STUDIES ON THE TERRESTRIAL AVIAN FAUNA OF KIZHAKKOTH PANCHAYATH WITH SPECIAL REFERENCE TO TREEPIE (*DENDROCITTA VAGABUNDA*)

Thesis submitted to the

UNIVERSITY OF CALICUT

In partial fulfillment of the requirements for the award of the degree of

DOCTOR OF PHILOSOPHY IN ZOOLOGY

By

Muhammad Basheer Palishakkottu Purayil

Under the guidance of

Dr. Sabu K. Thomas

P.G. & RESEARCH DEPARTMENT OF ZOOLOGY

ST. JOSEPH'S COLLEGE, DEVAGIRI, CALICUT, KERALA

2010

PG & RESEARCH DEPARTMENT OF ZOOLOGY
ST: JOSEPH'S COLLEGE, DEVAGIRI
CALICUT – 673 008, KERALA, INDIA
Ph: 0495-2373050, 9447349744
e-mail: sabukthomas@gmail.com

Dr. Sabu K. Thomas
Reader in Zoology

Certificate

Certified that the thesis entitled "**Studies on the terrestrial avian fauna of Kizhakkoth panchayath with special reference to Treepie (*Dendrocitta vagabunda*)**" submitted by Mr. Muhammad Basheer Palishakkottu Purayil to the University of Calicut for the award of the degree of Doctor of Philosophy in Zoology, is a bonafide record of research work done by him in this department under my guidance and supervision. This has not previously been formed the basis for any award of degree or diploma.

Mr. Muhammad Basheer Palishakkottu Purayil has successfully completed the preliminary qualifying examination prescribed by the University of Calicut.

Sabu K. Thomas

Declaration

I do hereby declare that the thesis entitled "**Studies on the terrestrial avian fauna of Kizhakkoth panchayath with special reference to Treepie (*Dendrocitta vagabunda*)**" submitted to the University of Calicut for the award of the Degree of Doctor of Philosophy in Zoology has not been submitted for the award of any other degree or diploma and represents the original work done by me.

Devagiri
Date :

Muhammad Basheer Palishakkottu Purayil

Acknowledgements

I am greatly indebted to my supervisor Dr. Sabu K. Thomas for his constant guidance, advice and support. His encouragement provided me with the impetus to complete the study, though at times it did seem whether completion of this work would be reality. It was his experience, inquisitiveness and regular deliberations that helped me to approach my work with clear perception.

I am thankful to Dr A.T. Thomas, Head of the Department and all other staff members of the Department of Zoology, St. Joseph's college Devagiri, for their valuable suggestions and constant encouragements through out the period of my studies.

I express my sincere thanks to Rev. Fr. Benny Sebastian CMI, the principal, and Rev. Fr. Dr. K.M. Joseph CMI, the former principal, St. Joseph's college, Devagiri, Calicut for providing me all the necessary facilities.

I am happy to record my deep felt appreciation and indebtedness to Mr. Thomachan K.T., Selection Grade Lecturer, Department of Economcs, St. Joseph's college, Devagiri, Calicut for his excellent suggestions and help in analyzing the statistical data.

I am very much thankful to Dr. Santhosh Nampy, Reader, Department of Botany, St. Joseph's College, Devagiri who helped me to prepare a checklist of plants in the study area.

I am thankful to Dr. A.K. Pradeepkumar, Curator, Department of Botany, University of Calicut for helping me in identifying the plant materials and Mr. Aarif K.M., Researcher, Kannur University who helped me in collecting several books and journal articles for this thesis work.

I express my deep felt thanks to P.P. Abdurahiman Master (Manager), K. Usman Master (Principal) and my colleagues of M. J. Higher Secondary School, Elettil for all their support and co-operation to complete this work.

With immense pleasure I express my thanks to Mr. A.J. Thomson, Librarian, St. Joseph's college, Devagiri; Ms. Reddy Nirmala. P., Librarian, Bombay Natural History Society, Mumbai and Mr. Abdul Azeez T.A., Librarian in charge, CHMK library, University of Calicut for helping me in literature collection.

I am thankful to Dr. P.A. Azeez, Director, Salim Ali Centre for Ornithology and Natural History for extending the library facilities of SACON, Dr. Jafer Palot, ZSI, Kozhikode and Mr. Sasikumar C. (Ornithologist) for sharing their ideas with me on the subject.

I express my gratitude to Dr. Vineesh P.J., Dr. Vinod K.V. and Dr. Abhitha Prabhakar for their valuable suggestions and timely help to shape the thesis.

I acknowledge and appreciate the services of all my collegues in the Entomology Research Laboratory, Department of Zoology, St. Joseph's college, Devagiri, Calicut, especially Shiju T. Raj, Arunraj C., Nirdev P. M., Ramith M. and Nithya S. who showed keen interest in my work and had always lent a helping hand in this endeavour.

I am thankful to Mr. Shyjal C. Moosa, Ashique Rahman P.C. and Shereef T., who assisted me in the field during the work.

I am indebted to my parents who have given me the moral support and encouragement in my academic career. I extend my gratitude to my wife Nubla K. and my children Aban and Najad for their tolerance and encouragement.

Above all I express my heartfelt gratitude towards almighty for enabling me to successfully complete this work.

Muhammad Basheer Palishakkottu Purayil

Dedicated to My Parents and Teachers.....

Contents

LIST OF PLATES

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION AND REVIEW OF LITERATURE

1.1. Introduction

1.1.1. Avian fauna in agro-ecosystem

Birds are a highly visible and audible part of the fauna of agricultural landscapes. Traditional agricultural areas depend on birds for the tremendous role they play in pest control, seed dispersal, and pollination. Common village birds like Bulbuls, Mynas, Drongos, Treepies, Crows, Magpie-Robins, Egrets, and Waterhen are voracious eaters of insect pests. Owls, Kites, Crow pheasants, Pond-Heron and many other birds prey up on non insect pests like crabs, rats and mice in agricultural fields. Birds like Kites, Crows and Mynas help in cleaning up large amount of garbage from house yards. Ponds and streams with surrounding vegetation, especially *Pandanus*, the mat's plant of the tribals of Kerala is a special niche of water birds in village ecosystem. Paddy field is a transient wetland habitat, as its plant cover, water profile and animal assemblages change with season. Birds form part of this ecosystem at all stages of paddy growth and their occurrence vary temporarily with fine changes in the structure of this ecosystem (Palot 2000).

Since natural vegetation patch is very scanty in villages, majority of birds depend cultivated areas like palm plantations and paddy fields for survival. Birds in agricultural belts are generally small assemblages of opportunists, who are able to exploit the changing environment caused by agricultural practice and are human commensals (Campbell 1953; McKay 1980). However, farming activities like cleaning of natural vegetation, cutting and canopy cutting of non crop plants, filling of paddy fields, use of

pesticides and fertilizers leading to the vanishing of many native birds from the village ecosystem (Benton *et al.* 2003; Wretenberg *et al*. 2006). Majority of birds in village ecosystem nests on non-crop plants and hence periodical cutting of these plants and clearing of natural vegetation affect the breeding activities of avian fauna. Greenish rice fields with flocks of Egrets were a common scene in rural Kerala about 10-12 years ago. Nowadays paddy fields are being either filled up for residential or industrial purposes or are being converted in to plantations of areca palm *(Areca catechu)*, banana (*Musa* sp.) and tapioca (*Manihot utilisima*). Both activities lead to the shrinking of water logging sites in village ecosystem and there by disappearance of many common marshland birds like Pond-Herons, Ruddy Crakes and White-breasted Waterhen (Nair 2003). Use of agrochemicals in the form of pesticides, herbicides and fertilizers may cause direct toxic effects and loss of food via decreased availability of plants and invertebrates to birds. Villagers and farmers are least bothered or ignorant about the beneficiary role of birds in agriculture and considered majority of birds as pests and kill or repel them from the fields by using poison or explosives.

Sacred groves are an important ecosystem for many localized population of animals and plants, especially birds. The groves are repositories of biological wealth of the nation, housing a variety of genetic pools and the last refuge for many threatened, endangered and endemic plant and animal species (Malhotra *et al.* 2001). About 500 ha of forest area was under sacred groves (Prasad and Mohanan 1995) contributing 0.05% of the total forest area of Kerala (Chandrashekara and Sankar 1998). Due to

disappearance of old joint family system and partition of family properties along with changing socio-economic scenario, erection of temples (Kalam 1996), no faith or less faith, modernisation, construction of roads, installation of power lines and mobile towers, extension of agricultural land and cattle grazing these traditional patches of natural vegetation surviving in the man-modified landscapes are shrinking or disappearing day by day from the rural landscape of Kerala. Although the majority of these groves are less than one hectare in size and cover only 0.01% of the total geographic area of the country, it is their number and spatial distribution that make them so valuable for biodiversity conservation (Bhagwat *et al*. 2005). Sacred groves are being increasingly exposed to various kinds of threats leading to either qualitative degradation or total disappearance (Jayarajan 2004; Chandrakanth *et al*. 2004).

Intensive modern farming lead to loss of habitats and habitat heterogeneity, and thus contributed to the decline of many farmland bird species and to the impoverishment of farmland biodiversity in general (Vepsäläinen 2007). Over the last three decades, substantial decline occurred in the range and abundance of a number of farm land bird species, which have been linked to the intensification of agriculture (Chamberlain *et al.* 2000; Donald *et al.* 2001; Newton 2004). Cultivated areas when compared to a number of primary habitats including forests have proven to be more species rich in birds and have taken a high conservation value (Daniels *et al*. 1990 b).

Though several autecological studies of birds have done at national level (Kannan (1994) on Great pied Horn bills; Balachandran *et al.* (1995) on Bulbuls of the genus Pycnonotus; Natrajan (1997) on Southern Crow Pheasant; Mudappa (2000) on Malabar Grey Hornbill; Gokula (2001) on Spotted Munia) and at regional level Vijayan (1975) on Bulbuls; Khan (1977) on Black and Orenge Flycatcher; Zacharias (1978) on Babblers; Shukkur and Joseph (1980) on Black Drongo; Yahya (1980) on Barbets; Islam (1985) on Laughingthrushes; Santhanakrishnan (1988) on Barn Owls; Zacharias and Mathew (1998) on Babblers; Yahya (1988) on Barbets; Johny (1990) on Magpie-Robin; Neelakantan (1990) on River Tern, Venugopal (1991) on Red-wattled Lapwing; Neelakantan (1991a) on Bluebreasted Banded Rail, (1991b) on Kora or Watercock and (1993) on Crested Honey Buzzard; Santharam (1995) on Woodpeckers) very little data (e.g.: Johnsingh *et al.* 1992) is available from agricultural habitats.

Understanding the distribution and abundance of organisms where they are found, how many individuals occur there, when and why is critical for the development of effective conservation plans and comprises the core of ecology as a science (Caughley and Sinclair 1994; Krebs 1994). The distribution of individuals among habitats is particularly important because conservation plans for animal species are usually realized through the management of their habitats (Morrison *et al.* 1998). Successful conservation management requires an understanding of species distributions (Roy 2003).

1.1.2. Bio-ecology of Indian Treepie

Indian Treepie (*Dendrocitta vagabunda parvula*), Valkakai (in Tamil), Ole-njali, Kanakkan (in Malayalam), Karyatty (regional name) is a colourful bird which catch the attention of village people, due to its peculiar behaviours and sounds. It belongs to the family of Crows, Magpies and Jays, viz; The *Corvidae* family of Passeriformes order under the aves class. It is a species of open country closely associated with man and agriculture, especially coconut and areca palm plantations and it has been assigned the status of "Least Concern" in the Red List of threatened species (Birdlife international 2009). It is a wide spread resident throughout Pakistan, India, Burma, and Western Thailand, patchier in Laos, Cambodia and Vietnam but surprisingly no records from Sri Lanka (Ali and Ripley 1972; Ali 1999 & 2002; Grimmett *et al.* 2006).

There are seven species of Treepies (Myers *et al*. 2008) namely Indian Treepie (*Dendrocitta vagabunda*), Andaman Treepie (*Dendrocitta bayleyi*), Bornean Treepie (*Dendrocitta cinerascens*) Grey Treepie (*Dendrocitta formosae*), Collared Treepie (*Dendrocitta frontalis)*, White-bellied Treepie, (*Dendrocitta leucogastra*) and Sumatran Treepie, (*Dendrocitta occipitalis*). Except Bornean Treepie and Sumatran Treepie all the other five species were recorded in Indian subcontinent (Manakadan and Pittie 2001). Indian Treepie (*Dendrocitta vagabunda*) and White bellied Treepie (*Dendrocitta leucogastra*) were resident species in Kerala. Among the following nine sub species of Indian Treepie (*Dendrocitta vagabunda*); *D. v. bristoli, D. v. kinneari, D. v. pallida, D. v. parvula, D. v. sakeratensis*,

D. v. saturatior, *D. v. sclateri*, *D. v. vagabunda*, and *D. v. vernayi* only, *D. v. parvula* is distributed in Kerala (Ali and Ripley 1972).

Eventhough Treepie is a voracious eater of many pests of agricultural crops like coconut palm, areca palm and banana, it is included among vermins. Dharmakumarsihji and Lavkumar (1981) denoted this bird as 'Lovable rascal of avian community', dangerous than crow, which causes nuisance to horticulturists as it pecks and eats fruits and should be discouraged in a garden if other birds are to find a home there. It damages banana crops locally (Ali 1999) and labelled as scourge to eggs and fledglings of smaller birds (Neelakantan 2004). There are several myths in connection with the sounds or cries of this bird. People predict their good and bad luck by the different calls of this bird. People in Ponnani (Malappuram, Kerala) believe that money will increase in the coming days whenever they hear a peculiar call (one courtship call) of this bird (Neelakantan 2004). Rural Malabar people consider this bird as a bad omen; villagers believe that seeing or hearing the bird would lead to danger in the immediate future and hence they drive away this bird whenever it comes to residential areas, kill and destroy the nestlings and nest.

1.2. Review of literature

Mason and Lefroy (1912) were the first to study the food habits of birds in the agricultural environment of Indian subcontinent. Later, Hussain and Bhalla (1937) and Mathew *et al.* (1980) studied the food habits and highlighted the importance of birds in controlling insect pests. Lister (1952), Agarwal and Bhatnagar (1982), Ali and Ripley (1983), Dhindsa and Saini

(1994), Srinivasulu *et al.* (1997), Dhindsa *et al.* (1998) and Shyama (1998) listed birds associated with cultivated lands; Thirumurthy (1981) studied the insectivorous birds associated with the rice ecosystem at Madurai; Francisnathan and Rajendran (1982) listed avifauna of the rice ecosystem of Pondicherry; Gandhi (1986) studied the birds in a monoculture plantation and natural scrub near Madras; Majumdar and Brahmachari (1987) studied the avian predation on insects and rodents in paddy ecosystem; Daniels *et al.* (1990 a) studied the bird status in manmade ecosystems; Daniels *et al.* (1990 b) studied the changes in bird faunas in relation to land use.

Most of avian studies in Kerala are from protected areas or forests and they are listed below:

Palat (1983) studied on the birds of Malabar forests; Daniels (1989) studied on the birds of Uttara Kannada district; Nameer and George (1991) studied on the avifauna of Chinnar Wildlife Sanctuary; Robertson and Jackson (1992) studied on the birds of Periyar; Bashir and Nameer (1993) studied on the birds of silent Valley National Park; Zacharias and Gaston (1993) studied on the birds of Wayanad; Uthaman (1993) studied on the birds of the Wayanad Wildlife Sanctuary; Nameer (1994) studied on the birds of Parambikulam Wildlife Sanctuary; Jayson (1994) studied on the synecological and behavioural aspects of certain species of forest birds; Sugathan and Varghese (1996) studied on the birds of Thattakad Bird Sanctuary; Susanthkumar (1997) studied on the birds of Shendurney Wildlife Sanctuary; Uthaman (1998) studied on the birds of the Eravikulam National Park; Pramod (1999) studied on the bird community structure in

the different vegetation types of Silent Valley and adjacent forest area; Zacharias and Gaston (1999) studied on the recent distribution of endemic, disjunct and globally uncommon birds in the forests of Kerala; Jayson and Mathew (2000) studied on the diversity and species-abundance distribution of birds in the tropical forests of silent valley; Sasikumar *et al.* (2000) studied on the birds of Aralam Wildlife Sanctuary; Raman (2001) studied on the community ecology and conservation of tropical rain forest birds in the southern Western Ghats; Antoney (2005) studied on the bird communities in the forest Habitats of Wayanad.

Avian studies in the agro-ecosystems of Kerala are;

Mathew *et al.* (1980) studied the feeding habits of birds in agricultural ecosystem; Zacharias and Gaston (1983) studied the breeding seasons of birds at Calicut; Rajan (1989) studied the synecology of birds in paddy fields from Kerala; Kurup (1991) studied the bird fauna of Malabar cost in Calicut and Malappuram districts of Kerala; Palot (2000) studied the bird community in different stages of the crop in the paddy field wetlands of north Malabar; Seedikkoya (2003) studied the comparative ecology of certain paddy field birds with emphasis on habitat quality; Cheruvath (2004) studied the avian diversity and interactions in Kaipad, a traditional system of farming in north Malabar; Thomas (2006) studied the ecology of certain species of granivorous birds in Malabar.

Though the sacred groves have been fairly well studied in India from biological conservation points of view (Gadgil and Vartak 1976; Deshmukh *et al.* 1998; Gokhale *et al.* 1998; Ramakrishnan *et al.* 1998; Tiwari *et al.*

1998; Chandran, *et al.*1998; Singh and Saxena 1998; Jamir and Pandey 2002; Upadhyay *et al*. 2003; Jayarajan 2004), the information on avian fauna was from Deb *et al.* 1997; Sasikumar 1998; Palot 2000.

Ali and Repley (1972); Dharmakumarsihji and Lavkumar (1981); Ali (1999); Neelakantan (2004) and Grimmett *et al.* (2006) provided brief notes on Indian Treepie. Zacharias and Gaston (1983); Thirumurthy and Balashanmugam (1987) studied the feeding preferences. Pittie (1984) made some observations on the nests of Indian Treepie. Bharucha (1987) observed the realationship between a Sambar and a Treepie; Chaudhuri and Maiti (1989, 1998 & 1999) studied the pineal gland activity during the seasonal gonadal cycle, effects of gonadotropins and prolactin on ovarian activity and the oviductal function during the annual ovarian cycle of Indian Treepie. Begbie (1905) observed the curious ferocity of the Indian Treepie; Krishnakumar and Sudha (2002) noticed Treepie as a predatory bird of red palm weevil *Rhynchophorus ferrugineus* (Coleoptera: Rhynchophoridae); Tandon *et al.* (2003) noticed Treepie as a visitor of flowers of *Butea monosperma*; Chhangani (2004) observed the Cannibalism in Treepie; Raju *et al.* (2005) noticed the role of Treepie in pollinating *Bombax ceiba*; Kothari (2007) highlighted Treepie as a scavenger and Thomas (2008) recorded the breeding season of Indian Treepie in the Western Ghats.

1.3. Aim of the study

It is obvious from the review of literature, that there is very limited data on the diversity, distribution and abundance of avian fauna associated with the agro-ecosystem in the Kerala region of Western Ghats and bio-ecology of

Indian Treepie. Present study aims to analyse the following aspects of avian community in an agro-ecosystem at Kizhakkoth panchayath.

1) Distribution and abundance of avian fauna in paddy field, coconut plantation and sacred grove,
2) Seasonality, feeding guilds, migratory visits and local movements of avian fauna in paddy field, coconut plantation and sacred grove,
3) Abundance and seasonality of Indian Treepie in paddy field, coconut plantation and sacred grove,
4) General behaviour of Indian Treepie which includes territoriality, interactions, aggressiveness, foraging activities, food preferences, feeding behaviour and habitat selection or habitat preferences; and
5) Breeding biology (Nesting, Clutch size, survivability, behaviour of nestlings and parental care) of Indian Treepie.

1.4. Plan of the thesis

Chapter 1: Introduction and review of literature- general introduction and a broad review about the ecology of birds associated with agro-ecosystems, history and previous works on the Indian Treepie were presented.

Chapter 2: Materials and methods- this chapter deals with the location, geography, climate, and flora of the Kizhakkoth panchayath and the methods adopted.

Chapter 3: Results- distribution, diversity, seasonality, feeding guilds, migratory visits and local movements of avian fauna in three habitats namely paddy field, coconut plantation and sacred grove; and the status,

general behaviours, breeding biology and major threats to Indian Treepie are presented in this chapter.

Chapter 4: Discussion and conclusion- in this chapter the findings on avian fauna of the three habitats at Kizhakkoth panchayath and the studied bio-ecological aspects of Indian tree pie were discussed and concluded with reference to the earlier works.

Chapter 5: Summary- an overall summary on the avian status and bio-ecology of Indian Tree pie at Kizhakkoth panchayath is presented in this chapter.

Chapter 6: References.

Chapter 2

MATERIALS AND METHODS

2.1. Study area

Selected study area is at Kizhakkoth, a rural agricultural village (19.85 sq. km) in the Kozhikode taluk, Kozhikode district which falls under Malabar Coast moist deciduous forest eco-region. This area is located 20 km (Northeast) by road from Kozhikode district headquarters, and 22 km (northwest) from the foot hills of the Wayanad region of Western Ghats (Plate 1 & 2). Soil is lateritic with underlying rocks or disintegrated gneiss. Three main streams namely Elettil-Avilora stream, Mariveettil Thazham-Karippidy stream, Kacherimukku stream and their 9 sub streams that drain in to Korappuzha (Poonoor river) is flowing through the region. In addition to this there are 19 ponds of various sizes in the panchayath. Intensive deforestation during 1960–70s led to replacement of all the forests by coconut, areacanut plantations and rice paddies, except the small remnant patches in sacred groves.

2.1.1. Climate and rainfall

Southwest and northeast monsoon control the climate of this region. The major portion of the rain was from southwest monsoon. April and May are the hottest months and December and January are the coolest months. Annual rain fall was 5583 mm during 2003–2007 period (CWRDM Kozhikode). Maximum rainfall was in June during 2003 (849.8 mm), 2004 (1190.8 mm), and in 2006 (1006.6 mm) and in July during 2005 (897.4 mm) and 2007 (1383.2 mm).

2.1.2. Vegetation

Vegetation includes coconut plantations with under crops like colocasia (*Colocasia esculenta)*, turmeric (*Curcuma longa*), yam (*Dioscorea esculenta, Amorphophallus paeoniifolius* & *Dioscorea alata*), ginger (*Zingiber officinale*), banana (*Musa* sp.), tapioca (*Manihot utilisima*), pepper (*Piper nigrum*) etc, plantations of areca palm (*Areca catechu*), rice paddies (*Oryza sativa*), banana and tapioca fields and a few sacred groves. Predominant wild plants and fruit bearing trees present in the region are *Anacardium occidentale, Lucuma nervosa, Annona squamosa* sp., *Pisidium guajava, Carica papaya, Artocarpus heterophyllus, Mangifera indica, Syzygium aqueum, Tamarindus indica, Carallia brachiata, Bombax ceiba, Anogeissus latifolia, Calycopteris floribunda, Ailanthus malabarica, Casearia* sp., *Dalbergia latifolia, Caryota urens, Corypha umbraculifera, Melicope lunu-ankenda, Moringa oleifera, Pandanus tectorius, Lagerstroemia microcarpa, Holigarna arnottiana, Tectona grandis, Xylia xylocarpa, Pterocarpus marsupium, Litsea coriacea, Macaranga peltata, Strychnos nux-vomica, Malvaviscus penduliflorus, Memecylon malabaricum, Ficus exasperata, Ficus hispida, Glyricidia sepium, Ziziphus oenopila, Canthium coromandelicum, Chromaulena odorata, Sida cordifolia, Costus speciosus, Mimosa pudica, Acacia intsia, Centrosema virginianum, Cyclea peltata, Hemidesmus indicus, Ichnocarpus frutescens, Drymoglossum piloselloides, Helicanthes elasticus, Pothos scandens, Vanda* sp., *Ischaemum* sp. and *Oldenlandia auricularia.*

2.2. Study sites

Three habitat types (Paddy field; Coconut plantation and Sacred grove) are selected for the study.

2.2.1. Paddy field is situated (11^0 24.2' N; 075^0 53.6' E) along the side of the Elettil - Avilora stream (Plate 3). During monsoon period this field was flooded by the over flowing water from the stream. Paddy is cultivated two times a year; during April to October and October to February. During March, April, October and November preparatory activities like ploughing, puddling and levelling are done in paddy field.

2.2.2. Coconut plantation is situated at the northern part of the study area (11^0 24.5' N; 075^0 54.4' E) with under crops and 49 houses (Plate 3). Ploughing, weeding, bunding, chopping of organic manure and coconut basin opening are major agricultural activities in the site.

2.2.3. Sacred grove (Thechott Pallyarakkotta Sri Bagavathy Temple Grove) is the biggest patch (5 acres) of natural vegetation in the study area (11^0 22.1' N; 075^0 51.7' E) (Plate 3). Human interference was almost totally absent in the site. Vegetation represents semi-evergreen and deciduous type of plants. Floristic elements belonging to trees, shrubs, herbs, climbers, stragglers and epiphytes were present. Massive growth of climber *Acacia intsia* in the canopy was distinct.

2.3. Methodology

2.3.1. General avian study

Line transect method (Gaston 1973) was employed for surveys during 2003–2005 period. In paddy field (site 1) and coconut plantation (site 2) a permanently marked track of one km length and 100 m width was selected. Observations were made by walking through this tract at uniform speed, counting the birds in the forward direction. Birds flew above 40 m height were ignored. Due to limited area and poor accessibility a 200 m long × 100 m width transect was taken for survey in sacred grove (site 3). All surveys were conducted between 7.00 hrs to 12.00 hrs and 15.00 hrs to 18.00 hrs. Periods of rain and windy weather were avoided because of the influence of these conditions on the activities of birds (Robbins 1981). Birds were observed with a Zenith prismatic binocular (8 × 40) and a portable tape recorder was used for recording the sounds. Two counts were taken at every month with an interval of two weeks. Identification of birds was made using the field guide of Grimmett *et al.* (1998) and birds were grouped on the basis of their family, residential status, feeding preference and feeding zone. Common names and classification were followed after Manakadan and Pittie (2001). Birds were classified into residents (R), local migrants (LM), migrants (M) and stragglers (S) on the basis of their residential status. On the basis of breeding, birds were grouped as breeding species (B) and non breeding species (NB). According to the feeding preference birds were classified in to carnivores (C), frugivores (F), frugivores/granivores (F/G), frugivores/necterivores (F/N), granivores (G), insectivores (I),

insectivores/frugivores (I/F), insectivores/granivores (I/G), nectarivores/insectivores (N/I), omnivores (O), piscivores (P), piscivores/carnivores (P/C), piscivores/insectvores (P/I), raptors (R) (Ali and Ripley 1983). On the basis of feeding zones, birds were classified in to ground foragers (G), tree foragers (T), canopy foragers (C), aerial foragers (A), ground/shrub foragers (G/S), ground/tree foragers (G/T), shrub/tree foragers (S/T), shrub/canopy foragers (S/C), ground/shrub/tree foragers (G/S/T) (Antoney 2005).

2.3.2. Status and general behaviour of Indian Treepie

Population of Indian Treepie was estimated following line transect method. In paddy field (site 1) and coconut plantation (site 2) a permanently marked track of one km length and 100 m width was selected. Due to limited area and poor accessibility a 200 m long × 100 m wide transect was taken for survey in sacred grove (site 3). Surveys were conducted between 7.00 hrs to 12.00 hrs and 15.00 hrs to 18.00 hrs. Counts were taken biweekly during 2003–2006 period. Data collection was not made during hazy, unduly cloudy, windy and rainy days.

Behaviour and activities of Indian Treepie was observed following the direct focal observation method (Altman 1974). Birds were monitored from a distance of 10 - 15 m by hiding behind trees with a binocular and a telescope (20 x).

Roosting and awakening behaviour were recorded by following the birds between 5.30 am – 6.30 am and 6.00 pm – 7.00 pm. Awakening was noticed by reaching the roost site early in the morning before the bird had

moved out of the roost and roosting was analysed by following the bird till it roosted. Vocalizations were studied by recording and analysing the nature of calls and the circumstances in which they were made (Oommen and Andrews 1996). Pattern of preening was studied by monitoring the birds for seven days. Food items of Indian Treepie were identified qualitatively by direct observations, faecal matter analysis (Corlett 1998; Girish 2006) and gut content analysis of the dead specimens. Fresh faecal matter collected from the ground was rinsed in water and the materials were sorted and identified, using a brush and magnifying glass. Animals were identified with the help of their body parts and plant materials were identified by identifying seeds, fruit skins and other remains. Foraging techniques and food preference was studied by following the birds for one hour per day at the rate of 10 days per month, during 2005 period.

2.3.3. Breeding biology of Indian Treepie

Analysis of breeding biology was done during 2005–2007 period. In the first year of the study (2005), focal observations were done in all habitats on breeding birds. From the second year (2006) onwards observations were limited to breeding season (January to June). The breeding season is defined here as the period elapsed from the date of the building of the first nest to the date of the fledging of the last chick. Nests were located by following birds searching for nest site, or collecting nesting materials or carrying nesting materials or based on aggressiveness towards Jungle Crow or House Crow that come in the nesting territory (Neelakantan 2004) or begging food from the partner or by identifying the unique vocalization during incubation

(Kilham 1986). Aspects like pair formation, establishment of territory, nest building, nest site, egg laying, weights and measurements of eggs, clutch size, incubation, growth of nestlings and fledglings, parental care and dispersal of young ones were taken for detailed study.

Territory was marked as the area around the nest encompassed by the radial distance from the nest up to the region where the Jungle/House Crow entered the home range (Shukkur 1978). Since most territories were roughly circular, area of territory was estimated by assuming that the longest axis represented the diameter of a circle and the area of that circle was calculated as

$$A = \pi r^2,$$

where A = area, π = 3.14 and r = radius of the circle (Mc Gowan 2001).

Nests were monitored from the beginning of their construction to the fledging of chicks for three hours per day. Continuous day long observations were conducted while following the stages of nest construction, incubation and nestling period.

Nesting trees were measured to record:

(i) Tree height: Measured as the vertical height of the topmost point in the crown using a measuring tape and a marked aluminium tube.

(ii) Canopy diameter: Measured as horizontal distance between the two extreme ends of the canopy. One measurement was taken along the axis with the maximum canopy spread and the second one at right

angle to the first. The average of the two measurements was considered as canopy diameter.

(iii) Diameter at breast height (DBH): Girth of the tree trunk at 1.37 m above the ground was measured and divided by pie (i.e. 3.14) to calculate DBH.

(iv) Nest height: The nest height was measured with a measuring tape.

(v) Relative nest height: Calculated by dividing the nest height by nest-tree height, and

(vi) Direction of the Nest: Measured by using a magnetic compass.

Ten deserted nests were collected immediately after fledging and their components identified. To minimize disturbance early stage of Indian Treepie nests were examined with the aid of a mirror mounted on an aluminium tube from the ground or making observation by climbing up the nearest plant. From the last stage of incubation onwards, all nests were examined by climbing the nesting plant itself. The nest building activities and rhythm of incubation were observed from 06.00 to 18.00 hrs. The time of arrival of the bird at the nest and leaving the nest were noted and the total daily attentive and inattentive periods were calculated.

Eggs were weighed using electronic balance with a precision of 0.01 g. length and breadth of eggs was measured to the nearest 0.1 mm using the sliding calipers.

Egg volume index was calculated from the length and breadth using the formula (Hoyt 1979),

$$V = 0.51 \times L \times B^2/1000,$$

where V is volume (in cm^3), L is length and B is egg breadth (in mm).

Shape index of the eggs were analyzed by using the formula explained by Ramanoff and Ramanoff (1949) and Prasant *et al.* (1994),

$$Si = B \times 100/L,$$

where Si is Shape index, B is breadth and L is length of the egg.

Year wise and overall Hatching success (total number of eggs hatched/total number of eggs laid), fledging success (number of nestlings hatched/number fledged), breeding success (number of nestlings fledged/total number of eggs laid) and nest success (number of nests producing at least one flying young /total number of nests) were calculated.

2.4. Data analysis

To understand the diversity patterns, alpha diversity indices (richness and diversity) and Bray Curtis similarity index (Beta diversity index) were considered.

For analyzing taxa richness, **Margalef's index (d)** (Clifford and Stephenson 1975; Magurran 2004) was calculated by using the following formula.

$$d = S - 1 / \log (N)$$

S = total number of taxa

N = total number of individuals

Among the diversity indices, **Shannon-Weaver diversity index (H')** (Shannon and Weaver 1949) is the most commonly used because it incorporates both species richness and evenness components and can provide heterogeneity of information (Rosenstock 1998; Cheng 1999). Also, it is possible to test the differences between two communities using a Shannon *t*-test/ANOVA (Magurran 2004; Cheng 1999).

$$H' = - \Sigma_i P_i (\log (P_i))$$

where P_i is the proportion of the total count arising from the $_i{}^{th}$ species ($\log_e$ was used in its formulation).

Bray-Curtis similarity coefficient (Bray and Curtis 1957) was used to quantify and compare the similarity of avian community composition of three habitats. This index is calculated as

$$BC_{jk} = 100\left\{1 - \frac{\sum_{i=1}^{p}\left|y_{ij} - y_{ik}\right|}{\sum_{i=1}^{p}\left(y_{ij} + y_{ik}\right)}\right\}$$

where BC_{jk} is the similarity between the j^{th} and k^{th} habitats and y_{ij} represents the abundance for the i^{th} avian species in the j^{th} habitat.

This method start from a triangular matrix of similarity coefficients computed between every pair of habitats. To measure the similarity coefficients between various habitats, a data matrix with p rows (avian species) and n columns (habitats), filled with entries of abundance counts of each avian species for each habitat was first constructed. The similarity based on the Bray-Curtis coefficient was calculated between every pair of habitats, and an abundance similarity matrix was then constructed. The Bray-Curtis similarity coefficient was used because it is often a satisfactory

coefficient for biological data on community structure (Clarke and Warwick 1994). Furthermore, to reduce the large disparities in counts between species and to validate statistical assumptions for parametric techniques, square root transformation were applied to the original abundance counts of avian species before computing the Bray-Curtis coefficient.

Although there are many classes of clustering methods (Johnson and Wichern 1992; Clarke and Warwick 1994), this study applies **hierarchical clustering** with group-average linking to achieve its purpose because the technique has proven useful in a number of ecological studies conducted during the last two decades (Clarke and Warwick 1994). Habitats were grouped and the groups themselves form clusters at the levels of similarity of avian abundance. These take a similarity matrix as their starting point and successively fuse the samples into groups and the groups into large clusters, starting with the highest mutual similarities then gradually lowering the similarity level at which groups are formed. The process ends with a single cluster containing all samples. The result of the hierarchical agglomerative clustering is represented by a dendrogram, with the X axis defining similarity level at which two samples or groups are considered to have fused and the Y axis representing the full set of samples (habitats).

All diversity analysis was done with PRIMER 5 software version 5.2.9 (Clarke and Gorley 2001).

Non-parametric statistics (**Mann–Whitney U tests**) after multivariate comparison through **Kruskal–Wallis H tests** (Sachs 1992), were used for

pair wise comparison of guild wise and overall abundance of birds and abundance of Indian Treepie during different seasons in the three habitats.

The relationship between the various egg parameters, clutch size and period of incubation, clutch size and hatching period, territory size and nesting tree characteristics *viz.*, tree height, canopy diameter, height of the nest, relative nest height, presence of residential buildings were analysed with **Pearson's correlation**. For all analysis, significance was determined at $P<0.05$.

Non parametric multiple comparison **steel test (Dunnett-equivalent)** was used to compare the number of nest built in different months of the breeding season and the number of courtship calls at different hours of the days. The influence of nest characteristics on the nest success, egg predation and nestling predation was analysed using **chi-squire test**

Statistical analysis was done with KY plot Software (Yoshioka 2000) and Mega Stat version 10.0 (Orris 2005).

Chapter 3

RESULTS

3.1. Distribution of avian fauna in Kizhakkoth panchayath

Seventy seven species of birds belonging to 11 orders and 37 families were recorded. Order Passeriformes with 36 species and Ciconiformes with 14 species dominated the assemblage. Charadriformes represented by a single species was the least recorded. Ardeidae with eight species was the most speciose family. Phalacrocoracidae, Anhingidae, Ciconiidae, Sclopacidae, Tytonidae, Meropidae, Capitonidae, Pittidae, Campephagidae, Pycnonotidae, Turdinae, Timaliinae, Sylviinae, Monarchinae, Dicaeidae, Zosteropidae, Passerinae, Sturnidae and Artamidae were represented with a single species each (Table 1).

Among the 77 species, 41 were residents, 11 were migrants, 24 were local migrants and one was straggler species. Other than the 11 migrants (Common snipe, Blue-tailed Bee-eater, Indian Pitta, Yellow Wagtail, Grey Wagtail, Asian Paradise-Flycatcher, Forest Wagtail, Asian Brown Flycatcher, Eurasian Golden Oriole, Ashy Drongo and Black-naped Oriole), 19 local migrants (Asian Openbill-Stork, Emarald Dove, Large Cuckoo-Shrike, Malayan Night-Heron, Common Iora, Indian Cuckoo, Heart-spotted Woodpecker, Cattle Egret, Large Egret, Little Egret, Brainfever Bird, Chestnut Bittern, Median Egret, Brown Breasted Flycatcher, Black-crowned Night-Heron, Slaty-legged Crake, Small Blue Kingfisher, Darter and Gold-fronted Chloropsis) and one straggler (Green Imperial-Pigeon) all other species bred in the area (Table 1).

Among the migrants Forest Wagtail, Asian Brown Flycatcher, Ashy Drongo, Black-naped Oriole were recorded in pre-summer and northeast

monsoon. Common snipe, Blue-tailed Bee-eater, Indian Pitta, Yellow Wagtail, Grey Wagtail, Asian Paradise-Flycatcher, and Eurasian Golden Oriole were recorded during the pre-summer, summer and northeast monsoon season. During the southwest monsoon season migrants were totally absent.

Among the 14 feeding guilds, insectivorous guild was the most speciose guild (25 species). Carnivores and frugivores/nectarivores guilds were the least represented guilds with a single species (Table 2). Among the nine foraging guilds, ground foraging species were most predominant (33.8% of the total species), followed by tree and ground/tree foragers (14% each) (Figure 1).

Among the 77 species, 42 species were recorded in all the three habitats studied. Fifty six species were common in paddy field and coconut plantation, 43 species were common in paddy field and sacred grove and 43 species were common in coconut and sacred grove. Sixteen species were restricted only in paddy fields (Table 1). Highest similarity of the assemblage was observed between paddy field and coconut plantation, combined in the dendrogram at a similarity level of 70.12%. Sacred grove showed the highest dissimilarity from other assemblages (Figure 2).

3.2. Habitat specific details of avian fauna in Kizhakkoth panchayath

3.2.1. Paddy field

a. Diversity, abundance and seasonality

A total of 10584 birds belonging to 73 species from 36 families under 11 orders were recorded (Table 1). Ardeidae with eight species was the most speciose family (Figure 3). House Crow was the most abundant species. Black-napped Oriole, Malayan Night-Heron, Emarald Dove, Large Cuckoo-Shrike were the least abundant species recorded (Table 4). Overall species richness (d) and diversity (H') were 7.769 and 3.606 respectively. There was no significant variation in the overall (H = 5.304, DF = 3, P = 0.15) and feeding guild wise (H = 2.55, DF = 3, P = 0.47) seasonal abundance of birds. Diversity and species richness were highest during the northeast monsoon season and lowest during southwest monsoon season (Table 3).

b. Migrant and non migrant birds

Among the 73 species, 40 were residents 22 were local migrants and 11 were migrants. Common snipe, Blue-tailed Bee-eater, Indian Pitta, Yellow Wagtail, Grey Wagtail and Asian Paradise-Flycatcher were recorded during the pre-summer, summer and northeast monsoon season. Forest Wagtail, Asian Brown Flycatcher, Eurasian Golden Oriole and Ashy Drongo were recorded in pre-summer and northeast monsoon. Black-naped Oriole was recorded only in northeast monsoon season (Table 4).

Among the local migrants, Large Cuckoo-Shrike was recorded during pre-summer; Asian Openbill-Stork, Ashy Woodswallow and Emarald Dove during summer season; Malayan Night-Heron during northeast monsoon season; Common Iora, Indian Cuckoo and Heart-spotted Woodpecker during pre-summer and northeast monsoon; Brahminy Kite during summer and

south west monsoon; Cattle Egret, Large Egret, Little Egret, Brainfever Bird, Brown Breasted Flycatcher, Black-crowned Night-Heron, Plum-headed Parakeet, and Median Egret during pre-summer, summer and northeast monsoon season; Chestnut Bittern during summer, southwest monsoon and northeast monsoon and Large Pied Wagtail and Slaty-legged Crake during pre-summer, southwest monsoon and northeast monsoon season (Table 4).

The most abundant resident species was House Crow and least abundant species was Barn Owl. The most abundant local migrant species was Median Egret and the least abundant species was Large Cuckoo-Shrike. The most abundant migrant species was Asian Paradise-Flycatcher and the least abundant species was Black-naped Oriole (Table 4).

c. Feeding and foraging guilds

Insectivorous guild represented by 24 species was the most speciose guild. Carnivorous and frugivorous/necterivorous guilds with single species each were the least speciose guilds. Omnivorous guild showed the highest abundance (38.79 ± 9.40). Frugivorous/necterivorous guild was the least abundant guild (1.65 ± 1.30) (Table 5). The most abundant species representing omnivore guild was House Crow (14.10 ± 4.73), granivore guild was Blue Rock Pigeon (12.73 ± 10.67), frugivore/granivore guild was Rose-ringed Parakeet (12.00 ± 3.17), insectivore/frugivore guild was Jungle Babbler (11.40 ± 6.04), insectivore/granivore guild was White-breasted Waterhen (9.65 ± 2.97), piscivore/insectivore guild was Indian Pond-Heron (8.67 ± 2.00), insectivore guild was Asian Palm-Swift (8.35 ± 6.84),

necterivore/insectivore guild was Purple Sunbird (8.31.±.1.99), piscivore/carnivore guild was White-breasted Kingfisher (5.06 ± 1.14), carnivore guild was Greater Coucal (4.19 ± 1.27), frugivore guild was White-cheeked Barbet (3.08 ± 1.65), frugivore/necterivore guild was Tickell's Flowerpecker (1.65 ± 1.30), piscivore guild was Small Blue Kingfisher (1.50 ± 1.22) and raptors was Spotted Owlet (0.79 ± 0.80)(Table 4).

Ground foraging guild, represented by 26 species showed the highest species richness. Ground/shrub, ground/shrub/tree and shrub/canopy guilds were represented by a single species each. Ground foragers were the most abundant (34.2%) and shrub/canopy foragers were the least abundant guilds (0.3%) (Table 6). The most abundant ground/tree forager was House Crow (14.10 ± 4.73), ground forager was Blue Rock Pigeon (12.73 ± 10.67), ground/shrub forager was Spotted Munia (8.81 ± 5.78), shrub/tree forager was Purple Sunbird (8.31 ± 1.99), canopy forager was Oriental White-Eye (4.29 ± 3.86) ground/shrub/tree forager was Greater Coucal (4.19 ± 1.27), aerial forager was Black Drongo (3.29 ± 1.22), tree forager was White-cheeked Barbet (3.08 ± 1.65) and shrub/canopy forager was Common Tailorbird (0.60 ± 0.87) (Table 4).

3.2.2. Coconut plantation

a. Diversity, abundance and seasonality

11692 birds belonging to 58 species from 32 families under 10 orders were observed (Table 1). Overall species richness (d) and diversity (H') were 6.085 and 3.155 respectively. Species richness was highest during the

pre-summer and lowest during the southwest monsoon season (Table 7). There was no significant variation in the overall (H = 3.970, DF = 3, P = 0.27) and feeding guild wise (H = 1.53, DF = 3, P = 0.67) abundance of birds in different seasons.

Columbidae, Cuculidae, Nectariniidae and Dicruridae were the most speciose families with four species each (Figure 4). House Crow was the most abundant and Emarald Dove, Green Imperial-Pigeon and Collared Scops-Owl were the least abundant species (Table 8).

b. Migrant and non migrant birds

Out of the 58 species 37 were residents, 11 were local migrants, nine were migrants and one was straggler species. Among the migrants Eurasian Golden Oriole and Blue-tailed Bee-eater were recorded during pre-summer, summer and northeast monsoon, whereas Indian Pitta, Yellow Wagtail, Grey Wagtail, Asian Brown Flycatcher, Asian Paradise-Flycatcher, Black-naped Oriole and Ashy Drongo were recorded during pre-summer and northeast monsoon (Table 8).

Among the local migrants Emarald Dove was recorded during pre-summer; Brahminy Kite during Summer**;** Ashy Woodswallow during pre-summer and summer; Large Cuckoo-Shrike during pre-summer and northeast monsoon; Cattle Egret, Plum-headed Parakeet, Brainfever Bird, Indian Cuckoo, Gold-fronted Chloropsis and Brown Breasted Flycatcher during pre-summer, summer and northeast monsoon season (Table 8).

Among the residents House Crow was the most abundant and Collared Scops-Owl was the least abundant species. Yellow Wagtail was the

most abundant and Black-naped Oriole was the least abundant migrant species. Among the local migrants Plum-headed Parakeet was the predominant species and Emarald Dove was the least abundant species (Table 8).

c. Feeding and foraging guilds

Insectivorous guild was the most speciose guild (19 species) and carnivorous, frugivorous/necterivorous, insectivorous/granivorous and piscivorous/carnivorous guilds with single species each were the least speciose guilds. Omnivorous guild was the most abundant (93.46 ± 8.45) and insectivorous/granivorous was the least abundant guilds (0.25 ± 0.56) (Table 9). The most abundant species representing omnivore guild was House Crow (37.54 ± 6.35), insectivores/frugivore guild was Jungle Babbler (21.56 ± 3.43), necterivore/insectivore guild was Oriental White-Eye (12.81 ± 5.03), frugivore guild was White-cheeked Barbet (6.52 ± 2.02), insectivore guild was Black Drongo (6.10 ± 0.88), carnivore guild was Greater Coucal (4.96 ± 1.35), frugivore/granivore guild was Rose-ringed Parakeet (4.88 ± 6.15), frugivore/necterivore guild was Tickell's Flowerpecker (3.10 ± 1.48), granivore guild was Blue Rock Pigeon (2.46 ± 5.63), raptors was Spotted Owlet (1.40 ± 0.87), piscivore/carnivore guild was White-breasted Kingfisher (1.06 ± 1.06), piscivore/insectivore guild was Cattle Egret (0.75 ± 1.18) and insectivores/granivore was White-breasted Waterhen (0.25 ± 0.56).

Ground/tree guild was the most speciose (14 Species) and abundant (51.6%) and ground/shrub/tree guild was the least speciose (one species) and

abundant (2.0%) foraging guilds (Table 10). The most abundant ground/tree forager was House Crow (37.54 ± 6.35), canopy forager was Oriental White-Eye (12.81 ± 5.03), shrub/tree forager was Purple Sunbird (12.15 ± 2.71), tree forager was White-cheeked Barbet (6.52 ± 2.02), aerial forager was Greater Racket-tailed Drongo (6.10 ± 1.29), ground forager was Oriental Magpie-Robin (5.42 ± 1.35), shrub/canopy forager was Common Tailorbird (5.38 ± 1.30) and ground/shrub/tree forager was Greater Coucal (4.96 ± 1.35) (Table 8).

3.2.3. Sacred grove

a. Diversity, abundance and seasonality

1879 birds belonging to 45 species from 27 families under eight orders were recorded from sacred grove (Table1). Overall species richness (d) and diversity (H') were 5.837 and 3.283 respectively. Species richness and diversity were highest during pre-summer and lowest during southwest monsoon season (Table 11).There was no significant variation in the overall ($H = 6.023$, $DF = 3$, $P = 0.11$) and feeding guild wise ($H = 1.11$, $DF = 3$, $P = 0.77$) abundance of birds during different seasons.

Cuculidae and Nectariniidae represented by four species each were the speciose families (Figure 5). Purple Sunbird was the most abundant and Emarald Dove, Small Yellow-naped Woodpecker, Large Cuckoo-Shrike and Black-naped Oriole were the least abundant species in sacred grove (Table 12).

b. Migrant and non migrant birds

Among the 45 species recorded 30 were residents, six were migrants and nine were local migrants. Among the migrants Eurasian Golden Oriole was observed during pre-summer, summer and northeast monsoon seasons; Indian Pitta, Asian Brown Flycatcher and Asian Paradise-Flycatcher during pre-summer and northeast monsoon season; Black-naped Oriole during pre-summer; and Blue-tailed Bee-eater during northeast monsoon.

Among the local migrants Large Cuckoo-Shrike was recorded during pre-summer; Emarald Dove during summer; Malayan Night-Heron during pre-summer and summer; Brainfever Bird, Gold-fronted Chloropsis and Brown Breasted Flycatcher during pre-summer and northeast monsoon and Indian Cuckoo during pre-summer, summer and northeast monsoon season (Table 12).

Purple Sunbird was the most abundant and Small Yellow-naped Woodpecker was the least abundant resident birds in the sacred grove. House Swift was the most abundant and Large Cuckoo-Shrike was the least abundant local migrants. Indian Pitta was the most abundant and Black-naped Oriole was the least abundant migrants (Table 12).

c. Feeding and foraging guilds

Insectivorous guild was the most speciose (15 species) and carnivorous, frugivorous/granivorous, frugivorous/necterivorous, piscivorous and piscivorous/carnivorous guilds represented with a single species each were the least speciose guilds .Insectivorous guild was the most abundant (9.46 ± 4.72) and frugivorous/granivorous was the least abundant (0.02 ± 0.14) guilds (Table 13). The most abundant species representing

necterivore/insectivore guild was Purple Sunbird (4.27 ± 1.12), insectivore guild was House Swift (2.54 ± 2.18), insectivore/frugivore guild was Jungle Babbler (2.17 ± 3.23), frugivore guild was White-cheeked Barbet (2.08 ± 1.44), omnivore guild was Indian Treepie (1.71 ± 1.15), carnivore guild was Greater Coucal (1.52 ± 0.68), raptors was Jungle Owlet (1.06 ± 0.73), frugivore/necterivore guild was Tickell's Flowerpecker (0.85 ± 0.71), piscivore/carnivore guild was White-breasted Kingfisher (0.06 ± 0.32), piscivore guild was Malayan Night-Heron (0.06 ± 0.24) and frugivore/granivore guild was Emarald Dove (0.02 ± 0.14).

Birds falling under eight feeding zones were recorded with ground/tree foragers being the most speciose (12 species) and abundant (24.7%) and shrub/canopy was the least speciose (single species) and abundant (0.1%) guilds (Table 14). The most abundant shrub/tree forager was Purple Sunbird (4.27 ± 1.12), ground/tree forager was Jungle Babbler (2.17 ± 3.23), tree forager was White-cheeked Barbet (2.08 ± 1.44), ground/shrub/tree forager was Greater Coucal (1.52 ± 0.68), aerial forager was Greater Racket-tailed Drongo (1.02 ± 0.97), ground forager was Oriental Magpie-Robin (0.75 ± 0.91), canopy forager was Common Iora (0.53 ± 1.14) and shrub/canopy forager was Common Tailorbird (0.04 ± 0.20).

3.3. Status and general behaviour of Indian Treepie

3.3.1. Abundance and seasonality

Highest abundance of Treepie was recorded in coconut plantation and lowest in sacred grove. Highest abundance of Indian Treepie was during

southwest monsoon season in coconut plantation, whereas no seasonality was recorded in the paddy field and sacred grove (Table 15 & 16).

3.3.2. Roosting behaviour

a. Roosting time and activities

Treepies roost 4-26 minutes (12.27 ± 6.22) after sun set between 6.14 and 6.56 pm (Table 17). Prior to roosting, Treepies assembled on a tree and engaged in inter pair fights, feather preening and fluffing with uttering calls and Courtship displays (during breeding season). Subsequently they separated and roamed individually and settled in the midst of selected tree foliage. During brooding period parents were observed to roost in the breeding territory. During nestling time, breeding pairs roosted on the same tree, otherwise the birds in a pair roost individually on different trees. Group roosting was observed only among the early fledglings. Though same tree was selected at many occasions, they generally changed the roosting trees day by day.

b. Roosting plants and height of the roost

Out of the 173 observations, *Areca catechu* was the most preferred plant for roosting (Table 18), followed by *Artocarpus heterophyllus, Mangifera indica, Macaranga peltata* and *Strychnos nux-vomica.* Mean height of the roost was 8.66 ± 1.61 m from the ground (range 3-14 m).

3.3.3. Awakening behaviour

Treepies woke up 20-26 minutes (24.00 ± 1.79) before sun rise between 5.41 am and 6.30 am (Table17). Soon after wake up bird flies out,

perched on the neighbouring tree, made calls and started foraging activities. The female bird woke up earlier than the male.

3.3.4. Vocalizations

Indian Treepie made 19 types of calls with repetitive notes of varying frequencies as listed below.

a. Roosting call

'*Ke-ke-ke-ke-ke-ke-ke-ke-ke*' was produced by both sexes before roosting.

b. Wake up call

It was produced at the time of wake up. The female bird produced a harsh low pitched '*Ke-ke-ke-ke-ke-ke-ke-ke-ke*' or '*Ke-ke-ke*' call followed by male partner responded by a high pitched musical '*Kooea…*' call.

c. Alarm call

A long, harsh, call '*Ke-ke-ke-ke-ke-ke-ke-ke-ke*' or '*Ke-ke-ke-ke.…ke.…ke.…ke.…ke.…ke.…*'was produced on sighting enemies and it was the most common call produced by the Indian Treepie. While producing the call *Ke-ke-ke-ke-ke-ke-ke-ke-ke*' birds lowered its head slightly and moved the body to right and left by perching on a tree. The second call was produced rarely and while producing this call, bird slightly leaned its body forward, raised and vibrated wings.

d. Frightened call

A loud and rare call '*Kokkereeo…*' or '*Kokkeree…* was produced by the male bird, when the nest or nestlings were attacked by a stronger enemy and the birds were helpless. While making the frightened call wings were kept drooped and the mouth was kept open.

e. Attacking call

A short low pitched call '*Kir-kir*' was produced by breeding birds while defending the breeding territory.

f. Contact call

Male bird produced a musical call '*Kooea…*' and in response to this the female produced '*Ke-ke-ke*' sound to locate or meet each other during foraging.

g. Courtship call

During courtship assembly both sexes produced different calls. Male called first, and immediately the female responded by its call, and the pattern repeated for 10-15 minutes. The most predominant courtship call was '*Kooee…*' by male '*hu-hutlu*' by female or '*Kutrooeee…*' by male '*hu-hutlu*' or '*hutlu*' by female. The other calls produced during courtship were;

'*Kokereeoo...*' by male '*Ke-ke-ke-ke-ke*' by female,

'*Kooee…*' by male '*Keke-keke-keke-keke*' by female,

'*Kooea …*' by male '*Ke-ke-ke*' by female,

'*Kutrooku*' or '*Kutroo*' by male '*ke-ke-ke-ke-ke*' by female and

'*Kutrooku*' or '*Kutroo*' by male '*hutlu*' by female.

Calls produced by male were long and high pitched, whereas the corresponding calls of the female were short and low pitched. At the end of

the courtship both males and females produced the common '*Ke-ke-ke-ke-ke-ke-ke-ke-ke*' call.

h. Food searching call or Prey alerting call

Male produced a single noted high pitched '*Kutrooku*' or '*kutroo*' sound and the female produced a harsh and metallic three noted '*Ke-ke-ke*' or five noted '*Ke-ke-ke-ke-ke*' sound while searching for prey in the crevices and foliages.

i. Food demanding call

'*Kre...kre*' or '*Kur-kur-kur*' was produced by breeding females to get food from the male partner.

j. Mate feeding call

'*Keer-kere-kere*' or '*Keer-keer-kere-kere*' was produced by the female, while mate feeding by the male. Female spreaded wings and raised its beak towards the partner with widely opened mouth.

k. Fledgling call

This call was produced by hungry fledglings. During the first week they produced a single noted harsh call '*Kre…*', from the second week onwards they produced a call with two notes '*Kre…kre…*' and from the third week onwards a lengthy four noted '*Ke..ke..ke...ke*' call was produced.

3.3.5. Body maintenance behaviour

a. Bathing

In the course of foraging, Treepies bathed in irrigation canals (n = 46), leaking pipes (n = 9), ditches (n = 59), shallow streams (n = 26) and water tanks (n = 11). Bathing involved dipping the head and beak followed

by flapping of wings and ruffling of feathers, which helped to spread water over the plumage on the back. Soon after bath, the bird preened and flapped wings by perching on a nearest tree. It was followed by roaming through the sunny upper canopies of trees by preening and flapping the wings for drying. Bathing was never observed before 9 am and after 5 pm. Treepies bath in the company of common Myna (n = 9), Jungle Babbler (n = 14) and Red-vented Bulbuls (n = 3).

b. Sun bathing

During cold season, during the sunshine part of the day (12.00 – 2.00 pm) Treepies were seen laying on coconut leaves with wings spread.

c. Preening

Treepies preened the body at intervals of foraging spells, before roosting, after wake up and bath. They preferred shady places for preening activities but selected lighted area for post bath preening. Preening started from the second day of fledging.

Bird gave more attention for preening the wing feathers. Preening was interrupted by beak wiping, head scratching, stretching of wing and leg, fluffing and shaking of feathers (Plate 4). Allopreening of head feathers was observed among breeding pairs, fledglings and between fledglings and parents.

3.3.6. Food and feeding behaviour

Indian Treepie consumed 57 food items **(**Plate 5 and 6). The animal food ranged from invertebrate to vertebrate items (Table 19). Among the invertebrates, beetles were the predominant items. Vertebrate prey consisted

of nestlings of birds, young ones of House rat (*Rattus rattus*) and nestlings of Squirrel (*Funambulus* sp.). Fruits of *Casearia sp, Macaranga peltata and Syzygium aqueum* were the major plant food items (Table 20).

Treepies prefer coconut and areca palm plantations for foraging activities. All the trees in the vicinity were foraged by both birds simultaneously. Treepies adopted a search and capture method for catching prey present on the foliages. Small and soft pray item was picked up singly and swallowed as such from the site of the catch, larger preys were held firmly between the beaks for a while and held under toes, tore in to pieces and consumed. After feeding an item, birds invariably rubbed their bills on the tree branches. No sharing of the food with the partner was observed except during early phase of breeding season.

While foraging, Indian Treepies followed Jungle Babblers, Racket-tailed Drongo, Black-headed Oriole, Greater Coucal, Common Myna and Squirrel. During this social foraging Treepies did not compete for food. Treepies regularly visited the house yards in the company of Crows and Mynas for consuming the kitchen scrapes, and stored the food remnants in the crouches of coconut and areca palm crowns. Treepies adopted the following strategies to capture prey.

a. Gleaning/pecking

It is the general method for capturing static and slow moving prey from the surface of leaves and tree trunks (Plate 4).

b. Hang feeding

Common method employed for capturing the insects, spiders etc. which are hiding in the leaf fronds of coconut and areca palms. While foraging through the coconut and areca palm plantations, Treepie jumps or flies from one leaf frond to the other and walks or jump through the mid rib by searching frequently on the ventral side of the fronds. Spotted prey was preened out by clinging to the fronds with the toes.

c. Shake and wait catching

A peculiar prey capture strategy used while foraging on coconut fronds or crown infested with Rhinoceros beetle (*Oryctes rhinoceros*) (Plate 4). Bird perched close to the attacked site, produced calls and fluttered wings probably for disturbing the hiding beetles or cockroaches and the flown out beetles were caught.

d. Fly-catching

An opportunistic feeding method employed at the time of termite swarms, coconut harvesting, arecanut harvesting, farm firing and during sun set time. By this method the Treepies caught the flying insects from air in its beak and returned to a perch to devour it.

e. Stealing

Treepie visited the nests of other birds (Red-vented Bulbul, Black-headed Munia, Black-headed Oriole and Blue Rock Pigeon) and inserted their head in to the nests for stealing the eggs and nestlings. Treepies suck

out the egg contents by making a hole on the shell from the nest itself. Nestlings were carried in the beak to a perch and consumed.

f. Chase capture

It is a method for capturing lizards. Treepies chase and capture Wall lizards and Draco.

g. Tearing catch

Treepies tore open the withered part of dead trees for catching the dead wood dwelling insects and of banana petiole base for catching the larvae and adults of banana stem weevil (*Odoiporus longicollis*).

For collecting the plant foods Treepies frequently visited the fruit bearing plants and feed the ripened fruits. Small fruits of *Macaranga peltata, Cinnamomum verum, Casearia* sp., *Zanthoxylum rhetsa,* etc. were swallowed and larger fruits of *Artocarpus heterophyllus, Mangifera indica, Musa* sp., *Carica papaya, Anacardium occidentale, Ananas comosus* and *Annona squamosa* were eaten after tore open with beaks. Fruits of *Cinnamomum verum* bored by weevils (Curculionidae) (Plate 6) were selected more often.

h. Drinking

Treepies are observed to drink water from ditches, banana petiole base, arecanut inflorescence, crevices of tree trunks and from water kept for cows.

3.4. Breeding biology of Indian Treepie

3.4.1. Breeding season

Breeding season of Indian Treepie extended from January to June; nests were recorded from January through May with young fledging from March to June. There was no significant variation in nest in different months of the breeding season during the study period (P > 0.05) (Table 21). A nesting cycle takes at least 44 days, with only one successful brood in each year. Rain fall had no influence on the nest building activities of the bird (P = >0.05) (Figure 6).

3.4.2. Courtship and pair formation

Courtship calls and flights started from last week of November and continued through the breeding season. No variation observed in the number of calls made during different periods of the day (P= >0.05) (Figure 7). During courtship activity two to seven Treepies assembled in shaded canopies and engaged in calls and displays, and it was followed by pairing of male and females. Female produced a short low pitched sound by raising the body vertically with hunched neck, head and opened mouth. In response, the male produced a high pitched musical long sound by raising the body twice, with extended neck, slightly opened and drooped wings. While making the calls, birds moved along the branch and came closer to each other (Plate 4). Subsequently male pecked on the beak of female and pulled tail feathers. Female responded by display of ventral side by hanging upside down on the tip of the branch. It was followed by female bird flying out by producing a metallic sound and the male cling on the ventral side of the

female by pecking on her neck or ventral feathers and locking the toes. During this activity, birds go downwards in a rolling motion and with fluttering of wings. Ventral to ventral copulation occurred in the mid air and the pair separated before reaching the ground. Soon after copulation both birds perched on trees, produced alert calls, defecated, fluffed and shaped the feathers and then engaged in foraging activities. Copulation was repeated during the periods of nest site selection, nest building and egg laying.

3.4.3. Mate feeding

Mate feeding started after the first copulation and continued throughout nest building, incubation and brooding periods. During mate feeding the female received the food from the male by vibrating the slightly drooped wings with a juvenile type call. Incubating female received the food without making any sound or movement. After feeding, both birds rubbed their beaks on the perching branch. However beak rubbing was not exhibited by incubating bird.

3.4.4. Nest site selection

After pairing, both birds searched the nest site by wriggling the body in different positions, in the crotches of trees with the twigs or fibers collected from the same plant. Females were more active in nest site selection. Both birds searched the same plant repeatedly for three to five days.

3.4.5. Territory and defence

During breeding season, Treepies established a well defended territory or core area around the nesting plant. Both interspecific and

conspecific intruders were chased or attacked by both parents. The mean size of the territory was 0.55 ± 0.11 ha (range = 0.41-0.92) (Appendix 1). Characteristics of the nesting tree like height, canopy diameter, height of the nest, relative nest height had no influence on the size of the territory where-as the presence of residential buildings (expressed as distance to the nearest house) showed negative correlation with the size of the territory ($\rho = -0.397$, $P = 0$).

Treepies defend the nests from enemies by exhibiting territorial behaviours. Defence behaviours included alarm call, frightened call, chasing, mobbing around, attack or pecking. House Crow, Jungle Crow, Kites, Shikra, Spotted Owlet and Jungle Owlet were not tolerated within the territory. Red-vented Bulbul, Common Golden-backed Woodpecker, Oriental Magpie-Robin, Black-headed Oriole, Common Myna, Greater Coucal, White-cheeked Barbet and Squirrel were attacked, when they came closer to the nesting tree.

Dogs, House cats, Rat snakes, Mongoose and Human beings passing through the territory are not attacked but led to the production of alarm calls. Snakes on the nesting tree or nearby tree were attacked by pecking. When mongoose and humans climbed on the nesting tree or adjoining trees, Treepies produced frightened calls. Crows and Shikra that flew across the territory within the nest height was chased up to the boundary by producing attacking calls.

Treepies directly attacked the smaller birds (Oriental Magpie-Robin, Red vented bulbul, Black-headed Oriole and White-cheeked Barbet) without

warning displays. While attacking bigger birds (House Crow, Jungle Crow and Shikra), the Indian Treepie exhibited aggressive displays like puffing of body by erecting head and dorsal feathers with partially opened mouth and slightly spread wings, up and down movement of the head and bending of the body.

3.4.6. Nest

a. Nesting site

Indian Treepie selected a fork on trees, preferably multiple in characters for nest building that they can crouch in with a firm support beneath or twigs that offer some screening and support all round. On *Areca catechu*, *Cocos nucifera* and *Corypha umbraculifera* all nests were located at the junction of leaf and trunk in the crown. Nests located on *Artocarpus heterophyllus, Melicope lunu-ankenda* and *Mangifera indica* were all on solid main stems where junction of branches formed a cup in which the nest was built. 58.6% of the nests studied on the *Areca catechu* were placed on the second leaf, 27.6% on the third leaf and 13.8% on the first leaf. 37.5% nests were placed on branch or leaf directed towards southeast, followed by 37.5% towards southwest and 25% towards northeast from the nesting tree trunk (Figure 8, Appendix 1).

Out of the 56 nests spotted, 47 (84%) were on the cultivated crops (29 on *Areca catechu*, three on *Cocos nucifera*, 11 on *Artocarpus heterophyllus*, and four on *Mangifera indica*) and nine (16%) were built on non cultivated plants (two on *Corypha umbraculifera*, and seven on *Melicope lunu-ankenda)*. Nests were located most frequently on *Areca catechu* (52%). Mean height of nesting tree was 13.55 ± 3.76 m with a range of 4-21m.

Mean nest height was 9.85 ± 3.50 m with a range of 2.5-16.5m (Table 22). Most nests (23.2%) were placed at a height of 12-14 m (Figure 9). The lowly placed nest was recorded at a height of 2.5 m on an areca palm with four meter height and highly placed nest was on a coconut palm at 16.5 m height. Mean diameter of the nesting plant at breast height was 19.89 ± 10.21cm and the mean canopy diameter of the nesting plant was 3.23 ± 0.93 m (Appendix 1).

b. Nesting materials and nest building

Nest of Indian Treepie consisted of an outer coarse shell of sticks, thorns and an inner lining of softer substances. An intermediate binding layer of flexible twigs or climbers was interposed between the outer shell and the inner lining. The inner part of the nest was round, cup shaped and opened at the top (Plate 7).

Thirty nine nest materials were identified from the 10 nests studied, 18 materials from the outer shell, 12 materials from the rim of the nest cup and nine from the inner lining. The most abundant nest material was leaf sheath fibres of *Cocos nucifera* (47.00 ± 37.82). Twigs of *Tamarindus indica* (13.60 ± 8.09), Stems of *Ichnocarpus frutescens* (18.00 ± 10.06) and leaf sheath fibers of *Cocos nucifera* (47.00 ± 37.82) were the most predominant materials used in the shell, rim and cup of the nest respectively (Table 23).

Mean number of materials used for nest building was 185.40 ± 27.11. Twigs of *Tamarindus indica, Ziziphus oenopila* and *Ichnocarpus frutescens* were found in all nests. Leaf base and husk fibers of *Cocos nucifera*, stems

of *Cyclea peltata*, twigs of *Flacourtia montana*, *Punica granatum*, *Jasminum* sp. and *Lagerstroemia microcarpa* were found in 10% of the nests. Pieces of plastic ribbon were observed in one nest.

Both sexes took part in nest building. Nesting materials were broken or tore off from trees, fences or from the sides of the mud or stone walls, but collected very rarely from ground. All materials were collected from within the limits of 100 m distance. Both male and female broke the distal portion of the leafless twigs with beak by bending it in different planes. Twigs which were dropped down while taking to the nest site or arranging in the nest were not retrieved. Treepies never used materials from old nests. Nest building lasted for three to seven days.

As a first step both birds placed sticks and thorns in the junction of tree branches until some hold firm and formed a base for the nest. Then both birds arranged the materials to form the outer shell. Subsequently flexible twigs and stems of climbers were collected for making the rim of the nest cup. During this phase male only collects the nest material and dump in the nest or transfer to female for arranging it in the nest. Female arranged and moulded the materials collected by herself and by the partner, one after the other by rotating in the cup, pressing with breast and wings and kicking backwards with the feet while pressing the tail up in the nest rim. Finally female lined the nest cup with softer materials like grasses or fibres of coconut leaf sheath or dried inflorescence of areca palm. No nesting materials were added to the nest after eggs were laid.

3.4.7. Egg and clutch size

Eggs were laid after completing the nest. Eggs were oval, pale salmon-white in colour, blotched and mottled with pinkish red with denser markings on the broader end (Plate 7). Dimensions of the egg were as follows: - Length: 2.75 ± 0.09 cm (range = 2.61-2.85); breadth: 2.11 ± 0.06 cm (range = 2.02-2.17); weight: 5.84 ± 0.19 g (range = 5.69-6.26) and shape index: 76.61 ± 0.90 (range = 75.44-77.62) (Table 24). Length and breadth of the egg showed positive correlation ($\rho = 0.924$, $P = 0$), whereas the length or breadth of the egg showed no correlation with egg weight and shape index. Clutches were of two, three or four eggs, with a mean value of 3.74 ± 0.49 eggs (Table 25, Appendix 1).

3.4.8. Incubation

Indian Treepie was observed incubating eggs during the period of first week of February to mid week of May. Female bird start incubating soon after laying the first egg and continued until the last egg was hatched. Incubation patch developed within a week and persisted up to the end of the nestling period. Incubation period was 16.52 ± 0.87days (range = 16-19 days). Clutch size and period of incubation showed negative correlation (ρ = -0.794, P = 0, n = 21). Incubation continued for a period of 23-25 days and the unhatched eggs were found to be broken by the activities of nestlings and eaten by the parents.

Incubating bird did not produce sound. Occasionally it changed direction of incubation, turned the eggs with the bill and poked at the bottom of the nest with a trembling movement. Incubating birds were careful while moving in and out of the nest.

Incubation was discontinuous during day time and included spells of attentiveness (19.68 ± 11.22 minutes) and inattentiveness (7.31 ± 9.83 minutes) (Table 26). Longest duration of attentiveness was 53 minutes and shortest was one minute. Attentive periods were shorter during evening and morning hours. Total attentiveness increased from the first day of incubation to the day of the first hatch and then declined (Figure 10). During inattentive periods, birds were preening or defending the intruders from the territory.

3.4.9. Hatching

Hatching period was March to June, with the highest occurrence of hatching during May. A clutch hatched out completely with a mean period of 1.8 ± 0.44 days (n = 21). Size of the clutch and the time span for complete hatching does not show any correlation (ρ = 0.356, P = 0.11). Eggs hatch asynchronously in the order they laid, but the interval between hatching of the eggs was shorter than the intervals between their laying. Since the eggs hatched asynchronously, nests had both eggs and nestlings during the last days of incubation, during which brooding was staggered with incubation.

3.4.10. Nestlings

The young was born altricial (blind and naked) with yellowish flesh colour and unproportionally large belly (Plate 8). Mean weight of newly hatched young was 7.56 ± 0.27 g (range 7-8 g). Soon after hatching nestlings were unable to raise their head and neck and hence they remained head sprawled in the nest. One day after hatching, nestlings raised the head with gaped mouth and produced faint sounds, when parents perched on the nesting tree (Plate 8). Chicks respond only to vibrations on the nesting tree and could not respond to sounds from outside. On second day, they develop grasping capacity and squirmed in the nest. On fourth day, they raised abdominal region after receiving food from parents for voiding the fecal matter. On fifth day, opened eye lids and flapped their wings while fed by the parents. On sixth day, nestlings showed leaping movements inside the nest. On seventh day, nestlings stood up on leg and produced loud sounds while receiving food. On fourteenth day, nestlings developed perching mechanism and started to fluff feathers. On fifteenth day, they

preened, and remained low in the nest when any movements happened in the premises.

Development of plumage started from the posterior end of the body and continued to anterior end. Pin feathers began to emerge on the third day of hatching and feathers started unsheathing in most tracts when nestlings were seven days of age. By eighteen day, loose bright plumage with ill developed primaries and secondaries, short and stubby tail feathers appeared (Table 27 and Plate 8).

3.4.11. Fledglings

Fledging period lasted from third week of March to the last week of June. Nestlings left the nest within 19-21 days (mean = 19.9 ± 0.64 days) and never returned. Fledging occurred between 3 pm–6 pm. During fledging, nestlings perched on the flattened outer shell of the nest, looking at the parents, who made ‘zig zag’ flights in the vicinity of nest as if to prompt the nestlings to fly out from the nest. Subsequently, oldest nestling flew out clumsily from the nest. Due to weak flight capacity and inability for proper landing, fledglings more often fell down to the understory vegetation or ground. Fallen fledglings walk off by hiding through grasses and occasionally fluttering to a shorter distance. During this period both parents fed fledglings from the ground and directed them towards bushes and sloping trees or fence by making alarm calls. Within a day, fledglings climbed up through the sloping tree trunks. Nestlings from a clutch fledged out asynchronously within 24 hours.

Fledglings attained good perching and flying capacity and exhibited aggressive displays by puffing the feathers within a week. By second week, they started clinging on the coconut leaf fronds, producing alarm calls, and flying out of the territory along with the parents. From third week onwards, chicks started to feed and forage occasionally along with the parents. The parents fed and protected them up to three months. Subsequently parents started driving away the chicks approaching them for food and within two to three days chicks dispersed and started feeding themselves, either alone or in the company of the siblings.

3.4.12. Hatching, fledging and brood success

Out of the 80 nests observed, 56 nests were built completely, clutches were completed in 50 nests and 187eggs were recorded. 122 eggs were hatched (60 eggs were lost and 5 eggs remain unhatched). Out of 122 chicks emerged, 73 fledged out and 49 were lost at the nestling period (Table 28). Average number of young fledged per nest was 1.52 ± 1.61 (Appendix 1). Overall hatching success, fledging success and breeding success were 65.2%, 59.8% and 39% respectively. Mean number of hatchlings and fledglings per nest did not vary with the size of the clutch; that is the mean number of hatchlings in nests with clutch size three and clutch size four were 2.09 ±1.36 and 2.55 ± 1.50 respectively. Similarly, the mean number of fledglings in nests with clutch size three and clutch size four were 1.36 ± 0.36 and 1.50± 1.70 respectively (Apendix 1). Mean number of hatchlings and fledglings per nest for each clutch size in three breeding season (2005–2007) were shown in (Figure.11, 12 and 13).Out of the 56 nests monitored, 25 nests were recorded as successful nest and the remaining 31 were considered as failed nests. Overall percentage of nest success was 45% (47% in 2005, 35% in 2006 and 53% in 2007). Analysis revealed that nesting tree or nest characteristics did not influence the nest success or failure (Table 29).

Predation by Jungle Crow (32%), House Crow(15%), Indian Treepie (5%), arecanut harvesting practices (23%) and logging of nesting trees (12%) were the factors that led to the loss of 60 eggs from 24 nests during 2005–2007 (Table 30 and Figure 14).

Predation by Jungle Crow (29%), House Crow (10%), Shikra (8%) Brahminy Kite (6%), Parayah Kite (2%), Mongoose (8%), Rat snake (6%), House cat (4%), arecanut harvesting practices (13%) and logging of nesting trees (8%) were the factors that led to the loss of 49 nestlings from 19 nests (Table 30 and figure 15). Killing by Human beings (45%), predation by House Cat (27%), Shikra (18%) and Dog (9%) were the factors that led to the mortality of early fledglings.

Height of the nesting tree, height of the nest and size of the territory had influence on the egg loss (Table 31), whereas the nestling loss was not related with the nesting tree species, nesting tree height, height of the nest, relative height of the nest, canopy diameter of the nesting tree, orientation of the nest, territory size and distance to the nearest residential building (Table 32).

3.4.13. Parental care

Prolonged parental care of 105-119 days, starting from nestling period was observed in Indian Treepie. Both birds shared parental duties. Incubating female removed the broken shells of the peeped eggs to facilitate the emergence of chicks. Soon after hatching, females picked up the egg shells and disposed 20-35 meters away from the nest.

Female bird brood the nestlings for two days after complete hatching of the clutch. Regular feeding was started one day after hatching of the complete clutch. Both parents regurgitated the food and placed in the throat of nestlings. All nestlings, from the first emerged to the most recent emerged were fed by the parents. Both parents removed the faecal materials from the

nest, fed and protected the fledglings from predators for three months till they start to feed themselves.

Chapter 4

DISCUSSION AND CONCLUSION

4.1. General avian fauna

Present study reveals in contrast to the earlier reported trend of the dominance of granivorous and frugivorous birds in agrifields (Dhindsa and Saini 1994), insectivorous guild dominated in the region. This may be due to the scarcity of grain bearing grasses, shrubs, fruit bearing wild plants and the abundance of insect prey resources in the vast stretches of coconut and areca palm plantations in the region. Dominance of ground foraging birds is attributed to the high availability of ground dwelling invertebrate preys and anthropogenic food sources in the area.

Arrival of 11 species of winter visitors and 24 species of local migrants lead to the high species richness during pre-summer and northeast monsoon season. During pre-summer and northeast monsoon periods, paddy field becomes suitable for the foraging activities of wetland birds as the preparation of soil for cultivation by ploughing the soil exposes the below ground invertebrate fauna. Flowering and fruiting of plants following the monsoon period and the related availability of food resources like insects, flowers and fruits must be another factor leading to the high abundance during pre-summer period. Similarly, the high abundance during northeast monsoon period is attributed to the fruiting of shrubs and herbs and related rise in food resources following the summer and southwest monsoon. Low species richness during southwest monsoon period is attributed to the migratory movement of local migrants namely Median Egret, Cattle Egret, Little Egret, Large Egret, Black-crowned Night-Heron, Malayan Night-Heron, Brahminy Kite, Asian Openbill-Stork, Emerald Dove, Heart-spotted

Woodpecker, Gold-fronted Chloropsis, Plum-headed Parakeet, Large Cuckoo-Shrike, Common Iora, Brainfever Bird, Brown-breasted Flycatcher, Indian Cuckoo and Ashy Woodswallow. Interaction with the old timers revealed that Common Teal, Ruddy-breasted Crake, Mottled Wood-Owl, Collared Scops-Owl, Brown Fish-Owl, Common Iora, Emerald doves, Mountain Imperial-Pigeon, Malabar Grey Hornbill Woodpeckers, Sunbirds, Munias, Parrots and Bulbuls, were very common in the region before the introduction of plantations of areca and coconut palms. Disappearance of native trees and shrubs, invasion of banana and areca palm into paddy fields, shift in agriculture practices and intensive application of chemical fertilizers and pesticides might have caused unfavourable living conditions for these birds. Removal of old and dead trees especially *Cocos nucifera* (Coconut palm) and *Macaranga peltata* (Chandada) and eradication of *Corypha umbraculifera* (Talipot palm) might have lead to the low abundance of common hole nesting birds like Parrot, Woodpeckers, Barbets and Common Myna. Similarly, the precautionary steps taken to scare off birds by shooting and placement of scare crows might have led to the decline of granivorous and frugivorous birds like Spotted Dove, Black-headed Munia and Plum-headed Parakeet. Lower abundance of White-breasted Waterhen is attributed to bund construction along the stream sides and disappearance of *Pandanus tectorius* (Screw pine).

Presence of birds representing 14 feeding guilds and nine forging zones in the paddy field indicates that it is a typical habitat for birds in the village ecosystem. High abundance and richness of birds in the paddy field

is attributed to the dynamic nature of the study region (Subramanya and Veeresh 1998), where the features of this habitat vary seasonally due to the different cultivation practices and agricultural activities like ploughing, puddling and leveling. Paddy field with cultivation of ginger, leguminous plants, banana and tapioca as inter crops during pre-summer and summer, in the midst of vast stretches of coconut and areca palm monoculture plantations meets the habitat and food requirements of a broad range of species leading to their greater species richness.

Percentage of area under rice cultivation is decreasing due to the rising labour costs and conversion into coconut plantations (Nair 2003). As the birds visiting rice fields come from two distinct habitat pools- the grasslands and marshlands, the structural change in this habitat might have adversely affected the avian community structure than in the other two habitats in the study area. Lack of other marshy and wetland habitats in this area makes Little Cormorant, Darter, Little Egret, Large Egret, Median Egret, Black-crowned Night-Heron, Chestnut Bittern, Asian Openbill-Stork, Common Snipe, Slaty-legged Crake, Small Blue Kingfisher Stork-billed Kingfisher, Heart-spotted Woodpecker, Forest Wagtail, Large Pied Wagtail and Spotted Munia depend on this habitat for their foraging activities and conversion of paddy fields to arecanut and coconut plantations and tapioca fields would lead to the disappearance of these birds from the study area.

Dominance of insectivorous and ground foraging birds support the findings of Subramanya and Veeresh (1998) that the availability of different prey types in rice fields viz., soil invertebrates, both pest and non pest

groups, air bone insects and rice grains affect their population structure. Decrease in species richness during the south west monsoon is attributed to the raising water level in paddy fields which affects the activity of ground foragers. Rise in richness during northeast monsoon is due to the arrival of ground foraging local migrant and migrant species which feed on prey that got exposed by way of the preparatory activities done in the field prior to the sowing of seeds.

Coconut plantations were typically monoculture habitats with very little dynamism. Near absence of non crop plants and human interference are attributed as the reason for the low species richness in the habitat. Higher abundance of omnivorous birds like Jungle Crow, House Crow, Common Myna and Indian Treepie in the coconut plantation is due to the availability of anthropogenic food (Andren 1992). Total absence of migrant birds namely Common Snipe, Forest Wagtail and local migrants like Darter, Little Egret, Large Egret, Median Egret, Black-crowned Night-Heron, Malayan Night-Heron, Chestnut Bittern, Asian Openbill-Stork, Small Blue Kingfisher, Heart-spotted Woodpecker, Large Pied Wagtail, and Slaty-legged Crake in coconut plantation is attributed to the non marshy nature of the habitat. High richness and abundance of birds during the pre summer season is attributed to the flowering and fruiting phenology of the native plants.

Small size of the sacred grove, presence of vast fields of agricultural land with more invertebrate and vertebrate groups as prey resources, possible influence of colonial roosting of Indian flying fox (*Pteropus*

giganteus), occasional religious festivals, fireworks and the resulting noisy atmosphere that disturbs the avian fauna might have contributed to the lower abundance and richness of birds in the sacred grove. Sacred grove appeared to be the final refuge of House Swift in the region, due to the availability of deserted old temple buildings which provide nesting substratum for the species. Higher abundance of nectarivore/insectivores namely Purple Sunbird, Little Spiderhunter and Lotens Sunbird in the habitat was due to the abundance of non crop flowering trees and shrubs.

Avian fauna in paddy field was more diverse and richer than that of sacred grove and coconut plantation. Dynamic nature of paddy fields with stray trees and scattered vegetation cover might have extended comfortable shelter and suitable foraging grounds for birds. Availability of food sources like fish, crustaceans, invertebrates, water plants and planktons might have added to the diversity of birds as suggested by Basavarajappa (2004) and Butler *et al*. (2005). Bird species found in paddy field and coconut plantation consisted of opportunists able to exploit the changing environment caused by agricultural practice and anthropogenic source of food, whereas sacred grove supported birds with specific demands.

4.2. Bio - ecology of Indian Treepie

Selection of coconut and areca palm plantations for foraging activities by Indian Treepie was due to its ability to feed up on the leaf fronds of coconut and areca palms, less frequently visited by other insectivorous birds as well as the foliage structure of the plants that enable protection from predators, and possibly to pray availability and easy detection. High

abundance of Indian Treepie in the coconut plantations was attributed to the availability of its food resources. High abundance during southwest monsoon season is related to the fledgling period and the high incidence of young ones during the period.

Awakening before sunrise and roosting after sunset enabled Indian Treepie to feed during twilight period that coincide with the activity period of many insects. Wandering through the plantation before finalizing the roosting plant must be enabling the bird to acquaint with the area and in assessing the risks involved. Group roosting by early fledglings in contrast to the solitary roosting of adults is attributed to the poor flight capacity and it must be enabling the fledglings to keep the body warmer. Avoidance of tall trees for roosting may be enabling protection from wind and avoidance of low elevation trees must be enabling protection from predators and human interference.

Dissimilarity in calls may be enabling for social integration (Rowell and Hinde 1962; Morton 1996). Waking call of the female worked as a stimulus for the male partner to come out from its roost. Alarm call worked as a signal for conspecific congregation and to be vigilant towards predators like Parayah Kite, Brahminy Kite, Rat snake, Mongoose, House cat and Dog. Fledgling calls helped parents to locate the young ones. The musical nature of the calls produced by the males during the courtship seems to be for attracting the partner as in many other species (Pettingil 1970; Catchpole and Slater 1995).

Sun bathing is considered to be a thermoregulatory behaviour (Simmons 1985) to maintain the optimum body temperature as well as for disturbing the ectoparasites (Goodwin 1976). Bathing in the company of other birds must be for easier detection of predators.

Treepie is an omnivorous bird consuming fruits, insects, egg and nestlings of birds and small mammals (Zacharias and Gaston 1983; Ali 1999; Krishnakumar and Sudha 2002; Neelakantan 2004; Raju *et al.* 2005; Kothari 2007). Even though Treepies cause threat to small breeding birds and fruiting plants, the unique prey catching methods like hang feeding, tearing catch, shake and wait catching enable the bird to consume pests like Grass hopper, Red palm weevil, Banana stem weevil, and Cockroaches from the lengthy leaf fronds of coconut and areca palms, which are less visited by other birds in the study area. Treepie is a pollinator and seed dispersal agent of *Erythrina indica* (Indian coral tree), *Zanthoxylum rhetsa* (Indian prickly ash) and *Macarenga peltata* (Chandada) which are being displaced from the agricultural belts. Pair foraging behaviour and methods like selective consumption of ripened fruits burrowed mostly by beetles possibly minimizes the feeding effort of Indian Treepie. Multiple foraging strategies of the bird are considered to be a common pattern found in omnivorous birds for procuring different food items. Foraging along with Jungle Babbler, Greater Racket-tailed Drongo, Black-headed Oriole, Greater Coucal, Common Myna and Squirrel provided mutual aid in securing food and to escape from the attack by predators as suggested by VanTyne and Berger (1971). Variations in the foraging techniques adopted by Indian Treepie like

gleaning/pecking, and hang feeding, were attributed to the variations in the foliage structure of the foraging tree species and helps the bird to forage efficiently through various tree species especially in late summer, when food requirements are high owing to the emergence of nestlings and fledglings (Whelan 1989). Hoarding food for future consumption is well known among corvids (Bednekoff *et al.* 1997; Brodin 2005). However hiding food materials by Indian Treepie is noticed as a temporary adjustment for meeting surplus food, as the hoarded food was consumed within a short period of time.

Breeding season of Indian Treepie lasts from January to June as recorded earlier (Ali and Ripley 1972; Zacharias and Gaston 1983; Chaudhuri and Maiti 1989; Neelakantan 2004; Padmanabhan 2007). Breeding season of Indian Treepie is correlated with the fruiting phenology of *Syzygium aqueum* (Water apple), *Ficus exasperata* (Sandpaper (leaf) tree), *Artocarpus hirsutus* (Wild jack), *Annona squamosa* (Custard apple), *Helicanthes elasticus, Cinnamomum verum* (True cinnamon tree), *Macaranga peltata*, (Chandada), *Zanthoxylum rhetsa* (Indian prickly ash), *Litsea coriacea, Lannea coromandelica* (Indian ash tree) and *Pothos scandens* (Peacock's tail) in the study area. As hypothesized by (Lack 1968; Kannan 1994), natural selection favour the birds that time their breeding with the peak in food abundance and availability so that the peak demand for food, usually during feeding of nestlings could be met with. Heavy rain during the southwest monsoon may negatively affect the breeding activities

and that must be the reason for vacating the nest before the onset of southwest monsoon.

Courtship displays exhibited by Indian Treepies were mutual displays, a common pattern in monogamous species that are not sexually dimorphic (Loffredo and Borgia (1986). Courtship assemblies just before and during the early part of the breeding season rarely results in pair formation, as reported in corvids (Goodwin 1976). Sexual chasing and mate feeding were the most frequently encountered pre-nesting behaviour of the Indian Treepie. Chasing was important as a means of synchronizing the sexual cycle and bringing birds into breeding condition and is also considered as a signal indicating readiness to copulate (Smith 1981). Grooming, beak touching, patting and dragging the feathers of the female by male partner, during the courtship were considered to be sexually motivated actions. Ventral side display of female by hanging on the extreme end of the branch and food begging call towards the end of the courtship activities stimulate the male bird for copulation.

Mate feeding in many species may function as the final pre copulatory step in mate choice (Nuechterlein 1989). However, in Indian Treepie mate feeding begins only after initiation of copulation as in Rose-ringed Parakeet (Dhanda and Dhindsa 1998) and continues up to the brooding period. Thus it is considered as a post-mating sexually selected signal, which enables strengthening the pair bond (Lack 1968; Andrews 196l) and a source of female nutrition during egg production and incubation period (Royama 1966; Nisbet 1977; Tasker and Mills 1981) and helps the

female to utilize her energy and time for incubation. The begging call of the female, while receiving food from the male partner seems to be linked with feeling of dependence or infantile reliance on the creature begged from and a demand behaviour by the females (Smith 1980). However, absence of begging during incubation may be to minimize the vibrations of eggs in the nest as well as to protect the nest from the predators (Halupka 1998; Dearborn 1999).

Territoriality is observed only during the breeding season for protecting the nest and young ones. The small size of the territory (range from 0.41–0.92 ha) compared to other corvids (Fox 2003) was due to higher nesting density in the area. Sharing of breeding territories by Indian Treepies, Greater Racket-tailed Drongo, Black-headed Oriole and Red-vented Bulbul as reported by Padmanabhan (2007) and Neelakantan (2004) may be for availing the antipredator defence benefits (Ricklefs 1980), utilization of limited nesting sites in the manmade habitats and also a behavioural adjustment for breeding with the minimum requirements.

The intruders were defended by both parents through direct attacks, displays, or vocalizations. Defense mechanisms towards intruders depend on the capacity of birds to perceive risk associated with the particular predator (McLean and Rhodes 1991; Burhans 2000) and capacity to deter or distract it (Blancher and Robertson 1982; Komdeur and Kats 1999; Schmidt *et al*. 2001). Aggression towards intruders from the breeding territory revealed that during breeding season the bird's most concern was given to protect the nest and egg than to procure food. Among the intruders House Crow, Jungle

Crow, Shikra, House cat, Mongoose and Dogs were predated on eggs and chicks; Squirrels, Red-vented Bulbul, Common Golden-backed Woodpecker, Oriental Magpie-Robin, Black-headed Oriole, Common myna, Greater Coucal and White-cheeked Barbet were disturbing the nest or egg. Tolerance of Greater Racket-tailed Drongo, Black-headed Oriole, Magpie-Robin and Red-vented Bulbul breeding in the same territory revealed that their aggression was more concentrated for mobbing the common predators from the territory than their disturbances.

Nesting tree characteristics in the study area indicated that there is a selection of trees based on the availability of the crotches to get enough support for the nest. Selection of arecanut and coconut plants, frequently visited by man for harvesting and selection of tall trees for nest building supposed to be due to non availability of native wild plants and a behavioural adjustment of the bird in manmade habitat (Natarajan 1997).

Nest was a platform with an outer shell, inner cup and a rim, with twigs as the main building materials. Thorny twigs of *Ziziphus oenopila* (Jackal jujube), *Mimosa pudica* (Touch me not), *Bamboo* sp., *Lawsonia inermis* (Henna), *Strychnos nux-vomica* (Snake wood), *and Canthium coromandelicum* (Coromandel boxwood) increase the strength of the nest shell. Climbers and flexible twigs in the nest rim enable flexibility to the nest cup. Like all other corvids (Cramp and Perrins 1994; Valencia *et al*. 2000; Liebezeit and George 2002), Indian Treepies raise single brood per year, due to its prolonged nesting cycle and parental care. Clutch size of Indian Treepie ranges from 2–4. Clutch size and incubation period were

similar to other corvids (Fox 2003). The range of clutch size in the study area was smaller than the findings of Ali (1999) and higher than the observations of Padmanabhan (2007). This variation in the clutch size may be attributed to the difference in the study environment (Cody 1966), predation risk (Slagsvold 1982) and sample size.

During incubation time distinct resource partitioning was observed between the male and female Treepies. Females do all the incubation and males assist with nest building, feeding the female throughout incubation and early chick rearing as in other corvids (Goodwin 1976). According to Pettingill (1970) there is some correlation between colour of the male and his role in incubation, and if the colour is similar to that of the female, the male also incubates. However in Indian Treepies no such pattern is distinct.

Incubation started soon after laying the first egg and hatching occurred asynchronously in the order of eggs laid. It is an adaptation to bring brood size and available food supply in to correspondence (Lack 1947; Magrath 2008). Interval between hatching of eggs was shorter than the interval between their laying so that the time that elapses between laying of an egg and its hatching progressively decreases with each additional egg in the clutch (Kendeigh 1963). In Treepies, entire clutch hatch within two days and hence asynchronous hatching lead no size differences within a brood of chicks, in contrast to the other corvids (Gill 1995). Treepies incubate unhatched eggs for 7–9 days and consume egg contents, as a nest sanitation measure. Turning the eggs by incubating female is a step to provide adequate warmth as well as to prevent the chorioallantois from getting stuck

to the shell membranes which prevents normal egg development (Gill 1995). Periodical departures of incubating female from nest enables to defend the intruders, preen the body and wet the belly feathers for cooling the eggs and maintaining a humid microclimate in the nest (VanTyne and Berger 1971).

Inability of nestlings to rise head and neck indicate that nestlings need warmth, not food during the early days of hatching. Hence the two days of brooding by the female helps in maintaining an optimum nest temperature for altricial young (VanTyne and Berger 1971). Gaping for food in vertical direction elicited by non visual stimuli was considered as the first social behaviour performed by the altricial birds (Van Tyne and Berger 1971). Lack of hungry calls of nestlings reveals that surplus food resources are readily available in the area and this may be the reason for absence of nest mortality due to starvation.

The incubation period and nestling period were more or less same in Indian Treepies as in other small altricial birds (Skutch 1945). Large head and abdomen, which are in marked contrast to very short and undeveloped limbs of the nestlings agree with the common feature of the altricial nestlings of passerines. Rising of abdominal region with a wavering action immediately after receiving food from the parent seem to be an action to draw the attention of the parent towards disposal of faeces.

Parents of altricial birds preferentially feed the largest, most competitive chicks in a brood (Mock and Parker 1997). Starvation is the chief cause of death in nestlings with asynchronous hatching, in which it is particularly the younger nestling that starve (Lack 1954). However, Treepies

shared the collected food among the young ones and this may be the reason for the lack of nest mortality from starvation. This was against the findings of Goodwin (1976) and Royle *et al.* (1999) that the younger appear not to be recognized as individuals and parent feeds first whichever begs most vigorously and stretches up highest when begging, as a result the oldest young may suffer little or not at all while the youngest weaken and then die. The order of feeding from most eldest to the youngest helps for getting the nacently collected less prepared food to the eldest and more prepared food to the youngest.

Arecanut harvesting practices (nut collection of arecanut palm) and predation by Jungle Crow were the major causes of egg loss and nestling loss of Indian Treepie. Egg and nestling loss due to harvesting was a consequence of species preferring to nest in manmade habitats and due to human induced factor, this loss appears to be an extra cost the species have to pay for preferring to nest in manmade habitats (Subramanya and Veeresh 1998). Among the studied nest characteristics nesting tree height and height of the nest shows positive correlation with the egg loss. Nests on tall trees were easily detected and predated due to the less concealment .Egg loss by nut collection practices were common in areca palm plantations. This was due to a particular method adopted by the areca nut collectors, who after collecting nuts from first plant, brought the nearby plant by close to the first one and moved on to the trunk of the second plant and released the first plant. Release of the first plant led to its jerking along with movement in the opposite direction and falling of the eggs in the nest.

As recorded earlier (Dharmakumarsihji and Lavkumar 1981; Ali 1999), Indian Treepie is not a vermin instead it is a beneficial bird, helping to control many pests, which attack coconut palms, areca palms and banana crops. Its prey catching methods like hang feeding, shake and wait catching helps to catch the hiding insect pests, caterpillars and their pupal stages from the lengthy fronds of coconut and areca palms, which are inaccessible to other insectivorous birds. Coconut and areca palm plantations are the main foraging and nesting habitats of the Indian Treepie in the study area, hence their conversion to rubber plantation which resulted in the total eradication of wild trees must led to the disappearance of this beneficial bird from our village ecosystem.

Chapter 5

SUMMARY

1. Avian faunal assemblage of Kizhakkoth panchayath is comprised of 77 species of birds belongs to 11 orders and 37 families. Order Passeriformes and Ciconiformes dominated the assemblage.
2. Avian fauna in paddy field was more diverse and richer than that of sacred grove and coconut plantation. Availability of food sources like fish, frog, invertebrates, water plants and planktons as well as dynamic nature of paddy fields with stray trees and scattered vegetation cover might have extended suitable foraging grounds and comfortable shelter for birds.
3. No seasonality was observed in the abundance of birds in paddy field, coconut plantation and sacred grove. Seasonal variation in avian richness was observed in all the three habitats due to the seasonal arrival and departure of migrant and local migrant birds.
4. Omnivores was the most abundant feeding guild in paddy field and coconut plantation, and insectivores was the most abundant guild in sacred grove.
5. Ground/tree guild was the most speciose and abundant foraging guild in coconut plantation and sacred grove, whereas in paddy field ground foragers were the most abundant guild due to the high availability of ground dwelling invertebrate and vertebrate prey.
6. Highest abundance of Indian Treepie was in coconut plantation due to the availability of the preferred food sources namely, beetles, grass hopper, cockroaches, caterpillars and its ability to feed up on the leaf fronds of coconut, less frequently visited by other insectivorous birds.

7. Distinct seasonality in the abundance of Indian Treepie was recorded in coconut plantation with high abundance during south west monsoon season due to the fledging period and high incidence of young ones. No seasonality was recorded in the paddy field and sacred grove.

8. Awakening and roosting time of Indian Treepie coincided with the sun rise and sunset. Indian Treepie makes 19 types of calls.

9. Treepie is an omnivore, consuming 57 food items, including seven insect pests of agricultural crops in the study area. Major food items were Grasshopper (Orthoptera), Earwig (Forficulidae), Caterpillars, fruits of *Casearia* sp., *Macaranga peltata* (Chandada) and *Syzygium aqueum* (Water apple).

10. Indian Treepie displayed territoriality during breeding season for protecting the nest and young ones. It shared breeding territories with Greater Racket-tailed Drongo, Black-headed Oriole and Red-vented Bulbul must be for availing the antipredator defence benefits and utilization of limited nesting sites in the manmade habitats.

11. House Crow, Jungle Crow, Shikra, Spotted Owlet, Red-vented Bulbul, Oriental Magpie-Robin, Black-headed Oriole, Common Myna, Greater Coucal, White-cheeked Barbet and Squirrel were the main intruders of Indian Treepie territory. Defence mechanisms of Indian Treepie include direct attacks, aggressive displays and vocalisations.

12. Breeding season of Indian Treepie was from January to June, and it correlated with the fruiting phenology of the main food plants.
13. Sexual chasing and mate feeding were the most frequently encountered pre nesting behaviours of Indian Treepie. Grooming, beak touching, patting and dragging the feathers of the female by male partner, during the courtship were considered to be sexually motivated actions for copulation.
14. Mate feeding is considered as a post-mating sexually selected signal, which enables to strengthening the pair bond and a source of female nutrition during egg production and incubation period.
15. Nest was of platform type and was present most frequently on *Areca catechu* (Areca palm), *Artocarpus heterophyllus* (Jack tree) and *Mangifera indica* (Mango tree). Both sexes participated in the nest construction.
16. Clutch size of Indian Treepie ranged from 2–4. Female incubated the egg for 16 days and the eggs hatched asynchronously. During incubation time distinct resource partitioning was observed between the male and female birds.
17. Parental care lasted up to a period of four months. Indian Treepie raised single brood per year, due to its prolonged nesting cycle and parental care.
18. Arecanut harvesting practices (nut collection of areca palm) and predation by Jungle Crow were the major causes of egg loss and nestling loss of Indian Treepie in the study area.

19. Indian Treepie is a beneficial bird preying on beetles, grass hoppers and caterpillars present on coconut palms, areca palms and banana crops. Areca and coconut palm plantations are the main foraging and nesting habitats of the Indian Treepie in the study area.

20. Conversion of areca and coconut palm plantations in to rubber plantations along with the removal of wild trees will lead to the declining of Indian Treepie in the region.

Chapter 6

REFERENCES

Agarwal, R.A. & Bhatnagar, R.K. (1982) *Management of problem birds in aviation and agriculture.* Ministry of Defence and ICAR, New Delhi.

Ali, S. (1999) *Birds of Kerala*. Kerala Forests and Wildlife Department, Thiruvananthapuram.

Ali, S. (2002) *The book of Indian birds* (Thirteenth edition). Oxford University Press, New Delhi.

Ali, S. & Ripley, S.D. (1972) *Hand book of the birds of India and Pakistan together with those of Nepal, Sikkim, Bhutan and Ceylon.* Volume 5. Oxford University Press, New Delhi.

Ali, S. & Ripley, S.D. (1983) *Compact hand book of the birds of India and Pakistan*. Oxford University Press, New Delhi.

Altman, J.C. (1974) Observational study of behaviours, sampling method. *Behaviour*. 49: 227–285.

Andren, H. (1992) Corvid density and nest predation in relation to forest fragmentation: a landscape perspective. *Ecology*. 73: 794–804.

Andrews, R.J. (1961) The displays given by passerines in courtship and reproductive fighting: a review. *Ibis.* 103: 315–348.

Antoney, P.U. (2005) Bird communities in the forest Habitats of Wayanad, South India. Ph.D. thesis, University of Calicut, Calicut.

Balachandran, S., Mohanapatra, K.K. & Hussain, S.A. (1995) Moult in three species of Bulbuls of the genus *Pycnonotus* from Tirupathi Hills of the Eastern Ghats, Andhra Pradesh. *Journal of Bombay Natural History Society*. 92(2): 152–159.

Basavarajappa, S. (2004) Avifauna of agro-ecosystems of Maidan area of Karnataka. *Zoos' Print Journal*. 21(4): 2217–2219.

Bashir, C.A.A. & Nameer, P.O. (1993) Birds of Silent Valley National Park. In: Varghese, A.A., Sridhar, S. & Chakravarthy, A.K. (Eds.) *Bird conservation strategies for the ninties and beyond.* Ornithological Society of India, Bangalore, pp 131–136.

Bednekoff, P.A., Balda, R.P., Kamil, A.C. & Hile, A.G. (1997) Long-term spatial memory in four seed-caching corvid species. *Animal Behaviour*. 53: 335–341.

Begbie, A. (1905) Curious ferocity of the Indian Treepie (*Dendrocitta rufa*). *Journal of Bombay Natural History Society*. 16: 502–503.

Benton, T.G., Vickery, J.A. & Wilson, J.D. (2003) Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology & Evolution*. 18: 182–188.

Bhagwat, S.A., Kushalappa, C., Williams, P. & Brown, N. (2005) The role of informal protected areas in maintaining biodiversity in the Western Ghats of India. *Ecology and Society*. 10(1): 8. Available online: http:\\ www.ecologyandsociety.org\vol10\iss1\art8. Accessed on august 2008.

Bharucha, E. (1987) An observation on the relationship between a Sambar and a Treepie. *Journal of Bombay Natural History Society*. 84: 675.

Birdlife International (2009). *Dendrocitta vagabunda*. In: IUCN 2009. IUCN Red List of threatened species. Accessed on November 2009.

Blancher, P.J. & Robertson, R.J. (1982) Kingbird aggression: it deters predation? *Animal Behaviour*. 30: 929–930.

Bray, J.R., Curtis, J.T. (1957) An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographs.* 2: 325–349.

Brodin, A. (2005) Mechanisms of cache retrieval in long-term hoarding birds. *Journal of Ethology*. 23: 77–83

Burhans, D.E. (2000) Avoiding the nest: responses of field sparrows to the threat of nest predation. *Auk*. 117: 803–806.

Butler, S.J., Bradbury, R.B. & Whittingham, M.J. (2005) Stubble height affects the use of stubble fields by farmland birds. *Journal of Applied Ecology*. 42: 469–476.

Campbell, B. (1953) A comparison of bird populations upon "industrial" and "niral" farmland in South Wales. *Report of Transaction of Cardiff Natural Society.* 4–65.

Catchpole, C.K. & Slater, P.J.B. (1995) *Bird song: biological themes and variations*. Cambridge University Press, Cambridge, United Kingdom.

Caughley, G. & Sinclair, A.R.E. (1994) *Wildlife ecology and management*. Blackwell Science Publications, Cambridge, United Kingdom.

Chamberlain, D.E., Fuller, R.J., Bunce, R.G.H., Duckworth, J.C. & Shrubb, M. (2000) Changes in the abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. *Journal of Applied Ecology*. 37: 771–788.

Chandrakanth, M.G., Bhat, M.G., & Accavva, M.S. (2004) Socio-economic changes and sacred groves in South India: protecting a community-based resource management institution. *Natural Resources Forum.* 28: 102–11.

Chandran, M.D.S., Gadgil, M. & Hughes, J.D. (1998) Sacred groves of the Western Ghats. In: Ramakrishnan, P.S., Saxena, K.G. & Chandrasekara, U.M. (Eds.) *Conserving the sacred for biodiversity management.* Oxford and IBH Publishing Co., New Delhi, pp 211–232.

Chandrashekara, U.M. & Sankar, S. (1998) Structure and Function of sacred groves: case studies in Kerala. In: Ramakrishnan, P.S., Saxena, K.G. & Chandrashekara, U.M. (Eds.) *Conserving the sacred for biodiversity management*. Oxford and IBH Publishing Co., New Delhi, pp 323–336.

Chaudhuri, S. & Maiti, B.R. (1989) Pineal activity during the seasonal gonadal cycle in a wild avian species, the Treepie (*Dendrocitta vagabunda*). *General and Comparative Endocrinology*. 76(3): 346–9.

Chaudhuri, S. & Maiti, B.R. (1998) Effects of gonadotropins and prolactin on ovarian activity of a wild avian species, the Treepie (*Dendrocitta vagabunda*). *Indian Journal of Experimental Biology*. 36: 790–795.

Chaudhuri, S. & Maiti, B.R. (1999) Oviductal function during the annual ovarian cycle of a wild avian species, the Treepie (*Dendrocitta vagabunda*). *Biological Rhythm Research*. 30(3): 290–296.

Cheng, W. (1999) Rhizosphere feedbacks in elevated CO_2. *Tree Physiology***.** 19: 313–320.

Cheruvath, D. (2004) Ecological studies on *Kaipad*, a traditional system of farming in North Malabar. Ph.D. thesis, University of Calicut, Calicut.

Chhangani, A.K. (2004) Cannibalism observed in Rufous Treepie (*Dendrocitta vagabunda*). *Newsletter for Birdwatchers.* 44(5): 79.

Clarke, K.R. & Gorley, R.N. (2001) Primer v5. User manual/ tutorial, PRIMER-E, Plymouth, United Kingdom.

Clarke, K.R. & Warwick, R.M. (1994) Similarity-based testing for community pattern: the 2-way layout with no replication. *Marine Biology*. 118: 167–176.

Clifford, H.T. & Stephenson, W. (1975) *An introduction to numerical classification*. Academic Press, New York.

Cody, M. L. (1966) A general theory of clutch size. *Evolution.* 20: 174–184.

Corlett, R.T. (1998) Frugivory and seed dispersal by birds in Hong Kong shrubland. *Forktail*. 13: 23–27.

Cramp, S. & Perrins, C.M., (1994) *Handbook of the birds of Europe, the Middle East and North Africa*. Volume 8. Oxford University Press, London.

Daniels, R.J.R. (1989) A conservation strategy for the birds of the Uttara Kannada district. Ph.D. thesis, Indian Institute of Science, Bangalore.

Daniels, R.J.R., Hodge, M. & Gadgil, M. (1990 a) Birds of man-made ecosystem: the plantations. *Proceedings of the Indian Academy of Sciences- Animal Science*. 99 (1): 79–89.

Daniels, R.J.R., Joshy, N.V. & Gadgil, M. (1990 b) Changes in bird fauna of Uttara Kannada, India, in relation to land use over the past century. *Biological conservation.* 52: 37–48.

Dearborn, D.C. (1999) Brown-headed cowbird nesting vocalizations and risk of predation. *Auk*. 116: 448–457.

Deb, D., Deuti, K. & Malhotra, K.C. (1997) Sacred grove relics as bird refugia. *Current Science*. 73(10): 815–817.

Deshmukh, S., Gogate, M.G. & Gupta, A.K. (1998) Sacred groves and biological diversity: Providing new dimensions to conservation issue. In: Ramakrishnan, P.S., Saxena K.G. & Chandrashekara, U.M. (Eds.) *Conserving the sacred for biodiversity management.* Oxford and IBH Publishing Co., New Delhi, pp 415–421.

Dhanda, S.K and Dhindsa, M.S (1998) Nest site selection and other aspects of breeding ecology of the Rose-ringed Parakeet (*Paittakula krameri*). In: Dhindsa, M.S., Rao, P.S. & Parasharya, B.M. (Eds.) *Birds in agricultural ecosystem.* Society for Applied Ornithology, Hyderabad, pp 85–102.

Dharmakumarsihji, R.S. & Lavkumar, K.S. (1981) *Sixty Indian birds*. Delhi Press, New Delhi.

Dhindsa, M.S., Rao, P.S. & Parasharya, B.M. (1998) *Birds in agricultural ecosystem*. Society for Applied Ornithology, Hyderabad.

Dhindsa, M.S. & Saini, H.K. (1994) Agricultural ornithology: An Indian perspective. *Journal of Biosciences.* 19(4): 391–402.

Donald, P.F., Green, R.E., & Heath, M.F. (2001) Agricultural intensification and the collapse of Europe's farmland bird populations. *Proceedings of the Royal Society of London Series B- Biological Sciences*. 268: 25–29.

Fox, T. (2003) Corvids- Crows, jays and magpies- husbandry and management: a brief review originally presented at the American Zoo and Aquarium Association, Knoxville.

Francisnathan, S.P. & Rajendran, B. (1982) Bird fauna of rice crop ecosystem in Pondicherry region. *Journal of Bombay Natural History Society*. 79(1): 204–206.

Gadgil, M. & Vartak, V.D. (1976) Sacred groves of India: a plea for continued conservation. *Journal of Bombay Natural History Society*. 72: 314–320.

Gandhi, T. (1986) A comparative study of birds in a monoculture plantation and natural scrub near Madras. M.Sc. thesis, University of Bombay, Bombay.

Gaston, A.J. (1973) Methods for estimating bird populations. *Journal of Bombay natural History Society.* 72 (2): 271–283.

Gill, F.B. (1995) *Ornithology* (Second edition). W.H Freeman and Co., New York.

Girish, A.J. (2006) Ecology and behaviour of the Forest Owlet (*Heteroglaux blevitti*). Ph.D. thesis, University of Bombay, Bombay.

Gokhale, Y., Velankar, R., Subash Chandran, M.D. & Gadgil, M. (1998) Sacred woods, grasslands and water bodies as self-organized systems of conservation. In: Ramakrishnan, P.S., Saxena, K.G. & Chandrashekara, U.M. (Eds.) *Conserving the sacred for biodiversity management.* Oxford and IBH Publishing Co., New Delhi, pp 365–398.

Gokula, V. (2001) Nesting ecology of the Spotted Munia (*Lonchura punctulata*) in Mudhumalai Wildlife Sanctuary (Southern India). *Acta zoologica.* 36(1): 1–5.

Goodwin, D. (1976) *Crows of the world*. Cornell University Press, Ithaca, New York.

Grimmett, R., Inskipp, C. & Inskipp, T. (1998) *Birds of the Indian subcontinent*. Oxford University Press, New Delhi.

Grimmett, R., Inskipp, C. & Inskipp, T. (2006) *Pocket guide to the birds of the Indian subcontinent*. Oxford University Press, New Delhi.

Halupka, K. (1998) Vocal begging by nestlings and vulnerability to nest predation in Meadow Pipits (*Anthus pratensis*): to what extent do predation costs of begging exist? *Ibis.* 140: 144–149.

Hoyt, D. F. (1979) Practical methods for estimating volume and fresh weight of bird eggs. *Auk.* 96: 73–77.

Hussain, M.A. & Bhalla, H.R. (1937) Some birds of Lyallpur and their food. *Journal of Bombay Natural History Society*. 39: 831–842.

Islam, M.A. (1985) Ecology of the Laughing thrushes of India with special reference to endemic species. Ph.D. thesis, University of Bombay, Bombay.

Jamir, S.A. & Pandey, H.N. (2002) Status of biodiversity in the sacred groves of Jaintia Hills, Meghalaya. *The Indian Forester*. 128(7): 738–744.

Jayarajan, M. (2004) Sacred groves of North Malabar, Kerala. Research Programme on local level development, Centre for Development Studies, Thiruvananthapuram.

Jayson, E.A. (1994) Synecological and behavioural studies of certain species of forest birds. Ph.D. thesis, University of Calicut, Calicut.

Jayson, E.A. & Mathew, D.N. (2000) Diversity and species-abundance distribution of birds in the tropical forests of Silent valley, Kerala. *Journal of Bombay Natural History Society*. 97(3): 390–397.

Johnsingh, A.J.T., Paramanandham, K. & Murali, S. (1992) Foraging behaviour and interactions of White headed Babblers, (*Turdoides affinis*) with other species. *Journal of Bombay Natural History Society*. 79: 503–514.

Johnson, R.A. & Wichern, D.W. (1992) *Applied multivariate statistical analysis* (Third edition). Prentice Hall, Englewood Cliffs, NJ.

Johny, U.P. (1990) Ecology and biology of the Magpie robin (*Cospsychus saularis* Linnaeus) in Southern India. Ph.D. thesis, University of Calicut, Calicut.

Kalam, M.A. (1996) *Sacred groves in Kodagu district of Karnataka* (*South India*)*: a sociohistorical study.* Institute Francais de Pondicherry, Pondicherry.

Kannan, R. (1994) Ecology and conservation of the Great Pied Hornbill (*Buceros bicornis*) in the Western Ghats of Southern India. Ph.D. thesis, University of Arkansas, Fayette Vile, U.S.A.

Kendeigh, S.C. (1963) New ways of measuring the incubation period of birds. *Auk* 80: 453–461.

Khan, M.A.R. (1977) Ecology and behaviour of the Black and Orange Flycatcher (*Muscicapa nigrorufa* Jordon). Ph.D. thesis, University of Bombay, Bombay.

Kilham, L. (1986) Vocalizations by female American Crows early in the nesting period. *Journal of Field Ornithology*. 57: 309–310.

Komdeur, J. & Kats, R.H. (1999) Predation risk affects trade off between nest guarding and foraging in Seychelles warblers. *Behavioral Ecology*. 10: 648–658.

Kothari, A. (2007) *Birds in our lives*. Universities Press, Hyderabad, India.

Krebs, C.J. (1994) *Ecology: the experimental analysis of distribution and abundance* (Fourth edition). Harper Collins Publishers, New York.

Krishnakumar, R. & Sudha, G. (2002) Indian Treepie (*Dendrocitta vagabunda parvula* Whistler and Kinnear) (Corvidae)- a predatory bird of Red palm weevil (*Rhynchophorus ferrugineus* Oliv.). *Insect Environment.* 8: 133.

Kurup, D.N. (1991) Ecology of birds of Malabar coast and Lakswadeep.

Ph.D. thesis, University of Calicut, Calicut.

Lack, D. (1947) The significance of clutch-size. *Ibis*. 47: 302– 352.

Lack, D. (1954) *The natural regulation of animal numbers*. Oxford University Press, London.

Lack, D. (1968) *Ecological adaptations for breeding in birds.* Methuen, London.

Liebezeit, J.R. & George, T.L. (2002) A summary of predation by Corvids on threatened and endangered species in California and management recommendations to reduce Corvid predation. Calif. Dept. Fish and Game, Species Conservation and Recovery Program Report, Sacramento, California.

Lister, M.D. (1952) Some bird association of Indian cultivated and waste lands. *Journal of Bombay Natural History Society*. 51(1): 19–28.

Loffredo, C.A. & Borgia, G. (1986) Sexual selection, mating systems and the evolution of avian acoustical displays. *American Naturalist.* 128: 773–794.

Magrath, R.D. (2008) Hatching asynchrony in altricial birds. *Biological reviews*. 65(4): 587–622.

Magurran, A.E. (2004) *Measuring biological diversity.* Blackwell Publishing Co., Oxford, United Kingdom.

Majumdar, N. & Brahmachari, G.K. (1987) Principal avian predators controlling insects and rodents of paddy in India, management of their eco niches- its feasibility and some suggestions. *Tiger paper*. 5 (14): 24–28.

Malhotra, K.C., Gokhale, Y. & Chatterjee, S. (2001) *Cultural and ecological dimensions of sacred groves in India.* Indian National Science Academy and the Indira Gandhi Rashtriya Manav Sangrahalaya, Bhopal.

Manakadan, R. & Pittie, A. (2001) Standardized common and scientific names of the birds of the Indian Subcontinent. *Buceros*. 6 (1): 1–37.

Mason, C.W. & Lefroy, H.M. (1912) The food of birds in India. *Memoirs of the Dept. of Agriculture in India* (Entomological series). 3: 1–371.

Mathew, D.N., Narendran, T.C. & Zacharias, V.J. (1980) A comparative account of the food habits of some species of birds affecting agriculture. *Journal of Bombay Natural History Society*. 76: 1178–1197.

McGowan, K.J. (2001) Demographic and behavioural comparisons of suburban and rural American Crows. In: Marzluff J.M., Bowman R. & Donelly, R. (Eds.) *Avian ecology and conservation in an urbanizing world.* Kluwer Academic Press, Norwell, MA, pp 365–381.

McKay, W.D. (1980) The influence of agriculture on avian communities near Villaviccncio, Colombia. *Wilson Bulletin*. 92: 381–389.

McLean, I.G. & Rhodes, G. (1991) Enemy recognition and response in birds. *Current Ornithology*. Plenum Press, New York. 8: 173–211.

Mock, D.W. & Parker, G.A. (1997) *The evolution of sibling rivalry*. Oxford University Press, London.

Morrison, M.L., Marcot, B.C. & Mannan, R.W. (1998) *Wildlife-habitat relationships* (Second edition). University of Wisconsin Press, Madison.

Morton, E.S. (1996) A comparison of vocal behaviour among tropical and temperate passerine birds. In: Kroodsma, D.E. & Miller, E.H. (Eds.) *Ecology and evolution of acoustic communication in birds*. Cornell University Press, Ithaca, New York, pp 258–268.

Mudappa, D. (2000) Breeding biology of the Malabar Grey Hornbill (*Ocyceros griseus*) in southern Western Ghats, India. *Journal of Bombay Natural History Society*. 97(1): 15–24.

Myers, P., Espinosa, R., Parr, C.S., Jones, T., Hammond, G.S. & Deway, T.A. (2008) The animal diversity web Available online: http:\\ animal diversity. org. Accessed on March 2008.

Nair, R.M. (2003) Pesticides spell doom for bird life in Wayanad, The Hindu, dated 1st April.

Nameer, P.O. (1994) Birds of Parambikulam Wildlife Sanctuary - a survey report. Report submitted to the Kerala forests and Wildlife Department, Thiruvananthapuram.

Nameer, P.O. & George, S.J. (1991) Avifauna of Chinnar Wildlife Sanctuary. *Newsletter for Birdwatchers.* 31(9 & 10): 7–9.

Natrajan, V. (1997) Breeding biology of the Southern Crow-Pheasant (*Centropus sinensis parroti* Stresemannn) (Aves: Cuculidae) at Point calimere, Tamil Nadu. *Journal of Bombay Natural History Society*. 94: 56–64.

Neelakantan, K.K. (1990) Breeding of the River Tern (*Sterna aurantia*) in Kerala. *Journal of Bombay Natural History Society*. 87(1): 144–145.

Neelakantan, K.K. (1991a) Bluebreasted Banded Rail (*Rallus striatus* Linnaeus) nesting in Kerala. *Journal of Bombay Natural History Society*. 88(3): 448–450.

Neelakantan, K.K. (1991b) Breeding of the Kora or Watercock (*Gallicrex cinerea*) in Kerala. *Journal of Bombay Natural History Society*. 88(3): 450–451.

Neelakantan, K.K. (1993) The Crested Honey Buzzard (*Pernis ptilorhyncus* Temminck) breeding in Kerala. *Journal of Bombay Natural History Society*. 90(2): 286–288.

Neelakantan, K.K. (2004) "*Keralathilae pakshikal*" (Fourth edition). Kerala Sahitya Academy, Trichur.

Newton, I. (2004) The recent declines of farmland bird populations in Britain. An appraisal of causal factors and conservation actions. *Ibis*. 146: 579–600.

Nisbet, I.C.T. (1977) Courtship feeding and clutch size in Common Terns *Sterna hirundo*. In: Stonehouse, B. & Perrins, C.M. (Eds.) *Evolutionary ecology*. Macmillan, London, pp l0l–109.

Nuechterlein, G.L. (1989) Mate feeding by Western and Clark's Grebes. *Condor*. 91: 37–42.

Oommen, M. & Andrews, M.I. (1996) Awakening, roosting and vocalization behaviour of the White Breasted Kingfisher (*Halcyon smyrnensis fusca* Boddaert). *Pavo*. 34(1 & 2): 43–46.

Orris, J.B. (2005) *Megastat version 100*. Distributed by McGraw-Hill Available online: http:\\www.mhhe.com\support.

Padmanabhan, P.V. (2007) *Keralathile pakshi koodukal*. The State Institute of Languages, Kerala.

Palat, R. (1983) Environmental studies on the birds of Malabar forests. Ph.D. thesis, University of Calicut, Calicut.

Palot, M.J. (2000) Habitat use of birds of the north Malabar cost with special reference to the White Bellied Sea Eagle, (*Haliaeetus leucogaster*). Ph.D. thesis, University of Calicut, Calicut.

Pettingil, O.S. (1970) *Ornithology in laboratory and field*. Burgess Publishing Co.,Minnesota, U.S.A.

Pittie, A. (1984) Some observations at the nest of an Indian Treepie (*Dendrocitta vagabunda*). *Mayura.* 5(1): 26–28.

Pramod, P. (1999) Bird community structure in the three different vegetation types of Silent Valley and adjacent forest area. In: Manoharan, T.M., Biju, S.D., Nayar, T.S. & Easa, P.S. (Eds.) *Silent Valley whispers of Reason*. Kerala forests and Wildlife Department, Thiruvananthapuram, pp 325–350.

Prasad, G.A. & Mohanan, C.N. (1995) The Sacred groves of Kerala and biodiversity Conservation. In: Iyenger, P.K. (Eds.) *Proceedings of the 7th Kerala Science Congress.* State Committee on Science, Technology and Environment, Kerala, pp 125–126.

Prasant, J.J., Rao, V.V., & Nagulu, V. (1994) Nesting, egg size, incubation and factors affecting clutch size in Little egret, (*Egretta garzetta*) at Nellore, Andhra Pradesh. *Pavo.* 34(1&2): 39–41.

Rajan, N.P. (1989) A Synecological study on birds in certain paddy fields of Tenhilpalem. M.Phil. thesis, Department of Zoology, University of Calicut, Calicut.

Raju, A.J.S., Rao, S.P. & Rangaiah, K. (2005) Pollination by bats and birds in the obligate outcrosser *Bombax ceiba* Linn. (*Bombacaceae*), a tropical dry season flowering tree species in the Eastern Ghats forests of India. *Ornithological Science*. 4: 81–87.

Ramakrishnan, P.S., Saxena, K.G. & Chandrashekara, U.M. (1998) *Conserving the Sacred for biodiversity management,* Oxford and IBH Publishing Co., New Delhi.

Raman, T.R.S. (2001) Community ecology and conservation of tropical rain forest birds in the Southern Western Ghats, India. Ph.D. thesis, Centre for Ecological Science, Indian Institute of Science, Bangalore.

Ramanoff, A.L. & Ramanoff, A.J. (1949) *The avian egg*. John Wiley & Sons Inc. New York.

Ricklefs, R.E. (1980) ‘‘Watch-dog’’ behavior observed at the nest of a cooperative breeding bird, the Rufous-margined flycatcher (*Myiozetes cayanensis*). *Ibis*. 122: 116–118.

Robbins, C. S. (1981) Bird activity levels related to weather. In: Ralph, C. J. & Scott, J. M. (Eds.) *Estimating numbers of terrestrial birds- Studies in Avian Biology No. 6.* Cooper Ornithological Society, pp 265–270.

Robertson, A. & Jackson, M.C.A. (1992) *Birds of Periyar, an aid to bird watching in the Periyar Sanctuary*. Truism and Wildlife Society of India, Jaipur.

Rosenstock, S.S. (1998) Influence of Gambel Oak on breeding birds in Ponderosa pine forests of Northern Arizona. *Condor*. 100: 485–492.

Rowell, T.E. & Hinde, R.A. (1962) Vocal communication by Rhesus Monkey. *Proceedings of Zoological Society*, London. 138: 279–294.

Roy, P.S. (2003) Biodiversity conservation perspective from space. *National Academy Science Letters-India.* 26: 169–184.

Royama, T. (1966) A re-interpretation of courtship feeding. *Bird Study.* 13: 116–l 29.

Royle, N.J., Hartley, I.R., Owens, I.P.F. & Parker, G.A. (1999) Sibling competition and the evolution of growth rates in birds. *Proceedings of the Royal Society of London*, pp 923–922.

Sachs, L. (1992) *Angewandte statistik.* Springer, Heidelberg.

Santhanakrishnan, R. (1988) Studies on population, food habits and nesting of Barn Owl (*Tyto alba* Scopoli) in a portion of Cauvery basin. M.Phil. thesis, Bharathidasan University, Tiruchirapalli.

Santharam, V. (1995) Ecology of sympatric wood pecker species of Western Ghats, India. Ph.D. thesis, Bharatidasan University, Tiruchirapalli.

Sasikumar, C. (1998) *A study on the avifauna of some sacred groves of North Kerala, India.* A report submitted to Oriental Bird Club Conservation Grant.

Sasikumar, C., Pramod, P. & Palot, M.J. (2000) Birds of Aralam Wildlife Sanctuary - a survey report. Report submitted to Kerala Forests and Wildlife Department, Thiruvananthapuram.

Schmidt, K.A., Goheen, J.R. & Naumann, R. (2001) Incidental nest predation in songbirds: behavioral indicators detect ecological scales and processes. *Ecology*. 82: 2937–2947.

Seedikkoya, K. (2003) Comparative ecology of certain paddy field birds with emphasis on the habitat quality. Ph.D. thesis, University of Calicut, Calicut.

Shannon, C.E. & Weaver, W. (1949) *The Mathematical theory of communication*. University of Illinois Press, Urbana, Illinois.

Shukkur, E.A.A. (1978) Ecology, biology and behaviour of the Black Drongo (*Dicrurus adsimilis*). Ph.D. thesis, University of Calicut, Calicut.

Shukkur, E.A.A. & Joseph, K.J. (1980) Breeding biology of the Black Drongo(*Dicrurus adsimilis*). *Journal of Bombay Natural History Society*. 75: 1212–1226.

Shyama, S.K. (1998) Survey of the bird pests of agricultural crops in Goa. In: Dhindsa, M.S., Rao, P.S. & Parasharya, B.M. (Eds.) *Birds in agricultural ecosystem.* Society for Applied Ornithology, Hyderabad, pp 18–20.

Simmons, K.E.L. (1985) Sunning. In: Campbell, B. & Lack, E. (Eds.) *A dictionary of birds.* T. & A.D. Poyser, Catton.

Singh, G.S. & Saxena, K.G. (1998) Sacred groves in the rural landscape: A case study of the Shekhala village in Jodhpur district of desert Rajasthan. In: Ramakrishnan, P.S., Saxena, K.G. & Chandrashekara, U.M. (Eds.) *Conserving the sacred for biodiversity management.* Oxford and IBH Publishing Co., New Delhi, pp 277–288.

Skutch, A. F. (1945) Incubation and nestling periods of Central American birds. *Auk.* 62: 8–37.

Slagsvold, T. (1982) Clutch variation in passerine birds: the nest predation hypothesis. *Oecologica*, 54: 159–169.

Smith, C.W. (1981) A breeding ecology of the endangered Palila (*Psittirostra bailleui*) on Mauna Kea, Hawaii. Technical Report 42, University of Hawaii, Manoa.

Smith, S.M. (1980) Demand behaviour: a new interpretation of courtship feeding. *Condor*. 82: 291–295.

Srinivasulu, B.C., Srinivasulu, C., Rao, V.V., Koteshwarulu. & Nagulu, V. (1997) Avian use of paddy agro-ecosystem. *Pavo*. 35: 75–84.

Subramanya, S. & Veeresh, G.K. (1998) Avifaunal pattern in the Rice fields of Banglore. In: Dhindsa, M.S., Rao, P.S. & Parasharya, B.M. (Eds.) *Birds in agricultural ecosystem*. Society for Applied ornithology, Hyderabad, pp 30–53.

Sugathan, R. & Varghese, A. P. (1996) A review of the birds of Thattakad Bird Sanctuary, Kerala. *Journal of Bombay Natural History Society.* 93(3): 487–506.

Susanthkumar, C. (1997) Birds of Shendurney Wildlife Sanctuary, Kerala. *Newsletter for Birdwatchers.* 37(6): 94–96.

Tandon, R., Shivanna, K.R. & Ram, H.Y.M. (2003) Reproductive biology of *Butea monosperma* (Fabaceae). *Annals of Botany.* 92: 715–723.

Tasker, C.R., & Mills, J. A. (1981) A functional analysis of courtship feeding in the Red-billed Gull, *Larus novaehollandiae scopulinus. Behaviour*. 77: 222–241.

Thirumurthy, S. (1981) Insectivorous birds associated with the rice ecosystem at Madurai. *Journal of Bombay Natural History Society*. 78(3): 603–605.

Thirumurthy, S. & Balashanmugam, P.V. (1987) Birds associated with fruiting Cashew trees. *Cashew*. 1(2): 18.

Thomas, A.T. (2006) Ecological studies on certain species of granivorous birds in Malabar. Ph.D. thesis, University of Calicut, Calicut.

Thomas, J. (2008) Seasonal cycle in Indian insectivorous birds. Ph.D. thesis, University of Calicut, Calicut.

Tiwari, U.K., Bank, S.K. & Tripathi, R. (1998) Sacred groves of Meghalaya. In: Ramakrishnan, P.S., Saxena, K.G. & Chandrashekara, U.M. (Eds.) *Conserving the sacred for biodiversity management.* Oxford and IBH Publishing Co., New Delhi, pp 253–262.

Upadhyay, K., Law, P.S. & Pandey, H.N. (2003) Biodiversity in the sacred groves of Meghalaya: floristic composition and traditional conservation practices. In: Baruah, P.P. (Eds.) *Biodiversity of Eastern*

Himalayan protected areas. Handuique College, Guwahati, pp 14–24.

Uthaman, P.K. (1993) Birds of the Wayanad Wildlife Sanctuary. *Blackbuck.* 9(1): 1–17.

Uthaman, P.K. (1998) Birds of the Eravikulam National Park - a survey report. *Blackbuck.* 14(2): 45–53.

Valencia, J., Carlos de la Cruz. & Carranza, J. (2000) Second broods in a Mediterranean cooperatively-breeding corvid: the Azure-winged Magpie. *Etología.* 8: 25–28.

Van Tyne, J.V. & Berger, A.J. (1971) *Fundamentals of ornithology*. Dover Publications, New York.

Venugopal, K. (1991) Comparative biology and ecology of the Red-wattled Lapwing (*Vanellus indicus*) and the Yellow-wattled Lapwing (*Vanellus malabaricus*) and a preliminary comparative study on the vocalization of certain species of Indian birds. Ph.D. thesis, University of Calicut, Calicut.

Vepsäläinen, V. (2007) Farmland Birds and habitat heterogeneity in intensively cultivated Boreal agricultural landscapes. Academic dissertation, Department of Biological and Environmental Sciences, Faculty of Biosciences, University of Helsinki, Finland.

Vijayan, V.S. (1975) Ecological isolation of Bulbuls (Pycnonotidae, Aves) with special reference to *Pycnonotus cafer* and *Pycnonotus lutteolus* at Point calimere, Thamilnadu. Ph.D. thesis, University of Bombay, Bombay.

Whelan, C.J. (1989) Avian foliage structure preferences for foraging and the effect of prey biomass. *Animal Behaviour*. 38: 839–846.

Wretenberg, J., Lindstrom, A., Svensson, S., Thierfelder, T. & Part, T. (2006) Population trends in Sweden and England: similar trends but different patterns of agricultural intensification. *Journal of Applied Ecology*. 43: 1110–1120.

Yahya, H.S.A. (1980) A comparative study of ecology and biology of Barbets, (*Megalaima* sp.) (Capitonidae: Piciforms) with special reference to *Megalaima viridis* (Boddaert) and *Megalaima rubricapilla malabarica* (Blyth) at Periyar Tiger Reserve, Kerala. Ph.D. thesis, University of Bombay, Bombay.

Yahya, H.S.A. (1988) Breeding biology of Barbets, *Megalaima* sp. (Capitonidae: Piciformes) at Periyar Tiger Reserve, Kerala. *Journal of Bombay Natural History Society*. 85: 493–511.

Yoshioka, K. (2000) Ky plot for windows. Available online: http:\\ qualest. co. jp. Accessed on March 2008.

Zacharias, V.J. (1978) Ecology and biology of certain species of Indian Babblers (*Turdoides* sp.) in Malabar. Ph.D. thesis, University of Calicut, Calicut.

Zacharias, V.J. & Gaston, A.J. (1983) Breeding seasons of birds at Calicut, Southwest India. *Ibis.* 125: 407–412.

Zacharias, V.J. & Gaston, A.J. (1993) The birds of Wayanad, Southern India. *Forktail.* 8: 11–23.

Zacharias, V.J. & Mathew, D.N. (1998) Behaviour of the White-headed Babbler (*Turdoides affinis* Jerdon). *Journal of Bombay Natural History Society*. 95(1): 8–14.

Zacharias, V.J. & Gaston, A.J. (1999) The recent distribution of endemic, disjunct and globally uncommon birds in the forests of Kerala state, southwest India. *Bird Conservation International*. 9: 191–225.

Appendix 1: Characteristics of the nest and details of the clutch of Indian Treepie at Kizhakkoth Panchayath during 2005–2007 period (DBH = Diameter at breast height, N = North, S = South, E = East, W = West, SE = Southeast, SW = Southwest, NW = Northwest, NE = northeast).

Year	Sl. No.	Nesting tree	Tree height (m)	Height of the nest (m)	Relative nest height (m)	DBH (cm)	Orientation of the nest	Canopy diameter (m)	Area of the territory (ha)	(m)Distance to nearest house	No. of eggs laid	Eggs predated/lost	No. of unhatched eggs	No. of hatched eggs	No. of nestlings predated	No. of nestlings fledged
2005	1	*Areca catechu*	16.30	14.50	0.89	11.46	SE	3.00	0.53	28.00	3	0	0	3	3	0
	2	*Areca catechu*	13.50	12.00	0.89	12.10	SW	3.20	0.58	14.00	4	2	0	2	0	2
	3	*Areca catechu*	8.50	7.40	0.87	10.19	SW	2.60	0.43	59.00	4	0	0	4	4	0
	4	*Areca catechu*	14.50	12.75	0.88	13.06	SE	3.00	0.48	54.00	4	0	1	3	0	3
	5	*Areca catechu*	12.00	10.50	0.88	10.19	SW	2.60	0.55	22.00	3	3	0	0	0	0
	6	*Cocos nucifera*	19.00	14.00	0.74	26.75	NE	3.00	0.48	21.00	4	0	1	3	3	0
	7	*Artocarpus heterophyllus*	20.00	10.50	0.53	40.13	SE	4.00	0.58	23.00	4	4				
	8	*Artocarpus heterophyllus*	17.00	9.00	0.53	35.03	SE	5.00	0.41	39.00	4	1	0	3	0	3
	9	*Artocarpus heterophyllus*	17.00	10.40	0.61	31.21	NE	3.80	0.55	18.00	2	0	0	2	1	1
	10	*Artocarpus heterophyllus*	18.50	8.00	0.43	28.34	SW	4.00	0.48	16.00	3	0	0	3	1	2
	11	*Artocarpus heterophyllus*	16.00	6.70	0.42	28.34	NE	3.80	0.58	42.00	4	2	0	2	2	0
	12	*Artocarpus heterophyllus*	15.00	9.00	0.60	27.07	NE	4.50	0.53	14.00	4	4				
	13	*Melicope lunu-ankenda*	10.50	7.50	0.71	16.56	SW	1.80	0.82	51.00						

	14	*Melicope lunu-ankenda*	9.00	6.30	0.70	16.88	NE	2.00	0.45	49.00	3	0	0	3	0	3
	15	*Melicope lunu-ankenda*	7.00	4.70	0.67	13.06	NE	2.10	0.58	11.00	4	0	0	4	4	0
	16	*Mangifera indica*	13.00	8.40	0.65	31.21	SE	4.50	0.55	36.00	4	0	0	4	0	4
	17	*Mangifera indica*	10.50	6.00	0.57	31.53	SE	5.00	0.92	22.00	4	1	0	3	1	2
2006	18	*Areca catechu*	15.00	13.60	0.91	12.42	SE	3.20	0.48	44.00	4	0	0	4	0	4
	19	*Areca catechu*	4.00	2.50	0.63	11.46	SW	2.50	0.41	51.00	3	0	0	3	0	3
	20	*Areca catechu*	14.00	12.50	0.89	13.38	SE	3.00	0.58	38.00	4	0	1	3	0	3
	21	*Areca catechu*	10.75	9.00	0.84	12.10	NE	2.80	0.69	26.00	4	4				
	22	*Areca catechu*	16.00	14.50	0.91	13.69	SW	3.20	0.66	31.00						
	23	*Areca catechu*	9.75	8.00	0.82	11.15	SE	3.00	0.50	51.00	4	4				
	24	*Areca catechu*	14.00	12.50	0.89	11.46	SW	3.00	0.48	37.00	4	0	0	4	4	0
	25	*Areca catechu*	16.75	15.35	0.92	12.10	SE	2.50	0.61	42.00	4	4				
	26	*Areca catechu*	13.00	11.40	0.88	11.46	SW	3.00	0.69	45.00	4	0	0	4	0	4
	27	*Areca catechu*	7.00	5.58	0.80	10.51	SE	2.60	0.61	48.00	4	1	0	3	0	3
	28	*Areca catechu*	15.00	13.30	0.89	13.38	NE	3.00	0.53	37.00						
	29	*Areca catechu*	15.50	14.10	0.91	13.06	SW	2.75	0.58	34.00	4	4				
	30	*Areca catechu*	13.50	12.00	0.89	13.69	NE	3.00	0.53	52.00	4	0	1	3	3	0
	31	*Cocos nucifera*	21.00	16.50	0.79	28.03	SE	2.50	0.53	42.00						
	32	*Artocarpus heterophyllus*	18.00	5.20	0.29	48.09	SE	5.00	0.48	37.00	4	2	0	2	2	0
	33	*Artocarpus heterophyllus*	17.50	8.20	0.47	35.67	SW	4.50	0.53	22.00	4	1	0	3	0	3
	34	*Artocarpus heterophyllus*	12.00	3.50	0.29	26.11	SE	5.00	0.66	23.00	3	3	0	0	0	0
	35	*Melicope lunu-ankenda*	9.50	5.00	0.53	14.65	SW	2.50	0.45	47.00	4	0	0	4	0	4
	36	*Melicope lunu-ankenda*	9.00	6.00	0.67	13.38	SE	2.25	0.53	47.00	4	0	0	4	4	0
	37	*Corypha umbraculifera*	16.50	11.80	0.72	38.54	SE	3.75	0.61	14.00						
2007	38	*Areca catechu*	16.25	14.70	0.90	13.06	SW	2.80	0.45	42.00	4	1	0	3	0	3
	39	*Areca catechu*	13.50	12.00	0.89	11.78	NE	2.50	0.48	39.00	3	0	0	3	1	2

	40	*Areca catechu*	7.25	5.80	0.80	11.15	SW	3.00	0.43	48.00	4	2	0	2	2	0
	41	*Areca catechu*	14.75	13.20	0.89	13.69	SW	3.00	0.45	40.00						
	42	*Areca catechu*	14.00	12.60	0.90	13.06	NE	2.60	0.41	53.00	4	0	0	4	0	4
	43	*Areca catechu*	10.00	8.40	0.84	13.69	SW	3.00	0.53	37.00	3	3	0	0	0	0
	44	*Areca catechu*	14.50	12.80	0.88	13.38	SE	3.00	0.48	38.00	4	1	0	3	0	3
	45	*Areca catechu*	8.00	6.74	0.84	11.78	SW	3.00	0.53	27.00	4	0	0	4	3	1
	46	*Areca catechu*	13.70	12.28	0.90	12.10	SE	2.50	0.45	47.00	4	4				
	47	*Areca catechu*	12.50	10.90	0.87	11.46	SE	2.20	0.43	52.00	4	0	1	3	0	3
	48	*Areca catechu*	14.00	12.55	0.90	13.06	SE	3.20	0.55	35.00	3	0	0	3	3	0
	49	*Cocos nucifera*	19.75	14.95	0.76	27.07	NE	2.75	0.66	27.00	4	4				
	50	*Artocarpus heterophyllus*	15.00	7.40	0.49	34.71	SW	4.00	0.88	21.00	3	0	0	3	0	3
	51	*Artocarpus heterophyllus*	13.00	7.50	0.58	30.57	SE	4.50	0.53	34.00	4	0	0	4	4	0
	52	*Melicope lunu-ankenda*	11.50	8.40	0.73	17.83	NE	2.00	0.55	21.00	3	1	0	2	0	2
	53	*Melicope lunu-ankenda*	7.50	5.70	0.76	13.38	SW	1.50	0.43	42.00	4	0	0	4	0	4
	54	*Corypha umbraculifera*	18.50	14.00	0.76	36.94	SW	4.20	0.69	16.00	4	2	0	2	2	0
	55	*Mangifera indica*	16.50	7.00	0.42	35.03	NE	5.00	0.53	16.00	4	2	0	2	2	0
	56	*Mangifera indica*	13.50	6.30	0.47	32.48	SW	5.20	0.43	39.00	4	0	0	4	0	4
		Mean ± SD	**13.55 ± 3.76**	**9.85 ± 3.50**	**0.73 ± 0.18**	**19.89 ± 10.22**		**3.23 ± 0.93**	**0.55 ± 0.11**	**35.02 ± 12.82**	**3.74 ± 0.49**					**1.52 ± 1.61**

Appendix II: Scientific, common and regional names of plants mentioned in the thesis**.**

Sl. No.	Scientific name	Common name	Regional name
1	*Abrus precatorius*	Crabs eye	Kunni
2	*Acacia intsia*	Soap bark	Incha
3	*Ailanthus malabarica*	White bean	Matti
4	*Amorphophallus paeoniifolius*	Elephant foot yam	Chena
5	*Anacardium occidentale*	Cashewnut	Parangi Mavu
6	*Ananas comosus*	Pine apple	Kaitha chakka
7	*Annona squamosa*	Castard apple	Seethappayam
8	*Anogeissus latifolia*	Axlewood	Kalkanjiram
9	*Areca catechu*	Areca palm	Kamugu
10	*Artocarpus heterophyllus*	Jack tree	Plavu
11	*Artocarpus hirsutus*	Wild jack	Anjili, Aini
12	*Bamboo* sp.	Bamboo	Mula
13	*Bauhinia acuminata*	White orchid-tree	Vellamandaram
14	*Bombax ceiba*	Red silk cotton	Ilavu, Poola
15	*Calycopteris floribunda*	Paper flower climber	Pullanhi
16	*Canthium coromandelicum*	Coromandel boxwood	Karamullu
17	*Capsicum frutescens*	Green chilly	Kantharimulaku
18	*Carallia brachiata*	Indian oak	Vengana
19	*Carica papaya*	Papaya	Papaya
20	*Caryota urens*	Fishtail palm	Anappana
21	*Casearia* sp.		Kunnan
22	*Centrosema virginianum*	Spurred butterfly pea	Poombattappayar
23	*Chromaulena odorata*	Siam weed	Communist pachcha
24	*Cinnamomum verum*	True cinnamon Tree	Karuka
25	*Cocos nucifera*	Coconut palm	Thengu
26	*Colocasia esculenta*	Taro	Chembu
27	*Corypha umbraculifera*	Talipot palm	Kudappana
28	*Costus speciosus*	Spiral ginger	Channakkoova

29	*Curcuma longa*	Turmeric	Manjal
30	*Cyclea peltata*	Pata root	Padathali
31	*Dalbergia latifolia*	Rosewood	Veetti
32	*Dioscorea alata*	Yam	Kachil
33	*Dioscorea esculenta*	Yam	Kachil
34	*Drymoglossum piloselloides*	Dragon scales	Seethathali
35	*Erythrina indica*	Indian coral tree	Murikku
36	*Ficus exasperata*	Sandpaper (leaf) tree	Therakam
37	*Ficus hispida*	Hairy fig	Parakam, Erumanaakku
38	*Flacourtia montana*	Mountain sweet thorn	Caralwazham, Loopikka
39	*Garcinia gummi-gutta*	Brindal berry	Kudambuli
40	*Glyricidia sepium*	Glyricidia	Sheemakonna
41	*Helicanthes elasticus*		Iththilkanni
42	*Hemidesmus indicus*	Indian sarsaparilla	Nannari, Naruneendi
43	*Holigarna arnottiana*	Black varnishing tree	Cheru
44	*Ichnocarpus frutescens*	Black creeper	Palvalli
45	*Ischaemum* sp.	Wild grass	Pullu
46	*Lagerstroemia microcarpa*	Nacked maiden of forest	Venthekku
47	*Lannea coromandelica*	Indian ash tree	Karasu
48	*Lawsonia inermis*	Henna	Mylanchi
49	*Litsea coriacea*		Maravettithali
50	*Lucuma nervosa*	Egg fruit plant	Muttapazham
51	*Macaranga peltata*	Chandada	Vatta, Uppoothi
52	*Malvaviscus penduliflorus*	Sleeping hibiscus	Mulakuchembarathi
53	*Mangifera indica.*	Mango tree	Mamaram
54	*Manihot utilisima*	Cassara, Tapioca	Kappa
55	*Melicope lunu-ankenda*		Kambili
56	*Memecylon malabaricum*		Kashavu
57	*Mimosa pudica*	Touch me not	Thottavadi
58	*Moringa oleifera*	Moringa	Moringa
59	*Musa* sp.	Banana	Vazha

60	*Myristica fragrans*	Nut mug	Jaathi
61	*Naregamia alata*	Goanese ipecac	Nilanarakam
62	*Oldenlandia auricularia*		Erachiketti
63	*Oryza sativa*	Rice	Nellu
64	*Pandanus tectorius*	Screw pine	Kaitha
65	*Phyllanthus myrtifolius*	Hedge plant	Nellichedi
66	*Piper nigrum*	Black pepper	Kurumulaku
67	*Pisidium guajava*	Guava	Pera
68	*Pothos scandens*	Peacock's tail	Anapparuva
69	*Pterocarpus marsupium*	Indian kino tree	Venga
70	*Punica granatum*	Pome granate	Mathalam
71	*Schleichera oleosa*	Ceylon oak	Poovam
72	*Sida cordifolia*	Country mallow	Kurunthoti
73	*Strychnos nux-vomica.*	Snake wood	Kanjiram
74	*Swietenia macrophylla*	Mahagoni	Mahagoni
75	*Syzygium aqueum*	Water apple, Bell fruit	Chamba
76	*Tamarindus indica.*	Tamarind	Puli
77	*Tecoma stans*	Yellow bell	
78	*Tectona grandis.*	Teak	Thekku
79	*Vanda* sp.	Orchid	Maravazha
80	*Vernonia scandens*	Curtain creeper	
81	*Xylia xylocarpa*	Iron wood	Irool
82	*Zanthoxylum rhetsa*	Indian prickly ash	Mullilam
83	*Ziziphus oenopila*	Jackal jujube	Vanthudali

Plate 1: A) Map of Kerala state and B) Kozhikode district showing the study site.

Plate 2: An overview of Kizhakkoth panchayath showing the study sites A) Paddy field, B) Coconut plantation and C) Sacred grove.

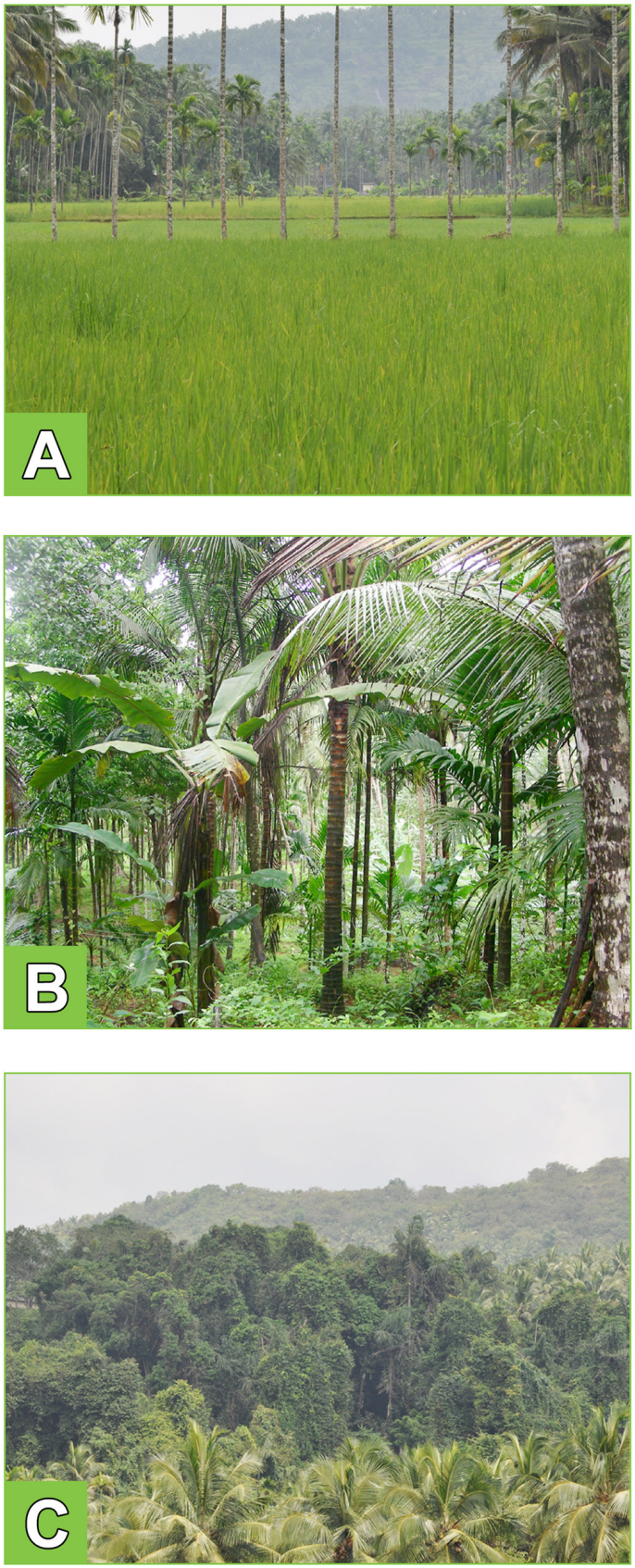

Plate 3: Study habitats at Kizhakkoth panchayath A) Paddy field, B) Coconut plantation and C) Sacred grove.

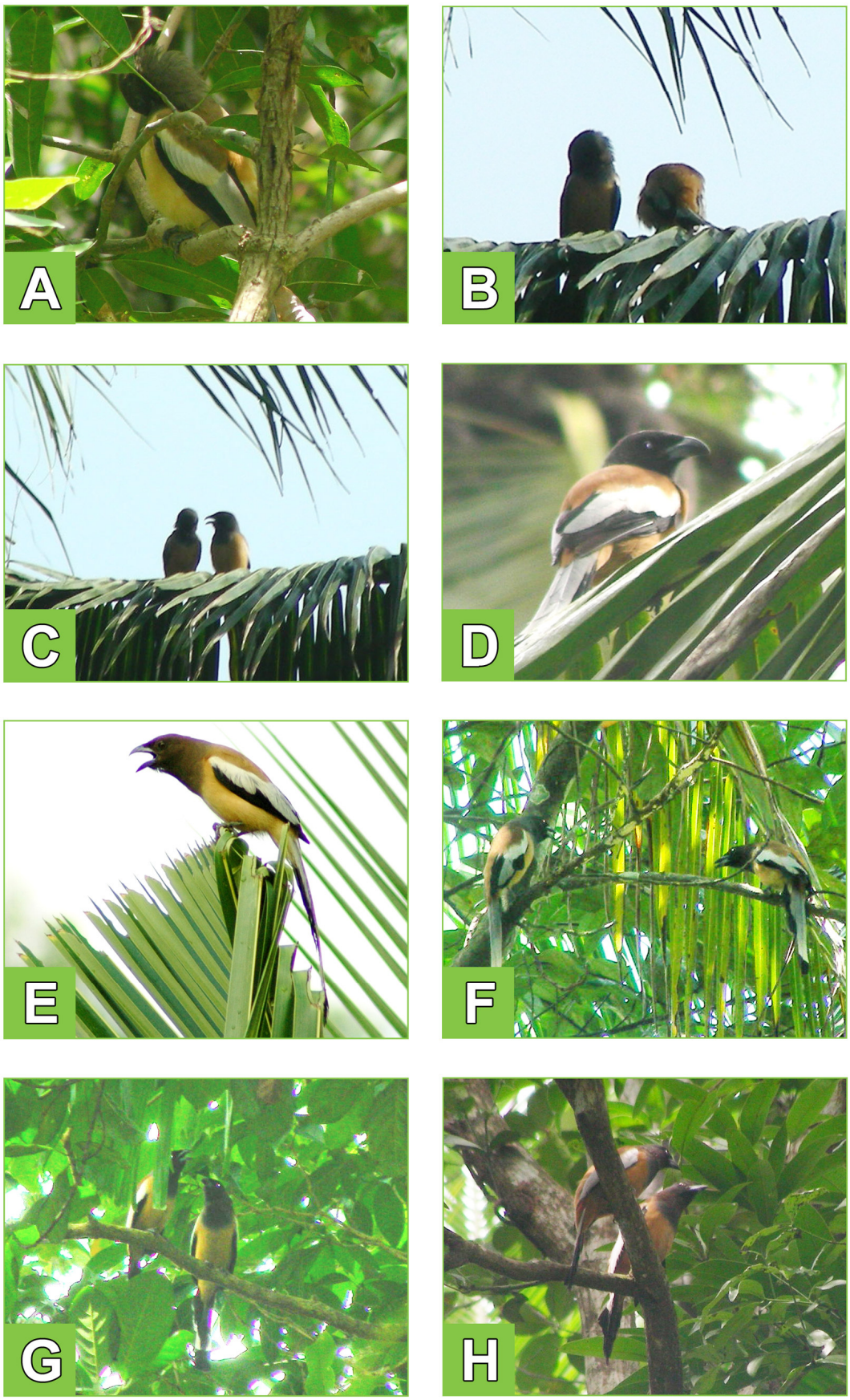

Plate 4: Behaviour of Indian Treepie; (A, B & C) Preening behaviour; (D & E) Foraging behaviour; (F, G & H) Courtship behaviour.

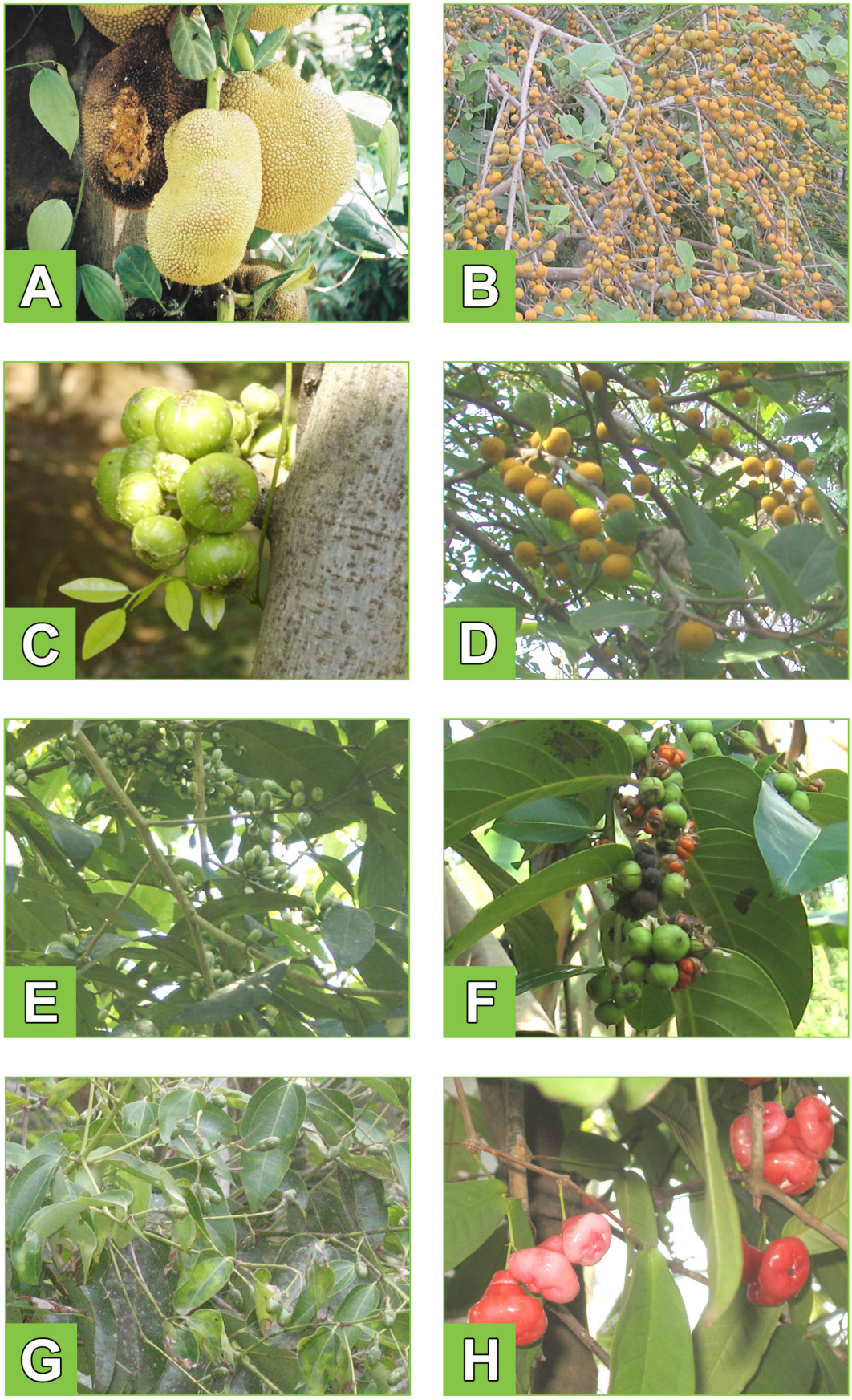

Plate 5: Common food plants of Indian Treepie; A) *Artocarpus heterophillus*, B) *Ficus* sp., C) *Ficus hispida*, D) *Ficus exasperata*, E) *Litsea coriacea*, F) *Casearia* sp., G) *Cinnamommum verum* and H) *Syzygium aqueum*.

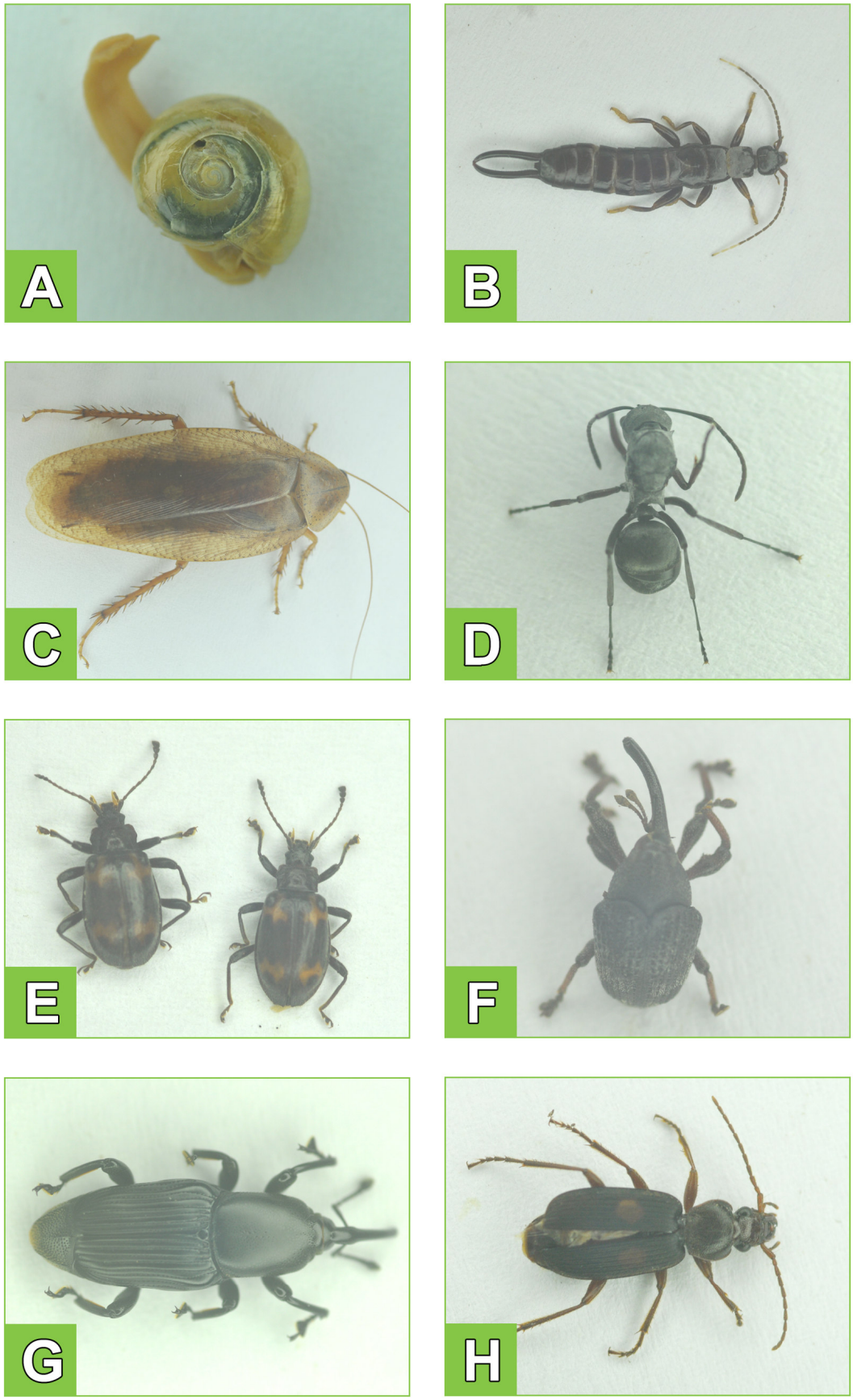

Plate 6: Prey items of Indian Treepie; A) Snail, B) Forficulidae, C) Blattidae, D) Formicidae, E) Cercopidae, F) Curculionidae sp.1, G) Curculionidae sp.2 and H) Carabidae.

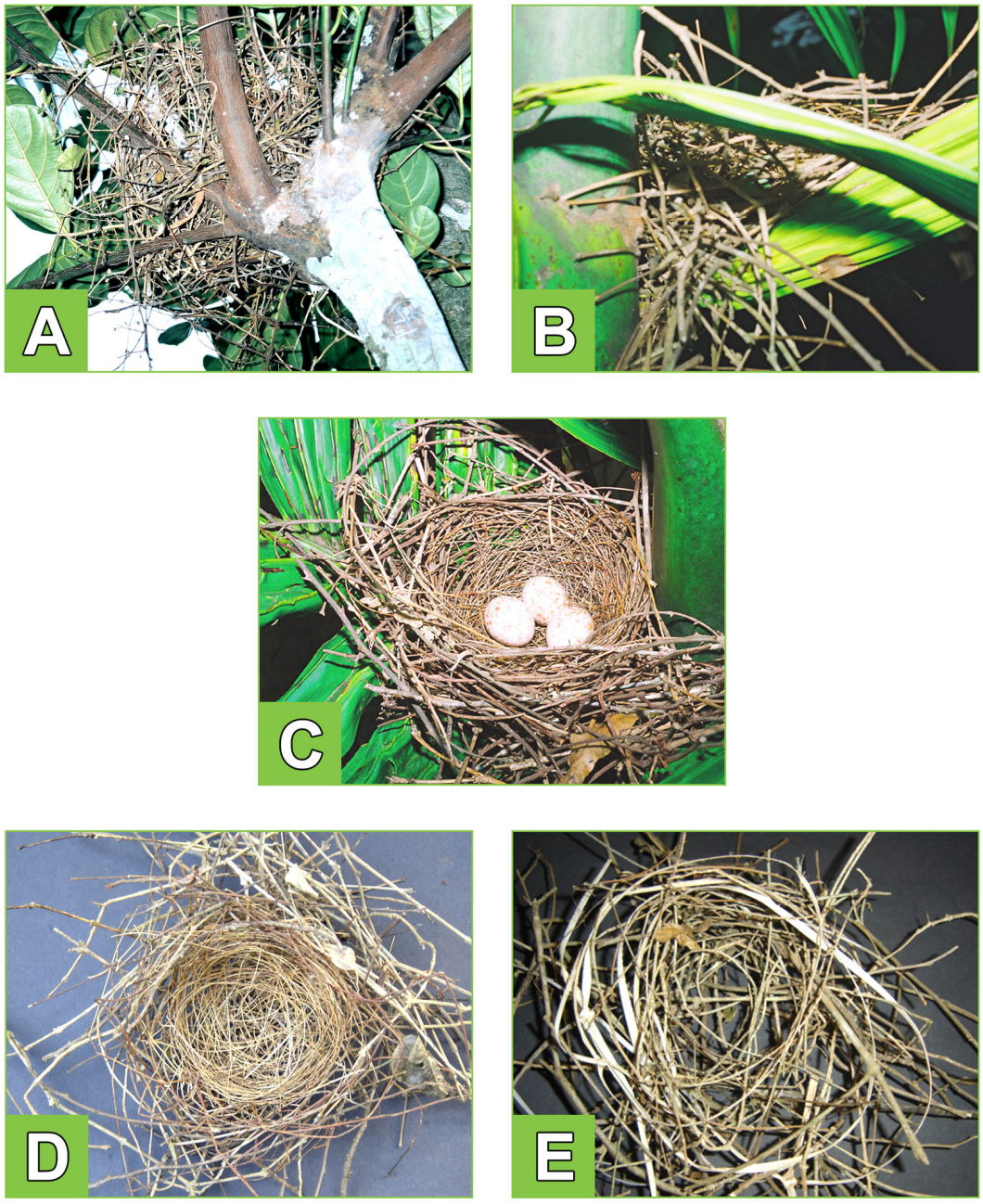

Plate 7: A) Indian Treepie nest on Jack tree; (B & C) Nest on Araeca palm and (D & E) Nest collected after fledging.

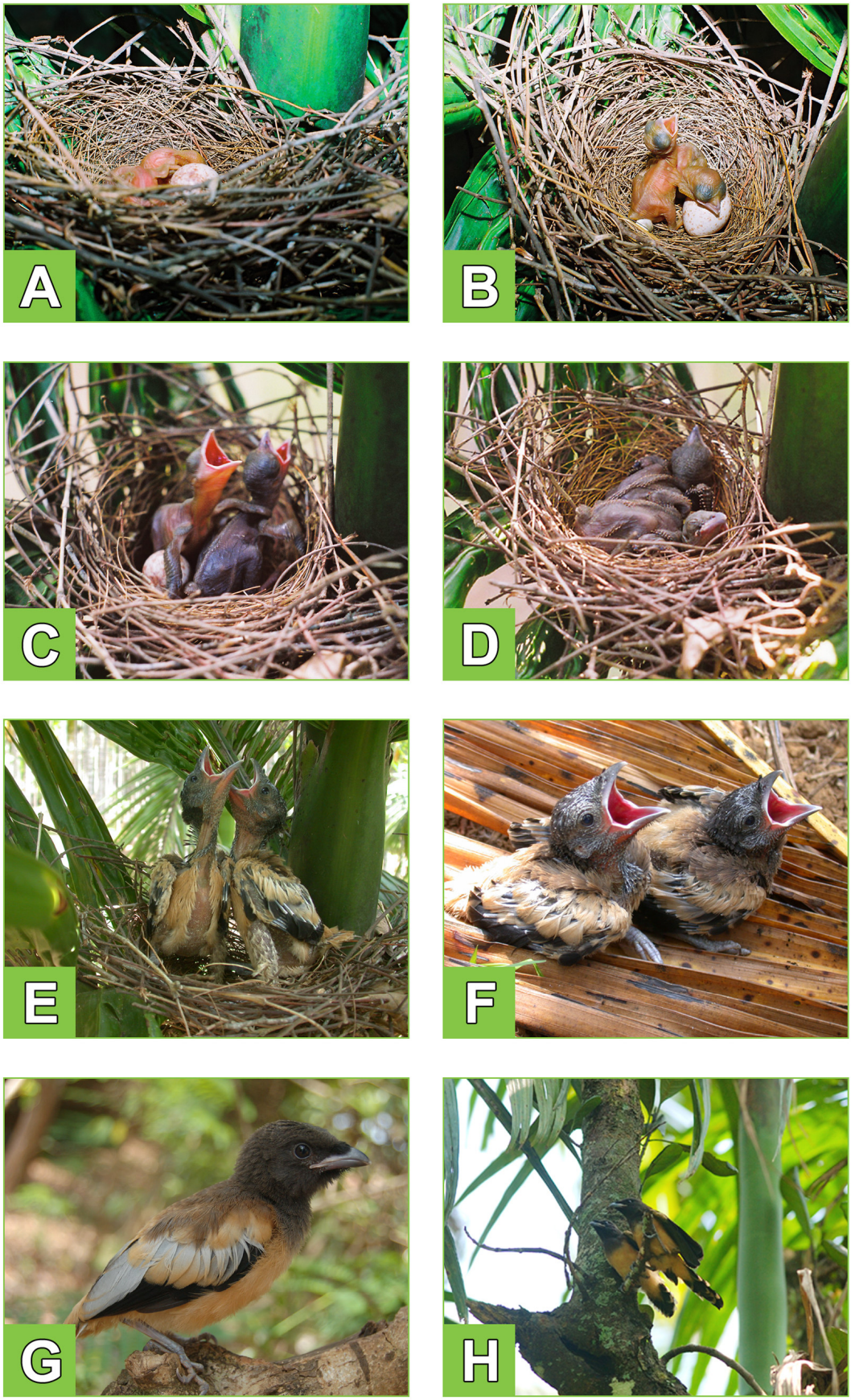

Plate 8: Different stages of the nestlings and fledglings of Indian Treepie; (A-F) Different stages of nestlings: A) 0 day (after 2 hrs), B) 1st day (after 24 hrs), C) 4th day, D) 6th day, E) 12th day, F) 14th day; (G & H) Different stages of fledglings: G) 1st day and H) 12th day.

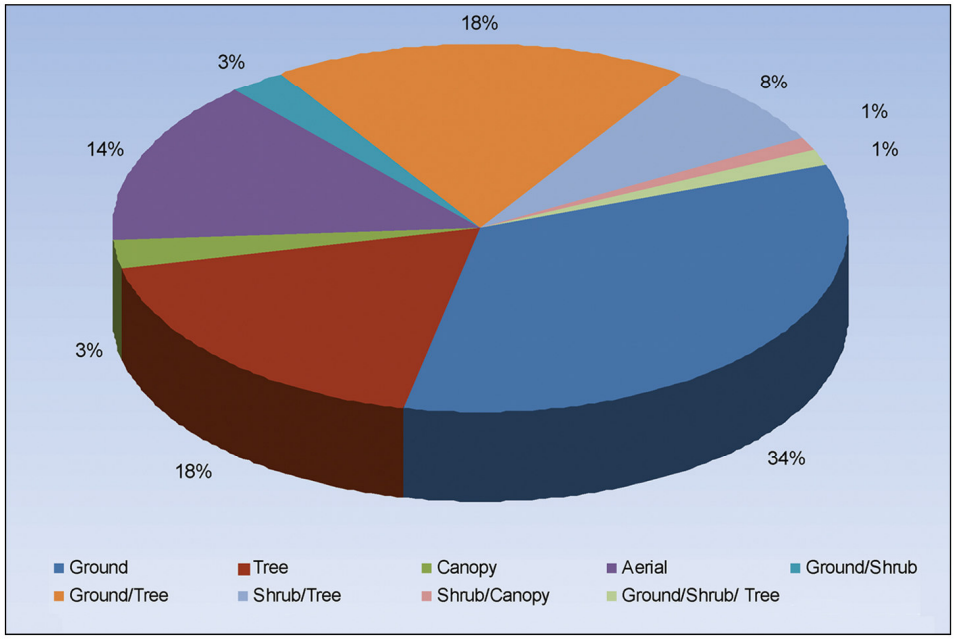

Figure 1: Foraging guild wise richness of avian fauna at Kizhakkoth panchayath during 2003–2005 period.

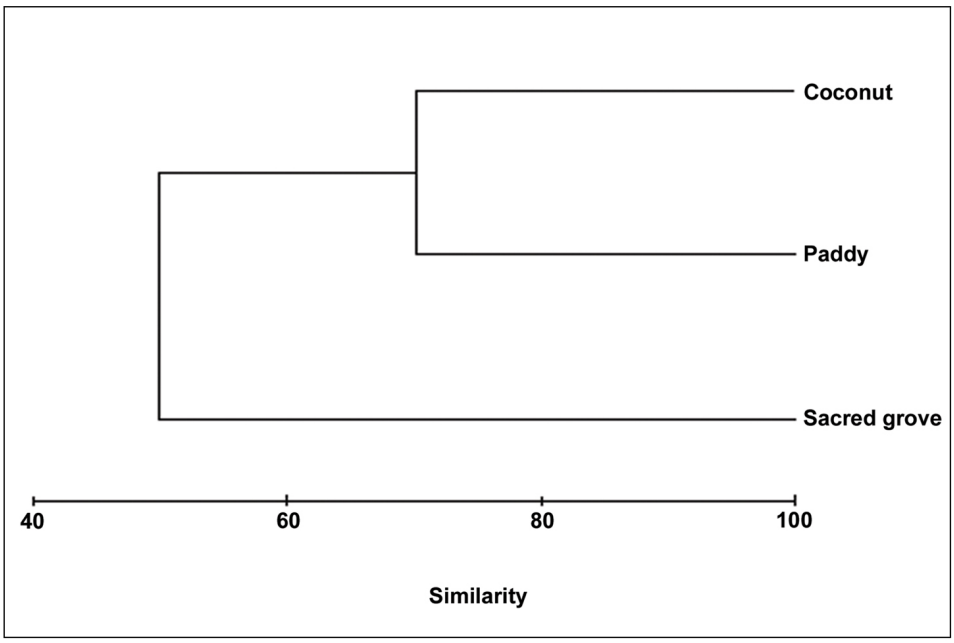

Figure 2: Dendrogram based on hierarchial agglomerative clustering (group–linking) of avian faunal assemblage in different habitats at Kizhakkoth panchayath during 2003–2005 period.

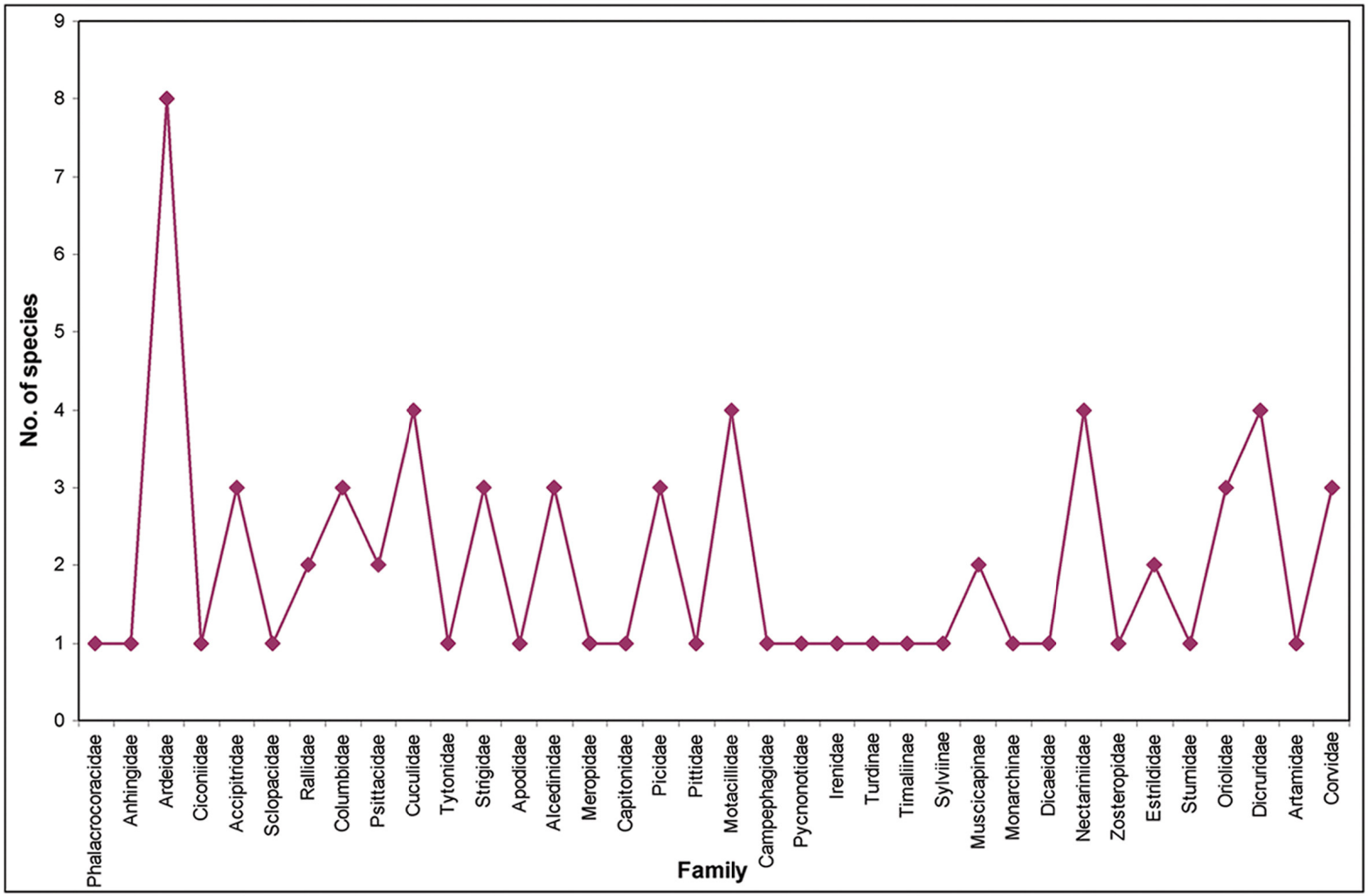

Figure 3: Family wise richness of avian fauna in paddy field at Kizhakkoth panchayath during 2003–2005 period.

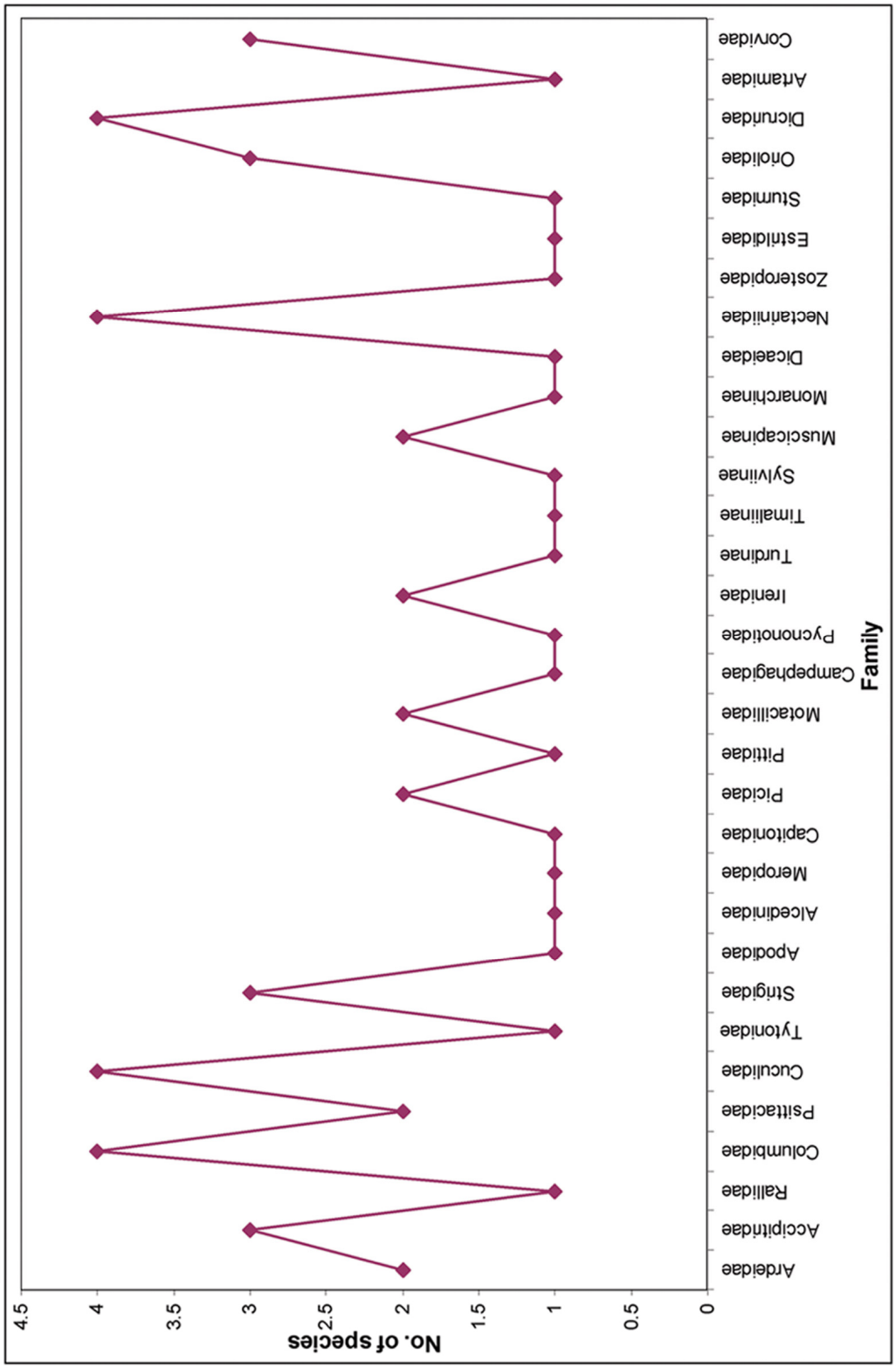

Figure 4: Family wise richness of avian fauna in coconut plantation at Kizhakkoth panchayath during 2003–2005 period.

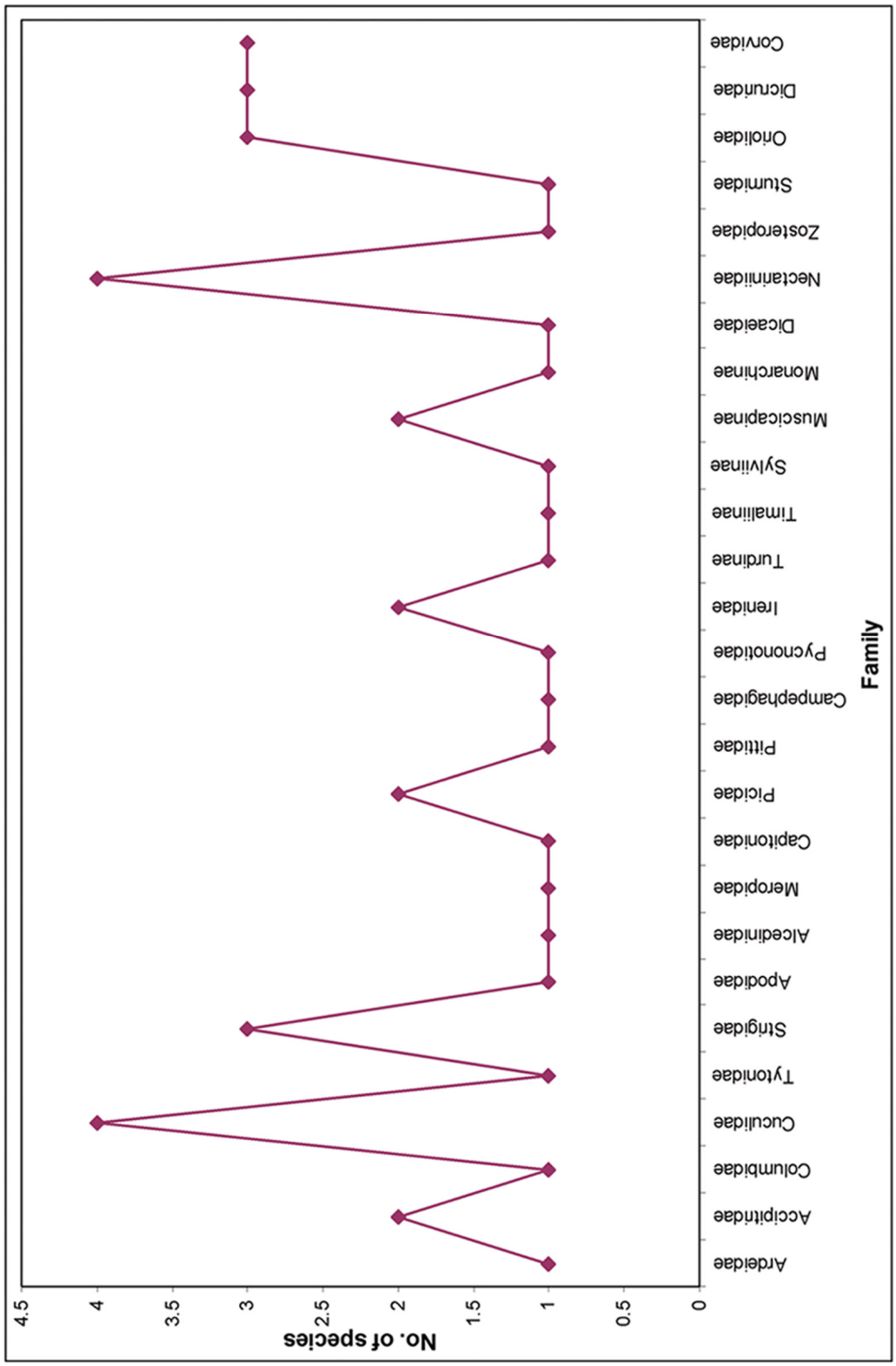

Figure 5: Family wise richness of avian fauna in sacred grove at Kizhakkoth panchayath during 2003–2005 period.

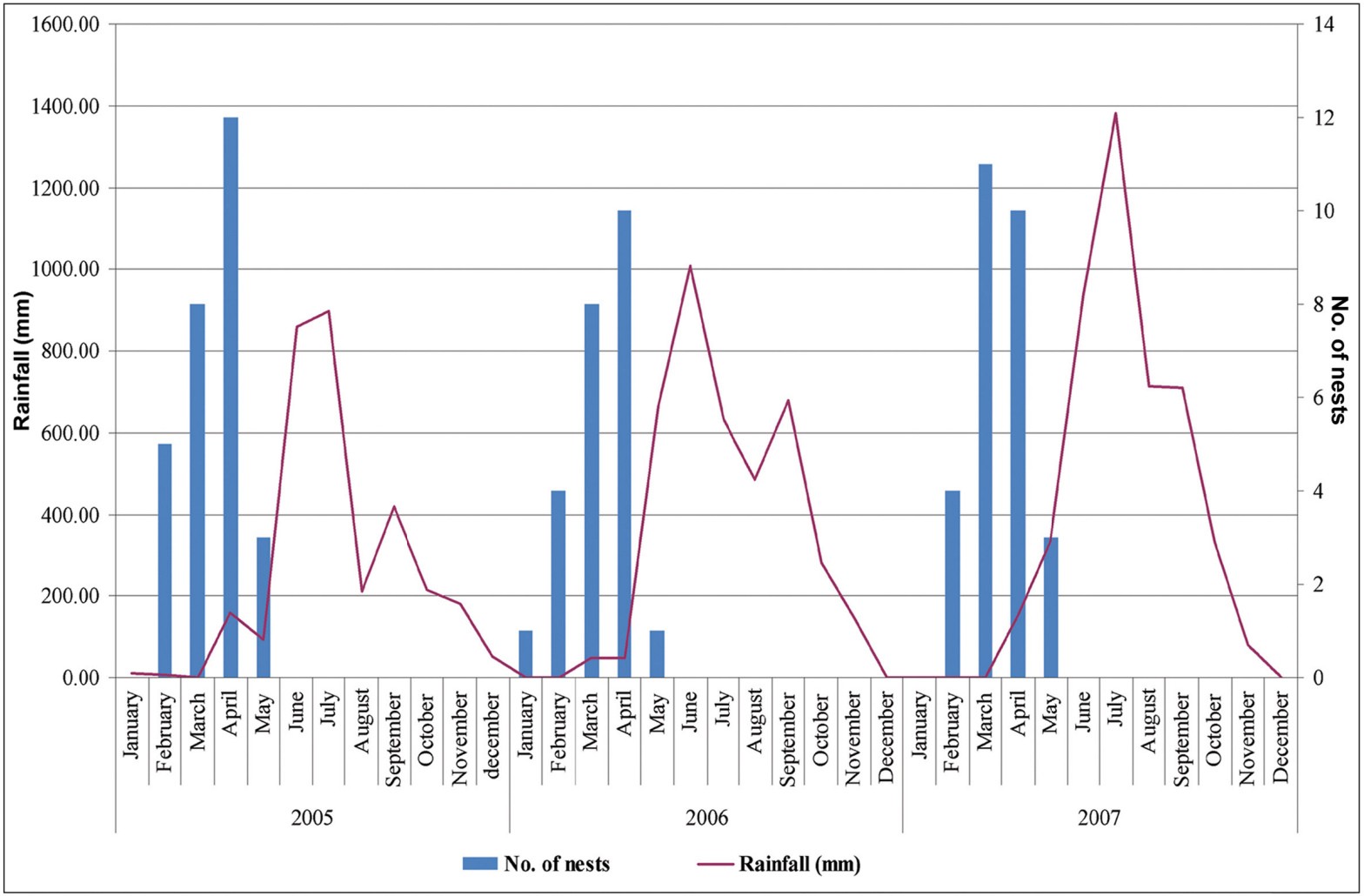

Figure 6: Number of nests of Indian Treepie in relation to rainfall at Kizhakkoth panchayath during 2005–2007 period.

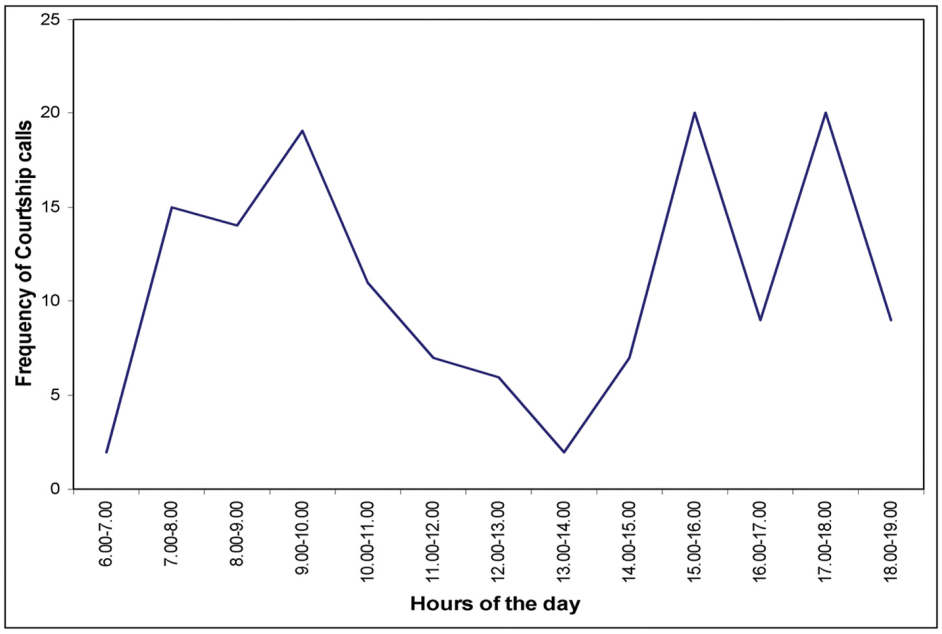

Figure 7: Frequency of courtship calls made by Indian Treepie at Kizhakkoth panchayath during 2005 period.

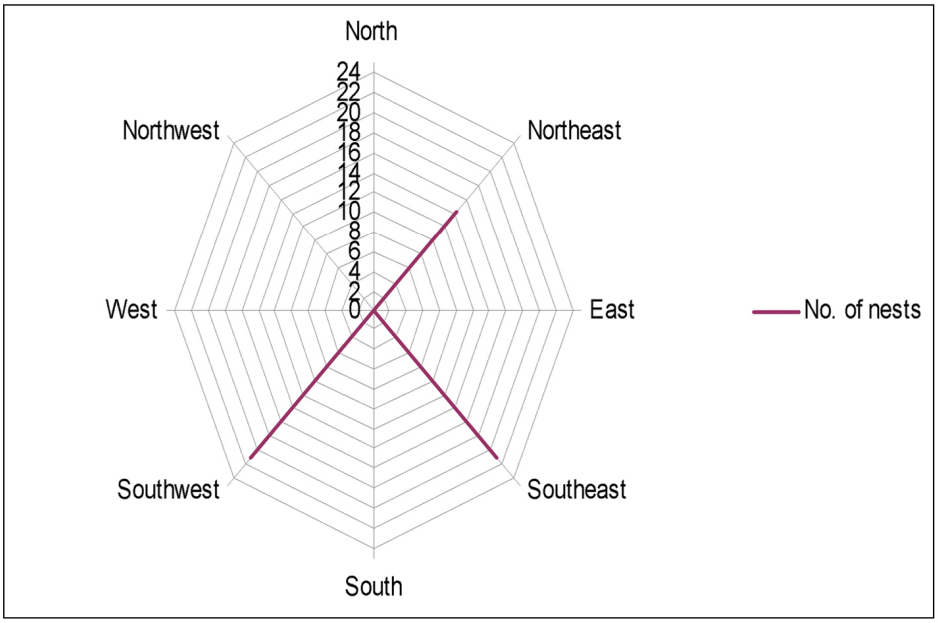

Figure 8: Orientation of the nests of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

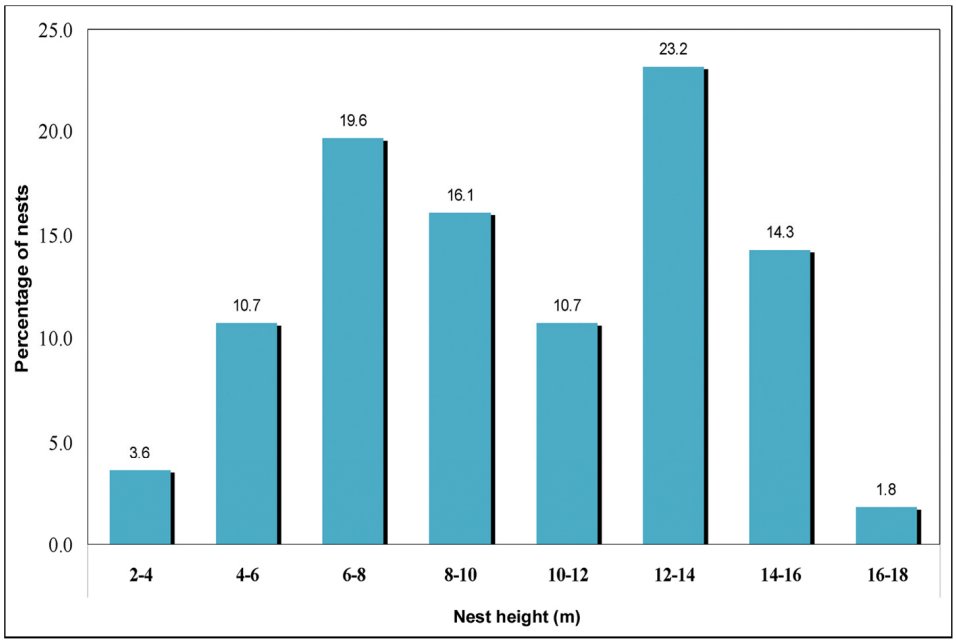

Figure 9: Distribution (%) of Indian Treepie nests at different heights in Kizhakkoth panchayath during 2005–2007 period.

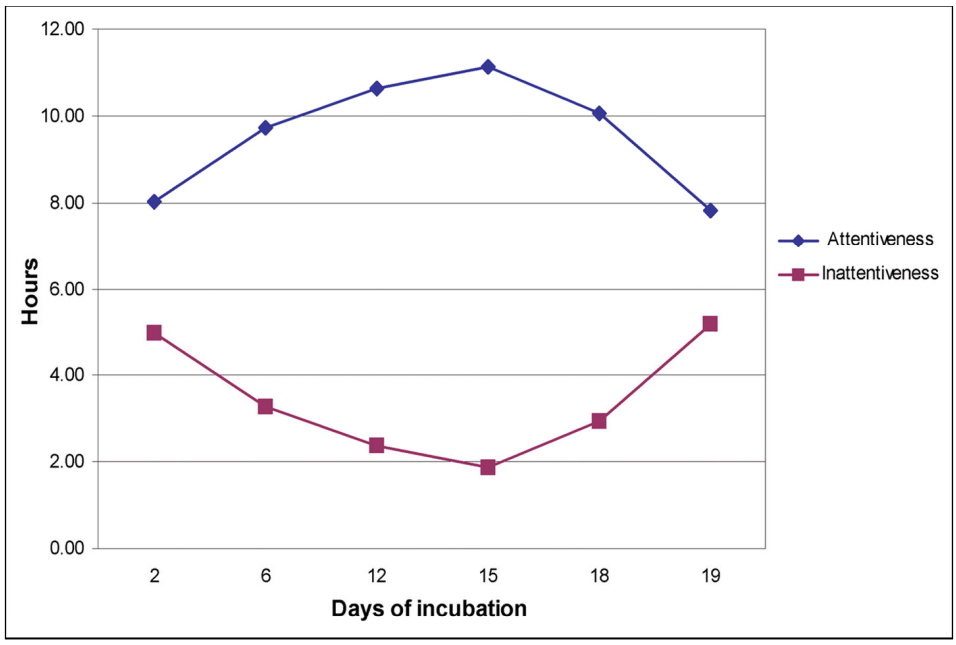

Figure 10: Duration of attentiveness and inattentiveness of Indian Treepie during the incubation period at Kizhakkoth panchayath during 2007 period.

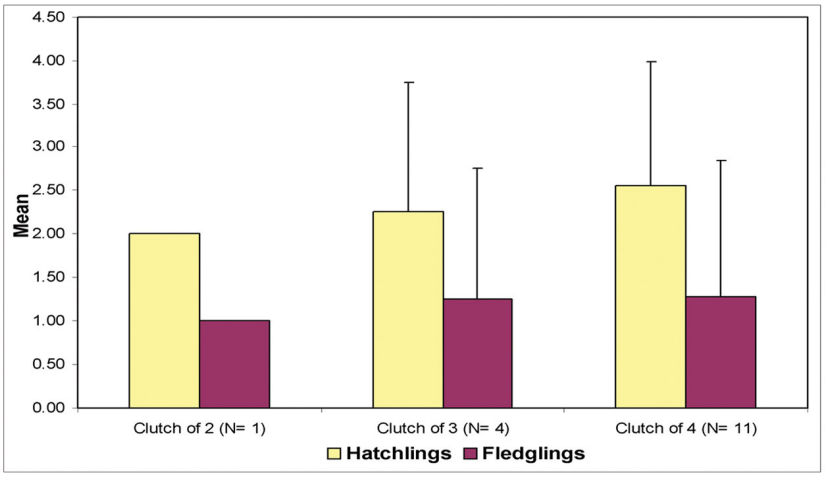

Figure 11: Clutch wise number of hatchlings and fledglings of Indian Treepie (Mean ± SD) at Kizhakkoth panchayath during 2005 period.

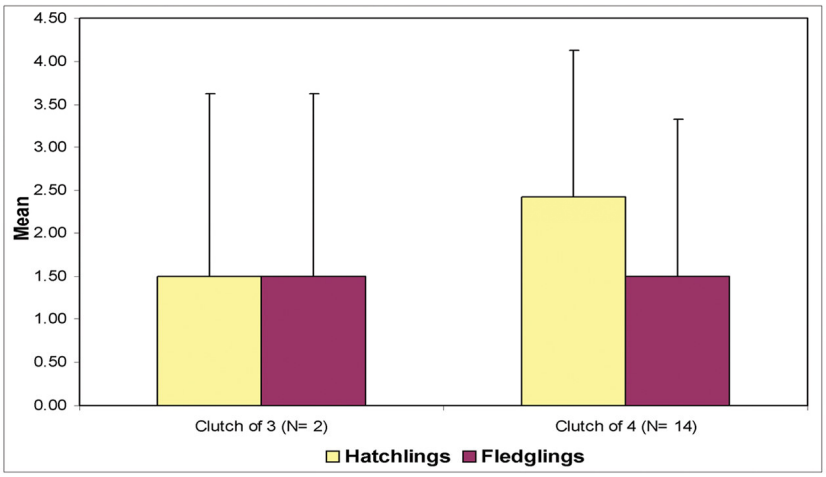

Figure 12: Clutch wise number of hatchlings and fledglings of Indian Treepie (Mean ± SD) at Kizhakkoth panchayath during 2006 period.

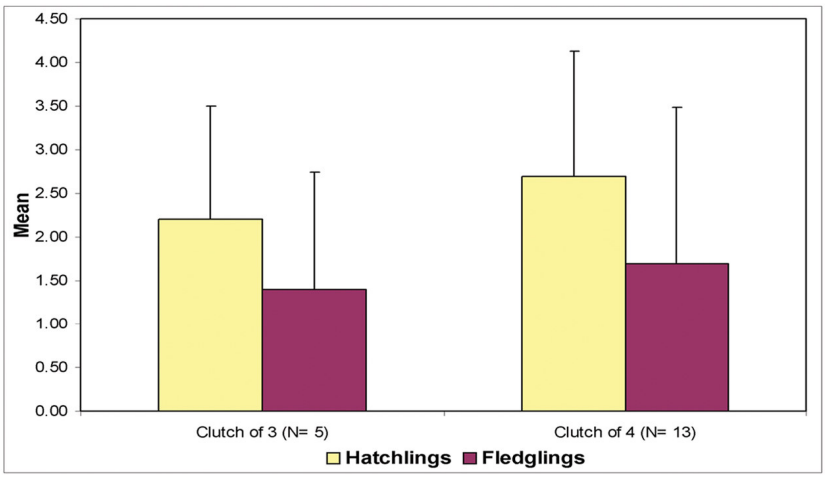

Figure 13: Clutch wise number of hatchlings and fledglings of Indian Treepie (Mean ± SD) at Kizhakkoth panchayath during 2007 period.

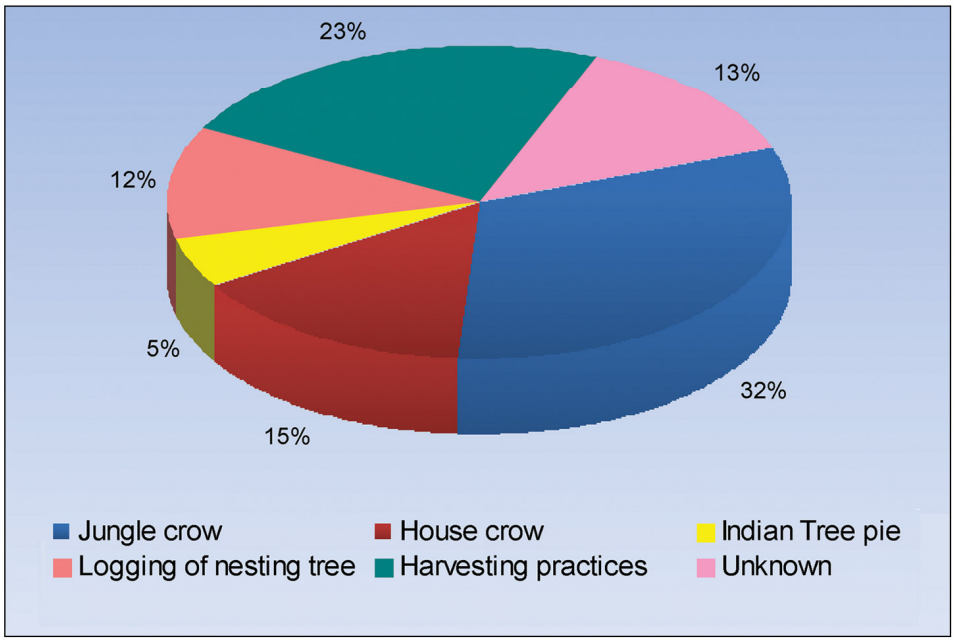

Figure 14: Factors leading to the egg loss of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

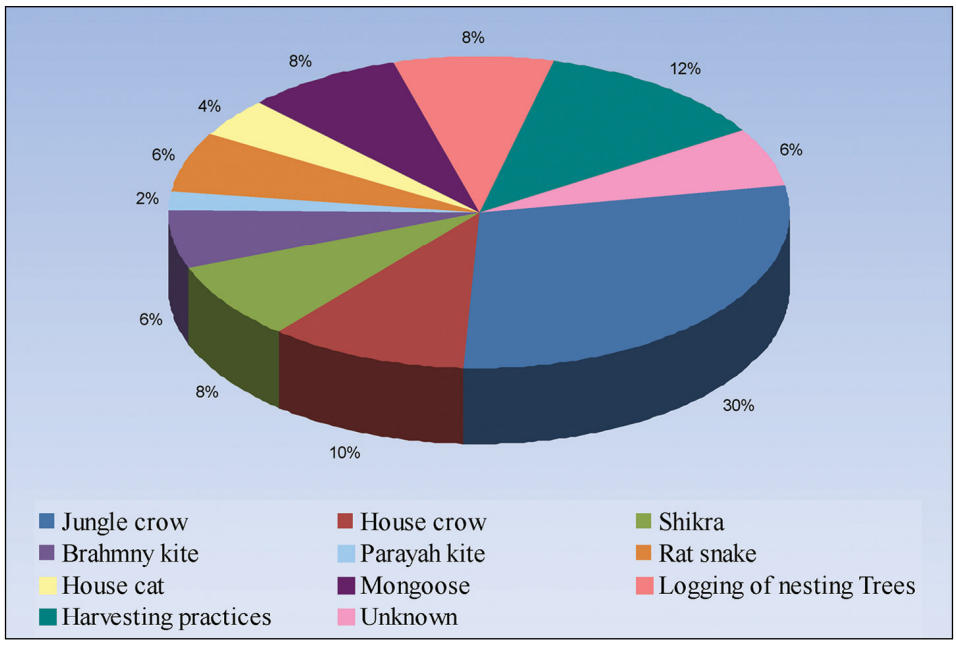

Figure 15: Factors leading to the nestling loss of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Table 1: Check list of avian fauna in the Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Order	Family	Scientific name	Common name	Residential status	Breeding status	Diet	Feeding zone	Paddy field	Coconut plantation	Sacred grove
1	Ciconiformes	Phalacrocoracidae	*Phalacrocorax niger*- Vieillot	Little Cormorant	R	B	P/I	G	✓	×	×
2		Anhingidae	*Anhinga melanogaster*- Pennant	Darter	LM	NB	P	G	✓	×	×
3		Ardeidae	*Egretta garzetta*- Linnaeus	Little Egret	LM	NB	P/I	G	✓	×	×
4			*Casmerodius albus*- Linnaeus	Large Egret	LM	NB	P	G	✓	×	×
5			*Mesophoyx intermedia*- Wagler	Median Egret	LM	NB	P/I	G	✓	×	×
6			*Bubulcus ibis*- Linnaeus	Cattle Egret	LM	NB	P/I	G	✓	✓	×
7			*Ardeola grayii*- Sykes	Indian Pond-Heron	R	B	P/I	G	✓	✓	×
8			*Nycticorax nycticorax*- Linnaeus	Black-crowned Night-Heron	LM	NB	P/I	G	✓	×	×
9			*Gorsachius melanolophus*- Raffles	Malayan Night-Heron	LM	NB	P	G	✓	×	✓
10			*Ixobrychus cinnamomeus*- Gmelin	Chestnut Bittern	LM	NB	P/I	G	✓	×	×
11		Ciconiidae	*Anastomus oscitans*- Boddaert	Asian Openbill-Stork	LM	NB	P/I	G	✓	×	×
12		Accipitridae	*Milvus migrans*- Boddaert	Black Kite	R	B	R	G/T	✓	✓	✓
13			*Haliastur Indus*- Boddaert	Brahminy Kite	LM	B	R	T	✓	✓	×
14			*Accipiter badius*- Gmelin	Shikra	R	B	R	G/T	✓	✓	✓
15	Charadriformes	Sclopacidae	*Gallinago gallinago*- Linnaeus	Common snipe	M	NB	I	G	✓	×	×
16	Gruiformes	Rallidae	*Amaurornis phoenicurus*- Pennant	White-breasted Waterhen	R	B	I/G	G	✓	✓	×
17			*Rallina eurizonoides*- Lafresnaye	Slaty-legged Crake	LM	NB	I	G	✓	×	×

18	Columbiformes	Columbidae	*Columba livia*- Gmelin	Blue Rock Pigeon	R	B	G	G	✓	✓	×
19			*Streptopelia chinensis*- Scopoli	Spotted Dove	R	B	G	G	✓	✓	×
20			*Chalcophaps indica*- Linnaeus	Emarald Dove	LM	NB	F/G	G/T	✓	✓	✓
21			*Ducula aenea*- Linnaeus	Green Imperial-Pigeon	S	NB	F	T	×	✓	×
22	Psittaciformes	Psittacidae	*Psittacula krameri*- Scopoli	Rose-ringed Parakeet	R	B	F/G	G/T	✓	✓	×
23			*Psittacula cyanocephala*- Linnaeus	Plum-headed Parakeet	LM	B	F/G	G/T	✓	✓	×
24	Cuculiformes	Cuculidae	*Hierococcyx varius*- Vahl	Brainfever Bird	LM	NB	I/F	T	✓	✓	✓
25			*Cuculus micropterus*- Gould	Indian Cuckoo	LM	NB	I	T	✓	✓	✓
26			*Eudynamys scolopacea*- Linnaeus	Asian Koel	R	B	F	T	✓	✓	✓
27			*Centropus sinensis*- Stephens	Greater Coucal	R	B	C	G/S/T	✓	✓	✓
28	Strigiformes	Tytonidae	*Tyto alba*- Scopoli	Barn Owl	R	B	R	G/T	✓	✓	✓
29		Strigidae	*Otus bakkamoena*- Pennant	Collared Scops-Owl	R	B	R	G/T	✓	✓	✓
30			*Glaucidium radiatum*- Tickell	Jungle Owlet	R	B	R	G/T	✓	✓	✓
31			*Athene brama*- Temminck	Spotted Owlet	R	B	R	G/T	✓	✓	✓
32	Apodiformes	Apodidae	*Cypsiurus balasiensis*- J.E. Gray	Asian Palm-Swift	R	B	I	A	✓	✓	×
33			*Apus affinis*- J.E. Gray	House Swift	LM	B	I	A	×	×	✓
34	Coraciformes	Alcedinidae	*Alcedo atthis*- Linnaeus	Small Blue Kingfisher	LM	NB	P	G	✓	×	×
35			*Halcyon capensis*- Linnaeus	Stork-billed Kingfisher	R	B	P/C	G	✓	×	×
36			*Halcyon smyrnensis*- Linnaeus	White-breasted Kingfisher	R	B	P/C	G	✓	✓	✓
37		Meropidae	*Merops philippinus*- Linnaeus	Blue-tailed Bee-eater	M	NB	I	A	✓	✓	✓
38	Turniciformes	Capitonidae	*Megalaima viridis*- Boddaert	White-cheeked Barbet	R	B	F	T	✓	✓	✓
39		Picidae	*Picus chlorolophus*- Vieillot	Small Yellow-naped Woodpecker	R	B	I	T	✓	✓	✓
40			*Dinopium javanense*- Ljungh	Common Golden-backed Woodpecker	R	B	I	T	✓	✓	✓
41			*Hemicircus canente*- Lesson	Heart-spotted Woodpecker	LM	NB	I	T	✓	×	×

42	Passeriformes	Pittidae	*Pitta brachyura*- Linnaeus	Indian Pitta	M	NB	I	G	✓	✓	✓
43		Motacillidae	*Dendronanthus indicus*- Gmelin	Forest Wagtail	M	NB	I	G	✓	×	×
44			*Motacilla maderaspatensis* - Gmelin	Large Pied Wagtail	LM	B	I	G	✓	×	×
45			*Motacilla flava*- Linnaeus	Yellow Wagtail	M	NB	I	G	✓	✓	×
46			*Motacilla cinerea*- Tunstall	Grey Wagtail	M	NB	I	G	✓	✓	×
47		Campephagidae	*Coracina macei*- Lesson	Large Cuckoo-Shrike	LM	NB	I/F	T	✓	✓	✓
48		Pycnonotidae	*Pycnonotus cafer*- Linnaeus	Red-vented Bulbul	R	B	I/F	S/T	✓	✓	✓
49		Irenidae	*Aegithina tiphia*- Linnaeus	Common Iora	LM	NB	I	C	✓	✓	✓
50			*Chloropsis aurifrons*- Temminck	Gold-fronted Chloropsis	LM	NB	I/F	T	×	✓	✓
51		Turdinae	*Copsychus saularis*- Linnaeus	Oriental Magpie-Robin	R	B	I	G	✓	✓	✓
52		Timaliinae	*Turdoides striatus*- Dumont	Jungle Babbler	R	B	I/F	G/T	✓	✓	✓
53		Sylviinae	*Orthotomus sutorius*- Pennant	Common Tailorbird	R	B	I	S/C	✓	✓	✓
54		Muscicapinae	*Muscicapa dauurica*- Pallas	Asian Brown Flycatcher	M	NB	I	A	✓	✓	✓
55			*Muscicapa muttui*- Layard	Brown Breasted Flycatcher	LM	NB	I	A	✓	✓	✓
56		Monarchinae	*Terpsiphone paradisi*- Linnaeus	Asian Paradise-Flycatcher	M	NB	I	A	✓	✓	✓
57		Dicaeidae	*Dicaeum erythrorhynchos*- Latham	Tickell's Flowerpecker	R	B	F/N	S/T	✓	✓	✓
58		Nectariniidae	*Nectarinia zeylonica*- Linnaeus	Purple-rumped Sunbird	R	B	N/I	S/T	✓	✓	✓
59			*Nectarinia asiatica*- Latham	Purple Sunbird	R	B	N/I	S/T	✓	✓	✓
60			*Nectarinia lotenia*- Linnaeus	Loten's Sunbird	R	B	N/I	S/T	✓	✓	✓
61			*Arachnothera longirostra*- Latham	Little Spiderhunter	R	B	N/I	S/T	✓	✓	✓
62		Zosteropidae	*Zosterops palpebrosus*- Temminck	Oriental White-Eye	R	B	N/I	C	✓	✓	✓
63		Estrildidae	*Lonchura punctulata*- Linnaeus	Spotted Munia	R	B	I/G	G/S	✓	×	×
64			*Lonchura Malacca*- Linnaeus	Black-headed Munia	R	B	G	G	✓	✓	×
65		Passerinae	*Passer domesticus*- Linnaeus	House Sparrow	R	B	I/G	G/S	×	×	×
66		Sturnidae	*Acridotheres tristis*- Linnaeus	Common Myna	R	B	O	G/T	✓	✓	✓

67		Oriolidae	*Oriolus oriolus*- Linnaeus	Eurasian Golden Oriole	M	NB	I/F	T	✓	✓	✓
68			*Oriolus chinensis*- Linnaeus	Black-naped Oriole	M	NB	I/F	T	✓	✓	✓
69			*Oriolus xanthornus*- Linnaeus	Black-headed Oriole	R	B	I/F	T	✓	✓	✓
70		Dicruridae	*Dicrurus macrocercus*- Vieillot	Black Drongo	R	B	I	A	✓	✓	✓
71			*Dicrurus leucophaeus*- Vieillot	Ashy Drongo	M	NB	I	A	✓	✓	×
72			*Dicrurus aeneus*- Vieillot	Bronzed Drongo	R	B	I	A	✓	✓	✓
73			*Dicrurus paradiseus*- Linnaeus	Greater Racket-tailed Drongo	R	B	I	A	✓	✓	✓
74		Artamidae	*Artamus fuscus*- Vieillot	Ashy Woodswallow	LM	B	I	A	✓	✓	×
75		Corvidae	*Dendrocitta vagabunda*- Latham	Indian Treepie	R	B	O	G/T	✓	✓	✓
76			*Corvus splendens*- Vieillot	House Crow	R	B	O	G/T	✓	✓	✓
77			*Corvus macrorhynchos*- Wagler	Jungle Crow	R	B	O	G/T	✓	✓	✓

Residential status : R= Resident, **LM**= Local migrant, **M**= Migrant, **S**= Straggler.
Breeding status : B= Breeder, **NB**= Non Breeder.
Diet : P= Piscivore, **I**= Insectivore, **R**= Raptor, **C**= Carnivore, **G**= Granivore, **F**= Frugivore, **O**= Omnivore, **P/I**= Piscivore/Insectivore, **G/F**= Granivore/Frugivore, **I/C**= Insectivore/Carnivore, **P/C**= Piscivore/Carnivore, **I/F=** Insectivore/Frugivore, **N/I**= Nectarivore/Insectivore, **I/G**= Insectivore/Granivore,
Feeding Zone : G= Ground, **T=** Tree, **A**= Aerial, **C**= Canopy, **G/T**= Ground/Tree**, S/T=** Shrub/Tree, **G/S**= Ground/Shrub, **S/C=** Shrub/Canopy, **G/S/T**= Ground/Shrub/Tree.

Table 2: Feeding guild wise richness of avian fauna at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Feeding guild	No. of species	Percentage
1	Insectivores	25	32
2	Insectivores/Frugivores	8	10
3	Piscivores/Insectivores	8	10
4	Raptors	7	9
5	Nectarivores/Insectivores	5	6
6	Omnivores	4	5
7	Piscivores	4	5
8	Frugivores	3	4
9	Frugivores/Granivores	3	4
10	Granivores	3	4
11	Insectivores/Granivores	3	4
12	Piscivores/Carnivores	2	3
13	Carnivores	1	1
14	Frugivores/Necterivores	1	1

Table 3: Diversity of avian fauna in paddy field at Kizhakkoth panchayath during 2003–2005 period.

Season	No. of species (S)	No. of individuals (N)	Margalef's index (d)	Shannon diversity index (H')
Pre-summer	66	3223	8.05	3.57
Summer	61	2820	7.55	3.49
Southwest monsoon	42	1658	5.53	3.35
Northeast monsoon	68	2883	8.41	3.60
Overall	73	10584	7.77	3.61

Table 4: Residential status, breeding status, diet, feeding zone and abundance of avian fauna in paddy field at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Common name	Residential status	Breeding status	Diet	Feeding zone	Pre-summer	Summer	SW monsoon	NE monsoon	Overall
						Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
1	House Crow	R	B	O	G/T	14.00 ± 2.83	18.58 ± 4.38	9.50 ± 2.94	14.33 ± 3.82	14.10 ± 4.73
2	Blue Rock Pigeon	R	B	G	G	21.83 ± 4.04	16.75 ± 10.76	1.25 ± 4.33	11.08 ± 8.98	12.73 ± 10.67
3	Rose-ringed Parakeet	R	B	F/G	G/T	12.58 ± 1.78	12.25 ± 4.33	11.33 ± 4.25	11.83 ± 1.40	12.00 ± 3.17
4	Common Myna	R	B	O	G/T	10.67 ± 2.81	13.25 ± 2.77	9.75 ± 2.49	12.67 ± 2.64	11.58 ± 2.97
5	Jungle Babbler	R	B	I/F	G/T	12.33 ± 2.02	8.92 ± 5.04	7.00 ± 7.11	17.33 ± 2.96	11.40 ± 6.04
6	Black-headed Munia	R	B	G	G	20.92 ± 7.00	2.92 ± 7.20	5.67± 8.38	10.17 ± 9.37	9.92 ± 10.42
7	White-breasted Waterhen	R	B	I/G	G	11.17 ± 1.99	11.25 ± 3.14	6.83 ± 1.90	9.33 ± 2.50	9.65 ± 2.97
8	Spotted Munia	R	B	I/G	G/S	12.42 ± 1.93	9.50 ± 5.07	4.67 ± 6.04	8.67 ± 6.58	8.81 ± 5.78
9	Indian Pond-Heron	R	B	P/I	G	9.67 ± 1.72	8.25 ± 2.18	7.25 ± 1.29	9.50 ± 1.88	8.67 ± 2.00
10	Asian Palm-Swift	R	B	I	A	14.08 ± 1.68	11.75 ± 5.89	0.00 ± 0.00	7.58 ± 6.08	8.35 ± 6.84
11	Purple Sunbird	R	B	N/I	S/T	8.33 ± 0.89	9.25 ± 2.09	7.08 ± 2.23	8.58 ± 2.02	8.31 ± 1.99

12	Indian Treepie	R	B	O	G/T	6.75 ± 0.97	6.50 ±1.09	6.75 ± 1.54	7.00 ± 1.13	6.75 ± 1.18
13	Jungle Crow	R	B	O	G/T	4.67 ± 0.98	8.50 ± 2.81	4.25 ± 0.87	8.00 ± 2.63	6.35 ± 2.76
14	Median Egret	LM	NB	P/I	G	9.50 ± 1.31	11.25 ± 4.35	0.00 ± 0.00	4.58 ± 4.42	6.33 ± 5.40
15	Loten's Sunbird	R	B	N/I	S/T	5.25 ± 1.14	5.50 ± 1.09	4.42 ± 1.16	6.58 ± 0.51	5.44 ± 1.25
16	Little Spiderhunter	R	B	N/I	S/T	5.42 ± 1.16	4.17 ± 0.83	3.92 ± 1.31	7.75 ± 2.05	5.31 ± 2.05
17	White-breasted Kingfisher	R	B	P/C	G	4.92 ± 1.38	4.42 ± 0.79	5.00 ± 0.95	5.92 ± 0.90	5.06 ± 1.14
18	Cattle Egret	LM	NB	P/I	G	8.67 ± 1.61	7.25 ± 4.25	0.00 ± 0.00	3.75 ± 2.67	4.92 ± 4.24
19	Little Egret	LM	NB	P/I	G	5.67 ± 0.78	9.58 ± 3.45	0.00 ± 0.00	2.58 ± 2.75	4.46 ± 4.21
20	Purple-rumped Sunbird	R	B	N/I	S/T	4.58 ± 0.79	3.83 ± 0.83	3.42 ± 0.90	5.42 ± 0.67	4.31 ± 1.09
21	Oriental White-Eye	R	B	N/I	C	5.25 ± 4.00	2.00 ± 3.10	2.42 ± 3.12	7.50 ± 2.58	4.29 ± 3.86
22	Greater Coucal	R	B	C	G/S/T	4.58 ± 1.24	3.17 ± 0.94	3.75± 0.87	5.25 ± 0.97	4.19 ± 1.27
23	Oriental Magpie-Robin	R	B	I	G	3.92 ± 1.38	3.33 ± 0.89	3.75 ± 1.42	5.42 ± 1.44	4.10 ± 1.49
24	Greater Racket-tailed Drongo	R	B	I	A	3.17 ± 0.72	3.25 ± 0.87	4.42 ± 1.38	4.50 ± 0.80	3.83 ± 1.14
25	Plum-headed Parakeet	LM	B	F/G	G/T	4.83 ± 3.07	5.42 ± 3.45	0.00 ± 0.00	3.33 ± 3.11	3.40 ± 3.43
26	Black Drongo	R	B	I	A	3.58 ± 0.51	3.75 ± 1.48	2.25 ± 1.29	3.58 ± 0.79	3.29 ± 1.22
27	White-cheeked Barbet	R	B	F	T	3.58 ± 1.44	2.67 ± 1.07	1.50 ± 1.31	4.58 ± 1.00	3.08 ± 1.65
28	Little Cormorant	R	B	P/I	G	2.50 ± 1.24	3.42 ± 1.44	2.08 ± 1.24	3.58 ± 1.16	2.90 ± 1.39
29	Common Golden-backed	R	B	I	T	2.42 ± 0.79	2.92 ± 0.90	3.17 ± 0.58	2.75 ± 0.97	2.81 ± 0.84

	Woodpecker									
30	Red-vented Bulbul	R	B	I/F	S/T	2.83 ± 0.94	3.00 ± 1.04	3.17 ± 1.95	2.17 ± 2.12	2.79 ± 1.60
31	Black-headed Oriole	R	B	I/F	T	1.75 ± 1.22	1.67 ± 0.49	1.75 ± 1.06	2.58 ± 1.24	1.94 ± 1.08
32	Bronzed Drongo	R	B	I	A	1.83 ± 1.03	1.17 ± 0.83	0.83 ± 1.27	3.17 ± 0.94	1.75 ± 1.34
33	Tickell's Flowerpecker	R	B	F/N	S/T	2.58 ± 1.08	1.42 ± 1.16	0.42 ± 0.67	2.17 ± 1.11	1.65 ± 1.30
34	Asian Koel	R	B	F	T	1.08 ± 0.79	2.58 ± 0.67	2.25 ± 0.87	0.42 ± 0.79	1.58 ± 1.16
35	Small Blue Kingfisher	LM	NB	P	G	1.00 ± 0.95	0.42 ± 1.00	2.42 ± 0.90	2.17 ± 0.83	1.50 ± 1.22
36	Stork-billed Kingfisher	R	B	P/C	G	1.00 ± 0.74	1.33 ± 0.78	1.42 ± 0.67	1.08 ± 1.00	1.21 ± 0.80
37	Spotted Dove	R	B	G	G	1.58 ± 0.79	1.00 ± 0.95	0.33 ± 0.65	0.67 ± 0.98	0.90 ± 0.95
38	Spotted Owlet	R	B	R	G/T	0.83 ± 0.72	0.50 ± 0.80	1.08 ± 0.90	0.75 ± 0.75	0.79 ± 0.80
39	Blue-tailed Bee-eater	M	NB	I	A	1.17 ± 1.11	0.17 ± 0.39	0.00 ± 0.00	1.25 ± 0.97	0.65 ± 0.93
40	Ashy Drongo	M	NB	I	A	1.67 ± 0.78	0.00 ± 0.00	0.00 ± 0.00	0.83 ± 0.94	0.63 ± 0.91
41	Common Tailorbird	R	B	I	S/C	0.58 ± 0.90	0.67 ± 0.89	0.42 ± 0.79	0.75 ± 0.97	0.60 ± 0.87
42	Common Iora	LM	NB	I	C	1.33 ± 1.56	0.00 ± 0.00	0.00 ± 0.00	0.83 ± 1.34	0.54 ± 1.15
43	Large Egret	LM	NB	P	G	0.33 ± 0.65	1.17 ± 1.19	0.00 ± 0.00	0.50 ± 0.80	0.50 ± 0.88
44	Black-crowned Night-Heron	LM	NB	P/I	G	0.92 ± 1.08	0.17 ± 0.39	0.00 ± 0.00	0.75 ± 1.22	0.46 ± 0.90
45	Shikra	R	B	R	G/T	0.50 ± 0.52	0.67 ± 0.49	0.33 ± 0.49	0.25 ± 0.45	0.44 ± 0.50
46	Small Yellow-naped	R	B	I	T	0.58 ± 0.67	0.83 ± 0.83	0.08 ± 0.29	0.25 ± 0.45	0.44 ± 0.65

	Woodpecker									
47	Asian Paradise-Flycatcher	M	NB	I	A	1.08 ± 0.90	0.08 ± 0.29	0.00 ± 0.00	0.58 ± 0.79	0.44 ± 0.74
48	Brainfever Bird	LM	NB	I/F	T	1.08 ± 0.51	0.08 ± 0.29	0.00 ± 0.00	0.42 ± 0.67	0.40 ± 0.61
49	Jungle Owlet	R	B	R	G/T	0.67 ± 0.78	0.33 ± 0.65	0.25 ± 0.45	0.33 ± 0.49	0.40 ± 0.61
50	Grey Wagtail	M	NB	I	G	0.92 ± 0.79	0.17 ± 0.39	0.00 ± 0.00	0.42 ± 0.67	0.38 ± 0.64
51	Brown Breasted Flycatcher	LM	NB	I	A	0.92 ± 0.79	0.08 ± 0.29	0.00 ± 0.00	0.42 ± 0.67	0.35 ± 0.64
52	Brahminy Kite	LM	B	R	T	0.00 ± 0.00	1.17 ± 1.03	0.17 ± 0.58	0.00 ± 0.00	0.33 ± 0.75
53	Large Pied Wagtail	LM	B	I	G	0.25 ± 0.45	0.00 ± 0.00	0.50 ± 0.80	0.58 ± 0.79	0.33 ± 0.63
54	Yellow Wagtail	M	NB	I	G	0.50 ± 0.67	0.17 ± 0.39	0.00 ± 0.00	0.67 ± 0.78	0.33 ± 0.60
55	Asian Brown Flycatcher	M	NB	I	A	1.08 ± 0.79	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.39	0.31 ± 0.62
56	Collared Scops-Owl	R	B	R	G/T	0.33 ± 0.49	0.55 ± 0.82	0.00 ± 0.00	0.33 ± 0.49	0.30 ± 0.55
57	Chestnut Bittern	LM	NB	P/I	G	0.00 ± 0.00	0.17 ± 0.58	0.92 ± 0.79	0.08 ± 0.29	0.29 ± 0.62
58	Indian Cuckoo	LM	NB	I	T	0.75 ± 0.45	0.00 ± 0.00	0.00 ± 0.00	0.42 ± 0.51	0.29 ± 0.46
59	Black Kite	R	B	R	G/T	0.33 ± 0.49	0.25 ± 0.45	0.00 ± 0.00	0.42 ± 0.51	0.25 ± 0.44
60	Slaty-legged Crake	LM	NB	I	G	0.25 ± 0.45	0.00 ± 0.00	0.33 ± 0.49	0.33 ± 0.49	0.23 ± 0.42
61	Darter	LM	NB	P	G	0.17 ± 0.39	0.33 ± 0.49	0.08 ± 0.29	0.09 ± 0.30	0.17 ± 0.38
62	Barn Owl	R	B	R	G/T	0.17 ± 0.39	0.33 ± 0.49	0.00 ± 0.00	0.17 ± 0.39	0.17 ± 0.38
63	Indian Pitta	M	NB	I	G	0.33 ± 0.49	0.08 ± 0.29	0.00 ± 0.00	0.25 ± 0.45	0.17 ± 0.38

64	Eurasian Golden Oriole	M	NB	I/F	T	0.50 ± 0.52	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.39	0.17 ± 0.38
65	Common snipe	M	NB	I	G	0.17 ± 0.39	0.08 ± 0.29	0.00 ± 0.00	0.25 ± 0.62	0.13 ± 0.39
66	Ashy Woodswallow	LM	B	I	A	0.00 ± 0.00	0.42 ± 0.79	0.00 ± 0.00	0.00 ± 0.00	0.10 ± 0.42
67	Asian Openbill-Stork	LM	NB	P/I	G	0.00 ± 0.00	0.33 ± 0.78	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.40
68	Heart-spotted Woodpecker	LM	NB	I	T	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.39	0.06 ± 0.24
69	Forest Wagtail	M	NB	I	G	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.04 ± 0.20
70	Malayan Night-Heron	LM	NB	P	G	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.02 ± 0.14
71	Emarald Dove	LM	NB	F/G	G/T	0.00 ± 0.00	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14
72	Large Cuckoo-Shrike	LM	NB	I/F	T	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14
73	Black-naped Oriole	M	NB	I/F	T	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.02 ± 0.14

Table 5: Feeding guild wise richness and abundance of the avian fauna in paddy field at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Feeing guild	No. of species	Mean ± SD	Percentage
1	Insectivores	24	30.17 ± 12.00	13.7
2	Piscivores/Insectivores	8	28.10 ± 14.15	12.7
3	Insectivores/Frugivores	7	16.73 ± 6.54	7.6
4	Raptors	7	2.67 ± 1.91	1.2
5	Necterivores/Insectivores	5	27.67 ± 7.41	12.5
6	Omnivores	4	38.79 ± 9.40	17.6
7	Piscivores	4	2.19 ± 1.23	1.0
8	Granivores	3	23.54 ± 17.52	10.7
9	Frugivores/Granivores	3	15.42 ± 5.32	7.0
10	Insectivores/Granivores	2	18.46 ± 6.84	8.4
11	Piscivores/Carnivores	2	6.27 ± 1.40	2.8
12	Frugivores	2	4.67 ± 1.40	2.1
13	Carnivores	1	4.19 ± 1.27	1.9
14	Frugivores/Necterivores	1	1.65 ± 1.30	0.7

Table 6: Foraging guild wise richness and abundance of avian fauna in paddy field at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Feeding zone	No. of species	Mean ± SD	Percentage
1	Ground	26	75.46 ± 28.99	34.2
2	Ground/Tree	14	67.94 ± 17.11	30.8
3	Tree	12	11.15 ± 2.68	5.1
4	Aerial	10	19.71 ± 9.94	8.9
5	Shrub/Tree	6	27.81 ± 5.23	12.6
6	Canopy	2	4.83 ± 4.12	2.2
7	Ground/Shrub	1	8.81 ± 5.78	4.0
8	Ground/Shrub/Tree	1	4.19 ± 1.27	1.9
9	Shrub/Canopy	1	0.60 ± 0.87	0.3

Table 7: Diversity of avian fauna in coconut plantation at Kizhakkoth panchayath during 2003–2005 period.

Season	No. of species (S)	No. of individuals (N)	Margalef's index (d)	Shannon diversity index (H')
Pre-summer	55	3086	6.72	3.26
Summer	45	2930	5.51	3.06
Southwest monsoon	30	2653	3.68	2.94
Northeast monsoon	52	3023	6.36	3.16
Overall	58	11692	6.09	3.16

Table 8: Residential status, breeding status, diet, feeding zone and abundance of avian fauna in coconut plantation at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Common name	Residential status	Breeding status	Diet	Feeding zone	Pre-summer	Summer	SW monsoon	NE monsoon	Overall
						Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
1	House Crow	R	B	O	G/T	40.33 ± 3.03	40.17 ± 3.59	30.00 ± 7.80	39.67 ± 2.50	37.54 ± 6.35
2	Jungle Babbler	R	B	I/F	G/T	20.08 ± 2.31	21.00 ± 4.22	21.75 ± 3.11	23.42 ± 3.32	21.56 ± 3.43
3	Jungle Crow	R	B	O	G/T	22.58 ± 2.15	21.58 ± 3.68	16.67 ± 5.37	23.08 ± 2.47	20.98 ± 4.36
4	Common Myna	R	B	O	G/T	16.17 ± 2.52	17.75 ± 2.05	20.17 ± 3.01	18.33 ± 2.53	18.10 ± 2.86
5	Indian Treepie	R	B	O	G/T	16.83 ± 1.59	16.00 ± 2.70	19.58 ± 1.78	14.92 ± 0.90	16.83 ± 2.50
6	Oriental White-Eye	R	B	N/I	C	11.50 ± 4.30	15.17 ± 4.24	16.17 ± 3.90	8.42 ± 3.90	12.81 ± 5.03
7	Purple Sunbird	R	B	N/I	S/T	11.25 ± 2.73	12.75 ± 2.45	10.67 ± 2.84	13.92 ± 1.62	12.15 ± 2.71
8	Loten's Sunbird	R	B	N/I	S/T	9.67 ± 1.37	9.92 ± 1.62	10.08 ± 2.47	11.75 ± 1.29	10.35 ± 1.88
9	Little Spiderhunter	R	B	N/I	S/T	8.17 ± 2.25	6.00 ± 1.54	5.08 ± 1.00	8.67 ± 3.08	6.98 ± 2.54
10	Purple-rumped Sunbird	R	B	N/I	S/T	6.25 ± 1.22	6.83 ± 1.34	6.17 ± 1.70	6.92 ± 1.38	6.54 ± 1.41
11	White-cheeked Barbet	R	B	F	T	7.08 ± 1.51	5.08 ± 1.16	5.17 ± 1.40	8.75 ± 1.36	6.52 ± 2.02

12	Black Drongo	R	B	I	A	5.92 ± 0.90	6.17 ± 0.83	6.75 ± 0.87	5.58 ± 0.51	6.10 ± 0.88
13	Greater Racket-tailed Drongo	R	B	I	A	6.17 ± 0.72	5.92 ± 1.08	7.25 ± 1.14	5.08 ± 1.24	6.10 ± 1.29
14	Oriental Magpie-Robin	R	B	I	G	4.33 ± 0.89	5.17 ± 1.03	6.83 ± 1.11	5.33 ± 1.07	5.42 ± 1.35
15	Common Tailorbird	R	B	I	S/C	5.83 ± 1.03	5.17 ± 1.19	4.58 ± 1.31	5.92 ± 1.31	5.38 ± 1.30
16	Common Golden-backed Woodpecker	R	B	I	T	4.42 ± 1.00	5.42 ± 0.90	5.75 ± 1.06	5.42 ± 1.08	5.25 ± 1.10
17	Greater Coucal	R	B	C	G/S/T	4.50 ± 1.31	4.17 ± 1.11	5.25 ± 1.29	5.92 ± 1.08	4.96 ± 1.35
18	Rose-ringed Parakeet	R	B	F/G	G/T	7.75 ± 5.80	8.67 ± 6.50	0.00 ± 0.00	3.08 ± 5.62	4.88 ± 6.15
19	Bronzed Drongo	R	B	I	A	3.75 ± 1.14	3.58 ± 0.51	4.75 ± 0.97	4.33 ± 0.98	4.10 ± 1.02
20	Asian Koel	R	B	F	T	2.92 ± 0.79	3.25 ± 1.36	5.00 ± 0.74	1.58 ± 1.16	3.19 ± 1.59
21	Black-headed Oriole	R	B	I/F	T	3.58 ± 0.67	3.33 ± 0.65	3.08 ± 1.44	2.58 ± 0.67	3.15 ± 0.97
22	Tickell's Flowerpecker	R	B	F/N	S/T	3.33 ± 1.23	3.50 ± 1.09	1.75 ± 1.29	3.83 ± 1.47	3.10 ± 1.48
23	Blue Rock Pigeon	R	B	G	G	5.00 ± 7.51	3.67 ± 6.77	0.00 ± 0.00	1.17 ± 4.04	2.46 ± 5.63
24	Plum-headed Parakeet	LM	B	F/G	G/T	2.67 ± 3.45	0.92 ± 2.23	0.00 ± 0.00	2.00 ± 3.05	1.40 ± 2.68
25	Spotted Owlet	R	B	R	G/T	1.50 ± 0.67	1.42 ± 0.90	1.00 ± 0.85	1.67 ± 0.98	1.40 ± 0.87
26	Black-headed Munia	R	B	G	G	0.67 ± 2.31	1.83 ± 4.30	0.00 ± 0.00	3.08 ± 5.62	1.40 ± 3.79
27	Small Yellow-naped Woodpecker	R	B	I	T	1.25 ± 0.75	1.58 ± 0.79	1.58 ± 1.16	1.00 ± 1.04	1.35 ± 0.96
28	Red-vented Bulbul	R	B	I/F	S/T	1.25 ± 0.87	0.75 ± 0.87	2.08 ± 1.38	1.08 ± 0.90	1.29 ± 1.11

29	Jungle Owlet	R	B	R	G/T	1.83 ± 0.72	1.08 ± 1.00	0.83 ± 0.94	1.17 ± 1.11	1.23 ± 0.99
30	Common Iora	LM	NB	I	C	1.75 ± 2.18	1.17 ± 1.59	0.17 ± 0.58	1.42 ± 1.88	1.13 ± 1.72
31	Shikra	R	B	R	G/T	1.00 ± 0.85	0.83 ± 0.83	1.17 ± 1.03	1.25 ± 0.75	1.06 ± 0.86
32	White-breasted Kingfisher	R	B	P/C	G	1.92 ± 0.67	0.83 ± 1.11	0.00 ± 0.00	1.50 ± 0.90	1.06 ± 1.06
33	Cattle Egret	LM	NB	P/I	G	1.58 ± 1.24	0.67 ± 1.30	0.00 ± 0.00	0.75 ± 1.14	0.75 ± 1.18
34	Brainfever Bird	LM	NB	I/F	T	1.58 ± 0.67	0.17 ± 0.39	0.00 ± 0.00	0.58 ± 0.79	0.58 ± 0.82
35	Black Kite	R	B	R	G/T	0.67 ± 0.78	0.75 ± 0.75	0.33 ± 0.49	0.50 ± 0.52	0.56 ± 0.65
36	Spotted Dove	R	B	G	G	0.83 ± 0.94	0.40 ± 0.84	0.00 ± 0.00	0.83 ± 0.83	0.52 ± 0.81
37	Gold-fronted Chloropsis	LM	NB	I/F	T	1.25 ± 0.87	0.08 ± 0.29	0.00 ± 0.00	0.67 ± 0.89	0.50 ± 0.80
38	Yellow Wagtail	M	NB	I	G	1.00 ± 0.85	0.00 ± 0.00	0.00 ± 0.00	0.92 ± 0.90	0.48 ± 0.77
39	Brown Breasted Flycatcher	LM	NB	I	A	0.75 ± 0.97	0.08 ± 0.29	0.00 ± 0.00	1.00 ± 0.85	0.46 ± 0.77
40	Indian Cuckoo	LM	NB	I	T	1.00 ± 0.74	0.08 ± 0.29	0.00 ± 0.00	0.67 ± 0.49	0.44 ± 0.62
41	Brahminy Kite	LM	B	R	T	1.00 ± 0.74	0.67 ± 0.78	0.00 ± 0.00	0.00 ± 0.00	0.42 ± 0.68
42	Eurasian Golden Oriole	M	NB	I/F	T	1.17 ± 0.83	0.17 ± 0.58	0.00 ± 0.00	0.33 ± 0.65	0.42 ± 0.74
43	Ashy Drongo	M	NB	I	A	1.00 ± 0.85	0.00 ± 0.00	0.00 ± 0.00	0.42 ± 0.79	0.35 ± 0.70
44	Asian Brown Flycatcher	M	NB	I	A	0.67 ± 0.78	0.00 ± 0.00	0.00 ± 0.00	0.58 ± 1.00	0.31 ± 0.69
45	Asian Paradise-Flycatcher	M	NB	I	A	0.75 ± 0.62	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 0.67	0.31 ± 0.55
46	White-breasted Waterhen	R	B	I/G	G	0.08 ± 0.29	0.00 ± 0.00	0.83 ± 0.83	0.08 ± 0.29	0.25 ± 0.56

47	Indian Pitta	M	NB	I	G	0.50 ± 0.52	0.00 ± 0.00	0.00 ± 0.00	0.50 ± 0.80	0.25 ± 0.53
48	Blue-tailed Bee-eater	M	NB	I	A	0.58 ± 0.79	0.08 ± 0.29	0.00 ± 0.00	0.25 ± 0.62	0.23 ± 0.56
49	Asian Palm-Swift	R	B	I	A	0.00 ±0.00	0.00 ± 0.00	0.00 ± 0.00	0.75 ± 2.60	0.19 ± 1.30
50	Grey Wagtail	M	NB	I	G	0.42 ±0.51	0.00 ± 0.00	0.00 ± 0.00	0.33 ± 0.49	0.19 ± 0.39
51	Large Cuckoo-Shrike	LM	NB	I/F	T	0.50 ± 0.52	0.00 ± 0.00	0.00 ± 0.00	0.25 ± 0.45	0.19 ± 0.39
52	Indian Pond-Heron	R	B	P/I	G	0.00 ± 0.00	0.00 ± 0.00	0.58 ± 0.51	0.00 ± 0.00	0.15 ± 0.36
53	Barn Owl	R	B	R	G/T	0.08 ± 0.29	0.17 ± 0.39	0.00 ± 0.00	0.08 ± 0.29	0.08 ± 0.28
54	Black-naped Oriole	M	NB	I/F	T	0.25 ± 0.45	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.08 ± 0.28
55	Ashy Woodswallow	LM	B	I	A	0.08 ± 0.29	0.17 ± 0.39	0.00 ± 0.00	0.00 ± 0.00	0.06 ± 0.24
56	Emarald Dove	LM	NB	F/G	G/T	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14
57	Green Imperial-Pigeon	S	NB	F	T	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14
58	Collared Scops-Owl	R	B	R	G/T	0.00 ± 0.00	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14

Table 9: Feeding guild wise richness and abundance of avian fauna in coconut plantation at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Feeing guild	No. of species	Mean ± SD	Percentage
1	Insectivores	19	38.1 ± 5.12	15.6
2	Insectivores/Frugivores	8	27.77 ± 3.99	11.4
3	Raptors	7	4.77 ± 2.39	2
4	Necterivores/Insectivores	5	48.83 ± 7.36	20
5	Omnivores	4	93.46 ± 8.45	38.4
6	Frugivores	3	9.73 ± 1.78	4
7	Frugivores/Granivores	3	6.29 ± 7.03	2.6
8	Granivores	3	4.38 ± 7.51	1.8
9	Piscivores/Insectivores	2	0.9 ± 1.13	0.4
10	Carnivores	1	4.96 ± 1.35	2
11	Frugivores/Necterivores	1	3.1 ± 1.48	1.3
12	Piscivores/Carnivores	1	1.06 ± 1.06	0.4
13	Insectivores/Granivores	1	0.25 ± 0.56	0.1

Table 10: Foraging guild wise richness and abundance of avian fauna in coconut plantation at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Feeding zone	No. of species	Mean ± SD	Percentage
1	Ground/Tree	14	125.67 ± 14.19	51.6
2	Tree	13	22.10 ± 4.03	9.1
3	Ground	11	12.90 ± 7.82	5.3
4	Aerial	10	18.23 ± 3.01	7.5
5	Shrub/Tree	6	40.42 ± 6.88	16.6
6	Canopy	2	13.94 ± 5.38	5.7
7	Shrub/Canopy	1	5.38 ± 1.30	2.2
8	Ground/Shrub/Tree	1	4.96 ± 1.35	2.0

Table 11: Diversity of avian fauna in sacred grove at Kizhakkoth panchayath during 2003–2005 period.

Season	No. of	No. of	Margalef's	Shannon

	species (S)	**individuals (N)**	**index (d)**	**diversity index (H')**
Pre-summer	43	645	6.49	3.35
Summer	33	422	5.29	3.11
Southwest monsoon	26	289	4.41	2.94
Northeast monsoon	39	523	6.07	3.20
Overall	45	1879	5.84	3.28.

Table 12: Residential status, breeding status, diet, feeding zone and abundance of avian fauna in sacred grove at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Common name	Residential status	Breeding status	Diet	Feeding zone	Pre -summer	Summer	SW monsoon	NE monsoon	Overall
						Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
1	Purple Sunbird	R	B	N/I	S/T	4.33 ± 0.65	3.92 ± 0.90	3.50 ± 1.24	5.33 ± 0.78	4.27 ± 1.12
2	Little Spiderhunter	R	B	N/I	S/T	4.17 ± 1.11	2.67 ± 0.98	2.67 ± 0.89	3.50 ± 1.24	3.25 ± 1.21
3	House Swift	LM	B	I	A	3.50 ± 1.38	4.17 ± 1.53	0.67 ± 1.61	1.83 ± 2.29	2.54 ± 2.18
4	Loten's Sunbird	R	B	N/I	S/T	2.67 ± 1.15	1.75 ± 0.62	1.83 ± 1.34	3.75 ± 0.87	2.50 ± 1.29
5	Jungle Babbler	R	B	I/F	G/T	1.82 ± 3.19	1.75 ± 3.19	1.75 ± 3.17	3.33 ± 3.50	2.17 ± 3.23
6	White-cheeked Barbet	R	B	F	T	3.17 ± 1.03	2.00 ± 1.21	0.83 ± 1.27	2.33 ± 1.30	2.08 ± 1.44
7	Common Golden-backed Woodpecker	R	B	I	T	1.58 ± 1.08	1.33 ± 0.98	2.00 ± 0.74	1.92 ± 0.90	1.71 ± 0.94
8	Indian Treepie	R	B	O	G/T	2.25 ± 1.06	1.75 ± 1.22	0.92 ± 0.79	1.92 ± 1.16	1.71 ± 1.15
9	Greater Coucal	R	B	C	G/S/T	1.42 ± 0.67	1.58 ± 0.79	1.67 ± 0.65	1.42 ± 0.67	1.52 ± 0.68
10	Jungle Crow	R	B	O	G/T	4.00 ± 4.90	0.67 ± 1.50	0.42 ± 0.79	0.92 ± 1.24	1.50 ± 2.97
11	Purple-rumped Sunbird	R	B	N/I	S/T	1.33 ± 0.78	1.08 ± 0.90	1.17 ± 0.83	1.67 ± 0.49	1.31 ± 0.78
12	House Crow	R	B	O	G/T	3.08 ± 6.22	0.67 ± 1.78	0.50 ± 1.24	1.00 ± 1.86	1.31 ± 3.47

13	Jungle Owlet	R	B	R	G/T	1.00 ± 0.60	1.17 ± 0.72	0.67 ± 0.78	1.42 ± 0.67	1.06 ± 0.73
14	Greater Racket-tailed Drongo	R	B	I	A	1.25 ± 0.87	1.25 ± 0.87	0.73 ± 1.27	0.83 ± 0.83	1.02 ± 0.97
15	Asian Koel	R	B	F	T	1.08 ± 0.90	1.50 ± 0.80	0.75 ± 0.87	0.75 ± 0.75	1.02 ± 0.86
16	Spotted Owlet	R	B	R	G/T	1.42 ± 0.51	0.67 ± 0.49	0.50 ± 0.52	1.08 ± 0.51	0.92 ± 0.61
17	Oriental White-Eye	R	B	N/I	C	1.00 ± 2.34	0.42 ± 1.44	0.42 ± 1.44	1.67 ± 3.08	0.88 ± 2.18
18	Tickell's Flowerpecker	R	B	F/N	S/T	1.25 ± 0.62	0.83 ± 0.58	0.42 ± 0.67	0.92 ± 0.79	0.85 ± 0.71
19	Black Drongo	R	B	I	A	1.33 ± 0.78	1.42 ± 0.79	0.33 ± 0.65	0.08 ± 0.29	0.79 ± 0.87
20	Bronzed Drongo	R	B	I	A	1.58 ± 0.67	0.67 ± 0.78	0.00 ± 0.00	0.82 ± 0.87	0.77 ± 0.87
21	Oriental Magpie-Robin	R	B	I	G	1.08 ± 0.90	0.92 ± 1.08	0.33 ± 0.65	0.67 ± 0.89	0.75 ± 0.91
22	Red-vented Bulbul	R	B	I/F	S/T	1.17 ± 1.03	0.58 ± 0.90	0.33 ± 0.78	0.58 ± 0.90	0.67 ± 0.93
23	Black-headed Oriole	R	B	I/F	T	1.08 ± 0.90	0.50 ± 0.90	0.17 ± 0.39	0.58 ± 0.51	0.58 ± 0.77
24	Common Iora	LM	NB	I	C	0.67 ± 0.98	0.58 ± 1.24	0.73 ± 1.62	0.17 ± 0.58	0.53 ± 1.14
25	Indian Pitta	M	NB	I	G	0.92 ± 0.79	0.00 ± 0.00	0.00 ± 0.00	1.00 ± 1.13	0.48 ± 0.82
26	Gold-fronted Chloropsis	LM	NB	I/F	T	1.00 ± 1.54	0.00 ± 0.00	0.00 ± 0.00	0.92 ± 1.73	0.48 ± 1.22
27	Asian Brown Flycatcher	M	NB	I	A	0.83 ± 0.72	0.00 ± 0.00	0.00 ± 0.00	0.83 ± 0.94	0.42 ± 0.71
28	Shikra	R	B	R	G/T	0.50 ± 0.52	0.17 ± 0.39	0.33 ± 0.49	0.50 ± 0.67	0.38 ± 0.53
29	Collared Scops-Owl	R	B	R	G/T	0.42 ± 0.51	0.25 ± 0.45	0.25 ± 0.62	0.25 ± 0.45	0.29 ± 0.50
30	Common Myna	R	B	O	G/T	0.25 ± 0.62	0.17 ± 0.58	0.33 ± 0.78	0.25 ± 0.62	0.25 ± 0.64
31	Eurasian Golden Oriole	M	NB	I/F	T	0.58 ± 0.67	0.17 ± 0.39	0.00 ± 0.00	0.25 ± 0.62	0.25 ± 0.53

32	Indian Cuckoo	LM	NB	I	T	0.50 ± 0.52	0.08 ± 0.29	0.00 ± 0.00	0.17 ± 0.39	0.19 ± 0.39
33	Brown Breasted Flycatcher	LM	NB	I	A	0.33 ± 0.49	0.00 ± 0.00	0.00 ± 0.00	0.42 ± 0.67	0.19 ± 0.45
34	Brainfever Bird	LM	NB	I/F	T	0.50 ± 0.67	0.00 ± 0.00	0.00 ± 0.00	0.17 ± 0.39	0.17 ± 0.43
35	Malayan Night-Heron	LM	NB	P	G	0.08 ± 0.29	0.17 ± 0.39	0.00 ± 0.00	0.00 ± 0.00	0.06 ± 0.24
36	Black Kite	R	B	R	G/T	0.17 ± 0.39	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.06 ± 0.24
37	Barn Owl	R	B	R	G/T	0.08 ± 0.29	0.08 ± 0.29	0.00 ± 0.00	0.08 ± 0.29	0.06 ± 0.24
38	White-breasted Kingfisher	R	B	P/C	G	0.08 ± 0.29	0.17 ± 0.58	0.00 ± 0.00	0.00 ± 0.00	0.06 ± 0.32
39	Common Tailorbird	R	B	I	S/C	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.04 ± 0.20
40	Asian Paradise-Flycatcher	M	NB	I	A	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.04 ± 0.20
41	Blue-tailed Bee-eater	M	NB	I	A	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.29	0.02 ± 0.15
42	Emarald Dove	LM	NB	F/G	G/T	0.00 ± 0.00	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14
43	Small Yellow-naped Woodpecker	R	B	I	T	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14
44	Large Cuckoo-Shrike	LM	NB	I/F	T	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14
45	Black-naped Oriole	M	NB	I/F	T	0.08 ± 0.29	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.02 ± 0.14

Table 13: Feeding guild wise richness and abundance of avian fauna in sacred grove at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Feeding guild	No. of species	Mean ± SD	Percentage
1	Insectivores	15	9.46 ± 4.72	24.2
2	Insectivores/Frugivores	8	4.31 ± 3.81	11.0
3	Raptors	6	2.77 ± 1.31	7.1
4	Necterivores/Insectivores	5	12.21 ± 4.01	31.2
5	Omnivores	4	4.77 ± 5.81	12.2
6	Frugivores	2	3.10 ± 1.78	7.9
7	Carnivores	1	1.52 ± 0.68	3.9
8	Frugivores/Necterivores	1	0.85 ± 0.71	2.2
9	Piscivores/Carnivores	1	0.06 ± 0.32	0.2
10	Piscivores	1	0.06 ± 0.24	0.2
11	Frugivores/Granivores	1	0.02 ± 0.14	0.1

Table 14: Foraging guild wise richness and abundance of avian fauna in sacred grove at Kizhakkoth panchayath during 2003–2005 period.

Sl. No.	Feeding zone	No. of species	Mean ± SD	Percentage
1	Ground/Tree	12	9.69 ± 7.14	24.7
2	Tree	11	6.54 ± 3.67	16.7
3	Aerial	8	5.75 ± 3.77	14.7
4	Shrub/Tree	6	12.85 ± 3.84	32.8
5	Ground	4	1.35 ± 1.41	3.5
6	Canopy	2	1.40 ± 2.39	3.6
7	Ground/Shrub/Tree	1	1.52 ± 0.68	3.9
8	Shrub/Canopy	1	0.04 ± 0.20	0.1

Table 15: Abundance of Indian Treepie during different seasons in the three habitats of Kizhakkoth panchayath during 2003–2006 period.

Habitat	Year	Pre-summer	Summer	SW monsoon	NE monsoon
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Paddy field	2003-2004	6.83 ± 1.17	6.67 ± 0.82	7.00 ± 1.67	7.00 ± 1.41
	2004-2005	6.67 ± 0.82	6.33 ± 1.37	6.50 ± 1.52	7.00 ± 0.89
	2005-2006	5.67 ± 0.52	5.67 ± 1.51	6.50 ± 1.05	6.50 ± 1.52
Coconut plantation	2003-2004	17.50 ± 1.64	17.33 ± 2.16	20.83 ± 1.17	14.67 ± 0.82
	2004-2005	16.17 ± 1.33	14.67 ± 2.66	18.33 ± 1.37	15.17 ± 0.98
	2005-2006	14.83 ± 1.94	15.67 ± 1.21	16.83 ± 2.79	15.50 ± 2.07
Sacred grove	2003-2004	2.17 ± 1.47	1.83 ± 1.17	0.67 ± 0.82	1.50 ± 1.52
	2004-2005	2.33 ± 0.52	1.67 ± 1.37	1.17 ± 0.75	2.33 ± 0.52
	2005-2006	1.50 ± 0.84	2.33 ± 1.03	1.33 ± 0.82	1.83 ± 1.17

Table 16: Results of Kruskal-Wallis and Mann-Whitney tests on the seasonal abundance of Indian Treepie in coconut plantation during 2003–2006 period.

Habitat	Kruskal-Wallis			Mann-Whitney	
	H	d.f.	*p*-value	Seasons	*p*-value
Coconut plantation	14.160	3	0.003	Pre summer- Summer	0.87
				Pre summer- SW monsoon	0.01
				Pre summer- NE monsoon	0.11
				Summer- SW monsoon	0.01
				Summer- NE monsoon	0.47
				SW monsoon- NE monsoon	0.01

Table 17: Roosting and waking time of Indian Treepie at Kizhakkoth panchayath during 2004–2005 period.

Season	Sunset (Hours)	Roosting time (Hours)	Difference (Minutes)	Mean ± SD	Sunrise (Hours)	Waking time. (Hours)	Difference (Minutes)	Mean ± SD
	5.59	6.18	19	20.	6.36	6.13	23.00	25.

Pre-summer	6.00	6.22	22	00 ± 3.79	6.42	6.17	25.00	08 ± 1.16
	6.07	6.18	11		6.46	6.20	26.00	
	6.07	6.27	20		6.49	6.23	26.00	
	6.11	6.33	22		6.50	6.24	26.00	
	6.13	6.39	26		6.51	6.25	26.00	
	6.18	6.37	19		6.54	6.29	25.00	
	6.18	6.41	23		6.54	6.30	24.00	
	6.26	6.45	19		6.54	6.28	26.00	
	6.30	6.51	21		6.53	6.27	26.00	
	6.31	6.47	16		6.49	6.24	25.00	
	6.32	6.54	22		6.47	6.24	23.00	
Summer	6.33	6.50	17	9.25 ± 3.77	6.44	6.18	26.00	23.83 ± 1.99
	6.34	6.45	11		6.41	6.17	24.00	
	6.34	6.43	9		6.41	6.19	22.00	
	6.34	6.50	16		6.41	6.16	25.00	
	6.34	6.40	6		6.25	6.04	21.00	
	6.34	6.40	6		6.22	6.02	20.00	
	6.35	6.44	9		6.20	5.56	24.00	
	6.36	6.45	9		6.17	5.54	23.00	
	6.37	6.46	9		6.11	5.47	24.00	
	6.37	6.43	6		6.09	5.43	26.00	
	6.38	6.45	7		6.08	5.42	26.00	
	6.40	6.46	6		6.06	5.41	25.00	
Southwest monsoon	6.43	6.52	9	7.17 ± 2.29	6.06	5.44	22.00	23.17 ± 1.99
	6.46	6.52	6		6.07	5.45	22.00	
	6.46	6.55	9		6.07	5.44	23.00	
	6.50	6.55	5		6.11	5.49	22.00	
	6.50	6.56	6		6.11	5.50	21.00	
	6.51	6.56	5		6.14	5.54	20.00	
	6.51	6.55	4		6.16	5.54	22.00	
	6.49	6.55	6		6.17	5.53	24.00	
	6.47	6.56	9		6.19	5.53	26.00	
	6.43	6.50	7		6.20	5.55	25.00	
	6.41	6.49	8		6.20	5.54	26.00	
	6.37	6.49	12		6.20	5.55	25.00	
Northeast monsoon	6.47	6.54	7	12.67 ± 5.26	6.20	5.55	25.00	23.92 ± 1.51
	6.43	6.48	5		6.20	5.54	26.00	
	6.41	6.47	6		6.19	5.58	21.00	
	6.37	6.46	9		6.19	5.57	22.00	
	6.14	6.25	11		6.19	5.55	24.00	
	6.09	6.23	14		6.20	5.56	24.00	
	6.04	6.18	14		6.20	5.58	22.00	
	6.02	6.14	12		6.21	5.56	25.00	
	5.58	6.14	16		6.23	5.58	25.00	

	5.57	6.15	18		6.27	6.03	24.00	
	5.56	6.17	21		6.28	6.04	24.00	
	5.56	6.15	19		6.30	6.05	25.00	
Overall Mean ± SD				12.27 ± 6.22	**Overall Mean ± SD**			24.00 ±1.79

Table 18: Roosting plants of Indian Treepie at Kizhakkoth panchayath during 2004–2005 period.

Sl. No.	Roosting Plants	Frequency	Mean height of the roost (m)	Range
1	*Areca catechu*	59	7.4 ± 1.6	3.5-11.0
2	*Artocarpus heterophyllus*	23	9.2 ± 1.4	7.0-12.0
3	*Mangifera indica*	17	7.7 ± 1.5	5.0-11.5
4	*Macaranga peltata*	15	6.8 ± 1.0	5.0-8.0
5	*Strychnos-nux vomica*	13	7.7 ± 0.8	6.5-9.0
6	*Tectona grandis*	9	9.4 ± 1.1	7.0-11.0
7	*Lucuma nervosa*	8	6.5 ± 0.5	6.0-7.0
8	*Cocos nucifera*	7	10.5 ± 1.0	9.0-12.0
9	*Xylia xylocarpa*	5	8.5 ± 1.0	7.5-10.0
10	*Holigarna arnottiana*	4	10.5 ± 0.7	9.5-11.0
11	*Myristica fragrans*	3	6.5 ± 1.3	5.0-7.5
12	*Caryota urens*	3	10.2 ± 0.8	9.5-11.0
13	*Swietenia macrophylla*	3	10.5 ± 0.5	10.0-11.0
14	*Garcinia gummi-gutta*	2	11.0 ± 1.4	10.0-12.0
15	*Schleichera oleosa*	2	7.5 ± 0.7	7.0-8.0

Table 19: Preys of Indian Treepie at Kizhakkoth panchayath during 2005 period.

Sl. No.	Common name	Order/Family/ Scientific name	Parts consumed	No. of observations
1	Grasshopper	Orthoptera	Parts except wings	96
2	Earwig	Forficulidae	Whole	86
3	Caterpillars		Whole	85
4	Larvae	Curculionidae	Whole	81
5	Red palm weevil	*Rhynchophorus ferrugineus*	Whole	74
6	Cockroach	*Periplanetta* sp	Whole	73

7	Earthworm	*Megascolex* sp.	Whole	68
8	Spider	*Arena* sp.	Whole	67
9	Beetle	Cercopidae	Whole	67
10	Snail	Pulmonata	Whole	64
11	Praying mantis	Mantidae	Whole	58
12	Beetle	Curculionidae	Whole	45
13	Unknown beetle		Whole	42
14	Banana stem weevil	*Odoiporus longicollis*	Whole	33
15	Beetle	Carabidae	Whole	22
16	Ant	Formicidae	Whole	13
17	Wall lizard	*Hemidactylus* sp.	Whole	12
18	Red-vented Bulbul	*Pycnonotus cafer*	Nestlings	6
19	Flying lizard	*Draco* sp.	Whole	4
20	Black-headed Munia	*Lonchura malacca*	Nestlings	4
21	Garden lizard	*Calotus versicolor*	Whole	3
22	Black-headed Oriole	*Oriolus xanthornus*	Eggs	3
23	Black-headed Munia	*Lonchura malacca*	Eggs	3
24	Red-vented Bulbul	*Pycnonotus cafer*	Eggs	3
25	Black-headed Oriole	*Oriolus xanthornus*	Nestlings	2
26	Squirrel	*Funambulus* sp.	Nestlings	2
27	House rat	*Rattus rattus*	Nestlings	2
28	Lime Butterfly	*Papilio demoleus*	Parts except wings	1
29	Mayfly larvae	*Centroptilum* sp.	Whole	1
30	Blue Rock Pigeon	*Columba livia*	Nestlings	1

Table 20: Plant food resources of the Indian Treepie at Kizhakkoth panchayath during 2005 period.

Sl. No.	Scientific name	Parts consumed	Number of observations
1	*Casearia* sp.	Fruit	89
2	*Macaranga peltata*	Fruit	62
3	*Syzygium aqueum*	Fruit	60
4	*Cinnamomum verum*	Fruit	43
5	*Ficus exasperata*	Fruit	37
6	*Pothos scandens*	Fruit	37
7	*Ficus* sp.	Fruit	36

8	*Pisidium guajava*	Fruit	36
9	*Carica papaya*	Fruit	35
10	*Litsea coriacea*	Fruit	30
11	*Helicanthes elasticus*	Fruit	29
12	*Capsicum frutescens*	Fruit	23
13	*Ficus hispida*	Fruit	22
14	*Lannea coromandelica*	Fruit	22
15	*Artocarpus heterophyllus*	Fruit	21
16	*Lucuma nervosa*	Fruit	18
17	*Zanthoxylum rhetsa*	Fruit	15
18	*Annona squamosa*	Fruit	13
19	*Erythrina indica*	Pollen	13
20	*Ananas comosus*	Fruit	12
21	*Mangifera indica*	Fruit	10
22	*Cocos nucifera*	Fruit	8
23	*Artocarpus hirsutus*	Fruit	6
24	*Bombax ceiba*	Pollen	6
25	*Anacardium occidentale*	Fruit	5
26	*Musa* sp.	Fruit	4
27	*Piper nigrum*	Fruit	3

Table 21: Number of nests of Indian Treepie observed at Kizhakkoth panchayath during 2005–2007 period.

Year	January	February	March	April	May	Total
2005	0	5	8	12	3	28
2006	1	4	8	10	1	24
2007	0	4	11	10	3	28
Total	1	13	27	32	7	80

Table 22: Number of nests and nesting tree height of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Nesting tree	No. of nests	%	Tree height (m)		Nest height (m)	
			Mean ± SD	Range	Mean ± SD	Range
Areca catechu	29	51.8	12.7 ± 3.2	4-16.5	11.2 ± 3.2	2.5-16.5
Artocarpus heterophyllus	11	19.6	16.3 ± 2.4	12-20	7.8 ± 2.1	3.5-10.5
Melicope lunu-ankenda	7	12.5	9.1 ± 1.6	7-11.5	6.2 ± 1.3	4.7-8.4
Mangifera indica	4	7.1	13.4 ± 2.5	10.5-16.5	6.9 ± 1.1	6-8.4
Cocos nucifera	3	5.4	19.9 ± 1.0	19-21	15.2 ± 1.3	14-16.5
Corypha umbraculifera	2	3.6	17.5 ± 1.4	16.5-18.5	12.9 ± 1.6	11.8-14
Total	56	100	13.5 ± 3.8	4-21	9.8 ± 3.5	2.5-16.5

Table 23: Materials used for nest construction by Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Sl No.	Part of the nest	Scientific name of the plant	Parts used	No. of nests observed	Mean ± SD
1	Outer shell	*Tamarindus indica*	Twigs	10	13.60 ± 8.09
2		*Ziziphus oenopila*	Twigs	10	11.50 ± 5.68
3		*Strychnos nux-vomica*	Twigs	9	11.40 ± 8.00
4		*Annona squamosa*	Twigs	6	3.50 ± 3.78
5		*Canthium coromandelicum*	Twigs	9	3.30 ± 2.00
6		*Bauhinia acuminata*	Twigs	6	3.00 ± 3.27
7		*Tecoma stans*	Twigs	6	2.50 ± 2.64
8		*Chromaulena odorata*	Twigs	6	1.20 ± 1.32
9		*Glyricidia sepium*	Twigs	6	1.00 ± 0.94
10		*Drymoglossum piloselloides*	Whole	5	0.70 ± 0.82
11		*Flacourtia montana*	Twigs	1	0.70 ± 2.21
12		*Artocarpus heterophyllus*	Twigs	3	0.40 ± 0.70
13		*Malvaviscus penduliflorus*	Twigs	2	0.30 ± 0.67
14		*Bamboo* sp.	Twigs	2	0.20 ± 0.42
15		*Jasminum* sp.	Twigs	1	0.20 ± 0.63
16		Unknown	Twigs	1	0.20 ± 0.63
17		*Lagerstroemia microcarpa*	Twigs	1	0.10 ± 0.32
18		Unknown	Twigs	1	0.10 ± 0.32
19	Rim	*Ichnocarpus frutescens*	Stem	10	18.00 ± 10.06
20		*Naregamia alata*	Stem	5	6.70 ± 10.51
21		*Centrosema virginianum*	Stem	8	3.10 ± 2.28
22		*Vernonia scandens*	Stem	4	1.90 ± 2.60
23		Unknown	Twigs	2	1.78 ± 4.06
24		*Phyllanthus myrtifolius*	Twigs	4	1.30 ± 1.77
25		*Pothos scandens*	Stem	4	0.90 ± 1.29
26		*Lawsonia inermis*	Twigs	2	0.90 ± 2.51
27		*Mimosa pudica*	Stem	2	0.70 ± 1.49
28		*Abrus precatorius*	Twigs	2	0.40 ± 0.97
29		*Cyclea peltata*	Stem	1	0.30 ± 0.95
30		*Punica granatum*	Twigs	1	0.30 ± 0.95

31	**Cup lining**	*Cocos nucifera*	Leaf sheath fibers	6	47.00 ± 37.82
32		*Caryota urens*	Leaf sheath fibers	6	22.50 ± 23.19
33		*Areca catechu*	Dried inflorescence	5	20.40 ± 27.94
34		*Ischaemum* sp.	Dried shoot	6	4.40 ± 4.99
35		*Cocos nucifera*	Leaf base fibers	1	2.00 ± 6.32
36		*Oldenlandia auricularia*	Dried shoot	5	1.30 ± 1.49
37		*Cocos nucifera*	Frond strips	5	0.90 ± 1.29
38		Unknown	Rootlets	2	0.90 ± 1.91
39		*Cocos nucifera*	Coconut husk fibers	1	0.20 ± 0.63

Table 24: Shape index and dimensions of the egg of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Clutch	Length (cm)	Breadth (cm)	Weight (g)	Volume (cm^3)	Shape index
1	2.85	2.15	5.83	6.72	75.44
	2.61	2.02	5.77	5.43	77.39
	2.77	2.15	6.26	6.53	77.62
2	2.81	2.17	5.79	6.75	77.22
	2.73	2.10	5.69	6.14	76.92
	2.82	2.13	5.80	6.52	75.53
	2.68	2.04	5.74	5.69	76.12
Mean ± SD	2.75 ± 0.09	2.11 ± 0.06	5.84 ± 0.19	6.25 ± 0.52	76.61 ± 0.90
Range	2.61-2.85	2.02-2.17	5.69-6.26	5.43-6.75	75.44-77.62

Table 25: Clutch details of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Clutch size	Frequency & Period			Total frequency
	2005	2006	2007	
2	1	0	0	1
3	4	2	5	11
4	11	14	13	38
Total	16	16	18	50

Table 26: Incubation rhythm of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Days of incubation	Attentiveness Mean ± SD(Minutes)	Range (Minutes)	Inattentiveness Mean ± SD(Minutes)	Range (Minutes)	(Hours)Total attentiveness	(Hours)Total inattentiveness
2nd	17.85 ± 8.67	1-32	11.46 ± 10.14	2-53	8.02	4.58
6th	23.32 ± 10.47	3-51	8.21 ± 8.72	2-44	9.43	3.17
12th	22.75 ± 10.21	6-46	5.30 ± 6.97	1-38	10.37	2.23
15th	29.04 ± 11.42	6-53	5.09 ± 8.81	1-44	11.08	1.52
18th	18.30 ± 11.93	4-49	5.50 ± 5.86	1-30	10.04	2.56
19th	12.05 ± 7.36	1-32	8.16 ± 13.89	1-63	7.50	5.10
Total	19.68 ± 11.22	1-53	7.31 ± 9.83	1-63		

Table 27: Details of plumage development of Indian Treepie nestlings at Kizhakkoth panchayath during 2005–2007 period.

Age in days	Plumage	Remarks
0*	Naked body with yellowish flesh colour.	Presence of white egg tooth at the tip of the upper mandible. Claws are white in colour. Faecal sac was yellowish fluidy with yellow and white residues.
1**	Spiny margin appeared through the dorsal and pelvic regions of the spinal tract. Feather pins of rectrices and one line of upper tail coverts started to emerge through the skin.	Able to raise head and produced faint sounds with widely gaped mouth.
2	Primaries, secondaries and alulae were ready to emerge through skin. Pins of anal circlet (inner most rows) and femoral tract appear under skin.	Body became black in colour. Developed grasping capacity. Exhibit squirming and turning movement.

3	Pins of dorsal and pelvic regions of the spinal tract started to emerge out of the skin. Pins of primaries secondaries and alulae (4 Nos.) emerged out of the skin. Pins of humeral tract, crural tract, greater primary coverts (7 Nos.), greater secondary coverts (10 Nos.), marginal coverts (4 Nos.) and two rows of anal circlets became clearer under skin. All rectrices and upper tail covert pins emerged out of the skin. Pins of the abdominal region of the ventral tract ready to come out.	Capital region became more blackish.
4	Greater primary and secondary coverts emerged out of skin. Pins of primaries and secondaries attained about one mm length.	Distal end of claws became black. Elevated the cloacal region when voiding faecal sac.
5	Pins of primaries attained about 2.5 mm size. Middle primary coverts ready to emerge out of skin. Middle secondary covert pins, spinal tract feather pins (except cervicals), femoral tract and humeral tract pins emerged out of skin. Pin tips of greater secondary coverts and alulae became brownish.	Eyes partially opened. Colouration appeared at the feather pin tips. Scales appeared on the front side of the leg. Tried to move by flapping the wings.
6	Middle primary coverts, Marginal coverts and under tail coverts emerged out of skin. Ventral tract pins at the abdominal and axillar region emerged out, the remainings except cervical region became more visible under skin. Feather pins of capital tract appeared under skin. Rectal bristles start to sprout through the skin. Pin tips of upper tail coverts and marginal coverts became brownish.	Exhibited leaping movement. Responded to sound and vibrations.
7	Pins of sternal region of the ventral tract and crural tract emerged out of skin. Pins of under wing coverts, cervical region of the spinal tract and anal circlet started to emerge out	Start to raised on the leg while receiving food. Developed gulping capacity. Disappeared the white spot on the beak tip. Beak

	through the skin. Pins of cervical, submalar, malar and inter ramal regions of ventral tract are more visible under skin. Few pins at the dorsal and pelvic regions of the spinal tract, few at the femoral tract, few marginal coverts, all upper tail coverts, few at the abdominal region of the ventral tract start to unsheath and became bushy.	blackened through sides. Start moving by beating wings and legs. Tried to squeak or trap the nest materials while fed by the parent. Faecal matter became less fluidy
8	Pins of auricular region and capital tract emerged out of the skin. Pins of the spinal tract (except cervical), femoral tract, distal marginal coverts, few greater secondary coverts and upper tail coverts emerged from the sheath.	
9	All primaries, secondaries, greater secondary coverts, middle secondary coverts, middle primary coverts start to emerge from the sheath, humeral tract feathers, axillar pins of the ventral tract under tail coverts emerged from the sheath (sternal region is still with big spines)	
10	Greater primary coverts, sternal pins of the ventral tract, crural tract and under wing coverts unsheathed	
11	Feather pins at the cervical region of the spinal tract unsheathed. Rectrices (except the outer most pair) and pins of the cervical region of the ventral tract start to unsheath.	
12	Feather pins (except frontal region) of the capital tract started to emerge from the sheath. Feather rings around eyes appeared.	Defecated with a wavering action of the raised abdominal region just after feeding.
13	All rectrices emerged out. Feather pins of cervical region unsheathed	Able to grasp and perch on the nesting materials. Shook

	but submalar, malar and inter ramal regions are still in pins. Anal circlets emerged out from the sheath	wing and body occasionally. Responded to visual stimuli.
14	All capital feathers unsheathed.	Started grooming. Start to cower and sinking lower in the nest while any moving objects seen in the premise.
15	Submalar, malar and inter ramal pins unsheathed.	
16	All the pins except primaries and secondaries are well feathered. Skin was visible only through the midline of the breast, belly and sides of the hinder dorsal region of the spinal tract.	
17	Only the base of primaries and secondaries are sheathed.	Stretched the wing and legs.
18	Primaries, secondaries and wing coverts fully emerged. Whole area of the body covered with feathers.	Walked through the outer rim of the nest by flapping the wings.
19	Well developed plumage with loose cover feathers. The wing and tail quills are weaker and shorter. Tail feathers were short and stubby.	Sat most of the time on the flattened outer shell of the nest by looking out side.

* 0 day indicates 2 hrs after hatching, **1 day indicates 24 hrs after hatching

Table 28: Hatching, fledging, breeding and nest success of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Sl. No.		2005	2006	2007	Total
1	No. of nest building started.	28	24	28	80
2	No. of nest building completed	17	20	19	56
3	No. of clutches started	16	16	18	50
4	No. of clutches completed	16	16	18	50
5	No. of nests incubation completed	13	11	15	39

6	Total No. of eggs laid	58	62	67	187
7	No. of eggs predated/lost	17	23	20	60
8	No. of eggs unhatched	2	2	1	5
9	No. of eggs hatched	39	37	46	122
10	Percentage of hatching success.	67.2	59.7	68.7	65.2
11	No. of nestlings predated/lost	19	13	17	49
12	No. of nestlings fledged	20	24	29	73
13	Percentage of fledging success	51.3	64.9	63.0	59.8
14	Percentage of breeding success	34.5	38.7	43.3	39.0
15	No. of nests producing at least one flying young	8	7	10	25
16	Percentage of nest success	47	35	53	45

Table 29: Chi-squire test results showing the influence of nest parameters on nest success of Indian Treepie at Kizhakkoth panchayath during 2005–2007 period.

Sl. No.	Parameters	Chi-value	d.f.	*P*-value
1	Nesting tree species	5.97	5	0.31
2	Canopy diameter of the nesting tree	0.61	4	0.96
3	Nesting tree height	5.82	5	0.33
4	Height of the nest	5.20	7	0.64
5	Relative height of the nest	3.39	3	0.34
6	Orientation of the nest	0.99	2	0.61
7	Territory size	2.59	2	0.27
8	Distance to nearest residential building	0.48	4	0.98

Table 30: Eggs and nestlings of Indian Treepie lost at Kizhakkoth panchayath during 2005–2007 period.

Sl. No.	Causative factors	Eggs			Nestlings		
		2005	2006	2007	2005	2006	2007
1	Jungle Crow	6	7	6	6	4	4
2	House Crow	4	2	3	2	2	1
3	Indian Treepie	1	0	2	0	0	0
4	Shikra	0	0	0	2	0	2
5	Brahminy Kite	0	0	0	3	0	0
6	Parayah Kite	0	0	0	1	0	0
7	Rat Snake	0	0	0	1	0	2

8	House Cat	0	0	0	2	0	0
9	Mongoose	0	0	0	0	4	0
10	Logging of nesting tree	4	3	0	0	0	4
11	Harvesting practice	0	8	6	0	3	3
12	Unknown	2	3	3	2	0	1
13	Total	17	23	20	19	13	17

Table 31: Chi-squire test results showing the relationship of different nest parameters with egg loss at Kizhakkoth panchayath during 2005–2007 period.

Sl. No.	Parameters	Chi-value	d.f.	*P*-value
1	Nesting tree species	7.70	5	0.17
2	Nesting tree height	12.12	5	0.03
3	Relative height of the nest	2.94	3	0.40
4	Orientation of the nest	0.71	2	0.70
5	Canopy diameter of the nesting tree	3.93	4	0.42
6	Territory size	7.69	2	0.02
7	Distance to the nearest residential building	5.78	4	0.22
8	Height of the nest	14.25	6	0.03

Table 32: Chi-squire test results showing the influence of different nest parameters on nestling loss at Kizhakkoth panchayath during 2005–2007 period.

Sl. No.	Parameters	Chi-value	d.f.	*P*-value
1	Nesting tree species	3.18	5	0.67
2	Nesting tree height	6.48	5	0.26
3	Relative height of the nest	1.39	3	0.71
4	Orientation of the nest	1.84	2	0.40
5	Canopy diameter of the nesting tree	3.40	4	0.49
6	Territory size	1.45	2	0.49
7	Distance to the nearest residential building	3.58	4	0.47
8	Height of the nest	10.87	6	0.09
