

The avifauna of the forest mosaic habitats of the Mariarano region, Mahajanga II district, north-west Madagascar



Authors:

Rachel H. Palfrey¹ 
 Jack Baddams¹ 
 Bruno A. Raveloson¹ 
 Solohery Rasamison² 
 Fionn Ó Marcaigh^{3,4} 
 Jamie Neaves¹ 
 Peter R. Long⁵ 
 Thomas E. Martin¹ 

Affiliations:

¹Conservation, Education and Research Department, Operation Wallacea, Lincolnshire, United Kingdom

²Departement de Biologie Animale, Faculte des Sciences, Universite Antananarivo, Antananarivo, Madagascar

³Department of Zoology, The University of Dublin, Dublin, Ireland

⁴Trinity Centre for Biodiversity Research, Trinity College Dublin, The University of Dublin, Dublin, Ireland

⁵Oxford Long-Term Ecology Laboratory, Department of Zoology, University of Oxford, Oxford, United Kingdom

Corresponding author:

Thomas Martin,
 tom_martin_2010@yahoo.co.uk

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Background: The West Malagasy dry forests support numerous endemic species and experience heavy anthropogenic pressures, yet remain very poorly studied. Further research is required to understand species distributions and overall diversity in these threatened forest ecosystems.

Objectives: We aimed to provide a description of the avifaunal community of a particular dry forest, Mariarano forest, north-western Madagascar, as well as other habitats that are heavily integrated with these Forests. The study site possesses a highly endemic bird community and is under severe environmental pressure, but remains poorly explored.

Method: We compiled all records from a 9-year (2010–2018) bird survey data set (the most extensive compiled from a Madagascan dry forest to date), which yielded data from a combination of point count and mist-netting protocols. This was further supplemented by approximately 4384 h of opportunistic observation effort.

Results: In total, 95 species were detected, including 63 regional endemics (66.3% of all species), 2 local endemics and 7 Threatened or Near-Threatened species.

Conclusion: We highlight the forest mosaic habitats of Mariarano as a potential new Important Bird Area, given the regional importance of its endemic avifauna.

Keywords: birds; endemic; Madagascar; inventory; dry forest.

Introduction

The West Malagasy dry forests Endemic Bird Area (EBA 093) encompasses a large section of western Madagascar and supports seven locally endemic bird species, including Van Dam's Vanga (*Xenopirostris damii*) and Coquerel's Coua (*Coua coquereli*) (Stattersfield et al. 1998). They also represent the core range of several endangered mammal species, such as Coquerel's sifaka (*Propithecus coquereli*) (Salmona et al. 2014). These habitats are also under heavy anthropogenic pressure; over 40% of Madagascar's dry forests were lost in the second half of the 20th century (Harper et al. 2007), and deforestation rates continued at a rate of between 0.46% and 1.17% per annum between 2000 and 2010 (Grinand et al. 2013). Remaining stands of dry forest are also mostly highly fragmented (Safford & Hawkins 2013). However, despite their ecological value and the degree of conservation urgency they represent, these dry forests remain very poorly known ornithologically, with little research having been produced from them in recent years. This lack of detailed fieldwork data has led to some uncertainty regarding species distributions within this EBA generally, along with the overall richness and conservation value of many specific dry forest ecosystems found within its delimitations.

In this study, we summarise records from the monitoring programme run in Mariarano dry forest and its immediate vicinity by Operation Wallacea – a UK-based expedition company (www.opwall.com) – and its partners. While the biological value of Mariarano is expected to be high (Long et al. 2012), at present, it possesses no legal protection and represents one of the last few patches of unprotected deciduous dry forest larger than 8 km² remaining in western Madagascar (Moat & Smith 2007; Nicoll 2003). Like most remaining stands of dry forest in western Madagascar, Mariarano is highly threatened by clearance related to expanding agriculture, charcoal production and timber extraction (Long et al. 2012). A previous study by Ackerman (2003) quantified annual deforestation rates of 3%, more than twice the higher

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estimates of regional average rates (Grinand et al. 2013). The Operation Wallacea programme here has supported one of the longest running ornithological surveys yet completed in western Madagascar. These have encompassed not only the closed-canopy forests of Mariarano, but also other important habitats that occur adjacent to, and are often entwined within, these forest ecosystems. As with many other West Malagasy dry forests (World Wildlife Fund 2019), Mariarano represents a heterogeneous mosaic landscape where stands of forest are integrated with patches of non-forest habitats (Evans et al. 2013). As forests may support different species to the non-forest habitats that occur in close proximity, survey effort was completed in all major habitats in the study area to determine a more comprehensive overview of diversity within the Mariarano landscape as a whole. These records represent the first description of Mariarano's avifauna, apart from a previous short communication reporting the presence of Van Dam's Vanga (*Xenopirostris damii*) in the study area (Rasamison et al. 2018). We report all species records made from these surveys, giving particular attention to the status of threatened species and local endemics. We then examine this information to assess the conservation value of the study area.

Methods

Study area

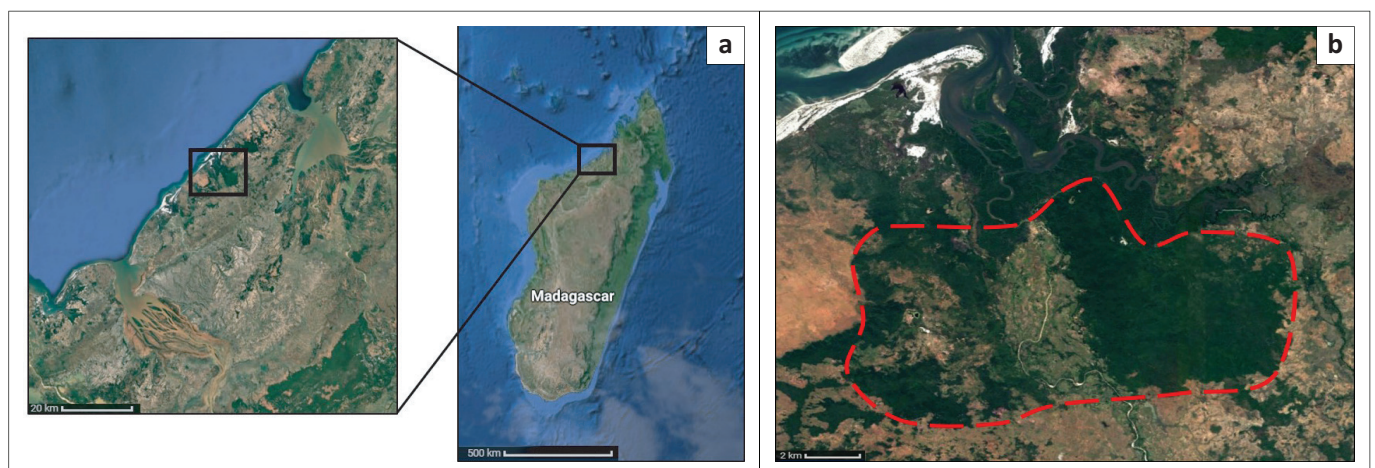
Mariarano classified forest (15°29'S, 46°41'E) and the immediately adjacent Matsedroy forest fragment (15°29'S, 46°38'E) (collectively referred to henceforth as Mariarano forest) are located in Mahajanga II district, Boeny region, north-western Madagascar, approximately 80 km northeast of Mahajanga city (Figure 1). The study site encompasses approximately 65 km² and comprises a matrix of low-lying dry deciduous forest interspersed with areas of wetlands (small- to medium-sized lakes), lightly wooded grassland, scrub habitats and agricultural land, reaching a maximum elevation of 80 metres above sea level (Evans et al. 2013; Moat & Smith 2007). Approximately 38 km² (58.5%) of this area consists of forest, with the remaining area being

encompassed by non-forest habitats. The area experiences a tropical savannah climate classified as *Am* on the Köppen climate classification system (Peel, Finlayson & McMahon 2007) with fairly constant monthly temperatures (mean 27.3 °C). Monthly rainfall is highly variable (1 mm – 360 mm) with a distinct wet season peaking in intensity between December and February followed by a pronounced dry season running between July and September (unpublished Operation Wallacea data).

Data collection and analysis

Bird surveys in Mariarano forest were completed annually between 2010 and 2018, as a component of the long-term ecological monitoring programme run as a collaborative partnership between Operation Wallacea, the Malagasy NGO 'Development and Biodiversity Conservation Action for Madagascar' (DBCAM), the University of Antananarivo and local community forest management groups. All bird surveys were completed in the dry season over a 6–8-week period between June and August, and comprised two main methodologies – point counts and mist-netting. This survey work was conducted by Rachel Hannah Palfrey (RHP), Jack Baddams (JB), Bruno Andriandraotomalaza Raveloson (BAR), Solohery Rasamison (SR), Fionn Ó Marcaigh (FÓM) and Jamie Neaves (JN).

Unlimited-radius circular-plot points (Bibby et al. 2002) were completed along 11 randomly placed transects situated throughout the dry deciduous forest habitats of the study area. Grassland, scrub, agricultural land and wetlands were not covered by the point count surveys. Transects were between 2 km and 4 km long and had between 8 and 10 permanent point count stations located along their length, each separated by a distance of at least 200 m. In total, 92 point count stations were established in the study area. Attempts were made to survey these sites three times per season, although this was not possible in every year because of some sites not being established at the start of formal survey work in 2010. Point counts were completed between



Source: Google Earth Pro 2019

FIGURE 1: Maps showing (a) the location of the Mariarano study area within Madagascar as a whole and within the Mahajanga II district of north-western Madagascar and (b) satellite image of the Mariarano region, with the boundary of the study area demarked with a dashed red line.

06:00 and 09:30 each morning. Each count lasted 10 min, during which observers recorded all birds seen and heard, with the distance of each contact from the observer noted. Specific observers completing these point count surveys varied between years. Point counts were not completed in heavy rain or other adverse weather conditions, although as all survey work was conducted in the dry season, such conditions almost never occurred.

Mist-netting surveys were completed mostly on an informal basis in forest habitats throughout the study period. Mist-netting was conducted most mornings between 06:00 and 09:00. Four 25 m nets were used for these sessions, and these were checked at 30 min intervals after opening.

Records from point count and mist net surveys were further supplemented by the authors' opportunistic records. These records included sightings made when travelling to and from sample points, as well as records made during casual exploration of Mariarano forest and the surrounding area. Grassland, scrub, agricultural land (chiefly rice paddies) and wetland habitats in Mariarano, which were not covered by our formal point count surveys, were a particular focus for opportunistic recording.

Once all records from surveys and opportunistic sightings were collated, we compiled a full inventory of all species detected in Mariarano forest following the taxonomy provided by Gill and Donsker (2018). Endemism and conservation status of each species was also noted. Two levels of endemism were recorded – regional endemics restricted to the Madagascan and the Indian Ocean Islands biodiversity hot spot as defined by Myers et al. (2000), and local endemics restricted to the West Malagasy dry forests EBA as defined by Stattersfield et al. (1998). Conservation status followed the International Union for the Conservation of Nature (IUCN 2018). We also identified non-native species using descriptions in Safford and Hawkins (2013), Sinclair and Langrand (2013) and the IUCN (2018). We recorded species as notable range extensions if they were not indicated as occurring in the study area by previous published work from the study area (Rasamison et al. 2018), maps provided in authoritative online resources (BirdLife International & NatureServe 2018; Del Hoyo et al. 2018; IUCN 2018), or in two of the region's widely used ornithological references (Safford & Hawkins 2013; Sinclair & Langrand 2013). We also assigned categorical abundance estimates for each species in our inventory, based on frequency of observations. Relative abundance categories followed those used in previous ornithological papers by the authors (e.g. Martin et al. 2012, 2014, 2018). These were: abundant (typically recorded multiple times each day in suitable habitat), common (typically recorded at least once per day), fairly common (typically recorded about once per week), uncommon (recorded less than five or six times, on average, per field season) and rare (known from less than five observations within the study area). Species restricted to highly specific habitats only found in limited parts of the study area were also denoted with an additional 'local' categorisation (locally abundant, locally common, locally fairly common and

local and uncommon). We also noted which species were observed by which authors, and which of the five main habitat types occurring in the heterogeneous matrix of Mariarano forest (agricultural land, forest, grasslands, scrub and wetlands) each species was observed in. Following recommendations from Lees et al. (2012), we also collated photographs taken from within the study area of as many species on our checklist as we possessed, and uploaded them to an online depository (Lynx Edicions 2018), noting the unique voucher numbers of each record to provide evidence of occurrence for as many species on our inventory as possible. Where possible, we also collated sound recordings for species we were unable to obtain a photograph for. These were uploaded to the same online depository. Finally, we tallied the number of species detected by point count surveys in the Mariarano's forest habitats for each survey year, in order to examine changes in forest bird diversity over time. We restricted this analysis to forest habitats for two reasons. Firstly, because forests represent the most threatened habitat in the Mariarano study area and are the most likely to have been affected by land use pressures since surveys began. Secondly, because applying this analysis to other habitats that were not consistently surveyed by a systematic methodology would strongly influence the amount of opportunistic survey effort directed towards them, which was inconsistent between years.

Ethical considerations

This article followed all ethical standards required for conducting bird survey work in Madagascar, with mist-netting surveys being led by suitably qualified bird ringers.

Results

We reviewed a total of 40 144 individual birds detected in the course of our point count surveys. Opportunistic observations (mist-netting and author personal records generated outside of the point count surveys) equated to approximately 4384 person-hours (based on an average of 8 h per day for each author where they were in the field, but not conducting formal point count surveys). Mist-netting yielded 1192 individual captures (including 204 recaptures). In total, we recorded 95 species in Mariarano forest and its vicinity, including 63 regional endemics (66.3% of overall community richness) and two local endemics restricted to the West Malagasy dry forests EBA (2.1% of overall community richness). Recorded diversity of forest birds was lowest in 2010 (34 species detected); this is in likelihood an artefact of fewer point count stations being established in this year. Recorded diversity was then fairly consistent between 2011 and 2018, fluctuating between 39 and 45 species detected per year (Figure 2). The small variations in species detections per year may be a result of minor annual changes in the diversity of these forest ecosystems, but could also be a result of differential skill levels between observers, who were not always consistent between years. Four species in the study area are considered to be Near-Threatened, two species Endangered, and one species Critically Endangered (IUCN 2018). None of our records represents notable species range

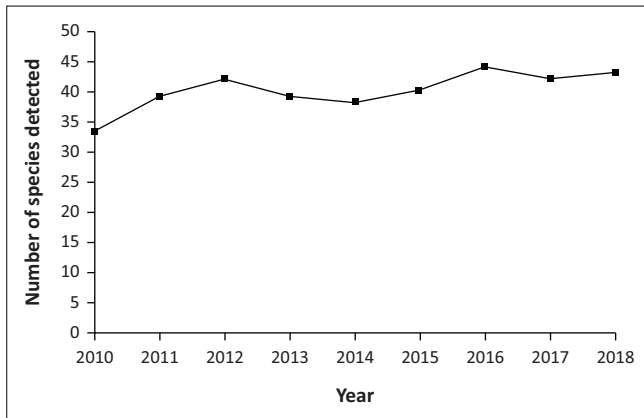


FIGURE 2: Number of species detected per year by formal point count surveys in the Mariarano study area's forest habitats.

extensions following our criteria, although numerous species are only noted to occur in the region by some of our consulted sources, with others indicating them to be absent in this region of Madagascar. The most notable of these is Coquerel's Coua (*C. coquereli*) (see details below). We were able to obtain photographic records for 74 species in our inventory (77.9%), and sound recordings for a further one species for which we could not obtain a photograph. These can be accessed here: <https://www.hbw.com/ibc/u/36081>. Table 1 summarises our findings from the main study area.

Discussion

The results presented in this article represent one of the most complete inventories of a western Madagascan dry forest completed to date, casting new light on the biological value of this otherwise poorly studied area. Particularly notable records include:

Malagasy Pond Heron (*Ardeola idae*) – An Endangered species that is a locally fairly common breeding visitor to the lakes and other wetlands found in Mariarano forest, where it is most often observed singly (although sometimes in loose groups of up to three individuals) within shallow waterbodies with plentiful floating vegetation, which are in close proximity to the forest edge, in concordance with habitat descriptions in Safford and Hawkins (2013) and Del Hoyo et al. (2018).

Madagascan Fish Eagle (*Haliaeetus vociferoides*) – A Critically Endangered species which is known to breed in the adjacent Ankobohobo Wetlands. Single individuals have also been occasionally seen passing over the wetlands of the Mariarano forest, although no evidence has ever been provided for the species breeding here.

Coquerel's Coua (*C. coquereli*) – A local endemic confined to the West Malagasy dry forests EBA. It is an uncommon resident in the Mariarano study area, being cryptic and rarely observed directly. Most detections have been from vocalisations, and it has been detected by camera traps several times (Operation Wallacea unpublished data). Prior to the records reported here, the species' presence in this part of Madagascar appears to be ambiguous. It is not noted to

occur anywhere in the vicinity of Mariarano forest by Del Hoyo et al. (2018), while Sinclair and Langrand (2013), BirdLife International and NatureServe (2018) and IUCN (2018) indicate its status here as 'possibly extant' or 'unconfirmed'. The work of Safford and Hawkins (2013) is the only consulted source to indicate its occurrence within the region of Mariarano forest, albeit at lower densities than in certain other parts of its range. Formal point counts, camera traps and opportunistic observations detected this species 21 times in total, providing confirmation of the species' occurrence within and the Mariarano study area.

Van Dam's Vanga (*Xenopirostris damii*) – An Endangered local endemic confined to the West Malagasy dry forests EBA. It is an uncommon species in our study area, having been recorded once per season in 2011 and 2014, and twice per season in 2015 and 2017. Details of our observations of Van Dam's Vanga in the Mariarano study area have previously been published elsewhere (Rasamison et al. 2018).

While this study provides important data on the avifauna of Mariarano forest, it should be acknowledged that our results are limited to a degree by the seasonal nature of our fieldwork. Given all our surveys were conducted between June and August, it is likely that certain wintering migrants may have been missed – for example, Sooty Falcon (*Falco concolor*), Ruddy Turnstone (*Arenaria interpres*) and Eurasian Curlew (*Numenius arquata*), all of which could conceivably occur in the study area according to distribution maps provided in other sources (BirdLife International & NatureServe 2018; Sinclair & Langrand 2013). As this period also does not correspond to the main breeding period for Malagasy birds (Safford & Hawkins 2013), our results may have been influenced by decreased detectability in certain species, given breeding species tend to be more localised and more vocal, and hence more detectable (Bibby et al. 2002). It is worth noting that seasonal detectability in dry forest species is not thought to be as pronounced as that found in the rainforest ecosystems of eastern Madagascar (Sinclair & Langrand 2013), although it is still possible that some species may be present in Mariarano in the wet season, but absent during our study period. The vast majority of our records (including all our formal point count surveys) were also made during daylight hours, with no specialist survey effort being dedicated towards the surveying of nocturnal birds. This could also have led to some other species being overlooked, such as White-browed Owl (*Athene supercilialis*), which we never observed, despite it being indicated to occur in the Mariarano region by multiple sources (BirdLife International & NatureServe 2018; Safford & Hawkins 2013; Sinclair & Langrand 2013). Most non-forest habitats in our main study area, as well as the extensive mangroves in the adjacent Ankobohobo Wetland, would also benefit from more intensive exploration. Further fieldwork effort in these habitats may yield new species for our site inventory, and also allow for more accurate assessments of the relative abundance values presented in Table 1.

TABLE 1: Checklist of bird species recorded in Mariarano Forest and its vicinity between 2010 and 2018.

Family	Common name	Scientific name	Abundance	Observers	Habitats	IBC code
Anatidae	White-faced Whistling Duck	<i>Dendrocygna viduata</i>	La	Multiple	W	IBC1435052
	Fulvous Whistling Duck	<i>Dendrocygna bicolor</i>	R	Multiple	W	-
	White-backed Duck	<i>Thalassornis leuconotus</i>	Lc	Multiple	W	IBC1435051
	Knob-billed Duck	<i>Sarkidiornis melanotos</i>	Lc	Multiple	W	IBC1407171
	African Pygmy Goose	<i>Nettapus auratus</i>	Lfc	BR, JB	W	IBC1407155
Numididae	Helmeted Guineafowl (I)	<i>Numida meleagris</i>	C	Multiple	F,G,S	IBC1414634
Phasianidae	Madagascar Partridge*	<i>Margaroperdix madagarensis</i>	R	BR	A,G	-
	Harlequin Quail	<i>Coturnix delegorguei</i>	R	BR	A,W	-
Podicipedidae	Little Grebe	<i>Tachybaptus ruficollis</i>	Lu	Multiple	W	IBC1414636
	Madagascar Grebe*	<i>Tachybaptus pelzelni</i>	Lc	Multiple	W	IBC1414644
Ciconiidae	Yellow-billed Stork	<i>Mycteria ibis</i>	R	BR, JB	W	IBC1435053
Threskiornithidae	Madagascar Ibis *†	<i>Lophotibis cristata</i>	R	Multiple	F	IBC1438202
Ardeidae	Striated Heron	<i>Butorides striata</i>	Lfc	BR	W	-
	Squacco Heron	<i>Ardeola ralloides</i>	Lu	BR, RP	W	-
	Malagasy Pond Heron*†	<i>Ardeola idae</i>	Lfc	Multiple	W	IBC1414656
	Western Cattle Egret	<i>Bubulcus ibis</i>	Lc	Multiple	W	IBC1407168
	Grey Heron	<i>Ardea cinerea</i>	Lu	BR	W	IBC1439792
	Purple Heron	<i>Ardea purpurea</i>	R	Multiple	A,W	-
	Great Egret	<i>Ardea alba</i>	Lfc	Multiple	W	-
	Dimorphic Egret*	<i>Egretta dimorpha</i>	Lu	BR, RP	W	IBC1409182
Scopidae	Hamerkop	<i>Scopus umbretta</i>	R	BR	W	-
Accipitridae	Madagascar Harrier-hawk*	<i>Polyboroides radiatus</i>	C	Multiple	A,F,G,S,W	IBC1414647
	Bat Hawk	<i>Macheiramphus alcinus</i>	R	BR, SR	F	IBC1438895
	Frances's Sparrowhawk*	<i>Accipiter francesiae</i>	Fc	Multiple	A,F	IBC1409183
	Madagascar Sparrowhawk*†	<i>Accipiter madagascariensis</i>	R	BR, SR	F	-
	Henst's Goshawk*†	<i>Accipiter henstii</i>	R	BR, SR	F	-
	Black Kite	<i>Milvus migrans</i>	U	JB, FÓM	A,F,G,S,W	IBC1435057
	Madagascar Fish Eagle*†	<i>Haliaeetus vociferoides</i>	R	BR	W	IBC1435056
	Madagascar Buzzard*	<i>Buteo brachypterus</i>	C	Multiple	A,F,G,S,W	IBC1414639
Rallidae	White-throated Rail*	<i>Dryolimnas cuvieri</i>	Lfc	BR, RP	W	-
	African Swampphen	<i>Porphyrio madagascariensis</i>	Lfc	BR, RP	W	-
	Allen's Gallinule	<i>Porphyrio alleni</i>	R	BR	W	-
	Common Moorhen	<i>Gallinula chloropus</i>	Lc	Multiple	W	IBC1407172
Turnicidae	Madagascar Buttonquail*	<i>Turnix nigricollis</i>	Fc	Multiple	A,F,S	IBC1414638
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	R	BR, JB	W	IBC1407165
Charadriidae	Three-banded Plover	<i>Charadrius tricollaris</i>	Lc	Multiple	W	IBC1435050
Rostratulidae	Greater Painted-snipe	<i>Rostratula benghalensis</i>	Lu	BR, RP	W	-
Jacaniidae	Madagascar Jacana*†	<i>Actophilornis albinucha</i>	Lc	Multiple	W	IBC1414649
Pteroclididae	Madagascar Sandgrouse*	<i>Pterocles personatus</i>	U	BR, JB	G,W	IBC1414658
Columbidae	Malagasy Turtle Dove*	<i>Streptopelia picturatus</i>	C	Multiple	A,F	IBC1414661
	Namaqua Dove	<i>Oena capensis</i>	C	Multiple	A,F,G,S	IBC1414738
	Madagascar Green Pigeon*	<i>Treron australis</i>	U	Multiple	F	IBC1414735
Cuculidae	Malagasy Coucal*	<i>Centropus toulou</i>	C	Multiple	A,F,S	IBC1414641
	Crested Coua*	<i>Coua cristata</i>	C	Multiple	F	IBC1409174
	Red-capped Coua*	<i>Coua ruficeps</i>	U	Multiple	F	IBC1435032
	Coquerel's Coua‡	<i>Coua coquereli</i>	U	Multiple	F	IBC1409179
	Madagascar Cuckoo*	<i>Cuculus rochii</i>	U	Multiple	A,F	IBC1414642
Tytonidae	Western Barn Owl	<i>Tyto alba</i>	R	BR	A,F	IBC1438199
Strigidae	Torotoroka Scops Owl*	<i>Otus madagascariensis</i>	Fc	Multiple	A,F	IBC1414659
	Madagascar Owl*	<i>Asio madagascariensis</i>	R	BR	A,F	-
Caprimulgidae	Madagascar Nightjar*	<i>Caprimulgus madagascariensis</i>	C	Multiple	A,F,G	IBC1414654
Apodidae	Madagascar Spinetail*	<i>Zoonavena grandidieri</i>	U	BR	G	-
	African Palm Swift	<i>Cypsiurus parvus</i>	A	Multiple	F	IBC1407150
	Malagasy Black Swift*	<i>Apus balstoni</i>	R	BR	W	-
Leptosomidae	Cuckoo Roller*	<i>Leptosomus discolor</i>	U	Multiple	F	IBC1438201
Alcedinidae	Madagascar Pygmy Kingfisher*	<i>Corythornis madagascariensis</i>	Fc	Multiple	F	IBC1414657
	Malagasy Kingfisher*	<i>Corythornis vintsioides</i>	Lc	Multiple	W	IBC1414653
Coraciidae	Broad-billed Roller	<i>Eurystomus glaucurus</i>	R	BR	A,F	IBC1439779
Meropidae	Olive Bee-eater	<i>Merops superciliosus</i>	A	Multiple	A,F,G,S,W	IBC1435619
Upupidae	Madagascar Hoopoe*	<i>Upupa marginata</i>	Fc	Multiple	F	IBC1414648

Table 1 continues on the next page →

TABLE 1 (Continues...): Checklist of bird species recorded in Mariarano Forest and its vicinity between 2010 and 2018.

Family	Common name	Scientific name	Abundance	Observers	Habitats	IBC code
Falconidae	Malagasy Kestrel*	<i>Falco newtoni</i>	Fc	Multiple	G	IBC1414651
	Banded Kestrel*	<i>Falco zoniventris</i>	R	BR, FOM	F	IBC1439773
	Peregrine Falcon	<i>Falco peregrinus</i>	R	JB	W	IBC1414746
Psittacidae	Greater Vasa Parrot*	<i>Coracopsis vasa</i>	U	BR, JN	A,F,G	IBC1515645
	Lesser Vasa Parrot*	<i>Coracopsis nigra</i>	C	Multiple	F	IBC1409184
	Gray-headed Lovebird*	<i>Agapornis canus</i>	A	Multiple	A,F,G,S	IBC1435622
Vangidae	Hook-billed Vanga*	<i>Vanga curvirostris</i>	U	Multiple	F	IBC1414650
	Van Dam's Vanga‡†	<i>Xenopirostris damii</i>	U	Multiple	F	IBC1438204
	Sickle-billed Vanga*	<i>Falculea palliata</i>	C	Multiple	F	IBC1435035
	White-headed Vanga*	<i>Artamella viridis</i>	U	Multiple	F	
	Chabert Vanga*	<i>Leptopterus chabert</i>	Fc	Multiple	F	IBC1407170
	Blue Vanga*	<i>Cyanolanius madagascarinus</i>	U	Multiple	F	IBC1407166
	Common Newtonia*	<i>Newtonia brunneicauda</i>	A	Multiple	F	IBC1407174
Campephagidae	Madagascar Cuckooshrike*	<i>Coracina cinerea</i>	U	Multiple	F	IBC1407164
Dicruridae	Crested Drongo*	<i>Dicrurus forficatus</i>	C	Multiple	F	IBC1409181
Monarchidae	Malagasy Paradise-Flycatcher*	<i>Terpsiphone mutata</i>	C	Multiple	F	IBC1414655
Corvidae	Pied Crow	<i>Corvus albus</i>	C	Multiple	A,G	IBC1415040
Alaudidae	Madagascar Lark*	<i>Eremopterix hova</i>	Lc	Multiple	G	IBC1438203
Pycnonotidae	Malagasy Bulbul*	<i>Hypsipetes madagascariensis</i>	A	Multiple	F	IBC1438108
Hirundinidae	Mascarene Martin*	<i>Phedina borbonica</i>	R	BR	G,W	
Acrocephalidae	Malagasy Brush Warbler*	<i>Nesillas typica</i>	Fc	Multiple	S	IBC1439329
Bernieridae	Long-billed Bernieria*	<i>Bernieria madagascariensis</i>	C	Multiple	F	IBC1414637
Cisticolidae	Common Jery*	<i>Neomixis tenella</i>	C	Multiple	F	IBC1435623
	Madagascar Cisticola*	<i>Cisticola cherina</i>	C	Multiple	A,G	IBC1414640
Zosteropidae	Malagasy White-eye*	<i>Zosterops maderaspatanus</i>	Fc	Multiple	F	IBC1414737
Sturnidae	Common Myna (I)	<i>Acridotheres tristis</i>	Fc	Multiple	A,G	IBC1407173
	Madagascar Starling*	<i>Hartlaubius auratus</i>	R	BR	A,F	
Muscicapidae	Madagascar Magpie-robin*	<i>Copsychus albospectus</i>	C	Multiple	F	IBC1414652
	Madagascar Stonechat	<i>Saxicola sibilla</i>	R	Multiple	A	IBC1435055
Nectariniidae	Souimanga Sunbird*	<i>Cinnyris sovimanga</i>	A	Multiple	F	IBC1435037
	Malagasy Green Sunbird*	<i>Cinnyris notatus</i>	Fc	Multiple	F	IBC1414645
Ploceidae	Sakalava Weaver*	<i>Ploceus sakalava</i>	C	Multiple	A,G	IBC1435033
	Red Fody*	<i>Foudia madagascariensis</i>	Fc	Multiple	A,G	IBC1435621
Estrildidae	Madagascar Munia*	<i>Lepidopygia nana</i>	U	Multiple	A,S	IBC1438197
Motacillidae	Madagascar Wagtail*	<i>Motacilla flaviventris</i>	A	Multiple	A,G	IBC1414662

Source: IUCN 2018; Lynx Edicions 2018; Myers et al. 2000; Stattersfield et al. 1998

Note: All taxonomy follows Gill and Donsker (2018). Species marked * are regionally endemic to the Madagascar and the Indian Ocean Islands biodiversity hot spot as defined by Myers et al. (2000). Species marked ‡ are locally endemic to the West Malagasy dry forests Endemic Bird Area as defined by Stattersfield et al. (1998). Species marked † are assessed as Threatened or Near-Threatened by the IUCN (2018). Species marked (I) are introduced to the study area.

Abundance estimates are denoted as follows: A, abundant; La, locally abundant; C, common; Lc, locally common; Fc, fairly common; Lfc, locally fairly common; U, uncommon; Lu, local and uncommon; R, rare. Initials in the 'observers' column indicate authors possessing records of each species. Species that have been observed by three or more authors are notated 'multiple'. Habitat categories are denoted as follows: A, agricultural land; F, forest; G, grassland; S, scrub; W, wetlands. IBC codes correspond to voucher numbers for species photographs or sound recordings uploaded to the Internet bird collection (Lynx Edicions 2018).

In summary, while further work in the area is desirable, our results highlight Mariarano Forest as an area of high conservation importance, which supports at least 57% of the 168 non-vagrant species known to occur in western Madagascar (Safford & Hawkins 2013), including numerous threatened and endemic species. Other recent survey work demonstrates that this high conservation value is also reflected in other taxa, especially mammals and herpetofauna (Evans et al. 2013; Long et al. 2012; Mann et al. 2015). The consistency of richness in forest bird communities over time indicated by our point count surveys also suggests that population of most species probably remains stable at present, and still represents a relatively intact ecosystem. It is also important to note that the conservation value of Mariarano is heavily bolstered by the non-forest habitats that occur within the mosaic landscape of the study area. For example, of the 95 species detected by survey work, 46 (48.4%) were only detected in non-forest habitats, including 20 regional endemics (31.7% of all endemics encountered),

and three out of the seven Threatened or Near-Threatened species recorded. We therefore recommend that Mariarano Forest, as well as the non-forest habitats that are heavily integrated within it, be considered for further conservation attention and legislative protection. The site supports sufficient endemic and threatened species to be considered an Important Bird Area (IBA) in its own right, located immediately adjacent to the existing Ankobohobo wetland IBA. The designation of a protected forest status for the Mariarano area would also be an important step in safeguarding the future of its high-value biodiversity.

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Competing interests

The authors have declared that no competing interests exist.

Authors' contributions

R.H.P. and T.E.M. conceived the study, analysed the data and wrote the manuscript. P.L. designed the field methodologies and curated the data set. R.H.P., J.B., B.A.R., S.R., F.Ö.M. and J.N. collected the data. All authors read and approved the final manuscript.

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Data availability statement

The data analysed in this study belong to Peter R. Long. Reasonable requests for data sharing can be directed towards the corresponding author.

Disclaimer

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