# BIRD COMMUNITY STRUCTURE IN THE SACRED GROVES OF NORTHERN KERALA

By

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(2011 27 105)

THESIS

Submitted in partial fulfillment of the requirement for the degree of

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# DECLARATION

I hereby declare that this thesis entitled **BIRD COMMUNITY STRUCTURE IN THE SACRED GROVES OF NORTHERN KERALA** is a bona fide record of research done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree diploma fellowship or other similar title of any other University or Society

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# *Introduction*

# INTRODUCTION

Sacred groves as name signifies are wooded land connected to God or ded cated to a rel gious purpose Sacred groves are conserved beyond any legal leg slation due to fear of deity It is believed that cutting trees or harming any animal n sacred groves leads to wrath of deity (Gadgil and Vartak 1974 Samati and Gogoi 2007 Dagla *et al* 2007) In develop ng country l ke India the wooded area are be ng deforested to fulfil the bas c need of increasing populat on what remain unharmed to some extend are Sacred groves

India is exceptionally rich in sacred groves and has about 22 968 sacred groves spread across 20 States (Malhotra *et al* 2007) The State of Kerala harbours 1500 to 2000 sacred groves The extent of these sacred groves varies from 0 004 ha to > 20ha (Rajendraprasad 1995 Menon 1997) Induchoodan (1996) reported 361 sacred groves n Kerala having an area of more than 0 02 ha Sacred groves are often situated n remote and forested areas and are associated with tribal community (Malhotra *et al* 2001 Khan *et al* 2008 Singh and Garg 2014a) But in Kerala the picture s quite different sacred groves are mostly placed in the midst of human habitation and do not overlap with forested areas (Prasad and Mohanan 1995) They are managed e ther by individual famil es groups of families or by the statutory agencies for temple management (Dewasom Board) (Chandrashekara and Sankar 1998) Sacred groves are called by different names in different states in Kerala they are known as *Kav i*

Sacred groves conserved through ages are repositories for threatened and endem c flora and fauna Sacred groves provide good n che arboreal birds and small mammals like Bonnet macaque (Gadg l and Vartak 1974 Deb 1997 Sashikumar 2004 Deb 2007) The importance of sacred grove in conserv ng biodiversity is widely known worldwide

Exploration of flora in sacred grove of India has been done through ages Some of the important pioneer study was done by Gadgil and Vartak (1974) in Maharashtra and Induchoodan (1988) in Kerala But the fauna in the sacred groves is not been paid much attention scientific exploration of fauna in sacred groves are very less

Sacred groves also play an important role in maintaining ecosystem balance They maintain microclimate of the region conserve soil and water The nutrients generated are also made available to the adjoining agro ecosystems (Khumbongmayum *et al* 2005) Many of the sacred groves are associated with pond streams springs or rivers which act as a watershed and are a reservoir during rainy season and maintain water table throught the year (Venkatachalam *et al* 2005) Sacred groves also help to compensate increasing carbon emissions (Chandrashekara 2010 and Singh and Garg 2014)

In Kerala sacred groves are distributed in all the 14 districts The highest numbers of sacred groves having area more than 0 02 ha are found in northern region *i e* Kasargod district rich with 60 and Kannur districts with 54 sacred groves (Induchoodan 1996) Sacred groves of northern Kerala have unique ecosystems like fresh water *Myristica* swamps and mangrove (Deepamol and Khaleel 2009) Sacred groves of northern Kerala are also famous for its incredible festival of *Theyyam* Devotees believe that *Theyyam* protect them from epidemic diseases natural calamities increase the animal wealth and bring prosperity to the village as a whole (Chandrashekara 2010)

Though the small patchs of wooded lands play magnificent roles they are under threat The important reasons are loosening of belief in young generation fragmentation tourism and waste dumping encroachment for agriculture grazing sanskritisation partition of the joint fam lies *etc* (Bhandary and Chandrashekar 2003 Laloo *et al* 2006 Deb 2007 Bhakat 2009 Kumar *et al* 2011) Protection of the sacred groves can be fruitful by the collaboration of

government and the local community Bhagwat and Rutte (2006) suggest sacred groves as community reserves which could improve the value of protected area and enrich the livelihood of the local people

The present study was conducted with following objectives to study tl e bird community structure of the sacred groves of northern Kerala To understand the significance of the sacred groves in conserving the threatened and endemic birds To find out the relationsh p between patch size of the sacred groves and bird community structure and to analyze the social perspective about significance of sacred grove

# *Review of Literature*

# REVIEW OF LITERATURE

## 2 1 SACRED GROVES IN WORLD

Sacred groves are age old luxuriant patch of vegetation preserved for deity (Gadgil and Vartak 1974) They are protected through spiritual beliefs termed as social fencing by Khumbongmayum *et al* (2005) rather than any law imposed by government for protection as other forests Grazing cutting and poaching are completely restricted in sacred groves even fallen twig are not removed due to fear of punishment from deity (Gadgil and Vartak, 1976 Agmhotri *et al* 2010) But in some of the sacred groves litter collection collection of dried branches honey collection is allowed (Patil 2011 Divya and Manonmani 2013)

Sacred groves are found across the globe Earlier the existence of sacred grove was reported from Asia and many regions of Africa (Gadgil and Vartak, 1976) Later in addition to these two continents Hughes and Chandran (1998) reported the distribution of sacred groves in other continents like Europe Australia and America

In African country Ghana more than half of forest cover had been deforested Only the portions of land surviving are sacred groves They call sacred groves locally as Tenggbama (plural) or Teng gban (singular) Sacred groves vary in size from more than thirty hectares to less than a hectare (Barre *et al* 2009) Studies were conducted in sacred groves of Ghana to document bird species richness and abundance (Kesse *et al* 2009) Sacred groves reported from the Moyamba District of Sierra Leone in Africa harbours over 75 medicinal plants and are used by people to cure diseases (Lebbie and Guries 1995) Sacred groves are reported from Timor an island in Indonesia and are known as Lulic (McWilliam 2001)

The sacred groves of China play an important role in local biodiversity conservation and management Study on plant diversity revealed that total plant species and endemic species in the sacred grove community were higher than those in natural reserve and common forest (Liu *et al* 2000) Tibetan sacred groves are known to be ecologically unique and conserv ng different landscape community and species (Salick *et al* 2007)

## 2 2 SACRED GROVES IN INDIA

Sacred groves are distributed throughout India They are present throughout Western Ghats Eastern Ghats all along the Himalaya from the northwest to northeast western Himalaya of Kumaun and Garhwal Khasia hills of Assam Meghalaya and tribal hill of Mizoram Aravali ranges of Rajasthan and in some regions of Madhya Pradesh in Central India (Gadgil and Vartak 1976 Gadgil 1992 Burman 1992)

Number of sacred groves in India varies as many new sacred groves keeps on discovering Malhotra *et al* (2001) had reported 13 720 sacred groves from 20 states in India but the number later increased to 22 968 (Malhotra *et al* 2007) (Table 1) There is more addition in the present numbers of sacred groves Bar k *et al* (2006) reported 12 new sacred groves from Khasi hills Samati (2006) reported seven new sacred groves form Jaintia hills of Meghalaya Malhotra *et al* (2007) had mentioned presence of only a single sacred grove from Uttaranchal but Bisht and Ghildiyal (2007) believe that the number may go so high up to 1000 as every village or group of village have their own deity and s often surrounded by forest patch which is sacred Samkhediya and Ray (2014) documented presence of 12 sacred groves from Nimar region of Madhya Pradesh Also in other states like Jammu and Kashmir (Kumar *et al* 2011) Goa (Singh and Garg 2014) and Nagaland (Khan 2003) presence of groves were reported

Table 1 Distribution of sacred groves in different states of India

| Sl No | State | No of sacred grove Malhotra *et al* (2001) | No of sacred grove Malhotra *et al* (2007) |
|---|---|---|---|
| 1 | Andhra Pradesh | 685* | 685* |
| 2 | Arunachal Pradesh | 58 | 58 |
| 3 | Assam | 40 | 40 |
| 4 | Chhattisgarh | 600 | 600 |
| 5 | Gujarat | 29 | 29 |
| 6 | Haryana | 248 | 248 |
| 7 | Himachal Pradesh | 5000 | 10000 |
| 8 | Jharkhand | 21 | 21 |
| 9 | Karnataka | 1424 | 4050 |
| 10 | Kerala | 2000 | 2000 |
| 11 | Maharashtra | 1600 | 2799 |
| 12 | Manipur | 365 | 365 |
| 13 | Meghalaya | 79 | 79 |
| 14 | Orissa | 322 | 322 |
| 15 | Rajasthan | 9 | 9 |
| 16 | Sikkim | 56 | 56 |
| 17 | Tamil Nadu | 448 | 448 |
| 18 | Telengana | 65* | 65* |
| 19 | Uttarakhand | 1 | 1 |
| 20 | West Bengal | 670 | 1093 |
| | **Total** | **13 720** | **22 968** |

*Modified

Sacred groves are recognised by different names in different states (Malhotra *et al* 2007 Khumbongmayum *et al* 2004 Dash 2005 Mohanta *et al* 2012 Sukumaran and Raj 2010 Khan *et al* 2008 Induchoodan 1996) but Haryana is an exceptional case where there is no such generic name for sacred groves (Malhotra *et al* 2001)

In Assam the bodo and rabha tribes locally call sacred groves as Than and dimasa tribe call as madaico In Arunachal Pradesh and Sikkim sacred groves are associated with Buddhist community managed by Lamas and are called as Gumpa In Manipur sacred groves are commonly known as Lai umang but the gangte tribe call sacred grove protected around their habitation as Gamkhap and they also have small reserve of bamboo called Mauhak The Bamboo reserves are called as Mawmund in Mizoram In Odisha sacred groves are called as Jahira and Thakuramma In Meghalaya different groves are protected for different purpose Ki law adong is protected for non commercial purpose like water and in K law lyngdoh public use is not permitted Ki law kyntang and Ki law niam are religious forest and Ki law shnong is for village use Sacred groves in West Bengal are known by many names as Garamthan Sh talathan Harithan Sabitrithan and Santalburithan It is known as Jahera in Himachal Pradesh Dev van in Chhatt sgarh Matagud Devgudi Gaondevi Saranas or Jahera in Jarkhand Sarana or Jaherthan in Uttar Pradesh and Bugyal Dev ban Saran or Dev in Madhya Pradesh In Bihar they called as Saran In different parts of Rajasthan they are refered as Vanis Orans Kenkris Shamlat dehs and Devbanis In Maharashtra they are known as Devrai or Devrahati in western region and Devgudi by mad ya tribes in eastern region In Goa called as Devrai Devgal Devran or Devavan In Karnataka they are referred by many different names like Devarabana Davarakadu Hulidevarakadu Nagabana Bhutappanbana Chowdibana Kans Pavithravanam or Sindhravanam In Kerala sacred groves are commonly known as Kavu and if the deity worshiped is snake it is

called as Nagam In Tamil Nadu sacred groves are called as Iyarkaikovilkal Kovilkadu or Kavu (Malhotra *et al* 2007)

## 2 3 SACRED GROVES IN KERALA

There are numerous sacred groves all along the Western Ghats and the west coast (Gadgil and Chandran 1992) The State harbours 1500 to 2000 sacred groves the extent of which varies from 0 004 ha to > 20ha (Rajendraprasad 1995 Menon 1997) Induchoodan (1996) revealed 761 sacred groves in Kerala out of that 361 were having area more than 0 02 ha (Table 2)

Sacred groves are commonly known as Kavu in state but prefix varies with the deity like *Ayyappan* Kavu if the deity is lord *Ayyappan Bagavathy* Kavu if the deity is goddess *Bagavathy Muthappan* Kavu if the deity is muthapan (incarnation of God Shiva) and if the deity is serpent it is called as *Sarpa* Kavu *nagakavu* or *nagam* There are also sacred groves dedicated to spirits demons or ancestors called as Yakshi Kavu (Malhotra *et al* 2001)

## 2 4 ROLE OF SACRED GROVE IN CONSERVING BIODIVERSITY

Sacred groves are repositories of flora and fauna conserving rare species and are last safe haven for arboreal birds and monkeys (Gadgil and Vartak 1974) Sacred groves are one of the important *in situ* conservation of biodiversity Exploration of flora and fauna in sacred groves is always a curious field of study to many scientists biologists and taxonomists

Table 2 Distribution of sacred groves in Kerala (area more than 0 02 ha)

| Sl No | Districts | No of sacred grove |
|---|---|---|
| 1 | Thiruvananthapuram | 43 |
| 2 | Kollam | 44 |
| 3 | Pathanamthitta | 33 |
| 4 | Alappuzha | 49 |
| 5 | Idukki | 3 |
| 6 | Kottayam | 10 |
| 7 | Ernakulam | 7 |
| 8 | Thrissur | 16 |
| 9 | Palakkad | 3 |
| 10 | Malapuram | 11 |
| 11 | Kozhikode | 23 |
| 12 | Wayanad | 5 |
| 13 | Kannur | 54 |
| 14 | Kasargod | 60 |
| | **Total** | **361** |

Source Induchoodan (1996)

**2 4 1 Floral diversity in sacred groves**

Flora play very important role among local community associated with the sacred groves They are used in rituals worshiped during religious festivals and many are used for their medicinal values (Khumbongmayum *et al* 2004 Anthwal *et al* 2006) The multifarious uses of plants are preserved among local communities through folklore (Agnihotri *et al* 2012)

Importance of sacred grove in conserving threatened and endemic species of flora has been revealed long back Contribution in exploration of medicinally important rare endemic and threatened species in sacred groves from different parts of country is done by many authors throughout India

Gadgil and Vartak (1974) revealed presence of *Dysoxylum binectariferum Syzygium cumini Memecylon umbellatum Sterculia gutata Ficus arnottiana Terminalia paniculata Mangifera indica Holigarna graham Alstonia scholaris* climbers like *Acacia rugosa Combretum ovalifolium Schefflera venulosa Entada phaseoloides* and *Gnetum ula* in the sacred grove of Maharashtra Punde (2007) reported rare and climax forest tree species like *Antiaris toxicaria Saraca asoca Hydnocarpus pentandra* and *Strychnos nux vomica* from 15 sacred groves of Konkan region of Maharashtra Singh and Garg (2014) reported 14 endemic 26 medicinal and 40 Rare Endangered and Threatened (RET) plants from Kurdi Angod sacred site Sanguem taluk in South Goa

Kodagu region of Karnataka being a hot spot area for sacred groves is had been explored by many taxonomists Bhagwat *et al* (2005) reported threatened tree species such as *Actinodaphne lawsonii Hopea ponga Madhuca neriifolia Syzygium zeylanicum Michelia champaca Pittosporum dasycaulon* in sacred groves of Kodagu district of Karnataka Page *et al* (2010) reported 47 species of trees 12 species of lianas 29 species of shrubs and 55 species of epiphytes from 11 sacred grove of Kodagu Karnataka Bhandary and Chandrashekar (2003)

studied sacred groves of Dakshina Kannada and Udupi districts of Karnataka and found that plants in the sacred grove are very diverse and endemic also are different from those found in surrounding areas

Floristic diversity in sacred groves of Kerala had been extensively surveyed by many taxonomists and new species like *Kunstleria keralensis* had also reported (Mohanan and Nair 1981) Induchoodan (1996) reported 722 species representing 128 families and 474 genera from 361 sacred groves in Kerala Spec es such as *Caryota urens Vateria indica Holigarna arnottiana Adenanthera pavonina Strychnos nux vomica Hydnocarpus pentandra Olea dioica Mimusops elengi Alstonia scholaris Macaranga peltata Ixora coccinea Glycosmis arborea Calycopteris floribunda and Tabernaemontana heyneana* were distributed in more than 100 sacred groves Threatened species l ke *Cleome burmann* and *Pterospermum reticulatum* were also reported from sacred groves of Kerala Subramanian *et al* (2005) reported 94 species of plants coming under 85 genera and 52 families from Iringole Kavu one of the largest Kavu with an extent of 20 ha from Ernakulum district of Kerala The majority of species found in th s sacred grove had straight bole buttressed roots and height upto 40 meters Deepamol and Khaleel (2009) documented 20 plants each from Poongotu Kavu a fresh *Myristica* swamp and Thazhe Kavu a salt water mangrove ecosystem at Kannur district of Kerala In Poongotu Kavu *Hopea parviflora Myristica malabarica* and *Knema attenuata* were abundant and in Thazhe Kavu *Bruguiera cylindrica Avicennia officinalis* and *Rhizophora apiculata* species were dom nant Vidyasagaran *et al* (2005) reported 28 species of flowering plants from Kalasamala sacred grove a fresh water swamp forest of Thrissur district Kerala Gopikumar *et al* (2005) reported 99 species of flowering plants from Mannarashala sacred grove They found sacred grove as repository to many endemic species like *Antiaris toxicaria Myristica malabarica* and *Holigarna beddomei*

Sukumaran and Jeeva (2008) reported endemic species like *Calamus rotang Gloriosa superba Hemidesmus indicus Justicia beddomei* and endangered species like *Atlantia monophylla Nymphaea pubescens Naregamia alata* from the sacred grove in Agastheeshwaram Tamil Nadu Sukumaran and Raj (2010) documented 329 plant species from 201 sacred groves of Kanyakumari district out of which 34 were medicinal plants Floristic diversity of two sacred groves from Pondicherry region was explored by Devraja *et al* (2005) Chambra Iyyappan Koil having an extend of 0 06 ha harbours 23 species of trees 16 species of herbs seven species of shrubs and two species of epiphytes Trees like *Semecarpus travancorica Ampelocissus araneosa Salacia oblonga Madhuca neriifolia* and a large climber shrub *Dalbergia horrida* are some of the Rare Endangered and Threatened species found in this sacred grove Second sacred grove was Pandakkal Iyyappan Koil with extent of 0 86 ha harbouring 32 species of trees 29 climbers 17 species of herbs and 12 species of shrubs

Laloo *et al* (2006) documented 80 medicinally important tree species from Swer and Mairang Sacred grove of Meghalaya Bhakat (2009) reported 89 trees 45 shrubs 208 herbs and 46 climber species from Chilkigarh Kanak Durga sacred grove of West Bengal Some of the important trees reported were *Adina cordifolia Alangium salvifolium Alstonia scholaris Anthocephalus cadamba Holoptelea integrifolia Mimusops elengi* and *Strychnos nux vomica* Mohanta *et al* (2012) reported 58 tree species from 13 sacred groves of Odisha

Sacred grove from Ramsar site till now were not ever been explored for its floral diversity in India Mandu sacred grove and Siddhwari sacred grove are sacred groves in Upper Ganga Ramsar site in Uttar Pradesh one of the Ramsar site in India Mandu sacred grove harbours 11 tree species 10 medicinally important herbs and 5 species of climbers (Garg and Singh 2013a) and Siddhwari sacred grove is rich with 12 different trees species four shrubs six medicinally important herbs and five species of climbers (Garg and Singh 2013b)

Singh *et al* (2010) reported 42 angiosprems seven gymnosperms four pteriodophytes 15 bryophytes and 35 l chens from Haat Kali sacred grove in Pithoragarh district of central Himalaya Uttarakhand They feel that m cro cl mate in this sacred grove is suitable for growth of orchids like *Cymbidium maci orhizon* and *Malaxis acuminate* Agnihotri *et al* (2010) studied floristic diversity of 10 sacred groves from Kumaon reg on of Himalaya and noticed high diversity They reported 112 spec es of plants 56 aromatic and medicinally important 14 wild edible plants six oil yielding and four timber yielding plants Later Agmhotri *et al* (2012) reported 25 medic nal plants from new sacred grove called Patalbhuvneshwar sacred grove from Kumaon Himalaya in Pithoragarh District of Uttarakhand Bisht and Gh ldiyal (2007) revealed presence of 343 species of plant representing 256 genera from 107 families in the sacred grove of Tarkeshwar sacred grove in Gharwa Himalaya of which 50 were medicinally important

Kumar *et al* (2011) for the first time reported sacred grove from Srinagar Jammu and Kashmir They revealed 112 medicinal species 68 weed species 36 poisonous plants 23 exotic species 14 fodder species 12 species used in regional art and crafts 12 edible species and nine religious species

Dagal *et al* 2007 revealed that Orans of Rajasthan harbours endemic plants like *Pi osopis cinei ai ia Cappai is deciduas Zizyphus nummulai ia Haloxylon salicoi nicum Leptadenia pyi otechnica Ci otalai ia bui hia Glossonema varians Blephai is sindica Cai alluma edulis Ti ibulus tei i esti is Lasiui us sindicus* and *Bi achiai ia i amose*

Patel and Patel (2013) explored floristic diversity from 7 different sacred groves in Banaskantha district of Northeast Gujarat They reported 4ɔ plant species and largely concentrated species were *Azadi acta indica Aegle mai melos Ficus benghalensis Ficus glomei ata Ficus i eligiosa Mangifei a indica* and *Salvadoi a oleoides* A few rare and threatened plants like *Acacia catechu*

*Bombax ceiba Butea monosperma Calotropis gigantea Datura innoxia* were also found in these groves In Gujarat Shravan Kavadia of Kachchh region harbours mangrove sacred grove with *Avicennia marinas* as dominating species This is the only inland mangrove in the World (Tripathi *et al* 2013)

**2 4 2 Faunal diversity in sacred groves**

Faunal diversity in the sacred grove is worth mentioning but has not received much attention as that of flora in the sacred grove (Deb *et al* 1997 Nair *et al* 1997 Deb 2007) Fauna in the sacred groves are worshiped and conserved by many communities Indian gazelle (*Gazella gazella*) Blackbuck (*Antelope cervicarpa*) and the migratory bird Demoiselle Crane (*Anthropoides virgo*) are protected by the Bishnoi community in the Orans of Rajasthan (Malhotra 2003) Serpent is worshiped in many sacred groves of Kerala (Murugan *et al* 2008) Ponds in the sacred grove also provide habitat for many fishes tortoises frogs and water snakes (Warrier 2005)

Sacred grove harbours fauna like birds hare porcupine rats bats snake lizards frogs insects like honey bees butterflies beetles and other invertebrates (Deb 2007) Chandran *et al* (1993) also feels that it could not be expected that an isolated patch of sacred groves would harbour any major mammals rather than providing shelter to numerous birds butterflies bats primates and other small mammals

**2 4 2 1 *Composition of mammals amphibians reptiles and other invertebrates in sacred grove***

Das and Chanda (1997) discovered a new species of frog (*Philautus sanctisilvaticus*) from the sacred forest of Amarkantak Madhya Pradesh Fourteen different species of spiders were observed from the three sacred groves in Kerala (Sivaperuman 2008) Bhakta (2009) reported one amphibian species

six reptile species and six species of mammals from Chilkigarh Kanak Durga sacred grove of West Bengal Mohanta *et al* (2012) documented presence mammals and lizards from 13 sacred groves of Odisha Patil (2011) reported 55 butterflies and 59 spider species from seven sacred groves of Maharashtra Similarly Palot and Radhakrishnan (2004) reported 130 butterflies from sacred groves of northern Kerala

**2 4 2 2 *Bird composition in sacred grove***

Sashikumar (2004) reported 129 species of birds from 15 sacred groves of Kerala Chandrashekara (2010) also reported 122 bird species from 27 sacred groves of Kerala However Patil (2011) reported 53 bird species from the sacred groves of Maharashtra and there were reports of two threatened birds Great Pied Hornbill and Malabar Pied Hornbill (Punde 2007 and Patil 2011)

Bhakta (2009) documented 13 species of birds from Ch lkigarh Kanak Durga sacred grove of West Bengal Deb *et al* (1997) recorded 23 bird species and noticed that Yellow legged Green Pigeon Purple rumped Sunbird Coppersmith Barbet and Large Indian Parakeet were found only in the sacred grove when a comparison study for bird diversity in Chilkigarh Kanak Durga temple Sal forest and human habitation were done

In sacred groves of Cherrapunjee in Meghalaya 153 species were reported including four globally threatened species The species richness of the sacred grove was equal to the richness of Nokrek National Park harbouring 156 b rd species which lacks above threatened species (Ahmed 2004)

Jeeva *et al* (2005) found sacred grove n Meghalaya supporting 13 globally threatened species like Rufous necked Hornbill (*Aceros nepalensis*) White winged Duck (*Cairina scutulata*) Ferruginous Pochard (*Aythya nyroca*) Pallas s fish Eagle (*Haliaeetus leucoryphus*) Marsh Babbler (*Pellorneum palustre*)

Tawny breasted wren Babbler (*Spelaeornis longicaudatus*) Manipur bush quail (*Perdicula manipurensis*) Bristled grass Bird (*Chaetornis striatus*) Blyth s Kingfisher (*Alcedo hercules*) Greater spotted Eagle (*Aquila clanga*) Black breasted parrot Bill (*Paradoxornis flavirostris*) Dark rumped Swift (*Apus acuticaudata*) and Beautiful Nuthatch (*Sitta formosa*)

## 2 5 FACTORS AFFECTING BIRD COMMUNITY STRUCTURE

Size of the sacred grove isolation of sacred grove from its nearest forest altitude tree density of sacred groves are some of the independent factors influencing the bird community in the sacred groves (Raman 2001 Beier *et al* 2002 and Benassi *et al* 2007)

The Theory of Island Biogeography explains the differences in species diversity based on size and proximity of island from mainland According to this theory the number of species found on an island can be determined by a balance between the immigration rate (the movement of species onto the island from other slands) and the extinction rate (the rate at which species already on the island become nonexistent) This theory states that immigration and extinction rates are affected by the size of the island and its distance from a main source of immigrant species In this regard a larger island has higher species divers ty for two reasons being a larger target gives it a greater probability of becoming the home to immigrants and it has a larger supply of resources necessary to prevent extinctions Another prediction assumed by this theory is that distance of the island from a mainland is a source of new immigrants despite its size *i e* even if two islands are having exact same size and all other factors are constant the island closest to the mainland is more likely to attract a larger number of immigrant species due to its proximity and convenience (MacArthur and Wilson 1967)

Considering fragmented patches as an island many studies have been carried out around the globe to know species area relationship and the differences in species composition due to proximity of a patch from main land

Sacred groves are considered as natural laboratory to study the The Theory of Island Biogeography as the luxuriant patch preserved by our ancestors is vanishing and has formed an island between human habitations due to fragmentation which lead to decrease in size and increases isolation

Beier *et al* (2002) in their study about forest fragments of West Africa found that bird species richness per transect increased with patch size Fifteen species of birds in study were never found in smaller patch but isolation of patch showed negative correlation

Benassi *et al* (2007) found that species richness was strictly correlated to fragment area number of bird species increases with increas ng area of fragments Similarly Raman (2001) studied the influence of fragmentation on birds he found that in rainforest bird species richness increased significantly with fragment area and tended to also increase with the structural development of rainforest vegetation But the species richness of open country b rds was unrelated to fragment area

On the other hand Bhagwat *et al* (2005) could not found any significant result between patch size and species richness of birds and microfungi hence they feel that the habitat within the sacred grove and the surrounding matrix may have major contribution in determining the composition

Studies were also done to know the influence of size of sacred groves on tree species richness Page *et al* (2010) reported that tree species richness increased consistently with area in Virajpet Taluk of Kodagu district in Karnataka Species richness in shrub and liana did not show any particular trend with area

while in epiphytes species richness peaked at intermediate sized fragments According to them this was partly because smaller fragments had lower stem density and density increased with an increase in fragment area Area showed a strong influence only on tree species This is because among the studied life forms trees probably experience the greatest space constraint and thus are directly influenced by patch area

Similar results were obtained by Upadhaya *et al* (2003) during study of woody species in Ialong and Raliang sacred groves of the Jaintia hills in Meghalaya northeast India Number of species gradually increased with increase in area in both the sacred groves About 80 per cent of the species were found in a 0 35 ha area while 88 99 per cent of the species were encountered in 0 4 ha

Tambat *et al* (2005) conducted a study to know the effect of size of the sacred grove on seedling mortality of two endemic tree species *Canarium strictum* and *Artocarpus hirsutus* in sacred groves of Kodagu district They found a significant decline in per cent seedling mortality with increase in area of the grove ($P < 0\ 05$ in both the species) for *Artocarpus* The per cent seedling mortality ranged from as high as 100 per cent in the small groves to none in the large groves In *Canarium* the mortality ranged from about 60 per cent in the smaller groves to about 10 per cent in the larger groves The observed increase in per cent seedling mortality with decrease in grove size could be due to the closed mating among the fewer individuals in the small groves compared to the large

However Liang *et al* (2011) observed that the tree species richness was not significantly affected by patch size They suggest that the other factors affecting like patch shape artificial disturbance and regeneration of the interior forest community should be assessed

Alvarenga and Porto (2007) felt that reduction in size of patch and greater insularity from other forest fragments affect flora negatively as in their study at

Brazilian Atlantic forest the fragment with less isolation and large in size had richest epiphyllous bryophytes but for epiphytes no such effect was found

In case of mammals *Rattus rattus* there was no difference in the persistence between different age or sex classes The persistence time of sub adult females were particularly high in the large patch while the persistence time of juvenile and sub adult females were particularly low in the small patches (Shanker and Sukumar 1998)

## 2 6 SOCIO ECONOMIC STUDIES IN THE SACRED GROVES

Sacred groves are highly concentrated for its biodiversity rituals traditions and festivals It is hardly tried to interact with the villagers and to know there depth of awareness about the biodiversity or the perception about the significance of sacred grove The influences of gender age education occupation family size etc of the stakeholders on the conservation or protection issues are hardly studied

Patil (2011) had studied the dependence of communities on sacred grove in Maharashtra He had tried to know the social perspective about restriction n entering the sacred grove collection of fuel wood and litter conflicts on sacred groves etc He also tried to know the responses of stakeholders regarding the biodiversity of the sacred grove He recognised that highly educated and employed respondents were only aware about the word Biodiversity Fifty per cent of the respondents felt that biodiversity was important for them and had knowledge about rare species while 36 per cent had no idea about its role or importance and 13 per cent felt that biodiversity of sacred grove was not important for them

## 2 7 THREATS TO SACRED GROVE

Though the sacred grove is bound by its belief it is getting eroded due to many threats Anthropogenic activities loosening belief on deity by young generation, sanskritisation fragmentation grazing encroachment for agriculture tourism and waste dumping are some of the threats realised in the sacred groves of India (Deb 2007 Kushalappa and Bhagwat 2001 Bhakat 2009 Bhandary and Chandrashekar 2003 Garg and Sing 2013a Kumar *et al* 2011 Laloo *et al* 2006)

A large sacred grove in Baghmara village of Neturia block of Purulhya district was destroyed in the 1960 s by the National Thermal Power Corporation in a bid to extend power lines over the area The Sacred grove had to be cleared because it was too dense to extend the line through it Many other constructions like road rail and dam also lead to destruction of sacred grove In Vishnupur block Bankura district the Santals discontinued their SG rites because they were ashamed of the association of their animistic rituals to witchcraft and other superstitions Santal devotees abandoned the grove for years until its trees were chopped down in 1999 In Bankura and Birbhum districts of West Bengal images of Shiva Kali Manasa Shitala and other Hindu deities have been erected in a number of ancient Sacred groves and most of the trees in the groves have been cleared to make room for elaborate temple structures (Deb 2007) In sacred grove of Dakshina Kannada and Udupi districts of Karnataka vegetations were cleared to create a new concrete shrines in place of former symbolic worship stones Modernizing the deity and tree felling in sacred groves should be ban and reforestation of partially degraded sacred grove should be encouraged (Bhandary and Chandrashekar 2003)

Mandu sacred grove in upper ganga Ramsar site Uttar Pradesh approved for developing it into a tourist centre which has a fear to be prone to alteration in the race of modernization and vanishing religious sentiments (Garg and Sing 2013a)

On the other hand Samati and Gogoi (2007) feel that sacred groves can be made as destination for tourists by creating awareness for conservation

An important threat is encroachments and fragmentations leading to reduce size of the sacred grove The area of sacred groves is illegally captured for agriculture by local people adjoining the grove (Bhandary and Chandrashekar 2003) In Kodagu the first inventory of Sacred Groves was done in 1873 when 873 groves covering an area of 4398 hectares were listed Later in 1985 there were 1214 groves covering an area of 2550 hectares Hence in the last eighty years 42 per cent of the area under sacred groves was lost and the groves got fragmented resulting in an increase in their number (Kushalappa and Bhagwat 2001)

Sarabhai (2007) have reported threat due to Forest Invasive Species (FIS) like *Lantana camara Eupatorium glandulosum Parthenium* sp *Mimosa* sp *Eichhornia crassipes Mikania micrantha Ulex europaeus Prosopis juliflora Cytisus scoparius Euphorbia royleana* etc Also Patil (2011) have noticed extensive removal of fallen wood twigs or litter causing threat to sacred groves Forest fire incidence is also noticed from sacred grove of Srinagar Jammu and Kashmir (Kumar *et al* 2011) In addition to all other threats poaching also is reported from Patalbhuvneshwar sacred grove from Kumaon Himalaya (Agmhotri *et al* 2012)

Agmhotri *et al* (2010) feels that though the sacred grove is bounded by belief there should be legal rules protection schemes buffer zone and government should provide economic incentives to conserve biological and cultural association as sacred groves in many places are undergoing threat the cultural and biological integrity is vanishing

According to Bhakat (2009) steps should be taken to create awareness and stakeholders should be entrusted to look after the sacred grove and conservation

activities should be initiated taking local people scientists administrative bodies and NGO s in confidence

# *Materials and Methods*

## MATERIALS AND METHODS

### 3 1 STUDY AREA

Sacred groves are sacred natural sites preserved through its incredible rituals and beliefs Sacred groves in Northern Kerala are rich in flora and fauna with rich ecosystem like mangrove and Fresh water *Myristica* swamps which makes them distinct from other sacred groves in the state (Deepamol and Khaleel 2000) They harbour rich bird diversity Unique rituals and festivals called *Theyyam* which is performed in this region is also the po nt of attraction

The study area the Kannur and Kasargod districts of northern Kerala is surrounded by Arabian Sea in the west Kozhikode and Wayanad districts in the south and Karnataka State to the north and east The area experiences a monsoon type of climate The mean annual rainfall is 3000mm The area receives southwest monsoon from June to September northeast monsoon from October to November December and January are the colder months and April and May are the hottest The weather parameter during the present study is shown in Fig 1 and Fig 2 (KAU Meteorological station 2014) Criteria for selection of sacred grove was the size of sacred grove and three size classes of the sacred groves were selected small (<3ha) medium (3 to 6ha) and large (>6ha) Under each size classes five sacred groves each were selected from Kannur and Kasargod districts Thus a total of 15 sacred groves eight from Kannur and seven from Kasargod district were selected for study (Plate 1)

Present study proposed to find out the bird species diversity and bird community structure of sacred groves of northern Kerala and the relationship of the birds and the vegetation of the sacred groves The study was also proposed to find out the relationship between patch size of the sacred groves and bird community structure Apart from these ecological parameters the present study was also proposed to study the socio economic significance including the

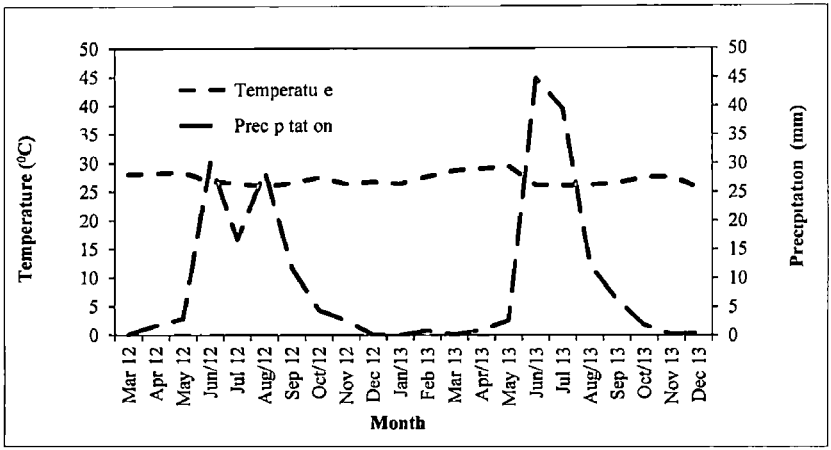



Figure 1 Weather parameters in Kasaragod district of Kerala

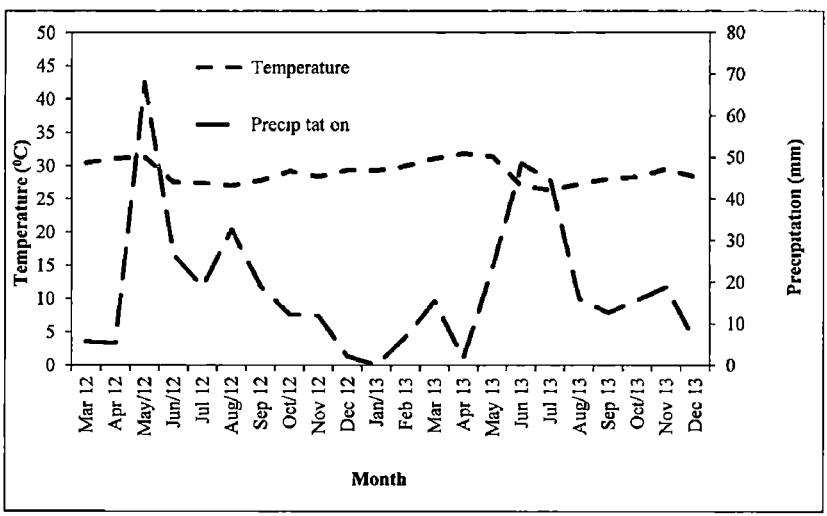



Figure 2 Weather parameters in Kannur district of Kerala

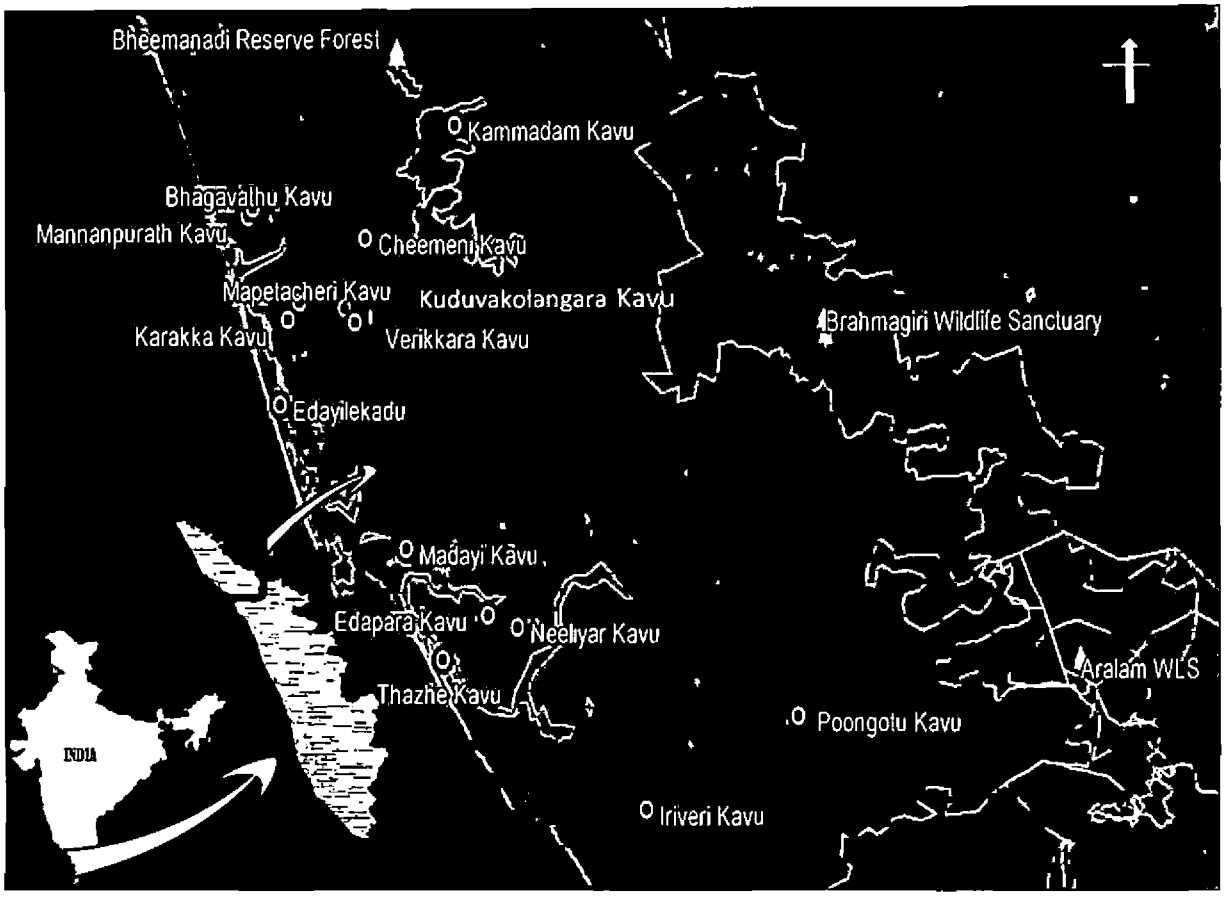



Plate 1. Google Earth Image of locations selected for study

perception of the people towards of sacred groves and awareness about birds among the respondents in the sacred groves of Kannur and Kasargod district

**3 1 1 The description of sacred groves selected for the study is detailed below**

The description of fifteen sacred groves selected for the study (Plate 2)

1) Cheemeni Kavu Cheemeni Kavu is also called as Cheemeni Shree Dharmashastavu Kavu and is located in Cheemeni village of Kasargod district between 12°14 20 7 N latitude and 075°14 20 7 E longitude and has an altitude of 99m It has an extent of 4 00 ha and is 11 30km away from Bheemanadi Reserve Forest The dominant tree species are *Garcinia* sp *Ixora brachiata Chionanthus mala elengi* etc Sacred grove is surrounded by a road paddy field homesteads and human settlements There is a pond located next to this sacred grove Bonnet Macaque (*Macaca radiata*) is one diurnal large mammal present here

2) Edayilakadu Edayilakadu is also called as Edayilakadu Sree Nagalayam or Nagamand is located at Valayaparambu village Kasargod district It is located at 12°08 10 72 N and 075°09 23 88 E and has an altitude of 12m It has an area of 6 40 ha and is nearly 20km away from Bheemanadi Reserve Forest The dominant trees are *Madhuca neriifolia Vateria indica Diospyros malabarica Cinnamomum malabatrum Hopea ponga Syzigium zeylanicum* The sacred grove is approachable by road it is surrounded by paddy fields and homesteads The Bonnet Macaque (*Macaca radiata*) is protected and worshipped in this sacred grove Pond is the water source of the grove

3) Kammadam Kavu Kammadam Kavu is located at Kammadam in Kasargod district and is located between 12° 18 41 0 N and 075° 18 55 8 E at an elevation of 85m It is the largest sacred groves in northern

Kerala with area of 24 40 ha It is 3 56 km away from Bheemanadi Reserve Forest The vegetat on is dominated by evergreen trees with fresh water *Myristica* swamp The tree species found are *Myristica malabarica Myristica beddomei Litsea sp Vateria indica Antiaris toxicaria etc* It is surrounded by plantations of rubber banana coconut and areca nut There is a stream flowing through the sacred grove and is the source of perennial water to the adjoining villages The major large mammals present here are Bonnet Macaques Malabar Giant Squirrel (*Ratufa indica*) Wild Boar (*Sus scrofa*) and Porcupine (*Hystrix indica*)

4) Mannanpurath Kavu Mannanpurath Kavu also called as Mannanpurath Bagavathy Kshetra Kavu is located n Nileshwar town of Kasargod district This is located between 12°15 27 6 N and 075°07 59 4 E with an altitude of 8m and has an extent of 2 80 ha It is about 17km from Bheemanadi Reserve Forest Species found are *Hydnocarpus pentandra Caryota urens Adenthera pavonina Holigarna arnottiana Ficus benghalensis* etc This sacred grove is surrounded by settlements and homesteads and is near to Nileshwar railway station There is a big pond adjacent to this sacred grove which is a source of water

5) Mapetachery Kavu Mapetachery Kavu is located in Paduvalam village of Kasargod d strict It is located between 12°12 04 3 N and 075°10 36 8 E with an altitude of 17m and has an extent of 4 00ha It is about 18km from Bheemanadi Reserve Forest The dominant trees are *Vateria indica and Hopea ponga* The temple and a pond are within the sacred grove It is surrounded by a road paddy fields human settlements and homesteads

6) Karaka Kavu Karaka Kavu is located in Pilicode panchayat of Kasargod district It is located between 12°11 22 2 N and 075°10 00 8 E w th an altitude of 19m and has an extent of 3 05 ha It is nearly 20km from Bheemanadi Reserve Forest The vegetation here is very peculiar the two

dominant tree species are *Vateria indica* and *Hopea ponga* which exists as two more or less distinct patches of vegetation in each of the patches the respective species dominate Sacred grove is surrounded by road human settlements and a play ground A pond and a well located in the sacred grove are the perennial source of water

7) Puthiya Parambathu Bhagavathi Kavu Bagavathi Kavu is located in Nileshwar town of Kasargod district Geographical co ordinates are 12°15 51 84 N and 075°08 11 8 E has an altitude of 8m Extend of the sacred grove is 1 92 ha It is nearly 16 50 km from Bheemanadi Reserve Forest Species like *Hopea ponga Holigarna arnotiana Caryota urens* and *Strychnos nux vomica* are the dominant tree species Sacred grove is surrounded by settlements and a road A well in the sacred grove is the source of water Puthiya Parambathu Bhagavathi Kavu will be mentioned as Bhagavathi Kavu in the thesis here after

8) Edapara Kavu Edapara Kavu also called as Edapara Chamundeshweri Kshetram is located at Morazha taluk of Kannur district between geographical co ordinates 11°59 16 2 N latitude and 075°20 18 7 E longitude and has an altitude of 16m Extent of the sacred grove is 2 80ha Nearest forest is Brahmagiri Wildlife Sanctuary which is 11 30 km from the sacred grove Tree species found are *Carelia brachiata Syzigium caryophyllatum Holigarna arnotiana etc* Sacred grove is near to a road and surrounded cashew plantations and settlements A well located inside the grove is the perennial water source

9) Kuduvakolangara Kavu The Kuduvakolangara Kavu is located at Puthur village in Kannur district Geographical co ordinates are 12°11 45 88 N and 075° 13 03 24 E has an altitude of 24m Extent of the sacred grove is 3 40ha It is nearly 17km from Bheemanadi Reserve Forest Spec es

found are *Holigarna arnottiana Macaranga peltata Elaeocarpus serratus Adenanthera pavonina etc* Sacred grove is surrounded by road human settlements and homesteads There is a small stream adjoining the sacred grove which gets flooded in rainy season

10) Poongotu Kavu Poongotu Kavu is situated in Koleri village of Mattanur taluk in Kannur district Geographical co ordinates are 11° 55 14 7 N and 075°36 58 9 E It has an altitude of 90m and the terrain is hilly and undulating in nature Extent of the sacred grove is 14 60ha It s nearly 13km from Aralam Wildlife Sanctuary Sacred grove is a fresh water *Myristica* swamp and species like *Myristica malabarica* is a dominant species The sacred grove is surrounded by settlement homesteads and rubber plantations A stream passing through the sacred grove is the perennial source of water The diurnal large mammals present here are Bonnet Macaque and also have Wild Boar

11) Iriveri Kavu Iriver Kavu also called as Iriveri Pulideva Kshetram is located at Iriveri Kannur district Geographical co ordinates are 11° 51 36 9 N and 075° 28 39 4 E has an altitude of 42m Extent of the sacred grove is 2 12ha It is nearly 18 km from Aralam Wildlife Sanctuary Trees like *Adenanthera pavonina Olea dioica Hydnocarpus pentandra Cinnamomum perrottetii Vitex altissima Holigarna arnottiana Syzigium caryophyllatum Lagerstroemia speciosa etc* are found in these sacred groves The sacred grove is surrounded by a road human settlement and homesteads A pond and well is the source of water

12) Madayi Kavu Madayi Kavu also called as Thiruvarkadu Bagavathy Kavu is located at Pazhayangadi Kannur Geographical co ordinates are 12°01 59 7 N and 075°15 46 5 E has an altitude of 43m Extent of the sacred grove is 1 60ha this is the smallest sacred grove in the present study area It is nearly 25km from Bheemanadi Reserve Forest and Brahmagiri

Wildlife Sanctuary in Karnataka Trees found are *Catunaregam spinosa Aglaia elaegnoidea Benkara malabarica Falconeria insignis etc* The sacred grove is surrounded by laterite formation which is devoid of any trees from one side and settlements by the other side

13) Neeliyar Kavu Also known as Mangatuparambu Neeliyar Kottam is located in Mangad village in Kannur district Geographical co ordinates are 11°59 02 6 N and 075°21 53 1 E has an altitude of 31m Extent of the sacred grove is 8 07ha It is nearly 30km from Brahmagiri Wildlife Sanctuary Trees found are *Memecylon umbellatum Strychnos nux vomica Olea dioica Hopea ponga Eleocarpus* sp etc There are three wells within the sacred grove and are the sources of water

14) Thazhe Kavu Thazhe Kavu is situated in Tekumbad Island one of the backwater island of Mattol panchayat Kannur district Geographical co ordinates are 11°57 54 6 N and 075°17 54 5 E has an altitude of 3m Extent of the sacred grove is 7 52 ha It is nearly 38 km from Brahmagiri Wildlife Sanctuary Habitat is mangrove and the trees found are *Bruguiera cylindrica Aegiceras corniculatum Rhizophora mucronata Avicenna officinalis Sonneratia caseolaris Excoecaria agallocha etc* Sacred grove is surrounded by salt water from three side and paddy fields by the other side A small well located in the sacred grove is the source of fresh water

15) Verikkara Kavu Verikkara Kavu is located in Peralam panchayat of Kannur district Geographical co ordinates are 12°11 08 6 N and 075°13 36 0 E has an altitude of 20m Extend of the sacred grove is 4 40ha It is nearly 17 km from Bheemanadi Reserve Forest Trees found are *Bridelia retusa Ziziphus trinervia Carelia brachiata etc* A small patch of the sacred grove has also been planted with cashew trees *Anacardium occidentale* It is surrounded by paddy field play ground


**a) Cheemeni Kavu**


**b) Edayilekadu**


**c) Kammadam Kavu**

Plate 2. Google image of sacred groves selected for study


j) **Poongotu Kavu**


k) **Iriveri Kavu**

l) **Madayi Kavu**

Plate 2. Google image of sacred groves selected for study


**m) Neeliyar Kavu**


**n) Thazhe Kavu**


**o) Verikkara Kavu**

Plate 2. Google image of sacred groves selected for study

rubber plantations and human settlements A rain fed stream and a well are the source of water

3 2 METHODOLOGY

The sacred groves were categorized into three classes based on their size small sized (S) a grove with area less than or equal to ɔ ha medium sized (M) area within 3 6 ha and large sized (L) sacred grove with are more than or equal to 6 ha In each category of size classes five sacred groves were selected Thus a total of 15 sacred groves were studied (Table 3) Distance between two nearest sacred groves ranged from 0 82 km to 16 62 km (Table 4)

**3 2 1 Methodology used for bird survey**

Two methods were used for studying the birds in the present study Po nt count method for small sized sacred groves and line transect method for the medium and bigger sized sacred groves (Bibby *et al* 1992) The bird study was done for three hours from 7h to 11h and 15h to 18h in each of the fifteen sacred groves The study was repeated once in every two months in each of the sacred groves between March 2012 to December 2013 Thus a total of 168 visits and 1008 h of field work is done during the study period The details recorded include the species of birds number of individuals and the distance of individuals or group of individuals from the point of observation (Appendix I)

In the point count methods three points were chosen randomly in the small sized sacred groves One hour each was spent on each of these points All the birds that were encountered and heard within a radius of 30m were recorded (Bibby *et al* 1992)

Table 3 Sacred groves selected for the study from Kannur and Kasargod districts of northern Kerala

| Sl No | Name of Sacred grove | Area of sacred grove (ha) | Size |
|---|---|---|---|
| 1 | Madayı Kavu | 1 60 | S |
| 2 | Bagavathy Kavu | 1 92 | S |
| 3 | Iruveri Kavu | 2 12 | S |
| 4 | Mannanpurath Kavu | 2 80 | S |
| 5 | Edapara Kavu | 2 80 | S |
| 6 | Karaka Kavu | 3 05 | M |
| 7 | Kuduvakolangara Kavu | 3 40 | M |
| 8 | Mapetachery Kavu | 4 00 | M |
| 9 | Cheemeni Kavu | 4 00 | M |
| 10 | Verikkara Kavu | 4 40 | M |
| 11 | Edayilekadu | 6 40 | L |
| 12 | Thazhe Kavu | 7 52 | L |
| 13 | Neeliyar Kavu | 8 07 | L |
| 14 | Poongotu Kavu | 14 60 | L |
| 15 | Kammadam Kavu | 24 40 | L |

Table 4 Distance between two nearest sacred groves in study

| Sl No | Sacred Grove | Distance (km) |
|---|---|---|
| 1 | Bagavathy Kavu Mannanpurath Kavu | 0 82 |
| 2 | Karaka Kavu Mapetachery Kavu | 1 68 |
| 3 | Edapara Kavu Neeliyar Kavu | 2 96 |
| 4 | Verikkara Kavu Kuduvakolangara Kavu | 1 25 |
| 5 | Kuduvakolangara Kavu Cheemeni Kavu | 5 40 |
| 6 | Madayı Kavu Thazhe Kavu | 7 73 |
| 7 | Iruveri Kavu Poongotu Kavu | 16 62 |
| 8 | Edayilekadu Karaka Kavu | 6 15 |

In the line transect method one 750m long transect was selected in each of the bigger sacred groves The transect was walked at uniform pace and all the birds encountered (including those heard) were recorded species wise their number and sighting distance from the transect recorded in four distance bands such as 0 5m 5 10m 10 30m and >30m (Bibby *et al* 1992)

Birds recorded in the sacred groves of northern Kerala were categorized into resident birds forest birds endemic birds migratory birds and threatened birds A resident bird is one that is known to breed in Kerala Forest birds are the one that is primarily seen in the different forest habitats in Kerala (Ali 1969 Ripley 1982 Ali and Ripley 1987 Sashikumar *et al* 2011 BirdLife International 2013 and IUCN 2014)

The bird species were also assigned to various feeding guilds such as aerial (AER) aquatic (AQ) bark surface feeders (BAR) canopy insect vores (CAN) carnivorous (CAR) frugivores (FRU) nectarivore insectivore (NEC) omnivore (OMN) piscivores (PIS) terrestrial insectivores (TER) understorey insectivores (UND) modified after Raman et al (1998) and Praveen and Nameer (2009)

The birds were identified using the binoculars with a magnification of 10x50 The field guides consulted were Ali and Ripley (1987) Grimmett and Inskipp (2005) Kazmierczak (2000) and Rasmussen and Anderton (2012) The taxonomy and common English names in the checklist follow Birdlife International (2013)

**3 2 2 Methodology for Vegetation study**

Ten quadrats of 10x10m were taken in each sacred grove for the study of the vegetation Thus a total of 150 quadrats were studied Within these quadrats the vegetation parameters such as species of the plants having more than 10cm

Girth at Breast Height (GBH) were selected and GBH and height of each tree were recorded Undergrowth cover percentage and the canopy closure percentage were estimated using ocular method Undergrowth cover percentage was measured by taking seedling cover shrub cover and grass cover on the ground and converting the same into the percentage of the ground cover such as 25 50 75 and 100 per cent cover as the case may be While the canopy closure percentage was estimated based on the penetration of sunlight through the canopy which was estimated by looking up in the sky though the canopy and assessed by the percentage of the sky that was visible though the canopy This was also measured to 25 50 75 and 100 per cent

**3 2 3 Methodology used for socio economic survey**

The socio economic survey was carried out to know awareness about birds and perception about significance of sacred grove among respondents of northern Kerala A total of 150 respondents were surveyed Ten respondents each from 15 sacred groves were selected for study from Kasaragod and Kannur district of northern Kerala Respondents were the people residing near to the sacred grove and some of them who were associated with the sacred grove

Socio personal characteristics like age gender caste education family size occupation and other parameters like type of association of respondents with sacred grove frequency of visit of respondents to the sacred grove knowledge about bird diversity in the sacred grove understanding about the beneficial role played by birds were taken as independent variables in the study

Since the main objective of study was to know the awareness about the birds and perception about the significance of sacred grove among the respondents in the sacred grove of northern Kerala these variables were considered dependent in the study

a) *Measurements of Independent variables*

a) Age

Age was operationally defined as The number of years completed by the respondents at the time of study The age of the respondents were categorized into eight groups from 21 30 to more than 90 and score was give from one to eight (Table 5)

Table 5 Categorization of age of the respondents and its respective scores

| Sl No | Category of response | Code |
|---|---|---|
| a | 21 30 | 1 |
| b | 31 40 | 2 |
| c | 41 50 | 3 |
| d | 51 60 | 4 |
| e | 61 70 | 5 |
| f | 71 80 | 6 |
| g | 81 90 | 7 |
| h | >90 | 8 |

b) Caste

Caste was also taken as variables in the study as most of the sacred groves are looked after by community Thiyya Pedaram Mamyani Nair Nambiyar and Yadavar were the caste associated with the sacred groves in study and were give score as shown in Table 6

c) Gender

Male and female both were studied and were scored as one and two respectively

Table 6 Caste of the respondents and its respective scores

| Sl No | Category of response | Code |
|---|---|---|
| a | Thiyya | 1 |
| b | Pedaram | 2 |
| c | Maniyam | 3 |
| d | Nair | 4 |
| e | Nambiyar | 5 |
| f | Yadavar | 6 |

d) Education

Education indicated the level of formal education of the respondents which was quantified using the procedure adopted by Santoshkumar (2008) with slight modification Educational level was categorized into illiterate to professional college and were scored one to five (Table 7)

e) Family size

Total number of adults and children in the family of the respondents were recorded

f) Occupation

This variable was operationally defined as The vocation from which the respondent derives major part of income Occupations were categorized into four daily wages from to professionals and were coded as depicted in Table 8

Table 7 Education of the respondents and its respective scores

| Sl No | Category of response | Code |
|---|---|---|
| a | Illiterate | 1 |
| b | Primary School Level | 2 |
| c | Secondary School Level | 3 |
| d | College | 4 |
| e | Professional College | 5 |

Table 8 Occupations of the respondents and its respective scores

| Sl No | Category of response | Code |
|---|---|---|
| a | Daily wages | 1 |
| b | Agriculture | 2 |
| c | Semi skilled/ Housewives | 3 |
| d | Professional | 4 |

a) Type of association of respondents with sacred grove

Associations of respondents with sacred grove were like fuel wood collection regular prayer play area for children used for the conduct of marriage and festival associated with the sacred grove These variables were given a cumulative score

b) Frequency of observing bird visiting the sacred grove

Frequency of observing birds visiting the sacred grove by the respondents was categorized and scored as shown in Table 9

Table 9 Frequency of observation of birds by the respondents and its respective scores

| Sl No | Category of response | Code |
|---|---|---|
| a | Never | 0 |
| b | Rarely | 1 |
| c | Sometimes | 2 |
| d | Frequently | 3 |
| e | Always when i am there | 4 |

c) Understanding about the beneficial effects from the birds

These variables was explained as bird s help in pollination control of harmful insects aesthetic pleasure ecosystem benefits and if others specify and were measured by cumulative scale

d) Understanding about the harmful role played by birds

The harmful role played the birds asked to the respondents were birds causing noise disturbance dirtying grounds threat to children or if others specify and these variables measured by cumulative scale

e) Number of bird visiting the sacred grove known to respondents

The knowledge about the number of bird visiting the sacred grove were categorized into five classes and was scored as shown in Table 10

**b)** ***Measurements of dependent variables***

Awareness about the bird structure was measured by the number of bird known to the respondents higher the names known higher was score given

Perception of the respondents about significance of the sacred grove was studied using scale developed by Supe (1969) Ten statements were developed of which five were negative the responses were collected on a four point continuum Table 11

The Scoring Pattern was reversed for negative statements The total score thus obtained by an individual was taken as his score for perception

The questionnaire that was used for the socio economic survey is given in Appendix II

Table 10 Number of bird visiting the sacred grove known to the respondents

| Sl No | Category of response | Code |
|---|---|---|
| a | <10 | 1 |
| b | 11 20 | 2 |
| c | 21 30 | 3 |
| d | 31 40 | 4 |
| e | 41 50 | 5 |
| f | >50 | 6 |

Table 11 Four point continuum method used for studying perception among the respondents

| Sl No | Points in the Continuum | Code |
|---|---|---|
| a | Strongly Agree | 4 |
| b | Agree | 3 |
| c | D sagree | 2 |
| d | Strongly Disagree | 1 |

## 3 3 STATISTICAL ANALYSIS

### 3 3 1 Statistical methods used for studying bird community structure in the sacred groves of northern Kerala

#### *3 3 1 1 Rarefraction cures*

Before the commencement of the analysis of the data it is essential check the completeness and adequacy of the sampling It is tested by the comparison of observed species richness with estimated species richness (Gotelli and Colwell 2001) Individual rarefaction curves was plotted using the software PAST for each of the sacred groves to know the completeness of the study

#### *3 3 1 2 Correspondence analysis*

Contingency tables were created for the abundance of birds for different sacred groves and abundance of birds in different feeding guilds for each sacred grove Association of bird species and bird feeding guild abundance with respect to the sacred groves were analysed by chi square test for associations The contingency table was visualized using correspondence analysis to understand the nature of the association

#### *3 3 1 3 Dendrogram*

Similarity between the sacred grove based on the bird species abundance and feeding guild abundance as well as co occurrence of different feeding guilds was studied by plotting Dendrogram based on Bray Curtis similarity matrix and paired group method

*3 3 1 4 Diversity indices*

Different diversity indices were calculated to understand the biodiversity profile of the sacred groves (Magurran 1988)

a) Margalef's richness index (R)

Margalef's richness index (R) was used to compare bird species richness and feeding guild richness across different sacred grove Margalef's richness index takes care of the difference if any in the sample size

R (S 1) / ln N

Where S is the total number of species and N is the total number of individuals

b) Shannon index of diversity (H )

Shannon index of diversity (H ) was used to compare bird species diversity and feeding guild diversity across different sacred grove

H $\Sigma$pi (ln pi)

Where pi – ni/N N $\Sigma$ni ni number of individuals of ith species

c) Simpson s index of diversity (D)

Simpson s index of diversity (D) was used to compare bird species diversity and feeding guild diversity across different sacred grove

D 1 $\Sigma$pi2

Where p n /N

N $\Sigma$ni

ni – number of individuals of ith species

d) Berger Parker (BP) index of dominance

Berger Parker (BP) index of dominance was used to understand whether one or few bird species or feeding guilds dominated the particular sacred grove

BP – n max/N

Where

n max is the number of individuals of the most abundant species

N is total number of individuals

e) Pielou s evenness index (E)

Pielou s evenness index was used to calculate whether species and feeding guilds are distributed evenly across different sacred grove

E H / ln S

Where

H – Shannon index of diversity

S number of species

### *3 3 1 5 Beta diversity and Principal component analysis*

The beta diversity in the bird species composition and feeding guild composition was studied using Whittaker s beta diversity index To study how the bird and feeding guild diversity profiles differed for different sacred groves Principal Component Analysis (PCA) was used PCA was performed on correction matrix Scree plot was constructed to understand how many important components were extracted by PCA

### *3 3 1 6 Correlation*

Correlation was performed to understand whether the distance from the nearest forest size of the sacred grove and altitude of the sacred grove and tree

density had any effect on the number of total bird species total number of individuals forest birds and endemic birds

### 3 3 2 Statistical methods used for studying tree diversity and abundance in the sacred groves of northern Kerala

The vegetation was quantitatively analyzed for their density abundance frequency relative density percentage frequency relative frequency basal area relative basal area and important value index (Curtis and McIntosh 1950)

Formulae used were as following

1 Density (D) – No of individuals/hectare

2 Relative Density (R D) $\frac{\text{No of individuals of the species}}{\text{No of individuals of all species}} \times 100$

3 Abundance (A) – $\frac{\text{Total No of individuals of the species}}{\text{No of quadrats of occurrence}}$

4 Percentage Frequency (PF) $\frac{\text{No of quadrats of occurrence}}{\text{Total No of quadrats studied}} \times 100$

5 Relative Frequency (RF) $\frac{\text{Percentage Frequency of individuals species}}{\text{Sum Percentage Frequency of all species}} \times 100$

6 Basal Area (BA) – $\frac{GBH^2}{4\Pi}$

7 Relative Basal Area (RBA) $\frac{\text{Basal area of the species}}{\text{Basal area of all species}} \times 100$

8 Important Value Index (IVI) RD + RF + RBA

### 3 3 3 Statistical method used for studying awareness and perception among respondents in the sacred grove of northern Kerala

Spearman s rank correlation was worked out to know extent of relationship of the parameters (age caste gender education occupation family size of the respondents number of family members employed association and frequency of visit of respondents to sacred grove diversity of birds and beneficial roles played birds) with awareness about bird and perception about significance of sacred grove among the respondents in the sacred grove of northern Kerala

The independent variables which were correlated with awareness about bird and perception about significance of sacred grove were ndependently sorted out and datasets was generated for both awareness about bird structure and perception about sign ficance of sacred grove so as to work out the contribution of each of the member of data sets to both the dependent variables using non parametric method of regression analysis And the equations were fitted with the help of Levenberg Marquardt technique Fox (2002) Mean Square Error was worked out to know the fit of equation Mean Square Error (RMSE) measure the sum of squared deviation of observation from the actual value

RMSE SQRT (Σyi y)^2/n

Where

yi Observed value
y – Expected value
n – Total number of observation

All statistical analysis done in the study were performed in Microsoft EXCEL® XLSTAT ® and PAST (Hammer *et al* 2001) and SPSS version 20 package

# Results

# RESULTS

## 4 1 BIRD COMMUNITY STRUCTURE IN THE SACRED GROVES OF NORTHERN KERALA

A total of 111 bird species belonging to 15 orders 47 families and 90 genera were identified from the 15 sacred groves of northern Kerala (Appendix III) Species richness ranged from maximum 55 Cheemeni Kavu to minimum 23 in Bagavathy Kavu In case of number of individuals of birds the maximum numbers of individuals were seen at Verikkara Kavu (576) and lowest number of individual was in Poongotu Kavu (203)

Total number of orders families genera species and individuals recorded from all sacred groves is shown in Table 12 and the complete checklist of bird species recorded in the sacred groves of northern Kerala is given in Appendix III

### 4 1 1 Bird diversity in the sacred groves of northern Kerala

Birds recorded during the present study were categorized into Resident migratory forest threatened and endemic birds (Table 13)

*a) Resident birds in the sacred groves of northern Kerala*

A total of 94 (86 68%) birds out of 111 birds in the sacred groves of northern Kerala were recognized as residents Highest number of resident birds was found in Verikkara Kavu 51 out of 54 which accounted to 94 44 per cent followed by 50 out of 55 birds in Cheemeni Kavu (90 90%) Across the different sacred groves studied nearly 80 85 per cent birds were resident birds (Table 13 and Appendix III)

Table 12 Bird diversity in the sacred groves of northern Kerala

| Sacred Grove | Order | Family | Genera | Species (S) | Individuals (N) |
|---|---|---|---|---|---|
| Cheemeni Kavu | 12 | 31 | 45 | 55 | 472 |
| Edapara Kavu | 7 | 24 | 31 | 36 | 439 |
| Edayilekadu | 9 | 20 | 29 | 31 | 369 |
| Iriveri Kavu | 6 | 22 | 30 | 36 | 339 |
| Kammadam Kavu | 12 | 27 | 37 | 44 | 265 |
| Karaka Kavu | 10 | 27 | 33 | 40 | 539 |
| Kuduvakolangara Kavu | 7 | 24 | 37 | 37 | 360 |
| Madayi Kavu | 7 | 27 | 36 | 49 | 539 |
| Mannanpurath Kavu | 7 | 24 | 29 | 35 | 344 |
| Mapetachery Kavu | 10 | 25 | 41 | 46 | 473 |
| Neeliyar Kavu | 4 | 19 | 25 | 32 | 365 |
| Poongotu Kavu | 9 | 25 | 32 | 36 | 203 |
| Bagavathy Kavu | 5 | 14 | 20 | 23 | 248 |
| Thazhe Kavu | 10 | 25 | 38 | 42 | 434 |
| Verikkara Kavu | 11 | 29 | 44 | 54 | 576 |
| **Total** | **15** | **47** | **90** | **111** | **5965** |

*b) Migratory birds in the Sacred groves of northern Kerala*

All the 15 sacred groves were found supporting migratory birds A total of 17 species of migratory birds were sighted during the present study (Table 15) Madayi Kavu supported 11 species followed by seven species each in Mannanpurath Kavu and Cheemem Kavu While the following four sacred groves such as Iriveri Kavu Kammadam Kavu Karaka Kavu and Mapetachery Kavu supported five species each of migratory birds

Eurasian Golden Oriole (*Oriolus oriolus*) a long distance migratory b rd was sighted from nine sacred groves Brown Shrike (*Lanius cristatus*) from three sacred groves Indian Pitta (*Pitta brachyuran*) and Chestnut tailed Starling (*Sturnus malabaricus*) from two sacred groves each

*c) Forest birds in sacred groves of northern Kerala*

Twenty five per cent of the birds seen in the sacred groves of northern Kerala were forest dependent birds (Table 14) Forest birds were mostly seen in Kammadam Kavu (57%) followed by Kuduvakolangara Kavu and Venkkara Kavu both harbouring (46%) However some of the sacred groves such as Bagavathy Kavu and Thazhe Kavu did not support any forest birds

Some of the forest dependant birds found n the sacred groves of northern Kerala include Little Spiderhunter (*Arachnothera longirostra*) which was sighted from four sacred groves Malabar Trogon (*Harpactes fasciatus*) sighted from one sacred grove Malabar Whistling Thrush (*Myophonus horsfieldii*) sighted from one sacred grove Grey Junglefowl (*Gallus sonneratii*) from four sacred groves Asian Fairy Bluebird (*Irena puella*) and Tickell s Blue flycatcher (*Cyornis tickelliae*) from one sacred grove etc

*d) Threatened bird in sacred groves of northern Kerala*

Oriental white ibis (*Threskiornis melanocephalus*) a Near Threatened bird was recorded from Thazhe Kavu during the present study

*e) Endemic birds to Western Ghats in sacred groves of northern Kerala*

Sacred groves help in conservation of endemic birds as is evidenced by the presence of the two Western Ghats endemic species such as Malabar Grey Hornbill (*Ocyceros griseus*) and Rufous Babbler (*Turdoides subrufa*) from the sacred groves of northern Kerala Malabar Grey Hornbill was sighted from Kammadam Kavu and Poongotu Kavu while Rufous Babblers were found at Kammadam Kavu Kuduvakolangara Kavu and Verikkara Kavu

Table 13 Bird species richness in the sacred groves of northern Kerala

| Sacred Grove | Resident Birds | Migratory Birds | Forest Birds | Threatened bird | Endemic Birds | Species richness |
|---|---|---|---|---|---|---|
| Cheemeni Kavu | 50 | 5 | 10 | 0 | 0 | 55 |
| Edapara Kavu | 34 | 2 | 5 | 0 | 0 | 36 |
| Edayilekadu | 28 | 3 | 3 | 0 | 0 | 31 |
| Iriveri Kavu | 31 | 5 | 7 | 0 | 0 | 36 |
| Kammadam Kavu | 39 | 5 | 16 | 0 | 2 | 44 |
| Karaka Kavu | 35 | 5 | 3 | 0 | 0 | 40 |
| Kuduvakolangara Kavu | 35 | 2 | 13 | 0 | 1 | 37 |
| Madayi Kavu | 38 | 11 | 4 | 0 | 0 | 49 |
| Mannanpurath Kavu | 28 | 7 | 3 | 0 | 0 | 35 |
| Mapetachery Kavu | 41 | 5 | 7 | 0 | 0 | 46 |
| Neeliyar Kavu | 30 | 2 | 6 | 0 | 0 | 32 |
| Poongotu Kavu | 35 | 1 | 7 | 0 | 1 | 36 |
| Bagavathy Kavu | 20 | 3 | 0 | 0 | 0 | 23 |
| Thazhe Kavu | 39 | 3 | 0 | 1 | 0 | 42 |
| Verikkara Kavu | 51 | 3 | 13 | 0 | 1 | 54 |

Table 14 Forest birds in the sacred groves of northern Kerala

| Sl No | Common Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Grey Junglefowl | | | | | 3 | | 9 | | | 2 | | | | | 3 | 17 |
| 2 | Crested Serpent eagle | | 1 | | 1 | 2 | | | | | 2 | 1 | | | | 1 | 8 |
| 3 | Oriental Honey buzzard | | | | | | | | | | | 1 | | | | | 1 |
| 4 | Emerald Dove | | 2 | | | 4 | | | | | | 1 | | | | | 7 |
| 5 | Vernal Hanging Parrot | 2 | | | | 3 | | 6 | | | | | | | | 2 | 13 |
| 6 | Plum headed Parakeet | 1 | | | | 10 | | | | | | | | | | | 11 |
| 7 | Banded Bay Cuckoo | | | | 2 | | | | | | | | | | | | 2 |
| 8 | Blue faced Malkoha | 1 | | | | | | 2 | 5 | | | | | | | 15 | 23 |
| 9 | Malabar Trogon | | | | | 1 | | | | | | | | | | | 1 |
| 10 | Malabar Grey Hornbill | | | | | 4 | | | | | | 1 | | | | | 5 |
| 11 | Rufous Woodpecker | | | | | | | 1 | | | | | | | | | 1 |
| 12 | Greater Flameback | | | 2 | | | | | | | | | | | | | 2 |
| 13 | Heart spotted Woodpecker | 2 | | | | | | 4 | | | | | | | | 4 | 10 |
| 14 | Indian Pitta | | | | 2 | | | | | 1 | | | | | | | 3 |
| 15 | Scarlet Minivet | 2 | | | 2 | 1 | | 2 | | | | | | | | | 7 |
| 16 | Bronzed Drongo | | | | | 21 | | | | | | | | | | 3 | 24 |
| 17 | Black naped Monarch | 10 | | 7 | | 5 | | 4 | | | 13 | 9 | | 2 | | | 50 |
| 18 | Black crested Bulbul | | | | | | | | | | | | | 1 | | | 1 |
| 19 | Yellow browed Bulbul | 2 | 5 | | 5 | 4 | | 6 | 2 | | 5 | 34 | | 28 | | 6 | 97 |
| 20 | Puff throated Babbler | 3 | 9 | | 6 | | 16 | 7 | 14 | | 40 | 2 | | 3 | | 11 | 111 |
| 21 | Rufous Babbler | | | | | 9 | | 4 | | | | | | | | 14 | 27 |
| 22 | Asian Fairy bluebird | | | | | | | | | 1 | | | | | | | 1 |
| 23 | Malabar Whistling thrush | | | | | 1 | | | | | | | | | | | 1 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Orange headed Thrush | 12 | 1 | 1 | 3 | 1 | 6 | 2 | 2 | 3 | 13 | 1 | | 3 | | 4 | 52 |
| 25 | Tickell s Blue flycatcher | | | | | 3 | | | | | | | | | | | 3 |
| 26 | Golden fronted Leafbird | 10 | | | | | | 8 | | | | | | 7 | | 7 | 32 |
| 27 | Plain Flowerpecker | | | | | | | | | | | | | | | 2 | 2 |
| 28 | Little Spiderhunter | | | | | 2 | | 3 | | | 5 | | | | | 1 | 11 |
| | **Species Richness** | **10** | **5** | **3** | **7** | **16** | **2** | **13** | **4** | **3** | **7** | **8** | **0** | **6** | **0** | **13** | |
| | **Abundance** | **45** | **18** | **10** | **21** | **74** | **22** | **58** | **23** | **5** | **80** | **50** | **0** | **44** | **0** | **73** | |

Legend

1 Cheemem Kavu
2 Edapara Kavu
3 Edayilekadu
4 Iniveri Kavu
5 Kammadam Kavu
6 Karaka Kavu
7 Kuduvakolangara Kavu
8 Madayi Kavu
9 Mannanpurath Kavu
10 Mapetachery Kavu
11 Poongotu Kavu
12 Bagavathy Kavu
13 Neeliyar Kavu
14 Thazhe Kavu
15 Venikkara Kavu

Table 15 Migratory birds in the sacred groves of northern Kerala

| Sl No | Common Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Little Ringed Plover | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 2 | Caspian Plover | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 3 | Kentish Plover | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 4 | Common Sandpiper | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 38 | 0 | 40 |
| 5 | Whiskered Tern | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 | 0 | 31 |
| 6 | Blue tailed Bee eater | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 2 | 0 | 0 | 0 | 3 | 2 | 18 |
| 7 | Indian Pitta | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 8 | Brown Shrike | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 4 |
| 9 | Eurasian Golden Oriole | 3 | 0 | 0 | 0 | 9 | 10 | 0 | 6 | 4 | 9 | 2 | 15 | 0 | 0 | 6 | 64 |
| 10 | Ashy Drongo | 3 | 0 | 7 | 3 | 3 | 5 | 6 | 2 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 39 |
| 11 | Asian Paradise flycatcher | 7 | 3 | 7 | 1 | 2 | 6 | 3 | 2 | 3 | 4 | 0 | 0 | 2 | 0 | 0 | 40 |
| 12 | Barn Swallow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 13 | Wire tailed Swallow | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 14 | Greenish Warbler | 2 | 9 | 2 | 6 | 4 | 12 | 0 | 2 | 1 | 0 | 0 | 3 | 10 | 0 | 0 | 51 |
| 15 | Booted Warbler | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 16 | Chestnut tailed Starling | 23 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| 17 | Asian Brown Flycatcher | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 6 |

Legend

1 Cheemen Kavu
2 Edapara Kavu
3 Edayilekadu
4 Iruveri Kavu
5 Kammadam Kavu
6 Karaka Kavu
7 Kuduvakolangara Kavu
8 Madayi Kavu
9 Mannanpurath Kavu
10 Mapetachery Kavu
11 Poongotu Kavu
12 Bagavathy Kavu
13 Neeliyar Kavu
14 Thazhe Kavu
15 Verikkara Kavu

### 4 1 2 Birds of Prey at the sacred groves of northern Kerala

Sacred groves of northern Kerala support good populations of the birds of prey Five species of raptors and four species of owls were reported from the sacred groves of northern Kerala during the present study (Table 16)

14 out of the 15 sacred groves had shown the presence of raptors Kuduvakolangara Kavu did not harbour any raptor Species reported were Black Kite (*Milvus migrans*) from 14 sacred groves Brahminy Kite (*Haliastur indus*) from 11 sacred groves Crested Serpent Eagle (*Spilornis cheela*) from six sacred groves Shikra (*Accipiter badius*) from six sacred groves White bellied Sea Eagle (*Haliaeetus leucogaster*) was found at two sacred groves White bellied Sea Eagle was found nesting in Edayilekadu sacred grove In addition to this Oriental Honey Buzzard was sighted at Poongotu sacred grove outside the transect walk

Four species of owls were sighted from four sacred groves These are Brown Fish Owl (*Bubo zeylonensis*) from Mannanpurath Kavu Mottled Wood Owl (*Strix ocellata*) from Karaka Kavu Brown Wood Owl (*Strix leptogrammica*) from Cheemeni Kavu and Spotted Owlet (*Athene brama*) from Edayilekadu

## 4 2 RAREFRACTION TO CHECK THE COMPLETENESS OF THE INVENTORIES

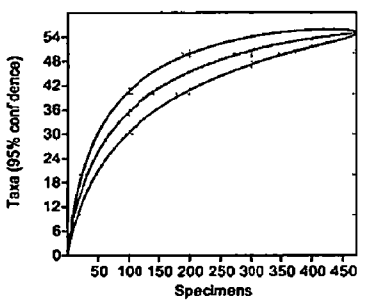
For all the sacred groves in study the curves derived showed asymptotes indicating the samplings done were adequate exceptionally Poongottu Kavu (Fig 3)

Table 16 Raptors and nocturnal birds in the sacred groves of northern Kerala

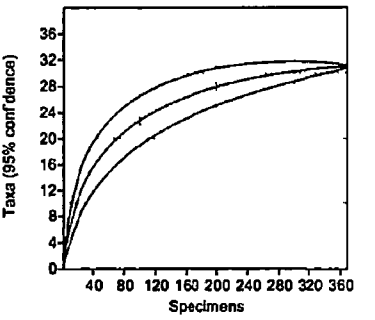
| Sl No | Common Name | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Black Kite | 4 | 5 | 12 | 4 | 4 | 3 | | 32 | 35 | 5 | 7 | 17 | 3 | 27 | 4 |
| 2 | Brahminy Kite | | 28 | 97 | 3 | | 25 | | 30 | 12 | 7 | | 3 | 7 | 25 | 3 |
| 3 | White bellied Sea eagle | | | 8 | | | | | | | | | | | 1 | |
| 4 | Crested Serpent eagle | | 1 | | 1 | 2 | | | | | 2 | 1 | | | | 1 |
| 5 | Oriental Honey Buzzard | | | | | | | | | | | 1 | | | | |
| 6 | Shikra | 3 | 1 | | 1 | | 3 | | | 1 | 1 | 1 | 3 | | | 2 |
| 7 | Brown Fish owl | | | | | | | | | 2 | | | | | | |
| 8 | Mottled Wood owl | | | | | | 1 | | | | | | | | | |
| 9 | Brown Wood owl | 1 | | | | | | | | | | | | | | |
| 10 | Spotted Owlet | | | 5 | | | | | | | | | | | | |
| | **Total Species** | **3** | **4** | **4** | **4** | **2** | **4** | **0** | **2** | **4** | **4** | **3** | **3** | **2** | **3** | **4** |
| | **Total Abundance** | **8** | **35** | **122** | **9** | **6** | **32** | **0** | **62** | **50** | **15** | **9** | **23** | **10** | **53** | **10** |

Legend

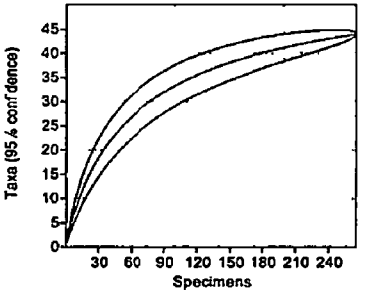
1 Cl eemem Kavu
2 Edapara Kavu
3 Eday lekadu
4 Iriveri Kavu
5 Kammadam Kavu
6 Karaka Kavu
7 Kuduvakolai gara Kavu
8 Madayi Kavu
9 Mannanpurath Kavu
0 Mapetacl ery Kavu
1 Poongotu Kavu
12 Bagavathy Kavu
13 Neeliya Kavu
14 Thazl e Kavu
15 Verikkara Kavu



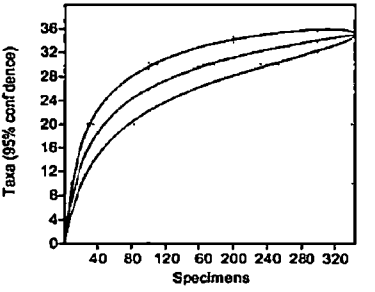

Cheemeni Kavu



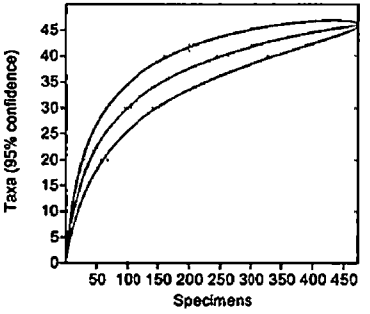

Eday lekadu



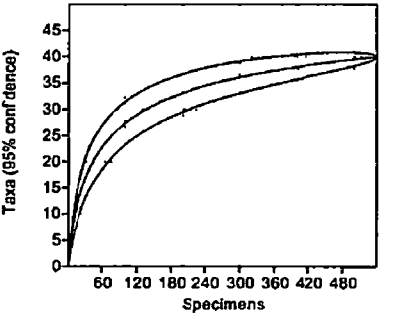

Kammadam Kavu




Mannanpurath Kavu




Mapetachery Kavu




Karaka Kavu

Figure 3 Rarefraction curves for bird in selected sacred groves of northern Kerala (Red line indicated observed values blue line is standard deviation at 95% confidence level)

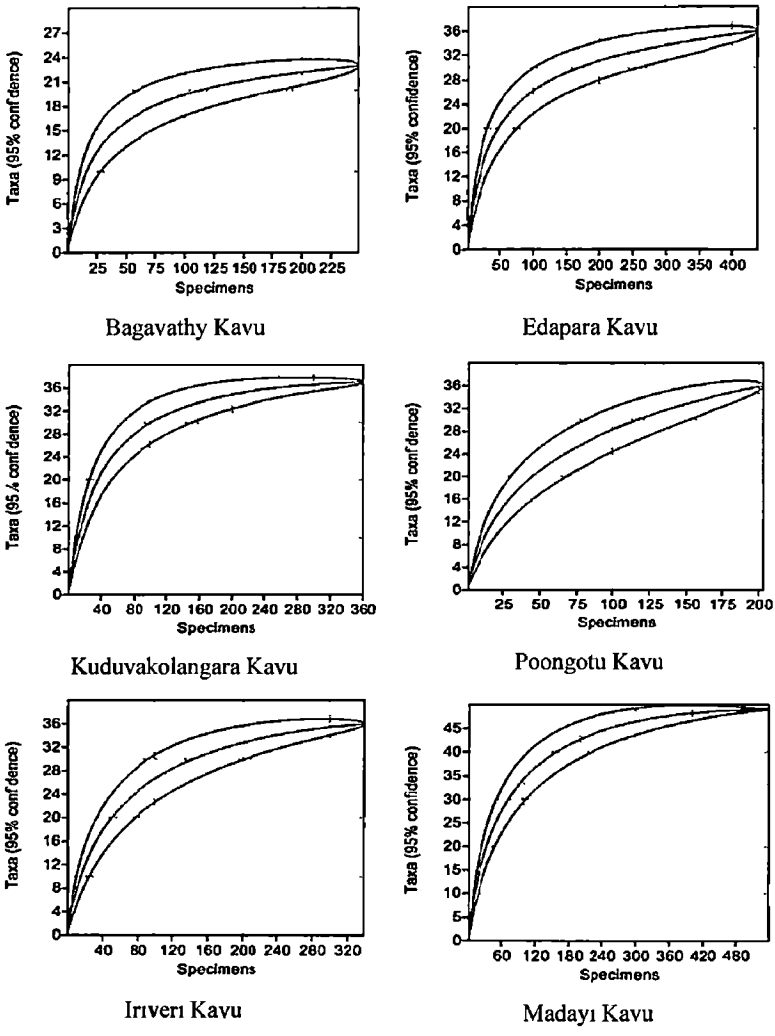



Figure 3 Rarefraction curves for bird in selected sacred groves of northern Kerala (Red line indicated observed values blue line is standard deviation at 95% confidence level)

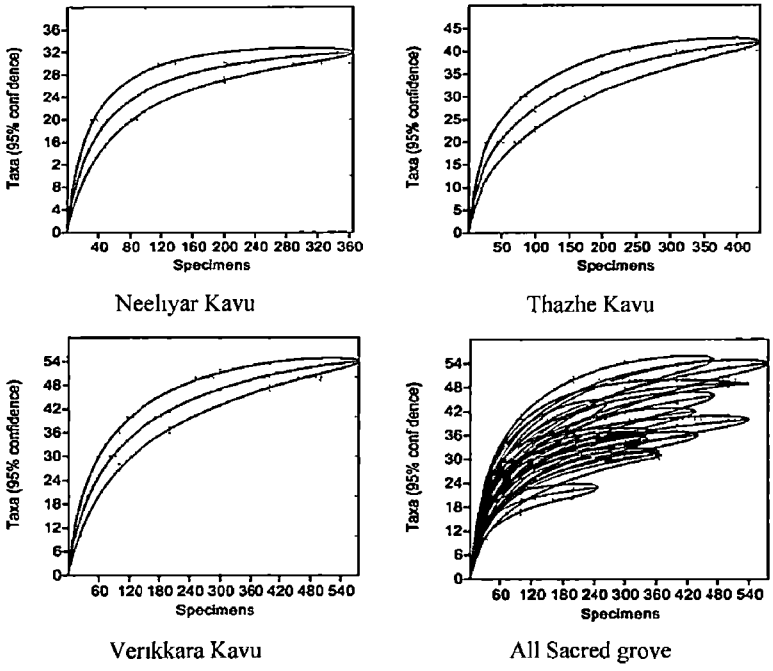



Figure 3 Rarefraction curves for bird in selected sacred groves of northern Kerala (Red line indicated observed values blue line is standard deviation at 95% confidence level)

## 4 3 DIVERSITY AND ABUNDANCE OF THE BIRDS OF THE SACRED GROVES OF NORTH KERALA

### 4 3 1 Bird diversity of the sacred groves of northern Kerala

Diversity indices were calculated to understand the bird diversity profile of the 15 sacred groves of North Kerala (Table 17) Margalef's richness index varied from 3 99 to 8 77 Higher species richness was found in Cheemeni Kavu The Shannon index of diversity values for the sacred groves of northern Kerala varied between 2 72 to 3 51 The sacred groves reported with the maximum bird species diversity was Cheemeni Kavu Simpson s index of diversity (1 D) varied from 0 92 0 96 Simpson s index also showed maximum diversity in Cheemen Kavu Berger Parker (BP) index ranged from 0 10 to 0 26 Maximum dominance was found in Edayilekadu

### 4 3 2 Bird abundance in sacred groves of northern Kerala

The correspondence analysis was carried out extracting two axes axis 1 gave 19 84 per cent of variation and axis 2 gave 15 70 per cent variations (Fig 4) It is evident that all the Sacred groves of northern Kerala had a similar bird structure except Kammadam Kavu and Thazhe Kavu ($\chi 2$ 11040 df 1540 and $P <$ 0 0001)

### 4 3 3 Principal component analysis for sacred groves and bird abundance

Principal Component Analysis based on all diversity indices were worked out for bird species abundance (Fig 5) Two axes were extracted in Principal Component Analysis axis 1 gave 58 46 per cent of variation and axis 2 gave 28 65 per cent variation This accounts for total variation of 87 11 per cent Scree plot in the inset of the graph also shows that variation decreased faster after two axes

Table 17 Diversity indices based on Bird abundance in the sacred grove of northern Kerala

| Sacred Grove | Species (S) | Individuals (N) | Margalef (R) | Shannon (H ) | Simpson (1 D) | Berger Parker (BP) | Evenness (E) |
|---|---|---|---|---|---|---|---|
| Kuduvakolangara Kavu | 37 | 360 | 6 12 | 3 29 | 0 95 | 0 12 | 0 73 |
| Verikkara Kavu | 54 | 576 | 8 34 | 3 23 | 0 93 | 0 18 | 0 47 |
| Bagavathy Kavu | 23 | 248 | 3 99 | 2 74 | 0 92 | 0 13 | 0 67 |
| Mannanpurath Kavu | 35 | 344 | 5 82 | 3 08 | 0 94 | 0 11 | 0 62 |
| Cheemeni Kavu | 55 | 472 | 8 77 | 3 51 | 0 96 | 0 10 | 0 61 |
| Mapetachery Kavu | 46 | 473 | 7 31 | 3 26 | 0 95 | 0 10 | 0 57 |
| Karaka Kavu | 40 | 539 | 6 20 | 3 15 | 0 94 | 0 10 | 0 59 |
| Kammadam Kavu | 44 | 265 | 7 71 | 3 35 | 0 95 | 0 12 | 0 64 |
| Madayi Kavu | 49 | 539 | 7 63 | 3 42 | 0 95 | 0 15 | 0 62 |
| Edapara Kavu | 36 | 439 | 5 75 | 3 09 | 0 94 | 0 11 | 0 61 |
| Edayilekadu | 31 | 369 | 5 08 | 2 72 | 0 89 | 0 26 | 0 49 |
| Neeliyar Kavu | 32 | 365 | 5 25 | 2 97 | 0 93 | 0 19 | 0 61 |
| Thazhe Kavu | 42 | 434 | 6 75 | 3 14 | 0 94 | 0 09 | 0 55 |
| Poongotu Kavu | 36 | 203 | 6 59 | 3 06 | 0 93 | 0 17 | 0 59 |
| Iriveri Kavu | 36 | 339 | 6 01 | 2 96 | 0 92 | 0 21 | 0 54 |

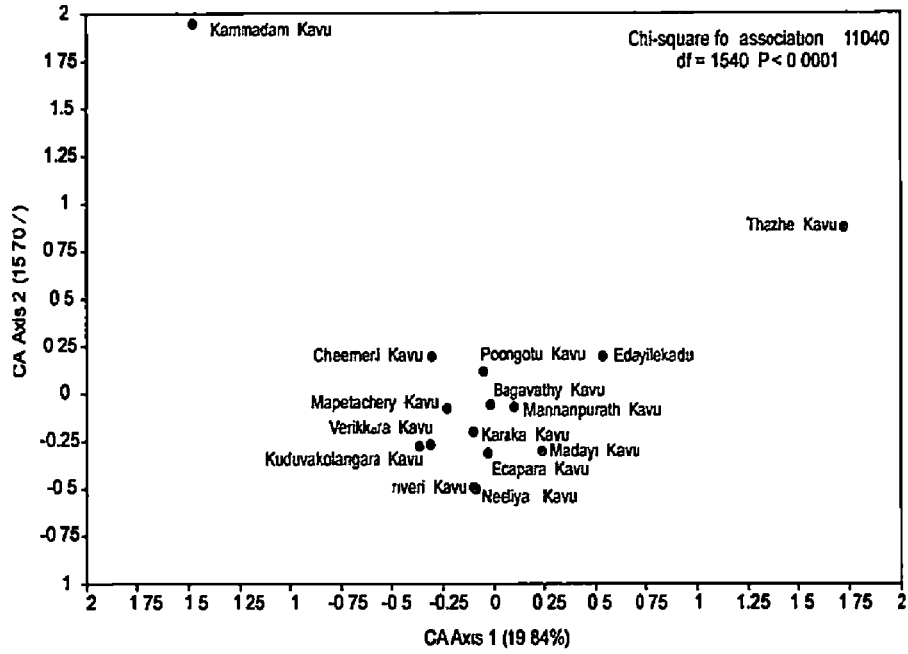



Figure 4 Correspondence analysis of using the bird abundance at sacred groves of northern Kerala

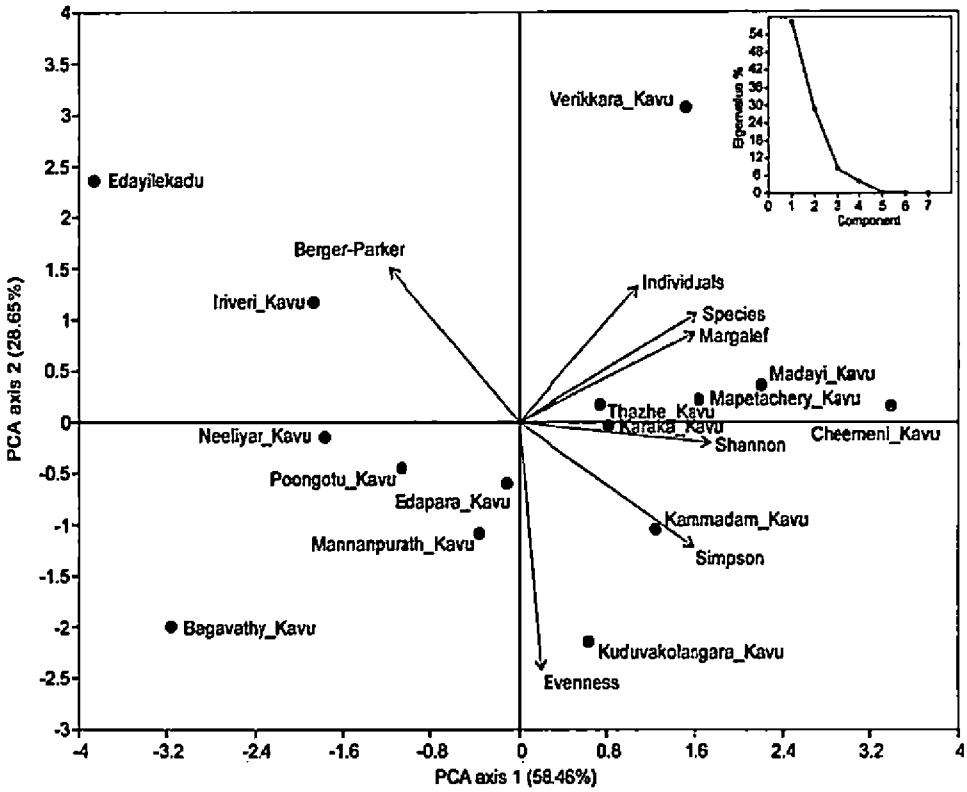



Figure 5. Principal component analysis for sacred groves and bird abundance. Scree plot of % eigenvalues for different component is shown in the inset

PCA show that the bird diversity and bird species richness were higher at the following sacred groves such as Cheemeni Kavu, Verikkara Kavu, Madayi Kavu, Mapetachery Kavu, Karaka Kavu, Thazhe Kavu, Kammadam Kavu and Kuduvakolangara Kavu.

Axis 1 show that Berger-Parker index of dominance was more in Edayilekadu and Iriveri Kavu which depict that these sacred groves had one species dominant over others.

### 4.3.4 Beta diversity for bird species richness of various sacred groves of Northern Kerala

Dendrogram based on Bray-Curtis similarity matrix were worked out to know similarity between bird abundance in the selected sacred groves of northern Kerala. Bootstrap values indicate the significance of clusters. Broadly three clusters were identified *viz.* Karaka Kavu to Cheemeni Kavu, Edapara Kavu to Kuduvakolangara Kavu and Thazhe Kavu to Kammadam Kavu (Fig. 6 and Table 18). This indicates the similarity of species between these clusters. It was interesting to note that the four big sized sacred groves form a distinct group.

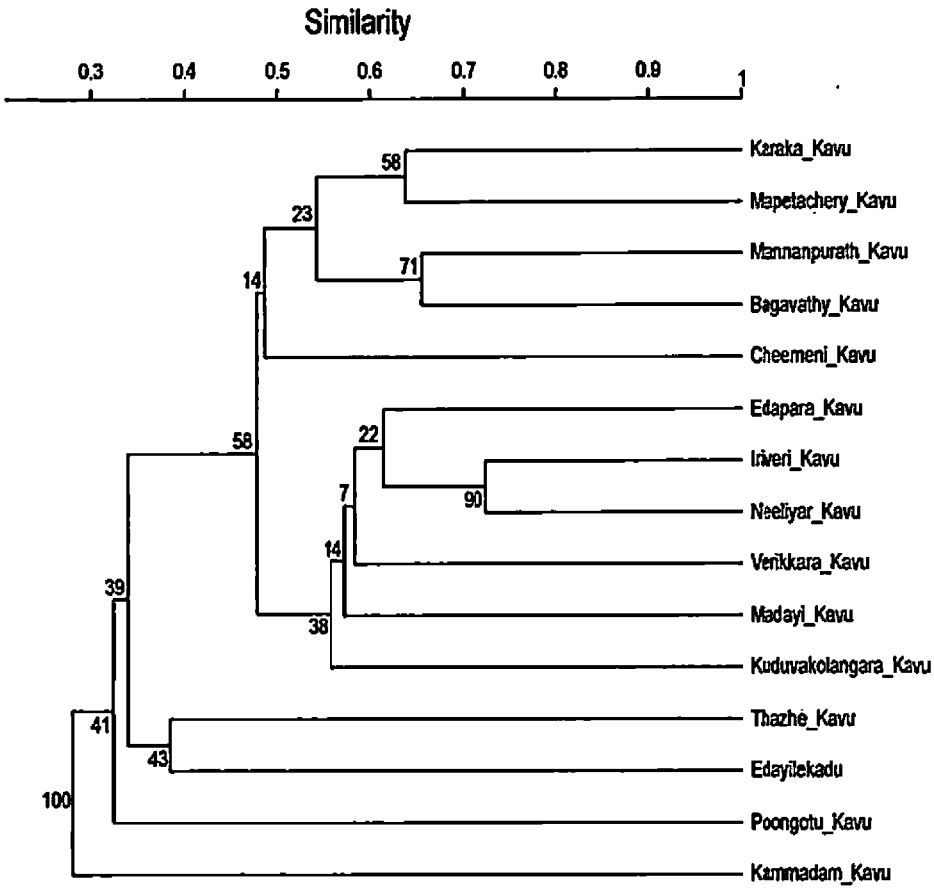



Figure 6. Dendrogram of the relation between bird abundance and sacred groves, based on Bray-Curtis similarity index. (Numerical indicates bootstrap value)

Table 18. Beta diversity for bird species richness in sacred groves of northern Kerala

| | Sacred Grove | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cheemeni Kavu | 0.00 | | | | | | | | | | | | | | |
| 2 | Edapara Kavu | 0.36 | 0.00 | | | | | | | | | | | | | |
| 3 | Edayilekadu | 0.47 | 0.46 | 0.00 | | | | | | | | | | | | |
| 4 | Iriveri Kavu | 0.41 | 0.22 | 0.49 | 0.00 | | | | | | | | | | | |
| 5 | Kammadam Kavu | 0.35 | 0.48 | 0.55 | 0.53 | 0.00 | | | | | | | | | | |
| 6 | Karaka Kavu | 0.33 | 0.26 | 0.41 | 0.32 | 0.52 | 0.00 | | | | | | | | | |
| 7 | Kuduvakolangara Kavu | 0.35 | 0.34 | 0.50 | 0.32 | 0.46 | 0.43 | 0.00 | | | | | | | | |
| 8 | Madayi Kavu | 0.37 | 0.27 | 0.50 | 0.32 | 0.53 | 0.30 | 0.37 | 0.00 | | | | | | | |
| 9 | Mannanpurath Kavu | 0.40 | 0.32 | 0.39 | 0.35 | 0.54 | 0.25 | 0.47 | 0.36 | 0.00 | | | | | | |
| 10 | Mapetachery Kavu | 0.27 | 0.29 | 0.40 | 0.34 | 0.42 | 0.28 | 0.35 | 0.33 | 0.33 | 0.00 | | | | | |
| 11 | Poongotu Kavu | 0.36 | 0.39 | 0.55 | 0.44 | 0.43 | 0.42 | 0.45 | 0.51 | 0.44 | 0.39 | 0.00 | | | | |
| 12 | Bagavathy Kavu | 0.51 | 0.36 | 0.48 | 0.39 | 0.61 | 0.30 | 0.53 | 0.42 | 0.34 | 0.39 | 0.49 | 0.00 | | | |
| 13 | Neeliyar Kavu | 0.40 | 0.21 | 0.46 | 0.29 | 0.53 | 0.31 | 0.30 | 0.31 | 0.37 | 0.36 | 0.44 | 0.42 | 0.00 | | |
| 14 | Thazhe Kavu | 0.48 | 0.51 | 0.40 | 0.59 | 0.67 | 0.44 | 0.62 | 0.45 | 0.45 | 0.41 | 0.54 | 0.57 | 0.54 | 0.00 | |
| 15 | Verikkara Kavu | 0.30 | 0.31 | 0.53 | 0.40 | 0.45 | 0.36 | 0.32 | 0.36 | 0.37 | 0.22 | 0.42 | 0.51 | 0.40 | 0.46 | 0.00 |

## 4.4 DOMINANT BIRD FAMILIES IN THE SACRED GROVES OF NORTHERN KERALA

A total of 47 families were reported from the sacred grove of northern Kerala. Family Ardeidae had the maximum numbers of species of six followed by Acciptridae, Muscicapidae, Charadriidae and Pycnonotidae, which had five species each. Family with fore more than four species found in the sacred groves of Northern Kerala is given in Fig. 7.

The families Megalaimidae, Cuculidae, Cisticolidae, Corvidae, Nectariniidae were reported from all 15 sacred groves of northern Kerala followed by Acciptridae, Muscicapidae, Sturnidae and Dicruridae from 14 sacred groves each and family Pycnonotidae, Alcedinidae, Oriolidae, Columbdae, Turdidae was reported from 13 Sacred groves. While family Irenidae, Ciconiidae, Hirundinidae, Trogonidae, Threskiornithidae and Sternidae represented only from one sacred grove (Table 19).

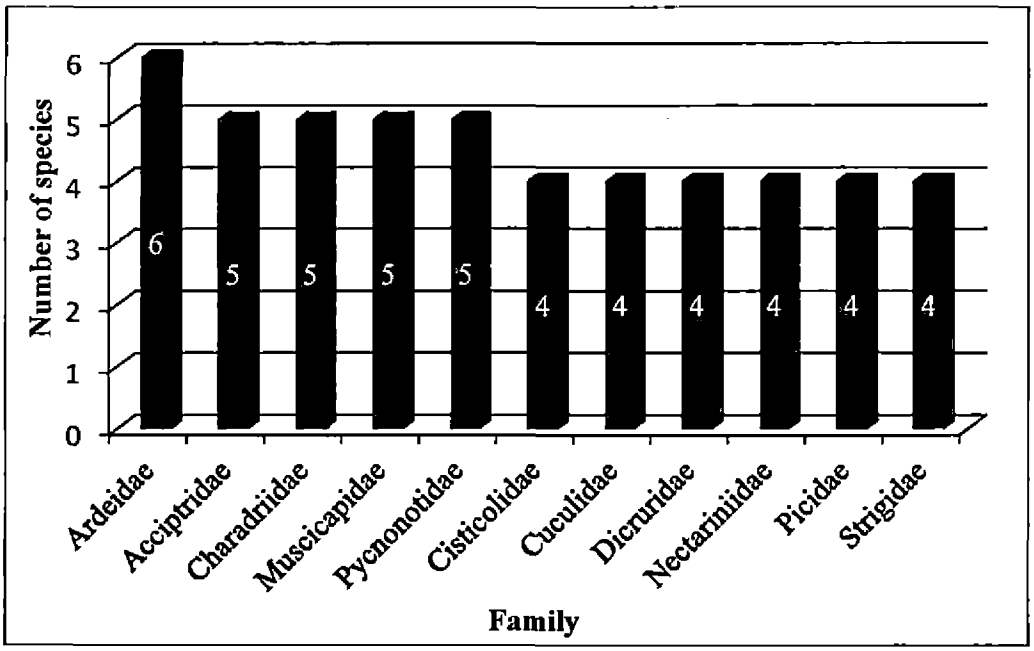



Figure 7. More specious family found in sacred groves of northern Kerala

Table 19. Number of species in different family in the sacred groves of northern Kerala

| Sl. No | Family of Birds | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cisticolidae | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 3 | 1 | 15 |
| 2 | Cuculidae | 3 | 2 | 2 | 3 | 1 | 2 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 15 |
| 3 | Megalaimidae | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 15 |
| 4 | Corvidae | 3 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 15 |
| 5 | Nectariniidae | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 4 | 1 | 2 | 3 | 3 | 4 | 15 |
| 6 | Acciptridae | 2 | 4 | 3 | 4 | 2 | 3 |  | 2 | 3 | 4 | 3 | 3 | 2 | 3 | 4 | 14 |
| 7 | Muscicapidae | 2 | 1 |  | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 14 |
| 8 | Sturnidae | 2 | 1 | 1 |  | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 14 |
| 9 | Dicruridae | 3 | 2 | 2 | 3 | 4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |  | 3 | 14 |
| 10 | Pycnonotidae | 4 | 4 |  | 2 | 2 | 2 | 3 | 4 | 2 | 3 | 3 |  | 5 | 1 | 4 | 13 |
| 11 | Oriolidae | 2 | 1 |  | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1 |  | 1 | 13 |
| 12 | Columbidae | 2 | 2 |  | 1 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 |  | 1 | 2 | 13 |
| 13 | Alcedinidae | 2 | 1 | 2 |  | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 |  | 3 | 1 | 13 |
| 14 | Turdidae | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |  | 1 |  | 1 | 13 |
| 15 | Monarchidae | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 1 |  | 2 |  |  | 12 |
| 16 | Meropidae | 1 | 1 | 1 | 1 |  | 1 | 1 | 2 | 2 | 1 | 1 |  |  | 2 | 2 | 12 |
| 17 | Aegithinidae | 1 | 1 | 1 | 1 |  | 1 | 1 | 1 | 1 | 1 |  |  | 1 | 1 | 1 | 12 |
| 18 | Acrocephalidae | 1 | 1 | 1 | 2 | 1 | 1 |  | 1 | 1 |  |  | 1 | 1 |  |  | 10 |
| 19 | Leiothrichidae | 1 | 1 |  | 1 | 2 | 1 | 1 | 1 |  | 1 |  | 1 |  |  | 3 | 10 |
| 20 | Pellorneidae | 1 | 1 |  | 1 |  | 1 | 1 | 1 |  | 1 | 1 |  | 1 |  | 1 | 10 |
| 21 | Picidae | 2 |  | 2 |  | 1 | 1 | 2 |  | 1 | 1 |  |  |  | 1 | 2 | 9 |
| 22 | Ardeidae | 3 |  | 3 |  | 1 | 1 |  |  |  | 4 | 3 |  |  | 5 | 3 | 8 |
| 23 | Phasianidae |  | 1 |  | 1 | 1 |  | 2 | 1 |  | 1 |  |  | 1 |  | 2 | 8 |
| 24 | Charadriidae | 1 | 1 |  |  | 1 |  |  | 5 |  | 1 |  |  |  | 1 | 1 | 7 |
| 25 | Chloropseidae | 2 |  |  |  |  |  | 1 |  | 1 | 1 | 1 |  | 1 |  | 2 | 7 |
| 26 | Campephagidae | 2 | 1 |  | 1 | 1 |  | 1 |  |  |  | 1 |  |  |  |  | 6 |
| 27 | Pisttacidae | 3 |  | 1 |  | 3 |  | 1 |  |  |  |  |  |  |  | 1 | 5 |
| 28 | Phalacrocoracidae | 1 |  |  |  | 1 | 1 |  |  |  |  | 1 |  |  | 1 |  | 5 |
| 29 | Dicaeidae |  | 1 |  |  |  | 1 |  |  |  |  |  |  | 1 | 1 | 2 | 5 |
| 30 | Rallidae | 1 |  | 1 |  |  |  |  |  |  | 1 |  |  |  | 2 | 1 | 5 |
| 31 | Strigidae | 1 |  | 1 |  |  | 1 |  |  | 1 |  |  |  |  |  |  | 4 |
| 32 | Estrildidae |  |  |  | 1 |  |  | 1 |  |  |  | 1 |  |  |  | 1 | 4 |
| 33 | Artamidae | 1 |  |  |  | 1 |  |  |  |  |  | 1 |  |  |  |  | 3 |
| 34 | Laniidae |  |  |  |  |  | 1 |  |  | 1 |  |  |  |  |  | 1 | 3 |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coracidae | | | 1 | | | | | 1 | | | | | | 1 | | 3 |
| Motacillidae | 1 | | | | | | | 1 | | | | | | 1 | | 3 |
| Scolopacidae | | | | | | | | 1 | | | | | | 1 | | 2 |
| Apodidae | | | | | | 1 | | | | | 1 | | | | | 2 |
| Pittidae | | | | 1 | | | | | 1 | | | | | | | 2 |
| Alaudidae | | | | | | | | 1 | | | | | | 1 | | 2 |
| Bucerotidae | | | | | 1 | | | | | | 1 | | | | | 2 |
| Irenidae | | | | | | | | | 1 | | | | | | | 1 |
| Ciconiidae | | | | | | | | | | | | | | | 1 | 1 |
| Hirundinidae | | | | | | | | 2 | | | | | | | | 1 |
| Trogonidae | | | | | 1 | | | | | | | | | | | 1 |
| Threskiornithidae | | | | | | | | | | | | | | 1 | | 1 |
| Sternidae | | | | | | | | | | | | | | 1 | | 1 |
| Total | 31 | 24 | 20 | 22 | 27 | 27 | 24 | 27 | 24 | 25 | 25 | 14 | 19 | 25 | 29 | |

Legend

1 Cheemeni Kavu
2 Edapara Kavu
3 Edayilekadu
4 Iriveri Kavu
5 Kammadam Kavu
6 Karaka Kavu
7 Kuduvakolangara Kavu
8 Madayi Kavu
9 Mannanpurath Kavu
10 Mapetachery Kavu
11 Poongotu Kavu
12 Bagavathy Kavu
13 Neeliyar Kavu
14 Thazhe Kavu
15 Verikkara Kavu

## 4.5 FEEDING GUILD STRUCTURE OF THE BIRDS OF THE SACRED GROVES OF NORTHERN KERALA

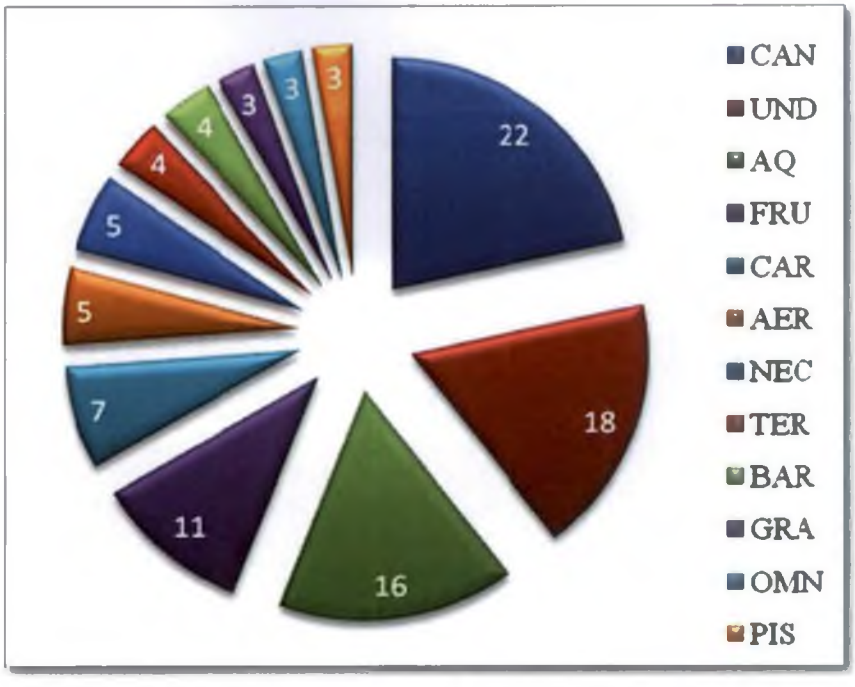
The dominant feeding guilds in the sacred groves of northern Kerala are Canopy Insectivore (CAN) 22 per cent, Understorey Insectivore (UND) 18 per cent, Aquatic (AQ) 16%, Frugivores (FRU) 11%, and Carnivorous (CAR) 7 per cent (Fig. 8).

Number of species in different feeding guild category in the sacred groves of northern Kerala is given in Table 20. Canopy Insectivore and frugivores were more in Cheemeni Kavu, Understorey Insectivore were more in Verikkara Kavu and Aquatic were more in Thazhe Kavu.

### 4.5.1 Diversity profile for feeding guilds in the sacred groves of northern Kerala

Diversity indices were calculated to understand the biodiversity profile of the feeding guilds of the sacred groves (Table 21). Total numbers of feeding guilds identified in the sacred groves of northern Kerala were 12. All the 12 feeding guilds were observed only in five out of the 15 sacred groves *viz.* Cheemeni Kavu, Kammadam Kavu, Mapetachery Kavu, Verikkara Kavu and Thazhe Kavu.

Margalef's richness index showed Kammadam Kavu (1.97) had more number of feeding guilds followed by Neeliyar Kavu (1.85) and Thazhe Kavu (1.81). Shannon index of diversity showed more diversity of feeding guilds in Madayi Kavu (2.01) followed by Mannanpurath Kavu (1.94) and Edayilekadu (1.92). Simpson's index of dominance was more in Thazhe Kavu (0.76) followed by Neeliyar Kavu (0.75) and Kammadam Kavu (0.72). In case of evenness, Iriveri Kavu (0.80) showed more evenness followed by Neeliyar Kavu (0.79) and




Legend:

| | | | | | |
|---|---|---|---|---|---|
| CAN | Canopy insectivore | NEC | Nectarivore-insectivore | CAR | Carnivorous |
| UND | Understorey insectivore | TER | Terrestrial insectivore | AER | Aerial |
| AQ | Aquatic | BAR | Bark surface feeder | OMN | Omnivore |
| FRU | Frugivores | PIS | Piscivores | GRA | Granivorous |

Figure 8. Feeding guild structure of the birds in the sacred groves of northern Kerala

Bagavathy Kavu (0.75). Berger-Parker index of dominance was more in Kammadam Kavu (0.46) followed by Neeliyar Kavu and Thazhe Kavu (0.40).

Table 20. Number of species in different feeding guild categories in the sacred groves of northern Kerala

| Sl. No. | Feeding Guilds | CAN | UND | FRU | OMN | NEC | CAR | PIS | GRA | AQ | AER | BAR | TER |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cheemeni Kavu | 16 | 8 | 9 | 3 | 2 | 3 | 2 | 2 | 6 | 1 | 2 | 1 |
| 2 | Edapara Kavu | 9 | 8 | 6 | 2 | 4 | 4 | 1 | 1 | 1 | 0 | 0 | 0 |
| 3 | Edayilekadu | 9 | 3 | 3 | 2 | 2 | 4 | 1 | 0 | 4 | 2 | 2 | 0 |
| 4 | Iriveri Kavu | 11 | 9 | 5 | 2 | 3 | 4 | 0 | 2 | 0 | 0 | 0 | 0 |
| 5 | Kammadam Kavu | 15 | 7 | 7 | 2 | 3 | 2 | 1 | 1 | 3 | 1 | 1 | 1 |
| 6 | Karaka Kavu | 10 | 8 | 5 | 2 | 4 | 4 | 2 | 1 | 3 | 1 | 1 | 0 |
| 7 | Kuduvakolangara Kavu | 11 | 8 | 6 | 3 | 3 | 0 | 1 | 2 | 0 | 0 | 2 | 1 |
| 8 | Madayi Kavu | 11 | 9 | 7 | 3 | 3 | 2 | 1 | 2 | 6 | 4 | 0 | 2 |
| 9 | Mannanpurath Kavu | 11 | 7 | 4 | 2 | 3 | 4 | 1 | 1 | 0 | 1 | 1 | 0 |
| 10 | Mapetachery Kavu | 10 | 7 | 5 | 3 | 4 | 4 | 2 | 2 | 6 | 1 | 1 | 1 |
| 11 | Poongotu Kavu | 10 | 7 | 4 | 3 | 1 | 3 | 1 | 1 | 4 | 2 | 0 | 0 |
| 12 | Bagavathy Kavu | 6 | 5 | 3 | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| 13 | Neeliyar Kavu | 9 | 7 | 7 | 3 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 14 | Thazhe Kavu | 4 | 5 | 3 | 3 | 4 | 3 | 2 | 1 | 12 | 3 | 1 | 2 |
| 15 | Verikkara Kavu | 9 | 11 | 7 | 3 | 6 | 4 | 1 | 3 | 6 | 1 | 2 | 1 |
| | **Count** | **15** | **15** | **15** | **15** | **15** | **14** | **13** | **13** | **10** | **10** | **9** | **7** |

Table 21. Diversity profile for feeding guilds in the sacred groves of northern Kerala

| Sacred Grove | Number of Feeding guilds | Individuals (N) | Margalef (R) | Simpson (1-D) | Shannon (H) | Evenness (E) | Berger-Parker (BP) |
|---|---|---|---|---|---|---|---|
| Cheemeni Kavu | 12 | 472 | 1.79 | 0.77 | 1.78 | 0.49 | 0.34 |
| Edapara Kavu | 9 | 439 | 1.32 | 0.82 | 1.84 | 0.70 | 0.28 |
| Edayilekadu | 10 | 369 | 1.52 | 0.82 | 1.92 | 0.68 | 0.33 |
| Iriveri Kavu | 7 | 339 | 1.03 | 0.80 | 1.72 | 0.80 | 0.27 |
| Kammadam Kavu | 12 | 265 | 1.97 | 0.72 | 1.65 | 0.43 | 0.46 |
| Karaka Kavu | 11 | 539 | 1.59 | 0.81 | 1.87 | 0.59 | 0.32 |
| Kuduvakolangara Kavu | 9 | 306 | 1.40 | 0.80 | 1.77 | 0.66 | 0.28 |
| Madayi Kavu | 11 | 539 | 1.59 | 0.84 | 2.01 | 0.68 | 0.28 |
| Mannanpurath Kavu | 10 | 344 | 1.54 | 0.84 | 1.94 | 0.70 | 0.24 |
| Mapetachery Kavu | 12 | 473 | 1.79 | 0.77 | 1.78 | 0.49 | 0.34 |
| Poongotu Kavu | 10 | 203 | 1.69 | 0.81 | 1.88 | 0.65 | 0.32 |
| Bagavathy Kavu | 8 | 248 | 1.27 | 0.81 | 1.79 | 0.75 | 0.30 |
| Neeliyar Kavu | 6 | 365 | 1.85 | 0.75 | 1.56 | 0.79 | 0.40 |
| Thazhe Kavu | 12 | 434 | 1.81 | 0.76 | 1.76 | 0.48 | 0.40 |
| Verikkara Kavu | 12 | 576 | 1.73 | 0.78 | 1.74 | 0.47 | 0.33 |

### 4.5.2 Correspondence analysis for feeding guilds in sacred groves of northern Kerala

The correspondence analysis was carried out extracting two axes axis 1 gave 19.84 per cent of variation and axis 2 gave 15.70 per cent variation (Fig. 9). It is evident that all the Sacred groves of northern Kerala had a similar feeding guild structure, except Edayilekadu and Thazhe Kavu ($\chi 2$= 2924.7, df =154 and P < 0.0001).

### 4.5.3 Principal component analysis for feeding guilds and sacred groves

Principal component analysis based on all diversity indices was worked out for the feeding guilds. Two axes were extracted in Principal component analysis, axis 1 gave 50.53 per cent of variation and axis 2 gave 34.42 per cent variation. This accounts for total variation of 84.97 per cent. Scree plot in the inset of the graph also shows that variation decreased faster after two axes (Fig. 10).

Berger-Parker index of dominance was more in Kammadam Kavu, Thazhe Kavu which depict that these sacred groves had one species dominant over others. Verikkara Kavu, Cheemeni Kavu, Madayi Kavu, Mapetachery Kavu and Karaka Kavu had more diverse feeding guilds.

### 4.5.4 Similarity analysis for different feeding guilds in sacred groves.

Further Bray-Curtis similarity matrix with 1000 bootstrap was worked out to know similarity between feeding guilds in the selected sacred groves of northern Kerala (Table 22 and Fig. 11). Three groups could be identified having significant similarity Edapara Kavu and Iriveri Kavu, Mannanpurath and Bagavathy and Karaka and Mapetachery. Thazhe Kavu and Poongotu Kavu stand very distinct from all other sacred groves for feeding guilds.

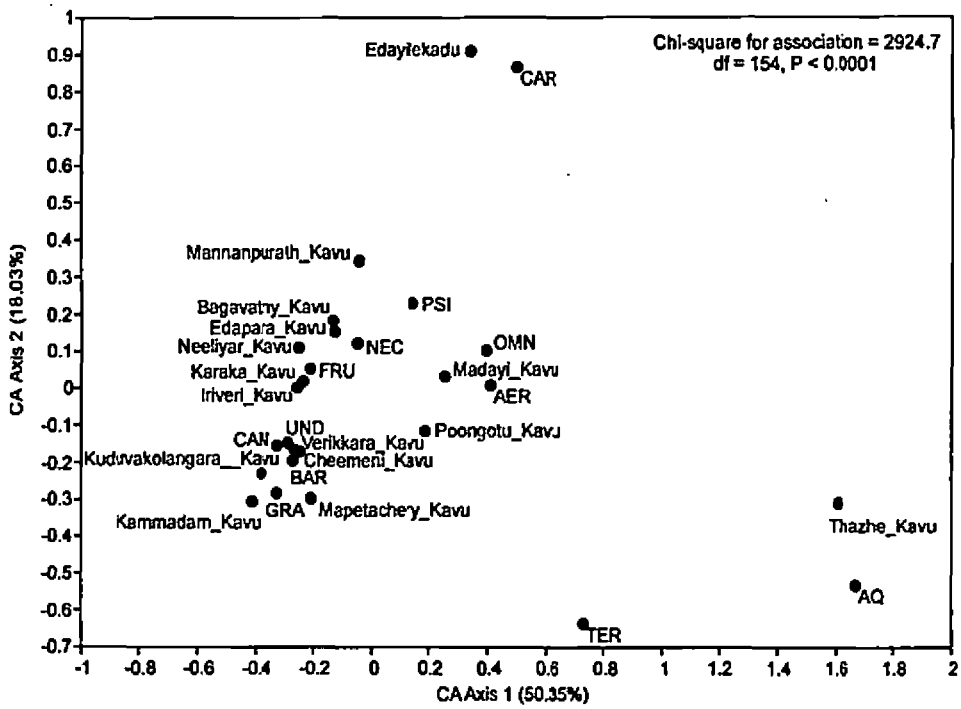



Figure 9. Correspondence analysis for feeding guilds in sacred groves of northern Kerala

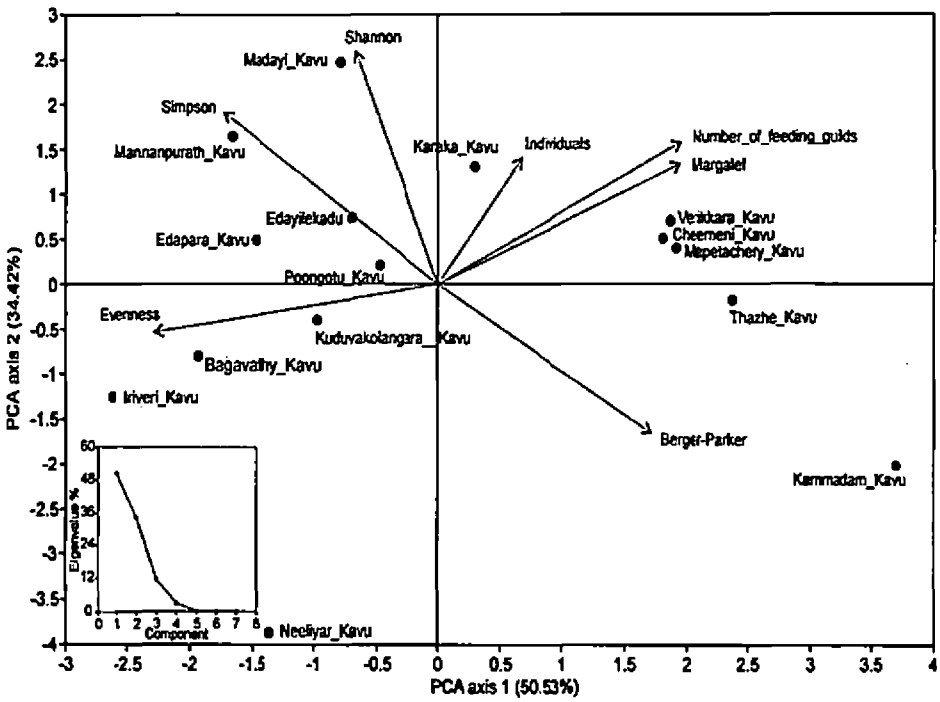



Figure 10. Principal component analysis for feeding guilds and sacred groves

Table 22. Beta diversity in the Feeding guilds of different sacred groves

| | Sacred groves | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Cheemeni Kavu | 0.00 | | | | | | | | | | | | | | |
| 2 | Edapara Kavu | 0.14 | 0.00 | | | | | | | | | | | | | |
| 3 | Edayilekadu | 0.09 | 0.16 | 0.00 | | | | | | | | | | | | |
| 4 | Iriveri Kavu | 0.26 | 0.13 | 0.29 | 0.00 | | | | | | | | | | | |
| 5 | Kammadam Kavu | 0.00 | 0.14 | 0.09 | 0.26 | 0.00 | | | | | | | | | | |
| 6 | Karaka Kavu | 0.04 | 0.10 | 0.05 | 0.22 | 0.04 | 0.00 | | | | | | | | | |
| 7 | Kuduvakolangara Kavu | 0.14 | 0.22 | 0.26 | 0.25 | 0.14 | 0.20 | 0.00 | | | | | | | | |
| 8 | Madayi Kavu | 0.04 | 0.10 | 0.14 | 0.22 | 0.04 | 0.09 | 0.20 | 0.00 | | | | | | | |
| 9 | Mannanpurath Kavu | 0.09 | 0.16 | 0.10 | 0.18 | 0.09 | 0.05 | 0.16 | 0.14 | 0.00 | | | | | | |
| 10 | Mapetachery Kavu | 0.00 | 0.14 | 0.09 | 0.26 | 0.00 | 0.04 | 0.14 | 0.04 | 0.09 | 0.00 | | | | | |
| 11 | Poongotu Kavu | 0.09 | 0.05 | 0.10 | 0.18 | 0.09 | 0.05 | 0.26 | 0.05 | 0.10 | 0.09 | 0.00 | | | | |
| 12 | Bagavathy Kavu | 0.20 | 0.06 | 0.22 | 0.07 | 0.20 | 0.16 | 0.18 | 0.16 | 0.11 | 0.20 | 0.11 | 0.00 | | | |
| 13 | Neeliyar Kavu | 0.33 | 0.20 | 0.25 | 0.08 | 0.33 | 0.29 | 0.33 | 0.29 | 0.25 | 0.33 | 0.25 | 0.14 | 0.00 | | |
| 14 | Thazhe Kavu | 0.00 | 0.14 | 0.09 | 0.26 | 0.00 | 0.04 | 0.14 | 0.04 | 0.09 | 0.00 | 0.09 | 0.20 | 0.33 | 0.00 | |
| 15 | Verikkara Kavu | 0.00 | 0.14 | 0.09 | 0.26 | 0.00 | 0.04 | 0.14 | 0.04 | 0.09 | 0.00 | 0.09 | 0.20 | 0.33 | 0.00 | 0.00 |

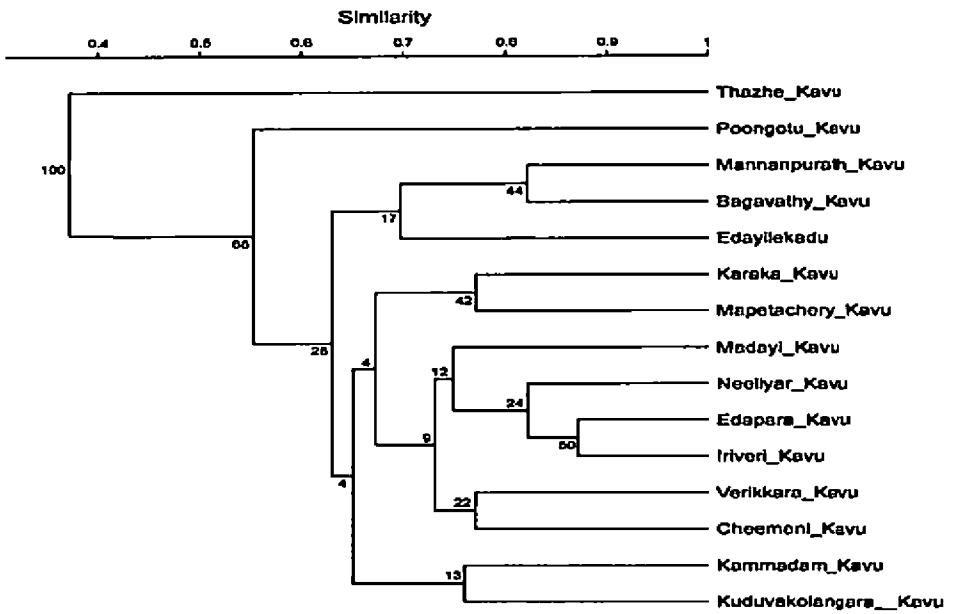



Figure 11. Dendrogram of the relation between feeding guilds and sacred groves, based on Bray-Curtis similarity index

## 4.6 VEGETATION IN THE SACRED GROVE OF NORTHERN KERALA

A total of 130 species were recorded from sacred groves of northern Kerala. Out of which 14 species were found to be endemic to Western Ghats (Table 23) and seven were threatened (IUCN, 2014) (Table 24). *Holigarna arnottiana* was found to be dominant species recorded from 12 sacred groves and having 6.22 IVI. Tree species found in five and more than five sacred groves is given in Table 25.

Verikkara Kavu (34) had highest number of tree diversity followed by Cheemeni Kavu (23). Tree abundance was highest in Karaka Kavu (165) followed by Cheemeni Kavu (139). Total number of trees and total number of individuals found in the sacred grove of northern Kerala is given in Table 26.

Relative density, relative frequency, relative basal area and Important Value Index (IVI) of all the sacred grove is given in Appendix IV.

Table 23. Trees found endemic to Western Ghats in the sacred grove of northern Kerala

| Sl. No. | Endemic to western Ghats |
|---|---|
| 1 | *Artocarpus hirsutus* |
| 2 | *Chionanthus mala-elengi* |
| 3 | *Cinnamomum malabatrum* |
| 4 | *Cinnamomum perrottetii* |
| 5 | *Holigarna arnottiana* |
| 6 | *Hopea parviflora* |
| 7 | *Hopea ponga* |
| 8 | *Hydnocarpus pentandra* |
| 9 | *Ixora brachiata* |
| 10 | *Myristica malabarica* |
| 11 | *Syzygium caryophyllatum* |
| 12 | *Syzygium zeylanicum* |
| 13 | *Tabernaemontana hyneana* |
| 14 | *Vateria indica* |

Table 24. Threatened trees found in the sacred grove of northern Kerala

| Sl. No | Threatened trees | Status |
|---|---|---|
| 1 | *Vateria indica* | Critically Endangered |
| 2 | *Chionanthus mala-elengi* | Endangered |
| 3 | *Hopea parviflora* | Endangered |
| 4 | *Hopea ponga* | Endangered |
| 5 | *Evodia lunu-ankenda* | Endangered |
| 6 | *Santalum album* | Vulnerable |
| 7 | *Cinnamomum perrottetii* | Vulnerable |

Table 25. IVI of dominant tree species found in the sacred grove of northern Kerala

| Sl. No. | Tree species | IVI |
|---|---|---|
| 1 | *Holigarna arnottiana* (12) | 6.22 |
| 2 | *Hopea ponga* (7) | 5.3 |
| 3 | *Vitex altissima* (7) | 2.31 |
| 4 | *Caryota urens* (9) | 2.19 |
| 5 | *Carallia brachiata* (6) | 2.00 |
| 6 | *Hydnocarpus pentandra* (5) | 1.90 |
| 7 | *Anacardium occidentale* (7) | 1.89 |
| 8 | *Mimusops elengi* (7) | 1.84 |
| 9 | *Olea dioica* (8) | 1.73 |
| 10 | *Adenanthera pavonina* (6) | 1.52 |
| 11 | *Strychnos nux-vomica* (7) | 1.10 |
| 12 | *Mangifera indica* (6) | 1.07 |
| 13 | *Alstonia scholaris* (5) | 0.89 |

Table 26. Tree diversity and abundance in the sacred groves of northern Kerala

| Sl. No | Sacred groves | Tree diversity | Tree abundance |
|---|---|---|---|
| 1 | Cheemeni Kavu | 23 | 139 |
| 2 | Edapara Kavu | 19 | 125 |
| 3 | Edayilekadu | 19 | 87 |
| 4 | Iriveri Kavu | 20 | 96 |
| 5 | Kammadam Kavu | 19 | 96 |
| 6 | Karaka Kavu | 8 | 165 |
| 7 | Kuduvakolangara Kavu | 19 | 45 |
| 8 | Madayi Kavu | 19 | 70 |
| 9 | Mannanpurath Kavu | 18 | 72 |
| 10 | Mapetachery Kavu | 6 | 82 |
| 11 | Neeliyar Kavu | 17 | 99 |
| 12 | Poongotu Kavu | 20 | 108 |
| 13 | Bagavathy Kavu | 5 | 121 |
| 14 | Thazhe Kavu | 15 | 119 |
| 15 | Verikkara Kavu | 34 | 106 |

## 4.6 RELATIONSHIP BETWEEN DIFFERENT PARAMETERS OF THE SACRED GROVE AND BIRD DIVERSITY PROFILES

Sacred grove parameters like area of the sacred groves, distance of sacred grove from its nearest forest, altitude, tree diversity and tree abundance was correlated with forest birds and endemic bird. The number of forest bird was positively correlated with altitude and tree density in the sacred groves. As the altitude and tree density increases number of forest bird's increased but Endemic bird was not significantly correlated with altitude and tree density. In case of size of the Sacred groves, a positively correlation was found with number of endemic birds; however, the size did not have any significant relation with number of forest bird's presence in a sacred grove (Table 27).

Table 27. Relation between parameters of sacred grove with forest and endemic bird of Western Ghat

| Parameters | | Forest Birds | Endemic Birds |
|---|---|---|---|
| Distance to nearest forest (Aerial distance in km) | r | -0.500 | -0.485 |
| | p | 0.058 | 0.067 |
| Area (ha) | r | 0.361 | 0.517* |
| | p | 0.186 | 0.048 |
| Altitude | r | 0.724** | 0.434 |
| | p | 0.002 | 0.106 |
| Tree diversity | r | 0.637* | 0.454 |
| | p | 0.011 | 0.090 |
| Tree Abundance | r | -0.220 | -0.192 |
| | p | 0.431 | 0.494 |

* Correlation is significant at the 0.05 level.
** Correlation is significant at the 0.01 level.
r is correlation co-efficient, p is significance

## 4.7 AWARENESS ABOUT BIRDS AND PERCEPTION ABOUT SIGNIFICANCE OF SACRED GROVE AMONG RESPONDENTS

### 4.7.1 **Profile of sample studied**

#### 4.7.1.1 ***Profile of independent variables used for study***

Out of 150 respondents studied 78 (52%) were male and 72 (48%) were female. The age group of the respondents ranged from 21-30 to >90 (Table 28). Number of respondents in age-group of 41-50 was maximum with 29.33 per cent. In case of community 82 (54.66%) respondents were from '*thiyya*' community and five (3.33%) from '*maniyani*' community and from 'yadavar' community (Table 29). Educational qualification of maximum respondents surveyed was upto secondary school (54.66%) (Table 30) and maximum respondents of 70 per cent were semi skilled labours (Table 31).

Associations of respondents with sacred grove were given cumulative scale and frequency of association of respondents is given in Table 32. Maximum association of respondents with the sacred grove was for festival (53.33%) alone followed by festival and prayer (36.66%) and less than one per cent of the respondents are associated with sacred grove for regular prayer, festival and fuel wood collection together.

In case of the frequency of observing birds by the respondents in the sacred grove, 28 per cent of respondents observe birds very rarely and nearly seven per cent of the respondents have never watched the birds in sacred grove (Table 33).

Knowledge about beneficial effect brought by birds among respondents were given is given in Table 34. It was interesting to note that 74 per cent of respondents felt bird brings aesthetic pleasure alone. Birds in the sacred grove were not inconvenience to any of the 150 respondents surveyed from the sacred groves of northern Kerala.

Table 28. Frequency table for age-group of the respondents in the sacred groves of northern Kerala

| Sl. No | Category of response | Frequency of respondents (n=150) | |
|---|---|---|---|
| | | Number | Percentage |
| a. | 21-30 | 14 | 9.33 |
| b. | 31-40 | 30 | 20.00 |
| c. | 41-50 | 44 | 29.33 |
| d. | 51-60 | 27 | 18.00 |
| e. | 61-70 | 22 | 14.67 |
| f. | 71-80 | 8 | 5.33 |
| g. | 81-90 | 4 | 2.67 |
| h. | >90 | 1 | 0.67 |

Table 29. Frequency table for caste of the respondents in the sacred groves of northern Kerala

| Sl. No | Category of response | Frequency of respondents (n=150) | |
|---|---|---|---|
| | | Number | Percentage |
| a. | Thiyya | 82 | 54.66 |
| b. | Pitaram | 18 | 12 |
| c. | Maniyani | 5 | 3.33 |
| d. | Nair | 18 | 12 |
| e. | Nambiyar | 22 | 14.66 |
| f. | Yadavar | 5 | 33.33 |

Table 30. Frequency table for education of the respondents in the sacred groves of northern Kerala

| Sl. No | Category of response | Frequency of respondents (n=150) | |
|---|---|---|---|
| | | Number | Percentage |
| a. | Illiterate | 1 | 0.67 |
| b. | Primary School Level | 44 | 29.33 |
| c. | Secondary School Level | 76 | 50.67 |
| d. | College | 28 | 18.67 |
| e. | Professional College | 1 | 0.67 |

Table 31. Frequency table for occupation of the respondents in the sacred groves of northern Kerala

| Sl. No | Category of response | Frequency of respondents (n=150) | |
|---|---|---|---|
| | | Number | Percentage |
| a. | Daily wages | 20 | 13.33 |
| b. | Agriculture | 17 | 11.33 |
| c. | Semi skilled | 105 | 70.00 |
| d. | Professional | 7 | 4.67 |

Table 32. Frequency table for association of respondents with the sacred grove

| Sl. No | Category of response | Frequency of respondents (n=150) | |
|---|---|---|---|
| | | Number | Percentage |
| a. | Festival | 80 | 53.33 |
| b. | Regular prayer and festival | 55 | 36.67 |
| c. | Festival and children play area | 4 | 2.67 |
| d. | Regular prayers, festivals and children play area | 3 | 2.00 |
| e. | Regular prayers, festivals and marriages | 7 | 4.67 |
| f. | Regular prayer, festival and fuel wood collection | 1 | 0.67 |

Table 33. Frequency of bird observation by respondents in sacred grove

| Sl. No | Category of response | Frequency of respondents (n=150) | |
|---|---|---|---|
| | | Number | Percentage |
| a. | Always when i am there | 14 | 9.33 |
| b. | frequently | 13 | 8.67 |
| c. | Sometimes | 70 | 46.67 |
| d. | Rarely | 42 | 28.00 |
| e. | Never | 11 | 7.33 |

Table 34. Frequency table for beneficial effects brought by birds

| Sl. No | Beneficial effects brought by birds | Frequency of respondents (n=150) | |
|---|---|---|---|
| | | Number | Percentage |
| a. | Aesthetic pleasure | 111 | 74 |
| b. | Control harmful insects | 8 | 5.33 |
| c. | Helpful Pollination | 1 | 0.67 |
| d. | Aesthetic pleasure and Control harmful insects | 2 | 1.33 |
| e. | Aesthetic pleasure and ecosystem benefits | 9 | 6.00 |
| f. | Aesthetic pleasure and pollination | 4 | 2.67 |
| g. | Aesthetic pleasure, control insect pests and help in pollination | 5 | 3.33 |
| h. | Control insect pests and provide ecosystem services | 1 | 0.67 |
| i. | Help in pollination and provide ecosystem services | 1 | 0.67 |
| j. | Aesthetic pleasure, control insect pests and help in pollination, provide ecosystem services | 2 | 1.33 |

4.7.2 ***Profile of dependent variables used for study***

a) Awareness about birds among the respondents

In the present study the awareness about birds among the respondents scored from highest eight to lowest one.

b) Perception about significance of sacred grove among the respondents

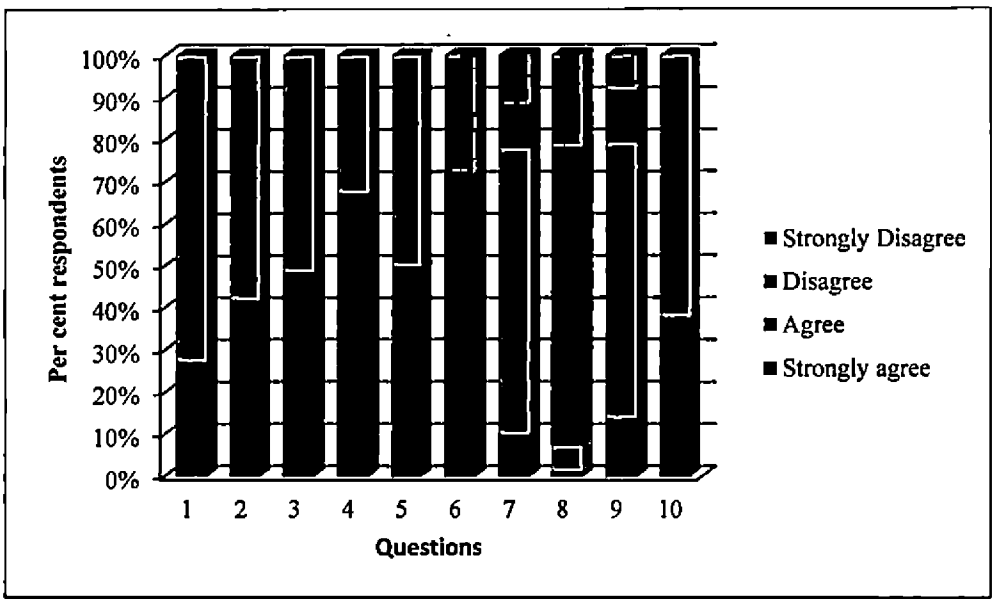
The number and percentage of respondents for the perception about significance of sacred grove is given in Table 35 and Figure 12 respectively.

Out of 150 respondents 109 (27%) of respondents strongly agreed that sacred grove provides shelter to threatened plants and birds. 63 (42%) respondents strongly agreed that sacred grove help in conservation of biodiversity. Role of sacred grove in protecting medicinal plants was strongly agreed by 73 (49%) respondents. 101 (67%) respondents strongly agreed that sacred grove help in temperature regulation and role of sacred grove in water conservation was strongly agreed by 75 (50%) of respondents.

For the question 'sacred grove are wastage of space for owner'. 4 (3%) of the respondents strongly agreed, 105 (70%) disagreed and 41(27%) strongly disagreed. For the question 'Whether they maintain sacred grove just because that is the custom of our family' 15 (10%) respondents strongly agreed and 102 (68%) agree, 16 (11%) disagreed, 17 (11%) strongly disagreed. For the next question 'It is no more economical to maintain sacred groves' 2 (1%) respondents strongly agreed and 9 (6%) agree, 107 (71%) disagreed, 32 (21%) strongly disagreed. For the question 'It is doubtful whether next generation will maintain sacred groves' 21 (14%) respondents strongly agreed and 98 (65%) agree, 19 (13%) disagreed, 12 (8%) strongly disagreed. 57 (38%) of respondents strongly agree that modernization is major threat to sacred grove.

Table 35. Frequency of respondents for perception about significance of sacred grove

| **Perception about significance of sacred grove** | **Strongly agree** | **Agree** | **Disagree** | **Strongly Disagree** |
|---|---|---|---|---|
| Provides shelter to plants and birds | 41 | 109 | 0 | 0 |
| Conserve biodiversity | 63 | 87 | 0 | 0 |
| Protect medicinal plant | 73 | 77 | 0 | 0 |
| Regulate temperature | 101 | 49 | 0 | 0 |
| Conserve water | 75 | 75 | 0 | 0 |
| Wastage of space | 4 | 0 | 105 | 41 |
| Custom of family | 15 | 102 | 16 | 17 |
| Not ecomonical to maintain | 2 | 9 | 107 | 32 |
| Doubtful to maintain by next generation | 21 | 98 | 19 | 12 |
| Modernization a treat | 57 | 93 | 0 | 0 |




Legend:

| | | | |
|---|---|---|---|
| 1 | Sacred groves provide shelter to threatened plants and birds | 6 | They are wastage of space for the owner |
| 2 | They help in conservation of biodiversity | 7 | We maintain them just because that is the custom of our family |
| 3 | They help to protect medicinal plants | 8 | It is no more economical to maintain sacred grove |
| 4 | They help in temperature regulation | 9 | It is doubtful whether next generation will maintain sacred grove |
| 5 | They help in water conservation | 10 | Modernization is major threat to sacred grove |

Figure 12. Per cent perception about significance of scared grove among respondents in the sacred groves of northern Kerala

### 4.7.3 Distribution of respondents based on their awareness about birds and perception about significance of sacred grove among the respondents

Overall, the awareness about birds and perception about significance of sacred grove among the respondents was categorized into high, medium and low. The respondents of northern Kerala had medium awareness about birds and perception about significance of sacred grove (Table 36).

Table 36. Frequency of awareness and perception among the respondents in the sacred groves of northern Kerala

| | Awareness | | Perception | |
|---|---|---|---|---|
| Range | Frequency | Percentage | Frequency | Percentage |
| High | 37 | 24.67 | 23 | 15.33 |
| Medium | 76 | 50.67 | 123 | 82.00 |
| Low | 37 | 24.67 | 4 | 2.67 |

### 4.7.4 Relation between socio-economic variables and awareness about birds and perception about significance of sacred grove among the respondents

Spearman's rank correlation was worked out to know extent of relationship between socio-economic variables with awareness about bird community and perception about significance of sacred grove among respondents (Table 37).

#### 4.7.4.1 *Relation between socio-economic variables and awareness about bird community among respondents.*

Awareness about bird community in the sacred groves among the respondents was significantly correlated with gender, caste, education, occupation, frequency of observing birds by the respondents in the sacred groves,

knowledge about number of birds visiting the sacred grove, understanding about beneficial role played by birds (Table 38).

**4.7.4.2** ***Socio-economic variables and perception about significance of sacred grove among the respondents.***

Spearman's rank correlation was also worked out to know extent of relationship of the parameters with perception about the significance of the sacred grove (Table 39).

Perception about significance of sacred groves among respondents was significantly correlated with occupation, frequency of observing birds by the respondents in the sacred groves, knowledge about number of birds visiting the sacred grove, understanding about beneficial role played by birds

Table 37. Inter-correlation matrix of socio-economic study (n=150)

| | Variables | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Age | 1.000 | 0.097 | 0.069 | -0.613** | -0.015 | 0.046 | 0.092 | 0.003 | 0.063 | 0.008 | 0.096 | -0.073 | 0.047 |
| 2 | Caste | | 1.000 | 0.160* | 0.066 | -0.019 | 0.018 | 0.019 | 0.171* | 0.067 | 0.137 | -0.031 | 0.197* | -0.051 |
| 3 | Gender | | | 1.000 | 0.172* | -0.086 | -0.181* | 0.017 | 0.052 | 0.112 | 0.072 | 0.111 | 0.197* | 0.133 |
| 4 | Education | | | | 1.000 | 0.063 | 0.185* | -0.055 | 0.076 | 0.155 | 0.155 | 0.231** | 0.234** | 0.123 |
| 5 | Family Member | | | | | 1.000 | 0.017 | 0.287** | 0.073 | 0.046 | 0.016 | 0.004 | -0.023 | -0.077 |
| 6 | Occupation | | | | | | 1.000 | -0.099 | 0.002 | -0.081 | 0.015 | 0.068 | -0.167* | 0.188* |
| 7 | No of members Employed in family | | | | | | | 1.000 | 0.097 | -0.162* | -0.026 | -0.018 | -0.117 | -0.096 |
| 8 | Association with sacred grove | | | | | | | | 1.000 | -0.019 | -0.053 | -0.133 | -0.053 | -0.063 |
| 9 | Frequency of observing birds in sacred grove | | | | | | | | | 1.000 | 0.588** | 0.395** | 0.564** | 0.241** |
| 10 | Diversity of birds in sacred grove | | | | | | | | | | 1.000 | 0.322** | 0.415** | 0.215** |
| 11 | Benificial role played by birds | | | | | | | | | | | 1.000 | 0.264** | 0.270** |
| 12 | Awareness | | | | | | | | | | | | 1.000 | 0.072 |
| 13 | Perception | | | | | | | | | | | | | 1.000 |

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Table 38. Correlation between socio-economic variables and awareness about birds among respondents in the sacred groves of northern Kerala

| Sl. No | Variables | Correlation Coefficient |
|---|---|---|
| 1. | Age | -0.073 |
| 2. | Caste | 0.197* |
| 3. | Gender | 0.197* |
| 4. | Education | 0.234** |
| 5. | Family Size | -0.023 |
| 6. | Occupation | -0.167* |
| 7. | No. of members employed in family | -0.117 |
| 8. | Association with Sacred grove | -0.053 |
| 9. | Frequency of observing birds in Sacred grove | 0.564** |
| 10. | Knowledge about diversity of birds in Sacred grove | 0.415** |
| 11. | Understanding of beneficial role played by birds | 0.264** |

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

Table 39. Correlation between socio-economic variables and perception about significance of sacred grove among respondents in the sacred groves of northern Kerala

| Sl. No | Variables | Correlation Coefficient |
|---|---|---|
| 1. | Age | 0.047 |
| 2. | Caste | -0.051 |
| 3. | Gender | 0.133 |
| 4. | Education | 0.123 |
| 5. | Size of family | -0.077 |
| 6. | Occupation | 0.188* |
| 7. | No of members employed in family | -0.096 |
| 8. | Association with Sacred grove | -0.063 |
| 9. | Frequency of observing birds in Sacred grove | 0.241** |
| 10. | Diversity of birds in Sacred grove | 0.215** |
| 11. | Understanding of beneficial role played by birds | 0.270** |

** Correlation is significant at the 0.01 level

* Correlation is significant at the 0.05 level

### 4.7.5 **Non-parametric regression for socio-economic study**

The independent socio-economic variables of respondents that correlated significantly with awareness about birds and perception about significance of sacred grove was further used for non-parametric regression to know the variability of significance between the said variables. Root mean square for both awareness about birds and perception about significance of sacred grove was less which means that fit is good (Table 40). Regression equation fitted for Awareness and Perception is as following:

(1) $y_1 = \alpha + x_1 + x_2 + x_3 + x_4 + x_5 + x_6 - x_7$

(2) $y_2 = \alpha + x_7 + x_4 + x_5 + x_6$

Table 40. Output from Nonparametric regression

| Sl. No | Variables | Values |
|---|---|---|
| 1. | Root mean square (Awareness) | 0.24 |
| 2. | Root mean square (Perception) | 0.25 |
| 3. | α (Awareness) | -6.620 |
| 4. | α (Perception) | 20.887 |

Where

$y_1$= Awareness
$y_2$= Perception
$x_1$= Caste of respondent
$x_2$ = Gender of respondent
$x_3$ = Education of respondent
$x_4$ = Frequency of bird observation
$x_5$ = Size of bird population
$x_6$ = Beneficial effect of birds
$x_7$ = Occupation of respondent

## 4.8 HISTORY RELATED TO THE ORIGIN OF SACRED GROVE, RITUALS, FESTIVALS AND BELIEFS.

Every Sacred grove has their distinct rituals, festivals and beliefs. Especially in northern Kerala the tradition and festival of 'Theyyam' is unique. In most of the sacred groves deity worshiped are *Bagavathy, Chamundi, Kaali, Nagam*, or *Ayyappan*. Sacred grove may have single deity or number of deities. The symbol of deity worshiped varies from stone to idol. Also the place of deity is worshiped vary from open shelter to well developed shrine in some of the sacred grove (Plate 3).

Entering in the noon is restricted in every sacred grove and if the deity worshiped is d*evi*, on Tuesday and Friday entrance is avoided as it is belived that deity appears ferocious, with all powers.

The deity worshiped, rituals, myths and important festivals celebrated in the sacred groves are as following:

1 Cheemeni Kavu:

Cheemeni Kavu is looked after by *Maniyani* community. Committee of 12 members is formed for a period of three years. Deity worshiped in this sacred grove is *Ayappan, Bagavathy* and *Ganapathy*. Puja is done in the morning and evening every day by priest. Important festival is *Pratishta dinam* on January 22$^{nd}$ and 23$^{rd}$ every year.

2 Edapara Kavu:

Edapara Kavu is looked after by four families *Valiyavedu, Vadakevedu, Pathaipara* and *Kartil*. Alternately deepam is lit by four families for one year. Deities worshipped in this sacred grove are *Thazhe paradevatha, Chamundeshwari Kutishasthappan, Bhairavan, Karival bhagavathi* and *Echitta*. Important festival performed in the sacred grove is Theyyam in the month of March every year. Daily deepam is lit in

evening at *banarapura* and the temple is opened only on every *sankramam*, puja is done by priest. Hen is sacrificed on Friday as offerings. *Tulabharam* is also offered, Women's are allowed to see *Elankol theyyam* in this sacred grove. Loud speaker and photography is prohibited inside the temple. No idea about the origin of the sacred grove. There is strong belief within the people that deity fulfills their wants.

3 Edayilekadu:

Edayilekadu is looked after by a committee selected by villagers. Deity worshiped is *Nagam* (Serpent). Deepam is lit by priest on A*yilyam* in the month of *kumbham* and *dhanu* and also on the day of *Prathistha*. Monkeys are protected in this sacred grove, it is belived that harming monkeys leads to wrath of deity to village. It was seemed that the number of monkeys started decreasing due to scarcity of food so the villagers started feeding them. One has to go barefoot inside the grove. No idea about the origin of the sacred grove.

4 Iriveri Kavu :

Iriveri Kavu is looked after by four families *Kezakevalapil, Mannembeth, Umbrandi* and *Kunumel*. The rituals and festivals are looked after by these families. Deities worshipped in this sacred grove are *Ganapathy, Kalaporiyan, Puli kanan, Kollurkanan, Pulikarinkali, Pulitheyyam, Kalangil Pukuluvan, Puli muttapan, Puli Muttachi, Appakallam* and *Charakan (Guligan).* Important festival followed are Theyyam *during* 28th-31st and *Putheri* in the month of *magaram* (Jan-Feb), *Sankramam* (last day of each Malayalam month) and *Tulam* (Oct-Nov). Offerings to the deities are made on every Friday and Tuesday, except in the month of *Karkadagam* (July-Aug). Important Offerings are *Vellapam* and Banana. *Guligan* is offered with hen. Loud speaker is not allowed in premises of sacred grove.

5 Kammadam Kavu:

Kammadam Kavu is looked after by families *Mannathika vedu* and *Kottara taravadu*. Dieties worshipped are *Anthiyadangan pootham, Cheriye Bagavathy, Kuttichathan, Bhairavan, Vishnu moorthy, Chamundi, Kammadath Bagavathy* and *Koodeyullor*. Important festival is Theyyam in the month of December every year. Shrine of the deity is 1.5 km away from the sacred forest. The symbol of worship in the sacred forest is stone and *Tara* (place constructed by stone). On the previous day of festival, the priest goes to the sacred forest and offers a coconut to *Bhagavahty* placed under a tree so as to bring the goddess to the temple and perform the *pujas*. *Vishnumoorti* is the important Theyyam of the sacred forest, in the early dawn of the festival day the *Theyyam Vishnumoorthi* goes alone to the forest and brings the coconut offered to the goddess and hands over it to the priest to perform rituals. Rituals and *Theyams* go on for a week. Offering are made up of rice and vegetables.

6 Karaka Kavu:

Karaka Kavu is looked after by two families *Puthiye valapukaru and Valeye vedu*. Deities worshiped are *Karakeyil bhagavathy, Vishnumurthi, Raktha Chamundi* and *Angakolangara Bhagavathy*. Important festival is *Pura maholsavam* in the month of *Kumbham* and *Meenam*. Daily deepam is lit in evening, Hen is sacrificed during *Theyyam*.

The origin of sacred grove goes as; Madayi Kavu devi sent a person *pisharadi* to Mannanpurath village in search of toddy. On the way back to madayi it was evening, he wanted to lit lamp and pray as he would not be able to reach madayi before evening, he asked one man for place to lit lamp. Man allowed him to lit the lamp in his cattle shed, after replacing his cow from there. *Pisharadi* prayed and went away. That night cows

disappeared. The cows were caught by Leopard. Later villagers came to know presence of Devi in that place and constructed temple.

7 Kuduvakolangara Kavu:

Kuduvakolangara Kavu is looked after by *Adiyodi* family. The inheritors who look after the Kavu are *Padineta, Kendura, Madatelivedu.* Deities worshiped in this sacred grove are *Kudakolangara bhagavathy, Narambil bhagavathy, Vishnumurthi, Torakan, Guligan, Kshetrapalan, Chamundi, Pulikandan, Manikandan* and *Tera.* Important festival performed is *Theyyam* in the month of *medham* (April-May). Priest lit deepam on every *sankramam* at temple. There is a separate place for *Guligan* and deepam is lit there on every Tuesday and Friday evening.

8 Madayi Kavu :

Madayi Kavu is looked after by four families *Thalathilellam, Naduveleillam, Aayiramvalli illam* and *Ethemel illam.* Also there are other inheritors of temple *Kannan vedu, Papini vedu* and *Payan Vedu.* Deities worshipped in this sacred grove are *Bhadrakali, Shiva, Shastav, Kshetrapalan, Ganapathy, Brahmani, Maheshwari, Kaumari,Vaishnavi, Varahi, Indrani* and *Chamundi.* Daily puja is done in the temple, Ritual at morning 5 am with *Abhishegam*, followed by other puja's like *Ravile Puja* (7 am), *Panthiradi* (12.00), *Uchapuja* (6.30 pm) and *Naivadya puja* (8.00 pm). Other major puja's are *Yaga puja, Gurushipuja, Karimkalasham, Shatrusambhara puja, Rakta pushpanjali.* Hen is sacrificed as offerings.

Madayi Kavu is associated with *Raja Rajeshwari* temple, Taliparambu. The origin of the temple goes the way as, one priest from a family '*Pedaram*' was found eating meat. That family was asked to leave that area. The Priest was devotee of Godess. He threw a conch invoking Godess towards the west, the place where the conch landed turned into

divine tremor. The rituals in the temple are done by other Brahmins but *Pedaram* cast is the only one who knows *shakti puja*. Priest who know *Uchapuja* can only do *Pandiradipuja*. *Maha prasadam* (Food) is offered on every Sunday to the devotees.

9 Mannanpurath Kavu:

Mannanpurath Kavu is looked after by three families *Kezakeillam*, *Pazheillam* and *Nadukekeillam*. Diety worshipped is *Bagavathy*. Important festival is *Pura maholsavam* in the month of *meenam* (March-april). Daily puja's and offering are offered, hen is sacrificed on Friday as offerings. *Maha prasadam* is offered to devotee's everyday as offering by other devotees. Cleaning of the temple is the duty of two inheritor families *Ambalavasi* and *Puthiyevalapu*, they do alternately for six months.

There is a myth of Devi killing *Mannan* a notorious ruler. Villagers prayed Devi at Madayi Kavu to get them rid of *Mannan* for cruel activities, Devi came to Nileshwar and killed *mannan* and thereafter temple was constructed in Nileshwar known as *Mannanpurath Bagavathy* Kavu

10 Mapetachery Kavu:

Mapetachery Kavu is looked after by *thiyya* community of the village. Deity worshipped here are *Bhagavathy, Chamundi, Paradevatha and Padaveeran*. Important festival is *Pura maholsavam* in the month of *meenam* (March-April). Daily deepam is lit in evening at *banarapura* and the temple is opened only on sankranti and putheri, Photography of deity is prohibited. No idea about the origin of the sacred grove.

11 Neeliyar Kavu:

Neeliyar Kavu is looked after by family of *Cheriye Vedu*. Deity worshipped is *Kottatamma*. Preist lits deepam at 12.00 noon every day

except on Tuesday and Sunday if it's not *snakramam*. Offerings are made of of rice and *paysam* (pudding). Devotees also make offering of *Theyyam*, to solve their problems like infertility or bachelorate. *Theyyam* starts at evening 5.30. Devi is been placed in open environment surrounded by trees, she doesn't require any shrine. A stone called *peedkallu* and *trishoolam is* worshiped as *Devi*. Every year on *karkada sankramam*, Devi goes to her native place called 'Kalangoth' for 16 days, during these days no offerings are made, no one is allowed to enter in the forest as it is believed that she will not be there to protect them.

12 Poongotu Kavu:

Poongotu Kavu is looked after by four families *Puttan vedu, Karadattu chundakadu, Uruvanbetta* and *Adathatta*. Diety worshipped is *Ayyappan.* Deepam is only lit on every *sankramam*, on the birthday of *Ayappan i.e meenathil uttram* and during the month of *mandalam* (Nov-Dec). During the month of *mandalam* devotees perform *pujas* for going to *shabarimala.* Puja called '*Putheri*' is followed in the month of *chingam*.

People do not have any clear idea about the origin of the sacred grove. But some of them say that once they went to sow rice in that place and started digging the land with sickle suddenly the roots of trees in sickle shaped come out from the tree, the time since they didn't go for farming in that place and protected it as sacred grove.

13 Bagavathy Kavu:

Bagavathy Kavu is looked after by three families *Velliyavayalil, Kavunkal* and *Nambivalapil.* Deity worshiped here are *Adiparashakthi, Pumala bhagavathy, Brahmavu, Vishnu, Maheshwaran, Palakurumaghan devam, Pumarudhan, Padarkulangara bhagavathy, Cheraloth bhagavathy,Vishnu moorthy, Raktha Chamundi and Tuvakarran* . Important festival is *pura mahalsavam* in the month of magaram. Deepam

is lit every evening, but temple is opened only at the time of *Sankramam*, hen is sacrificed during festivals.

14 Thazhe Kavu:

Thazhe Kavu is looked after by Nair community and belongs to three families *Konnamaru Vedu, Korancharith Vedu and Kummel Vedu*. Deities worshipped in this sacred grove are *Thazhe paradevatha, Elankolam, Shastavu* and *Erinikel Bhagavthi*. Important festival is Theyyam which is performed in every alternate year in the month of December. Daily deepam is lit and daily offerings of *Onakachoru* (Dry rice) and *Payasam* (Pudding) is offered. Even though the sacred grove is surrounded by Salt water from three sides the well inside the sacred grove fetches fresh water which is believed as a miracle by villagers.

Women do not fetch water from the well inside the sacred grove also they are also not allowed to see *Elangol Theyyam*. The story goes as once harijan lady and her daughter from the other bank came to catch prawns in the backwater, suddenly she saw bright light from the temple on the other side of the bank, she described it as '*burning flame of coconut kernel*' sooner she turned into stone and the *Theyyam* was covered by forest. The age old people say that many of the rituals has been stopped, long year back many rituals were followed during *Theyyam* like *Mapilapatu* and *Vaniyan parath etc* and only few of them are followed. *Theyyam* goes only to houses of Nair community and Maniyani in the village.

15 Verikkara Kavu:

Verikkara Kavu is looked after by *Kakaporam* family. Deity worshiped are *Verikkara acchi, Eshtamurthi, Raktha chamundi, Manikandan and Pullikandan*. Important festival performed is *Theyyam* in the month of *medham* (April-May). The sacred grove belongs to Nair

**Cheemeni Kavu**

**Edapara Kavu**

**Edayilekadu**

**Iriveri Kavu**

**Kammadam Kavu**

**Madayi Kavu**

Plate 3. Worship place in the sacred grove

**Mannanpurath Kavu**

**Mapetachery Kavu**

**Neeliyar Kavu**

**Poongotu Kavu**

**Thazhe Kavu**

**Verikkara Kavu**

Plate 3. Worship place in the sacred grove

community, other lower cast devotees are not allowed entering the temple beyond some limit. Priest lits deepam every day in the morning and evening. Tuesday *nirmalyam* is followed and *karyappam* is offered to deity.

## 4.9 TREATS FACED BY THE SACRED GROVES OF NORTHERN KERALA

General threat of carelessness towards biodiversity of Kavu is faced by most of the sacred groves in the study. More importance is given to rituals, festivals rather than the conservation of the flora and fauna of the sacred grove. Only few people near Cheemeni Kavu, Edapara Kavu, Kammadam Kavu, Iriveri Kavu, Mapetachery Kavu and Thazhe Kavu are aware of the significance of biodiversity and have made some approaches towards its conservation. Many of the sacred groves selected for study is funded by government for conservation of biodiversity. Important threat to be highlighted are encroachment, degradation of vegetation in the sacred grove, dumping of waste into the sacred groves, deposition of solid waste through contaminated water, use of some of the sacred groves by anti-social elements for consumption of liquor, playing cards etc, excessive movement of people through the sacred grove, who use it as short cuts and various construction activities taking places in some of the sacred groves are all challenges faced by the sacred groves of northern Kerala. Details of threat to biodiversity in some of the sacred groves selected for present study are given in Table 41.

## 4.10 APPROACHES MADE FOR CONSERVATION OF BIODIVERSITY AND CREATING AWARENESS ABOUT SIGNIFICANCE OF CONSERVING SACRED GROVES

Sacred groves are facing severe threats due to anthropogenic disturbances. The Social Forestry wing of the Kerala Forest Department (KFD) has taken various steps for the conservation of sacred groves of Kerala for the past few

years. Apart from the KFD, the sacred grove management committee is also involved in the conservation initiatives of sacred groves. Some of the conservation initiatives done by these group include, awareness creation among the people in and around the sacred groves, enrichment planting using indigenous plant species etc. The conservation initiatives done at the various sacred groves of northern Kerala are given in Table 43.

## 4.11 STATUS OF THE SACRED GROVE

Sacred grove were given total positive score based on number of resident, forest, endemic and migratory birds were present and Threats was considered ad total negative score. Threat was scored in cumulative scale and was subtracted from the total positive points scored by the sacred groves. Sacred groves were ranked from 1 to 12, with the sacred groves with highest score securing higher rank (Table 43).

Table 41. Threat to biodiversity in some of the sacred groves of northern Kerala

| Sl. No. | Sacred Grove | Threat |
|---|---|---|
| 1 | Edapara Kavu | New construction within the sacred grove |
| 2 | Edayilekadu | Dumping of solid waste |
| 3 | Kammadam Kavu | Encroachment |
| 4 | Karaka Kavu | Trails, used by villagers as short cuts. New sanitary constructed within the sacred grove |
| 5 | Madayi Kavu | Dumping of wastes in the grove, anti-social elements |
| 6 | Mannanpurath Kavu | Dumping of wastes in the grove, anti-social elements |
| 7 | Mapetachery Kavu | Purple moorhen was poached from a paddy field adjoining to the sacred grove |
| 8 | Neeliyar Kavu | Dumping of waste and trails from the sacred grove are used as short cuts |
| 9 | Bagavathy Kavu | Degradation of vegetation and trail from the sacred grove is used as short cuts |
| 10 | Thazhe Kavu | Deposition of solid through water and a new path is constructed within the vegetation |
| 11 | Verikkara Kavu | Encroachment and conflict between families (Plate 4) |

(a) Edapara Kavu (New construction)

(b) Edayilekadu (Waste Disposal)

(c) Karakka Kavu (Trek path)

(d) Karakka Kavu (New construction)

(e) Madayi Kavu (Waste disposal)

(f) Madayi Kavu (Anti-social activities)

Plate 4. Threats faced by sacred groves under study in northern Kerala

(g) Neeliyar Kavu (Plastic bottles disposal)

(h) Poongotu Kavu (Waste disposal)

(i) Puthiya Parambath Bagavathy Kavu (Habitat degradation)

(j) Thazhe Kavu (Waste accumulation through water)

(k) Thazhe Kavu (New trek path within vegetation of sacred grove)

Plate 4. Threats faced by sacred groves under study in northern Kerala

Table 42. Conservation initiatives done at the various sacred groves of northern Kerala

| Sl. No. | Sacred Grove | Conservation approaches |
|---|---|---|
| 1 | Cheemeni Kavu | No entry banner is placed at the entrance of the sacred grove and the sacred grove boundary has been fenced with barbed wire by the sacred grove management committee |
| 2 | Edapara Kavu | KFD helped to fix a banner depicting the importance of biodiversity. They also provided the seedlings for the enrichment planting in the sacred grove with the support of the local people |
| 3 | Edayilekadu | KFD sponsored banner is placed depicting the prohibition of use/misuse of plastics and other waste materials and regulations in entering into the sacred grove |
| 4 | Iriveri Kavu | KFD sponsored banner is placed at the sacred groves, highlighting the significance of sacred grove, Enrichment planting done. |
| 5 | Kammadam Kavu | KFD sponsored banner kept highlighting the significance if Sacred groves, do and don't and biodiversity values. |
| 6 | Karaka Kavu | Boundary of the sacred grove is demarcated by stone |
| 7 | Mannanpurath Kavu | Sacred grove is fenced with barbed wire |
| 8 | Mapetachery Kavu | Banner placed saying prohibition of photography |
| 9 | Neeliyar Kavu | Banner is placed inside the grove saying 'Keep sacred grove clean' |
| 10 | Bagavathy Kavu | The sacred grove is fenced with barbed wire with the support of KFD |
| 11 | Thazhe Kavu | KFD sponsored banner kept. The boundary is protected by the nylon net, to keep away the water driven waste coming to the sacred grove from the nearby areas |
| 12 | Verikkara Kavu | KFD supported in fixing a banner and also to dig a pond to conserve and harvest the rainwater (Plate 5) |

(a) Edapara Kavu (Awareness board)


(b) Edayilekadu (Awareness board)

(c) Iriveri Kavu (Awareness board)

(d) Kammadam Kavu (Awareness board)

Plate 5: Conservation Approaches in the sacred groves of northern Kerala

(e) **Mannanpurath Kavu (Barbed wire fencing)**

(f) **Mannanpurath Kavu (Fencing by nylon net)**

**(g) Verikkara Kavu (Awareness board)**

**(h) Verikkara Kavu (Water hole)**

Plate 5: Conservation Approaches in the sacred groves of northern Kerala

Table 43. Ranking of sacred groves

| Sl. No. | Sacred grove | Resident Birds | Forest Birds | Endemic Birds | Migratory Birds | Total positive score of the Sacred grove | Total negative score of the Sacred grove | Total score for sacred grove | Rank |
|---|---|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e = (a + b + c + d) | f | e - f | |
| 1 | Cheemeni Kavu | 50 | 10 | 0 | 5 | 65 | 0 | 65 | 1 |
| 2 | Verikkara Kavu | 51 | 13 | 1 | 3 | 68 | 3 | 65 | 1 |
| 3 | Kammadam Kavu | 39 | 16 | 2 | 5 | 62 | 1 | 61 | 2 |
| 4 | Mapetachery Kavu | 41 | 7 | 0 | 5 | 53 | 1 | 52 | 3 |
| 5 | Kuduvakolangara Kavu | 35 | 13 | 1 | 2 | 51 | 0 | 51 | 4 |
| 6 | Madayi Kavu | 38 | 4 | 0 | 11 | 53 | 3 | 50 | 5 |
| 7 | Poongotu Kavu | 35 | 7 | 1 | 1 | 44 | 1 | 43 | 6 |
| 8 | Iriveri Kavu | 31 | 7 | 0 | 5 | 43 | 0 | 43 | 7 |
| 9 | Karaka Kavu | 35 | 3 | 0 | 5 | 43 | 3 | 40 | 8 |
| 10 | Thazhe Kavu | 39 | 0 | 0 | 3 | 42 | 2 | 40 | 8 |
| 11 | Edapara Kavu | 34 | 5 | 0 | 2 | 41 | 1 | 40 | 8 |
| 12 | Neeliyar Kavu | 30 | 6 | 0 | 2 | 38 | 2 | 36 | 9 |
| 13 | Mannanpurath Kavu | 28 | 3 | 0 | 7 | 38 | 4 | 34 | 10 |
| 14 | Edayilekadu | 28 | 3 | 0 | 3 | 34 | 1 | 33 | 11 |
| 15 | Bagavathy Kavu | 20 | 0 | 0 | 3 | 23 | 3 | 20 | 12 |

# *Discussion*

# DISCUSSION

## 5.1 BIRD COMMUNITY STRUCTURE IN THE SACRED GROVES OF NORTHERN KERALA

Sacred groves being undisturbed patch of vegetation harbour rich bird diversity. A study to know the bird community structure in the sacred groves of northern Kerala was conducted during the period March 2012- October 2013. The bird diversity of the sacred groves was studied, because in addition to aesthetic value of birds, they play significant role of pollination, seed dispersal, controlling insect-pests and are excellent indicator of biodiversity (Chandrashekara, 2010).

A total of 111 bird species were recorded, belonging to 15 orders, 47 families and 90 genera in 15 selected sacred groves of Kannur and Kasargod districts of northern Kerala. The earlier studies on the bird community from the sacred groves also reported similar diversity of bird species from the sacred groves of Kerala (Sashikumar, 2004; Chandrashekara, 2010). Good number of bird diversity signifies that sacred grove provide good niche for feeding, nesting and roosting.

Number of species of birds per sacred groves of northern Kerala ranged from 23 to 55. Maximum species diversity was found in Cheemeni Kavu might be due to undisturbed condition of the sacred grove and there was no highlighting threat noticed. Lowest number of species was found in Bagavathy Kavu which is facing with several anthropogenic disturbances.

### 5.1.1 Resident, migratory, forest, endemic and threatened birds in Sacred groves of northern Kerala

a) *Resident birds in the sacred groves of northern Kerala*

During the present study it was observed that 94 (84.68 %) species of birds of sacred groves were resident birds to Kerala (Rasmussen and Anderton, 2012). Similar observations were also made by Sashikumar (2004) from the sacred groves of northern Kerala. Highest number of resident birds was found in Verikkara Kavu (51) might be due to the undisturbed nature of the Sacred grove.

*d) Migratory birds in the sacred groves of northern Kerala*

All the 15 sacred groves selected for the study were found supporting good number of migratory birds. A total of 17 species of migratory birds were sighted during the present study. Maximum number of migratory birds i. e 11 number of birds were supported by Madayi Kavu. Sashikumar (2004) has reported 22 species of migratory birds from the sacred groves of northern Kerala.

b) *Forest birds in sacred groves of northern Kerala*

Interestingly the 25% the birds of the sacred groves were forest dependant birds (Rasmussen and Anderton, 2012), which highlights the significance of the Sacred groves in providing the habitat for the forest dependent birds and thus playing an important role in ensuring the biodiversity conservation of the region. However; in an earlier study, Sashikumar (2004) reported the occurrence of 50 per cent of forest-birds in the sacred groves of north Kerala.

It was observed that the Kammadam Kavu supported good population of forest birds such as Malabar Grey Hornbill, Malabar Trogon and Malabar

Whistling-Thrush. This could be due to the larger size of the sacred grove and the proximity to it to a larger contiguous patch of reserved forests (Sashikumar 2004).

The Thazhe Kavu and Bhagavathy Kavu were the two sacred groves which did not support any forest birds during the present study. The Thazhe Kavu though was a big-sized sacred grove, it was located in the coastal region and the major habitat was mangroves, which is an unsuitable habitat for the forest birds. Bagavathy Kavu was a highly disturbed sacred grove, has very low tree density and the tree species diversity. This might be the reason for these sacred groves not supporting any forest dependent bird species.

c) *Threatened bird found in the sacred groves of northern Kerala*

Presence of Oriental white ibis in the sacred groves of northern Kerala signifies the importance in conserving threatened birds, Thazhe Kavu is a coastal sacred grove surrounded by large stretch of paddy field from one side and water by other three sides, easy food availability and calm location of the sacred grove might be the reason in attracting this bird.

d) *Birds Endemic to Western Ghats found in the sacred groves of northern Kerala*

Endemic species like Malabar Grey Hornbill (*Ocyceros griseus*) and Rufous Babbler (*Turdoides subrufa*) were reported from sacred groves of northern Kerala during the present study. However Sashikumar (2004) had reported four species of endemic birds from the sacred groves of northern Kerala. Apart from the above two species, Chandrashekra (2010) reported Grey-headed Bulbul (*Pycnonotus priocephalus*) and Small Sunbird (*Leptocoma minima*) also from the sacred groves. This signifies the importance of sacred groves as repositories of the biodiversity and they even act as the 'sanctuaries' for endemic birds.

The endemic Malabar Grey Hornbill is present in Kammadam Kavu and Poongotu Kavu, probably because these sacred groves support evergreen forests, which is the most preferred habitat of Malabar Grey Hornbill (Rasmussen and Anderton, 2012). Sashikumar (2004) has also reported Malabar Grey Hornbill at Kammadam Kavu, which is a large sized sacred grove. Another endemic bird to the Western Ghats, found from the sacred groves of north Kerala was the Rufous Babblers, which were sighted from the Kuduvakolangara Kavu, Kammadam Kavu and Verikkara Kavu. These Sacred groves are characterised by the presence of dense undergrowth, which is a prerequisite for the survival of Rufous Babbler.

### 5.1.2 Raptors and nocturnal birds in the sacred groves of northern Kerala

All the sacred groves of northern Kerala except Kuduvakolangara Kavu supported good population of raptors. Presences of the raptors, which are predatory birds, indicate the health of the ecosystem. Moreover, Edayilekadu sacred grove acted as the nesting site for the White-bellied Sea-Eagle (*Haliaeetus leucogaster*). Breeding of the White-bellied Sea-Eagle has been reported from Edayilekadu in 2000 (Palot 2000 and 2011), and it is significant to note that this species continue to breed at this sacred grove even now. Sashikumar (2004) and Deb (2007) also reported that sacred groves provide habitat for the roosting and breeding of raptors.

Four species of owls were sighted from the sacred groves of northern Kerala, while Sashikumar (2004) had reported only two species such as Mottled Wood-Owl (*Strix ocellata)* and Brown Wood-Owl (*Strix leptogrammica*) from the sacred groves of northern Kerala. Apart from these two species, the other two species of owls that have been added during the present study were Brown Fish-Owl (*Bubo zeylonensis*) and Spotted Owlet (*Athene brama*).

## 5.2 BIRD DIVERSITY PROFILE IN THE SACRED GROVES OF NORTH KERALA

### 5.2.1 Bird diversity at the sacred groves of Kerala

Diversity indices were calculated to understand the biodiversity profile of the sacred groves. Accordingly it was found that Cheemeni Kavu had the maximum species richness and species diversity, evidenced by the higher Margalef's richness index and Shannon index of diversity values. Cheemeni Kavu the habitat is relatively less disturbed, this could be the reason for the higher bird species diversity and richness in this sacred grove, when compared to the rest.

### 5.2.2 Bird community at the sacred groves of Kerala

The bird community of the Kammadam Kavu and Thazhe Kavu was found to be distinct among the 15 sacred groves studied using the Correspondence analysis. This may be due the presence of certain distinct species of birds such as Malabar Trogon, Malabar Whistling-Thrush, Southern Hill-Myna, and Tickell's Blue-Flycatcher at Kammadam Kavu which were not present in any other sacred groves. The probable reason for the distinctiveness of the Thazhe Kavu could be that it was the only sacred grove in the study site, possessing a mangrove habitat. And the bird species such as Oriental White Ibis, Ruddy-breasted Crake, Whiskered Tern and Common Sandpiper were present only at Thazhe Kavu.

All the fifteen sacred groves of northern Kerala was found supporting feeding guilds like understorey insectivore, canopy insectivore, omnivores, nectarivores and frugivores.

## 5.3 RELATIONSHIP BETWEEN DIFFERENT PARAMETERS OF THE SACRED GROVE AND BIRD DIVERSITY

The 'forest birds' in the sacred groves of northern Kerala showed a significant positive correlation ($p<0.05$) with altitude and tree density. There was a significant positive correlation ($p<0.05$) between the endemic birds and the extent of the sacred grove. Thus the bigger the size of the sacred grove, the larger was the number of the endemic birds. Raman (2001) also reported that rainforest bird species richness increased significantly with increase in the fragment area. Bhagwat *et al.* (2005) feels that the habitat within the sacred grove and the surrounding matrix may have major contribution in determining the composition of birds.

## 5.4 PROFILE CHARACTERISTICS OF RESOPNDENTS AND THEIR RELATION WITH AWARENESS AND PERCEPTION

Awareness regarding birds and perception about significance of sacred groves was studied in Kannur and Kasargod district of northern Kerala. A total of 150 respondents were surveyed.

Nearly equal numbers of male and female respondents were obtained and all of them were aware of birds. Males were more aware about biodiversity than females.

Nearly 55% of the respondents associated with the sacred grove were of caste *Thiyya*. Looking into the age class, nearly 60% of respondents were having age less than 50. Awareness was more in young age class than the elders. As the age went on increasing the awareness went on decreasing. This may be because as the age increase responsibility increases resulting in lack of time to observe the surrounding increases. However, the perception was more or less same among all the age classes.

Family size gave an interesting result, awareness about bird community structure and perception about significance of sacred grove decreases with increasing number family member. This again may be due to the increasing responsibility in the family.

Maximum respondents i.e. 50% were having educational level of secondary school. Awareness about bird community structure in the sacred groves increased with educational level. This may be because education makes us more environment conscious. But had no significant difference for perception about significance of sacred grove with higher level of education. This signifies that all the respondents are aware of the role played by sacred grove.

70% of respondents were house wives and semi skilled labourers. Very interestingly awareness decreased with occupation. The awareness was decreasing from among respondents working on daily wages > Agriculturist > House wife's and semi skilled labours > Government jobs. But perception about significance of sacred grove was reverse. This might be because towards the end of the scale, the nature of the occupation takes away the time of the person to observe nature, leading to his low awareness. At the same time the occupation pave away for more exposure of the person leading to better perception about significance of sacred groves.

As the number of members employed in the family increased awareness about bird's community structure increased and perception about significance of sacred grove decreased. May be because respondents look in the surrounding nature but they get more concentrated into work and are less exposed to significance of sacred grove issues.

Association of respondent with the sacred grove decreased awareness about birds. This signifies the respondent's are mostly concentrated on prayers and festivals. But more association with the sacred grove gives respondents more

exposure about significance of sacred grove. The habit of observing birds increased the awareness about bird community and perception about significance of sacred grove which is a natural outcome for person having an eye for nature.

As the understanding of beneficial role played by birds in the sacred grove made the respondents more aware about community structure and surrounding nature, awareness and perception increased with the same.

Perception was assessed using a scale developed for the study. All the 150 respondents felt that sacred groves provide shelter to threatened plants and birds, help in conservation of biodiversity, protect medicinal plants, regulate temperature. In case of temperature regulation 68% respondents strongly agreed as they were aware of the important role played by sacred grove against increasing temperature, helping in water conservation was also of interest as in many villages, as in some of the villages sacred grove provides perennial water and recharges the area. Chandrashekara and Sankar (1998) also reported that stakeholders who are near to the sacred grove enjoy indirect benefits like amelioration of microclimate, wind shelter belt effect, protection and regulation of local hydrology, maintenance of visual quality and fresh air from the dense vegetation.

Four respondents from Edayilekadu sacred grove felt that sacred grove was wastage of space for owner may be because they may not be aware of important role played by sacred grove but rest of the others disagreed. Majority of the respondents said that they maintain sacred grove just because that is the custom of the family. Also few of the respondents felt that sacred grove is no more economical to maintain, may be because it is maintained by the committee formed by villagers and not by dewaswom board. Also they have to look after Bonnate Macaque in the sacred grove as the ritual of the sacred grove. Majority of the respondents felt that the next generation will maintain the sacred grove but few of

them are doubtful. All of the respondents felt modernization is a major threat to sacred grove.

Caste, gender, education, frequency of bird observation by the respondents, knowledge about bird diversity in the sacred grove and understanding the beneficial effect by birds had positive correlation with the awareness about bird community and occupation had negative relation with awareness about bird community. The variables that contributed to the awareness about bird structure generally indicate the information status and nature orientedness of the respondents. Those who observe bird more naturally have more nature orientedness and hence are more aware of the bird and also education makes us more environments conscious. The frequency distribution of the respondents based on the different beneficial effects shows that more than 74% (111/150) of the respondents see the sole beneficial effect of bird as aesthetic pleasure. Such people will naturally like observing birds and will have a better awareness about them.

The negatively significant or inverse relationship of occupation with awareness points to an interesting aspect. The scale of variables was expressed as 1-4 for daily wage workers, farmers, housewives /small business person and government employees respectively. It is very logical that government employees and small business people will have lower awareness on bird community structure as their occupation takes them away from nature.

For perception on significance of the sacred groves, frequency of bird observation, knowledge about bird diversity in the sacred grove, understanding of beneficial effect by birds and occupation of the respondents were the contributing variables.

Respondents who observed bird more frequently and who had more understanding about their beneficial effect had better perception about the

significance of sacred grove. Contrary to the case of awareness, occupations like small business and government employments led to better perception. These occupations lead to more exposure of the people which will make them conscious of the value of an important natural resource like the sacred grove.

The socio-economic study generally indicates the need for more awareness creation among direct and indirect stakeholders associated with the sacred groves. The disparity in result about awareness and perception points towards this. Even when respondents had relatively medium awareness about bird structure, the majority felt the major beneficial effect of birds was aesthetic pleasure. The Fact that 80 % of the respondents had only school education might explain this ignorance. Vast Majority of the respondents felt modernization was a threat to the sustainability of sacred grove. This also reinfocus the need for comprehensive efforts to promote the invaluable contribution of these rich ecosystems to sustain natural resources.

# *Summary*

## SUMMARY

Sacred groves, as name signifies are wooded land connected to God or dedicated to a religious purpose. Sacred groves are conserved beyond any legal legislation, due to fear of deity. A study on the 'Bird community structure in the sacred groves of northern Kerala' was carried out during 2011-2014. Fifteen sacred groves, eight from Kannur and seven from Kasargod districts were selected for the study.

The bird community was studied at each of these sacred groves. The bird study was done for three hours from 7h to 11h and 15h to 18h in each of the fifteen sacred groves. The study was repeated once in every two months in each of the sacred groves between March 2012 to December 2013. Thus a total of 168 visits and 1008 h of field work is done during the study period. The bird diversity was then correlated with various variables such as the size of the sacred grove, distance of the sacred grove to the nearest forest, altitude of the area and tree density. Tree diversity in the sacred groves was also studied and was correlated to bird diversity. Ten quadrats of 10x10m were taken in each of the sacred groves and trees having more than 10 cm girth was selected and GBH and height was measured. Socio-economic study was undertaken to understand the awareness about the birds of the sacred grove and the perception about the significance of sacred grove among villagers. A total of 150 respondents were interviewed to meet this objective.

The salient findings of the study are summarised below,

1. A total of 111 bird species, belonging to 15 orders, 47 families and 90 genera were reported. The species richness per sacred grove ranged from maximum of 55 to minimum 23. And the number of individuals of birds per sacred grove ranged from 576 to 203 birds.

2. Sacred groves of northern Kerala supported 84.68% of resident birds and 15.31% of migratory birds. Among the resident birds it was also found that 25% were forest-dependent birds. One Near-Threatened bird Oriental white ibis was found supported by the sacred groves of northern Kerala. The Western Ghats endemic species of birds seen in the sacred groves of northern Kerala were Malabar Grey Hornbill (*Ocyceros griseus*) and Rufous Babbler (*Turdoides subrufa*). The sacred groves of northern Kerala also supported good population of raptor and owls.

3. The dominant bird families in the sacred groves were Ardeidae, Acciptridae, Muscicapidae, Charadriidae and Pycnonotidae. The dominant feeding guilds in the Sacred groves of northern Kerala are Canopy Insectivore, 22% (CAN), Understorey Insectivore, 18% (UND), Aquatic, 16% (AQ), Frugivores, 11% (FRU) and Carnivorous, 7% (CAR).

4. All the fifteen sacred groves of northern Kerala was found supporting feeding guilds like understorey insectivore, canopy insectivore, omnivores, nectarivores and frugivores.

5. The bird community of the Kammadam Kavu and Thazhe Kavu was found to be distinct among the 15 sacred groves studied using the Correspondence analysis.

6. Dendrogram based on Bray-Curtis similarity matrix identified broadly three clusters viz. Karaka Kavu to Cheemeni Kavu, Edapara Kavu to Kuduvakolangara Kavu and Thazhe Kavu to Kammadam Kavu.

7. A total of 130 tree species were reported from the sacred groves of northern Kerala Fourteen trees species were found to be endemic to western and seven threatened were reported. Threatened species were,

*Vateria indica* a critically endangered species, *Chionanthus mala-elengi*, *Hopea ponga*, *Hopea parviflora* and *Evodia lunu-ankenda* are four endangered species and *Cinnamomum perrottetii* and *Santalum album* were two vulnerable species found from sacred groves of northern Kerala.

8. *Holigarna arnottiana* was the dominant tree species found in maximum sacred groves of Kerala. Verikkara Kavu had maximum tree density, however maximum abundance was found in Karaka Kavu.

9. A positive correlation was between the altitude as well as the tree density and the presence of the number of forest birds. Accordingly as the altitude of the sacred groves increases, the number of forest birds in the sacred grove also increased. Similarly as the tree density within the sacred grove increases then also the number of forest birds in such sacred groves increased. However, the numbers of endemic birds were greatly influenced by the extent of the sacred grove, and accordingly as the size of the sacred grove increases the number of endemic birds presence also increased.

10. The socio-economic studies proved that the awareness about the birds among the respondents in the sacred grove of northern Kerala were found to be influenced by caste, gender, education, frequency of bird observation, knowledge about bird diversity in sacred grove, understanding the beneficial effect by birds. The perception about the significance of the sacred groves was influenced by frequency of bird observation, knowledge about bird diversity in sacred grove, and understanding of beneficial effect by birds and occupation of the respondents.

11. The sacred groves of Northern Kerala were ranked based on bird community and threat faced by the sacred grove. Cheemeni Kavu and Verikkara Kavu stood first followed by Kammadam Kavu.

12. All the sacred groves selected for the present study have its unique history behind it. In 11 sacred groves had deity worshipped is *bagavathy* or her incarnation, Two sacred groves, the deity is *Ayyappan*, while in one sacred grove it is *puli-deva* (leopard) and in another one the deity is *nagam* (serpent).

13. Important threats faced by sacred grove in northern Kerala are encroachment, degradation of vegetation in the sacred grove, dumping of waste into the sacred groves, deposition of solid waste through contaminated water, use of some of the sacred groves by anti-social elements for consumption of liquor, playing cards etc, excessive movement of people through the sacred grove, who use it as short cuts and various construction activities taking places in some of the sacred groves. The sacred groves primarily survived through mythological reasons that was continued through generations, who had stronger believes in Gods and Goddesses. However, the newer and younger generation not only the belief levels have come down substantially, they are more focused towards quicker economic benefits, which is causing a big challenge to many of the sacred groves of Kerala in general and northern Kerala in particular.

14. For the conservation of the biodiversity within the sacred grove a separate committee should be formed involving newer generation. Eco-friendly board depicting the endemic flora and fauna harboured by sacred grove should be placed in every sacred grove to create awareness among new generations. Sacred grove with high anthropogenic disturbance should be fenced with restricted entry. Enrichment planting should be done with the help of indigenous trees. No new constructions should be allowed in the sacred grove. KFD should try to give award to the sacred grove that made effective use of incentives provided for conservation of sacred groves.

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# Appendix

## Appendix I

Bird survey data sheet used for study

**BIRD SURVEY DATA SHEET OF SACRED GROVES OF NORTHERN KERALA - 2011-2013**

**Name of Sacred Grove:**
**Date:**
**Time From: To:**
**Transect From: To:**
**Name (s) of observers:**
**Name (s) of trackers:**
***Weather: CS, CL, SU, DR, RA, WI, MI, O**

| Time | Species | No. of birds | Habitat ** | Distance band | | | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | 0-5m | 5-10m | 10-30m | >30m | |
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- * CS-clear sky, CL- cloudy, SU- sunny, DR-drizzle, RA-rainy, WI- windy, MI-misty, O-others (specify)
- ** EG- evergreen, MDF-moist deciduous, DDF-Dry deciduous, CR- Costal Region, O- other (specify)
- + The closest distance from the transect line to the point of first detection of a bird

## APPENDIX II

Questionnaire used for socio-economic study in the sacred groves of northern Kerala

KERALA AGRICULTURAL UNIVERSITY
College of Forestry, KAU (P.O), Thrissur.

Doctoral research program

Title of the doctoral research: **Bird community structure in the sacred groves of Northern Kerala**

**Interview schedule**

**A. Information about the sacred grove:**

1. Name of sacred grove:
2. Panchayat/Taluk & District:
3. GPS Location:
4. Extent of sacred grove:
5. Ownership: (Individual/Community/Dewasom/State)
6. Deity worshiped:
7. Tree worshiped (if any):
8. Threat: trek paths/roads/pollution (air, water, noise, soil) /renovation/change in the mind set of the younger generation
9. Details on the rituals followed at the sacred grove:
10. Approximate distance of the scared grove from the nearby reserved forest:
11. Selected for Long-term assistance by the State Forest department: Yes /No

**B. Background information of the respondent:**

1. Name:
2. Address:
3. Age:
4. Caste:
5. Gender:
6. Education: (Illiterate/Primary/Secondary/College/Professional College)
7. Family members: Adult: M= F= Children: M= F= Total:
8. Occupation:

9. How many members in the family employed:
10. Type of association with the sacred grove: (fuel wood collection, regular prayers, play area of the children, used for the conduct of the marriage, festival associated with the sacred grove)

**C. Awareness about the bird communities and their significance among the respondents:**

1. Name of Birds

| | |
|---|---|
| i | vi |
| ii | vii |
| iii | viii |
| iv | ix |
| v | x |

2. Have you observed the birds visiting or in the sacred grove?
   Always when i am there/frequently/ sometimes/rarely
3. How many birds do you think are visiting the sacred grove on an average?
   <10, 11-50, >50
4. What beneficial effects do you think the birds bring?
   Help in pollination/ control of harmful insects/aesthetic pleasure/ecosystem benefits/others, specify
5. Do you think that birds in the sacred grove are an inconvenience? What way?
   Noise/ dirtying grounds/threat to children/others, specify

D) Perception on the significance of the respondents about sacred groves

a) Positive significance (Strongly agree/agree/ disagree/strongly disagree)

i. Sacred groves provide shelter to threatened plants and birds
ii. They help in conservation of biodiversity
iii. They help to protect medicinal plants
iv. They help in temperature regulation
v. They help in water conservation

b) Negative significance (Strongly agree/agree/ disagree/strongly disagree)

i. They are wastage of space for the owner
ii. We maintain them just because that is the custom of our family
iii. It is no more economical to maintain them
iv. It is doubtful whether next generation will maintain them
v. Modernization is major threat to sacred grove

E) How do you think, the sacred groves originated?

F) Indigenous Knowledge associated with sacred groves

i. Legends:
ii. Beliefs:
iii. Roles of sacred groves
iv. Customs associated with sacred groves
v. Others

## Appendix III

Checklist of birds found in sacred groves of northern Kerala

| Common Name (BLI) | Scientific Name (BLI) | Status | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total Abundance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. GALLIFORMES/ PHASIANIDAE | | | | | | | | | | | | | | | | | | |
| 1. Red Spurfowl | *Galloperdix spadicea* | R | 0 | 6 | 0 | 4 | 0 | 0 | 3 | 6 | 0 | 0 | 0 | 0 | 6 | 0 | 10 | 35 |
| 2. Grey Junglefowl | *Gallus sonneratii* | F/R | 0 | 0 | 0 | 0 | 3 | 0 | 9 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 3 | 17 |
| II. CORACIIFORMES/ CICONIIDAE | | | | | | | | | | | | | | | | | | |
| 3. Asian Openbill | *Anastomus oscitans* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| III. PELECANIFORMES/ THRESKIORNITHIDAE | | | | | | | | | | | | | | | | | | |
| 4. Black-headed Ibis | *Threskiornis melanocephalus* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 11 |
| IV. PELECANIFORMES/ ARDEIDAE | | | | | | | | | | | | | | | | | | |
| 5. Indian Pond-heron | *Ardeola grayii* | R | 7 | 0 | 9 | 0 | 1 | 1 | 0 | 0 | 0 | 10 | 11 | 0 | 0 | 26 | 2 | 67 |
| 6. Cattle Egret | *Bubulcus ibis* | R | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 8 | 0 | 0 | 13 | 6 | 41 |
| 7. Purple Heron | *Ardea purpurea* | R | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 | 0 | 8 |
| 8. Great Egret | *Casmerodius albus* | R | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| 9. Intermediate Egret | *Mesophoyx intermedia* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 3 |
| 10. Little Egret | *Egretta garzetta* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 6 | 0 | 8 |
| V. SULIFORMES/ PHALACROCORACIDAE | | | | | | | | | | | | | | | | | | |
| 11. Little Cormorant | *Phalacrocorax niger* | R | 3 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 9 |
| VI. FALCONIFORMES/ ACCIPTRIDAE | | | | | | | | | | | | | | | | | | |
| 12. Black Kite | *Milvus migrans* | R | 4 | 5 | 12 | 4 | 4 | 3 | 0 | 32 | 35 | 5 | 7 | 17 | 3 | 27 | 4 | 162 |
| 13. Brahminy Kite | *Haliastur indus* | R | 0 | 28 | 97 | 3 | 0 | 25 | 0 | 30 | 12 | 7 | 0 | 3 | 7 | 25 | 3 | 240 |
| 14. White-bellied Sea-eagle | *Haliaeetus leucogaster* | R | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 |
| 15. Crested Serpent-eagle | *Spilornis cheela* | F/R | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 1 | 8 |
| 16. Shikra | *Accipiter badius* | R | 3 | 1 | 0 | 1 | 0 | 3 | 0 | 0 | 1 | 1 | 1 | 3 | 0 | 0 | 2 | 16 |
| VII. GRUIFORMES/ | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RALLIDAE | | | | | | | | | | | | | | | | | | |
| 17. White-breasted Waterhen | *Amaurornis phoenicurus* | R | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 6 | 2 | 12 |
| 18. Ruddy-breasted Crake | *Porzana fusca* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 3 |
| VIII. CHARADRIIFORMES/ CHARADRIIDAE | | | | | | | | | | | | | | | | | | |
| 19. Yellow-wattled Lapwing | *Vanellus malarbaricus* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 20. Red-wattled Lapwing | *Vanellus indicus* | R | 1 | 5 | 0 | 0 | 1 | 0 | 0 | 32 | 0 | 4 | 0 | 0 | 0 | 34 | 5 | 82 |
| 21. Little Ringed Plover | *Charadrius dubius* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 22. Caspian Plover | *Charadrius asiaticus* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 23. Kentish Plover | *Charadrius alexandrinus* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| IX. CHARADRIIFORMES/ SCOLOPACIDAE | | | | | | | | | | | | | | | | | | |
| 24. Common Sandpiper | *Actitis hypoleucos* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 38 | 0 | 40 |
| X. CHARADRIIFORMES/ STERNIDAE | | | | | | | | | | | | | | | | | | |
| 25. Whiskered Tern | *Chlidonias hybrida* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 31 | 0 | 31 |
| XI. COLUMBIFORMES/ COLUMBIDAE | | | | | | | | | | | | | | | | | | |
| 26. Rock Pigeon | *Columba livia* | R | 5 | 0 | 0 | 0 | 0 | 8 | 0 | 7 | 3 | 5 | 0 | 1 | 0 | 1 | 2 | 32 |
| 27. Spotted Dove | *Stigmatopelia chinensis* | R | 5 | 11 | 0 | 5 | 10 | 0 | 20 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 59 |
| 28. Emerald Dove | *Chalcophaps indica* | F/R | 0 | 2 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 7 |
| XII. PSITTACIFORMES/ PISTTACIDAE | | | | | | | | | | | | | | | | | | |
| 29. Vernal Hanging-parrot | *Loriculus vernalis* | F/R | 2 | 0 | 0 | 0 | 3 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 13 |
| 30. Rose-ringed Parakeet | *Psittacula krameri* | R | 39 | 0 | 33 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 78 |
| 31. Plum-headed Parakeet | *Psittacula cyanocephala* | F/R | 1 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| XIII. CUCULIFORMES/ CUCULIDAE | | | | | | | | | | | | | | | | | | |
| 32. Banded Bay Cuckoo | *Cacomantis sonneratii* | F/R | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 33. Asian Koel | *Eudynamys scolopaceus* | R | 8 | 3 | 15 | 2 | 0 | 14 | 3 | 9 | 13 | 2 | 0 | 7 | 5 | 6 | 4 | 91 |
| 34. Blue-faced Malkoha | *Phaenicophaeus* | F/R | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 23 |

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| XXII. PICIFORMES/ PICIDAE | | | | | | | | | | | | | | | | | | | |
| 51. Rufous Woodpecker | *Celeus brachyurus* | F/R | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 52. Black-rumped Flameback | *Dinopium benghalense* | R | 3 | 0 | 2 | 0 | 5 | 7 | 0 | 0 | 6 | 11 | 0 | 0 | 0 | 2 | 2 | 38 |
| 53. Greater Flameback | *Chrysocolaptes lucidus* | F/R | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 54. Heart-spotted Woodpecker | *Hemicircus canente* | F/R | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 10 |
| XXIII. PASSERIFORMES/ PITTIDAE | | | | | | | | | | | | | | | | | | | |
| 55. Indian Pitta | *Pitta brachyura* | F/M | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| XXIV. PASSERIFORMES/ ARTAMIDAE | | | | | | | | | | | | | | | | | | | |
| 56. Ashy Woodswallow | *Artamus fuscus* | R | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 9 |
| XXV. PASSERIFORMES/ AEGITHINIDAE | | | | | | | | | | | | | | | | | | | |
| 57. Common Iora | *Aegithina tiphia* | R | 9 | 8 | 1 | 5 | 0 | 9 | 3 | 10 | 2 | 7 | 0 | 0 | 11 | 3 | 4 | 72 |
| XXVI. PASSERIFORMES/ CAMPEPHAGIDAE | | | | | | | | | | | | | | | | | | | |
| 58. Black-headed Cuckooshrike | *Coracina melanoptera* | R | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 59. Small Minivet | *Pericrocotus cinnamomeus* | R | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 5 |
| 60. Scarlet Minivet | *Pericrocotus flammeus* | F/R | 2 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| XVII. PASSERIFORMES/ LANIIDAE | | | | | | | | | | | | | | | | | | | |
| 61. Brown Shrike | *Lanius cristatus* | M | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 4 |
| XVIII. PASSERIFORMES/ ORIOLIDAE | | | | | | | | | | | | | | | | | | | |
| 62. Eurasian Golden Oriole | *Oriolus oriolus* | M | 3 | 0 | 0 | 0 | 9 | 10 | 0 | 6 | 4 | 9 | 2 | 15 | 0 | 0 | 6 | 64 |
| 63. Black-hooded Oriole | *Oriolus xanthornus* | R | 2 | 1 | 0 | 2 | 9 | 2 | 11 | 7 | 0 | 20 | 4 | 1 | 2 | 0 | 0 | 61 |
| XXIX. PASSERIFORMES/ DICRURIDAE | | | | | | | | | | | | | | | | | | | |
| 64. Black Drongo | *Dicrurus macrocercus* | R | 15 | 9 | 4 | 10 | 13 | 32 | 13 | 3 | 8 | 23 | 17 | 4 | 6 | 0 | 9 | 166 |
| 65. Ashy Drongo | *Dicrurus leucophaeus* | M | 3 | 0 | 7 | 3 | 3 | 5 | 6 | 2 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 39 |
| 66. Bronzed Drongo | *Dicrurus aeneus* | F/R | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 24 |
| 67. Greater Racket-tailed Drongo | *Dicrurus paradiseus* | R | 18 | 17 | 0 | 17 | 15 | 52 | 14 | 6 | 17 | 36 | 8 | 22 | 15 | 0 | 18 | 255 |
| XXX. PASSERIFORMES/ | | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *viridirostris* | | | | | | | | | | | | | | | | | |
| 35. Greater Coucal | *Centropus sinensis* | R | 15 | 13 | 32 | 10 | 1 | 26 | 17 | 18 | 23 | 23 | 3 | 18 | 7 | 7 | 25 | 238 |
| XIV. STRIGIFORMES/ STRIGIDAE | | | | | | | | | | | | | | | | | | |
| 36. Brown Fish-owl | *Ketupa zeylonensis* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 37. Mottled Wood-owl | *Strix ocellata* | F/R | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 38. Brown Wood-owl | *Strix leptogrammica* | R | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 39. Spotted Owlet | *Athene brama* | R | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| XV. APODIFORMES/ APODIDAE | | | | | | | | | | | | | | | | | | |
| 40. Little Swift | *Apus affinis* | R | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 0 | 0 | 14 |
| XVI. PASSERIFORMES/ TROGONIDAE | | | | | | | | | | | | | | | | | | |
| 41. Malabar Trogon | *Harpactes fasciatus* | F/R | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| XVII. CORACIIFORMES/ CORACIDAE | | | | | | | | | | | | | | | | | | |
| 42. Indian Roller | *Coracias benghalensis* | R | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 |
| XVIII. CORACIIFORMES/ ALCEDINIDAE | | | | | | | | | | | | | | | | | | |
| 43. Stork-billed Kingfisher | *Pelargopsis capensis* | R | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 5 |
| 44. White-throated Kingfisher | *Halcyon smyrnensis* | R | 5 | 1 | 12 | 0 | 3 | 10 | 4 | 5 | 2 | 9 | 1 | 4 | 0 | 4 | 1 | 61 |
| 45. Common Kingfisher | *Alcedo atthis* | R | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 7 |
| XIX. CORACIIFORMES/ MEROPIDAE | | | | | | | | | | | | | | | | | | |
| 46. Little Green Bee-eater | *Merops orientalis* | R | 15 | 7 | 2 | 3 | 0 | 3 | 4 | 14 | 12 | 0 | 3 | 0 | 0 | 4 | 6 | 73 |
| 47. Blue-tailed Bee-eater | *Merops philippinus* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 2 | 0 | 0 | 0 | 3 | 2 | 18 |
| XX. TROGONIFORMES/ BUCEROTIDAE | | | | | | | | | | | | | | | | | | |
| 48. Malabar Grey Hornbill | *Ocyceros griseus* | F/R/EN | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 |
| XXI. PASSERIFORMES/ MEGALAIMIDAE | | | | | | | | | | | | | | | | | | |
| 49. White-cheeked Barbet | *Megalaima viridis* | R | 32 | 30 | 16 | 11 | 9 | 43 | 15 | 24 | 24 | 24 | 13 | 22 | 20 | 4 | 16 | 303 |
| 50. Coppersmith Barbet | *Megalaima haemacephala* | R | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 5 |

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| XXII. PICIFORMES/ PICIDAE | | | | | | | | | | | | | | | | | | |
| 51. Rufous Woodpecker | *Celeus brachyurus* | F/R | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 52. Black-rumped Flameback | *Dinopium benghalense* | R | 3 | 0 | 2 | 0 | 5 | 7 | 0 | 0 | 6 | 11 | 0 | 0 | 0 | 2 | 2 | 38 |
| 53. Greater Flameback | *Chrysocolaptes lucidus* | F/R | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 54. Heart-spotted Woodpecker | *Hemicircus canente* | F/R | 2 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 10 |
| XXIII. PASSERIFORMES/ PITTIDAE | | | | | | | | | | | | | | | | | | |
| 55. Indian Pitta | *Pitta brachyura* | F/M | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| XXIV. PASSERIFORMES/ ARTAMIDAE | | | | | | | | | | | | | | | | | | |
| 56. Ashy Woodswallow | *Artamus fuscus* | R | 6 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 9 |
| XXV. PASSERIFORMES/ AEGITHINIDAE | | | | | | | | | | | | | | | | | | |
| 57. Common Iora | *Aegithina tiphia* | R | 9 | 8 | 1 | 5 | 0 | 9 | 3 | 10 | 2 | 7 | 0 | 0 | 11 | 3 | 4 | 72 |
| XXVI. PASSERIFORMES/ CAMPEPHAGIDAE | | | | | | | | | | | | | | | | | | |
| 58. Black-headed Cuckooshrike | *Coracina melanoptera* | R | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 59. Small Minivet | *Pericrocotus cinnamomeus* | R | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 5 |
| 60. Scarlet Minivet | *Pericrocotus flammeus* | F/R | 2 | 0 | 0 | 2 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| XVII. PASSERIFORMES/ LANIIDAE | | | | | | | | | | | | | | | | | | |
| 61. Brown Shrike | *Lanius cristatus* | M | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 4 |
| XVIII. PASSERIFORMES/ ORIOLIDAE | | | | | | | | | | | | | | | | | | |
| 62. Eurasian Golden Oriole | *Oriolus oriolus* | M | 3 | 0 | 0 | 0 | 9 | 10 | 0 | 6 | 4 | 9 | 2 | 15 | 0 | 0 | 6 | 64 |
| 63. Black-hooded Oriole | *Oriolus xanthornus* | R | 2 | 1 | 0 | 2 | 9 | 2 | 11 | 7 | 0 | 20 | 4 | 1 | 2 | 0 | 0 | 61 |
| XIX. PASSERIFORMES/ DICRURIDAE | | | | | | | | | | | | | | | | | | |
| 64. Black Drongo | *Dicrurus macrocercus* | R | 15 | 9 | 4 | 10 | 13 | 32 | 13 | 3 | 8 | 23 | 17 | 4 | 6 | 0 | 9 | 166 |
| 65. Ashy Drongo | *Dicrurus leucophaeus* | M | 3 | 0 | 7 | 3 | 3 | 5 | 6 | 2 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 39 |
| 66. Bronzed Drongo | *Dicrurus aeneus* | F/R | 0 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 24 |
| 67. Greater Racket-tailed Drongo | *Dicrurus paradiseus* | R | 18 | 17 | 0 | 17 | 15 | 52 | 14 | 6 | 17 | 36 | 8 | 22 | 15 | 0 | 18 | 255 |
| XXX. PASSERIFORMES/ | | | | | | | | | | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONARCHIDAE | | | | | | | | | | | | | | | | | | |
| 68. Black-naped Monarch | *Hypothymis azurea* | F/R | 10 | 0 | 7 | 0 | 5 | 0 | 4 | 0 | 0 | 13 | 9 | 0 | 2 | 0 | 0 | 50 |
| 69. Asian Paradise-flycatcher | *Terpsiphone paradisi* | M | 7 | 3 | 7 | 1 | 2 | 6 | 3 | 2 | 3 | 4 | 0 | 0 | 2 | 0 | 0 | 40 |
| XXI. PASSERIFORMES /CORVIDAE | | | | | | | | | | | | | | | | | | |
| 70. Rufous Treepie | *Dendrocitta vagabunda* | R | 11 | 11 | 2 | 9 | 23 | 41 | 14 | 5 | 28 | 45 | 3 | 30 | 9 | 2 | 41 | 274 |
| 71. House Crow | *Corvus splendens* | R | 11 | 37 | 30 | 7 | 0 | 50 | 16 | 12 | 37 | 9 | 5 | 16 | 12 | 40 | 18 | 300 |
| 72. Jungle Crow | *Corvus levaillantii* | R | 2 | 0 | 0 | 38 | 1 | 0 | 1 | 8 | 0 | 1 | 4 | 0 | 27 | 25 | 1 | 108 |
| XXII. PASSERIFORMES/ HIRUNDINIDAE | | | | | | | | | | | | | | | | | | |
| 73. Barn Swallow | *Hirundo rustica* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 74. Wire-tailed Swallow | *Hirundo smithii* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| XXIII. CORACIIFORMES/ ALAUDIDAE | | | | | | | | | | | | | | | | | | |
| 75. Malabar Lark | *Galerida malabarica* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 7 |
| XXIV. PASSERIFORMES/ CISTICOLIDAE | | | | | | | | | | | | | | | | | | |
| 76. Grey-breasted Prinia | *Prinia hodgsonii* | R | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 9 |
| 77. Ashy Prinia | *Prinia socialis* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| 78. Plain Prinia | *Prinia inornata* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 2 | 0 | 4 |
| XXV. PASSERIFORMES/ PYCNONOTIDAE | | | | | | | | | | | | | | | | | | |
| 79. Black-crested Bulbul | *Pycnonotus melanicterus* | F/R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 80. Red-whiskered Bulbul | *Pycnonotus jocosus* | R | 29 | 50 | 0 | 72 | 0 | 28 | 44 | 79 | 16 | 1 | 15 | 0 | 68 | 6 | 105 | 513 |
| 81. Red-vented Bulbul | *Pycnonotus cafer* | R | 45 | 8 | 0 | 0 | 8 | 0 | 0 | 13 | 9 | 0 | 2 | 0 | 5 | 0 | 2 | 92 |
| 82. White-browed Bulbul | *Pycnonotus luteolus* | R | 1 | 27 | 0 | 0 | 0 | 1 | 13 | 24 | 0 | 2 | 0 | 0 | 20 | 0 | 10 | 98 |
| 83. Yellow-browed Bulbul | *Iole indica* | F/R | 2 | 5 | 0 | 5 | 4 | 0 | 6 | 2 | 0 | 5 | 34 | 0 | 28 | 0 | 6 | 97 |
| XXVI. PASSERIFORMES/ CISTICOLIDAE | | | | | | | | | | | | | | | | | | |
| 84. Common Tailorbird | *Orthotomus sutorius* | R | 4 | 8 | 4 | 16 | 3 | 7 | 17 | 25 | 6 | 15 | 1 | 1 | 6 | 1 | 13 | 127 |
| XVII. PASSERIFORMES/ ACROCEPHALIDAE | | | | | | | | | | | | | | | | | | |
| 85. Greenish Warbler | *Phylloscopus trochiloides* | M | 2 | 9 | 2 | 6 | 4 | 12 | 0 | 2 | 1 | 0 | 0 | 3 | 10 | 0 | 0 | 51 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 86. Booted Warbler | *Iduna caligata* | M | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| XVIII. PASSERIFORMES/ PELLORNEIDAE | | | | | | | | | | | | | | | | | | |
| 87. Puff-throated Babbler | *Pellorneum ruficeps* | F/R | 3 | 9 | 0 | 6 | 0 | 16 | 7 | 14 | 0 | 40 | 2 | 0 | 3 | 0 | 11 | 111 |
| XIX. PASSERIFORMES/ LEIOTHRICHIDAE | | | | | | | | | | | | | | | | | | |
| 88. Rufous Babbler | *Turdoides subrufa* | F/R/EN | 0 | 0 | 0 | 0 | 9 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 27 |
| 89. Jungle Babbler | *Turdoides striata* | R | 0 | 0 | 0 | 0 | 33 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 42 |
| 90. Yellow-billed Babbler | *Turdoides affinis* | R | 23 | 44 | 0 | 18 | 0 | 21 | 0 | 9 | 0 | 44 | 0 | 8 | 0 | 0 | 70 | 237 |
| XL. PASSERIFORMES/ IRENIDAE | | | | | | | | | | | | | | | | | | |
| 91. Asian Fairy-bluebird | *Irena puella* | F/R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| XLI. PASSERIFORMES/ STURNIDAE | | | | | | | | | | | | | | | | | | |
| 92. Hill Myna | *Gracula religiosa* | R | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 93. Common Myna | *Acridotheres tristis* | R | 10 | 24 | 2 | 0 | 6 | 6 | 15 | 11 | 14 | 2 | 5 | 22 | 1 | 37 | 7 | 162 |
| 94. Chestnut-tailed Starling | *Sturnus malabaricus* | M | 23 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| XLII. PASSERIFORMES/ MUSCICAPIDAE | | | | | | | | | | | | | | | | | | |
| 95. Malabar Whistling-thrush | *Myophonus horsfieldii* | F/R | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| XLIII. PASSERIFORMES/ TURDIDAE | | | | | | | | | | | | | | | | | | |
| 96. Orange-headed Thrush | *Zoothera citrina* | F/R | 12 | 1 | 1 | 3 | 1 | 6 | 2 | 2 | 3 | 13 | 1 | 0 | 3 | 0 | 4 | 52 |
| XLIV. PASSERIFORMES/ MUSCICAPIDAE | | | | | | | | | | | | | | | | | | |
| 97. Oriental Magpie-robin | *Copsychus saularis* | R | 14 | 4 | 0 | 16 | 0 | 13 | 10 | 17 | 8 | 8 | 1 | 6 | 13 | 2 | 17 | 129 |
| 98. Indian Robin | *Saxicoloides fulicatus* | R | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 99. Asian Brown Flycatcher | *Muscicapa dauurica* | M | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 4 | 0 | 0 | 0 | 6 |
| 100. Tickell's Blue-flycatcher | *Cyornis tickelliae* | F/R | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| XLV. PASSERIFORMES/ CHLOROPSEIDAE | | | | | | | | | | | | | | | | | | |
| 101. Jerdon's Leafbird | *Chloropsis jerdoni* | R | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 2 | 8 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 102. Golden-fronted Leafbird | *Chloropsis aurifrons* | F/R | 10 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 7 | 32 |
| XLVI. PASSERIFORMES/ DICAEIDAE | | | | | | | | | | | | | | | | | | |
| 103. Pale-billed Flowerpecker | *Dicaeum erythrorhynchos* | R | 0 | 2 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 12 |
| 104. Plain Flowerpecker | *Dicaeum concolor* | F/R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| XLVII. PASSERIFORMES/ NECTARINIIDAE | | | | | | | | | | | | | | | | | | |
| 105. Purple-rumped Sunbird | *Nectarinia zeylonica* | R | 19 | 34 | 35 | 31 | 5 | 49 | 17 | 26 | 29 | 36 | 15 | 33 | 32 | 31 | 43 | 435 |
| 106. Purple Sunbird | *Nectarinia asiatica* | R | 6 | 2 | 0 | 5 | 3 | 3 | 0 | 3 | 5 | 2 | 0 | 0 | 4 | 2 | 11 | 46 |
| 107. Long-billed Sunbird | *Nectarinia lotenia* | R | 0 | 12 | 9 | 14 | 0 | 12 | 19 | 10 | 3 | 4 | 0 | 7 | 26 | 6 | 15 | 137 |
| 108. Little Spiderhunter | *Arachnothera longirostra* | F/R | 0 | 0 | 0 | 0 | 2 | 0 | 3 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 1 | 11 |
| XLVIII. PASSERIFORMES/ ESTRILDIDAE | | | | | | | | | | | | | | | | | | |
| 109. White-rumped Munia | *Lonchura striata* | R | 0 | 0 | 0 | 2 | 0 | 0 | 20 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 25 |
| XLIX. PASSERIFORMES/ MOTACILLIDAE | | | | | | | | | | | | | | | | | | |
| 110. White-browed Wagtail | *Motacilla madaraspatensis* | R | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 111. Paddyfield Pipit | *Anthus rufulus* | R | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 10 |
| Abundance | | | 472 | 439 | 369 | 339 | 265 | 539 | 360 | 539 | 344 | 473 | 203 | 248 | 365 | 434 | 576 | |
| Species Richness | | | 55 | 36 | 31 | 36 | 44 | 40 | 37 | 49 | 35 | 46 | 36 | 23 | 32 | 42 | 54 | |

egend

| | | | |
|---|---|---|---|
| 1 | Cheemeni Kavu | 9 | Mannanpurath Kavu |
| 2 | Edapara Kavu | 10 | Mapetachery Kavu |
| 3 | Edayilekadu | 11 | Poongotu Kavu |
| 4 | Iriveri Kavu | 12 | Pudiya Parambatu Bagavathy Kavu |
| 5 | Kammadam Kavu | 13 | Neeliyar Kavu |
| 6 | Karakka Kavu | 14 | Thazhe Kavu |
| 7 | Kuduvakolangara Kavu | 15 | Verikkara Kavu |
| 8 | Madayi Kavu | R | Resident bird |
| M | Migratory bird | EN | Endemic bird |
| F | Forest birds | | |

| | | | | |
|---|---|---|---|---|
| *Memecylon* sp | 0.72 | 1.49 | 1.01 | 3.224 |
| *Olea dioica* | 2.88 | 4.48 | 4.20 | 11.55 |
| *Sapindus trifoliate* | 2.16 | 2.99 | 2.94 | 8.08 |
| *Toona* sp. | 2.88 | 4.48 | 8.50 | 15.85 |
| *Vitex altissima* | 5.04 | 8.96 | 6.18 | 20.17 |
| *Zanthoxylum rhetsa* | 5.76 | 5.97 | 1.53 | 13.26 |
| Unidentified 1 | 0.72 | 1.49 | 1.09 | 3.3 |
| Unidentified 2 | 6.47 | 7.46 | 1.66 | 15.59 |
| Unidentified 3 | 0.72 | 1.49 | 4.05 | 6.259 |
| Unidentified 4 | 0.72 | 1.49 | 6.23 | 8.443 |
| Unidentified 5 | 0.72 | 1.49 | 1.25 | 3.461 |
| Unidentified 6 | 0.72 | 1.49 | 7.40 | 9.609 |
| Unidentified 7 | 0.72 | 1.49 | 0.45 | 2.662 |

5) Mapetachery Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Vateria indica* | 81.71 | 55.56 | 17.80 | 155.06 |
| *Madhuca neriifolia* | 1.22 | 5.56 | 37.87 | 44.65 |
| *Caryota urens* | 14.63 | 27.78 | 16.38 | 58.79 |
| *Adenanthera pavonina* | 1.22 | 5.56 | 11.11 | 17.89 |
| *Ixora* Sp. | 1.22 | 5.56 | 16.83 | 23.61 |

6) Neeliyar Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Acacia auriculiformis* | 6.06 | 2.86 | 1.06 | 9.98 |
| *Agrostistachys borneensis* | 1.01 | 2.86 | 0.13 | 4 |
| *Anacardium occidentale* | 2.02 | 5.71 | 10.57 | 18.3 |
| *Caryota urens* | 2.02 | 2.86 | 3.96 | 8.83 |
| *Elaeocarpus* sp. | 2.02 | 2.86 | 2.77 | 7.65 |
| *Holigarna arnottiana* | 12.12 | 14.29 | 0.86 | 27.3 |
| *Hopea ponga* | 3.03 | 2.86 | 0.37 | 6.25 |
| *Hydnocarpus pentandra* | 12.12 | 8.57 | 3.17 | 23.9 |
| *Mangifera indica* | 2.02 | 2.86 | 3.27 | 8.14 |
| *Memecylon umbellatum* | 46.46 | 25.71 | 0.99 | 73.2 |
| *Mimusops elengi* | 2.02 | 5.71 | 2.11 | 9.85 |

## Appendix IV

List of tree diversity in the sacred groves of northern Kerala

1) Madayi Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Aglaia elaeagnoidea* | 20.00 | 14.29 | 0.61 | 34.89 |
| *Alstonia scholaris* | 2.86 | 5.71 | 21.00 | 29.57 |
| *Anacardium occidentale* | 1.43 | 2.86 | 21.00 | 25.29 |
| *Benkara malabarica* | 4.29 | 2.86 | 0.75 | 7.892 |
| *Carallia brachiata* | 1.43 | 2.86 | 0.30 | 4.588 |
| *Catunaregam spinosa* | 25.71 | 11.43 | 0.61 | 37.75 |
| *Chionanthus mala-elengi* | 4.29 | 5.71 | 0.61 | 10.61 |
| *Diospyros sp.* | 2.86 | 2.86 | 14.58 | 20.3 |
| *Falconeria insignis* | 12.86 | 14.29 | 2.59 | 29.73 |
| *Gliricidia sepium* | 7.14 | 5.71 | 2.28 | 15.13 |
| *Memecylon randerianum* | 1.43 | 2.86 | 0.11 | 4.399 |
| *Mimusops elengi* | 2.86 | 5.71 | 7.73 | 16.3 |
| *Olea dioica* | 1.43 | 2.86 | 1.49 | 5.779 |
| *Santalum album* | 1.43 | 2.86 | 0.84 | 5.126 |
| *Stereospermum chelonoides* | 1.43 | 2.86 | 18.29 | 22.58 |
| *Strychnos nux-vomica* | 2.86 | 5.71 | 2.24 | 10.81 |
| *Terminalia paniculata* | 2.86 | 2.86 | 2.62 | 8.336 |
| *Vitex altissima* | 2.86 | 5.71 | 2.33 | 10.9 |

2) Mannanpurath Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Adenanthera pavonina* | 6.68 | 6.98 | 2.46 | 16.12 |
| *Ailanthus triphysa* | 0.25 | 2.33 | 8.39 | 10.96 |
| *Alstonia scholaris* | 1.73 | 2.33 | 1.75 | 5.81 |
| *Aphanamixis polystachya* | 0.25 | 2.33 | 0.63 | 3.20 |
| *Caryota urens* | 5.69 | 11.63 | 1.44 | 18.76 |
| *Ficus benghalensis* | 0.74 | 2.33 | 54.16 | 57.23 |

| | | | | |
|---|---|---|---|---|
| *Garcinia Sp* | 0.25 | 2.33 | 1.44 | 4.02 |
| *Holigarna arnottiana* | 29.21 | 11.63 | 0.79 | 41.62 |
| *Hopea ponga* | 31.68 | 13.95 | 1.02 | 46.66 |
| *Hydnocarpus pentandra* | 9.16 | 16.28 | 1.14 | 26.58 |
| *Mangifera indica* | 2.23 | 2.33 | 20.28 | 24.84 |
| *Mesua ferrea* | 0.74 | 4.65 | 0.59 | 5.98 |
| *Mimusops elengi* | 2.72 | 4.65 | 0.33 | 7.70 |
| *Pongamia pinnata* | 1.24 | 6.98 | 1.53 | 9.74 |
| *Strychnos nux-vomica* | 3.47 | 2.33 | 3.12 | 8.91 |
| *Trema orientalis* | 2.48 | 2.33 | 0.63 | 5.43 |
| Unidentified 1 | 1.49 | 4.65 | 0.30 | 6.43 |

3) Thazhe Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Cerbera odollam* | 4.20 | 6.25 | 4.60 | 15.05 |
| *Cinnamomum verum* | 2.52 | 3.13 | 4.38 | 10.02 |
| *Excoecaria agallocha* | 15.97 | 15.63 | 2.18 | 33.77 |
| *Holigarna arnottiana* | 6.72 | 9.38 | 13.21 | 29.31 |
| *Mimusops elengi* | 14.29 | 12.50 | 33.26 | 60.05 |
| *Pongamia pinnata* | 1.68 | 3.13 | 22.15 | 26.96 |
| *Sonneratia caseolaris* | 7.56 | 6.25 | 5.00 | 18.82 |
| *Trema orientalis* | 0.84 | 3.13 | 6.84 | 10.80 |

4) Cheemeni Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Aglaia elaeagnoidea* | 3.60 | 5.97 | 2.07 | 11.64 |
| *Alstonia scholaris* | 0.72 | 1.49 | 1.42 | 3.633 |
| *Anacardium semicarpus* | 0.72 | 1.49 | 2.81 | 5.023 |
| *Briedelia retusa* | 0.72 | 1.49 | 10.03 | 12.24 |
| *Canarium* sp. | 0.72 | 1.49 | 1.70 | 3.912 |
| *Chionanthus mala-elengi* | 11.51 | 10.45 | 29.39 | 51.34 |
| *Euphorbiaceae* | 6.47 | 5.97 | 1.42 | 13.87 |
| *Garcinia* sp. | 32.37 | 14.93 | 3.01 | 50.31 |
| *Ixora brachiata* | 12.95 | 11.94 | 1.67 | 26.56 |

| | | | | |
|---|---|---|---|---|
| *Memecylon* sp | 0.72 | 1.49 | 1.01 | 3.224 |
| *Olea dioica* | 2.88 | 4.48 | 4.20 | 11.55 |
| *Sapindus trifoliate* | 2.16 | 2.99 | 2.94 | 8.08 |
| *Toona* sp. | 2.88 | 4.48 | 8.50 | 15.85 |
| *Vitex altissima* | 5.04 | 8.96 | 6.18 | 20.17 |
| *Zanthoxylum rhetsa* | 5.76 | 5.97 | 1.53 | 13.26 |
| Unidentified 1 | 0.72 | 1.49 | 1.09 | 3.3 |
| Unidentified 2 | 6.47 | 7.46 | 1.66 | 15.59 |
| Unidentified 3 | 0.72 | 1.49 | 4.05 | 6.259 |
| Unidentified 4 | 0.72 | 1.49 | 6.23 | 8.443 |
| Unidentified 5 | 0.72 | 1.49 | 1.25 | 3.461 |
| Unidentified 6 | 0.72 | 1.49 | 7.40 | 9.609 |
| Unidentified 7 | 0.72 | 1.49 | 0.45 | 2.662 |

5) Mapetachery Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Vateria indica* | 81.71 | 55.56 | 17.80 | 155.06 |
| *Madhuca neriifolia* | 1.22 | 5.56 | 37.87 | 44.65 |
| *Caryota urens* | 14.63 | 27.78 | 16.38 | 58.79 |
| *Adenanthera pavonina* | 1.22 | 5.56 | 11.11 | 17.89 |
| *Ixora* Sp. | 1.22 | 5.56 | 16.83 | 23.61 |

6) Neeliyar Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Acacia auriculiformis* | 6.06 | 2.86 | 1.06 | 9.98 |
| *Agrostistachys borneensis* | 1.01 | 2.86 | 0.13 | 4 |
| *Anacardium occidentale* | 2.02 | 5.71 | 10.57 | 18.3 |
| *Caryota urens* | 2.02 | 2.86 | 3.96 | 8.83 |
| *Elaeocarpus* sp. | 2.02 | 2.86 | 2.77 | 7.65 |
| *Holigarna arnottiana* | 12.12 | 14.29 | 0.86 | 27.3 |
| *Hopea ponga* | 3.03 | 2.86 | 0.37 | 6.25 |
| *Hydnocarpus pentandra* | 12.12 | 8.57 | 3.17 | 23.9 |
| *Mangifera indica* | 2.02 | 2.86 | 3.27 | 8.14 |
| *Memecylon umbellatum* | 46.46 | 25.71 | 0.99 | 73.2 |
| *Mimusops elengi* | 2.02 | 5.71 | 2.11 | 9.85 |

| | | | | |
|---|---|---|---|---|
| *Olea dioica* | 3.03 | 5.71 | 0.37 | 9.11 |
| *Strychnos nux-vomica* | 1.01 | 2.86 | 0.09 | 3.96 |
| *Vitex altissima* | 3.03 | 8.57 | 1.67 | 13.3 |
| Unidentified 1 | 1.01 | 2.86 | 0.09 | 3.96 |
| Unidentified | 1.01 | 2.86 | 68.53 | 72.4 |

7) Verikkara Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Acacia auriculiformis* | 1.90 | 3.45 | 6.40 | 11.76 |
| *Adenanthera pavonina* | 1.90 | 3.45 | 1.53 | 6.88 |
| *Alstonia scholaris* | 3.81 | 3.45 | 14.84 | 22.10 |
| *Anacardium occidentale* | 18.10 | 8.62 | 5.11 | 31.83 |
| *Aporusa lindleyana* | 4.76 | 1.72 | 3.62 | 10.11 |
| *Artocarpus heterophyllus* | 1.90 | 1.72 | 2.80 | 6.43 |
| *Bauhinia racemosa* | 0.95 | 1.72 | 0.33 | 3.00 |
| *Briedelia retusa* | 0.95 | 1.72 | 0.37 | 3.05 |
| *Careya arborea* | 0.95 | 1.72 | 0.64 | 3.32 |
| *Carallia brachiata* | 3.81 | 5.17 | 8.92 | 17.90 |
| *Caryota urens* | 0.95 | 1.72 | 3.62 | 6.30 |
| *Delonix regia* | 0.95 | 1.72 | 2.32 | 4.99 |
| *Erythrina sp.* | 0.95 | 1.72 | 2.32 | 4.99 |
| *Falconeria insignis* | 0.95 | 1.72 | 2.93 | 5.61 |
| *Ficus sp.* | 0.95 | 1.72 | 3.62 | 6.30 |
| *Gliricidia sepium* | 6.67 | 6.90 | 1.74 | 15.31 |
| *Holigarna arnottiana* | 4.76 | 5.17 | 0.75 | 10.69 |
| *Hopea parviflora* | 1.90 | 3.45 | 1.30 | 6.66 |
| *Macaranga peltata* | 5.71 | 8.62 | 2.39 | 16.73 |
| *Madhuca sp.* | 0.95 | 1.72 | 9.27 | 11.94 |
| *Mallotus philippensis* | 1.90 | 3.45 | 0.73 | 6.09 |
| *Mangifera indica* | 0.95 | 1.72 | 3.34 | 6.01 |
| *Evodia lunu-ankenda* | 1.90 | 1.72 | 0.26 | 3.89 |
| *Olea dioica* | 0.95 | 1.72 | 2.09 | 4.77 |
| *Chrysophyllum cainito* | 0.95 | 1.72 | 0.64 | 3.32 |
| *Sterospermum* | 0.95 | 1.72 | 1.77 | 4.45 |
| *Strychnos nux-vomica* | 3.81 | 3.45 | 1.96 | 9.21 |
| *Syzygium caryophyllatum* | 8.57 | 3.45 | 1.74 | 13.76 |
| *Tabernaemontana heyneana* | 4.76 | 5.17 | 1.15 | 11.09 |
| *Trema orientalis* | 8.57 | 3.45 | 1.00 | 13.02 |
| *Zanthoxylum rhetsa* | 1.90 | 3.45 | 1.67 | 7.03 |

| | | | | |
|---|---|---|---|---|
| *Zizyphus trinervia* | 0.95 | 1.72 | 8.81 | 11.49 |

8) Bagavathy Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Caryota urens* | 4.13 | 8.70 | 5.74 | 18.57 |
| *Holigarna arnottiana* | 17.36 | 39.13 | 20.91 | 77.39 |
| *Hopea ponga* | 76.86 | 43.48 | 6.02 | 126.36 |
| *Strychnos nux-vomica* | 1.65 | 8.70 | 67.32 | 77.67 |

9) Edayilekadu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Acacia mangium* | 3.45 | 2.63 | 5.14 | 11.22 |
| *Adenanthera pavonina* | 2.30 | 2.63 | 3.45 | 8.38 |
| *Aglaia elaeagnoidea* | 16.09 | 5.26 | 2.09 | 23.44 |
| *Anacardium occidentale* | 1.15 | 2.63 | 11.14 | 14.92 |
| *Artocarpus hirsutus* | 1.15 | 2.63 | 11.14 | 14.92 |
| *Caryota urens* | 2.30 | 5.26 | 2.45 | 10.01 |
| *Cinnamomum malabatrum* | 8.05 | 7.89 | 2.83 | 18.77 |
| *Diospyros peregrina* | 3.45 | 5.26 | 13.59 | 22.30 |
| *Holigarna arnottiana* | 17.24 | 15.79 | 13.46 | 46.49 |
| *Hopea parviflora* | 2.30 | 5.26 | 1.90 | 9.46 |
| *Hopea ponga* | 10.34 | 10.53 | 2.15 | 23.02 |
| *Madhuca neriifolia* | 8.05 | 7.89 | 5.29 | 21.24 |
| *Syzygium sp.* | 4.60 | 2.63 | 1.98 | 9.21 |
| *Syzygium zeylanicum* | 2.30 | 2.63 | 4.18 | 9.11 |
| *Vateria indica* | 2.30 | 5.26 | 7.82 | 15.38 |
| *Vitex altissima* | 6.90 | 7.89 | 10.28 | 25.07 |
| Unidentified 1 | 1.15 | 2.63 | 0.63 | 4.41 |
| Unidentified 2 | 6.90 | 5.26 | 0.48 | 12.64 |

10) Iriveri Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Acacia auriculiformis* | 2.08 | 2.04 | 5.40 | 9.53 |
| *Adenanthera pavonia* | 14.58 | 12.24 | 6.86 | 33.69 |
| *Anacardium occidentale* | 1.04 | 2.04 | 2.67 | 5.75 |
| *Carallia brachiata* | 3.13 | 4.08 | 8.48 | 15.68 |
| *Caryota urens* | 2.08 | 4.08 | 1.97 | 8.14 |
| *Cinnamomum perrottetii* | 1.04 | 2.04 | 4.17 | 7.26 |
| *Gliricidia sepium* | 2.08 | 4.08 | 4.71 | 10.88 |
| *Holigarna arnottiana* | 11.46 | 10.20 | 15.95 | 37.61 |
| *Hydnocarpus pentandra* | 7.29 | 6.12 | 7.73 | 21.14 |
| *Lagerstroemia flos-reginae* | 5.21 | 4.08 | 7.33 | 16.62 |
| *Leucaena leucocephala* | 1.04 | 2.04 | 1.26 | 4.35 |
| *Mimusops elengi* | 2.08 | 4.08 | 7.75 | 13.92 |
| *Olea dioica* | 14.58 | 14.29 | 1.54 | 30.41 |
| *Santalum album* | 2.08 | 4.08 | 3.77 | 9.93 |
| *Strychnos colubrina* | 3.13 | 2.04 | 10.91 | 16.08 |
| *Syzygium caryophyllatum* | 7.29 | 6.12 | 1.59 | 15.01 |
| *Vitex altissima* | 17.71 | 12.24 | 5.22 | 35.17 |
| Unidentified 1 | 1.04 | 2.04 | 1.63 | 4.71 |
| Unidentified 2 | 1.04 | 2.04 | 1.04 | 4.13 |

11) Kammadam Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Alstonia scholaris* | 1.04 | 3.23 | 0.92 | 5.19 |
| *Cinnamomum sp* | 2.08 | 6.45 | 4.47 | 13 |
| *Holigarna arnottiana* | 1.04 | 3.23 | 0.75 | 5.01 |
| *Hopea ponga* | 5.21 | 3.23 | 0.09 | 8.53 |
| *Ixora sp.* | 1.04 | 3.23 | 1.42 | 5.69 |
| *Lagerstroemia* | 1.04 | 3.23 | 5.32 | 9.58 |
| *Litsea Sp.* | 10.42 | 16.13 | 2.01 | 28.56 |
| *Myristica malabarica* | 61.46 | 29.03 | 1.86 | 92.35 |
| *Olea dioica* | 1.04 | 3.23 | 0.11 | 4.37 |
| *Tetrameles nudiflora* | 1.04 | 3.23 | 7.03 | 11.30 |
| Unidentified 1 | 1.04 | 3.23 | 28.94 | 33.21 |
| Unidentified 2 | 6.25 | 3.23 | 8.58 | 18.06 |
| Unidentified 3 | 1.04 | 3.23 | 17.22 | 21.49 |

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|---|---|---|---|---|
| Unidentified 4 | 1.04 | 3.23 | 1.33 | 5.60 |
| Unidentified 5 | 1.04 | 3.23 | 9.45 | 13.72 |
| Unidentified 6 | 1.04 | 3.23 | 4.47 | 8.73 |
| Unidentified 7 | 2.08 | 3.23 | 0.55 | 5.86 |
| Unidentified 8 | 1.04 | 3.23 | 5.49 | 9.76 |

12) Karaka Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Carallia brachiata* | 0.61 | 6.25 | 58.25 | 65.10 |
| *Holigarna arnottiana* | 0.61 | 6.25 | 2.46 | 9.32 |
| *Hopea ponga* | 24.24 | 12.5 | 1.94 | 38.68 |
| *Mangifera indica* | 1.21 | 12.5 | 32.56 | 46.27 |
| *Vateria indica* | 70.30 | 50 | 3.18 | 123.48 |
| Unidentified 1 | 3.03 | 12.5 | 1.61 | 17.14 |

13) Kuduvakolangara Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Adenthera pavonia* | 2.22 | 3.23 | 1.01 | 6.45 |
| *Alseodaphane semecarpifolia* | 2.22 | 3.23 | 16.10 | 21.54 |
| *Anacardium occidentale* | 4.44 | 6.45 | 22.70 | 33.59 |
| *Aporosa lindleyana* | 6.67 | 9.68 | 2.12 | 18.46 |
| *Artocarpus heterophyllous* | 4.44 | 6.45 | 3.26 | 14.16 |
| *Carelia brachiata* | 6.67 | 6.45 | 6.71 | 19.83 |
| *Caryota urens* | 2.22 | 3.23 | 5.09 | 10.54 |
| *Elaeocarpus serratus* | 4.44 | 6.45 | 2.42 | 13.31 |
| *Ficus sp.* | 8.89 | 3.23 | 16.10 | 28.21 |
| *Holigarna arnotiana* | 26.67 | 12.90 | 3.66 | 43.23 |
| *Macaranga peltata* | 11.11 | 12.90 | 2.58 | 26.59 |
| *Mangifera indica* | 4.44 | 3.23 | 3.54 | 11.21 |
| *Mimosops elengi* | 2.22 | 3.23 | 2.26 | 7.71 |
| *Olea Dioica* | 2.22 | 3.23 | 2.26 | 7.71 |

| | | | | |
|---|---|---|---|---|
| *Stryconus nux-vomica* | 2.22 | 3.23 | 1.57 | 7.02 |
| *Syzigium sp.* | 2.22 | 3.23 | 1.57 | 7.02 |
| *Tectona grandis* | 2.22 | 3.23 | 6.29 | 11.74 |
| *Vitex altissima* | 4.44 | 6.45 | 0.77 | 11.67 |

14) Edapara Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Acacia auriculiformis* | 7.20 | 7.58 | 5.28 | 20.05 |
| *Anacardium occidentale* | 8.80 | 9.09 | 8.01 | 25.90 |
| *Briedelia retusa* | 0.80 | 1.52 | 2.77 | 5.08 |
| *Carallia brachiata* | 24.80 | 13.64 | 4.78 | 43.22 |
| *Caryota urens* | 4.00 | 6.06 | 13.62 | 23.68 |
| *Cinnamomum sp* | 5.60 | 9.09 | 3.49 | 18.18 |
| *Holigarna arnottiana* | 16.80 | 15.15 | 9.13 | 41.08 |
| *Hydnocarpus pentandra* | 2.40 | 4.55 | 5.15 | 12.10 |
| *Macaranga peltata* | 0.80 | 1.52 | 2.51 | 4.82 |
| *Evodia lunu-ankenda* | 4.00 | 3.03 | 3.26 | 10.29 |
| *Mimusops elengi* | 3.20 | 6.06 | 5.18 | 14.45 |
| *Olea dioica* | 3.20 | 4.55 | 1.71 | 9.45 |
| *Santalum album* | 4.00 | 4.55 | 1.49 | 10.03 |
| *Strychnos nux-vomica* | 3.20 | 3.03 | 18.46 | 24.69 |
| *Syzygium caryophyllatum* | 7.20 | 4.55 | 5.32 | 17.06 |
| *Vitex altissima* | 2.40 | 3.03 | 7.54 | 12.97 |
| Unidentified 1 | 0.80 | 1.52 | 0.90 | 3.22 |
| Unidentified 2 | 0.80 | 1.52 | 1.41 | 3.73 |

15) Poongotu Kavu

| Species | Relative Density | Relative Frequency | Relative Basal area | IVI |
|---|---|---|---|---|
| *Agrostistachys borneensis* | 2.78 | 4.55 | 2.29 | 9.62 |
| *Artocarpus hirsutus* | 0.93 | 2.27 | 9.71 | 12.91 |
| *Elaeocarpus tuberculatus* | 2.78 | 4.55 | 17.40 | 24.72 |
| *Gymnacranthera furcariana* | 3.70 | 6.82 | 3.47 | 13.99 |
| *Holigarna arnotiana* | 12.96 | 15.91 | 4.64 | 33.51 |
| *Hopea parviflora* | 0.93 | 2.27 | 0.69 | 3.89 |
| *Hopea ponga* | 5.56 | 9.09 | 7.55 | 22.20 |

# BIRD COMMUNITY STRUCTURE IN THE SACRED GROVES OF NORTHERN KERALA

By

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## ABSTRACT

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## ABSTRACT

A study on the 'Bird community structure in the sacred groves of northern Kerala' was carried out during 2011-2014. Fifteen sacred groves, eight from Kannur and seven from Kasargod districts were selected for the study.

The bird community was studied at each of these sacred groves. The bird study was done for three hours from 7h to 11h and 15h to 18h in each of the fifteen sacred groves. The study was repeated once in every two months in each of the sacred groves between March 2012 to December 2013. Thus a total of 168 visits and 1008 h of field work is done during the study period. The bird diversity was then correlated with various variables such as the size of the sacred grove, distance of the sacred grove to the nearest forest, altitude of the area and tree density.

Tree diversity in the sacred groves was also studied and was correlated to bird diversity. Ten quadrats of 10x10m were taken in each of the sacred groves and trees having more than 10 cm girth was selected and GBH and height was measured.

Socio-economic study was undertaken to know the awareness about the birds of the sacred grove and the perception about the significance of sacred grove among villagers. Ten respondents from each of the sacred groves were interviewed.

A total of 111 bird species, belonging to 15 orders, 47 families and 90 genera were recorded from the sacred groves of northern Kerala. The species richness per sacred grove ranged from maximum of 55 to minimum 23. And the number of individuals of birds per sacred grove ranged from 576 to 203 birds. The bird diversity was highest in the Cheemeni Kavu, while the bird species richness was highest in the Verikkara Kavu.

Sacred groves of northern Kerala supported 86.48 per cent of resident birds and 14.52 per cent of migratory birds. Twenty five percent of the birds found in the sacred groves were found to be forest-dependent birds. Two species of birds that are endemic to Western Ghats *viz.*, Malabar Grey Hornbill (*Ocyceros griseus*) and Rufous Babbler (*Turdoides subrufa*) were recorded from sacred groves of northern Kerala.

The bird community of the Kammadam Kavu and Thazhe Kavu was found to be distinct among the 15 sacred groves studied using the Correspondence analysis. Dendrogram based on Bray-Curtis similarity matrix identified broadly three clusters viz. Karaka Kavu to Cheemeni Kavu, Edapara Kavu to Kuduvakolangara Kavu and Thazhe Kavu to Kammadam Kavu.

The numbers of endemic birds were found to be greatly influenced by the extent of the sacred grove. However number of forest birds was influenced by the altitude and tree density.

A total of 130 tree species were reported from the sacred groves of northern Kerala. 14 species of trees were endemic to Western Ghats and seven were threatened, this includes one Critically Endangered (*Vateria indica*) and four Endangered (*Hopea ponga, Hopea parviflora* and *Chionanthus mala-elengi, Evodia lunu-anekanda*) and two Vulnerable tree (*Cinnamomum perrottetii, Santalum album*) species.

Respondents in the sacred groves of northern Kerala had medium awareness about the birds and perception about the significance of the sacred groves of northern Kerala. Awareness was found to be influenced by caste, gender, education, knowledge about bird diversity in sacred grove and understanding the beneficial effect by birds among the respondents. The

perception was influenced by occupation of the respondent, knowledge about bird diversity in sacred grove and understanding of beneficial effect by birds among the respondents.

Important threats faced by sacred groves in northern Kerala were encroachment, degradation of vegetation in the sacred grove, dumping of waste into the sacred groves, deposition of solid waste through contaminated water, passages within the sacred grove, use of sacred grove for anti-social activities like for consumption of liquor, playing cards etc, and various construction activities taking places in some of the sacred groves.

The Government should step in and take some bold initiatives for the conservation of the sacred groves. Incentives should be provided for the owners of the sacred groves for preserving these important biodiversity repositories outside the reserved forests and protected areas. Restoration planting should be taken up in the degraded sacred groves with community participation.