BIOLOGY, ECOLOGY AND BEHAVIOUR OF PURPLE MOORHEN PORPHYRIO PORPHYRIO

Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology

BY

ABDULLA.E.V

Department of Zoology,
Farook College, Kozhikode
University of Calicut
Kerala, India

DECEMBER 2006

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CERTIFICATE

This is to certify that this thesis entitled 'Biology, Ecology and Behaviour of Purple moorhen, *Porphyrio porphyrio*' is an authentic record of the bonafide research work carried out by Sri. Abdulla E.V. 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.

Dr. P.A.Azeez

Supervising teacher and co-Guide

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Prof. P.A Muhammed

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DECLARATION

I hereby declare that the thesis Biology, Ecology and Behaviour of Purple moorhen *Porphyrio porphyrio* submitted to the University of Calicut for the award of the degree of Doctor of Philosophy in Zoology is a bonafide work done by me and that it has not been submitted earlier in part or in full to any other university for award of any degree or diploma.

Signature of candidate

Supervising teacher and co-Guide

Dr P A Azeez
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E.V.Abdulla

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CHAPTER I

GENERAL INTRODUCTION

Porphyrio porphyrio poliocephalus belongs to the family Rallidae and the order Gruiformes. The Rallidae includes rails, coots and gallinules. Their origin can be traced back to the tertiary period of 70 million years ago. The members of this family are characterised by short rounded wings, short erect tails, long legs and toes; the bills of some are long and slightly decurved, whilst others are stubby and conical in shape. These birds are usually secretive found in marshes and grasslands (Coomber 1990).

Rails are distinguished by the narrowness of their bodies adapted to swift running through the underbush. The expression 'thin as a rail' originates from these birds.These are usually well camouflaged birds. Generally rails are weak fliers. Many have been so long isolated that they have developed monotypic genera and a large percentage have become flightless (Day 1981). For example the Atlantes rail which lived in South America came to Inaccessible island thousands of years ago. Living in an entirely different habitat on the island the bird lost its flight capability.

In rails the external sex differences are usually absent or slight. Males are sometimes a little larger. In some genera and species the colours of male differ from those of females.

Rails are distributed world over except polar regions and higher

latitudes of Northern Hemisphere. The Rallidae comprises 41 genera and 132 species. More than 45 species are found on Islands and in archipelagoes. Many of the insular species are endangered and about 16 species already have become extinct. They might have been largely exterminated by man. A few of them are so threatened that would soon vanish (Day 1981).The Indian subcontinent is home for 10 genera and 17 species of rallids.There are 8 genera and 9 species of rails in kerala. 7 species are found in the study area (Azhinjilam), (Appendix I).

The genus Porphyrio enjoys world wide distribution and includes species such as extinct *Porphyrio albus* (Taylor 1998). One of the largest rail, *Porphyrio albus,* commonly called white swamphen or white gallinule was found on Lord Howe Island,Tasman sea. It was whalers, naval crews and convict supply ships which extirpated the species in 1830 (Day 1981). For thirty years the well known "snoring bird", the snore rail was believed to be extinct but was rediscovered by Gerd Heinrich on his exploration to Celebes from 1930 to 1932. Only ten individuals of this have been captured so far. The Cuba rail *Cynolimmas cerverai* occurs only in a marsh land area of the south of Cuba. The Horned Coot *Fulica cornuta* breeds only beside a few lakes in the high Andes in the Chilean province of Atacama (Grzimek 1990).

The genus is commonly called Purple gallinule for the five of the six extant species have predominantly purple and blue plumage. But the Azure

gallinule, the smallest species of South America has pale plumage. Generally these gallinules have brightly coloured bare parts including the bill, the frontal shield and legs. The long legs and toes are adept at walking and climbing in marsh plants and on floating vegetation. The gallinules are split into 3 genera, Porphyrio, Porphyrula and Notornis but they are obviously monophyletic. The Porphyrula which shares some important characters with Porphyrio and Notornis is a recent derivative of Porphyrio.

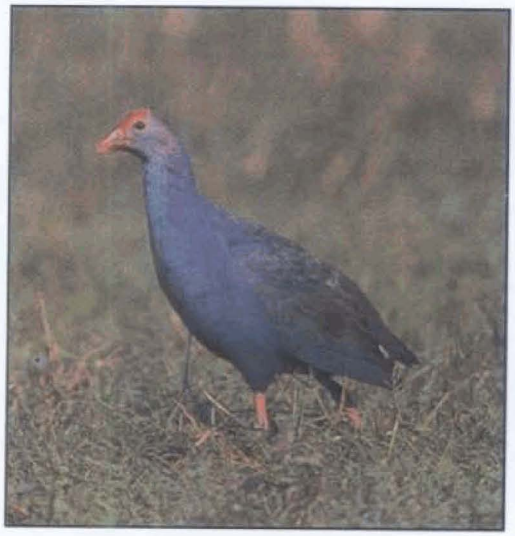
Porphyrio is widely distributed and occurs in southern Europe, Asia Africa, Australia and West Pacific Islands. They show great regional variation in plumage. The Takahe, *Porphyrio mentalli,* of Newzealand, the largest living rail, is an endemic endangered bird with only about 200 individuals in the wild. Unlike other extant species Takahe inhabits grasslands, scrub and forest (Bunin and Jamieson 1995).

Purple Swamphen *Porphyrio porphyrio* species is found in Asia and America i.e. Lands bordering the western Mediterranean. Its taxonomy is complex and inadequately studied. Thirteen subspecies are recognised. But recent phylogenetic studies using mt DNA sequences suggest that at least *Porphyrio porphyrio medagascarensis*, *Porphyrio porphyrio pulveruntus* and *Porphyrio porphyrio melanotus* could be raised to species status. It has also been suggested that *Porphyrio porphyrio poliocephalus* and *Porphyrio porphyrio indicus* should be raised to specific status (Taylor

1998). Indian subcontinent is home to only one species, *Porphyrio porphyrio* but that has two sub species *Porphyrio porphyrio seistanicus* and *Porphyrio porphyrio poliocephalus* (Ali and Ripley 1983). *Porphyrio porphyrio seistanicus* subspecies is not found in India but in some parts of Azerbaijan, Iran, Iraq, South west Afganistan and Pakistan. *Porphyrio porphyrio seistanicus* is a local migrant and is larger than *Porphyrio porphyrio poliocephalus* (Taylor1998). *Porphyrio porphyrio poliocephalus* (Plate I) the subspecies inhabiting the present study area is found in Pakistan (East Baluchistan, Sind and Punjab), Nepal, India (from Kashmir and Plains at foot of Himalayas), Sri Lanka, Bangladesh, Andaman & Nicobar Island and Burma, South Central China and Northern Thailand (Taylor 1998) (Fig1.1). The occurence of the species in various locations in India were reported by various authors (Table 1.1). This subspecies is smaller than the *P.p. seistanicus* but the female is as large as male or tend to be larger (Ali 1969, Ali and Ripley 1983).

In Kerala *P. p. poliocephalus* is found in surroundings of inundated backwater paddy cultivation and reed beds (Ali 1969). It also inhabits the 'kole' wetlands of Malapuram and Trissur districts (Neelakantan 1958, Jayson 2002). This bird is distributed throughout the state in several small and large wetland pockets which may be seasonal or perennial and natural or man-made. *P.p. poliocephalus* has not been found

Plate .I.



Picture 1. ***Porphyrio porphyrio poliocephalus***

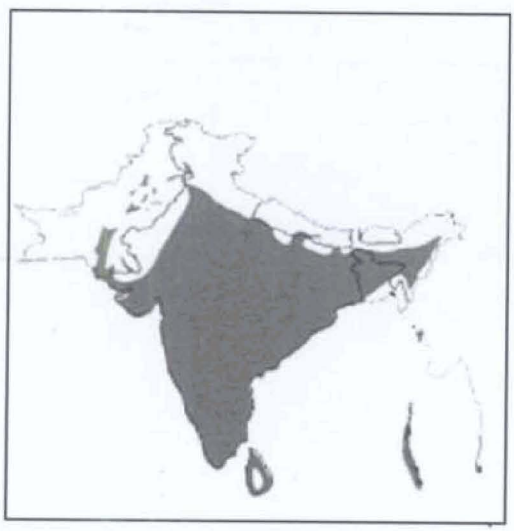


Fig.1.1 Map showing the distribution of *Porphyrio porphyrio*

Table.1.1 Reports on occurrence of Purple moorhen

Location	Year	Author
Chitral	1939	Stransfield
Kathiawar	1948	D Sinhji
Andaman	1971	Das
Ahammedabad	1981	Rawal
Andrapradesh	1985	Kumar
Bhutan	1996	Moet
Kashmir	1946	Philips
Delhi, Agra and Bharathpur	1978	Abdul Ali and Panday
Kerala	1898	Ferguson
	1969	Ali
	1958	Neelakantan
	1992	Raveendran
	2002	Jayson
	1998	Shukkur
	1998	Abdulla and Shukkur

in estuaries, salt water lakes and open water bodies like lakes and ponds. They invariably inhabit wetlands with vegetation. They prefer water bodies with mixed emergent and floating vegetation to those with only floating vegetation.

The bird in Kerala is called by various names like 'challikkozhi' which means a 'bird of weed' since it inhabits many Salvinia infested marshes or Jheels in the state and 'pandarakozhi' referring to the damages caused to paddy cultivation by the bird.

1.1. Objectives

The main objectives of the study were the following

1. explore the status and population fluctuation of the species.
2. understand the microhabitat requirements of the bird.
3. examine the extent of habitat alteration, poaching and predators which effect the status of the species.
4. to document the behaviour, activity pattern and the breeding biology of the bird.

The study is expected to get a picture of status of the bird in Azhinjilam and in various localities in Kozhikode district. The study would also reveal the behaviour and ecology of the bird. The findings would be helpful to chalk out a plan to conserve the species and its habitats.

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CHAPTER II

THE STUDY AREA

2.1. Introduction

In 1997 a reconnaissance survey was conducted in various locations of Kozhikode and Malapuram districts of Kerala state to identify pockets of Purple moorhen. As the Azhinjilam jheel was found supporting a notable population of the species it was selected as an area for intensive study (Fig.2.1.). 25other areas in the Kozhikode district were also identified and regularly visited to collect information on the species (Fig.2.2.).

2.2. Topography

The main study area is Azhinjilam wetland, $11^{0}12'$ 01.7" N 075^{0} 48'59.8" E, which is located on the northern border of Malapuram district, half a kilometer from Chaliyar river on its south bank. Azhinjilam is located about 6 kilometer of aerial distance from Chaliyar river mouth on the west coast and about 15 kilometer by road from Kozhikode district headquarters. A seasonal wetland of 30 hectare, Azhinjilam wetland, is inundated from the onset of Southwest monsoon (June to September) to the end of Northeast monsoon (October to January).

The jheel is formed within the last one and half centuary as a result of the removal of the most suitable top soil from paddy fields for tile and brick factories at Feroke, a village situated three kilometers from the study

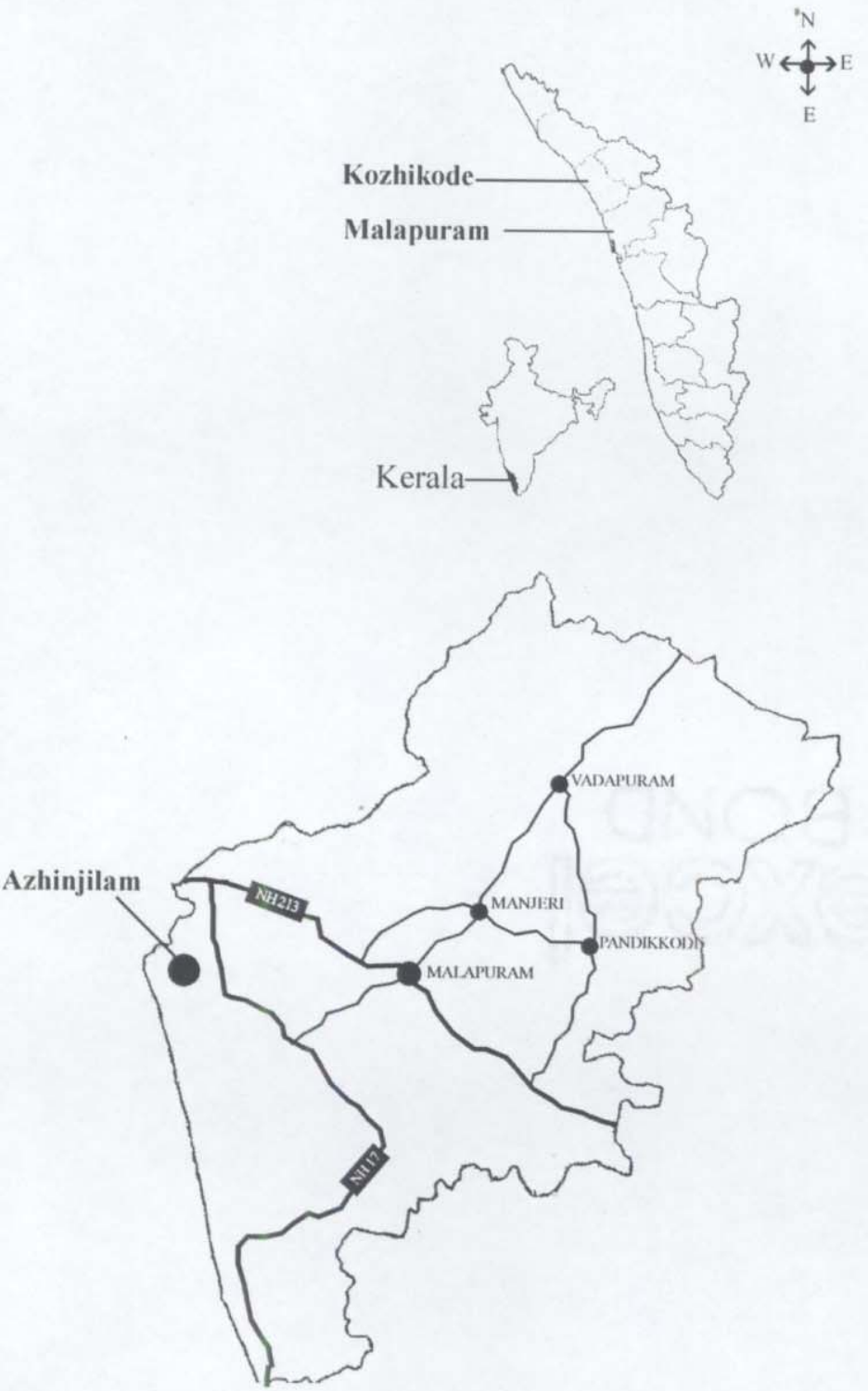
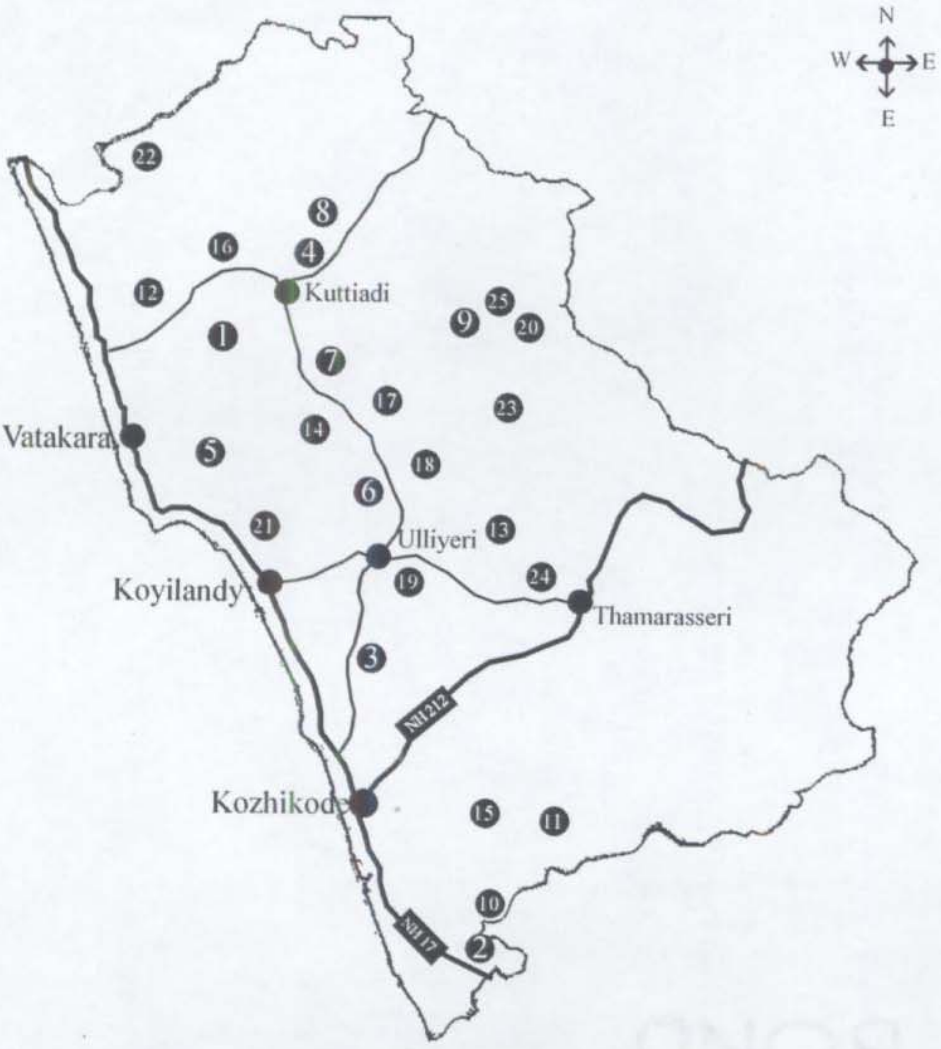


Fig. 2.1.Map of Malapuram District showing main study area, Azhinjilam



Fg. 2.2. Map showing the jheels visited in kozhikode district

1. Cherandathur
2. Poolakkadavu
3. Nelliadikkadavu
4. Ayancheri
5. Payyoli
6. Tholeri
7. Maniyur
8. Kayakkodi
9. Kakkakuni
10. Feroke Chungam
11. Kundayithode
12. Thodannur
13. Theruvathakadavu
14. Iringath
15. Olavanna
16. Orkkatteri
17. Avala
18. Chaniyamkadavu
19. Kulathoor
20. Chengaroth
21. Purakkad
22. Peringathoor
23. Kayanna
24. Omasseri
25. Kannatty

area, well known for tile factories. In the peripheral area of the jheel soil was removed at three meter depth from 1981 to 1983. Prior to 1981 the jheel was just half its present size.

The Farook College - Karad road (Karad - a small town located six kilometer from the study area) passes across northern border of jheel. The elevation of the road approximately indicates the original level of land before digging out the soil. Along the eastern border of the jheel lies Azhinjilam - Ramanattukara (a small town one kilometer away from the study area) road. On the eastern side of this road between the Farook College - Karad road and Chaliyar river there are some smaller jheels. Bordering the jheel there are Coconut and Areca palms, Plantains, Jackfruit and Mango trees.

Monthly average of water depth was taken using a graduated rode. In 1998 the maximum water level in the jheel was in July (2.40m), in 1999 it was in September (2.8m) and in 2000 in August (2.6m). The lowest water level in 1998 was in May (0.8m), in 1999 it was in November (2.2m) and in 2000 in May (0.75m) (Figure 2.3). Water from the jheel is drained into Chaliyar through a circuitous rivulet of about 1.5 kilometer. January on-wards the water in the jheel recedes and farmers start setting some portions of Jheel for summer paddy cultivation (Puncha). By the end of summer most of the jheel gets dried leaving a few patches of water.

In 1999 soil was dumped in the eastern border of the main study

area for construction of a proposed highway. As a result the rivulets got blocked and water did not drain from the jheel even during summer months. Therefore, the jheel acquired a perennial status for the year 1999 with abundant vegetation throughout the year.

2.3. Climate and rainfall

The climatic data was obtained from Centre for Water Resources Development and Management (CWRDM), Kozhikode. The temperature was maximum in May in 1997 (33^0C) and in 2000 (31.4^0C) but it was in April in 1998 (33.8^0C) and in March in 1999 (31.7^0C) (Fig 2.4-2.5). The study area receives plenty of rain (Table 2.1). Rainfall mainly occurs in the two seasons annually: Southwest Monsoon season and Northeast monsoon. Usually the South West monsoon begins in the last week of May or from the first week of June.The season stretches between June and September. The rainfall from October and January is considered to be North East Monsoon which is comparatively weak. Heavy rainfall occurs during the South West monsoon. April and May are the hottest months and December and January are the coolest months; usually the temperature slowly rises from March to May.

2.4. Flora

The wetland harbours various types of aquatic vegetation. A quadrate of 0.5x0.5m was laid in the jheel and plants in the quadrate were identified, catagorised and grouped into families. Total plant species were

Fig. 2.3. Monthly fluctuation in water depth from 1998- 2000

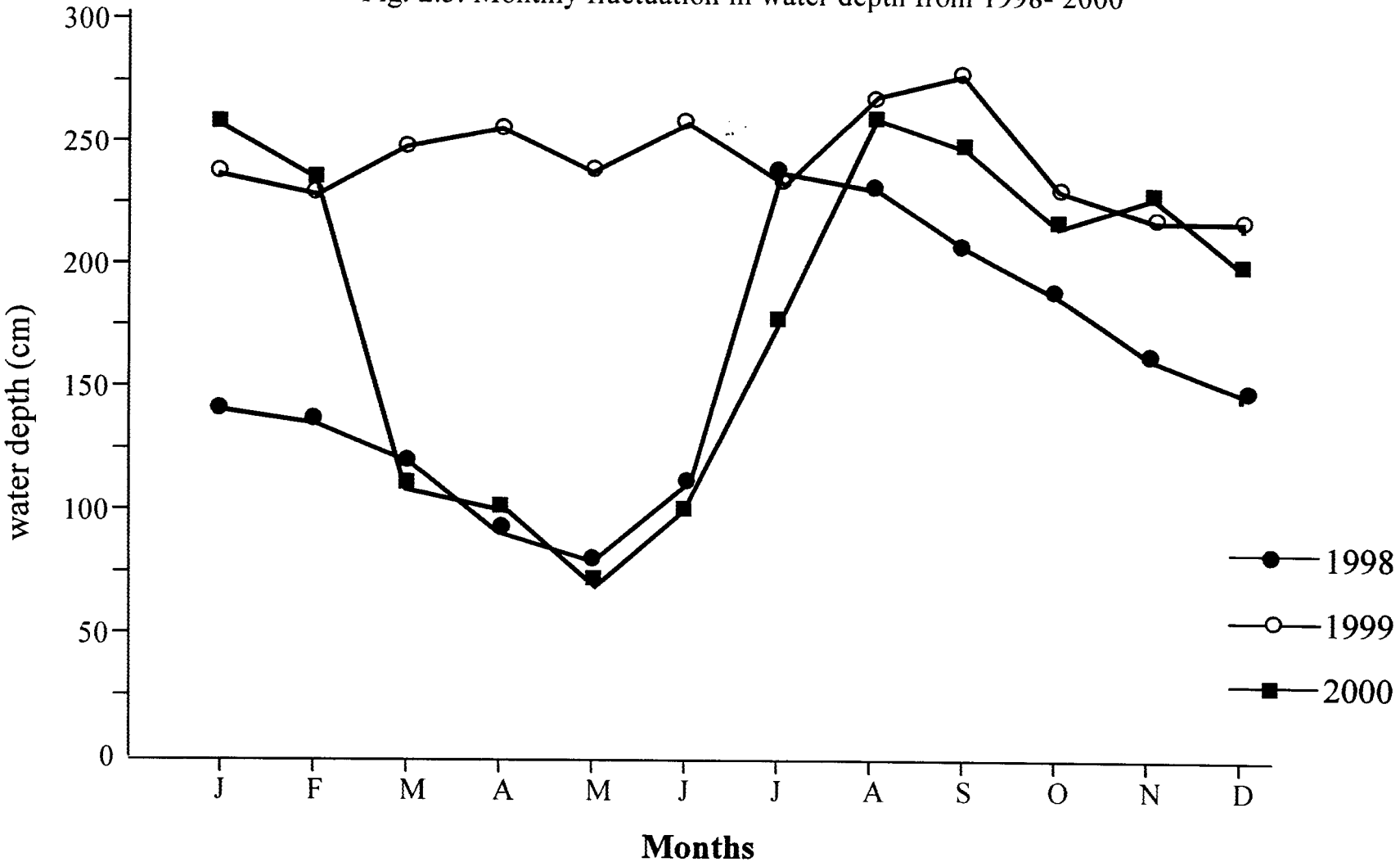


Table : 2.1. **Monthly rain fall in Kozhikode (in mm.)**

(1997- 2000)

Years / Months	J	F	M	A	M	J	J	A	S	O	N	D	Total
1997	0.0	0.0	26.00	0.0	34.00	642.40	1493	414.20	157.20	242.80	191.40	13.80	3214.8
1998	0.0	0.0	0.0	5.60	247.20	733	526	312.40	366.40	307.00	51.00	87.00	2635.60
1999	0.0	35.00	44.00	89.00	427.00	573	673.5	427.04	39	393.00	44.00	29.09	2773.63
2000	0.0	0.0	0.0	63.20	83.00	619.40	370.20	308.00	207.6	164.4	76.20	16	1908

Source CWRDM, Kozhikode

Fig. 2.4. Monthly minimum and maximum Temperature(mean) in Kozhikode (1997, 1998)

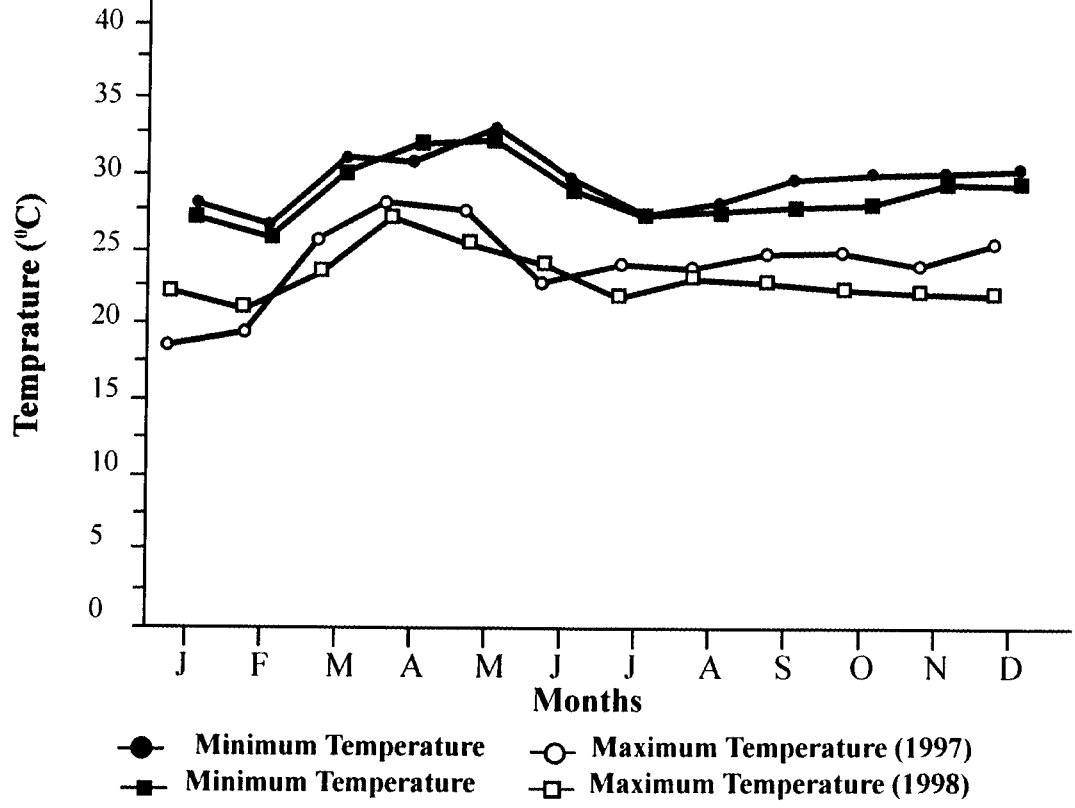
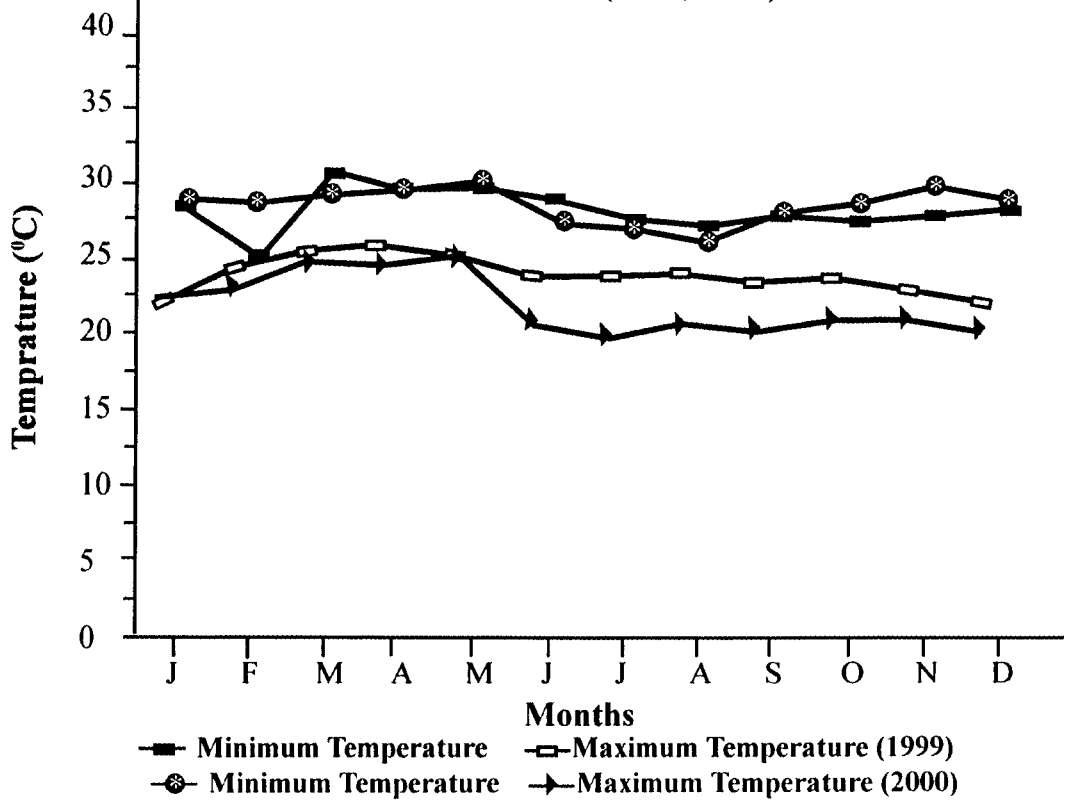


Fig. 2.5. Monthly minimum and maximum Temperature (mean) in Kozhikode(1999, 2000)



assessed from the sampling data. The data were collected once in a month. The plants were identified using the relevent floral volumes. Help was also sought from the curator, Calicut university. The prominent types are described below.

Hydrilla verticellata found in the jheel is a highly branched glabrous monoecious herb. *Eclipta prostrata* is a partly submerged hydrophyte. *Damasonium heterophyllum* is a perennial with leaves submerged or floating or emergent. *Hygrophila salcifolia* found is a plant with stem erect or ascending and is a troublesome weed.

Nymphaea stellata present in the jheel, an aquatic herb with floating leaves has large berry fruits with many seeds. *Utricularia gibba* is a rootless perennial plant. *Marsilea minuta* a hydrophyte with floating stem and roots at the node and have rolled leaves when young. A troublesome weed, *Azolla pinnata* have floating stem. *Salvinia molesta* a fern with enormous growth rate and rapidly covering the water surface, is a serious weed in the paddy fields.

Panicum ripens growing in the jheel is an aquatic perennial commonly called Torpedo grass. *Oryza granulata* in the jheel is a leafy tall grass with leaves long flat and narrow grains. The plant often covers relatively large areas. A weed in rice fields and serious pest in many aquatic systems. *Sacciolepis indica* a small tufted annual is said to form part of good grazing

ground. However because of its small yield it is rarely used as fodder. *Hygroryza aristata* is a perennial grass, trailing over the surface of water, 5 to 40 cm long with spongy nodes. *Ludwigia adscendens* is a small ramous plant, annual, flowering in rainy season. *Cyperus exaltatus* is a plant with erect stem and simple leaves. *Eleocharis acutangula* is a plant with glabrous stem that is simple and erect without nodes. *Fimbristylis mileaceae* is an annual, tufted ;stem with one meter tall and is a weed in rice fields. *Cryptocrene retrospiralis* is a herb with fleshy tuberous root flowering in summer (Table 2.2).

Salvinia molesta was found in highest frequencies (31%) in winter (Fig 2.6) and (58%) in Summer followed by *Oryza granulata* (27%), *Nymphaea stellata* (19%), *Hydrilla verticellata* (14%) in winter and *Oryza granulata* (16%), *Nymphaea stellata* (7%) and *Hydrilla verticellata* (7%) in summer (Fig 2.7).

2.5. Fauna

The study of water sample taken from the Jheel shows the presence of various micro and macro invertebrates (Appendix II).Varieties of vertebrate animals also inhabit the jheel (Appendix III).

2.6. Invertebrates

Amoeba proteus, Paramecium caudatum, Euglena viridis were found in the water sample. *Hydra vulgaris* and *Planaria lugubris* were also

seen attached to the stones and rotten leaves. Hirudinaria sp. (Leech) was seen in the jheel. Earth worms, *Megascolex* sp, were found in the burrows in the dykes and mounds. There were *Daphnia* sp, Copepods, Cyclops, and fresh water Prawn inhabiting the jheel. Various species of Dragon flies and their larvae were seen in the vegetation. The jheel harbours aquatic insects, ants, termites, spiders, butterflies, moths, grass hoppers, centipedes and millipedes. *Pila globosa,* the apple snail was also seen in the jheel.

2.7. Vertebrates

The jheel is a suitable breeding ground for fishes like Ophiocephalus, trouts and Catfishes. Frog *Rana* sp. and *Ichthyophis* sp. also breed in this wetland.The reptiles like Garden lizard *Calotes versicolor*, Monitor lizard *Varanus bengalensis*, Skink *Mabuya carinata*, Pondsnake *Natrix piscator* and Ratsnake *Ptyas mucosus* were sighted. The Jackal *Canis aurius*,The Common Mongoose *Herpestis edwardsi* and The Field Mouse *Mus* sp also frequent the jheel.

2.8. Avifauna

Azhinjilam jheel harbours many species of resident and migratory birds (AppendixVIII). The jheel is one of the well known wintering grounds in Malabar for the Palearctic migrants. The wintering species include Blue

Table .2.2. Prominent Aquatic plants in the study Area

Family	Plants	Category
Poaceae	*Panicum ripens*	Emergent
	Oryza granulata	,,
	Sacciolepis indica	,,
	Hygroryza aristata	,,
Onagracea	*Ludwigia adsendens*	Emergent
Cyperaceae	*Cyperus exaltatus*	Emergent
	Eleocharis acutangula	,,
	Fimbristylis mileacea	,,
Lytheraceae	*Rotala indica*	Emergent
Hydrocharitaceae	*Hydrilla verticellata*	Submerged
Asteraceae	*Eclipta prostrata*	Submerged
Alismataceae	*Damsonium heterophyllum*	Submerged
Acanthaceae	*Hygrophila salcifolia*	Submerged
Lentibulariaceae	*Utricularia gibba*	Rooted floating
Nymphaeaceae	*Nymphaea stellata*	Rooted floating
Marsileaceae	*Marsilea minuta*	Floating
Azollaceae	*Azolla pinnata*	Floating
Salviniaceae	*Salvinia molesta*	Floating

Fig.2.6 **Relative abundance of dominant plant species in Azhinjilam in winter 1998**

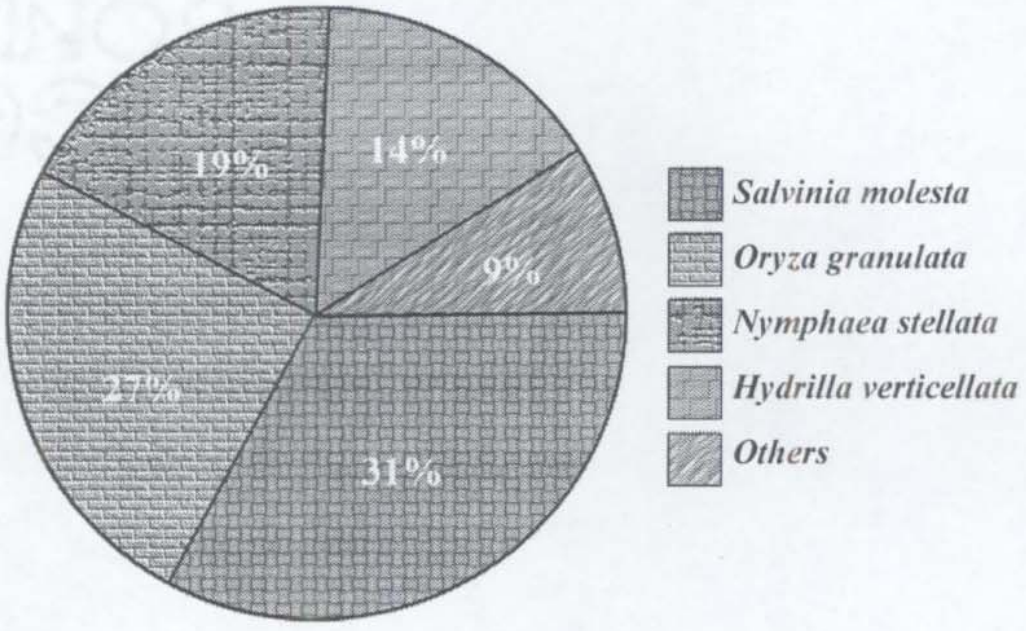
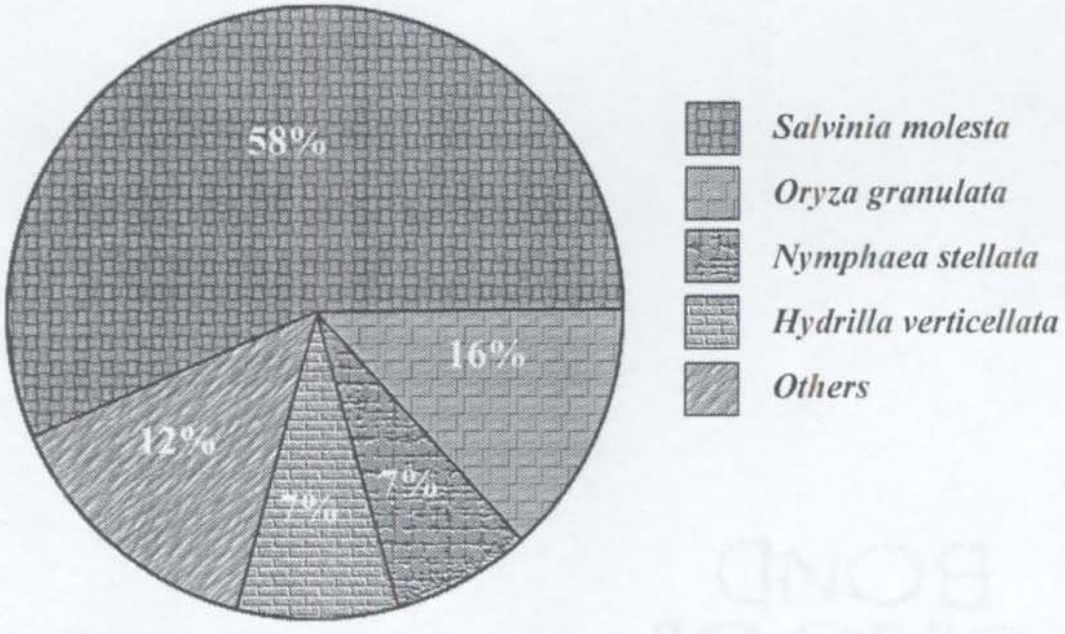


Fig.2.7 **Relative abundance of dominant plant species in Azhinjilam in Summer 1998**



winged teal *Anas querquedula* and Spoonbill *Platalea leucorodia.* However, the birds in the jheel reportedly show a trend in decline because of the pressure from habitat alteration, construction of buildings and roads and Salvinia infestation.

2.9. Subsidiary study areas

The subsidiary study areas mainly include 25 wetlands in Kozhikode district.Theruvathakadavau wetland with an area 17 ha, is situated 15 km south east of coastal town of Koyilandy. Avala jheel located 20 km east of Vatakara town having 25 ha area. Cherandathur of 20 ha is situated 10 km south east of Vatakara town. Most of the vegetation types found in the main study area are found in these jheels. Out of 25 jheels visited only 3 were perennial and the remaining 22 were seasonal (Table 2.3). These wetlands have copious growth of *Eichhornia crassipes, Nelumba nucifera* and clusters of *Pandanus odoratissimus.* For the study Akkulam lake of Thiruvanathapuram was also visited thrice and Kole wetlands of Malapuram district twice. Several other small jheels in Kozhikode and Malapuram districts were also visited for random observations.

Table 2.3 Nature of jheels in Kozhikode District

Sl No	Name of jheels	jheels			
		Perennial	seasonal	Breeding	Non breeding
1	Cherandathur	✔	✔	✔	
2	Poolakkadavu		✔		✔
3	Nelliadikkadavu		✔		✔
4	Ayancheri		✔	✔	
5	Payyoli		✔	✔	
6	Tholeri	✔		✔	
7	Maniyur		✔		✔
8	Kayakkodi		✔		✔
9	Kakkakuni		✔		✔
10	Feroke Chungam		✔		✔
11	Kundayithode		✔		✔
12	Thodannur		✔	✔	
13	Theruvathakadavu		✔		✔
14	Iringath		✔	✔	
15	Olavanna		✔		✔
16	Orkkatteri		✔		✔
17	Avala	✔		✔	
18	Chaniyamkadavu*		✔		✔
19	Kulathoor*		✔		✔
20	Chengaroth*		✔		✔
21	Purakkad*		✔		✔
22	Peringathoor*		✔		✔
23	Kayanna*		✔		✔
24	Omasseri*		✔		✔
25	Kannatty*		✔		✔

*Birds vanished since 2000

BIOLOGY, ECOLOGY AND BEHAVIOUR OF PURPLE MOORHEN PORPHYRIO PORPHYRIO

Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology

BY

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DECEMBER 2006

CHAPTER III

POPULATION

3.1. Introduction

Purple moorhen occupies several small and large wetlands throughout Kerala. Azhinjilam jheel in Malapuram district is one pocket where in moorhen is seen in notable numbers. Kurup (1991) and George Mathew (2002) have conducted preliminary studies on the population diversity of the birds in Azhinjilam Jheel. Post graduate students of wild life department, Farook college have also monitored the population of birds in the jheel for more than 10 years. Shukkur (1998) has carried out population studies especially on Bronze winged jacana and Pheasant tailed jacana. Abdulla and Shukkur (1998) have also reported a preliminary study on the population dynamics of Purple moorhen in the wetland. However, the data on the population of the bird was felt scanty and hence the present study was undertaken. The population of Purple moorhen in the jheel was monitored from 1998 to 2000. In the light of the reports that Purple moorhen was facing an uncertain future, a survey on the status of the birds in various jheels in Kozhikode district (Table 2.3) was also presented.

3.2. Objectives

The major objectives of the study were:

1. to understand the population fluctuation in various months and seasons

during the years 1998, 1999 and 2000.

3.3. Methodology

Line transect method (Gaston 1973) was employed to estimate the population of Purple moorhen. In this method the observer walked along the predetermined transect of 100 m long and all birds encountered were recorded. The count was taken between 7.00 am and 11.00am. In the main study area, Azhinjilam, four counts were taken every month for a period of three years from 1998-2000 and the monthly average count was pooled. Bird counts were also conducted in 25 jheels in Kozhikode districts in January, April and August (2001) which fell in winter, summer and monsoon seasons respectively. From the monthly data in each jheel the total population of birds in the district were estimated.

Dykes and roads were used as transects. Binoculars of 8X40 and a monocular spotting scope were used for counting. In the main study area the adults, subadults and chicks were enumerated separately. Counting of the adult birds in general and the chicks in particular was very difficult owing to the elusive behaviour of the birds. The chicks often hid in water and amidst the vegetation. However, they were visible when they followed their parents wandering around in the habitat.

For the convenience of the seasonal analysis of the bird population the months in a year were categorised into three seasons namely

Summer (February to May), Monsoon (June to September) and Winter (October to January). The data of counting were tabulated and analysed statistically.

3.4. Statistical analysis

Basic statistical analysis was used to compare the population mean of adults, subadults and chicks in summer, monsoon and winter seasons of 1998, 1999 and 2000. Triennial comparison of the mean population was also made for the same period. Scheffe multiple test was used to find significance of annual and seasonal variation in the mean population. The patterns obtained in the result were plotted as Whisker boxes.

3.5. Results

3.5.1 *Monthly fluctuation*

The adults, subadults, and chicks showed a trend of monthly fluctuation from 1998 to 2000. In 1998 and 2000 adults were most abundant in January (mean = $\bar{x}$ =9.3 in 1998 and $\bar{x}$ =175 in 2000) whereas in 1999 the highest number of adults ($\bar{x}$ =300) were found in April. The least number of adult birds were seen in May in 1998 ($\bar{x}$ =29) and in 2000 ($\bar{x}$ =51.3). In 1999 the least number of adults ($\bar{x}$ =41) was found in August. In 1998 gradual decrease in population from January ($\bar{x}$ =219.3) to May ($\bar{x}$ =29) was seen while May onwards the adult population gradually increased till December

($\bar{x}$ =180). Same trend was seen in 2000 as the population decreased from January ($\bar{x}$ =175) to May ($\bar{x}$ =51.3) and started rising from May ($\bar{x}$ =51.3) to December ($\bar{x}$ =153.5). However, such a trend of increase or decrease in population of adults in 1999 was not observed (Fig 3.1).

The subadults were highest ($\bar{x}$ =32) in December and the least ($\bar{x}$ =7) in April 1998. The highest number of subadults ($\bar{x}$ =29.3) was seen in August and the lowest was ($\bar{x}$ =15.8) in October 2000. Subadults were seen highest ($\bar{x}$ =30.5) in February and the least ($\bar{x}$ =10) in June 1999. The data do not show a definite trend in the fluctuation of population in sub-adults as observed in the case of population of adult in 1998 and 2000 (Fig 3.2).

The chicks were not observed (zero population) from January to June and in December in 1998 and 2000. During these years the chicks were seen from July to November. In 1998 the highest number of chicks ($\bar{x}$=14.3) were found in September and in 2000 in August and September ($\bar{x}$=29). The least ($\bar{x}$ =8) number of chicks were seen in November in 1998. In 2000 the maximum number of chicks ($\bar{x}$ =29) were found in August and September while the lowest ($\bar{x}$ =7.5) was seen in November.

Chicks were seen in all months in 1999 with maximum number ($\bar{x}$ =29.3) in August and minimum number ($\bar{x}$ =2) in January. As in the case of subadults there was no regular trend in the number of chicks in 1998,

1999 or 2000 (Fig.3.3).

3.5.2. *Seasonal fluctuation of population*

The population of adult moorhen was highest in the winter season of 1998 (mean = $\bar{x}$ =630.3) compared to that of summer and monsoon of the year. The summer population of 1998 was $\bar{x}$ =308 and that of 2000 was $\bar{x}$ =346.1. The monsoon population of 1998 was $\bar{x}$ =286.6 and that of 2000 $\bar{x}$ =398.8. In contrast, in 1999 the population was highest in summer ($\bar{x}$ =766.6). The patterns in the number of adults in 1998 and 2000 showed some close similarities and there was no significant difference in the comparative seasonal population of the two years (Fig. 3.4-3.6).

Comparing to the winter population of 1998, 1999 and 2000 the highest number was seen in 1998 ($\bar{x}$ =630.3). It followed by winter of 2000 ($\bar{x}$ =583.6). Among the summer population of 1998, 1999 and 2000 the highest number was seen in the summer of 1999 ($\bar{x}$ =766.6), (Fig 3.7-3.12).

The total number of the birds did not differ greatly among monsoon seasons of 1998, 1999 and 2000. In the overall analysis there was no significant variation in the adult population of the bird over the years 1998,1999 and 2000.

In 1998, the winter population of subadults ($\bar{x}$ =88.8) was higher than that in summer and monsoon. The lowest population was seen in summer of 1998 ($\bar{x}$ =39.8) which was the least of all the seasons of 1998, 1999

Fig. 3.1 Monthly fluctuation of population of adults, subadults and chicks in 1998

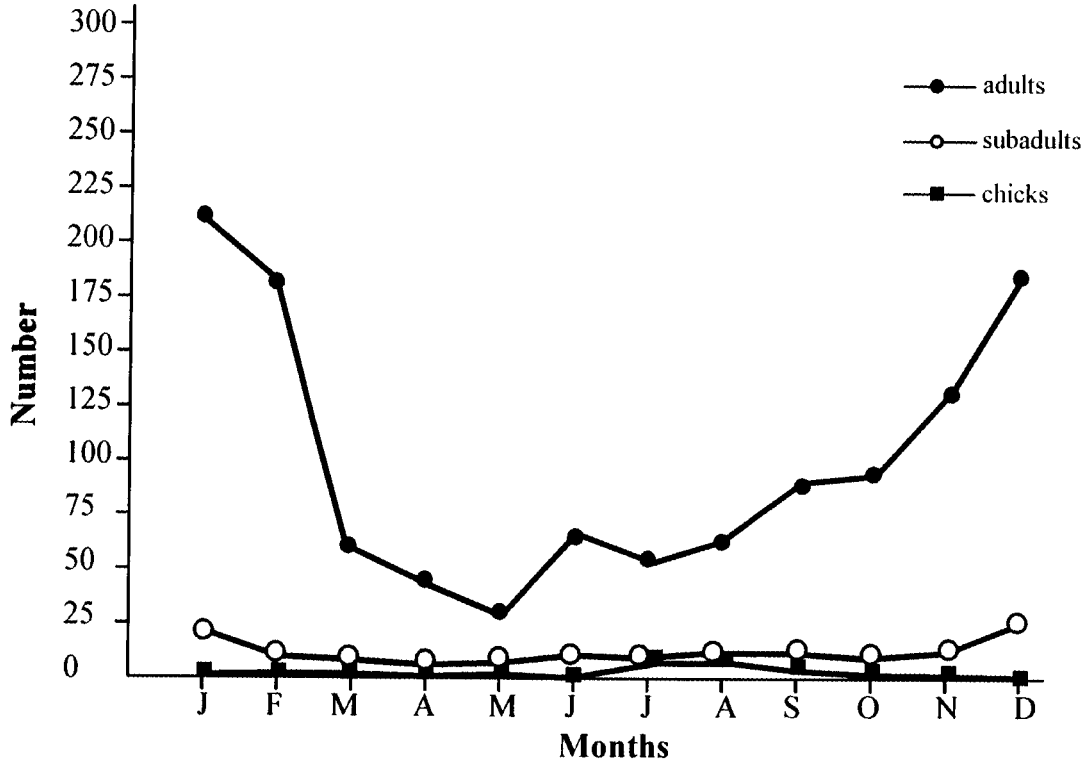


Fig.3 .2 Monthly fluctuation of population of adults, subadults and chicks in 1999

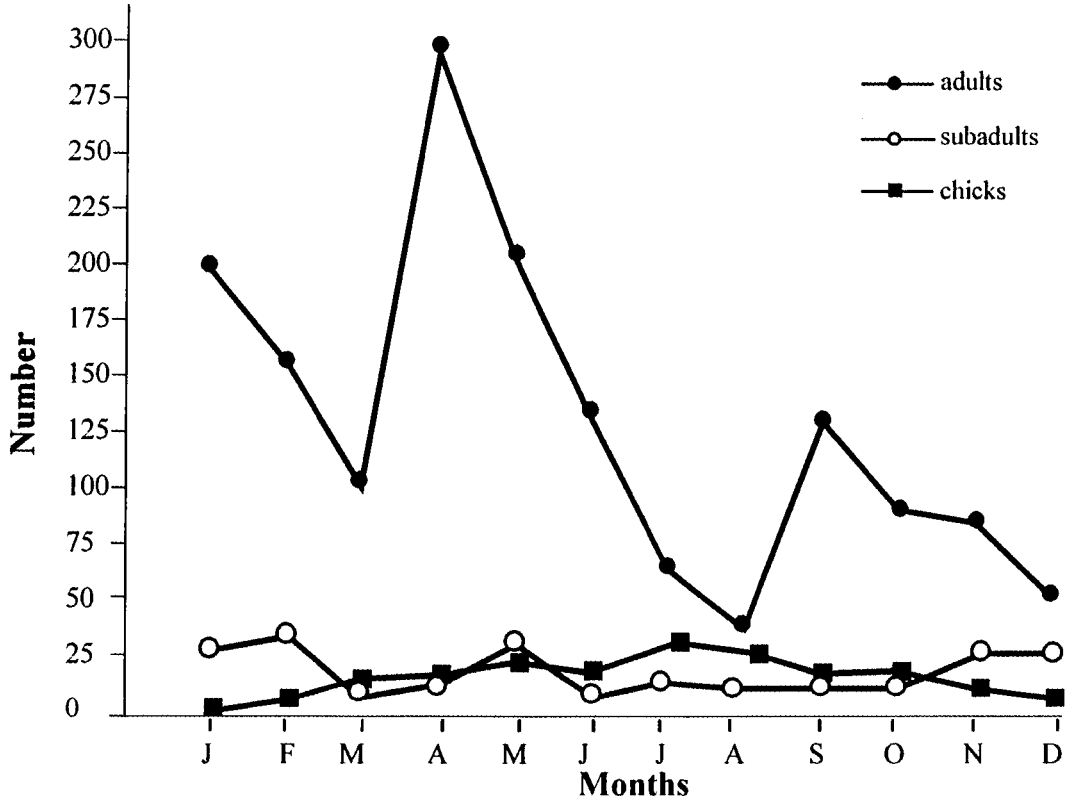


Fig. 3.3 Monthly fluctuation of population of adults, subadults and chicks in 2000

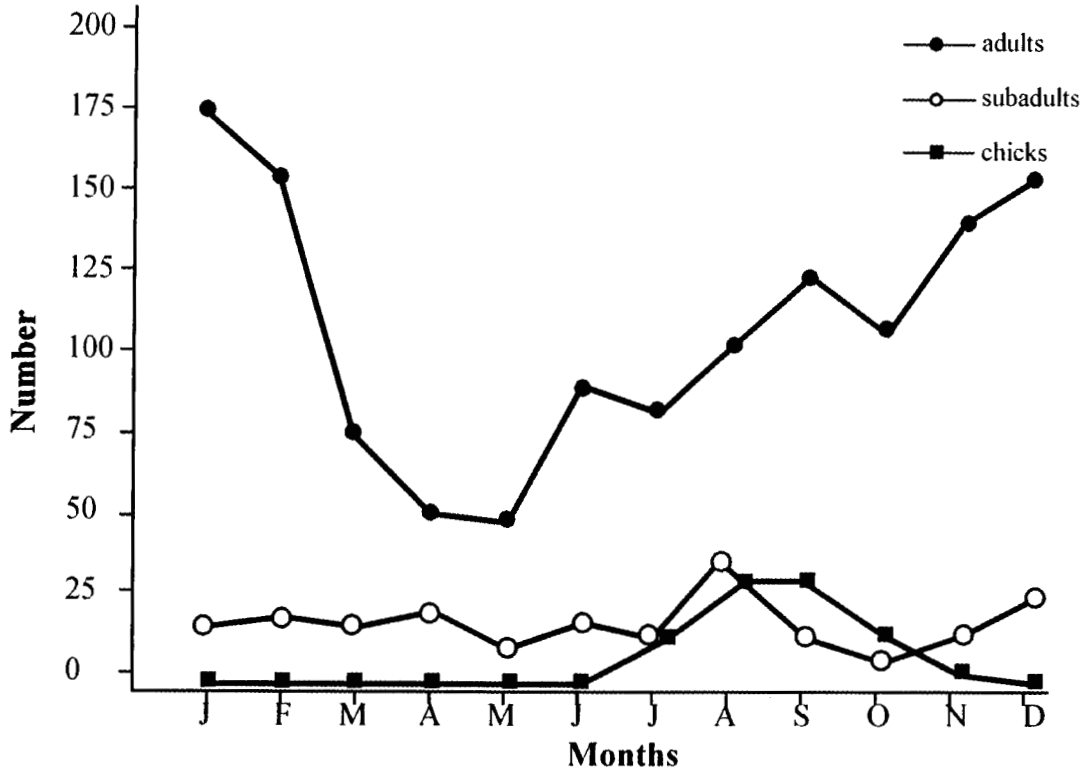


Fig. .3.4 Monthly fluctuation of population of adults during 1998, 1999 and 2000

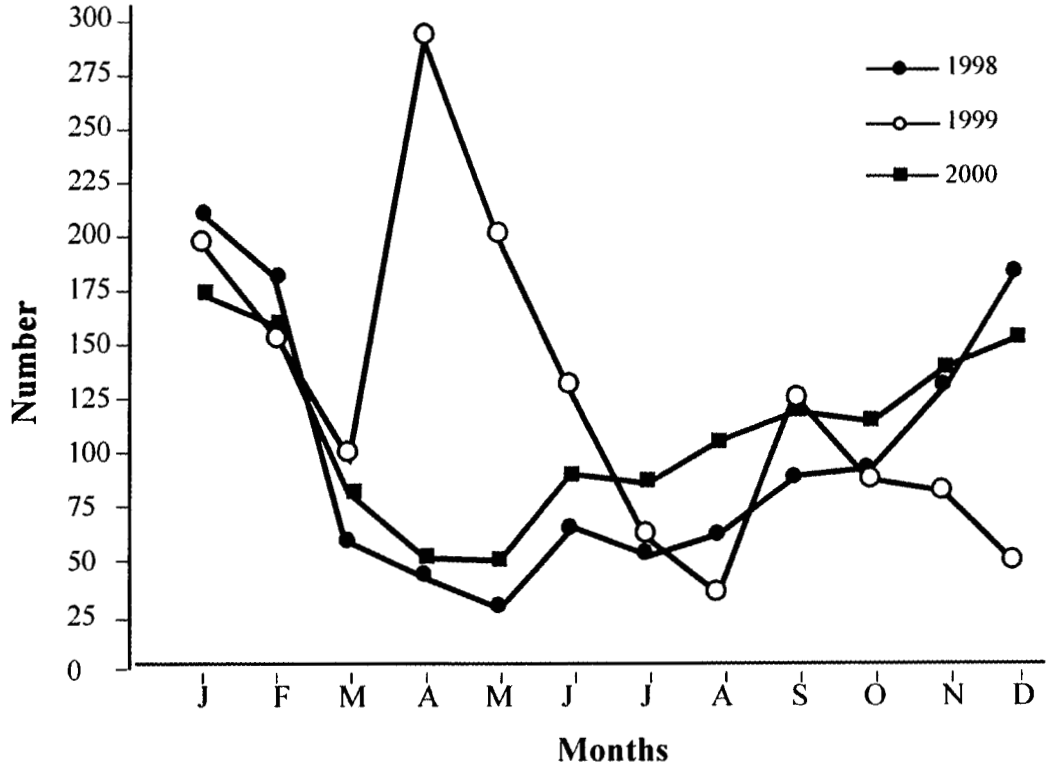


Fig. 3.5 Monthly fluctuation of population of subadults during 1998, 1999 and 2000

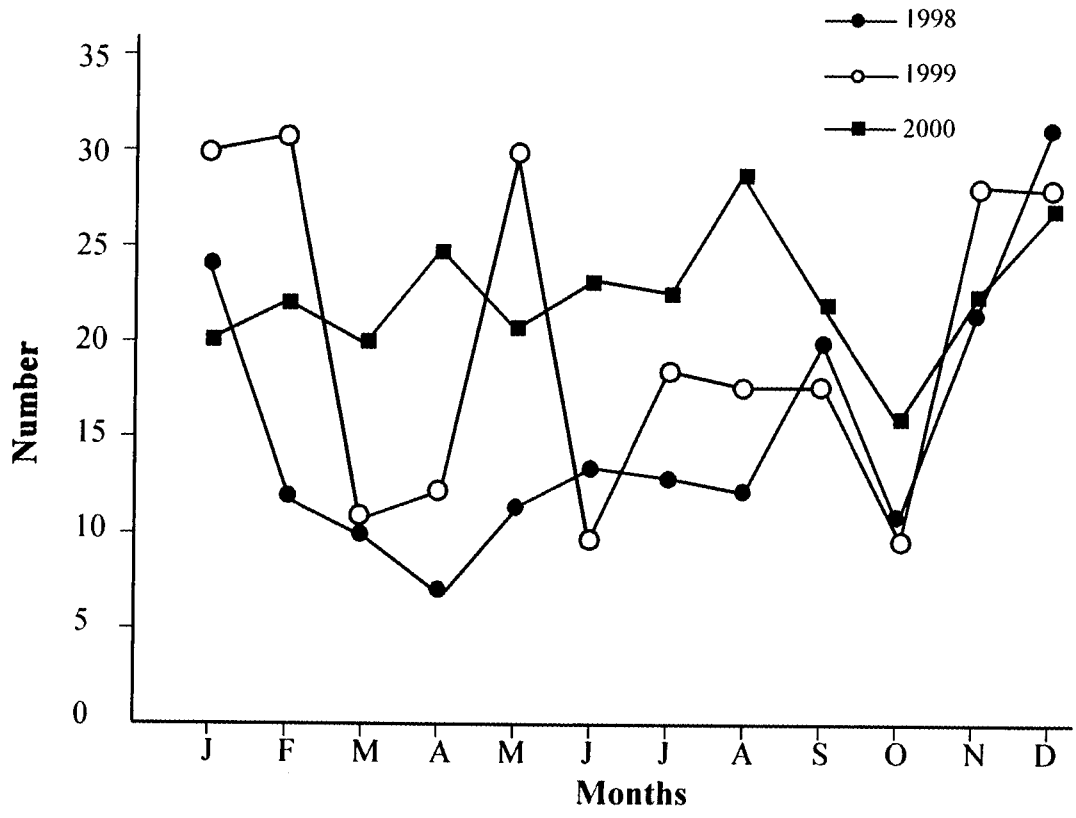
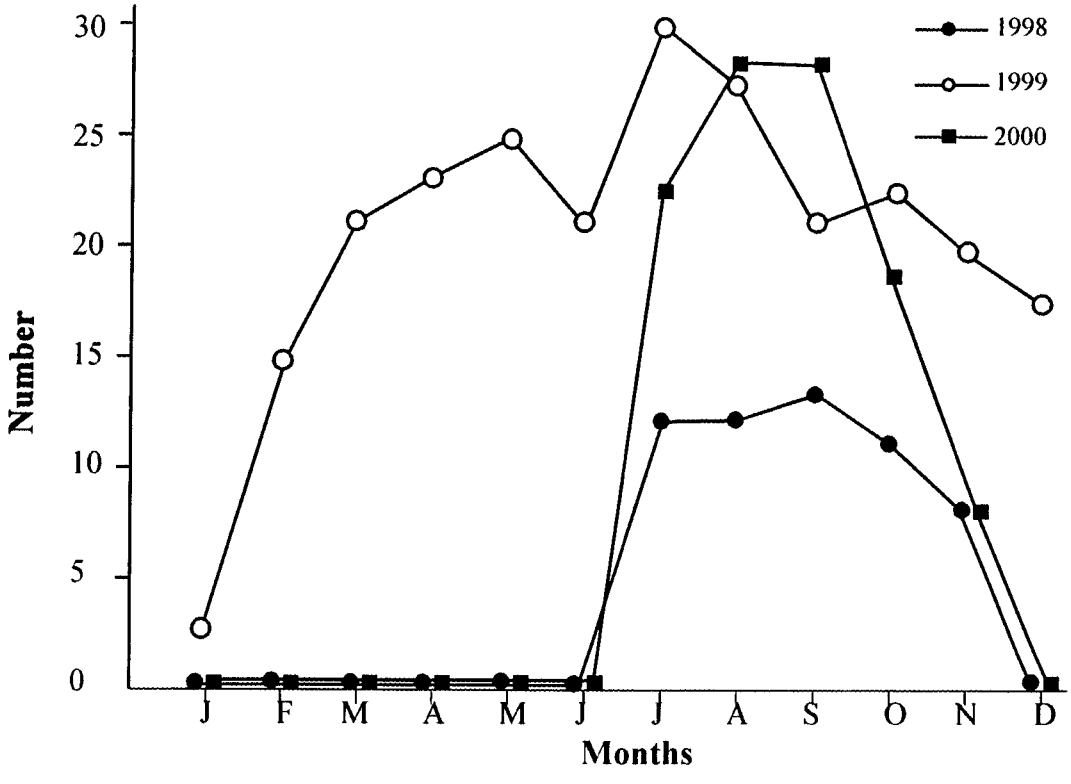


Fig. 3.6 Monthly fluctuation of population of chicks during 1998, 1999 and 2000



Seasonal and annual variation in the adult population from 1998-2000

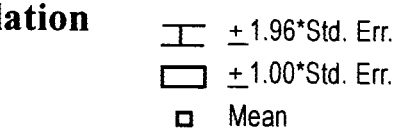
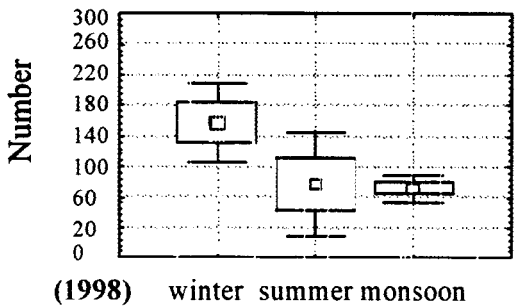


Fig. 3.7



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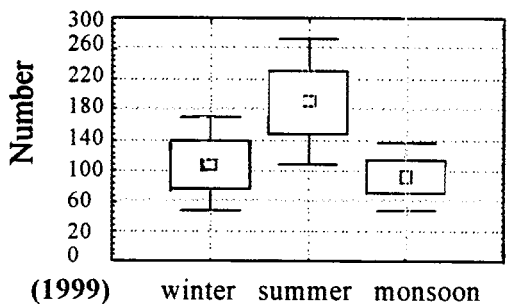
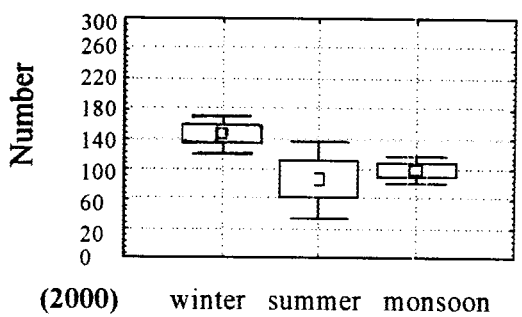


Fig. 3.9



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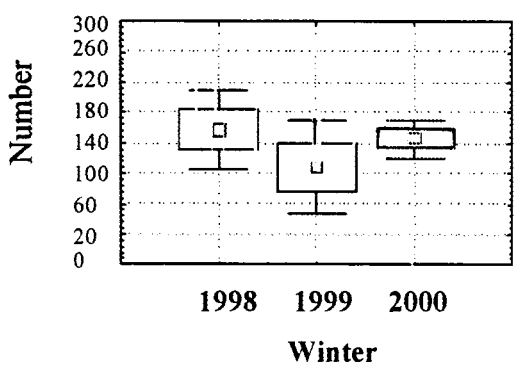


Fig. 3.11

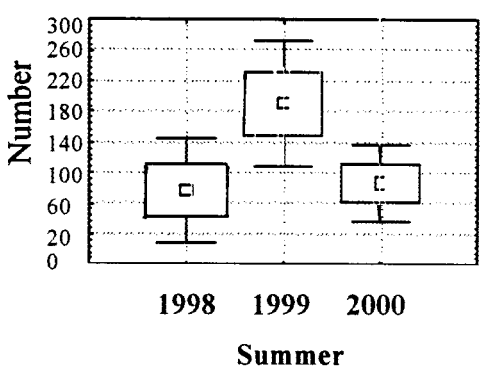
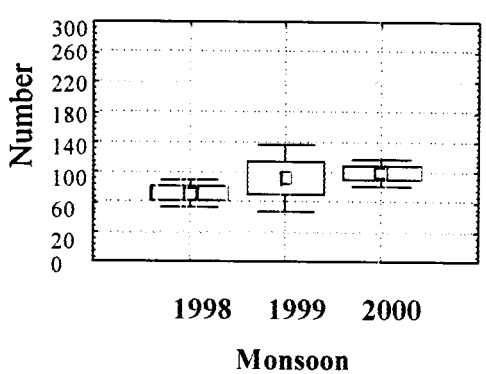


Fig. 3.12



and 2000. In 1999, contrary to the adult population subadult population was highest in winter and the least in monsoon (Fig 3.13 - 3.18). However in 2000 the population in general was high in winter ($\bar{x}$ =86.1), summer ($\bar{x}$ =89.4) and monsoon ($\bar{x}$=98.6) without much interseasonal fluctuation (Fig 3.16-3.18). Among the winter population of 1998, 1999 and 2000 there was no significant variation.

The data analysed by Scheffe Test (Appendix V) shows significant seasonal variations in the population of chicks (Fig. 3.19- 3.24). Chicks were totally absent in the summer of 1998 and 2000. Whereas there was notable numbers in summer of 1999 ($\bar{x}$ =83.3). The monsoon chick population was slightly higher than the winter population. In 1999 there was comparatively large population of chicks in winter ($\bar{x}$ =98.3), summer ($\bar{x}$ =83.3) and monsoon ($\bar{x}$ =98.6) seasons with the highest being in monsoon. In 2000 also the largest population of chicks was seen in monsoon ($\bar{x}$ =61.3) and the winter population was relatively small ($\bar{x}$=26.8). The winter population of the chicks was the highest in 1999 ($\bar{x}$ =98.3) compared to that of 1998 ($\bar{x}$ =98.3) and 2000 ($\bar{x}$ =26.8), (Fig 22-24). Of the three consecutive summer seasons the chicks were found only in the summer of 1999 ($\bar{x}$ =83.3). All the monsoons of the three years had chick population and the highest was seen in 1999 ($\bar{x}$ =98.6). Only in 1999, the chicks were seen throughout the year.

Seasonal and annual variation in the subadult population from 1998-2000

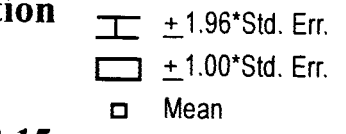


Fig. 3.13

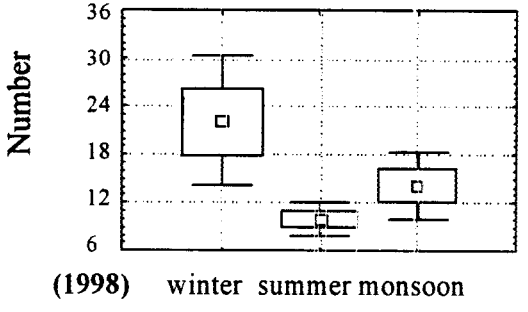


Fig. 3.14

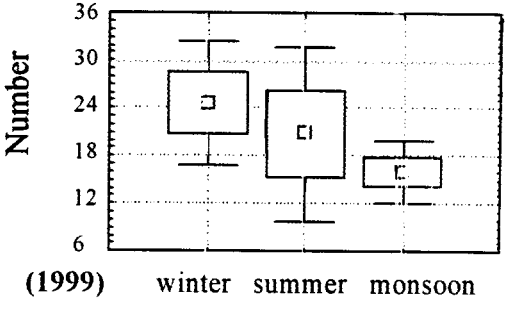


Fig. 3.15

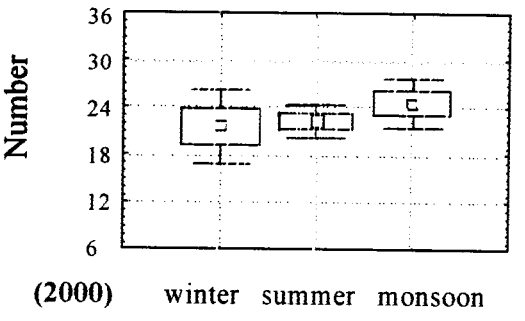


Fig. 3.16

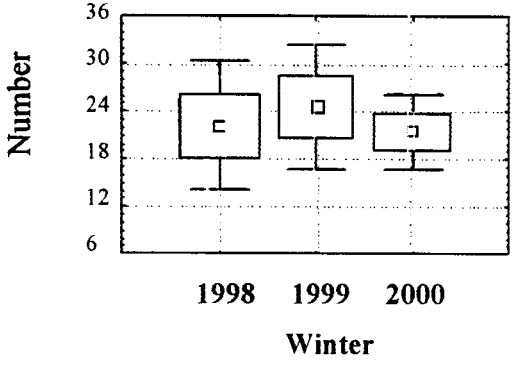


Fig. 3.17

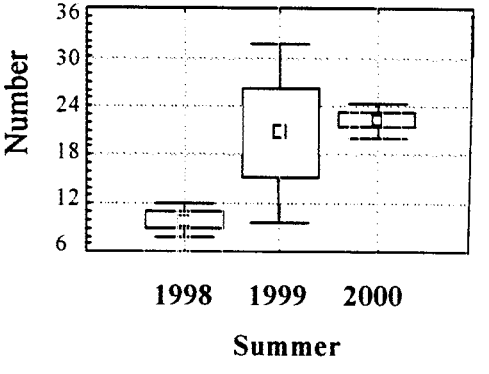
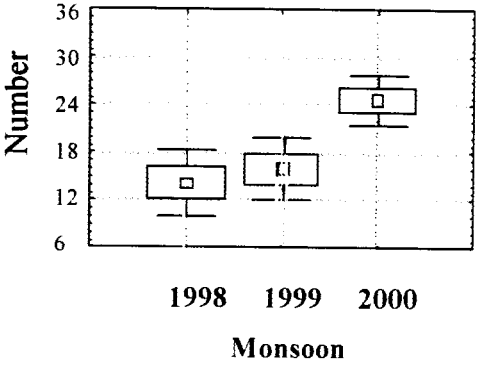


Fig. 3.18



Seasonal and annual variation in the chick population from 1998-2000

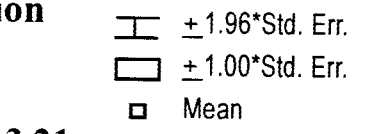


Fig. 3.19

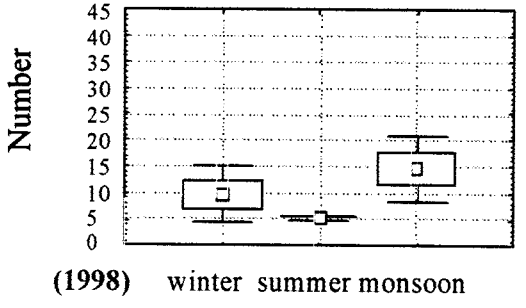


Fig. 3.20

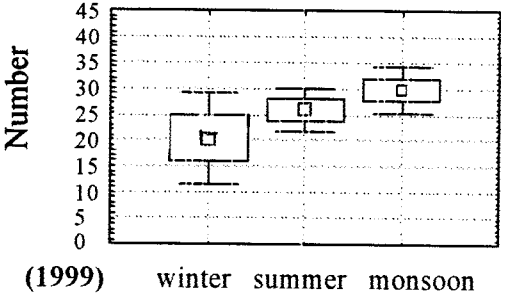


Fig. 3.21

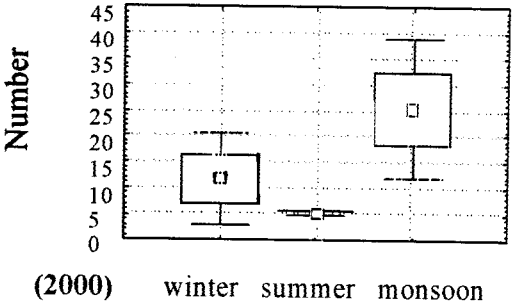


Fig. 3.22

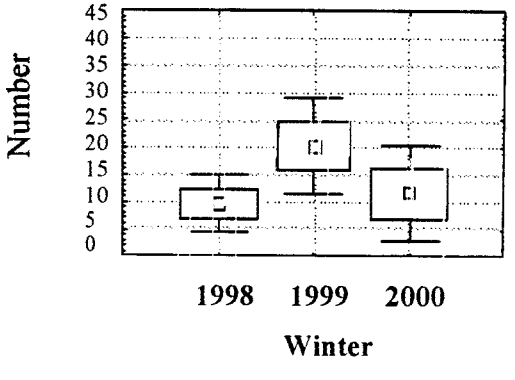


Fig. 3.23

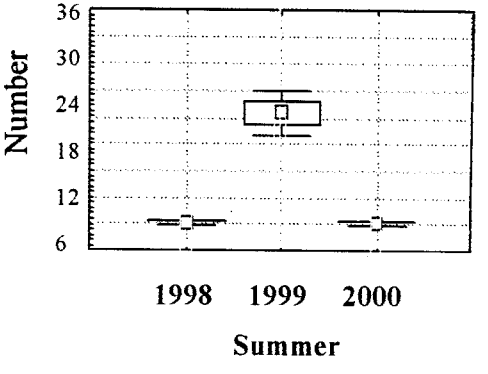
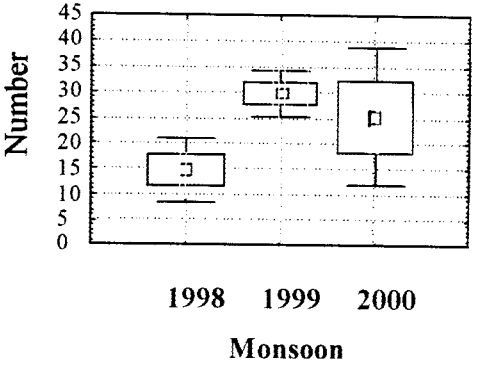


Fig. 3.24



3.5.3. *Population of Purple moorhen in Kozhikode District*

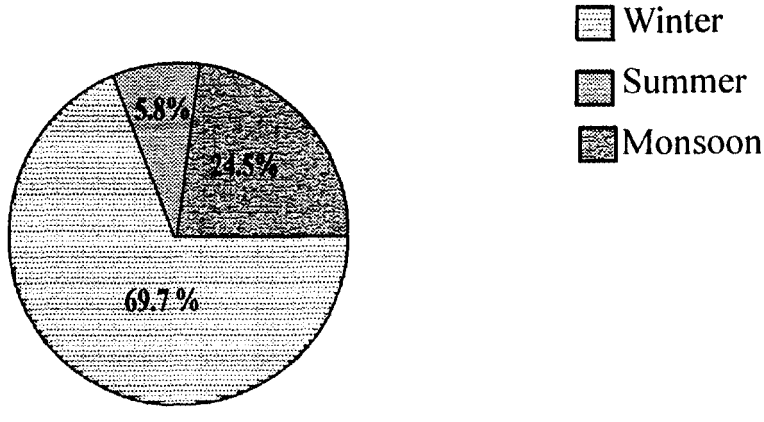
The farmers opined that the birds colonised in various jheels in the district since 1990.There was no previous record of sighting the bird in these jheels. However it was reported by the farmers that the appearance and disappearance of the birds in the jheels in various years during the last decade. In three seasonal jheels Kundayithode, Poolakadavu and Olavanna the birds were seen only for five months (June to October) and were left thereafter. In the eight jheels the birds were not found since 2000. These jheels had harboured hundreds of Purple moorhen before 2000 (Table 3.1). In January 2001 the largest number of birds were seen in the three perennial jheels: 192 in Cherandathoor, 88 in Tholeri and 210 in Avala. In April the birds were found only in three perennial jheels: 51 in Cherandathoor, 30 in Tholeri and 20 in Avala. In August also the largest number of birds were seen in the same jheels: 80 in Cherandathoor, 30 in Tholeri and 98 in Avala (Fig 3.25).

In January there were totally 1225 birds (Perennial 490 and Seasonal 735). In April there were 101 birds (Perennial 101 and seasonal nil) and in August there were 430 birds (Perennial 217 and Seasonal 213). The total number of birds observed in January, April and August in the various jheels of Kozhikode district were 1756. According to the data collected from farmers and bird watchers various jheels in the district harboured a total of 3500 birds between 1990 and 2000 (Table 3.2).This suggests a

Tab3.1 Abundance of Purple moorhen in Kozhikode District in 2001

Sl No	Name of jheels	Population count			
		January	April	August	Mean
1	Cherandathur	192	51	80	107.6
2	Poolakkadavu	27	-	16	21.5
3	Nelliadikkadavu	31	-	16	23.5
4	Ayancheri	42	-	23	32.5
5	Payyoli	36	-	2	19
6	Tholeri	88	30	39	52.3
7	Maniyur	43	-	15	29
8	Kayakkodi	54	-	16	35
9	Feroke Chungam	59	-	21	40
10	Kakkakuni	68	-	25	46.5
11	Kundayithode	96	-	20	58
12	Thodannur	25	-	14	19.5
13	Theruvathakadavu	59	-	10	34.5
14	Iringath	59	-	11	35
15	Olavanna	68	-	13	40.5
16	Orkkatteri	68	-	11	36.5
17	Avala	210	20	98	109.3
	Total	1225	101	430	

Fig 3.25 Seasonal abundance of birds in Kozhikode District, 2001.



notable fall of population in the district during the last decade.

3.5.4. *Causes of population depletion*

(a) poaching

According to the data collected from farmers and local bird watchers in 2001, 128 birds were killed in the various parts of Kozhikode district. Of these 16 were shot down, 33 were trapped in snares, 20 poisoned and 14 by pelting stones. The birds were mainly killed for their meat. The people who consumed the meat of moorhen was of the opinion that the meat is deliceous. The farmers also killed 29 birds in the district accusing them as a pest of paddy.

(b) Collection of eggs

Farmers and grass cutters collected 208 eggs from the nests in various jheels of the district in 2001. The eggs were for consumption and reportedly not for sale. Eggs were tasty according to a villager who consumed the eggs every year.

(c) Destruction of nests

The nests destroyed by grass cutters and farmers affect the breeding success of the bird adversely. 11 nests were destroyed in the district in 2001.

(d) Predation

Non human predators also posed severe threats to the adults, chicks and eggs (See chapter **VII**, Breeding biology).

Table 3.2 Abundance of Purple moorhen in Kozhikode district between1990-2000

Sl No	Name of jheels	No. of birds
1	Cherandathur	< 300
2	Poolakkadavu	< 200
3	Nelliadikkadavu	> 100
4	Ayancheri	> 200
5	Payyoli	> 200
6	Tholeri	< 100
7	Maniyur	> 200
8	Kayakkodi	< 200
9	Kakkakuni	> 100
10	Feroke Chungam	< 200
11	Kundayithode	> 100
12	Thodannur	> 50
13	Theruvathakadavu	> 100
14	Iringath	> 100
15	Olavanna	> 200
16	Orkkatteri	> 200
17	Avala	> 200
18	Chaniyamkadavu	> 100
19	Kulathoor	< 100
20	Chengaroth	> 100
21	Purakkad	< 100
22	Peringathoor	> 100
23	Kayanna	< 100
24	Omasseri	> 50
25	Kannatty	< 100
	Total	3500

(c) Loss of habitat

In Kerala high human population density has increased the demand for land resulting in rapid decline in wetlands. Many wetlands had been reclaimed for construction of houses, apartments, roads, industrial and business complexes. Cash crops like rubber, tea and coffee are planted at the cost of many wetlands. Agrochemicals like pesticides, herbicides and fertilizers had degraded the quality of wetlands (Jayson 2002). Construction of dams, land reclamation, removal of top soil and weed infestation had also affected the quality of wetlands. The reclamation for cultivation of paddy, plantains and vegetables is also common.

3.6. Discussion

The adult population in January 1998 and 2000 was the highest as the habitat had optimum water level and vegetation. Since January is the last month of winter the birds declined gradually from February to May which were the months of summer. May, in 1998 and 2000, harboured the least population as the water level declined sharply resulting in shrinkage of vegetation. With the advent of rain in June the population increased till January. There was also Northeast monsoon during this season which contributed to set the habitat suitable for Purple moorhen.

In 1998 and 2000 the birds did not breed in months from January to June and therefore there were no chicks seen during this months. The

chicks were also absent in December since it was a non breeding month for the bird. As the rain brought sufficient water resulting in growth of flora and fauna, with September the breeding became peak with the highest number of chicks seen in September 1998 and 2000.

It was noted that the trend in the monthly or seasonal or yearly fluctuation in population in 1999 was different from 1998 and 2000. This would be due to the alteration of the habitat in 1999 when there was a construction of highway across the jheel. Consequently the jheel acquired almost a perennial status in 1999. When nearby jheels such as Kundayithode and Poolengara got dried in summer 1999 there was the influx of the birds into the Azhinjilam jheel. Therefore the highest population of bird in 1999 was in April. The jheel was unfavourably inundated in some months(June - August) in monsoon and the least number of birds were seen in August. Further, many birds probably left for other minor jheels such as Kundayithode and Poolengara jheels in the locality as that became favourable habitats in monsoon. In 1999 the birds bred throughout the year and hence there were chicks in all months of the year. However in 2000 when water channels in the jheel were restored it returned to its seasonal nature.

In winter there was an ample vegetation cover in most of the habitat. The fauna was also rich in this season and the water level was neither too high nor too low. This would be accounted for the large population of the

birds in winter season of 1998 and 2000. However, towards the end of winter the jheel was subjected to a lot of changes mainly due to the decline in water level and shrinkage of vegetation.The jheel also became more accessible to the predators resulting in a downward trend of population density in summer.

The summer population in the jheel was subjected to wide fluctuation. The birds were observed in small flocks here and there in the jheel where patches of water and vegetation were present. When the jheel started drying the birds moved out seeking other suitable sites for foraging and sheltering. The predators like Jackals and Stray dogs also disturbed the birds that the summer population was found to be highly inconsistent in the jheel.

Heavy rain appeared to be not favourable for the birds since the large area of the habitat would be inundated. There was also intense competition among adults for selection of the breeding site. Therefore there was no notable increase in the adult population of the moorhen in the early months of monsoon.

The density of subadults was mainly determined by the breeding success of the birds in the previous years. This might be the reason why the population of the subadults in 2000 was higher than that in 1998 and 1999. A considerable population of chicks were seen in summer of 1999. However there was the zero number of chicks in summer of 1998 and 2000. This might

be due to the change in the habitat in 1999 from 1998 and 2000 as explained elsewhere. Similarly the sharp decline in population of subadult in the summer of 1998 could indicate that the breeding success of the bird was poor in 1997.

The chicks were seen in the monsoon and winter seasons of 1998 and 2000 since the birds bred in Southwest and Northeast monsoon seasons though the former was the main breeding season.

The population of Purple moorhen was highly dynamic in nature. The adults and subadults showed local movements mainly in summer. When newly hatched chicks were added to the population many chicks bred earlier would have grown to the subadults and the later would have become adults. Many adults were found leaving the habitat due to the competition for food and the roost. The pressure from the predators and the habitat shrinkage also had forced the birds for interwetland movements.

Ali and Ripley (1983) have raised the doubt whether the Purple moorhen would be a local migrant. The bird shows local movement (Grimmet *etal* 1998). The present study also confirmed the local movement of the bird. The subspecies of Purple moorhen, *Porphyrio seistanicus* is a local migrant (Taylor 1998). When a habitat became unfavourable the birds left for favourable habitats. Sudden appearance, disappearance and sometimes reappearance of the birds were observed in some jheels during different seasons

of the year. This nomadic behaviour of the Purple moorhen was noted by many bird watchers (Jafer Palot, Satheesh chandran nair, E. Kunhikrishnan-Personal communication). Neelakantan (1958) observed the sudden appearance of the birds in paddy fields. Seasonal fluctuation of Purple moorhen was noted in Keoladeo N.P., Bharathpur in relation to the abundance of vegetation and plentiness of water (Vijayan 1991). He concluded that the species could be considered as an indicator species because its population was very low (60) during the drought years but increased with water and vegetation in 1988-1989 in Bharathpur. Kurup (1991) has also noticed population fluctuation and the local movement of the bird in Azhinjilam wetland. The abundance of waterfowls in a wetland are mainly influenced by water and vegetation (Bhupathy and Vijayan 1991, Sreedharan 1989). Seasonal variation of Purple moorhen in numbers has been reported in Kole wetland of Trissure (Ravindran 1992). These observations have been in agreement with the result of present study.

It was noted that the population of Purple moorhen in the study area had not declined considerably over the years 1998, 1999 and 2000. This would be due to the fact that the awareness generated by the wildlife biology students of Farook College among the local people to protect the birds in Azhinjilam wetland. Mathew (2002) has observed the jheel as a least disturbed habitat. An increase in population of the birds in winter of 1993

has also been reported by him. However, presently the jheel is under threat of filling, reclamation and encroachment.

The survey conducted in various parts of Kozhikode district in 2001 had revealed that the population in general was on a trend of decline compared to the status of the birds in the previous decade. Based on the information collected from the farmers there was about 50% decline in the population within one decade. The population count was less than hundred in some of the jheels and the vanishing of the birds from 8 jheels since 2000 suggests the gravity of the threats being faced by the birds.

There are many reports from various parts of the state pointing to the vulnerability of the bird. Pallom, a small wetland of 15 acre extent in Kottayam district harboured 75 birds during the years 1996 and 1997. The above wetland was rich in Eichhornia weed. However in 2000 none of the birds was seen in the wetland. The total disappearance of the bird was due to the conversion of the wetland for fish culture (Marry chandy- Personal communication). Neelakantan and Satheeshchnadran Nair in late seventies observed up to 65 pair of birds in Akkulam lake of Thiruvanathapuram. However, in the early nineties there was only one or two pairs of the birds in the lake (Satheeshchandran Nair-Personal communication). A small wetland in Trissur district was filled in by soil and the Purple moorhen which was around 50 totally disappeared from there in 1988 (E. Kunhikrishnan-Personal

communication). According to Ravindran (1992), the birds are facing severe threats in the 'Kole' wetlands of Trissur and Malapuram districts. Hundreds are being killed by poachers; eggs are collected by grass cutters." At this rate, the Purple moorhen may become extinct in the 'Kole' wetland in a short time from now".

3.7. Summary

The population census in the main study area shows that the adults, subadults and chicks fluctuated monthly and seasonally during 1998, 1999 and 2000 but there was a notable summer population in 1999 since the vegetation was abundant and water level was high in the habitat in1999. This suggests that plenty of water along with vegetation contributed to the high population of moorhens without much fluctuation. Chicks were found only in Southwest and Northeast monsoon seasons (breeding seasons) in 1998 and 2000 whereas they were seen throughout the year in 1999 because the moorhens bred in all seasons in 1999. Moorhens were almost safe in Azhinjilam due to the positive attitude of the local people towards birds. Count taken in 2001 from 17 jheels in Kozhikode district showed that there were toally 1756 moorhens in the district against 3500 between 1990 and 2000. The population declined in the last decade due to poaching, collection of eggs, nest destruction, predation and loss of habitat.

BIOLOGY, ECOLOGY AND BEHAVIOUR OF PURPLE MOORHEN PORPHYRIO PORPHYRIO

Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology

BY

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CHAPTER IV

MOORHENS IN MICROHABITATS

4.1. Introduction

The term habitat has been used variously by ornithologists to relate birds to various aspects of the environment. Definitions have ranged from how species are associated with broad landscape scale vegetation types to very detailed description of the physical environment used by species (Block and Brennan 1993). According to Odum (1971) the habitat of an organism is the place where it lives or the place where one would go to find it. Habitat generally refers to strong environmental continuities at large scale (Svenning 1999) and usually characterised by the dominant physical characteristics (Reclefs 1990). Microhabitat of an organism is its immediate surroundings along with physical and biological factors (Menges 1999) which vary at small scale (Svenning 1999). At the finest scale, the microhabitat of an individual is the site it occupies at a given point in time (Baltz 2002). Changes in the microhabitat can critically influence the survival of an organism. Craig (1979) has examined the social organisation and dispersal of *P.melanotus*. He has concluded that the group size is related to the cost of territorial defence which in turn is linked to habitat structure. The study of numerical abundance of a species in its microhabitats sets ground for the study of habitat use. Purple moorhen exclusively lives in a habitat with open water and mixed vegetation.

The macrohabitat of the bird is a mosaic of microhabitats namely open water, floating vegetation, emergent vegetation and emergent floating vegetation which were variously utilised by the bird. The present study is mainly about numerical distribution of the birds in various microhabitats.

4.2. Objectives

1. to study the numerical abundance of the birds in the microhabitats
2. to understand the monthly and seasonal variation of the birds in the microhabitats.
3. to record the information from farmers on the damage done by the bird on Paddy cultivation.

4.3. Methodology

The number of birds found in the microhabitats were assessed by censusing the birds in each habitat in different months and seasons during the years 1998, 1999 and 2000. The monthly mean number of birds in each microhabitat was pooled. Information on the damage done by the bird on paddy cultivation was collected from the farmers of various locations of Kozhikode district. Multivariate analysis was used to compare the mean population of Purple moorhen which was found in open water, floating vegetation, emergent vegetation and emergent floating vegetation. Scheffe multiple test was used to find whether there was any signifcance both in the annual and seasonal variation in the mean population of the birds in the

microhabitats. The patterns obtained in the result were plotted as Whisker boxes.

4.4. Result

The floating vegetation mainly consists of *Salvinia molesta* and *Azolla pinnata.* The prominent emergent vegetation includes *Oryza granulata* and *Sacciolepis indica.* The rooted floating vegetation mainly consists of *Nymphaea stellata* and *Utricularia gibba.* The emergent floating vegetation harbours both emergent and floating plants (See Chapter II, The Study Area). The microhabitats play vital roles in the life of the birds (Table 4.1).

4.4.1. *Monthly variation*

In 1998 the number of birds in open water was highest in September ($\bar{x}$=21.8) whereas in 1999 the highest number was in May ($\bar{x}$=32.5) and in 2000 in August ($\bar{x}$=27.5). In 1998 the least population in open water zone was recorded in April ($\bar{x}$=2) but in 1999 it was in February ($\bar{x}$=2.8) and in 2000 in March ($\bar{x}$=2) (Fig 4.1). In floating vegetation the number of birds was highest ($\bar{x}$ =35.5) in January 1998 whereas it was highest ($\bar{x}$ =75.3) in March 1999 and in August 2000 ($\bar{x}$ =27.3). The least population was in July ($\bar{x}$ =4.8), in June ($\bar{x}$ =6.8) and in November ($\bar{x}$ =4) in the three consecutive years of 1998, 1999 and 2000 respectively (Fig 4.2). The highest number ($\bar{x}$=124.8) of birds found in emergent vegetation was in February 1998 whereas it was in April ($\bar{x}$ =164.8) in 1999 and in February ($\bar{x}$ =134) in 2000.

Table 4.1 Importance of microhabitats

Open water	Emergent vegetation	Floating vegetation
* Provide security	* Provide food	* Provide food
* Hide for chicks	* Hide for adults and chicks	* Provide nest support and nest materials
* Used for bathing and swimming	* Provide nest materials	* Provide substra tum for various activities like
* Provide food * Support other flora and fauna	* Provide site for roosting	locomotion, resting, preening, sunning, mounting and displays

Plate II

Picture 1. A flock of moorhens on the Salvinia mat in May 1998

Picture 2. A flock of moorhens forage in a patch of emergent floating vegetation in February 1998

Fig. 4.1 Monthly fluctuation in mean abundance of birds in open water from 1998- 2000

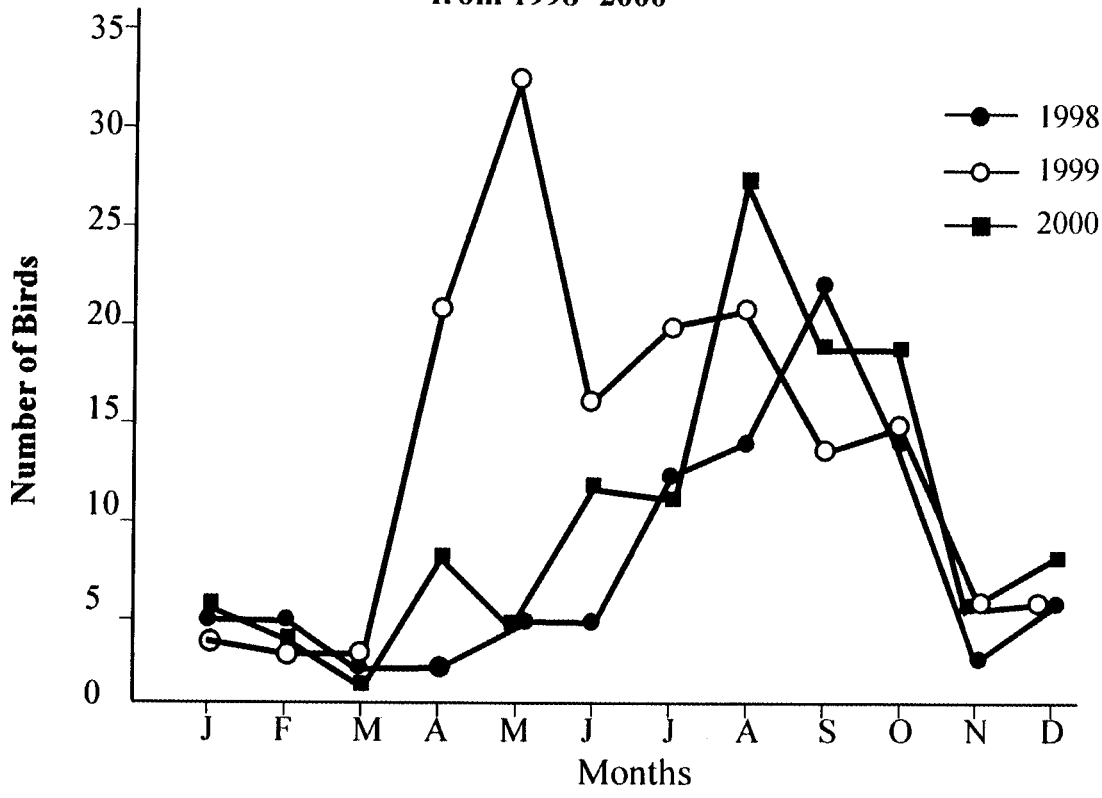
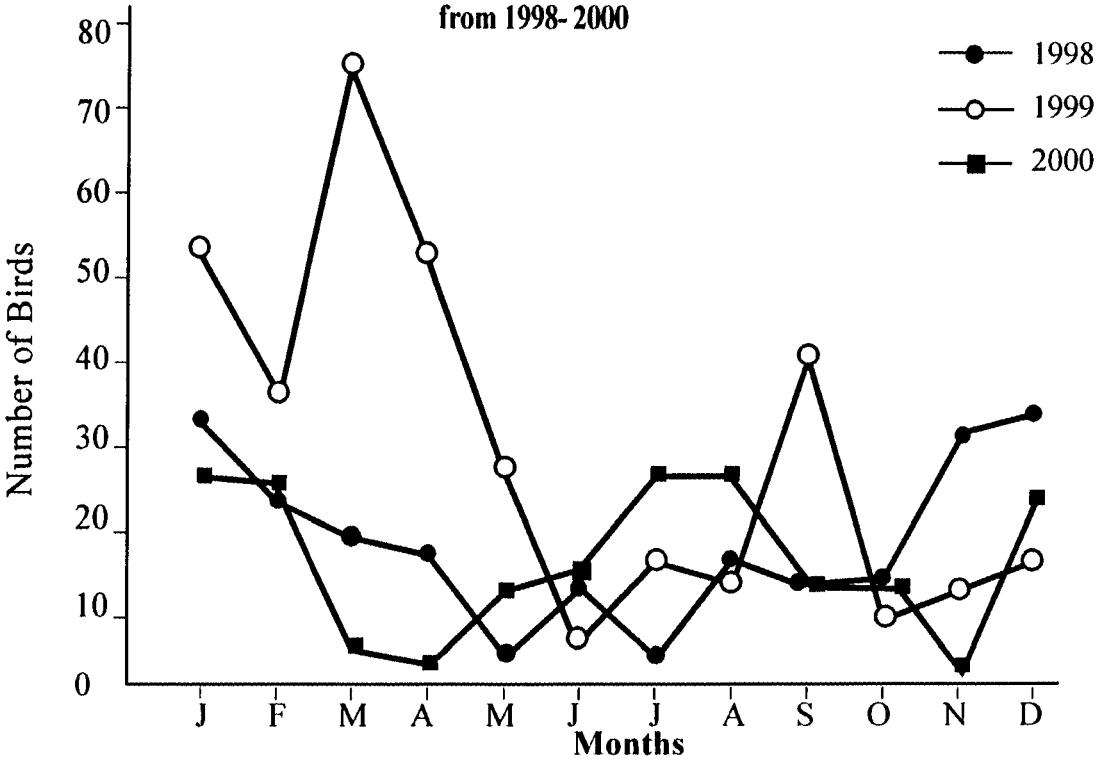


Fig. 4. 2 Monthly fluctuation in mean abundance of birds in floating vegetation from 1998- 2000



In 1998 the number of birds seen in emergent vegetation was least in June ($\bar{x}$ =23.8) followed by October ($\bar{x}$ =38.8) 1999 and in August ($\bar{x}$ =17) 2000 (Fig 4.3). The birds found in the emergent floating vegetation was highest in January ($\bar{x}$ =84.3) in 1998 whereas it was highest in April ($\bar{x}$ =99.3) in 1999 and in November ($\bar{x}$ =59.3) in 2000. The least number of birds found in emergent floating vegetation in 1998, 1999 and 2000 was in the same month August in 1998($\bar{x}$ =5), in 1999 ($\bar{x}$ =5) and in 2000($\bar{x}$ =2.3), (Fig 4.4).

4.4.2. *Seasonal variation*

The highest number of birds found in open water zone was in monsoon ($\bar{x}$ =192.2) compared to summer ($\bar{x}$ =90.7) and winter ($\bar{x}$ =96.8), (Fig.4.5). However the number of birds seen in open water in summer and winter was almost equal. The Whisker Box patterns indicate that the population of birds in open water in summer was less stable than that of winter and monsoon. Though the variation in the population of floating vegetation over three seasons was not significant (Schiffe Test-Appendix V). The largest number of birds were seen in floating vegetation in summer ($\bar{x}$=305.7) and the least in monsoon ($\bar{x}$ =185.3). In winter also a considerable number of birds ($\bar{x}$ =269.5) were found in this habitat (Fig 4.6). The analysis shows that the largest number of birds were seen in emergent vegetation in winter ($\bar{x}$ =136.1) whereas the least number of birds was seen in summer ($\bar{x}$ =116.5), (Fig 4.7). There was no well defined variation between the number of birds found in

Fig. 4.3 **Monthly abundance in mean population of birds in emergent vegetation from 1998-2000**

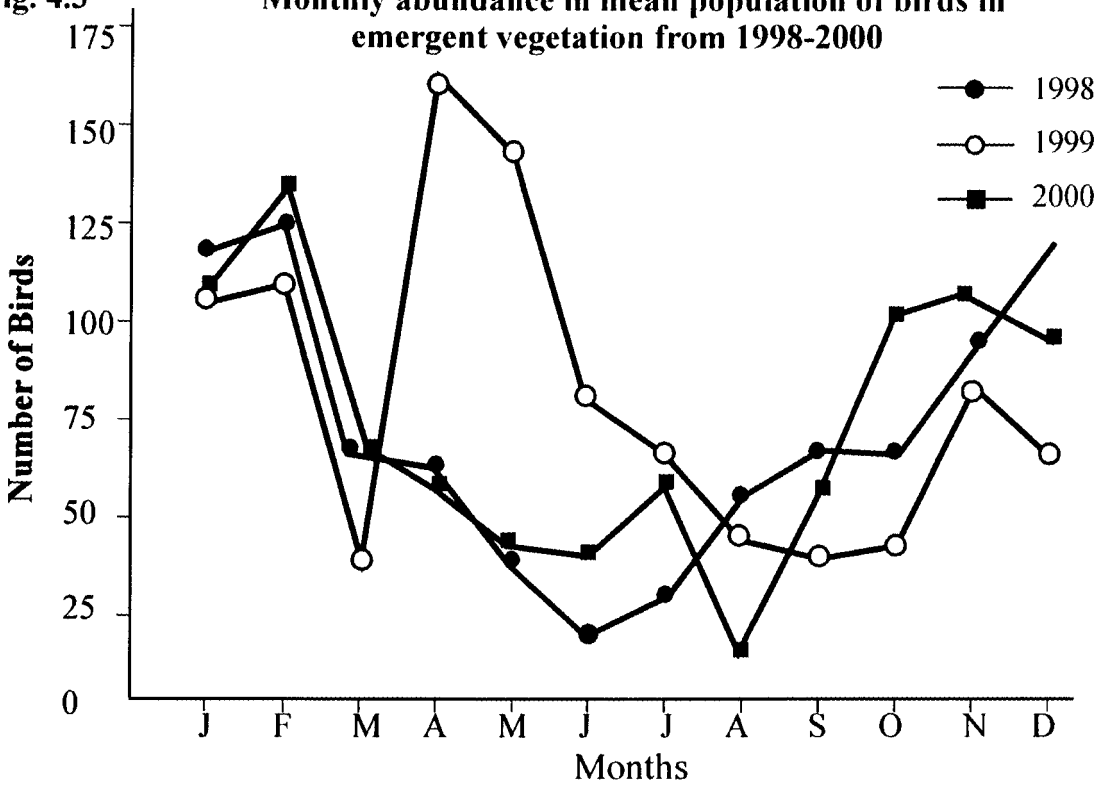
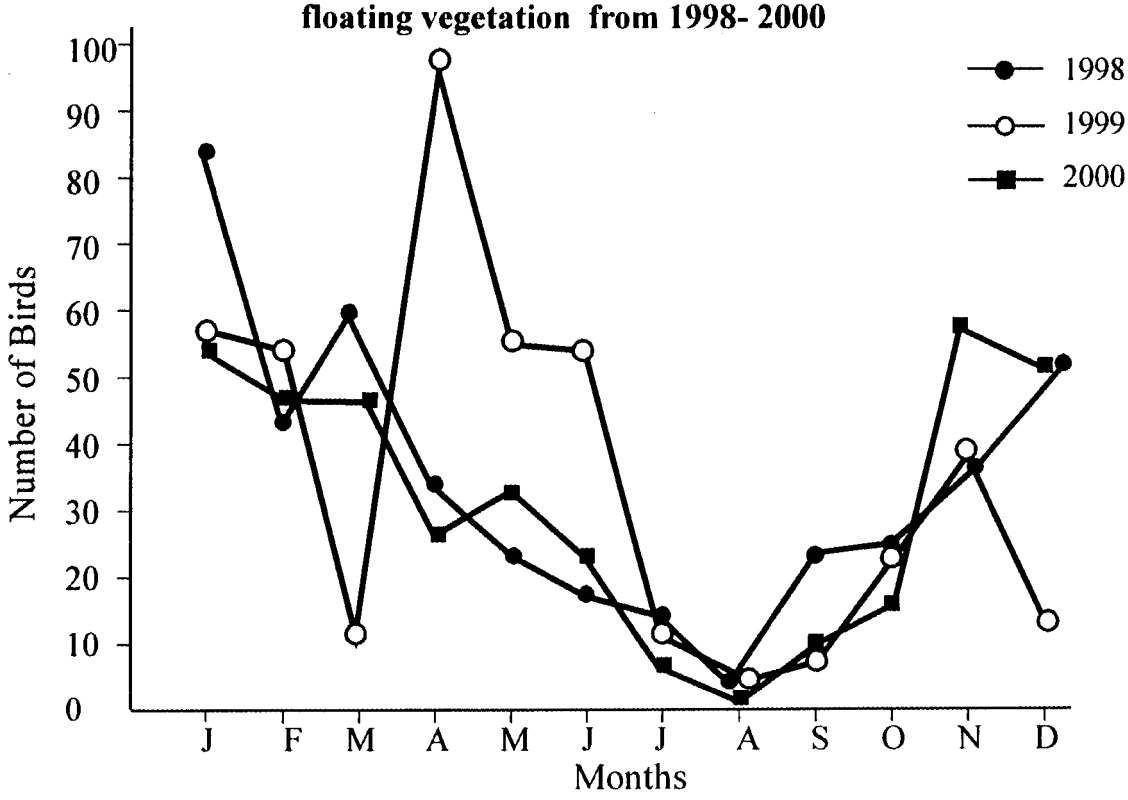


Fig. 4.4 **Monthly abundance in mean population of birds in Emergent floating vegetation from 1998- 2000**



emergent floating vegetation in summer and winter (Fig 4.8). However the number of birds found in this habitat in summer ($\bar{x}$ =537.4) was slightly higher than that in winter ($\bar{x}$ =519). The least number of birds were seen in this microhabitat in Monsoon ($\bar{x}$ =182.2).

Generally there was no considerable variation between population size in winter and summer in open water, floating vegetation and emergent floating vegetation. However high degree of variation existed between the number of birds found in monsoon and summer or winter. The variation between summer or winter and monsoon population in the microhabitat, the open water, was significant (p=0.02). The variation between the summer or winter and monsoon population in emergent and emergent floating vegetation was highly significant (p=0.005).

4.4.3. *Damage to the paddy cultivation*

The moorhen destroying the paddy cultivation was observed in the main study area, Azhinjilam and in two subsidiary areas Avala and Cherandathoor.

The damage was done in various stages of paddy cultivation. The birds were often seen in large flocks in paddy fields. The birds not only fed on the sown seeds but immersed the seeds in mud while they were skulking about and such immersed seeds did not germinate properly. The sprouted

Seasonal variation in abundance of birds in the microhabitats from 1998-2000

Fig. 4.5

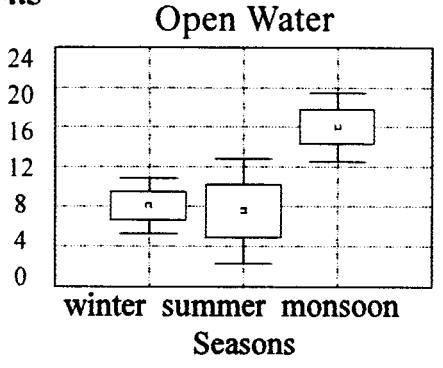


Fig. 4.6

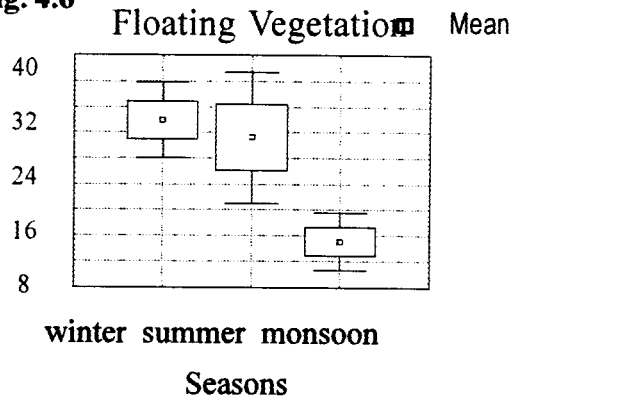


Fig. 4.7

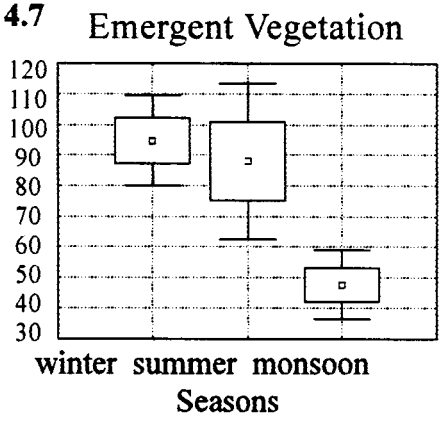
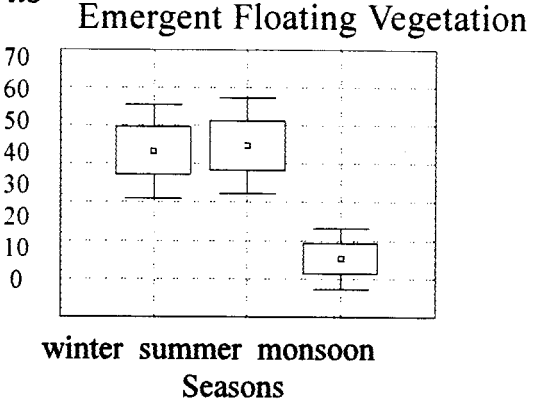


Fig. 4.8



seeds were also damaged by the birds in the field.

The young paddy stands were pulled out in large numbers for eating the pith and the rest was discarded. This appeared to be the most severe mode of damage done to the paddy by the bird. The plants bearing the panicle were trampled down to cut off the panicle. It was observed that only a few seeds (3-14%, N=21) from each panicle were eaten and the rest discarded. Usually several flocks of birds consisting of 4-15 members in each flock entering the paddy field made significant loss to the farmers.

In Cherandathoor jheel it was observed that a single bird spending 25 minutes in a paddy field with freshly replaced stands damaged about 72 plants. In the same jheel in 1999 the moorhen damaged one acre paddy cultivation called Makaram cultivation in which the seeds were sown in August or September and harvested in January. According to the farmers about 100 birds arrived in the morning and totally damaged the freshly transplanted stands within 4-6 hours. The bird was also seen damaging the Puncha cultivation (summer cultivation) of paddy in Purakkad, Cherandathoor and Kayakkodi jheels (Table 4.2).

The farmers in the various parts of the district used to cultivate Kuttadan variety of paddy, a tall variety of *Oryza sativa* which took 9-10 months for maturing and were suitable for cultivating in the inundated paddy

Table 4.2 Damage of Paddy by the bird

Location	Type of cultivation	Stages of cultivation	Mode of damege	Extend of damage
Cherandathoor	Makaram	Young stands	Trampling, Pulling out	1 Acre
Cherandathoor	Puncha	Sown seeds, Young stands	Trampling, Pulling out	¾ Acre
Purakkad	Puncha	Ripe panicle	Cutting, Trampling	1 Acre
Kayakkodi	Puncha Kuttadan	Young stands, Ripe seeds Ripe seeds	Trampling, cutting Immersing	¼ Acre ½ Acre
Avala	Kuttadan	Ripe seeds	Immersing	½ Acre
Azhinjilam	Puncha	sownseed,Cutting, ripe seeds, young stands	Nest making	1 Acre

fields. This flood resistant variety of paddy was usually left unattended and provided good yield to the farmers. The rice of Kuttadan paddy was delicious and the tall stalks provided ample fodder to cattle. The birds arrived at the Kuttadan field in large numbers and did considerable damage to the crop rendering it uneconomical. Damage was also done by making use of stalks and leaves of Paddy for nest construction as was observed in Avala and Kayakkody jheels. The farmers, therefore, in the various parts of the district were compelled to abandon Kuttadan cultivation since 2000.

4.5. Discussion

Patch choice and microhabitat selection by wetland birds is influenced by many factors including aspects of social foraging (Caldwell 1981, Erwin 1983), seasons and water level (Strong et al 1977, Bencroft et al 2002) proximity and height of vegetation (Safran et al 2000). In the monsoon of 1998 and 2000 most of the habitat was inundated. A large number of birds spent in open water throughout the monsoon and particularly in August and September. In the summer and winter of 1998 and 2000 there was no extensive open water bodies available for the birds. In the year 1999, unlike in 1998 and 2000 vast open water bodies were available that attracted large number of birds in summer especially in May. In summer of 1998 and 2000 the birds were highly mobile in the open water bodies mainly due to the disturbance from predators which got easy access to the habitat of Purple

moorhen. Sites are presumably selected to optimize an individual's net energy gain while avoiding predators (Baltz 2002).

After the monsoon the water gradually receded from the habitat and the water retained only in the isolated patches in the later months of winter and throughout the summer. However the birds had to depend on vegetation for breeding and feeding.

The floating vegetation mainly composed of *Salvinia molesta* and the birds did not frequent this niche in monsoon when the floating vegetation was seen only in minor zones. In summer and winter the floating vegetation attracted the largest number of the birds which used the vegetation as a substratum for various activities (See chapter VI, Activity pattern).

The least number of birds were seen in emergent vegetation and emergent floating vegetation in monsoon because the birds mainly used the vegetation for breeding in monsoon and the vegetation available was quantitatively less in the habitat due to inundation of the major part of the jheel.

When the intensity of monsoon decreased the vegetation spread in the most of the habitat and that the vegetation was maximum in winter and early summer months. Therefore, in winter and summer birds preferred the vegetation zones. The availability and requirement of food and water and feeling of safety would be the major factors which influenced the habitat preference of the birds in the various seasons. Microhabitat selection is

assumed to be adaptive such that fitness is higher in selected habitat causing natural selection to maintain the habitat preference if they have a genetic basis (Jaenike and Holt 1991). However studies of habitat selection in birds often do not examine the fitness and instead measure density because density is positively correlated with habitat selection (Petit and Petit 1996) and consequently with fitness (Pulliam 1988).

The Purple moorhen has been called a pest bird by many farmers in southern parts of Kerala (Jafer Palot, Personal communication). Ali and Ripley (1983) has observed that the bird is doing considerable damage to the rice crop not only by cutting the stalks above the roots to eat the tender pith and ripening grains but trampling down the plants. The bird causes 20-35% damage to shoots and seeds of paddy (Thakkur and Bhatacharjee 1996). Whistler (1935) also has noted that the bird does great damage to growing rice. Neelakantan (1958) also has noted that the birds appear in the paddy fields in large numbers and destroy the paddy. It has been noted that *P.melanotus* in Newzealand takes the young rice plants and rice seeds (Taylor1998). Naturally the birds inhabit the fresh water jheels and wetlands. However gradually the habitats are being filled up and reclaimed turning bird homeless. Therefore the birds are forced to paddy fields for food, shelter and nesting.

4.6. Summary

The study suggested that the birds were dispersed in its habitat occupying various microhabitats such as open water, floating vegetation, emergent vegetation and emergent floating vegetation. The abundance of the birds in the microhabitats differ in months and seasons mainly depending on availability of vegetation, water and the presence of predators. In monsoon of 1998 and 2000 more birds were seen in open water bodies than in Summer and winter due to abundant water in the habitat in monsoon. However, in 1999 large number of birds occupied open water bodies throughout the year due to abundant water and vegetation in all the seasons. The least number of birds were found in open water in May, the last month of Summer, in 1998 and 2000 since the habitat almost dried up. Notable number of birds were seen in floating vegetation, emergent and emergent floating vegetation in winter and also in early Summer due to the extensive cover of vegetation in this season. In Kozhikode district the bird damaged the paddy at its various stages of cultivation and farmers were even forced to abandon Kuttadan rice.

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DECEMBER 2006

CHAPTER V
FOOD AND FEEDING

5.1. Introduction

The species Porphyrio is omnivorous, primarily vegetarian taking shoots, leaves, roots, stems, flowers and seeds of aquatic and semi aquatic plants. Principal food items include leaf bases, pith, stem bases, grasses and sedges (Marchant and Higgins 1993). The animal food items include insects, molluscs, fishes, amphibians, water snakes, birds, eggs and small rodents (Taylor 1998). In Australia *Porhyrio porphyrio* fed on weeds in areas where plants were in high densities and the ground soft (Diez and Clarke 1996). Powerful bill and feet allow birds to climb on vegetation to get at seed heads (Paul 1994). These results are based on the studies mainly conducted on *Porphyrio melanotus* in Newzealand and Australia. The waterfowls in general adopt various feeding techniques such as grazing, picking from surface, bill submerged, head submerged, neck submerged, up ending and diving (Lalitha Vijayan 1994). The Coots can secure food, by diving in shallow waters, from submerged plants (Grzimek 1990). Cripps (1878) made an attempt to study the food and feeding behaviour of rail. The study of Bhupathy (1985) has revealed that the *P. p. poliocephalus* mainly feeds on plants. However, the bird also feeds on insects, molluscs and fishes (Ali & Ripley 1983, Whistler 1935). But in general the information on food and feeding of Purple moorhen

is scanty. This chapter deals with the study conducted on food and various feeding strategies of *P.p. poliocephalus*.

5.2. Objectives

1.To study the food items of the bird.

2.To explore the food preferences and feeding techniques adopted by the bird.

5.3. Methodology

In order to study the food items of the bird slaughter method was not adopted since the bird is facing severe threats from poachers and farmers that the population was not as safe as in the past. Direct observations were made to identify food plants, food items, the time spent by the bird to feed on a particular plant and to identify various feeding strategies adopted by the bird. A stop watch was used to assess time spent by the bird to feed on each plant and thus preferred food plants were identified. The study mainly focussed on the feeding of plants since the bird was predominantly a herbivore. Certain animal food items of the bird were also identified by direct observation.

5.4. Result

5.4.1. *Food plants and food items*

The study showed that the Purple moorhen predominantly fed on plant materials. However the species dependent on animal food to some extent. The abudance of food plants assessed in the habitat included *Oryza granulata* (27%), *Nymphaea stellata* (19%) and *Hydrilla verticellata* (14%) (Table 5.1). The most preferred food plant of the bird appeared to be the *Oryza granulata.* Out of 300 hours of observation the bird spent 159.44 hours (53.14%) feeding on *O. granulata.* The least preferred food plant of the bird was *Fimbristylis meleaceae* since the bird spent only 0.24 hours (0.08%) feeding on the plant. The second preferred food item was *Eleocharis acutangula* as the bird spent 40.6 hours (13.53%) on this plant. The bird spent 28.64 hours (9.54%) on *Hydroryza aristata;* 18.46 hours (6.15%) on *Cyperus exaltatus;* 15 hours (5%) on *Sacciolepis indica;* 13.04 hours (4.34%) on *Panicum ripens;* 11.8 hours (3.93%) on *Oryza sativa;* 10.46hours (3.48%) on *Nymphaea stellata* and 1.92 hours (0.64%) on *Ludwigia adscendens* for feeding (Table 5.2).

The bird fed on the pith, seeds and tender leaves of the plant *Oryza granulata.*The most preferred food item was the pith and it discarded the hard outer portion of the stem, mature leaves and roots. The bird ate the

Table 5.1 Proportion of dominant food plants in the habitat

Food plants	
Name	%
Oryza granulata	27
Nymphaea stellata	19
Hydrilla verticellata	14

Table 5.2 Food plants and food preferences

Sl.No.	Food plants	Time allotment (hours)	%
1.	*Oryza granulata*	159.44	53.14
2.	*Eleocharis acutangula*	40.6	13.54
3.	*Hydroryza aristata*	28.64	9.54
4.	*Cyperus exaltatus*	18.46	6.15
5.	*Sacciolepis indica*	15	5.00
6.	*Panicum ripens*	13.04	4.34
7.	*Oryza sativa*	11.8	3.93
8.	*Nymphaea stellata*	10.46	3.48
9.	*Ludwigia adscendens*	1.92	0.64
10.	*Rotala indica*	0.4	1.33
11.	*Fimbristylis meleaceae*	0.24	0.08

tender basal portion of the stem of *Eleocharis acutangula* and the rest was discarded. The bird was seen feeding on the grains and the pith of the plant *Hydroryza aristata* but it never fed on the stem. It fed on the fleshy part of rhyzome, basal portion of the stem and the seeds of *Cyperus exaltatus.* The pith, seeds and the tender leaves of *Sacciolepis indica* were eaten by the bird. It fed on the seeds and the tender leaves of *Panicum ripens.* The bird devoured the tender stem, the tender leaves and the grains of the plant *Oryza sativa* mainly that of young stand. Only a small portion of the plant was eaten and the rest was discarded. The bird pecked open the flowers of *Nymphaea stellata* to eat the seeds inside but it did not feed on the petals, leaves or peduncle of Nymphaea. The bird fed on the leaves and flowers of *Ludwigia adscendens*. The flowers and the seeds of the weed *Rotala indica* were eaten by the bird and it ate the leaves of *Fimbristylis meleaceae* (Table 5.3).

5.4.2. *Feeding strategies*

a. Pulling out

The entire plant was pulled out by the bird for feeding. While pulling, the plant was held tightly between the upper and lower mandibles. Then applying force on the legs the bird moved down its body slightly and the plant was pulled out. The bird would make more than one attempts to pull out the grass and the attempts ranged between 1 and 4. While pulling, the wings were held half closed and the tail was kept parallel to the ground. The

Table 5.3 **Food items**

Sl No.	Food plants	Food items				
		Pith	Seeds	Leaves	Flowers	Rhizome
1	*Oryza granulata*	✓	✓	✓	-	-
2	*Eleocharis acutangula*	✓	-	-	-	-
3	*Hydroryza aristata*	-	✓	✓	-	-
4	*Cyperus exaltatus*	✓	✓	-	-	✓
5	*Sacciolepis indica*	✓	✓	✓	-	-
6	*Panicum ripens*	-	✓	✓	✓	-
7	*Oryza sativa*	✓	✓	✓	-	-
8	*Nymphaea stellata*	-	✓	-	✓	-
9	*Ludwigia adscendens*	-	✓	-	-	-
10	*Rotala indica*	-	✓	✓	-	-
11	*Fimbristylis meleaceae*	-	-	✓	-	-

pulled out plant was shaken vigorously to dislodge mud. The bird also rubbed the plant against the ground to remove attached rubbish. Afterwards it stood on one leg holding the plant with the toes of other leg or putting the plant under the foot. After peeling off the outer hard part of the stem the bird started eating the tender stem (Pith). Frequency of feeding by this method was 109 (16.8%).

b. Grazing

Feeding while walking could be said as grazing. The bird was seen feeding in the grass by pecking continuously. While grazing the bird fed on the fallen grains, small insects, earth worms, fishes and molluscs. The bird often adopted this strategy for feeding with a frequency of 330 (50.7%).

c. Gleaning

The bird gleaned the panicles of the plants like *Oryza graunulata* and *Oryza sativa* for feeding the grains. The frequency of feeding by gleaning was observed to be 75 (11.5%).

d. Ducking

The bird dived, mainly in summer, in shallow water bodies in search of food under water and it often brought up to the surface submerged plants like *Hydrilla* sp. The bird adopted this feeding technique in a frequency of 53 (8.2%).

e. Jumping and pecking

The bird jumped to get hold of the panicle of the tall food plants with beak and the panicle was pecked at. The frequency of feeding by adopting this strategy was 21 (3.2%).

f. Bending

The bird bent down the food plant like *Oryza graunulata* by holding the stem with long toes. The frequency of feeding by bending was 40 (6.1%).

g. Stem cutting

The bird was seen cutting the stem of plants with the beak without being pulling out the entire plant and the pith was cut into pieces and was consumed. The bird infrequently used this technique of feeding with frequency of 23(3.5%), (Table 5.4).

5.4.3. *Animal food*

The bird also infrequently fed on animal food items like earth worms (N=80), dragon flies (N=120), frog (N=3), fish (N=8), insect larvae (N=7) and *Pila globosa* (N=1). Once a bird caught a pila and carried it in the beak to some distance. Then put down the Pila on the salvinia mat. The pila was held between toes and pecked to open the shell. It was after repeated attempts for about 5 minutes the bird managed to break the shell. The bird fed on the soft meat of pila and sharing some with the chicks.

Table 5.4 **Frequency of feeding techniques**

Mode of feeding	Frequency	Percentage
Grazing	330	50.7
Gleaning	75	11.5
Ducking	53	8.2
Jumping and pecking	21	3.2
Bending	40	6.1
Stem cutting	23	3.5
Pulling out	109	16.8

5.4.4. *Flock feeding*

The bird mainly fed in flocks although it indulged in solitary feeding. Feeding in flocks appeared to be advantageous for the bird :

a. Flock feeding would be safer than solitary feeding as some birds in the flock will be on partial vigil while others were feeding actively.
b. Location of food was easier in flocks since the bird that located the food first would send a vocal signal (a low pitch call) to other members of the flock.
c. The rate of feeding appeared to be higher for a bird in a flock than it for a solitary bird.

5.5. Discussion

The studies in India and elsewhere suggested that the Purple moorhen and related species were mainly herbivores, although it is known eating insects and molluscs (Ali and Ripley 1983,Whistler 1935). Taylor (1998) states that *Porphyrio melanotus* is an omnivore but primarily a vegetarian, taking shoots, leaves, roots, stems, flowers and seeds of aquatic and semiaquatic plants. He has also observed that the bird feeds on the fronds of *Salvinia natans* in Newzealand. However the present study reveals that the *P. p. poliocephalus* never eats any part of *Salvinia molesta* eventhough most of the habitat of the bird was covered with the weed (31%). Taylor

(1998) reports that in Spain the stomach content analysis of *P.melanotus* shows 98% vegetative parts and 2% animal materials. The species in Australia feeds on the weed Onion grass (Diez and Clarke 1996). When Bhupathy (1985) analysed the fresh droppings of *P.P. poliocephalus* there was no much evidence of this species feeding on insects. He has concluded that the bird was by and large a herbivore. The results of the study regarding the feeding strategies adopted by *P.melanotus* also agree with my observations of feeding techniques in *Porphyrio poliocephalus* . *P.melanotus* in Newzealand feeds on grasses, in shallow water and on floating vegetation. It dabbles for feeding and it splays its leg for support while pulling up the well rooted plants (Taylor 1998). Craig (1977) has observed that *P.melanotus* uses its bill to cut, dig up or pull out surface or submerged plants and their roots, tubers, rhizomes to move stones or gravel, to turn over matted vegetation and to tear the food items. The heaviness of the bill and the length of the toes are adapted well for its mode of feeding.

The most preferred food item of the bird was the pith. The pith contains high content of carbohydrate is easily digestible and is soft. The bird avoided eating spongy stem with air cavities and its hard portions. The reason for this could be the low carbohydrate content and the hardness of the food items that make digestion difficult. This is supported by the findings of

undigested fibers and hard portions of the plants in droppings of the birds collected from the habitat.

5.6. Summary

The study shows that the bird mainly fed on the pith, seeds, flowers and rhyzome of about eleven aquatic plants. Of these it had highest preference for the pith of *Oryza granulata* and the least preference for the leaves of *Fimbristylis meleaceae* as the bird spent the highest percentage of time (53.14%) for feeding on *Oryza granulata* and the least time (0.08%) for feeding on *Fimbristylis meleaceae*. It was noted that the bird predominantly fed on weeds in the jheel. The bird also ate animal food including insects and thier larvae, molluscs, fishes and prawns. The bird adopted various feeding strategies like pulling out the rooted plants, grazing, gleaning, jumping and pecking, bending and stem cutting. The bird often ate the pulled out plant after dislodging the mud. Even though the habitat was rich in *Salvinia molesta* (31%) the bird never ate any part of the weed .

BIOLOGY, ECOLOGY AND BEHAVIOUR OF PURPLE MOORHEN PORPHYRIO PORPHYRIO

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for the Degree of
Doctor of Philosophy
in Zoology

BY

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CHAPTER VI

ACTIVITY PATTERN

6.1 Introduction

The study of behaviour of birds (ethology) has assumed a great significance since each species has an impressive repertoire of innate behaviours and its learning ability is comparable to most mammals and many of the basic behaviours are applicable to human life (Pettingill 1970). According to him the behaviour is what a bird does and how it responds to its surroundings. Behaviour is also believed to be consisting of the expressions of a bird in response to the internal stimuli mainly related to the physiological needs. Development of effective conservation strategies for a species requires a thorough understanding of its behaviour (Sutherland 1998).

Physical displays or posture is one of the several means of animal communications and birds effectively use visual signals (Collias 1943, Butcher and Rower 1989). In birds visual signals are communicated by the movements of the head, body, tail, wings and body feathers (Maler and Hamilton 1966). Many signals may act as stimuli to which members of the same species or other species respond instinctively (Krebs and Devies 1987).

For correct interpretation of the gross behavior of a species one must first describe and categorise the individual units, thus establishing a behavioural repertoire (Craig 1977).There are also tendencies associated with

postures i.e adoption of a particular posture signals the tendencies for the future action (Hinde 1956). However, many displays are associated with more than one tendencies. Calls are vocal displays of birds. Study of calls or vocalization has assumed a great significance in understanding the behaviour of a species, for the calls serve various functions. Willingness for courtship, threat, fright, grief and hunger are a few among the feelings and behaviors of birds that can be effectively commmunicated through calls.

The birds show various activities in response to the intrinsic and extrinsic stimuli. The intrinsic stimuli are closely related to the physiology of the birds whereas the exrinsic stimuli depend on the biotic and abiotic factors of the habitat. Many of these activities normally occur in patterns. The behaviour pattern is not always constant since the activities could change or modify according to the changes in the physiology of the birds and in the spaciotemporal conditions of the surroundings. However, the birds perform at the most opportune time (Smith 1976). The study of activity pattern enables us to understand how ecological factors influence the behaviour of the bird (Boetcher and Haig 1994). However, the allotment of time for an activity is determined by natural selection to maximize the chance of survival (Fagen 1974, Macfarland 1977).

Detailed investigation on the gross behaviour of the birds has been conducted by Timbergen (1948), Lorenz (1950), Allee (1936), Andrew (1961), Brown (1964), Emlen(1952), Alock (1993), Miller(1988), Smith and Harper (2003). The time budget and activity patterns of water birds have mainly been studied by Burton and Hudson (1978) on geese, Eguchi (1988) on waders and Baldesarre and Bolen (1994) on ducks.

In India although several workers have documented behaviour and activity patterns of birds it needs further more to be done in view of the diverse avifauna available in the country. Some of the workers on related species are Ramachandran (1998) on Pheasant tailed Jacana and Bronze winged Jacana and Jayaraman (1985) on Coot. Bhupathy (1985), Ali and Ripley (1983), Whistler (1935) and Martin (1990) have reported their observations on behaviour and activity patterns in Purple moorhen. Butler (1875-76) has described some calls of the species. Jose (1978) has given a brief account of a frightened Purple moorhen. The present study is an attempt on the behaviour and activity patterns of the bird in Azhinjilam in 2002.

6.2. Objectives

1. to study various activities of the species
2. to assess the time of various activities.

6.3. Methodology

Direct focal observation method (Altman 1974) was adopted to study the behaviour and activities of Purple moorhen. The birds were observed with the binoculars (10x7) and a spotting scope (32x). A particular bird was followed and its activities noted down.The duration of each activity was recorded using a stop watch. When the bird under the observation was moved out of sight another bird was focussed. To reduce disturbance to the focal bird close observations were made hiding behind plantains and trees in the periphery of the jheel. Various activities of the birds such as awakening, roosting, calls, movements, maintenance and agonistic behaviours, postures and displays were also noted.

6.4. Result

6.4.1. *Awakening and roosting*

The waking time of bird was 10-15 minutes before sunrise therefore the time of awakening was subject to change according to the change in the time of sunrise.

The bird went to the roosting site 10-20 minutes after sunset when the darkness fell in the habitat. The time of roosting coincided with the time of sunset and therefore subject to change accordingly.

6.4.2. *Roosting site*

The roosting site lay in the core zone of the habitat except in summer months (Fig.6.1). The core zone was rich in overgrown vegetation with high water level. The access to the core zone was hindered by the thick salvinia mat. In summer especially in the months April and May the bird took roost on the coconut trees in the peripheral land of the jheel.

6.4.3. *Movements between buffer and core zones*

The habitat of moorhen could be divided into two main zones: 1. The central core zone characterised by abundant vegetation, high water level and difficult accessibility and 2. The peripheral buffer zone is characterised by sparse vegetation, low water level and easy accessibility (Table 6.1). The birds were observed remaining flocked in core zone some time after awakening, in the early morning. The birds gradually started moving from core zone to the buffer zone (Fig.6.2). They actively moved out and feeding began when sufficient sunlight fell in the habitat. In the late morning (07.00-12.00) about 80% birds were seen in the buffer zone which provided ample food (Fig. 6.3). Then the birds scattered well in the buffer zone for feeding.

However as time advanced the birds were seen retreating from buffer zone to the core. In the noon (12.00-14.00) about 70 % of the birds were seen in the core zone with least activities (Fig. 6.4).

Table 6.1 **Nature of habitat zones**

Characteristics	Buffer zone	Core zone
Vegetation	Sparse	Abundant
Water level	Low	High
Accessibility	Easy	Difficult

Table 6.2 **Bird in core and buffer zones**

Time	Core zone (% of birds)	Buffer zone (% of birds)
07.00-12.00	20	80
12.00-14.00	70	30
14.00-17.00	20	80
17.00-18.00/19.00	80	20

In the early evening (14.00-17.00) the birds were seen moving from core zone to the buffer zone. Then about 80 % of the birds were scattered in the peripheral area and were active in feeding (Fig 6.5).

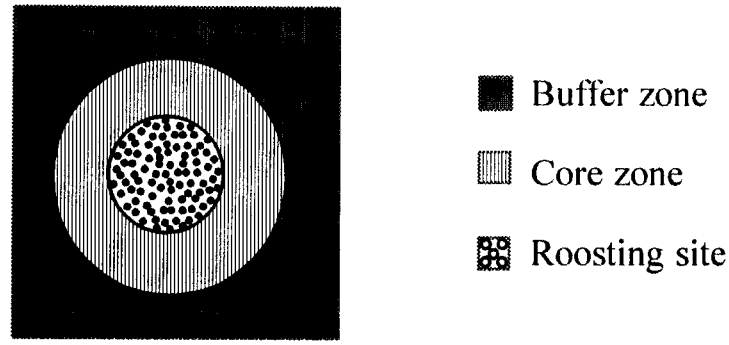
In the late evening (17.00-18.00\19.00) the birds were seen returning from buffer zone to the core zone and about 80% of the birds were seen in the core zone (Fig. 6.6). As soon as the sun was set all the birds moved to their roosting site in the core zone (Fig 6.7).

6.4.4. *Vocalization*

The birds made varieties of calls at different occasions. The Krr... Krr... krr...calls were made by females. The intensity of calls varied depending on their functions. The soft calls with short interval between consecutive notes were heard for keeping the members together in a flock. Same calls became sharper and shriller when the female perceived a predator either visually or by noise. It was observed that the breeding female made a sharpest call of this kind when it saw a raptor. Same calls with higher intensity were also used to threaten the intruders. When the female chased an intruder she made sharper krr... krr... calls. These calls with sharper tone were also heard while the bird was on wings.

The female made Luck... Luck ... calls frequently and apparently that were believed to be contact calls since these were often heard while the birds were feeding in flock. Generally the calls were soft and repetitive but not

Fig. 6.1 **Habitat zones with roosting site**



Patterns of daily movements in the habitat zones

Fig.6.2 Birds in the early morning (0.500- 0.700)

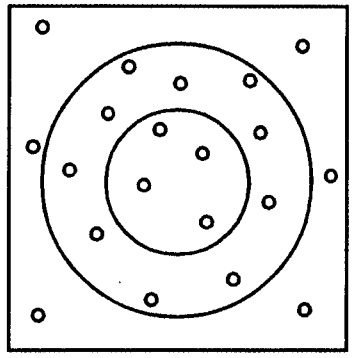


Fig. 6.3 Birds in the late morning (0.700-12.00)

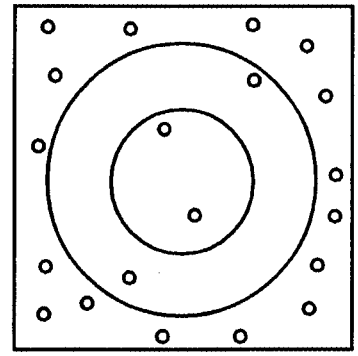


Fig. 6.4 Birds at noon (12.00-14.00)

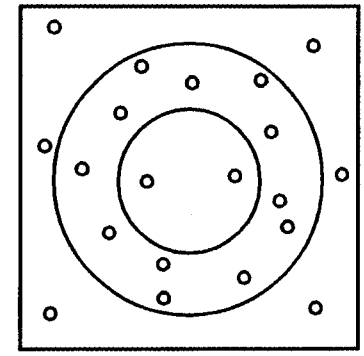


Fig. 6.5 Birds in the early evening (14.00--17.00)

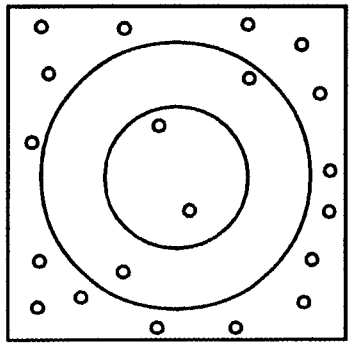


Fig. 6.6 Birds in the late evening (17.00-18.00)

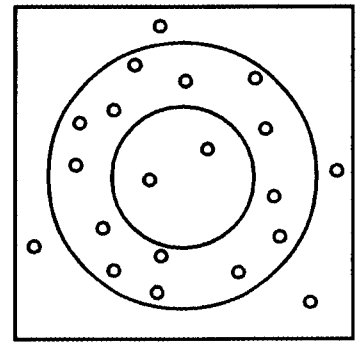
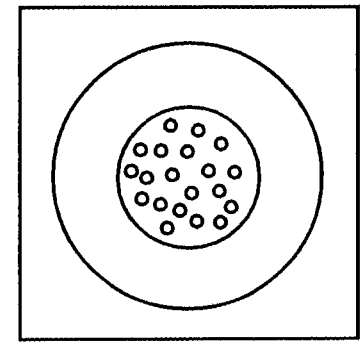


Fig. 6.7 Birds in the roost (18.00)



available from far.

Loud Gwe... Gwe... Gwe.. calls were repeated by males in response to seeing a predator. The calls became louder when the predators approached the nests. These alarm calls invited other conspecifics for defence.

The hooting Gu... Gu... Gu... calls were mainly heard at night. The sex which made these calls was not identified. The role of this call was also not known. The interval between two consecutive notes was very short.

The cat like Mew... Mew... Mew...calls were rarest types of calls heard. The syllables were loud but slow. The functions of these calls were not understood.

The Swee... Swee... Swee... calls were made by chicks mainly for begging food from the adults that were their parents or subadults. The begging calls were soft. The sharper calls of this type were also heard when the chicks were frightened. When the chicks saw a predator the calls became sharper. The chicks also made soft swee...swee...calls with discontinuous notes while the adults were offering food to them. As soon as the chicks emerged out of eggs they were capable of making such calls.

6.4.5. *movements and locomotion*

a. Flying

The bird is usually reluctant to fly but preferred to run and walk over the floating vegetation. In flight the bird extended its head and neck

forward coinciding with the upper body line. The tail was kept horizontally. In short distance flight, usually an intrawetland flight, or slow flight the legs were kept at 45^0 to the undertail coverts. In long distance flight the bird kept its legs closer to the under tail coverts. The short distance flight was often accompanied by Krr..Krr.. calls.

b. Skulking

The bird usually skulked about in the vegetation mainly over the Salvinia mat and Nymphaea leaves. The skulking was characterised by an unsteady gait. The bird skulked about in search of food or when it perceived a visual or auditory signal of predator or any movement in the vicinity. While skulking the bird often moved its head and neck to different directions. But it kept its head and neck erect as in a vigilant posture when it skulked in response to the presence of a predator. The wings and feathers were kept sleeked while skulking.

c. Walking

This was the main type of locomotion with steady steps over the vegetation. The neck and head moved forward and backward while walking. The wings and feathers were sleeked with tail flicking upward and downward strokes. The movement of neck and tail flicking became faster when the speed of walking increased.

d. Running

The bird could run fast over the floating vegetation. It chased the intraspecific and interspecific intruders by running swiftly. While running the movement of head, neck and tail flicking became faster and such movements increased as the speed of running increased. While running, sometimes the bird kept its head, neck and tail horizontal to the ground with the wings flapped accompanied by the repeated Krr..Krr..Kr..calls. Usually the bird kept its wings sleeked while running but at times the wings were held half folded and feathers fluffed. While running faster with very quick wing flaps the bird could take off slightly above water level or vegetation, keeping the legs at about 45^0 to the under tail coverts (Fig 6.8).

e. Hopping

The bird often hopped over the ditches in the habitat since it was very reluctant to enter water. While crossing the water bodies the wings were kept sleeked or were half folded or fully open.When the bird hopped the neck and head were held stretched forward keeping the wings fully folded. But the neck and head were kept slightly backward (in 'S' like posture) when the bird crossed the water bodies keeping the wings half folded or fully open. While hopping the tail was oriented horizontally or slightly decurved.

f. Swimming

The bird swam very rarely for it preferred to keep away from water

as much as possible. The bird was capable of swimming well even though its feet were not webbed. It swam in water holding the neck and tail up. The chicks were able to swim soon after hatching.

6.4.6. *Maintenance behaviour*

a. Bathing

The bird first dipped its head and then neck and shoulder in a scooping motion. The number of dips in a bout ranged between 3-10 times ($\bar{x}$ =4.5, N=73). Then the bird dipped its beak and tail for 2-5 times ($\bar{x}$ =3, N=73). The dips were followed by the flapping of wings and ruffling of feathers which helped to spread water over the plumages of its back. The flapping of wings lasted for 60-122 seconds ($\bar{x}$ =98 seconds, N=73). The bird spent 180-362 seconds for a single bath ($\bar{x}$ =302 seconds, N=73). The bath was often followed by running by shaking its head and flapping its wings. After running for some distance it stood still on mounds or dykes or in the vegetation for a few seconds.

b. Sunning

The bird was seen standing on mounds or dykes or on floating vegetation for sunning. It spreads its wings for 60-122 seconds ($\bar{x}$ =82 seonds, N=65). The bird more often beated its feathers of wings while sunning. Mostly the bird kept its two wings open at the same time. Less often it kept open only

one of the wings. The wings were held open against sun and wind. Out of 65 in 23 incidents sunning was followed by preening.

c. Preening

Standing on the dykes or mounds or in the vegetation mainly on the Salvinia mat or Nymphaea leaves the bird preened elaborately. The bird first seized the neck feathers between the bill and nibbled them. It was followed by nibbling the wing feathers and then the breast and flank plumages. While preening the bird ruffled its feathers. The preening was performed slowly and carefully. It lasted for 6-10.5 minutes ($\bar{x}$ =7.2 minutes, N=72).

The bird scratched its head and nibbled its neck by its toes. The head scratch would be a separate event or in combination with preening and sunning.

d. Fanning

In fanning the bird fully unfolded its wings and its tail was kept in up position. Head and neck were kept in normal position. The wings were moved slowly up and down. Sometimes the wings were held above the body. The bird often fanned both the wings simultaneously. But less often the bird unfolded one of its wings and fanned it keeping the other wing closed.

e. Resting

The bird took rest standing almost still without being involved

fully in any other activities. The head and neck were kept in normal position and the tail was seen flicking slowly. The wings and feathers were held sleeked.

6.4.7. *Agonistic behaviour*

a. Fight

The Purple moorhen is seen chasing an intruder to drive it away from its territory. If the intruder was a conspecific most probably a fight would take place when the trespasser turned back to the chaser. First the rivals stood at a beak-to-beak position, staring at each other, keeping the wings partly folded. The tail was slightly decurved. Then both the opponents kept their tail in 'up' position. Moving one or two steps backward and then forward, making shrilling calls both the birds raised their heads simultaneously. Then they leaped in air with the flapping wings. In mid air both the rivals pecked and kicked at each other. The 'leap- fight' continued for 2-5 times ($\bar{x}$ =3.5, N=22). The fight continued on the ground till one got victory over the other. The shrilling fight calls were heard throughout the fight. The bird which lost the fight bowed to the winner and retreated from the winner's territory. The fight lasted for 1-6 minutes ($\bar{x}$ =2.8 minutes, N=22). Of the total fights observed during the present study male to male fight was observed for 22 times whereas male to female fight for 4 times and female to female fight for 9 times.

b. Subadult as a trouble shooter

It was observed that when two birds were about to fight a subadult rushed to the spot and stood in between the opponents (N=3). Then one of the opponents charged the subadult twice or thrice and the fight was given up.

c. Chasing

The bird chased not only a conspecific intruder but also an alien species. The chasing continued until the intruder was driven away from the territory. While chasing the bird made sharp threatening calls. Usually the intruder would be an associatory species like Herons, Egrets, Waterhen and Jacanas. The bird also chased away avian and nonavian predators but never a human intruder. The bird usually kept away from human intruder but was seen moving very close to grass cutters and grazing cattle (Fig 6.8).

d. Flocking

In the presence of a predator many birds gathered in a spot in the habitat for defence or offence. The flock comprised not only the adults but also subadults. Such flocking was mainly observed during the breeding seasons. Seeing a predator the birds made alarm calls as a signal to the conspecifics to congregate in an area. Even the appearance of a raptor like Pariah kite or Brahmini kite in the sky tempted the birds for assembling. The birds showed social defence or offence not only against the avian predators

but also against the nonavian predators like Jackal, Mongoose, Rat snake and Monitor lizard.

e. Attacks

The process of attack in moorhen includes claw rip, pecking and charging. Claw rip is a prominent mode of attack. The birds at fight were found ripping each other violently with their claws. Claw rip may injure the birds. Pecking is another method of attack. While pecking the bird kept its bill partly open. In a fight the rivals pecked at each other at back, neck and head. The bird charged an interspecific or intraspecific intruder. While charging the bird kept its neck and head horizontally. More often forceful charge was delivered to the opponent.

6.4.8. *Postures and displays*

a. Alert posture

The bird became alert when it perceived any signal of a predator. In this posture the bird still kept its neck and head stretched up and the feathers sleeked. The bird would move to an elevated substratum such as dykes or mounds in the habitat and stayed there watchful. It looked out for the predator by tilting the head fast. The tail flicking was faster and the calls were soft. The bird remained vigilant till the predator left the territory.

b. Position of wings

The wings were kept folded while the bird was at rest. While skulk-

ing or walking or in alert the wings were held close to the body. In the beginning of an intraspecific fight and while running and hopping the birds often kept their wings half folded. During fanning and sunning the bird kept their wings fully open parallel to the ground. In aggressive displays the bird sometimes held the wings at extreme height. The bird stood stretched up the neck and head ; the wings clapped audibly and rapidly. This wing clap display was aimed at driving the predator away from the chicks and nests. The wings also flapped vigorously during splattering.

c. Position of tail

The tail was held down when the bird lost a fight. When the bird was watchful the tail was kept up above the upper body line, exposing the undertail coverts. In aggressive displays also the tail was held up to exhibit the white undertail coverts to the invader at maximum. The bird flicked its tail as a characteristic behaviour in general. The rate of tail flicking was not constant; when the bird was walking the rate of flicking ranged between 44 and 53 times ($\bar{x}$=47, N=100) per 50 seconds. When the bird was frightened or it felt the presence of a predator from auditory or visual signal the flicking became faster ranging between 55 and 69(x=56, N=100). The tail flicking was slow or infrequent when the bird was at rest. The bird kept its tail still while feeding other than grazing.

d. Body orientation

The head and neck were kept at about 45^0 towards the opponent. More often a downward peck was delivered in this posture if the opponent did not retreat. In a fight the bird kept its bill, head and neck horizontal to the ground and the frontal shield was exposed to the opponent. The bird was standing still in this position but sometimes a peck would be delivered. The bird held its head and neck down, vertical almost 90^o to the ground. The body and tail kept at about 45^0 to the ground. This appeared to be a submissive posture of the weak opponent (Fig 6.12).

e. Hunch

The body as a whole was vertically oriented and the neck was hunched with the head downward. The wings were kept close to the body. Sometimes a hunch posture with expanded wings was observed. This display was also exhibited by a weak bird before a powerful dominant opponent. The bird dropped its posture when the opponent moved away (Fig6.13).

6.4.9. *Time budget and activity pattern*

a.Winter

The analysis shows that out of 12 activities studied the bird allotted the highest percentage of daily hours for feeding. There were two peaks of feed-

Fig.6.8 Take off running

Fig. 6.9 Chasing posture

Fig. 6.10 Splattering posture

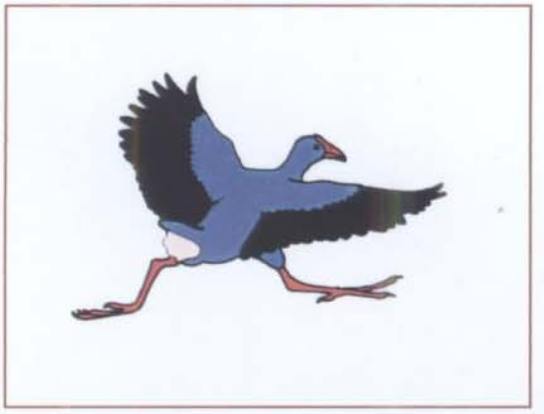


Fig.6.11 Feeding standing on one leg

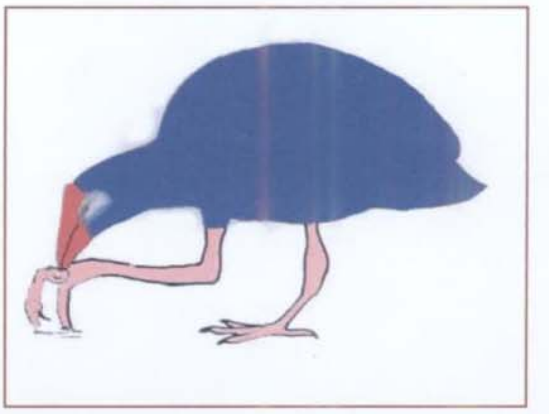


Fig. 6.12 Submissive display

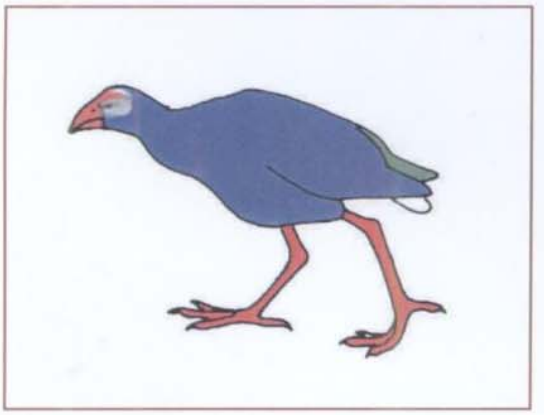
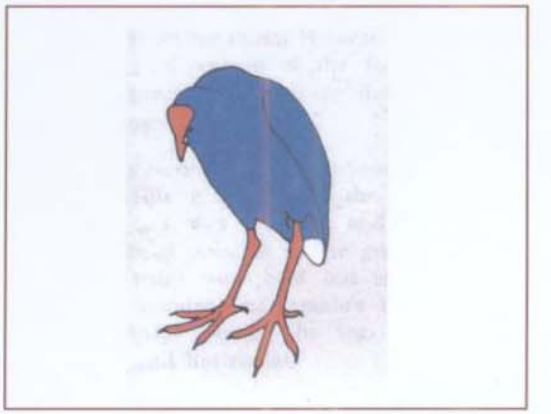


Fig. 6.13 Hunch posture



ing in the morning hours; one between 08.00 and 09.00 (82.7%) and another between 09.00 and 10.00 (75.4%). The feeding activity was low in the noon hours and the least was observed between 12.00 and 13.00 (36%). Thereafter the feeding gradually increased till 17.00 to 18.00 when the feeding rate reached at its peak (78.7%) in the evening (Fig 6.14).

The bird mainly indulged in fighting in the evening hours with a peak of 10.39% between 18.00 and 19.00 (very late evening). Considering the morning hours the bird spent more time (1.9 %) for fighting in the very early morning. Fighting was not observed between 11.00 - 12.00 and 12.00-13.00 (Fg 6.15). The time budget and pattern of preening was almost similar to bathing. The bird allotted considerable time for preening in the noon hours; 13% between 11.00 and 12.00 and 12.77% between 12.00 and 13.00 (Fig 6.16). The bird did not take rest in the very early morning (07.00-08.00). The bird allotted significant time for taking rest in the noon hours and the peak (25.5%) was between 12.00 and 13.00. The bird also spent considerable time for resting (18.4%) between 18.00 and 19.00. The chasing was not observed between 13.00 and 14.00 (Fig. 6.17).

In the early morning (0700-0800) the bird made frequent calls allotting 6.8% time for calling which was the highest daily rate of calling. The bird spent the highest percentage of time (30.2%) for moving in the

early morning (07.00-08.00). The bird moved slowly in the noon hours as it spent only 0.3% between 12.00 and 13.00 and 0.13% between 13.00 and 14.00. However the mobility was low in the late evening spending only 0.91% time between 18.00 and 19.00 (Fig 6.18). No sexual activity was observed between 07.00 and 09.00, 12.00 and 14.00, 16.00 and 17.00 and 18.00 and 19.00. There was a significant sexual behaviour (2.1%) exhibited by the bird between 15.00 and 16.00 (Fig 6.19). It spent highest percentage of time (12.9%) for chasing between 16.00 and 17.00. Bathing was not at all observed or very insignificant in the early morning and evening hours. The bird mainly took bath between 13.00 and 14.00 (10.3%) and between 14.00 and 15.00 (10.1%).

The pattern of swimming almost coincided with that of preening and bathing. The bird was not swimming in the early morning hours between 07.00 and 08.00 and in the evening hours (15.00 - 16.00 and 16.00 -17.00). The bird swam considerably in the noon hours with 7.45% between 12.00 and 13.00 hours and with 11.43% between 13.00 and 14.00 which was the peak rate of swimming.

The hopping was not observed between 07.00 and 08.00, 14.00 and 15.00, 15.00 and 16.00, 16.00 and 17.00 and 18.00 and 19.00 hours. The bird spent the highest time (2.60%) for hopping between 13.00 and 14.00.

Fig. 6.14. **Feeding of Purple moorhen in summer, monsoon and winter (2002)**

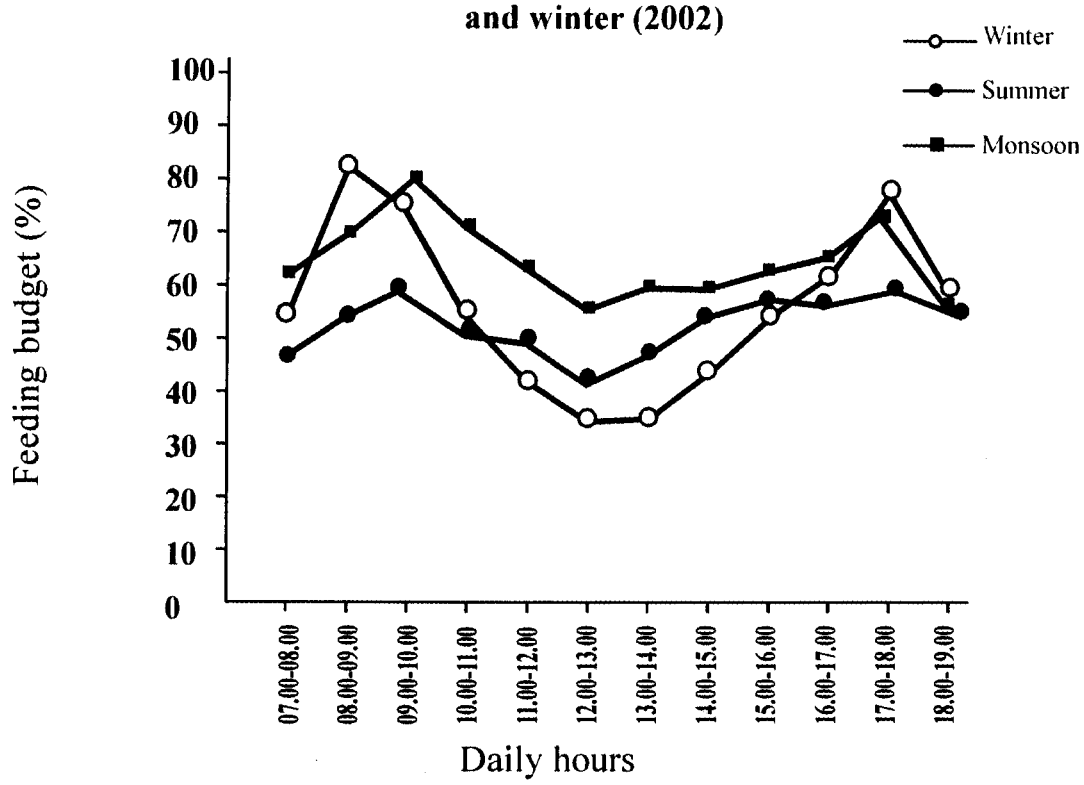


Fig. 6.15. **Agonistic behaviour of Purple moorhen in winter, summer and monsoon (2002)**

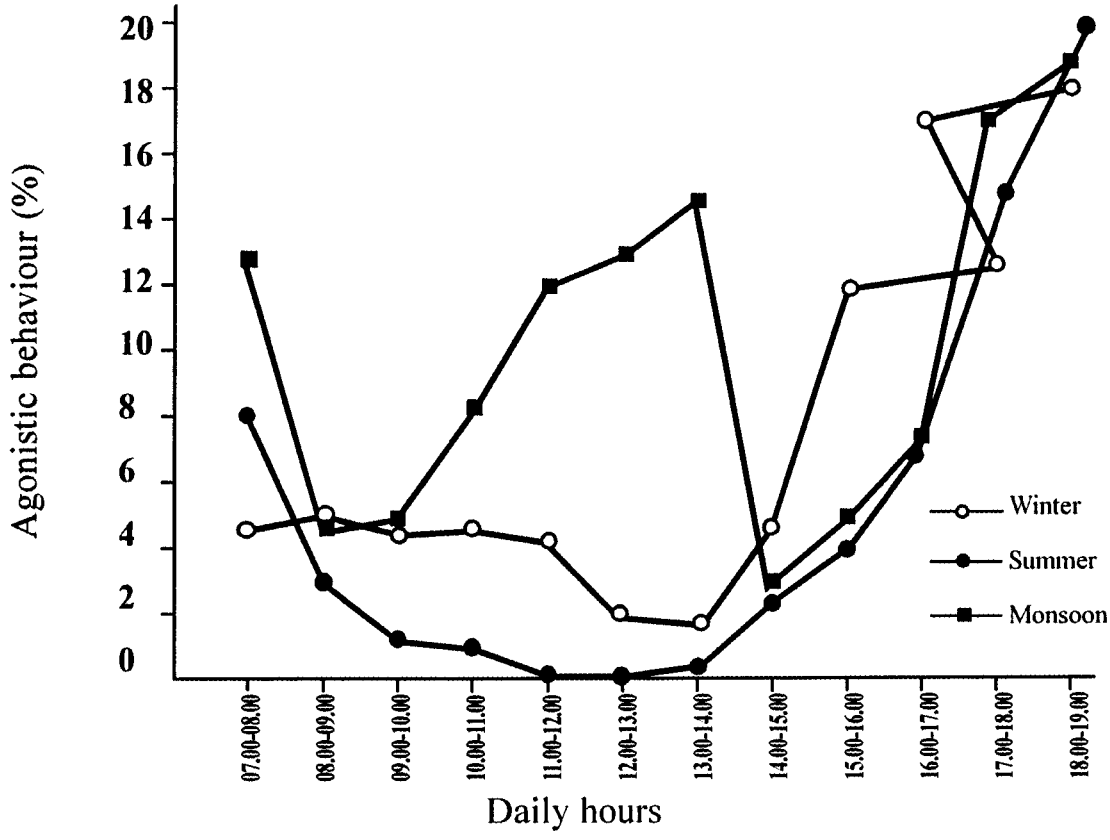


Fig. 6.16. **Maintenance behaviour of Purple moorhen in winter, Summer and Monsoon (2002)**

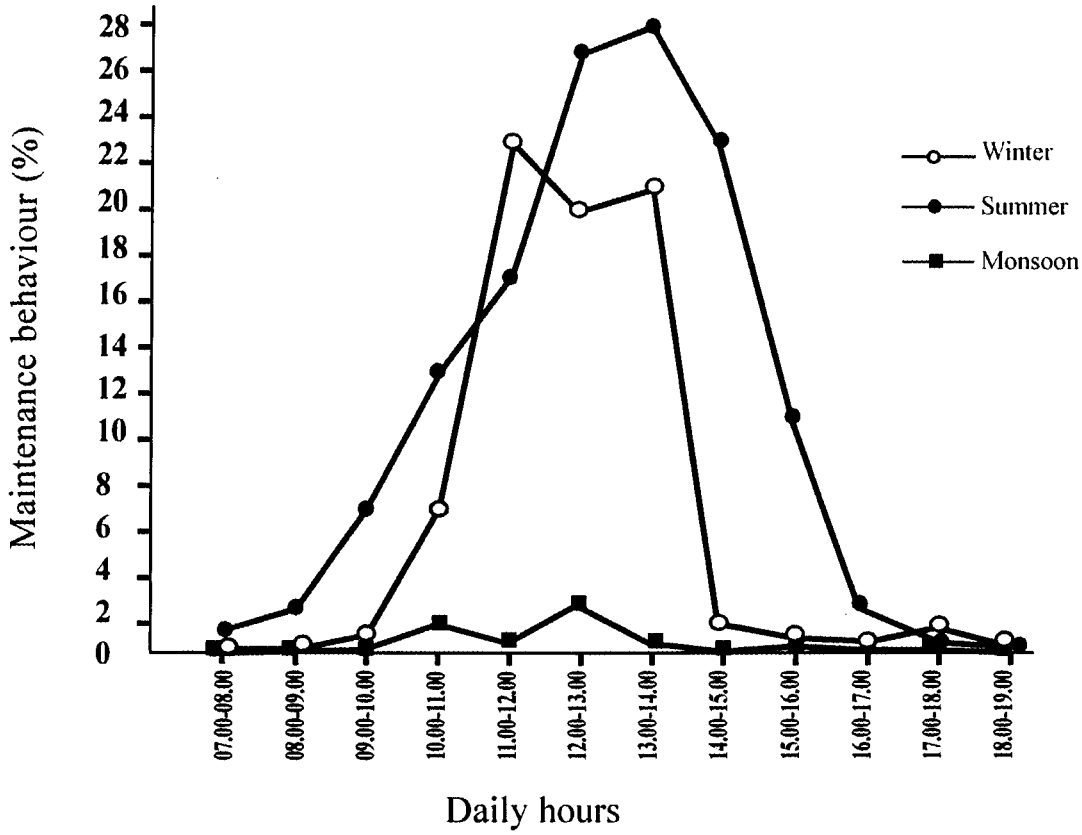


Fig. 6.17. **Resting of Purple moorhen in winter, summer and monsoon (2002)**

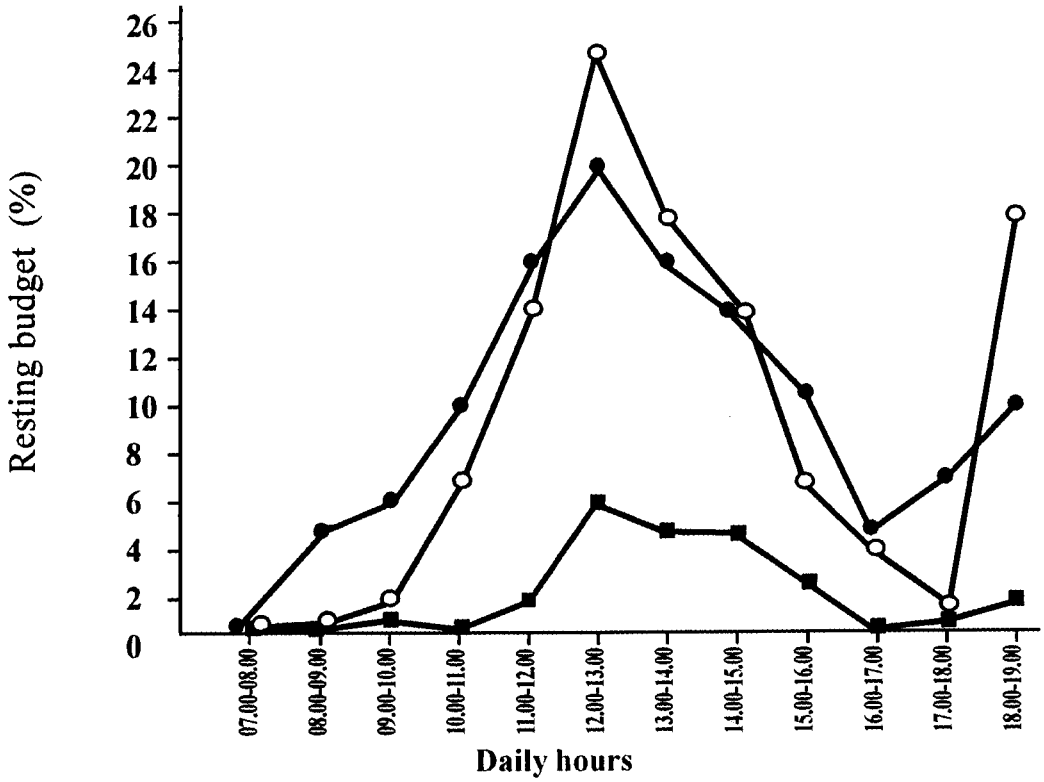


Fig. 6.18. **Locomotion of Purple moorhen in winter, summer and monsoon (2002)**

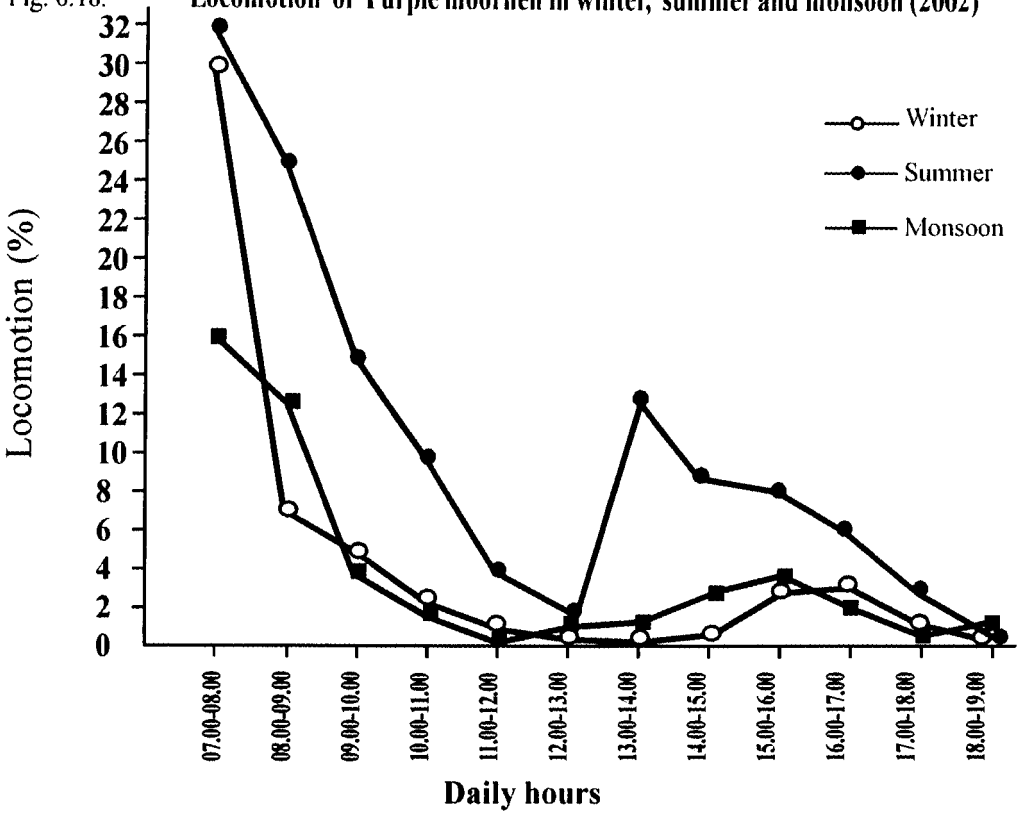


Fig. 6.19. **Sexual behaviour of Purple moorhen in winter and monsoon (2002)**

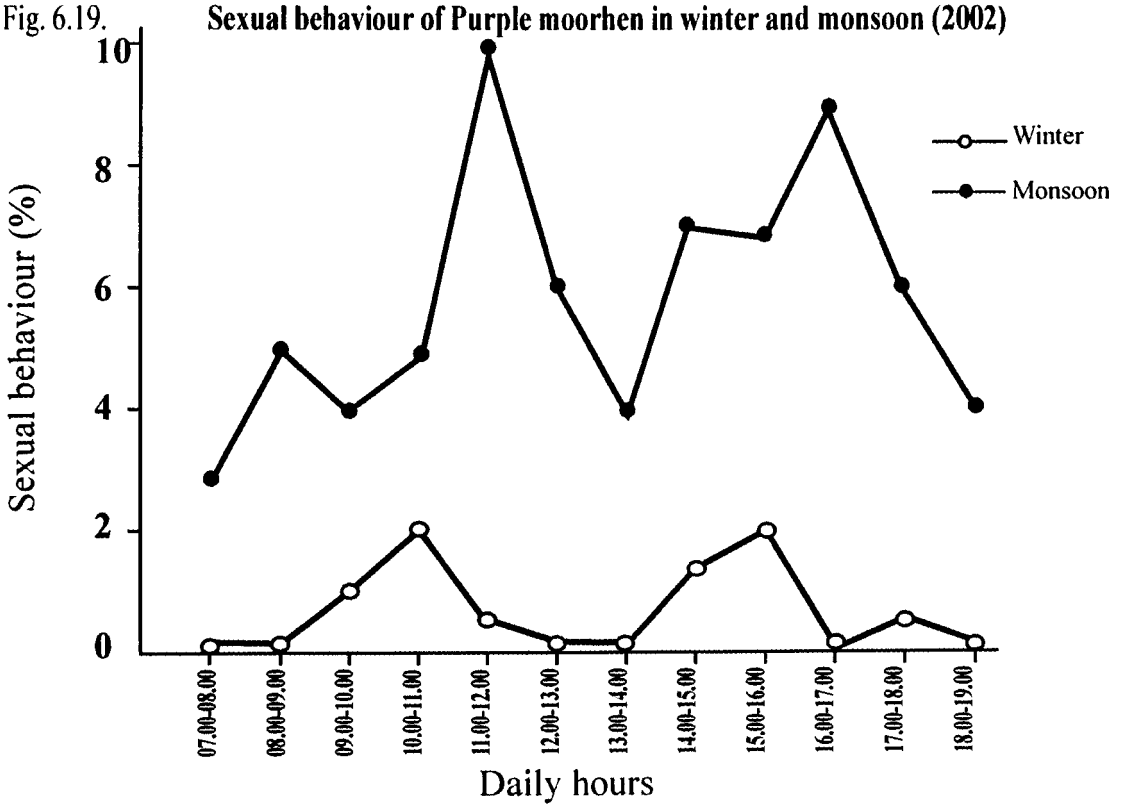
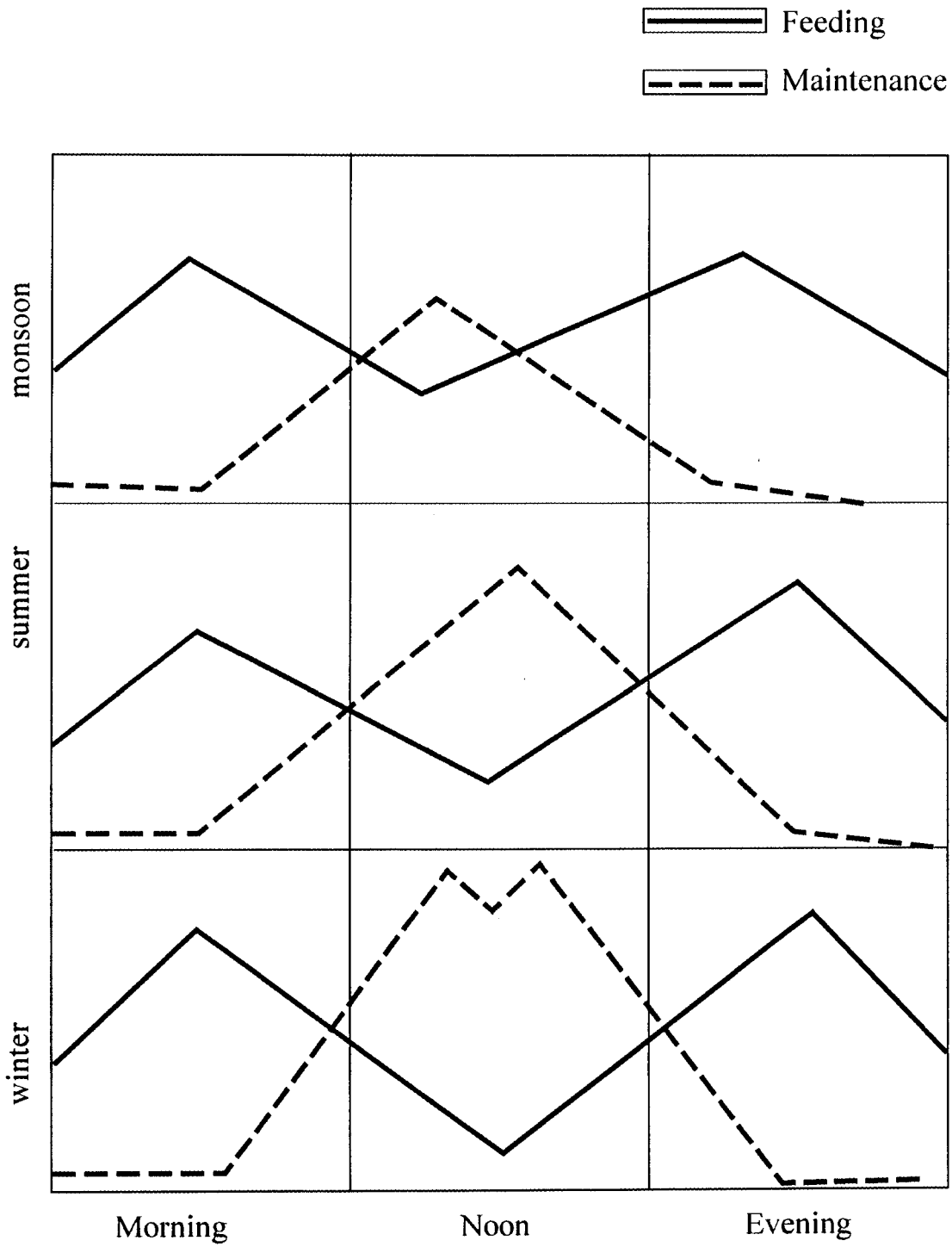


Fig. 6.20. Pattern of feeding versus maintenance behaviour in winter, summer and monsoon (2002). (not up to scale)



The bird took vigil throughout the daily hours without much difference between the time budget. However the bird was less vigilant in the very early morning (07.00-08.00) with a time budget of 0.52% and very late evening (18.00 - 19.00) spending only 0.17% of time. There were three peaks in the time budget of vigil; one in the late morning (10.00-11.00) with 9.32% another in the early noon (11.00 -12.00) with 8.77% and third in the early evening (15.00-16.00) with 8.43%.

In winter the bird allocated the highest share of time for feeding and the least for sexual behaviour. Based on the decreasing order of time budget the activities can be presented for winter as follows: feeding > resting > agonistic behaviour > maintenance behaviour > locomotion > vigil > sexual behaviour (Fig 6.21).

b. Summer

The pattern of feeding in summer showed some similarities with that of winter. The bird spent more time for feeding in the morning and evening than noon. There was one peak (60%) in the morning (09.00-10.00) and another one (60.4%) in the evening (17.00 - 18.00). The rate of feeding was least (42.1%) in the noon (12.00-13.00). As observed in winter the bird spent the highest time (6.32%) for calling in the early morning (07.00-08.00). Calling was not heard during the noon hours between 11.00 and 14.00.

The pattern of moving was similar to that of winter as the bird showed the highest mobility (32.7%) in the early morning (07.00-08.00) and the least (2.10%) in the noon (12.00-13.00). The bird also allotted considerable time for moving in the evening hours. In summer no sexual activity was observed in any of the daily hours. The bird did not take rest in the early morning (07.00-08.00) but it spent considerable time in the noon hours with a peak (78.67%) in the mid noon. This observation was similar to that seen in winter. There was no chasing activity between 11.00 and 13.00 hours. The bird comparatively spent very less time for chasing in noon whereas the bird chased for significant period in the morning with a peak (6.53%) between 07.00 and 08.00. In the evening about 14.0% time between 18.00 and 19.00 was spent on chasing.

The bird bathed infrequently in the morning between 07.00 and 08.00 and in the evening between 15.00 and 16.00 and 16.00 and 17.00. As seen during winter, in summer the bird mainly took bath in noon hours with a peak spending almost 8% time between 12.00 and 13.00. The preening was uncommon in the morning with the least time used for it as 0.5% between 07.00 and 08.00. In the evening no preening activity was seen.The bird spent the highest percentage of time (19.21%) for preening between 16.00 and 13.00.

The moorhen used about 2% of its time for hopping in the early morning (07.00-08.00). About 1.1% of time between 15.00 and 16.00 in the same activity. No hopping was observed between 11.00 and 13.00 whereas in winter the bird spent highest time for hopping during the same time period.

As observed in winter the bird did not appear vigilant in the early morning (07.00-08.00). The bird was frequently on vigil in the late morning and evening hours. It was more frequently on vigil in the evening between 17.00 and 18.00. The bird spent less time for feeding in summer than that in winter. Second highest time duration after the time allocated for feeding was allotted for resting in summer. The bird spent more time for maintenance in summer than in winter whereas the time budget for agonistic behaviour was less in summer. There was no notable difference in the allotment of time for calling and vigil in the winter and summer. The time budget for sexual behaviour was zero in summer. Altogether the bird was less active in summer than winter (Fig6.22).

c. Monsoon

As observed in winter and summer the bird fed more actively in the morning and evening hours than noon. There was one peak (79.4%) in the morning (09.00-10.00) and another one (72.2%) in the evening

(17.00-18.00). Contrary to the observation made in winter and summer there was no well defined pattern for the calling activity in the daily hours of monsoon. The highest allotment of time (9.5%) for calling was observed between 14.00 and 15.00 and the least (0.6%) between 17.00 and 18.00 hours. Similar with the observation in the winter and summer, the bird spent highest time (16.4%) for moving between 0.700 and 0.800 hours in monsoon whereas the bird was less mobile in the noon hours.

The bird spent considerable time for sexual behaviour in monsoon. The sexual activity was observed throughout the day hours without a specific pattern of time allocation in the morning, noon and evening hours.

The bird was very active in the morning and evening hours whereas significant time was allotted for rest in the noon with two peaks; one (7.7%) between 12.00 and 13.00 and another (7.2%) between 13.00 and 14.00. Almost similar pattern was observed in summer and winter. As in the case of summer and winter the bird spent considerable time for chasing in the morning and evening hours in monsoon. The chasing peaked (9.4%) between 07.00 and 08.00 in the morning and 11.2 % between 17.00 and 18.00 in the evening. The bird took very little time for bathing in monsoon as it occurred only between 10.00 and 11.00 (0.7%), 12.00 and 13.00 (1.2 %) and 13.00 and 14.00 (0.6%) hours of the day. It was in disagreement with the time

budget and pattern of bathing observed in summer and winter.

Preening was uncommon in the day hours of monsoon. Comparatively the bird spent more time for preening in the noon hours with a peak (3.4 %) between 12.00 and 13.00. But the time budget for preening was higher in the winter and summer. The moorhen allotted significant time for fighting throughout the day hours in monsoon without a temporal order of peak and crush in the time budget as observed in the winter and summer. Swimming was a rare activity of the bird in the monsoon occurring only between 0.700 and 0.800 (0.1 %), 10.00 and 11.00 (12.7%), and 12.00 and 13.00 (0.38%) hours. The frequency of swimming was higher in summer and winter than in monsoon. The bird spent very little time for hopping in monsoon. It spent 0.25 % between 0.900 and 10.00, 1.2% between 13.00 and 14.00 and 0.3 % between 18.00 and 19.00. There was no hopping in the rest of the daily hours (Fig 6.23).

There was less allotment of time for vigil in the day hours of monsoon than in winter and summer. The bird was not at all acted as vigilant between 07.00 and 08.00, 11.00 and 12.00 and 14.00 and 15.00.

6.5. Discussion

Apparently awakening and roosting of the bird was found coinciding with the time of sunrise and sunset respectively. However in a

Fig. 6.21. Activity pattern of Purple moorhen in winter (2002)

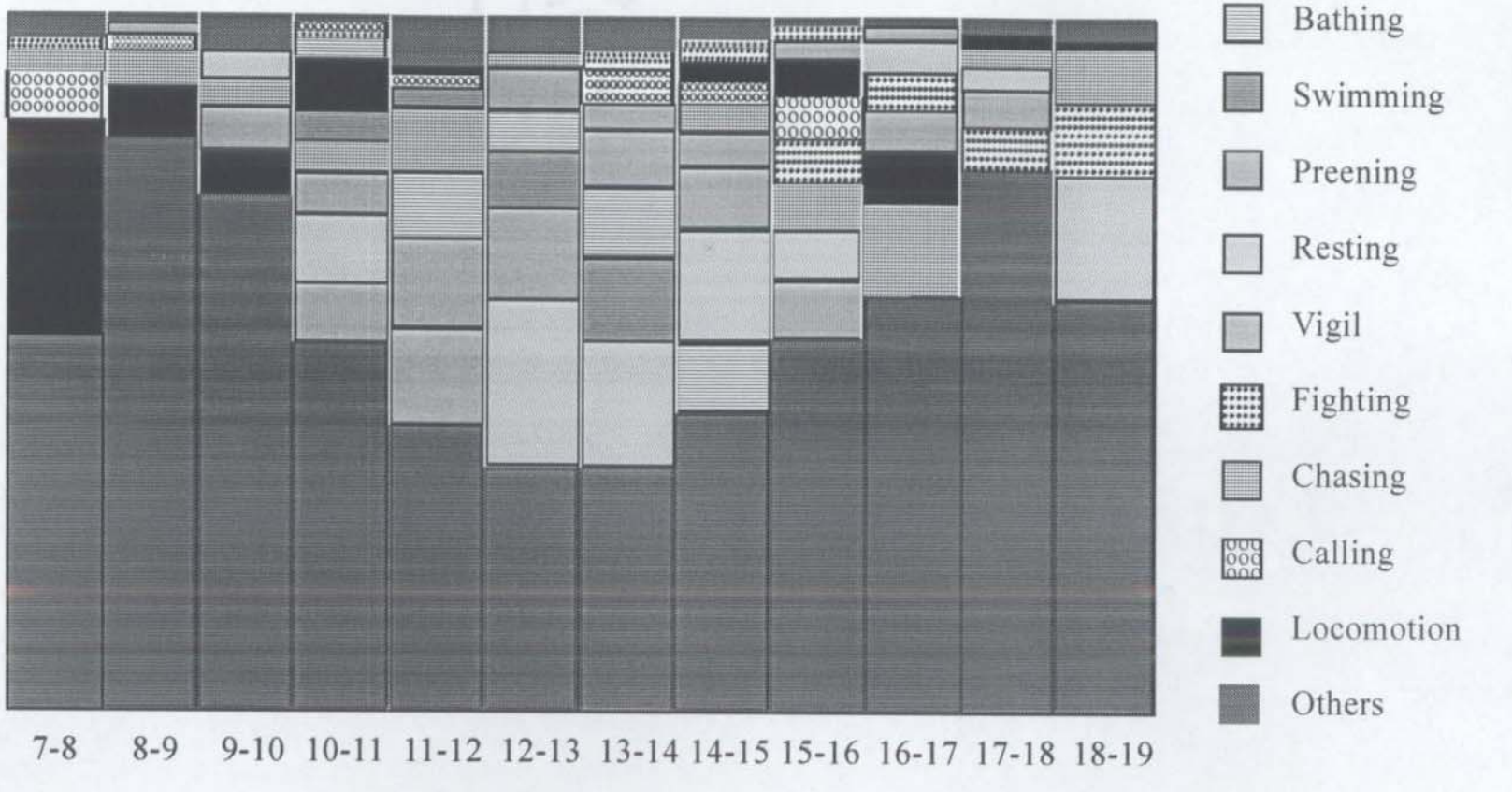


Fig. 6.22. Activity pattern of Purple moorhen in summer (2002)

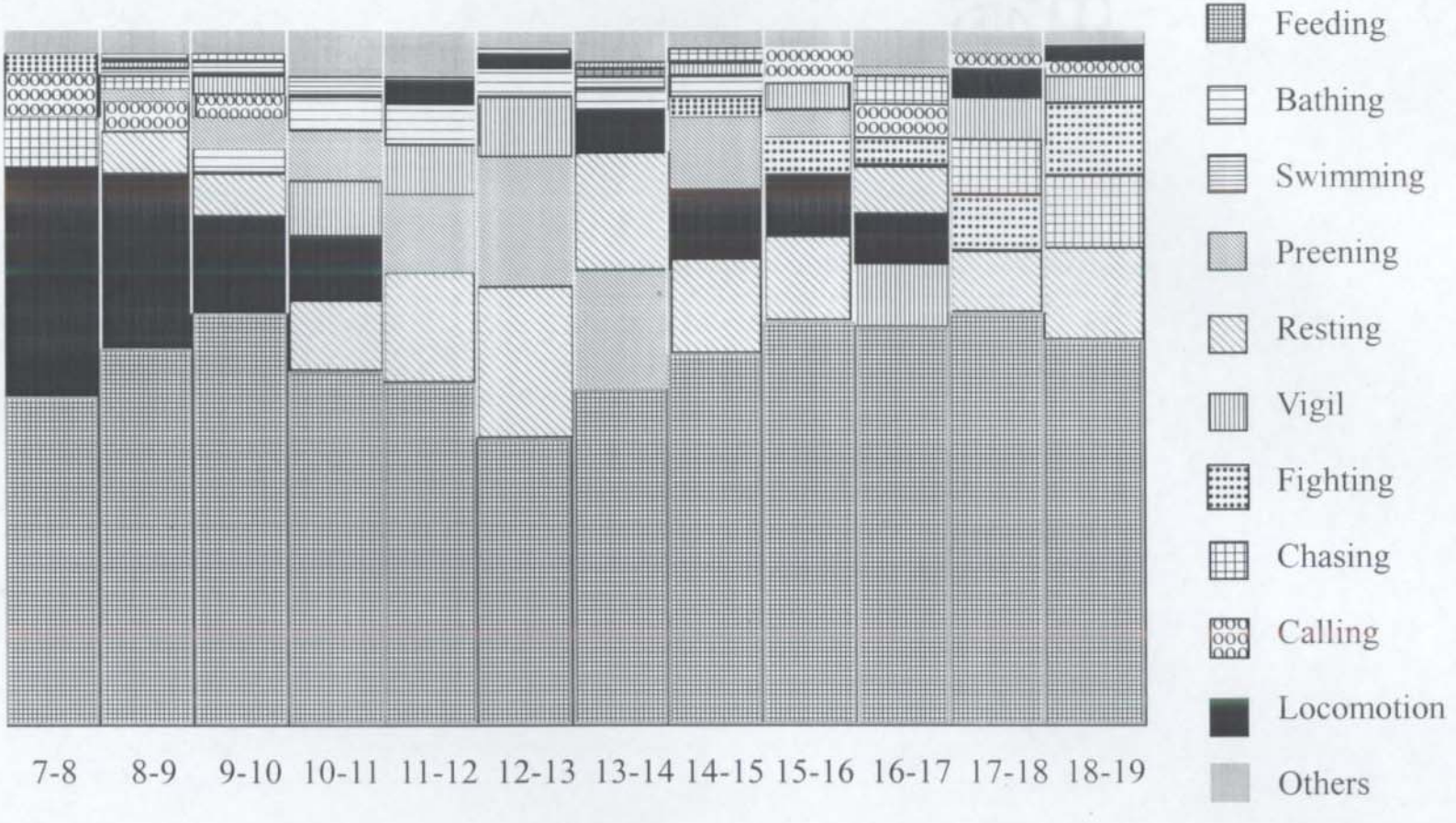
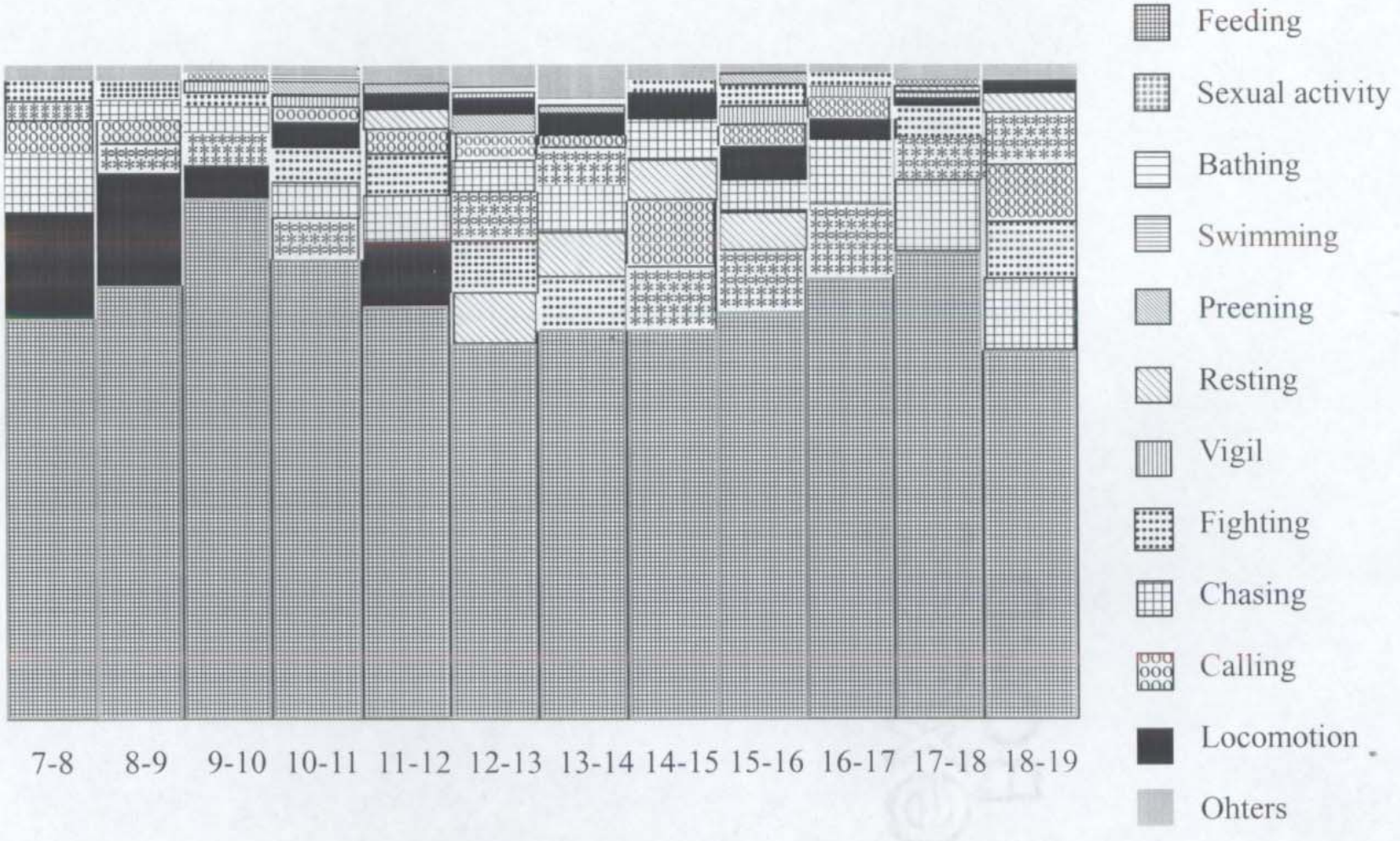


Fig. 6.23. Activity pattern of Purple moorhen in monsoon (2002)



wider sense these two activities could be tuned with the circadian rhythm of the bird being influenced by various endogenous and exogenous factors like intensity of the light, temperature of the surrounding and the level of the hormones in the blood. In many birds roosting time is strongly influenced by abiotic factors (Eiserer 1984) and follows the rules of endogenous light entrained rhythmicity (Gwinner 1975). Temperature,light intensity and external disturbunces like human interferences influence the time of awakening and roosting in birds (Schmit 1994). Ravelling (1969) and Swingland (1976) have reported that in the low intensity of light and temperature the birds roost earlier. The birds roost communally helping them to reduce thermoregulation demands and predation risk (Beachamp 1999). Usually a bird selects a roosting site ensuring the safety and protection from predators. This is true in the case of study species also as it selected the core zone of the habitat for roosting. The core zone has abundant vegetation and high water surrounded by making it inaccessible to the predators. In summer as the most of the habitat dried up the bird roosted on coconut trees which were safer.

As soon as the birds woke up they hurriedly moved to the foraging zone. Therefore in the early morning they were found scattered well throughout the buffer zone, feeding actively. However, human and nonhuman inter-

ference increasing in the habitat in the late morning forces the birds to move to the core zone. In the noon most of the birds in the core zone became less active with feeding becoming slow. In the afternoon again being undisturbed the birds reached the peripheral zone for active feeding but in the evening with the frequent interference from people the birds were forced to return to the core zone. The human intruders mainly include the children accompanying the grass cutters and the nonhuman intruders were cattle and dogs.

The bird makes varieties of calls (Ali and Ripley 1983, Grimmet *etal* 1998). *P.melanotus* in Newzealand makes 25 different calls which are essential for social life but functions of many calls remain unknown (Craig 1974, Merchant and Higgins 1993). The present study also documents various calls uttered by *P.p.poliocephalus* and the functions of some calls are not clear. Clapperton (1982) has observed that in *P.melanotus* the syrinx is highly adapted for making varieties of calls. However there was no report of such anatomical features in *P.p.poliocephalus*. Ali and Ripley (1983) has recognised that the soft calls are meant for maintaining party and rough calls for assembling. The alarm is very loud and contact calls are soft (Grimmet *etal* 1998). Merchant and Higgins (1993) has noted that male and female of *P.melanotus* make different calls.

The male has low sonorous calls and the female has shriller soft

calls. Sexual difference of some calls could be seen but most of the calls are uttered similarly by male and female of *Porphyrio porphyrio* (Tunicleffe 1965). This supports the observations with the present study that the male and female *P.p. poliocephalus* made certain calls differently. Sexual difference in calls has been reported in some other rails including the Common moorhen *Gallinula chloropus* (Howard 1940), Coot *Fulica atra* (Rupell 1933) and American coot (Guillion 1950). Rowell and Hinde (1962) have hypothesised that the role of varieties of calls may be effective for social integration. Similar roles of calls might be attributed to the *P.p. poliocephalus* also since it is a social or communal species. Merchant and Higgins (1993) has noted that *P. melanotus* makes calls at day and night whereas *P.p. poliocephalus* was heard making only one type of call (hooting call) during night. The reduced calls at night would be to ensure better safety in the roost from predators.

Like most of the rails the study species was also a fast runner facilitated by the long spidery spread toes and long legs. The bird although swims well is generally averse to swimming unless often forced to (Ali and Ripley 1983). This agrees with the observation made in the present study. The *P. melanotus* swims little while feeding. Taylor (1998) also reports that the bird swims infrequently and the head moved back and forth while swimming. The components and mode of swimming of both *P.melanotus* and

P.p.poliocephalus appeared to be similar. In the main study area the leaves of *Nymphaea stellata* and Salvinia mat provided suitable substratum for walking, running and skulking. It could move at ease over floating vegetation without getting sunk in water for the body weight was evenly shared by long toes.

Displays, songs and calls are basic mechanism of communication in birds. Purple moorhen being a social species the communication through displays are important for the interaction among individuals. Craig (1977) has observed wide ranges of vocal and signal displays in *P.melanotus.* The roles of various kinds of displays and postures observed in the moorhen were not clearly understood. Head up display is used in fighting in many passerine birds. One of the important aggressive displays is the apparent fluffing of neck (Timbergen 1951) and many displays help to avoid unwanted fights (Smith and Harper 2003). Head up displays and ruffling of neck feathers were observed in the study species also. The main weapons of aggression in many birds are bill and wings (Andrew 1961). However in *P.p.poliocephalus* the heavy bill and clawed toes were effectively used to attack the opponent. Head up posture is also used by Magpie Robin for defence and fighting (Kumar and Bhatt 2001). In the head forward posture the *P.p. poliocephalus* showed its red beak and shield towards the opponent. This put the opponent

in a great difficulty of pecking until the other bird turned away or faced away. In splattering the bird ran fast towards its opponent. It might serve to show the increasingly aggressive tendency to the opponent. The *P.melanotus* will clap its wings to distract a predator from the nest (Merchant and Higgins 1998). Similar posture was exhibited by the *P.p. poliocephalus* also.

The *P.p. poliocephalus* exposed its under tail coverts at various occasions. Tasmanian native hen shows its black under tail coverts to the aerial predator (Woodland etal 1980). The white under tail coverts in various species of genus Porphyrio might have evolved to provide a contrast in colour and location to the aggressive signal of the red shield and beak (Craig 1977). Displays of many species are centered around releasers (Timbergen 1951) which are the structural features of the individual. The red beak, red frontal shield and white undertail coverts of Purple moorhen could serve the functions of social releasers. *P.melanotus* in hunch was not usually attacked by a conspecific and the bird often escapes by running away or moving away or leaping to water from a powerful opponent (Merchant and Higgins 1993). In the present study similar observations were made in *P.p. poliocephalus* .

The Purple moorhen was not an exception to the general rule that the herbivorous birds feed actively in the morning and evening. In the early morning prior to leaving for foraging the birds are highly vocal spending

considerable time for calling. As soon as they woke up they competed to reach the feeding areas. On the other hand the bird returned rather slowly to the core zone in the evening. In the winter the bird was very active in the morning. Like many other species the Purple moorhen was very inactive in the noon hours. It might be a technique to save energy and to involve in maintenance behaviour in the noon hours especially in summer. This could also be a thermoregulatory strategy adopted by the bird. The frequent agonis tic behaviours common among the birds in the early morning and evening could be due to the closer assemblage of the birds in the core zone. The frequency of presence of intruders was high in the morning and evening that the birds spent considerable time on vigil during that time. In winter the birds indulged in courtship activities as the minor breeding season of the birds, Northeast monsoon, is in winter. During Southwest monsoon the bird allotted major share of its time for breeding, since it was the main breeding season. The bird spent significant time for calling in monsoon as the bird was highly vocal during breeding season. The bird took less food and more rest in the summer. The birds spent more time for maintenance in summer than winter and monsoon. The bird swam less often in monsoon than summer and winter even though most of the habitat was inundated in monsoon. This shows that tendancy for swimming was not influenced by the availabil-

ity of water but tuned with an internal physiological needs of the species. The bird spent highest time for feeding in monsoon and it could be due to the higher need of energy for executing breeding activities. The birds indulged in frequent agonistic encounters in monsoon probably because they became more territorial in the breeding season and also they provided protection to the eggs and chicks from predators. The breeding birds were very active in the monsoon as they were busy in courtship displays, mounting, nest construction, brooding and parental caring. Therefore they hardly took rest in the season. However the reason for low time allotment for vigil in monsoon could not be explained satisfactorily because more alertness was expected in breeding season. Probable reason might be that the flooded habitat reduced the access of land predators to the vicinity of the nest. In every daily hour most of the time was set apart for feeding by Jacanas irrespective of the seasons (Ramachandran 1998). He has also observed that the time allocated for feeding is inversely proportional to that of maintenance. These findings agree with the behaviour patterns of Purple moorhen obtained in the current study. Jayaraman (1985) has also obtained similar pattern in Coot .

6.6. summary

The study reveals that the bird woke up 10-15 minutes before sun rise and went to roosting site 10-20 minutes after sunset but waking up time

and roosting time were subject to change according to the time of sun rise and sun set. In the early morning the birds started moving from roosting site to the buffer zone for feeding but in noon large number of birds were seen in the core zone. In the evening the birds moved again to the buffer zone but in the late evening the birds returned to the core zone for roosting. The birds were heard making varieties of calls like Kr..Kr.., Luck..Luck..Luck at various occasions. The movements of birds included skulking, walking, running, flying, hopping and swimming. Bathing, sunning, preening, fanning and resting were important maintenance behaviours of the bird. The agonistic behaviours included chasing and fighting. It showed various displays keeping tails, wings, head and neck at various orientations. The tail flicking rate ranged between 44-69 times per minute (N=100) depending on situations. In the morning and evening of all seasons the birds actively fed with peaks of 82.7% between 08.00 and 09.00 and 78.6% between 17.00 and 18.00 in winter, 60% between 09.00 and 10.00 and 60.4% between 17.00 and 18.00 in summer and 79.4% between 09.00 and 10.00 and 72.2% between 17.00 and 18.00 in monsoon. The maintenance, agonistic, sexual and moving activities also showed seasonal variations.

BIOLOGY, ECOLOGY AND BEHAVIOUR OF PURPLE MOORHEN PORPHYRIO PORPHYRIO

Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology

BY

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CHAPTER VII

BREEDING BIOLOGY

7.1. Introduction

The breeding biology of Rallids has not been studied widely mainly because of their elusive behaviour, largely inaccessible habitats and complex breeding systems that prevailed in some gallinules. Period of incubation, male participation and components of courtship display are not studied (Ali and Ripley 1983). Some of the studies documenting the breeding biology of gallinules are Ferguson (1898), Baker (1929), Whistler (1935), Ali and Ripley (1983), Vijayan (1991), Bhupathy (1985), Nair and Nair(1980),Venkatesan (1988),Gibbons (1987), Acharya and Smitha (2000). Vijayan (1991) has studied some aspects of breeding biology of Purple moorhen in Keoladeo National Park, Bharathpur. In Keoladeo National Park the productivity of the bird was 3 chicks per nest in 1984 and 0.4 chicks per nest in 1988. Concerning the breeding of the bird in Kerala only a few scant notes are available such as Ferguson (1898), Ali (1969), Neelakantan (1958) and Ravindran (1992). However the breeding ecology of the *P. melanotus* has been investigated in detail in Newzealand and Australia[(Craig (1979), Brown (1974), Jameison (1988), Emlen (1982), Ridpath (1972) and White (1982)]. Pywell and Lilla (2003) have studied the reproduction of Dusky moorhen in

Australia. This chapter reports the results of the present study on the breeding biology of *P. p. poliocephalus* in Azhinjilam jheel.

7.2. Objectives

1. to study about various phases of nesting of the bird.
2. to explore its breeding success and the development of chick.

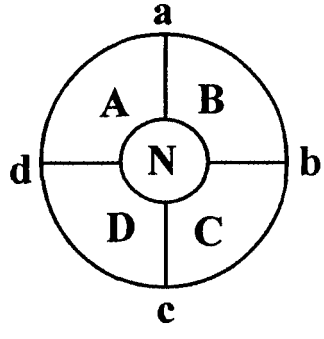
7.3. Methodology

The study was undertaken in 1998. Walking along the dykes and standing on the mounds, the birds were observed with binoculars (10x7) and monocular spotting scope (32x). The breeding activities of the birds were followed continuously for 6 hrs in each bout of observation. 29 nests (24 during Southwest monsoon, 5 during Northeast monsoon) were located and studied. However, the various phases of nesting cycle could not be followed in all the 29 nests. Therefore, 12 nests were randomly selected for intensive study to collect data on clutch size, egg loss, incubation, productivity and parental care. The ecological parameters like floating vegetation, emergent vegetation, water depth, open water body and associated species within 50m radius of 4 randomly selected nests were studied using radial rope method. In this method 4 ropes (a,b,c,d) each of 50m length was tied radially from sites close to the the nests to the 4 directions. Keeping the nest as center the

areas between the ropes were marked as A,B,C,D and the ecological parameters in the areas A,B,C,D were studied (Fig 7.1).

After the breeding activities were over the nests were measured and analysed. Egg measurements were taken using a vernier calliper. Eggs were weighed in a common balance and volume was found out using water displacement method. The observations totalled 250 hrs. Most of the observations were made between 06.00hrs. and 18.00hrs. The birds observed within 5 meter radius of the Purple moorhen were considered as the associated species.

Fig 7.1 **Radial rope method**



N - Nest
a,b,c,d - Ropes
A,B,C,D - Study areas

7.4. Result

7.4.1. *Breeding season*

There were two breeding seasons observed in the main study area. One was during the Southwest monsoon (June- September) and the other during Northeast Monsoon (October-November). 24 nests were found during Southwest monsoon season and 5 during Northeast monsoon. Largest number of nests (14, 58 %) were found in August. No nest was found in June. There were 2 nests in July and 8 in September. In the second breeding season 5 nests were found in November (Table 7.1). The first observation of the bird collecting nest materials was noted on June 20 in the first breeding season and in the second breeding season the first nesting attempt was seen on October 29. However, in a subsidiary study area, Avala Jheel, a part of which permanently held water, breeding activities, nests and chicks were found throughout the year (Figure 7.2). But only 12 birds used this jheel as a breeding ground. 5 birds were found involved in breeding activities in a small seasonal jheel (Olavanna Jheel) of 2 acres, situated 10km north of the main study area. Breeding activity was found only during Northeast Monsoon (October - November) here. The birds were found using this jheel only for breeding purpose. By the end of March all the breeders and their fledglings left the jheel. In 1999 breeding activities, nests, eggs and chicks were observed in the main study area even in summer months. Other than the

breeding areas mentioned above there were several small and large wetlands in the Kozhikode and Malapuram districts used as breeding habitats by Purple moorhen.

7.4.2. *Flocking and flock composition*

With the onset of South West Monsoon 77 birds flocked into small groups having the flock size from 1 to 9 (Table 7.2). The birds in all such flocks except two with a solitary male bird each, were found involved in courtship and breeding activities. The pairflock was found in the highest frequency (12) and the 9 member flock was in the least frequency (1). In 1 member unit (frequency 2) there was only 1 female whereas in the 2 member unit or pair unit (frequency 12) there was 1 male and 1 female. There were 3 units with 4 members. In the one unit of 4 members there were 2 males and 2 females. Whereas there were 1 male and 3 females in another 4 member unit. The third 4 member unit comprised 1 male, 2 females and 1 subadult. There were totally 6 units with 5 members in which there were 2 males in 2 units and 1 male in 4 units. 3 females were found in 2 units and 2 females in 3 units. But 4 females were found only in 1 unit. There were two subadults in 2 units and 1 subadult in 2 units. No subadults were found in remaining 2 units. The single 9 member unit comprised 3 males 4 females and 2 subadults (Fig 7.3). Totally there were 29 adult males (37.6%), 39 adult females (50.6%) and 9 sub adults (11.6%), (Table 7.3).

7.4.3. *Territory and defence*

The breeding birds made their own loose territory having no borders. The breeding territory was defended by the pairs or groups. The males in each unit were the chief guards of the territory. The females and subadults also participated in the territory defence. The birds did tolerate neither conspecific nor interspecific intrusion into their respective territories. The conspecific intruders were those members of units which trespassed for food or mate or to escape from interspecific intruders. The interspecific intruders mainly were Cattle egrets, Little egrets and Median egrets. Also Pond heron and White breasted waterhen frequently intruded into the territory of moorhen.

Purple moorhen showed various modes of defence such as sharp threat calls, chasing, pecking, threat displays and fight. Chasing the intruder was the frequently observed mode of defence. They maintained their defence posture or display till the intruder left their territory (See chapter VI, Activity pattern).

7.4.4. *Courtship and mating*

Triggering the breeding activity the male held a piece of food plant in the beak and offered to a chosen female. The courtship displays started only after the female accepted the offer. The female touched the wing of male with her beak. The male turning face to the female, took erect posture

Table 7.1. **Number of nests during the breeding season**

Breeding seasons								
Southwest monsoon						Northeast monsoon		
Months	Jun	Jly	Aug	Sept	Total	Oct	Nov	Total
No. of Nests	1	2	14	7	24	Nil	5	5

Fig 7.2. **Breeding months in the main study area and a subsidiary area**

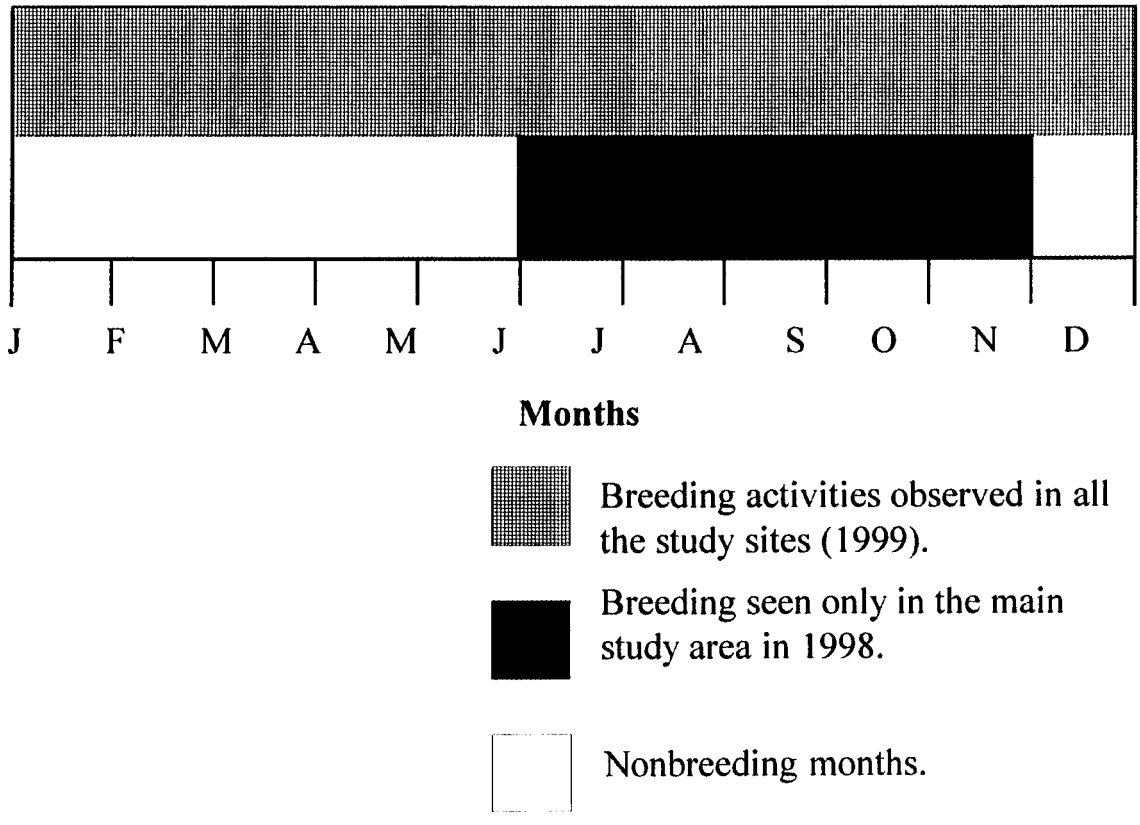


Fig 7.3 **Flocking prior to breeding in the main study area, Azhinjilam**

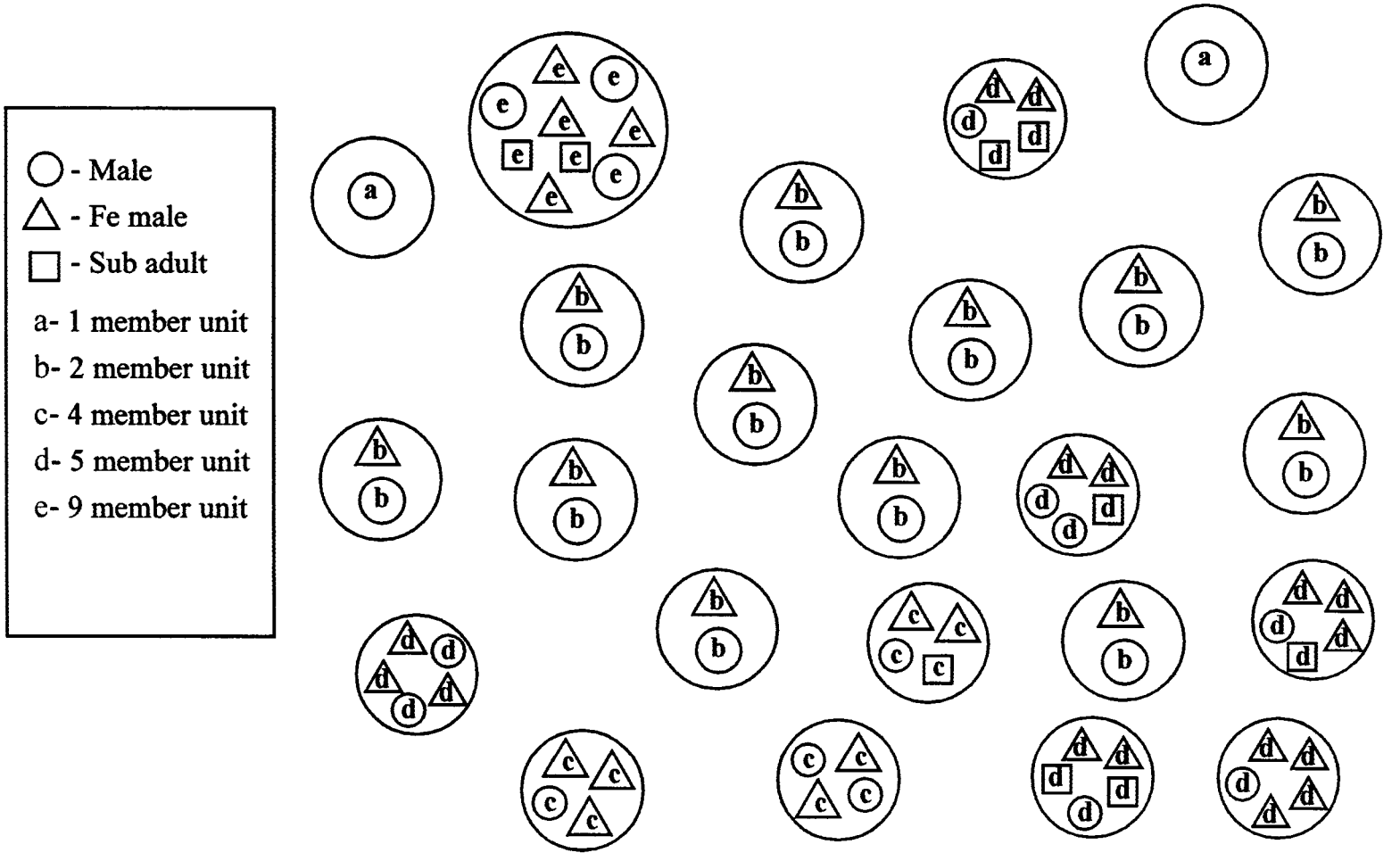


Table 7.2 **Flock composition and frequency**

Flock size	Male	Female	Subadults (M/F)	Frequency	Ratio of male, female and subadult
1	1	0	0	2	1 : 0 : 0
2	1	1	0	12	1 : 1 : 0
4	2	2	0	1	2 : 2 : 0
	1	3	0	1	1 : 3: 0
	1	2	1	1	1 : 2 : 1
5	2	3	0	1	2 : 3 : 0
	2	2	1	1	2 : 2 : 1
	1	2	2	1	1 : 2 : 2
	1	4	0	1	1 : 4 : 0
	1	3	1	1	1 : 3 : 1
	1	2	2	1	1 : 2 : 2
9	3	4	2	1	3 : 4 : 2

with his wings half folded. In this upright posture the male kept his tail down. Then the male followed the female making Que....Que.. Que calls. These calls were louder and were repeated many times. The female made soft calls Kre.....Kre..... Kre (reply calls) showing its willingness to mate. Then the female stood still and turned her face to the chasing male. She bent down her head and turned her back to the male. The female kept her body almost parallel to the ground. The male raised his head above the body level of female. The male first put one of his feet over the back of female, followed by the second foot. He clasped the female's back with long toes. Sitting on the back of female, the male made continuous shrilling mounting calls. He kept on flapping his wings for balance. The calls made during mounting were similar to the invitation calls. The tail of female was kept up for facilitating cloacal contact. The female kept her wings partly unfolded (Fig7.4). The mounting lasted for 20 to 42 seconds ($\bar{x}$=33 seconds, N = 6).

Having dismounted, female and male touched their beaks each other. Then they indulged in autopreening and allopreening. After copulation the male was found preening elaborately by himself for about 10 minutes. He rubbed his toes with beak and vice versa. Then both the male and the female set about feeding. It was also observed that the male preened the female for 5 to 10 seconds and then parted (Fig 7.5). But the female was not seen preening herself or male after copulation.

Well defined specific time interval was not observed between two consecutive mountings. The interval varied like 30 minutes (N=30), 90 minutes (N =18) and 110 minutes (N = 6) between two consecutive mountings by any pair.

Totally 157 mountings were observed during a single breeding season (Southwest monsoon) of which in 131 (83.4%) occasions the mounting was monogamous (among the same pairs), in 18 (11.4%) occasions polygynous, in 5(3.18%) occasions polyandrous and there were 3 (1.9%) homosexual mountings [(male x male) (N = 1) and female x female (N = 2)]. In polyandrous mounting one female was being mounted by 2 to 4 males one after another. The courtship displays, pre and post copulatory behaviours were same as in the monogamous mounting. In polygynous mounting a male mounted 2(N =12) to 4 (N =7) females (Table 7.4). Here also the courtship displays, pre and post copulatory behaviours were as same as in monogamous mounting. In homosexual mounting neither courtship displays nor pre and post copulatory behaviours were observed.

7.4.5. *Nest site selection*

The nest site was mostly selected in inaccessible areas of the habitat. The access to the nest was difficult due to vegetation like thick mat of Salvinia and Nymphaea around or overgrown vegetation or deep water. The nests

Table 7.3 **Composition of flock**

Total Adult (M)	Total Adult (M)%	Total Adult (F)	Total Adult(F)%	Total Sub Adults (M/F)	Total SubAdult %
29	37.6	39	50.6	9	11.6

Table 7.4 **Different types of mountings in Purple Moorhen**

Sl.No	Types of Mountings	Frequency	Number of Mountings month wise			
			Jun	Jly	Aug	Sept
1	Monogamy	131	19	38	60	14
2	Polygyny	18	6	9	3	-
3	Polyandry	5	1	3	-	1
4	Homosexual	3	1	-	-	2

were mostly not easily accessible to human and non human predators and nor visible to aerial predators due to the vegetation cover. Out of 29 nests 23 (62.06%) were found among overgrown vegetation, 3 (10.3%) over Nymphaea leaves and 3 (10.3%) over Salvinia mat. The nests over the Nymphaea and Salvinia were without adequate covering of vegetation.

Some ecological parameters (floating vegetation, emergent vegetation, water depth, open water body and associated species) were studied around 4 randomly selected nests (N1, N2, N3 and N4). It was found that emergent vegetation was exclusively found within 50m radius of all the nests. Floating vegetation was present around 3 nests (N1, N3 and N4) but not found around 1 nest (N2). Open water body was also found near all the nests except one (N4). There were associated species within 50m range of all the nests. Water depth around all the nests ranged between 1.42m.and 2.42m. (Table 7.5).

17 species of birds were found in and around the territories of breeding moorhen and could be associated species (Table7.6). Of these White breasted water hen, Bronzewinged Jacana and Little grebe bred in the same jheel. However the nest was located 25 to 50 meters away from the nest of moorhen. Territorial rivalry was observed between breeding moorhen and associated species.

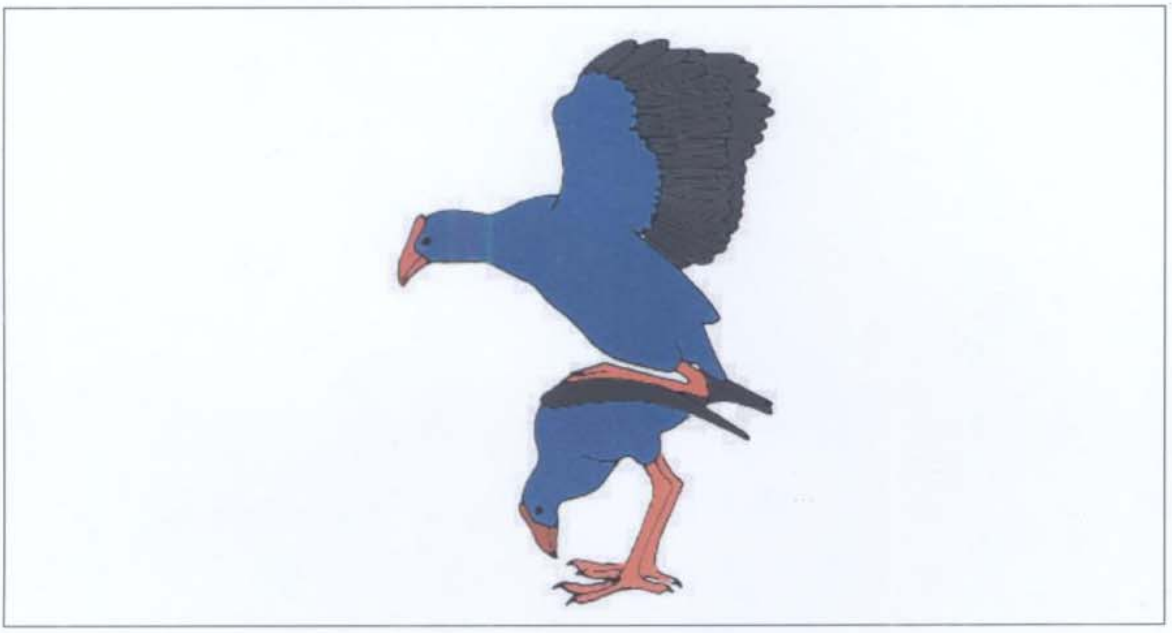


Fig.7.4 **Mounting**

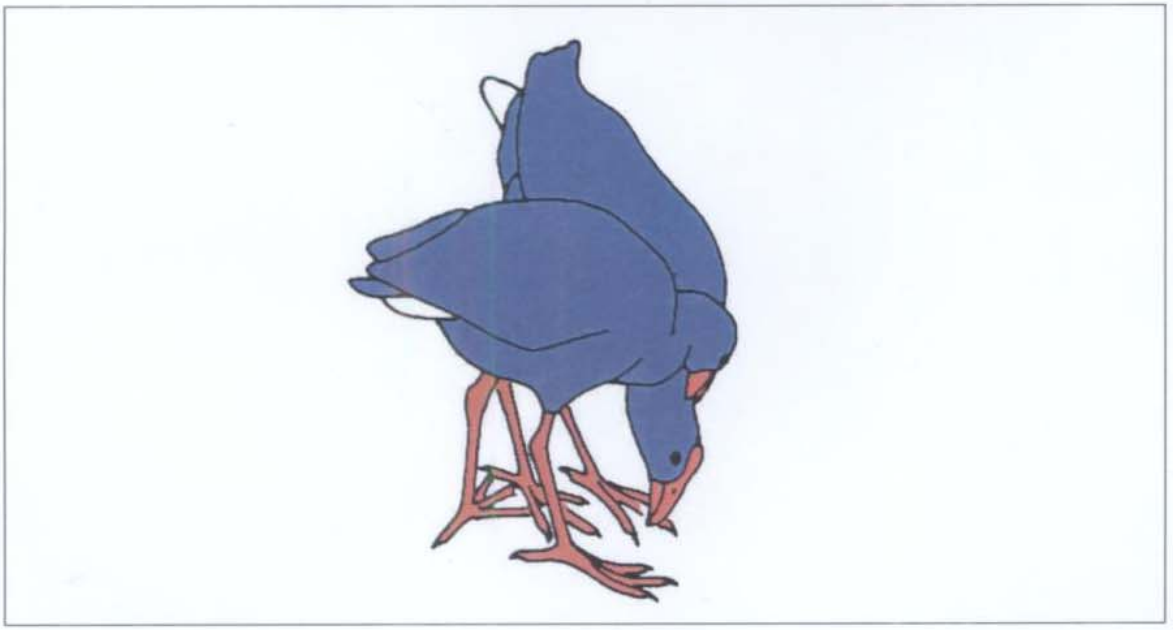


Fig. 7.5 **Allopreening**

7.4.6. *Nest*

The 22 (72.4%) nests were compactly built but 8 (27.5%) were loosely built. The nests were constructed at an average 34.03 cm above water level. Mean diameter of the nests was 46.6cm (N=29) and the mean depth was 24.1cm (N=29). The circular rim of nest was made up of stems of grasses and *O. granulata.* The floor of the nests was lined with bits of stem, leaves, sepals and petals of Nymphaea flower, Salvinia, dry leaves of Oryza. sp and several other grasses (Table 7.7). Materials that were used higher in numbers were the stems and leaves of *Oryza granulata.* The distance between two nests ranged from 20m. to 150 m. The closest nests were placed 20m apart and the maximum distance between 2 nests was 150m.

Both the parents and subadults participated in the nest construction. They collected the nest materials and carried in the beak to the sight of construction. Female took care of major work of nest making. Exact number of days taken for nest construction could not be assessed as the nest materials were found added to the nest even after the first egg was laid. But the interval between the onset of nest construction and laying the first egg was 3 - 7 days ($\bar{x}$ =4.66 days, N=12). In the pair unit it took up to 7 days to complete a nest. The multi member flock finished the nest within 3 to 4 days. Mating was observed even during the nest construction.

To construct the nest, first the rim was built by bending stems of

Table 7.5 **Nest site analysis**

Nests / Parameters	N1				N2				N3				N4			
	a	b	c	d	a	b	c	d	a	b	c	d	a	b	c	d
Emergent Vegetation	✓	✓	✓	-	✓	✓	✓	✓	-	-	✓	✓	✓	-	-	-
Floating Vegetation	✓	✓	✓	-	-	-	-	-	-	-	-	✓	-	✓	✓	✓
Openwater	-	-	-	✓	-	✓	✓	-	✓	✓	-	✓	-	-	-	-
Associatory Species	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water depth (mean m)	2.00	2.13	2.00	2.00	1.45	1.42	1.56	1.43	1.69	1.50	1.50	1.54	2.40	2.41	2.32	2.42

N1, N2, N3, N4 - nests
a, b, c, d -Areas around nests between ropes

tall grasses and *Oryza granulata* in a circular shape. The grasses were inter-woven by the beak and toes. The nest was camouflaged with the surroundings and were made invisible by bending down the over grown vegetation (Plate III, picture 1).

7.4.7. *Egg laying*

The first egg was found in a nest on June 23rd at 0.700 hrs. and the last one on June 27 (Clutch size was 4) at 0730 hrs. Major construction of the nest was completed 2 to 3 days (N=12) before laying the first egg. But nest materials were added even after the complete clutch was laid mainly to conceal the nest. After laying the eggs the females did not go far away from the nest and they sought food within 5 to 10m distance of the nests.

7.4.8. *Clutch size*

Out of 24 nests observed in Southwest monsoon 6 were without eggs and out of 5 nests observed in Northeast monsoon one was without egg. The clutch size varied from 1 to 9. Clutch size 1 and 9 were found only in 2 nests each. 4 eggs were found in 9 nests, 5 eggs in 4 nests and 8 eggs in one nest. Out of 4 nests with eggs observed in Northeast monsoon 3 were with the clutch size 4 and one nest with 5. Four egged nests were found in the highest frequency: in Southwest monsoon it was 9 (37.5%) and in Northeast monsoon it was 3 (60%), (Table 7.8).

Table 7.6 **Associatory species in the breeding site**

Sl.No.	Common Name	Scientific Name	Family	Breeding
1.	Little Cormoront	*Phalacrocorax niger*	Phalacrocoracidae	_
2.	Little Egret	*Egretta grazetta*	Ardeidae	_
3.	Large Egret	*Egretta alba*	Ardeidae	_
4.	Median Egret	*Egretta intermedia*	Ardeidae	_
5.	Cattle Egret	*Bubulcus ibis*	Ardeidae	_
6.	Purple Heron	*Ardea purpurea*	Ardeidae	_
7.	Pond Heron	*Ardeola grayii*	Ardeidae	_
8.	Lesser whistling Teal	*Dendrocygna javanica*	Dendrocygnidae	_
9.	Banded Crake	*Rallina eurizonoides*	Rallidae	_
10.	White breasted water hen	*Amaurornis phoenicurus*	Rallidae	✓
11.	Ruddy Crake	*Porzana fusca*	Rallidae	_
12.	Water Cock	*Gallicrex cinerea*	Rallidae	_
13.	Indian moorhen	*Gallinula chloropus*	Rallidae	_
14.	Coot	*Fulica atra*	Rallidae	_
15.	Bronze Winged jaccana	*Metopidius indicus*	Jacanidiae	✓
16.	Little Grebe	*Tachybaptus ruficollis*	Podicipedidae	✓
17.	Darter	*Anhinga melanogaster*	Anhingidae	_

Table 7.7 **Plants used for nest building**

Sl. No	Plants	Building materials
1	*Sacciolepis indica*	Stem, leaves
2	*Oryza granulata*	Stem, leaves
3	*Nymphaea stellata*	sepals, peduncle
4	*Salvinia molesta*	leaves
5	*Cyperus exaltatus*	stem, leaves
6	*Eleocharis acutangula*	stem, leaves

Table 7.8 **Clutch size**

Southwest monsoon			Northeast monsoon		
Clutch size	Frequency	Clutch size %	Clutch size	Frequency	Clutch size %
0	6	25	0	1	20
1	2	8.3	1	0	0
4	9	37.5	4	3	60
5	4	16.6	5	1	20
8	1	4.1	8	0	0
9	2	8.3	9	0	0
Total Nests = 24 **Total Eggs = 84**			**Total Nests = 5** **Total Eggs = 17**		

7.4.9. *Egg*

The egg is oval in shape; light yellowish cream. Egg surface has several dark reddish spots. Several light or ashy spots and blotches are also seen sparsely. The ashy spots are dimmer than the brown spots. Most of the spots are roughly circular with varying circumfrances. A few blotches are larger and shapeless than the others. The colouration camauflages the egg among dry grasess and other vegetation used as building materials of the nests. Major axis of the egg was about 4.2cm long (N=25), while minor axis was about 3.1 cm (N=25). The egg weighed about 31.3 gm (N=25) and the average egg volume was 29.9 cm^3 (N=25), (Plate III, Picture2).

7.4.10. *Egg loss*

Human and non human predators were found posing threats to the breeding success of the bird. People, mainly grass cutters, collected the eggs to eat. The eggs were said to be delicious and nutritious. While collecting the eggs many nests were destroyed.

7.4.11. *Predators*

The important birds which preyed on the eggs and chicks of Purple moorhen were Pariah Kite, Brahmini Kite, House Crow and Shikra (Table 7.9). These birds made frequent visits in the habitat during breeding season. During South West Monsoon breeding period the predator birds were sighted 425 times. House Crow appeared in the highest frequency of 274 (64.4%)

and they preyed on 31 eggs (59.6%) and 6 chicks (40%). Although the Crows made 65 attempts they succeeded in 56.9% times. The Brahmini Kite appeared in the habitat totally 131 times (32.2%). It made 21 attempts out of which 66.6% were successful. The toll of eggs taken by this raptor was 12 and chick was 2. Pariah Kite visited 77 times (18.1%). It made 10 attempts and 80% were successful. It took away 7 eggs and 1 chick. Shikra visited 37 times (8.7%) and made 17 attempts of which 47.05% were successful. It took a toll of 2 eggs and 6 chicks (Fig 7.6). The predator birds used some trees in the peripheral land for perching namely *Cocos nucifera, Musa paradisiaca, Areca catechu, Macaranga indica, Mimusops elenji, Anacardium occidentale, Terminalia alata,* and *Artocarpus heterophyllus.*

The non avian predators found in the breeding site were Rat snake, Jackal, Stray dog and Mongoose. Stray dogs were found consuming one full size clutch (4 eggs) and Jackal once preyed on 2 eggs and remaining 4 eggs were damaged in a nest. A Rat snake also was found swallowing an egg. A Mongoose once took away an egg from a nest. Predators such as the Dogs and Jackals damaged nests in their attempts of predation (Table7.10).

7.4.12. *Sample nest study*

The mean clutch size in the 12 nests was 4.8. There were totally 57 eggs in the 12 nests. The frequency of nests with 4 eggs was the highest 7 (41.1%) followed by 5 egged nests (2,16.6%), nests with 6 eggs (2, 16.6%)

Plate III

Picture 1. **A nest with broken egg shell**

Picture 2. **A four egged nest**

Table 7.9 **Predators of eggs and chicks**

Birds		Mammals	
English Name	**Scientific Name**	**English Name**	**Scientific Name**
House Crow	*Corvus splendens*	Stray dog	*Canis familiaris*
Brahmini Kite	*Haliastur indus*	Jackal	*Canis aureus*
Pariah Kite	*Milvus migrans*	Mangoose	*Herpestes edwardsi*
Shikra	*Accipiter badius*	Rat Snake	*Rattus rattus*

Fig 7.6 **Predation attempts**

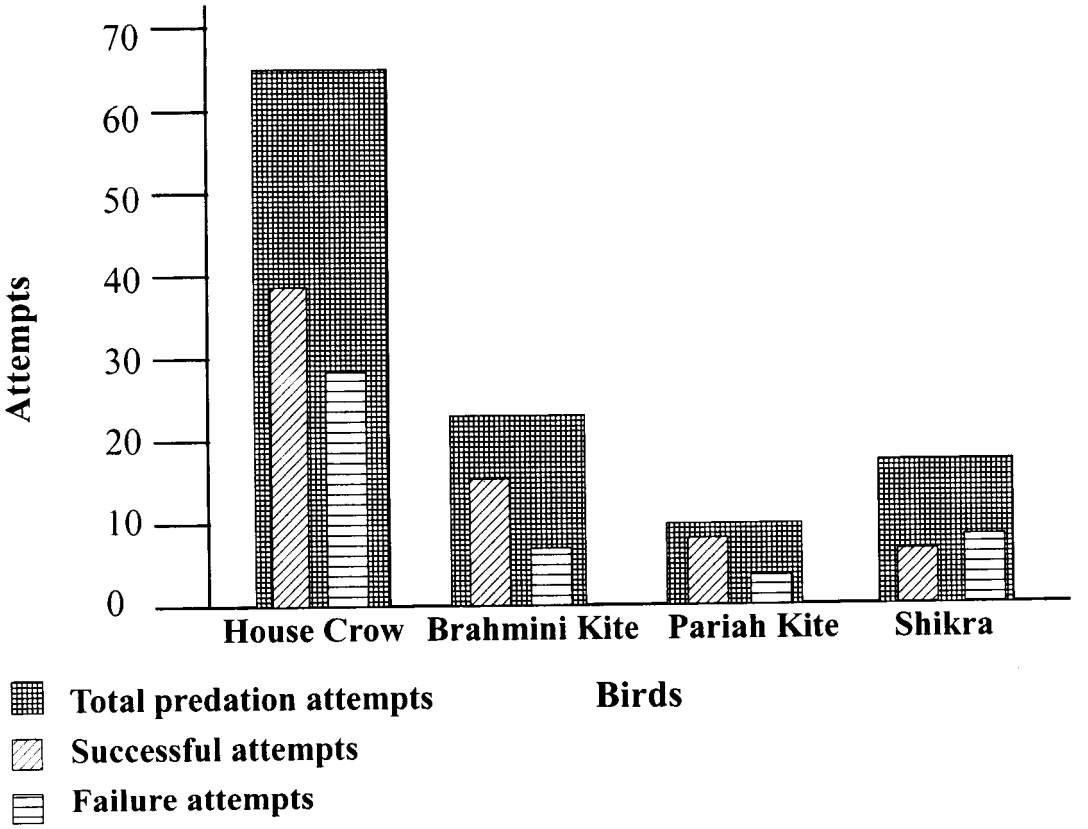


Table 7.10 **Predation of eggs and chicks by birds during southwest monsoon breeding season (1998)**

Predator Birds	Eggs						Chicks					
	Jun	July	Aug.	Sept.	Total	%	Jun	Jly.	Aug.	Sept.	Total	%
House Crow	4	10	17	-	31	59.6	-	1	3	2	6	40
Brahmini Kite	-	5	7	-	12	23	-	-	2	-	2	13.3
Pariah Kite	-	4	2	1	7	13.4	-	1	-	-	1	6.6
Shikra	1	-	1	-	2	3.8	-	-	2	4	6	40
Total	5	19	27	1	52		-	4	7	4	15	

Table 7.11 Sightings of predator birds during Southwest monsoon in the Moorhens breeding location (1998)

Predator birds	Sightings												Total
	June			July			August			Sept			
	Air	Ground	Perch	Air	Ground	Perch	Air	Ground	Perch	Air	Ground	Perch	
House Crow	19	2	16	17	9	33	29	32	40	10	26	41	274
Brahmini Kite	9	-	4	5	11	19	3	13	26	3	18	20	131
Pariah Kite	5	-	-	7	4	13	2	11	12	1	8	14	77
Shikra	2	-	-	1	-	6	4	-	9	3	1	11	37

and nests with 7 eggs (1,8.3%). Out of 57 eggs, 17 (29.8%) were lost due to predation (Table 7.12).

7.4.13. *Incubation*

Incubation started before laying complete clutch (N=10). Both the male and female were found incubating the eggs. The female incubated during day time and the male during night. The incubation was discontinuous. If disturbed the incubating female left the nest and kept on foraging about the vicinity. When an intruder approached the nest the incubating bird protected the nest by threatening displays, calls and fight. Sometimes the bird drove away the the predator by moving from the nest for some distance. Standing there it made alarm calls along with threatening displays. Both the male, female and subadults attempted defending the eggs. The incubation period was 20-23 days($\bar{x}$=21.2, N=12). Male share of incubation was 6-7 days ($\bar{x}$=6.6days, N=12). The male replaced the female in incubating in the late evening. After the male took the charge of night incubation, the female was found foraging in the vicinity. Whether the night incubation was continuous is not known. The female took the charge of incubation between 0600hrs. and 0700hrs (N=12 nests).

7.4.14. *Hatching*

The first chick was found in a nest in July 20 at 01100 hrs. The incubating female was found helping to remove the broken shells of the peeped

eggs to facilitate the emergence of chicks. The eggs in a clutch hatched out at different times. It took about 4-6 hrs to hatch out all the eggs in a clutch of 3 nests. In 9 nests it took 2 days to hatch the full clutch. The 7 unhatched eggs were collected and examined in the laboratory. The 5 eggs had rotten embryos and the reason for the hatching failure of 2 eggs were not clear (Plate IV).

7.4.15. *Chicks*

The chicks were precocial, nidifugous and ptilopaedic. The body of newly hatched one was wet with albumin. Most of the body was covered with black sparse down. Pinkish skin was visible through the down especially around the neck. The eyes of newly hatched ones were fully opened. The legs were pink and the beak white with a tinge blue. At the base of upper and lower mandibles a red spot was found. Forehead had white patch and the orbital ring was pink. On the upper bill towards the base was seen a brown mark. The mouth cavity was red. Within a few minutes of hatching the albumin got dried and the chicks started moving about just outside the nest. Soon after hatching the chicks often made swee.....swee....swee.. calls and followed the parents. The chicks were found quivering their rudimentary wings before the parents, probably to convey that they are hungry (PlateV) .

7.4.16. *Begging calls*

The chick made swee.... swee.... calls repeatedly to communicate

their need for food. The chicks also expressed their hunger by pecking at the beak of parents or subadults which approached the chicks. Hearing these begging calls the parents ran towards the chicks and offered food. Within 2 or 3 days, the chicks were found foraging with their parents. However they had continued dependence on the parents for getting sufficient food. Even the subadults at occasions were offered food by parents and other subadults.

7.4.17. *Parental care*

Not only the parents but also the subadults were noticed providing parental care -feeding and protecting the chicks. However, the subadults were not seen incubating the eggs. Male and female parents and subadults supplied the food to the chicks soon after they started moving about the nest. Mainly the female parent offered food to the chick of a week age. Plant materials (mainly soft pith) were the major food items given to the chicks. The entire grass was also seen plucked out and made into small pieces and supplied. The plant bits were placed in the beak of the chick. The parents were seen carrying the food plant from far away to the nest. Sometimes the chicks themselves were seen picking up food from the beak of their parents.

The characteristic flickering of tail of parents presumably acted as a visual signal to the chicks. While the parents were foraging in the grass they became almost invisible. Flickering tail helped chicks to find out the whereabouts of their parents. Exposure of white undertail coverts of the

Plate IV

Picture 1

Picture 2

Picture 3

Picture 4

Various stages of hatching
(Ist day)

Plate V

Picture 1.

Picture 2.

Picture 3.

Different views of a chick (2nd day)

parents to the chicks also served as a visual signal of direction and presence.

The parents and subadults offered protection to the chicks from predators and intruders. The parents defended their chicks by making threatening calls; deep Krrr.....krrrr.....krrr.....calls (female) and Que.....Que.....Que.....(male). Assuming a threatening posture the parents were found flapping their wings along with sharp calls and the intruders were often chased away. If the predators were unwilling to leave the chicks, the parents also indulged in severe fight.

7.4.18. *Escape strategies of chicks*

Seeing an aerial or terrestrial predator the chicks made some attempts to escape. They hid in the vegetation or dived in water keeping only the beak above the water surface. The chicks were capable of remaining in water for 3 - 8 minutes. The chicks remained concealed under growth and silently remained there till the enemies had left the scene.

Incidence of a Black drongo, *Dicrurus adsimilis* acting as a guard to Moorhen chicks was seen. This occured when a Brahmini Kite, *Haliastur indus*, appeared in the sky. After circling there in the sky for a few minutes the raptor flew down to the chicks. Seeing the kite approaching the chicks, the parents stopped feeding and indulged in threatening displays with harsh calls krrrr...krrr...krrr. (female) Que...Que...Que...(male). When the raptor

was about 2m high from the moorhens they intensified their calls and that seemed to be a signal for the flocks to close in. Within seconds 6 birds congregated in an area to defend the young ones. A few in the flock took to their wings to drive out the kite. Overlooking the feeble protest from the rails the kite continued to annoy them. At that instance a black drongo *Dicrurus adsimilis* flew into the scene and chased the kite, almost about 8 times larger than the drongo. The drongo pecked twice or thrice at the back of the raptor and within a few minutes the intruder was driven out of the habitat.

7.4.19. *Hatchling development*

The average weight of a chick at hatching was $\bar{x}$ =29.9gm. (N = 10). The frontal shield appeared at four weeks but was bluish black in colour. The shield at an age of three months old was turned red coloured. The beak blackish and it acquired red colour after 4 months. Till then the beak was blackish. The white filament and downs of chick disappeared by two weeks. Purplish colour started appearing in the body after one month. A month old bird has white under tail coverts. The two month old bird was brightly purplish. The bird acquired capacity of flight by three months. The juvenile of Moorhen has blackish beak and ashy grey legs and toes. Its breast is purplish, upper wings bluish green and frontal shield pinkish. Whitish feathers appeared below the tail which is stumpy. The wings had not developed well

and the entire body was duller and paler than the immature bird. The immature moorhen is almost similar to the adult but it has duller purplish violet in upper parts and head. Its breast and belly had dark grey and whitish feathers which were similar to the juvenile feathers. The frontal shield became red but duller and a brown patch was seen in the bill.

The chick underwent a series of changes during the first month after hatching, transforming it to juvenile stage. The morphological transformation of the juvenile took place during the first month. After the first month of hatching the immature features started appearing in the body. When the bird attained about the age of five months the adult morphological features appeared. A six month old bird was not easily distinguishable from the adult in respect of morphology. However body and frontal shield were smaller than that of the adult. One year old bird is believed to be an adult with deep purple body and with bright red bill and frontal shield.

7.4.20. *Hatching and breeding success*

Hatching success varied in different nests. Out of 57 eggs(in 12 nests)17 were lost (29.8%). Of the remaining 40 eggs 33 hatched (57.8%) and 7 remained unhatched (12.2%). In 2 nests (clutch size 4) all eggs hatched out (the hatching success was 100%). In another nest (clutch size 5) 4 eggs were lost and remaining one did not hatch. In total hatching success in the 12 nests was 82.5% (Table 7.13). Totally there were 33 chicks (57.8%) of which

8 were preyed upon and 3 (9%) died. 22 (66%) chicks survived. The cause of mortality (except for the predation) of chicks was not known. The overall breeding success was 66.6% (Table 7.14).

7.5. Discussion

In the main study area the major breeding season of Purple moorhen was Southwest and Northeast monsoon. However in another area, Avala it was observed that even in summer season the birds indulged in nesting activities. This variation was probably due to that the main study area became almost dry during summer months whereas the water level in the other location does not go below 1.9m even in the hottest month, May. The Avala area also harboured sufficient vegetation, a conducive factor for breeding. When the rivulets of the Jheel in the main study area get blocked in 1999 the breeding activities were observed throughout the year even in summer months. This unusual breeding activities in Azhinjilam could be accounted for the sufficient water and vegetation which are believed to be two prime factors for the breeding of the moorhen. Sutherland and Maher (1987) report that vegetation is a crucial factor influencing breeding habitat suitability. It was also noticed that the nests of Common moorhen were positively correlated with the presence of standing water (Fredrickson 1971). Keslall and Leopold (2002) noticed lowered water levels may reduce the abundance of aquatic plants affecting the breeding of wetland birds. Accord-

Table7.12 **Sample nest study**

Nests	Clutch size	Eggs predated	Eggs hatched	Eggs unhatched	Chicks predated	Chicks died	Chicks survived
1	4	2	1	1	-	-	1
2	6	1	5	-	1	-	4
3	4	-	4	-	1	-	3
4	4	-	2	2	-	1	1
5	5	4	-	1	-	-	-
6	4	-	3	1	2	-	1
7	5	3	2	-	-	-	2
8	7	2	4	1	1	-	3
9	6	-	5	1	2	-	3
10	4	-	4	-	-	2	2
11	4	2	2	-	-	-	2
12	4	3	1	-	1	-	-

Table 7.13 **Hatching success**

Total No. of eggs laid	Eggs lost	No. of eggs remained	No. of eggs hatched	No. of eggs unhatched	Hatching success
57	17 (29.8%)	40 (70.1%)	33 (57.8%)	7 (12.2%)	82.5%

Table 7.14 **Breeding success**

Total number of chicks hatched	Number of chicks lost	Number of chicks survived	Breeding success
33 (29.8%)	11 (33.3%)	22 (66.6%)	66.6%

ing to Craig (1979) the breeding success of *P.melanotus* depends on depth of water and amount of emergent vegetation. It is also indicated that minimum level of water depth (0.5m) to prevent terrestrial predators and minimum level of emergent vegetation to hide nest are necessary for breeding. Present study also shows that water and emergent vegetation were found as inevitable factors for the breeding of *P.p. poliocephalus.* Most of the nests of *P.melanotus* were placed in an area with water and vegetation but offshore islands nests were often built away from water (Craig and Jameison 1987). Their study suggests that the breeding success became low with low water level. The breeding season of Bronze winged Jaccana and Pheasant tailed Jaccana in Barathpur was found depending on timing and intensity of South west monsoon, availability of water, thick patches of emergent vegetation and suitable habitat (Vijayan 1991). Local variations in breeding season were also noted elsewhere : A.P (November to February) and Mysore (November to January) (Ali and Ripley 1983). The peak month was August when the largest number of nests were observed. This observation has been in agreement with the observation of Whistler (1935). Bhupathy(1985) observed mating in 23 occasions in Bharathpur from January to March. Eventhough the 12 matings were successful he found the birds not attempting to build nests. This mating could be mock mating or for maintaining the bonds.

In Kerala most of the earlier reports showed that the Purple moorhen bred only during Southwest monsoon mainly in July and August (Ali 1969, Neelakantan 1958, Ravindran 1992). However, in January 1989 an adult with two chicks were reported in a perennial Jheel (Sasikumar 1989, personal communication). The bird is also said to breed throughout the year in a wetland in Gauhati, Assam, (Snehal Patel 1999, per.comm) which holds water even during summer months. These reports suggest that the breeding season of Purple moorhen depends on the nature of breeding habitat. In Australia, the breeding season of *P.melanotus* depends on rain fall, temperature and photoperiod (Halse and Jaensch 1989). In Subsaharan Africa Taylor (1998) reports that this subspecies has two breeding seasons coinciding with bimodal rain regimes.

The birds defended their territory individually and groupwise. The former was seen against the conspecific intrusion and the later against the interspecific intrusion. The members of various units were found congregating to defend the eggs and chicks from predators. In *P. melanotus* group defence is required for the persistance of breeding territories in the most of the habitats and all members of the group including subadults participated in defence (Craig 1974, Ricklefs 1975). Large territories usually with undefined boundaries were defended mainly by males but by females and helpers (Craig 1977). In *P.melanotus* many territories are defended all year but some

break down after breeding (Jameison 1990).

The present study suggests the pair and group breeding in *P.p. poliocephalus*. The subadults helping for nest building, feeding and protecting the young ones is an evidence for communal breeding in this gallinule. The instance of communal breeding in the birds was first explained by Skutch (1935). There were 9 subadults which provided food and protection to the young ones. They were distributed in 4 member, 5 member and 9 member units. The sex and parents of the subadults could not be identified in the present study. Craig (1991) defines "Communal or cooperative breeding is a reproductive system in which one or more members of a social groups provide care to young ones that are not their own offsprings".The care givers may be nonbreeders called helpers or auxiliaries or joint breeders (Stacey and Koening 1990). Researchers have noticed the communal breeding systems (Brown 1978, Emlen 1982, Maynard smith and Ridpath 1972, Vehrencamp 1977). Out of 9000species of birds in the world less than 3% breeds communally (Brown 1987, Emlen 1984). Of these majority are tropical species (Craig 1991). Craig (1980) reports that pair breeding is more successful than group breeding. The *P.p. melanotus* opts for communal breeding probably because of limit in the resources required for breeding and variability in food availability prevents all pairs from breeding (Craig 1991).

In *P.melanotus* various breeding systems have been observed: pair

breeding, promiscuous breeding, and with the help of juveniles of earlier brood (Craig 1979,1980). Monogamous, polyandrous, polygynous and homosexual matings were observed in *P.poliocephalus*. Monogamy prevails in *Porphyrio porphyrio medagascarensis* but *P.p. poliocephalus* and *P. melanotus* breed communally (Harrison 1970, Holyoak 1970). In *P. melanotus* breeding groups contain 2-7 breeding males, 1-2 breeding females and up to 7 non breeding helpers (Taylor 1998).

In Newzealand, the birds disperse before breeding, leaving some small flocks of non breeders in the habitat (Marchant and Higgins 1993). In the present study also dispersal of *P.p. poliocephalus* before breeding was observed. It was likely that some flocks from stock breeding population moved to nearby minor jheels and returned to the main habitat after breeding when the young ones attained capability of flight. However ringing study is necessary to draw a conclusion on the dispersal movement of the *P.p.poliocephalus*.

Mating of one female with more than one male while each male mates with only one female is known as polyandry. This mating system is found in less than 1% of bird species and is found mostly in waders (Paul 1994). Pettingill (1970) states polyandry as a system where in a female mates with two or more males. In *P.p. poliocephalus* one female was found mating with more than one males but could not be checked whether the same males mated with more than one females. The common pattern of sexual

dimorphism in polyandrous birds in which female is larger than male is true in *P.p. poliocephalus* (Ali 1969). Contrary to the sex reversal roll both the male and female shared the duties of parental care in *P.p.poliocephalus* although the females are seen performing most of the duties of nest building incubation and care of chicks (Paul 1994).

The abnormal clutch size of 9 was found in 2 nests.The number of eggs more than 6 suggest the probability of egg laying in the same nest by more than one birds - the conspecific brood parasitism as studied in British moorhen *Gallinula chloropus* (MaCrae 1997). Communal breeding and brood parasitism were observed in moorhens by Forman (2005). In British moorhen MaCrae(1997) noted 10% of nests have received eggs from conspecifics. Craig (1980) reports that more than one females of *P.melanotus* lays eggs in one nest. Although the number of eggs in the clutches of *P.p. poliocephalus* variable upto 10 is reported by Whistler (1935); he has not mentioned the intraspecific brood parasitism probably because this unusual breeding system in birds was not known to ornithologists of that period. Ali and Ripley (1983) reported the largest clutch size of 7 egg. Vijayan(1991) has noted clutch size 5 to 10 with mean 6.2 in Indian moorhen *Gallinula chloropus.* But further study is necessary to prove conspecific brood parasitism in *P.p.poliocephalus.*

There is a direct relationship between clutch size of *P.melanotus* and

the area of its breeding territory (Craig 1979). In *P.melanotus* more than one females laid eggs in one nest evidently due to the presence of two eggs with different colours laid in the same nest in a single day (Craig 1980). Clutch size of birds varies with age, weather conditions, season, individual variation, geographical area, presence of predators and types of nests (Pettingill 1970). Clutch size in *P.p.melanotus* is also found related to position of female in hierarchy, age, size of group and whether first or subsequent clutches (Craig 1980). Study in *P.melanotus* in Newzealand has shown the incestuous mating and multiple paternity in group (Craig and Jameison 1987, Jameison 1986). In Australia breeding trios reported in *P.melanotus* (Ridapth 1972). Electrophoretic analysis of egg protein in *P. melanotus* has confirmed multiple paternity of a clutch because more than one male copulates with a female even during egg laying period (Stacey and Koening 1990). In the present study it is not clear whether the female laid more than one clutch in a breeding season as observed in *P.melanotus* by Craig (1980) and in the British moorhen, *Gallinula chloropus* by McRae(1997), which is found to be multiple brooded in a breeding season.

Most of the workers have noted that majority of helpers are close relatives, especially the young one of the previous years (Brown 1981). Birds feed the begging offsprings purely as a stimulus response mechanism (Jameison 1986, 1988). However, some studies have shown that birds help-

ing not only their kins but unrelated individuals eventhough the familiarity is a mechanism for kin recognition (Davies 1990, Stacy and Koening 1990).

During courtship display the male held a peice of weed in his beak, as was reported byAli and Ripley (1983) and Bhupathy (1985) and also seen in the present study. The piece is the food offered to the mate. In *P.melanotus* Ricklefs (1975) has noted *Lemna* leaves and occasionally *Typha* shoot being offered to the mate.The *P. melanotus* adds materials to the nest during incubation (Brown 1981). Similar observation was made in *P.p.poliocephalus.* The *P.melanotus* has built trial nests (Craig 1980). This behaviour not noted in the *P.p. poliocephalus.*

Observation of 7 (24.1%) nests, out of 29, without eggs could be due to the disertion or loss of complete clutch. Absence of egg shell fragments in any of these eggless nests rules out predation. Most probably the nests were deserted befeore egg laying. Several studies have shown that birds desert their nests finding the eggs or chicks would not be safe. Craig (1979) has noted desertion of 22 % nests in *P.melanotus.*

The incubation began where there were 3 or more eggs in the nests (N =12). But the bird continued incubating even when a single egg remained in a clutch after losing all the rest. One spell of incubation lasted for mean 30.2 minutes (N= 12) if the incubating bird was not disturbed. The nest relief displays were not seen in the *P.p.poliocephalus* unlike in the birds where in

both sexes incubate the egg. Incubation by subadults has been observed in *P.melanotus* (Jameison et al 1987). Factors stimulating incubation in birds are not clear but hormones play imoprtant role in the onset of incubation (Brown 1985). Prior courtship and nest building stimulate incubation but not necessarily in all species (Eisner 1960, Lofts and Murton 1973, Brown 1985).

Asynchronous hatching has been observed in Parrots, Hornbills, Bea eaters and in Kingfishers (Lofts and Murton 1973). In *P.p.poliocephalus* the eggs laid before starting the incubation hatched synchronously but the rest hatched asynchronously within a span of two days. Incubation period in birds is found to vary even when the incubation begins after the last egg is laid (Ridpath 1972). Synchronous hatching takes place mostly when the incubation starts when the last egg was laid (Ricklefs 1975). However, in Europian starling Ricklefs (1975) has found hatching is spread through six hours. In the precocial Galliformes and Anseriformes communication among chicks prior to hatching has stimulated or inhibited the hatching of the rest thereby enhancing synchrony (Nice 1949). Earlier hatching chicks are less probably exposed to time dependent mortality and death due to sibling competition (Ricklefs 1975). But it has been found that asynchronous broods of Cattle egrets, *Bubulcus ibis* showing less sibling competition than those artificially synchronised (Nice 1949). In *P.poliocephalus* the incubation period was

calculated as the time between the laying of the last egg and its hatching as suggested by Nice (1949). However, it was difficult to identify the last laid egg and the last hatched egg. The hatching in *P.poliocephalus* was spread 1 to 2 days and therefore the incubation period was 1 or 2 days more or less than the actually observed incubation period. Kendeigh (1963) has noticed that the intervals between the hatching of the eggs are shorter than the intervals between their laying. In *P.melanotus* (Newzealand) the incubation begins when the clutch is complete or mid way (Craig 1980). The incubation period in *P.melanotus* is 22 to 27 days in Newzealand while it is 25 to 27 days in Australia (Marchant and Higgins 1993).

A wetland supporting diverse plant communities interspersed with open water will provide suitable nesting habitat (Post 1998). The present study has confirmed that open water bodies and overgrown vegetation contributed to the survival of the chick since the former hindered the approach of predators and the later effectively concealed the chicks from the predators. Ali and Ripley (1983) has also noted that the chicks have concealed beneath water exposing their culmen. The chicks of *P.melanotus* have also concealed in water to escape from danger (Taylor 1998). The young ones of *P. melanotus* also hides beneath the nest at the approach of danger (Marchant and Higgins 1993). Parental antipredator behaviour was noticed in *P.melanotus* (Craig 1977). This agrees with the observation in the present

study. He elaborates that parents and subadults rush to the chicks if the predators are nearby and parents flap their wings to mislead attention of the predators from the chicks. Similar antipredator response was observed in *P.poliocephalus.*

"Seep ..Seep..Seep" begging calls with continuous notes or series of rapidly repeated notes were noticed in *P. pmelanotus* (Taylor 1998). In the present investigation it was found that the intensity and repetition of notes increased when the delivery of food to the chick was delayed by the parents. While one chick was offered the food the others rushed to the parents for food making begging calls with higher intensity.

In *P.p. melanotus* the tail flicking is a signal for the young to follow the adult and also a response to the predator and conspecifics (Taylor 1998). Craig (1974) also observed shivering of wings in the chicks of *P.melanotus* but has not explained the role of this behaviour. In the present study the chick was found stopping the shivering of its wings when its parents started feeding it. It seems likely that shivering of wings helped the chicks to express their need for food.

The human and nonhuman predators posed great threat to the breeding success of *P.poliocephalus*. Cattle moving to the breeding sites of the birds adversely affected the breeding success since they damaged the eggs and nests. The incubating birds and the chicks were also disturbed by the

cattle. Desertion of nests and incomplete clutches due to predation were noticed in Bharathpur (Vijayan 1991).

7.6. Summary

The study suggested that the bird bred in Azhinjilam in Southwest monsoon (24 nests) and North east monsoon (5nests) seasons in 1998 and 2000 but in all seasons in 1999 because the jheel was inundated throughout the year 1999. Prior to the breeding the birds flocked into separate groups with size ranging from 1-9 comprising males, females and subadults in various proportions. The bird showed monogamous(83.4%), polygynous (11.4%), polyandrous (3.9%) and homosexual (2%) mountings. The nests were made among thick vegetation with high water level and the nest was protected individually or groupwise. Courtship feeding and preening were observed. 17associated species of birds were identified around the nests. Nests were made out of various aquatic plant materials by the courting male and female with assistance from subadults. The clutch size varied from 1-9(mean 4.8). The predators included man, birds like kites, crows and shikra and the mammals like dogs and jackals. Both male and female incubated the eggs. The incubation period was 20 -23 days (mean 21.3 days, N=12) and the hatching was mostly asynchronous. The chicks were precocial and nidifugous and that were cared by the parents and subadults. Hatching success was 82.5% and the breeding success 66.6%. The juvenile was paler but the immature was almost similar to the adult in morphology. The three month old bird acquired capacity of flight.

BIOLOGY, ECOLOGY AND BEHAVIOUR OF PURPLE MOORHEN PORPHYRIO PORPHYRIO

Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology

BY

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CHAPTER VIII

SUMMARY AND CONCLUSION

A study was conducted on Biology, Ecology and Behaviour fo Purple moorhen *Porphyrio porphyrio poliocephalus* in Azhinjilam jheel from 1998 to 2002. Data were also collected from 25 minor wetlands in Kozhikode district. To study the population of moorhen in Azhinjilam a census adopting line trasect method was conducted from 1998 to2000. The adults, subadults and chicks were counted separately. The study suggested a trend of monthly, seasonal and annual fluctuation in population. The adult population was highest in January in 1998 and 2000 probably due to abundant vegetation and plenty of water which appeared to be two prime habitat factors detremining the population abundance. But from February to May the population declined due to the shrinkage of habitat. However with the advent of monsoon the population increased from June to February. In 1998 and 2000 the chicks were not seen from January to June and December since the birds did not breed during these months. However in 1999 unlike 1998 and 2000 the birds were found in high population with chicks in all months because the jheel was inundated throughout 1999. The jheel in 1998 and 2000 supported high population in early winter due to abundant vegetation and high water level. But from the end of winter and throughout summer the

population declined sharply as the habitat almost dried up. The early monsoon was favourable for the birds but the population decreased in the late months due to the flooding of the habitat. In 1999 the population was large in all seasons even in summer because of change in habitat. Further the birds moved to Azhinjilam from other surrounding wetlands which dried up in summer. It was observed that the moorhens were more or less safe in Azhinjilam because of conservation awareness of local people. The census of birds in 17 jheels in Kozhikode district in 2001 showed that there were totally 1756 birds but according to farmers there were more than 3500 birds between 1990 and 2000 emphasising a population decline of about 50% during a decade. The main causes of decline were poaching, collection of eggs, loss of nests and habitat.

It was observed that the macrohabitat of the birds comprised four different types of microhabitats namely open water, floating vegetation, emergent vegetation, emergent floating vegetation. The birds found in each microhabitat was counted separately during the years 1998,1999 and 2000. The analysis showed that in monsoon of 1999 and 2000 large number of birds were seen in open water bodies particularly in August and September probably because the most part of the jheel was inundated. However in 1999 more or less high water level in all the seasons attracted large population of birds to the open water bodies. In monsoon the birds did not frequent the

floating vegetation since most of the habitat was inundated whereas in summer and winter considerable population was seen in floating vegetation. In monsoon a few birds were seen in emergent and emergent floating vegetation due to the low availability of these microhabitats. However, in winter and early summer the birds more preferred the emergent and emergent floating vegetation.

In 2001 the food and feeding of the moorhen was studied by adopting direct focal observation method. The study revealed that the bird was predominantly a herbivore mainly feeding on pith, seeds, rhyzome and tender leaves of various aquatic plants most of which were troublesome weeds.The bird spent 53.2% time, out of total feeding time, to feed on *Oryza granulata*, 13.6% to feed on *Eleocharis acutangula*, 9.6% on *Hydroryza aristata,* 6.2% on *Cyperus exaltatus*, 5% on *Sacciolepis indica*, 4% on *Oryza sativa*, 3.5% on *Nymphaea stellata*, 0.7% on *Ludwigia adscendens* and 0.08% on *Fimbristylis meleaceae*. Eventhough the habitat was rich in *Salvinia molesta* the bird was never seen feeding on it. It was observed that the bird adopted various feeding strategies including pulling out, grazing, gleaning, ducking, jumping and pecking, bending and stem cutting.The bird often dislodged the mud from the pulled out plant before eating. The bird also fed on animal food like insects, larvae, earthworms, leeches, fishes, molluscs and amphibians. The moorhens preferred to feed in flock than in single or in

pairs since the flock feeding appeared to be adventageous for the bird.

The behaviour and various activities of the bird were investigated by focal observation method (Altman, 1974) using binoculars, spotting scope and a stop watch to monitor the duration of each activity. The moorhens habitat comprised a central core zone with plenty of vegetation and water and a buffer zone with sparse vegetation. The bird roosted in core zone in winter and monsoon but on coconut trees in the periphery of the jheel in summer. The roosting time of the bird was 10-20 minutes after sun set and the waking up time was 10-15 minutes before sun rise which were subject to change according to the change in the time of sun rise and sun set. The bird moved between the core zone and buffer zone in the morning, noon and evening. In the early morning the birds moved from core zone to the buffer zone and 80% birds were seen actively feeding in the buffer zone in the late morning. In the noon about 70% birds were seen in the core zone with least activities and in the evening 80% birds were found in buffer zone for active feeding. In the late evening around 80% birds returned to the core zone and all the birds took roost when the sun was set.

The study of vocalization shows that the bird made varieties of calls at different occasions. The prominant calls included Kr...Kr.., Luck.. Luck.., Gwe..Gwe..and Gu..Gu. The chicks made Swee..Swee (begging calls) for getting food from parents. The calls with different notes and tones played

important role in communication. In making some calls sexual difference was very clear. The bird made various types of locomotion and movements including skulking, walking, running, hopping, flying and swimming. Bathing, sunning, preening and fanning were important maintenance behaviour of the bird. The prominant agonistic behaviours shown by the bird included chasing, clawrip, pecking and charge. The bird showed spectacular displays and postures orienting the wings, tail, neck and head at different directions which appeared to be very effective in communication. The characteristic tail flicking also seems to be used for communication. The tail flicking rate ranged between 44-69 times per minute (N=100) depending on situations. It was observed that out of 12 activities studied the bird allotted the highest percentage of its active hours for feeding. In the morning and evening of all seasons the birds actively fed with peaks of 82.7% between 08.00 and 09.00 and 78.6% between 17.00 and 18.00 in winter, 60% between 09.00 and10.00 and 60.4% between 17.00 and 18.00 in summer and 79.4% between 09.00 and 10.00 and 72.2% between 17.00 and 18.00 in monsoon. The maintenance, agonistic, sexual and moving activities also showed seasonal variations.

The study of breeding biology conducted in 1998 was aimed at understanding various phases of nesting, hatching and breeding. The study was made by direct observation, measuring and counting the eggs and nests

and analysing the nest site characteristics. The study suggested that the bird bred in Azhinjilam in Southwest monsoon (24 nests) and Northeast monsoon (5 nests) seasons in 1998 and 2000 but in all seasons in 1999 because the jheel was inundated throughout the year (1999). Prior to the breeding the birds flocked into separate groups with size ranging from 1-9 comprising males, females and subadults in various proportions.The bird showed monogamous (83.4%), polygynous (11.4%), polyandrous (3.9%) and homo-sexual (2%) mountings. The nests were made among thick vegetation with high water level and the nest was protected individually or groupwise. Court-ship feeding and preening were observed. 17associated species of birds were identified around the nests. Nests were made out of various aquatic plant ma-terials by the male and female with assistance from subadults. The clutch size varied from 1-9 (mean 4.8). The predators included man, birds like kites, crows and shikra and the mammals like dogs and jackals. Both male and female incubated the eggs. The incubation period was 20 -23 days (mean 21.3 days, N=12) and the hatching was mainly asynchronous. The chicks were precocial and nidifugous and that were cared by the parents and sub-adults. Hatching success of 57 eggs in 12 nests were 82.5% and the breeding success was 66.6%. The juvenile was paler but the immature was almost similar to the adult in morphology. Three month old birds acquired capacity of flight. The study is helpful to draw a conclusion that the species is under

threat in the most of its pockets. The farmers in general see the bird as a pest of paddy trying to eliminate them at any cost. The birds are also hunted in large numbers for meat. Extensive reclamation of wetlands is another threat to the survival of the bird.

Based on the present study the following recommendations are felt necessary to conserve the Purple moorhen and its habitats. Enact rules to punish the poachers of wetland birds including Purple moorhen. Alteration of natural wetlands by any means shall be banned legally. Farmers should be made aware of the cheap techniques to scare the birds from the paddy fields. There should be restrictions in the use of chemical pesticides and fertilizers in the farm lands. People should be educated about the importance of wetlands and their birds. Purple moorhen should be included in the schedule I of wildlife protection act 1972. More and more wetlands shall be identified and categorised as Ramsar sites in Kerala.

BIOLOGY, ECOLOGY AND BEHAVIOUR OF PURPLE MOORHEN PORPHYRIO PORPHYRIO

Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology

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Thesis submitted to the University of Calicut
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Appendix I

Rails in India, Kerala and Study area

Sl.No.	English Name	Scientific Name	India	Kerala	Studyarea
1.	Water Rail	*Rallus aquaticus*	✔		
2.	Blue Breasted Banded Rail	*Rallus striatus*	✔	✔	
3.	Red legged Banded Crake	*Rallina fasciata*	✔		
4.	Banded Crake	*Rallina eurizonoides*	✔	✔	✔
5.	Andaman banded Crake	*Rallina canningi*	✔		
6.	Corn crake	*Crex crex*	✔		
7.	Little crake	*Porzana parva*	✔		
8.	Baillon's Crake	*Porzana pusilla*	✔	✔	
9.	Spotted crake	*Porzana porzana*	✔		
10.	Ruddy crake	*Porzana fusca*	✔	✔	✔
11.	Elwes's Crake	*Amaurornis bicolor*	✔		
12.	Brown crake	*Amaurornis akool*	✔		
13.	White breasted Waterhen	*Amaurornis phoenicurus*	✔	✔	✔
14.	Water cock	*Gallicrex cinerea*	✔	✔	✔
15.	Indian Moorhen	*Gallinula chloropus*	✔	✔	✔
16.	Purple Moorhen	*Porphyrio porphyrio*	✔	✔	✔
17.	Coot	*Fulica atra*	✔	✔	✔

Appendix II

Invertebrates	
Amoeba proteus	Larvae of dragon flies
Paramecium caudatum	Ants
Euglena viridis	Termites
Hydra vulgaris	Spiders
Planaria lugubris	Butterflies
Hirudinaria sp	Moths
Megascolex sp	Grass hoppers
Daphnia sp	Centipedes
Copepods	Millipedes
Cyclop	*Pila globosa*
Prawn	

Appendix III

Vertebrates	
Ophiocephalus sp	Skink
Trouts	Pondsnake
Catfishes	Rat snake
Rana sp	Jackal
Ichthyophis sp	Mongoose
Garden lizard	Mouse
Monitor lizard	

Appendix IV

(a) Analysis of abundance of moorhens in microhabitats

Months	Year	Openwater	Floating vege.	Emergent vege.	Emergent floating vege.
J	1998	4.5	33.5	124.3	84.3
F	1998	4.5	23.3	124.8	44
M	1998	2.3	19.8	70.8	60
A	1998	2	16.5	64.3	31.8
M	1998	5	5.3	38.5	23.3
J	1998	4.5	12	23.8	19
J	1998	12	4.8	30.3	14.8
A	1998	13.5	17.5	50.5	5
S	1998	21.8	17.5	71	22
O	1998	14.3	13.8	71.3	24.8
N	1998	3	30.5	90	37.3
D	1998	6.3	32.5	123.8	51
J	1999	4	52.8	108.8	68.3
F	1999	2.8	38	111	55.8
M	1999	3	75.3	41.5	13
A	1999	20.5	51.8	164.8	99.3
M	1999	32.5	29.3	142	55.8
J	1999	15.8	6.8	80	53.3
J	1999	20	16.8	65.3	13.5
A	1999	21	14.3	45.5	5
S	1999	13.8	14.8	39.8	6.5
O	1999	14.5	9.8	38.8	23
N	1999	6.3	12.3	78	38
D	1999	5.8	16.8	67.8	12.8
J	2000	6.3	25.8	111	53
F	2000	3.8	24.8	134	47.3
M	2000	2	7.3	70.8	46.5
A	2000	7.8	3.5	52.5	28.3
M	2000	4.5	10.8	40	32.3
J	2000	12	15	30.3	23.8
J	2000	11.3	27	58.5	7
A	2000	27.5	27.3	17	2.3
S	2000	19	11.5	59.8	10
O	2000	18.8	13.8	109.3	16.8
N	2000	5.5	4	114	59.3
D	2000	7.5	23.8	99	51.3

Appendix V

Scheffe test

Association with vegetation

Multivariate Analysis of variance with Year as covariate

1-SEASON

Wilks' Lambda	Rao's R	df 1	df 2	p-level		
Season	0.439139	3.690497	8	58	0.00153	**Signifi-**

cant

Significant difference between different seasons with respect of vegetation

Multivariate Tests (shad_2.sta)

Within-Cells Regression due to year

1 Covariates

	Value	p-level	
Wilks' Lambda	0.961098		
Rao R Form 2 (4, 29)	0.293453	0.879814	Insignificant
Pillai-Bartlett Trace	0.038902		
V (4,29)	0.293453	0.879814	Insignificant

Year wise difference is not significant

(b) Analysis of population census
Summary of all Effects; design:

1-YEAR, 2-SEASON

	Wilks' Lambda	Rao's R	df 1	df 2	p-level	
Year	0.299686	6.889139	6	50	2.27E-05	**Significant**
Season	0.492775	3.537855	6	50	0.00537	**Significant**
Interaction (Year X Season)	0.388863	2.375242	12	66	0.01302	**Significant**

Scheffe test; variable ADULTS

Probabilities for Post Hoc Tests INTERACTION: 1 x 2

	{1}	{2}	{3}	{4}	{5}	{6}	{7}	{8}	{9}
	157.5750	77.00000	71.65000	108.3250	191.6500	92.57500	145.9000	86.52500	99.70000
1998 Winter {1}		0.775905	0.710631	0.983999	0.998687	0.919122	1	0.873016	0.95745
1998 Summer {2}	0.775905		1	0.999285	0.336758	0.999996	0.890858	1	0.999935
1998 Monsoon {3}	0.710631	1		0.997787	0.279237	0.999965	0.843554	0.999998	0.999683
1999 Winter {4}	0.983999	0.999285	0.997787		0.743128	0.999996	0.997377	0.999953	1
1999 Summer {5}	0.998687	0.336758	0.279237	0.743128		0.534329	0.990043	0.453552	0.631278
1999 Monsoon {6}	0.919122	0.999996	0.999965	0.999996	0.534329		0.973803	1	1
2000 Winter {7}	1	0.890858	0.843554	0.997377	0.990043	0.973803	0.950743	0.989387	
2000 Summer {8}	0.873016	1	0.999998	0.999953	0.453552	1	0.950743		0.999999
2000 Monsoon {9}	0.95745	0.999935	0.999683	1	0.631278	1	0.989387	0.999999	

No significant variation in the adult population

Scheffe test; variable Sub adults and Chicks

Probabilities for Post Hoc Tests

INTERACTION: 1 x 2

	{1}	{2}	{3}	{4}	{5}	{6}
{7}	{8}	{9}				
	22.20000	9.950000	14.17500	24.57500	20.77500	16.00000
21.52500	22.35000	24.65000				
1998 Winter {1}		0.447753	0.888788	0.999971	0.999999	0.973483
1	1	0.999963				
1998 Summer {2}	0.447753		0.997897	0.222411	0.613138	0.977166
0.525126	0.431091	0.21685				
1998 Monsoon {3}	0.888788	0.997897		0.662386	0.961528	0.999996
0.92954	0.878136	0.653781				
1999 Winter {4}	0.999971	0.222411	0.662386		0.999013	0.846946
0.999805	0.999982	1				
1999 Summer {5}	0.999999	0.613138	0.961528	0.999013		0.99509
1	0.999999	0.998864				
1999 Monsoon {6}	0.973483	0.977166	0.999996	0.846946	0.99509	
0.9871	0.969377	0.84066				
2000 Winter {7}	1	0.525126	0.92954	0.999805	1	0.9871
	1	0.999766				
2000 Summer {8}	1	0.431091	0.878136	0.999982	0.999999	0.969377
1		0.999977				
2000 Monsoon {9}	0.999963	0.21685	0.653781	1	0.998864	0.84066
0.999766	0.999977					

No significant variation in the sub adult population

Scheffe test; variable Chicks

Probabilities for Post Hoc Tests

INTERACTION: 1 x 2

	{1}	{2}	{3}	{4}	{5}	{6}
{7}	{8}	{9}				
	4.700000	0.000000	9.575000	15.20000	20.82500	24.65000
6.700000	0.000000	20.32500				
1998 Winter {1}		0.998653	0.998252	0.821904	0.307167	0.097989
0.999998	0.998653	0.34777				
1998 Summer {2}	0.998653		0.884665	0.384462	0.072467	**0.017092**
0.985003	1	0.086238				
1998 Monsoon {3}	0.998252	0.884665		0.995268	0.760863	0.395603
0.999965	0.884665	0.802475				
1999 Winter {4}	0.821904	0.384462	0.995268		0.995268	0.891974
0.938142	0.384462	0.997513				
1999 Summer {5}	0.307167	0.072467	0.760863	0.995268		0.999701

0.484532	0.072467	1				
1999 Monsoon {6}	0.097989	**0.017092**	0.395603	0.891974	0.999701	
0.185267	**0.017092**	0.999261				
2000 Winter {7}	0.999998	0.985003	0.999965	0.938142	0.484532	0.185267
	0.985003	0.533496				
2000 Summer {8}	0.998653	1	0.884665	0.384462	0.072467	**0.017092**
0.985003		0.086238				
2000 Monsoon {9}	0.34777	0.086238	0.802475	0.997513	1	0.999261
0.533496	0.086238					

Significant variability exists in the chicks population

Appendix VI

Egg measurements

No.	Major axis (cm)	Minor axis (cm)	Weight (gm)	Volume (cm^3)
1	4.8	3.1	30.45	29.50
2	4.3	3.00	30.23	29.10
3	4.00	3.2	32.26	30.30
4	4.2	3.7	30.25	29.00
5	4.2	3.00	31.25	29.50
6	4.00	3.2	30.00	30.40
7	4.00	3.2	33.65	30.00
8	4.00	3.3	31.50	31.00
9	4.3	3.4	33.00	29.80
10	4.8	3.00	33.50	29.60
11	4.4	3.7	33.63	29.50
12	4.2	3.7	33.50	30.40
13	4.00	3.6	30.00	30.50
14	4.00	3.00	31.41	29.20
15	4.00	3.00	30.55	29.00
16	4.2	3.1	30.60	29.00
17	4.00	3.00	31.25	30.50
18	4.5	3.2	30.71	29.50
19	4.3	3.7	31.10	29.60
20	4.00	3.00	32.00	30.40
21	4.2	3.00	31.34	30.00
22	4.00	3.6	31.25	29.50
23	4.2	3.2	30.00	29.00
24	4.00	3.2	30.61	30.80
25	4.00	3.00	30.71	31.00
	(mean 4.2)	(mean 3.1)	(mean 31.4)	(mean 29.9)

Appendix VII

Nest measurements

Nests	Height (cm)	Diameter (cm)	Depth (cm)
1	40	51	18
2	42	48	22
3	35	50	20
4	30	46	21
5	30	47	20
6	31	50	19
7	32	53	22
8	33	48	23
9	40	46	24
10	30	44	17
11	29	51	24
12	26	50	20
13	25	43	21
14	32	42	22
15	33	47	24
16	30	53	16
17	34	50	22
18	40	42	23
19	41	40	25
20	40	39	20
21	40	46	19
22	27	44	21
23	35	51	24
24	30	50	22
25	33	42	22
26	40	50	20
27	36	41	25
28	31	49	20
29	42	40	21
	(mean 34.03)	(mean 46.6)	(mean 24.1)

Appendix VIII

Birds in Azhinjilam (1998-2002)

Sl. No.	*Common name*	*Scientific Name*	*Status*
Family : Podicepedidae			
1.	Little grebe	*Podiceps ruficollis*	R
Family : Phalacrocoracidae			
2.	Little cormorant	*Phalacrocorax niger*	R
3.	Indian darter	*Anhinga rufa*	R
Family : Ardeidae			
4.	Purple heron	*Ardea purpurea*	R
5.	Indian pond heron	*Ardeola grayii*	R
6.	Cattle egret	*Bubulcus ibis*	R
7.	Large egret	*Ardea alba*	R
8.	Median egret	*Egretta intermedia*	R
9.	Little egret	*Egretta grazetta*	R
10.	Night heron	*Nycticorax nycticorax*	R
11.	Malay or tiger bittern	*Gorsachius melanolophus*	R
12.	Little bittern	*Ixobrychus minutus*	R
13.	Chestnut bittern	*Ixobrychus cinnamomeus*	R
14.	Yellow bittern	*Ixobrychus sinensis*	R
15.	Black bittern	*Ixobrychus flavicollis*	R
16.	Eastern Grey Heron	*Ardea cinerea*	R

Family : Ciconiidae			
17.	Openbill stork	*Anastomus oscitans*	R
Family : Threskiornithidae			
18.	White ibis	*Threskiornis aethiopica*	R
19.	Spoonbill	*Platalea leucorodia*	M
Family : Anatidae			
20.	Lesser whistling teal	*Dendrocygna javanica*	R
21.	Common teal	*Anas crecca*	M
22.	Garganey	*Anas querquedula*	M
23.	Cotton teal	*Nettapus coromandelianus*	R
Family : Rallidae			
24.	Banded Crake	*Rallina eurizonoides*	R
25.	Ruddy crake	*Porzana fusca*	R
26.	White breasted waterhen	*Amaurornis phoenicurus*	R
27.	Water cock	*Gallicrex cinerea*	R
28.	Indian Moorhen	*Gallinula chloropus*	R
29.	Purple Moorhen	*Porphyrio prophyrio*	R
30.	Coot	*Fulica atra*	R
Family : Jacanidae			
31.	Pheasant tailed jacana	*Hydrophasianus chirurgus*	R
32.	Bronzewinged jacana	*Metopidius indicus*	R

Family : charadriidae			
33.	Redwattled lapwing	*Vanellus indicus*	R
34.	Little ringed plover	*Charadrius dubius*	M
35.	Green sandpiper	*Tringa cropus*	M
36.	Wood sandpiper	*Tringa glareola*	M
37.	Common Sandpiper	*Tringa hypoleucos*	M
38.	Marsh sandpiper	*Tringa stagnatilis*	M
39.	Common Snipe	*Capella gallinago*	M
40.	Eastern Golden plover	*Pluvialis dominica*	M
41.	Little Stint	*Calidris minutus*	M
Family : Laridae			
42.	Whiskered tern	*Chlidonias hybridus*	M
Family : Recurvirostridae			
43.	Blackwinged Stilt	*Himantopus himantopus*	M
Family : Accipitridae			
44.	Common Pariah kite	*Milvus migrans*	R
45.	Brahminy Kite	*Haliastur indus*	R
46.	Marsh Harrier	*Circus aeruginosus*	M
47.	Osprey	*Pandion haliaetus*	M
48.	Ceylon Shikra	*Accipter badius*	R

Family : Alcedinidae			
49.	**Common Ceylon Kingfisher**	*Alcedo atthis*	**R**
50.	**Whitebreasted Kingfisher**	*Halcyon smyrnensis*	**R**
51.	**Kerala Pied Kingfisher**	*Ceryle rudis*	**R**
52.	**Brownheaded Storkbilled Kingfisher**	*Pelargopsis capensis*	**R**
Family : Hirundinidae			
53	Eastern Swallow	*Hirundo rustica*	M
54.	Redrumped Swallow	*Hirundo daurica*	R
Family : Columbidae			
55	BlueRock Pigeon	*Columba livia*	R
56.	Indian Spotted Dove	*Streptopelia chinensis*	R
Family : Psittacidae			
57.	Roseringed Parakeet	*Psittacula krameri*	R
58.	Blossomheaded Parakeet	*Psittacula cyanocephala*	R
Family : Artamidae			
59.	Ashy Swallow Shrike	*Artamus fuscus*	R
Family : Motacillidae			
60.	Large Pied Wagtail	*Motacilla maderaspatensis*	R
61.	Malay Pipit	*Anthus novaeseelandiae*	M

Family : Cuculidae			
62.	Koel	*Eudynamys scolopacea*	R
63.	Southern Crow pheasant	*Centropus sinensis*	R
Family : Apodidae			
64.	Indian Alpine Swift	*Micropus melba*	R
65.	Palm Swift	*Cypsiurus parvus*	R
Family : Pycnonotidae			
66.	Redvented Bulbul	*Pycnonotus cafer*	R
Family : Muscicapidae			
67.	Tailor Bird	*Orhotomus sutorius*	R
68.	Southern AshyWrenWarbler	*Prinia socialis*	R
69.	Kerala Streaked Fantail Warbler	*Cisticola juncidis*	R
70.	Malabar Jungle Babbler	*Turdoides striatus*	R
71.	Whiteheaded Babbler	*Turdoides affinis*	R
Family : Sturnidae			
72.	Common Myna	*Acridotheres tristis*	R
73.	Southern Jungle Myna	*Acridotheres fuscus*	R
Family : Oriolidae			
74.	South Indian Blackheaded Oriole	*Oriolus xanthornus*	R
75.	Golden Oriole	*Oriolus oriolus*	M

Family : Dicruridae			
76.	Black Drongo	*Dicrurus adsimilis*	R
77.	Large Racket tailed Drongo	*Dicrurus paradiseus*	R
Family : Corvidae			
78	TreePie	*Dendrocitta vagabunda*	R
79.	House Crow	*Corvus splendens*	R
80.	Jungle Crow	*Corvus macrorhynchos*	R
Family : Nectariniidae			
81.	Indian Purple Sunbird	*Nectarinia asiatica*	R
82.	Indian Purplerumped sunbird	*Nectarinia zeylonica*	R
Family : Meropidae			
83.	Small Green Bea eater	*Merops orientalis*	R
84.	Bluetailed Bea eater	*Merops philippinus*	M
Family : Alaudidae			
85.	Malabar Crested Lark	*Galerida malabarica*	R
86.	Black bellied Finch Lark	*Eremopteryx grisea*	R
Family : Ploceidae			
87.	Whitebacked Munia	*Lonchura striata*	R
88.	Spotted Munia	*Lonchura punctulata*	R

R-Resident
M-Migrant