

18. Lin, S., Jiang, D. and William, P. F., Importance of differentiating ductile slickenside striation from stretching lineation and variation of shear direction across a high strain zone. *J. Struct. Geol.*, 2007, **29**, 850–862.
19. Passchier, C. W. and Sara, C., An outline of shear-sense analysis in high-grade rocks. In *Memoirs of Gondwana Research: Crustal Structure and Tectonic Evolution of the Southern Granulite Terrain, India* (eds Chetty, T. R. K. *et al.*), 2006, pp. 66–76.
20. Santosh, M., Shigenori, M. and Sato, K., Anatomy of a Cambrian suture in Gondwana: Pacific-type orogeny in southern India? *Gondwana Res.*, 2009 (in press).
21. Geological Survey of India, District Resource Map, Karnataka Office, Bangalore, 2005.

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Monitoring bird diversity in Western Ghats of Kerala

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This communication elaborates a case study in Kerala, where 61 surveys have been conducted from 1990 to 2008 in 21 protected areas and reserve forests in the southern Western Ghats for monitoring bird fauna using the amateur bird-watcher network. Four different methodologies have been used in these surveys, with encounter-based transects being the most common. A significant result of these surveys is in identifying the relative conservation value of these forest areas in protecting endemic and threatened avifauna.

THE Western Ghats, identified as one of the biodiversity hotspots of the world, is a 1600 km long chain of mountain ranges running parallel to the western coast of the Indian peninsula. Among the three distinct sections of the Western Ghats, the southern Western Ghats is one of the richest abodes of tropical moist forests in the country. A large portion of the southern Western Ghats falls within Kerala, with a few significant spur hills extending into the neighbouring Tamil Nadu, viz. Nilgiris, Palani, High-Wavies and the Kalakkad. The restricted range and habitats of many of these endemics are under threat. Among the 16 Western Ghats endemics, one is Endangered, three Vulnerable and four Near-Threatened. Three of the endemics have different races in the Western

Ghats – Grey-breasted Laughing-thrush (*Garrulax jerdoni*) has three races, White-bellied Shortwing (*Brachypteryx major*) and Rufous Babbler (*Turdoides subrufus*) have two races each. Some of these races are considered as full species by recent authors¹.

Avian studies in the southern Western Ghats have been sporadic. Figure 1 summarizes the periods of important ornithological workers in the region. However, ornithological expeditions into these bio-rich areas have been much restricted until the advent of the large-scale, coordinated bird surveys, which began in the 1990s; an activity which is significantly contributing to the ornithological knowledge in the Western Ghats of Kerala.

Bird monitoring using volunteer-based networks is a tested strategy to cover large areas in several countries, mostly resulting in bird atlases. Dunn and Weston² reviewed 272 bird atlas projects from 50 countries in six continents and found that most of them (82.4%) are from Europe and North America. These projects were mostly run by ornithological societies, and had resulted in at least 27.9 million records of birds over an area roughly 31.4% the land area of the earth, involving at least 108,000 contributors. Two such efforts worth mentioning in India are Asian Wetland Count conducted since 1987 and MigrantWatch³ launched by the National Centre for Biological Sciences (NCBS) in 2007. In Kerala, the Malabar Nature History Society (MNHS) runs a Common Bird Monitoring Programme (CBMP) using volunteers in several districts and has had moderate success (Sashikumar, pers. commun.).

The concept of a bird survey using the amateur bird-watcher network for monitoring the protected areas in Kerala was envisaged in the Silent Valley National Park in December 1990. Since then 61 surveys have been conducted till date and the Kerala Forest Department (KFD) has played a pivotal role in the activity – logistically and financially (Figure 2). Most of these surveys were anchored by various NGOs (Figure 3), and they now form the backbone of the Indian Bird Conservation Network (IBCN) in Kerala. Results of these surveys are prepared as a report by the NGOs and circulated among the participants and the KFD. When found relevant, a concise report in the form of an article is published by the coordinator(s) in a peer-reviewed journal⁴⁻⁹.

Details of the bird surveys conducted between 1990 and 2008 in the Western Ghats of Kerala are given in Table 1 and Figure 4. About three bird surveys per year have been conducted during this time. However, there have been years (2003) during which up to eight surveys were done, while there have been some of the early years which had only one bird survey. Regular bird monitoring has been done in Shendurney Wildlife Sanctuary (WLS; 13 years) in South Kerala and at Aralam WLS (9 years) in North Kerala. Round-the-year monitoring with surveys in three different seasons has been conducted in Chinnar WLS (1998–99) and Silent Valley National Park

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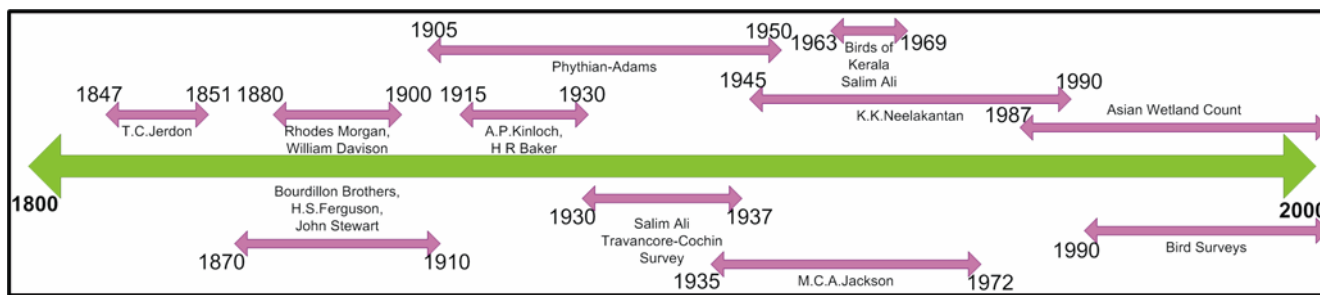


Figure 1. History of ornithology in the Western Ghats of Kerala.

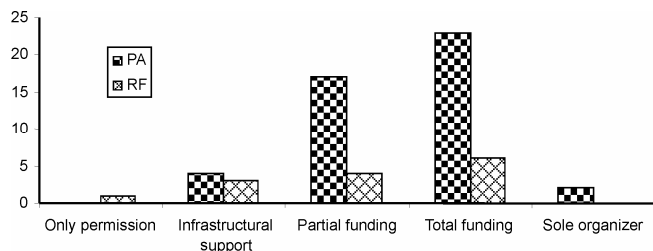


Figure 2. Role of the Kerala Forest Department in bird surveys. PA, Protected area; RF, Reserve forest.

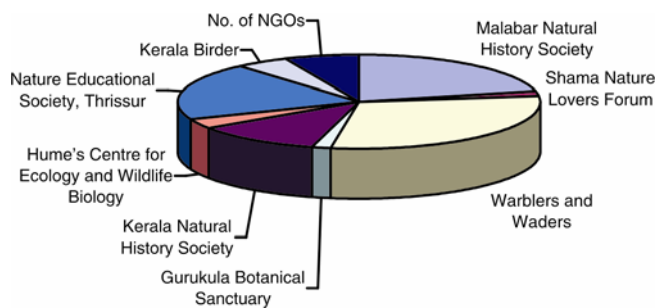


Figure 3. Role of NGOs in bird surveys.

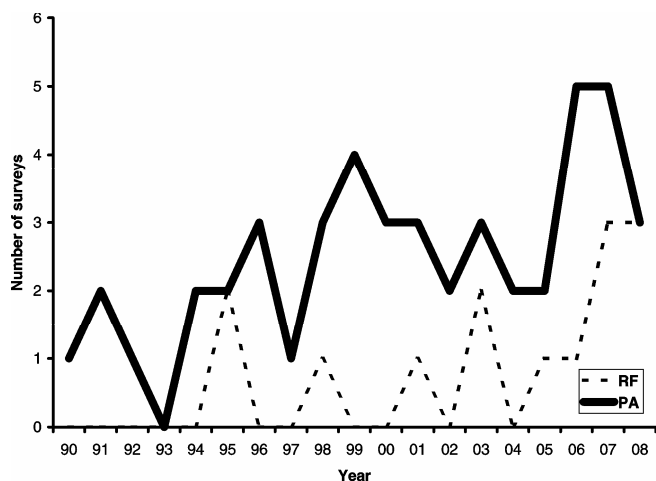


Figure 4. Trend of bird surveys from 1990 to 2008.

(2006–07). The fact that bird surveys have been done in almost all the protected areas in the state has enabled the creation of authentic bird checklists for all of them; an achievement quite unique to Kerala.

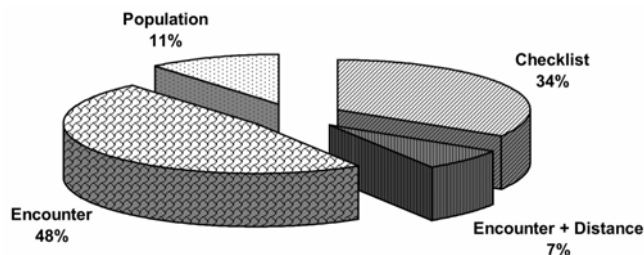


Figure 5. Methodologies used in bird surveys of Kerala.

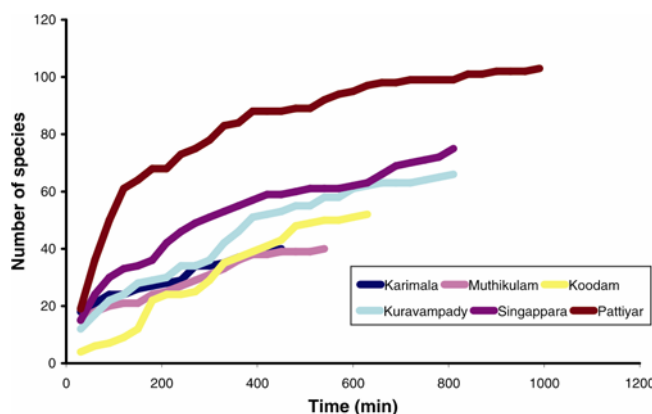


Figure 6. Species accumulation curves comparing six base camps at Siruvani.

Bird surveys are generally organized under the banner of an NGO (or NGI) from the respective regions. The permission to conduct a survey has to be secured from the Chief Conservator of Forests (Wildlife), for the protected areas or the Chief Conservator of Forests (Protection), for the territorial forest divisions. Once they accord sanction the key organizer(s) meet the respective Wildlife Wardens/Divisional Forest Officers for the logistic support, which includes the camping, trackers, cooks, provisions, local transport, etc. The base camps within the study locations are selected after a reconnaissance of the study area by the organizers. The selection of the base camps is made in such a way that they represent all the habitat types available within the study area.

Bird surveys usually have a duration of about four days. On the forenoon of the first day all the participants assemble at one place; they would be briefed about the

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Table 1. Bird surveys in the Western Ghats of Kerala from 1990 to 2008

Forest area	Status [†]	IBA	Size	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	Total
Aaralam	WLS	Yes	55											√	√	√	√	√	√	√	√	√	9
Kottiyur	RF	Yes	60																		√	√	2
North Wayanad	RF	No	215														√						1
Kakkayam	RF	No	127														√*						2
Wayanad	WLS	Yes	344		√					√												√	3
South Wayanad	RF	No	326																		√		1
Nilambur	RF	Yes	758				√																1
Silent Valley	NP	Yes	89	√				√												√*	√		5
Siruvani	RF	No	129																		√		1
Nelliampathy	RF	Yes	256														√						1
Paramabikulam	WLS	Yes	285					√													√		2
Peechi-Vazhani	WLS	Yes	125		√																√		2
Chimmony	WLS	Yes	85			√															√		2
Vazhachal	RF	Yes	413							√		√			√							√	4
Thattakkad	WLS	Yes	25												√								2
Chinnar	WLS	Yes	90							√		√	√*										4
Eravikulam	NP	Yes	97									√											1
Idukki	WLS	Yes	105													√	√						2
Periyar	TR	Yes	777														√					√	2
Shendurney	WLS	Yes	100						√	√	√	√	√	√	√	√	√	√	√	√	√	√	13
Ponmudi	RF	No	107											√									1
Total			4568	1	2	1	1	2	1	4	1	4	4	3	4	3	8	2	2	7	6	5	61

*Two surveys were conducted in the same year.

[†]WLS, Wildlife Sanctuary; NP, National Park; TR, Tiger Reserve, and RF, Reserve Forest.

Table 2. Endemic and threatened species density in forests of the Western Ghats

Species	Number per thousand birds						
	PTR	NEL	SVL	SRV	PAR	CHM	PEE
Darter, <i>Anhinga melanogaster</i> NT	0.67	0.00	0.00	0.42	0.59	7.98	0.00
Lesser Grey-headed Fish-Eagle, <i>Ichthyophaga humilis</i> NT	0.38	0.00	0.00	0.00	0.44	0.61	0.33
Pallid Harrier, <i>Circus macrourus</i> NT	0.38	0.34	0.29	0.00	0.00	0.00	0.00
Lesser Kestrel, <i>Falco naumanni</i> VU	1.25	0.00	0.00	0.00	0.00	0.00	0.00
*Nilgiri Wood-Pigeon, <i>Columba elphinstonii</i> VU	6.34	0.69	1.16	1.56	0.15	0.00	0.00
*Blue-winged Parakeet, <i>Psittacula columboides</i>	34.59	62.00	3.75	15.43	39.49	53.41	13.70
*Malabar Grey Hornbill, <i>Ocyroceros griseus</i>	10.86	8.61	4.40	5.95	10.68	9.82	6.68
Malabar Pied Hornbill, <i>Anthracoceros coronatus</i> NT	0.38	0.69	0.07	0.00	0.15	0.00	0.00
Great Pied Hornbill, <i>Buceros bicornis</i> NT	3.36	6.72	0.51	0.00	3.80	1.84	0.00
*Nilgiri Pipit, <i>Anthus nilghiriensis</i> NT	1.25	0.52	0.58	0.00	0.29	0.00	0.00
*Grey-headed Bulbul, <i>Pycnonotus priocephalus</i>	2.31	0.52	1.37	4.39	0.44	0.00	0.00
*White-bellied Shortwing, <i>Brachypteryx major major</i> VU	0.00	0.00	0.43	0.14	0.00	0.00	0.00
*White-bellied Shortwing, <i>Brachypteryx major albiventris</i> VU	0.10	0.00	0.00	0.00	0.00	0.00	0.00
*Indian Rufous Babbler, <i>Turdoides subrufus subrufus</i>	0.00	0.00	3.90	4.81	0.00	0.00	0.00
*Indian Rufous Babbler, <i>Turdoides subrufus hyperythrus</i>	10.86	2.41	0.00	0.00	6.58	0.00	4.01
*Wynaad Laughingthrush, <i>Garrulax delesserti</i>	7.69	6.54	5.70	6.37	0.44	0.00	0.00
*Nilgiri Laughingthrush, <i>Garrulax cachinnans</i> EN	0.00	0.00	2.45	1.56	0.00	0.00	0.00
*Grey-breasted Laughingthrush, <i>Garrulax jerdoni fairbanki</i> NT	13.64	0.69	0.00	0.00	0.00	0.00	0.00
Tytler's Leaf-Warbler, <i>Phylloscopus tytleri</i> NT	0.00	0.00	1.66	0.85	0.00	0.00	0.00
*Broad-tailed Grass-Warbler, <i>Schoenicola platyura</i> VU	0.10	0.00	0.36	0.14	0.00	0.00	0.00
*Black-and-Orange Flycatcher, <i>Ficedula nigrorufa</i> NT	2.69	0.00	0.79	0.57	0.00	0.00	0.00
*Nilgiri Flycatcher, <i>Eumyias albicaudata</i> NT	3.94	1.55	2.96	2.55	0.29	0.00	0.00
*White-bellied Blue-Flycatcher, <i>Cyornis pallipes</i>	1.35	0.52	4.62	0.57	0.00	0.61	0.00
*Small Sunbird, <i>Nectarinia minima</i>	22.19	25.84	98.98	72.90	15.65	36.83	38.10
*White-bellied Treepie, <i>Dendrocitta leucogastra</i>	12.78	5.34	1.95	0.42	1.76	6.75	2.01
Endemics	130.67	115.23	133.42	117.35	75.76	107.43	64.51
Red Data species	34.49	11.20	11.27	7.78	5.85	10.44	0.33

*Endemic species; EN, Endangered; VU, Vulnerable; NT, Near-threatened; PTR, Periyar; PAR, Parambikulam; PEE, Peechil WLS; CHM, Chimmony WLS; NEL, Nelliampathies; SVL, Silent Valley and SRV, Siruvani.

methodology, and the teams would be divided. It is ensured that each team has at least one person who can identify all the birds of that region confidently. The teams would be provided with data sheets, handouts about the methodology, a map of the study area and a write-up about the habitat conditions such as the forest type, altitudinal range, etc. of the different base camps. After an early lunch, different teams are transported to their respective base camps. On the final day of the survey, there will be a plenary session, wherein each team would be making a brief presentation about its findings. The plenary session of the bird survey is like a scientific seminar. The team leader must clarify unequivocally, all the queries by the rest of the participants during the course of the presentation. The doubtful entries would be summarily rejected.

Though there has not been one single bird survey methodology followed in Kerala, each of the surveys had a specific one – they could be classified into four different categories, each of them backward compatible to the former (Figure 5). The simplistic of all is a checklist-based survey (34%), which marks the presence–absence data of a species from a base camp. A slightly more

involved survey is based on the population of birds recorded from a base camp (11%). So, along with the presence–absence data, the total number of birds seen of every species is also counted. The time spent by bird-watchers in the field in each base camp is also collected as effort expended in field hours. This effort is used for normalizing the data during analysis. However, the most popular methodology (48%) followed in Kerala has been encounter-based surveys. At each camp, prefixed transects radiating from the base camps are walked at a uniform pace of about 1–1.5 km/h in the morning (7.30–10.30 h) and in the afternoon (14.30–17.30 h); the timings are adjustable to local light conditions and movement of large land mammals. During the transect, all the birds sighted/heard are recorded as one encounters them, along with the time of their sighting, number of birds and habitat of encounter. The transect is done for the first three hours of a session and from then on, only those species that are not seen on that transect on that day, are recorded. The data are useful in finding out the survey coverage at each base camp using species accumulation curves (Figure 6). All the birds opportunistically sighted/heard are also recorded separately in a camp checklist.

The data are analysed using standard software like BIODIVERSITY PRO Version 2 to calculate the various diversity and richness indices for each base camp or habitat¹⁰. Similarity indices between base camps or habitats are plotted (Figure 7). Feeding guild structure of birds in the area as well as in different habitats is also generated (Figure 8). However, this analysis has been possible largely due to the software available and many of the earlier surveys did not attempt the same.

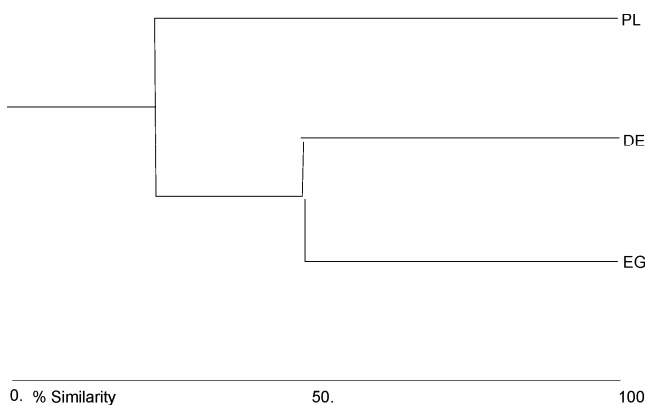


Figure 7. Similarity analysis of three habitat types at Chimmony WLS. PL, Plantations and reservoir; DE, Deciduous forests, and EG, Evergreen forests.

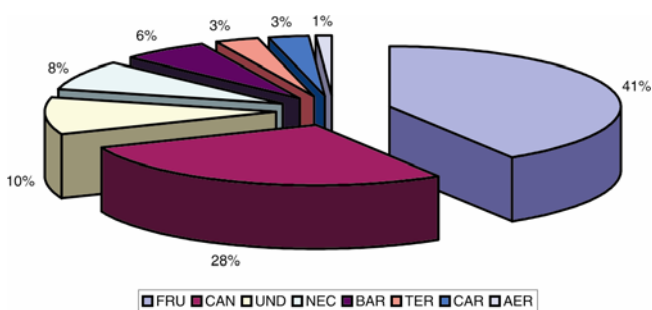


Figure 8. Feeding guild analysis of birds of the evergreen forest at Nelliampathies. FRU, Frugivores; CAN, Canopy insectivores; UND, Understorey insectivores; NEC, Nectarivores; BAR, Bark-surface feeders; TER, Terrestrial insectivores; CAR, Carnivores, and AER, Aerial insectivores.

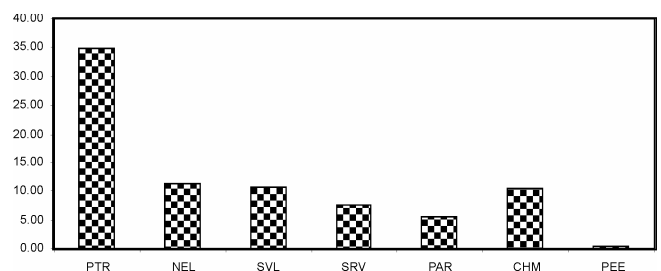


Figure 9. Relative density of Red Data species.

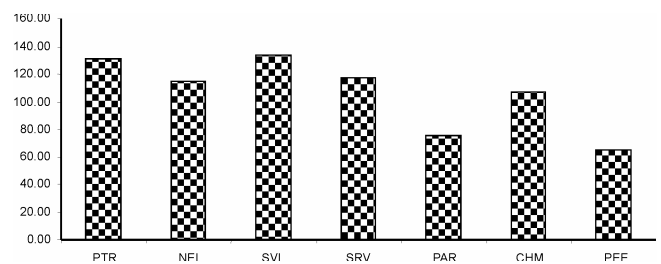


Figure 10. Relative density of endemic species.

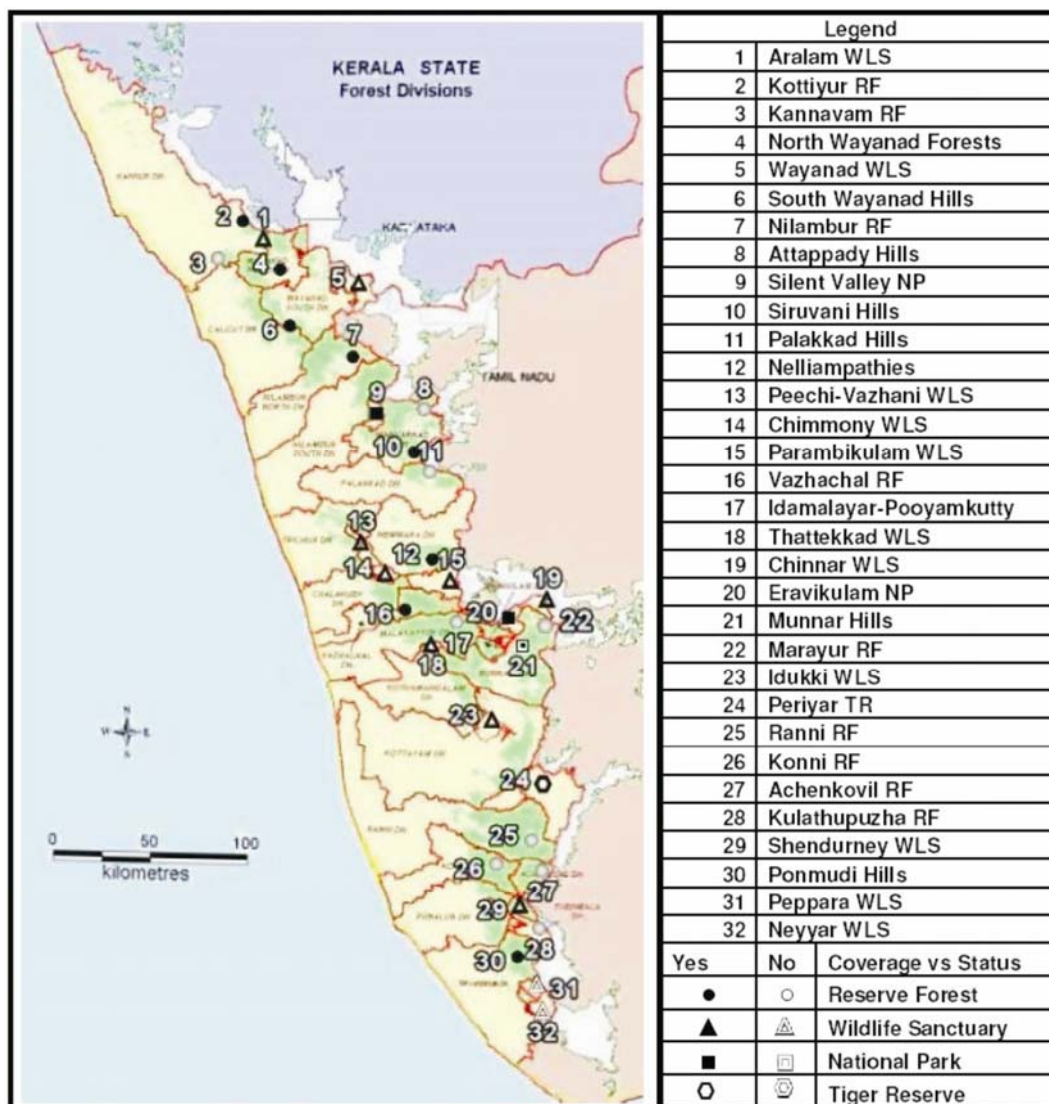


Figure 11. Forest areas in Kerala with information on bird surveys. (Source: P. Vijayakumaran Nair, Kerala Forest Research Institute, Peechi.)

Recently (in 2007–08), the encounter methodology was modified to measure the distance of sighting for each sample. The ‘perpendicular’ distance of the bird encountered from the transect line was estimated as three ‘distance bands’, i.e. <5 m, 5–20 m and >20 m. This modification can be used to adjust the errors in density estimation due to variations in detectability across bird species and across habitats¹¹. However, the results are yet to be analysed to gauge the pragmatism and benefits.

One of the important results of the bird surveys is summarized in Table 2, which compares seven forest areas in Central and South-Central Kerala, where the bird surveys were coordinated. Table 2 provides a quantitative measure for comparing these forest regions to evaluate their relative importance in conserving endemic and threatened avifauna. Each entry is expressed as the number of birds of a particular species recorded for every 1000 individuals recorded across all bird species.

The Periyar Tiger Reserve stands out among the seven areas as a prominent bird area which also houses a good amount of threatened species (Figure 9). Together with the Silent Valley National Park, this area also houses an excellent population of endemic species (Figure 10). However, clearly, two areas which fall outside the protected area (PA) network, Siruvani and Nelliampathies, are almost equally important in terms of endemic bird richness; perhaps more significant than the PAs of Parambikulam, Peechi–Vazhani and Chimmony. Many such intact pockets like South Wayanad Hills, Nilambur RF, Idamalayar–Pooyamkutty, etc. which are non-PAs, also have high endemic richness. Hence conservation efforts should be targeted towards the protection of these remaining tracts of good reserve forests.

Table 1 depicts the areas where the bird surveys have been conducted over the past 18 years. Though the coverage in area is only 30% (4568 km² out of 11,126 km²) of

Table 3. Potential bird-rich areas in the Western Ghats of Kerala where no bird surveys have been conducted

Forest area	Status	IBA	Area	Checklist available for the area	Bird-watchers visiting the area	Quality of bird surveys in the neighbouring areas
Kannavam	RF	No	94	Preliminary	Occasional	Good
Attappady Hills	RF	No	249	None	Rarely	Fair
Palakkad Hills	RF	No	166	Comprehensive	Occasional	Fair
Idamalayar–Pooyamkutty Valley	RF	No	357	Preliminary	Frequent	Fair
Munnar Hills	NP, WLS, RF*	No	430	Preliminary	Frequent	Fair
Marayur	RF	No	71	Preliminary	Rarely	Fair
Ranni	RF	Yes	1059	None	Rarely	Fair
Konni	RF	Yes	331	None	Rarely	Not good
Achenkovil	RF	No	269	None	Rarely	Not good
Kulathupuzha	RF	Yes	219	Comprehensive	Frequent	Good
Peppara	WLS	Yes	53	Comprehensive	Rarely	Fair
Neyyar	WLS	Yes	128	Comprehensive	Rarely	Not good

*Munnar Hills consists of Shola National Park, Kurinji Wildlife Sanctuary and several pockets of reserve forests in the Munnar and Mankulam Division.

forest area in Kerala, the coverage across the region has been rather uniform (Figure 11). It is also worthwhile to note that most of the critical bird habitats have been covered by bird surveys. There has been a drive in recent years to specifically target high-potential reserve forests, which have been neglected in the past from being surveyed, and the results have been overwhelming. Table 3 depicts some of the other important forest areas where no bird surveys have been conducted till now, along with associated data on the existence of avi-faunal inventory by other sources. Surveying these forest regions will improve the area covered under bird surveys by another 30% (3530 km²).

It is worth mentioning that one of the contiguous stretches of high-potential bio-rich area in South-Central Kerala, the Pandalam Hills, lying in Ranni–Konni–Achenkovil sector, still remains largely uncovered; in terms of bird surveys as well as regular visits by bird-watchers. Hence, the immediate target should be to sample this area for bird survey during the next birding season.

This communication concludes by emphasizing the existence of a sustainable amateur bird-watcher network that could be tapped to obtain baseline ornithological data for biodiversity hotspots like the Western Ghats. The fairly rigorous methodology for data collection used in many of these surveys has been well received by the bird-watchers and they are ready to run an extra mile for good results.

Bird surveys have become popular with the birding fraternity of Kerala. However, there is need from a central agency to channelize this effort in a more systematic manner for a greater goal, and one of these could be creating a bird atlas for the Western Ghats in Kerala. A better alignment at the state level is required to fine-tune the different methodologies for achieving this. This shall be the main focus for the future in Kerala ornithology.

1. Rasmussen, P. C. and Anderton, J. C., *Birds of South Asia: The Ripley Guide*, Smithsonian Institution & Lynx Edicions, Washington DC, 2005, two volumes.

2. Dunn, A. M. and Weston, M. A., A review of terrestrial bird atlases of the world and their application. *Emu*, 2008, **108**, 42–67.
3. Quader, S. and Raza, R. H., MigrantWatch: A citizen science programme for the study of bird migration. *Indian Birds*, 2008, **3**, 202–209.
4. Bashir, C. A. A. and Nameer, P. O., Some observations on the birds of Silent Valley National Park. In *Bird Conservation: Strategies for the Nineties and Beyond* (eds Verghese, A., Sridhar, S. and Chakravarthy, A. K.), Ornithological Society of India, Bangalore, 1993, pp. 131–136.
5. Uthaman, P. K., Birds of the Wayanad Wildlife Sanctuary. *Black-buck*, 1993, **9**, 1–17.
6. Praveen, J. and Nameer, P. O., A checklist of birds of Nelliampathy Hills, southern Western Ghats. *Zoo's Print J.*, 2006, **22**, 2695–2701.
7. Praveen, J. and Nameer, P. O., Bird diversity of Siruvani and Muthikulam Hills, Western Ghats, Kerala. *Indian Birds*, 2008, **3**, 210–217.
8. Susanthkumar, C., Birds of Shendurney Wildlife Sanctuary – Kerala. *Newsl. Birdwatchers*, 1997, **37**, 94–96.
9. Uthaman, P. K., Birds of the Eravikulam National Park – a survey report. *Blackbuck*, 1998, **14**, 45–53.
10. McAleece, N., Lamshead, P. J. D., Paterson, G. L. J. and Gage, J. D., Biodiversity Pro: free statistics software for ecology. The Natural History Museum and the Scottish Association for Marine Science, UK, 1997.
11. Urifi, A. J., Sen, Monalisa, Kalam, A. and Meganathan, T., Counting birds in India: Methodologies and trends. *Curr. Sci.*, 2005, **89**, 1997–2003.

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