ENVIRONMENTAL STUDIES OF SOME SELECTED WETLANDS IN MALABAR WITH SPECIAL REFERENCE TO BIRDLIFE

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in Zoology

By

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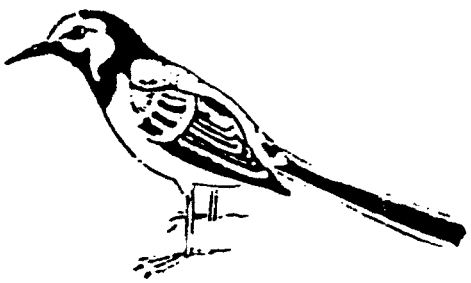
CERTIFICATE

This is to certify that this thesis entitled ***'Environmental Studies of some Selected Wetlands in Malabar with special reference to birdlife'*** is an authentic record of the bonafide research work carried out by Shri.George Mathew under my supervision and guidance and that neither this thesis nor any part of it has previously formed the basis for the award of any degree or diploma.

February 2002
Chennai

Dr. D.N. Mathew



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Introduction

CHAPTER I

INTRODUCTION

An ecosystem is basically an energy producing system whose components have evolved together over a long period of time. The boundaries of the system are determined by what forms of life can be sustained by the environmental conditions of that particular region. The system functions through the plant and animal populations present in it.

Wetlands are among the most important ecosystems of the earth. They are valuable as sources, sinks and transformers of a number of chemical, biological and genetic materials. Wetlands are sometimes described as the "kidneys of the landscape" for the functions they perform in hydrologic and chemical cycles, and as the downstream receivers of the wastes from both natural and human sources. They have been found to cleanse polluted waters, prevent floods, protect shorelines and recharge ground water aquifers. Apart from that, wetlands play major roles in the landscape by providing unique habitat for a wide variety of flora and fauna.

Of the total area of the globe, 6.4 percent is covered by wetlands (Maltby & Turner, 1983). The 1971 'Ramsar Convention on Wetlands of International Importance' defines wetlands as areas of marsh, fen, peat land

or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salty including areas of sea water, whose depth at low tides does not exceed six meters. Marshes, swamps, jheels, bogs, bheels, reed-beds, lagoons, mangroves, backwaters, estuaries, large ponds, and lakes are terms used for wetlands in Ali and Ripley (1983). Wetlands are ubiquitous, found on every continent except the Antarctic and in every clime from the tropics to the tundra (Cowardin *et. al.* 1979). They are very unstable when compared to other ecosystems and change according to the changes in season, vegetation and the rate of sediment formation. Wetland communities are not climax; they are transitional from water to terrestrial community. Smith (1980) describes wetlands as a half way world between terrestrial and aquatic ecosystems exhibiting some of the characteristics of each.

Wetlands are ecotones, since they are transition zones between two adjacent ecological communities. This position often leads to high biodiversity. Some wetlands are considered to be the most productive ecosystems on earth.

The wetlands of India are deteriorating both qualitatively and quantitatively due to human intervention. Wetlands are disappearing at an alarming rate. Large areas have been filled for housing and industry or drained for agriculture causing habitat destruction and elimination of a

Plate I

Picture 1. Azhingillam (during summer)

Picture 2. Azhingillam (during winter)

large number of animal and plant species. The quality of a particular environment is reflected by the density and diversity of its biota. Animals and plants can act as indicators of the nature of the environmental conditions. Since wetlands attract many kinds and numbers of birds the changes in bird community structure in wetlands indicate the change in environmental conditions.

Wetlands are stressed by many factors. Growing demand for food as a result of increasing population has led to a substantial increase in the production of agro-chemicals like pesticides, herbicides and fertilizers. Some of these lead to environmental pollution. Decomposition of animal and plant materials, domestic and industrial effluents, sewage and municipal wastes can all cause pollution. Construction of dams, land reclamation, removal of topsoil etc. are other factors stressing the wetlands.

The importance of wetlands is now being recognized and translated into protection laws, regulations and management plans. In Kerala, the increasing demand of land for residential purpose has resulted in a rapid decrease in the wetland area particularly paddy fields. Being one of the most populated states of India, this demand is expected to increase with time. More and more wetlands are being drained to build large housing and industrial complexes, playgrounds and brick kilns. Cash crops like

Plate II

Picture 3. A view of the study area - Elathur

coconut, arecanut, rubber, etc. are planted in wetlands creating more dry land.

1.1. Objectives

The objective of the present study is the assessment of the ecological health of some selected wetlands in and around Kozhikode, Kerala with special reference to birds. The work was started at the three selected sites viz., Azhingillam, Elathur and Kadalundy in April 1993 and concluded in September 1996. During the years 1993-1995 all the study areas were surveyed for the following parameters of bird populations:

(a) quality and quantity of birdlife.

(b) species diversity.

(c) similarity between the habitats.

(d) changes in species composition of birds over the period of time.

(e) monthly fluctuations in comparative abundance of each species.

After the first two years of observation it appeared that the Azhingillam plot, which had much more varied conditions of physiography and vegetation, had much better biodiversity than the other two plots. A hypothesis was formed that the plot at Azhingillam had the most diverse bird community among the three areas of work selected here.

Plate III

Picture 4. Kadalundy (during high tide)

Picture 5. Mangroves at Kadalundy

In the second phase of the study i.e. during the years 1995-1996, monitoring of some of the water quality parameters were carried out. The parameters under investigation were:

(a) pH

(b) Dissolved oxygen (DO)

(c) Biochemical oxygen demand (BOD)

(d) Nitrite nitrogen

(e) Phosphate phosphorous

(f) Primary productivity

These parameters were related to the biological diversities of the study areas.

1.2. REVIEW OF LITERATURE

Studies of Indian wetlands were started after the establishment of the Ramsar Convention in 1971. Birds are a group, which have been studied extensively. Much information has been documented on the field characteristics, status, distribution and general ecology of many species of the Indian birds. These included many wetland species of birds (Ali, 1949, 1962,1968, 1969; Ali and Ripley, 1949,1983,1987). Odum (1983) observed that of the wetland habitat, coastal freshwater marshes supported the largest population of birds. The Government of India initiated a national inventory of wetlands, entitled the All India Wetland Survey, in the late

1960s. A large number of sites were listed and the biota described and updated over the years (Govt. of India, 1990a,1990b).

Zoological Survey of India conducted many surveys and studies on the resource base of several wetland biota. Among the wetland sites covered by them were the Chilka lagoon, Orissa (1916-17, 1983-89), Salt Lakes Swamp (1963-69), the peri-urban wetlands of Calcutta and Wetlands in North and South 24 Parganas district, West Bengal, Wetland in and around the twin city of Hyderabad-Hussain sagar and Osman Sagar, among others. The Z.S.I. surveys covered Kabartal (Bihar), Ujni (Maharashtra), Astamudi (Kerala), Kolleru (AP), Luktak (Manipur) and Renuka (Himachal Pradesh), all wetlands which are identified by the Ministry of Environment and Forests for special conservation action (MOEF, 1990, 1990b).

The Bombay Natural History Society has conducted studies on migratory and residential waterfowl at Keoladeo Ghana,(Ali and Vijayan 1983,1986), Chilka lake, Kolleru Lake and Point Calimere. The society completed a decade-long (1980-90) ecological study of the Keoladeo Ghana National Park (Vijayan,1986, 1991).

Studies on the wetlands of Gujarat and Rajasthan were carried out by Gole (1984) in an attempt to identify the important wintering sites of the Bar-headed Goose; the Demoiselle Crane and the Common Crane. In

January 1987 a concerted effort was made to carry out simultaneous waterfowl counts at wetlands throughout India, as part of a major international waterfowl census in Southern Asia organized by the International Waterfowl Research Bureau. Eversince, the Asian waterfowl census is held every year and since 1992-93 the Asian counts are coordinated by the Asian wetland Bureau, Kuala Lumpur, Malaysia.

Madras Naturalist's Society has conducted an ornithological Study of the Pitti Island, Lakshadweep in 1991 and recommends that the tern population of the island be protected since it is the breeding ground for four species of terns. Mathew and Gandhi (1998) worked out a prioritisation of the biota of the various Lakshadweep Islands.

In the other parts of the world, a number of studies have been conducted on the distribution, migration and ecology of the wetland birds (Pitelka, 1979; Harris,1967; Salo, 1975; Spans, 1978; Brown and Gaskin, 1988). The study of bird species diversity has been concerned primarily with nesting bird communities (Mac Arthur & Mac Arthur, 1961; Recher, 1969; Karr, 1977; Roth, 1977; Smith and Mac Mahon, 1981). Mac Arthur and Mac Arthur (1961), Karr and Roth (1971), Willson (1974) and Roth (1976) studied the relationship between vegetation structure and the avian species number in their respective study areas and found out that avian community diversity is related to vegetational complexity. Several studies

have been conducted on the seasonality, abundance, landuse, dynamics, energetics and ecological succession of the bird populations (Fogden, 1972; Herman and Douglas, 1973; George and Barbara, 1974; Peter, 1978; Bell, 1982; Bongiorno, 1982).

The occurrence of waders on some estuarine habitats along the Pacific coast has been discussed by Page *et al.* (1979) and those of tidal mudflats of Costa Rica by Smith and Stiles (1979). The status and population of palearctic waders that winter in tropical Asia and Australia are mentioned since 1983 (Parish, 1985). Population estimates of breeding birds in North Dakota was carried out by Stewart and Kantrud (1972, 1974).

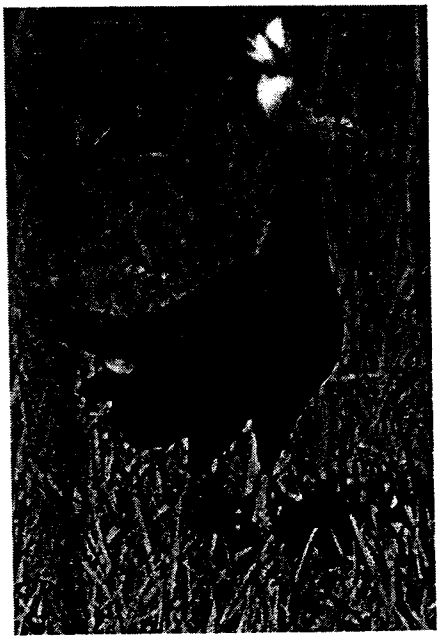
The ecology, management and conservation of the birdlife of fresh water marshes in the new world have been discussed in detail by Weller and Spatcher (1965), Weller (1981) and Scot (1982). While the ecology of island waters and estuaries are described by Reid (1961), Chapman (1977). The ecology and migrant shorebirds of Seychelles Islands have been discussed by Feare (1977, 1979).

In Kerala the Asian Wetland Bureau surveyed about 20% of the wetland covering 20,000 ha. and over 25,000 birds were recorded as a part of the International Water fowl census (Joost Van der Ven, 1987). Ecological studies of the birds of selected wetlands in Kozhikode and Malappuram districts were carried out by George Mathew (1988), Ebrahimkutty (1988),

Rajan (1989), Ashraf Mayan (1993). A study of the coastal wetlands as habitats of population of avifauna was carried out by Kurup (1989). A study conducted by Nameer (1992) of the birds of Kole Wetlands in Thrissur shows that the wetlands are attractive habitat for waterfowl.

A number of studies have found that the wetlands of stagnant or continuously deep water have low productivities. While wetlands that are slowly flowing, strands or are open to flooding by rivers have high productivities. Brinson, Lugo and Brown (1981), Moore and Bellamy (1974) have shown that bogs and fens are less productive than most other wetland types. Flooding of the riparian wetlands has been found by Brinson *et al.* (1981) to increase productivity. The important factors that control primary productivity are tidal run off and water chemistry factor. Carter *et al.* (1973), Lugo and Snedaker (1974), Reader (1978) found that soil nutrients limit primary production. Grazing, parasites and toxins were found by de la Cruz (1978) to limit primary produciton. Gorham (1974) found that nitrogen limitation also influenced wetland productivity.Other Studies have shown that primary productivity depends on hydrologic and nutrient conditions. Carter *et al.* (1973), Burns (1978), Conner and Day (1976), Conner, Gosselink and Parrondo (1981). The relationship between hydrology and ecosystem primary productivity has been investigated by several workers (Conner and Day, 1976; Mitsh and Ewel, 1979; Brown, 1981).

Nutrients like phosphorous and nitrogen are carried into wetlands by hydrological inputs of precipitation, river flooding, tides and surface and groundwater inflows. Outflows of nutrients are controlled primarily by the outflow of water. Studies conducted by Valiela and Teal (1974) and Smart and Barko (1980) have shown that salt marsh vegetation is primarily nitrogen limited. Mendelssohn (1979) found ammonium to be the dominant form of inorganic nitrogen in salt marsh intertidial water in North Carolina. Phosphorous is often a nutrient, limiting plant growth. But in salt marsh soils, it accumulates in high concentrations and does not limit plant growth. Pomeroy *et al.* (1972), Broome, Woodhouse and Seneca (1975a) found that only concentrations of extractable phosphorus and zinc in the soil were correlated with plant biomass. Studies conducted by Sloey, Spangler and Fetter (1978) revealed that nutrients detained in the biomass account for only about 20% of the total nutrients detained in the marsh. Wetland vegetation often acts as a nutrient pump, taking up nutrients from the soil, translocating them to shoots and releasing them on the marsh surfaces when the plant dies(Klopatek ,1978).



Chapter II

Study Area

CHAPTER II

THE STUDY AREA

The study areas are situated in three wetlands in the western sea board of the districts of Malappuram and Kozhikode in Kerala State, Southern India.

Kerala has almost all forms of wetland types because all the natural attributes like geology, physiography, climate, rainfall and the natural boundaries favour their development. The long and irregulr coastline on the west, low-lying coastlands, the tall mountains of the Western Ghats in the east, sloping terrain, high prevailing rainfall, and the large number of rivers are some of these attributes. Kerala leads all the other states in the country having the highest area under wetlands ie. 63% of natural and 5.42% of artificial wetlands, while figures of the all India are 0.45% and 0.02% respectively (MOEF, 1990).

In the prsent study, three wetland areas namely Azhingillam and Kadalundy in Malappuram and Elathur in Kozhikode districts were selected for monitoring the changes in bird population and water quality parameters. These selected areas represent three different types of wetlands, which are commonly found in and around Kozhikode.

2.1. Climate and rainfall

All the three study areas have humid climate with hot summer season extending from March to May. The most important rainy season is during South West monsoon, which sets in the first week of June and extends upto September. The northeast monsoon extends from second half of October to November. From October onwards temperature gradually increases to reach the maximum in May, which is the hottest month of the year. The mean maximum and minimum temperature at Kozhikode for the entire study period are given in table 2.1. Monthly rainfall in Kozhikode during the study period is given in table 2.2. Details of the climate of Malabar are given by Logan (1887) and Gaston *et al.* (1979).

2.2. Azhingillam

Azhingillam (11°12'N 75°52' E) lies about 15 km Southeast of the city of Calicut now known as Kozhikode. It is located in the Malappuram District. It is a fresh water jheel of 34 ha which was a paddy field at the turn of the century. Now the entire area is inundated during the monsoon and exposed and dry in summer. The clayey soil is dug up for making bricks, every summer season. This activity has resulted in the formation of large ponds and pools into which water from adjacent areas drains. The ponds and pools so formed do not dry up during the summer season.

Table 2.1. Monthly mean, maximum and minimum temperature at Kozhikode in degree celsius (1993-1996)

Years \ Months		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1993	Max.	31.4	31.9	32.6	33.4	33.4	30.2	28.7	29.1	30.1	30.5	31.6	31.5
	Min.	21.4	22.8	25.1	26.2	26.3	24.6	23.5	23.8	24.0	24.1	24.1	23.0
1994	Max.	32.0	32.1	33.0	32.5	32.8	29.1	27.8	28.8	30.7	31.3	32.1	32.0
	Min.	22.9	24.0	25.4	25.5	26.1	23.7	22.9	23.6	23.8	23.9	23.9	22.3
1995	Max.	31.9	32.7	33.1	33.5	32.8	30.3	28.5	28.9	30.1	31.6	31.2	32.0
	Min.	22.6	24.3	25.2	25.9	26.0	24.8	23.6	24.3	24.5	24.5	24.0	21.6
1996	Max.	32.0	32.6	33.4	32.8	32.9	30.0	28.4	28.8	29.6	30.6	32.1	31.9
	Min.	22.8	23.5	25.6	26.1	26.4	24.5	23.7	23.8	24.2	23.6	24.3	22.4

Source: Meteorological Centre, Thiruvananthapuram.

Table 2.2. Monthly Rainfall (in mm) of Kozhikode (1993-1996)

Months / Years	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1993	0.0	0.0	0.8	9.9	148.2	794.7	786.7	286.2	41.4	372.3	166.9	42.1	2648.9
1994	0.0	0.0	53.8	187.4	59.5	1083.5	1467.1	461.2	177.7	446.9	83.4	12.9	4033.4
1995	2.2	0.0	0.0	67.5	249.9	751.3	726.9	413.6	251.9	185.8	50.3	0.0	2699.4
1996	0.0	0.0	54.7	42.2	29.1	799.5	872.6	324.6	317.7	303.0	28.1	76.4	2847.9

Source: Meteorological Centre, Thiruvananthapuram.

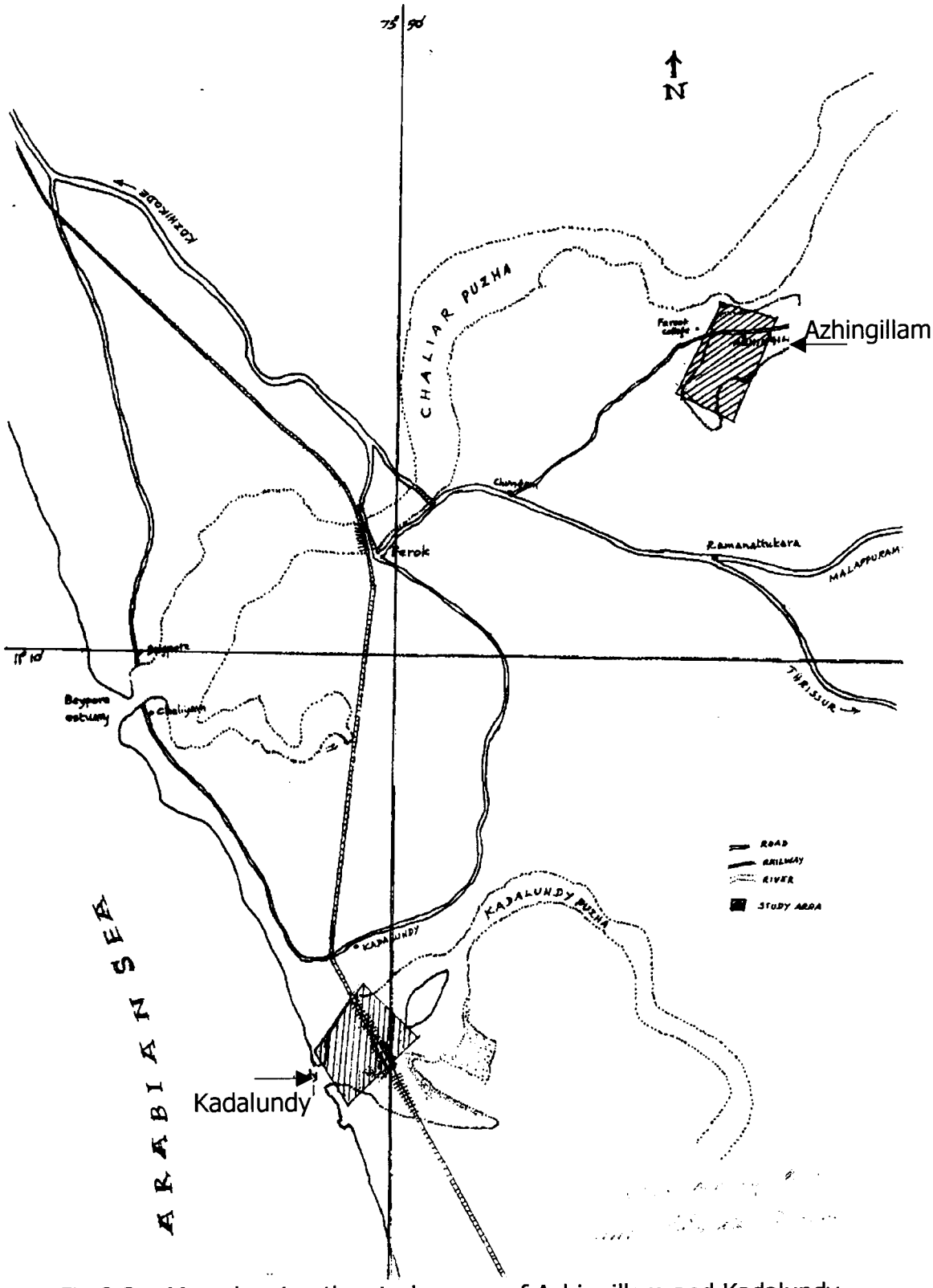


Fig 2.2 – Map showing the study areas of Azhingillam and Kadalundy

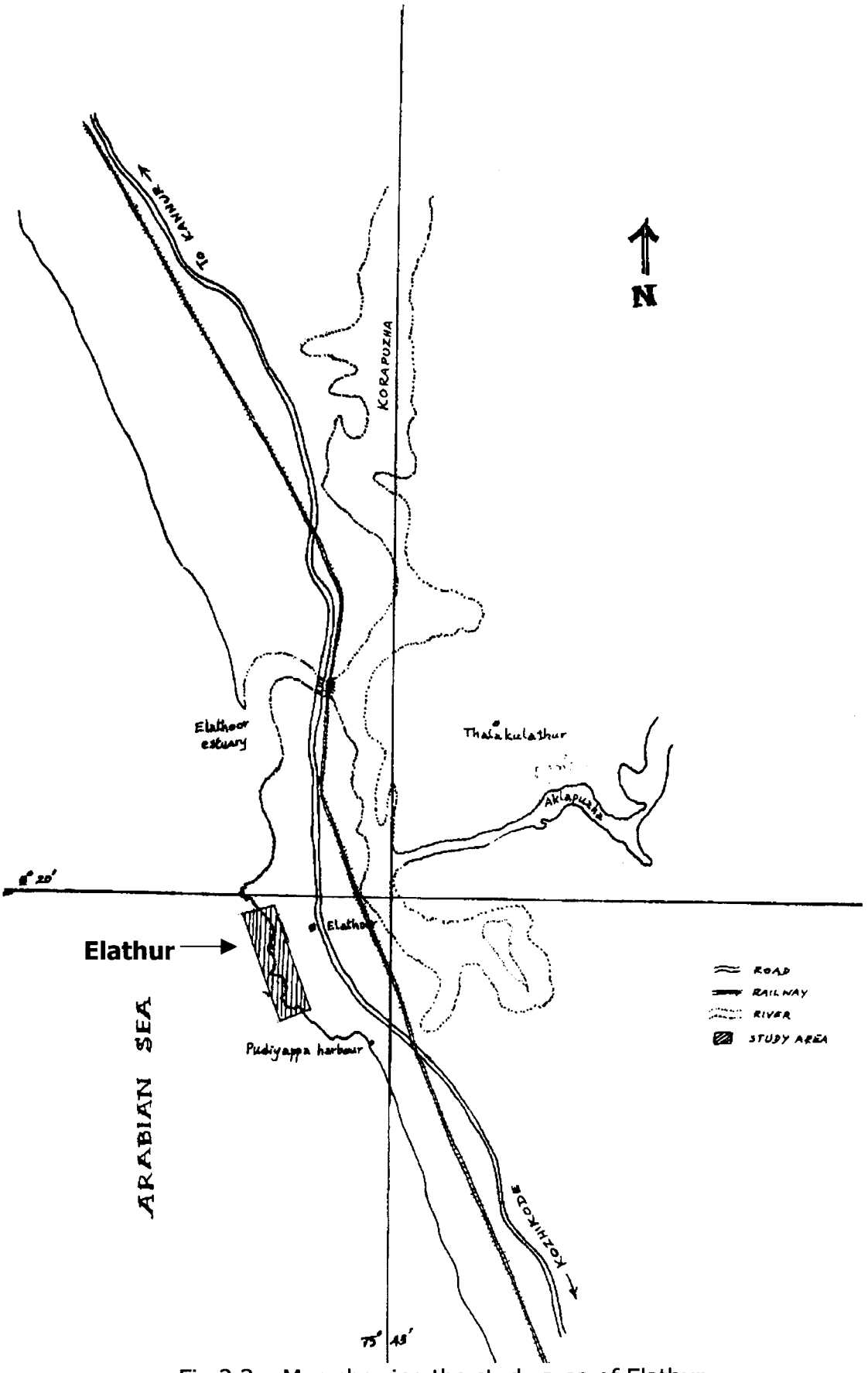


Fig 2.3 – Map showing the study area of Elathur

Plate IV

Picture 6.

Picture 7.

Reclamation of Wetland at Azhingillam

Recently much of the wetland area has been reclaimed for the construction of a highway. The road divides the wetland into a small eastern portion and a western portion, which includes the major share of the wetland area. Physical continuity between the two portions of the wetlands has been established by means of large pipes and culverts through which water flows.

Paddy is cultivated in this area once every year ie. from December to March when the water level sinks. The area is covered with thick vegetation, mainly hydrophytes, matt grasses, reeds and sedges during the rest of the time. Along the border and some elevated parts of the wetlands, vegetables like peas, cucumber, ladies finger, bittergourd, Amaranthus etc. are cultivated during summer season. There are irregular patches of coconut trees also. The flora of Azhingillam jheel is shown in Appendix I

Cattle were allowed to graze in the shallow areas of the wetlands. From December to March various activities connected with the growing of paddy attract large number of men to Azhingillam. From March to May, temporary roads were constructed through the wetlands for transporting clayey soil to the neighbouring kilns and tile factories. There were no hunting or any other form of human interference on the bird community in the study area.

Plate V

Picture 8. Purple Moorhens at Azhingillam

Picture 9. A flock of Lesser Whistling Teals at Azhingillam.

The river Chaliyar that originates from Ilambaleri hills in Tamilnadu at an elevation of 2066 m above MSL flows along the northern side of the study area.

Azhingillam jheel is connected to Chaliyar river, through a number of channels. During the monsoon season river water, rich in silt and sediments flood the wetlands. This process replenishes the nutrients and restores some of the silt lost during summer.

2.3. Elathur

Kozhikode district has a vast coastline of about 81 km extending from Chaliyam in the south to Azhiyur at North. Elathur (11°19'N, 75°44'E) is situated in a coastal zone about 10 km North of Kozhikode. It extends between Elathur estuary where Korapuzha meets Arabian sea and the Pudiyappa harbour. Korapuzha is formed by the confluence of the Aglapuzha outlet with Pannurpuzha. Aglapuzha is more or less a backwater; the Pannurpuzha originates from Arikkankunnu at about 610 m above MSL. The river has a total length of 40 km. This marine habitat has both sandy and rocky shores. The rocks are of the laterite type. This rocky shore harbours a very good number of invertebrate intertidal fauna. The seaward slope of the shores forms a unique habitat for mollusks like sea-mussel, *Perna viridis*. Fishermen used to collect mussels from this area during low tide when the waves recede exposing the rocky bottom. A large

number of people predominantly women make a living by collecting sea mussel, which is sold for food, and collecting shells for making lime. The flora of this area includes marine algae and Angiosperms. A list of algae and plants identified from Elathur is given in Appendix II.

The coastal area also forms the retting ground for coconut husks. Small pits or ponds prepared by digging the laterite, are used for the purpose.

The strong waves during the monsoon season cause havoc in the sea coast. Along the coast, sea erosion is a common phenomenon during the monsoon period. Sea-wall of granite has been built along the coast at places where the waves are very strong. Even these walls have sometimes been found to be washed away by strong waves.

2.4. Kadalundy

Kadalundy estuary (11°07'N, 75°49'E) is located at the boundary of the adjacent districts of Malappuram and Kozhikode, a point 20 km south of Kozhikode city. The study area spreads over about 24 hectares of mudflats. The mudflats are formed by the deposition of alluvium by the Kadalundy river which is formed by the confluence of Olipuzha and Veliyar originating from Silent Valley about 130 km east. At Kadalundy, the river is divided into two channels by the formation of mudflats. These two channels later join together and discharge into the Arabian Sea. The

mudflats become exposed at low tide and form the foraging ground of a large number of birds of several orders. During high tide, the entire area will be covered by water and it becomes very difficult to walk through the mudflats due to the presence of large pits dug by the local people for retting coconut husks. The mud is collected by farmers to be used as manure for coconut palms.

A railway line with two bridges of the Shornur-Mangalore route has been built above the mudflat in the North-South direction. This railway line divides the study area into two portions. On the eastern side of the railway track, there is a small aquaculture farm for prawns.

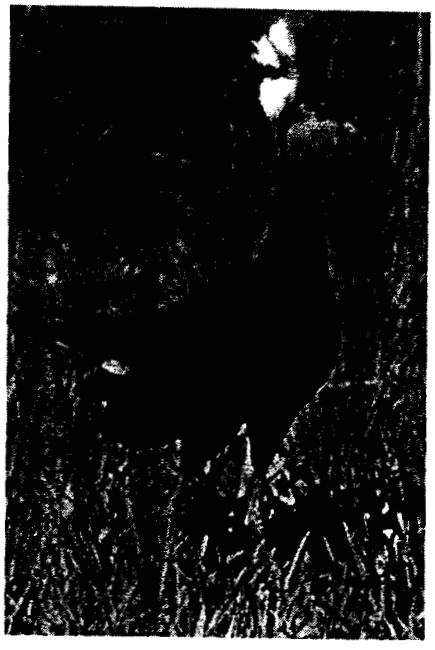
This wetland area is used for retting husks of coconuts for many years. Husks are brought to the site by country boats and deposited in large pits, covered with mud and kept undisturbed for six months. This retting activity releases hydrogen sulfide. After six months, the husks are removed and the same pits are used again for retting. Other human interferences in this area include fishing and collection of shells for lime industry.

Vegetation is limited to the marshy area near the railway track where a large numbers of mangroves and reeds grow. The embankments of the railway track also support a number of plants. The plants identified at Kadalundy are shown in Appendix III.

Picture 10. Coconut husk retting at Kadalundy

Picture 11. Collection of alluvium at Kadalundy

The estuary is the habitat of a number of gastropods, pelicipods, polychaete worms, crabs and fishes. Change in salinity is a very prominent feature of the estuary. However the habitat supports a rich and varied avifauna.



Chapter III

Materials and Methods

CHAPTER III

MATERIALS AND METHODS

The study aimed at a comparison of the bird communities of three selected wetlands situated in the coastal area of the districts of Kozhikode and Malappuram. For this purpose, few parameters of the bird communities mentioned below were studied:

i) Species composition and occurrence

ii) Species abundance

iii) Species diversity

iv) Seasonal changes of birdlife

An attempt was also made to monitor some of the water quality parameters of the three selected wetlands and to see if these factors had any influence on bird community. Parameters like pH, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD), nitrogen, phosphorous and primary productivity were analysed. Bird life was surveyed during the first two years (1993-1995) of the study and water quality was analysed during the last year (1995-96) of the study period using the techniques described below:

3.1. Bird Community

Area mapping, mist-netting, line transect, point transect and nest searching are some of the standard methods commonly used for counting birds. The first two transects are the most commonly used because they have the advantage of being suitable for all seasons. The methods require less time but cover more area. The point transect produces more accurate estimate of bird population. But a wider area can be covered in unit census time by the line transect method (Emlen, 1971; Gaston, 1973). Line transect method was used for counting birds in my study.

3.2. The line transect method

In this method, the observer walks on a predetermined transect and records the birds, which he sees or hears. The relative frequency of different species of birds and the relative frequencies of same species in different habitats can be obtained from the data collected by line transect method. However this is a relative method and the densities obtained are underestimates (Emlen, 1971). The efficiency of the method is fifty percent because a single observer has fifty percent probability of missing an individual bird.

The transect was preplanned, and in Azhingillam and Elathur it extended 2 km in length. In Kadalundy, due to the difficulties of physiography the transect extended only 1.5 km in length. The width of the

sampling area was fixed as 150 m (75 m on either side along the tract). Two transects were conducted every month during the years 1993 to 1995.

For censusing I walked slowly along trails, stopped to observe birds. In each recording of the species encountered, the activities like feeding, flying, resting, etc. were also noted. Each species observed on the study plot was categorised according to its status there: resident, a species that could be seen almost daily on the study area, regular, species during many months but generally as less than 50% of the survey in any particular month, irregular, species that were seen only once; or at most a few times during the study and migrant, non breeding transients involving long distance migration or winter visitor.

Counting was done during morning hours between 07 hrs and 10 hrs and evening between 15.30 hrs and 18.30 hrs. A Carl Zeis binoculars of the power 8x30 was used for observing birds. All the birds sighted or heard were recorded while sampling. A bird, which is sighted, or heard from the backside of the moving observer, was not recorded. In order to avoid observational bias created by the observer moving in one direction, I reversed the direction of movement in the successive counts. If the birds were flying above 40 m from ground without any other activity in the area they were ignored. During monsoon, some of the plots were inaccessible due to weather and road conditions and during that time counting was

made by observing the birds from elevated parts in the study area. No census was made during rain.

The number of birds observed is inversely proportional to the speed of conducting the census (Emlen, 1977). The speed of the census depends on factors like vegetation, terrain features, experience of the observer etc. To get a comparable result I walked slowly at a constant speed during each time.

3.4. Water quality parameters

A study on variation in water quality parameters of the three wetlands was carried out during the year 1995-96. The parameters under investigation were pH, dissolved oxygen (DO), biochemical oxygen demand (BOD) nitrite, phosphate and primary productivity.

Water samples were collected from five selected sites in each study area using glass or polythene beakers. The pH of the water samples was measured immediately. The samples for dissolved oxygen analysis were fixed by adding 2 ml each of the Winkler reagent A and Winkler reagent B after taking the samples in BOD bottles. The water samples were then brought to the laboratory for analysis. For primary productivity determination, the light and dark bottles were filled with the water samples and suspended on water surface for a period of three hours from 8 am to 11 am. After this, the samples were fixed by adding 2 ml each of Winkler

reagent A and Winkler reagent B. The DO content of the bottles were analysed and primary productivity was calculated.

Standard methods (Arnold *et al.*, 1980) used for the measurement of each parameter is mentioned below:

1. pH

pH of the water samples of the three study areas were determined by the indicator paper method as described in Appendix IV .

2. Dissolved Oxygen (DO)

Estimations of dissolved oxygen were carried out using Azide modification of the Winkler method (Appendix V).

3. Biochemical Oxygen Demand (BOD)

The dilution method described in Appendix VI was used for the measurement of BOD of the water samples of the three study areas.

4. Inorganic phosphate phosphorus

Phosphate content of the water samples were analysed by American Public Health Association Method (A.P.H.A. Method) as described in Appendix VII.

5. Nitrite nitrogen (NO_2-N)

A colorimetric Azodye method was used to determine the nitrite nitrogen concentration of the water samples as given in Appendix VIII.

6. Primary Productivity

Primary productivity of the three water bodies were determined by Light and Dark bottle method of Gaarder and Gran described in Appendix IX.

Chapter IV

Occurrence and Abundance of Species

CHAPTER IV

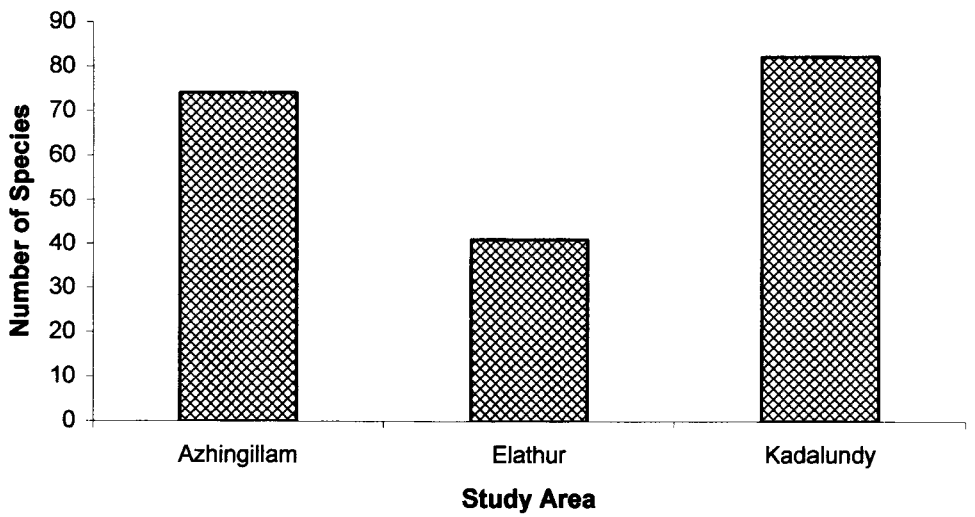
OCCURRENCE AND ABUNDANCE OF SPECIES

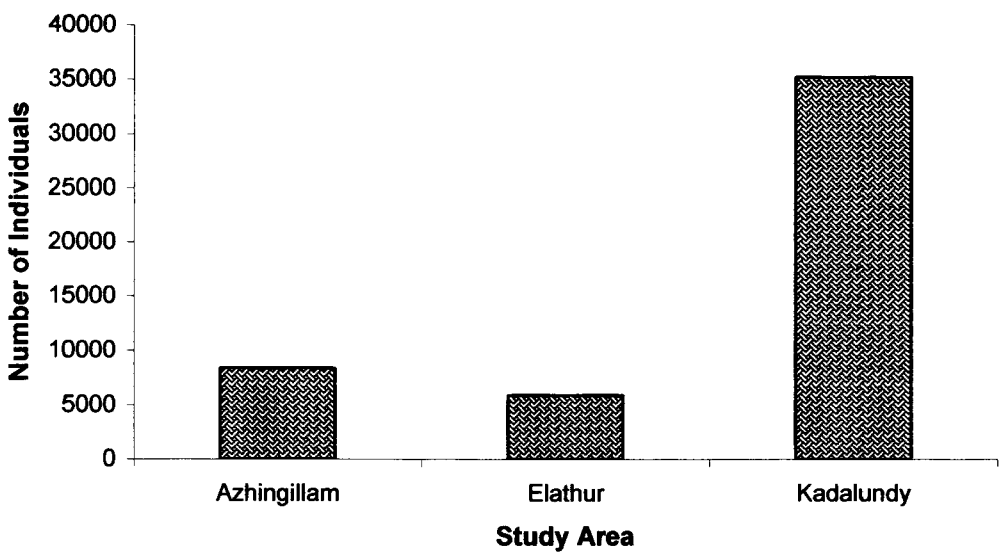
This chapter deals with my observations on the community parameters studied in the three study plots described in chapter II. Studies of avian communities are difficult because birds are highly mobile and seasonal. Their distribution varies from one place to another both qualitatively and quantitatively due to the difference in their ecological niches. The quality of an environment is to some extent indicated by the organisms occupying that area. The number of avian species present in a given area is thus a very good indicator of the quality of the environment.

The species composition of birds in an area may change in winter due to the arrival of migrants. Sometimes, the resident birds show local movements to nearby places to overcome unfavourable conditions, leading to some change in the species composition of a particular area.

In the present study, bird populations were monitored in three wetlands namely, Azhingillam, Elathur and Kadalundy. Azhingillam is a freshwater jheel, Elathur is an intertidal area close to the estuary of Korapuzha and Kadalundy is an estuarine habitat. Observations were carried out twice in every month from April 1993 to March 1995 at all the three study areas. Forty eight line transect counts were conducted during

Fig. 4.1. Number of Species and individuals in different study areas





the two years of field observations at each site and the list of species observed in each area is given in Tables 4.1-4.3.

The maximum number of bird species was recorded from Kadalundy. Eighty two species of birds were observed there. Azhingillam had the next highest number of 74 bird species. At Elathur 41 species of birds were recorded (Fig.4.1.)

4.1. Bimonthly occurrence

Bimonthly occurrence of the number of bird species of the three study area is given in Tables 4.4-4.6 and represented graphically in Figs. 4.5-4.7.

In Azhingillam, a maximum of 36 species was recorded in the second half of February 1994. During my study period, the bird population at Azhingillam showed a tendency to increase from September 1993 and from August in 1994. This increase in bird population coincided with the arrival of migratory birds. The maximum number of species was occurred in February in 1994 and in January 1995 (36 and 35 species respectively).

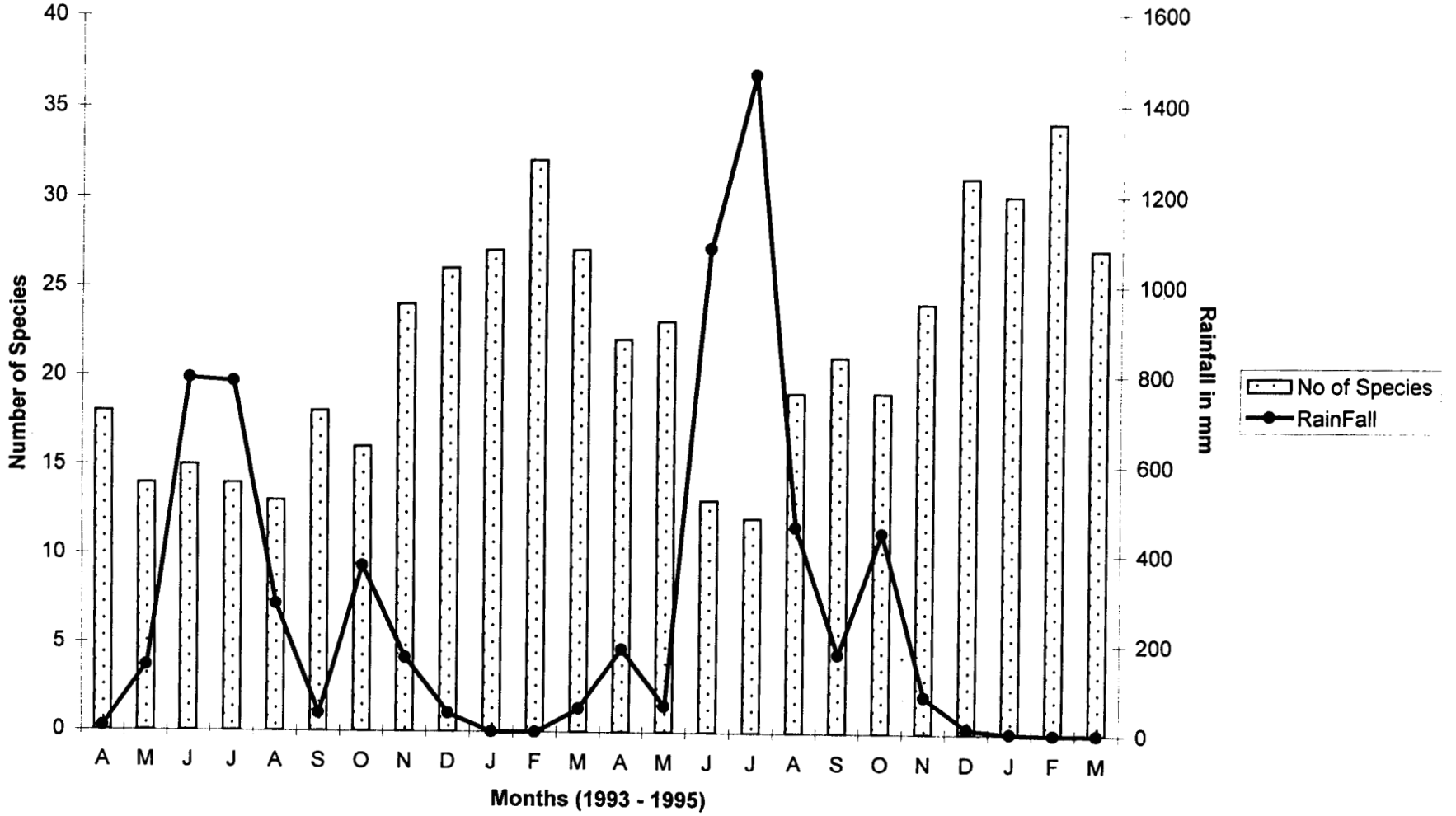


Fig 4.2 - Average Monthly Rainfall / Average Bird Species Occurrence in Azhingillam

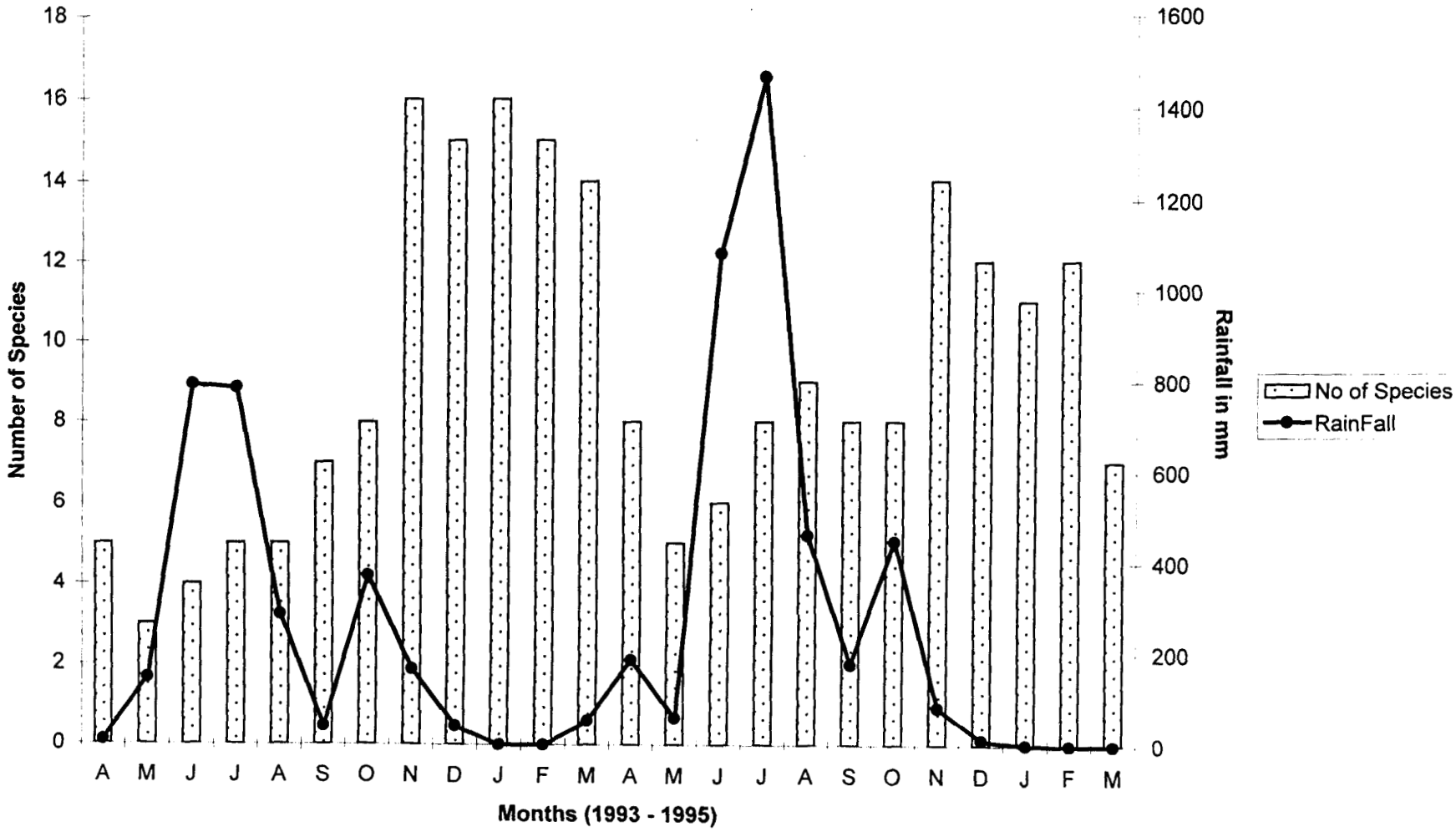


Fig 4.3 - Average Monthly Rainfall / Average Bird Species Occurrence in Elathur

Table 4.1. List of Species Observed at Azhingillam

Species Code	Common Name	Scientific Name
1	Darter	*Anhinga rufa*
2	Little Cormorant	*Phalacrocorax niger*
3	Little Egret	*Egretta garzetta*
4	Median Egret	*Egretta intermedia*
5	Large Egret	*Ardea alba*
6	Cattle Egret	*Bubulcus ibis*
7	Pond Heron	*Ardeola grayii*
8	Purple Heron	*Ardea purpurea*
9	Yellow Bittern	*Ixobrychus sinensis*
10	Chestnut Bittern	*Ixobrychus cinnamomeus*
11	White Ibis	*Threskiornis aethiopica*
12	Cotton Teal	*Nettapus coromandelianus*
13	Lesser Whistling Teal	*Dendrocygna javanica*
14	Garganey	*Anas querquedula*
15	Little Grebe	*Tachybaptus ruficollis*
16	Common Teal	*Anas crecca*
17	Purple Moorhen	*Porphyrio porphyrio*
18	Indian Moorhen	*Gallinula chloropus*
19	Whitebreasted Waterhen	*Amaurornis phoenicurus*
20	Blue Breasted banded Rail	*Rallus striatus*
21	Bronzewinged Jacana	*Metopidius indicus*
22	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*
23	Blackwinged Stilt	*Himantopus himantopus*
24	Little Ringed Plover	*Charadrius dubius*
25	Golden Plover	*Pluvialis dominica*

26	Redwattled lapwing	*Vanellus indicus*
27	Common Sandpiper	*Tringa hypoleucos*
28	Wood Sandpiper	*Tringa glareola*
29	Green Sandpiper	*Tringa ochropus*
30	Marsh Sandpiper	*Tringa stagnatilis*
31	Snipe	*Gallinago sp.,*
32	Little Stint	*Calidris minuta*
33	Whiskered Tern	*Chlidonias hybrida*
34	Pariah Kite	*Milvus migrans govinda*
35	Brahminy Kite	*Haliastur indus*
36	Marsh Harrier	*Circus aeruginosus*
37	Small Blue Kingfisher	*Alcedo atthis*
38	Whitebreasted Kingfisher	*Halcyon smyrnensis*
39	Lesser Pied Kingfisher	*Ceryle rudis*
40	Storkbilled Kingfisher	*Pelargopsis capensis*
41	Swallow	*Hirundo rustica*
42	Redrumped Swallow	*Hirundo daurica*
43	Blue Rock Pigeon	*Columba livia*
44	Spotted Dove	*Streptopelia chinensis*
45	Roseringed Parakeet	*Psittacula krameri*
46	Blossomheaded Parakeet	*Psittacula cyanocephala*
47	Ashy Swallow - Shrike	*Artamus fuscus*
48	Large Pied Wagtail	*Mottacilla maderaspatensis*
49	Paddyfield Pipit	*Anthus novaeseelandiae*
50	Koel	*Eudynamys scolopacea*
51	Crow Pheasant	*Centropus sinensis*
52	Alpine Swift	*Apus melba*

53	Palm Swift	*Cypsiurus parvus*
54	Redvented Bulbul	*Pycnonotus cafer*
55	Ashy Wren Warbler	*Prinia socialis*
56	Streaked Fantail Warbler	*Cisticola juncidis*
57	Jungle Babbler	*Turdoides striatus*
58	Whiteheaded Babbler	*Turdoides affinis*
59	Common Myna	*Acridotheres tristis*
60	Jungle Myna	*Acridotheres fuscus*
61	Golden Oriole	*Oriolus oriolus*
62	Black Drongo	*Dicrurus adsimilis*
63	Racket-tailed Drongo	*Dicrurus paradiseus*
64	Indian Tree Pie	*Dendrocitta vagabunda*
65	House Crow	*Corvus splendens*
66	Jungle Crow	*Corvus macrorhynchos*
67	Purple Sunbird	*Nectarinia asiatica*
68	Purplerumped Sunbird	*Nectarinia zeylonica*
69	Green Bea- eater	*Merops orientalis*
70	Bluetailed Bea- eater	*Merops philippinus*
71	Crested Lark	*Galerida cristata*
72	Blackbellied Finch-Lark	*Eremopteryx grisea*
73	White backed Munia	*Lonchura striata*
74	Spotted Munia	*Lonchura punctulata*

Table 4.2. List of Species Observed in Elathur

Species Code	Common Name	Scientific Name
1	Little Cormorant	*Phalacrocorax niger*
2	Little Egret	*Egretta garzetta*
3	Median Egret	*Egretta intermedia*
4	Large Egret	*Ardea alba*
5	Cattle Egret	*Bubulcus ibis*
6	Pond Heron	*Ardeola grayii*
7	Reef Heron	*Egretta gularis*
8	Golden Plover	*Pluvialis dominica*
9	Grey Plover	*Pluvialis squatarola*
10	Kentish Plover	*Charadrius alexandrinus*
11	Lesser Sand Plover	*Charadrius mongolus*
12	Common Sandpiper	*Tringa hypoleucos*
13	Terek Sandpiper	*Tringa terek*
14	Greenshank	*Tringa nebularia*
15	Whimbrel	*Numenius phaeopus*
16	Curlew	*Numenius arquata*
17	Turnstone	*Arenaria interpres*
18	Whiskered Tern	*Chlidonias hybrida*
19	Caspian Tern	*Hydroprogne caspia*
20	Little Tern	*Sterna albifrons*
21	Large Crested Tern	*Sterna bergii*
22	Common Tern	*Sterna hirundo*
23	Herring Gull	*Larus argentatus*

24	Lesser Blackbacked Gull	*Larus fuscus*
25	Great Blackbacked Gull	*Larus ichthyaetus*
26	Brownheaded Gull	*Larus brunnicephalus*
27	Blackheaded Gull	*Larus ridibundus*
28	Pariah Kite	*Milvus migrans govinda*
29	Brahminy Kite	*Haliastur indus*
30	Small Blue Kingfisher	*Alcedo atthis*
31	Whitebreasted Kingfisher	*Halcyon smyrnensis*
32	Swallow	*Hirundo rustica*
33	Redrumped Swallow	*Hirundo daurica*
34	Roseringed Parakeet	*Psittacula krameri*
35	Grey Wagtail	*Mottacilla cinerea*
36	Alpine Swift	*Apus melba*
37	Palm Swift	*Cypsiurus parvus*
38	Common Myna	*Acridotheres tristis*
39	Black Drongo	*Dicrurus adsimilis*
40	House Crow	*Corvus splendens*
41	Lesser Goldenbacked Woodpecker	*Dinopium benghalense*

Table 4.3. List of Species Observed in Kadalundy

Species Code	Common Name	Scientific Name
1	Little Cormorant	*Phalacrocorax niger*
2	Little Egret	*Egretta garzetta*
3	Median Egret	*Egretta intermedia*
4	Large Egret	*Ardea alba*
5	Cattle Egret	*Bubulcus ibis*
6	Pond Heron	*Ardeola grayii*
7	Reef Heron	*Egretta gularis*
8	Grey Heron	*Ardea cinerea*
9	Black Bittern	*Ixobrychus flavicollis*
10	White Ibis	*Threskiornis aethiopica*
11	Openbill Stork	*Anastomus oscitans*
12	Whitebreasted Waterhen	*Amaurornis phoenicurus*
13	Blue Breasted banded Rail	*Rallus striatus*
14	Blackwinged Stilt	*Himantopus himantopus*
15	Avocet	*Recurvirostra avosetta*
16	Little Ringed Plover	*Charadrius dubius*
17	Golden Plover	*Pluvialis dominica*
18	Grey Plover	*Pluvialis squatarola*
19	Large Sand Plover	*Charadrius leschenaultii*
20	Kentish Plover	*Charadrius alexandrinus*
21	Lesser Sand Plover	*Charadrius mongolus*
22	Common Sandpiper	*Tringa hypoleucos*
23	Wood Sandpiper	*Tringa glareola*
24	Green Sandpiper	*Tringa ochropus*
25	Terek Sandpiper	*Tringa terek*
26	Redshank	*Tringa totanus*
27	Greenshank	*Tringa nebularia*

28	Whimbrel	*Numenius phaeopus*
29	Curlew	*Numenius arquata*
30	Blacktailed Godwit	*Limosa limosa*
31	Bartailed Godwit	*Limosa lapponica*
32	Marsh Sandpiper	*Tringa stagnatilis*
33	Turnstone	*Arenaria interpres*
34	Snipe	*Gallinago sp.,*
35	Eastern Knot	*Calidris tenuirostris*
36	Sanderling	*Calidris alba*
37	Little Stint	*Calidris minuta*
38	Dunlin	*Calidris alpina*
39	Whiskered Tern	*Chlidonias hybrida*
40	Caspian Tern	*Hydroprogne caspia*
41	Gullbilled Tern	*Gelochelidon nilotica*
42	Little Tern	*Sterna albifrons*
43	Large Crested Tern	*Sterna bergii*
44	Sandwich Tern	*Sterna sandvicensis*
45	Common Tern	*Sterna hirundo*
46	Herring Gull	*Larus argentatus*
47	Lesser Blackbacked Gull	*Larus fuscus*
48	Great Blackbacked Gull	*Larus ichthyaetus*
49	Brownheaded Gull	*Larus brunnicephalus*
50	Blackheaded Gull	*Larus ridibundus*
51	Pariah Kite	*Milvus migrans govinda*
52	Brahminy Kite	*Haliastur indus*
53	Marsh Harrier	*Circus aeruginosus*
54	Osprey	*Pandion haliaetus*
55	Shikra	*Accipter badius*
56	Small Blue Kingfisher	*Alcedo atthis*
57	Whitebreasted Kingfisher	*Halcyon smyrnensis*

58	Lesser Pied Kingfisher	*Ceryle rudis*
59	Storkbilled Kingfisher	*Pelargopsis capensis*
60	Swallow	*Hirundo rustica*
61	Redrumped Swallow	*Hirundo daurica*
62	Blue Rock Pigeon	*Columba livia*
63	Spotted Dove	*Streptopelia chinensis*
64	Roseringed Parakeet	*Psittacula krameri*
65	Blossomheaded Parakeet	*Psittacula cyanocephala*
66	Rufous Backed Shrike	*Lanius schach*
67	Ashy Swallow - Shrike	*Artamus fuscus*
68	Large Pied Wagtail	*Mottacilla maderaspatensis*
69	Paddyfield Pipit	*Anthus novaeseelandiae*
70	Koel	*Eudynamys scolopacea*
71	Crow Pheasant	*Centropus sinensis*
72	Alpine Swift	*Apus melba*
73	Palm Swift	*Cypsiurus parvus*
74	Tailor Bird	*Orthotomus sutorius*
75	Ashy Wren Warbler	*Prinia socialis*
76	Streaked Fantail Warbler	*Cisticola juncidis*
77	Common Myna	*Acridotheres tristis*
78	Indian Tree Pie	*Dendrocitta vagabunda*
79	House Crow	*Corvus splendens*
80	Jungle Crow	*Corvus macrorhynchos*
81	Purple Sunbird	*Nectarinia asiatica*
82	Green Bea- eater	*Merops orientalis*

Table 4.4. Bimonthly Occurrence of Species

AZHINGILLAM

	1993	1994	1995
January	--	29	25
	--	24	35
February	--	28	34
	--	36	34
March	--	28	33
	--	26	21
April	18	22	
	17	22	
May	16	22	
	12	23	
June	16	12	
	14	14	
July	14	16	
	13	18	
August	14	17	
	12	20	
September	16	20	
	20	22	
October	17	20	
	15	17	
November	22	23	
	25	25	
December	25	33	
	26	29	

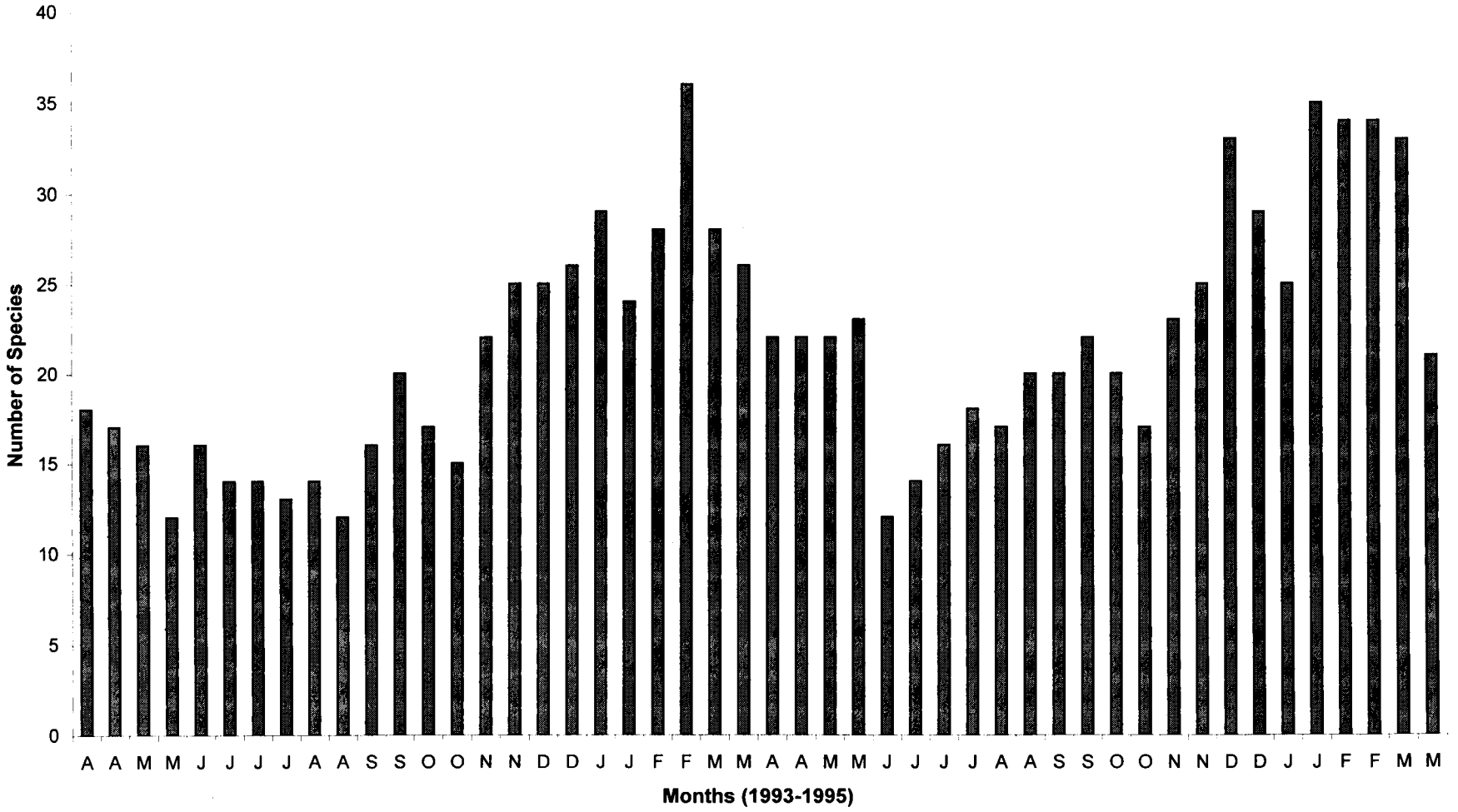


Fig 4.5 - Bimonthly occurrence of the number of bird species in Azhingillam

Table 4.5. Bimonthly Occurrence of Species

ELATHUR

	1993	1994	1995
January	–	11	11
	–	21	10
February	–	15	12
	–	14	11
March	–	16	7
	–	12	7
April	5	9	
	5	7	
May	3	6	
	3	4	
June	4	6	
	4	5	
July	5	7	
	5	7	
August	2	7	
	7	10	
September	6	8	
	7	8	
October	6	5	
	10	10	
November	15	13	
	17	15	
December	11	13	
	19	10	

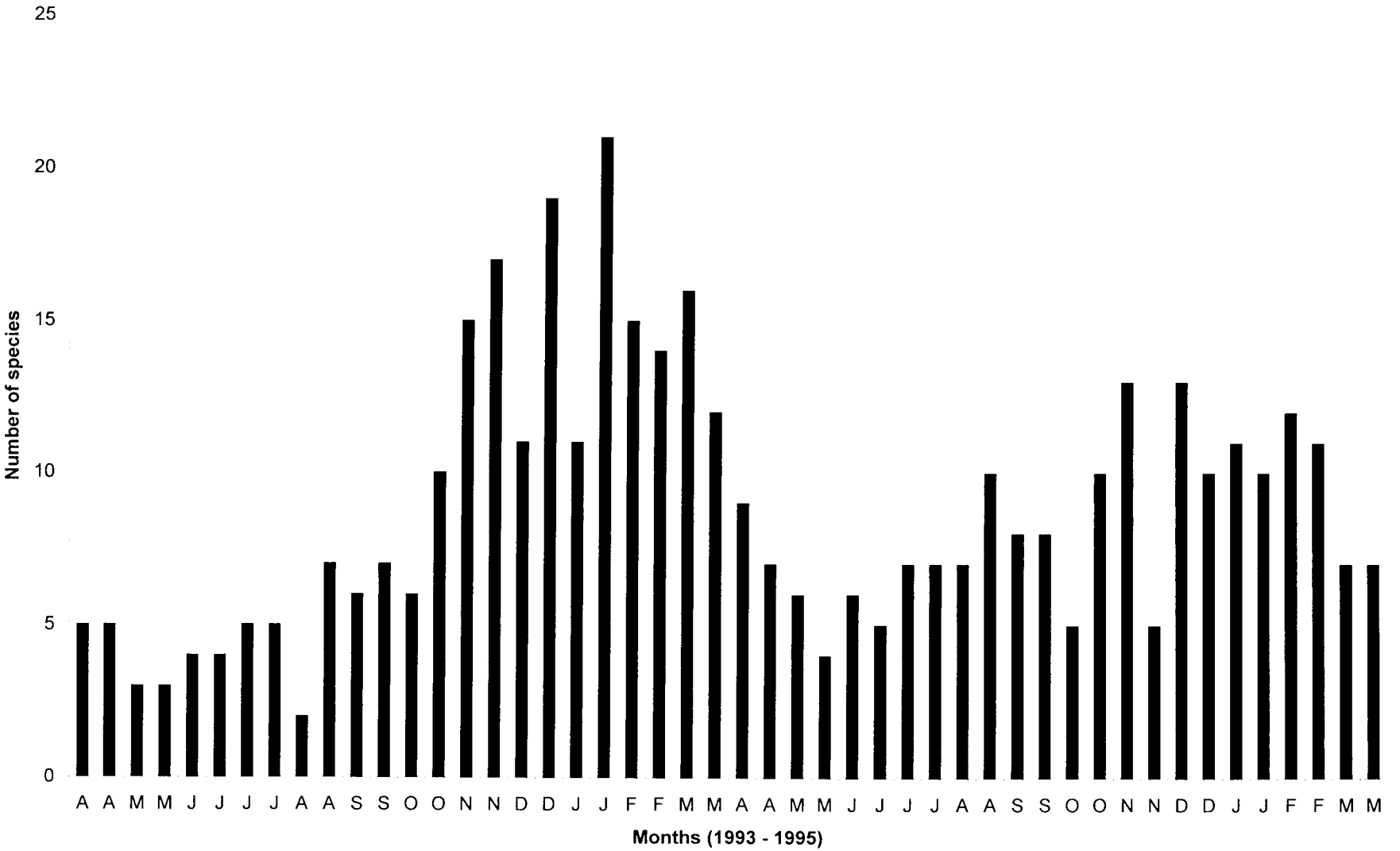


Fig 4.6 - Bimonthly occurrence of the number of bird species in Elathur.

Table 4.6. Bimonthly Occurrence of Species

KADALUNDY

	1993	1994	1995
January	--	28	27
	--	26	16
February	--	26	16
	--	29	33
March	--	30	33
	--	20	32
April	19	19	
	14	20	
May	15	17	
	17	13	
June	13	9	
	14	14	
July	8	9	
	10	11	
August	9	14	
	9	13	
September	20	13	
	23	15	
October	19	16	
	23	20	
November	25	26	
	27	23	
December	22	23	
	34	25	

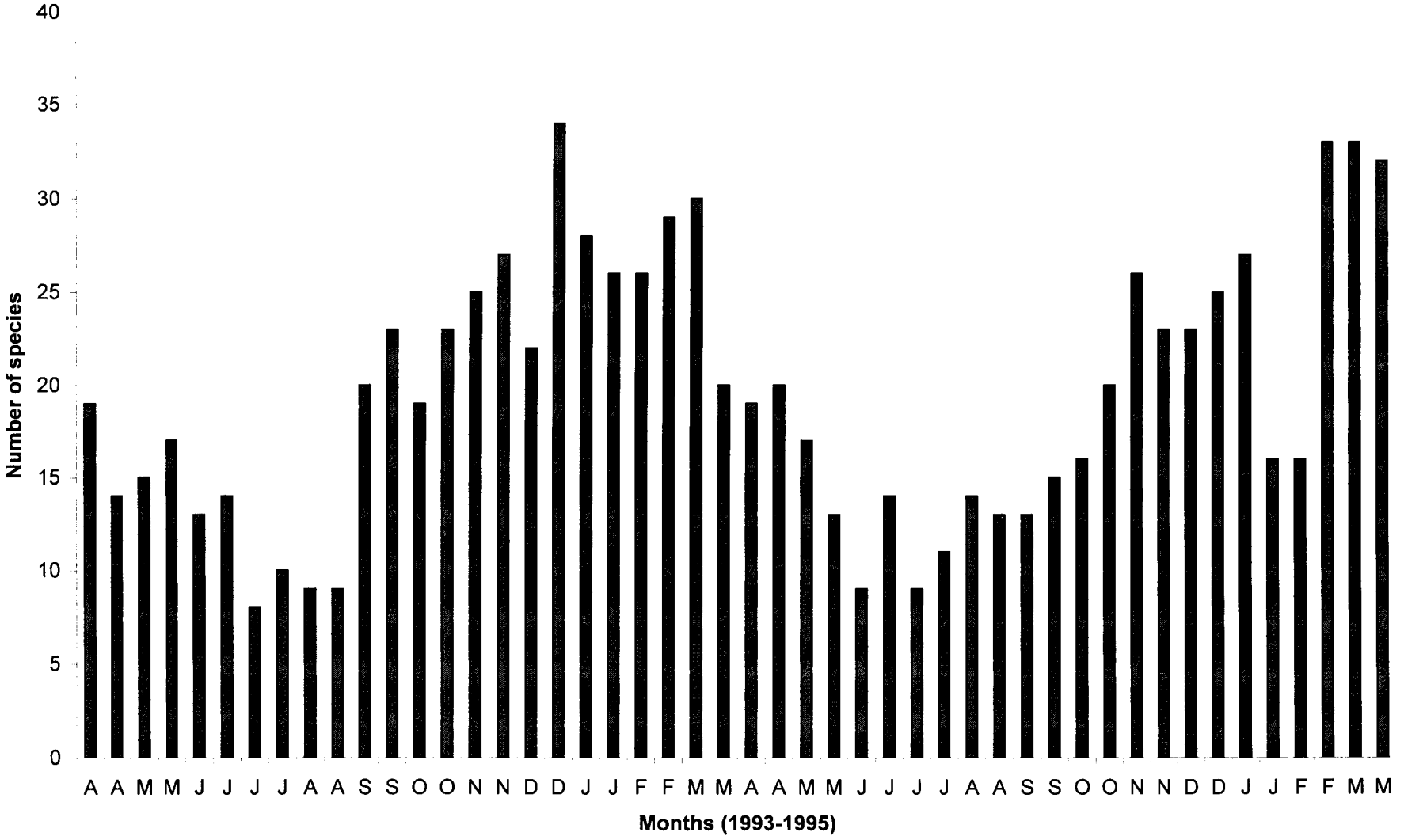


Fig.4.7. Bimonthly occurrence of the number of bird species in Kadalundy

Analysis of the occurrence of bird species in this study area shows that the number of bird species is much higher during the months of November through April. Azhingillam appears to be the least disturbed habitat covered in this study. The area is less disturbed during monsoon and the first half of the winter due to a rise in the level of water, which made the place inaccessible to men. But during the second half of winter and in summer, agricultural activities like ploughing, paddy cultivation, irrigation, harvesting of paddy etc. disturb birds. Extraction of clay to make bricks is another activity, which interferes with the birdlife of Azhingillam. In spite of all these disturbances, the bird species number is high in the first half of the summer season.

Elathur, which is an intertidal area, does not appear to be a very good habitat for birds. The number of species is lowest here. The bird population with 4 to 5 species during the summer and monsoon, increased slowly from September onwards and a maximum of 21 species was observed in January during the 1993-94-study period. During 1994-95-study period a maximum of 15 species was recorded in November.

Elathur has a rocky shore, interspersed with sandy beaches where human interference is high. Fishing, collection of mussels, retting of coconut husks and the presence of a fishing harbour near the study area are factors which disturb birds visiting the area, inspite of the availability of

plenty of food. In Elathur the habitat has been changed in some areas by the construction of a harbour and deposition of large stones and boulders along the seacoast to prevent sea erosion.

In Kadalundy, the influx of migratory birds increased the species number from September onwards during the year 1993 and from October onwards during 1994. A maximum of 34 species was recorded from this area in December 1994 and 33 species in February 1995. The avian population showed a marked reduction in number of species during the nonmigratory season.

Kadalundy is an estuary with mudflats, which are exposed during low tide. Local people utilize shallow patches of this area for retting coconut husks, fishing and collection of mussels. The fertile alluvium brought by the Kadalundy river is collected and transported using country boats to be used as manure for coconut palms. These activities interfere with the birdlife in this area. There is a long railway bridge and birds have got habituated to the noise of trains.

In all the three study areas, the number of avian species started increasing during the winter when the migratory birds arrived. It reached a maximum during the first part of summer in Kadalundy and Azhingillam, especially in February and March and then declined. At Elathur a maximum bird population was recorded during the winter season. In

Azhingillam and Kadalundy this increase in number of birds during the beginning of summer season could be due to the local migration of birds from surrounding wetlands when those areas get dried up. Azhingillam however maintains a substantial water level during the summer season except for the months of April and May. In Kadalundy, the tidal action produces daily rhythm of inundation and drying up of mudflats both of which are beneficial to birds adapted to feed on these habitats. The increase in number of birds of the Ardeidae family in Azhingillam is an example for this type of local movements during summer season.

4.2. Cumulative Occurrence

The cumulative number of species recorded at each study area was represented graphically in Fig. 4.8. The fresh water jheel of Azhingillam had 74 species of birds. A less complex and disturbed littoral habitat of Elathur had only 41 species of birds. The estuarine habitat of Kadalundy had 82 bird species.

In Azhingillam, fifty percent of the total bird species were observed during the first six months and about 87% during the first year itself (1993-94). Cent percent recording of the bird species observed was possible only towards the end of the study period.

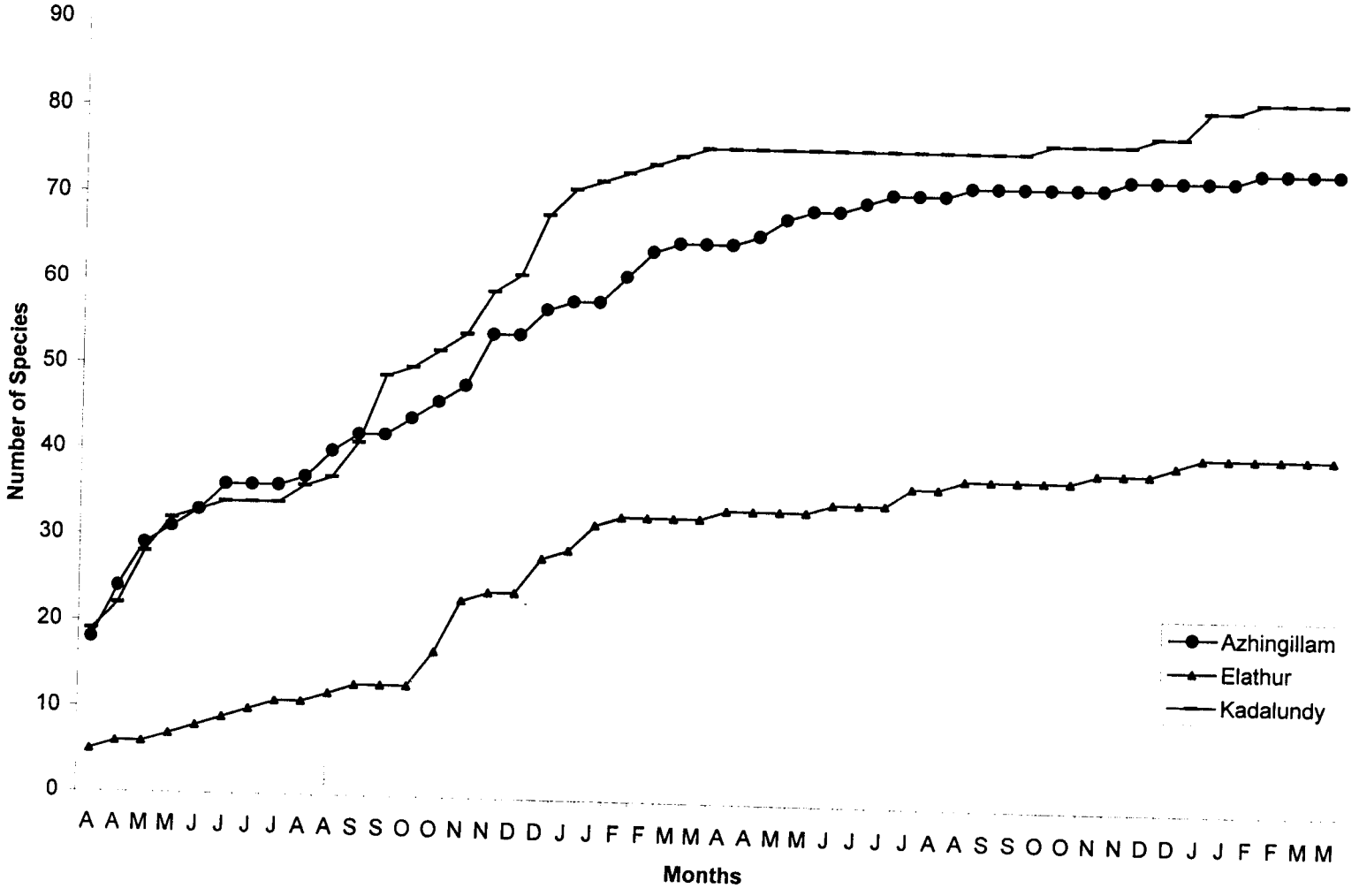


Fig. 4.8 - Cumulative Occurrence of Species

In Elathur, out of the 41 species present, 80.4% was recorded in the first year (1993-94). The rest of the bird species were added during the next year (1994-95).

Kadalundy had a total of 82 species of birds. Of these, 92.6% was recorded within the period of first year and the value reached 100% in January 1995.

In all the three study areas, 100% recording of the bird species observed was completed only towards the end of the study period. This may be accounted for the fact that the study areas selected were located in and around the coastal line, which forms the migratory route of many birds. These areas seem to receive a large number of migrants during their arrival and departure. This creates an abrupt change in bird population and species composition. It has also been noted that any sporadic occurrence of either a migratory bird or resident bird in the study area affects the cumulative occurrence data. Such occurrences of Masked Booby (Deepakumar, 1991), Carb Plover (George Mathew, 1998) and Frigate bird (Aboobacker Pers. Comm.) were noted in Kadalundy.

4.3. Frequency of Species Occurrence

In order to assess the frequency of species occurrence, the birds of the three study areas were arranged in four categories as shown in Table 4.7.

Table 4.7. Frequency range of different species in different categories in the study areas

Categories	Frequency
"Rare"	1/48 - 12/ 48 < 25%
"Fairly common"	12/48 - 24/48 25% - 50%
"Common"	24/48 - 36/48 50% - 75%
"Very common"	36/48 - 48/48 75% - 100%

The results are tabulated and given in Table 4.8.

Table 4.8. Number of species in different categories in the three study areas

Category	Range	Number of Species		
		Azhingillam	Elathur	Kadalundy
Rare	1 - 12	43	29	55
Fairly common	12 - 24	13	7	14
Common	24 - 36	11	1	5
Very common	36 - 75	7	4	8

In Azhingillam, 43 species out of 74 constituted less than 25% and they are "rare". This accounts for about 58.1% of the total population. Of the 41.9% of the rest of the population, 13 species (17.56%) belongs to the

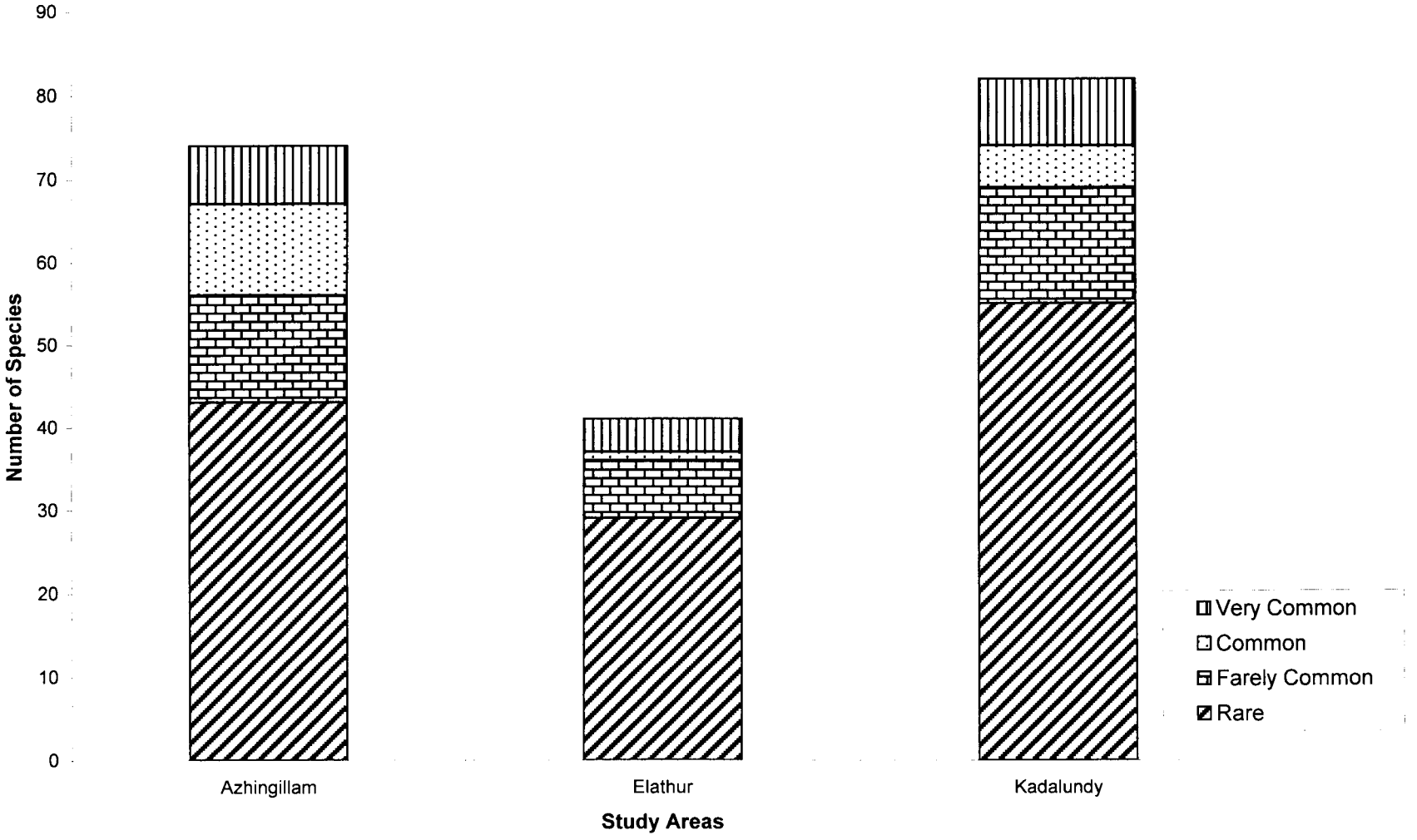


Fig.4.9 - Number of species in different categories of birds

'fairly common' category, 11 species (14.86%) to the 'common' group and 7 species (9.46%) of birds are included in the 'very common' class.

In Elathur, out of 41 bird species observed, 29 were 'rare' and constituted about 70.73% of the total population. Seven species were 'fairly common' and only 1 species (2.4%) was 'common'. The 'very common' class contained 4 species (9.75%).

In Kadalundy, a maximum number of 82 species were recorded by me. About 55 species (67.0%) of this area came under the category of 'rare'. Fourteen species (17.07%) were 'fairly common', 5 species (60.09%) were 'common' and 7 species (9.75%) were 'very common'.

It is interesting to note that in all the three study areas, the percentage of 'rare' birds is very high. This may be due to the fact that many of the birds included in this category were winter visitors. Therefore the analysis has an inherent bias for these birds. Some species were opportunistic users and others, which are vagrants, also come under in the 'rare' class, in these wetlands.

The percentage of very common birds of these three study areas showed an almost equal value around 10%. The names of the very common birds observed in the three study areas are given in table 4.9.

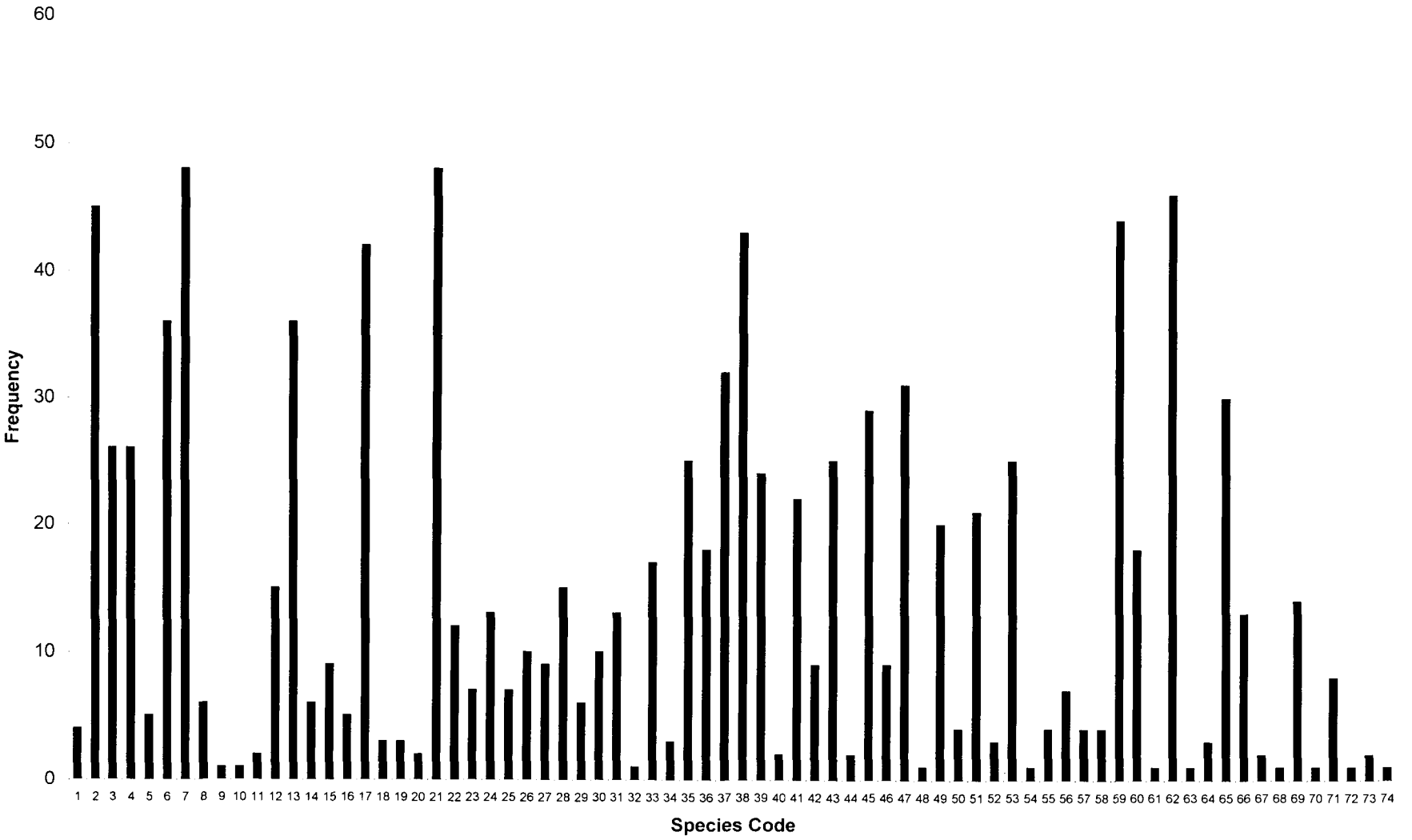


Fig 4.10 - Frequency of species - Azhingillam

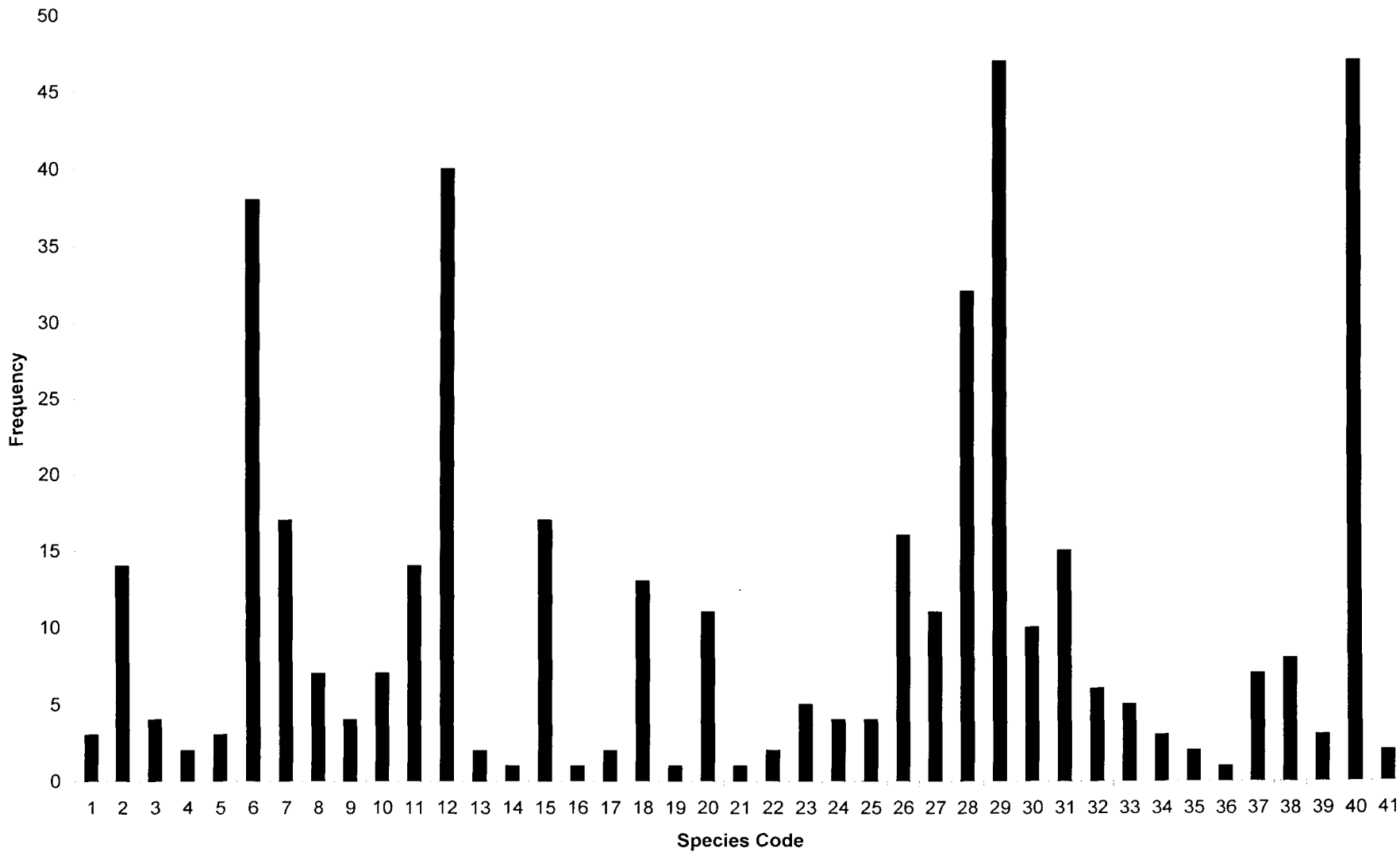


Fig. 4.11 - Frequency of species - Elathur

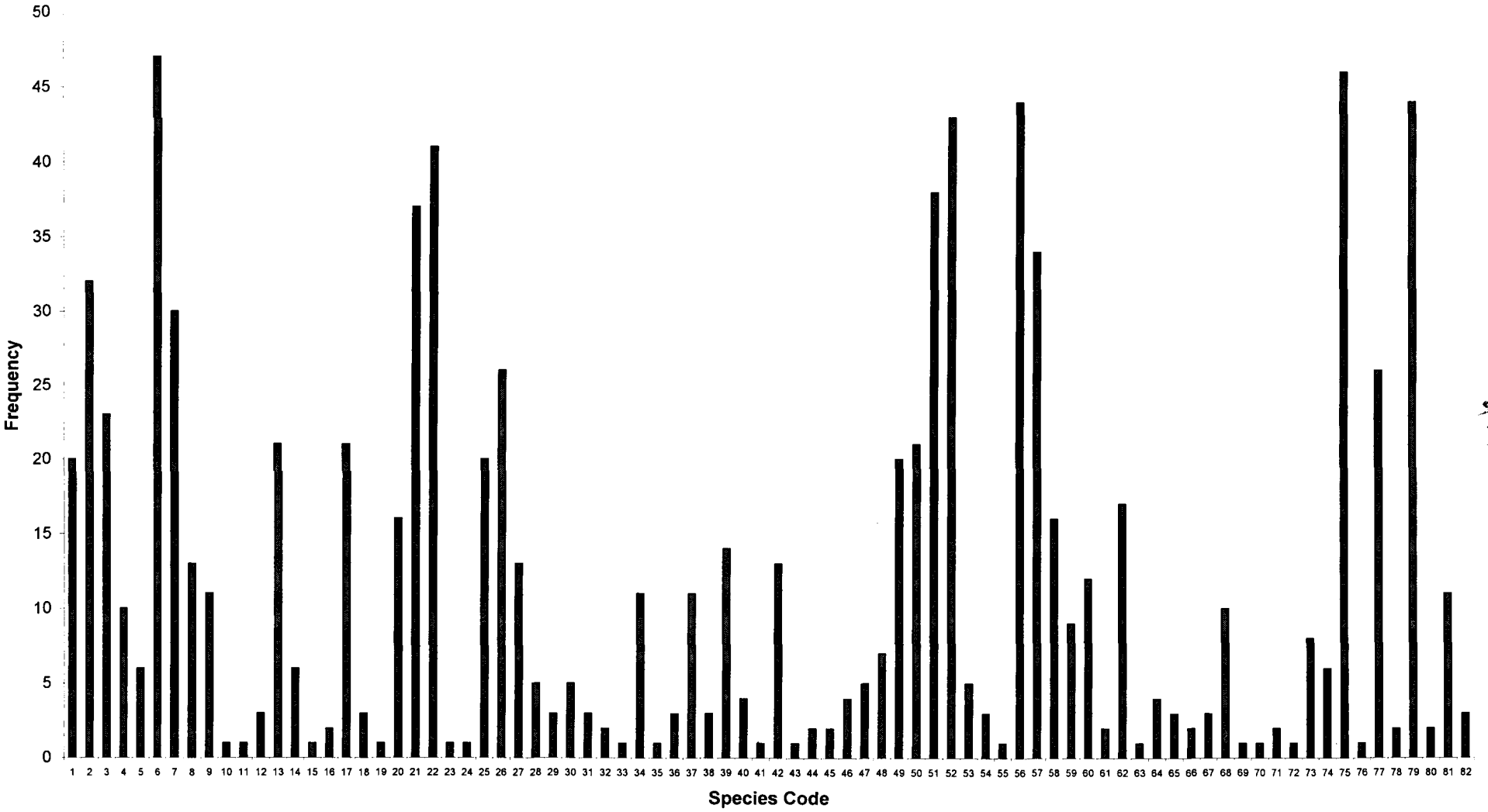


Fig. 4.12 - Frequency of species - Kadalundy

It is clear from the results that many of the 'very common' species of these wetlands were not true wetland types, but they formed more than 75% in frequency. In Azhingillam, out of the 7 'very common' birds only 5 were true wetland species. These were Little Cormorant, Pond Heron, Purple Moorhen, Bronzewinged Jacana and Whitebreasted Kingfisher. Common Myna and Black Drongo, were the other two very common birds. The availability of insects throughout the season and perching plants like Pandanus attracts these two bird species to the area throughout the year.

In Elathur, out of the 4 'very common' species of birds, two namely the Pond Heron and the Common Sandpiper belong to the true wetland types. House Crow and the Brahminy Kite are the other two birds. The fishing harbour adjacent to the study area attracted these birds.

Eight species of birds were 'very common' at Kadalundy. Of these, the true wetland species were the Pond Heron, the Common Sandpiper, the Small Blue Kingfisher and the Lesser Sand Plover. The other four species were Brahminy Kite, Pariah Kite, Ashy Wren Warbler and House Crow.

The Common sandpiper and Lesser Sand Plover, which are considered as migrants, were present in two of the study areas almost throughout the year. In Elathur, Common sandpiper was observed in 40 transects out of 48 (83%). In Kadalundy it was 41 out of 48 (85.4%). The frequency of occurrence of Lesser Sand Plover in Kadalundy is 37 out of 48

(77%). These observations clearly show that Common sandpiper and Lesser Sand Plover are overwintering in these study areas (Fig. 4.13 and 4.14).

Table 4.9. List of very common birds in the three study areas

	Name of the species	Azhingillam	Elathur	Kadalundy
1.	Little Cormorant	*		
2.	Pond Heron	*	*	*
3.	Purple Moorhen	*		
4.	Bronzewinged Jacana	*		
5.	Lesser Sand Plover			*
6.	Common Sandpiper		*	*
7.	Pariah Kite			*
8.	Brahminy Kite		*	*
9.	Small Blue Kingfisher			*
10.	Whitebreasted Kingfisher	*		
11.	Ashy Wren Warbler			*
12.	Common Myna	*		
13.	Black Drongo	*		
14.	House Crow		*	*

* - indicates occurrence of the bird species with frequency above 75%.

Analysis of the 'rare' birds of the study areas shows that out of the 43 'rare' bird species of Azhingillam, 11 species had an occurrence frequency

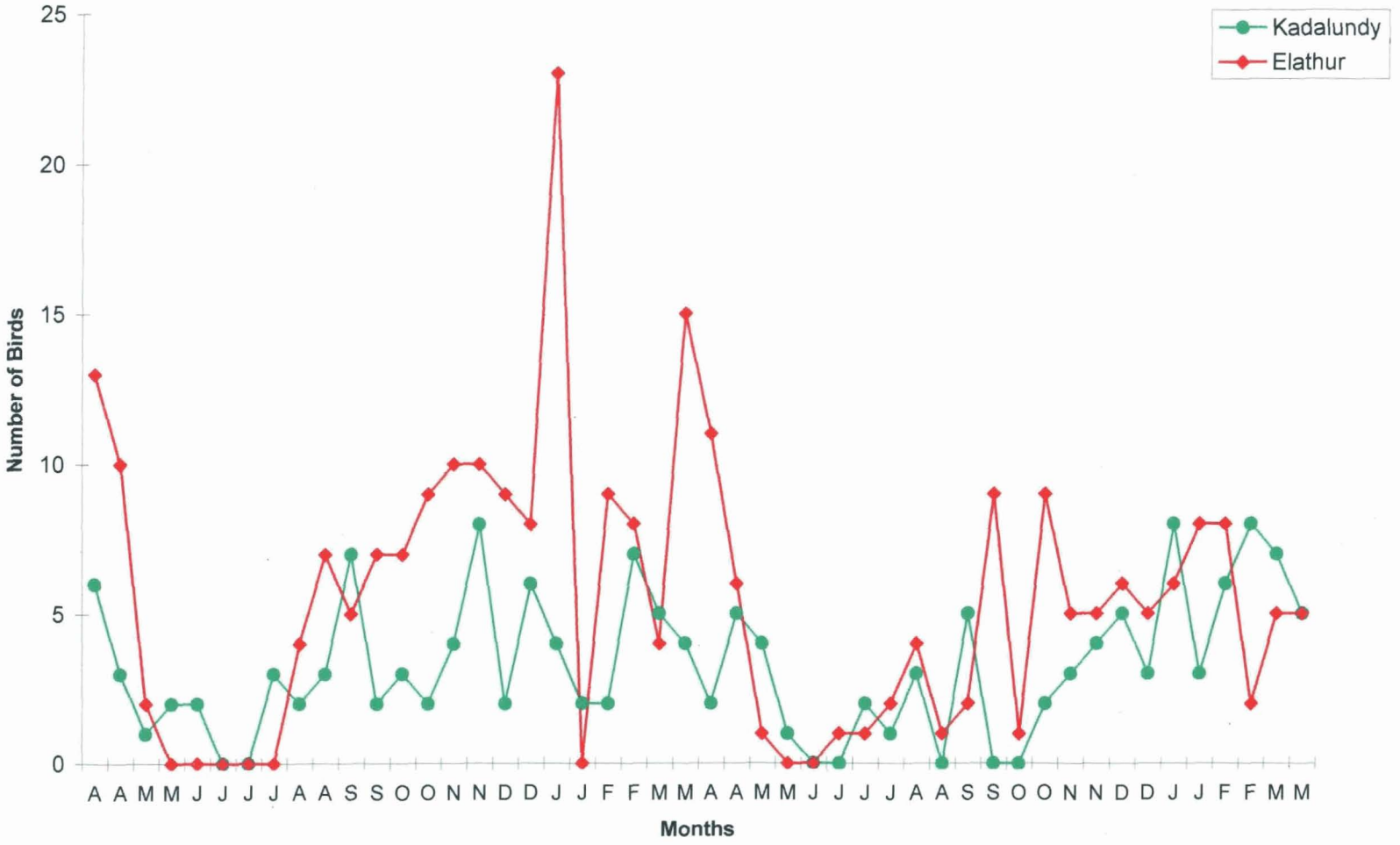


Fig. 4.13 - Bimonthly occurrence of Common Sandpiper *Tringa hypoleucos* in Kadalundy and Elathur during the years 1993 - '95

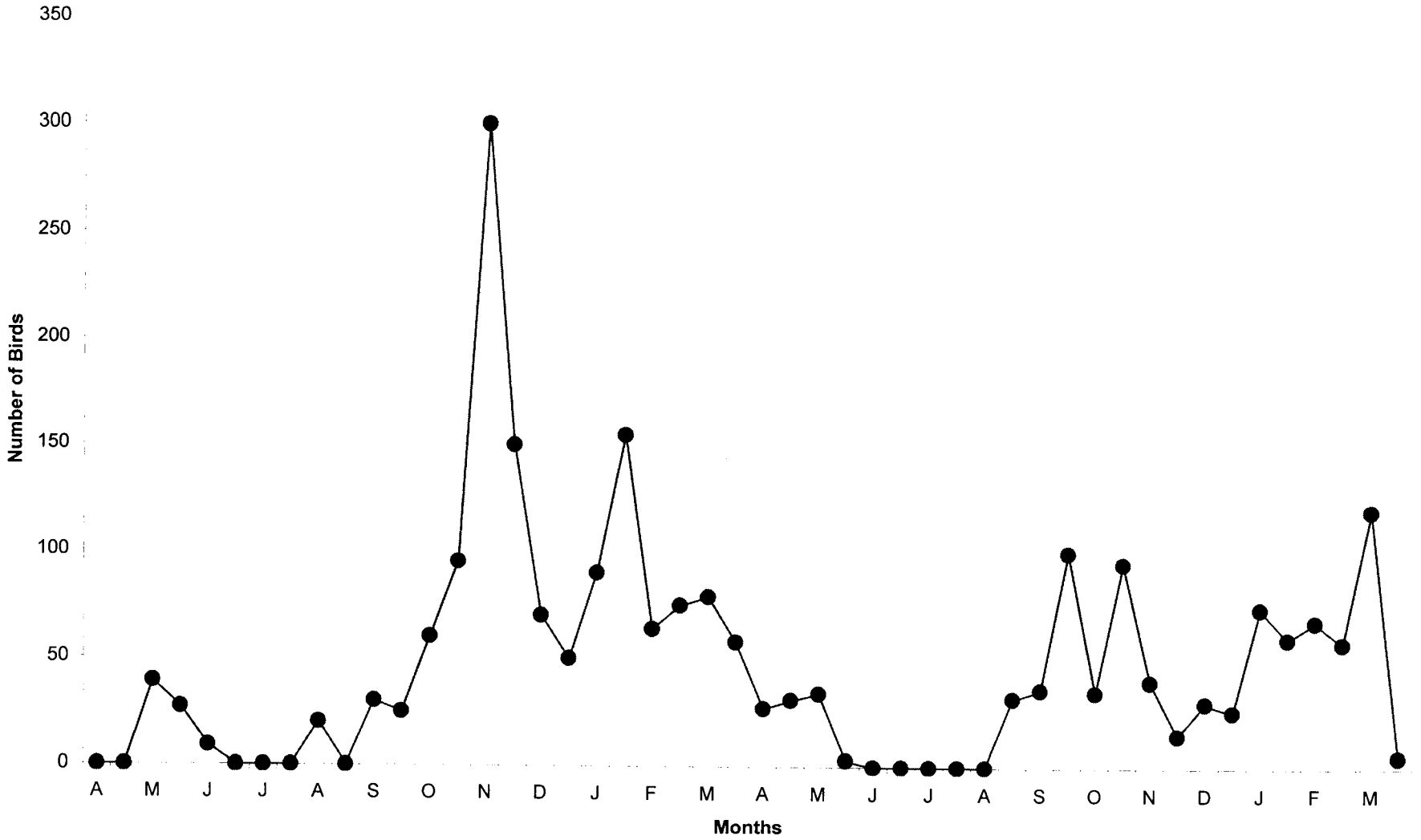


Fig. 4.14 - Bimonthly occurrence of Lesser Sand Plover *Charadrius mangolus* in Kadalundy during the years 1993 - '95

of less than 2% (1/48). In Elathur 29 species are 'rare'. Out of this, 5 had a frequency of less than 2%. In Kadalundy I have observed 55 'rare' species and in that 16 had frequency less than 2%. The list of birds having a frequency of occurrence less than 2% in each study area is given in tables 4.10, 4.11 and 4.12.

Table 4.10. List of 'rare' birds having frequency of occurrence ≤ 2 % at Azhingillam

Sl. No.	Name of the Bird
1.	Yellow Bittern
2.	Chestnut Bittern
3.	Little Stint
4.	Large Pied Wagtail
5.	Redvented Bulbul
6.	Golden Oriole
7.	Racket -tailed Drongo
8.	Purple Rumped Sunbird
9.	Bluetailed Bee- eater
10.	Blackbellied Finch- Lark
11.	Spotted Munia

Table 4.11. List of 'rare' birds having frequency of occurrence ≤ 2 % at Elathur

Sl. No.	Name of the Bird
1.	Greenshank
2.	Curlew
3.	Caspian Tern
4.	Large Crested Tern
5.	Alpine Swift

Table 4.12. List of 'rare' birds having frequency of occurrence ≤ 2 % at Kadalundy

Sl. No.	Name of the Bird
1.	White Ibis
2.	Openbill Stork
3.	Avocet
4.	Large Sand Plover
5.	Wood Sandpiper
6.	Green Sandpiper
7.	Turnstone
8.	Eastern knot
9.	Gullbilled Tern
10.	Large Crested Tern
11.	Shikra
12.	Spotted Dove
13.	Paddyfield Pipit
14.	Koel
15.	Alpine Swift
16.	Streaked Fantail Warbler

4.4. Abundance of species

Among the assemblage of species that make up a community most of them are rare and relatively few are abundant. Abundance of a community represents its relative distribution in it.

For determining the species abundance in the three study areas, I have collected data using the line transects method described in detail in chapter III.

Out of the 74 bird species recorded at Azhingillam, an accumulated total of more than 1000 was observed from 48 line transect events only in the case of two species namely Pond Heron and Purple Moorhen. Twenty species had an accumulated total of more than 100. There were 22 species for which less than 10 individuals were recorded for the whole study period. The list of species with an accumulated total of 100 and more and less than 10 is given in Table 4.13.

Table 4.13. List of species whose accumulated total is above 100 and below 10 in Azhingillam

Sl. No.	Name of the bird having accumulated total > 100	Sl. No.	Name of the bird having accumulated total < 10
1.	Little Cormorant	1.	Darter
2.	Little Egret	2.	Purple Heron
3.	Median Egret	3.	Yellow Bittern
4.	Cattle Egret	4.	Chestnut Bittern
5.	Pond Heron	5.	White Ibis
6.	Cotton Teal	6.	Indian Moorhen
7.	Lesser Whistling Teal	7.	Whitebreasted Waterhen
8.	Garganey	8.	Bluebreasted Banded Rail
9.	Purple Moorhen	9.	Little Stint
10.	Bronzewinged Jacana	10.	Pariah Kite
11.	Wood Sandpiper	11.	Storkbilled Kingfisher
12.	Whitebreasted Kingfisher	12.	Spotted Dove
13.	Swallow	13.	Large Pied Wagtail
14.	Blue Rock Pigeon	14.	Koel
15.	Ashy Swallow-Shrike	15.	Alpine Swift
16.	Palm Swift	16.	Redvented Bulbul
17.	Common Myna	17.	Golden Oriole
18.	Jungle Myna	18.	Racket -tailed Drongo
19.	Black Drongo	19.	Indian Tree Pie
20.	House Crow	20.	Purple Sunbird
		21.	Purplerumped sunbird
		22.	Bluetailed Bee-eater

The maximum species abundance was noted in the case of Purple Moorhen (1252) followed by Pond Heron (1135). The frequency of occurrence of Purple Moorhen was 87.5% and that of Pond Heron was 100%.

In Elathur only Brahminy Kite showed an accumulated total of greater than 1000 during the whole study period. Nine species in this area had an accumulated total greater than 100 and 16 species figured a value less than 10. The details are given in Table 4.14.

Kadalundy which is an estuarine habitat had twenty two bird species having an accumulated total of above hundred. Out of this 22 species, two namely, Brownheaded Gull and Blackheaded Gull showed very high abundance with values above 10,000. Twentynine species of birds in Kadalundy had an accumulated total of less than 10 individuals during the study period. The list of birds is given in Table 4.15.

Table 4.14. List of species whose accumulated total is above 100 and below 10 in Elathur

Sl. No.	Name of the species having accumulated total > 100	Sl. No.	Name of the species having accumulated total < 10
1.	Pond Heron	1.	Little Cormorant
2.	Lesser Sand Plover	2.	Median Egret
3.	Common Sandpiper	3.	Large Egret
4.	Little Tern	4.	Grey Plover
5.	Brownheaded Gull	5.	Terek Sandpiper
6.	Blackheaded Gull	6.	Greenshank
7.	Pariah Kite	7.	Curlew
8.	Brahminy Kite	8.	Turnstone
9.	House Crow	9.	Caspian Tern
		10.	Large Crested Tern
		11.	Herring Gull
		12.	Roseringed Parakeet
		13.	Grey Wagtail
		14.	Alpine Swift
		15.	Black Drongo
		16.	Goldenbacked Woodpecker

Table 4.15. List of birds whose accumulated total is above 100 and below 10 in Kadalundy

Sl. No.	Name of the bird having accumulated total > 100	Sl. No.	Name of the bird having accumulated total < 10
1.	Little Egret	1.	White Ibis
2.	Pond Heron	2.	Openbill Stork
3.	Reef Heron	3.	Whitebreasted Waterhen
4.	Golden Plover	4.	Avocet
5.	Kentish Plover	5.	Lesser Sand Plover
6.	Lesser Sand Plover	6.	Wood Sandpiper
7.	Common Sandpiper	7.	Green Sandpiper
8.	Bartailed Godwit	8.	Curlew
9.	Eastern Knot	9.	Marsh Sandpiper
10.	Little Stint	10.	Turnstone
11.	Whiskered Tern	11.	Caspian Tern
12.	Little Tern	12.	Gullbilled Tern
13.	Common Tern	13.	Large Crested Tern
14.	Lesser Blackbacked Gull	14.	Sandwich Tern
15.	Great Blackbacked Gull	15.	Marsh Harrier
16.	Brownheaded Gull	16.	Ospery
17.	Black headed Gull	17.	Shikra
18.	Pariah Kite	18.	Redrumped Swallow
19.	Brahminy Kite	19.	Spotted Dove
20.	Palm Swift	20.	Blossomheaded Parakeet
21.	Ashy Wren Warbler	21.	Rufousbacked Shrike
22.	House Crow	22.	Paddyfield Pipit
		23.	Koel
		24.	Crow Pheasant
		25.	Alpine Swift
		26.	Tailor Bird
		27.	Streaked Fantail Warbler
		28.	Indian Tree Pie
		29.	Jungle Crow

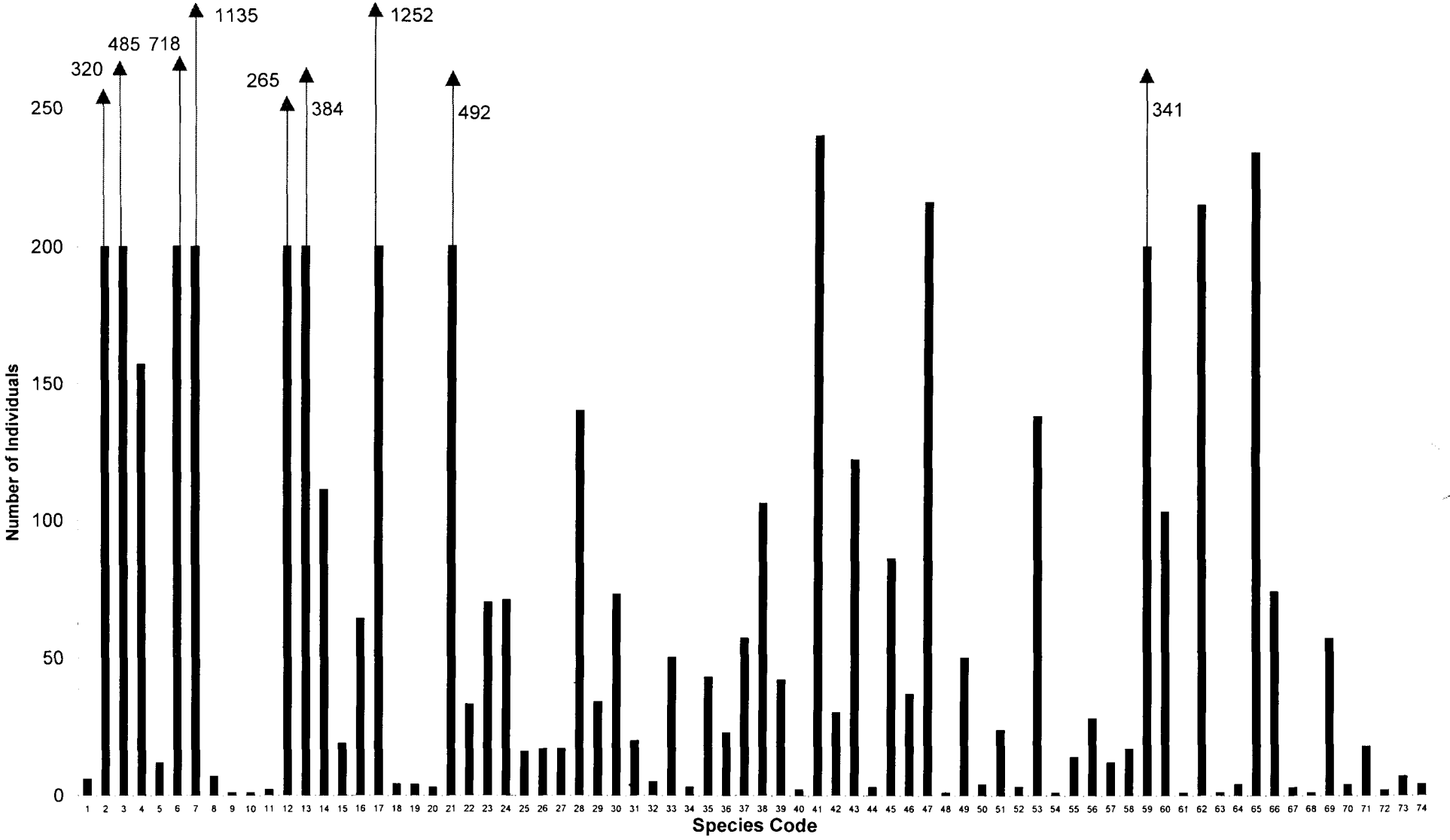


Fig. 4.15 - Species abundance - Azhingillam

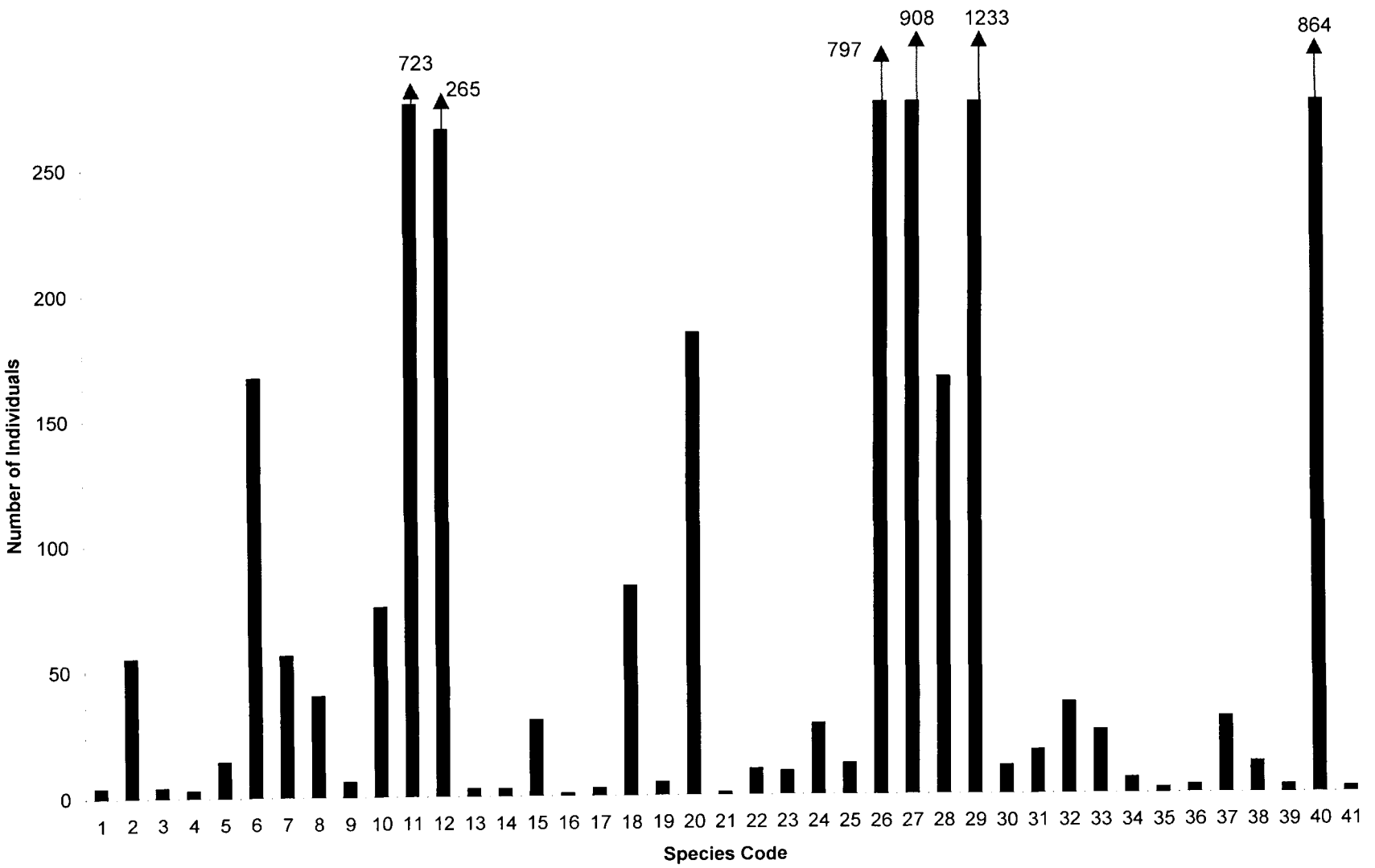


Fig.4.16 - Species abundance - Elathoor

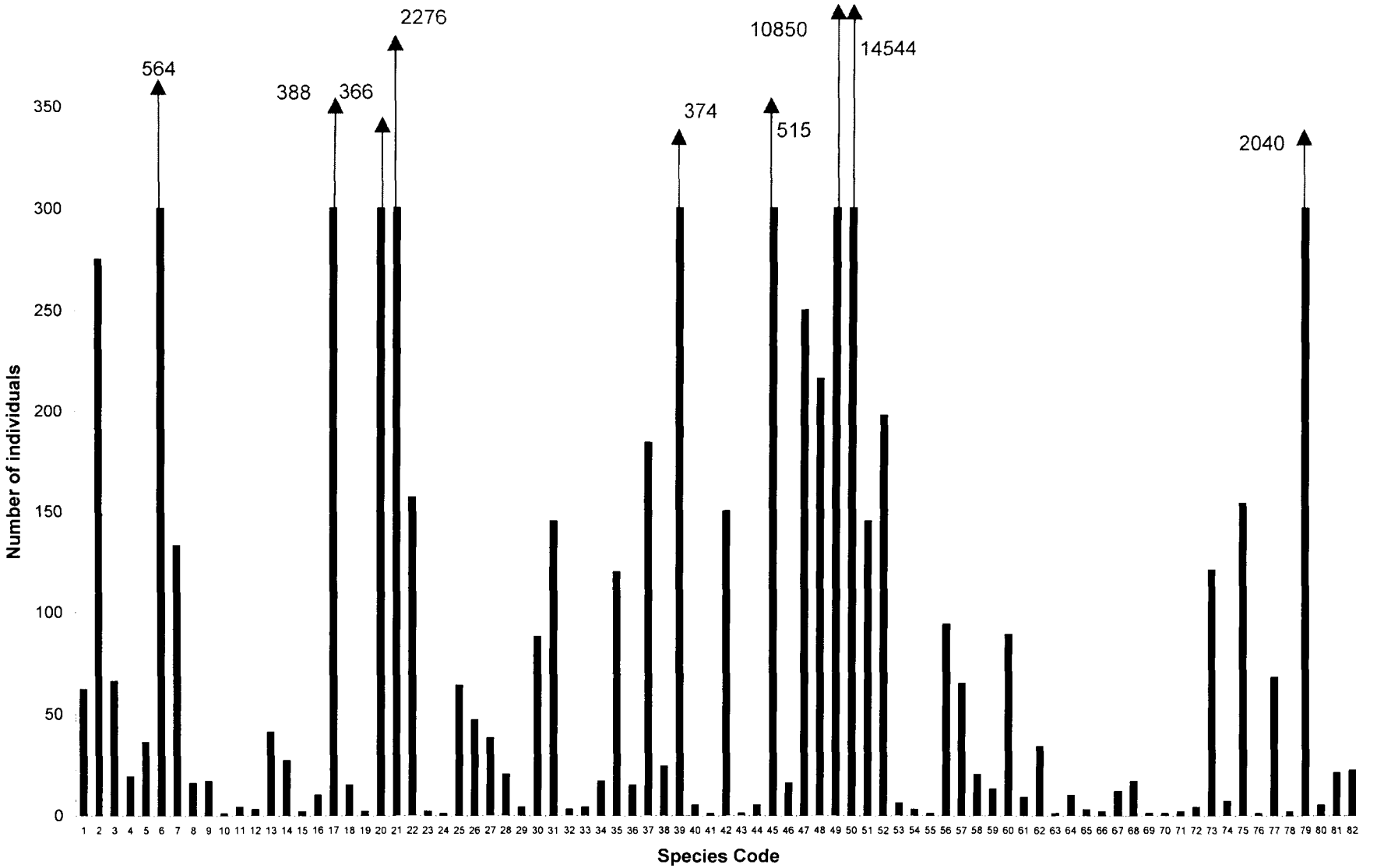


Fig.4.17 - Species Abundance - Kadalundy

It is noted that in all the three study areas viz. Azhingillam, Elathur and Kadalundy, the species richness is high in about 20-30% of the total species and very low in about 30-40% of the total species. The percentage of species with an accumulated total ranging between 10 and 100 is between 39 and 43. The results are tabulated in table 4.16and shown graphically in Fig.4.18.

Table 4.16. Percentage of species with an accumulated total above 100, between 10 and 100 and below 10 in the three study areas

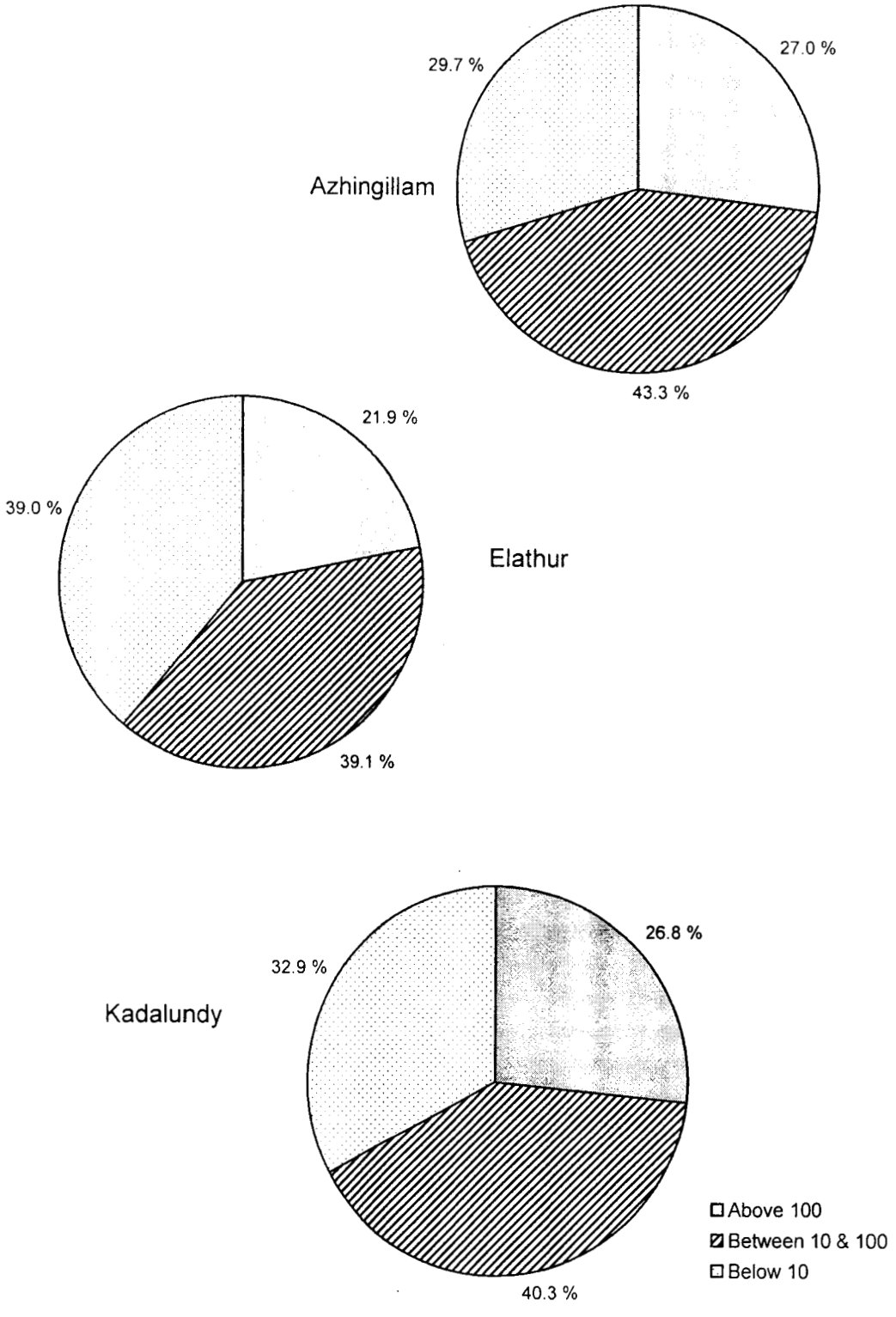
Percentage of species with accumulated total	Study areas		
	AZHINGILLAM	ELATHUR	KADALUNDY
Above 100	27.0%	21.9%	26.8%
Between 10 and 100	43.3%	39.1%	40.3%
Below 10	29.7%	39.0%	32.9%

The results show a uniform pattern of species abundance in all the three study areas with more than 60% of species having an accumulated total above 10.

4.5.Seasonal Abundance

In an attempt to assess the effect of different seasons on the abundance of species in the three study areas, I had divided each calendar year into 3 seasons based on temperature and rainfall as given below.

Fig.4.18. – Percentage of species with an accumulated total above 100, between 10 and 100 and below 10 in the three study areas.



Season	Months
Summer	February, March, April, May
Monsoon	June, July August, September
Winter	October, November, December, January.

In all the study areas, the abundance was high during the winter and summer seasons of the study period. The species richness of these area started increasing due to the arrival of migrants during winter. An interesting phenomenon noted in this study is that except in Elathur, all the study areas swelled up with maximum number of bird species during the early half of summer season. This is in contrast to the common notion that increase in species is maximum during winter season (Ramakrishan, 1983) due to the arrival of Palearctic migrants. During September - October they arrive in India and spread out and by the commencement of summer in March, April they return north for breeding. The spurt of bird species in Azhingillam and Kadalundy during the early period of summer could be attributed to the aggregation of birds in areas where water level is still high and food is abundant. During summer, when the wetlands of the surrounding areas get dried up, these two study areas are found to attract birds. The large number of birds during the first half of the summer season

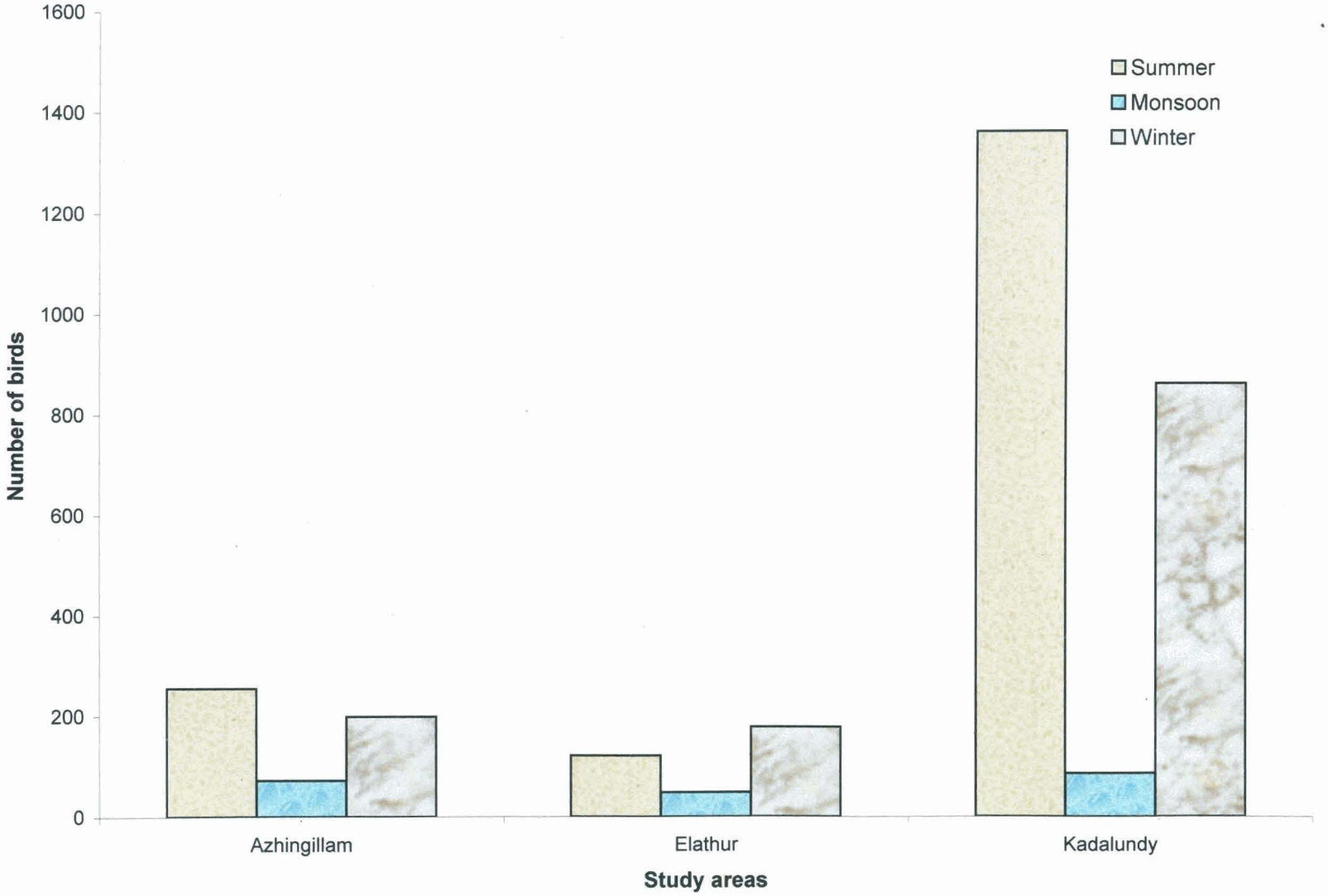


Fig.4.19 Seasonal abundance of birds in the study areas during the years 1993-1995

may also be due to the gathering of birds before their return trip northward.

The study area of Elathur showed an increasing trend in bird population during winter. Bird population was low during Monsoon and summer season as expected. The data is given in Table 4.17.

Table 4.17. Seasonal abundance of birds in the three study areas

Seasons / Study area	Summer	Monsoon	Winter
Azhingillam	255	72	199
Elathur	122	49	179
Kadalundy	1361	87	861

There was not much seasonal difference in abundance in the case of resident birds in any of the study areas except in the case of the family Ardeidae. Many members of the Ardeidae family showed an increase in the total number of individuals during summer season in all the study areas. Egrets and Herons whose main food is fish were found to prefer areas in these wetlands which still maintain patchy stretches of shallow water or pot holes to scare up food (Fig. 4. 20).

Observations on the resident and migratory birds of the three study areas show that in Azhingillam, the resident-migrant ratio is 4:1. In Elathur and Kadalundy the ratio is 1:1(Fig. 4.21).

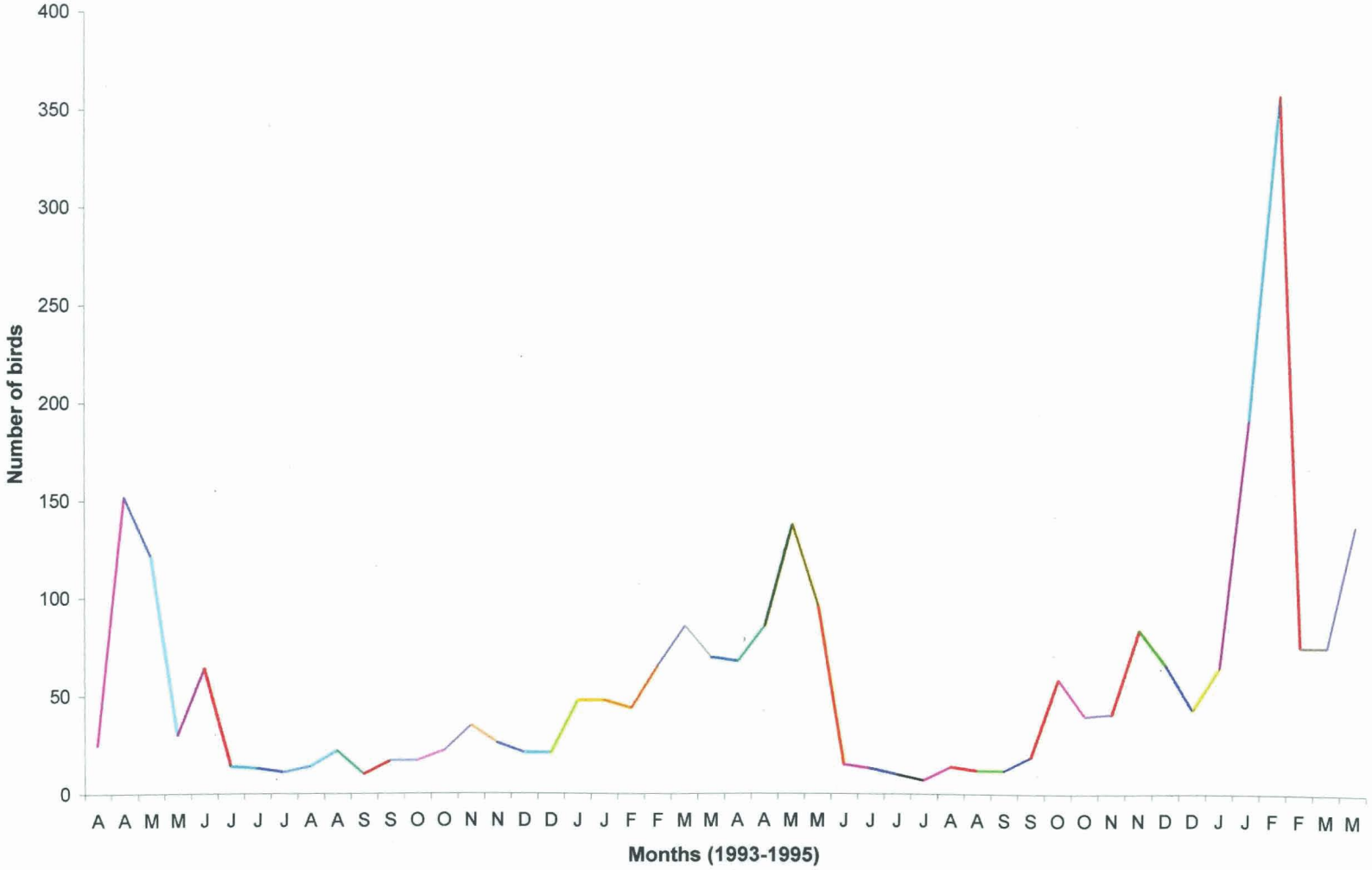


Fig.4.20 - Monthly variation in the number of birds in the Ardeidae family in Azhingillam

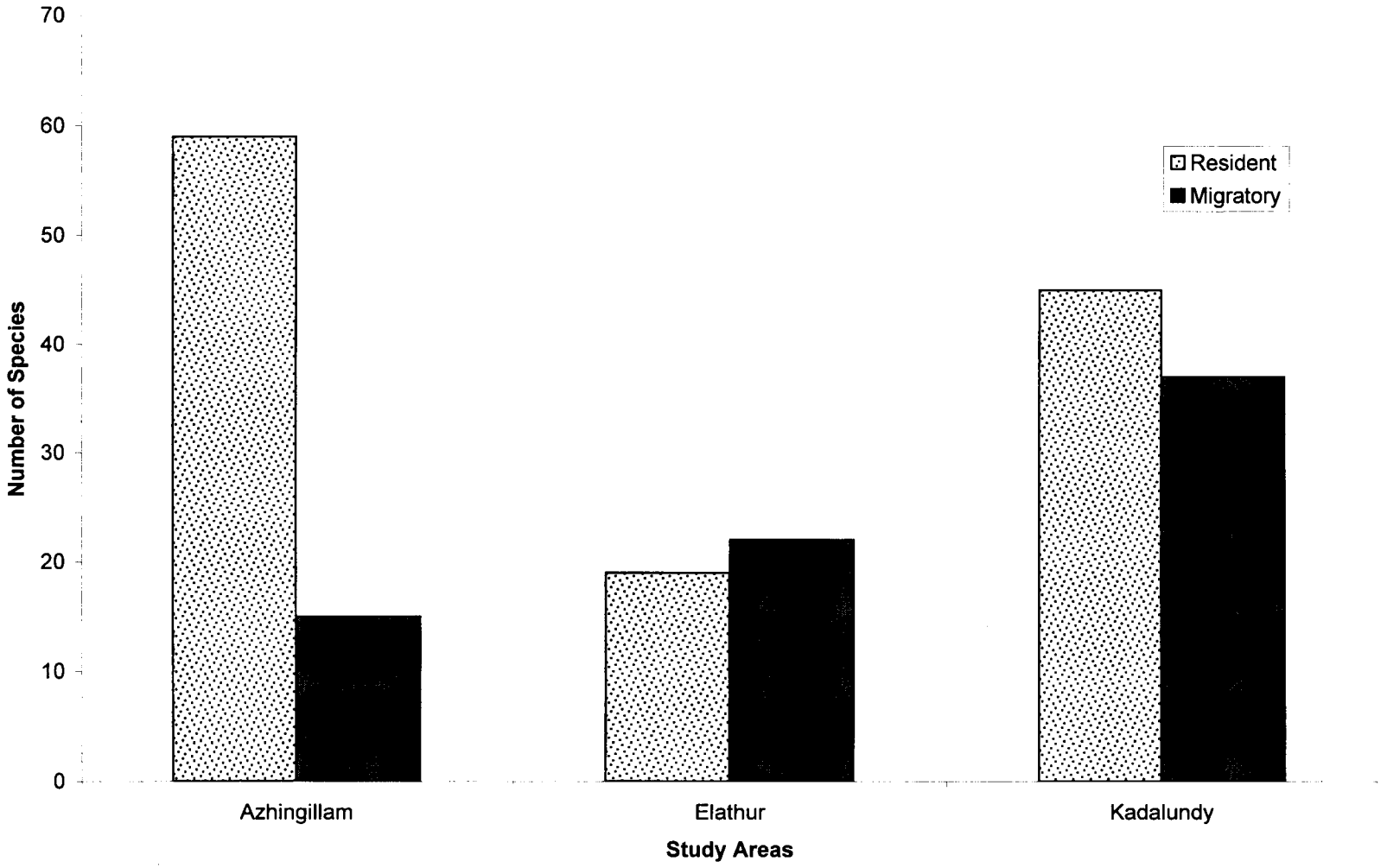


Fig.4.21 - Number of Resident and Migratory Species in Different Study Areas

4.5. Occurrence of families

In order to study the occurrence of different bird families in the three selected wetland viz. Azhingillam Elathur and Kadalundy, I used line transect method. Of the three study areas, Azhingillam had the maximum number of bird families. Here birds belonging to 28 families were recorded. At Elathur I could observe 14 families of birds and in Kadalundy 23. The bird families observed and their relative abundance in each study area is shown in Fig.4.22- 4.24.

Azhingillam is a diverse habitat, which shares the edges between different types of ecosystems surrounding it. Such areas are expected to have more number of bird species thus leading to high species diversity. Kadalundy estuary forms the winter ground for a large number of migratory shore birds and their arrival and the local movement of resident birds from the surrounding areas account for the comparatively high representation of bird families in this area. Among the three study areas, Elathur showed the minimum number of 14 families. It may be due to fact that, the rocky shores and sandy beaches of this area attract fewer shore birds, which prefer muddy shores.

Analysis of the data shows that, among the bird families, of the three wetlands, some of the families are common to all the study areas. The names of the families present in each study area and the number of species in each family is given in table 4.18.

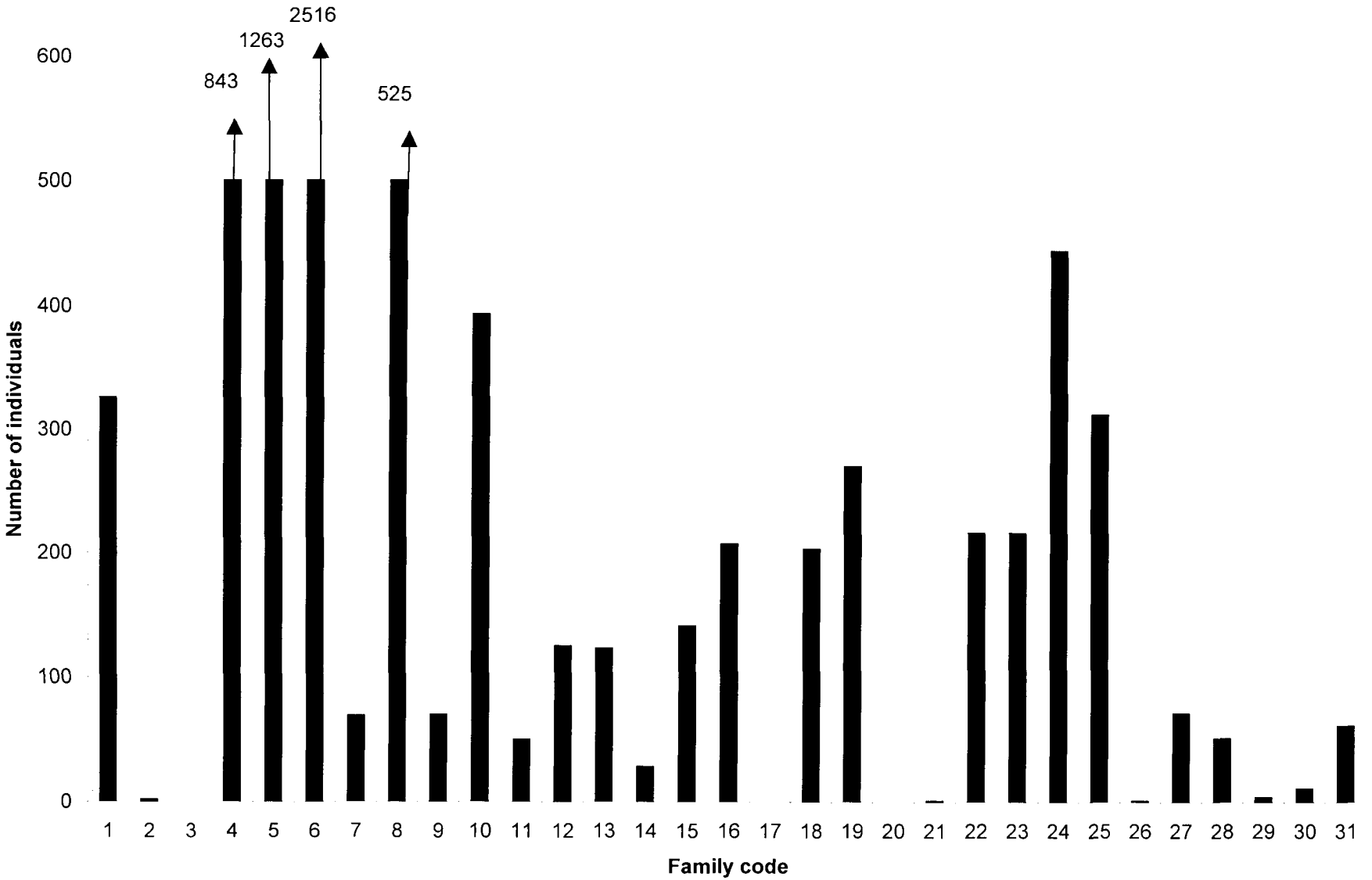


Fig 4.22 Abundance of familes-Azhingillam

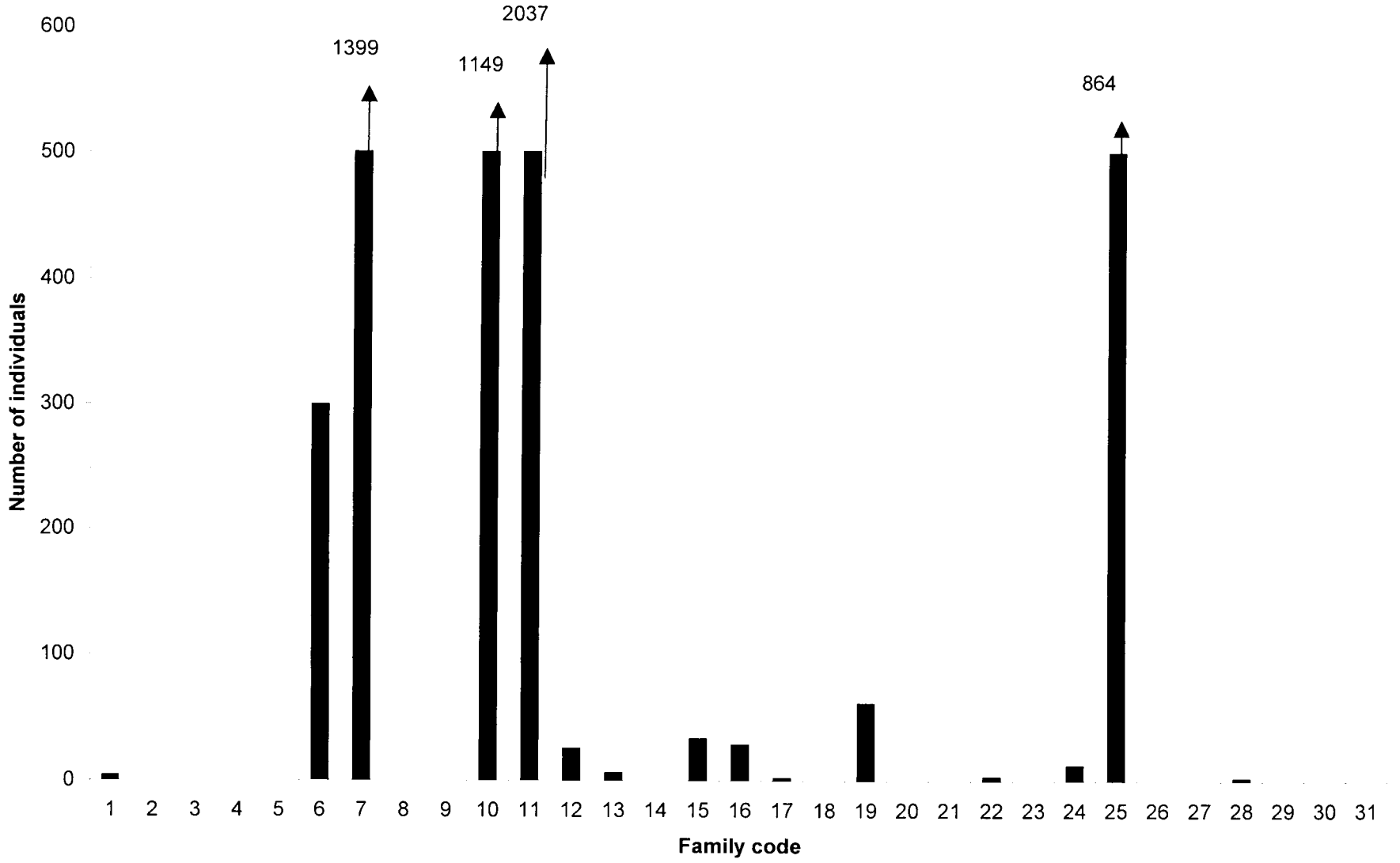


Fig 4.23 - Abundance of families-Elathur

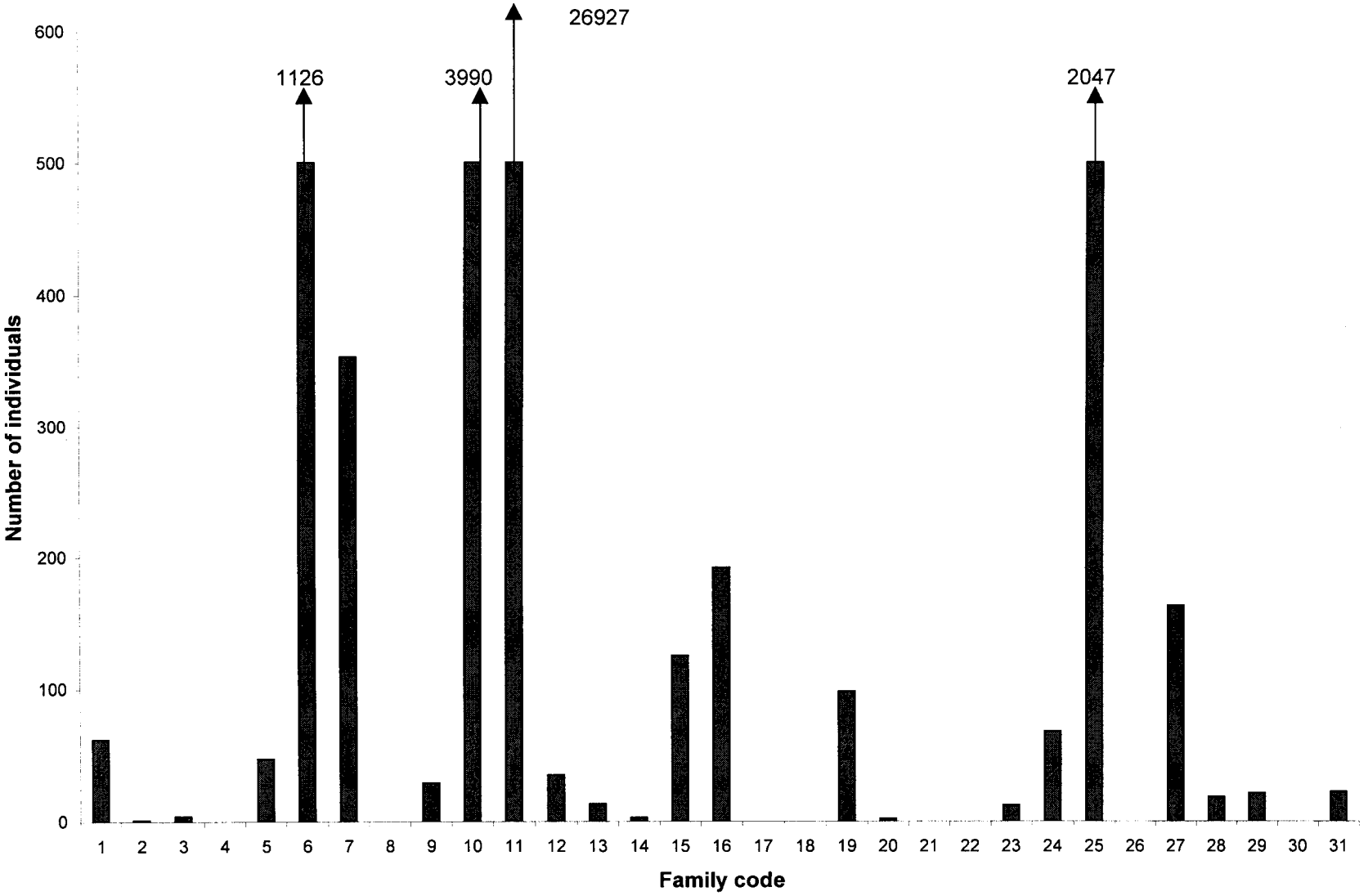


Fig 4.24 Abundance of families-Kadalundy

The families, which are common to all the study areas were Phalacrocoracidae, Ardeidae, Charadridae, Laridae and Alcedinidae. The members of these families are seemed to have high specialization and adaptation to exploit the resources from all the three wetland areas studied.

Four families viz., Threskiornithidae, Ciconidae, Rallidae and Recurvirostridae were found to be common between Azhingillam and Kadalundy only. However two families namely Anatidae and Jacanidae are observed only in the freshwater habitat of Azhingillam.

In Azhingillam, the families which carried the largest number of birds can be written in the descending order of number of individuals as Ardeidae > Rallidae > Anatidae > Jacanidae > Charadridae > Sturnidae > Plalacrocoracidae. These 7 families contribute the major share in the total population observed in Azhingillam. The Ardeidae family has a contribution of 30% of the total population and that of Rallidae family is 15%.

Elathur study area had 5 families, which constitute the major bulk of the total number of birds observed. They can be arranged in the descending order of bird numbers as Laridae > Accipitridae > Charadridae > Corvidae > Ardeidae. Family Laridae had 34.5% contribution and family Accipitridae had 23.71% contribution to the total population.

In Kadalundy, 4 families namely, Laridae, Charadridae, Corvidae and Ardeidae are found to be the most numerous. Among them, the family Laridae alone accounts for more than 76% the total population. The families can be arranged in the decreasing order of bird numbers as Laridae > Charadridae > Corvidae > Ardeidae. The family charadridae had the contribution of 11.28% in this study area.

Of the thirty one different families observed, the family Laridae was found to be the dominant one in two study areas namely Elathur and Kadalundy. In Azhingillam, the family Ardeidae is the dominant one followed by Rallidae. However, it is to be noted that, the largest representation of species per families was observed in the case of Charadridae in all the three study areas. The number of species present in the family Charadridae was 9, 10 and 23 in Azhingillam, Elathur and Kadalundy respectively. But in Elathur, the family Laridae also has the same number of species i.e. 10 followed by Ardeidae, which comes second with 6 species.

In Azhingillam, the family, which is having the second maximum number of species, is Ardeidae with 8 bird species and in Kadalundy it is the family Laridae with 12 bird species. The bird families of each study area and the number of species in each family per area the shown in Fig. 4.25.

Table 4.18. Number of species in each family of birds in the three study areas

Family Code	Name of the family	Number of species in each area		
		Azhingillam	Elathur	Kadalundy
1.	Phalacrocoracidae	2	1	1
2.	Threskiornithidae	1	0	1
3.	Ciconidae	0	0	1
4.	Anatidae	5	0	0
5.	Rallidae	4	0	2
6.	Ardeidae	8	6	8
7.	Accipitridae	3	2	5
8.	Jacanidae	2	0	0
9.	Recurvirostridae	1	0	2
10.	Charadridae	9	10	23
11.	Laridae	1	10	12
12.	Columbidae	2	0	2
13.	Psittacidae	2	1	2
14.	Cuculidae	2	0	2
15.	Apodidae	2	2	2
16.	Alcedinidae	4	2	4
17.	Picidae	0	1	0
18.	Alaudidae	2	0	0
19.	Hirundinidae	2	2	2
20.	Laniidae	0	0	1
21.	Oriolidae	1	0	0
22.	Dicruridae	2	1	0
23.	Artamidae	1	0	1
24.	Sturnidae	2	1	1
25.	Corvidae	3	1	3
26.	Pycnonotidae	1	0	0
27.	Muscicapidae	4	0	3
28.	Motacillidae	4	1	2
29.	Nectariniidae	2	0	1
30.	Ploceidae	2	0	0
31.	Meropidae	2	0	1

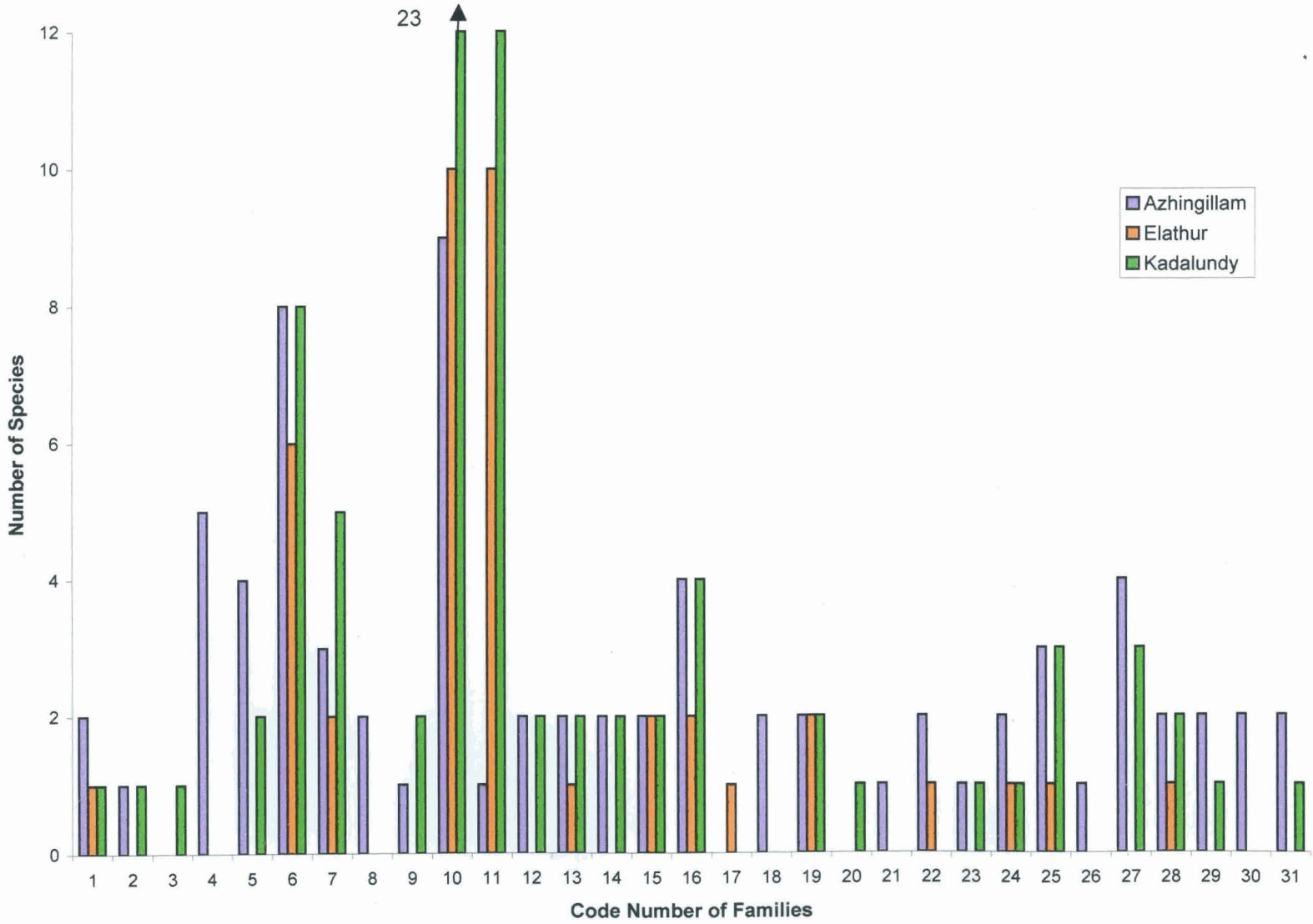


Fig. 4.25 - Number of species in each family of birds observed in Azhingillam, Elathur and Kadalundy

Chapter V

Bird Community Structure

CHAPTER V

BIRD COMMUNITY STRUCTURE

A community is an assemblage of populations in which each population constitutes the individuals of a species. The communities and populations of an area could be measured and studied by means of species diversity, species association, relative similarities etc.

5.1 Species diversity

Species diversity can be measured directly as number of species, however it has been expressed as an index that incorporates both species richness and relative abundance of species in the form of a single value for a given community (Weins, 1989). Therefore species diversity has two components; (a) the number of species in a community or species richness and (b) the species evenness or equitability.

In calculating the species diversity of the three study areas, I collected preliminary data using the line transect method. This data gives the number of species and number of individuals in each species of the study area. The data were collected by 48 line transects in each study area as described in detail in Chapter III.

For calculating species richness and evenness or equitability a number of indices have been proposed. Such indices are termed richness

indices and evenness indices. Diversity indices are those that combine both richness and evenness of a particular area.

5.2. Richness Indices

In my study species richness is calculated by two richness indices as follows.

(1) Margalef (1959) index

$$R_1 = \frac{S - 1}{\ln (n)}$$

(2) Menhinick (1964) index

$$R_2 = \frac{S}{\sqrt{n}}$$

Where 'S' is the number of species encountered and 'n' is the total number of individuals.

5.3.Diversity Indices

The diversity index is a combined value incorporating species richness and evenness and has got a major limitation. From the diversity index value it is impossible to assess the relative importance of species richness and evenness. Therefore Ludwig and Reynolds (1988) suggest the

series of diversity number presented by Hill (1973b) are probably the easiest way to assess the community.

Hill's diversity numbers are:

N_0 = S where 'S' is the total number of species

N_1 = $e^{H'}$ where H' is the Shannon's index

N_2 = $1/\lambda$ where λ is the Simpson's index

Of these three diversity numbers, N_0 represents the number of all the species in the sample. N_1 measures the number of abundant species and N_2 is a measure of very abundant species.

For computing Hill's diversity numbers, then two indices namely Simpson's index λ and Shannon's index H' are required. They are calculated using the following formula:

1. Simpson's index (1949) $\lambda = \sum_{i=1}^{S} (Pi)^2$

Where Pi is the proportional abundance of i^{th} species, given by $pi = (n_i/N)$, $i = 1, 2, 3, \ldots\ldots S$.

2. Shannon index $H' = -\sum_{i=1}^{S} [\, Pi \log_e (Pi) \,]$

where Pi is the proportional abundance of i^{th} species. This formula is influenced by both the number of species and the number of individuals of each species in the sample and therefore the diversity index is compounded by the interaction of these two factors.

5.4.Equitability or Evenness Indices

Equitability measures the evenness of species abundance and is complementary to the diversity concept (Lloyd and Ghelardi, 1964). Equitability is a measure of how the individuals are apportioned among the species. The index represents the ratio of the observed diversity H' to the maximum diversity possible for the same number of species. It has a maximum value of 1.0 when all the species are equally abundant. A minimum value is obtained when all species, except the most abundant are represented by only one individual (Tramer, 1969). Thus, the equitability index varies inversely with the measures of species diversity.

A number of indices have been proposed to calculate the evenness component of diversity. A series of five indices are used here. They are expressed as a ratio of Hill's numbers (Alatalo, 1981).

1. Evenness index I (Pielou, 1975, 1977) $E_1 = H'/\ln(S) = \ln(N_1)/\ln(N_0)$
2. Evenness index II (Shelden, 1969) $E_2 = eH'/S = N_1 / N_0$

3. Evenness index III $E_3 = eH'-1/S-1 = N_1 - 1 / N_0 - 1$
(Heip, 1974)

4. Evenness index IV $E_4 = (1/\lambda)/e^{H'} = N_2 / N_1$
(Hill, 1973b)

5. Evenness index V $E_5 = (1/\lambda) - 1/e^{H'}-1 = N_2-1/N_1-1$
(Alatalo, 1981)

Species richness, diversity and evenness indices are calculated and summarised in table 5.1.

Table 5.1. Species richness, diversity and evenness of the birds of Azhingillam, Elathur and Kadalundy

Indices		Azhingillam	Elathur	Kadalundy
Richness	N_0	74	41	82
	R_1	8.08	4.60	7.74
	R_2	0.81	0.53	0.46
Diversity	λ	0.56	0.13	0.27
	H_1	3.20	2.35	1.91
	N_1	24.53	10.49	6.75
	N_2	17.98	7.84	3.67
Evenness	E_1	0.74	0.63	0.43
	E_2	0.33	0.26	0.08
	E_3	0.32	0.24	0.07
	E_4	0.73	0.75	0.54
	E_5	0.72	0.72	0.46

The Margalef index R_1 of the three study areas give comparatively high values at Azhingillam and Kadalundy due to the large number of species present. The calculated R_1 value at Elathur is very low due to the less number of species observed there.

Menhinick index which is the ratio of the number of species to the square root of the total number of individuals showed very low values at Kadalundy and Elathur. This indicates a large increase in the total number of individuals on comparison with the total number species here. The total number of individuals at Elathur and Kadalundy was found to be influenced by the large populations of gulls and terns. Azhingillam is a freshwater habitat where the influx of such populations does not seem to occur.

The Shannon's index, which takes into account the relative abundance of each species gives, a maximum value of 3.20 at Azhingillam followed by Elathur (2.35) and Kadalundy (1.91). The measure of the number of abundant species (N_1) also showed the same pattern of decreasing trend from Azhingillam to Kadalundy as observed for Shannon index. The number of abundant and very abundant species (N_1 and N_2) is high at Azhingillam and Elathur but Kadalundy gave a comparatively lower value. It is apparent that in Azhingillam and Elathur the number of species having more individuals per species is higher on comparison with

the total number of species observed. In Kadalundy, the low value of H' inspite of the high value of N_0 is due to the extremely high number of individuals in very few species. Since species diversity is directly related to the species abundance, it would appear that areas having low diversity have low species abundance.

The analysis of evenness shows an orderly decrease in value from Azhingillam to Elathur and then to Kadalundy. It is noted that in Azhingillam apportionment of individuals among species is high when compared to the other two study areas. It is well known that species variety and number of individuals tends to be high at the interface or ecotone between two habitats. Azhingillam is a wetland surrounded by different types of habitats like scrub jungles, sacred groves, monoculture plantations etc. This may be the reason for the high equitability value of Azhingillam.

Elathur also showed a comparatively high value for different evenness indices. In this study area only 41 species birds could be recorded throughout the whole study period. But the total number of individuals in this area was quiet high to give an increased value while computing the evenness indices.

In Kadalundy, the edge effects of ecotones are diluted due to the monotony of habitat and life style of the substantial human population

there. This estuarine habitat itself seems to be less varied on comparison with Elathur. Therefore the low equitability value of this study area is not unexpected.

5.5.Similarity (Coefficient of Community C.C.)

In this part an attempt was made to compare the similarity between habitats. Each habitat was found to have its own bird species, but several of them were found to occur in other areas also.

Similarity or Coefficient of Community was calculated using the formula

$$\text{Similarity (Sim)} = 2C / A+B$$

where A = Number of species in site A

B = Number of species in site B

C = Number of species common to A and B

Similarity index between different habitats is shown in Table 5.2.

The similarity index varies from 0 to 1 to quantify the range from 0 similarity to cent percent similarity. The coefficient of community does not, however denote the relative abundance of the different species.

Table 5.2. Similarity index between different study areas

Habitats	Similarity Index (Sim)	Coefficient of Dissimilarity (1-Sim)
Azhingillam and Elathur	0.37	0.63
Azhingillam and Kadalundy	0.60	0.40
Elathur and Kadalundy	0.62	0.38

Of the three localities studied, maximum similarity was observed between Elathur and Kadalundy meaning thereby that they are similar in their species composition. Similarity index between Azhingillam and Kadalundy also gave a value very close to that between Elathur and Kadalundy showing the presence of a large number of birds common to these habitats. The results were not unexpected since the study areas of Elathur and Kadalundy were two habitats, which are similar. Azhingillam fresh water jheel, which is not located far away from the seacoast is found to be a good winter habitat for many migratory shore birds. This could be attributed to the high similarity index between Azhingillam and Kadalundy.

The names of species, which are common to all the habitats, common between two habitats and specific to a particular habitat, are given in Tables 5.3 to 5.9.

Table 5.3. List of species common to all the habitats

Sl. No.	Name of the species
1.	Little Cormorant
2.	Little Egret
3.	Median Egret
4.	Large Egret
5.	Cattle Egret
6.	Pond Heron
7.	Golden Plover
8.	Common Sandpiper
9.	Whiskered Tern
10.	Pariah Kite
11.	Brahminy Kite
12.	Small Blue Kingfisher
13.	Whitebreasted Kingfisher
14.	Swallow
15.	Redrumped Swallow
16.	Palm Swift
17.	Alpine Swift
18.	Common Myna
19.	House Crow
20.	Roseringed Parakeet

Table 5.4. List of species common between Azhingillam and Elathur

Sl. No.	Name of the species
1.	Little Cormorant
2.	Little Egret
3.	Median Egret
4.	Large Egret
5.	Cattle Egret
6.	Pond Heron
7.	Golden Plover
8.	Common Sandpiper
9.	Whiskered Term
10.	Pariah Kite
11.	Brahminy Kite
12.	Small Blue Kingfisher
13.	Whitebreasted Kingfisher
14.	Swallow
15.	Redrumped Swallow
16.	Roseringed Parakeet
17.	Alpine Swift
18.	Palm Swift
19.	Common Myna
20.	Black Drongo
21.	House Crow

Table 5.5. List of species common between Azhingillam and Kadalundy

Sl. No.	Name
1.	Little Cormorant
2.	Little Egret
3.	Median Egret
4.	Large Egret
5.	Cattle Egret
6.	Pond Heron
7.	Reef Heron
8.	Golden Plover
9.	Grey Plover
10.	Kentish Plover
11.	Lesser Sand Plover
12.	Common Sandpiper
13.	Tereck Sandpiper
14.	Greenshank
15.	Whimbrel
16.	Curlew
17.	Turnstone
18.	Whiskered Tern
19.	Caspian Tern

Sl. No.	Name
20.	Little Tern
21.	Large crested Tern
22.	Common Tern
23.	Herring Gull
24.	Lesser Blackbacked Gull
25.	Great Blackbacked Gull
26.	Brownheaded Gull
27.	Blackheaded Gull
28.	Pariah Kite
29.	Brahminy Kite
30.	Small Blue Kingfisher
31.	Whitebreasted Kingfisher
32.	Swallow
33.	Redrumped Swallow
34.	Roseringed Parakeet
35.	Alpine Swift
36.	Palm Swift
37.	Common Myna
38.	House Crow

Table 5.6. List of species common between Elathur and Kadalundy

Sl. No.	Name
1.	Little Cormorant
2.	Little Egret
3.	Median Egret
4.	Large Egret
5.	Cattle Egret
6.	Pond Heron
7.	Reef Heron
8.	Golden Plover
9.	Grey Plover
10.	Kentish Plover
11.	Lesser Sand Plover
12.	Common Sandpiper
13.	Terek Sandpiper
14.	Greenshank
15.	Whimbrel
16.	Curlew
17.	Turnstone
18.	Whiskered Tern
19.	Caspian Tern

Sl. No.	Name
20.	Little Tern
21.	Large Crested Tern
22.	Common Tern
23.	Herring Gull
24.	Lesser Blackbacked Gull
25.	Great Blackbacked Gull
26.	Brownheaded Gull
27.	Blackheaded Gull
28.	Pariah Kite
29.	Brahminy Kite
30.	Small Blue Kingfisher
31.	Whitebreasted Kingfisher
32.	Swallow
33.	Redrumped Swallow
34.	Roseringed Parakeet
35.	Alpine Swift
36.	Palm Swift
37.	Common Myna
38.	House Crow

Table 5.7. List of species observed only in Azhingillam

Sl. No.	Name
1.	Purple Heron
2.	Yellow Bittern
3.	Chestnut Bittern
4.	Cotton Teal
5.	Lesser Whistling Teal
6.	Garganey
7.	Little Grebe
8.	Common Teal
9.	Purple Moorhen
10.	Indian Moorhen
11.	Bronzewinged Jacana
12.	Pheasant- tailed Jacana
13.	Redwattled Lapwing
14.	Redvented Bulbul
15.	Jungle Babbler
16.	White headed Babbler
17.	Jungle Myna
18.	Golden Oriole
19.	Racket -tailed Drongo
20.	Purplerumped Sunbird
21.	Crested Lark
22.	Black bellied Finch lark
23.	Whitebacked Munia
24.	Spotted Munia

Table 5.8. List of species observed only in Elathur

Sl. No.	Name
1.	Grey Wagtail
2.	Goldenbacked woodpecker

Table 5.9. List of species observed only in Kadalundy

Sl. No.	Name
1.	Grey Heron
2.	Black Bittern
3.	Openbill Stork
4.	Avocet
5.	Large Sand Plover
6.	Redshank
7.	Blacktailed Godwit
8.	Bartailed Godwit
9.	Eastern Knot
10.	Sanderling
11.	Dunlin
12.	Gullbilled Tern
13.	Sandwich Tern
14.	Osprey
15.	Shikra
16.	Rufousbacked Shrike
17.	Tailor Bird

Chapter VI

Water Quality Parameters

CHAPTER VI

WATER QUALITY PARAMETERS

This chapter deals with the seasonal changes in some of the water quality parameters of Azhingillam, Elathur and Kadalundy. Parameters like pH, Dissolved oxygen (DO), Biochemical Oxygen Demand (BOD) inorganic phosphate phosphorus, nitrite nitrogen and Primary productivity were monitored for a period of one year from October 1995 to September 1996.

Wetlands have unique physico-chemical conditions of hydrology. Hydrological pathways such as precipitation, surface run off, ground water, tides and flooding rivers transport energy and nutrients to and from wetlands. The biota of a wetlands depends mainly on the chemistry of the soil and water which is influenced by water depth, flow patterns and duration and frequency of flooding which are the result of all of the hydrologic inputs and outputs (Gosselink and Turner, 1978).

Hydrology is probably the single most important determinant for the establishment and maintenance of specific types of wetland and wetland processes. The seasonal pattern of the water level of a wetland is called the hydroperiod and it is like a hydrologic signature of each wetland type (Mitsch and Gosselink, 1986). Hydroperiod is an integration of all inflow

and outflow of water, but it is also influenced by physical features of the terrain and by proximity to other bodies of water.

The three wetlands studied were found to be influenced by surface inflow of two types: (1) overland flow and (2) stream flow. Overland flow occurs during and immediately after rainfall or as tides rise. In Azhingillam channelized stream flow from Chaliyar river was observed during monsoon season. Elathur and Kadalundy are subjected to periodic and predictable tidal inundation.

6.1 pH

pH is a measure of the concentration of hydrogen ion in water. It is generally measured as the negative logarithm of hydrogen ion concentration. pH scale ranges from 0-14 with 7 as the neutral below seven being acidic and above 7 as alkaline.

Most natural waters are alkaline due to the presence of carbonates. pH of a water body changes with time due to biological activity, temperature changes and even exposure to air. pH also changes diurnally and seasonally due to variation in photosynthetic activity which increases the pH due to the consumption of CO_2 in the process. pH of a waterbody may change due to the disposal of industrial effluents also.

In the present study the pH of the water samples collected from the three wetlands namely Azhingillam, Elathur and Kadalundy was determined in every month for a period of one year using the Indicator paper method. The results are tabulated in Table 6.1.

The pH of the water samples of Azhingillam ranged between 6-7 almost throughout the study period. This study area is a freshwater jheel, which does not receive any effluents, or chemicals, which alter the acidity or alkalinity of the water.

pH values of the water samples of Elathur area also showed a range between 6-7 except for the month of December and May during which the hydrogen ion activity was slightly high.

Measurement of pH of Kadalundy wetland area showed almost neutral pH values throughout the study period.

The analysis of pH of the water samples of the aforesaid wetlands agree with the observation of Mitsch and Gosselink(1986) that 'wetlands which are open' to river flooding and inputs of neutral and generally well mineralized waters have a pH ranging between 6-7.

Fig 6.1 - Monthly Variation in P^H of water samples of Azhingillam, Elathur & Kadalundy

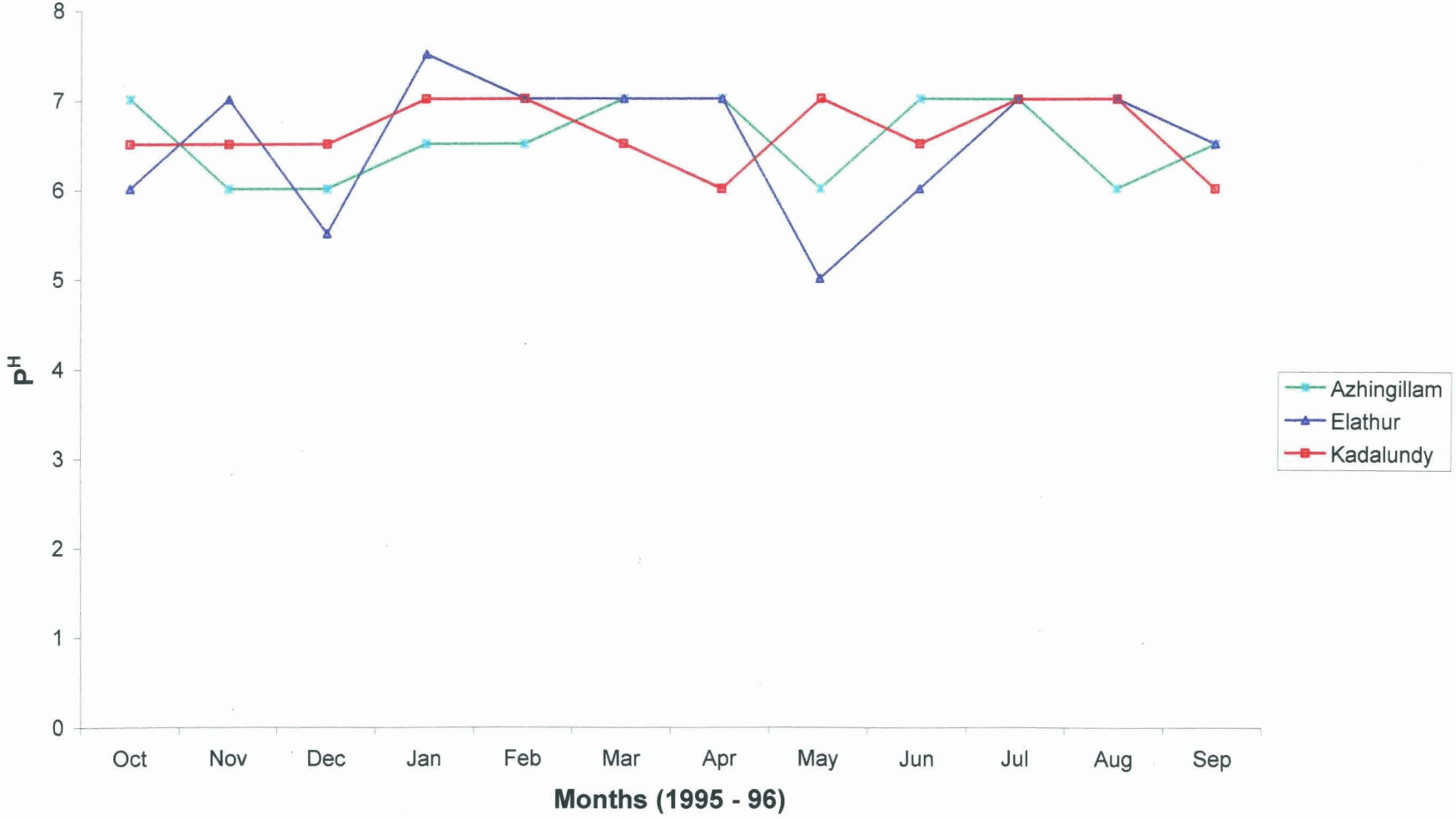


Table 6.1. Monthly variation in pH of water samples of Azhingillam, Elathur and Kadalundy

Months	Azhingillam	Elathur	Kadalundy
October	7	6	6.5
November	6	7	6.5
December	6	5.5	6.5
January	6.5	7.5	7.0
February	6.5	7	7.0
March	7	7	6.5
April	7	7	6
May	6	5	7
June	7	6	6.5
July	7	7	7
August	6	7	7
September	6.5	6.5	6

6.2. Dissolved Oxygen

All living organisms are dependent upon oxygen in one form or another to maintain the metabolic processes that produce energy for growth and reproduction. Dissolved oxygen in a water body is one of the most important parameters in water quality assessment, which reflect physical and biological processes prevailing in waters (Trivedy and Goel,

1984). The concentration of oxygen in water reflects the aerobic or anaerobic processes going on in the system. A low oxygen concentration is generally associated with heavy contamination by organic matter and in such conditions, oxygen, sometimes totally disappears from the water. The rate at which oxygen is depleted depends on the ambient temperature, the availability of organic substance for microbial respiration, and sometimes as chemical oxygen demand from reductants such as ferrous ion (Gambreel and Patrick, 1978).

Non-polluted surface waters are normally saturated with dissolved oxygen. The solubility of atmospheric oxygen in fresh water ranges from 14.6 mg/l at 0°C to about 7 mg/l at 35°C under 1 atm. of pressure (Sawyer & Mc Carty, 1978). Oxygen is a poorly soluble gas and its solubility varies directly with the atmospheric pressure and temperature. The solubility of oxygen is less in salt-containing water than it is in clean water (Whipple and Whipple, 1911).

Measurement of dissolved oxygen serve as efficient indicator of the state of pollution of any body of fresh water. Oxygen deficiency can kill fish and many other organisms present in water. Therefore it is desirable to maintain conditions favourable for the growth and reproduction of a normal population of fish and other aquatic organisms. This requires the

maintenance of dissolved oxygen levels that will support the desired aquatic life in a healthy condition at all times.

In the present study, the dissolved oxygen content of the water samples of three wetlands of Azhingillam, Elathur and Kadalundy was estimated by Winkler's method for a period of one year from October 1995 to September 1996. Water samples from all the three study areas were collected, monthly, in B.O.D. bottles and fixed using Winkler Reagent A and B. The bottles were then brought back to the laboratory and D.O. estimation was carried out. The results of the D.O. estimation were given in Table 6.2.

Azhingillam, which is a fresh water habitat, had an oxygen content of above 6 mg/l in 8 months and it reached a maximum value of 11.20 mg/l in November 1995. A low value of 3.52 mg/l was noted in the month of December 1995 (Fig. 6.2).

In Elathur, the water samples contained dissolved oxygen of above 6 mg/l in 9 months with a maximum value of 12.08 mg/l in May 1996. A low value of 3.06 mg/l was estimated in the month of April 1996.

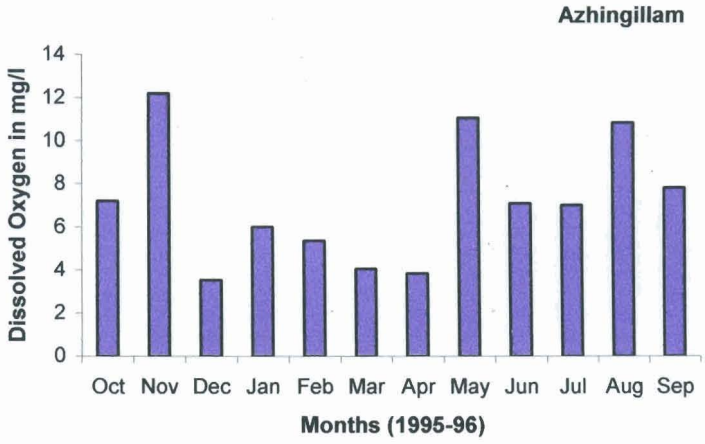
Water samples from Kadalundy area showed a comparatively high concentration of oxygen (above 6 mg/l) almost throughout the year except for the month of October 1995 and April 1996.

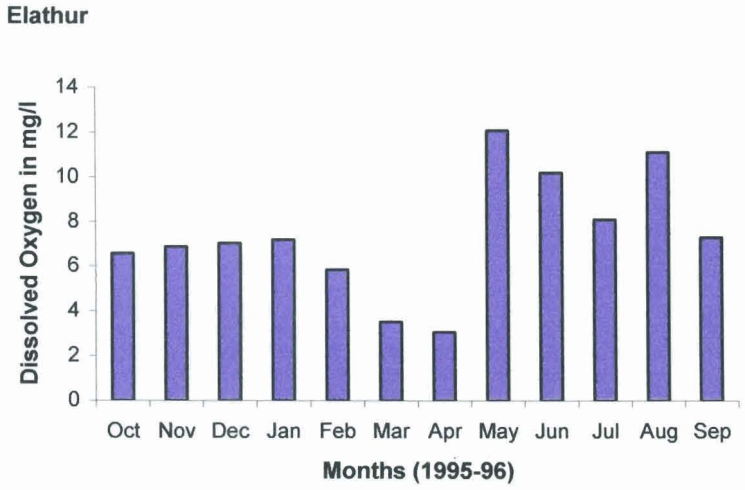
Table 6.2. Monthly variation in Dissolved Oxygen in Water Samples of Azhingillam, Elathur and Kadalundy (mg/l)

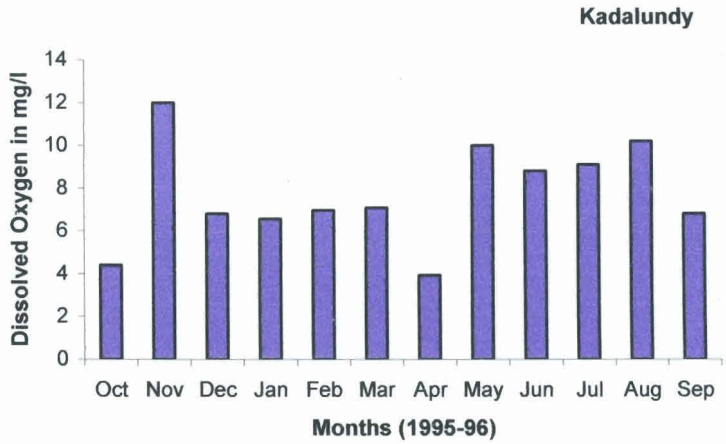
Study Area / Month	Azhingillam	Elathur	Kadalundy
October	7.20	6.56	4.40
November	12.20	6.88	12.00
December	3.52	7.04	6.80
January	6.00	7.20	6.56
February	5.36	5.84	6.96
March	4.04	3.52	7.08
April	3.84	3.06	3.92
May	11.06	12.08	10.00
June	7.08	10.20	8.80
July	7.00	8.09	9.10
August	10.81	11.11	10.20
September	7.80	7.30	6.80

It evident from the results that none of these study areas is under the threat of anoxic conditions. In Azhingillam and Elathur comparatively low levels of DO was estimated only during the summer season and in Kadalundy it is in the month of April. This could be attributed to the increase in water temperature during summer, which decreases the solubility of oxygen. Reduction in rainfall in summer months and a decreased run off in rivers may also influence the dissolved oxygen content of these wetlands. It is very clear from the above analysis that the DO

Fig 6.2 - Monthly variation in DO in water samples of Azhingillam, Elathur and Kadalundy







content of all the three study areas was fairly high throughout the study period inspite of the pollution caused by the coir retting activities at Elathur and Kadalundy. No anaerobic zones could be detected. In brief the impact of organic pollution appeared to be minimal.

6.3. Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is defined as the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. The BOD test is widely used to determine the pollution strength of domestic and industrial wastes in terms of the oxygen that they will require if discharged into natural water bodies in which aerobic conditions exist.

The BOD test is a bioassay procedure involving the measurement of oxygen consumed by living organisms, mainly bacteria while utilizing the organic matter present in a waste, under conditions as similar as possible to those that occur in nature. The test is useful in stream pollution control management and in evaluating the self-purification capacities of streams.

The complete degradation of the organic matter may take as long as 20-30 days. It has been found that a reasonably large percentage (70-80%) of the total BOD is exerted in 5 days; consequently, the test has been developed on the basis of a 5-day incubation period at 20°C.(Sawyer and Mc Carty, 1978.)

The BOD test in general gives a qualitative index of the organic substances, which are degraded quickly in a short period of time. It is largely influenced by the type of microorganisms, pH, presence of toxins, some reduced mineral matter and nitrification processes.

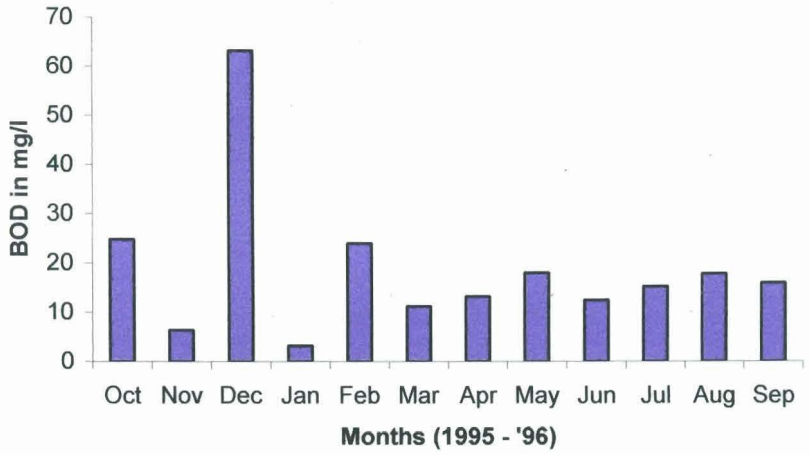
BOD estimations of the three wetland were carried out by the dilution method and the results are tabulated in Table 6..3.

Table 6.3.Monthly variation in BOD of Water Samples of Azhingillam, Elathur and Kadalundy (mg/l)

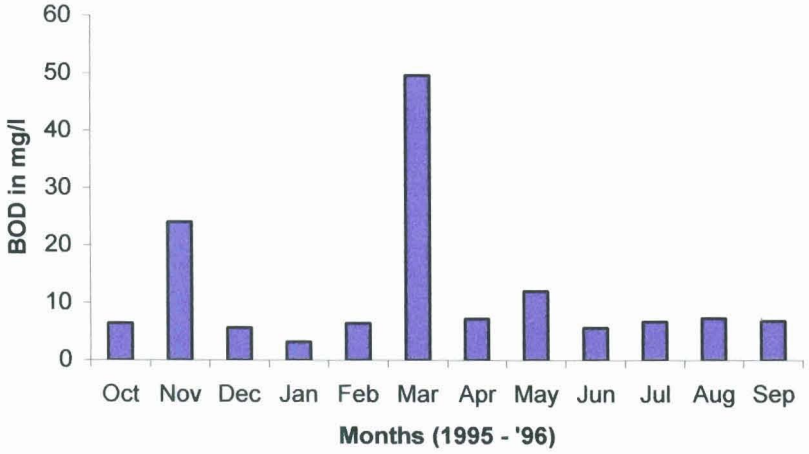
Study Area / Month	Azhingillam	Elathur	Kadalundy
October	24.8	6.4	3.2
November	6.4	24.0	6.4
December	63.2	5.6	55.2
January	3.2	3.2	1.6
February	24.0	6.4	6.4
March	11.2	49.6	18.4
April	13.2	7.2	12.1
May	18.0	12.0	13.2
June	12.4	5.6	12.4
July	15.2	6.7	10.0
August	17.8	7.3	21.0
September	15.9	6.8	32.8
$\bar{X}$	18.77	11.73	16.05

Fig.6.3 - Monthly variation in the BOD. of water samples of Azhingillam, Elathur and Kadalundy

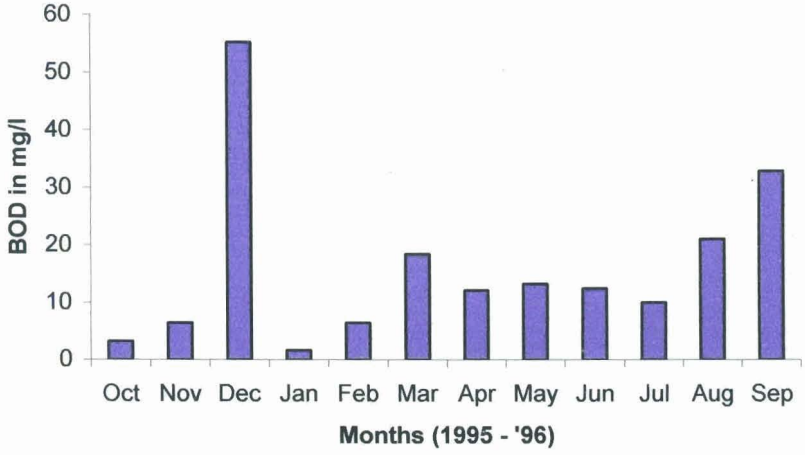
Azhingillam



Elathur



Kadalundy



In Azhingillam, the BOD values were found to be high throughout the study period except for the month of November and January (Fig.6.3). The highest BOD value of 63.2 mg/l was noted in the month of December. This high BOD values in this area may be due to the accumulation of dead and decaying matter in the form of leaves and plant debris, like hay. It is also noted that application of fertilizers and organic manures like cowdung during different stages of paddy cultivation adds to the organic loading of this wetland.

Elathur had comparatively low BOD values for the water samples collected. An average BOD value of 11.73 mg/l was noted from this study area. An exceptionally high value of 49.6 mg/l was recorded in the month of March. In Elathur, the influence of the Pudiyappa fishing harbour is found to be responsible for the biochemical oxygen demand of this area. The organic wastes like dead and decaying fish and fish parts are directly dumped into the sea water.

Kadalundy is an estuary, which receives all the organic wastes of the Kadalundy town and wastes from the upstream stations of the river. Moreover this estuarine area is widely used for coconut husk retting by local people. It is also noted that wastes from nearby animal slaughterhouses and chicken shops are dumped directly into the estuary.

All these factors may be responsible for the high BOD value recorded from here.

Of the three study areas, taking on an average, strength of pollution is highest in Azhingillam followed by Kadalundy. This is reflected in the average BOD values of these areas. Average BOD value of Elathur is low. But in general, it must be noted that all the three study areas receive large quantities of organic wastes and are prone to organic pollution.

6.4. Inorganic Phosphorous

Phosphorous is an important constituent of any biological system. It is present in natural water mostly in inorganic form such as $H_2PO_4^-$, HPO_4^{2-} and PO_4^{3-}. Phosphorus may also be present in the organic forms. The major sources of phosphorous are domestic sewage, detergents, agricultural effluents with fertilizers and industrial wastewaters. The higher concentration of phosphorous is therefore indicative of pollution.

Phosphorous has been described as a major limiting nutrient in northern bogs (Heilman, 1968), freshwater marshes (Klopatek, 1978) and southern deep-water swamps (Mitsch, Dorge and Wiemhoff, 1979; Brown, 1981). In other wetlands, such as agricultural wetlands (Gambrell and Patrick, 1978) and salt marshes (Whitney *et al.*, 1981), it is an important mineral although it is not considered a limiting factor due to its relative abundance and biochemical stability. Phosphorous is rendered relatively

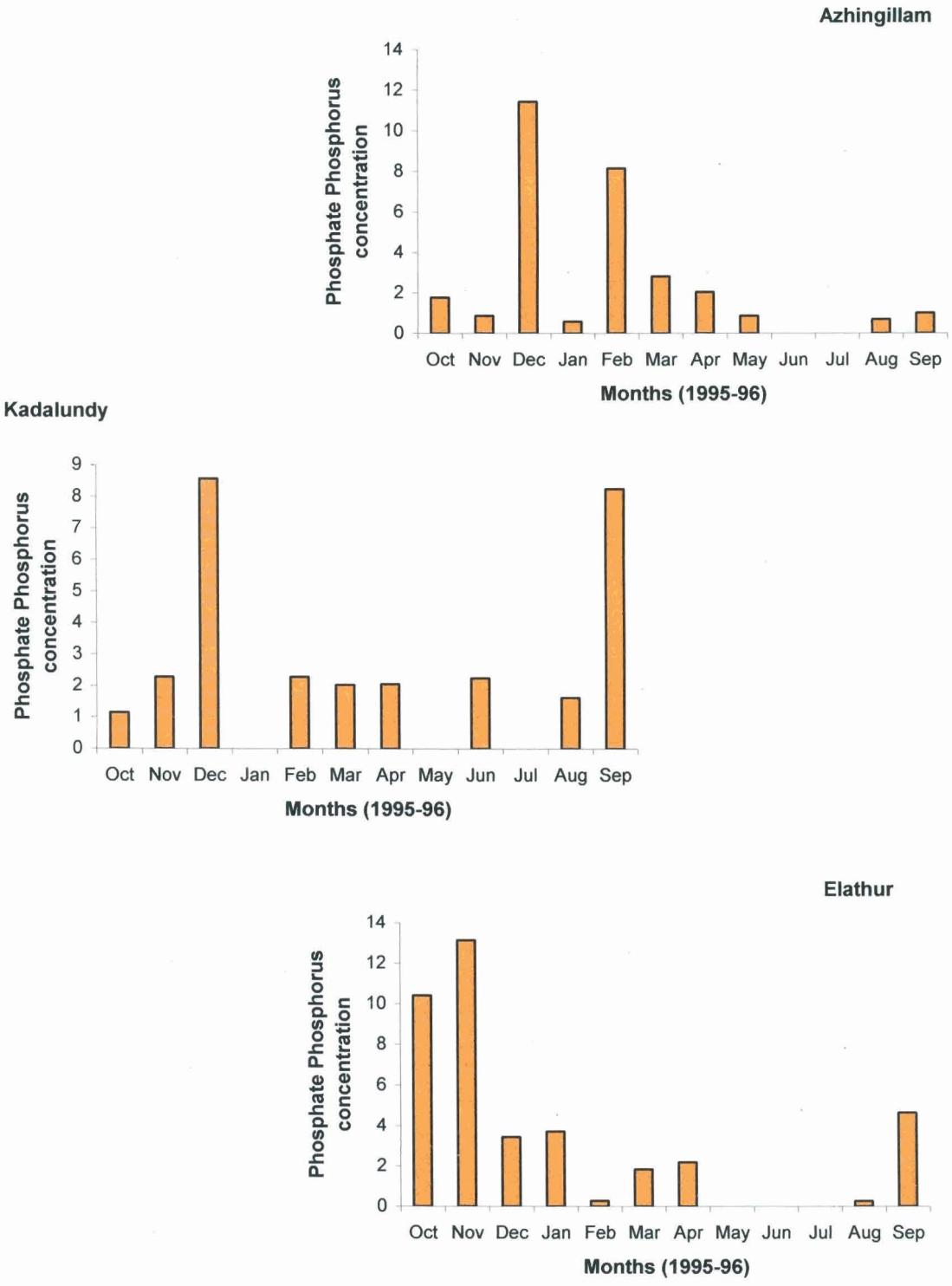
unavailable to plants and microorganisms by the precipitation of insoluble phosphorous with ferric iron, calcium and aluminum under aerobic conditions, absorption of phosphate onto clay particles, organic peat and the binding of phosphorous in organic matter as a result of incorporation into living biomass.

Analysis of the phosphate phosphorous content of the water samples of the three study areas was carried out by the A.P.H.A. method. The changes in phosphorous content of the water samples of the study areas are given in Table 6.4.

Table 6.4Monthly variation in inorganic phosphorous of Water Samples of Azhingillam, Elathur and Kadalundy (μg/l)

Study Area / Month	Azhingillam	Elathur	Kadalundy
October	1.77	10.42	1.14
November	0.86	13.14	2.28
December	11.43	3.43	8.57
January	0.57	3.71	0.0
February	3.14	0.28	2.28
March	2.80	1.83	2.02
April	2.04	2.19	2.05
May	0.86	0.0	0.0
June	0.0	0.0	0.24
July	0.0	0.0	0.0
August	0.68	0.26	1.62
September	1.02	4.64	8.24

Fig.6.4 - Monthly variation in the Phosphate Phosphorus content of water samples of Azhingillam, Elathur and Kadalundy in µg/l



In Azhingillam, the phosphate phosphorous content of the water samples was zero during the month of June and July. This could be due to the effect of monsoon when precipitation increases causing a dilution of the nutrients in the water body by way of increased volume of water. A maximum of 11.43 μg/l of phosphate phosphorous was registered from this area during the month of December. It is noted that during the post-monsoon season, some of the wetland areas of the Azhingillam have been used for cultivating paddy, plantain, vegetables etc. and application of fertilizers could cause an increase in the phosphorous content of water sample. During other months, the concentration ranged between 0.57 μg/l to 3.14 μg/l (Fig6.4).

The inorganic phosphate phosphorous content of the Elathur area during the months of May to July was found to be zero. In November, a maximum concentration of 13.14 μg/l was recorded here, followed by 10.42 μg/l in October. The estimation showed fluctuating value during the other months in a range of 0.25 μg/l to 4.64 μg/l.

Samples of water from the Kadalundy estuary showed zero concentration of phosphate phosphorous during January, May and July. In December and September high concentrations of 8.5 μg/l and 8.24 μg/l were recorded from this estuary and during the rest of the months the concentrations ranged between 1.14 μg/l to 2.28 μg/l.

Analysis of the phosphate phosphorous content of the three wetlands clearly shows that this nutrient does not evoke any problems of pollution in these areas. In all these areas, the arrival of migratory birds caused an increased deposition of excreta, which contain phosphorous. This is clearly reflected in analysis in the form of increased phosphorous content during the migratory period. The prime concern of phosphorous lies in the ability to increase the growth of nuisance algae and eutrophication. But in all the study areas, the phosphorous concentrations were found to be well below the USEPA standards of 50 μg/l.

6.5. Nitrite Nitrogen (NO_2N)

Nitrite represents an intermediate form during the denitrification and nitrification reactions in nitrogen cycle. Organic matter dumped into a water body undergoes bacterial decomposition. As time progresses, the organic nitrogen is converted to ammonia nitrogen. Oxidation of ammonia nitrogen to nitrites and nitrates occur under aerobic conditions. Nitrite is a very unstable ion and gets easily converted to either ammonia nitrogen or nitrate nitrogen. Presence of even a small quantity of nitrite will indicate organic pollution and the availability of partially oxidised nitrogenous matter.

The productivity of natural waters in terms of algal growth is related to plant nutrients like phosphorous, nitrogen and potassium that gain

entrance to the plants. Many wetlands have been shown to be nutrient traps that purify the water flooding them (Ewel and Odum, 1984; Boyt, Bayley and Zotltek, 1977; Nessel and Bayley, 1984; Simpson, Whigham and Walker, 1978). But several wetland studies (Valiela and Teal, 1974 and Smart and Barko, 1980) have shown that salt marsh vegetation is primarily nitrogen limited. According to Sawyer and Mc Carty (1978) the concentration of nitrite nitrogen in surface and ground waters is normally much below 0.1 mg/l.

In the present study, the nitrite nitrogen content of the water samples of the three wetland namely Azhingillam, Elathur and Kadalundy was estimated monthly for a period of one year using a colorimetric Azodye method. The results are tabulated in table 6.5.

The water samples of Azhingillam wetland were found to contain nitrite nitrogen below the lower limit of sensitivity of the method during six months of analysis. In October a maximum of 6.21 µg/l of nitrite nitrogen was recorded and the value ranged between 24 µg/l to 5.20 µg/l in the other months (Fig. 6.5.).

Elathur had a maximum of 12.52 µg/l of nitrite nitrogen during the month of December. Half of the total estimations from this area recorded zero concentration of nitrite nitrogen while it ranged between 0.6 µg/l to 4.14 µg/l during the other months

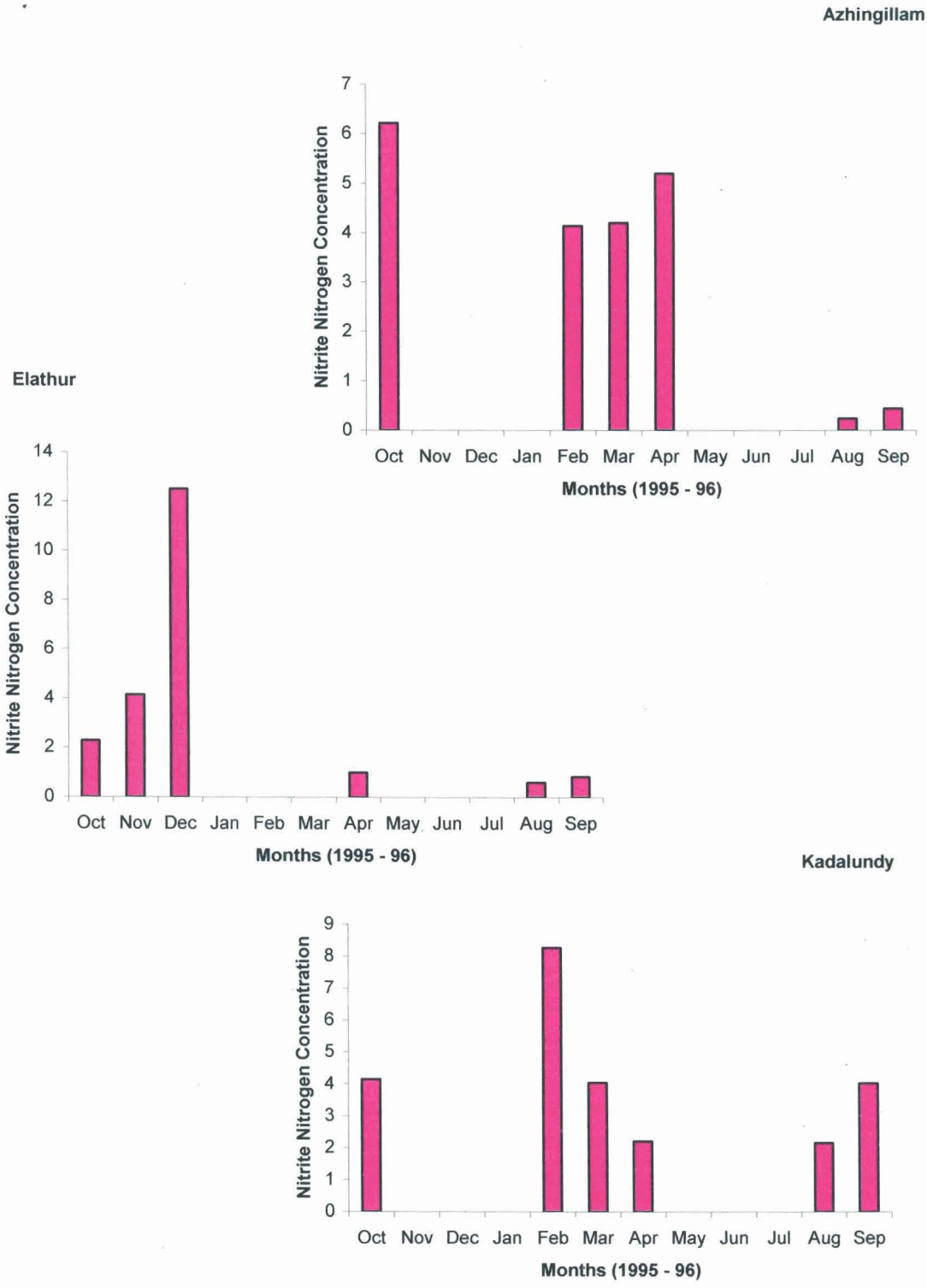
Out of twelve monthly estimations of nitrite nitrogen in the water samples of Kadalundy, detectable range of concentration was found only in six months. It reached a maximum value of 8.27 µg/l in February and the concentration was in between 2.16 µg/l to 4.14 µg/l during other months.

Table 6.5. Monthly variation in Nitrite nitrogen in Water Samples of Azhingillam, Elathur and Kadalundy (µg/l)

Study Area / Month	Azhingillam	Elathur	Kadalundy
October	6.21	2.28	4.14
November	0.0	4.14	0.0
December	0.0	12.52	0.0
January	0.0	0.0	0.0
February	4.14	0.0	8.27
March	4.20	0.0	4.04
April	5.20	1.0	2.21
May	0.0	0.0	0.0
June	0.0	0.0	0.0
July	0.0	0.0	0.0
August	0.24	0.6	2.16
September	0.44	0.84	4.02

A general feature observed in all the study areas is the absence of nitrite nitrogen during the monsoon season. This can be negatively correlated with the increased precipitation and river flooding during the

Fig.6.5 - Monthly variation in the Nitrite Nitrogen content of water samples of Azhingillam, Elathur and Kadalundy in µg/l



period. Since nitrite nitrogen is a very unstable ion it could easily be converted to other forms by oxidation or reduction. The absence of nitrite nitrogen during some other months of the three study area maybe due to the aforesaid reason or due to the low concentration which is below the lower limit of sensitivity of the method adopted for measurement.

6.6. Primary productivity

In any aquatic system, the rate of primary organic production is an important factor, which regulates the tropic chain. The capture of solar energy by green plants and the conversion of a portion of the light energy to chemical energy through photosynthesis is called primary production. Primary productivity is the rate at which the sun's radiant energy is stored by the photosynthetic activity of producer organism (various forms of algae, phytoplankton and higher plants in water) in the form of organic substances, which can be used as food material. The phytoplankton and other producers are grazed upon by zooplankton and other herbivores, which in turn form the food of the higher organisms in the environment. Therefore, the more the primary productivity, the richer will be the availability of food for upper trophic levels and higher the biomass of the ecosystem.

Several environmental factors are known to affect the rate of primary production. The relationship between hydrology and primary productivity

has been investigated by several wetland scientists. Niering and Warren, (1977) found that tidal marshes are the most productive ecosystem in the world. Brown (1981) found that variation in biomass productivity of cypress wetlands in Florida could be explained by the variation in nutrient inflow. The nutrients are carried into wetland by hydrologic inputs of precipitation, river flooding and tides. This nutrient flow is an important determinant of wetland productivity. The amount of sunlight available will influence the rate of photosynthesis and consequently primary production. Therefore, variation occurring in the rate of primary productivity depends on the time of the day, the weather conditions (cloud cover, seasonal changes, etc.) depth of light penetration, temperature and biological factors like population density of phytoplankton, the chlorophyll content of the phytoplankton and the rate of grazing.

Primary production studies are of paramount interest in understanding the effect of pollution on systems efficiency. High rate of production in natural ecosystem occurs when physico-chemical factors are favourable.

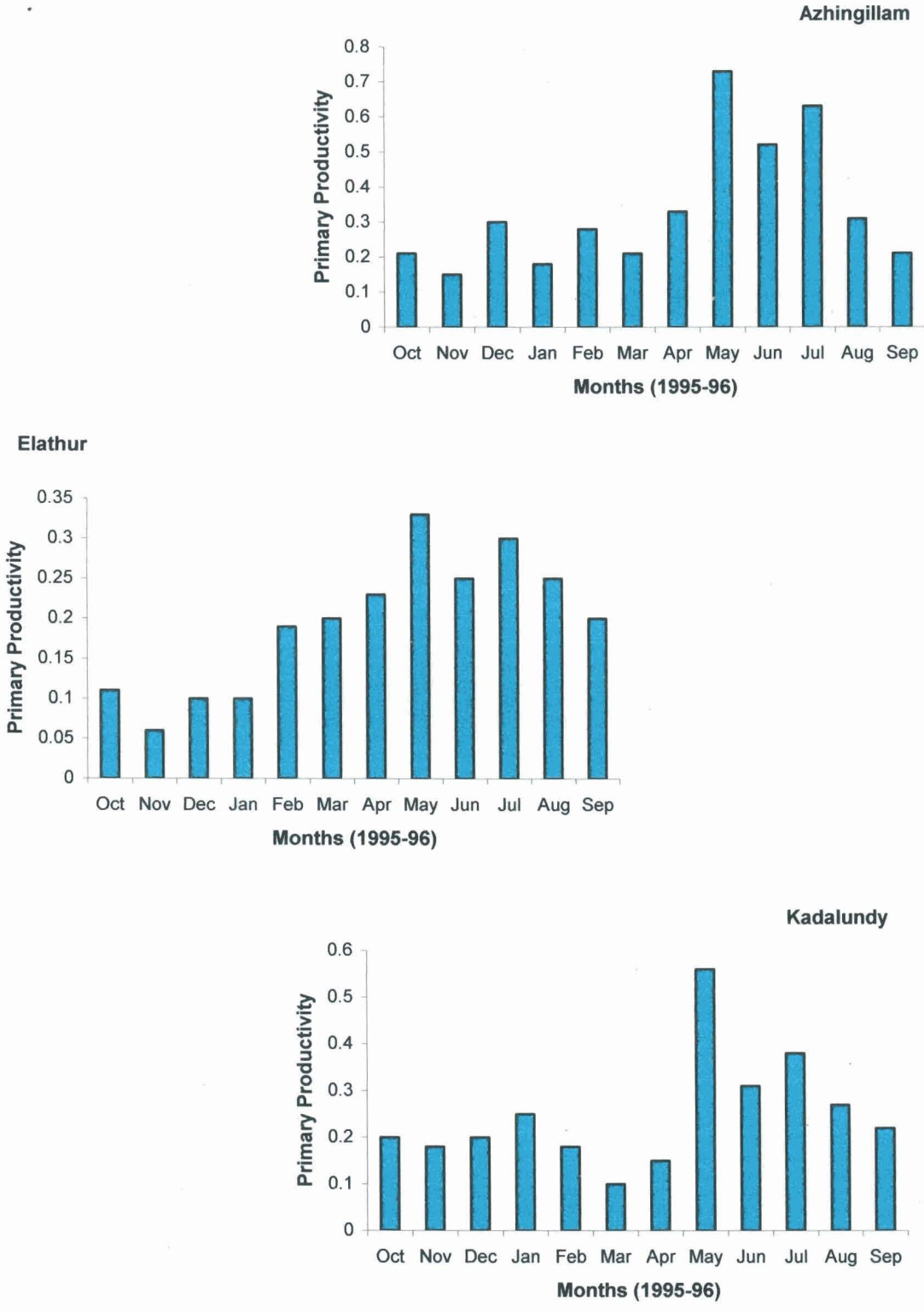
Light and Dark bottle method of primary productivity estimation was used to determine the primary productivity of the three wetlands and the results are given in Table 6.6.

Table 6.6. Monthly variation in Primary productivity of Water Samples of Azhingillam, Elathur and Kadalundy (in mg carbon/litre/hour)

Study Area / Month	Azhingillam	Elathur	Kadalundy
October	0.21	0.11	0.20
November	0.15	0.06	0.18
December	0.30	0.10	0.20
January	0.18	0.10	0.25
February	0.28	0.19	0.18
March	0.21	0.20	0.10
April	0.33	0.23	0.15
May	0.73	0.33	0.56
June	0.52	0.25	0.31
July	0.63	0.30	0.38
August	0.31	0.25	0.27
September	0.21	0.20	0.22

Of the three study area, Azhingillam was found to be more productive than the other two study areas. Kadalundy estuary, which comes second in the order, was found to have an average productivity value of .24 mg carbon/litre/hr. Elathur area had the least productivity with average value of 0.19 mg c/litre/hr.

Fig.6.6 - Monthly variation in the Primary productivity of Azhingillam, Elathur and Kadalundy in mg carbon / l / hr.



In all the three study areas, productivity had maximum value in the month of May 1996 (Fig. 6.6). It is also noted that during the monsoon season productivity was high in all the study areas. During other seasons, productivity was comparatively low.

Chapter VII

Summary and Conclusion

CHAPTER VII

SUMMARY AND CONCLUSION

The objectives of the study were to get information on the kinds, numbers and important ecological aspects of the birdlife of three different wetland areas of Malabar. It was expected that this study would generate the following types of information:

1. facts, which are useful in comparing the birdlife of these three interesting areas.
2. undertstanding of the community attributes influencing the birdlife of these areas, which could give insights valuable for their conservation
3. quantitative data on certain parameters of water quality of the three areas

The method used for the study was direct observation using Line transect. All the three study areas supported several species of migratory birds during the months from September to April. During this period Elathur and Kadalundy showed equal numbers of resident and migratory birds. But at Azhingillam the resident species were much more numerous (80%) than the migrants.

Of the three study areas Kadalundy had 82 species of birds. Azhingillam and Elathur had 74 and 41 species of birds respectively. There were more species of birds from November to April in all the study areas .The maximum species number was recorded at Azhingillam and Kadalundy during the months of February and March and at Elathur during the months of November and December. There were fewer birds in the monsoon season in all the study areas. Besides the regular migrants there were a few vagrant species also.

Cumulative occurrence of birds in each study area revealed highly fluctuating bird populations in all areas. It took about one year to record more than eighty percent of the total birds observed. The patterns of immigration, local movements and appearance of vagrants appeared to be influencing cumulative occurrence in the three localities studied.

More than fifty eight percent of the birds of Azhingillam were "rare" with a frequency of observation below twelve out of forty eight line transects. In Elathur and Kadalundy, "rare" birds constituted seventy one percent and sixty seven percent respectively. The very common species {with a frequency of occurrence above 75%} of birds constituted 10% of the total population. Some of these species like the Common Myna and the Black Drongo, which occurred at Azhingillam, are not true wetland birds. Pond Heron appeared to be the commonest species in all the three habitats.

The Common Sandpiper, Brahminy Kite and House Crow recorded at Elathur and Kadalundy were the other very common birds there.

The Common Sandpiper and Lesser Sand Plover, which are considered to be migrants, were present in Elathur and Kadalundy almost throughout the year. This suggests over wintering of these two species.

The abundance of species reflects the relative distribution of a species in a community. In Azhingillam Purple Moorhen was the most abundant species. In Elathur, Brahminy Kite was the most abundant species and at Kadalundy, Brownheaded Gull and Blackheaded Gull. The two species of gulls occurred in nearly equal proportions. In all the study areas, abundance was high in about twenty to thirty percent of the total species observed.

Seasonal abundance of birds increased progressively with the onset of winter and remained high during the early summer. From mid April the migratory species started leaving the area. Azhingillam and Kadalundy had an influx of bird species in early summer. It appeared that birds from adjacent areas were attracted to Azhingillam by the good supply of food and water. The surrounding areas would have dried up by this time. In these study areas, the members of the family Ardeidae were more numerous during summer seasons due to considerable immigration from adjacent areas.

Among the bird families of the three wetlands, some are common to all the study areas. They were Phalacrocoracidae, Ardeidae, Charadridae, Laridae and Alcedinidae. The members these families appeared to be better adapted for exploiting the resources of these wetlands. Families like Threskiornithidae, Ciconidae, Rallidae and Recurvirostridae were common between Azhingillam and Kadalundy. Two families namely Anatidae and Jacanidae are observed only in Azhingillam. In Azhingillam the family with maximum number of birds was Ardeidae while family Laridae had the greatest number of birds in Elathur and Kadalundy. However, the largest representation of species per family was observed in the case of family Charadridae in all the study areas.

Species diversity, which reflects the species richness and relative abundance of species in an area, had a value of 3.20 at Azhingillam followed by Elathur (2.35) and Kadalundy (1.91). At Kadalundy the low value of Shannon's index in spite of the high species number appeared to be due to the very large number of individuals present in two species namely Brownheaded Gull and Balckheaded Gull. At Elathur diversity was the result of scarcity of species and lower density. The high diversity value of Azhingillam showed a balanced apportionment of individuals among species. No one species of this area had very high density. This was the cause of high Shannon's index value. Azhingillam was a truly mixed habitat comprising scrub jungles, sacred groves and monoculture

plantations. This resulted in pronounced edge effect. This ecotonal quality appeared to be one of the reasons for the high species diversity here . Kadalundy and Elathur had very simple plant communities with very few ecotones. The habitat were almost monoculture plantations of coconut palms.

Of the three study areas, maximum similarity was observed between the habitats of Elathur and Kadalundy. The most dissimilar areas were Elathur and Azhingillam.

The pH of the water samples of all the study areas were close to neutral {6-7} throughout the study period.

Dissolved oxygen content of the water samples of the study areas was high throughout the study period indicating good aeration of water. None of these areas appeared to be under the threat of anoxic condition.

BOD, which determines the pollution strength of biodegradable materials present in a water body, had a comparatively high value at Azhingillam and Kadalundy. The three areas are prone to pollution due to the discharge of organic wastes from the adjacent housing colonies and retting of coconut husks.

Analysis of the nutrients like phosphorous and nitrogen in the water samples of the three study areas showed that their concentrations during

the monsoon season were below the detectable range of the method adopted. This is due to the dilution of the nutrients in rainwater. However these nutrients did not appear to act as limiting factors in these areas as indicated by the values during winter and summer seasons.

All the three areas appeared to be productive as shown by the productivity values. Maximum productivity was observed in May in all the three sites and it is quite high during monsoon season. Azhingillam is the most productive of the three wetlands and Elathur is the least productive. Productivity of an area reflects the availability of food, which supports the other members of the trophic levels. The high species diversity of Azhingillam, is thus found to be positively correlating with the high productivity

In general the pollution strength of the waters of the three wetlands appeared to be comparatively low in spite of the human interferences. This study suggests that the environmental quality of the three localities viz., Azhingillam, Elathur and Kadalundy is good at present. This must be the result of long periods of interaction between the various members of the community and the abiotic features.

7.1. Recommendations

In the light of the study I put forward the following recommendations.

1. The wetland area of Azhingillam should be conserved as an ideal reference area for birdlife in an agroecosystem.

2. Land filling, removal of clay and encroachment of wetland at Azhingillam should be prevented.

3. The potential of the Kadalundy wetland as a sanctuary for birds could be fully exploited.

4. A detailed investigation of the community metabolism is very much essential for planning the conservation strategies of these wetlands.

5. Awareness about the ecological and economical values of these wetlands should be increased among the public.

6. Step should be taken for the conservation and sustainable utilization of these wetlands.

7. A continuous monitoring of these wetlands should be done in order to assess the changes in quality and quantity.

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Appendices

Appendix I

List of Plants Identified at Azhingillam

1. *Salvinia molesta*
2. *Marsilea minuta*
3. *Azolla pinnata*
4. *Nymphaea nouchali*
5. *Nymphoides indicum*
6. *Cryptocoryne spiralis*
7. *Grangea maderaspatana*
8. *Eclipta prostrata*
9. *Lindernia crustacea*
10. *Lindernia antipoda*
11. *Lindernia pusilla*
12. *Panicum repens*
13. *Saccolepis indica*
14. *Scirpus articulatus*
15. *Fimbristylis miliacea*
16. *Heliotropium keralense*
17. *Aniseia martinicensis*
18. *Ludwigia hyssopifolia*
19. *Ludwigia adscendens*
20. *Blumea oxyodonta*
21. *Cleome burmanni*
22. *Rotala indica*
23. *Utricularia gibba*
24. *Coldenia procumbens*
25. *Lippia nodiflora*
26. *Hygrophila salicifolia*
27. *Desmodium heterophyllum*
28. *Phyllanthus reticulatus*
29. *Cocos nucifera*

Appendix II

List of Plants identified at Elathur

Algae

1. *Caulerpa taxifolia*
2. *Ulva lactuca*
3. *Gracilaria*

Angiosperms

1. *Calophyllum inophyllum*
2. *Aerva lanata*
3. *Clerodendrum inerme*
4. *Rungia pectinata*
5. *Tridax procumbens*
6. *Thespesia populnea*
7. *Tinospora cordifolia*
8. *Achyranthes aspera*
9. *Vernonia cinerea*
10. *Euphorbia hirta*
11. *Emilia sonchifolia*
12. *Vitex negundo*
13. *Cassia occidentalis*
14. *Gliricidia maculata*
15. *Sida acuta*

Appendix III

List of Plants Identified at Kadalundy

1. *Excoecaria agallocha*
2. *Vitex trifolia*
3. *Cyperus malaccencis*
4. *Cyperus pilosus*
5. *Avicennia officianalis*
6. *Avicennia marina*
7. *Acanthus ilicifolius*
8. *Pongamia pinnata*
9. *Clerodendrum inerme*
10. *Fimbristylis ferruginea*
11. *Panicum repens*
12. *Cosmostigma racemosa*
13. *Calotropis gigantea*
14. *Hyptis suaveolens*
15. *Ziziphus jujuba*
16. *Sida acuta*
17. *Rauvolfia tetraphylla*
18. *Centrosema virginianum*
19. *Chromolaena odorata*
20. *Enterolobium saman*
21. *Ipomoea biloba*
22. *Spinifex littoreus*

APPENDIX IV

Measurement of pH

pH was measured by dipping a piece of indicator paper into the water sample and comparing the colour developed after 2 minutes with the standard colours provided on the indicator paper. The appropriate pH value was then recorded.

APPENDIX V

Estimation of Dissolved Oxygen

Materials required

BOD bottle, pipette, burette, etc.

Reagents

1. Winkler A Solution. This solution was prepared by dissolving 100 g of $MnSO_4.4H_2O$ in 200 ml of boiled distilled water. The solution was then filtered.

2. Modified Winkler B Solution. (a) Dissolved 700 g KOH and 150 g KI in distilled water and made upto 1 litre. (b) Ten grams of sodium azide (NaN_3) were dissolved in 40 ml distilled water. The solution (a) and (b) were mixed to prepare the modified Winkler B solution.

3. Concentrated H_2SO_4.

4. 0.01 N Sodium thiosulphate solution

5. Starch solution (1%)

Method

Water sample was collected in the BOD bottle without entrapping air bubbles and stoppered. The sample was then fixed by adding 2 ml each of the Winkler A solution and Winkler B solutions. The reagents were added well below the surface by using separate pipettes. The bottle was then shaken well to facilitate the formation of a precipitate. The precipitate was then allowed to settle completely. The B.OD. bottle was then brought back to the laboratory and 2 ml concentrated H_2SO_4 was added along the sides of the bottle. The bottle was stoppered and the contents were shaken vigorously for one minute. Hundred ml of the treated sample was pippetted into a clean conical flask and titrated against standard sodium thiosulphate solution (0.01 N) using starch solution as indicator. The end point was marked by the disappearance of blue colour. Titrations were repeated to get concordant value. From the titre value the amount of dissolved oxygen was calculated.

Calculation

$$\text{Oxygen (mg/l)} = \frac{V_1 N_1}{V_2} \times 8 \times 1000$$

where V_1 = Volume of titrant in ml

V_2 = Volume of treated water sample

N_1 = Normality of titrant

8 = Equivalent weight of oxygen

APPENDIX VI

Estimation of Biochemical Oxygen Demand

Materials required

BOD bottles, aerator, pipette, burette, BOD incubator set a 20°C, Distilled water free from chlorine, chloramines and organic matter.

Reagents

1. Phosphate buffer solution: It is prepared by dissolving 8.5 g potassium dihydrogen orthophosphate, 21.75 g of disodium hydrogen phosphate, and 1.7 g of ammonium chloride in 1 litre of distilled water. pH of the buffer should be 7.2 without further adjustment and no biological growth should be present.

2. Magnesium sulphate solution: Dissolved 22.5 g of $MgSO_4.7H_2O$ in 1 litre distiled water.

3. Calcium chloride solution: Dissolved 27.5 g of anhydrous calcium chloride in 1 litre of distilled water.

4. Ferric chloride solution: Dissolved 23 g $FeCl_3.6H_2O$ in 1 litre of distilled water.

5. Sodium thiosulphate solution (0.01 N).

6. Winkler reagent A

7. Winkler reagent B

8. Conc. H_2SO_4

9. Starch solution (1%)

Procedure

Water samples were collected in glass bottles and brought to the laboratory as early as possible.

Preparation of dilute water: Distilled water was aerated for use as dilution water. The required volume of dilution water was placed in a vessel and 1 ml each of $MgSO_4$ solution, $CaCl_2$ solution, $FeCl_3$ solution and phosphate buffer was added per litre of dilution water. Phosphate buffer was added just before using the dilution water.

Dilution of samples

Different dilutions of the water samples were prepared according to the nature of the collected sample as follows. Carefully siphoned the standard dilution water into a graduated cylinder of 1000 ml capacity. Filled the cylinder half ful without entrapment of air. Added the quantity of water sample to make the desired dilution and diluted to approximate level with dilution water. Mixed well with a mixing rod, carefully, avoiding mixing of air.

The diluted sample was pipetted out into 2 BOD bottles: one for initial dissolved oxygen estimation and the other for 5 day incubation at 20°C. Initial dissolved oxygen was determined by azide modification of Winkler method. After 5 days the dissolved oxygen content of the incubated bottle was measured.

Dilution Water Control

Two BOD bottles were filled with dilution water only. The initial DO. in one of bottle was measured and the other bottle was incubated at 20°C for 5 days. Final DO. was determined after 5 days to get the oxygen depletion in the control.

Calculation

$$\text{BOD in mg/litre} = \frac{(D_5 - D_0) - (B_5 - B_0)}{p}$$

where D_0 is the initial DO. in the sample bottle

D_5 is the final DO. in the sample bottle

B_0 is the initial DO. in the control bottle

B_5 is the final DO. in the control bottle

p is the dilution factor of the sample.

APPENDIX VII

Estimation of Inorganic phosphate phosphorus

Materials required

Conical flasks, pipette, spectrophotometer, etc.

Reagents

1. 5 N H_2SO_4.

2. Potassium antimonyl tartarate solution. Dissolved 2.742 g. Potassium antimonyl tartarate in 1000 ml distilled water and stored in a glass bottle.

3. Ammonium molybdate solution: Dissolved 40 g of ammonium molybdate in 1000 ml distilled water and stored in a plastic bottle.

4. Ascorbic acid solution: Dissolved 1.76 g of ascorbic acid in 100 ml distilled water, stored at 4°C. This solution is stable for a week.

5. Combined reagent: To obtain 100 ml of combined reagent, all the above mentioned solution were mixed in the order given below with thorough mixing after the addition of each reagent

   (i) 5 N H_2SO_4 - 50 ml
   (ii) Potassium antimonyl tartarate solution - 5 ml
   (iii) Ammonium molybdate solution - 15 ml
   (iv) Ascorbic acid solution - 30 ml

   The combined reagent was then allowed to stand for a few minutes until turbidity disappears. This reagent is stable for 4 hours.

6. Standard phosphate solution: Dissolved 136 mg of anhydrous potassium dihydrogen phosphate in 100 ml distilled water. One ml of this solution contains 1 millimole phosphate phosphorous.

7. Working standard: Diluted 100 ml of the stock solution to 500 ml. One ml of this solution contains 0.2 millimole phosphate phosphorous.

8. Phenolphthalein indicator.

Procedure

(a) *Preparation of calibration curve*: Into a series of conical flasks 1, 2, 4, 6 & 8 mls of the working standard were pippetted and each flask was made up to 50 ml with distilled water. A drop of phenolphthalein was added to each flask. If a red colour appeared, it was discharged by adding a few drops of 5 N.H_2SO_4. Then 8 ml combined reagent was added and mixed well. After 10 minutes, the absorbance of the blue colour developed in each flask was measured at 620 nm against a reagent blank in a spectrophotometer. A calibration curve was drawn from the readings obtained.

(b) Analysis of sample was carried out by taking 50 ml of the sample in a conical flask. The sample was then treated in the same way as described above and the absorbance was measured. A standard was also done corresponding to 0.008 millimoles phosphate phosphorus per ml. Concentration of sample was calculated using the formula

$$\text{Concentration of sample} = \frac{\text{Absorbance of Sample}}{\text{Absorbance of standard}} \times \text{Concentration of standard}$$

APPENDIX VIII

Estimation of Nitrite nitrogen

Materials required

Conical flask, pipettes, spectrophotometer.

Reagents

(1) Sulphanilamide reagent: Dissolved 5 g of sulphanilamide in a mixture of 50 ml concentrated hydrochloric acid and about 300 ml distilled water and diluted to 500 ml.

(2) NEDA solution : It was prepared by dissolving 500 mg of naphthyl ethylene diamine hydrochloride in 500 ml distilled water. This solution was stable for one month under refrigeration.

(3) Stock nitrite solution: Dissolved 1.232 g of sodium nitrite in distilled water and made up to 1 litre. This solution contains 250 μg nitrite nitrogen per ml.

(4) Working standard: One ml of the stock standard was diluted to 500 ml with distilled water. One ml of this solution contains 0.5 μg nitrite nitrogen.

Procedure

(a) Preparation of calibration curve: Pipetted into a series of labelled conical flasks 2, 4, 6, 8 and 10 ml of the working standard and each was made upto 50 ml with distilled water. One ml of sulphanilamide reagent was added to each flask, mixed well and allowed to stand for two minutes. Then 1 ml of NEDA solution was added to eachflask, mixed well and allowed the pink coloured dye to develop for 10 minutes. After 10 minutes, the

absorbance of each flask was measured in a spectrophotometer at 530 nm against a reagent blank. A calibration curve was drawn using the data.

(b) Analysis of the sample: Fifty ml of the water sample was pipetted into a conical flask and 1 ml sulphanilamide reagent was added. Mixed well and after 2 minutes 1 ml of NEDA solution was added. After thorough shaking, the flask was kept undisturbed for 10 minutes for the development of colour. The intensity of red colour was then measured spectrophotometrically. A standard was also done corresponding to 0.04 micrograms of nitrite nitrogen per ml. The concentration of the sample was then calculated using the formula

$$\text{Conc. of sample} = \frac{\text{Absorbance of sample}}{\text{Absorbance of Std.}} \times \text{Conc. of standard}$$

APPENDIX IX

Measurement of Primary Productivity

Materials required

BOD bottles, Secchi disc, float, etc.

Reagents

1. Winkler Reagents A & B
2. Conc. H_2SO_4
3. 0.01 N $Na_2S_2O_3$
4. Starch indicator

Procedure

This method is based on the estimation of oxygen released by producers over a period of time. The oxygen produced from the photosynthetic activity is found out from the difference between the dissolved oxygen in the bottle exposed to light and the dark bottle.

Two sets of BOD bottles were prepared and one set was painted black on the surface including the stopper. Water samples were collected using polythene beakers and transferred into the light and dark BOD bottles. The bottles were then suspended at the water surface using floats. After a suitable period of time the bottles were taken out and the dissolved oxygen level in the bottles were estimated by Winkler method and primary productivity was calculated using the formula

$$\text{Net primary productivity (NPP), } O_2 \text{ mg/l/hr} = \frac{Dl - Di}{h}$$

where Di = Dissolved oxygen in the initial bottle in mg/l

Dl = Dissolved oxygen in the light bottle in mg/l

h = Duration of exposure in hr.

The value is converted to carbon using the formula

$$\text{NPP in g C / l / hr} = \text{NPP in mg } O_2 \text{ / l / hr} \times 0.375$$

Appendix X

List of Birds Observed at Azhingillam, Elathur and Kadalundy

Sl. No.	Common Name	Scientific Name	A	E	K
1	Darter	*Anhinga rufa*	*		
2	Little Cormorant	*Phalacrocorax niger*	*	*	*
3	Little Egret	*Egretta garzetta*	*	*	*
4	Median Egret	*Egretta intermedia*	*	*	*
5	Large Egret	*Ardea alba*	*	*	*
6	Cattle Egret	*Bubulcus ibis*	*	*	*
7	Pond Heron	*Ardeola grayii*	*	*	*
8	Purple Heron	*Ardea purpurea*	*		
9	Reef Heron	*Egretta gularis*		*	*
10	Grey Heron	*Ardea cinerea*			*
11	Yellow Bittern	*Ixobrychus sinensis*	*		
12	Chestnut Bittern	*Ixobrychus cinnamomeus*	*		
13	Black Bittern	*Ixobrychus flavicollis*			*
14	White Ibis	*Threskiornis aethiopica*	*		*
15	Openbill Stork	*Anastomus oscitans*			*
16	Cotton Teal	*Nettapus coromandelianus*	*		
17	Lesser Whistling Teal	*Dendrocygna javanica*	*		
18	Garganey	*Anas querquedula*	*		
19	Little Grebe	*Tachybaptus ruficollis*	*		
20	Common Teal	*Anas crecca*	*		
21	Purple Moorhen	*Porphyrio porphyrio*	*		
22	Indian Moorhen	*Gallinula chloropus*	*		
23	Whitebreasted Waterhen	*Amaurornis phoenicurus*	*		*
24	Blue Breasted banded Rail	*Rallus striatus*	*		*
25	Bronzewinged Jacana	*Metopidius indicus*	*		

A – Azhingillam; E – Elathur; K – Kadalundy

* indicates presence of species

26	Pheasant-tailed Jacana	*Hydrophasianus chirurgus*	*		
27	Blackwinged Stilt	*Himantopus himantopus*	*		*
28	Avocet	*Recurvirostra avosetta*			*
29	Little Ringed Plover	*Charadrius dubius*	*		*
30	Golden Plover	*Pluvialis dominica*	*	*	*
31	Grey Plover	*Pluvialis squatarola*		*	*
32	Large Sand Plover	*Charadrius leschenaultii*			*
33	Kentish Plover	*Charadrius alexandrinus*		*	*
34	Lesser Sand Plover	*Charadrius mongolus*		*	*
35	Redwattled lapwing	*Vanellus indicus*	*		
36	Common Sandpiper	*Tringa hypoleucos*	*	*	*
37	Wood Sandpiper	*Tringa glareola*	*		*
38	Green Sandpiper	*Tringa ochropus*	*		*
39	Terek Sandpiper	*Tringa terek*		*	*
40	Redshank	*Tringa totanus*			*
41	Greenshank	*Tringa nebularia*		*	*
42	Whimbrel	*Numenius phaeopus*		*	*
43	Curlew	*Numenius arquata*		*	*
44	Blacktailed Godwit	*Limosa limosa*			*
45	Bartailed Godwit	*Limosa lapponica*			*
46	Marsh Sandpiper	*Tringa stagnatilis*	*		*
47	Turnstone	*Arenaria interpres*		*	*
48	Snipe	*Gallinago sp.,*	*		*
49	Eastern Knot	*Calidris tenuirostris*			*
50	Sanderling	*Calidris alba*			*
52	Little Stint	*Calidris minuta*	*		*
53	Dunlin	*Calidris alpina*			*
54	Whiskered Tern	*Chlidonias hybrida*	*	*	*
55	Caspian Tern	*Hydroprogne caspia*		*	*

56	Gullbilled Tern	*Gelochelidon nilotica*			*
57	Little Tern	*Sterna albifrons*		*	*
58	Large Crested Tern	*Sterna bergii*		*	*
59	Sandwich Tern	*Sterna sandvicensis*			*
60	Common Tern	*Sterna hirundo*		*	*
62	Herring Gull	*Larus argentatus*		*	*
62	Lesser Blackbacked Gull	*Larus fuscus*		*	*
63	Great Blackbacked Gull	*Larus ichthyaetus*		*	*
64	Brownheaded Gull	*Larus brunnicephalus*		*	*
65	Blackheaded Gull	*Larus ridibundus*		*	*
66	Pariah Kite	*Milvus migrans govinda*	*	*	*
67	Brahminy Kite	*Haliastur indus*	*	*	*
68	Marsh Harrier	*Circus aeruginosus*	*		*
69	Osprey	*Pandion haliaetus*			*
70	Shikra	*Accipter badius*			*
71	Small Blue Kingfisher	*Alcedo atthis*	*	*	*
72	Whitebreasted Kingfisher	*Halcyon smyrnensis*	*	*	*
73	Lesser Pied Kingfisher	*Ceryle rudis*	*		*
74	Storkbilled Kingfisher	*Pelargopsis capensis*	*		*
75	Swallow	*Hirundo rustica*	*	*	*
76	Redrumped Swallow	*Hirundo daurica*	*	*	*
77	Blue Rock Pigeon	*Columba livia*	*		*
78	Spotted Dove	*Streptopelia chinensis*	*		*
79	Roseringed Parakeet	*Psittacula krameri*	*	*	*
80	Blossomheaded Parakeet	*Psittacula cyanocephala*	*		*
81	Rufous Backed Shrike	*Lanius schach*			*
82	Ashy Swallow - Shrike	*Artamus fuscus*	*		*
83	Large Pied Wagtail	*Mottacilla maderaspatensis*	*		*
84	Grey Wagtail	*Mottacilla cinerea*		*	
85	Paddyfield Pipit	*Anthus novaeseelandiae*	*		*

86	Koel	*Eudynamys scolopacea*	*		*
87	Crow Pheasant	*Centropus sinensis*	*		*
88	Alpine Swift	*Apus melba*	*	*	*
89	Palm Swift	*Cypsiurus parvus*	*	*	*
90	Redvented Bulbul	*Pycnonotus cafer*	*		
91	Tailor Bird	*Orthotomus sutorius*			*
92	Ashy Wren Warbler	*Prinia socialis*	*		*
93	Streaked Fantail Warbler	*Cisticola juncidis*	*		*
94	Jungle Babbler	*Turdoides striatus*	*		
95	Whiteheaded Babbler	*Turdoides affinis*	*		
96	Common Myna	*Acridotheres tristis*	*	*	*
97	Jungle Myna	*Acridotheres fuscus*	*		
98	Golden Oriole	*Oriolus oriolus*	*		
99	Black Drongo	*Dicrurus adsimilis*	*	*	
100	Racket-tailedDrongo	*Dicrurus paradiseus*	*		
101	Indian Tree Pie	*Dendrocitta vagabunda*	*		*
102	House Crow	*Corvus splendens*	*	*	*
103	Jungle Crow	*Corvus macrorhynchos*	*		*
104	Purple Sunbird	*Nectarinia asiatica*	*		*
105	Purplerumped Sunbird	*Nectarinia zeylonica*	*		
106	Green Bea- eater	*Merops orientalis*	*		*
107	Bluetailed Bea- eater	*Merops philippinus*	*		
108	Crested Lark	*Galerida cristata*	*		
109	Blackbellied Finch Lark	*Eremopteryx grisea*	*		
110	White backed Munia	*Lonchura striata*	*		
111	Spotted Munia	*Lonchura punctulata*	*		
112	Lesser Goldenbacked Woodpecker	*Dinopium benghalense*		*	