AREA DEPENDANT DISTRIBUTION OF AVIFAUNA IN THE SACRED GROVES OF NORTHERN KERALA, INDIA

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The sacred groves otherwise called sacred forests are small patches of natural habitats that act as a refugee for many species which are being protected by religious reasons. Seven sacred forests, are selected that belongs to Kerala, India having the areas varies between 3 and 6.4 hectares. The bird diversity in these selected sacred forests were studied from December 2017 to May 2019. The point count method was used for the bird survey which recorded 88 species of birds. A higher bird species richness was observed in Nelair kottam (6.4 ha) with 49 species, which is the largest study sites among the study sites and the less number of bird species belongs to Poil kavu (4.4 ha) with 14 species of birds. Shannon-Weiner Index was employed to determine the bird species diversity. Species-Area relationship in these ecosystems is also estimated. This study highlights that the area of the sacred forest is one of the important factors in determining the species richness and abundance of birds.

Keywords: Avifauna, sacred groves, point count, Shannon-Wiener Index, species-area relationship.

INTRODUCTION

Sacred forests, otherwise called sacred groves, are fragments of landscapes containing vegetation, life forms and geographical features, delimited and protected by human societies in a relatively undisturbed state, which usually have a religious connotation (Hughes & Chandran, 1998). These forests have historical existence from the pre-agricultural era and most of these conserve pristine vegetation (Gadgil & Vartak 1975). Religious and cultural beliefs are the major driving force behind the conservation of these forest patches (Ormsby & Bhagwat, 2010). They vary in size depending on their location and management profile. These are considered to be a small conservative area that provides ground for maintaining biodiversity and thus helps in the conservation of local and endemic species (Bhagwat *et al*., 2005; Kushalappa & Raghavendra, 2012). This is a very old tradition and still exists in various forms across the globe (Bhagwat & Rutte, 2006). Even though the estimation of the number of sacred groves found in India is difficult, recorded around 13,720 sacred groves from 19 states (Gokhale *et al*., 2001).

The state of Kerala, is also rich in sacred groves, recorded around 2000 sacred groves contributing 0.15% of land. The total area of these sacred groves

varies from 0.01 hectares to 24 hectares, with Kammadam kavu (24 hectares) of Kasargod district as the largest sacred grove. Sacred groves are called "kavu" in Malayalam (local language of Kerala), in which some are managed by private temple trustee, some are under devaswam boards, and some are owned by private family members (Chandrashekara & Sankar, 1998), thus signifies the close association of sacred groves with the people. These small conservatory patches support birds even in adverse conditions (Brandt *et al.*, 2013). This study examined the bird abundance, diversity, bird species richness in the sacred groves and also how the distribution of birds are related with the size or area of an ecosystem. This study also tests the species-area curve whether the relationship between bird species and area of sacred groves favors this curve.

Study area

The present study is conducted in seven sacred groves, three from Kasargod, two in Kannur and two sacred groves in Kozhikkode of Northern Kerala, India (Fig. 1). The detailed description of the selected study sites is given in the Table 1.

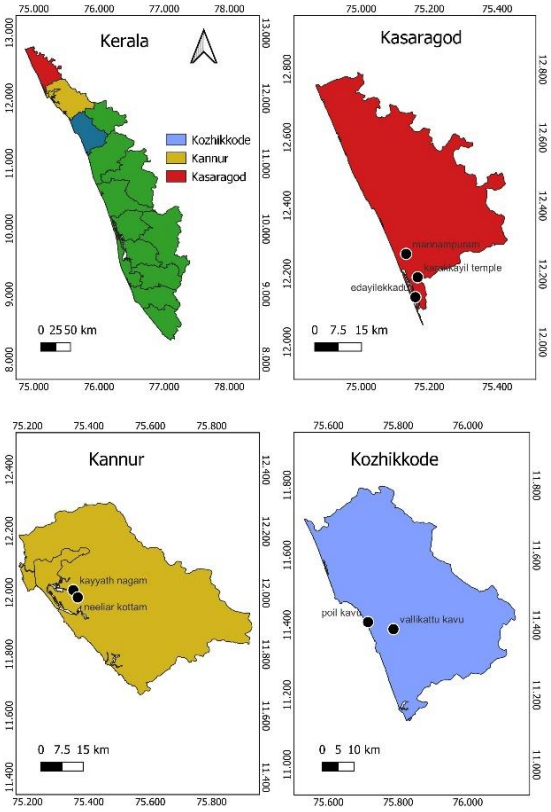

Fig 1. Selected study sites.

Table 1

Selected study sites description

Sl no	Sacred grove	Area (ha)	Coordinates	Ownership	Water source	Adjacent habitat
1.	Mannampuram kavu (Kasargod)	3	12.258608 75.132317	Malabar devaswam board	pond	Home steads
2.	Karakkayil kavu (Kasargod)	6	12.190213 75.166295	Private temple trust	Pond	field
3.	Neliar kottam (Kannur)	6.4	11.985404 75.363928	Private temple trust	Well	Home steads
4.	Kayyath nagam (Kannur)	6	12.009116 75.349348	Private temple trust	Pond	Hill top
5.	Edayilekadu kavu (Kannur)	5.2	12.131795 75.159621	Private trust	pond	Fields, home steads
6.	Poil kavu (kozhikkode)	4.4	11.408626 75.71358	Private temple trust	Nil	Home steads
7.	Vallikkatu kavu (kozhikkode)	6.3	11.38834 75.786571	Malabar devaswam board	stream	Fields

MATERIAL AND METHODS

Fixed point count method was used to determine the bird species abundance and diversity (Bibby *et al*., 1992; Raman, 2003) with five minutes duration after three hours of sunrise with 25 metre apart from each point. All the birds heard or seen within 30 metre radius at each point are recorded using binoculars (10 × 50) and the birds were identified using field guides (Grimmet & Inskipp, 2005).

The details included the number of bird species, the number of individual species and the distance from point of observation. This bird count was repeated once every two months from December 2017 to May 2019.

The obtained data is analyzed to detect the species richness abundance and diversity of bird species. The association between the area of patch and bird species is also analyzed to obtain the area-dependent distribution of birds in the selected sacred groves. All the data were analyzed using Microsoft excel 2011 version and SPSS software 2011 version.

RESULTS AND DISCUSSION

Bird species richness and diversity analysis

A total of 88 bird species were recorded from the seven sacred groves which belong to 41 families and 13 orders. Passeriformes were the most dominant (67%), followed by Piciformes (4.8%) and Coraciiformes (4.8%) (Table 2).

Table 2

Family wise distribution of birds

Sl. no	Family	Order
1.	Corvidae	Passeriformes
2.	Leiothrichidae	
3.	Nectariniidae	
4.	Sturnidae	
5.	Pycnonotidae	
6.	Dicruridae	
7.	Dicaeidae	
8.	Muscicapidae	
9.	Pittidae	
10.	Timaliidae	
11.	Oriolidae	
12.	Monarchidae	
13.	Chloropseidae	
14.	Rhipiduridae	
15.	Phylloscopidae	
16.	Acrocephalidae	
17.	Cisticolidae	
18.	Paridae	
19.	Laniidae	Passeriformes
20.	Vangidae	
21.	Pellorneidae	
22.	Zosteropidae	
23.	Turdidae	
24.	Campephagidae	

Table 2 (continued)

Sl. no	Family	Order
25.	Aegithinidae	
26.	Alcippeidae	
27.	Sittidae	
28.	Megalaimidae	Piciformes
29.	Picidae	
30.	Cuculidae	Cuculiformes
31.	Alcedinidae	Coraciiformes
32.	Meropidae	
33.	Hemiprocnidae	Apodiformes
34.	Strigidae	Strigiformes
35.	Accipitridae	Accipitriformes
36.	Apodidae	Apodiformes
37.	Phasianidae	Galliformes
38.	Rallidae	Gruiformes
39.	Psittaculidae	Psittaciformes
40.	Columbidae	Columbiformes
41.	Ardeidae	Pelecaniformes

Species abundance was more in Vallikkatu kavu (6.3 ha) with 131 individuals. Neliar kottam (6.4 ha) has 110 individuals where as 86 individuals were recorded from karakkayil kavu (6 ha). Least number of individual bird species was from Poil kavu (4.4 ha) with 25 individuals (Table 3).

Table 3

Descriptive statistics

Camp	Mannampuram (3 ha)	Karaka kavu (6 ha)	Neliar kottam (6.4 ha)	Edayilekadu kavu (5.2 ha)	Kayyath Nagam (6ha)	Poil kavu (4.4ha)	Vallikkatu kavu (6.3ha)
No. of species	27	43	49	33	30	14	37
Species abundance*	52	86	110	79	79	25	131
Shannon index	1.303	1.574	1.635	1.534	1.41	0.801	1.473
Mean individuals	0.591	0.977	1.25	0.898	0.898	0.284	1.489
Standard deviation*	1.21	1.313	1.464	1.26	1.547	1.241	2.344

*Species abundance - It is the number of individual birds belongs to different species in respective study sites;
*Standard deviation - Deviation from the mean value. Most of the data points are adjacent to each other indicting close resemblance between study sites in species composition and sample 6 is deviated more indicates Vallikkatu kavu has difference in bird species composition and showing more diverse bird species than others.

Neliar kottam (6.4 ha) had the most number of bird species whereas Poil kavu (4.4 ha) recorded 14 species (Fig. 2). Bird species diversity is determined by Shannon- Weiner index (Table 3) and feeding guild structure is also determined (Fig. 3). Most of them were insectivorous (37/88).

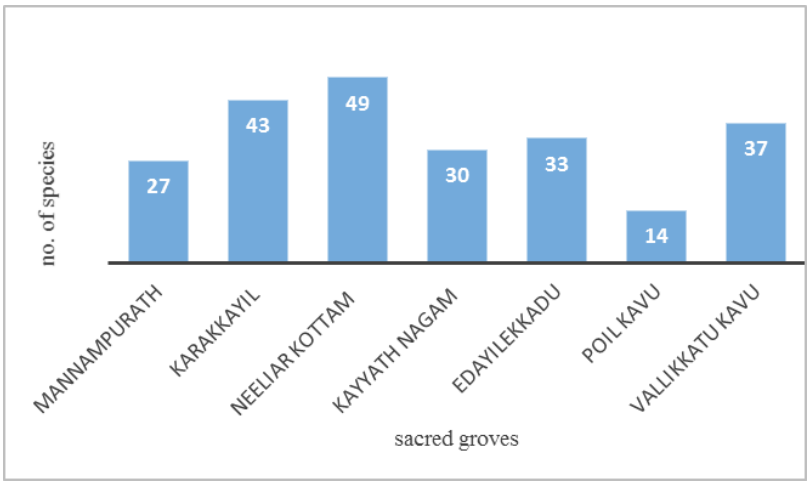

Fig. 2. Number of bird species in study sites recorded of Northern Kerala.

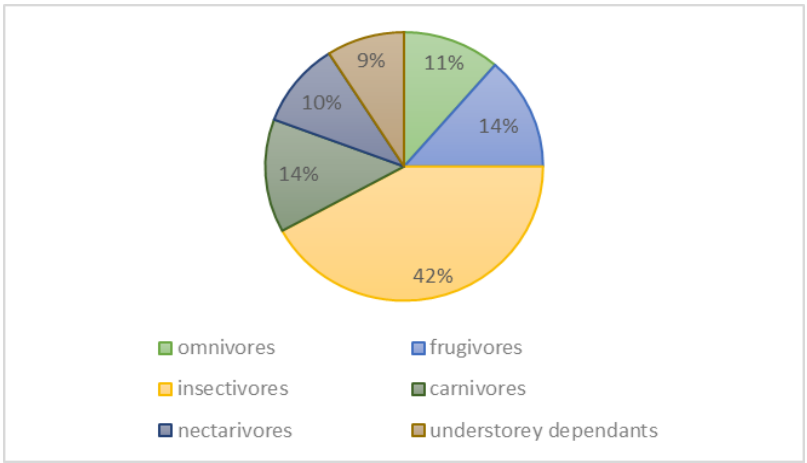

Fig 3. Feeding guild structure of birds.

Species richness or number of bird species belongs to each sacred grove is determined. The study sites, when arranging in descending order of species richness, will follow the pattern-Neliar kottam (49 bird species)>Karakkayil kavu (43)> Vallikkatu kavu (37)>Edayilekadu kavu (33)>Kayyath Nagam kavu (30)> Mannampurath kavu (27)> Poil kavu (14).

Neliar kottam contribute more percentage of bird species (55.68%), Karakkayil kavu has 48.86% of total identified bird species. Vallikkatu kavu recorded 42.04% bird species, Edayilekadu kavu has 37.5% of total bird species whereas Kayyath Nagam kavu has 34.09% bird species. Mannampurath kavu recorded 30.68% species of birds and the least percentage of bird species is recorded in Poil kavu with 15.90% of the total recorded bird species from all the selected study sites.

The sacred groves provide roosting and nesting sites for many birds. Poil kavu sacred grove is a roosting site for brown fish owl, brahminy kite. The threatened species white bellied sea eagle is nested in Edayile kadu sacred grove, its nesting and breeding were reported from here in 2000 (Palot, 2011), and even this time also, this species continues to choose Edayile kadu sacred grove as its nesting site, which is a good sign that these small patches act as refugee sites for endemic and endangered species.

To find out the area dependency of birds, a graph is plotted with bird species abundance and Area (ha) as coordinates, by using logarithmically transformed species numbers and area (Fig. 4). This study favors the species-area curve graph with R value equals 0.65 (R^2 = 0.4245) indicating that area of the ecosystem and the bird species richness has some correlation between themselves highlights that area of an ecosystem is a major factor that determine the bird species diversity and also indicates, apart from the area, some other factors influence the species diversity. The diversity of bird species is dependent on multiple factors, if the area is the primary factor, then a linear graph would be obtained in this study, thus highlighting the role of some other factors such as vegetation, climatic conditions, seasonal variations in determining the species abundance in an ecosystem.

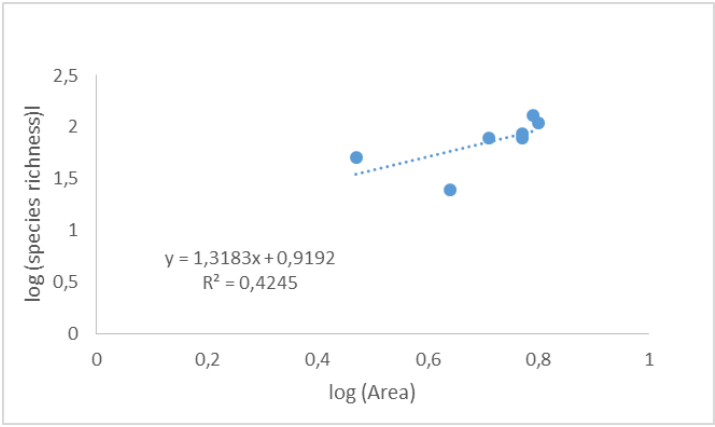

Fig. 4. Bird species-area relationship observed in the sacred groves of Northern Kerala.

The most widely used model to examine the species area relationship is $S=cA^z$, where S is species richness, A is the area, and c and z are constants. The value of slope (z), as plotted from this study is 1.31 and the intercept (c) is 0.91 (Fig. 4). The species-area relationship of birds are similar with other studies (Brashares *et al.*, 2001; Olivier *et al.*, 2013).

Species-area models have become the primary tool to predict baseline extinction rate for species in isolated habitats and have influenced conservation and land use planning worldwide (Brashares *et al.*, 2001). Extinction is an ongoing process ad its rate is predicted to increase due to increase rate of habitat conversion and to the extension debt, which is the future ecological cost of current habitat destruction, where the loss of natural habitats causes time-delayed extinctions (Tilman *et al.*, 1994). Conversion of natural habitats by human would reduce the species number and may leads to extinctions. An extinction debt may present in the human modified landscapes (Báldi & Vörös, 2006; Szabo *et al*., 2011), where the conversion of habitats results in species loss. The extinction debt is predicted by using species area curve (Olivier *et al*., 2013). This may happen in the sacred groves too, where the human activities such as deforestation, encroachment in these small patches would result in the species loss in future. As seen from this study, in case of white bellied sea eagle, which is nested in the sacred grove, it may lose its habitat when any anthropological disturbance occur in that landscape in future.

Sacred groves can be considered as examples for in situ biodiversity conservation (Sharma & Devi, 2014) .These are responsible for conserving natural resources by religious informal rules and regulations (Narasimha, 2015; Singh *et al*., 2017). These are not categorized as formal protected areas but may have conservational importance as that of protected areas (Boraiah *et al.*, 2003). Many endemic species are being conserves in these small islets and the proper management of these patches would ensure the protection of native species.

The details of bird species recorded from all the studied sacred groves is given in Table 4.

Table 4

Bird species recorded in each sacred groves

Sl no	Common name	Species	Family	Mannampuram	Karakayil kavu	Neliarkottam	Edayilekadu	Kayyath Nagam	Poil kavu	Vallikkatu kavu
1	House crow	*Corvus splendens*	Corvidae	5	4	4	6	4	5	5
2	Rufous treepie	*Dendrocitta vagabunda*	Corvidae	3	5	5	5	3	1	4
3	White cheeked barbet	*Megalaima viridis*	Megalaimidae	2	4	4	2	4	1	3
4.	Asian koel	*Eudynamys scolopaceus*	Cuculidae	0	3	3	1	2	0	0

Table 4 (continued)

Sl no	Common name	Species	Family	Mannampuram	Karakayil kavu	Neliarkottam	Edayilekadu	Kayyath Nagam	Poilkavu	Vallikkatukavu
5	White throated kingfisher	*Halcyon smyrnensis*	Alcedinidae	1	2	1	2	1	0	2
6	Crested tree swift	*Hemiprocne coronata*	Hemiprocnidae	0	1	3	2	2	0	1
7	Yellow billed babbler	*Turdoides affinis*	Leiothrichidae	4	3	5	4	7	0	6
8	Purple sunbird	*Cinnyris asiaticus*	Nectariniidae	1	1	2	1	2	0	6
9	Chestnut tailed starling	*Sturnia malabarica*	Sturnidae	3	0	0	0	0	0	0
10	Red vented bulbul	*Pycnonotus cafer*	Pycnonotidae	2	1	2	1	4	0	5
11	Indian golden oriole	*Oriolus kundoo*	Oriolidae	1	2	2	1	3	0	4
12	Jungle owlet	*Glaucidium radiatum*	Strigidae	1	1	1	0	1	0	2
13	Greater racket tailed drongo	*Dicrurus paradiseus*	Dicruridae	6	7	7	4	6	10	8
14	Purple rumped sunbird	*Leptocoma zeylonica*	Nectariniidae	2	1	3	2	2	0	4
15	Nilgiri flowerpecker	*Dicaeum concolor*	Dicaeidae	2	1	2	1	0	0	2
16	Black rumped flameback	*Dinopium benghalense*	Picidae	2	3	2	2	2	1	3
17	Black naped oriole	*Oriolus chinensis*	Oriolidae	0	1	2	2	1	0	1
18	Pale billed flowerpecker	*Dicaeum erythrorhynchos*	Dicaeidae	2	0	2	0	0	0	0
19	Black drongo	*Dicrurus macrocercus*	Dicruridae	1	2	1	1	0	1	2
20	Red whiskered bulbul	*Pycnonotus jocosus*	Pycnonotidae	2	0	4	3	6	0	12
21	Oriental magpie robin	*Copsychus saularis*	Muscicapidae	4	0	1	1	3	0	5
22	Greater coucal	*Centropus sinensis*	Cuculidae	1	2	2	1	3	1	4
23	Black kite	*Milvus migrans*	Accipitridae	1	0	0	0	0	0	0
24	Indian pitta	*Pitta brachyura*	Pittidae	1	1	1	0	0	0	2
25	Blue Capped rock thrush	*Monticola cinclorhynchus*	Muscicapidae	1	0	0	0	2	0	0
26	Dark fronted babbler	*Rhopocichla atriceps*	Timaliidae	3	0	0	2	0	0	0
27	blue tailed bee eater	*Merops philippinus*	Meropidae	1	0	2	0	0	0	0
28	Asian green bee eater	*Merops orientalis*	Meropidae	0	2	1	0	0	0	0

Table 4 (continued)

Sl no	Common name	Species	Family	Mannampuram	Karakayil kavu	Neliarkottam	Edayilekadu	Kayyath Nagam	Poilkavu	Vallikkatukavu
29	Black naped oriole	*Oriolus chinensis*	Oriolidae	0	1	2	1	0	0	2
30	Indian paradise flycatcher	*Terpsiphone paradisi*	Monarchidae	0	1	4	2	2	0	0
31	Common myna	*Acridotheres tristis*	Sturnidae	0	3	4	0	3	0	5
32	yellow browed bulbul	*Acritillas indica*	Pycnonotidae	0	1	0	0	0	0	0
33	Ashy drongo	*Dicrurus leucophaeus*	Dicruridae	0	1	0	0	0	0	3
34	crested serpent eagle	*Spilornis cheela*	Accipitridae	0	1	1	0	1	0	1
35	Tikell's blue flycatcher	*Cyornis tickelliae*	Muscicapidae	0	1	0	0	0	0	0
36	Golden fronted leafbird	*Chloropsis aurifrons*	Chloropseidae	0	2	0	0	0	0	0
37	White browed fantail	*Rhipidura aureola*	Rhipiduridae	0	3	3	0	0	0	0
38	large billed leaf warbler	*Phylloscopus magnirostris*	Phylloscopidae	0	2	0	0	0	0	0
39	Blyth's reed warbler	*Acrocephalus dumetorum*	Phylloscopidae	0	1	2	0	0	0	0
40	common tailorbird	*Orthotomus sutorius*	Acrocephalidae	0	2	0	2	0	0	0
41	ashy prinia	*Prinia socialis*	Cisticolidae	0	1	0	0	0	0	0
42	cinereous tit	*Parus cinereus*	Paridae	0	2	0	0	0	0	0
43	brown shrike	*Lanius cristatus*	Laniidae	0	1	0	1	0	0	0
44	malabar woodshrike	*Tephrodornis sylvicola*	Vangidae	0	2	0	2	2	0	0
45	malabar barbet	*Megalaima malabarica*	Megalaimidae	0	2	0	2	0	0	0
46	common kingfisher	*Alcedo atthis*	Alcedinidae	0	1	0	0	2	0	0
47	brown cheeked fulvetta	*Alcippe poioicephala*	Alcippeidae	0	2	0	0	0	0	0
48	puff throated babbler	*Pellorneum ruficeps*	Pellorneidae	0	2	3	2	3	0	0
49	Indian white eye	*Zosterops palpebrosus*	Zosteropidae	0	2	1	0	0	0	0
50	orange headed thrush	*Geokichla citrina*	Turdidae	0	2	0	0	0	0	0
51	indian robin	*Saxicoloides fulicatus*	Muscicapidae	0	2	2	1	0	0	0

Table 4 (continued)

Sl no	Common name	Species	Family	Mannampuram	Karakayil kavu	Neliarkottam	Edayilekadu	Kayyath Nagam	Poilkavu	Vallikkatukavu
52	pied bushchat	*Saxicola caprata*	Muscicapidae	0	1	1	0	0	0	0
53	Bronzed drongo	*Dicrurus aeneus*	Dicruridae	0	0	2	2	0	0	0
54	Orange minivet	*Pericrocotus flammeus*	Campephagidae	0	0	0	0	2	0	2
55	Crimson backed sunbird	*Leptocoma minima*	Nectariniidae	0	0	2	2	0	0	0
56	Common iora	*Aegithina tiphia*	Aegithinidae	0	0	1	0	0	0	1
57	Jerdon's leafbird	*Chloropsis jerdoni*	Chloropseidae	0	0	2	0	0	0	0
58	Verditer flycatcher	*Eumyias thalassinus*	Muscicapidae	0	0	2	0	0	0	0
59	Asian brown flycatcher	*Muscicapa latirostris*	Muscicapidae	0	0	1	0	0	0	0
60	coppersmith barbet	*Megalaima haemacephala*	Megalaimidae	0	0	2	2	0	0	0
61	Greenish warbler	*Phylloscopus trochiloides*	Phylloscopidae	0	0	1	0	0	0	0
62	Loten's sunbird	*Cinnyris lotenius*	Nectariniidae	0	0	2	0	0	0	4
63	Little spiderhunter	*Arachnothera longirostra*	Nectariniidae	0	0	1	0	0	0	0
64	Flame throated bulbul	*Rubigula gularis*	Pycnonotidae	0	0	1	0	0	0	0
65	Laughing dove	*Spilopelia senegalensis*	Columbidae	0	0	2	0	0	0	0
66	Indian jungle crow	*Corvus culminatus*	corvidae	0	0	2	0	0	0	0
67	Black naped Monarch	*Hypothymis azurea*	Monarchidae	0	0	1	0	0	0	0
68	large billed leaf warbler	*Phylloscopus magnirostris*	Phylloscopidae	0	0	2	0	0	0	0
69	common hawk cuckoo	*Hierococcyx varius*	Cuculidae	0	0	1	1	0	0	1
70	indian tit	*Machlolophus aplonotus*	Paridae	0	0	0	2	0	0	0
71	small minivet	*Pericrocotus cinnamomeus*	Campephagidae	0	0	0	3	0	0	0
72	brown hawk owl	*Ninox scutulata*	Strigidae	0	0	0	0	1	0	0
73	little swift	*Apus affinis*	Apodidae	0	0	0	2	0	0	0
74	Indian nuthatch	*Sitta castanea*	Sittidae	0	0	0	3	0	0	0
75	Jungle myna	*Acridotheres fuscus*	Sturnidae	0	0	0	2	3	0	0
76	spotted dove	*Spilopelia chinensis*	Columbidae	0	0	0	0	1	1	4

Table 4 (continued)

Sl no	Common name	Species	Family	Mannampuram	Karakayil kavu	Neliarkottam	Edayilekadu	Kayyath Nagam	Poil kavu	Vallikkatu kavu
77	black hooded oriole	*Oriolus xanthornus*	Oriolidae	0	0	0	1	0	0	0
78	mottled wood owl	*Strix ocellata*	Strigidae	0	0	0	0	1	0	0
79	white bellied sea eagle	*Haliaeetus leucogaster*	Accipitridae	0	0	0	2	0	0	0
80	Emerald dove	*Chalcophaps indica*	Columbidae	0	0	0	0	0	3	0
81	Brown fish owl	*Bubo zeylonensis*	Strigidae	0	0	0	0	0	1	0
82	Indian pond heron	*Ardeola grayii*	Ardeidae	0	0	0	0	0	0	3
83	Rose ringed parakeet	*Psittacula krameri*	Psittaculidae	0	0	0	0	0	0	5
84	Gray breasted prinia	*Prinia hodgsonii*	Cisticolidae	0	0	0	0	0	0	1
85	Grey junglefowl	*Gallus sonneratii*	Phasianidae	0	0	0	0	0	0	7
86	Cattle egret	*Bubulcus ibis*	Ardeidae	0	0	0	0	0	0	6
87	shikra	*Accipiter badius*	Accipitridae	0	0	0	0	0	0	1
88	White breasted waterhen	*Amaurornis phoenicurus*	Rallidae	0	0	0	0	0	0	4
				52	86	110	79	79	25	131

CONCLUSIONS

Sacred groves are small conservatory regions that are protected based on religious aspects. Apart from religious importance, these patches are responsible for the conservation of species and are also home to numerous bird species as seen from this study. Despite its closeness to human habituations and small area/size, these patches act as a refugee to many living species, as seen in the case of white bellied sea eagle. Poil kavu (4.4 ha), even though this has an ample area to support bird life, limited number of bird species is reported from here as compared to other sacred groves in this study. It highlights that, apart from area, there are some other factors responsible for the bird diversity. Level of disturbance, human activities inside the sacred grove may also affect the species abundance. Proper fencing, management policies would promote conservation of these small patches thereby conserving the endemic and endangered species. Conservation and proper management of these islands are necessary in the human dominated landscapes since their presence ensures the ecosystem balance.

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