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Original article

Avifaunal diversity in the peripheral areas of the Maduruoya National Park in Sri Lanka: With conservation and management implications

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ABSTRACT

A survey was randomly conducted in the marginal areas of Maduruoya National Park, Sri Lanka for a period of > 7 years. These study sites are located within the dry zone and the intermediate zone. The main vegetation type of the area is dry mixed evergreen forest. We recorded 196 bird species belonging to 66 families, and they included 161 breeding residents, 25 purely migrants, nine both resident and migrants, one vagrant, 14 nationally threatened, three globally threatened, and 10 endemic species. We also report the first-ever records of Chestnut-backed Owlet, Red-faced Malkoha, and Spot-winged Thrush from this dry area. However, these precious habitats and its species are threatened because of irresponsible human activities such as forest fires, land filings, hunting, road kills, encroachments, garbage dumping, agrochemicals, granite-rock blasting, logging, and road constructions. Therefore, we recommend that relevant authorities take immediate conservation action to increase the protection of these marginal areas or buffer zone in the near future.

Introduction

The tropical Island of Sri Lanka (5°55′–9°51′ N and 79°41′–81°54′ E) has a rich and diverse assemblage of avifauna that comprises a total of 453 species with 240 breeding residents and 213 purely migrants including 72 vagrants (Weerakoon and Gunawardena 2012; Warakagoda et al 2012). Among Sri Lanka's residential breeders, 21 species are also represented by migrating populations (Weerakoon and Gunawardena 2012). The number of endemic species has been disputed, and the number has fluctuated between 20 and 47 throughout the ornithological history of Sri Lanka (Kotagama et al 2006). Some ornithologists list 33 endemic species (Rasmussen and Anderton 2005; Warakagoda and Sirivardana 2009; Weerakoon and Gunawardena 2012), whereas others consider 27 species as being definitive endemic and the remaining six species as proposed endemics (Kaluthota and Kotagama 2009; Kotagama et al 2006; Weerakoon and Gunawardena 2012). At present, 67 species including 18 endemic species are categorized as "nationally threatened [Critically endangered (CR), Endangered (EN), and Vulnerable (VU)] according to the National Red List 2012 of Sri Lanka (MOE 2012). The distribution and habitat preference of the birds within the island of Sri Lanka are primarily governed by the vegetation and geoclimatic parameters such as temperature variability, precipitation, hydrology, and altitude (Harrison and Worfolk 2011; Kotagama et al 2006). Some avifauna are island-wide in distribution, whereas for others a substantial proportion are only recorded from one or two bioclimatic zones (Warakagoda et al 2012). For instance, more than 60% of the residential species are restricted to the southwestern wet

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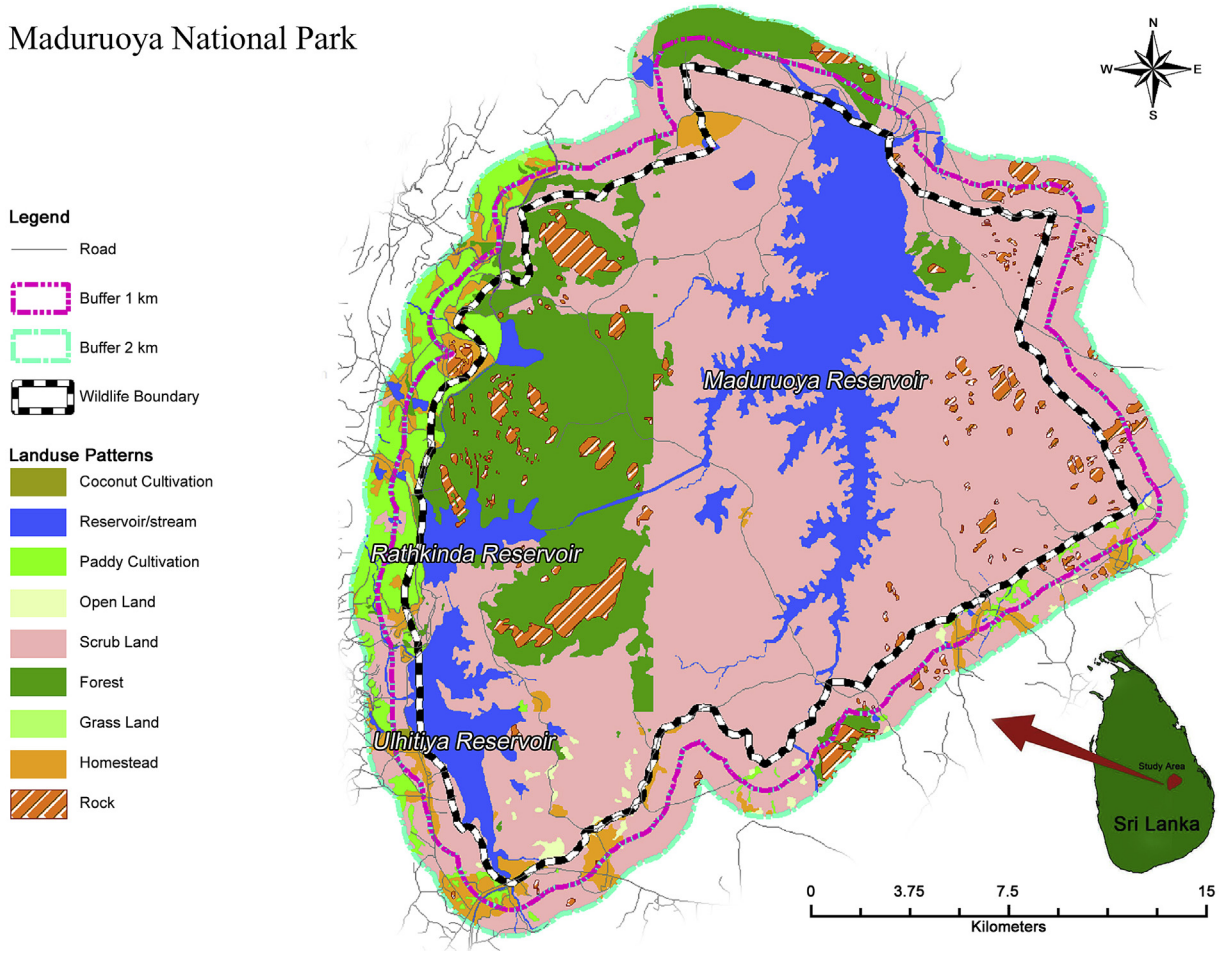

Figure 1. Map of the study area, located in North Eastern dry and intermediates zones of Sri Lanka, with different habitat types.
Department of Wildlife Conservation of Sri Lanka (2004) . A guide to national parks of Sri Lanka, Department of Wildlife Conservation, Colombo, Sri Lanka.

zone (annual average precipitation, >2000 mm) and the central highlands of Sri Lanka (Weerakoon and Gunawardena 2012).

Approximately one-third of residential breeders of Sri Lanka are forest birds (Weerakoon and Gunawardena 2012). Sri Lanka's forest covers constitute ~25% of the total land area (FAO 2010). Both primary and secondary forests in the island are rapidly diminishing and being severely fragmented as a result of expanding human settlements and agricultural lands, leading to adverse impacts on the rich native biodiversity (Bambaradeniya et al 2003; Senanayake et al 1977). Natural vegetation in Sri Lanka is represented by an adverse array of forest types with dry mixed evergreen forests, lowland evergreen rainforests, and moist montane forests being the most predominant (Gunatilleke and Gunatilleke 1990). The dry mixed evergreen forests of the dry zone (annual average precipitation, < 2000 mm) are the most extensive, covering 21% of the island (Wikramanayake et al 2001; FDGSL 2009). These forests are largely secondary in origin (resulting from secondary successions following abandonment of prehistoric agriculture and human civilizations), and distributed across most of the dry zone except in the Jaffna peninsula (Gunatilleke and Gunatilleke 1990; SDSL 2007). They have a mean annual temperature ~29°C, and the mean annual rainfall is ~1000–1500 mm. Most of the rain falls during the northeast monsoon season from October to February, and there is a noticeable dry period from May to August (Gunatilleke and Ashton 1987; SDSL 2007). The dry zone topography can be described as flat lowlands not exceeding 300 m (the 1st peneplains). However, there is some high-elevation, rock-outcrop vegetation in a few isolated, residual peaks of the dry zone (SDSL 2007).

Because a substantial proportion (> 30%) of Sri Lanka's avifauna is composed of forest species, monitoring the status of bird communities through surveys and implementing conservation actions are foremost in importance (Kotagama et al 2006; Weerakoon and Gunawardena 2012). The dry mixed evergreen forests of the north, north-central, and eastern regions of Sri Lanka remained relatively unexplored for about the past 30 years (1976–2009) owing to national security complications and civil unrests (Weerakoon and Gunawardena 2012). Given the greater spatial coverage of dry mixed evergreen forests in Sri Lanka, and the anthropogenic stressors that could potentially endanger these ecosystems, we intended to explore the avifaunal diversity in the vicinity of the Maduruoya National Park, a poorly-studied region covered with extensive dry mixed evergreen forests. Most faunal surveys in Sri Lanka has taken place inside protected areas with little to no attention given to the peripheral forests outside the park or reserve boundaries. Previous studies have underscored the importance of habitats surrounding the protected areas for the persistence of the native bird populations inside the park boundary (Wijesinghe and Brooke 2005; Gunawardene et al 2007). Our objectives for this

investigation were (1) to assess the bird diversity of the habitats bordering the Maduruoya National Park, (2) to identify threats that might endanger the native bird fauna of the region, and (3) to suggest conservation recommendations for the habitats adjoining the national park and to improve the habitat quality of the buffer area.

Materials and methods

Study area

Peripheral habitats around Maduruoya National Park are similar to those inside the park. Our study area is located within the dry zone with the southern edge of our study area bordering the intermediate bioclimatic zone (Figure 1), with close proximity to the Mahaweli development region (a government-sponsored, large-scale socioeconomic development scheme involving irrigation and reservoir construction through impoundments, establishment of human settlements, and infrastructure development), teak plantations, and unprotected woodlands that are subjected to repeated slash-and-burn cultivation (DWC 2004; IUCN 1990). The Maduruoya National Park (~58,850 ha; 7°23′–7°35′ N and 81°05′–81°20′ E) was established in the year 1983 (Gazette No. 270/9) under the Fauna and Flora Protection Ordinance as an integral part of the Mahaweli Protected Area Complex to provide habitats for the displaced wildlife and provide refuge for many other native fauna and flora, particularly elephants (DWC 2004; IUCN 1990; SDSL 2007). The Maduruoya National Park and surrounding areas also serve as a catchment for five regional reservoirs (Henanegala, Maduruoya, Pimburettawa, Ratkinda, and Ulhitiya) developed under the Mahaweli Programme (DWC 2004; IUCN 1990).

The main vegetation type of the area is tropical dry mixed evergreen forests "dominated by *Manilkara* sp." (Gunatilleke and Gunatilleke 1990). Given the forest regeneration aftermath of historical chena farms (a form of shifting agriculture) and early settlements, our study region has large areas of secondary vegetation and vast extensions of open dry tropical grasslands and wooded, lowland savannas (Premadasa 1990), and large wetlands (Figure 2A). The local topography can be described as mainly flat lowlands ranging from 30 m to 150 m in altitude, reaching a maximum at 685 m, and an 8-km stretch of rock-outcrop vegetation located southwest of Maduruoya National Park (Figure 2B). The mean annual temperature of our study area is ~27°C, and the mean annual rainfall is 1650 mm—received mostly during the northeast monsoon (from October to late January) season (DWC 2004; IUCN 1990). The Maduruoya National Park is not only significant from a biodiversity perspective but is also extremely rich in its archeological heritage, housing a number of ruins and artifacts dating back to various periods of Sri Lanka's imperial history.

Data collection

We conducted this survey for > 7 consecutive years (2007–2014). Our survey was based on a total of 36 field visits to multiple habitats adjoining Maduruoya National Park boundary (2 km buffer zone). We made observations through the unaided eye and (8 × 40) Nikon binoculars (Nikon Vision Co., Ltd. Tokyo, Japan) via multiple random walks. We used a Cannon EOS 50D SLR (Canon Inc., Tokyo, Japan) digital camera to take photographs and a Taylor digital thermometer (Taylor Precision Products Inc., Oak Brook, IL, USA) to measure and record some environmental parameters. The Global Positioning System (GPS) coordinates were recorded using a Garmin Etrex 10 GPS receiver (Garmin International, Inc., Olathe, KS, USA), and the habitat map was made by using Arc Gis version 10.1 (Esri, Redlands, CA, USA) software. Indirect observations such as calls and presence of plunged (or dropped) feather, nests, and eggs were also recorded. Our survey encompassed diverse habitat types (wetlands, scrublands, grasslands, home gardens, homestead, farmlands, and teak plantations) that are closely associated with dry mixed evergreen forests. Surveys were conducted during both day and night (from 0600 hours to 0800 hours in the morning, from 1400 hours to 1600 hours in the afternoon, and from 2000 hours to 2200 hours in the night). We also interviewed villagers using our own questionnaire forms to assess their forest needs. All the bird species were identified with reference to Harrison and Worfolk (2011), Henry (1998), Kotagama and Fernando (1994), and Rasmussen and Anderton (2005). The classification, nomenclature, and common names of the checklist were compiled according to Rasmussen and Anderton (2012) and Birdlife International (2014a). According to Warakagoda et al (2012), species common names containing "Ceylon" are upgraded to "Sri Lanka". The migratory and/or residential status was accorded with Rasmussen and Anderton (2012) and Warakagoda et al (2012). The national conservation status (Red List) is in accordance with MOE (2012), and the global conservation statuses are in accordance with IUCN (2014). The habitat types were determined according to the Birdlife International (2014b). The relative diversity (RDi) of orders was calculated using the following formula:

$$\text{RDi} = \text{number of bird species in an order/total number of species} \times 100.$$

Results

We recorded a total of 196 species of birds representing 66 families and 20 orders (Appendix 1); it represents ~43% of the islands' native bird fauna. Among the avifauna of our study area, 161 (~82%) were breeding residents including 10 (~5%) endemics,

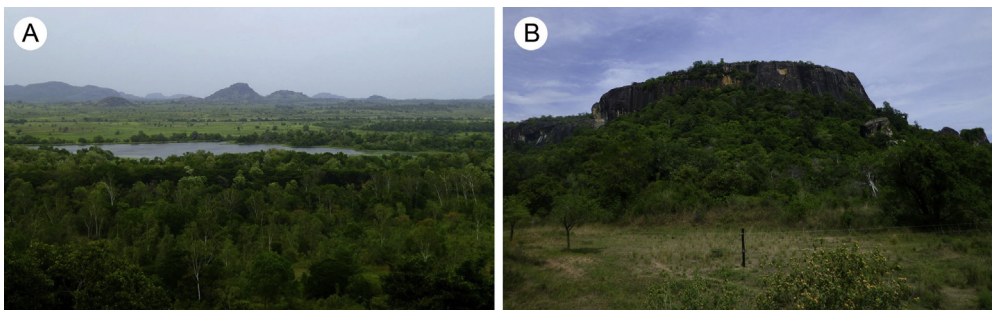

Figure 2. A, Man-made wetlands for agricultural practices (mainly for rice fields); B, Rock-out vegetations, with the electric elephant fence in border an around Maduruoya National Park (photos: Madhava Botejue).

25 (~12%) were purely migrants, one vagrant, and nine (~5%) species with mixed resident–migrant status (Figure 3A). Among the recorded species, 14 were "nationally threatened" (1 CR, 3 EN, and 10 VU), three were VU, and 27 near threatened (19 nationally and 8 globally) according to the International Union for Conservation of Nature (IUCN) Global Red List. Furthermore, 156 of the recorded species were forest birds (of which 17 were migrants and 7 were mixed residents–migrants); 134 used croplands (of which 17 were migrants and 7 were mixed residents–migrants) (Figure 3B); 44 used built-up areas (of which 7 were migrants and 3 were mixed residents–migrants); 88 used scrublands (of which 12 were migrants and 1 was mixed resident–migrant); 68 used grasslands (of which 10 were migrants and 3 were mixed residents–migrants); 91 were inland aquatic birds (of which 14 were migrants and 6 were mixed residents–migrants). We also calculated species diversity abundance within bird orders (Table 1).

Out of the 196 species, *Passer domesticus* (House Sparrow) and *Tyto alba* (Common Barn-owl) used all six habitats for their forage; 22 preferred only five habitat types (of which 5 were migrants and 1 was mixed resident–migrant); 44 preferred only four habitat types (of which 5 were migrants and 2 were mixed residents–migrants); 58 preferred only three habitat types (of which 5 were migrants and 2 were mixed residents–migrants); and 25 preferred only a single habitat type (of which 3 were migrants and 2 were mixed residents–migrants). Endemic birds (10 species) that were recorded from the study are *Ocyceros gingalensis* (Sri Lanka Grey Hornbill), *Phaenicophaeus pyrrhocephalus* (Red-faced Malkoha), *Xantholaema rubricapillus* (Sri Lanka Small Barbet), *Glaucidium castanotum* (Chestnut-backed Owlet), *Galloperdix bicalcarata* (Sri Lanka Spurfowl), *Gallus lafayetii* (Sri Lanka Junglefowl), *Loriculus beryllinus* (Sri Lanka Hanging parrot), *Pellorneum fuscocapillus* (Brown-capped Babbler), *Pomatorhinus melanurus* (Sri Lanka Scimitar-babbler), and *Geokichla spiloptera* (Spot-winged Thrush).

Table 1. Relative diversity (RDi) of various avifaunal orders at the buffer zone in Maduruoya National Park, Sri Lanka.

S. no.	Order	No. sp.	RDi
01	Accipitriformes	13	6.6
02	Anseriformes	3	1.5
03	Apodiformes	4	2.0
04	Bucerotiformes	2	1.0
05	Charadriiformes	14	7.1
06	Ciconiiformes	5	2.6
07	Columbiformes	6	3.1
08	Coraciiformes	10	5.1
09	Cuculiformes	12	6.1
10	Galliformes	4	2.0
11	Gruiformes	5	2.6
12	Passeriformes	71	36.2
13	Pelecaniformes	15	7.7
14	Piciformes	9	4.6
15	Podicipediformes	1	0.5
16	Psittaciformes	4	2.0
17	Strigiformes	12	6.1
18	Suliformes	4	2.0
19	Trogoniformes	1	0.5
20	Upupiformes	1	0.5
Total		196	100%

No. sp. = number of species; S. no. = serial number.

Discussion

Our study revealed that areas around the Maduruoya National Park have a rich community of avifauna (Appendix 1 and Figure 4A–F), comprising ~67% of the breeding residents (out of the 240 breeding residents in Sri Lanka) and ~12% of migrants (out of the 213 purely migrants in Sri Lanka). In addition, this avifaunal species represents 37% of the islands' endemic bird fauna (out of the 27 endemic birds in Sri Lanka). These figures on endemism and species richness is higher than those reported in many other dry zone forests (e.g., Ritigala Strict Nature Reserve: 97 species, including 5 endemics; Minneriya National Park: 135 including 3 endemics; Weerakoon and Goonatilake 2007). Biodiversity baseline surveys carried out in a regional national park (Wasgomuwa National Park) also resulted in comparable numbers (168 species in total including 8 endemics; DWC 2007, 2008). When compared to other similar regions of the dry zone, Maduruoya National Park and peripheral areas demonstrate similar or higher avifaunal richness in terms of residential and migrant species. It is followed by Galoya National Park (129 species, 5 migrants; Hettige et al 2000), Yala Protected Area Complex (168 species, 35 migrants; de Silva and de Silva 2004), Wilpattu National Park (137 species, 25 migrants; Weerakoon and Goonatilake 2007), and Panama area (143 species, 25 migrants; Somaweera et al 2004).

The high richness of birds in Maduruoya National Park and the surrounding areas can be attributed to the high habitat heterogeneity of both inland aquatic and terrestrial habitats of our study

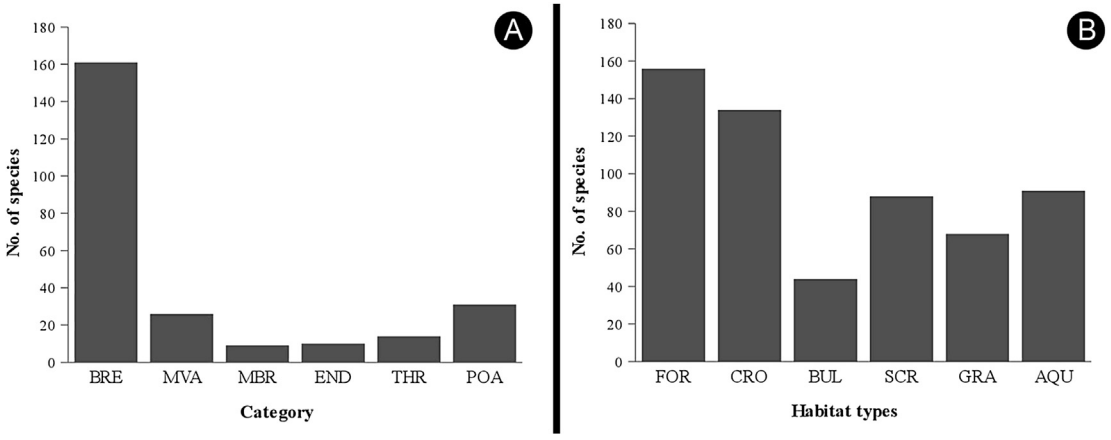

Figure 3. A, Avifaunal richness around Maduruoya National park and the surrounding areas represented based on the migratory and residential status; B, Avifaunal diversity of the Maduruoya National Park and the surrounding areas represented based on habitat types. (AQU = inland aquatic; BRE = breeding recidents; BUL = built-up; CRO = croplands; END = endemics; FOR = forested; GRA = grasslands; MBR = mixed breeding recidents and migrants; MVA = migrants and vagrants; POA = poaching; SCR = scrublands; THR = threatened).

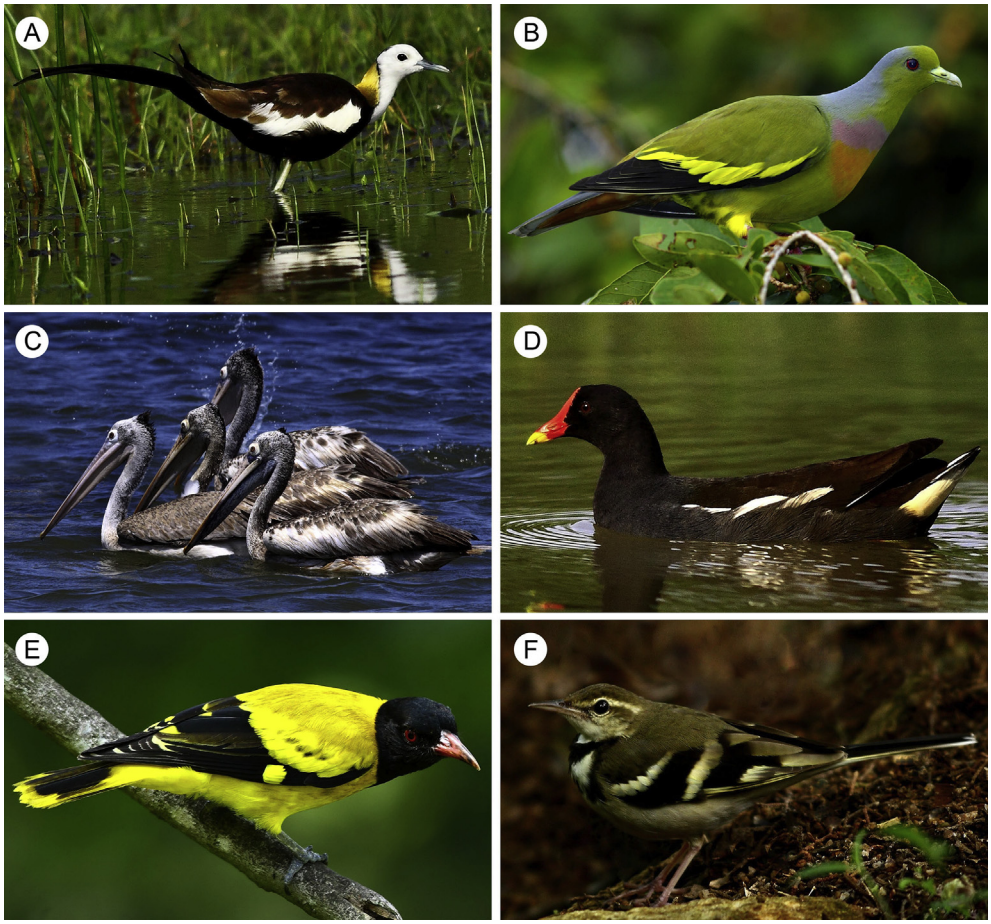

Figure 4. A, Pheasant-tailed Jacana (*Hydrophasianus chirurgus*), a native species, prefers inland aquatic habitat; B, Orange-breasted Green Pigeon (*Treron bicinctus*), a native species, prefers forested habitat; C, Spot-billed Pelican (*Pelecanus philippensis*), a native species, prefers inland aquatic habitat; D, Common Moorhen (*Gallinula chloropus*), a native species, prefers inland aquatic habitat; E, Black-hooded Oriole (*Oriolus xanthornus*), a native species, prefers forested habitat; F, Forest Wagtail (*Dendronanthus indicus*), a purely migrant species, prefers forested habitat (photos: Vimukthi Weeratunga).

region (Fernando 1996). The overall landscape of our study region comprises both "natural" and man-made habitats. Rivers and streams, semipermanent freshwater marshes, and seasonal waterholes are some of the "natural" aquatic habitats; perennial large tanks and reservoirs, seasonal small tanks, and rice fields serve as the man-made aquatic habitats. Natural terrestrial habitats comprise dry mixed evergreen forests, scrub forests, grasslands, riparian forests, and rock-outcrop (Perera 1975; Gunatilleke and Gunatilleke 1990), whereas man-made terrestrial habitats comprise farmlands, forest gardens, and home gardens (Nuberg et al 1994). Although the dominant vegetation type of the Maduruoya National Park and marginal areas is dry mixed evergreen forest, the core forests and ridge-top forests exhibit characteristics of the moist semievergreen forest of intermediate zone. Such mosaic habitat structure across the landscape may contribute to a highly diverse bird community in and around the Maduruoya National Park. Many previous studies in similar tropical dry habitats have suggested that landscape heterogeneity may lead to increased wildlife diversity (Turner and Corlett 1996; Da Silva and Bates 2002; Surasinghe and De Alwis 2010).

We encountered a high abundance of water birds (a total of 91 aquatic inhabitants, 12 exclusively water dwellers) in our study areas, especially during the migration period, indicating that habitats in and around Maduruoya National Park are high-density waterfowl area (see also Warakagoda and Sirivardana 2006). Moreover, our survey emphasized the importance of the Maduruoya National Park and surrounding areas for the conservation of forest birds given the high relative abundance (a total of 156 forest inhabitants, 24 exclusively forest species) of forest species we encountered. For instance, *Ciconia nigra* (Black Stork), one of the rarest birds found in Sri Lanka, was recorded twice in this area during our survey (December 2008 and March 2010). This bird was first recorded from Maduruoya area in 2004, which also was the fourth sighting in Sri Lanka (Gabadage 2007). Previously, the same species was recorded in Yala East National Park (Southeastern coastal area of Sri Lanka), near the estuary of Kalaoya and Kokmaduwa village near the Rajangane reservoir (later 2 from the Northwestern Sri Lanka) (Goonatilake 2006; Senaratna 2000). Our observations suggest that *Ciconia nigra* may associate with Maduruoya National Park and surrounding areas more relatively frequently than previously considered.

Our survey indicated that the Maduruoya National Park and surrounding areas hold ~43% of Sri Lanka's overall avifaunal diversity (67% of the breeding residents and ~12% of purely migrants in Sri Lanka). Given the presence of multiple terrestrial and aquatic habitat types that provide refuge to both threatened and endemic birds, Maduruoya National Park and the surrounding areas are crucial for the conservation of birds. Among the endemic birds we found during our survey, *Glaucidium castanotum* (Chestnut-backed Owlet), *Phaenicophaeus pyrrhocephalus* (Red-faced Malkoha), and *Geokichla spiloptera* (Spot-winged Thrush) are remarkable. Red-faced Malkoha is a nationally and globally vulnerable species

(MOE 2012; IUCN 2014) and mainly found in a few remaining tropical lowland rainforest fragments and adjoining hills; few fragmented colonies exist in the dry zone forests (Henry 1998). Also, the Chestnut-backed Owlet is a nationally vulnerable species (MOE 2012) and mainly found in a few tropical lowland rainforest fragments and adjoining hills, with no previous records from the dry zone forests (Kotagama and Ratnavira 2010; Rasmussen and Anderton 2012; Warakagoda et al 2012).

Areas in and around Maduruoya National Park are considered an Important Bird Area (IBA) because they harbor ~21% of island's threatened species and three globally threatened (VU) species [*Ciconia episcopus* (Woolly-necked Stork), *Leptoptilos javanicus* (Lesser Adjutant), and *Phaenicophaeus pyrrhocephalus* (Red-faced Malkoha); Birdlife International 2014a]. Our study revealed that Maduruoya area is home to "globally common locally rare" species (least concerned in the Global IUCN Red List, but CR according to the National Conservation assessments) such as *Merops philippinus* (Blue-tailed Bee-eater). Although this species has a wide distribution at the global scale with viable populations, the resident populations of Sri Lanka are limited in distribution (area of occupancy, $>100\ km^2$) and suffer from habitat fragmentation as well as decline in their geographical distribution (MOE 2012). Likewise, *Columba livia* (Rock Pigeon) is considered CR in Sri Lanka, because the wild populations of this species are confined to few isolated locations in northeast to south, mainly in the offshore rocky islets of Sri Lanka (Henry 1998; Warakagoda et al 2012). This bird is found rarely on large dams and other anthropogenically altered habitats (Warakagoda et al 2012). Even though this bird is recorded from Maduruoya National Park and surrounding areas, there were no considerable wild populations, but the domestic variety has a much larger population in the surrounding villages. The three nationally endangered rare species found here are the *Excalfactoria chinensis* (Blue-breasted Quail), *Eurystomus orientalis* (Dollarbird), and *Hierococcyx varius* (Common Hawk-cuckoo) are also noteworthy.

Nearly half (~47%) of Sri Lankan avifaunal diversity is composed of migratory birds. The geographic position and presence of multiple suitable habitats are the main reasons for the high number of migrants (Kotagama et al 2006). According to Kotagama and Ratnavira (2010), the eastern and the western routes are the major pathways for migrants entering the country. In addition, there is another route that brings birds from the Far East. Birds come via the eastern route, the Far East travel along the eastern coastline, and fly inland following the major river systems. Our study area is in close proximity to both eastern and the far eastern migratory routes. Nearly 12% of migrant species are found in and around the Maduruoya National Park, which accounts for a substantially high proportion. Maduruoya National Park and surrounding habitats in the vicinity of and within the Mahaweli river system provide the necessary refuge and stopover sites for birds traveling along the Mahaweli River, which then contribute to the high number of migrants species.

Prevalent threats

During our survey, we observed multiple environmentally adverse anthropogenic activities taking place in the Maduruoya National Park and the surrounding habitats. These stress factors have resulted in substantial degrees of habitat degradation and biodiversity loss. The most detrimental forms of habitat loss and overexploitation were illicit logging and extraction of nontimber products [firewood, medicinal plants, bird nests—especially of *Aerodramus unicolor* (Indian Swiftlet)]; poaching for bush meat; and encroachment of the national park boundary and adjoining public lands by clear-cutting and stashing-and-burning for cash crop farming and human settlements (see also Gunatilleke et al 2008). Land fillings, road kills, soil erosion, garbage dumping, rock exploitations, and fish net fences are all identified as additional reasons for habitat loss and fragmentation in the study area. Illegal logging and poaching have been imperiling the wildlife and other natural resources of the dry zone landscapes of Sri Lanka over several decades in the past (De Zoysa and Inoue 2008).

Large mammals, large reptiles (crocodiles and land monitors), and large birds such as endemic *Gallus lafayetii* (Ceylon Junglefowl), *Anastomus oscitans* (Asian Openbill), *Pelecanus philippensis* (Spot-billed Pelican), *Turnix suscitator* (Barred Buttonquail), *Ciconia episcopus* (Woolly-necked Stork), *Ducula aenea* (Green Imperial Pigeon), *Threskiornis melanocephalus* (Black-headed Ibis), and *Ichthyophaga ichthyaetus* (Grey-headed Fish-eagle), are killed for meat (sometimes people collect eggs); the latter is nationally and globally near threatened (MOE 2012). Officials of the Department of Wildlife Conservation in the area are doing creditable work to prevent these illegal activities. Yet, the lack of understanding of the principles of conservation science and knowledge on local and global biodiversity among the officials of the Department of Wildlife Conservation is a serious issue in Sri Lanka in relation to biodiversity conservation. Conservation is an important global issue, and it is incumbent upon educators, conservation managers, legal advisors, funding agencies, officials, and policy makers to work along with research scientists to ensure that accurate information is obtained because it is a vital tool to safeguard Sri Lanka's remaining endangered biodiversity treasures (Bahir and Gabadage 2009a, 2009b). Moreover, because of the lack of adequate and continuous patrolling, loopholes in the law enforcement system, and other logistical constraints, prevention of illicit human activities has become impractical. Improvements to address these problems should be geared to promote conservation of biological diversity. The threats we observed justify the need for innovative conservation actions superseding conventional fortress conservation.

Conservation actions

Given the high diversity and endemism among the avifaunal communities of the Maduruoya National Park and the surrounding areas, implementation of conservation actions is a pressing need. Effective conservation planning needs integration of four salient actions: (1) landscape-scale management of habitats, species, and ecosystem processes; (2) strengthening existing national policies on environmental management and biodiversity conservation; (3) continuous monitoring of habitat and population status, and promotion of ecology and conservation-driven research; and (4) raising public awareness of wildlife conservation and natural resource management (Groves et al 2002; Sanderson et al 2002; Pressey et al 2007; Sodhi et al 2010).The fact that Maduruoya National Park and surrounding areas are an IBA signifies the global-scale importance of our study region and the urgent need for conservation.

The local inhabitants of Maduruoya National Park and surrounding areas are constantly interacting with the wildlife and are highly dependent on many forest products and other natural resources (see Nuberg et al 1994). Therefore, conservation measures must be based on participatory management programs such as community forest management, local forest stewardship development, easement-like conservation-driven incentives, and shared governance through stakeholder participation (Klooster and Masera 2000; De Zoysa and Inoue 2008). With the high diversity of birds, along with high abundance of charismatic mega fauna such as elephants, community-based ecotourism may have some promising results not only as a source of local income but also as a

means of minimizing overutilization of natural resources (Kiss 2004). These improvements should target conservation of biological diversity. Furthermore, introduction of economically and environmentally sustainable agroforestry practices, forest gardening, subsistence farming, and delineation of biodiversity-integrated, resilient agricultural landscapes embedded with the Maduruoya National Park, other regional state protected areas, and relatively unaltered private lands may help mitigate some of the anthropogenic disturbances that are detrimental to avifauna and their habitats in our study area (Nuberg et al 1994; Bambaradeniya et al 2004; Harvey et al 2008).

Previous studies have emphasized the importance of the Maduruoya National Park and surrounding areas for multiple environmental and socioeconomic purposes: conservation of imperiled wildlife such as the Asian elephants, sloth bear, sambur, and Sri Lankan leopard (Ishwaran 1993; Ratnayeke et al 2007); capture fishery of inland water bodies (Amarasinghe and De Silva 1999); and watershed, water resource, and irrigation management (Hewavisenthi 1992). In addition, landscape-scale connectivity conservation through wildlife corridors, delineation of buffer zones, and preservation of riparian forests are vital actions to sustain the metapopulation and metacommunity dynamics and foraging movements of birds (Bonnot et al 2013; Trombulak and Baldwin 2010). In this study, we suggest that peripheral woodlands around the existing park boundary be demarcated as a buffer zone with minimal human activities.

To promote the conservation of water birds in the area, we recommend that the local water bodies found outside the park (wetlands and streams) and the associated uplands (such as riparian forests and wetland vegetation) be integrated into the buffer zone or declared as critical wildlife habitats to the Maduruoya National Park (see also Fischer and Fischenich 2000; Karunarathna et al 2008; Zhang et al 2014). Considering the occupancy of globally threatened species, range-restricted species, forest specialists, and migrants, the IBA of Maduruoya National Park should be expanded outwardly beyond the protected area boundary. Implementation of a conservation and management plan for the Wasgomuwa–Maduruoya–Galoya Protected Area Complex is crucial to ensure the long-term protection of these avifauna-rich landscapes. Conservation and management of this wilderness, conservation-forced research, and ecological monitoring should take place with the leadership of governmental conservation authorities and with the active participation of regional community-based organizations, private landowners, conservation research scientists, universities, and other affiliated accredited research institutes.

Much renovation needs to be undertaken with regard to the environmental and wildlife policies of Sri Lanka. Although Sri Lanka is a signatory to many international treaties (Convention on Wetlands of International Importance, especially as Waterfowl Habitat, Convention on International Trade in Endangered Species, United Nations Educational, Scientific and Cultural Organization and Biosphere Reserve Program and World Heritage Sites, Convention of Biological Diversity) that are strongly related to bird conservation, these international agreements have not had a substantial influence on national wildlife policies or environmental law framework. The three main bodies of law in Sri Lanka—the National Environmental Act, the Forest Ordinance, and the Fauna and Flora Protection Ordinance—do not provide a strong legal framework for the conservation of native avifauna and their unique habitats (see Zubair 2001). Furthermore, the support and encouragement given by the existing national environmental laws to research and education are grossly unsatisfactory (Pethiyagoda 2004). It is imperative that these laws be strengthened to safeguard the nation's biodiversity while encouraging scientific and academic explorations on Sri Lanka's wildlife. Because the security situation is favorable in the area, more in-depth and long-term research should be carried out to enhance our knowledge and to protect the rich biodiversity of the Maduruoya National Park and marginal areas. We hope that this study will influence and support future research and conservation measures in this area and also help other environmental educational programs in the future.

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Appendix 1. Checklist of bird species recorded during a survey that lasted > 7 years around the Maduruoya National Park.*

Order, family & species name	Common name	Forests	Croplands	Built-up	Scrublands	Grasslands	Inland aquatic	Migratory and breeding status
Accipitriformes								
Accipitridae								
Accipiter badius	Shikra	×	×	×	×	×		Br
Circus aeruginosus	Western Marsh Harrier		×				×	M
Elanus caeruleus	Black-winged Kite		×		×	×		Br
Haliaeetus leucogaster	White-bellied Sea-eagle						×	Br
Haliastur indus	Brahminy Kite	×		×			×	Br
Hieraaetus pennatus	Booted Eagle	×			×			M
Icthyophaga ichthyaetus■,NT	Grey-headed Fish-eagle		×				×	Br

(*continued on next page*)

(*continued*)

Order, family & species name	Common name	Forests	Croplands	Built-up	Scrublands	Grasslands	Inland aquatic	Migratory and breeding status
Ictinaetus malaiensis	Black Eagle	×			×			Br
Nisaetus cirrhatus	Crested Hawk-eagle	×	×			×	×	Br
Pernis ptilorhynchus	Oriental Honey-buzzard	×	×			×		Br
Spilornis cheela	Crested Serpent-eagle	×	×			×		Br
Lophotriorchis kienerii	Rufous-bellied Eagle	×						Br
Pandionidae								
Pandion haliaetus	Western Osprey	×					×	M
Anseriformes								
Anatidae								
Dendrocygna javanica	Lesser Whistling-duck	×	×			×	×	Br
Nettapus coromandelianus	Cotton Teal						×	Br
Querquedula querquedula	Garganey					×	×	M
Apodiformes								
Apodidae								
Aerodramus unicolor	Indian Swiftlet	×			×			Br
Apus affinis	Little Swift	×			×	×		Br
Cypsiurus balasiensis	Asian Palm-swift	×		×	×			Br
Hemiprocnidae								
Hemiprocne coronata	Crested Treeswift	×						Br
Bucerotiformes								
Bucerotidae								
Anthracoceros coronatus■	Malabar Pied Hornbill	×						Br
Ocyceros gingalensis[E]	Sri Lanka Grey Hornbill	×						Br
Charadriiformes								
Burhinidae								
Burhinus indicus	Indian Stone-curlew		×			×		Br
Esacus recurvirostris■	Great Thick-knee					×	×	Br
Charadriidae								
Charadrius alexandrines[VU]	Kentish Plover						×	M+Br
Charadrius dubius[VU]	Little Ringed Plover	×	×	×		×	×	M+Br
Pluvialis fulva	Pacific Golden Plover	×	×		×		×	M
Vanellus indicus	Red-wattled Lapwing					×	×	Br
Vanellus malabaricus	Yellow-wattled Lapwing					×	×	Br
Jacanidae								
Hydrophasianus chirurgus	Pheasant-tailed Jacana						×	Br
Laridae								
Chlidonias hybrida	Whiskered Tern		×				×	M
Recurvirostridae								
Himantopus himantopus	Black-winged Stilt		×			×	×	M+ Br
Rostratulidae								
Rostratula benghalensis[VU]	Greater Painted Snipe		×			×	×	Br
Scolopacidae								
Actitis hypoleucos	Common Sandpiper	×	×				×	M
Gallinago stenura	Pintail Snipe	×	×		×	×	×	M
Turnicidae								
Turnix suscitator	Barred Buttonquail	×			×	×		Br
Ciconiiformes								
Ciconiidae								
Anastomus oscitans	Asian Openbill		×				×	Br
Ciconia episcopus▲,[NT]	Woolly-necked Stork	×	×			×	×	Br
Ciconia nigra	Black Stork						×	VG
Leptoptilos javanicus▲,[VU]	Lesser Adjutant	×	×				×	Br
Mycteria leucocephala■	Painted Stork		×				×	Br
Columbiformes								
Columbidae								
Chalcophaps indica	Emerald Dove	×	×					Br
Columba livia	Rock Pigeon (hybreaded)	×	×					Br
Ducula aenea	Green Imperial Pigeon	×			×			Br
Spilopelia chinensis	Spotted Dove	×	×				×	Br
Treron bicinctus	Orange-breasted Green Pigeon	×	×				×	Br
Treron pompadora	Sri Lanka Green-pigeon	×						Br
Coraciiformes								
Alcedinidae								
Alcedo atthis	Common Kingfisher	×	×	×		×	×	Br
Ceryle rudis	Lesser Pied Kingfisher	×	×			×	×	Br
Ceyx erithaca	Black-backed Dwarf Kingfisher	×	×				×	Br
Halcyon smyrnensis	White-throated Kingfisher	×	×	×			×	Br
Pelargopsis capensis	Stork-billed Kingfisher	×	×				×	Br
Coraciidae								
Coracias benghalensis	Indian Roller	×	×	×				Br
Eurystomus orientalis[EN]	Dollarbird	×	×	×	×			Br
Meropidae								
Merops leschenaulti	Chestnut-headed Bee-eater	×	×		×		×	Br
Merops orientalis	Little Green Bee-eater	×	×		×		×	Br

(*continued*)

Order, family & species name	Common name	Forests	Croplands	Built-up	Scrublands	Grasslands	Inland aquatic	Migratory and breeding status
Merops philippinus[CR]	Blue-tailed Bee-eater	×	×	×			×	M+Br
Cuculiformes								
Cuculidae								
Cacomantis passerinus	Grey-bellied Cuckoo	×	×		×	×		M
Cacomantis sonneratii[NT]	Banded Bay Cuckoo	×	×		×			Br
Centropus parroti	Southern Coucal	×	×		×	×	×	Br
Clamator coromandus	Chestnut-winged Cuckoo	×	×		×			M
Clamator jacobinus	Jacobin Cuckoo					×		Br
Cuculus micropterus	Indian Cuckoo	×						M+Br
Eudynamys scolopaceus	Asian Koel	×	×	×	×			Br
Hierococcyx varius[EN]	Common Hawk-cuckoo	×	×					M+Br
Phaenicophaeus pyrrhocephalus[▲,VU,E]	Red-faced Malkoha	×						Br
Phaenicophaeus viridirostris	Blue-faced Malkoha	×			×			Br
Surniculus dicruroides	Drongo Cuckoo	×	×		×			Br
Taccocua leschenaultii[VU]	Sirkeer Malkoha	×			×			Br
Galliformes								
Phasianidae								
Excalfactoria chinensis[EN]	Blue-breasted Quail		×		×	×	×	Br
Galloperdix bicalcarata[NT,E]	Sri Lanka Spurfowl	×						Br
Gallus lafayetii[E]	Sri Lanka Junglefowl	×			×			Br
Pavo cristatus	Indian Peafowl	×	×		×			Br
Gruiformes								
Rallidae								
Amaurornis phoenicurus	White-breasted Waterhen	×	×		×	×	×	Br
Gallicrex cinerea[NT]	Watercock		×				×	Br
Gallinula chloropus	Common Moorhen						×	Br
Gallirallus striatus[VU]	Slaty-breasted Rail	×	×		×	×	×	Br
Porphyrio poliocephalus	Purple Swamphen						×	Br
Passeriformes								
Acrocephalidae								
Acrocephalus brunnescens	Indian Reed-warbler	×			×	×	×	Br
Acrocephalus dumetorum	Blyth's Reed-warbler	×			×	×	×	M
Aegithinidae								
Aegithina tiphia	Common Iora	×	×	×				Br
Artamidae								
Artamus fuscus	Ashy Woodswallow	×	×			×		Br
Alaudidae								
Alauda gulgula	Oriental Skylark		×		×	×	×	Br
Eremopterix griseus	Ashy-crowned Finch-lark				×	×		Br
Mirafra affinis	Jerdon's Bushlark	×	×		×			Br
Campephagidae								
Coracina macei	Large Cuckooshrike	×	×		×	×		Br
Hemipus picatus	Pied Flycatcher-shrike	×	×		×			Br
Pericrocotus cinnamomeus	Small Minivet	×	×		×			Br
Pericrocotus flammeus	Orange Minivet	×	×					Br
Tephrodornis affinis	Sri Lanka Woodshrike	×	×	×	×	×		Br
Chloropseidae								
Chloropsis jerdoni	Jerdon's Leafbird	×	×				×	Br
Chloropsis aurifrons	Golden fronted Leafbird	×	×					Br
Cisticolidae								
Cisticola juncidis	Zitting Cisticola		×	×	×	×	×	Br
Orthotomus sutorius	Common Tailorbird	×	×	×	×			Br
Prinia hodgsonii	Grey-breasted Prinia	×	×		×			Br
Prinia inornata	Plain Prinia	×	×		×	×	×	Br
Prinia socialis	Ashy Prinia	×			×	×	×	Br
Prinia sylvatica	Jungle Prinia	×			×	×		Br
Corvidae								
Corvus culminatus	Indian Jungle Crow		×	×		×		Br
Corvus splendens	House Crow		×	×				Br
Dicaeidae								
Dicaeum erythrorhynchos	Pale-billed Flowerpecker	×	×	×				Br
Dicruridae								
Dicrurus paradiseus[NT]	Greater Racket-tailed Drongo	×	×					Br
Edolius caerulescens	White-bellied Drongo	×	×			×		Br
Dicrurus leucophaeus	Ashy Drongo	×			×	×		M
Dicrurus macrocercus	Black Drongo		×	×	×	×		Br
Estrildidae								
Lonchura malacca	Tricoloured Munia	×	×		×		×	Br
Lonchura punctulata	Scaly-breasted Munia	×	×	×	×	×		Br
Lonchura striata	White-rumped Munia	×	×		×	×		Br
Hirundinidae								
Hirundo daurica	Red-rumped Swallow	×	×	×	×		×	M
Cecropis hyperythra	Sri Lanka Swallow	×	×		×			Br

(*continued on next page*)

(*continued*)

Order, family & species name	Common name	Forests	Croplands	Built-up	Scrublands	Grasslands	Inland aquatic	Migratory and breeding status
Hirundo rustica	Barn Swallow		×	×	×	×	×	M
Laniidae								
Lanius cristatus	Brown Shrike	×	×	×	×	×		M
Monarchidae								
Hypothymis azurea	Black-naped Blue Monarch	×	×				×	Br
Terpsiphone paradisi	Asian Paradise Flycatcher	×	×	×	×			M+Br
Motacillidae								
Anthus richardi	Richard's Pipit		×			×		M
Anthus rufulus	Paddyfield Pipit		×			×	×	Br
Dendronanthus indicus	Forest Wagtail	×	×	×				M
Motacilla cinerea	Grey Wagtail		×	×		×	×	M
Muscicapidae								
Saxicoloides fulicatus	Indian Robin		×		×			Br
Copsychus malabaricus	White-rumped Shama	×	×		×			Br
Copsychus saularis	Oriental Magpie-robin	×	×	×	×		×	Br
Cyornis tickelliae	Tickell's Blue Flycatcher	×	×	×	×			Br
Muscicapa latirostris	Asian Brown Flycatcher	×	×	×				M
Muscicapa muttui	Brown-breasted Flycatcher	×						M
Nectariniidae								
Nectarinia asiatica	Purple Sunbird	×	×		×		×	Br
Nectarinia lotenia	Loten's Sunbird	×	×		×			Br
Leptocoma zeylonica	Purple-rumped Sunbird	×	×	×	×	×		Br
Oriolidae								
Oriolus xanthornus	Black-hooded Oriole	×						Br
Paridae								
Parus major	Great Tit	×	×	×	×	×		Br
Passeridae								
Passer domesticus	House Sparrow	×	×	×	×	×	×	Br
Pycnonotidae								
Iole indica	Yellow Browed Bulbul	×	×				×	Br
Pycnonotus cafer	Red-vented Bulbul	×	×	×	×			Br
Pycnonotus luteolus	White-browed Bulbul	×	×		×			Br
Pycnonotus melanicterus	Black-capped Bulbul	×	×	×			×	Br
Phylloscopidae								
Phylloscopus magnirostris	Large-billed Leaf-warbler	×						M
Phylloscopus nitidus	Bright-green Warbler	×	×		×		×	M
Pittidae								
Pitta brachyura	Indian Pitta	×	×	×	×		×	M
Ploceidae								
Ploceus manyar[NT]	Streaked Weaver					×	×	Br
Ploceus philippinus	Baya Weaver	×	×		×	×		Br
Rhipiduridae								
Rhipidura aureola	White-browed Fantail	×	×	×	×	×		Br
Sturnidae								
Acridotheres tristis	Common Myna	×	×	×		×		Br
Gracula indica	Lesser Hill-myna	×	×					Br
Pastor roseus	Rosy Starling		×			×		M
Timaliidae								
Pellorneum fuscocapillus[E]	Brown-capped Babbler	×			×			Br
Pomatorhinus melanurus[E]	Sri Lanka Scimitar-babbler	×						Br
Rhopocichla atriceps	Dark-fronted Babbler	×	×		×		×	Br
Turdoides affinis	Yellow-billed Babbler		×		×	×		Br
Turdidae								
Geokichla spiloptera■,[VU,E]	Spot-winged Thrush	×	×		×			Br
Zosteropidae								
Zosterops palpebrosus	Oriental White-eye	×			×			Br
Pelecaniformes								
Ardeidae								
Ardea cinerea	Grey Heron	×	×			×	×	Br
Ardea purpurea	Purple Heron	×			×		×	Br
Ardeola grayii	Indian Pond-heron	×					×	Br
Bubulcus coromandus	Eastern Cattle Egret	×	×			×	×	Br
Dupetor flavicollis	Black Bittern	×					×	M+Br
Egretta alba	Great Egret					×	×	Br
Egretta garzetta	Little Egret	×	×			×	×	Br
Egretta intermedia	Intermediate Egret	×	×			×	×	Br
Ixobrychus cinnamomeus[NT]	Chestnut Bittern	×	×			×	×	Br
Ixobrychus sinensis[NT]	Yellow Bittern	×				×	×	M+Br
Nycticorax nycticorax[NT]	Black-crowned Night-heron	×					×	Br
Pelecanidae								
Pelecanus philippensis■	Spot-billed Pelican	×					×	Br
Threskiornithidae								
Platalea leucorodia	Eurasian Spoonbill	×	×				×	Br
Plegadis falcinellus	Glossy Ibis						×	M

(*continued*)

Order, family & species name	Common name	Forests	Croplands	Built-up	Scrublands	Grasslands	Inland aquatic	Migratory and breeding status
Threskiornis melanocephalus	Black-headed Ibis	×				×	×	Br
Piciformes								
Megalaimidae								
Megalaima zeylanica	Brown-headed Barbet	×	×	×	×			Br
× *antholaema haemacephalus*	Coppersmith Barbet	×	×	×	×			Br
× *antholaema rubricapillus*[E]	Sri Lanka Small Barbet	×	×				×	Br
Picidae								
Chrysocolaptes festivus[VU]	White-naped Flameback	×	×		×			Br
Chrysocolaptes stricklandi[VU]	Crimson-backed Flameback	×	×		×			Br
Dendrocopos nanus	Indian Pygmy Woodpecker	×	×	×	×			Br
Dinopium benghalense	Black-rumped Flameback	×	×					Br
Micropternus brachyurus	Rufous Woodpecker	×	×		×		×	Br
Picus chlorolophus[NT]	Lesser Yellownape	×	×		×			Br
Podicipediformes								
Podicipedidae								
Tachybaptus ruficollis	Little Grebe						×	Br
Psittaciformes								
Psittacidae								
Loriculus beryllinus[E]	Sri Lanka Hanging-parrot	×	×		×			Br
Psittacula cyanocephala[NT]	Plum-headed Parakeet	×	×					Br
Psittacula eupatria	Alexandrine Parakeet	×	×		×			Br
Psittacula krameri	Rose-ringed Parakeet	×	×		×	×	×	Br
Strigiformes								
Caprimulgidae								
Caprimulgus asiaticus	Indian Little Nightjar	×	×		×			Br
Caprimulgus atripennis	Jerdon's Nightjar	×	×					Br
Podargidae								
Batrachostomus moniliger	Sri Lanka Frogmouth	×						Br
Strigidae								
Glaucidium castanotum■,[VU,E]	Chestnut-backed Owlet	×	×					Br
Glaucidium radiatum[NT]	Jungle Owlet	×			×		×	Br
Ketupa nipalensis[NT]	Forest Eagle-owl	×						Br
Ketupa zeylonensis	Brown Fish-owl	×	×				×	Br
Ninox scutulata	Brown Hawk-owl	×	×	×	×			Br
Otus bakkamoena	Indian Scops-owl	×	×	×				Br
Otus sunia[NT]	Oriental Scops-owl	×	×	×	×			Br
Strix leptogrammica[NT]	Brown Wood-owl	×						Br
Tytonidae								
Tyto alba[NT]	Common Barn-owl	×	×	×	×	×	×	Br
Suliformes								
Anhingidae								
Anhinga melanogaster■	Oriental Darter	×					×	Br
Phalacrocoracidae								
Microcarbo niger	Little Cormorant	×	×				×	Br
Phalacrocorax carbo[NT]	Great Cormorant	×					×	Br
Phalacrocorax fuscicollis	Indian Shag	×					×	Br
Trogoniformes								
Trogonidae								
Harpactes fasciatus[NT]	Malabar Trogon	×	×					Br
Upupiformes								
Upupidae								
Upupa epops	Common Hoopoe	×	×	×		×		Br

■ = globally near threatened.
▲ = globally vulnerable; Br = breeding resident; CR = national critically; E = endemic; EN = nationally endangered; VU = nationally vulnerable; M = migratory; M + Br = mixed population of migratory and breeding residents; NT = nationally near threatened; VG = vagrant.
* Reference sources: migratory/breeding status (Rasmussen and Anderton 2012; Warakagoda et al 2012), habitat type (Birdlife International 2014b), conservation status (IUCN 2014; MOE 2012).

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