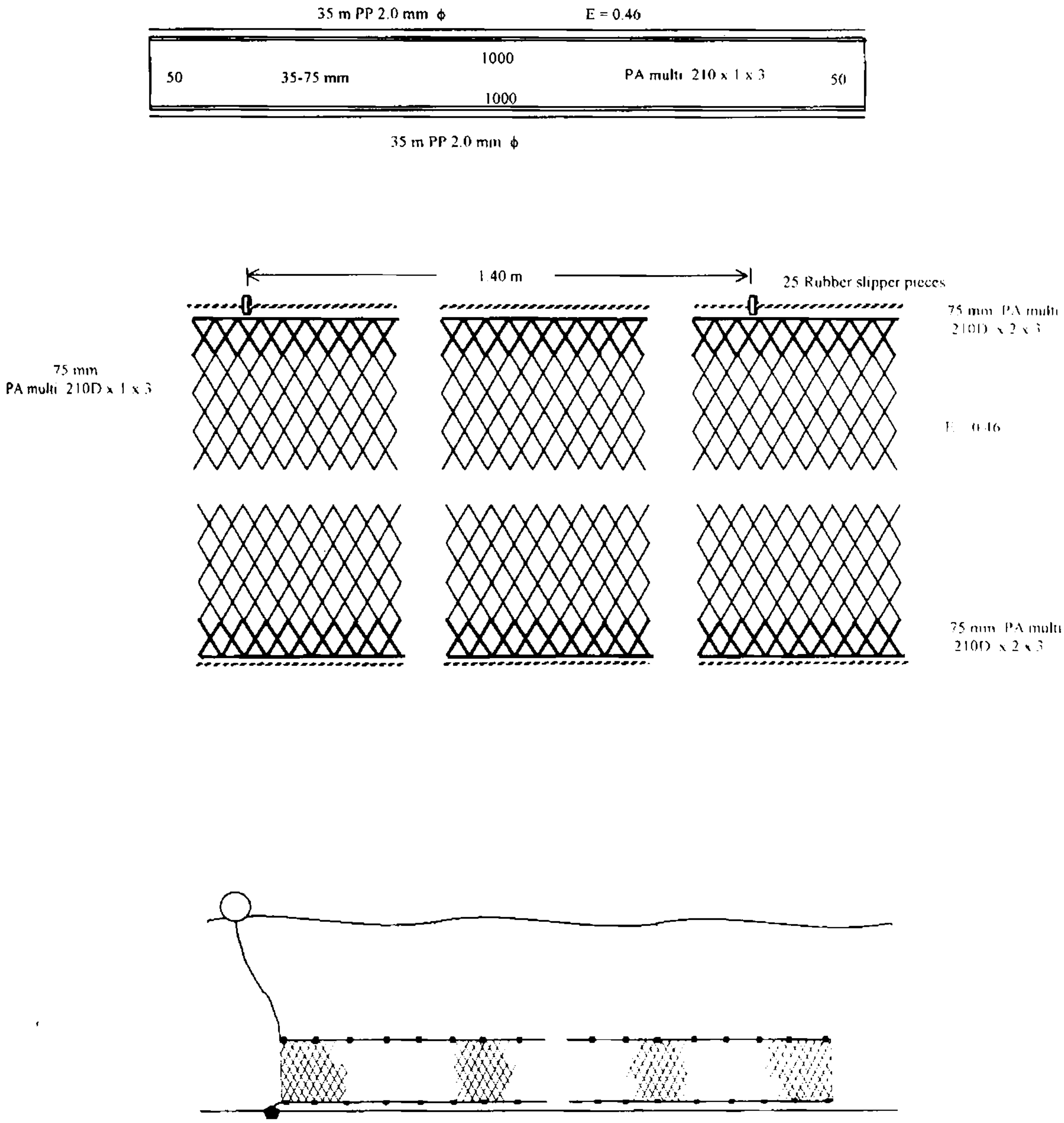


Fig. 26. ***Paachil***

Table 21. Specifications of *Kaara vala*

Gillnet Local name : Kaaravala	Main sp. : Prawn
Material	PA Monofilament
Mesh size (mm)	55
Twine size	0.16-0.23 mm
Length in mesh (No.)	1300-2000
Depth in mesh (No.)	50
Selvedge Top	0.5-1.0
Material	PA Multifilament
Mesh size (mm)	55 mm
Twine size	210Dx3x2
Selvedge Bottom	1
Material	PA Multifilament
Mesh size (mm)	55 mm
Twine size	210Dx3x2
HR	PP/PE
Twine size	2.5-3.0 mm ϕ
Length (m)	40-50
FR	Old PA webbings (twisted)
Twine size	12.0 mm ϕ
Length (m)	40-50
Hanging Coefficient	0.45-0.56
Float	Pieces of rubber slipper/PVC
Size (mm)	60 x 20
No. of floats	31
Distance between floats	1.3-1.6 m
Sinkers	FR also act as wt.

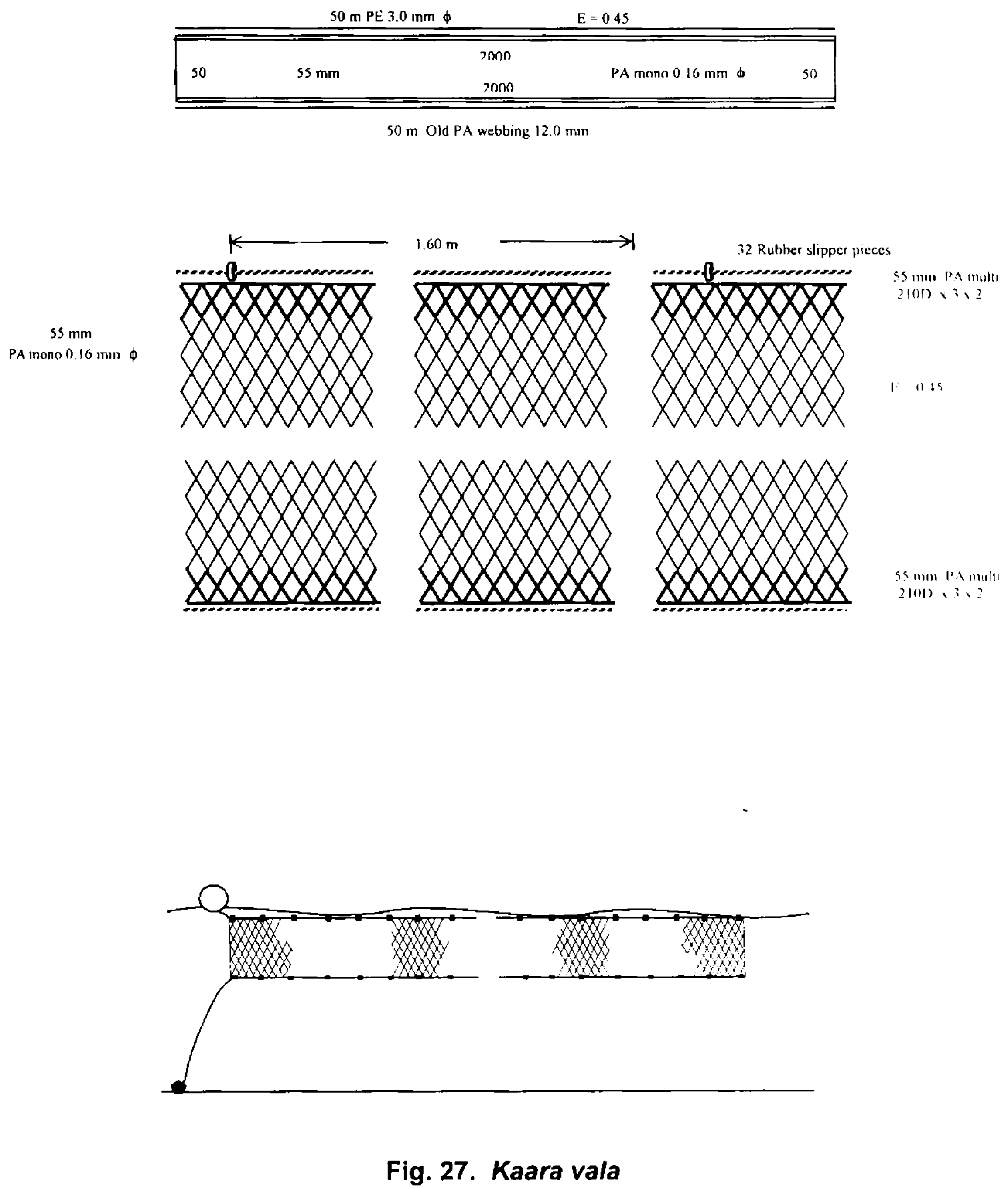


Fig. 27. ***Kaara vala***

Table 22. Specifications of *Kannadi vala*

Gillnet Local name : Kannadi vala	Main sp. : Misc. fish
Material	PA Monofilament
Mesh size (mm)	20-75
Twine size	0.16-0.23 mm ϕ
Length in mesh (No.)	1200-2000
Depth in mesh (No.)	25-100
Selvedge Top	0.5-1.0
Material	PA Multifilament
Mesh size (mm)	40-75
Twine size	210Dx2x2-210Dx3x3
Selvedge Bottom	Nil
Material	Nil
Mesh size (mm)	Nil
Twine size	Nil
HR	PP/PA Multifilament
Twine size	2.5-3.0 mm ϕ / 210Dx20x3
Length (m)	25-40
FR	Nil
Twine size	Nil
Length (m)	Nil
Hanging Coefficient	0.41-0.57
Float	PVC Apple shape
Size (mm)	50 x 10/60 x 20
No. of floats	16-29
Distance between floats	1.4-1.7 m
Sinkers	Stone
No. of sinkers	10--23
Distance between sinkers	1.0-2.0 m
Size	100-250 g
Shape	irregular

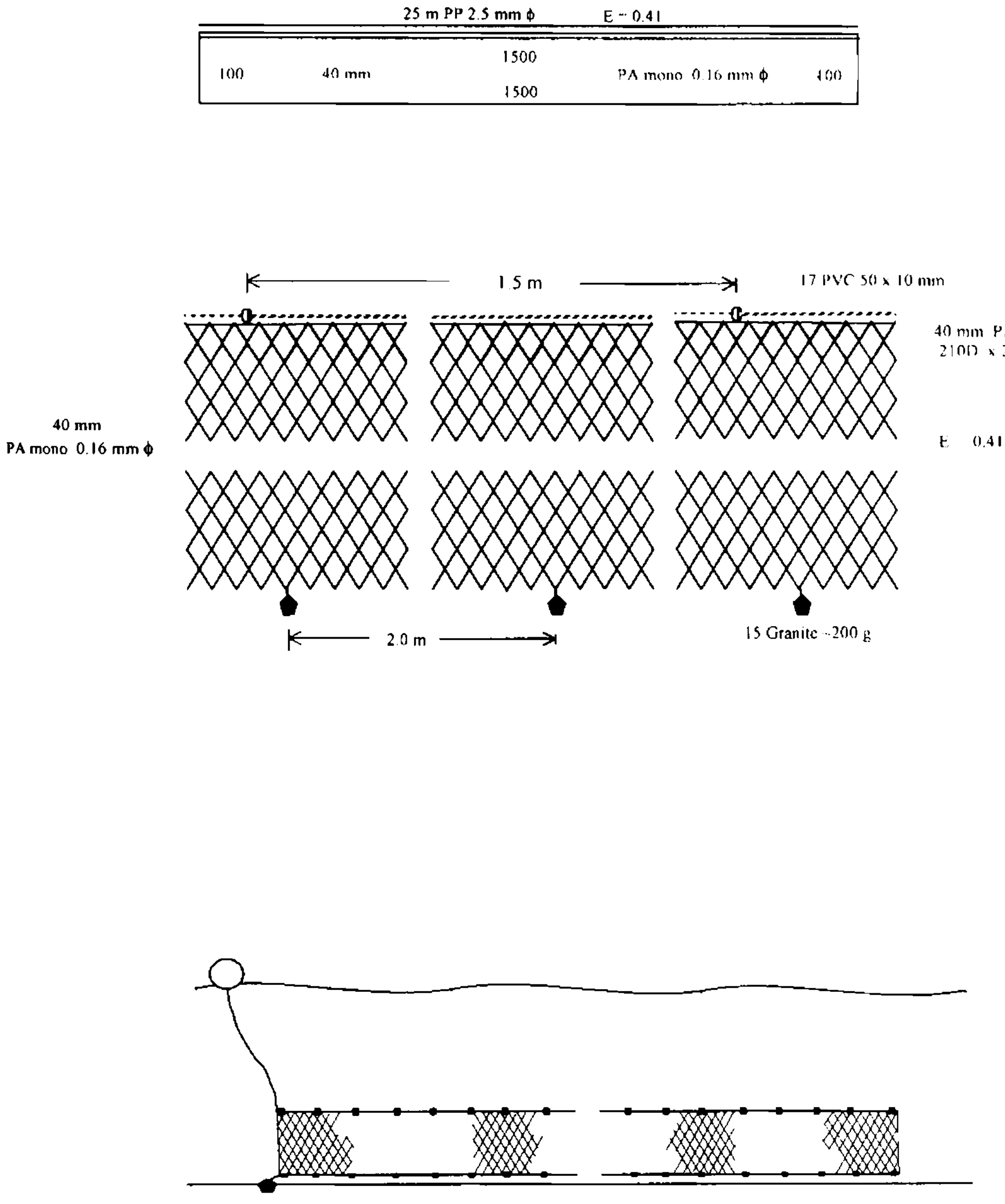


Fig. 28. ***Kannadi vala***

Table 23. Specifications of *Visaly vala*

Gillnet Local name : Visaly vala		Main sp. : Misc. fish
Specifications	Category I [1]	Category II [2]
Material	PA Monofilament	PA Monofilament
Mesh size (mm)	30-100	60-140
Twine size	0.16-0.23	0.16-0.32
Length in mesh (No.)	600-3000	700-1500
Depth in mesh (No.)	20-100	Dec-50
Selvedge Top	0.5-1.0	0.5-1.0
Material	PA Multifilament	PA Multifilament
Mesh size (mm)	50-100	60-150
Twine size	210Dx2x3	210Dx3x2
Selvedge Bottom	0.5-1.0	Nil
Material	PA Multifilament	Nil
Mesh size (mm)	50-100	Nil
Twine size	210Dx2x3	Nil
HR	PP/PE	PE
Twine size	2.5-3.0 mm ϕ	3.0 mm ϕ
Length (m)	30-50	45-50
FR	Jute/PE	PE
Twine size	2.5-8.0 mm ϕ	2.5 mm ϕ
Length (m)	30-50	45-50
Hanging Coefficient	0.43-0.51	0.50-0.52
Float	PVC	PVC/Thermocole/Plastic can
Size (mm)	50x10-80x20	80x40x40/50x10/1 litre
No. of floats	18-40	May-36
Distance between floats	1.1-1.8 m	1.2-2.0
Sinkers	Stone	Stone
No. of sinkers	14-23	20-23
Distance between sinkers	1.75-2.25 m	2.25 m
Size	150-250 g	250 g
Shape	irregular	irregular

1. Gillnets with top and bottom selvedges.
2. Gillnets with out bottom selvedge.

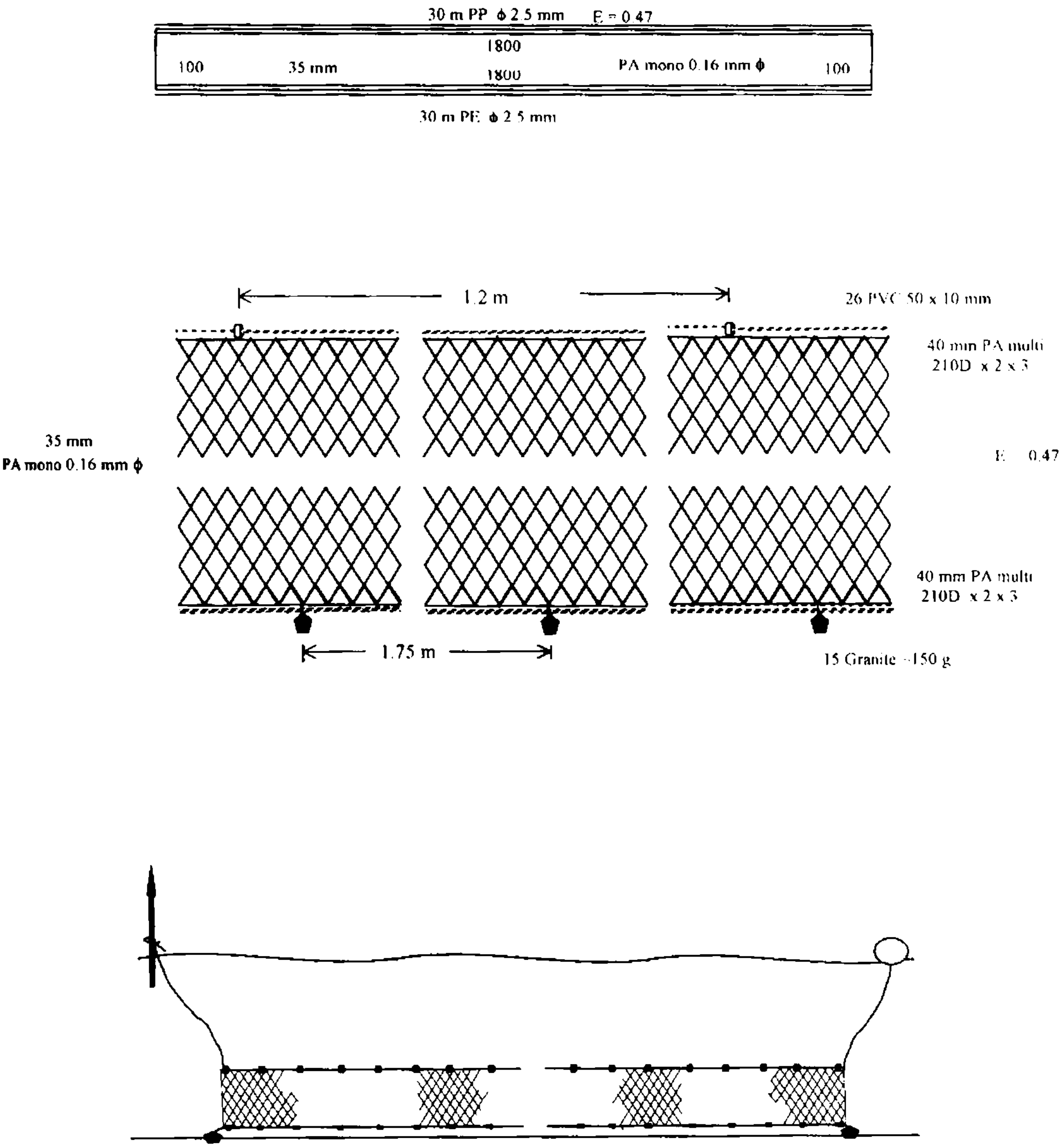


Fig. 29. ***Vaisaly vala***

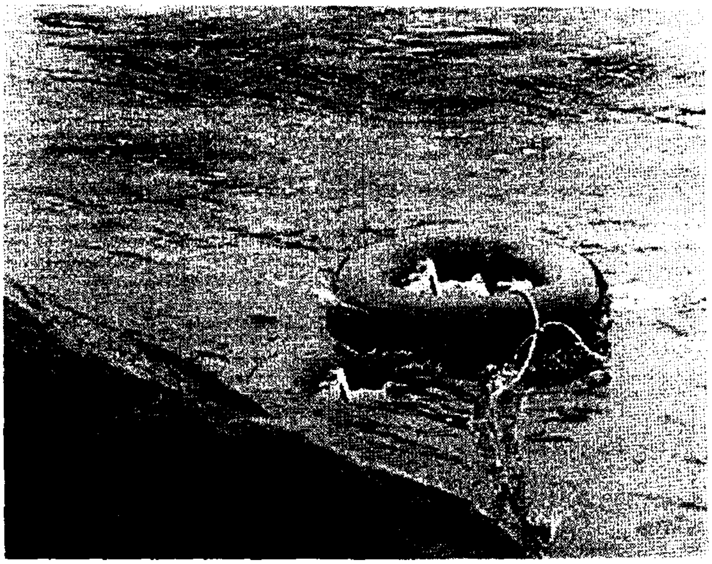


Fig.32. Old rubber tube

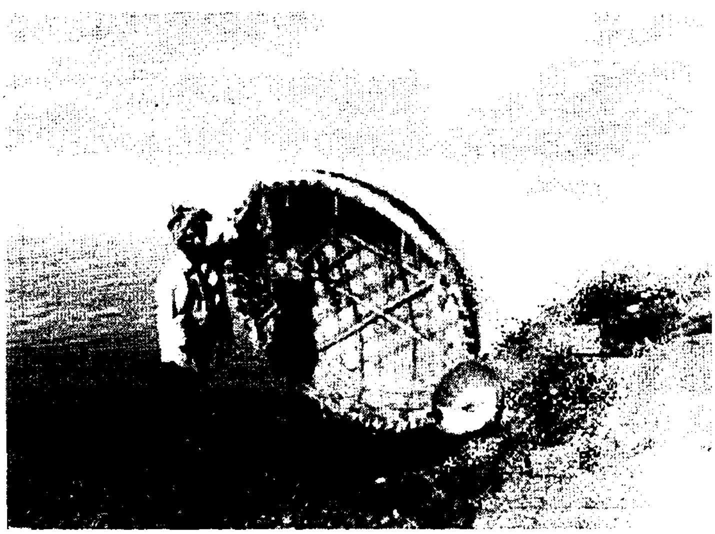


Fig. 33. Coracle

Fig. 33a. Plank built canoe

Fig. 33b. Coracle – Gillnet operation

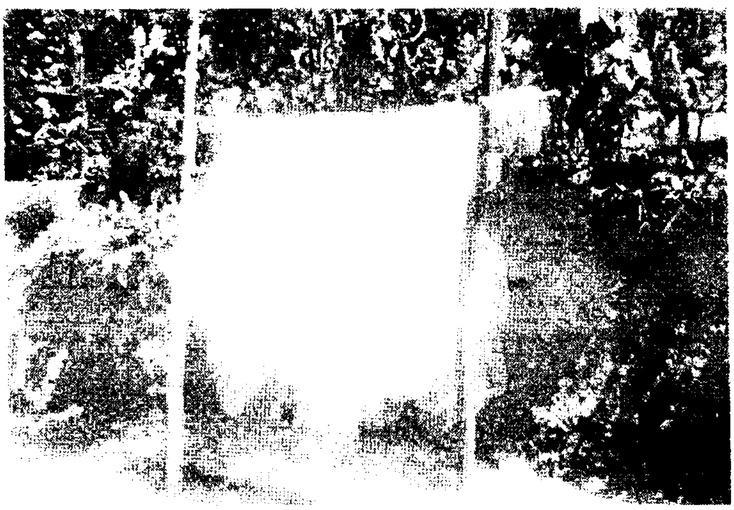


Fig. 33c. Gillnet – after operation

Selection of Materials

The nylon monofilament is very popular in riverine sector for the construction of gillnet. Eighty three percentage of the total gillnets are made of PA monofilament and seventeen percentage are of PA multifilament (Fig. 34). Materials like PE or PP were not found to be used in the riverine sector for the fabrication of the gillnet.

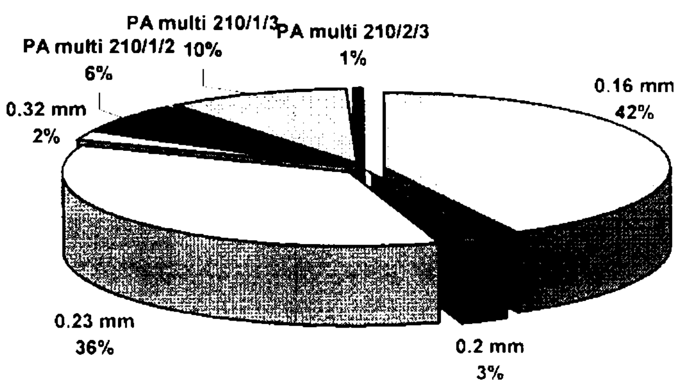


Fig. 34. Usage pattern of webbing in fabrication of riverine gillnets of Central Kerala

The majority of these gillnets (42 %) were made of 0.16 mm dia PA monofilament followed by 0.23 mm dia PA monofilament (36 %). (Fig. 34).

Nylon monofilament is the most common and popular material in the riverine sector for the construction of gillnet. The monofilaments with different twine thickness 0.16 mm, 0.20 mm, 0.23 mm and 0.32mm dia are used in this sector, out of which the most widely used material is 0.16 mm dia. (52 %), 0.23 mm dia. (43%) followed by 0.20 mm dia. (3%) and 0.32 mm dia. (2 %) (Fig. 35).

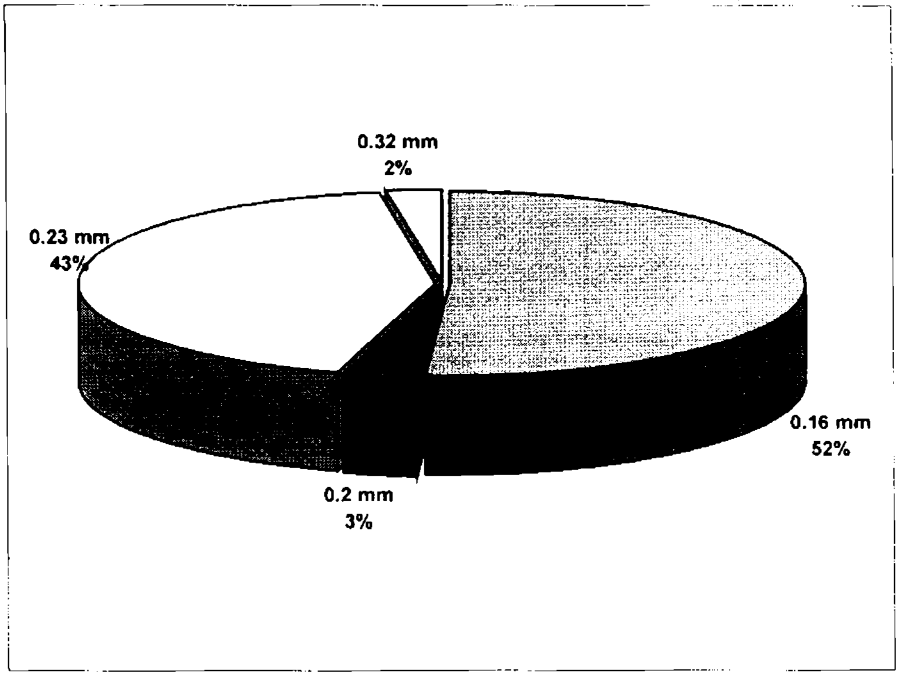


Fig. 35. Usage pattern of PA monofilament webbing in fabrication of riverine gillnets of Central Kerala

The PA multifilament webbing with different twine sizes such as 210Dx1x2, 210Dx1x3 and 210Dx2x3 are in operation in riverine sector. 210Dx1x3is the most common twine (60%), followed by 210Dx1x2 (37%) and 210Dx2x3 (3%). (Fig. 36).

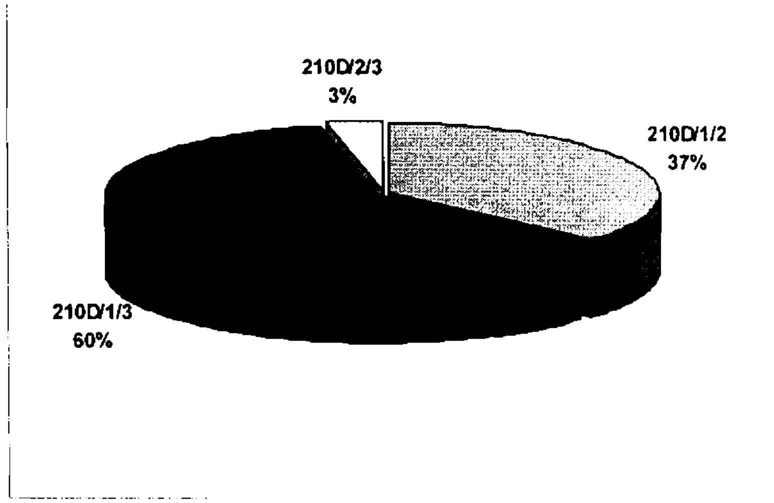


Fig. 36. Usage pattern of PA multifilament webbing in fabrication of riverine gillnets of Central Kerala

The Fig. 37 shows the relation between the twine size, mesh size and number of gears.

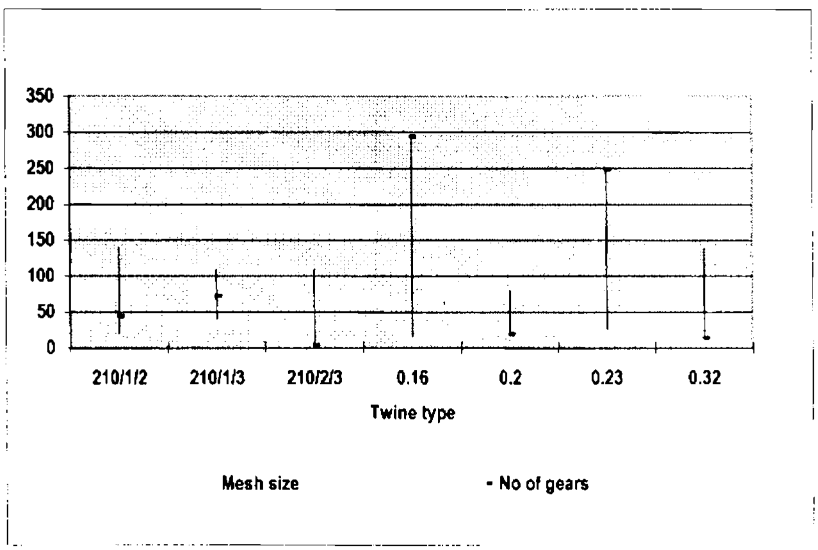


Fig. 37. Relation between twine size, mesh size and number of gears

The relation between the diameter of twine and mesh size in PA monofilament and PA multifilament are shown in the Table 24. The table shows that the gear with 210Dx1x2 has the widest range of mesh sizes starting from 20 mm to 140 mm in multifilament gillnet and 0.20 mm PA monofilament gillnet, mesh sizes range between 25 mm 120 mm.

Table 24. Relation between twine size and mesh size of gillnet

Central Kerala		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	15 – 90
	0.20 mm	35 – 80
	0.23 mm	25 – 120
	0.32 mm	80 – 140
PA Multifilament	210Dx1x2	20 – 140
	210Dx1x3	40 – 110
	210Dx2x3	40 – 110

The relation between the twine size and mesh size of monofilament and multifilament gillnet of each river is given in the Tables 25 to 31. In all the rivers the monofilament and multifilament gillnets are operated except in Puzhakkal River and in this river only the monofilament gillnets are used. It is a very small river with periodical dryness and the fishing is carried out by migrant fishermen during winter season.

Table 25. Relation between twine size and mesh size Gillnet of Bharathapuzha River

Bharathapuzha River		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	15 – 90
	0.20 mm	45 – 80
	0.23 mm	25 – 120
PA Multifilament	210Dx1x2	20 – 70
	210Dx1x3	55 – 100

Table 26. Relation between twine size and mesh size Gillnet of Chalakudy River

Chalakudy River		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	20 – 60
	0.23 mm	25 – 90
PA Multifilament	210Dx1x2	50 – 140
	210Dx1x3	55 – 100
	210Dx2x3	110 – 110

Table 27. Relation between twine size and mesh size Gillnet of Karuvannur River

Karuvannur River		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	35 – 70
	0.20 mm	35 – 35
	0.23 mm	35 – 90
PA Multifilament	210Dx1x3	60 – 60

Table 28. Relation between twine size and mesh size Gillnet of Keecheri River

Keecheri River		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	55 – 70
	0.23 mm	110 – 110
PA Multifilament	210Dx1x3	55 – 55

Table 29. Relation between twine size and mesh size

Gillnet of Muvattupuzha River

Muvattupuzha River		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	30 – 60
	0.20 mm	40 – 70
	0.23 mm	35 – 110
	0.32 mm	80 – 100
PA Multifilament	210Dx1x2	35 – 75
	210Dx1x3	55 – 110
	210Dx2x3	40 – 40

Table 30. Relation between twine size and mesh size

Gillnet of Periyar River

Periyar River		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	30 – 60
	0.20 mm	60 – 60
	0.23 mm	50 – 110
	0.32 mm	110 – 140
PA Multifilament	210Dx1x2	55 – 60
	210Dx1x3	55 – 110

Table 31. Relation between twine size and mesh size Gillnet of Puzhakkal River

Puzhakkal River		
Material	**Specification**	**Mesh size range (mm)**
PA Monofilament	0.16 mm	25 – 55

The size of the gillnet with respect to the mesh sizes are shown in Table 32. A wide range of mesh sizes and gear sizes are used in the riverine sector. The mesh size ranges from 15 mm to 140 mm and length of the gear varies from 300 meshes to 5000 meshes and the depth of the gear from 9 meshes to 100 meshes.

Table 32. Dimensions of riverine gillnets of central Kerala

Mesh size	Length range in mesh	Depth range in mesh
15	3500	24
20	2000 – 5000	17 – 100
25	2000 – 2800	17 – 100
30	1400 – 3200	50 – 100
35	1000 – 3000	19 – 100
40	1000 – 3000	30 – 100
45	750 – 2000	50 – 100
50	1000 – 2000	19 – 100
55	1000 – 2000	19 – 100
60	600 – 1700	30 – 65
65	900 – 1200	25 – 50
70	700 – 1800	20 – 50
75	700 – 1600	20 – 50
80	750 – 1100	20 – 25
85	900 – 1200	25 – 25
90	500 – 1200	18 – 25
100	500 – 1000	15 – 25
110	300 – 1000	9 – 22
120	400 – 800	12 – 15
140	480 – 700	12 – 25
15-140	**300 – 5000**	**9 – 100**

The Table 33 shows the different types of nylon monofilament gillnets operated in the rivers of central Kerala with respect to its twine size and mesh size.

Table 33. Mesh size and twine size (PA Monofilament) of different types of gillnet present in the rivers of central Kerala

Rivers of Central Kerala - PA Monofilament			
Local name	**Twine size (mm)**	**Mesh size min (mm)**	**Mesh size max (mm)**
Andhra vala	0.16	35	50
	0.20	55	55
	0.23	65	65
Chala vala	0.16	30	30
Chemmeen vala	0.16	30	30
Kaara vala	0.16	55	55
	0.23	55	55
Kannadi vala	0.16	20	30
	0.20	35	35
	0.23	55	75
Karimeen vala	0.23	55	55
Kuruva vala	0.16	40	40
	0.23	50	55
Neetu vala	0.16	35	60
	0.23	40	90
Odakku vala	0.16	25	75
	0.20	60	70
	0.23	25	110
	0.32	110	120
Pandi vala	0.16	35	60
	0.20	55	55
	0.23	55	55
Podi vala	0.16	30	30
Thandadi vala	0.16	15	90
	0.20	40	80
	0.23	25	120
Vaala vala	0.20	65	65
	0.23	80	110
	0.32	80	100
Vaisaly vala	0.16	30	45
	0.23	75	110
	0.32	120	140
Vazhutha vala	0.23	75	75
Vidu vala	0.23	35	60

The Table 34 shows the different types of nylon multifilament gillnet operated in the rivers of central Kerala with respect to its twine size and mesh size.

Table 34. Mesh size and twine size (PA Multifilament) of different types of gillnet present in the rivers of central Kerala

Rivers of Central Kerala - PA Multifilament			
Local Name	**Twine size (specification)**	**Mesh size min (mm)**	**Mesh size max (mm)**
Karimeen Vala	210Dx1x2	55	55
	210Dx1x3	55	55
Kuruva vala	210Dx1x2	50	60
Mani vala	210Dx1x2	20	35
Neetu vala	210Dx1x3	100	100
Njarampu vala	210Dx2x3	40	40
Odakku vala	210Dx1x2	45	60
	210Dx1x3	60	110
Paachil	210Dx1x2	35	35
	210Dx1x3	75	75
Podi vala	210Dx1x2	35	35
Thadamvali	210Dx1x3	55	55
Thandadi vala	210Dx1x2	30	140
	210Dx1x3	40	110
	210Dx2x3	110	110
Vaala vala	210Dx1x2	100	110
Vaisaly vala	210Dx1x3	60	60
Vazhutha vala	210Dx1x2	75	75

The river wise details of the gear such as material, twine size and mesh size are given in the Table 35 to 41.

Table 35. Material, mesh size and twine size of different types of gillnet present in the Bharathapuzha River

Local name	Material	Twine size (specification)	Mesh size Min (mm)	Mesh size Max (mm)
Mani vala	PA Multifilament	210Dx1x2	20	35
Odakku vala	PA Monofilament	0.16	30	75
		0.23	90	110
Paachil	PA Multifilament	210Dx1x2	35	35
		210Dx1x3	75	75
Thandadi vala	PA Monofilament	0.16	15	90
		0.20	45	80
		0.23	25	120
	PA Multifilament	210Dx1x2	30	70
		210Dx1x3	40	100
Vidu vala	PA Monofilament	0.23	35	60

Table 36. Material, mesh size and twine size of different types of gillnet present in the Chalakudy River

Local name	Material	Twine size (specification)	Mesh size Min (mm)	Mesh size Max (mm)
Andhra vala	PA Monofilament	0.23	65	65
Chala vala	PA Monofilament	0.16	30	30
Kannadi vala	PA Monofilament	0.16	20	30
		0.23	55	75
Kuruva vala	PA Multifilament	210Dx1x2	50	50
Neetu vala	PA Monofilament	0.16	35	60
		0.23	40	90
	PA Multifilament	210Dx1x3	100	100
Odakku vala	PA Monofilament	0.23	25	75
	PA Multifilament	210Dx1x3	60	80
Thandadi vala	PA Monofilament	0.23	55	90
	PA Multifilament	210Dx1x2	55	140
		210Dx1x3	55	90
		210Dx2x3	110	110
Vaala vala	PA Monofilament	0.23	80	80
	PA Multifilament	210Dx1x2	100	110

Table 37. Material, mesh size and twine size of different types of gillnet present in the Karuvannur River

Local name	Material	Twine size (specification)	Mesh size Min (mm)	Mesh size Max (mm)
Kannadi vala	PA Monofilament	0.20	35	35
		0.23	55	75
Thandadi vala	PA Monofilament	0.16	35	70
		0.23	35	90
	PA Multifilament	210Dx1x3	60	60
Vaala vala	PA Monofilament	0.23	90	90

Table 38. Material, mesh size and twine size of different types of gillnet present in the Keecheri River

Local name	Material	Twine size (specification)	Mesh size Min (mm)	Mesh size Max (mm)
Karimeen Vala	PA Multifilament	210Dx1x3	55	55
Odakku vala	PA Monofilament	0.16	55	70
		0.23	110	110

Table 39. Material, mesh size and twine size of different types of gillnet present in the Muvattupuzha River

Local name	Material	Twine size (specification)	Mesh size Min (mm)	Mesh size Max (mm)
Andhra vala	PA Monofilament	0.16	35	50
		0.20	55	55
Chemmeen vala	PA Monofilament	0.16	30	30
Kaara vala	PA Monofilament	0.16	55	55
		0.23	55	55
Karimeen vala	PA Monofilament	0.23	55	55
	PA Multifilament	210Dx1x2	55	55
		210Dx1x3	55	55
Kuruva vala	PA Monofilament	0.16	40	40
		0.23	50	55
	PA Multifilament	210Dx1x2	60	60
Njarampu vala	PA Multifilament	210Dx2x3	40	40
Odakku vala	PA Monofilament	0.16	30	50
		0.2	70	70
		0.23	35	75
	PA Multifilament	210Dx1x2	45	50
		210Dx1x3	60	110
Pandi vala	PA Monofilament	0.16	35	60
		0.2	55	55
		0.23	55	55
Podi vala	PA Monofilament	0.16	30	30
	PA Multifilament	210Dx1x2	35	35
Thandadi vala	PA Monofilament	0.16	35	35
		0.2	40	40
	PA Multifilament	210Dx1x2	45	45
		210Dx1x3	60	60
Vaala vala	PA Monofilament	0.2	65	65
		0.23	110	110
		0.32	80	100
Vazhutha vala	PA Monofilament	0.23	75	75
	PA Multifilament	210Dx1x2	75	75
Visaly vala	PA Monofilament	0.16	30	50
		0.23	80	100

Table 40. Material, mesh size and twine size of different types of gillnet present in the Periyar River

Local name	Material	Twine size (specification)	Mesh size Min (mm)	Mesh size Max (mm)
Andhra vala	PA Monofilament	0.16	35	35
Kaara vala	PA Monofilament	0.23	55	55
Karimeen vala	PA Multifilament	210Dx1x2	55	55
		210Dx1x3	55	55
Odakku vala	PA Monofilament	0.16	30	55
		0.2	60	60
		0.23	50	70
		0.32	110	120
	PA Multifilament	210Dx1x2	60	60
		210Dx1x3	75	75
Thandadi vala	PA Monofilament	0.16	30	60
		0.23	50	90
	PA Multifilament	210Dx1x3	75	110
Vaala vala	PA Monofilament	0.23	90	90
Visaly vala	PA Monofilament	0.16	30	60
		0.23	75	110
		0.32	120	140

Table 41. Material, mesh size and twine size of different types of gillnet present in the Puzhakkal River

Local name	Material	Twine size (specification)	Mesh size Min (mm)	Mesh size Max (mm)
Odakku vala	PA Monofilament	0.16	25	55

3.2. Gillnet Selectivity

Selectivity is the ability to target and capture fish by species, size, or a combination of these during harvesting operations allowing release of all incidental bycatch which may include undersized and non-target fish species, birds, mammals and other organisms encountered during fishing operations (Anon, 1995a)

Gillnet is efficient in catching sparsely distributed fish in large water basins like lakes where they can be economically operated from small boats with a minimal investment in manpower and equipment. It is a highly selective gear and a rule of thumb states that few fish are caught whose length differ from the optimum by more than 20 percent (Baranov, 1948). Hence knowledge of selectivity is needed in managing a commercial gill net fishery, as a proper mesh size aids in obtaining the maximum yield (Kennedy, 1950; Peterson, 1954; Mc Combie, 1961), protecting small fish (Hodgson, 1939), and minimizing escapement of injured or dying fishes (Ishida, 1969; Ueno *et. al.* 1965; Thomson *et. al.* 1971). Selection can be defined as the process that causes the probability of capture to vary with characteristics of the fish. The factors listed by Clark (1960), Steinberg (1964) and Fridman (1973 and 1986) as most important to gill net selectivity are mesh size, extension and elastic properties of the netting twine, shape of the fish including compressibility of its body and pattern of behaviour. Panikkar *et. al.* (1978) conducted selectivity studies with gill nets of three different mesh sizes, twine specifications and hanging coefficients to standardize an optimum net for exploiting the commercial size group of *Hilsa toil* and *Pampus argenteus*. Studies on gilled girth – total length retaliationship was studied by Mathai (1991). McCombie and Berst (1969) have chosen girth of the fish to investigate selectivity relationships.

Studies of Hicklin (1939), Havinga and Deelder (1949), Olsen (1959), Joseph and Sebastian (1964), Sulochanan *et. al.* (1968, 1975), Sreekrishna *et. al.* (1972) and John (1985) were aimed at determining optimum mesh size for gill nets, with reference to a specific species.

Optimum mesh sizes for important commercial species of India were worked out by many (Desai and Shrivastasva, 1990; Joseph and Sebastian, 1964; Sreekrishna *et.al.*, 1972; Sulochanan *et.al.*, 1975; Panikkar *et.al.*, 1978; Khan *et.al.*, 1989; Mathai *et.al.*, 1990; Kartha and Rao, 1991; George, 1991; Mathai *et.al.*, 1993; Luther *et.al.*, 1994 and Neethiselvan *et.al.*, 2000).

The effect of hanging coefficient of the net on the catch efficiency was studied by many (Baranov, 1948, Riedel, 1963, Miyazaki, 1964, Ishida, 1969; Panikkar *et. al.*, 1978; George 1991 and Samaranayaka *et. al.*, 1997).

This present study will help to evolve and develop a better design, with appropriate parameters for the gillnet used for harvesting the target species, *Hypselobarbus curmuca* (Fig. 38). It is commonly called as 'curmuca barb' or 'Kooral'. It belongs to the Family : Cyprinidae; Order: Cypriniformes and Class: Actinopterygii. It occurs in the rivers of Kerala, usually in deep pools and shady parts, Lives and breeds in hilly terrain and comes down to tidal reaches for feeding. Spawns in small streams with sandy and weedy bottoms. It feeds mainly on lagae and insect lavrvae (Talwar and Jhingran 1991). The *Hypselobarbus curmuca* is one of the potential food fishes recorded form the rivers of Kerala (Kurup *et.al.*, 2003). The reported maximum size is 120 cm and the length at maturity is 21 cm (Chandrashekrariah *et.al.*, 2000; Arun *et.al.*, 2001). The abundance of this species in the rivers of central Kerala were reported by Euphrasia and Kurup, 2000 Pillai (1929); John (1936). The distribution of this species in Travancore is described by Periyar Lake and stream system by Chacko, (1948); Arun, (1998), Lal, M.S. (2000) and Ranjeet *et.al.* (2002), Achenkoil by Jero, (1994); Chaliyar River by Shaji & Easa, (1997); Chalakudy River by Shaji & Easa, (1997); Bharathapuzha, Chalakudy, Periyar, Kabini, Valapattanam, Bhavani by Biju *et.al.* (2000); Malampuzha, Idukki, Periyar by Shaji and Easa (2001).

For the design of a more efficient gear, the basic dimensions of a single unit, such as its length and depth and the number of such units were depended on the riverine conditions. The other important design elements that contributed to the efficiency of the gear were then experimentally determined for the exploitation of the target species.

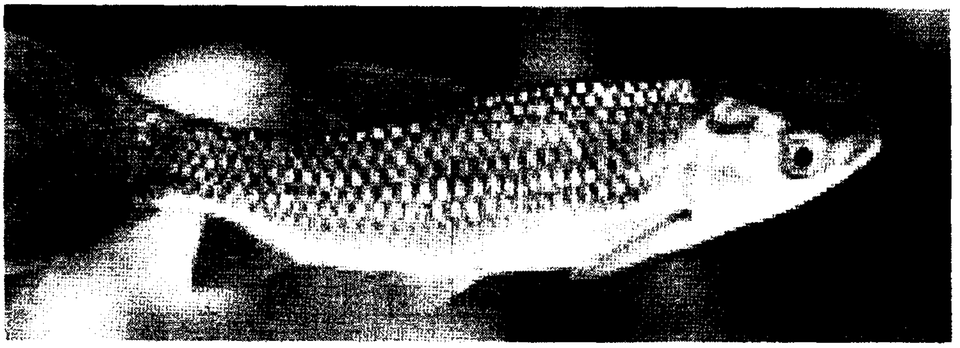


Fig. 38. *Hypselobarbus curmuca.*

Objectives of the present investigation were:

i) To study the mesh selectivity for *Hypselobarbus curmuca*.

ii) To study the Hanging coefficient most suitable for *Hypselobarbus curmuca*

3.2.1. Materials and Methods

To design a more efficient gear for the species *Hypselobarbus curmuca*, an optimum size of the species from both commercial and biological view point was ascertained. The size class was determined from the growth studies of the species (FishBase, www.fishbase.org).

Three centers were selected in the Muvattupuzha River for this study. The centres were Kadumpidy, Kolupra and Randar. These centers were selected on the basis of availability of gill nets targeted for the selected species *Hypselobarbus curmuca*. The design details of each type of gill nets such as mesh size, material, number of floats and sinkers, selvedges, headrope and footrope, etc., were collected during one year survey conducted as part of the study.

Gillnets with three different mesh sizes viz., 45, 55 and 65 mm were selected for the study (Fig. 40, 41 & 42) and seventy-two operations were conducted over a period of one year at Kadumpidy, Randar and Kolupra areas of Muvattupuzha river. The total length, weight and measurement of gill girth, gilled girth and maximum girth were collected for each individual fish.

On the basis of this study, a gillnet was designed with varying hanging coefficients to determine the appropriate hanging coefficient for the target species *Hypselobarbus curmuca*. Three different gillnets with varying hanging coefficients of 0.4, 0.5 and 0.6 were used to study the most appropriate hanging coefficient for the species selected. All other parameters were kept identical in all the experimental gears. Forty-five operations were conducted at Kadumpidy areas of the Muvattupuzha River for this study.

All the gears were shot in night and hauled up early in morning, the following day. The number of target species caught and their morphometric data such as standard length, weight, gill girth, gilled girth, maximum girth and weight of individual fish were collected.

Determination of Optimum Mesh Size of Gillnets

The most important factor controlling size selectivity of gillnet is its mesh size. In order to choose the mesh size suitable for exploiting the fish stock, Baranov (1976) have given the following equation:

$$A = kl \qquad \text{(Eq. 1)}$$

Where A the size of mesh bar

l optimum length of fish and

k a co-efficient specific for a given species determined empirically using length measurement and girth measurement

The mesh selection factor 'k' was determined from the length of the target species caught by gill nets of differing mesh sizes but similar in all other aspects and operated under identical conditions. It is a constant, which is species specific. The coefficient 'k' was also inferred from girth measurements to reduce the anomalies

Length based method

Plotting the length-frequency graph for a given net, gives the yield curve of the net. The yield curves of nets with different mesh sizes operating under identical conditions differ (Fridman, 1973). This hypothesis was employed to determine the selection factor. Determination of 'k' is more reliable if instead of two, three or more nets with different mesh sizes are used. Hence for this study three gill nets of a_1, a_2 and a_3 of mesh bar sizes 22.5 mm (a_1), 27.5 mm (a_2) and 32.5 mm (a_3) (Fig. 40, 41 & 42) were used for experimental fishing (Table 42).

The length frequency distribution of catch obtained in the three nets was prepared and the frequency curve plotted on a single graph corresponding to two of these nets.

From the graphs, the optimum length l_1 of fishes caught by nets with mesh size a_1 and the optimum size l_2 of fishes caught with mesh size a_2 were found out. The abscissa of the point of intersection of the yield curves gave the length of fish l_{01} for which fishing efficiency of both net was equal. Similarly l_{o2} for the combination of nets with mesh size a_2 and a_3 was also found out.

The deviation in the fish length l_{01}- l_1 and l_2 - l_{01} being proportional to the given mesh sizes,

$$\frac{l_0 - l_1}{a_1} = \frac{l_2 - l_0}{a_2} \quad \text{or}$$

$$l_0\left(\frac{1}{a_1} + \frac{1}{a_2}\right) = \frac{l_2}{a_2} + \frac{l_1}{a_1}$$

applying this in equation Eq 1.

$$k = \frac{2a_1a_2}{l_0(a_1 + a_2)} \qquad \text{(Eq. 2)}$$

In the same way the value of '*k*' was calculated from other two sets a_2 and a_3. Arithmetic mean of the values obtained by the different net pairs was used for further calculation.

The value of *k* for the given species determined as described above, was then substituted in equation Eq 1, to find the mesh bar size required to capture the fish of the optimum size group.

Girth based method

When a fish is swimming into a net, it is caught if its head girth is smaller than the mesh perimeter. When a fish is gilled, the perimeter of a section of body of fish where it is caught is S_1, girth at gill covers S_2 and the maximum girth S_3.

The selection factor *k* is found from the girth measurements using the formula proposed by Fridman (1973).

$$k = 0.25.n.n_0 \qquad \text{(Eq. 3)}$$

Where *n* is the ratio of the mesh perimeter 4a to the maximum circumference of the fish S .

$$n = 4a/S \qquad \text{(Eq. 4)}$$

n_0 is the ratio of the maximum circumference of the fish to its length, l.

$$n_0 = S/l \qquad \text{(Eq. 5)}$$

The theoretical estimates thus made were further checked by studying the ratio of gilled girth to mesh perimeter and maximum girth to mesh perimeter, following the method described by McCombie and Berst (1969).

Hanging Coefficient

The shape and looseness of webbing depends on the coefficient of hanging. To find out the most suitable gear for the effective capture of the fish *Hypselobarbus curmuca*, three gillnets of PA monofilament of 25 mm mesh bar with 0.16 mm dia. with varying hanging coefficient 0.4, 0.5 and 0.6 were used in this study (Fig. 52, 53 & 54). All other design parameters were kept identical. (Table 45).

These nets were operated at the Kadumpidy area of the Muvattupuzha River. All the gears were operated in the same place and same time. The fishing time was also kept identical. A total of 30 hauls in each gear were carried out in this centre. The gear were set at the late evening and hauled at early morning. The number and weight of fishes caught in the gear were collected. The operating time was about 10 h. All the nets gave equal chance of fishing

The number and weight of *Hypselobarbus curmuca* and other miscellaneous fishes caught in the nets were statistically analysed (Table 46), using the two way ANOVA technique.

3.2.2. Results and Discussion

Optimisation of gillnet for Hypselobarbus curmuca with respect to mesh size

Mesh size is the most important that influences size of the fish caught in a gillnet. The principles of geometric similarity discussed by Baranov (1948) that the mesh size as a function of the length of the fish caught and is used and the selectivity factor k for the *Hypselobarbus curmuca* was calculated by length frequency measurement (Table 43). Three gillnets with different mesh bar length of 22.5 mm (a_1), 27.5 mm (a_2) and 32.5 mm (a_3) were used for this study. The Length frequency curve of the gears with mesh bar length a_1 and a_2 are given in Fig. 45, a_2 and a_3 are given in Fig. 48.

From the graph (Fig. 43-48) the optimum length l_1 (188.77 mm) of fishes caught by nets with mesh size a_1 (45 mm) and the optimum size l_2 (230.72 mm) of fishes caught with nets of mesh size a_2 (55 mm) and the optimum size l_2 (234.68 mm) of fishes caught with nets of mesh size a_2 (55 mm) and the optimum size l_3 (277.35 mm) of fishes caught with nets of mesh size a_3 (65 mm) were found out. The abscissa of the point of intersection of the yield curves gave the length of the fish l_o for which the fishing efficiency of both nets was equal. The frequency curves of both the sets of nets follow the normal distribution pattern. The value of l_o of net a_1 and a_2 was 207.65 mm and that of a_2 and a_3 was 254.24 mm. Substituting the values in equation (Eq. 1), the value of k for nets a_1 and a_2 was found to be 0.0119 (k_1), and a_2 and a_3 was 0.0117 (k_2).

Applying this in equation (Eq. 1)

$$k = \frac{2.a_1.a_2}{lo(a_1 + .a_2)} \qquad \text{(Eq. 1.1)}$$

The value of '*k*' for the given species taken from the average value of k_1 and k_2 from the two sets of gears, determined from the above calculations was 0.0118. This value is then substituted in equation (Eq. 1) to find the mesh bar size required to capture the fish of the optimum size group.

Girth based method

The selection factor '*k*' is found out from the girth measurements using the formula proposed by Fridman (1973).

The selectivity factor was also estimated by maximum girth-frequency studies for the three nets (Table 42). The maximum frequency for net a_1 for girth was 46.24 mm and that for net a_2 was 56.52 mm from the first two sets (Fig. 49). The corresponding lengths of fish at these girths were 195 mm and 260 mm, respectively. In the second set of gears with a_2 and a_3 the maximum frequency for the net a_2 was for girth 52.89 mm and that of a_3 62.51 mm (Fig. 50). The corresponding lengths of fishes at these girths were 235 mm and 320 mm, respectively. The value of *k* worked out as suggested by Fridman (1973).

The average value of k_1 was 0.0118 for the net a_1 and a_2 and the average value of k_2 for a_2 and a_3 was 0.0109. The average of both these values was 0.0109.

Optimum mesh size

The average value of *k* from both the length-frequency and girth-frequency studies worked out to 0.011.

With the value of *k* as 0.011 the theoretical estimate of mesh size required to harvest the most desirable size group (210 mm in length) of *Hypselobarbus curmuca* worked out to 24 mm mesh bar size (stretched mesh size : 48 mm).

Optimisation of gillnet for Hypselobarbus curmuca with respect to hanging coefficient

There was significant difference in catch of *H. curmuca* between months ($p < 0.001$). There was significantly higher catch in the months of June and July compared to October, May, December, April, November, February and August. The difference in catching efficiency was significantly different ($p < 0.005$) between gillnets with different hanging coefficient. Hanging coefficient of 0.6 showed higher catching efficiency compared to gillnet with hanging coefficient 0.4 and 0.5.

The bycatch showed significant difference between months. The month July, June, September showed significantly higher catch compared to April, October, May, March and February. There was no significant difference between hanging coefficient in case of by catch.

There was significant difference in the catching efficiency with respect to total catch between months ($p<0.001$). Better catches of total catch were obtained in July and June followed by September compared to other months. There is no significant difference in catching efficiency with respect to total catch between nets with different hanging coefficient.

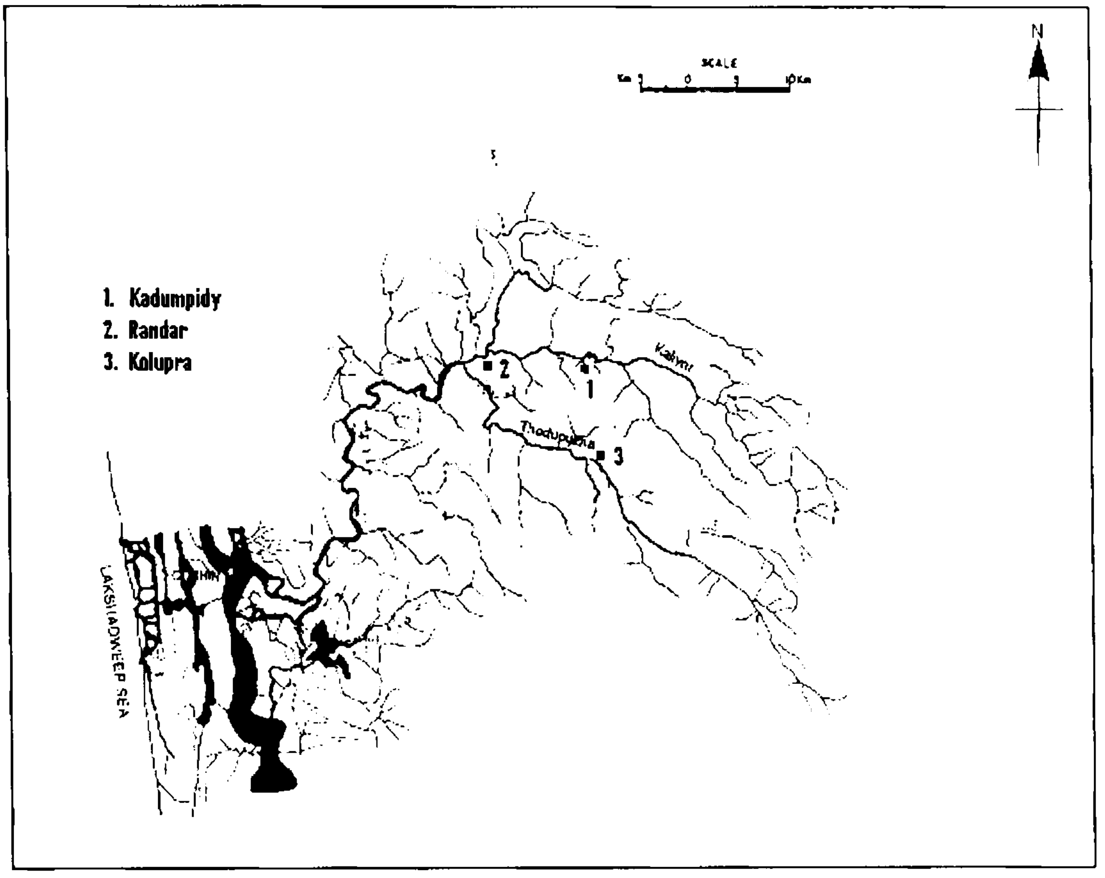


Fig. 39. Area selected for the Selectivity Studies of gillnets in Muvattupuzha River

Table 42. Experimental Gear for Mesh Size

Gillnet			
Specifications	a_1	a_2	a_3
Material	PA Monofilament	PA Monofilament	PA Monofilament
Mesh size (mm)	45	55	65
Twine size (mm ϕ)	0.16	0.16	0.16
Length in mesh	1330	1090	923
Depth in mesh	50	50	50
Selvedge Top	0.5	0.5	0.5
Material	PA Multifilament	PA Multifilament	PA Multifilament
Mesh size (mm)	45	55	65
Twine size	210Dx2x2	210Dx2x2	210Dx2x2
Selvedge Bottom	Nil	Nil	Nil
HR	PP	PP	PP
Twine size (mm ϕ)	2.0	2.0	2.0
Length (m)	30	30	30
FR	PE	PE	PE
Twine size (mm ϕ)	1.5	1.5	1.5
Length (m)	30	30	30
Hanging Coefficient	0.50	0.50	0.50
Float	PVC	PVC	PVC
Size, mm	60 x 20	60 x 20	60 x 20
No. of floats	21	21	21
Distance between floats	1.5 m	1.5 m	1.5 m
Sinkers	Stone	Stone	Stone
No. of sinkers	16	16	16
Distance between sinkers	2 m	2 m	2 m
Weight	100 g	100 g	100 g
Shape	Irregular	Irregular	Irregular

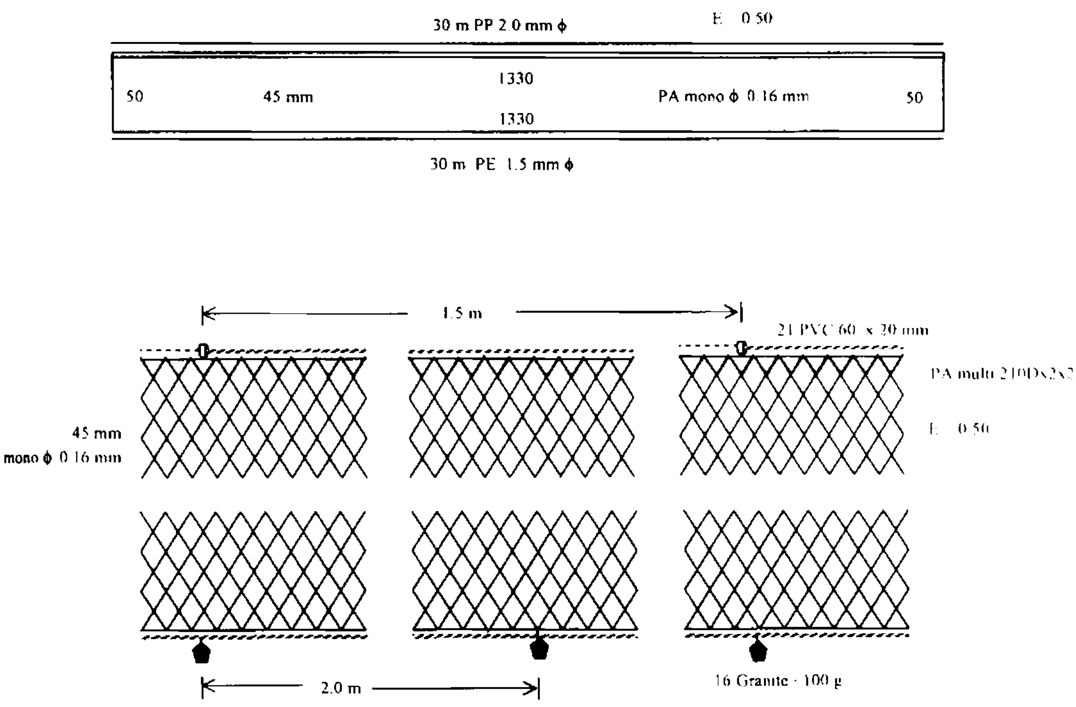


Fig. 40. Experimental gillnet for mesh selectivity studies with 45 mm meshes

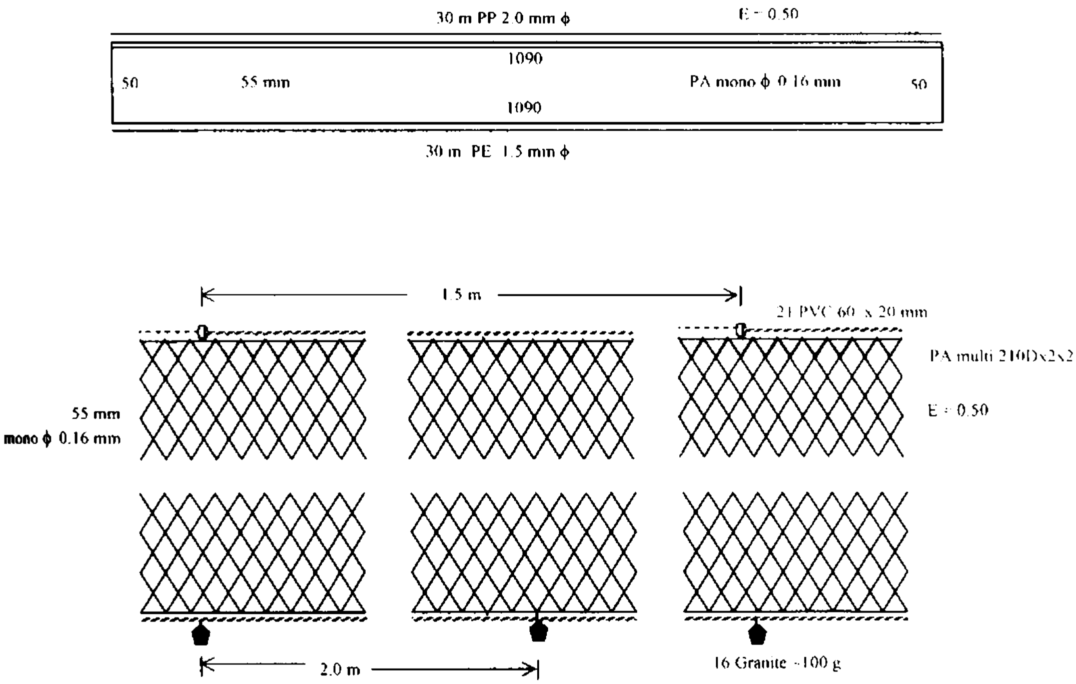


Fig. 41. Experimental gillnet for mesh selectivity studies with 55 mm meshes

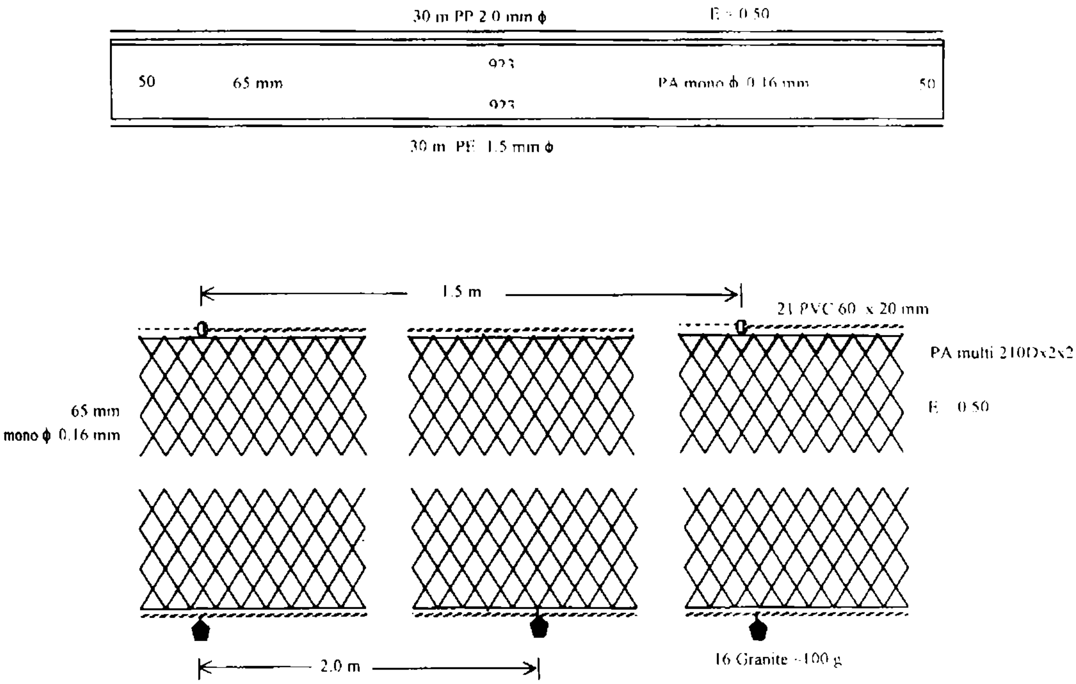


Fig. 42. Experimental gillnet for mesh selectivity studies with 65 mm meshes

Table 43. Length frequency table

Midpoint	Ca	Cb	Cc	Ln (Cb/Ca)	Ln(Cc/Cb)
L	4.5	5.5	6.5		
X					
135.5	6	2	0		
145.5	3	0	0		
155.5	10	2	0	-1.60944	
165.5	32	7	0	-1.51983	
175.5	46	9	0	-1.63142	
185.5	76	13	0	-1.76578	
195.5	71	20	6	-1.26695	-1.20397
205.5	60	34	3	-0.56798	-2.42775
215.5	23	34	2	0.390866	-2.83321
225.5	19	51	9	0.987387	-1.7346
235.5	16	58	24	1.287854	-0.88239
245.5	4	70	27	2.862201	-0.95266
255.5	3	41	45	2.61496	0.09309
265.5	4	43	52	2.374906	0.190044
275.5	2	22	57	2.397895	0.952009
285.5	2	9	52	1.504077	1.754019
295.5	0	9	30		1.203973
305.5	2	1	18		2.890372
315.5	0	1	13		2.564949
325.5	0	0	7		
335.5	1	0	7		

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-10.02	1.091938	-9.17631	3.47E-06
X Variable 1	0.047772	0.004893	9.76424	1.98E-06

Lower 95%	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
-12.453	-7.58697	-12.453	-7.58697
0.03687	0.058673	0.03687	0.058673

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-11.4159	1.45553	-7.84316	1.4E-05
X Variable 1	0.044591	0.005756	7.746724	1.56E-05

Lower 95%	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
-14.6591	-8.17282	-14.6591	-8.17282
0.031766	0.057416	0.031766	0.057416

Table 44. Girth frequency table

Midpoint	Ca	Cb	Cc	Ln (Cb/Ca)	Ln(Cc/Cb)
L	4.5	5.5	6.5		
X					
21	0	0	0		
23	0	0	0		
25	0	0	0		
27	1	0	0		
29	0	0	0		
31	5	7	10		
33	3	0	0		
35	10	2	0		
37	3	0	0		
39	29	8	0	-1.28785	
41	46	13	0	-1.26369	
43	48	7	0	-1.92529	
45	26	11	0	-0.8602	
47	81	15	0	-1.6864	
49	66	18	3	-1.29928	-1.79176
51	83	68	5	-0.19933	-2.61007
53	19	51	9	0.987387	-1.7346
55	20	123	54	1.816452	-0.8232
57	3	41	45	2.61496	0.09309
59	4	43	52	2.374906	0.190044
61	4	35	129	2.169054	1.304464
63	2	2	31	0	2.74084
65	0	0	0		
67	0	0	7		
69	0	0	0		
71	1	0	7		

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-14.3514	1.352101	-10.6142	0.00876	-20.1691
X Variable 1	0.295135	0.026875	10.98195	0.00819	0.179503

Upper 95%	*Lower 95.0%*	*Upper 95.0%*
-8.5338	-20.1691	-8.5338
0.410767	0.179503	0.410767

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-19.4098	1.636022	-11.864	0.00703	-26.449
X Variable 1	0.353687	0.029593	11.95155	0.006928	0.226357

Upper 95%	*Lower 95.0%*	*Upper 95.0%*
-12.3705	-26.449	-12.3705
0.481017	0.226357	0.481017

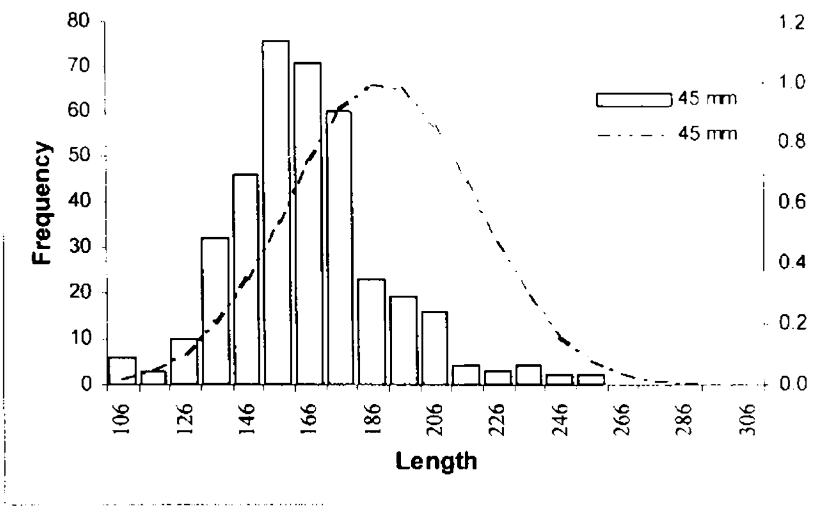


Fig. 43. Length frequency curve of 45 mm mesh size

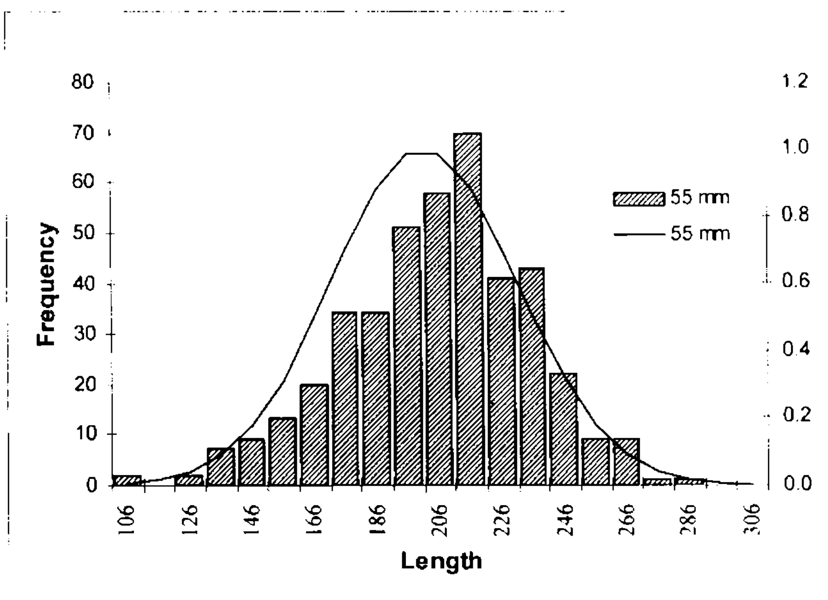


Fig. 44. Length frequency curve of 55 mm mesh size

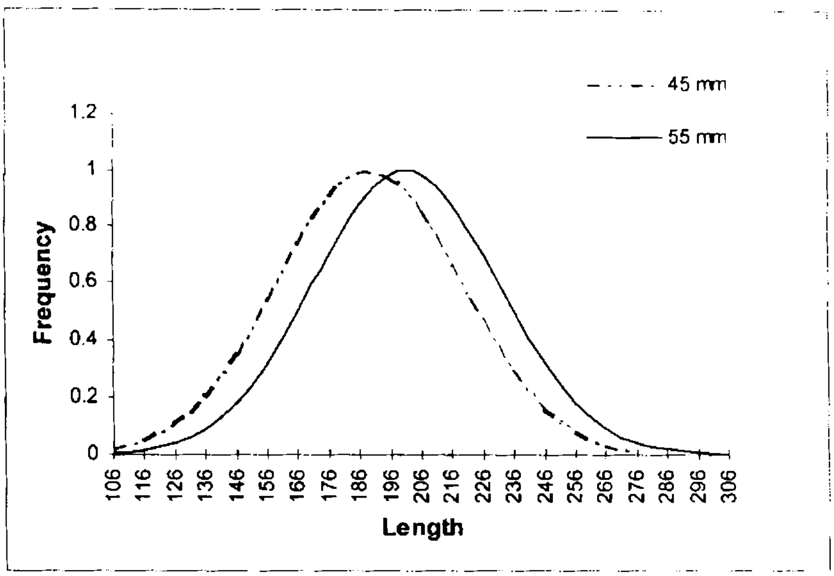


Fig. 45. Length frequency curve of 45/55 mm mesh size

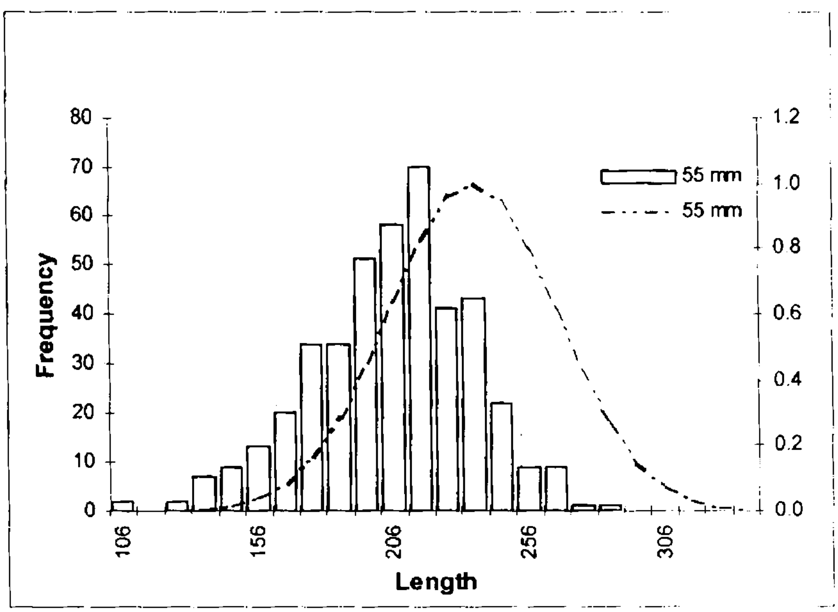


Fig. 46. Length frequency curve of 55 mm mesh size

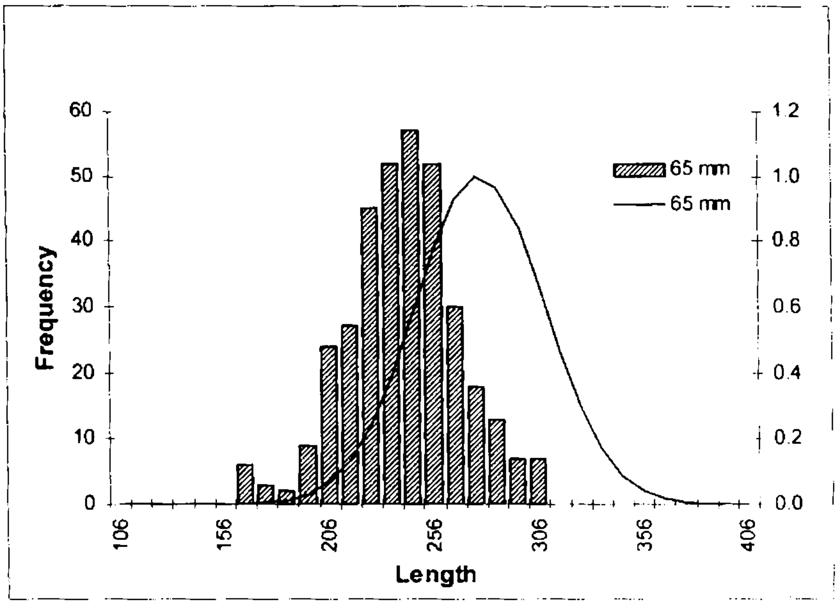


Fig. 47. Length frequency curve of 65 mm mesh size

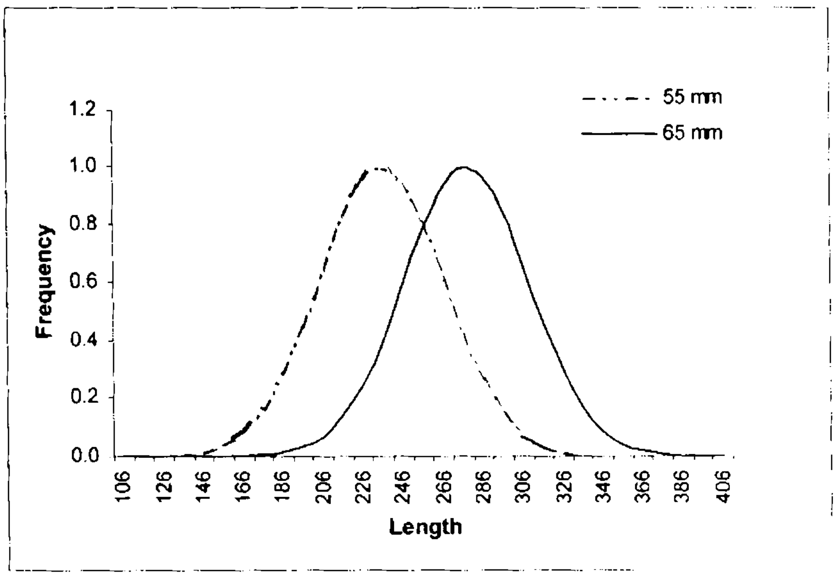


Fig. 48. Length frequency curve of 55/65 mm mesh size

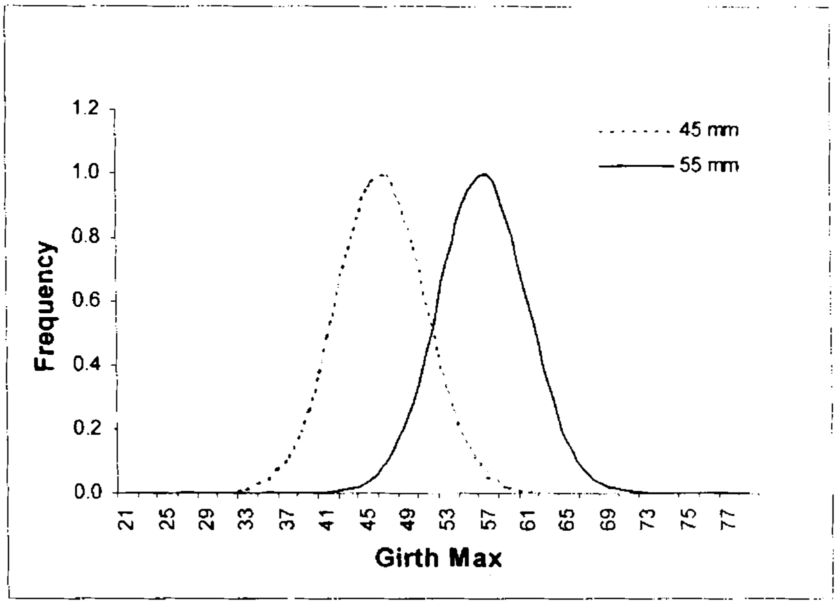


Fig. 49. Girth frequency curve of 45/55 mm mesh size

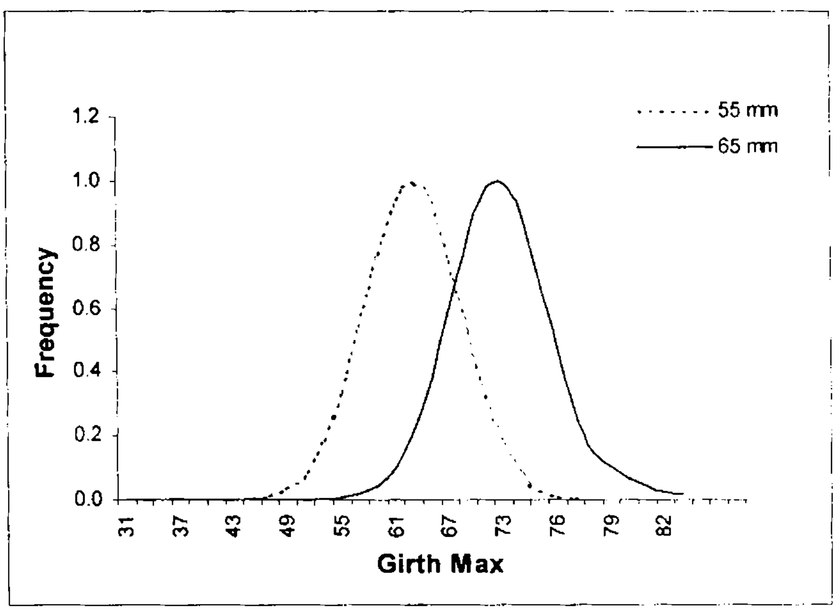


Fig. 50. Girth frequency curve of 55/65 mm mesh size

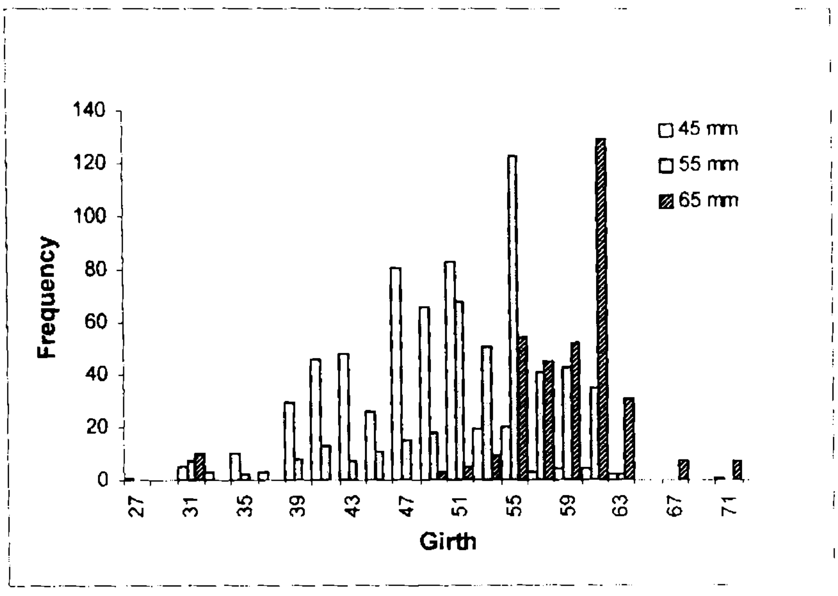


Fig. 51. Girth frequency graph of 45/55/65 mm mesh size

Table 45. Experimental Gillnet – Hanging Coefficient

Gillnet			
Specifications	a_1	a_2	a_3
Material	PA Monofilament	PA Monofilament	PA Monofilament
Mesh size (mm)	50	50	50
Twine size (mm ϕ)	0.16	0.16	0.16
Length in mesh	1500	1200	1000
Depth in mesh	50	50	50
Selvedge Top	0.5	0.5	0.5
Material	PA Multifilament	PA Multifilament	PA Multifilament
Mesh size (mm)	55	55	55
Twine size	210Dx2x2	210Dx2x2	210Dx2x2
Selvedge Bottom	Nil	Nil	Nil
HR	PP	PP	PP
Twine size (mm ϕ)	2.0	2.0	2.0
Length (m)	30	30	30
FR	PE	PE	PE
Twine size (mm ϕ)	1.5	1.5	1.5
Length (m)	30	30	30
Hanging Coefficient	0.40	0.50	0.60
Float	PVC	PVC	PVC
Size (mm)	60 x 20	60 x 20	60 x 20
No. of floats	21	21	21
Distance between floats	1.5 m	1.5 m	1.5 m
Sinkers	Stone	Stone	Stone
No. of sinkers	16	16	16
Distance between sinkers	2 m	2 m	2 m
weight	100 g	100 g	100 g
Shape	Irregular	Irregular	Irregular

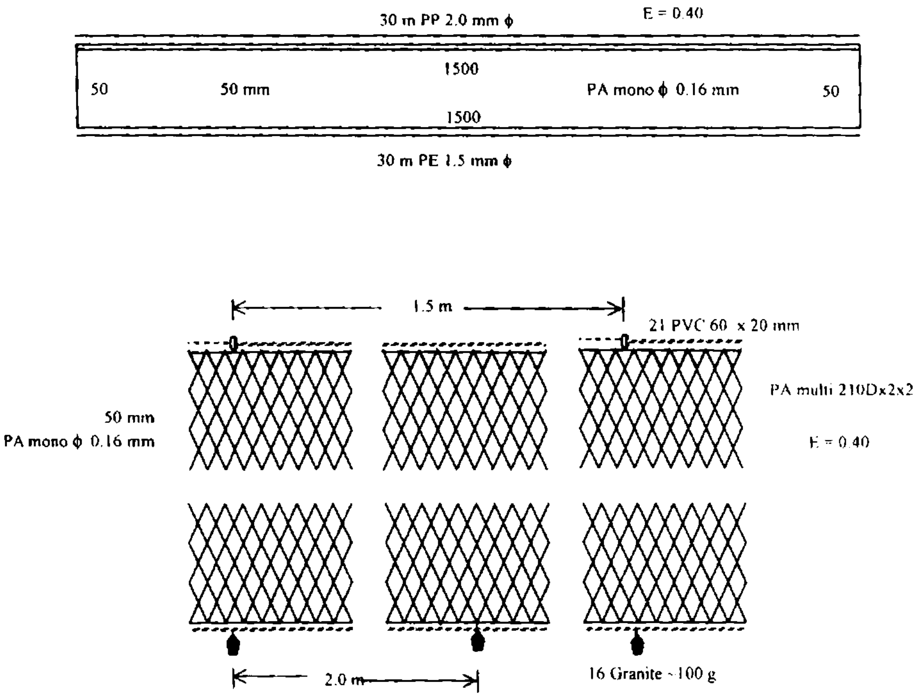


Fig. 52. Experimental Gillnet with hanging coefficient 0.4

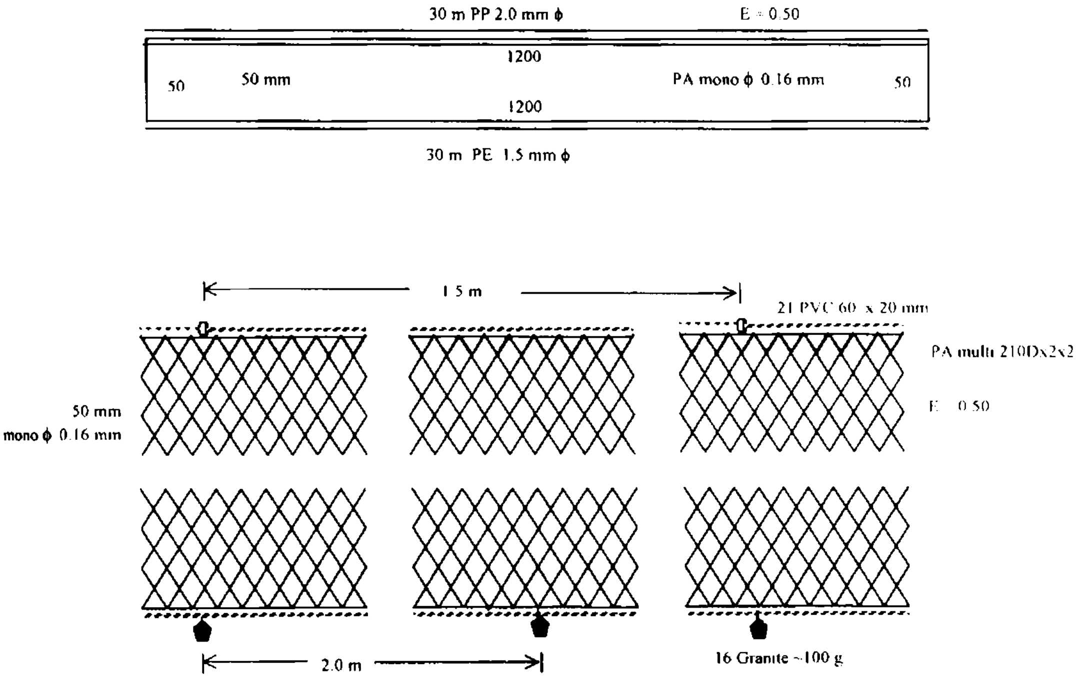


Fig. 53. Experimental gillnet with hanging coefficient 0.5

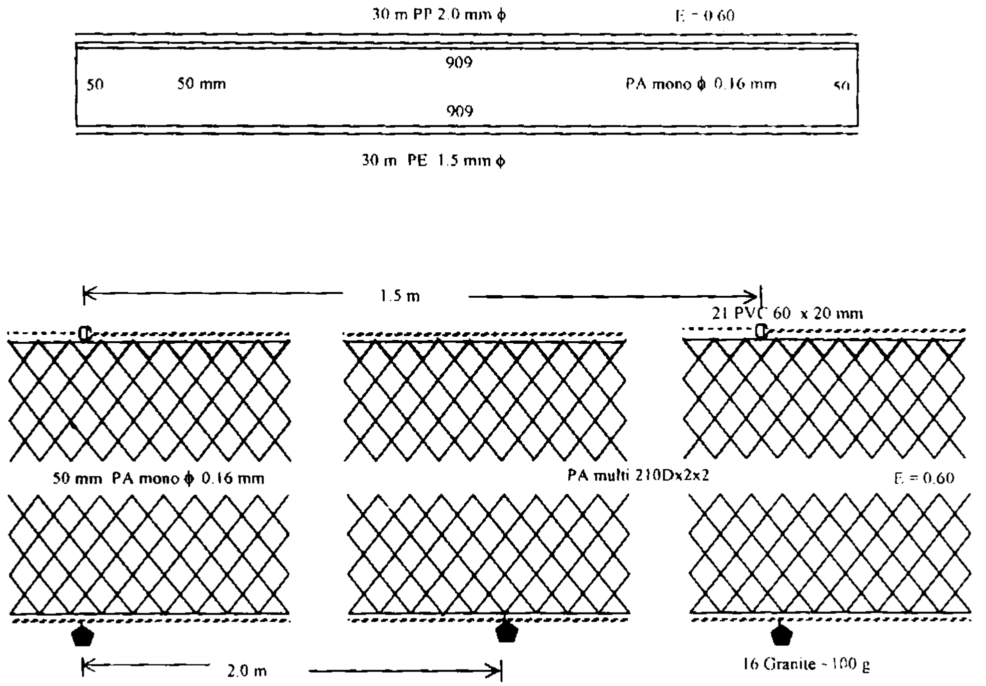


Fig. 54. Experimental gillnet with hanging coefficient 0.6

Table 46. ANOVA: (All species)

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	3	200508.8	66836.25	343161182.8
Row 2	3	136650	45550	56559900
Row 3	3	174791.3	58263.75	142077923.4
Row 4	3	105968.8	35322.92	38648763.02
Row 5	3	74520	24840	438347700
Row 6	3	305110	101703.3	91299433.33
Row 7	3	314405	104801.7	2192446858
Row 8	3	184882.5	61627.5	44236631.25
Row 9	3	247937.5	82645.83	287970052.1
Row 10	3	63922.5	21307.5	253174106.3
Row 11	3	141960	47320	27394900
Row 12	3	97695	32565	150355075
Column 1	12	778965	64913.75	1296928764
Column 2	12	678927.5	56577.29	823358771
Column 3	12	590458.8	49204.9	846171985.1

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	2.6E+10	11	2.36E+09	7.815507692	2.47E-05	2.258517
Columns	1.48E+09	2	7.41E+08	2.45261571	0.109256	3.443361
Error	6.65E+09	22	3.02E+08			
Total	3.41E+10	35				

3.3. Economic Analysis of Gillnet Operation

Very few studies have been conducted in the riverine sector of Kerala about the economic aspects of the fishing. A technology can be considered appropriate and successful only it lowers production cost per unit of catch or rises the productivity. The techno-economic efficiency of different fishing systems is an important decisive factor considered for the allocation of scarce resources such as capital. The sustainable development of fishing through co-existence of different gear system needs information on their comparative efficiency in terms of productivity and economics of operation.

The comparative technical and economic performance of different fishing systems in different parts of the world have been discussed by many (Yater, 1982; Librero *et. al.*, 1985; Panayotou *et. al.*, 1985; Tokrishna *et. al.,* 1985; Fredericks and Nair, 1985; Khaled, 1985 and Jayantha and Amarasinghe, 1998). In the Indian context, techno-economic aspects of purse seine was studied by Varghese (1994), and Mukundan and Hakkim (1980). Panikkar *et al* (1993), Shibu (1999), Iyer *et. al,* (1985), Devaraj and Smitha (1988) and John (1996) investigated the economics of trawling.

Economic analysis studies have been made in marine sector by Yahaya and Wells, (1980); Kurien and Willmann, (1982); Unnithan *et.al.* (1985); Sathiadhas and Panikkar, (1988); Sadananthan *et.al.*, (1988) and Dutta *et.al.* (1989).

The economics of operation of gill nets in India was studied by many (Nobel and Narayanan Kutty 1978; Kurien and Willmann, 1982; Silas *et.al.*, 1984; Sehera and Kharbari, 1989; Panikkar *et.al.*, 1990, 1993; Dutta and Dan 1992; Iyer 1993, Luther *et.al.*, 1997 and Thomas 2001). However, no systematic study has been carried out to assess the economics of operations of fishing gears operated in the riverine sector in spite of their popularity, efficiency, employment potential.

3.3.1. Materials and Methods

For collection of primary data five stations were selected from the Muvattupuzha River system. The centres were Piravam, Kadumpidy, Kanjar, Kolupra and Randar (Fig. 55). The centres were selected by taking in to consideration of the geographic spread of the rivers, convenience to collect the reliable data and the areas and geographic distribution of fishermen population. Twenty percentage of the fishing families were selected from each location (Pauly, 1991). The details of families selected for this study is given in the Table 47. Details of costs and earnings were collected for a period of one year from June 2000 to May 2001. The data collected during the visits were used for the analysis of technical and economic efficiency. It includes effort and productivity (catch per unit effort) and return on investment.

Table 47. Details of families selected for the economic analysis of gillnet

Stations	Total number of gillnet fishermen	No. of fishermen selected for the study
Piravam	20	4
Kadumpidy	8	2
Kanjar	25	5
Kolupra	20	4
Randar	40	8

The basic economic data on the investments on the gear, craft, other accessories and other fixed expenditures were collected in the initial period of the study. The operational costs and earning were collected from the field, at the time of fishing operation. The details of the costs, fishing time, fishing areas, catch composition, earnings, damage of the gear, repair and maintenance costs in each unit were collected at fort-nightly interval from the selected centres. These details cross checked by interviewing the operators of the gear.

Profitability ratios were calculated on the basis of investment and profit. Capital investments were calculated as the cost of craft and gear. Variable costs were calculated as the cost of maintenance and repair during the study period and also included the labour cost for the maintenance.

Fixed cost included as the interest on capital and variable costs. The interest was calculated at the rate of agriculture loan. The fixed cost also included the depreciation of the craft and gear. The depreciation is calculated as follows:

$$Depreciation = \frac{Cost\ \ price - Salvage\ \ value}{Avg.\ life\ \ span\ \ \times Cost\ \ price} \times 100$$

Operational cost consists mainly the labour, auction charges, ferry charges and levies.

Catch per unit effort (catch per hour) was calculated from all the stations on monthly basis. For this the weight of catch from all the stations and the total fishing time was taken as inputs.

Catch per haul is calculated from all the stations. The weight of the catch and number of hauls from all stations were taken as inputs.

Catch per area of net was also calculated and for this purpose 1000 square meter was taken as a single unit.

3.3.2. Results and Discussion

Representative samples of different types of gill nets operated in different areas were taken and their average cost and earning worked out for the study period.

Profitability ratio

The cost and earnings tables (Table 48) collected during the period of study gives a picture of the operative costs, earning and profitability of the craft and gear in each station.

Capital investment in gillnet operation include the cost of the net and the craft. The capital investment of gear in station 2 was the highest and the least was in station 1 with an average rate of Rs. 5585.42. The capital investment on the craft in station 2 was the highest and the least was in station 5 with an average rate of Rs. 729.18. The total capital investment in station 2 was the highest and the least was in station 1. In station 5 old rubber tube is also used as craft. Which made the cost of craft less compared to other stations.

The variable cost included the cost of maintenance and labour for the gear and craft. The maintenance of the gear includes the cost of repair of the damaged gear, cost of repairing materials and preservatives used in the gear. The variable cost of craft includes the cost of repair of the craft and cost of preservatives. In most cases, preservatives were used every six months for maintenance of crafts. The highest maintenance cost was in the station 2 and the least was in the station 5 with an average cost of Rs. 2325.75. In station 5 old rubber tube is used as craft. So the maintenance and repair cost is less compared to other stations.

Fixed cost included the interest on capital, interest on variable cost and depreciation on the craft and gear. Interest on capital and variable cost was calculated as 10.5% rate.

The highest fixed cost was in station 2 and the lowest was in station 1. In station 5 the depreciation cost of craft was less compared to other station due to the use of rubber tube along with plank built canoe as craft.

The capital investment on gear in station 1 was less compared to other stations, so the fixed cost becomes least in this station.

The operational cost included labour deployed in the fishing operation. The highest operational cost was in the station 2 and least was in the station 5, with an average cost of Rs. 30706. In station 2, two fishermen were engaged in fishing operation and, hence the operational cost was high in this station. In all other stations generally only one fisherman was engaged in the fishing operation and more than one fishermen occasionally were engaged during winter season.

The highest earning was from station 2 followed by station 3, station 1, station 4 and the least from station 5. The average earnings from these stations was Rs. 60472.55.

The profitability ratios shows the percentage of profit compared to different types of investments like returns on turnover, returns on capital, returns on total cost, returns on variable cost, returns on operational cost and break even point (Table 48).

Return on turnover

The highest percentage of return on turnover was from station 3 (32.74%), followed by station 1 (32.65 %), station 4 (27.94 %), station 2 (26.88 %) and station 5 (24.62 %). In station 3 the earning was too high compared to other stations and therefore the turnover was highest. The average returns on turnover was found to be 28.96%. Fig. 56 shows the relation of return on turnover between stations.

Return on capital

The highest return on capital investment was in station 1 (339.67 %) and the least returns on capital investment was from station 5 (194.13 %) with an average return on capital of 277.35%. Fig. 57 shows the relation of returns on capital between stations.

Return on total cost

The highest return on total cost was in station 3 (48.68 %) and the lowest was in station 5 (32.67 %) with an average return on total cost of Rs. 40.77%. Fig. 58 shows the relation of return on total cost between stations.

Return on variable cost

The highest return on variable cost was from station 2 (795.43 %) and the lowest was in station 5 (693.74 %), with an average return on variable cost of 753.02%. Fig. 59 shows the relation of return on variable cost between stations.

Return on operational cost

The highest returns on operational cost was from station 3 (68.86 %) and the lowest was in station 5 (47.51 %), with an average return on operational cost of 57.04%. Fig. 60 shows the relation of return on operational cost between stations.

Break-even point

The highest break-even point 3.06 was noted in station 5 and the lowest 2.05 was in station 3 with an average value of 2.45. Fig. 61 shows the break-even points of different stations.

Fishing Effort

Fishing effort was calculated in three different ways viz., catch per hour, catch per haul and catch per unit effort (in terms of 1000 sq.m of gillnet area).

Catch per hour

The catch per hour of gillnets operated in all the stations were calculated (Table 49). The highest catch per hour in the present study period of station 2 shows 0.52 $kg.h^{-1}$ and station 5 shows the least value 0.39 $kg.h^{-1}$ (Fig. 67).

The period from June to August showed the highest catch per hour in all the stations compared to other months and the peak was in the month of July. The June – August period the winter season is the most profitable period

In general, when are compared all the stations the highest catch per hour was in July (0.84 $kg.h^{-1}$) and lowest during January to March (0.34 $kg.h^{-1}$). Catch per hour in each station are given in Fig. 62 to 66.

Earnings per hour

The earnings per hour of gillnets operated in different stations were calculated (Table 50). The highest earnings per hour in the present study period was at station 2 (Rs. 23.11) and lowest at stations 4 and 5 (Rs. 16.66) (Fig. 73).

The period from June to August showed the highest earnings per hour in all the stations compared to other months and the peak was in the month of July. Earnings per hour for each station are given in Fig. 68 to 72.

Catch per haul

Catch per haul was calculated for all the stations (Table 51) in the study period. The highest catch per haul was from station 2 (5.59 kg) and the lowest was from station 5 (3.88 kg). On monthly basis the highest catch per haul was recorded during the month of July (8.39 $kg.haul^{-1}$) and the lowest was from the month of March (3.36 $kg.haul^{-1}$). Fig. 74 to 79 shows the catch per haul in different stations.

Earnings per haul

Earning per haul was calculated in all the stations (Table 52). The highest earnings per haul was in station 2 (Rs. 248.44) and the lowest was in station 5 (Rs. 166.61). The highest earnings per haul was calculated in the month of July and the lowest was in the month of October. Fig. 80 to 85 shows the catch per haul in different stations.

Catch per unit area

The catch per unit area is calculated as catch in kg per 1000 sq.m. of gillnet area. The Table 53 shows that the highest catch per unit area was from the station 1 (18.10 kg) and the lowest was from station 5 (8.19 kg). Fig. 86 shows the catch per unit area in all stations in different months.

The earnings per unit area calculated (Table 53) shows that the station 1 recorded the highest earnings of Rs. 715.06 and the lowest was from the station 5 which showed Rs. 353.96. Fig. 87 shows the earning per unit area in all stations in different months.

Statistical analysis

Monthly catch of gillnet showed significant different between months ($p<0.001$) and between stations ($p<0.001$). Among the months July showed significantly higher catch compared to February to August (Table 54). Between June and July there is no significant difference. Among stations there is significantly higher catch in station 2 and 3 compared to station 5.

Monthly earnings showed significant difference between months ($p<0.001$) and between stations ($p<0.001$). June and July shown significantly higher earnings compared to rest of the months (Table 55). Among stations there was significant difference in earning in station 2 followed by station 3, compared to station 5.

Catch per hour showed significant difference between months ($p<0.001$) and between stations ($p<0.001$). Months June and July were significantly having higher catch compared to rest of the months (Table 56). Among station 2 and 3 are having significantly higher catch compared to station 5.

Earning per hour showed significant difference between months ($p<0.001$) and between stations ($p<0.001$). June and July showed significantly higher earnings compared to rest of the months (Table 57). Among stations, station 2 showed significantly higher earning compared to the remaining four stations.

Catch per haul is significantly different between months ($p<0.001$) and between stations ($p<0.001$). June and July months were having significantly higher catch per haul compared to other months (Table 58). Stations 2 and 3 were having significantly higher catch per hour compared to station 5.

Earnings per haul showed significant difference between months ($p<0.001$) and between stations ($p<0.001$). Among months July showed significantly higher earning per haul compared to rest of the months (Table 59). Among stations, station 2 was having significantly higher earning compared to the remaining stations.

Comparison with cast net

Capital investment in all the stations were too high in gillnet compared to cast net. It is mainly due to 4-12 number of units were operated by each fishermen. The life of the gear is less compared to castnet, because nylon monofilaments are using as webbing in gillnets. So the fish catching ability of the gear is increasing. The average total cost in gillnet was Rs. 42959 and in cast net it was Rs. 21920.

Return on turn over of gillnet was 28.96 % and of cast net was 29.60 %. Return on capital of gillnet was 277.35 % and of cast net was 2002.89 % and. Return on total cost was 40.77 % in gillnet operation and 47.44 % in cast net operation. Return on variable cost of gillnet was 753.02 % and of cast net was 1282.44 %.

Return on operational cost was 57.04 % in gillnet operation and 55.15 % in cast net operation. The return on operational cost was higher in gillnet operation than in cast net operation.

Break-even point was 2.45 in gillnet and 1.70 in cast net.

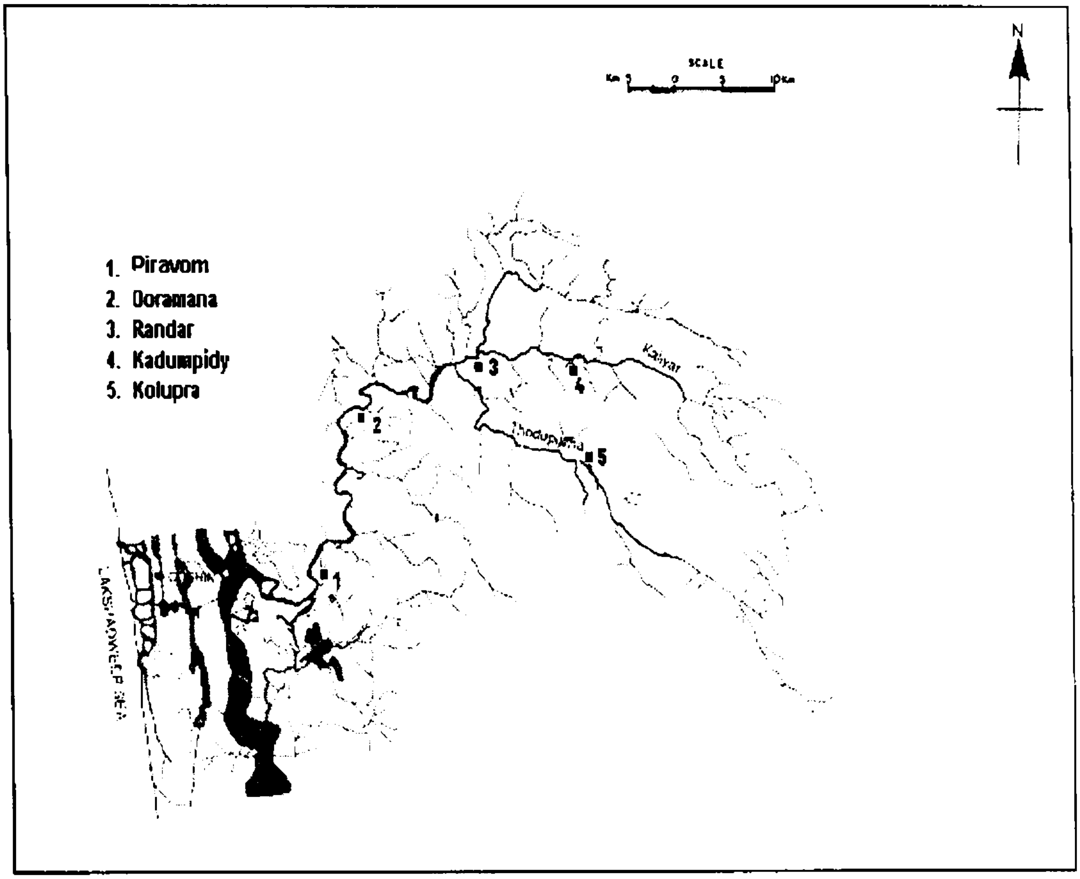


Fig. 55. Area selected for the Economic Analysis of gillnets in Muvattupuzha River

Table 48. Costs and earnings of gillnet operations in Muvattupuzha River

	Station 1	Station 2	Station 3	Station 4	Station 5	Average
tal investment (Rs.)						
Gear	4622.40	6319.79	5295.83	5693.23	5995.83	5585.42
Craft	825.00	850.00	800.00	626.88	544.00	729.18
	5447.40	7169.79	6095.83	6320.10	6539.83	6314.59
ible cost (Rs.)						
Labour	925.00	950.00	800.00	850.00	800.00	865.00
Maintenance	225.00	231.25	250.00	250.00	240.00	239.25
Labour	800.00	800.00	800.00	600.00	480.00	696.00
Maintenance	550.00	650.00	700.00	417.50	310.00	525.50
	2500.00	**2631.25**	**2550.00**	**2117.50**	**1830.00**	**2325.75**
d cost (Rs.)						
est on Capital @10.5 %	571.98	752.83	640.06	663.61	686.68	663.03
est on Variable cost @ 10.5%	262.50	276.28	267.75	222.34	192.15	244.20
reciation						
Gear	2161.20	3009.90	2497.92	2696.61	2847.92	2642.71
Craft	72.50	75.00	70.00	52.69	44.40	62.92
l	3068.17	4114.01	3475.73	3635.25	3771.15	3612.86
total	**11015.57**	**13915.05**	**12121.56**	**12072.85**	**12140.98**	**12253.20**
rational cost (Rs.)						
our	27150.00	43020.00	29240.00	27400.00	26720.00	30706.00
l cost	**38165.57**	**56935.05**	**41361.56**	**39472.85**	**38860.98**	**42959.20**
ings (Rs.)	56668.75	77864.38	61496.25	54776.88	51556.50	60472.55
profit (Rs.)	**18503.18**	**20929.33**	**20134.69**	**15304.02**	**12695.52**	**17513.35**
itability ratio (%)						
rn on turnover	32.65	26.88	32.74	27.94	24.62	28.96
rn on capital	339.67	291.91	330.30	242.15	194.13	277.35
rn on total cost	48.48	36.76	48.68	38.77	32.67	40.77
rn on variable cost	740.13	795.41	789.60	722.74	693.74	753.02
rn on operational cost	68.15	48.65	68.86	55.85	47.51	57.04
ak- even point	2.06	2.72	2.05	2.58	3.06	2.45

Table 49. Month-wise and Station-wise variations in catch per hour of gillnets of Muvattupuzha River

	Kg.h^{-1}					
Month	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Average**
January	0.22	0.40	0.36	0.34	0.32	0.34
February	0.34	0.35	0.40	0.28	0.33	0.34
March	0.40	0.42	0.40	0.19	0.23	0.34
April	0.38	0.41	0.39	0.36	0.26	0.37
May	0.57	0.43	0.58	0.41	0.30	0.44
June	0.74	0.80	0.71	0.70	0.56	0.71
July	0.94	0.94	0.75	0.76	0.71	0.84
August	0.60	0.76	0.60	0.51	0.55	0.63
September	0.40	0.48	0.48	0.37	0.45	0.44
October	0.30	0.41	0.29	0.41	0.33	0.36
November	0.33	0.43	0.41	0.33	0.26	0.36
December	0.30	0.40	0.33	0.31	0.36	0.35
Annual	0.46	0.52	0.47	0.41	0.39	0.46

Table 50. Month-wise and Station-wise variations in earnings per hour of gillnets of Muvattupuzha River

	Rs.h^{-1}					
Month	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Average**
January	9.88	18.92	17.38	13.45	15.40	15.01
February	14.25	17.50	18.00	12.08	14.70	15.31
March	17.81	20.20	18.63	9.05	11.39	15.42
April	15.63	19.39	17.00	14.88	12.44	15.87
May	21.19	20.20	23.38	20.54	14.20	19.90
June	27.91	33.14	27.25	27.50	22.45	27.65
July	33.54	38.52	27.00	26.90	26.80	30.55
August	23.00	30.12	22.75	18.57	22.25	23.34
September	16.25	21.92	19.00	17.14	17.05	18.27
October	13.50	19.59	13.25	12.98	14.90	14.84
November	14.57	19.27	18.00	13.10	12.80	15.55
December	13.93	18.55	14.00	13.75	15.55	15.16
Average	18.46	23.11	19.64	16.66	16.66	18.90

Table 51. Month-wise and Station-wise variations in catch per haul of gillnets of Muvattupuzha River

Kg.haul^{-1}						
Month	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Average**
January	2.20	4.26	3.55	3.59	3.24	3.37
February	3.40	3.77	4.00	2.91	3.32	3.48
March	3.96	4.55	3.98	2.00	2.32	3.36
April	3.83	4.38	3.93	3.78	2.61	3.70
May	5.64	4.68	5.78	4.29	2.97	4.67
June	7.31	8.63	7.08	7.31	5.58	7.18
July	9.26	10.09	7.50	7.94	7.14	8.39
August	6.03	8.12	6.00	5.38	5.46	6.20
September	4.00	5.18	4.80	3.90	4.50	4.48
October	2.98	4.44	2.90	4.31	3.28	3.58
November	3.26	4.59	4.08	3.45	2.62	3.60
December	2.97	4.35	3.33	3.28	3.55	3.49
Average	4.57	5.59	4.74	4.34	3.88	4.62

Table 52. Month-wise and Station-wise variations in earnings per haul of gillnets of Muvattupuzha River

Rs.haul^{-1}						
Month	**Station 1**	**Station 2**	**Station 3**	**Station 4**	**Station 5**	**Average**
January	98.75	203.44	173.75	141.25	154.00	154.24
February	142.50	188.13	180.00	126.88	147.00	156.90
March	178.13	217.19	186.25	95.00	113.89	158.09
April	156.25	208.44	170.00	156.25	124.44	163.08
May	210.63	217.19	233.75	215.63	142.00	203.84
June	275.63	356.25	272.50	288.75	224.50	283.53
July	331.25	414.06	270.00	282.50	268.00	313.16
August	230.00	323.75	227.50	195.00	222.50	239.75
September	162.50	235.63	190.00	180.00	170.50	187.73
October	135.00	210.63	132.50	136.25	149.00	152.68
November	145.71	207.19	180.00	137.50	128.00	159.68
December	139.29	199.38	140.00	144.38	155.50	155.71
Average	183.80	248.44	196.35	174.95	166.61	194.03

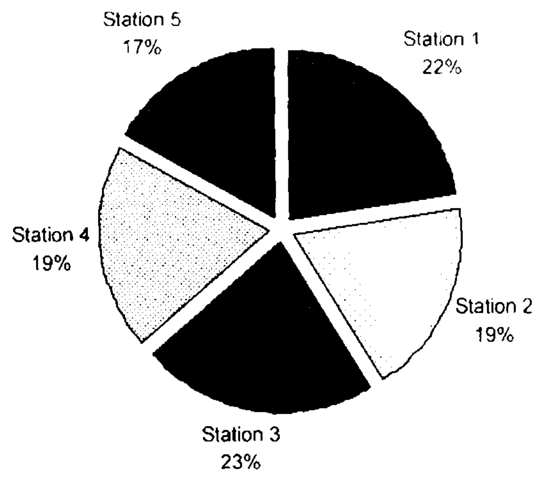


Fig. 56. Return on turn over of gillnets of Muvattupuzha River

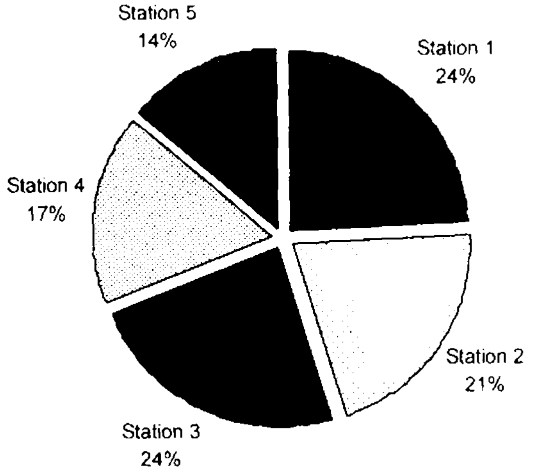


Fig. 57. Return on capital of gillnets of Muvattupuzha River

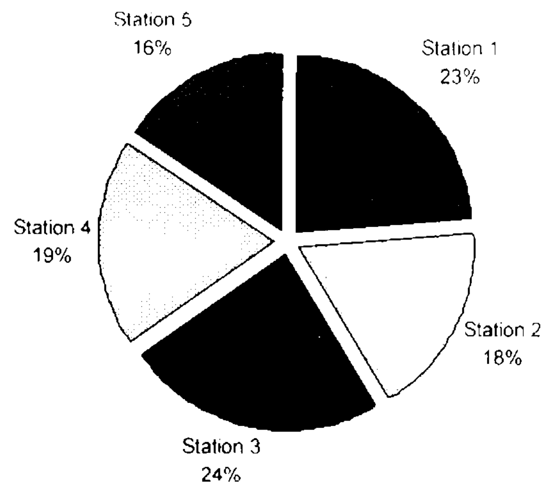


Fig. 58. Return on total cost of gillnets of Muvattupuzha River

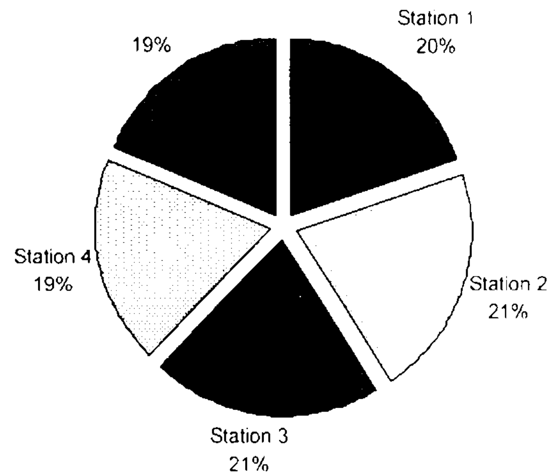


Fig. 59. Return on variable cost of gillnets of Muvattupuzha River

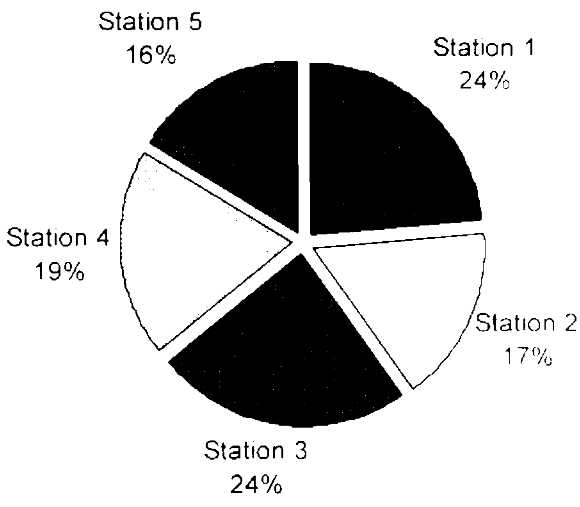


Fig. 60.Return on operational cost of gillnets of Muvattupuzha River

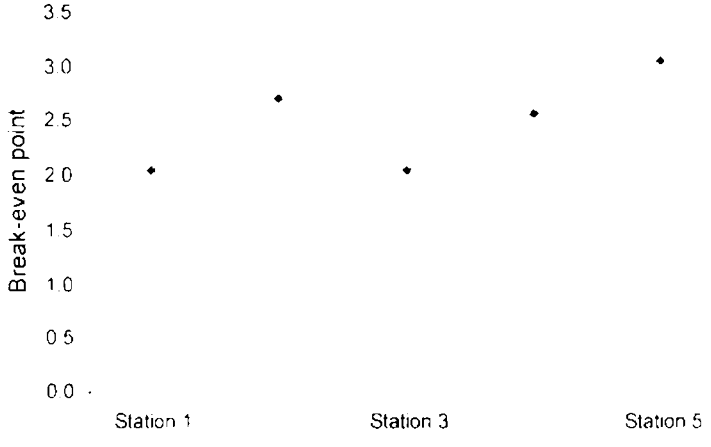


Fig. 61. Break-even point

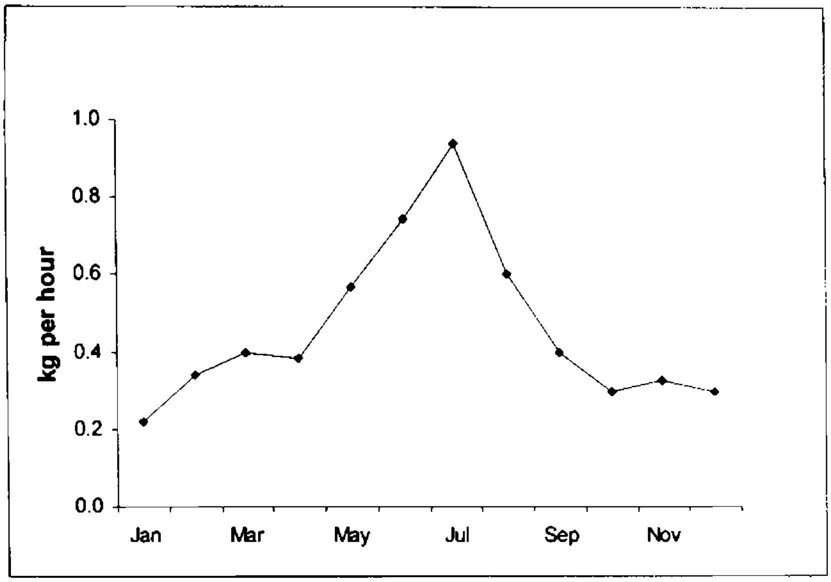


Fig. 62. Catch per hour of riverine gillnets at station 1

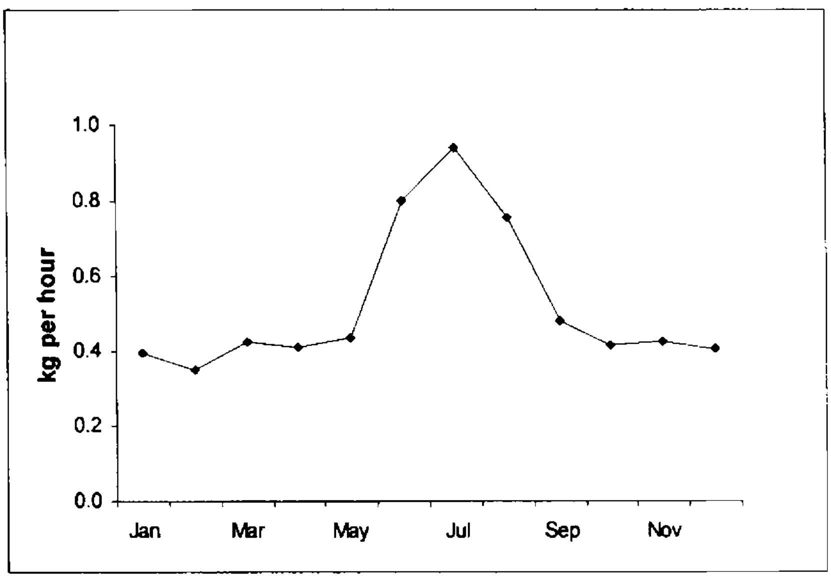


Fig. 63. Catch per hour of riverine gillnets at station 2

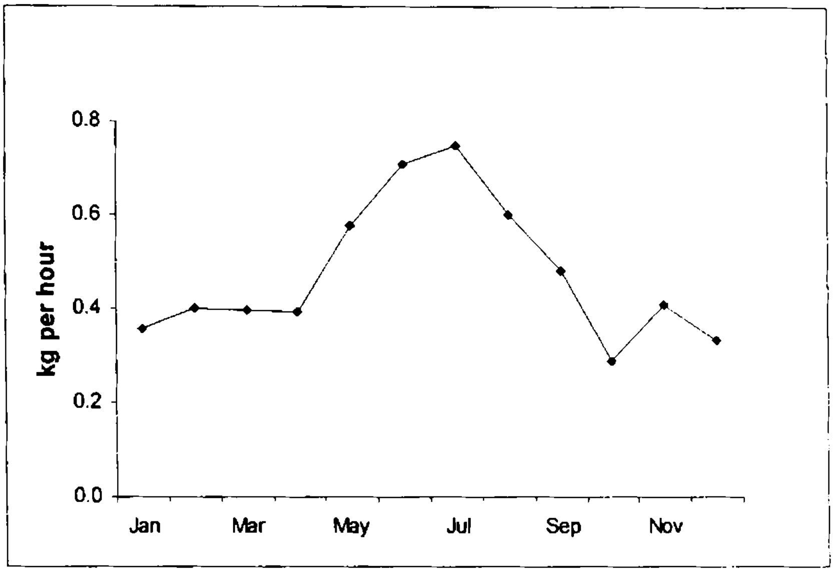


Fig. 64. Catch per hour of riverine gillnets at station 3

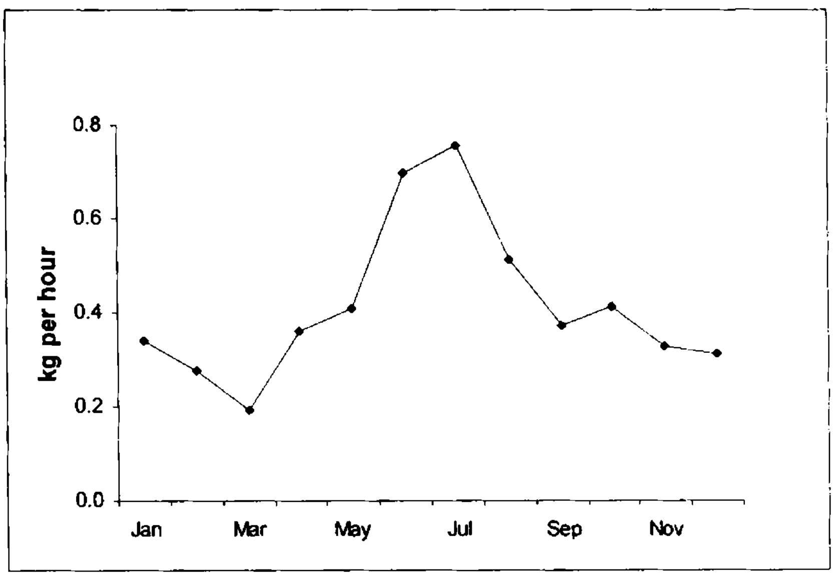


Fig. 65. Catch per hour of riverine gillnets at station 4

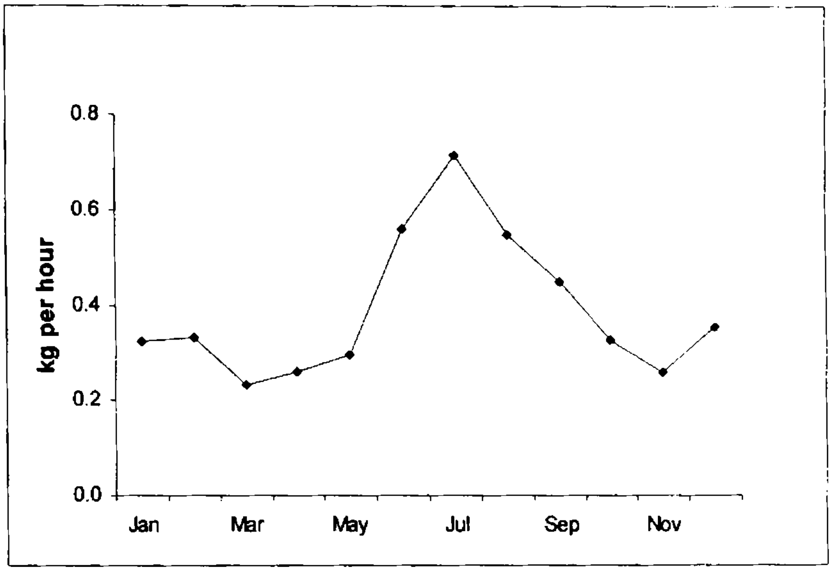


Fig. 66. Catch per hour of riverine gillnets at station 5

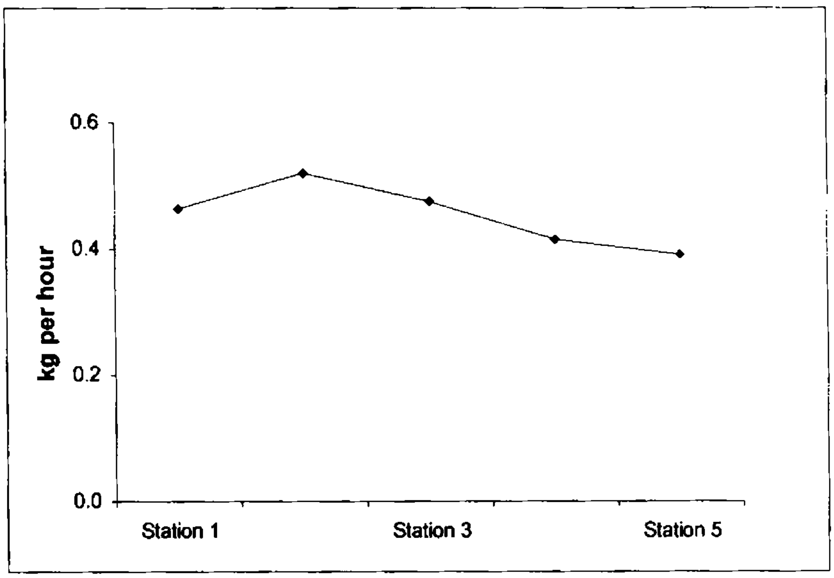


Fig. 67. Variations in catch per hour of riverine gillnets in different stations

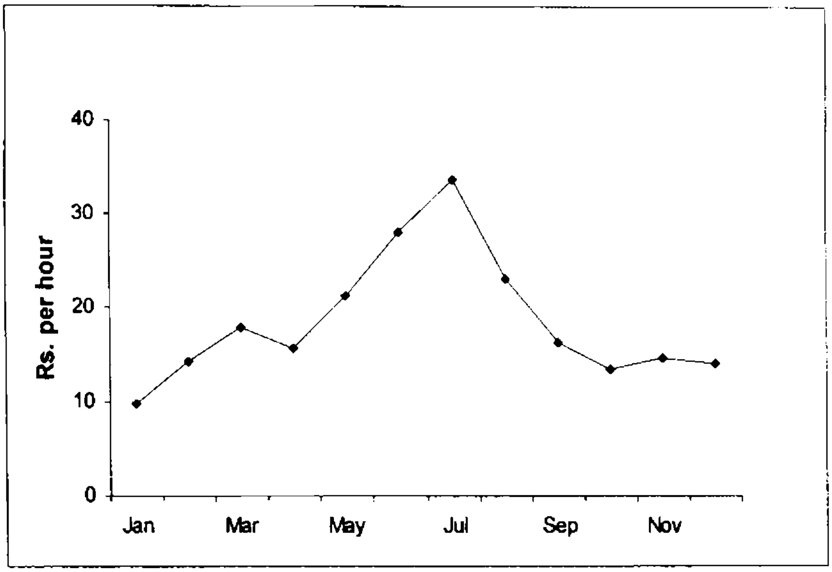


Fig. 68. Earning per hour of riverine gillnets at station 1

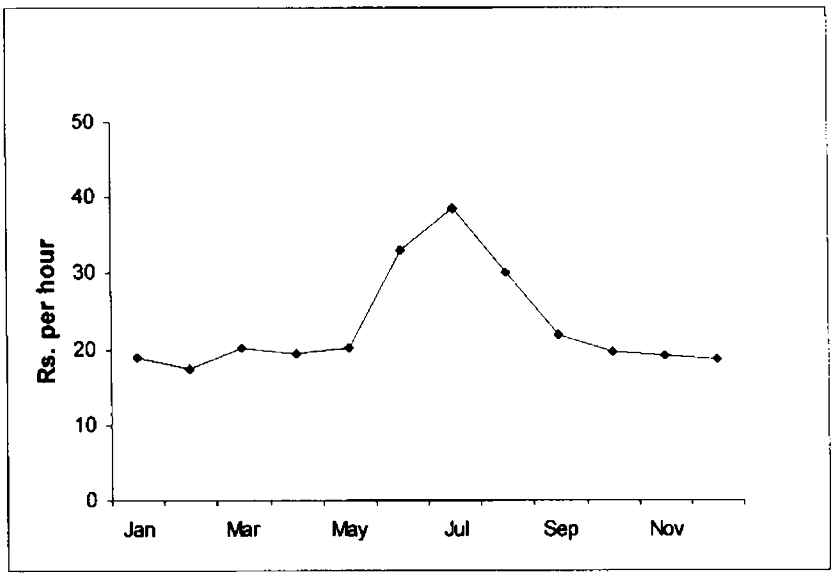


Fig. 69. Earning per hour of riverine gillnets at station 2

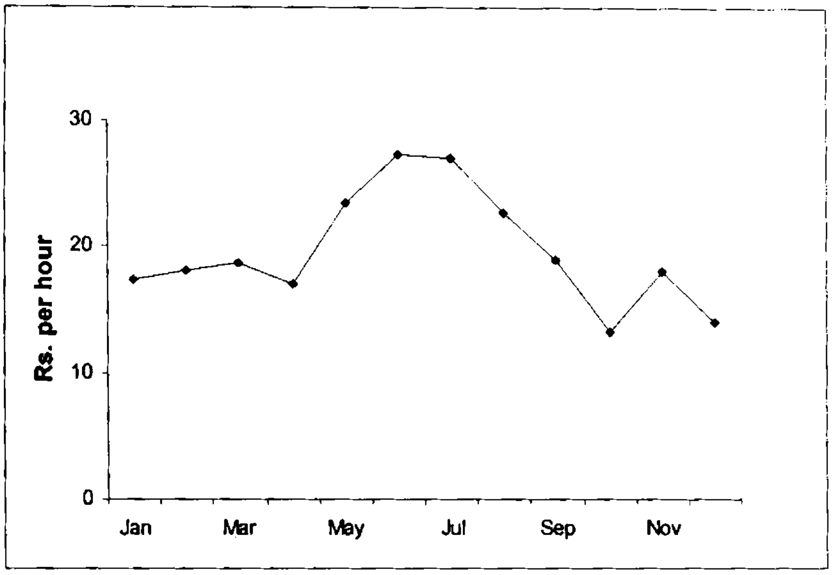


Fig. 70. Earning per hour of riverine gillnets at station 3

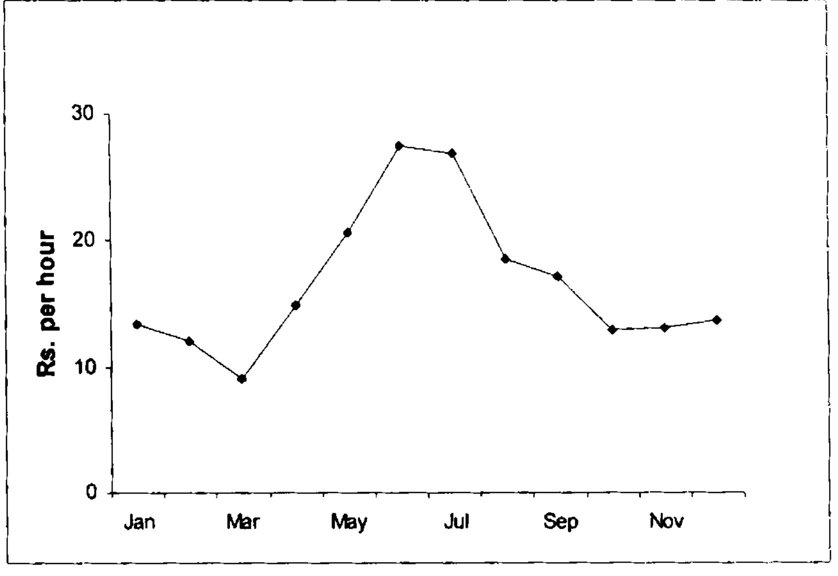


Fig. 71. Earning per hour of riverine gillnets at station 4

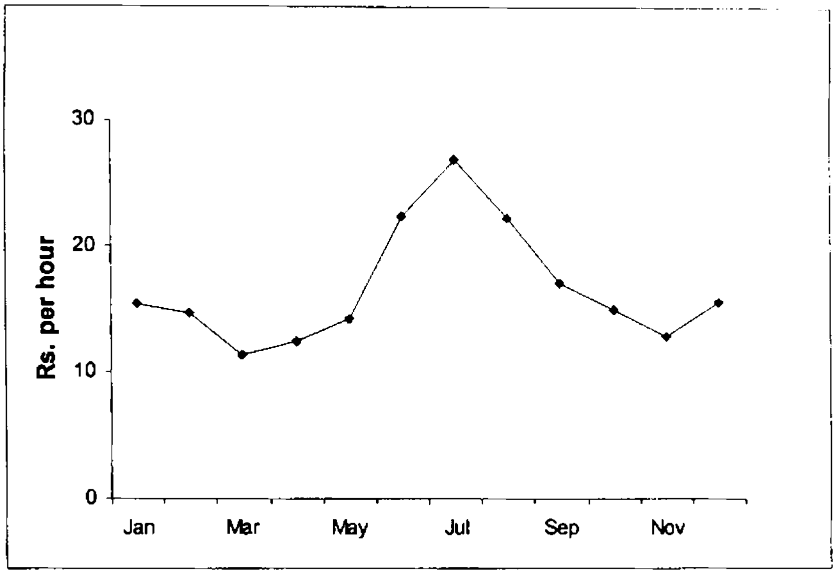


Fig. 72. Earning per hour of riverine gillnets at station 5

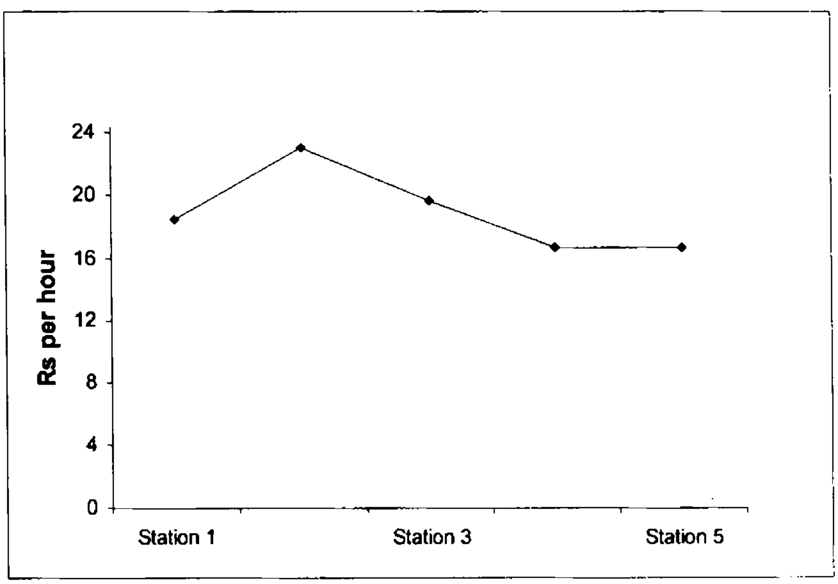


Fig. 73. Variations in earnings per hour of riverine gillnets in different stations

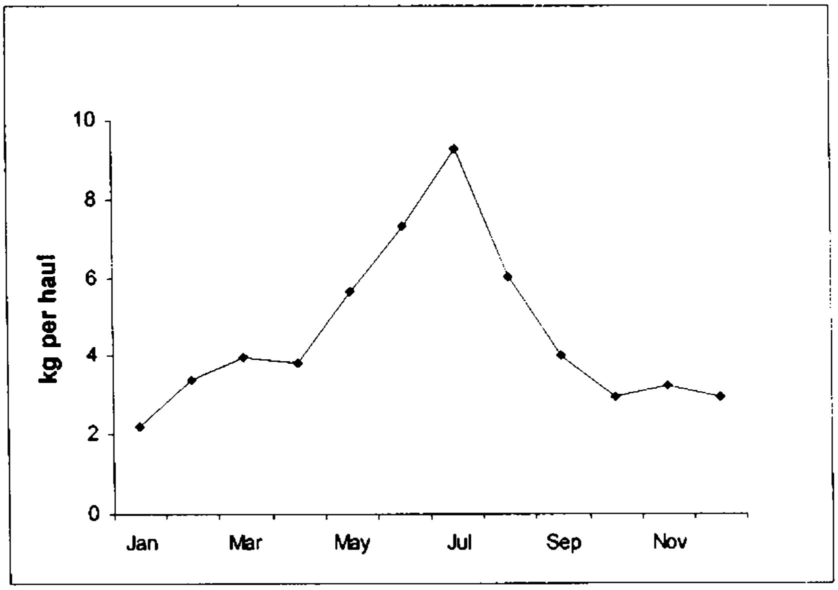


Fig. 74. Catch per haul of riverine gillnets at station 1

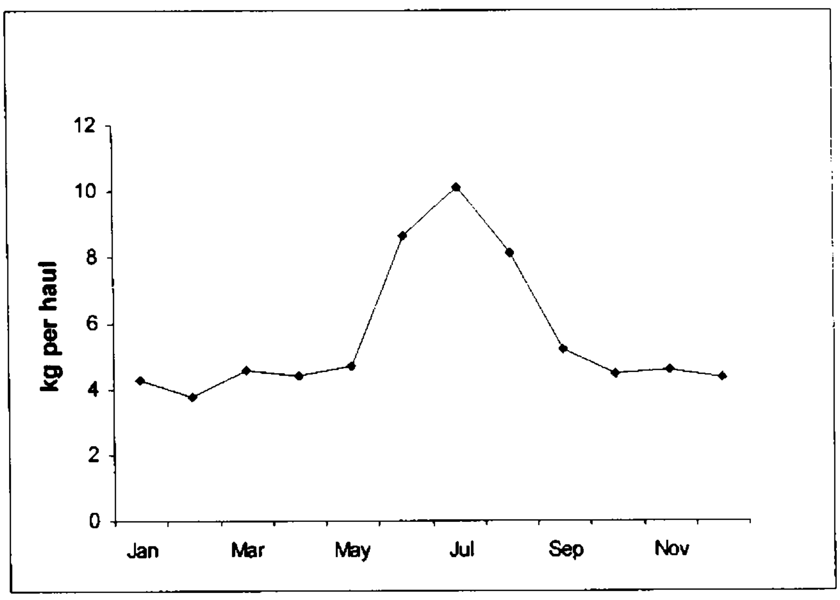


Fig. 75. Catch per haul of riverine gillnets at station 2

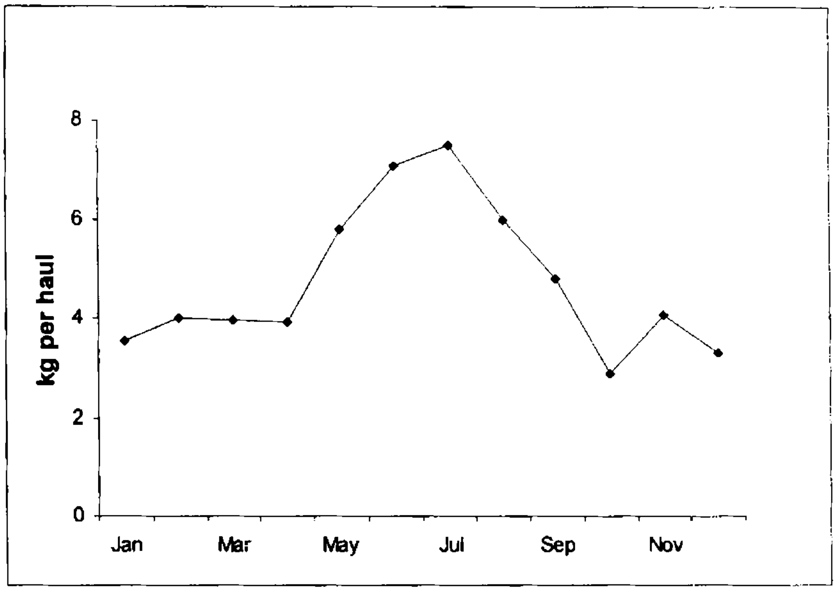


Fig. 76. Catch per haul of riverine gillnets at station 3

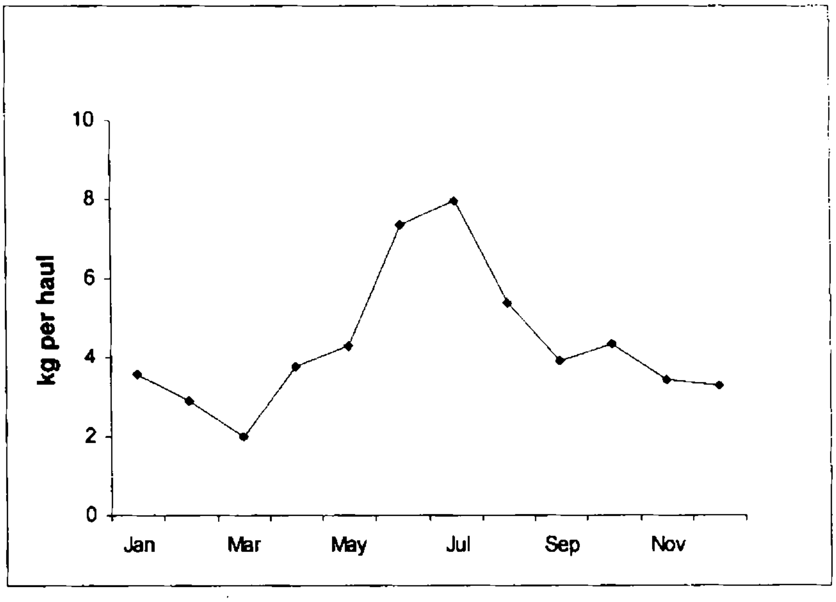


Fig. 77. Catch per haul of riverine gillnets at station 4

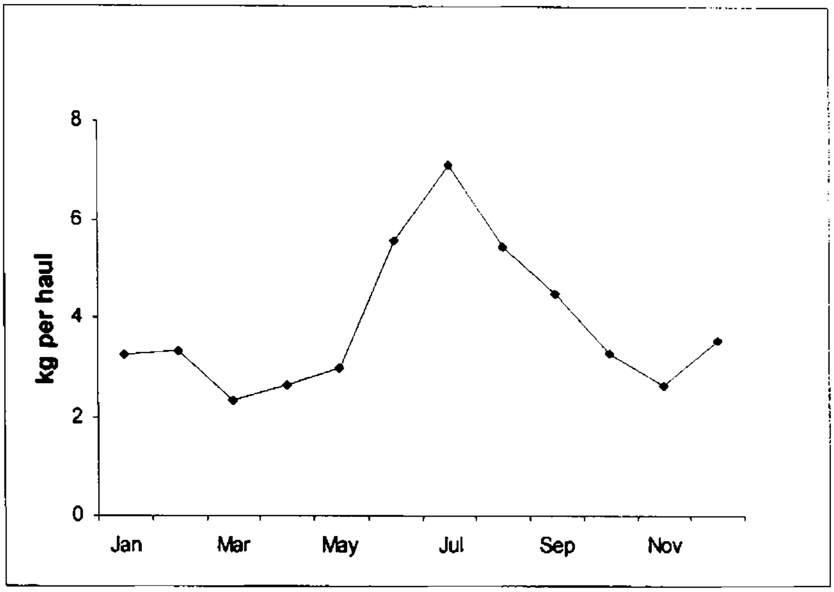


Fig. 78. Catch per haul of riverine gillnets at station 5

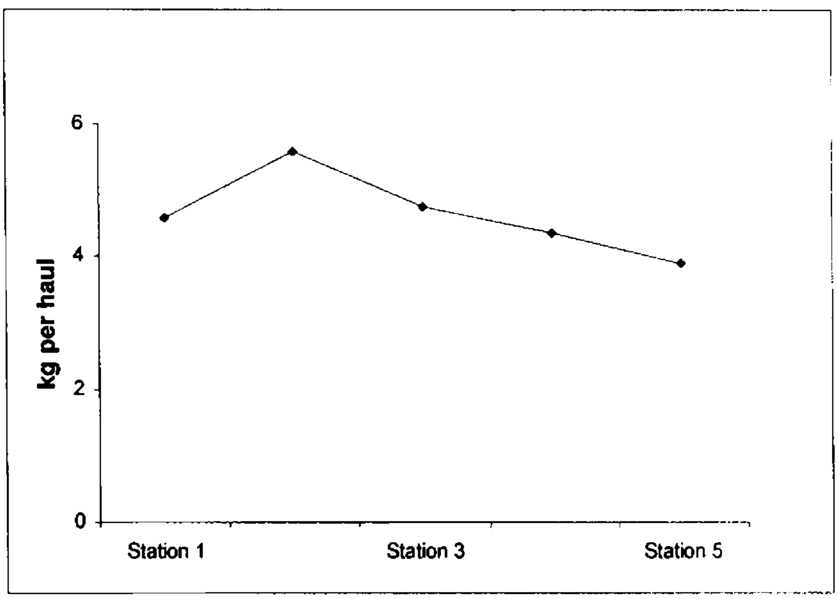


Fig. 79. Variations in catch per haul of riverine gillnets in different stations

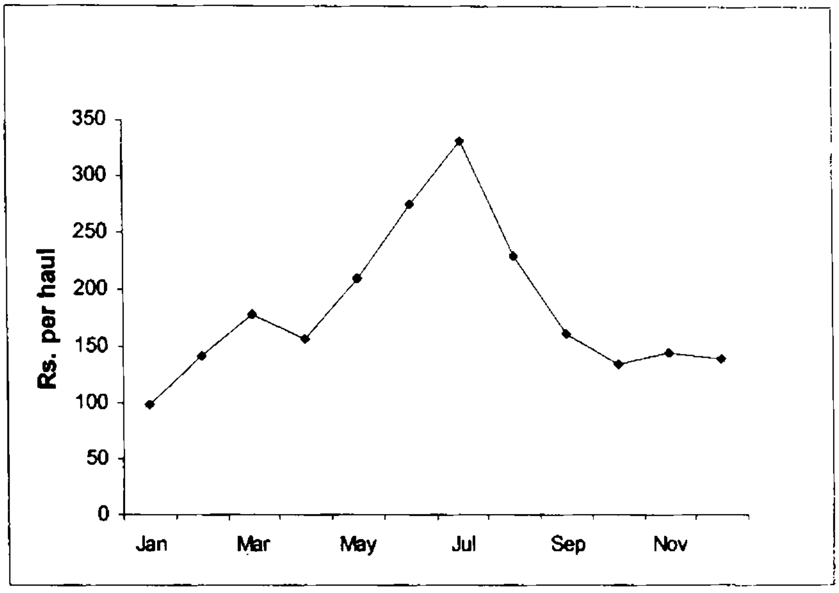


Fig. 80. Earning per haul of riverine gillnets at station 1

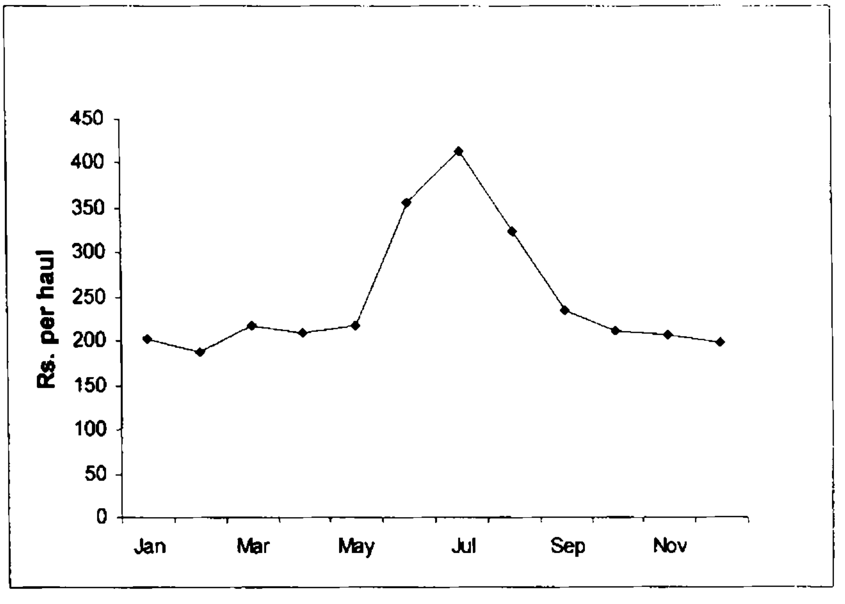


Fig. 81. Earning per haul of riverine gillnets at station 2

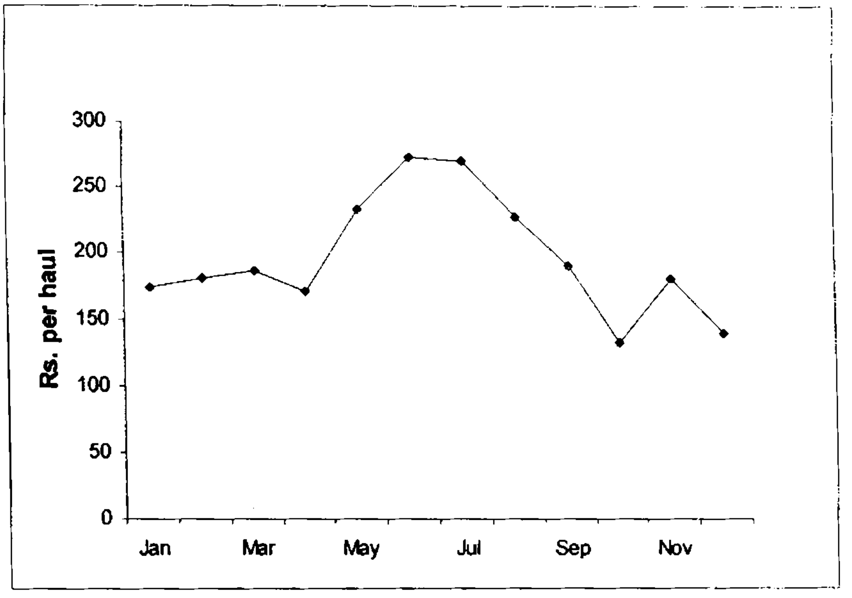


Fig. 82. Earning per haul of riverine gillnets at station 3

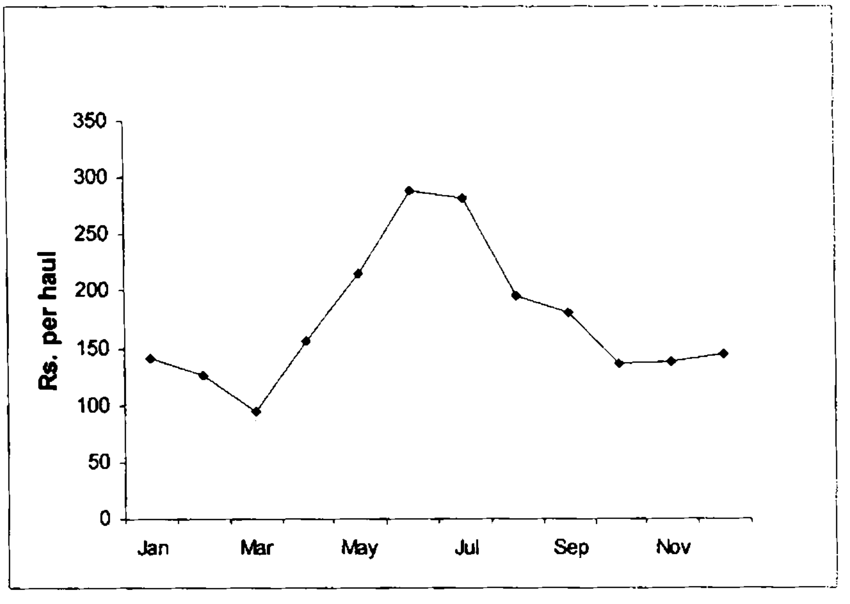


Fig. 83. Earning per haul of riverine gillnets at station 4

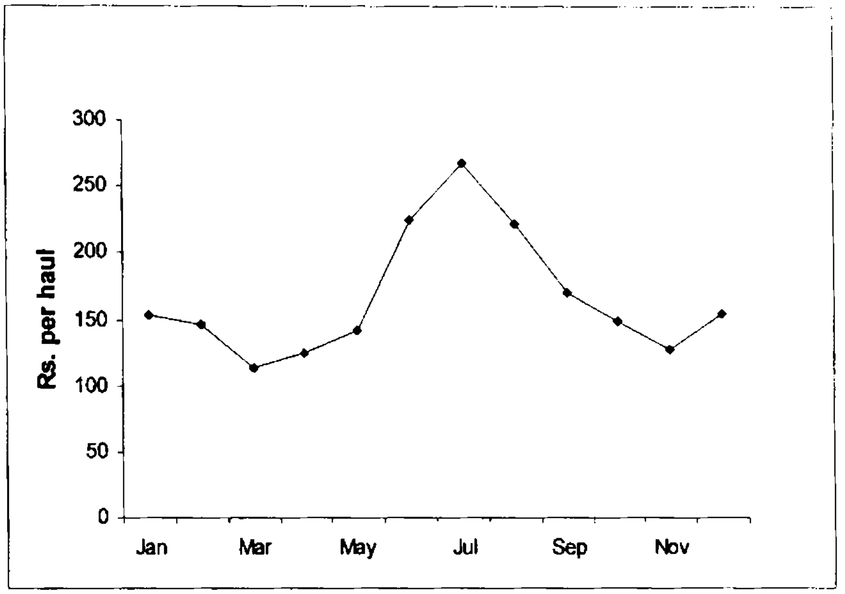


Fig. 84. Earning per haul of riverine gillnets at station 5

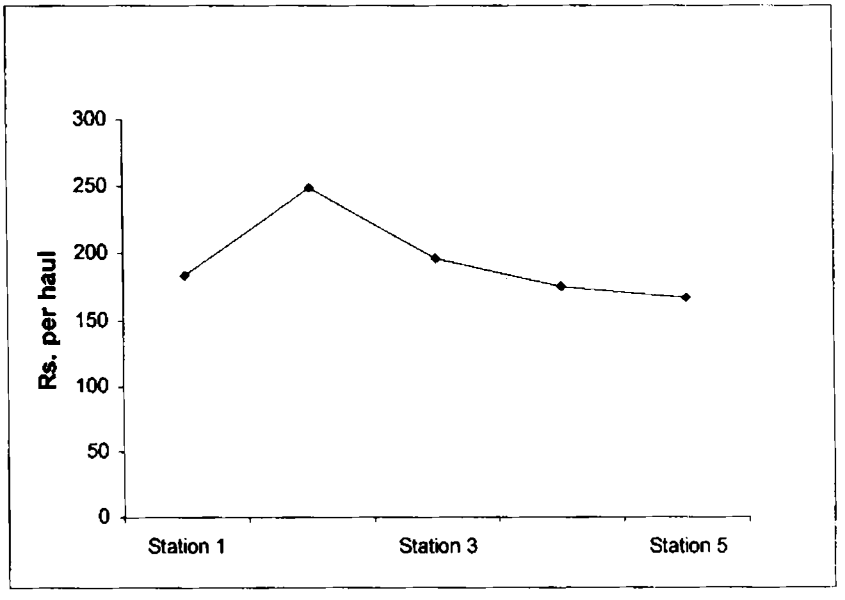


Fig. 85. Variations in earnings per haul of riverine gillnets in different stations

Table 53. Catch and earning per unit area

	Catch/Earnings per square area (1000 sq.m)					
	Station 1	Station 2	Station 3	Station 4	Station 5	Average
Catch (kg)	18.10	11.04	15.33	10.26	8.19	12.58
Earnings (Rs)	715.06	491.90	639.69	414.31	353.96	522.98

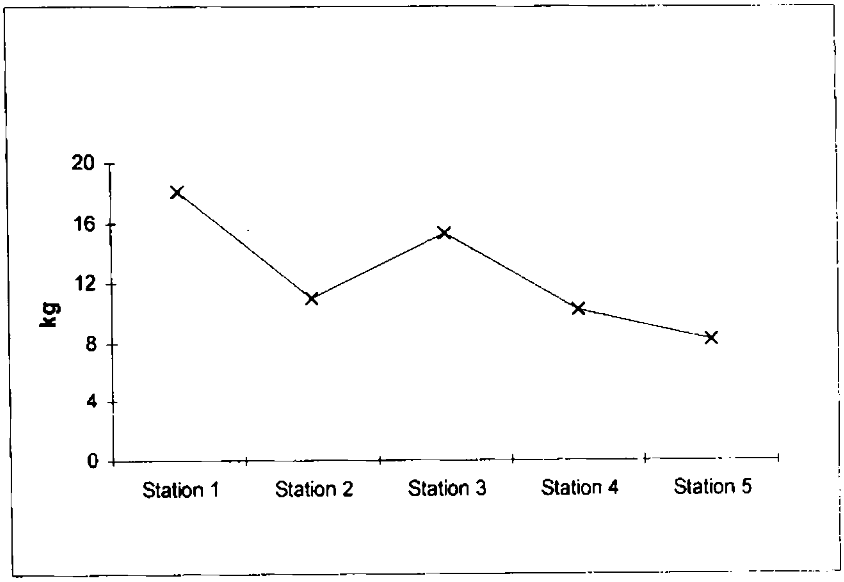


Fig. 86. Catch per unit area (1000 m^2)

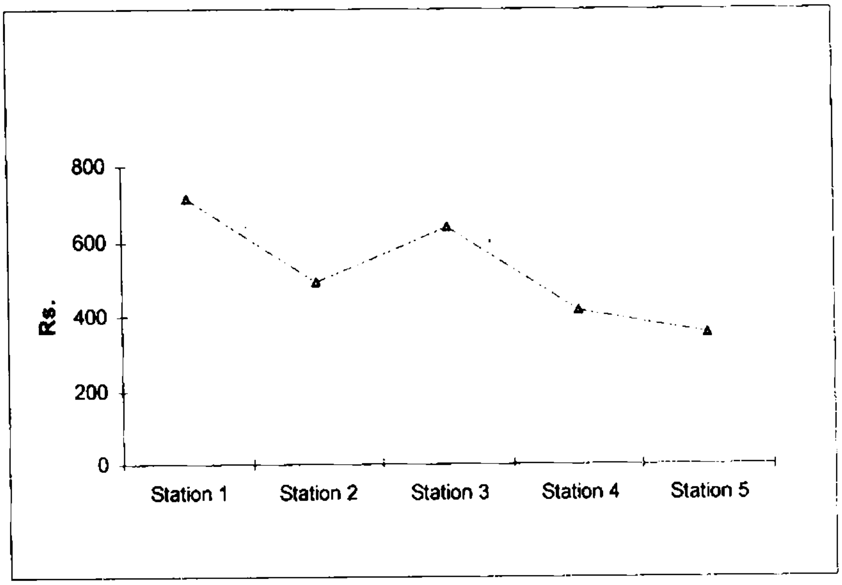


Fig. 87. Earning per unit area (1000 m^2)

Table 54. ANOVA: Catch per month of gillnets of Muvattupuzha River

SUMMARY	Count	Sum	Average	Variance
Row 1	5	522.18	104.436	412.257246
Row 2	5	477.63	95.526	101.92788
Row 3	5	515.0925	103.0185	1022.40974
Row 4	5	518.90625	103.7813	366.655273
Row 5	5	697.815	139.563	946.498517
Row 6	5	998.53	199.706	793.312617
Row 7	5	1155.115	231.023	1048.14096
Row 8	5	903.92625	180.7853	907.670838
Row 9	5	622.03125	124.4063	181.450195
Row 10	5	550.935	110.187	399.178986
Row 11	5	522.145	104.429	458.21308
Row 12	5	509.6	101.92	267.73825
Column 1	12	1567.975	130.6646	3193.83031
Column 2	12	1908.0938	159.0078	3108.54815
Column 3	12	1641.375	136.7813	1593.63161
Column 4	12	1517.8125	126.4844	2118.79534
Column 5	12	1358.65	113.2208	1597.40468

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	113667.2	11	10333.38	32.3214036	1.7946E-17	2.014047595
Columns	13554.7	4	3388.676	10.5993136	4.214E-06	2.58366839
Error	14067.11	44	319.7071			
Total	141289	59				

Table 55. Anova: Earnings per month of gillnets of Muvattupuzha River

SUMMARY	Count	Sum	Average	Variance
Row 1	5	20822.063	4164.413	1102425.12
Row 2	5	18828	3765.6	391029.3
Row 3	5	21034.688	4206.938	2138077.27
Row 4	5	20073.438	4014.688	746342.285
Row 5	5	27518.063	5503.613	926171.149
Row 6	5	36858.25	7371.65	1518319.24
Row 7	5	40711.125	8142.225	2594286.78
Row 8	5	32366.25	6473.25	1749827.81
Row 9	5	23465.625	4693.125	514416.016
Row 10	5	20611.125	4122.225	794778.581
Row 11	5	20284.875	4056.975	867756.378
Row 12	5	19789.25	3957.85	568861.394
Column 1	12	56668.75	4722.396	3348815.68
Column 2	12	77864.375	6488.698	3843442.72
Column 3	12	61496.25	5124.688	1493163.96
Column 4	12	54776.875	4564.74	2563005.36
Column 5	12	51556.5	4296.375	1719710.91

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.23E+08	11	11166162	24.7864777	2.5958E-15	2.014047595
Columns	35827425	4	8956856	19.8822936	2.0789E-09	2.58366839
Error	19821741	44	450494.1			
Total	1.78E+08	59				

Table 56. ANOVA: Catch per hour of gillnets of Muvattupuzha River

SUMMARY	Count	Sum	Average	Variance
Row 1	5	1.637178295	0.3274357	0.00432201
Row 2	5	1.699962348	0.3399925	0.00192428
Row 3	5	1.639704227	0.3279408	0.01166204
Row 4	5	1.80319306	0.3606386	0.00340037
Row 5	5	2.285012652	0.4570025	0.01378574
Row 6	5	3.504760482	0.7009521	0.00808494
Row 7	5	4.096299158	0.8192598	0.01204133
Row 8	5	3.01563732	0.6031275	0.00868282
Row 9	5	2.183405316	0.4366811	0.00242725
Row 10	5	1.739004983	0.347801	0.00361124
Row 11	5	1.7505299	0.350106	0.00449721
Row 12	5	1.701198782	0.3402398	0.0017717
Column 1	12	5.507383753	0.4589486	0.04505278
Column 2	12	6.234883721	0.5195736	0.03801965
Column 3	12	5.69	0.4741667	0.02252311
Column 4	12	4.964285714	0.4136905	0.02751688
Column 5	12	4.659333333	0.3882778	0.02185714

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1.5273607	11	0.138851	34.4573663	5.257E-18	2.0140476
Columns	0.1275393	4	0.0318848	7.91256237	6.775E-05	2.5836684
Error	0.1773044	44	0.0040296			
Total	1.8322044	59				

Table 57. ANOVA: Earnings per hour of gillnets of Muvattupuzha River

SUMMARY	Count	Sum	Average	Variance
Row 1	5	75.02679956	15.00536	12.4655731
Row 2	5	76.53333333	15.306667	5.98480556
Row 3	5	77.07749631	15.415499	23.9337092
Row 4	5	79.33993171	15.867986	6.60916915
Row 5	5	99.50917121	19.901834	11.6846974
Row 6	5	138.2509273	27.650185	14.3564548
Row 7	5	152.7665076	30.553302	28.0996728
Row 8	5	116.6877076	23.337542	17.5772503
Row 9	5	91.36146179	18.272292	5.17111016
Row 10	5	74.21921373	14.843843	7.59806054
Row 11	5	77.73992248	15.547984	8.6027679
Row 12	5	75.77508306	15.155017	4.11763829
Column 1	12	221.4631648	18.455264	46.3617966
Column 2	12	277.3255814	23.110465	46.9210937
Column 3	12	235.625	19.635417	20.660393
Column 4	12	199.9404762	16.661706	33.4966104
Column 5	12	199.9333333	16.661111	22.1826824

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	1622.914	11	147.53764	26.7218595	6.476E-16	2.0140476
Columns	341.86934	4	85.467335	15.4797522	5.602E-08	2.5836684
Error	242.9343	44	5.521234			
Total	2207.7177	59				

Table 58. Anova: Catch per haul of gillnets of Muvattupuzha River

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	16.84	3.368	0.565511
Row 2	5	17.40125	3.48025	0.176958
Row 3	5	16.80972	3.361944	1.270974
Row 4	5	18.51736	3.703472	0.430399
Row 5	5	23.345	4.669	1.298352
Row 6	5	35.905	7.181	1.173539
Row 7	5	41.9275	8.3855	1.550504
Row 8	5	30.97875	6.19575	1.24509
Row 9	5	22.38125	4.47625	0.29032
Row 10	5	17.905	3.581	0.547571
Row 11	5	17.98964	3.597929	0.575303
Row 12	5	17.47143	3.494286	0.271369
Column 1	12	54.82857	4.569048	4.350479
Column 2	12	67.025	5.585417	4.393646
Column 3	12	56.9	4.741667	2.252311
Column 4	12	52.125	4.34375	3.033736
Column 5	12	46.59333	3.882778	2.185714

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	159.6208	11	14.51098	34.04532	6.63E-18	2.014048
Columns	18.82963	4	4.707409	11.04441	2.74E-06	2.583668
Error	18.75392	44	0.426226			
Total	197.2044	59				

Table 59. ANOVA: Earnings per haul of gillnets of Muvattupuzha River

SUMMARY	Count	Sum	Average	Variance
Row 1	5	771.1875	154.2375	1512.243
Row 2	5	784.5	156.9	678.8703
Row 3	5	790.4514	158.0903	2655.247
Row 4	5	815.3819	163.0764	922.7983
Row 5	5	1019.188	203.8375	1270.468
Row 6	5	1417.625	283.525	2246.034
Row 7	5	1565.813	313.1625	3837.702
Row 8	5	1198.75	239.75	2400.313
Row 9	5	938.625	187.725	823.0656
Row 10	5	763.375	152.675	1090.231
Row 11	5	798.4018	159.6804	1090.12
Row 12	5	778.5357	155.7071	637.9299
Column 1	12	2205.625	183.8021	4456.812
Column 2	12	2981.25	248.4375	5422.319
Column 3	12	2356.25	196.3542	2066.039
Column 4	12	2099.375	174.9479	3693.001
Column 5	12	1999.333	166.6111	2218.268

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	169994.1	11	15454.01	25.73058	1.3E-15	2.014048
Columns	50233.31	4	12558.33	20.90934	1.03E-09	2.583668
Error	26426.78	44	600.6086			
Total	246654.1	59				

Chapter IV

CASTNET

Chapter IV

CAST NET

Cast nets are widely used all over the world. Cast nets were originally developed in India and spread to East, South Asia and Europe. Drawings of cast nets are seen in the ruins of Angkor in Cambodia, which are hundreds of years old.

Turkish fishermen in the Black Sea, use cast nets in very deep water of 150 meters and more. Sometimes the net is not cast but let down in the water which spreads itself when sinking in these great depths. The net is required to cover the fish when cast and, when being hauled, collapse and hold the fish in between its folds. Its edge is weighted with lead or chains to make sure that the net spreads when cast and collapse when hauled.

The gear is a circle of netting and the fish are retained inside the net, which collapses when carefully hauled. Many of the African cast nets are simple entangling fishing gear or are designed for keeping the fish in the meshes. The cast nets can have pockets at the edge where the fish get caught when the net is being hauled. The pockets can be fixed by turning over the lower rim and fastening it by small twines or else these twines can be connected with central line. In the latter case, the pockets are formed by hauling the central line and are pulled together when the net is hauled.

The correct method of casting the net can only be learnt by experience. The fishermen of south India are said to be especially skilful in operating cast net from a boat.

Cast nets known as "*veesuvala*" in vernacular are well adapted for the capture of small shoaling fishes. Its construction is so simple that the fisherman can make it himself. Cast nets differ from one another in the size of the meshes, the diameter of its circle and the lead line in its periphery and in other construction details.

The *veesuvala* (cast nets) are used all over Kerala. There are two types of cast nets - one with a string and the other without string.

Review of literature

Earlier study on inland gears in Kerala are limited. Hornell (1938) has explained different types and operation of gears used in the inland sector. Details of two types of cast nets operated in the inland areas of Travancore has been described by Hornell (1938). The simple type called *kattum vala*, is without internal closing strings and the more developed *vochu vala* is with closing strings.

The constructional details and general specifications of cast net were explained by Nedelec (1975). George (1981) classified the cast nets of Karnataka into two (i) nets with closing strings and (ii) nets with out closing strings. The construction details of cast net and method of operation in the rivers of Karnataka were presented by Sathyanarayanappa *et. al.* (1987). Use of cast net from boats at Andhra coast was explained by Narayanappa *et.al.* (1977). Use of different types of cast nets in the Vembanadu lake were described by Kurup *et.al.* (1991).

Two types of cast nets have been reported from the Muvattupauzha River by Baiju and Hridayanathan (2002).

Economics of fishing using small scale fishing gears like gillnet, cast net and long lines of Kainji Lake, Niger have been reported by Ayanda and Mdaihli (1996).

4.1. Materials and Methods

A detailed study was conducted for the identification of different types of cast nets present in the riverine sector of central Kerala. Seven rivers from the central Kerala viz., Bharathapuzha, Puzhakkal, Keecheri, Karuvannur, Chalakudy, Periyar and Muvattupuzha rivers were selected for this study. Surveys were conducted at various fishing centres and fish landing centres of rivers (8 stations from Bharathapuzha river, 3 stations from Chalakudy River, 8 stations from Karuvannoor River, 10 stations from Muvattupuzha River and 8 stations from Periyar River. (Table 61) to document the different types of cast nets operated in the river.

The design and construction details and method of operation, catch, catch composition and season of operation were collected for each type of cast net by direct observations. Details of catch and catch composition and other operational details were collected at fort night.

Economic analysis

The economic efficiency of cast net operations was analysed and compared with gillnet. Study was conducted at five centres viz., Piravam, Randar, Kadumpidy, Kolupra and Kanjar in Muvattupuzha River. One centre, which located in high stream, two centres in mid stream and two centres in down stream were selected for the study.

Centres were selected based on a baseline survey of cast net fishermen along the stretches of Muvattupuzha River in Central Kerala. Twenty percent of the total cast net fishermen were selected randomly for this study from each centre (Table 62).

Weekly surveys were carried out to collect the costs and earnings of the cast net fishermen for a period of one year from June 2000 to May 2001. The data collected during the visits are used for the determination of effort, productivity (catch per unit effort) and return of investment

The basic economic data on the investments on the gear, accessories and other fixed expenditure were collected by interviewing the owners in the initial period of the study. The data on operational costs and earnings were collected from the field, at the time of fishing operation. The details of the costs, fishing time, fishing areas, catch composition, earnings, damage of the gear, repair and maintenance costs in each unit were collected at weekly intervals from the different centres.

Profitability ratios were calculated on the basis of investments and profits. Capital investment was calculated as the cost of gear and craft. Variable cost was calculated as the cost of maintenance of the gear and labour during the period of study.

Fixed cost was calculated as the interest on capital and variable cost. The interest was calculated at 10.5%. Fixed cost also include the depreciation on the craft and gear. The depreciation was calculated as follows:

$$Depreciation = \frac{Cost\ \ price - Salvage\ \ value}{Avg.\ life\ \ span\ \ \times Cost\ \ price} \times 100$$

Operational costs involved were the labour, auction charges, ferry charges and levies.

Catch per unit effort (catch per hour) was calculated from selected stations on fort nightly basis and for this the weight of catch from all the stations and the total fishing time was taken as inputs. Catch per operation was also determined from the five stations

4.2. Results and Discussion

Survey on fishing gears in Central Kerala has shown that the rivers Puzhakkal and Keecheri, cast net operations were very few. These rivers were dry during most of the year and migratory fishermen were operating the gear in these rivers during rainy season. These rivers were, hence, excluded from the study of this gear.

The stations selected for the study were 8 stations from Bharathapuzha river, 3 stations from Chalakudy River, 8 stations from Karuvannoor River, 10 stations from Muvattupuzha River and 8 stations from Periyar River. (Table 61).

Classification of cast net

On the basis of construction two types of cast nets were observed: (i) cast net with strings (stringed cast net) and (ii) without string (string-less cast net). In stringed cast net, the central line divided and is connected to the peripheral line (lead line) In stringless cast nets, the central line is absent.

On the basis of materials used for the construction of cast nets, it can be divided in to two, viz., (i) PA multifilament cast net and (ii) PA monofilament cast net. The classification of cast net is given in the Fig. 90.

Stringed cast net

The basic construction of different types of cast nets is similar in general. It is a simple piece of net, circular in form, with a strong cord passing through the peripheral meshes (Fig. 91). At the apex of the cone is a small aperture strengthened by a ring of brass or lead laced to the netting. It is called horn or thimble. The net is completed by the attachment of one end of a long and supple hauling line to the central ring opening at the apex. The hauling line which passes through the central ring opening is subdivide into a number of secondary strings (16 to 23 in numbers). Each of these in turn is subdivided into three short branches at about 0.3 to 0.9 m from the periphery to which their distal ends are attached. (Baiju & Hridayanathan, 2002).

The circular margin of the base is weighted with sinkers set at short intervals. These sinkers are of lead or brass.

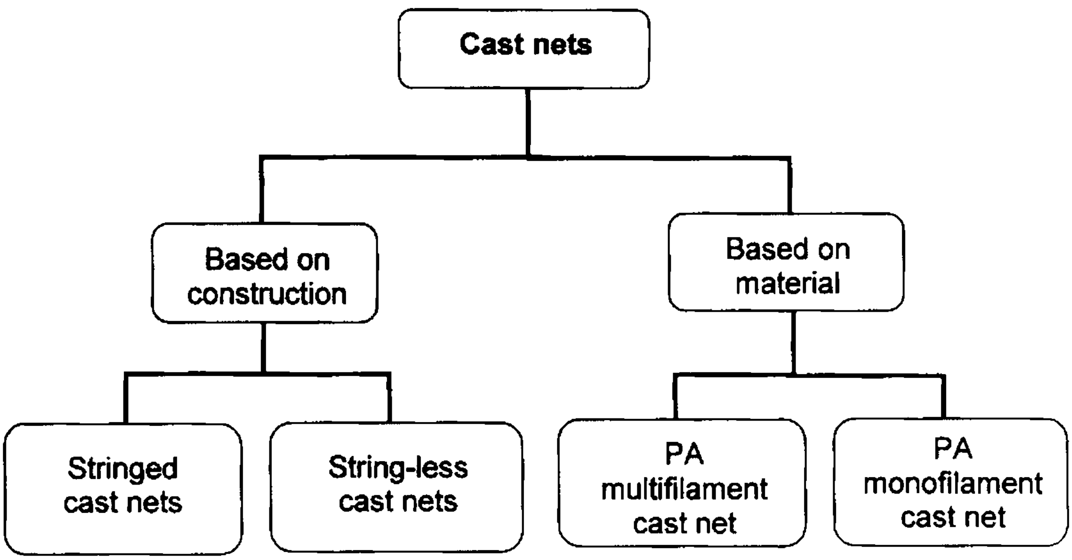


Fig. 90. Classification of cast nets

String-less cast net

String-less cast nets are commonly operated in the upstream and midstream areas of the river because the bottom of the river is rocky and uneven. It is a simple piece of net, circular in form, with a strong cord pass through the peripheral meshes (Baiju & Hridayanathan, 2002). Small lengths of sheet lead are wrapped to this cord, at short intervals, to serve as sinkers. The net is completed by the attachment of one end of a long and supple hauling line to the central point of the disc of netting; this point becomes the apex of a cone of the net when suspended from the end of the hauling line (Fig. 92).

Special types of stringless cast nets are operated in certain areas of the rivers of central Kerala. They are with peripheral pockets: The lower end of the main webbing is folded inwards and fixed to the body of the net at regular intervals to form pockets for collecting fishes. It is locally called *Pakkuvala*.

Cast nets without pockets are used in water in which plants or obstacles are expected and it is considered better for deep waters without stones and other bottom obstacles. Cast nets with fixed pockets are especially made for shallow water, free of obstacles.

PA multifilament cast net

PA multifilament cast net is very common in most of the parts of the rivers of central Kerala. The webbing is fabricated by the fishermen himself eventhough the machine made webbings are also used in certain areas.

PA monofilament cast net

PA monofilament cast net is very rare in the rivers of central Kerala. It is noted only in the down stream areas of Bharathapuzha River. Here the machine made webbings are used for the construction of the gear. The use of monofilament in fabrication of cast nets reduce the resistance of the gear during operation. However, the gear is comparatively vulnerable to damage when encountering obstructions under water.

General structure

The cast nets are generally made of PA multifilament. They are used for catching small fishes like *Etroplus suratensis, Puntius sp.* and *Oreochromis spp.* The length of the gear varies from 2 to 4.5 m length. Once the net is cast and drawn, the bottom part of it is closed together by the weight of the lead and the fish are entrapped inside the net. The net is hauled up and the fish is emptied.

There are high variability in the terms used in different areas for parts of the cast nets. The different parts of the net are explained below:

Throw line /Hand line: It is made with PP ropes of 3.0 to 5.0 mm dia with varying lengths of 6.0 to 8.0 m and in certain area up to 20.0 m. This is commonly called as 'kanjal/kaikayar/kanjani kayar'.

Handloop: It is a small loop at the end of hand line/throw line, which also allows a chaff-free surface against wrist.

Horn/Thimble: It is a small ring at the apex of the gear. It is a brass or lead ring that has netting wrapped and tied to it. It is locally known as *'kombu'*.

Selvedge: Thicker twines are used in the proximity of the horn and leadline to give the nets more strength and durability. PA multifilament of 210x2x3 are commonly used as selvedge.

Netting: PA multifilament webbings are most common type of netting material in the construction of riverine cast nets of Central Kerala. Webbing is mainly hand made. Fly meshes (*'Polikanni'*)are used for the increase of circumference of the gear. PA monofilament webbings are rarely used for the fabrication of cast nets in the riverine sector.

Leadline: The leadline consists of PA multifilament twine and (*'Vattacharadu/ Manicharadu'*) in certain areas polyethylene twine is used as leadline.

Assembly Line: The line passing between the netting and the leadline is called assembly line.

Weight: Lead weights (*'mani'*) are very common in cast nets. In addition to this, brass sinkers and mud sinkers are also used.

Design details

The gear was mainly made of PA multifilament. The mesh size varied from 15 to 50 mm. The twine size varied from 210Dx1x3 to 210Dx2x3. In most of the areas uniform size of mesh was used from top to bottom. Thicker twines were used at the top and bottom. It acted as selvedges, which gave extra strength to the gear. The length of the gear varied from person to person and ranged from 3.0 to 4.0 m (Fig. 93).

The mending of the gear is varied from area to area. The number of meshes at the top varied from 32 to 300 meshes and at the bottom it varied from 680 to 4800 meshes. The increasing rate of the meshes varied from gear to gear and from area to area (Table 60).

Thicker twines of PA multifilament (210Dx6x3 or 210Dx8x3) or PP twines of 1.5 mm dia are used as lead line and it is fixed to the circumference of the gear by using assembly line which are twisted between every mesh to lead line.

The size of the lead sinkers varied from 2.0 to 5.0 cm in length and the total weight of the gear varies from 3.0 to 7.0 kg. Dumbell shaped sinkers were common. The sinkers made of lead strips rolled around the marginal cord were also used in some areas. The cost of the sinkers varied from Rs. 40 to 60 per kg. Bronze sinkers were also used rarely in cast nets.

The long rope (hand line) commonly called as *Kanjal* or *kaikayaru* is mainly made of PP rope of 4.0 to 6.0 mm diameter. The length of the rope varies from 5.0 to 7.0 m. In Bhoothathankettu areas very long hand lines were in use. The length varied from 15.0 to 20.0 m. It is used to cast the gear from the bridge to the river.

The general structure of PA multifilament cast net is given in Fig. 93.

Construction of string-less cast nets

The fabrication of a common cast net is started from the top with 64 meshes and after each four mesh depth, 32 meshes are increased in circular manner by adding fly meshes (Fig. 94). In the last four meshes of the gear, 64 meshes are increased instead of 32 meshes to get a wider circumference at the bottom of the gear. The twine is little thicker (210Dx2x3) near the circumference meshes (4 to 10 meshes). It gives extra strength to the gear.

Construction of stringed cast nets

Stringed cast nets are very common in Muvattupuzha River. In Kadumpidy and Kolupra areas stringless cast nets with *pakkumadakku* are very common. In the stringed cast nets, the bottom meshes were folded backward and tightened to the 12th mesh from the bottom to avoid escapement of fish and the sinkers were fixed a little above the bottom (Fig. 91). In dry season the foldings are released and used as ordinary cast net.

Preservatives of cast nets

In Kolupra and Mannarkadu areas preservatives like extracts of bark of *maruthu* (*Terminalia paniculata*) was used and for this the bark of maruthu was boiled in water and the gear was dipped in it for 10 minutes. In Kadumpidy areas seed of *kudaippanai/condapana* (*Corypha umbraculifera*) is boiled in water was used as preservatives and dyes were also used in this area. In Chembu regions turmeric powder is used as preservatives whereas in most other areas dyes are using as preservatives.

Distribution of cast net

Stringed cast nets were very common in Periyar River. In Bhoothathankettu areas a special type of cast net with long hauling line was used. The length of the line varied from 15.0 to 20.0 m. It is used to cast the gear from the top of the bridge. Stringless cast nets were occasionally used in the upstream areas.

Stringed and stringless cast nets were common in the down stream areas of Chalakudy River. In upstream areas mainly stringless cast net were used.

In Bharathapuzha River the stringed cast net was very common. In areas like Mannarkadu, Thavanoor, Thirunavaya, Ottappalam, Lakkidi stringless cast net with *pakkumadakku* is common. PA monofilament cast nets are used in the down stream areas (Thavanoor and Thirunavaya) of the Bharathapuzha River.

The cast net was mainly operated in the mid stream and down stream areas of the Karuvannoor River. Stringed and string less cast nets were seen in these areas.

In Muvattupuzha river stringed cast nets were very common from upstream to down stream areas. Stringless cast nets were occasionally seen in the mid stream and up stream areas of the river.

Operation of cast net

Cast nets as the name implies, are thrown over water. They have to be thrown or cast with great skill in order to fall flat upon the water's surface. They, quickly sink due to their weighted edges, and fall over any fish available in the area below the net.

The correct method of casting the nets can only be acquired by practical experience as the net is cast by the skilled movement of the body. The cast nets are cast from the river bank.

The free end of the hauling cord is tied around the left wrist and the hand line is coiled into the left hand. The net is grabbed with left hand just below horn, again the net is grabbed at pocket height with right hand and the net is transferred back into left hand. At this point all of the net should be in the left hand with the lead line resting on the ground. Then the net is divided into two halves. At this point, the fisherman holds the hand-line, the horn, and half of the net in the left hand, and the other half in the right hand, the lead line with the right hand. The gear is thrown, keeping both of the hands together, simultaneously the body and hands are rotated at ninety degrees to left and without stopping, immediately the back is rotated toward the target in one smooth continuous motion (Fig. 95).

The net is released the net at a slight upward angle in the direction of the target and taking care not to overpower the throw. The net flies forward, opening out gracefully in a circular form, upon the water. As the weighted periphery drags the net downwards it quickly assumes the form of a hollow cone, enclosing any fishes over which it falls.

The fisherman waits for a little time to allow the weighted margin of the net to settle at the bottom. Then the cord is hauled cautiously and slowly till the attachment of the inner radial cords comes to hands at the apex ring. All the fishes inside the gear are entrapped inside of the gear when it collapses during hauling. The fishermen takes the gear to the shore, the radical cord is relaxed and the gear is shaken to release the fish and other retained material present in the gear.

Cast net was operated throughout the season, eventhough the peak period is from June to August.

Table. 60. Increasing rate of meshes in a typical cast net

Mesh in depth	Mesh in circle
1	64
5	96
9	128
13	160
17	192
21	224
25	256
29	288
33	320
37	352
41	384
45	416
49	448
53	480
57	512
61	544
65	576
69	608
73	640
77	672
81	704
85	736
89	768
93	800
97	832
101	864
105	896
109	928
113	960
117	992
121	1024
125	1056
129	1088
133	1120
137	1152
141	1184
145	1216
149	1248
153	1280
157	1312
161	1344
165	1376
169	1408
173	1440
177	1504
181	1568

Table . 61. Cast net - fishermen colonies

River	Place	Total
Bharathapuzha	Chittoor	2
	Koduvayoor	2
	Kumarampathoor	1
	Lakkidi	5
	Mannarkadu	5
	Ottappalam	3
	Thavanoor	3
	Thirunavaya	2
Bharathapuzha Total		23
Chlakudy river	Ayiroor	6
	Cheruvaloor	7
	Kurumassery	11
Chlakudy river Total		24
Karuvannoor	Chettuva	1
	Eenamavu	1
	Illikkal	4
	Karuvannoor	3
	Moorkanadu	1
	Pavaratty	1
	Peringottukara	1
	Pottichira	3
Karuvannoor Total		15
Muvattupuzha	Chembu	2
	Irumpanam	6
	Kadumpidy	5
	Kalampoor	8
	Kanjar	10
	Mrala	2
	Peruvanmuzhy	6
	Moolamattom	2
	Kothamangalam	2
	Randar	4
Muvattupuzha Total		47
Periyar	Bhoothathankettu	6
	Kalady	3
	Kuttanpuzha	1
	Malayattoor	2
	Palamittom	2
	Thattekkadu	1
	Vadattupara	2
	Vettampara	1
Periyar Total		18
Grand Total		127

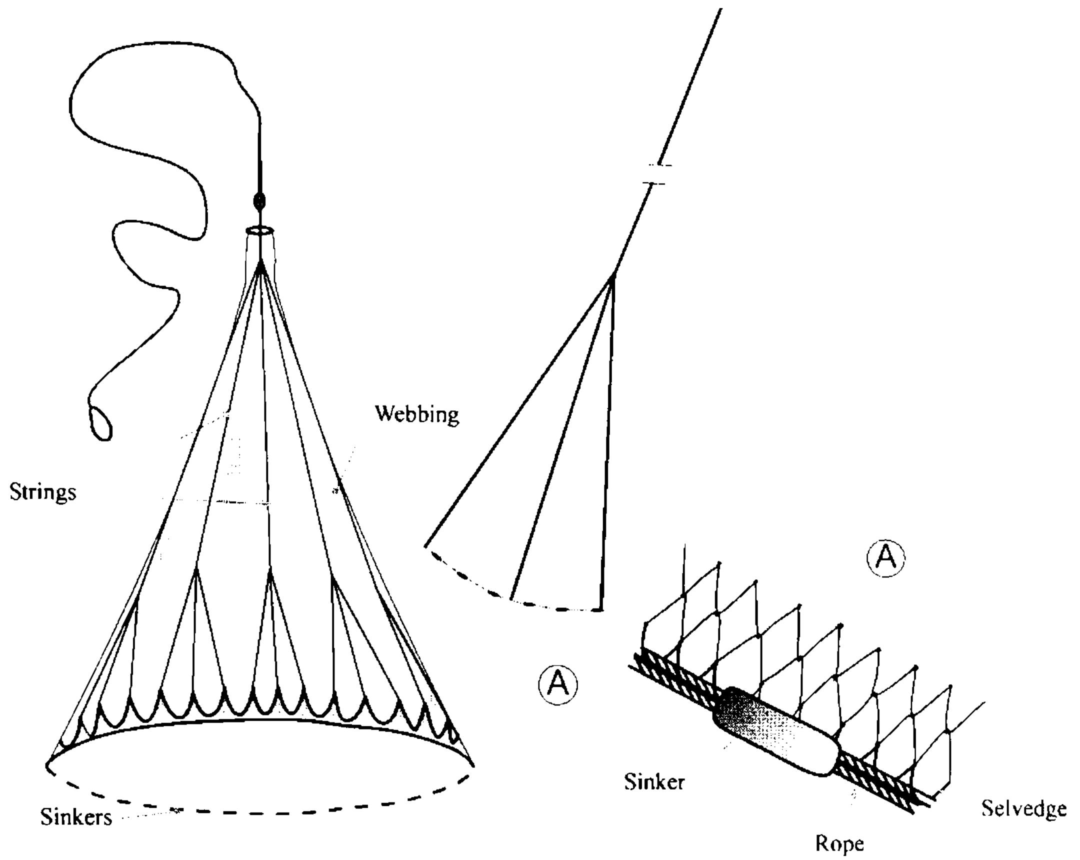


Fig. 91. Stringed cast net

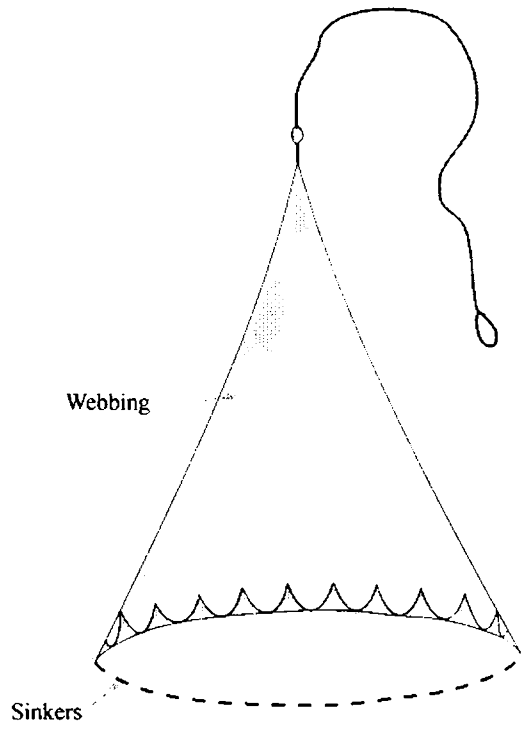


Fig. 92. Stringless cast net

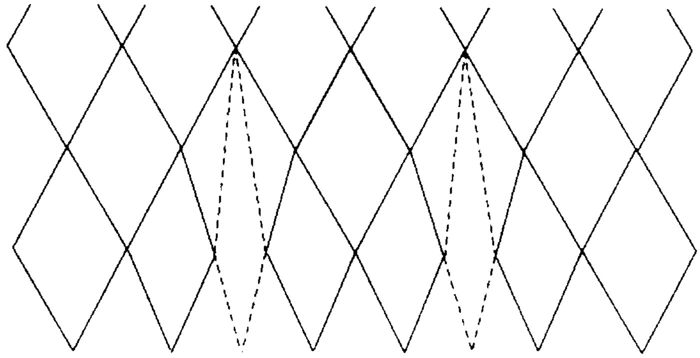


Fig. 94. Fly mesh using in the cast net fabrication

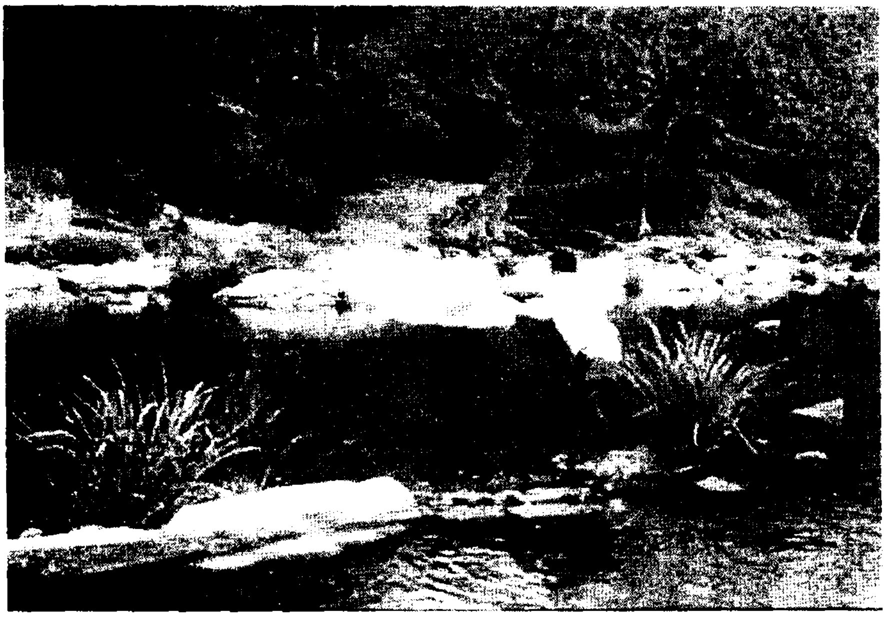


Fig. 95. Cast net operation

4.3. Economic Analysis of Cast net Operation

The technical and economic performance of different fishing systems were compared in different parts of world (Yater, 1982; Librero *et.al.*, 1985; Panayotou *et al.*, 1985; Tokrishna *et al.*, 1985; Fredericks and Nair, 1985; Khaled, 1985 and Jayantha and Amarasinghe, 1998). In the Indian context, techno-economic aspects of different fishing gears were studied by many, purse seine were studied by Varghese (1994), Mukundan and Hakkim (1980), Panikkar *et al* (1993), and Iyer *et. al*, (1985), Devaraj and Smitha (1988), John (1996), and Shibu (1999) investigated the economics of trawling.

The economic analysis studies have been made in marine sector (Yahaya and Wells, 1980; Kurien and Willmann, 1982; Unnithan *et.al.* 1985; Sathiadhas and Panikkar, 1988; Sadananthan *et.al.* 1988 and Dutta *et.al.* 1989).

But no systematic study has been carried out to assess the economic feasibility of the gears operated in the riverine sectors in Kerala in spite of their popularity, efficiency, employment potential

4.3.1. Materials and Methods

Five centres from Muvattupuzha River were selected for this study. The centres were Piravom, Randar, Kadumpidy, Kolupra and Kanjar and the locations are station 1 and 2 from Muvattupuzha River, station 3 from Kaliyar River and station 4 and 5 from Thodupuzha River (major tributaries of Muvattupuzha River). (Fig. 96). The number of fishermen families selected for this study is given in Table 62.

Table 62. Details of families selected for the economic analysis of cast net operations in Muvattupuzha River

Stations	Total number of gillnet fishermen	No. of fishermen selected for the study
Piravam	12	2
Kadumpidy	10	2
Kanjar	12	3
Kolupra	14	3
Randar	18	4

Weekly surveys were conducted in the above stations for a period of one year. The operational cost, fishing time, number of hauls, catch details and earnings of different cast nets were collected by direct observations at these centres. The investment, periodic maintenance, repair and labour cost were collected through questionnaire and from discussion with the fishermen. These data were cross checked through field observation.

Interest on capital and variable cost was calculated at 10.5%. The percentage depreciation of the cost of craft and gear is calculated as follows:

$$Depreciation = \frac{Cost\ \ price - Salvage\ \ value}{Avg.\ life\ \ span\ \ \times Cost\ \ price} \times 100$$

4.3.2. Results and Discussion

Profitability ratio

The cost and earnings (Table 63) collected during the period of study gives a picture of the operative costs, earning and profitability of the cast net operations in each station.

Capital investment in cast net operation was the cost of net and cost of craft. The capital investment of gear in Station 2 was the highest and the least was recorded in station 5 with an average rate of Rs. 626.40. Craft was not used in any of the station for the operation of the cast net. Capital investment in Station 2 was the highest and the least was in Station 5.

The variable cost includes the cost of maintenance and labour of the gear. The maintenance of the gear includes the labour for the repair of the damaged gear, cost of the repairing materials and preservatives used in the gear. The highest maintenance cost of Rs. 1100 was in station 1 and the least was in station 3 with an average cost of Rs. 990.

Fixed cost includes the interest on capital, interest on variable cost and depreciation on the gear.

The highest fixed cost was in Station 2 and the lowest was in Station 5 with an average cost of 272.19.

The operational cost is the labour in the fishing operation and it is almost same in all the stations except in station 5, which shows comparatively lower operational cost. The operation of the cast net in

September and November is less in this station because of the lack of water.

The highest earning was from Station 1 followed by Station 3, Station 5 and Station 2 and the lowest earning recorded from Station 4. The average earnings from these stations was Rs. 34359.63

Profitability parameters

The profitability ratios show the percentage of profit compared to different types of investments like returns on turnover, returns on capital, return on total cost, return on variable cost, return on operational cost and the break-even point.

Return on turnover

The highest percentage of return on turnover was recorded from Station 1 (41.61%), followed by Station 3 (39.00 %), Station 5 (38.29 %), Station 2 (35.96 %) and Station 4 (31.44 %). The station 4 has shown only 31.44 % profitability on turnover. The average return on turnover was 29.60% (Fig. 98).

Return on capital

The highest return on capital investment was in Station 1 (3206.78 %) and the least return was from Station 4 (2055.53 %) with an average return on capital of 2002.89% (Fig. 99).

Return on total cost

The highest return on total cost was in Station 1 (71.26 %) and the lowest from Station 4 (45.86 %) with an average return on total cost of Rs. 47.44% (Fig. 100).

Return on variable cost

The highest return on variable cost was from Station 3 (1910.27 %) and the lowest from Station 4(1233.32 %), with an average variable cost of 1282.44% (Fig. 101).

Return on operational cost

The highest return on operational cost was from Station 1 (69.95 %) and the lowest from Station 4 (40.00 %), with an average return on operational cost of 55.15 % (Fig. 102).

Break-even point

The highest break-even point 2.18 was noted in the Station 4 and the least 1.40 was in Station 1 (Fig. 103).

Fishing effort

Fishing effort was calculated both in terms of catch per hour and catch per haul.

Catch per hour

The catch per hour of cast nets operated in all the stations are presented in Table 64.

Station 3 showed the highest catch per hour during the present study period (1.05 $kg.h^{-1}$). Station 1 showed the least value of 0.93 $kg.h^{-1}$ (Fig. 104-109).

The month of July showed the highest catch per hour during the study period and the lowest was in December.

Catch per haul

The catch per haul was calculated in all the stations in the study period (Table 65). The stations 1 and 2 recorded the highest catch 0.36 kg per haul and the lowest 0.33 kgwas from Station 3 and Station 4.

On monthly basis, the highest catch per haul was in the month of July (0.46 kg) and the least was noted in the month of February (0.29 kg) (Figs. 118-124).

Earning per hour

Earning per hour was calculated in all stations (Table 66). Station 3 showed the highest value of earning per hour (Rs. 430.85) and station 4 the least value of earning per hour (Rs. 310.24).

The month of July showed the highest earning per hour (Rs. 43.16) and the least (Rs. 27.82) was in December (Fig. 111-117).

Earning per haul

Earning per haul was calculated in all stations (Table 67). Station 3 shows the highest value of earnings per hour Rs. 152.62 and station 5 shows the least value of earnings per hour Rs. 124.34.

The month of July shows the highest earning per hour (Rs. 15.08) and the least (Rs. 10.29) was in November (Fig. 125-130).

Statistical analysis

The data on earning per hour were analysed using two factor ANOVA, factors being months and stations. There was significant difference in earnings between months ($p<0.001$) and between stations ($p<0.001$). Among months, July registered significantly high earning compared to other months. There was no significant difference in earning between other months (Table 68). Among stations, station 2,3 and 5 are having significantly higher earnings compared to station 4. Between 2,3 and 5 there was no significant difference.

Two factor ANOVA of earning per haul showed significant difference between months ($p<0.001$) and between stations ($p<0.05$). The month July showed significantly higher earning per haul compared to rest of the months (Table 69). Among other months there was no significance. Among stations, station 3 showed significantly higher value compared to station 5. Between stations 1, 2, 4 and 5 there was no significant difference.

Catch per hour data showed significant difference between months ($p<0.01$) and significant difference between stations. ($p<0.01$). July had registered significantly higher catch per hour compared to rest of the months (Table 70). Among stations 2, 3 and 5 showed significantly higher catch per hour compared to station 4. Between station 1 and 4 there is no significant difference.

Catch per haul showed significantly higher value compared to rest of the months. There is no significant difference between stations (Table 71).

Monthly catch of cast net showed significantly higher value ($p<0.001$). The catch in July is significantly higher followed by June and August compared to rest of the months. There was no significant difference in monthly catch, among stations (Table 72).

Monthly earning of cast net showed significantly higher earning in July than all other months. The earning in August and June were significantly higher than other months (Table 73). There was no significant difference between stations.

Comparison with gillnet

Return on turn over of cast net was 29.60 % and of gillnet was 28.96 %. Return on capital of cast net was 2002.89 % and of gillnet was 277.35 %. Return on total cost was 47.44 % in cast net operation and 40.77 % in gillnet operation. Return on variable cost of cast net was 1282.44 % and of gillnet was 753.02 %.

The capital investment, total cost and variable cost of gillnet was too higher compared to cast net. So, the cast net shows more profitable in riverine conditions in most of the stations.

Return on operational cost was 55.15 % in cast net operation and 57.04 % in gillnet operation. The operational cost was mainly labour during operation. The labour was almost same in most of the stations except station 2. So the return on operational cost was higher in gillnet operation than cast net operation.

Break-even point was 1.70 in cast net and 2.45 in gillnet.

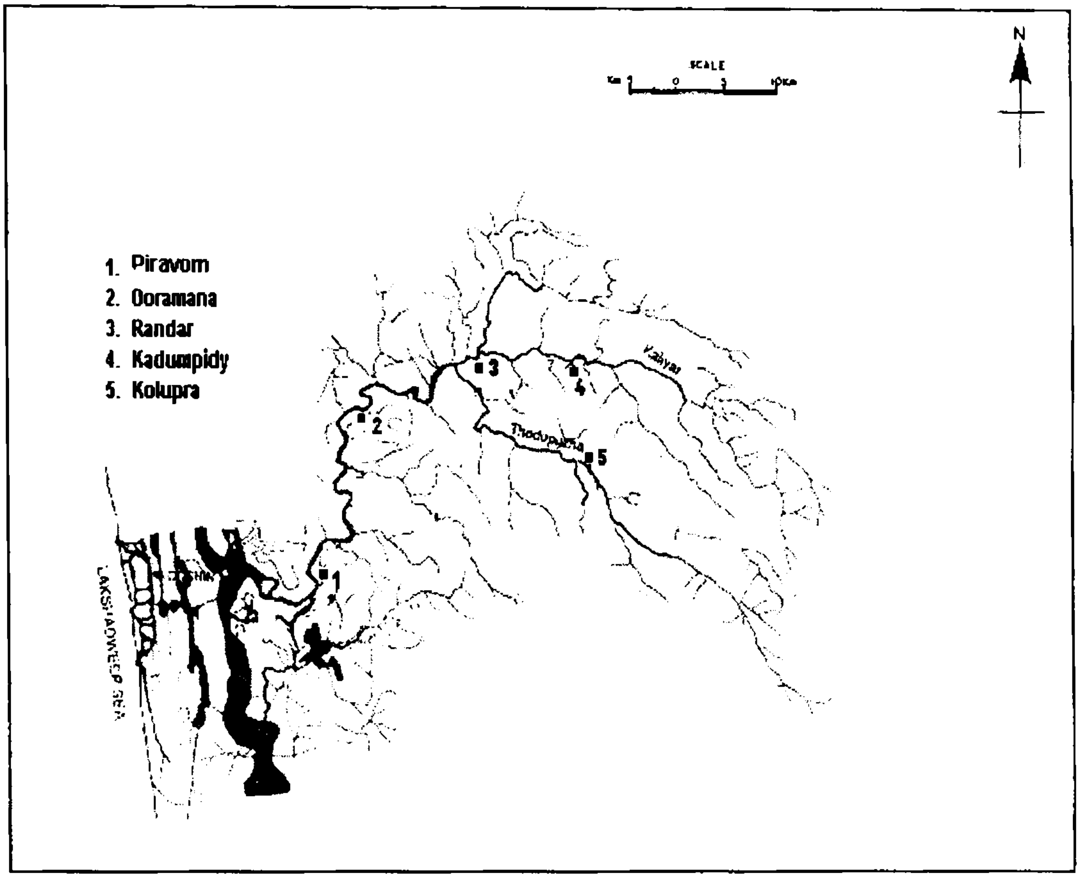


Fig. 96. Area selected for the Economic Analysis of cast nets in Muvattupuzha River

Table 63. Costs and earnings of cast nets operations in Muvattupuzha River

Place	Station 1	Station 2	Station 3	Station 4	Station 5	Average
Capital investment (Rs.)						
Gear	600.00	700.00	666.00	600.00	566.00	626.40
Craft	0.00	0.00	0.00	0.00	0.00	0.00
Total	600.00	700.00	666.00	600.00	566.00	626.40
Variable cost (Rs.)						
Gear						
Labour	600.00	600.00	600.00	600.00	600.00	600.00
Maintenance	500.00	400.00	300.00	400.00	350.00	390.00
Craft						
Labour	0.00	0.00	0.00	0.00	0.00	0.00
Maintenance	0.00	0.00	0.00	0.00	0.00	0.00
Total	**1100.00**	**1000.00**	**900.00**	**1000.00**	**950.00**	**990.00**
Fixed cost (Rs.)						
Interest on Capital @10.5 %	63.00	73.50	69.93	63.00	59.43	65.77
Interest on Variable cost @ 10.5%	115.50	105.00	94.50	105.00	99.75	103.95
Depreciation						
Gear	83.33	133.33	113.67	83.33	88.67	100.47
Craft	0.00	4.00	1.00	3.00	2.00	2.00
Total	261.83	315.83	279.10	254.33	249.85	272.19
Sub total	**1961.83**	**2015.83**	**1845.10**	**1854.33**	**1765.85**	**1888.59**
Operational cost (Rs.)						
Labour	25040.00	25040.00	25040.00	25040.00	24360.00	20032.00
Total cost	**27001.83**	**27055.83**	**26885.10**	**26894.33**	**26125.85**	**21920.59**
Earnings (Rs.)	46242.50	42250.63	44077.50	39227.50	42333.33	34359.63
Net profit (Rs.)	**19240.67**	**15194.79**	**17192.40**	**12333.17**	**16207.49**	**12439.04**
Profitability ratio (%)						
Return on turnover	41.61	35.96	39.00	31.44	38.29	29.60
Return on capital	3206.78	2170.68	2581.44	2055.53	2863.51	2002.89
Return on total cost	71.26	56.16	63.95	45.86	62.04	47.44
Return on variable cost	1749.15	1519.48	1910.27	1233.32	1706.05	1282.44
Return on operational cost	71.26	56.16	63.95	45.86	62.04	47.44
Break-even point	1.40	1.78	1.56	2.18	1.61	1.70

Table 64. Month-wise and Station-wise variations in catch per hour of cast nets of Muvattupuzha River

	Kg.h^{-1}					
Month	Station 1	Station 2	Station 3	Station 4	Station 5	Average
January	0.79	0.86	0.98	0.81	1.03	0.89
February	0.91	1.17	0.94	0.64	0.82	0.89
March	0.87	0.85	1.31	0.67	0.95	0.93
April	1.10	1.03	0.88	0.86	0.87	0.95
May	1.13	0.71	0.88	0.72	1.07	0.90
June	0.83	1.23	1.09	0.70	1.07	0.98
July	1.05	1.83	1.53	0.96	1.28	1.33
August	0.80	0.86	1.34	1.04	1.03	1.02
September	0.94	1.04	0.85	0.89	0.91	0.93
October	1.01	0.77	1.02	0.68	1.06	0.91
November	0.88	0.96	0.81	0.77	1.07	0.90
December	0.84	0.96	0.91	0.81	0.90	0.88
Annual	0.93	1.02	1.05	0.80	1.00	0.96

Table 65. Month-wise and Station-wise variations in catch per haul of cast nets of Muvattupuzha River

	Kg.haul^{-1}					
Month	Station 1	Station 2	Station 3	Station 4	Station 5	Average
January	0.32	0.34	0.31	0.26	0.35	0.32
February	0.27	0.34	0.27	0.26	0.30	0.29
March	0.30	0.33	0.39	0.34	0.32	0.34
April	0.47	0.36	0.25	0.32	0.29	0.34
May	0.40	0.29	0.27	0.34	0.36	0.33
June	0.36	0.41	0.35	0.28	0.37	0.35
July	0.37	0.61	0.48	0.41	0.44	0.46
August	0.40	0.28	0.42	0.45	0.37	0.38
September	0.39	0.37	0.25	0.43	0.34	0.36
October	0.37	0.33	0.31	0.30	0.41	0.35
November	0.36	0.31	0.28	0.28	0.35	0.31
December	0.32	0.36	0.33	0.29	0.34	0.33
Annual	0.36	0.36	0.33	0.33	0.35	0.35

Table 66. Month-wise and Station-wise variations in earnings per hour of cast nets of Muvattupuzha River

Rs.h^{-1}						
Month	Station 1	Station 2	Station 3	Station 4	Station 5	Total
January	27.37	35.18	29.29	25.87	31.14	148.84
February	30.31	25.17	38.33	19.62	30.45	143.88
March	27.37	29.20	30.00	19.38	43.26	149.20
April	38.24	34.00	45.71	28.33	34.00	180.28
May	38.13	34.81	29.33	23.44	27.00	152.71
June	31.72	36.79	42.73	25.00	36.03	172.28
July	38.71	42.87	55.00	33.51	45.71	215.81
August	25.45	36.25	28.24	36.20	42.50	168.64
September	30.00	28.78	36.67	27.50	27.37	150.32
October	30.67	32.22	27.69	19.80	31.50	141.88
November	28.46	34.04	34.29	24.35	26.11	147.24
December	22.06	27.93	33.57	27.25	28.33	139.14
Grand Total	368.49	397.25	430.85	310.24	403.41	1910.24

Table 67. Month-wise and Station-wise variations in earnings per haul of cast nets of Muvattupuzha River

Rs.haul^{-1}						
Month	Station 1	Station 2	Station 3	Station 4	Station 5	Total
January	11.06	12.01	11.71	08.26	09.79	52.84
February	08.98	09.10	11.22	07.85	08.82	45.96
March	09.45	09.73	11.84	09.89	12.92	53.85
April	16.25	11.49	15.61	10.44	08.61	62.39
May	13.56	11.60	11.89	11.03	08.31	56.39
June	13.73	12.81	14.24	10.18	11.48	62.45
July	13.79	14.82	18.33	14.32	14.16	75.42
August	12.73	12.97	09.06	15.60	13.20	63.56
September	12.35	10.76	13.10	13.33	08.13	57.66
October	11.22	12.43	12.00	08.84	09.69	54.18
November	11.56	11.20	10.91	08.75	09.04	51.46
December	08.33	10.66	12.70	09.73	10.20	51.63
Grand Total	143.03	139.58	152.62	128.23	124.34	687.78

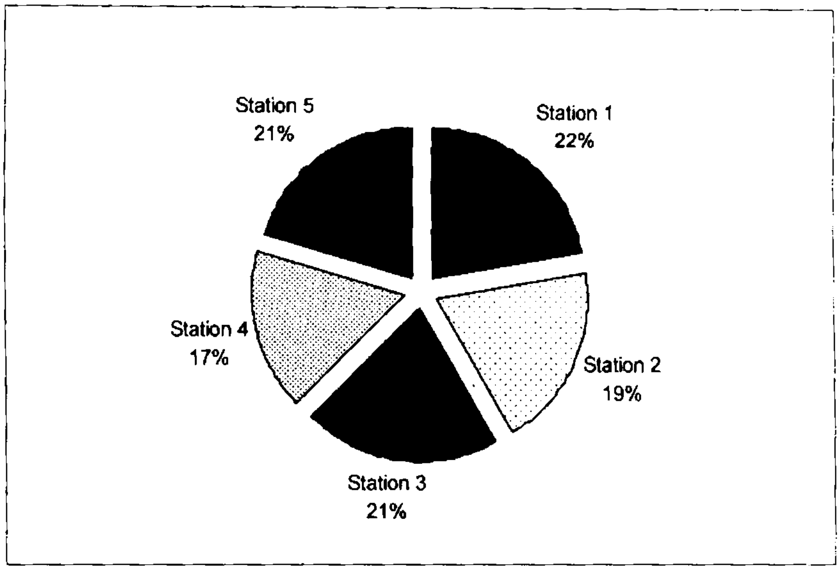


Fig. 98. Return on turn over of cast nets of Muvattupuzha River

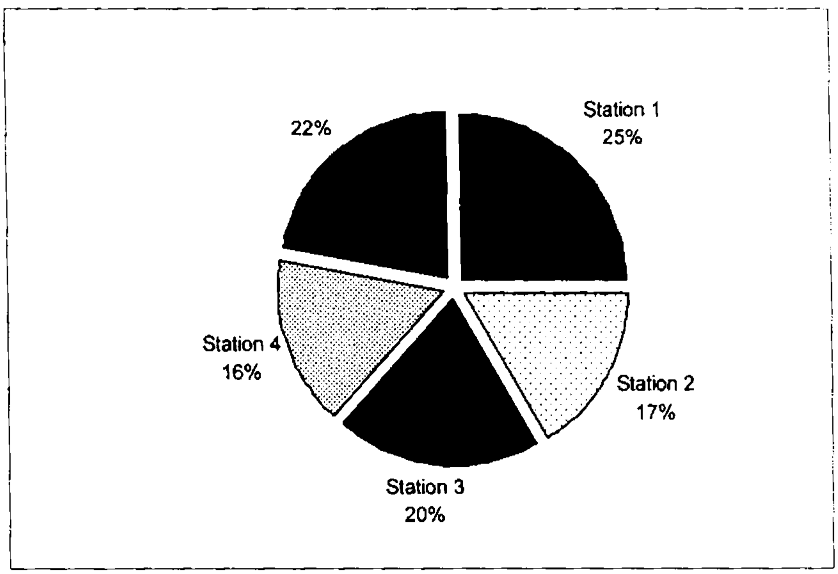


Fig. 99. Return on capital of cast nets of Muvattupuzha River

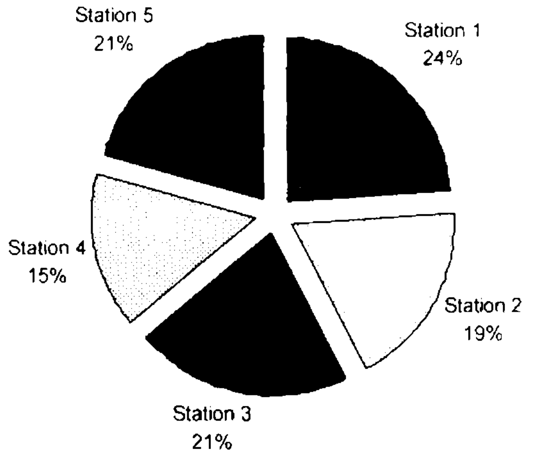


Fig. 100. Return on total cost of cast nets of Muvattupuzha River

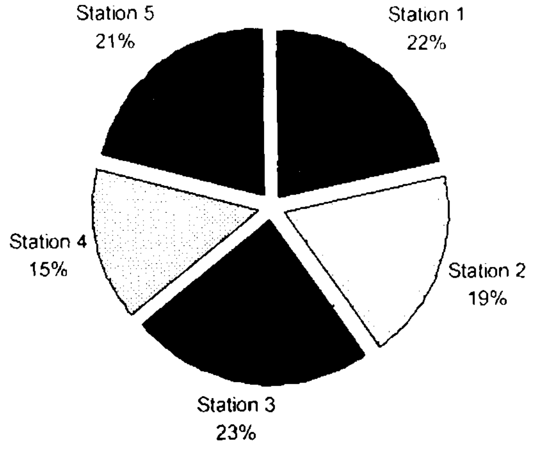


Fig. 101. Return on variable cost of cast nets of Muvattupuzha River

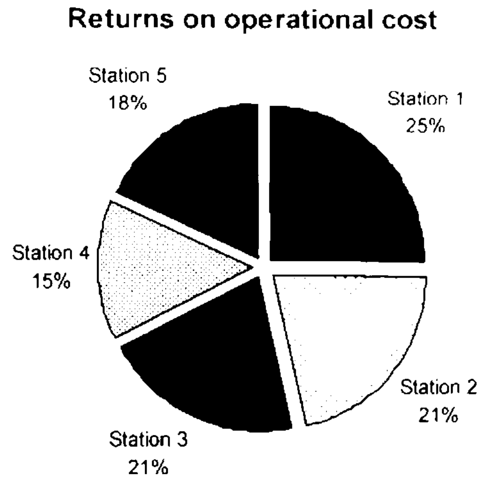


Fig. 102. Return on operational cost of cast nets of Muvattupuzha River

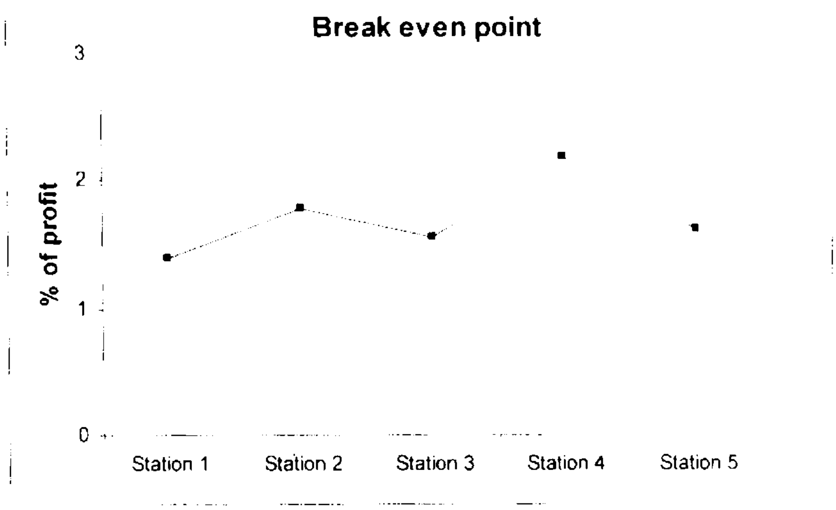


Fig. 103. Break- even point

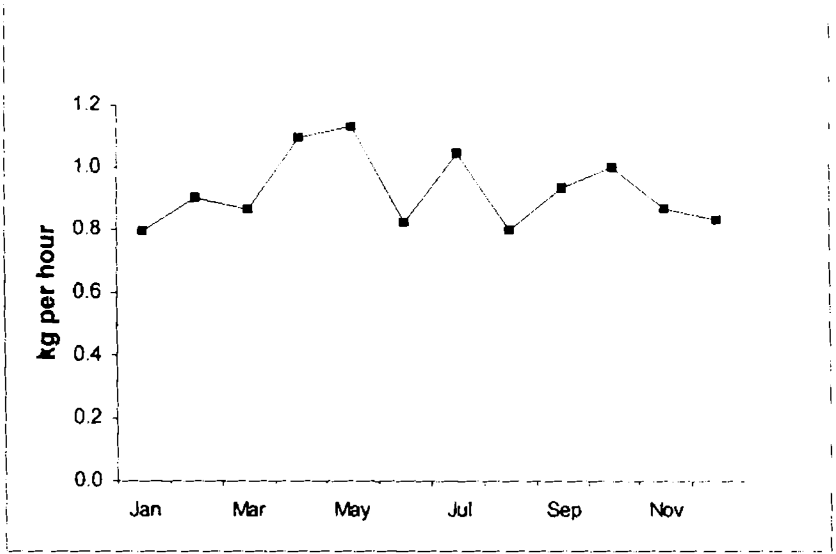


Fig. 104. Catch per hour of riverine cast nets at station 1

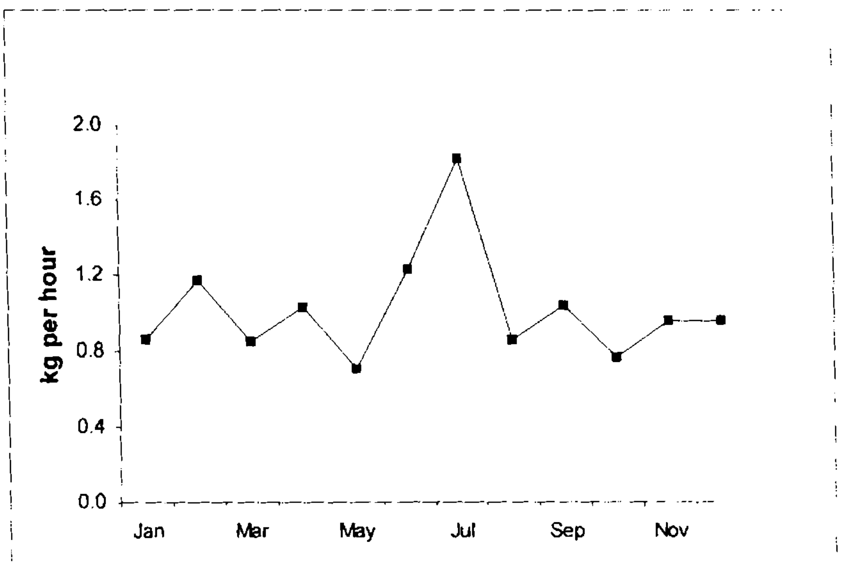


Fig. 105. Catch per hour of riverine cast nets at station 2

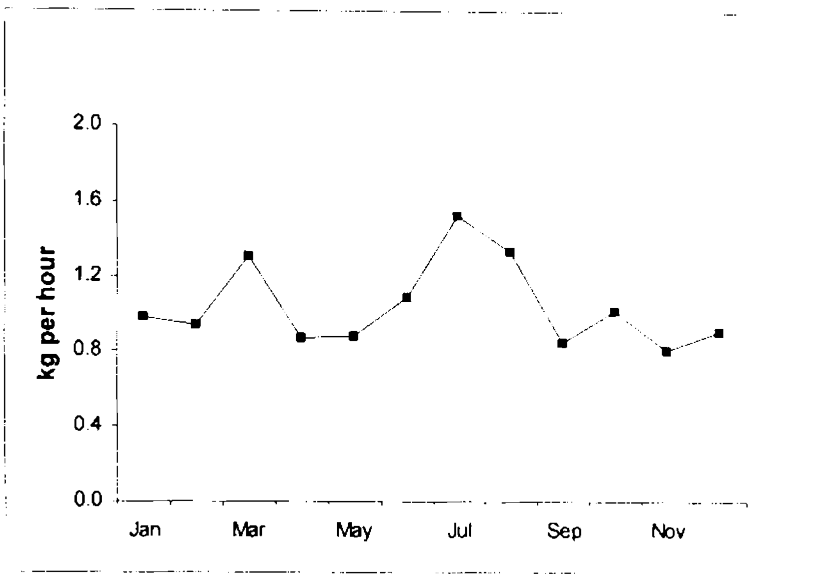


Fig. 106. Catch per hour of riverine cast nets at station 3

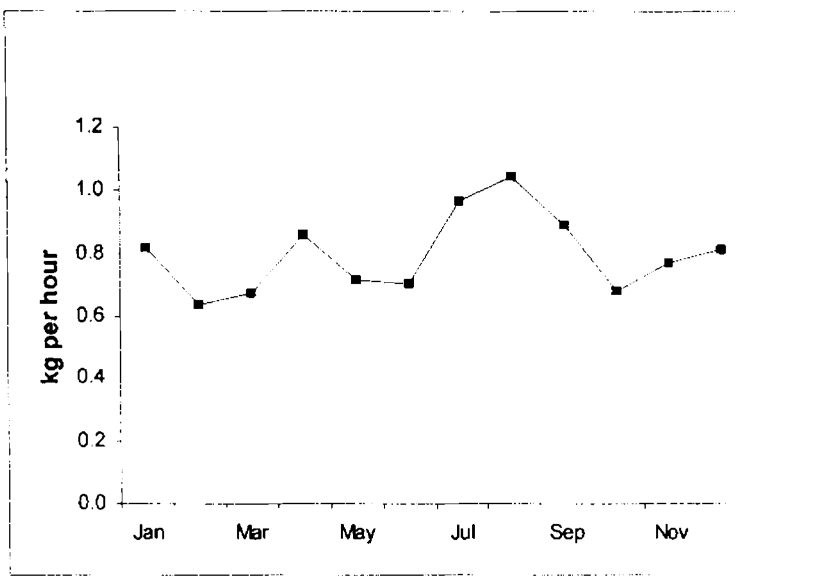


Fig. 107. Catch per hour of riverine cast nets at station 4

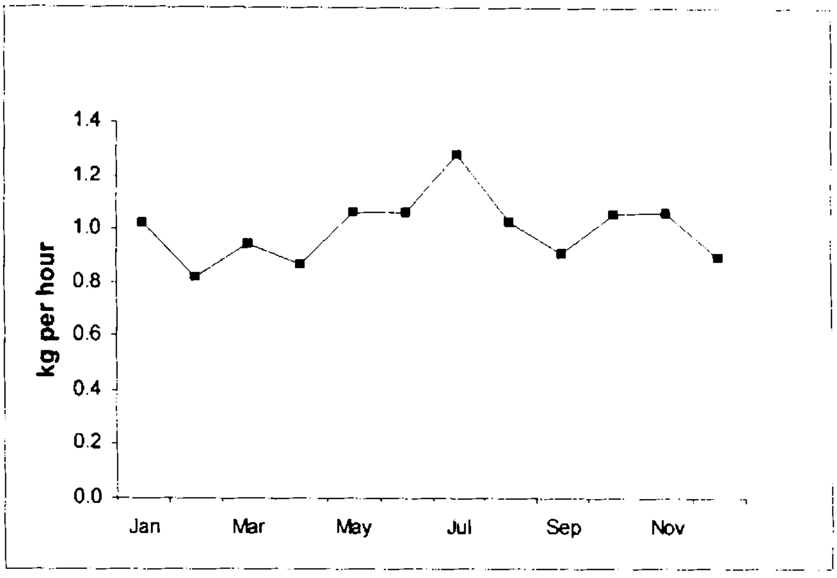


Fig. 108. Catch per hour of riverine cast nets at station 5

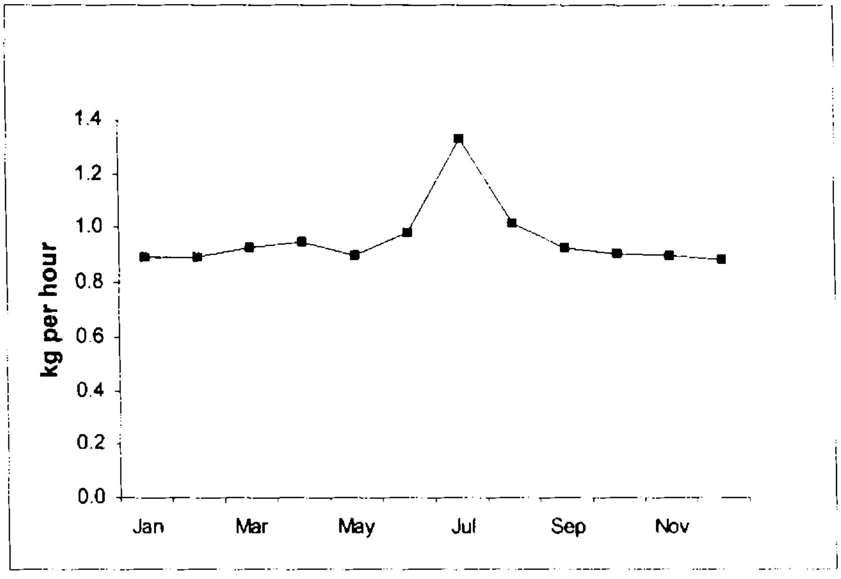
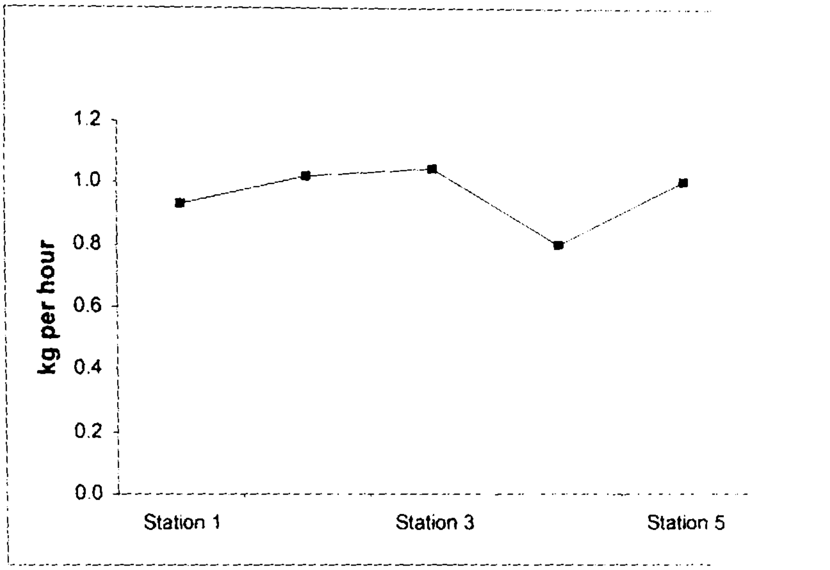


Fig. 109. Variations in catch per hour of riverine cast nets in different months



110. Variations in catch per hour of riverine cast nets in different stations

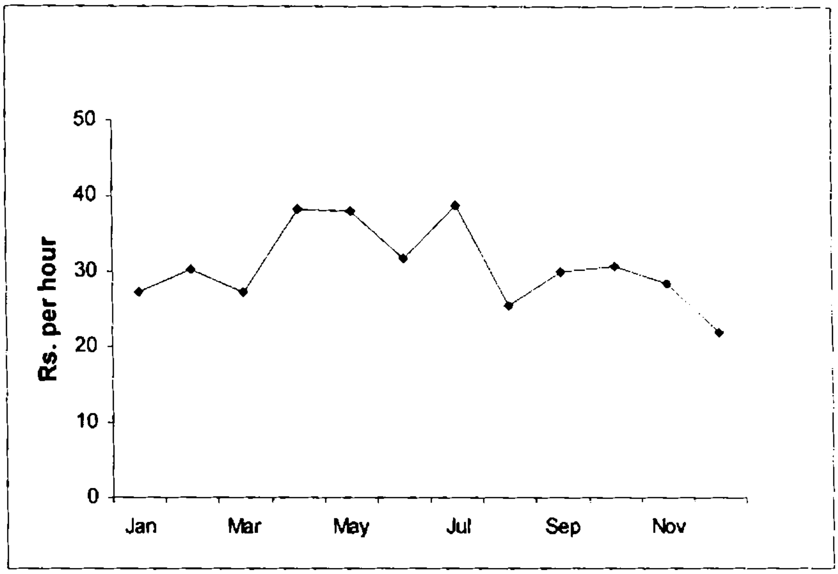


Fig. 111. Earnings per hour of riverine cast nets at station 1

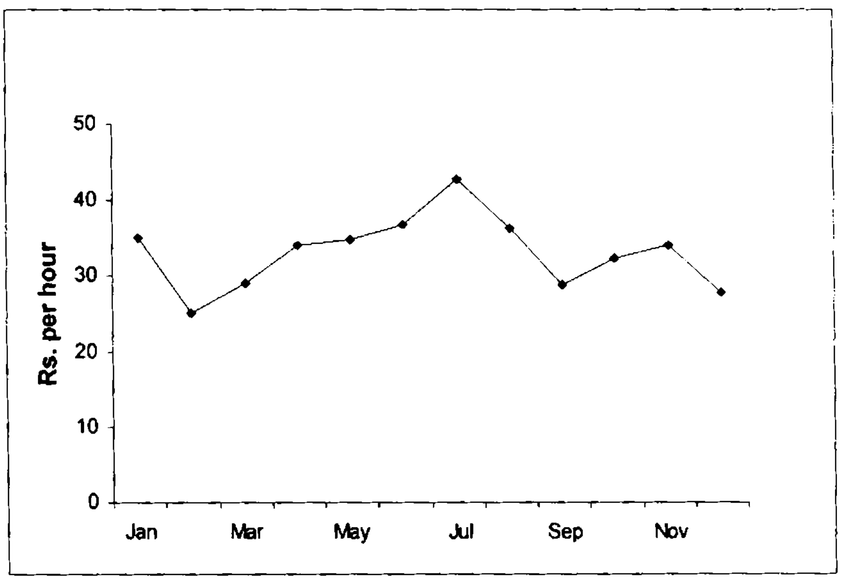


Fig. 112. Earnings per hour of riverine cast nets at station 2

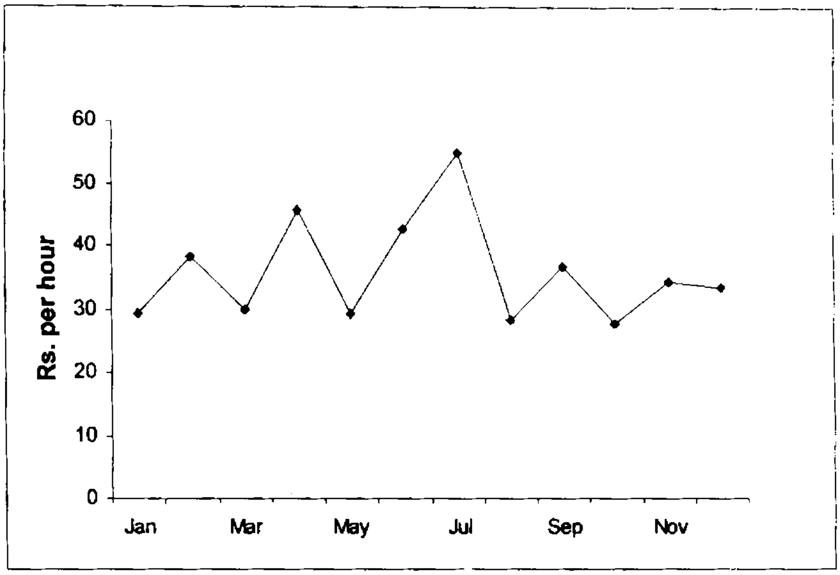


Fig. 113. Earnings per hour of riverine cast nets at station 3

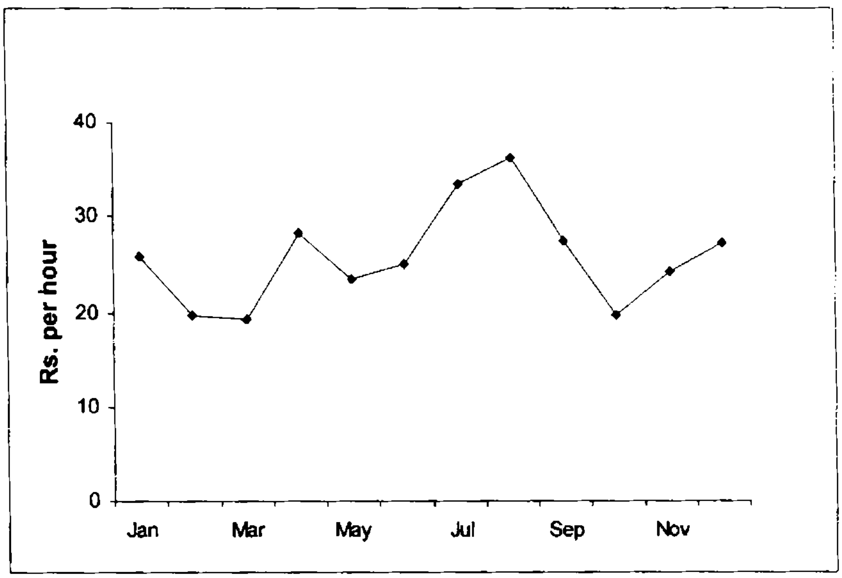


Fig. 114. Earnings per hour of riverine cast nets at station 4

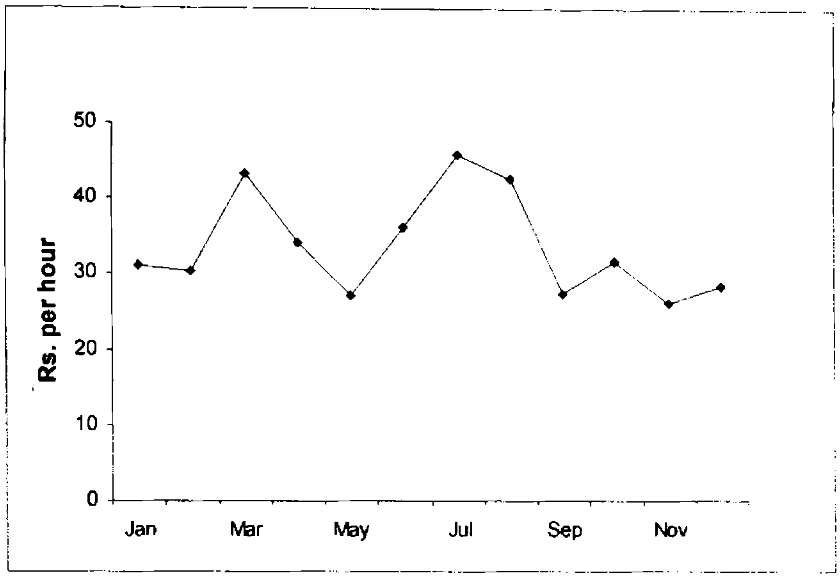


Fig. 115. Earnings per hour of riverine cast nets at station 5

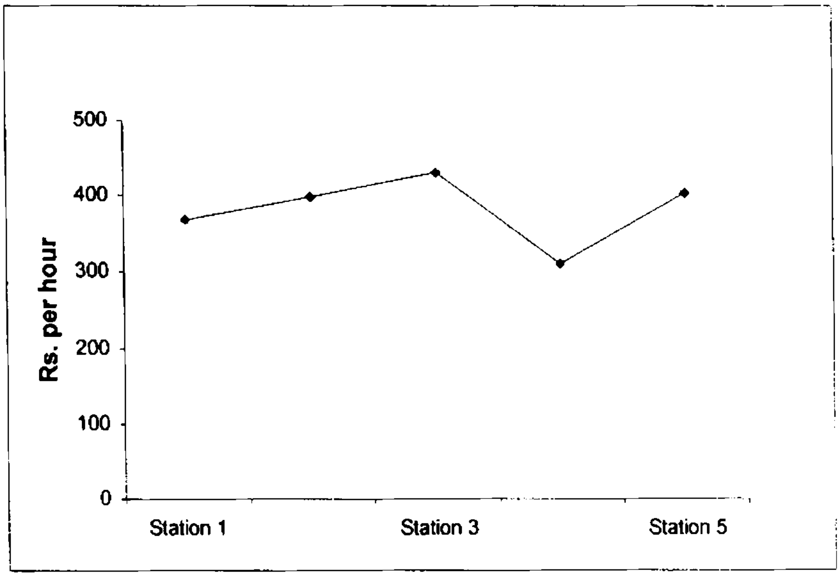


Fig. 116. Variations in earnings per hour of riverine cast nets in different stations

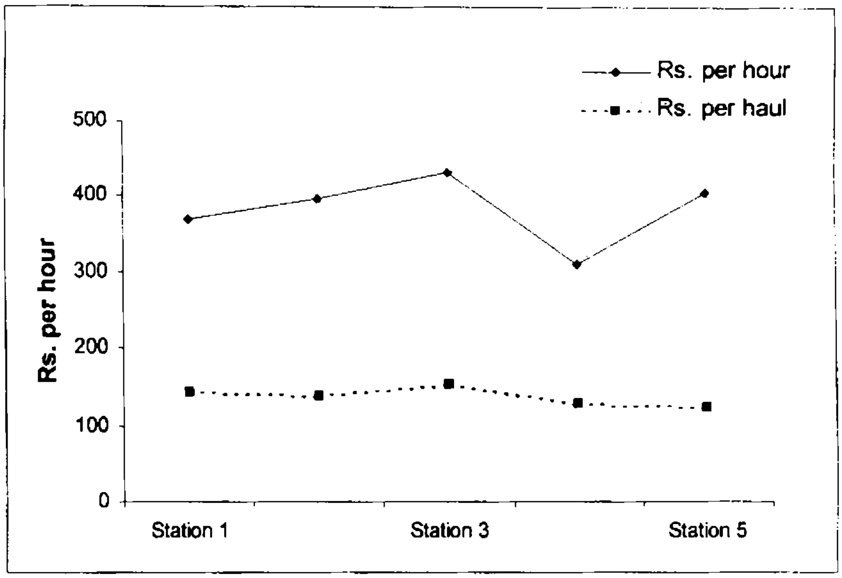


Fig. 117. Comparison of catch per hour and catch per haul of riverine cast nets in different stations

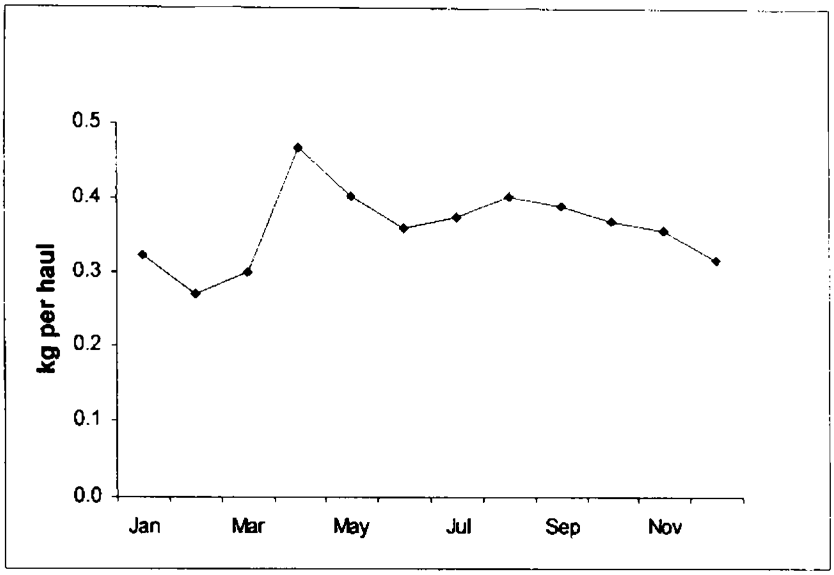


Fig. 118. Catch per haul of riverine cast nets at station 1

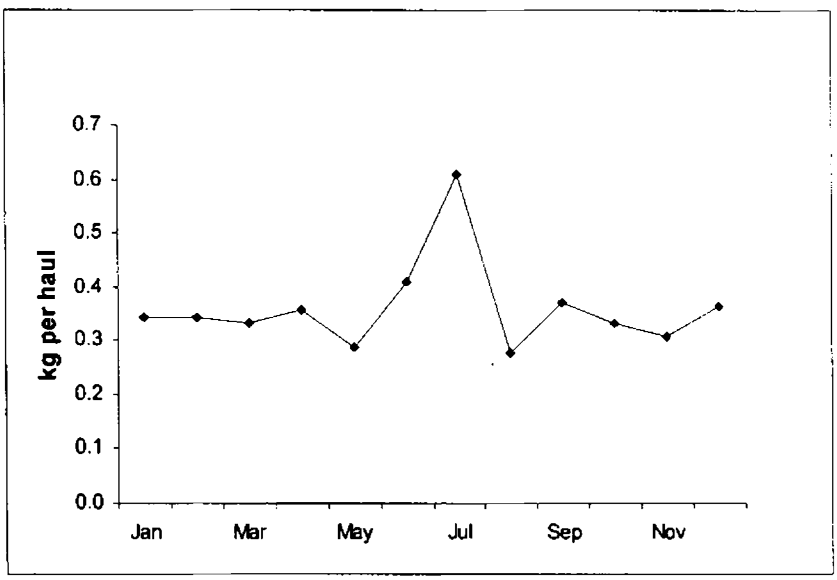


Fig. 119. Catch per haul of riverine cast nets at station 2

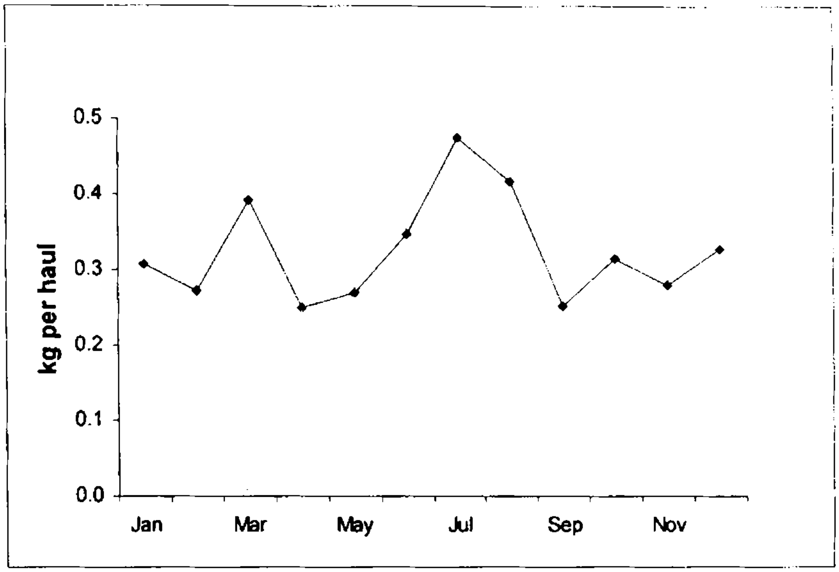


Fig. 120. Catch per haul of riverine cast nets at station 3

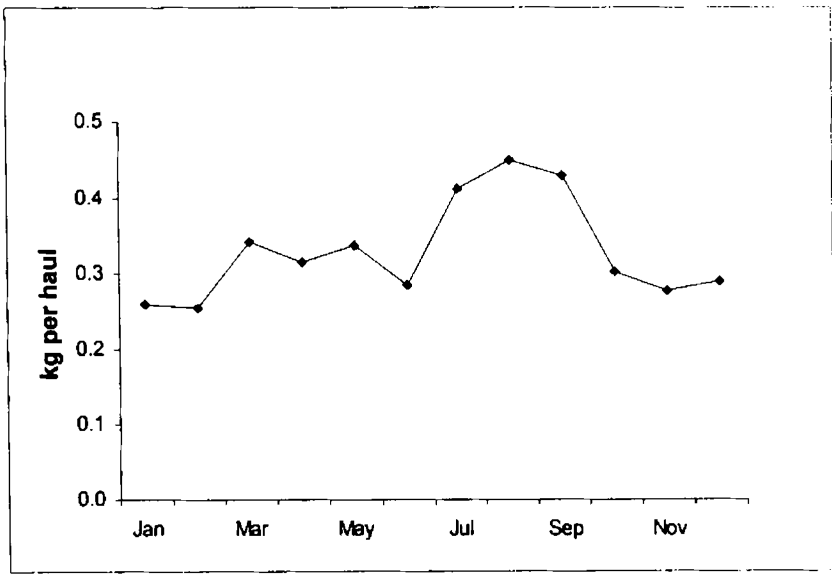


Fig. 121. Catch per haul of riverine cast nets at station 4

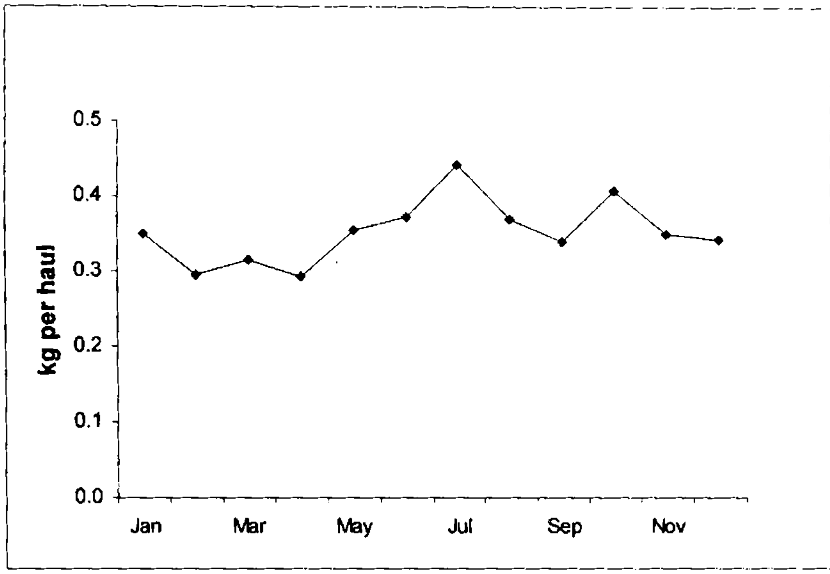


Fig. 122. Catch per haul of riverine cast nets at station 5

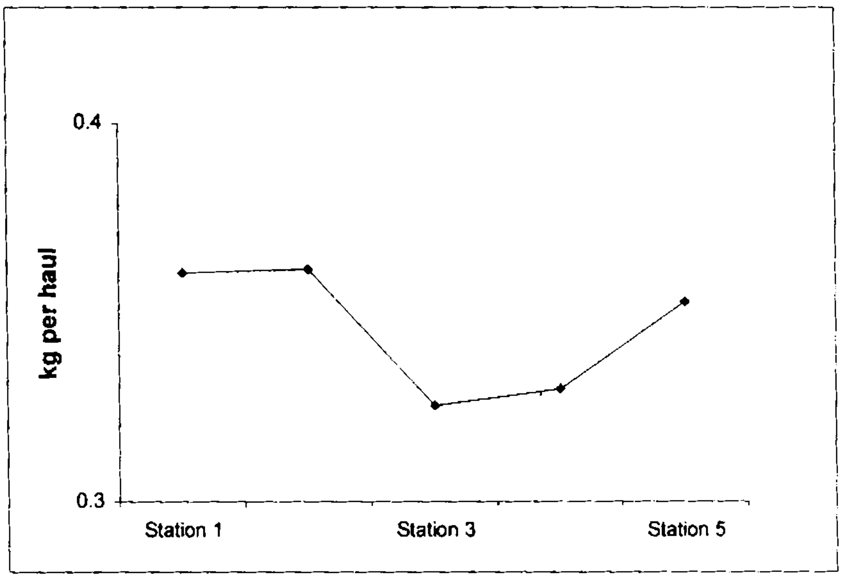


Fig. 123. Variations in catch per haul of riverine cast nets in different stations

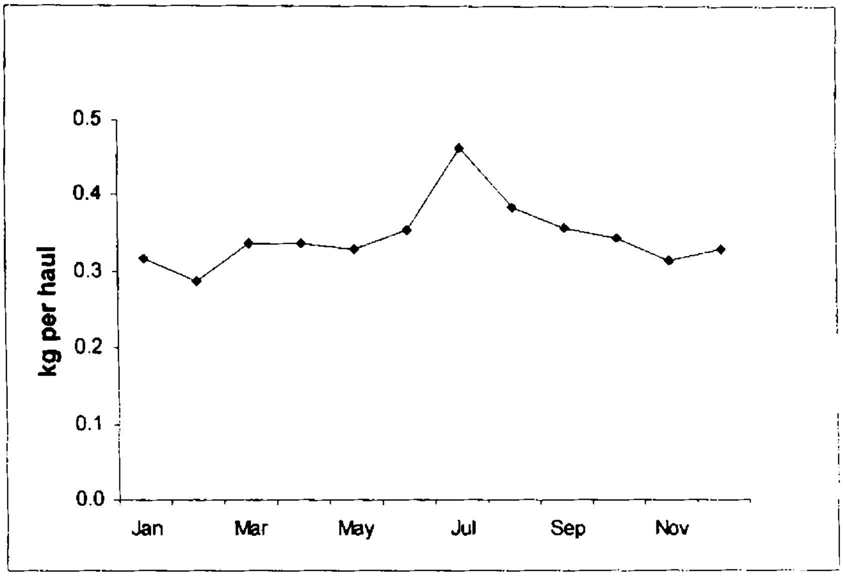


Fig. 124. Variations in catch per haul of riverine cast nets in different months

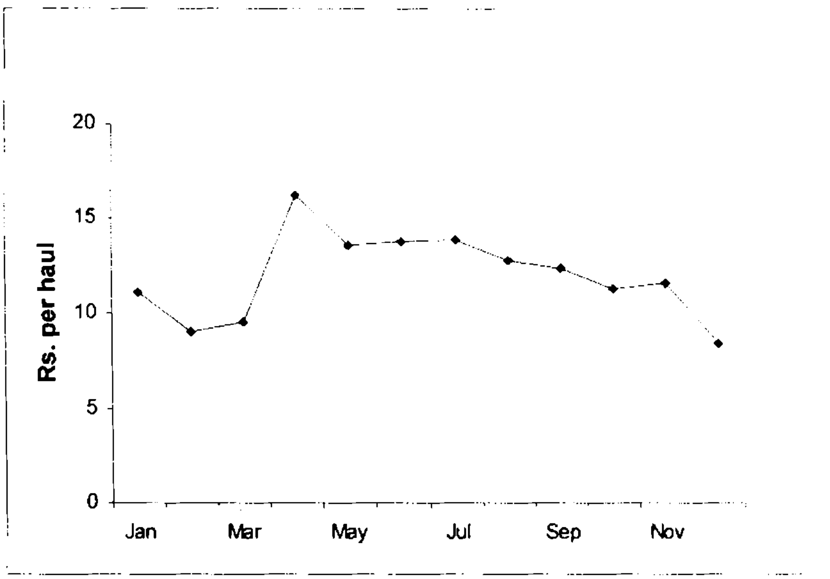


Fig. 125. Earnings per haul of riverine cast nets at station 1

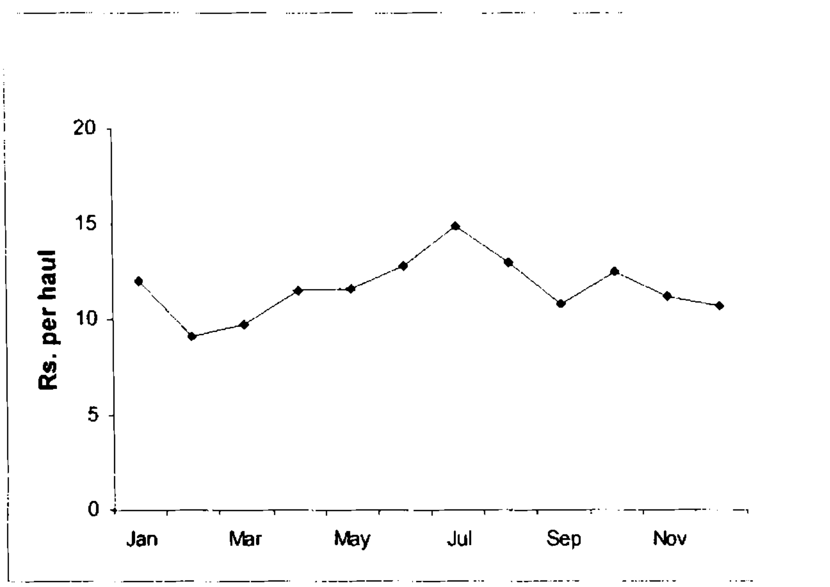


Fig. 126. Earnings per haul of riverine cast nets at station 2

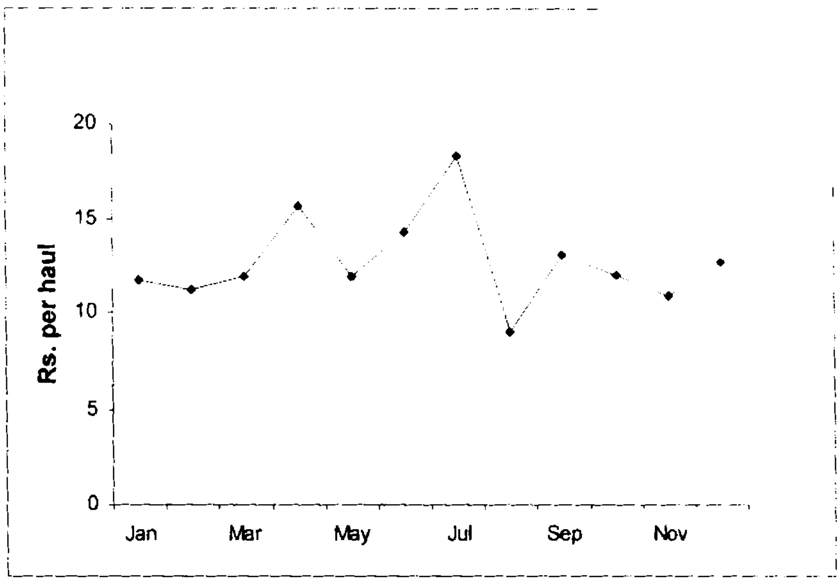


Fig. 127. Earnings per haul of riverine cast nets at station 3

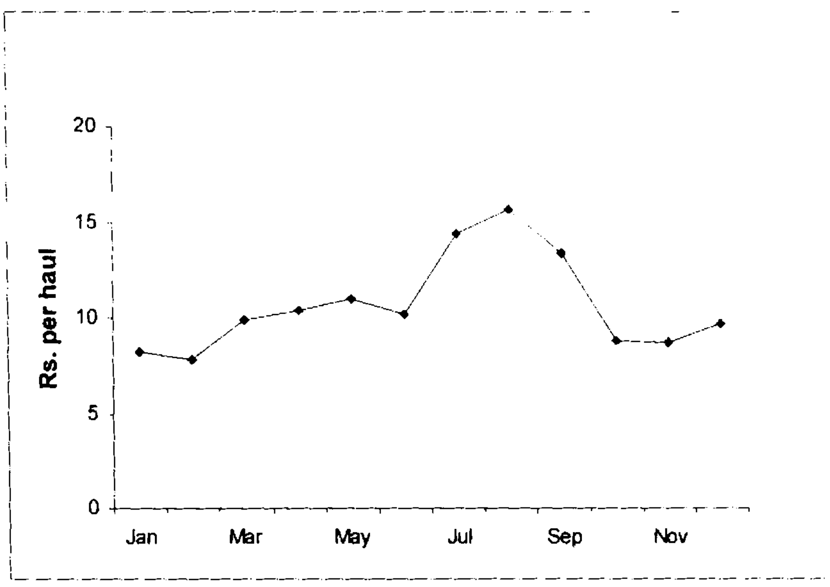


Fig. 128. Earnings per haul of riverine cast nets at station 4

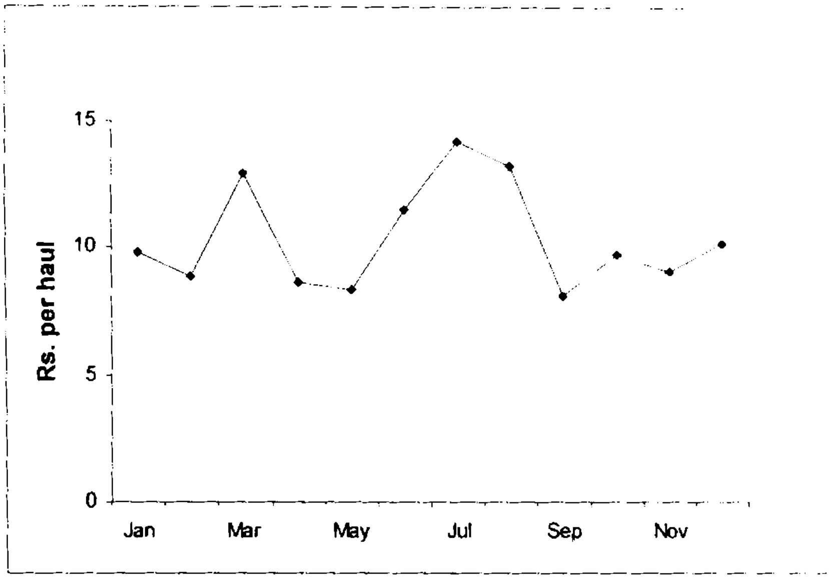


Fig. 129. Earnings per haul of riverine cast nets at station 5

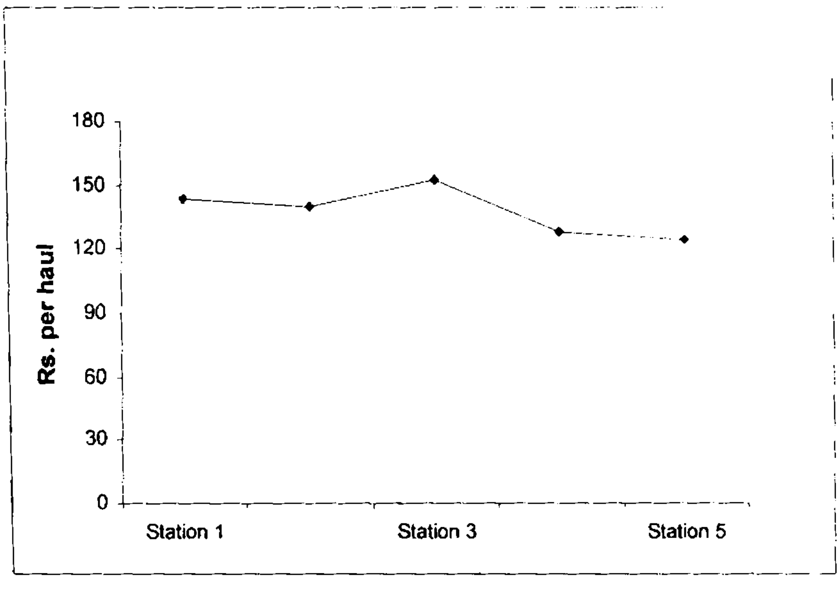


Fig. 130. Variations in earnings per haul of riverine cast nets in different stations

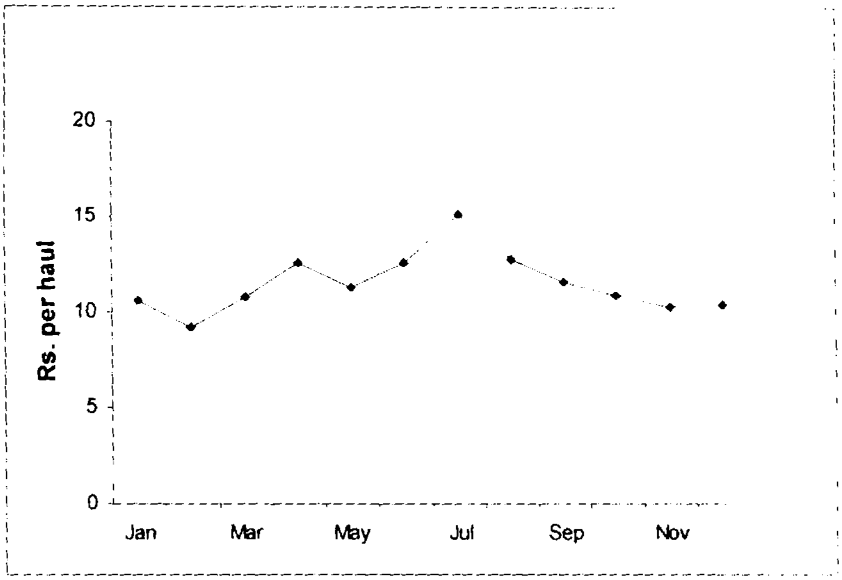


Fig. 131. Average earnings per haul of riverine cast nets

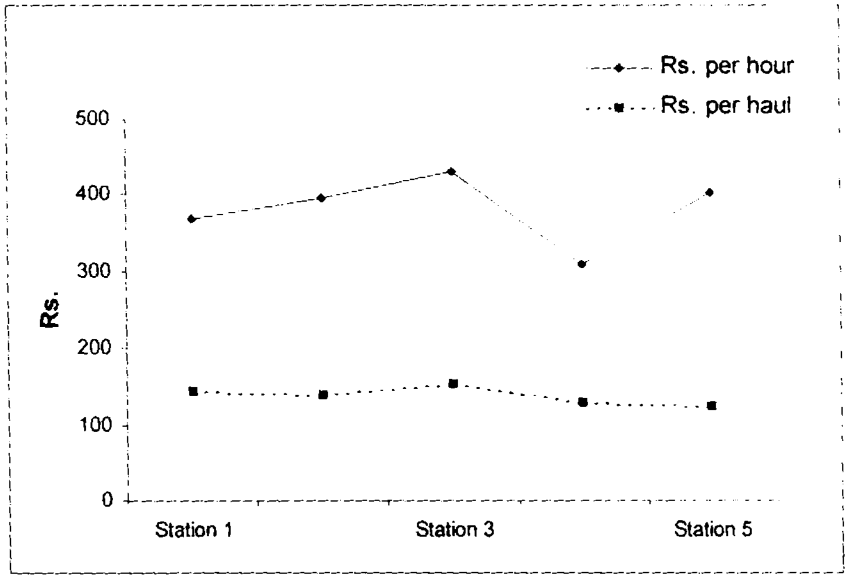


Fig. 132. Earnings per haul and earning per hour of riverine cast nets at different stations

Table 68. Anova: Earnings per hour of cast nets of Muvattupuzha River

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	148.838636	29.7677271	13.083769
Row 2	5	143.88243	28.776486	48.366282
Row 3	5	149.204291	29.8408581	74.044966
Row 4	5	180.282913	36.0565826	41.531414
Row 5	5	152.710648	30.5421296	35.059849
Row 6	5	172.280765	34.456153	43.313722
Row 7	5	215.806942	43.1613884	64.927067
Row 8	5	168.63984	33.7279679	47.00978
Row 9	5	150.318872	30.0637743	14.769625
Row 10	5	141.881197	28.3762393	25.953792
Row 11	5	147.244651	29.4489303	20.64888
Row 12	5	139.14462	27.828924	16.717607
Column 1	12	368.485026	30.7070855	27.922728
Column 2	12	397.252767	33.1043973	22.93554
Column 3	12	430.845351	35.9037792	70.006596
Column 4	12	310.239248	25.8532706	27.532301
Column 5	12	403.413413	33.6177844	46.542584

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	1063.40511	11	96.6731923	3.9351411	0.0005303	2.0140476
Columns	700.77487	4	175.193717	7.1313668	0.0001621	2.5836684
Error	1080.93213	44	24.5666394			
Total	2845.11212	59				

Table 69. Anova: Earnings per haul of cast nets of Muvattupuzha River

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	52.8399138	10.5679828	2.3916042
Row 2	5	45.9593225	9.19186451	1.5292755
Row 3	5	53.845679	10.7691358	2.3384977
Row 4	5	62.392434	12.4784868	11.039545
Row 5	5	56.3894898	11.277898	3.6388838
Row 6	5	62.4467752	12.489355	2.7697368
Row 7	5	75.4200871	15.0840174	3.4344682
Row 8	5	63.5586879	12.7117376	5.5074617
Row 9	5	57.6640884	11.5328177	4.6424595
Row 10	5	54.179677	10.8359354	2.3332903
Row 11	5	51.4625841	10.2925168	1.6932902
Row 12	5	51.6260736	10.3252147	2.5245324
Column 1	12	143.025418	11.9187849	5.2710531
Column 2	12	139.576068	11.631339	2.3681145
Column 3	12	152.616944	12.7180787	5.8415169
Column 4	12	128.225051	10.6854209	6.1316504
Column 5	12	124.34133	10.3617775	4.323561

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	131.46612	11	11.9514655	3.9889974	0.0004699	2.0140476
Columns	43.5434463	4	10.8858616	3.6333346	0.0121194	2.5836684
Error	131.828735	44	2.99610761			
Total	306.838301	59				

Table 70. Anova: Catch per hour of cast nets of Muvattupuzha River

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	4.4717414	0.8943483	0.0106595
Row 2	5	4.468954	0.8937908	0.0369944
Row 3	5	4.6469645	0.9293929	0.0562371
Row 4	5	4.7323584	0.9464717	0.0124633
Row 5	5	4.5002083	0.9000417	0.0382566
Row 6	5	4.914629	0.9829258	0.0457586
Row 7	5	6.6523537	1.3304707	0.1256397
Row 8	5	5.0829372	1.0165874	0.0444675
Row 9	5	4.6258337	0.9251667	0.0053155
Row 10	5	4.531453	0.9062906	0.0288195
Row 11	5	4.4817142	0.8963428	0.0144708
Row 12	5	4.423125	0.884625	0.0036616
Column 1	12	11.1488	0.9290667	0.0135487
Column 2	12	12.257291	1.0214409	0.0875287
Column 3	12	12.545945	1.0454954	0.0535187
Column 4	12	9.5500012	0.7958334	0.0156894
Column 5	12	12.030235	1.0025196	0.0153927

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.8410065	11	0.0764551	2.7999624	0.0074996	2.0140476
Columns	0.4895224	4	0.1223806	4.4818578	0.0039988	2.5836684
Error	1.201454	44	0.0273058			
Total	2.5319829	59				

Table 71. Anova: Catch per haul of cast nets of Muvattupuzha River

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	1.5824274	0.3164855	0.0012816
Row 2	5	1.4329157	0.2865831	0.0011469
Row 3	5	1.6849715	0.3369943	0.0012241
Row 4	5	1.6850084	0.3370017	0.0068634
Row 5	5	1.6517982	0.3303596	0.002829
Row 6	5	1.7720358	0.3544072	0.0020387
Row 7	5	2.311583	0.4623166	0.0080754
Row 8	5	1.9143258	0.3828652	0.0044511
Row 9	5	1.7809233	0.3561847	0.0044952
Row 10	5	1.7261865	0.3452373	0.0018068
Row 11	5	1.5691097	0.3138219	0.001454
Row 12	5	1.6420336	0.3284067	0.0007901
Column 1	12	4.324118	0.3603432	0.0028584
Column 2	12	4.3330541	0.3610878	0.0074193
Column 3	12	3.9072203	0.3256017	0.0050399
Column 4	12	3.9567108	0.3297259	0.0044824
Column 5	12	4.2322158	0.3526847	0.0018364

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	0.1060827	11	0.0096439	3.2166359	0.0027805	2.0140476
Columns	0.0139072	4	0.0034768	1.159653	0.341563	2.5836684
Error	0.1319176	44	0.0029981			
Total	0.2519075	59				

Table 72. Anova: Catch per month of cast nets of Muvattupuzha River

SUMMARY	*Count*	*Sum*	*Average*	*Variance*
Row 1	5	461.1375	92.2275	82.888313
Row 2	5	393.7	78.74	73.028
Row 3	5	485.4375	97.0875	684.76641
Row 4	5	461.25	92.25	306.75781
Row 5	5	473.175	94.635	401.74988
Row 6	5	743.6	148.72	291.56256
Row 7	5	1073.15	214.63	386.46075
Row 8	5	682.2	136.44	1405.4158
Row 9	5	470.41667	94.083333	395.52083
Row 10	5	433.9125	86.7825	205.11731
Row 11	5	391.40833	78.281667	121.54856
Row 12	5	406.46667	81.293333	103.87397
Column 1	12	1377.55	114.79583	1397.6271
Column 2	12	1286.0875	107.17396	1323.1416
Column 3	12	1277.2	106.43333	2458.7119
Column 4	12	1196.0667	99.672222	1475.6878
Column 5	12	1338.95	111.57917	2880.8644

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Rows	88639.103	11	8058.1003	21.809116	2.65E-14	2.014048
Columns	1577.503	4	394.37575	1.0673715	0.384044	2.583668
Error	16257.258	44	369.48313			
Total	106473.86	59				

Table 73. Anova: Earnings per month of cast nets of Muvattupuzha River

SUMMARY	Count	Sum	Average	Variance
Row 1	5	15361.875	3072.375	125999.3
Row 2	5	12655	2531	132530
Row 3	5	15581.25	3116.25	872015.63
Row 4	5	16031.25	3206.25	583355.03
Row 5	5	16065	3213	379535.63
Row 6	5	26265.417	5253.0833	552013.85
Row 7	5	35257.083	7051.4167	221994.41
Row 8	5	22595.625	4519.125	1422809.3
Row 9	5	15223.958	3044.7917	392138.67
Row 10	5	13533.75	2706.75	133498.13
Row 11	5	12864.583	2572.9167	182115.1
Row 12	5	12696.667	2539.3333	106247.01
Column 1	12	46242.5	3853.5417	2501317.6
Column 2	12	42250.625	3520.8854	1738922.3
Column 3	12	44077.5	3673.125	2105702.4
Column 4	12	39227.5	3268.9583	2080442.3
Column 5	12	42333.333	3527.7778	2647035.6

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Rows	103620756	11	9420068.7	22.790239	1.2E-14	2.014048
Columns	2230141.9	4	557535.48	1.3488614	0.267126	2.583668
Error	18186866	44	413337.87			
Total	124037764	59				

Chapter V

LINES, TRAPS AND OTHER MISCELLANEOUS GEARS

Chapter V

LINES, TRAPS AND OTHER MISCELLANEOUS GEARS

Hooks are the first fishing gear to be used by man. Hooks and lines are among the simplest of fishing gear. However, regardless of the development of fishing on a larger scale and mechanized fishing with nets and seines, hook and lines are still very important in contemporary commercial fishing. About 12% of all the catches in the world are made by hooks and lines (Mathai, 1995)

Hook and lines are more efficient in many cases for catching fish than nets. Large and swift predatory fish especially in transparent waters easily escape from net, which frighten them, whereas appropriately arranged, and set hooks and lines attract them with their bait. Fishing with powerful fishing gears such as the seines and trawls are impossible in rocky and uneven areas, where the more suitable gear is hooks and lines.

The function of the hooks is to ensure that the fish shall not spit out the bait after swallowing it. To ensure this basic premise, the point of the hook is often provided with a barb and its size depend upon its size. Another important function of the hook is to hold the bait properly and for this purpose the barbed point is extremely useful. Hooks are either used with or without baits.

In riverine sector, line fishing is an important fishing method. It is a cheaper method of fishing compared to gillnet and cast net fishing. A large number of different types of line fishing gears are employed in the riverine sector. The fishermen construct the line fishing gear according to the behaviour of targeted fish and nature of the water body. Rod and line is a universal method of catching fish and is very popular in the rivers (Hamilhan, 1930),

The basic construction and material is almost same in all places. Basically, the lines have mainly two parts. A line made of synthetic twine and a hook. The line is mainly composed of PA monofilament, PP or PE. The basic criteria for the selection of material are that the line should be strong enough to withstand the pressure exerted by the fish.

This chapter deals with different kinds of lines, traps and miscellaneous fishing gar prevalent in the rivers of central Kerala.

Review of literature

A number of studies have been conducted in line fishing all over the world as it is one of the most important fishing aid in the fishing industry. The studies on lines started very early in India (Hornell, 1937). The status of long lines of Ecuador is explained by Anon (1976).

The history of different line systems, their descriptions and status were described by Skeide (1984). Several workers have described about the indigenous gear used in India (Gopinath 1953; John 1936; Kurien and Sebastian 1986; Kurup and Samuel 1985). Different types of line fishing were discussed by Bach, (1989), Abe and Dotsu (1977), different types of line fishing in Veraval, Gujarat were discussed by Pravin and Ramesan (1998). The techniques of tuna fishing with pole and line was discussed by Ben-Yami (1980). Line fishing gear relevant to Indian conditions was explained by Narsapurkar *et. al.* (1988) with the help of theoretical analysis and model study through mechanical simulation.

Studies of Rao *et. al.* (1989) described the details of shark long lines and offered suggestions to improve the gear and its method of operations. Technological advances in the coastal and deep sea fishing with different fishing gears like gillnet, trammel nets, long lines, troll lines, seines and trawls were discussed by George (1998). The technical details and advantage of the long lines used for sword fish capture was presented by Lizama and Naranjo (1989). The development of long line fisheries in the Indian Ocean was discussed by Gubanov *et.al.* (1992). The method of operation, catch composition, season of operation of these gear were also described in detail. Long lines for shark fishing is less expensive compared to other methods of fishing (Rao, 1989).

Detailed study on long lines in estuarine areas in Karnataka were conducted by Sathyanarayanappa *et. al.* (1987a). There are a number of studies conducted to improve the efficiency of line fishing. Experiments on artificial baits for tuna long lines were discussed by Kobayashi (1975). Studies on vertical long lines in Lkinawa Islands were conducted by Sakamoto *et.al.* (1974). The effect of size and shape of hooks in catching efficiency of long line fishing were described by Takeuchi and Koike (1969) and Thomas, (1964). Breaking point of long lines were studies by Shinomiya *et. al.* (1985). Recent developments in longline gear, with respect to different gear components like hooks, swivels, main lines and barbs were discussed by Asmund Bjordal (1988). He also explained the conservations aspects of longlines compares with those of trawl gear.

Many modern techniques are used in long line fishing industry. The modern autoline system is widely used in long line vessels operating in Norway (Anon, 1978). Studies on monofilament main lines and snoods in long lines were conducted by Lange (1985). Experiments in long line hooking rate by using two kinds of baits were conducted in the Gulf of Thailand. (Kanehara *et. al.* 1985). The energy intensive long line fishery was discussed by Watanabe and Okubo (1989). Studies on breaking periods of main lines were conducted by Shinomiya *et. al.* (1985).

A number of studies have been carried out for the improvement of the materials used for the different types of lines. (Yanchenko, 1990). The materials have an important influence on gear performance with respect to fishing efficiency, selectivity, gear handling, investment and catch quality (Karlsen, 1988). He found out that the fishing time is important for the condition and quality of the catch of gillnets.

Efficiency and species selectivity of long lines were studied off the south coast of Potugal by Erzini *et. al.* (1996). Selectivity studies on long lines were also conducted by Dimitriou *et.al.* (2000). Comparative studies on of selectivity in different fishing methods like long lines and traps were carried out in the Mesolongi lagoon in Greece by Dimitriou *et. al.* (2000). The study on the catching efficiency and selection curve of the long line hooks for spiny goby, *Acanthogobius flavimanus* were conducted by Takeuchi and Koike (1969).

Study of Jorgensen (1995) showed that long line were up to 30 times more effective in catching large fish when compared to the trawls. The study of Olsen (1995) revealed efficiency of long lines for deep water fish.

Economic feasibility of longline fishing were studied by Lange(1985). Factors affecting catching efficiency of long lines were studied by Arimoto *et. al.* (1983). Comparative studies were conducted on long line and a bottom trawl by Jorgensen (1995). Cost of operation and advantages of long line for sword fish capture are described by Lizama and Naranjo (1989).

5.1. Materials and Methods

A survey was conducted in the rivers of central Kerala viz., Bharathapuzha River, Puzhakkal River, Keecheri River, Karuvannur River, Chalakudy River, Periyar River and Muvattupuzha River to identify the different types of gears, which are operated in the rivers. During the survey information on the different types of fishing gears operated in the riverine system were collected.

Based on the pilot survey 49 fishing centers were selected from these rivers. The location map of the centres surveyed is given in Fig. 2-8. The fishermen population are concentrated in these centres. Different centres in each rivers selected for the study are given in Table 61. Eight centres from the Bharathapuzha River, seven centres from the Chalakudy River, eight centres from the Karuvannoor River, two centres from the Keecheri River, fourteen centres from the Muvattupuzha River, eight centres from the Periyar River and two centres from the Puzhakkal River were selected.

The design details of different types of lines, traps and miscellaneous gears operated in the selected centres were collected from direct observation and interviews with the fishermen. Different types of lines like rod and line, hand line, long line and a number of miscellaneous gears like different types of traps, dip nets, spears, and other stupefying gears were studied during the survey.

Technical details of the lines such as material for main line and branch line, size and shape of hooks and baits used, method of operation, time and season of operation and the craft used for the operation and number of fishermen engaged in the operation were collected for different type of lines. Details of methods of operations, fishing areas, fishing time, season and catch details were collected through direct observations.

Technical details of traps, dip nets, etc. such as method of construction, mode of operation, operating season and catch details were collected. The design drawings of these gears were prepared as per conventions followed by Nedelec (1975).

A number of stupefying gears are operated in rivers. Details of different methods used in this category were collected through field survey.

5.2. Results and Discussion

Based on the study conducted in the fishing centres of the central Kerala a number of different types of gears were identified. Lines, traps, dip nets, spears, miscellaneous fishing methods like fishing without gears, vallivala, etc. are discussed in this chapter. In addition to these stupefying methods like use of poisons, explosives and electric fishing are prevalent in riverine sectors of Central Kerala are discussed.

5.2.1. Lines

There are three categories of lines in the riverine sector of central Kerala viz. (i) hand lines (ii) rod & lines and (iii) long lines (Fig. 134). Hand lines are mainly three types viz., Eruchoonda, Kaichoonda and Vettuchoonda. Three types of rod and lines were practiced in riverine sector viz., Vadichoonda, Madachoonda and Kuthochoonda. Longlines were mainly used as set longlines and drift longlines.

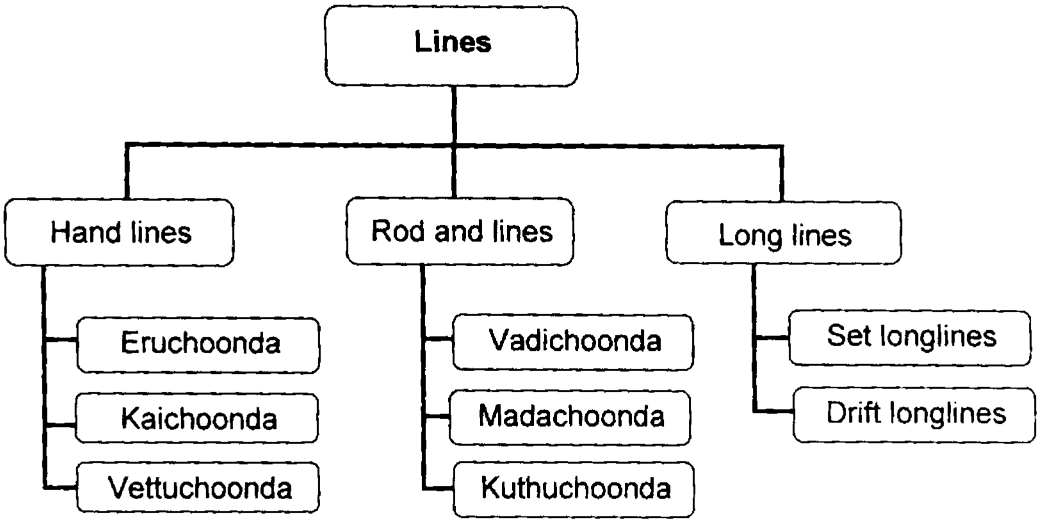


Fig. 134. Classifications of lines operated in Rivers of Central Kerala

Hand Lines

Hand line is the simplest form of fishing line. A line with a single hook or multiple hooks, with bait is operated by a single man. Hand line with single hook and multiple hooks were prevalent in riverine sector. Handline with multiple hooks is called multiple hand line.

Handline was made of polyamide monofilament line having a terminal lead sinker and a hook. The length of the line varied from 1.5 m to 100 m according to the depth of the area where gear is operated. Various sizes of hooks (No. 5 to 18) and different types of baits were used according to the targeted fish.

Types of hand lines

Eruchooda

Two types of handlines locally known as eruchoonda were operated in the area studied, viz., (i) lines with single hook and (ii) lines with multiple hook.

Eruchoonda with single hook

It consisted of a main line and a hook, attached to the end of it. The upper end of the line was reeled on a spool and an appropriate length of line was released according to the depth of the fishing area. A small lead weight was attached 30 to 150 cm above the hook. The position of the sinkers varied according to the depth of the river.

The mainline is made of PA monofilament of 1.0 mm to 2.0 mm dia. The length of the line varied from 30 m to 100 m. The line is reeled in spool and released according to the depth and flow of water. (Fig . 135).

The branch line was made of PA monofilament of 1mm dia. The branch line started from the lead sinker. The length of the branch line varied from 50 cm to 150 cm according to the depth of the fishing area.

Small bead like sinkers of 50 to 200 g weight were commonly used and dumbbell shaped sinkers were also used.

A small thermocole float is used in calm waters, where the flow is minimum. The thermocole float of size 50x30x30 mm was attached a little above (50 to 150 cm) the sinker. Hook No. 5 to 14 were used in this line.

Operation

On reaching the fishing ground, the fishermen throw the baited hooks with line. The line was released according to the depth and current of the river. Due to the presence of the small sinker the hook sinks to the bottom.

The gear was pulled back when the fishermen felt the hooked fish on the line and the fish is collected. The commonly used baits were small prawns and small live fishes. The catch comprises *Puntius* spp., *Oreochromis* spp., *Etroplus* sp. and cat fishes.

Eruchoonda with multiple hooks

In upstream areas of Periyar and Muvattupuzha River (Bhoothathankettu, Kadumpidy and Moolamattom) some of the eruchoonda operated have 3 to 5 branch lines.

The main line was made of PA monofilament of 1.0 to 2.0 mm thickness. The length of the line varied from 30 m to 100 m. The branch line was made of PA monofilament of 1.0 mm thickness. The length of the branch line varied from 30 to 50 cm. The distance between the lines was little more than the length of the branch line. (Fig. 136).

The lead sinkers of 100 to 500 g used as weight in this gear. It was attached at the tip of the main line. Floats are absent in this type of lines. Hooks No. 7 to 14 were used in this gear and hook No.7 and 8 were very common. Live baits were used for the operation and commonly used baits were small prawns and small miscellaneous fishes.

Operation

The fishing was carried out in fairly deeper waters. The fishermen released the lines after the baits were fixed to the hooks. After that the fishermen wait for 10 to 30 minutes. After 30 minutes the twine was reeled to the spool and the hooked fishes if any, were collected and the process was repeated. The catch comprises *Oreochromis* spp., *Etroplus* sp. cat fishes and eels.

Kaichoonda

The simplest method employed for catching fish was the Kaichoonda. It has a main line, branch line, lead sinker and a hook.

The main line consisted of a PA monofilament of 1.0 mm to 2.0 mm dia., wound on a wooden piece. The length of the line varied from 5 to 30 m. The lower end of the line was provided with a lead weight of 50 to 100 g.

The branch line started from the lead sinker. The branch line was made of PA monofilament of 1 mm dia. The length of the branch line varied from 50 to 150 cm depending on depth of the water column. (Fig. 137)

The hook was tied at the end of the branch line and the lead sinker was tied between the mainline and branch line. The lead sinker kept the line straight and also served as a cushion when sudden strain is applied to the line. A small thermocole float was used in deeper waters. The hook No. 7 to 8 was commonly used in most of the areas.

Live and dead baits were used according to the species of fish targeted. The live baits were small prawns, small fishes, earthworms and tadpole. The dead baits included pieces of fishes, chicken waste, tapioca, etc. Tapioca was mainly used for catching *Catla catla*. The tapioca was fried made in to small balls, and used as bait for *Catla catla*.

Operation

This fishing was carried out in calm waters. The fishermen released the line to the water after baiting the hooks. The fishermen consciously attend any movement of the line and when the presence of fish was felt in the hook, the line was pulled out immediately to collect the hooked fish. The catch of this gear comprises *Oreochromis* spp., cat fishes and *Catla* sp.

Vettuchoonda (Vala choonda)

Vettuchoonda otherwise known as Vala choonda was mainly used for catching Vala (*Wallagu attu*), and hence the term *vala choonda*. It is very simple in construction. It has a main line made of PA monofilament of 1.0 to 2.0 mm dia. or PP twines of 2.0 to 2.5 mm dia. The length of the gear varied from 2.0 to 3.0 m. At the end of the main line, a steel wire of 2.0 mm dia is attached. The length of the steel wire was 30 to 50 cm with a hook of size 5 to 7 at the tip of it. (Fig. 138).

Operation

Generally, the gear was fastened to the nearby trees or small shrubs keeping the steel wire of the gear below water level. The live baits attract the fish to be caught. Different kinds of baits such as small prawns, tadpole, small fishes, pieces of fish and chicken waste were used as bait.

Rod and line

Rod and line is a very common fishing method practiced in the riverine sector. The construction of the gear is very simple and can be easily fabricated by fishermen themselves. The cost of the gear is also very less, compared to other fishing methods such as gillnet and cast net. The rod and line has several local varieties such as *Vadi choonda*, *Vettuchoonda*, *Mada choonda* and *Vala choonda*.

Vadi choonda

In vadi choonda a PA monofilament line is tied to a long bamboo pole or any other hard wooden pole. The hooks of different sizes (No. 6 to No. 14) are used according to the fish sought after. The commonly used baits were small prawns, earthworms and small fishes.

The simplest kind of gear with baited hooks was the vadi choonda (rod and line). The gear has three parts viz., a pole, a line and a hook.

The typical poles were made of bamboo or some other hardwood. The length of the pole varied from 2.0 to 3.0 m and was approximately 50 mm dia at the butt and tapered towards the tip. They are seized with twines or steel wires at bottom and top to prevent splitting. In some cases the butt end of the pole was wound with small twines to provide a firm gripping surface. (Fig. 139).

The line was firmly tied at the tip of the pole. The length of the line varied from 2 to 3.5 m. The line was made of PA monofilament of 0.5 to 1.5 mm dia. At the tip of the line, the hook was attached. Hook size varied from No. 6 to 14.

A small float was attached 50-100 cm above the hook. The distance varied according to the depth of operation. The float is made of thermocole or locally available floating materials like pith of tapioca or small pieces of reed.

Live baits like small fishes, prawns, earthworms and tadpoles and dead baits like pieces of fishes, chicken waste, and fried tapioca pieces were used for pole and line fishing.

Operation

Usually 1 to 3 poles were used at a time by a single fisherman. The operation was carried out mainly during day time. After reaching the fishing ground the fishermen released the baited hooks and consciously watch the movements of the float. The bait varied according to the fish sought. The movements of the live bait attract the fish, and immediately the fish swallows the bait with hook. The jerking movements of the float indicated the presence of fish in the hook. Immediately after the fish took the bait the fisherman jerked the rod and pulled out the catch. Fried tapioca pieces were used as bait for catching *Catla catla*.

Madachoonda

It is a special type of line which is mainly used for the capture of fish living in crevices locally known as 'mada' and therefore it is called m*adachoonda*. In areas like Moolamattom this gear is called as *malamchoonda* It has three parts a pole, a line and a hook.

The pole used has a length of 100 cm to 150 cm and was made of bamboo or nayinkana (*Saccharum spontaneum)* or some other hardwood.

A small length of line was attached at the end the pole. The length of the line varied from 25 cm to 40 cm. The line was made of PA monofilament of 1.0 mm to 2.0 mm dia.. A single hook of size No. 7 or 8 was fixed at the end of the line (Fig. 140).

Live baits like prawns of small fishes were used in this gear. In certain areas, this gear was used without a pole and such types of gears are locally called *Vettuchoonda*.

Operation

After the live bait was fixed on the hook, the pole is pushed deep into the crevices. The movements of the live bait attracted the fish present in the crevices and the bait was taken by the fish and the fishermen pulled out the gear immediately to collect the catch.

In the operation of *Vettuchoonda,* the baited hooks were lowered into the crevices with the help of small twigs. The other end of the rope was tied to a small piece of wood and firmly held in hand. The catch comprised mainly of cat fishes.

Kuthu choonda

Kuthu choonda is a rod and line gear with slight modification. The length of the pole was only 1.5 m and bamboo poles were commonly used (Fig. 141). One to two numbers of PP twines (1.0 to 2.0 mm) were twisted together and used as line. The length of the line is only 1.0 m and hook (No. of 6 to 8) was tied to the line. Small fishes were used as bait. Vala (*Wallagu attu*), eel, cat fishes were the main catch in this gear.

Long lines

Long line is a common fishing gear in riverine sector of central Kerala. It has a long main line (10 to100 m) and a number of small branch lines (10 to 50 Nos.). At the end of the branch line, the hook was attached. On the basis of operation the long lines are divided in to set long line and drift long lines (Fig. 142).

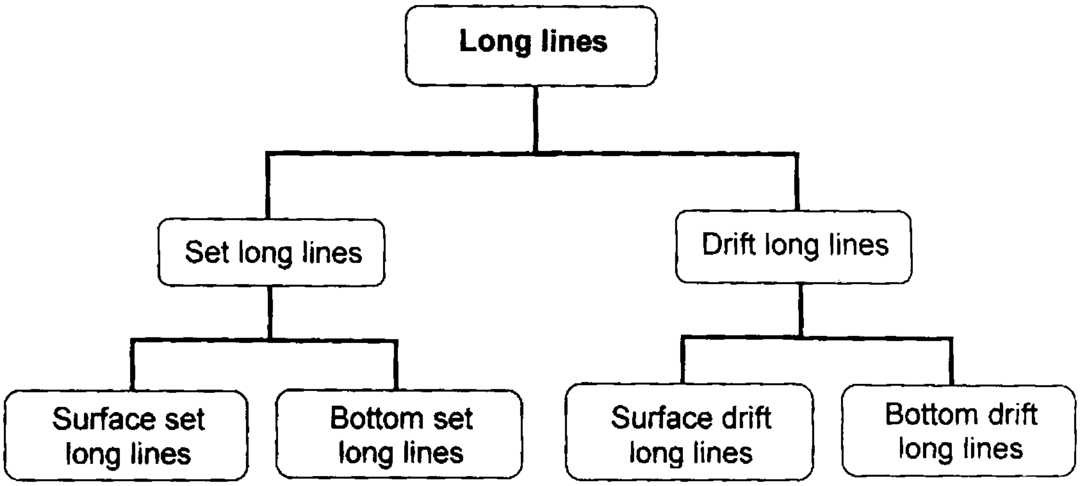


Fig. 142. Classification of long lines

Set long lines

Set long lines are set on the bottom or surface and they are not free to drift with the current. Two types of set long lines were operated in riverine sector. viz., bottom set long lines and surface set long lines.

Bottom set long lines: In the bottom set long lines were anchored or attached to the bottom. The gear was tied to roots of the trees or to the rocks or submerged objects in the water. Three to seven numbers of sinkers were attached to the gear. Locally available material like stone, brick and tile pieces were used as sinkers (Fig. 143).

Surface set long lines: In the surface set long lines, the lines were tightened to the rocks or twigs / roots of the neighbouring trees in such a way that free movement of the gear was arrested.

Drift long lines

Drift long lines are without fixed attachment to the bottom and which were free to drift along with the current. Drift long lines could be either floating or submerged type.

Bottom drift long lines: In the bottom drift long lines, one end of the gear was attached to the submerged obstacles like rocks, roots or the trees and the other end is left free (Fig. 144). In some gears, one sinker was placed near the anchored end of the gear. The gear was mainly for the bottom dwelling fishes like catfish and eel.

Surface drift long lines: In this type of gears, one end of the gear was attached to the twigs and the other end was free. One to five floats were attached to the gear, to facilitate its floating.

Small fishes, pieces of fish, tadpoles, earthworms and prawns were used as bait. Catfish, eel, vala (*Wallagu attu*) etc are the target fishes. Long lines were mainly operated by fishermen in areas where other gear cannot be operated.

Structure

Aayiram choonda is the common name used for the long line in the riverine sector of central Kerala. It consisted of a long rope called the main line, with attached branch lines carrying hooks and bait.

The main line material varied from place to place and station-to-station and immediately available suitable material was used as mainline of the gear (Table 76). In areas like Cheruvaloor, Kalady, Karakunnam, Kurumassery, Mannarkadu, Moolamattom and Ooramana, the main line was made of PA monofilament of 1.5 to 2.5 mm dia and 20 to 60 m long. In Bhoothathankettu, Illikal, Irumpanam, Kadumpidy, Kanjar, Kothamangalam, Moorkanadu, Mrala, Palamittam and Thattekkadu PP or PE twines of 2 to 3 mm dia were used as main line. In Karakunnu and Kurumassery areas different types of materials like PA monofilament, PP and PE twines were used as main line.

The number of branch lines varied from 7 to 25 numbers. The length of the branch lines varied from 1 to 5 m. The branch line was made of different materials in different stations. PA monofilament of 1.0 to 1.5 mm dia, PP twine of 1.5 to 2.0 mm dia, PE twine of 2.0 mm dia. and PA multifilament twine of 210Dx8x3/210Dx10x3 were used as branch lines. The distance between the branch lines was adjusted a little more than the double length of the branch line and is usually 1.0 to 2.0 m. The hooks of specification No. 7 to 12 were used in this lines.

In order to keep the master line afloat and for demarcating of line, each set of line was provided with a small plastic can or float attached to it.

Rock pieces were mainly used as sinkers in the bottom set long lines. Three to seven numbers of rock pieces weighing 100 to 500 g each were tied to the main line by using small pieces of PP or PE twine of 2 to 3 mm dia of 10 to 30 cm length.

Live baits like small fishes, prawns, earthworms and tadpoles and dead baits like pieces of fishes and chicken waste were used in long line operating in rivers of Central Kerala.

Operation

A unit consists of 1 to 5 sets of lines with a length of about 10 to 60 m were operated by a crew of 1 or 2 men. After reaching the fishing ground, the hooks were baited and the line was arranged across the river as a setline. The line was tied to the twigs or rock pieces on either side of the river. In fast lowing waters the line was never set across the river and instead the gear was set parallel to the water flow. In bottom set lines, 3 to 12 numbers of weights were attached to the main line. Granite stones, tile pieces or concrete pieces were used as sinkers.

In drift long line, one end of the line was attached to the twigs or roots of the plants in the rivers, and the other end was left free to drift. One to five numbers of floats were attached to the gear to facilitate floatation and also for locating the position of the gear.

The lines were hauled after 2 to 10 hours of soaking. The weight was lifted and the main line retrieved and pulled in by hand and coiled and kept in the craft. The hooked fish was removed and kept separately.

The entire operation took about 3 to 12 hours. In most cases, the fishermen waited till morning to start hauling of the line.

5.2.2. Traps

Traps and other miscellaneous fishing gears like urivala, vadivala, vallivala and spears are very common in the riverine sector of central Kerala. A number of such gears are operated from upstream to down stream areas. Several workers have described the indigenous gear used in Indian waters (John, 1936; Gopinath, 1953; Kurup and Samuell, 1985; Kurien and Sebastian, 1986). Different types of miscellaneous gears are reported by Hornell (1938) in Travancore and Malabar coast.

Traps are one of the important gears after gillnets and lines in the riverine sector. It is generally operated seasonally in the midstream areas of the rivers. It is very simple in construction and operation. Because of the simplicity in construction the fisherman fabricated most of the traps by himself. The shape and structure of the traps vary from station to station and river to river. Eventhough the basic construction is generally same the differences exist in the materials used and dimensions of the traps. Improvements in designs are suggested by Miyamoto (1962), Nair (1993), Rajan and Meenakumari (1982) and Rajan *et.al.* (1981; 1988).

In riverine sector two types of traps are recognised viz., filter traps and screen barriers. In filter traps, the water is filtered out and fish are entrapped and collected, and on screen barriers the fish is guided to the trap enclosure and collected by using scoop net. Nedelec and Prado (1990) classified traps according to fishing methods. Based on the method of trapping, shapes, position of entrance, materials used for making it, the traps are of several types.

Filter traps

Various types of filter traps were in use in different areas of the rivers and a number of local varieties were available in these rivers. Typically trap is a simple cylinder of closely set mid-rib slivers of palm leaflets or bamboo. It usually consisted of a cylinder of large size and a curved, fan shaped apron, the end of which was inserted into the mouth of the cylinder when the trap was placed in position (Baiju and Hridayanathan, 2000).

Water flows on to the apron and fishes or prawns that enter are led by the sides of the apron into the cylinder where they are entrapped. These types of traps were common in mid-stream areas during rainy season.

Aaro koodu

It is a type of trap mainly used to capture eel and vala (*Wallagu attu*). The length of the gear was 150 to 200 cm. The body of the trap was cylindrical in nature with a diameter of 30 to 50 cm. It is made of split bamboo pieces arranged in cylindrical fashion. Split bamboo slivers of 30-50 cm length, were tightened by using coir ropes (Fig. 145).

The tail end of the cylinder was tapered and closed by using the split bamboo. The other end of the trap was open and filtered with a cone like structure called *vakkoodu*. The *vakkoodu* was a fan like structure made of bamboo poles and steel rings. This fan like structure guided the fishes towards the trap. The outer most and inner most circles of the *vakkoodu* were made of steel rods. An opening was provided near the back end of the trap for collecting the trapped fishes, and it is closed by using a small door made of split bamboo.

Traps of the large size were used in areas like Ooramana and Peruvanmuzhy. The body of the trap was cylindrical and the length varied from 150 to 250 cm and the circumference extended up to 150 cm. The whole body of the traps was made of steel rods and pieces of bamboo. (Fig. 146). Galvanised iron rods were also used for the construction of traps in these areas.

Operation

The Aaro koodu was mainly operated during winter season. (June to September). The fishermen reached the fishing ground in the evening and kept the trap in the channels. The fish was guided to the trap enclosure by *vakkoodu*. Once the fish entered the trap, it cannot easily escape from the trap. During early morning, the fisherman examined the trap and collected the trapped fishes through the opening in the body. When the catch of the fish was high, the fishermen examined the trap every hour during night and also collected the fish during day time. The most important aspect was that the fishermen could collect the catch without disturbing the position of the trap.

Iruvaachi

It is a type of filter trap similar in many aspects to *Aarokodu*. The difference was that it had two *Vakkoodu* over on each end, so that fish can enter from both sides and it cannot escape from the trap. The operation of the gear is same as that of above.

Screen barriers

Screen barriers are commonly used in the down stream areas of the rivers and in backwaters. The screen barriers observed in riverine sector were made of split bamboo or arecanut slivers. Narrow split strips of bamboo or arecanut were laced together with coir rope in transverse rows. The length of these sleeves varied from 1.0 to 2.5 m depending on the depth of the water column. At short intervals, strong bamboo poles or some hard wood poles were used to give extra strength to this barrier and these poles were fixed by driving them into the mud. (Fig. 147). Such screens were arranged as a vertical wall of screening and set in a circular or rectangular fashion and each end was curved inward and brought closed together leaving only a narrow passage leading into the trap enclosure in between (Rajan, 1993). The fishermen could easily collect these fishes by using a scoop net.

5.2.3. Miscellaneous gears

Handpicking

Hand picking was a very common method of fish collection practiced in shallow waters of the river where the flow of the water was slow. Mainly ladies were engaged in handpicking. They dived into the water and collected the fish with bare hand and stored it in the basket or threw it into the land. The small children present in the land collected the catch and kept it in a pot.

Thettali (Cross bow or *Parangi pathi*)

Cross bow is very popular in fishing sports in European countries. It is made of plastic alloy and fibreglass compressed Limbs (www.hunting-fishing-gear.com).

The cross bow was extensively used in Cochin-Travancore areas in the beginning of this century (Hornell, 1938). Nowadays this gear is very rarely used as a fishing device. During the present study the gear was observed in certain areas mainly in the upstream and midstream areas of rivers. The bow was made of several thin wooden slivers (2 to 4) of arecanut tree. These slivers were tightened by using coir rope or metal wires and fitted to the rectangular opening provided in the forepart of a wooden butt. At the distal end of the butt a handle is provided and a trigger. Both ends of the sliver were connected by using a strong rope (Fig.

148). An arrow is fired from the bow. The arrow was made of wood with sharpened metal tips.

It was used for shooting the fish in rivers and backwaters. The fishermen constantly watched in the water for a fish. The trigger is pressed and the arrow released from the cross bow on locating the fish. This gear was mainly used for big sized fishes.

Plunge Basket (*ottal*) .

The plunge basket locally known as 'Ottal' was operated in shallow waters especially in tributaries and paddy fields when the water level is low. It was very common in rainy season. It consisted of a sub-conical, tapered cylinder with closely-set ribs of split bamboo. Both ends of the cylinder were open. The upper opening was narrower just wide enough to pass the arm. The lower opening was widely spread. The bamboo slivers were tightened together with coir ropes at every 20 to 30 cm so the ribs are kept in position. Height of the gears varied from 50 to 60 cm and the diameter at the bottom of the basket varied from 40 to 60 cm. The lower part of the ribs were pointed and projected. The upper opening of the gear was laced with coir ropes to give protection to the arm during operation (Fig. 149). Plunge basket used in the Malabar coast has been described by Hornell (1938).

The operation of the ottal was very simple. The fishermen moved through the water with the ottal and when any fish was located within striking distance, the *ottal* was skilfully dropped over the fish. The fisherman pressed the mouth of the ottal into the mud with one hand and passed the other hand through the narrow upper opening and collected the trapped fishes. The plunge basket was operated during day and night. In night, it was operated with the help of a light.

Vallivala

Vallivala was very common in shallow areas of the rivers studied. The gear was operated where the water is relatively calm and clear. In some areas it was called as *Vellavely*.

The gear consisted of a long coir rope of 70 - 100 m length. In this coir rope pieces of plastic carry bag of size 50 cm x 3 cm were fixed between the layers of ropes as shown in the figure (Fig. 150). The plastic pieces were fixed every 50 cm in the coir ropes. Only white plastic pieces were used for this purpose, because the glittering of the white coloured plastic pieces were thought to frighten the fish. In Bharathapuzha River, the same type of gear was in operation. However, here coconut leaves were used instead of plastic pieces. A similar type of gear was also reported by Kurup (1991) as *Kuruthola valikkal*.

Operation

The operation of vallivala was mainly during day time. Usually 5 to 7 fishermen were engaged in the operation of this gear. In preparation for the operation, two fishermen stood side by side at a distance of approximately 10 m. One end of the rope was tightened to the right leg of the left fisherman and the other end was tied to the left leg of the right fisherman. The fishermen then moved forward through the water and the ropes formed a semi-circular shape in water.

The other five members moved back to follow the gear as shown in figure. (Fig. 150). When the rope with plastic pieces moved thorough the surface of the water, the glittering of the plastic pieces frightened the fishes, which tried to dig into the bottom sand/mud. The fishermen identified the smashing of the mud and collected the fish with bare hand and put it into the folding of the dress (dhoti). This process was continued for 1 to 3 hours.

The life of the gear was about six months for the coir rope and 2 weeks for the plastic pieces. Every two weeks the plastic pieces were replaced.

The gear was mainly used for catching pearl spot (*Etroplus suratensis*). The average earning of this gear varied from Rs. 500 to 1500 per day.

Urivala

Urivala was a common fishing gear operated in most of the rivers. It was mainly used for catching crabs and prawns. It had a piece of circular webbing fixed on a ring of steel or cane of 50 to 100 cm dia. PA or PP webbings of 20 to 30 mm mesh size were used for this purpose. The webbing was attached to the steel ring by using PE or PP twines of 1 to 1.5 mm dia. Three or four PP twines of 2.5 to 3 mm dia were used as legs, one end of which was fixed on the circular ring at equal intervals. The length of the twine varied from 1.0 m to 3.0 m. (Fig. 151). A big piece of thermocole or plastic can was used as float, which was fixed at the end of the PP twine for locating the gear.

Operation

The gear was kept in the water with a weight of 250-500 g of granite piece in the centre of the gear. Pieces of fishes and chicken waste were used as bait, which was kept in the centre of the gear along with weight. The length of the float line were adjusted according to the depth of the water column.

In certain areas, the gear was tied using lines to the branches of nearby trees instead of using floats. The fishermen periodically examined the gear and collected the catch. The catch was mainly prawns and crabs.

Vadivala

This gear was operated in down stream areas of Muvattupuzha River. The net was 7.0 to 15.0 m long, 3.0 to 5.0 m wide with 30 to 50 mm mesh sizes. Material of webbing is PA multifilament with a twine size of 210Dx1x2. Selvedges of 60 mm to 200 mm mesh size of PA multifilament with twine size 210Dx3x2 or 210Dx3x3 were used in upper and lower parts of the gear. (Fig. 152). The head rope and foot rope were made of PP ropes of 6.0 to 8.0 mm dia. The middle portion of the gear was provided with a codend where catch was concentrated.

Ten to twelve bamboo poles were used in this gear. The length of the poles varied from 1.0 to 1.5 m. These poles were fixed between the head rope and foot rope. So the gear was kept open at all times. The poles at both ends were little longer than others (30 to 50 cm longer). These poles were fixed to the bottom of the river.

Operation

The gear was kept in the water against the water flow. The poles at both ends were fixed into the bottom areas of the water body. These poles were strengthened by providing additional support to the neighbouring trees or rocks. Water flowed through the gear and along with this the fishes also moved towards the cod end and they are entrapped. The backward movement of the fish was little difficult due to the presence of loose webbings in the middle of the cod end. The fishermen periodically collected the fishes by opening the codend or by lifting the gear itself.

This gear was operated in some other way also. Two fishermen were engaged in the operation of the gear. They hold the poles at both end and move along through the water and after sometime they came closer and closed the mouth of the gear when some fishes entered in the gear and the catch was collected. Catch comprises cat fishes, *Etroplus* sp., *Puntius* sp. and other miscellaneous fishes.

Spears

Use of spears has been reported in the fishing sector in earlier times by Hornell (1938). Only a few numbers of spears were in operation in the riverine sector of central Kerala during the period of study.

Kuthukol

Kuthukol was a type of spear seen in the riverine sector. It was made of wooden pole or iron rod of 2.0 to 2.5 m long. One end of the iron rod was pointed. The wooden pole was fitted with metallic arrow like pointer at the distal end (Fig. 153).

It was mainly used for collecting crab, prawns and occasionally fishes. When used to catch prawns the fishermen were careful not to damage the body of the prawns. In some gear, the other end of the rod was curved and this was used for collecting prawn and fishes from crevices.

Muppally

An arrow like fishing gear called muppally were in use for collecting of *Attu konchu (Macrobrachium rosenbergii)*. It has a long wooden pole, at the end of which a three forked arrow was fixed (Fig. 154). The pole is made of hard wood of length 2.0 to 2.5 m. Arecanut slivers were also used as poles. The arrow was made of steel rod. The total length of the arrow was 30 to 50 cm, out of which the length of forked end was 20 to 30 cm.

Operation

The operation was mainly conducted in the night for the capture of prawns and occasionally certain big fishes. The fishermen used a torch light with high beams for locating the prawns. The prawn was stuck using the *muppally* and the gear was pulled back to collect the catch.

Fish Aggregating Devices

The Fish Aggregating Devices (FAD) are very common in fishing industry all over the world. A number of studies have been carried out in different parts of the world on different types of FADs. (Wood, 1989; Cannizzaro 1999). In traditional fisherman, bundles of branches of trees like cashew nut tree and bamboo are used for the construction of FADs. In earlier time it was called as 'bush fishing' (Hornell, 1938)

The fishermen construct FADs mainly using branches of cashew nut trees (*Anacardium occidentele*) or branches of bamboos (*Dendrocalamus* sp.). The length of branches varied (2.0 to 3.0 m) according to the depth of the water column. These branches were fixing in the mud in the bottom parts of the river in an area of 15 to 25 m dia. After fixing the FADs, the fishermen wait for 20 to 30 days for aggregating the fishes. The submerged bundles of twigs or branches of trees make attractive hiding places for fishes. The movement of water in this area is little less compared to other areas of the water body and as a result a number of fishes aggregate in this area (Fig. 155).

After 20 to 30 days, the fishermen cover the FADs with the help of an encircling gillnet and then the tree branches are removed. Pushing the gear to the centre reduces the circumference of the gear and finally the fishermen collect the fish with hand or by using scoop net.

Stupefying fishing practices

Different types of stupefying fishing practices were observed in the rivers of central Kerala. Poisons and explosives were the common stupefying methods. This practice was mainly concentrated in the upstream and midstream areas of the rivers. Indiscriminate use of poison to collect fish from pools and refugial pockets where fish take shelter when rivers dry up, and dynamiting to collect fish in large numbers, would result in complete elimination of the fish species, since both juveniles and breeding fishes and other non-target species all fall prey to such destructive methods. (Remadevi, 1997). The use of explosive or poisonous substances have been banned under The Indian Forest Act, 1927. The Indian Fisheries Act IV of 1897 prohibited the use of poisons and explosives for the purpose of catching fish. The practice has, however, persisted throughout the province, especially in the hilly tracts.

Explosives

Explosives were a common stupefying method of fishing in the upstream areas of the rivers. The explosive material (*thotta*) was readily available in these areas as it was required for granite quarries and for frightening the wild animal away from the agricultural crops.

After lighting the explosives, they were thrown into the water. The effects of explosion affected all the aquatic organisms in a wide area and its environment. The dead and stupefied organisms afloat in the water surface, were collected by using small scoop net or by bare hand. In rivers like Chalakudy River and Karuvannoor River, this method was practiced in the down stream areas also.

Poisoning

Poisoning was observed to be very common in upstream areas where other fishing practices were difficult. It affects the ecological balance of the aquatic habitat, as all organisms in this area and nearby waters are affected.

The commonly used materials for this purpose were bleaching powder, lime, copper sulphate, Bordeaux mixture, nanchu *(Croton klosteschianus)*, and veli-avanakku (*Jairopha curcas).* As a result of poisoning, the affected species come out of the crevices and creeks in an unconscious stage and were then collected by a scoop net.

Electric fishing

Electric fishing was very common in most of the areas of the rivers. The equipment for the electric fishing mainly has three parts: a battery, a step-up transformer and a rod. Automobile battery was used for this purpose. The step-up transformer converts 12 volt current to 240 volt and with the help of the plastic pole the live terminal is dipped into water to pass the electric current for a second. As a result of this the fish, in the surrounding areas were narcotised or killed and float to the surface of water. The electro-narcoted and electrocuted fishes were collected using a scoop net or by bare hand.

Another type of electric fishing was also common in riverine sector. In this case, the high voltage electric line was passed across the river. A cycle chain was fixed at one end of an electric cable, and the fishermen fix the cable to the high voltage line by throwing the cycle chain to the line. The other end of the cable which is attached to a dry wooden pole was dipped into the river for a fraction of a second. The fishes which were electro-narcoted or electrocuted floated to the water surface and the fishermen collected them by using a scoop net. It is a very dangerous fishing practice, where many deaths were reported from different parts of the state due to accidental electrocution. In some areas electric current from nearby electric motor shed or nearby houses were used for this type of fishing.

Table. 76. Location-wise specifications of riverine long lines operated in Central Kerala

Place	Main line		Branch line		Hook size
	Material	Diameter (mm)	Material	Diameter (mm)	(No.)
Bhoothathankettu	PP	2-3	PP	1.5	7-10
Cheruvaloor	PA Mono	2	PA Mono	1-1.5	8-10
Illikkal	PE	2.5-3	PA Multi	210Dx8x3	7-8
		2.5	PE	2	7-10
	PP	3	PA Multi	210Dx8x3	8
Irumapanam	PP	2.5	PA Multi	210Dx10x3	8-12
		3	PP	1.5	8-10
Kadumpidy	PP	3	PA Mono	1	8-10
Kalady	PA Mono	1.5-2	PA Mono	1	7-8
Kanjar	PP	2.5	PA Mono	1	8-10
		2.5	PP braided	2	8-10
Karakkunnu	PA Mono	2	PA Mono	1	7-12
	PP	2-3	PA Mono	1	8-12
Kothamangalam	PP	2.5	PA Mono	1	8-10
Kurumassery	PA Mono	2	PA Mono	1	7-10
	PP braided	2.5	PA Mono	1	10
Mannarkadu	PA Mono	2	PA Mono	1	8-12
Moolamattam	PA braided	2.5	PE	2	8-10
Moorkanadu	PP	2.5	PP	1.5	7-10
Mrala	PP	3	PP	2	7-10
Ooramana	PA Mono	1.5-2	PA Mono	1	6-10
Palamittom	PE	2.5-3	PP	2	7-8
	PP	2-3	PP	1.5	7-8
Thattekkadu	PP	2.5-3	PA Mono	1	7-10

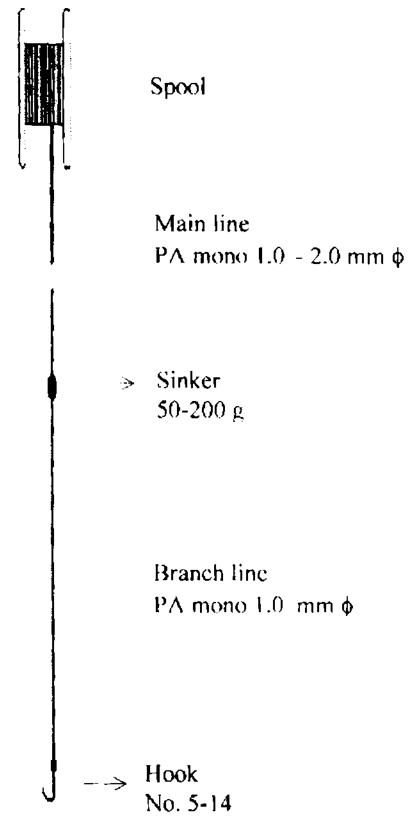


Fig. 135. Eruchoonda with single hook

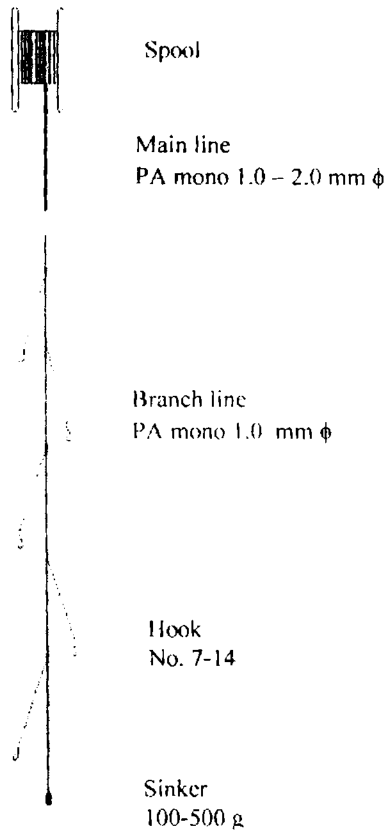


Fig. 136. Eruchoonda with multiple hooks

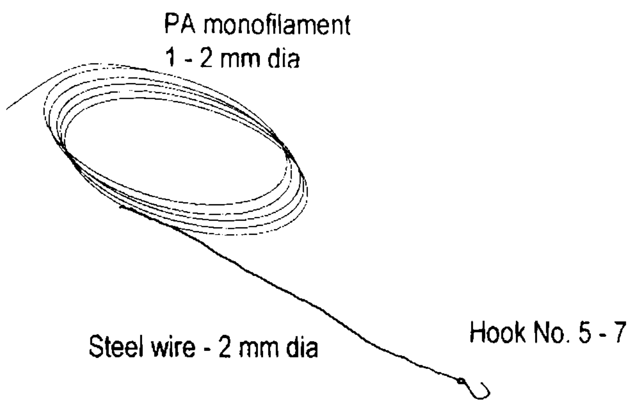


Fig. 138. Vettuchoonda

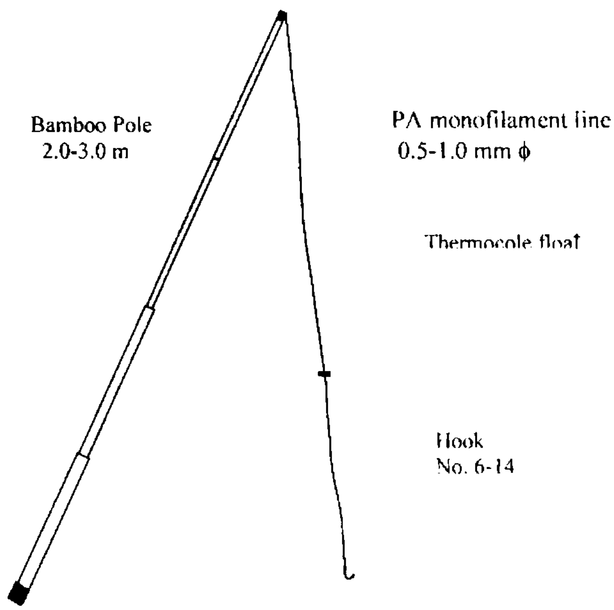


Fig. 139. Rod and line – Vadi chunda

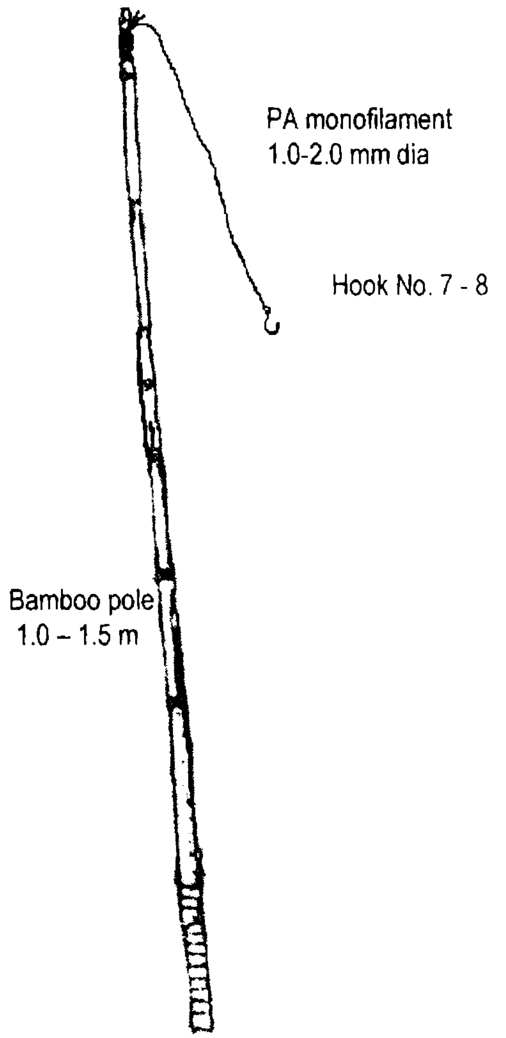


Fig. 140. Madachoonda

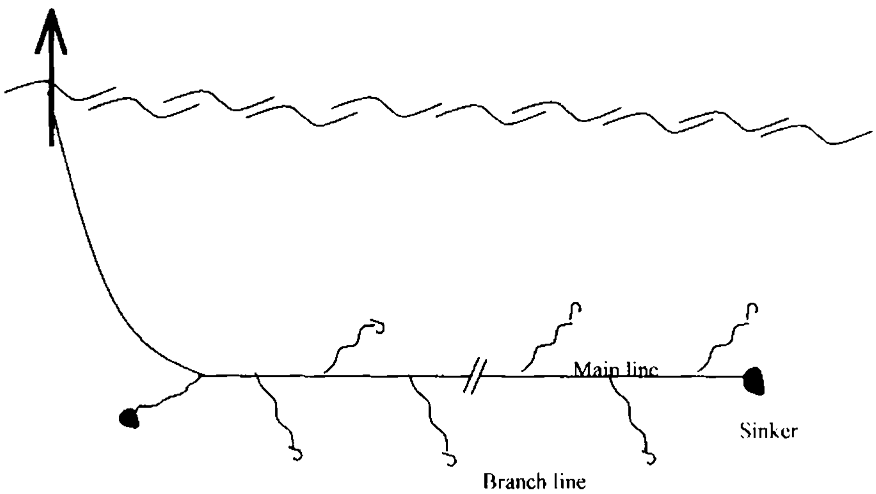


Fig. 143. Set longline

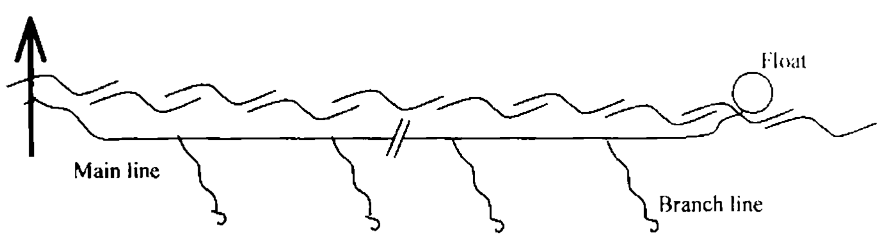


Fig. 144. Drift longline

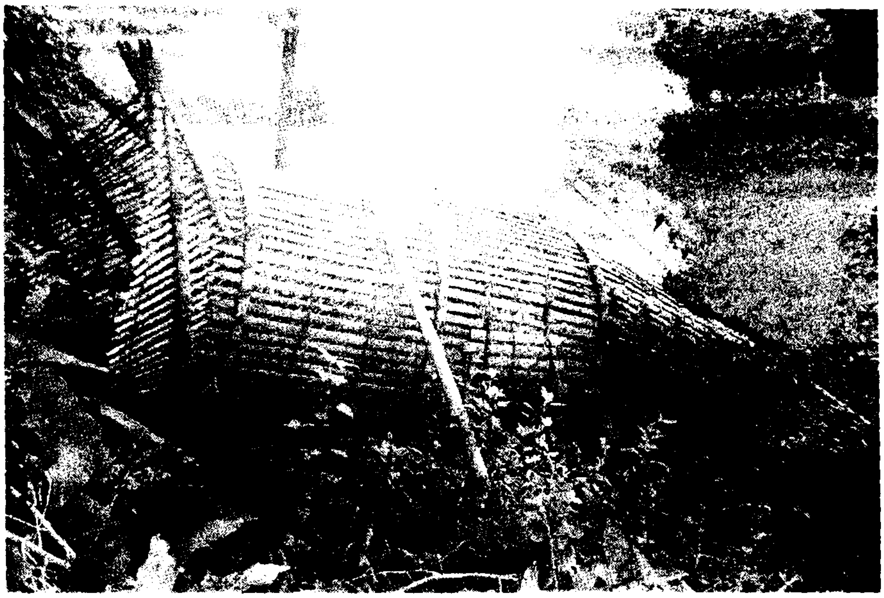


Fig. 145. Aarokoodu (Indigenous)

Fig. 146. Aarokoodu (Modern)

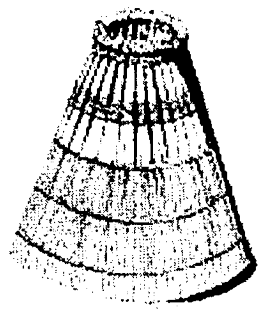


Fig. 149. Plunge basket

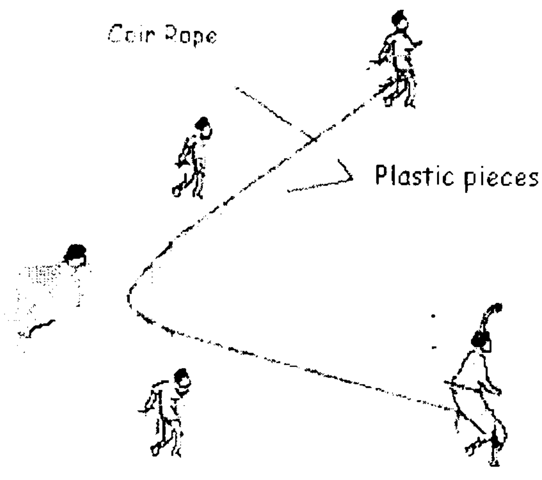


Fig. 150. Vallivala

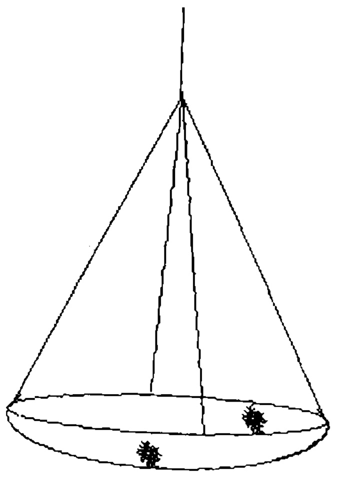


Fig. 151. Urivala

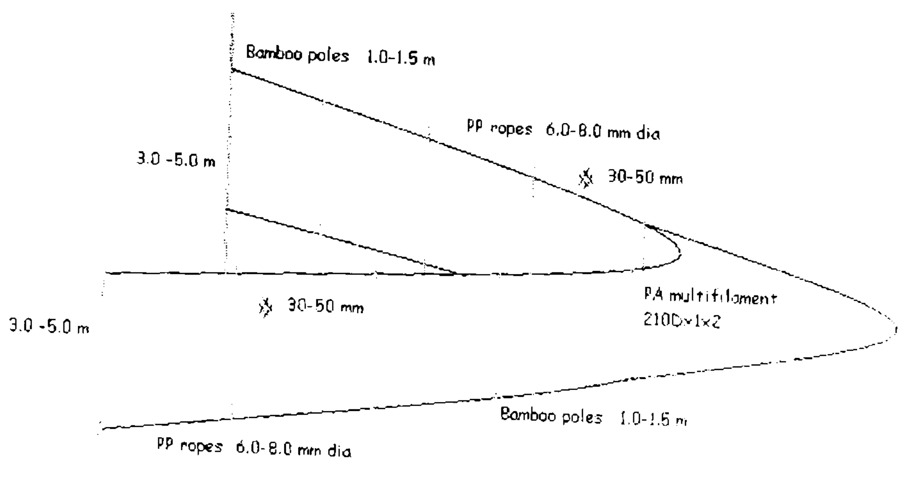


Fig. 152. Vadivala

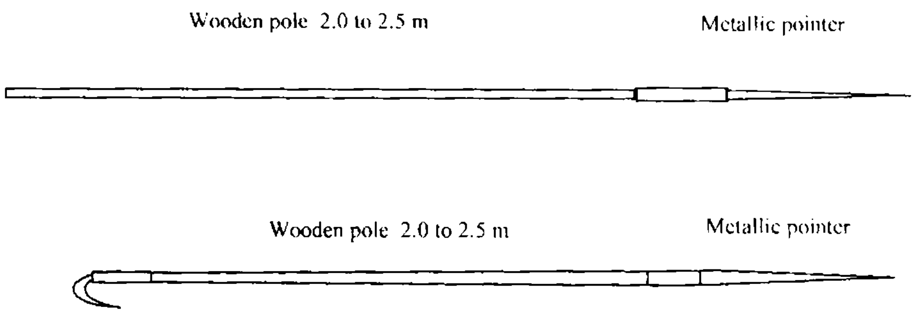


Fig. 153. Kuthukol

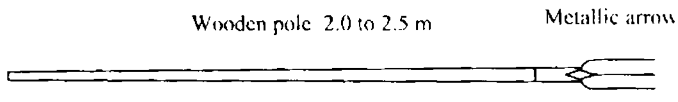


Fig. 154. Muppally

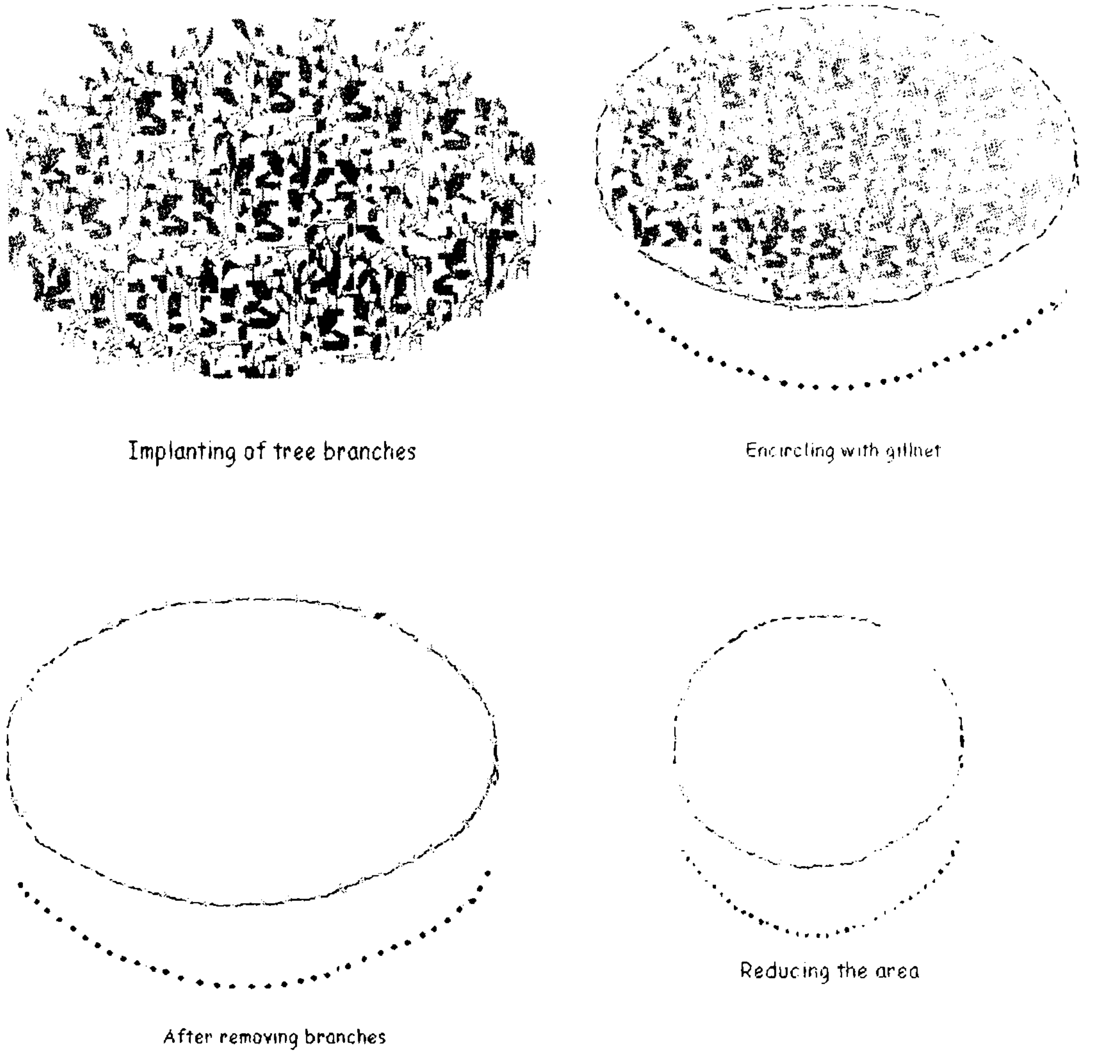


Fig. 155. Operation of FADs in rivers of Central Kerala

Chapter VI

SUMMARY AND RECOMMENDATIONS

Chapter VI

SUMMARY AND RECOMMENDATIONS

Rivers and reservoirs of India harbour a rich and varied spectrum of fishes exceeding 400 species, which include commercially important fishes such as Indian major carps, mahseer, minor carps, snow trouts, peninsular carps, catfishes, featherbacks, murrels and a number of exotic species. Rivers in Kerala has a total water spread area of 85,000 ha. Among the 44 rivers flowing through the state, only three are flowing eastwards (Bhavani, Kabbini and Pambar) while all others flow westwards and join the Arabian Sea. The total length of rivers and canals in the state is 3092 km.

The fish and fisheries play a crucial role in Kerala's economy, employment generation, food security and well being of its people. The inland fish production of Kerala was estimated at around 73,900 t against 5,75,500 t from the marine sector (Sudarsan, 2000). The successful technological advancements in marine sector cannot be applied to the inland fisheries directly. In inland sector low energy fishing techniques need to be adopted to upgrade the artisanal fishing gears and practices. Studies are required to improve the performance of these fishing techniques from the economic and ecological points of view, for the development of inland fishing communities and to ensure sustainable livelihood opportunities.

Fishery resources of the inland water areas are still exploited by traditional or artisanal fishing gears and methods. Depending on targeted species, nature of the fishing ground, and environmental factors, availability of materials and skills, a wide array of traditional fishing gear has been developed over the centuries. With the advent of new or improved fishing techniques, many of the fishing techniques prevalent earlier has become displaced or were rendered uneconomical. No detailed investigations has been attempted so far to study the design, construction and operation of riverine fishing gears of Central Kerala.

In the present study, results of investigations conducted during 2001-2002 on riverine fishing gears of Central Kerala are presented along with detailed description of fishing gears, their distribution and operation, covering aspects of selectivity and operational economics.

The content of the thesis is organised into 5 chapters.

Chapter I

Chapter I gives an introduction to the topic of the study highlighting the relevance of the study and reviews of the existing literature on fishing gears and practices in riverine sector and sets out objectives of the study.

The objectives of the study included (i) a comprehensive study of the riverine fishing gears of central Kerala; (ii) classification and documentation of the design, construction, method of operation of important riverine fishing gears operated at present in the rivers of central Kerala; (iii) comparative efficiency of major fishing gears and selectivity of gillnet; (iv) the economics of operation of major inland fishing gears; and (v) the scope for upgradation and optimization of gillnet for the judicious exploitation of 'Kooral' (*Hypselobarbus curmuca*), a predominant commercial species, in the rivers of Kerala.

Chapter II

The chapter II deals with the Materials and Methods used for the conduct of the investigations. In this chapter the area and the rivers selected for the study, reasons for the selection process and methodologies used for survey of riverine fishing gaear and investigations on design, structure and operation of different gear systems are presented.

Methodology used for the selectivity studies of gillnets, most important and populat fishing gear, and economic analysis of the gillnet and the cast net operations are briefly discussed in this chapter while detailed descriptions are given in sections dealing with respective studies.

Chapter III

The chapter III discusses gillnet and its operation. Gill netting is one of the simplest and oldest methods of fishing. They are the most widely operated fishing gear in the rivers of Central Kerala. Gill netting being a low cost fishing method is of special interest for artisanal fisheries. Twenty different types of gillnets are operated in this sector. Design, construction and methods of operation of these gears are discussed here. The technical specifications and design drawings, showing construction of the gear are furnished in this chapter.

A new design of gillnet optimised for the species *Hypselobarbus curmuca*, which is a commercially important species in the rivers of Central Kerala was, developed by determining optimum mesh size and hanging coefficient for harvesting the optimum size group of this species. The mesh selection parameters with respect to *Hypselobarbus curmuca* were determined by both length measurement and girth measurement. Selection factors thus determined were used for the estimation of optimum mesh size for the exploitation of *Hypselobarbus curmuca.* The result of the study shows that, gillnets for the exploitation of the most desirable size group (210 mm in total length) of *Hypselobarbus curmuca* was with 48 mm mesh size.

Three nets of different hanging coefficient of 0.4, 0.5 and 0.6 were field tested to assess the comparative efficiency of the gear. Statistical analysis using ANOVA techniques for numbers and weight of the species *Hypselobarbus curmuca* were studied. The catching efficiency was significantly different ($p<0.005$) between gillnets with different hanging coefficients. Gillnet with hanging coefficient of 0.6 showed higher catching efficiency compared to gillnet with other hanging coefficients.

Economic analysis of the gillnets was carried out in different regions of the river Muvattupuzha. The cost and earning studies applying the tools profitability ratios and break-even point for different areas during different months were studied. Average return on capital investment at different stations ranged from 194.13 % to 339.69 %. The percentage of return on turnover ranged from 24.62 % to 32.74% and the break-even point ranged from 2.05 to 3.06, among different stations in the study area.

Catch per hour, catch per haul and catch per 1000 m^2 area in respect of gillnets ranged from 0.39 to 0.52 $kg.h^{-1}$, 3.88 to 5.59 $kg.haul^{-1}$ and 8.19 to 18.10 $kg.km^{-2}$ among different stations in the selected study area. Earnings through gillnet operations ranged from Rs. 16.66 to Rs. 23.11 per hour during the study period.

Statistical analysis of catch and earnings showed significant difference between months ($p<0.001$) and between stations ($p<0.001$). Significantly higher catch and earnings were obtained during the months of June and July.

Chapter IV

Chapter IV deals with cast nets. The origin and evolution of cast net has been briefly described in the introductory part. Cast nets known as "*veesuvala*" in vernacular are well adapted for the capture of small shoaling fishes. The design, construction and operational details of the gear are described in detail in this chapter. The cast nets are classified into two based on the structure of the gear: (i) Stringless cast net and (ii) Stringed cast net. During the course of study, it was observed that the local fishermen had replaced PA multifilament with PA monofilament in cast nets in some areas.

The economic analysis of cast net operations were conducted in five different areas of Muvattupuzha River. Profitability ratios and break-even point for different areas were worked out and presented. Average return on capital investment for cast net operations ranged from 2055.53 to 3206.78 %. The highest percentage of return on turnover for the gear recorded was 41.61% and minimum of 31.44%. The highest return on total cost was 71.26 % and the lowest 45.86 % for different stations with an average value of Rs. 47.44%. The return on variable cost ranged from 1233.32 to 1910.27 %. The return on operational cost ranged from 40.00 to 69.95 % with an average value of 55.15 %. The highest break-even point was 2.18 and the lowest 1.40, among the different stations.

Chapter V

The chapter V deals with fishing lines, traps and other miscellaneous gears.

Hooks and lines are among the simplest of fishing gear. Different types of lines were observed during the study. The lines are classified in to (i) Hand lines, (ii) Rod and Lines and (iii) Long lines. The design, construction and operation of lines are described in detail with diagrams in this chapter. Three designs of hand line, three designs of rod and lines and two designs of long lines were operated during the study. Two types of traps are operated seasonally in the rivers of Central Kerala. The design and operation of these traps are explained with diagrams. A number of miscellaneous gears like *Vallivala, Urivala, Vadivala*, and different types of spears are explained with diagrams. Fish Aggregating Devices (FAD) are practiced in certain areas of the rivers. Different types of stupefying fishing practices like use of explosives, poisons and electric fishing are also discussed in this chapter.

Recommendations

- An optimum mesh size (stretched) of 48 mm is recommended for commercial harvesting of the species *Hypselobarbus curmuca*, prevalent in rivers of Central Kerala, on a sustainable basis.
- Hanging coefficient of 0.60 is recommended for gillnets for efficient harvesting of the species *Hypselobarbus curmuca*.
- The study has brought out that the months June - July are profitable for gillnet operation and months April and June - August for cast net operations, in the rivers of Central Kerala. This findings will be useful for riverine fishermen for deployment of appropriate gear systems during different seasons to ensure profitability of fishing operations.
- Further detailed studies are required in other parts of Kerala to get comprehensive picture of the present status of the riverine fishing in Kerala.

- Selectivity studies need to be conducted in respect of other riverine gears like cast net, lines and traps to facilitate introduction of conservation measures.
- The existing gears need to be upgraded and standardised incorporating optimum mesh size and design features for different target species and fishing zones, in order to protect juveniles and non-target species.
- Emphasis has to be given to promote eco-friendly fishing practices in the riverine sector and urgent measures may be taken to control the fishing practices like poisoning, use of explosives and unscientific conduct of electric fishing.
- Participatory management approach need to be promoted for conservation of riverine resources involving fishermen communities and educating them in sustainable fishing practices.

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