Bird diversity of tea plantations in Darjeeling Hills, Eastern Himalaya, India

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Abstract. *Chettri A, Sharma K, Dewan S, Acharya BK. 2018. Bird diversity of tea plantations in Darjeeling Hills, Eastern Himalaya, India. Biodiversitas 19: 1066-1073.* The biodiversity wealth and conservation potential of agro-ecosystems including cash crop plantations is gaining significance in recent years. Agro-forestry provides ecosystem services similar to forest and, hence, support a high diversity of flora and fauna. This study was undertaken to explore the bird community in different tea gardens of Kurseong Hill, Darjeeling, Eastern Himalaya, India. Darjeeling is globally known for its extent and magnificent tea production. We sampled birds using point count methods along transects during August 2015-January 2016. A total of 581 individual birds comprising 48 species were recorded during the study. Amongst the guild types, insectivorous birds were the most dominant both in terms of species and abundances. Depending on their habitat preferences most of the birds were forest generalists followed by forest specialists. This study highlights that tea plantations have a great potential in harbouring and conserving birds and other associated life forms. Thus, proper management of these landscapes would be an effective strategy to conserve biodiversity of the Himalayas.

Keywords: Agroecosystems, birds, conservation, Himalaya, Kurseong, tea plantation

INTRODUCTION

Tropical landscapes are dominated by various land-use systems including diverse production agroforestry systems (Tscharntke et al. 2008). Among such systems, agro-ecosystems which are primarily meant for production of crops, if managed organically, traditionally or maintained with diverse shade trees can conserve significant amount of wild biodiversity with unique community assemblages of plants and animals (Mayfield et al. 2005; Mcneely and Schroth 2006; Barlow et al. 2007; Harvey and Villalobos 2007; Vandermeer and Perfecto 2007; Lin et al. 2012; Sreekar et al. 2013; Sharma and Vetaas 2015; Mellink et al. 2017). While most of the agro-ecosystems are managed using traditional ecological knowledge, many are substantially modified using recent technology to meet food, fibre and other livelihood requirements of the ever-increasing human population (Laurance et al. 2014). Achieving conservation goals within such human-dominated landscapes, however, requires detailed understanding of the functioning of different agricultural ecosystems, their appropriate management, and potentiality of these systems to conserve flora and fauna (Flohre et al. 2011).

A number of studies have focused on biodiversity in shaded agroforestry systems using birds as an indicator and highlighted their importance in conserving the habitat of various organism including birds (Thiollay 1995; Uezu et al. 2008; Elsen et al. 2016). The impact of site-scale forest disturbance on organisms depend on the extent of forest cover within the surrounding landscape (Dahal et al. 2015) because species commonly interact with the agro-ecosystems even if their primary habitat is the natural forests (Pimentel et al. 1992).

The tea plantation is one of the important agro-ecosystems and contributes largely to a country's economy. Since most tea plantations strictly follow monoculture practices, biodiversity assemblages in such plantations are poor compared to forest ecosystems (Lin et al. 2012; Ahmed and Dey 2014) and other agroforestry ecosystems, such as pine plantations (Soh et al. 2006), home gardens (Yashmita-Ulman et al. 2016) but richer than Eucalyptus plantation monocultures (Kottawa-Arachchi and Gamage 2015) and agrosiliviculture systems (Yashmita-Ulman et al. 2016). Among the tea plantations, shade tea cultivation (tea cultivation with diverse shade trees) and surrounding forest patches has a high capacity to maintain biodiversity within itself (Lin et al. 2012; Sreekar et al. 2013; Ahmed and Dey 2014) than monoculture tea plantations (Soh et al. 2006) or abandoned tea plantations (Subasinghe and Sumanapala 2014) because shade trees provide habitat for both forest and open land birds and also acts as a buffer zone and feeding ground for the frugivorous and insectivorous species (Bhagwat et al. 2008; Sinu 2011). In some cases, the bird diversity in the shade tea plantations is comparable to the surrounding forest ecosystems (Ahmad and Yahya 2010; Sreekar et al. 2013). The natural windbreaks of native tree in tea dominated landscapes of Western Ghats enhanced bird diversity as they retain significant proportion of the resident birds found in the forests (Sreekar et al. 2013). Some studies have even reported that tea plantations are rich in birds including endemic, rare or IUCN Red List threatened species (Sreekar et al. 2013; Kottawa-Arachchi and Gamage 2015; Yashmita-Ulman et al. 2016). While

these ecosystems form the important habitats for various animal groups, exploration of biological wealth and recognition of significance of such systems as habitat is not given due consideration (Ahmed and Dey 2014).

The Eastern Himalayan region comprises diversity of agro-forestry systems and is considered as important land use practices (Sharma et al. 2007). Darjeeling is a northeastern district of West Bengal state in India and is one of the largest producers of tea in the world. The world-famous tea garden of Darjeeling hills represents one of the most important landuse systems in the Eastern Himalaya with mosaic of tea bushes, agricultural areas, and forest patches. The history of tea plantation in Darjeeling dates back to 1841, and from 1971 onwards the process of organic farming began by transforming tea plantation into an integrated, sustainable ecosystem (Datta 2010). While few studies have been undertaken to understand the conservation potential and community structure of birds in tea plantation in this region but are mostly explorative (Ahmad and Yahya 2010; Ahmed and Dey 2014). Ahmad and Yahya (2010) recorded a total of 130 species of birds in six different habitat types of Kurseong Hill out of which

48 species were encountered at the productive tea plantation. The present study explored different tea cultivation sites to understand the community structure, guild composition and habitat specialization of birds within the mosaic of agro-forestry systems covering four tea gardens in Kurseong Hill located in Darjeeling District, West Bengal, India-a globally significant but human modified landscape in the Eastern Himalaya.

MATERIALS AND METHODS

Study area

This study was undertaken in the various tea gardens of Kurseong Hill located in the Darjeeling District of West Bengal State in India (Figure 1, Table 1). All the tea gardens sampled in the present study are located in Kurseong block which has an area of 342.6 km^2, situated within Kurseong sub-division of Darjeeling District. The study sites were located at a distance of 1.5 to 3 km from each other with extent of the gardens ranging from 34.5 to 610 ha (Table 1).
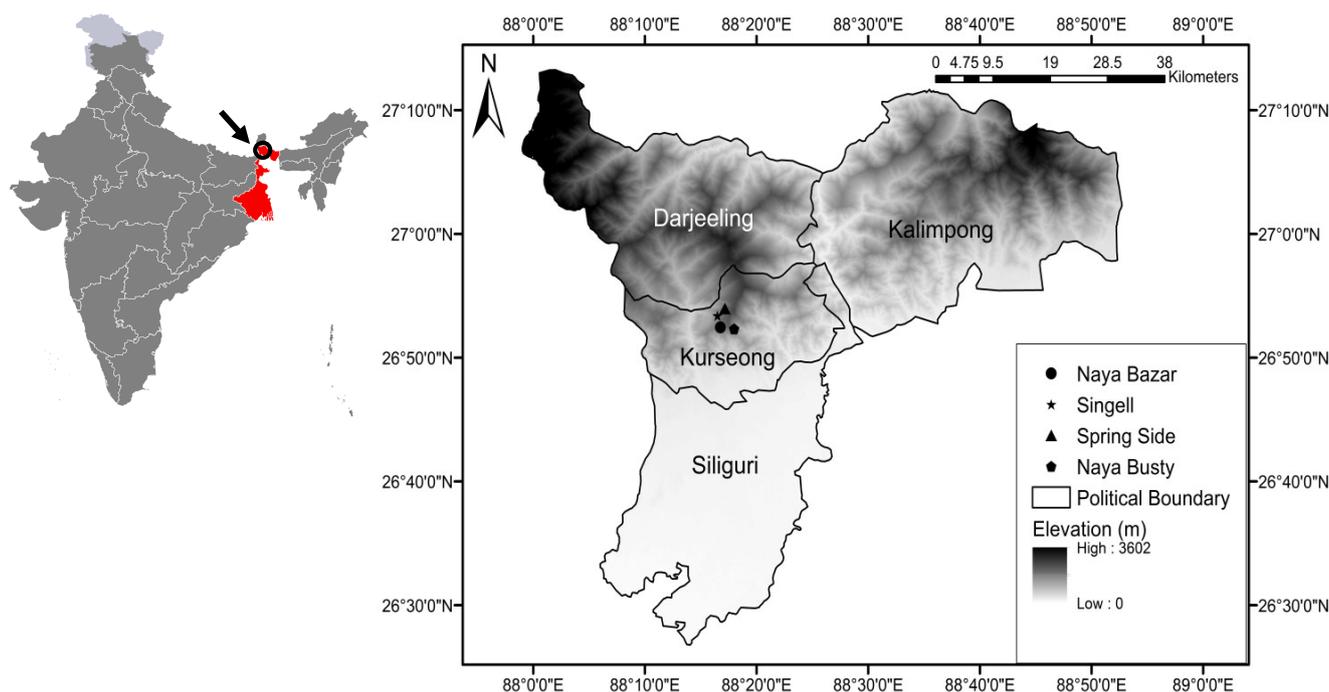

Figure 1. Map of the study area showing sampling sites in Kurseong Hill, Darjeeling, West Bengal, Eastern Himalaya, India

Table 1. Details of bird sampling sites located in Kurseong Hill, Darjeeling, Eastern Himalaya, India

Study site	Elevation (m)	Latitude	Longitude	Extent/area (ha)
Singell	1372	26^0 53.383'N	88^0 16.496'E	610
Spring side	1406	26^0 53.963'N	88^0 17.141'E	144.184
Naya Bazar	1533	26^0 52.443'N	88^0 16.755'E	170
Naya Busty	1598	26^0 52.430'N	88^0 17.936'E	34.5

The tea plantations in Darjeeling hills is unique as it has numerous important characteristic features of its own (Datta 2010). Kurseong, the land of white orchid, is a small hill station situated at an elevation of 1490 m above mean sea level. The study was conducted in four tea estates in Kurseong (Table.1). All the four tea gardens are organically managed. The topography comprises moderate slopes, with moderately permeable and reasonably well-drained soil. The plantation comprises tea shrubs (*Camelia sinensis var. sinensis*) which reaches a height of about 0.5-1 m. Shade trees that occur along with tea bushes are *Schima wallichii, Cryptomeria japonica, Albizia procera, Alnus nepalensis, Syzygium nervosum, Exbucklandia populnea, Eurya japonica, Ficus religiosa, Ficus benghalensis* and mixed bamboo groves. The tea gardens are characterized by several habitats such as home-garden, forest patches, wetlands in the form of streams and open grasslands making it ideal for variety of organism to thrive within its vicinity (Ahmed and Dey 2014; Ahmad and Yahya 2010). Six different habitat types (mixed bamboo, riverine, tea plantation, dense forest, edge, and scrub) are reported to be found in Makaibari tea estate of Kurseong Hill (Ahmad and Yahya 2010). However, in the absence of good forest patch in all the four different tea gardens in the present study, we focused only on the tea plantations as a study habitat.

Data collection

Variable width point count method along transect was used for sampling birds (Bibby et al. 2000). Transects were laid along tea plantations only. Point count method is an effective census technique because the stationary observer has a greater probability of detecting and hearing birds even if the birds are inside the bushes. This method was adopted keeping in view the hilly terrain and rough topography of the study area (Acharya et al. 2011; Acharya and Vijayan 2017). In each site mentioned in the study area above, four transects were established, and within transect five points were marked making a total of 20 points per site. The points within transects were spaced 100 m apart in order to avoid repetitive counting of same individuals during sampling. Hence, a total of 80 points were laid for the present study covering four study sites. In each point observation of birds were made for 10 minutes recording the number and identity of species seen or heard. Birds were scanned with the help of a binocular and identified using the standard field guide (Grimmett et al. 2011). Sampling was conducted in the morning hours (06:00-10:00 hrs) in clear sunny days during August 2015 to January 2016. Bird counts were repeated three times in each transect.

Data analysis

Various community parameters such as species richness, abundance, species per point, abundance per point and diversity indices were calculated for birds of the study area. Species richness is the cumulative list of species observed during the sampling. Similarly, abundance is the total number of individuals counted during the sampling. Shannon-Weiner index (H′) is calculated as H′ =-∑ pilnpi, where pi is the proportion of individuals of the ith species in the community and *ln* is the natural logarithm. Evenness (E) is computed as E = H′/H$_{max}$ = H′/lnS where S is the species richness. Species richness is the basic indicator considered during implementation of conservation measures, but there is a possibility of missing some species during sampling resulting into underestimation of real number of species present in the area or habitat. Hence, different non-parametric richness estimators were computed using the software EstimateS version 9.0.1 (Colwell 2014). Among the various non-parametric estimators, we selected Chao1 because it detects rare species and is widely used. To test whether the sampling effort was enough to detect all the species that occur in the study area species accumulation curve was produced, based on the observed and non-parametric estimator Chao1, by plotting the cumulative number of species detected against the sampling effort.

Feeding guild and habitat specialization of the birds were assigned according to their autecological traits following Sreekar et al. (2013) and Grimmett et al. (2011). We computed relative percentages of birds (both species richness and abundance) in each category (feeding guild and habitat specialization). Bird taxonomy follows Praveen et al. (2018).

RESULTS AND DISCUSSION

Species richness, diversity, and abundance

During this study, a total of 581 individual birds representing 48 species and 28 families were observed from four study sites in the tea garden of Kurseong Hill, Darjeeling, Eastern Himalaya (Table 2, Table S1). Shannon-Weiner diversity for birds was 3.2. Species richness per point was 3.3±1.1 and abundance per point was 7.3±3.3. Similarly, Evenness was 0.83 indicating that the species were fairly evenly distributed in the community. The different bird community parameters differed among the four tea gardens (Table 2). The diversity and species richness of birds observed in the present study are greater than (Soh et al. 2006; Lin et al. 2012; Sreekar et al. 2013; Subasinghe and Sumanapala 2014), comparable to (Ahmad and Yahya 2010; Ahmed and Dey 2014) or lesser than (Kottawa-Arachchi et al. 2010; Yashmita-Ulman et al. 2016) studies undertaken in tea plantations in India and elsewhere. Such differences could be due to variation in climatic conditions, elevation, area covered, shade trees, disturbance factors and proximity to primary forest.

The species accumulation curve based on observed and the non-parametric estimators of species richness almost reached an asymptote indicating likelihood of encountering few more species with increasing sampling effort (Figure 2).

Table 2. Species richness, abundance, diversity, evenness and non-parametric species richness estimators of bird communities in the four tea gardens of Kurseong Hill, Darjeeling, Eastern Himalaya, India

| Community parameters | Study site (tea gardens) | | | | Total |
	Singell	Spring Side	Naya Bazar	Naya Busty	
Species richness	28	29	28	21	48
Species per point (Mean±SD)	3.3±1.2	3.4±1.1	3.05±1.05	3.1±0.8	3.3±1.1
Abundance	139	159	131	152	581
Abundance per point (Mean±SD)	7.0±3.0	7.7±4.0	6.5±2.7	2.8±3.4	7.3±3.3
Shannon-Weiner index	3.01	2.89	2.89	2.61	3.2
Evenness	0.91	0.86	0.86	0.85	0.83
S (Est.) (mean±SD)	28±2.28	29±3.73	28±3.14	21±2.17	48±2.56
Chao 1 (mean±SD)	29.32±1.83	37.11±8.22	30.55±2.79	21.28±0.67	51.59±3.85
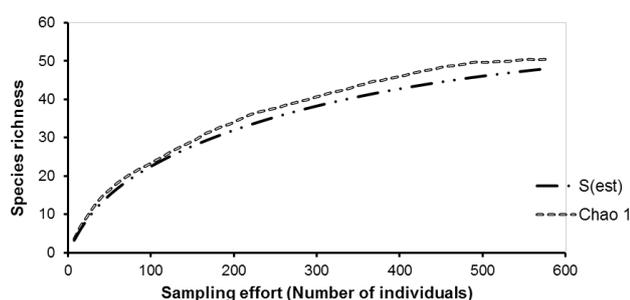
Figure 2. The species accumulation curves based on observed and estimated species of birds of tea garden of Kurseong Hill, Darjeeling, Eastern Himalaya, India

The non-parametric estimators Chao1 predicted 50 species which was 95.05% of the observed species richness (48 species). Out of the total 581 individual birds counted during the sampling, the three most dominant species (Olive-backed Pipit *Anthus hodgsoni*, Red-vented Bulbul *Pycnonotus cafer*, and Grey Bushchat *Saxicola ferreus*) contributed 34.6% of the total abundance.

Feeding guilds

The observed birds of the tea gardens were categorized into six feeding guilds namely, insectivore, omnivore, carnivore, frugivore, nectarivore and granivore. As expected, the bird community was highly dominated by the insectivores, both in terms of species richness (35 species; 72.92%) and abundance (88.81%) (Figure 3). The other five feeding guilds were not well represented in the bird community.

Habitat specialization

The birds observed in the present study belonged to three groups according to their habitat specialization namely, forest specialist, forest generalist, and open-land. The forest generalist birds were the most dominant group both in terms of species richness (33 species; 68.75%) and abundance (62.13%) contributing about two-third to the bird community. The second most dominant group was forest specialist but contributed only about one-fifth to the bird community (Figure 4).

Ahmad and Yahya (2010) recorded a total of 130 species of birds in six different habitat types (mixed bamboo, riverine, tea plantation, dense forest, edge, and scrub) of Kurseong Hill out of which 48 species were found in the productive tea plantation. The bird species richness observed in the present study was similar to the species found in tea plantations (48 vs. 48 species), and 37% of the birds reported to occur in different habitat types (48 vs. 130 species) of Kurseong Hill (Ahmad and Yahya 2010). During the present study, we observed 20 additional bird species not recorded by Ahmad and Yahya (2010), which makes up the total bird species of tea plantation of Kurseong Hill to 68 and total bird species of different habitats of Kurseong Hill to 150 species. Since tea plantation is the most dominant land uses in Darjeeling, the result indicates great potential of this agro-ecosystem in supporting and conserving avifaunal diversity. The non-parametric estimators estimated 50 species that might occur in the study area which is closer to the observation of Ahmad and Yahya (2010) and the present study. High bird diversity could be attributed to the presence of shade trees along with tea bushes providing habitats for various activities of birds. Studies have found strong correlation between bird community and habitat diversity suggesting the dependency of birds on the compositional complexity of trees, shrubs and herbs in both forest ecosystems (Acharya et al. 2011; Chettri et al. 2005; Chettri 2010; MacArthur et al. 1966) and tea plantations (Sreekar et al. 2013; Yashmita-Ulman et al. 2016). The potential factors affecting bird communities in tea plantation are patch size (Yashmita-Ulman et al. 2016), tree species richness and diversity (Sreekar et al. 2013; Yashmita-Ulman et al. 2016) and arthropod abundance (Sinu 2011).

The bird community in the present study was highly dominated by insectivores both in terms of species richness and abundance. Higher dominance of insectivorous species is a commonly observed phenomenon, both in tea plantations (Ahmad and Yahya 2010; Kottawa-Arachchi et al 2010; Sreekar et al. 2013; Ahmed and Dey 2014; Yashmita-Ulman et al. 2016) and other human-modified and forest ecosystems (Chettri et al. 2005; Chettri 2010; Bhatt and Joshi 2011; Sreekar et al. 2013). The present study system represents organic farming in which use of chemical fertilizers is prohibited, and insect abundances could be high favoring the occurrences of more number of insectivorous birds. These birds might play crucial role as a biocontrol agent in organically managed tea gardens and other farming ecosystems (Sinu 2011).
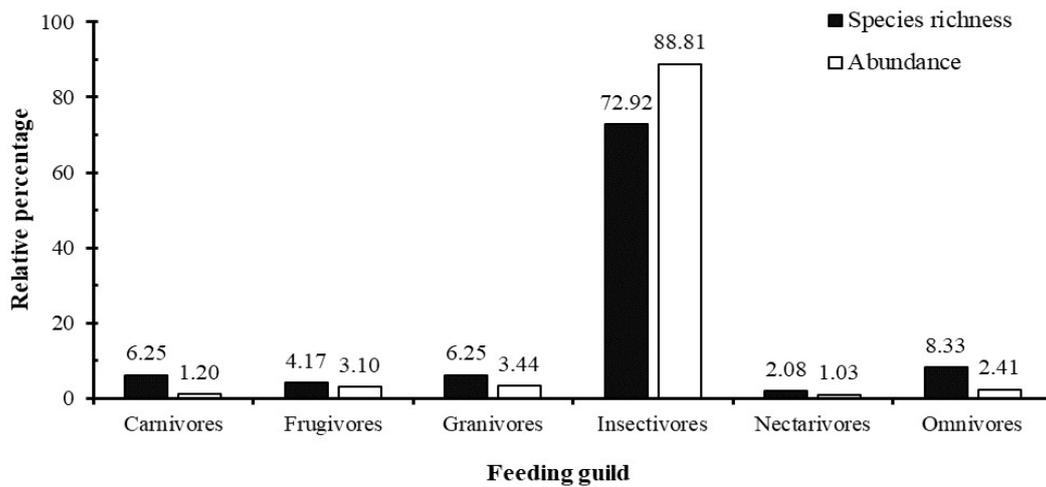
Figure 3. Proportion of birds according to their feeding guild observed in tea gardens of Kurseong Hill, Darjeeling, Eastern Himalaya, India
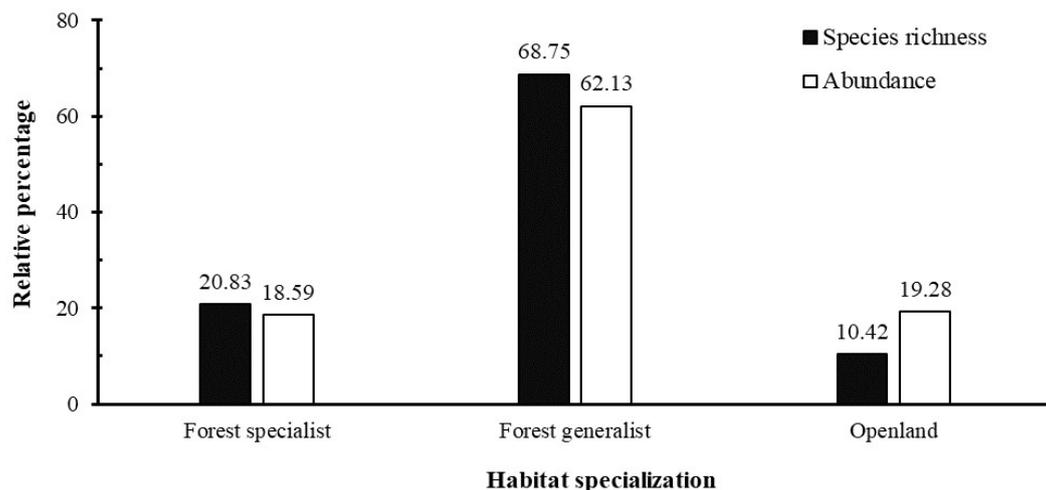

Figure 4. Proportion of birds according to their habitat specialization (forest specialist, forest generalist, and open-land) observed in tea gardens of Kurseong Hill, Darjeeling, Eastern Himalaya, India

The tea plantation in India has been reported to harbor and get infested by more than 300 species of phytophagous insects and mites (Hazarika et al. 2009). The high load of pest in the tea plantations are generally controlled by widespread and regular use of pesticides. The bio-control of this wide range of insect pests has been proposed through arthropod natural enemies namely, predators and parasitoids (Das et al. 2010) and also by insectivorous birds (Sinu 2011). High diversity of arthropod natural enemies (94 species of predators and 33 species of parasitoids) has been reported in sub-Himalayan tea plantations of North Bengal (Das et al. 2010). Sinu (2011) reported the bio-control role played by birds in tea plantations of Northeast India against the invasive geometrid looper caterpillars (*Hyposidra* spp.) and lymantriid hairy caterpillar (*Arctornis*

submarginata). These caterpillars caused large-scale defoliation of tea leaves but had no resident insect predator for any of their life stage.

In the present study, forest generalist birds were the most dominant group both in terms of species richness and abundance contributing about two-third of the bird community. In Argentina, most of the productive landscapes were dominated by forest generalists while the forest specialists were mostly confined to rain forests (Mastrangelo and Gavin 2014). Old-growth forest cover showed the strongest association with the diversity of forest specialist species in fragmented Lacandona rain forest (Carrara et al. 2015). Low occurrence of forest specialists in the tea gardens might be because of its vulnerability to changing landscapes. Traditional agro-forests, with a

mixture of cultivated and natural shade trees, can support a high number of species including many forest birds, especially in areas that are close proximity to natural forests (Greenberg 1981). Forest specialist bird species are also reported to use agro-ecosystems for different activities (Pimentel et al. 1992). Hence, shade tea plantations and other human-modified ecosystems such as home gardens, agrisilviculture, etc. may act as corridors between forest patches that occur in the proximity of such fragmented landscapes (Kottawa-Arachchi et al. 2010; Sreekar et al. 2013).

Conservation implications

We recorded 48 bird species from our study in tea plantations of Kurseong in Darjeeling hills, Eastern Himalaya. This short-term study highlighted that the organically managed tea plantations have great potential in harboring and conserving bird diversity. We did not record any endemic, or IUCN Red List threatened species in the present study. However, four species observed in the present study are listed in CITES Appendix II (Asian Barred owlet *Glaucidium cuculoides*, Common Kestrel *Falco tinnunculus*, Eurasian Sparrowhawk *Accipiter nisus*, Red-billed Leiothrix *Leiothrix lutea*) (CITES 2018). Eleven species can be considered as rare because five species were represented by two individuals and six species had single individuals. Presence of shade trees in tea gardens is of great importance as they improve connectivity with the forests and ensure suitable habitat for birds and other wild animals. Hence, the future of the Himalayan biodiversity depends more on the effective management of human-modified landscapes presenting a daunting challenge to the conservation practitioners and land-use managers in order to conserve avian and other floral and faunal diversity of this region. Being organically managed (in the absence of pest control by insecticides and pesticides) the role of natural pest predators and parasitoids in addition to insectivorous birds in control of tea pests becomes crucial. Therefore, a long-term extensive study covering different tea estates is necessary to understand the biodiversity conservation potential of tea plantations in the region. The roles of birds as a bio-control agent of tea pests must be addressed through long-term extensive study covering different tea estates and natural ecosystems.

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Table S1. Bird species recorded during the present study in tea gardens of Kurseong Hill, Darjeeling, Eastern Himalaya, India

Common name	Scientific name	[1]Feeding guild	[2]Habitat guild	[3]Study sites				Total
				A	B	C	D	
Olive-backed Pipit	*Anthus hodgsoni*	I	OL	20	18	20	18	76
Red-vented Bulbul	*Pycnonotus cafer*	I	FG	27	19	13	6	65
Grey Bushchat	*Saxicola ferreus*	I	FG	8	29	7	16	60
Green-backed Tit	*Parus monticolus*	I	FG	6	14	4	19	43
Aberrant Bush Warbler[#]	*Horornis flavolivaceus*	I	FS	20	8	9	3	40
Blue Whistling Thrush	*Myophonus caeruleus*	I	FG	7	12	2	7	28
Blue-fronted Redstart[#]	*Phoenicurus frontalis*	I	FG	10	4	9	5	28
Ashy Drongo	*Dicrurus leucophaeus*	I	FS	5		5	12	22
Long-tailed Shrike[#]	*Lanius schach*	I	FG	5	2	10	2	19
Great Barbet	*Psilopogon virens*	F	FS	5	2	6	2	15
Barn Swallow[#]	*Hirundo rustica*	I	OL	2		10	2	14
Red-billed Leiothrix*	*Leiothrix lutea*	I	FG		5	7	1	13
Eurasian Tree Sparrow	*Passer montanus*	G	OL		11			11
Black Bulbul	*Hypsipetes leucocephalus*	I	FS	6	0		3	9
House Crow[#]	*Corvus splendens*	O	FG		3	2	3	8
Rufous-breasted Accentor[#]	*Prunella strophiata*	I	OL		8			8
Oriental Turtle Dove[#]	*Streptopelia orientalis*	G	FG	3	2	1	1	7
White-browed Scimitar Babbler	*Pomatorhinus schisticeps*	I	FG			2	5	7
Chestnut-crowned Laughingthrush[#]	*Trochalopteron erythrocephalum*	I	FG			3	3	6
Cinereous Tit	*Parus cinereus*	I	FG	1		5		6
Green-tailed Sunbird	*Aethopyga nipalensis*	N	FG	2	1	3		6
Grey-crowned Warbler[#]	*Seicercus tephrocephalus*	I	FS		2	2	2	6
Grey Treepie	*Dendrocitta formosae*	I	FS			2	4	6
Rusty-cheeked Scimitar Babbler[#]	*Erythrogenys erythrogenys*	I	FG	3	1		2	6
Slaty-backed Forktail	*Enicurus schistaceus*	I	FG	3			3	6
Verditer Flycatcher[#]	*Eumyias thalassinus*	I	FG			2	4	6
Black-throated Tit	*Aegithalos concinnus*	I	FS	5				5
Common Kestrel*	*Falco tinnunculus*	C	FG			3	2	5
Scarlet Minivet	*Pericrocotus flammeus*	I	FG	3	2			5
Streaked Laughingthrush[#]	*Trochalopteron lineatum*	I	FG		5			5
White-capped Water Redstart	*Phoenicurus leucocephalus*	I	FG	2		3		5
Chestnut-bellied Nuthatch	*Sitta cinnamoventris*	I	FG	4				4
Blue-throated Barbet	*Psilopogon asiaticus*	F	FS			3		3
Common Myna	*Acridotheres tristis*	O	OL	3				3
Siberian Stonechat[#]	*Saxicola maurus*	I	FG	1			2	3
Red-tailed Minla	*Minla ignotincta*	I	FG	3				3
Rufous-necked Laughingthrush	*Garrulax ruficollis*	I	FG			3		3
Himalayan Bulbul	*Pycnonotus leucogenis*	I	FG	1			1	2
Large-billed Crow	*Corvus macrorhynchos*	O	FG		2			2
Spotted Dove[#]	*Streptopelia chinensis*	G	FG	1		1		2
Whiskered Yuhina[#]	*Yuhina flavicollis*	I	FG		2			2
White-throated Fantail	*Rhipidura albicollis*	I	FG	1			1	2
Asian Barred Owlet*[#]	*Glaucidium cuculoides*	C	FS			1		1
Common Green Magpie	*Cissa chinensis*	O	FS	1				1
Eurasian Sparrowhawk*[#]	*Accipiter nisus*	C	FG				1	1
Hill Prinia[#]	*Prinia superciliaris*	I	FG				1	1
Himalayan Bush Robin[#]	*Tarsiger rufilatus*	I	FG	1				1
Rusty-flanked Treecreeper[#]	*Certhia nipalensis*	I	FG			1		1
Total				159	152	139	131	581

Note:

[1]Feeding guild: Carnivore (C), Frugivore (F), Granivore (G), Nectarivore (N), Omnivore (O), Insectivore (I)

[2]Habitat specialization: Forest Specialist (FS), Forest Generalist (FG), Openland (OL)

[3]Study sites: Spring Side (A), Naya Busty (B), Singell (C), Naya Bazar (D). Numbers represents number of individuals recorded during the present study.

*Species listed in CITES Appendix II (CITES 2018). [#]New record of bird species for Tea plantations of Kurseong Hill.

Bird taxonomy follows Praveen et al. (2018).