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Avian inventory and key species of the Masoala Peninsula, Madagascar

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Summary

From mid-September 1993 to February 1994 avian species were inventoried at eight sites selected to sample the major biogeographic areas and threatened habitats of Masoala Peninsula of north-eastern Madagascar. The sites ranged from 10 to 1100 m elevation. Three forest types were inventoried: six sites included primary lowland rainforest (0–700 m), one site was characterized as moist montane forest (above 700 m), and one site was classified as littoral forest. Bird species and distribution were sampled using point counts and line transects, tree observations and opportunistic sightings; 85 avian species were detected. Line transects were the most productive technique for number of species detected. Twenty-four detected species were shared by all inventory sites. Six threatened and six near-threatened species were observed with notes on their ecology and behaviour. One endangered species, the Madagascar Serpent-eagle *Eutriorchis astur*, was first observed along a forest edge and then sighted several times at forest interior sites, suggesting that this secretive endangered raptor is not as rare as previously thought. Another species of indeterminate status, the Madagascar Red Owl *Tyto soumagnei*, was discovered by two villagers near one inventory site in modified habitat. Several rare and near-threatened species were found to be common throughout Masoala Peninsula: Scaly Ground-roller *Brachypteracias squamiger*, Short-legged Ground-roller *B. leptosomus*, Red-breasted Coua *Coua serriana*, Brown Mesite *Mesitornis unicolor*, Helmet Vanga *Euryceros prevostii*, Bernier's Vanga *Oriolia bernieri* and Rand's Warbler *Randia pseudozosterops*; the last was only found along pristine riverine habitat. Three species were detected only at the high elevation montane forest: Grey-crowned Greenbul *Phyllastrephus cinereiceps*, Forest Rock-thrush *Pseudocossyphus sharpei* and Madagascar Brush-warbler *Nesillas typica*. Forest degradation from subsistence agriculture, shifting cultivation and fuelwood collecting threatens natural resources and biodiversity but conservation and development efforts can provide alternatives to meet the needs of the local people.

Depuis la moitié du mois de septembre 1993 jusqu'au février 1994, nous avons inventorié la communauté avienne dans huit sites représentant la grande partie des habitats naturels de la Presqu'île de Masoala, Nord-Est de Madagascar. Ces sites ont des altitudes comprises entre 10 et 1100 m. Trois types de forêt ont été inventoriés: six sites de forêt primaire de basse altitude (0–700 m), un site considéré comme forêt humide de montagne (plus de 700 m), et le dernier classé comme forêt littorale. L'échantillonage était fait par point d'écoute et ligne de transect. Certains grands arbres ont été utilisés comme poste d'observation. Quatre-vingts cinq espèces d'oiseaux étaient détectées. Vingt quatre espèces sont communes aux sites inventoriés. Six espèces classées comme menacé et six autres en train de l'être sont observées avec des notes sur leur écologie et comportement.

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Une espèce en danger, l'Aigle serpentaire *Eutriorchis astur*, était observée pour la première fois le long d'une bordure forestière et puis vue plusieurs fois en pleine forêt. Ce qui suggère que cette espèce en danger et trèsdiscrète n'est pas très rare comme on a toujours pensé. Une autre espèce de statut indéterminé, l'Effraie de Soumagne *Tyto soumagnei* était découverte par deux villageois près d'un site d'inventaire dans un habitat dégradé. Quelques espèces rares et en train d'être menacées semblaient communes dans toute la Presqu'île de Masoala: Rollier terrestre écailleux *Brachypteracias squamiger*, Rollier terrestre leptosome *B. leptosomus*,Coua de Serre *Coua serriana*, Mésite unicolore *Mesitornis unicolor*, Eurycère de Prévost *Euryceros prevostii*, Oriolie de Bernier *Oriolia bernieri* et la Fauvette de Rand *Randia pseudozosterops*. Cette dernière se trouve seulement dans les habitats longeant les cours d'eau. Trois espèces sont seulement observées dans une forêt de haute altitude de montagne: Bulbul à tête grise *Phyllastrephus cinereiceps*, Merle de roche de forêt *Pseudocossyphus sharpei* et la Fauvette de Madagascar *Nesillas typica*. La dégradation forestière causée par le besoin de surface cultivable, la culture itinérante et la collecte de bois de chauffe, menacent les ressources naturelles et la biodiversité du milieu. Seulement, la conservation en parallèle avec des efforts de développement peut fournir une alternative aux besoins de la population locale. Ceci est parmi les objectifs du Projet Masoala; cherchant des alternatives pour la population locale en même temps que la création d'un Parc National qui pourrait protéger une grande partie de bloc forestier de basse altitude de Madagascar, plus de 210.000 hectares.

Introduction

Madagascar, the world's fourth largest island, has been isolated from mainland Africa for 120–150 million years (Rabinowitz *et al.* 1983). This long isolation has contributed to high species endemism. A majority of the Malagasy bird species are found in the forests that formerly covered the island. Today increasing human population pressure from slash-and-burn farming and fuelwood collecting is threatening many ecosystems on Madagascar, including what little natural forest remains. Consequently, Madagascar has become a high-priority conservation area (Myers 1988).

Humbert (1954) and White (1983) described two biogeographic regions in Madagascar, the eastern Malagasy region and the western Malagasy region. The western region is separated into the western and southern domains. The eastern region consists of the eastern, central, high mountains, and Sambirano domains. The eastern domain extends from north of Sambava to Tolagnaro along the east coast and is the most threatened type of vegetation (Langrand 1990).

The Masoala Peninsula lies along the north-eastern coast of Madagascar and is the only peninsula in the eastern Malagasy region. In 1927, an area of 27,682 hectares was decreed a nature reserve on the Masoala Peninsula. This nature reserve protected a small fraction of the 4,990,000 hectares of the forests then available on the peninsula. In 1964 this area was declassified and opened for exploitation, resulting in the current fragmented forest.

The Masoala Peninsula was recognized as a high priority area for conservation of biological diversity by the government of Madagascar because of endemic flora and fauna, such as Madagascar Serpent-eagle *Eutriorchis astur* and the red-ruffed lemur *Varecia variegata rubra* endemic to the Masoala, isolation from the otherwise continuous north–south rainforests, and the occurrence of

extensive lowland forest. The survival of many endemic fauna and flora will depend upon protecting the intact forests of Masoala Peninsula.

The Masoala Integrated Conservation and Development Project (MICDP) was established in 1993 to conserve Masoala's biodiversity and natural resources by creating a new National Park while, at the same time, providing sustainable and economic alternatives to slash-and-burn agriculture to meet the needs of local people. The majority of the 50,000 plus human inhabitants of the Masoala Peninsula are on coastal lands but an increasing number of settlements are being established in the forest interior along navigable rivers. Over one-quarter of the total land area of the peninsula has been cleared for human settlements. Tentatively, 210,000 ha of Masoala forest are being considered for what will be Madagascar's largest eastern lowland rainforest park. The Masoala Peninsula is the only forest where the endangered Madagascar Serpent-eagle has been sighted repeatedly and captured (Thorstrom *et al.* 1995) and where the rare Madagascar Red Owl *Tyto soumagnei* has been captured for study (Thorstrom *et al.* 1997). The forests on the peninsula are important for the continued survival of these endangered species, and for many other species restricted to lowland rainforests.

The purpose of this avian inventory was to generate a comprehensive species list for Masoala and provide information on the distribution of threatened, rare or unusual species so that knowledgable decisions could be made about the size and boundaries of the proposed National Park.

Study area and methods

Eight inventory sites were selected by the Park Delimitation Unit (PDU) of the MICDP to sample the major biogeographic areas and threatened habitats of Masoala Peninsula. Inventory sites were visited for 6 to 14 days each from September 1993 to February 1994. There are three readily distinguished forest types on Masoala Peninsula: lowland rainforest between 0 and 700 m altitude, mid-altitude moist montane forest above 700 m, and littoral forest in some coastal areas (Table 1). In most of the peninsula the dominant soil types are quartzitic and granitic atop a crystalline bedrock. In addition, an east-west moisture gradient is conspicuous though unmeasured. Western inventory sites were higher elevation and received more precipitation than eastern sites. These patterns may cause a distributional variation in the structure of the avian and other biotic communities that may be further modified by roughly north-south "peninsula effect". Human activity, particularly the formation of "tavies" (deforesting for subsistence and commercial agriculture), has penetrated and modified most of the river valley habitat. Considerations for inventory site selection such as minimizing the influence of tavy, minimizing distance traveled, and optimizing other logistics were finalized in the field by the PDU. Sites were selected for comparison along forest block edges and interiors. Despite efforts to choose sites with minimal signs of human disturbance, some sites were noticeably more disturbed than others (Table 1).

Many inventory sites were reached by boat or pirogue (dugout canoe) in one to two days travel. Some sites were reached by recruiting local porters to transport food supplies and equipment. At each inventory site a base camp was

Table 1. Date visited, geographic location, forest type, elevation and disturbance level of eight inventory sites selected by the Park Delimitation Unit

Inventory site and date visited	Geographic location	Forest type and elevation (m)	Disturbance level
1. Bedinta 18–28 September 1993	West	Lowland 500–730	Little disturbance
2. Ambohitsitondroina 4–14 October 1993	West	Montane >700	Little disturbance
3. Antsamanara 23–31 October 1993	North	Lowland 30–540	Little disturbance
4. Sarahandrano 2–14 November 1993	North	Lowland 50–400	Part disturbed
5. Ambery 22–27 November 1993	East	Lowland 20–100	Disturbed
6. Manosona 14–22 January 1994	South	Lowland 20–100	Slightly disturbed
7. Antafononona 23–30 January 1994	South	Lowland 20–370	Little disturbance
8. Andranomaity 1–6 February 1994	South	Littoral forest 20–30	Disturbed

established near water. After a base camp was set up we walked the designated and marked trails of each inventory site for reconnaissance, marking and mapping for point counts.

Bird species distributions were determined using point counts, line transects, observation from tree-tops and opportunistic sightings. Where we noticed certain habitat types, based on vegetation physiognomy, that were not sampled by the PDU's trails, we created additional trails to sample within them or to expand sample sizes within a specific habitat type or elevational gradient. All sampling methods were applied in each area characterized as unique in floral composition, elevation gradient, slope and exposure, accessibility, and/or relic forest stands such as the littoral forest.

Three experienced observers identified birds by sight and vocalizations. Observers spent two weeks learning bird identifications and vocalizations at Ranomafana National Park and Masoala Peninsula using Langrand (1990). A mini-cassette recorder was also used to record and play back vocalizations of unknown birds to draw them into view for visual identification. Surveys began only after investigators were competent at identifying most species expected to be seen based on previous studies (O. Langrand pers. comm.). Avian nomenclature follows Langrand (1990).

Point counts

Point counts were conducted for 10-minute periods, which allowed observers adequate time to listen and record species detected by vocalizations or sight. Point counts started nearly 30 minutes before sunrise, the earliest beginning 04h30 during January. Point counts were not conducted in rain because of the negative effect of noise interference on aural detection of birds. All point count sites were spaced a minimum of 200 m apart. Each inventory site was separated into two to three sections consisting of five to eight point counts. Each section was visited by one observer at least five times on separate days.

Line transects

Line transects began after the morning point counts were concluded and were conducted along the paths that connected adjacent counts. Line transects are

basically a moving point count (Bibby *et al.* 1992) that were employed to detect secretive ground-dwelling and quiet species. Most line transects were conducted on trails 800–1000 m long with a few 3–4 km in length. They were not conducted during rain because of the negative effect of noise interference on aural detection.

Tree observations and incidental sightings

Tree observations began in the afternoon after line transects were conducted by ascending a tree with climbing gear to a comfortable support position always above the canopy, ranging from 25 to 30 m above ground. Observations lasted two to five hours, during which all birds flying and vocalizing in and over the forest canopy were recorded. This method allowed us to detect species active above the canopy, such as soaring raptors and swifts. A final technique used was incidental and opportunistic sightings. We recorded every new species for a site, detected visually or aurally, whether during systematic observations or during any other activity.

Inventory sites

The eight inventory sites were located in the northern (Antsamanara 50°14′E, 15°18′S and Sarahandrano 50°18′E, 15°17′S), eastern (Ambery 50°12′E, 15°22′S), southern (Andranomainty 50°17′E, 15°47′S), southern interior (Antafononona 50°11′E, 15°45′S and Manosona 50°18′E, 15°17′S) and western (Bedinta 49°59′E, 15°40′S and Ambohitsitondroina 50°00′E,15°34′S) regions of Masoala Peninsula (Figure 1). We tried to sample inventory sites evenly but time, weather, logistics and at times dwindling food supplies affected working conditions. Bedinta, a western interior mid-elevation forest at 500–730 m, was the first site inventoried. The second site was Ambohitsitondroina-Ambanizana, a western mid-elevation and a higher moist montane forest at 600–1100 m elevation. The third site was Antsamanara, the most northern site characterized by a lowland rainforest at 30–540 m elevation. The fourth site was Sarahandrano, a northern lowland rainforest from 50 to 400 m altitude. The fifth site was Ambery, an eastern lowland rainforest at 20–100 m elevation. The sixth site was Manosona, a southern lowland rainforest at 20–100 m elevation. The seventh site was Antafononona, a southern interior lowland rainforest at 20–370 m elevation. The final site was Andranomainty, a south-eastern littoral forest with an average elevation of 25 m.

Results

Eighty-five bird species were detected with all survey methods (Appendix 1). The majority of species were detected by point counts and line transects. Cumulative species-effort curves for each site (Figure 2) show that the majority of species were detected in the first four days of sampling. Twenty-four detected species were shared by all inventory sites (Appendix 2). Some sites were noticably richer in species than others (Appendix 1). Antsamanara had the highest species richness, probably due to the diversity of habitat types (river,

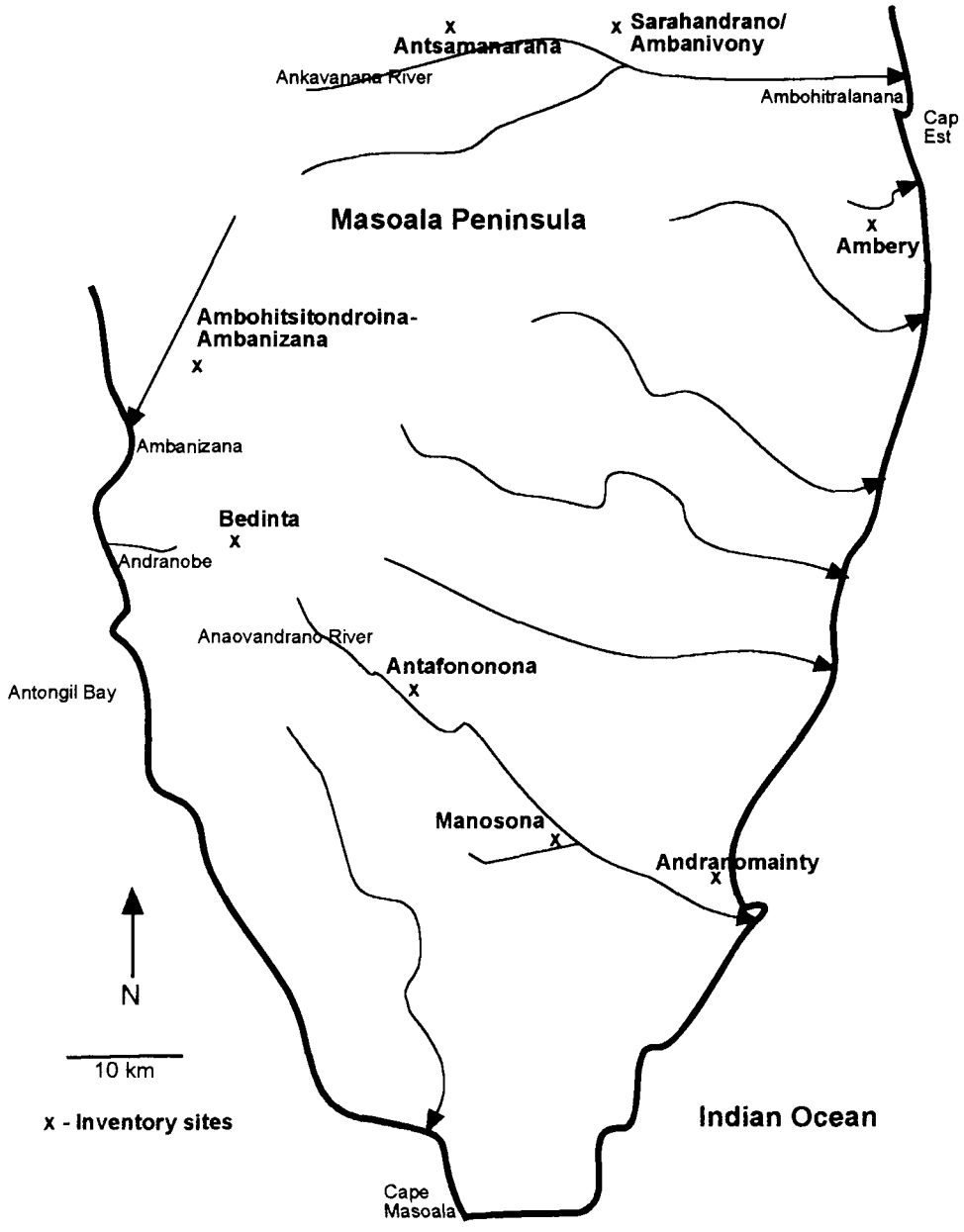

Figure 1. Map of inventory sites on Masoala Peninsula, north-eastern Madagascar.

riparian woodland and lowland forest) within this site. Andranomainty had the lowest species richness possibly because of the high level of human disturbance and/or the physical structure of a forest adapted to sandy soil. Species richness was lower at the high-elevation site Ambohitsitondroina-Ambanizana where rainfall was highest, temperatures generally lower and forest structure shorter than in lowland forests. However, three species were detected only at this

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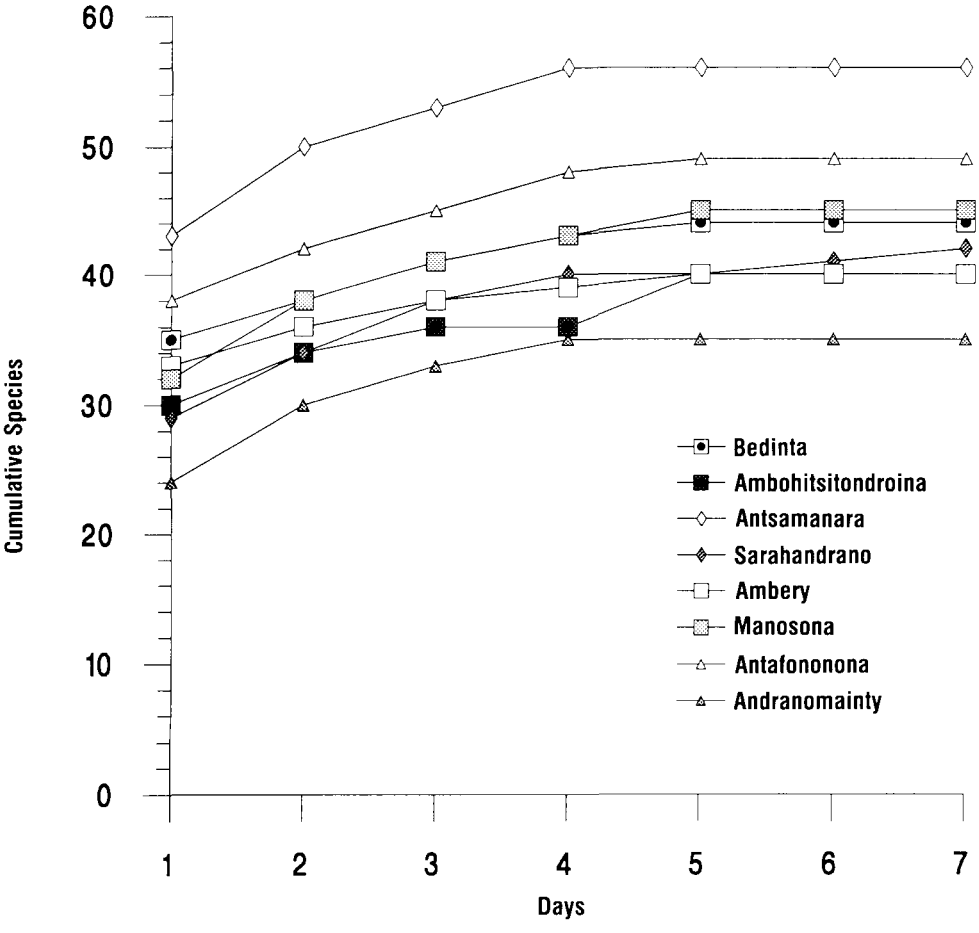

Figure 2. Cumulative species-effort curves for each inventory site.

moist montane site: Grey-crowned Greenbul *Phyllastrephus cinereiceps*, Forest Rock-thrush *Pseudocossyphus sharpei* and Madagascar Brush-warbler *Nesillas typica*.

Line transects were slightly more productive (6 of 8 sites) in number of species detected when compared with the other techniques, including point counts, tree observations, and opportunistic sightings, even though they were started from 1 to 2 hours later than point counts (Figure 3). Although line transects produced more species than point counts it was not significant (χ^2 = 42.0, *df* 36, $P>0.1$). The advantage of line transects over point counts was that the observer's movements occasionally flushed secretive and skulking species into view. For example, the Velvet Asity *Philepitta castanea* was detected visually more often during line transects than point counts at all sites except the littoral forest. This difference was probably because of the species's sedentary behaviour and relatively soft vocalization, which is barely audible farther than 25 m. Most of the individuals detected were either flushed off the trail or flew across the trail during surveys. A total of 64 species was detected by point

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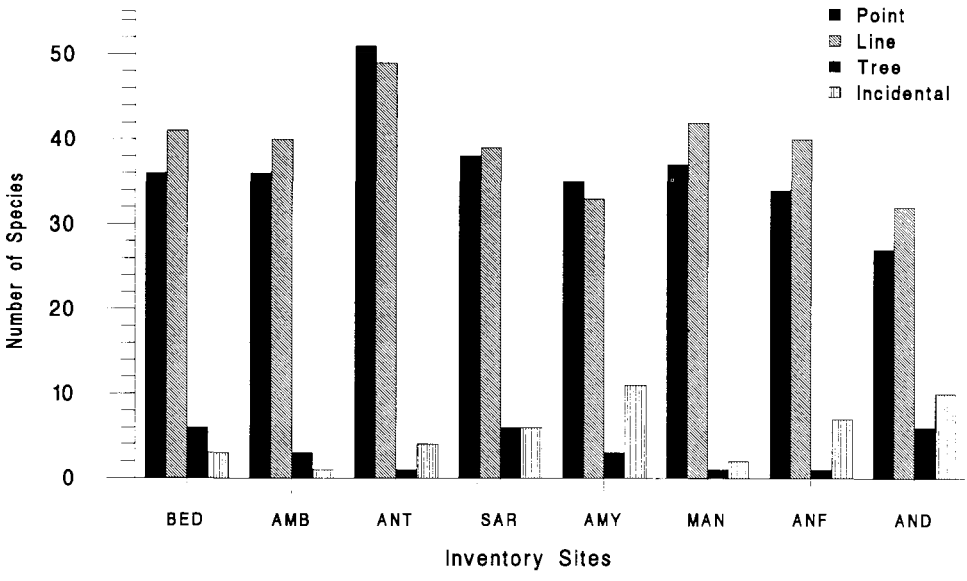

Figure 3. Number of species detected at eight inventory sites by different survey methods. See text for key to inventory sites.

counts, 66 by line transects, 13 by tree observations, and 27 by incidental sightings. Most of the incidental observations were sightings made from camp or in the tavies near camp. In general, those birds observed by incidental sightings were species that occupied open and brushy habitat characteristic of tavies.

Species accounts

Thirteen Madagascar rainforest bird species are categorized as "Threatened" in the ICBP/IUCN African Red Data Book (Collar and Stuart 1985). During five months of fieldwork six threatened and six near-threatened bird species were discovered at the eight inventory sites throughout the Masoala Peninsula. In addition, all four rainforest species identified by Langrand (1990) as vulnerable because of their range restriction to the north-eastern rainforests were found to be relatively numerous (these included two species not listed as threatened or near-threatened): Red-breasted Coua, Scaly Ground-roller, Bernier's Vanga and Helmet Vanga. This section details information collected for those 14 key species observed during the avian inventory work, and for the Madagascar Red Owl.

Madagascar Crested Ibis *Lophotibis cristata* Near-threatened

This species was detected at all eight inventory sites from 30 to 600 m elevation. At six of the sites it was observed during line transects where it was usually flushed off a trail in front of the observer. At several of the inventory campsites

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ibises could be heard vocalizing before roosting for the evening. At the littoral site, on 2 February 1994, an occupied nest was discovered adjacent to a creek trail we used for one of the sampling areas. The nest was a large stick nest placed in the crown of an unknown palm-like tree 6 m above the ground.

Madagascar Serpent-eagle *Eutriorchis astur* Endangered

At 05h40 on 2 November 1993 R.T. heard an unusual vocalization, similar to a coua or frog call. Tracing the source of the three-note call, R.T. observed a larger raptor fly and perch in the area where the call originated. The bird was observed with ×10 binoculars and the first characteristic apparent was the bright yellow iris (versus orange-yellow in Henst's Goshawk *Accipiter henstii*). Other characteristics observed included large and long eagle-like head; bill dark grey–black, upper mandible large; no noticeable cere colour; white-edged feathering on dark crown and nape presenting a scalloped appearance; no distinct white supercilium eye-line (present in Henst's Goshawk); medium brown colour on back; underparts of breast and belly white with fairly broad dark brown bars that thinned out towards lower belly and flanks. The bird vocalized again and R.T. saw the head, eyes and breast of the raptor. Upper tarsi were yellowish and tail long in proportion to body. These details agreed with those of *Eutriorchis astur*, which had not been recorded since the 1930s. That day at 11h30 R.T. and a Malagasy technician observed a serpent-eagle 25 m upslope from the earlier sighting by R.T.

At 16h00 on 11 November 1993, a serpent-eagle was observed flying to an isolated tree 100 m south in the tavy habitat near Sarahandrano camp. The bird perched for half an hour and then flew toward the forest as it was being mobbed by a Broad-billed Roller *Eurystomus glaucurus*, a Crested Drongo and a Madagascar Kestrel *Falco newtoni*. On 27 January 1994 a serpent-eagle was flushed off the inventory trail by a Malagasy technician. The bird flew to a tree and began uttering a call similar to, but more repetitive than, the call described earlier.

Henst's Goshawk *Accipiter henstii* Near-threatened

This rare large raptor was first observed when a local person claimed he knew of a Madagascar Serpent-eagle nest. We confirmed that it was a Henst's Goshawk nest on 12 December 1993. The nest tree was in a section of forest that was being cleared for a tavy. The large bowl stick nest was approximately 15 m above the ground in a fork of a main branch and the tree trunk. An adult was present on the nest incubating or brooding and was flushed from the nest uttering a loud, agitated ringing "kow-kow-kow". The nest site was at 80 m elevation. This large accipiter appeared to be scarce throughout the peninsula, possibly because it occupies a large territory size, ranges broadly and is not tolerant of human disturbance. Only one other Henst's Goshawk was seen during the inventory, an incidental sighting of a bird flying quickly by the campsite in the littoral forest.

Brown Mesite *Mesitornis unicolor* Insufficiently known

This wary and cryptic species was occasionally observed at inventory sites ranging from 30 to 800 m elevation. This species is difficult to detect because of its skulking and secretive behaviour. Individuals were observed crossing trails in front of the observer and more frequently detected vocalizing in the early morning hours. It is not possible to say how common this species was on Masoala Peninsula but we detected it at six of the eight study sites. It was most commonly observed on ridgetop trails, walking alone or in pairs or threes. The birds always escaped by scurrying down steep slopes and sometimes vocalizing a "cluck" alarm call. At Manosona several were observed and heard in the same area during point counts and line transects, suggesting that they were locally restricted to this area. All the birds observed on the Masoala Peninsula were of the atypical plumage (see Langrand 1990).

Red-breasted Coua *Coua serriana*

This species was detected by point counts and line transects at all eight inventory sites from sea level to 800 m. It was very common, relatively tame and very vocal, making detection easy. It was readily seen and heard while it moved through the understorey habitat. In November 1993, at Ambery, an adult was observed feeding a small skink or plated-lizard to a fledgling.

Short-legged Ground-roller *Brachypteracias leptosomus* Rare

This species was detected at seven of eight inventory sites, ranging from 50 to 600 m elevation and normally away from the forest edge. The only site where we did not detect this species was in the littoral forest, which lacks a tall forest structure, a possible reason for its absence at this inventory site. This species was occasionally flushed from the ground or from perches over trails. The hollow repetitive call was heard frequently both in early morning and late evening but is difficult to locate because of its ventriloquial quality. Normally, when one bird began calling another would respond. The birds gave their calls usually from concealed perches 10–20 m above ground. This species was fairly common throughout the Masoala Peninsula, at least where mature forest still existed.

Scaly Ground-roller *B. squamiger* Rare

The Scaly Ground-roller was detected at all but one site. The only site where it was not detected was the high elevation montane site Ambohitsitondroina-Ambanizana. This terrestrial species was observed frequently singly or in pairs when flushed off the trails by us. Several times the species gave a sharp harsh alarm call similar to that of the Madagascar Wood Rail *Canirallus kioloides*. Several were observed foraging upon large earthworms and small chameleons *Brookesia* sp. This species was observed occasionally uttering a hollow slow single-note call similar to the Short-legged Ground-roller but repeated every 20 to 30 seconds but usually from a perch 1–3 m above ground.

Pitta-like Ground-roller *Atelornis pittoides* Near-threatened

This species was detected only twice at Antsamanarana. Both times one individual was flushed off the trail as the observer approached the 350 m elevation mark. It was probably the same individual because the second sighting was within 100 m but two days later than the first sighting. This species has the broadest distribution of all ground rollers found in Madagascar, but on Masoala Peninsula it was apparently rare and may be replaced by the Scaly and Short-legged Ground-rollers.

Grey-crowned Greenbul *Phyllastrephus cinereiceps* Rare

This species was detected only at the high elevation site, Ambohitsitondroina-Ambanizana. Two individuals were observed foraging with two White-throated Oxylabes (*Oxylabes madagascariensis*) at 1010 m elevation. The two Grey-crowned Greenbuls were insect-gleaning from ground level to 2 m on the trunks of small-diameter moss-covered trees along a creek. The contact calls were similar to the insect-like calls of the Spectacled Greenbul *P. zosterops*.

Bernier's Vanga *Oriolia bernieri* Near-threatened

This vanga was recorded at several relatively undisturbed sites, ranging from 50 to 500 m elevation. At the heavily disturbed sites this species was not detected at all. Several individuals were observed flying and calling in the upper canopy near tree observation sites. At Antafononona one large group of 10 individuals were seen for several consecutive days in the same area. At this site one adult male was observed vocalizing a loud shrill interspersed with a jumble of squeaks, resembling a Crested Drongo, for several hours from the same perch 15 m above the ground. Occasionally several individuals were seen foraging in mixed-species vanga flocks.

Helmet Vanga *Euryceros prevostii*

This large vanga was detected at all sites except the littoral forest, ranging from 50 to 700 m elevation. It was very common at the undisturbed interior sites but rare along the forest edge. Two nests were discovered, one under construction in October 1993 and a second occupied by an incubating bird in December 1993. Nests were moss-lined cups placed 3 to 4 m high in a fork of a small tree overhanging a creek. Several birds were observed foraging on prey items consisting of a preying mantis, a small chameleon *Brookesia* sp. and several species of lepidopterans.

Rand's Warbler *Randia pseudozosterops* Near-threatened

This species was detected vocalizing in riverine forest at Bedinta, Ambohitsitondroina, and Antsamanara. All three of these sites consisted of pristine interior forests. No warblers were detected along rivers at the lower ends of the eastern flowing rivers characterized by human occupancy and lack

of forested habitat. Rand's Warblers were detected vocalizing or observed perched in tree tops along these rivers ranging from 30 to 600 m elevation. At Antsamanara these warblers were linearly spaced along the river, with one singing bird approximately every kilometre.

Ward's Flycatcher *Pseudobias wardi*

The Ward's Flycatcher, a small canopy flycatcher, was detected very infrequently from 30 to 600 m, mainly at wetter western sites. Most individuals were observed in the canopy near tree observation sites. It was observed several times in mixed-species flocks hawking insects in the upper canopy.

Madagascar Red Owl *Tyto soumagnei* Indeterminate

This rare owl was not detected during the inventory but just after its completion a bird was shown to us near a village. The bird was roosting among a small grove of bananas and next to a busy footpath that follows the edge of a large river. The roost site was approximately 5 m above sea level. This is the first time this species has been recorded on the Masoala Peninsula and at sea level. All previous sightings come from undisturbed forests at 800 to 1200 m altitude. The site where this owl was roosting is human-altered habitat for 2 to 3 km in all directions. Contrary to popular belief this owl may be a forest edge rather than a forest-obligate species. Further research is needed to determine the status, distribution and habitat requirements of this rare species (Thorstrom *et al.* in press).

Discussion

The eastern rainforest region contains the most diverse avifauna in Madagascar, and 36 species, only one which is not an endemic, are restricted to this region and are in peril due to loss of rainforest habitat (Langrand 1990). Of these forest-dependent birds, 21 (58%) were recorded at inventory sites and adjacent areas throughout Masoala Peninsula. Out of these 36 species, those listed as endangered, threatened or near-threatened in Collar and Stuart (1985) are of particular interest. This study recorded five near-threatened and six threatened rainforest species; of the latter, two (Madagascar Serpent-eagle and Red Owl) are amongst the rarest raptors in the world. The sighting of the Madagascar Red Owl makes Masoala Peninsula a new location and significantly extends the eastern and altitudinal range of one of the world's rarest owl species. The Grey-crowned Greenbul makes Masoala Peninsula a new range extension and another site where this relatively rare species occurs. Several species that are reported as endangered, rare or near-threatened in Madagascar (Evans *et al.* 1992, Thompson and Evans 1992) were found ubiquitously among the inventory sites sampled and surveyed in the Masoala Peninsula; species such as Madagascar Crested Ibis, Brown Mesite, Short-legged Ground-roller and Rand's Warbler.

The Red-breasted Coua, Scaly Ground-roller, Bernier's and Helmet Vanga are four vulnerable species because they are restricted to rainforest of the north-eastern part of the island (Langrand 1990). All four were found to be relatively common among the Masoala Peninsula inventory sites. This makes Masoala forests a critical area for protection because nearly all the forested area is of lowland eastern region habitat. Given the inaccessibility of the Masoala forest interior, due to the lack of trails and roads, and the poorly known biological knowledge of these forests, the development of the National Park should heighten the knowledge and conservation importance of avian species and other rare fauna and flora found in this pristine lowland forest.

Among the threatened species, several are of particular importance to the conservation of avifauna in Madagascar. The repeated sightings and capture of a Madagascar Serpent-eagle on the peninsula gives new information on the status and biology of one of the world's rarest forest raptors (Thorstrom *et al.* 1995). This species has been considered to be one of the rarest birds of prey in the world (Langrand and Meyburg 1984). Until recently, it was known from only 11 specimens collected in forests in the central-east and north-east of Madagascar between 1874 and 1930 (Collar and Stuart 1985, Collar and Andrew 1988). Raxworthy and Colston (1992) collected a decomposed carcass in Ambatovaky Reserve that was later identified as a Madagascar Serpent-eagle. There have been several possible sightings from Marojejy Reserve including a detailed account of a sighting made in 1988 by Sheldon and Duckworth (1990). This species has always been secretive and scarce in primary rainforest, and historical records and our Masoala sightings came from one of the most inaccessible, least-studied and poorly known biological areas of Madagascar.

The Masoala Peninsula may be the only area where some rare species (such as the Madagascar Serpent-eagle) may survive in viable numbers. Several different individuals were detected at inventory sites throughout the peninsula. Preliminary data suggests that this raptor is a forest-obligate species which rarely ventures beyond the forest edge. The establishment and control of a national park is critical for protecting the long-term survival of these rare animals and other fauna and flora. Masoala Peninsula is of obvious importance for conservation for Malagasy heritage and the world.

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Appendix 1. Avian species list for 8 inventory sites on the Masoala Peninsula September 1993–February 1994.

P, species detected by point counts; L, line transects; T, tree observations; I, incidental sightings. In total 85 species were detected. Inventory sites: 1, Bedinta; 2, Ambohitsitondroina-Ambanizana; 3, Antsamanara; 4, Sarahandrano; 5, Ambery; 6, Manosona; 7, Antafononona; 8, Andranomainty.

Species	Inventory site							
	1	2	3	4	5	6	7	8
Cattle Egret *Bubulcus ibis*			P	T		T		
Purple Heron *Ardea purpurea*			I	I		I		
Humblot's Heron *Ardea humbloti*						L		
Green-backed Heron *Butorides striatus*					I	I		
Madagascar Crested Ibis *Lophotibis cristata*	I	I	L	P,L	L	P,L	L	L
Black Kite *Milvus migrans*								T
Madagascar Serpent-eagle *Eutriorchis astur*				I			L	
Madagascar Harrier-hawk *Polyboroides radiatus*	T		P,L	P,L	L,T	L,T	L,I	T
Henst's Goshawk *Accipiter henstii*								I
Frances's Sparrowhawk *Accipiter francesii*	L		P,L	I		P,L	L	P,L
Madagascar Buzzard *Buteo brachypterus*	P,L	P,T	P,L	T	T	T	P,L,T	T
Madagascar Kestrel *Falco newtoni*	T	I		T,I	I	T	I	L
Helmeted Guineafowl *Numida meleagris*			I		I			
Brown Mesite *Mesitornis unicolor*		P	I	I	P	P,L	P	
Madagascar Buttonquail *Turnix nigricollis*							I	
White-throated Rail *Dryolimnas cuvieri*				P,I		L		P,L
Madagascar Wood Rail *Canirallus kioloides*		I	P,L	P,L	P,L	P,L	P,L	P,L
Madagascar Pratincole *Glareola ocularis*			P,L					
Madagascar Turtledove *Streptopelia picturata*	P,L	P,L	P,L	P,L	P,I	P,L	P,L	L
Madagascar Green Pigeon *Treron australis*			P	L	P	L	P,L	
Madagascar Blue Pigeon *Alectroenas madagascariensis*	T	L	L			I	I	
Greater Vasa Parrot *Coracopsis vasa*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Lesser Vasa Parrot *Coracopsis nigra*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Grey-headed Lovebird *Agapornis cana*								P,L
Madagascar Lesser Cuckoo *Cuculus rochii*	P,L	P,L	P,L	P,L	P,L	L	P,L	
Red-breasted Coua *Coua serriana*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Red-fronted Coua *Coua reynaudii*	P,L	P,L	P,L	P,L	P,L		P,L	P,L
Crested Coua *Coua cristata*			P	P,L	L	I	L	
Blue Coua *Coua caerulea*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Madagascar Coucal *Centropus toulou*	P		P,L	P,L	P,L	P<L	P,L	P,L
Malagasy Scops-owl *Otus rutilus*	P,I	P,I	P,I	P,I	P,I	P,I	P,I	P,I
White-browed Owl *Ninox superciliaris*			P,I	P,I	P,I	P,I	P,I	I
Madagascar Long-eared Owl *Asio madagascariensis*	I							
Madagascar Nightjar *Caprimulgus madagascariensis*					I			
Collared Nightjar *Caprimulgus enarratus*				I				P,L
Malagasy Spine-tailed Swift *Zoonavena grandidieri*	T	T	P,T	T	T		T	T

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Species	Inventory site							
	1	2	3	4	5	6	7	8
Malagasy Kingfisher *Corythornis vintsioides*	P,L		L		I	I	I	
Madagascar Pygmy Kingfisher *Ispidina madagascariensis*	L	I						
Madagascar Bee-eater *Merops superciliosus*							I	P,L
Broad-billed Roller *Eurystomus glaucurus*			P,L	P	P	L	P,L	L
Short-legged Ground-roller *Brachypteracias leptosomus*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	
Scaly Ground-roller *Brachypteracias squamiger*	L,I		P,L	P,L	P	L	P,L	L
Pitta-like Ground-roller *Atelornis pittoides*			I					
Cuckoo-Roller *Leptosomus discolor*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Velvet Asity *Philepitta castanea*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	
Sunbird-Asity *Neodrepanis coruscans*	P,L	P,L	P					
Madagascar Wagtail *Motacilla flaviventris*			P,L					
Ashy Cuckoo-shrike *Coracina cinerea*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Long-billed Greenbul *Phyllastrephus madagascariensis*	P,L	L	P,L	P,L	P,L	P,L	P,L	P,L
Spectacled Greenbul *Phyllastrephus zosterops*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	
Grey-crowned Greenbul *Phyllastrephus cinereiceps*		I						
Madagascar Bulbul *Hypsipetes madagascariensis*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Madagascar Magpie-robin *Copsychus albospecularis*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Forest Rock-thrush *Pseudocossyphus sharpei*		P,L						
Madagascar Brush-warbler *Nesillas typica*		P,L						
Madagascar Cisticola *Cisticola cherina*						I		
Rand's Warbler *Randia pseudozosterops*	P,L	P,L	P,L					
Dark Newtonia *Newtonia amphichora*	P,L	P,L	P,L	P,L				
Common Newtonia *Newtonia brunneicauda*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Common Jery *Neomixis tenella*	L		P,L	P,L	P,L	P,L	P,L	
Unidentified Jery or New Warbler[1]	P	P,L						
Ward's Flycatcher *Pseudobias wardi*	T	P,T	I	I				
Madagascar Paradise Flycatcher *Tersiphone mutata*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
White-throated Oxylabes *Oxylabes madagascariensis*	P,L	P,L				L	L	
Crossley's Babbler *Mystacornis crossleyi*	P,L	P,L	L	P,L		L	P,L	
Souimanga Sunbird *Nectarinia souimanga*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Long-billed Green Sunbird *Nectarinia notata*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Madagascar White-eye *Zosterops maderaspatana*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P
Red-tailed Vanga *Calicalicus madagascariensis*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	L
Rufous Vanga *Schetba rufa*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Hook-billed Vanga *Vanga curvirostris*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
White-headed Vanga *Leptopterus viridis*	P	P,L	P,L	P,L		L	L	L
Chabert's Vanga *Leptopterus chabert*	P,L		P,L	T	P		P	
Blue Vanga *Cyanolanius madagascarinus*	L,T	P	P,L	P,L	P,L	L	P,L	P,L
Bernier's Vanga *Oriolia bernieri*	T		P,L	L		P,L	P,L	
Helmet Vanga *Euryceros prevostii*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	
Nuthatch Vanga *Hypositta corallirostris*	L			I		I	L	
Tylas Vanga *Tylas eduardi*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Crested Drongo *Dicrurus forficatus*	P,L	P,L	P,L	P,L	P,L	P,L	P,L	P,L
Pied Crow *Corvus albus*								T
Madagascar Starling *Hartlaubius auratus*	I		P,L	I	T		I	

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Species	Inventory site							
	1	2	3	4	5	6	7	8
Nelicourvi Weaver *Ploceus nelicourvi*	P,L	P,L	P,L		P	L	L	L
Madagascar Red Fody *Foudia madagascariensis*			P,L		I			P,L
Forest Fody *Foudia omissa*			L	L		L		
Madagascar Mannikin *Lonchura nana*					I		I	
Total	54	48	62	57	51	56	57	44

[a] An unidentified jery-type or new warbler-type (Goodman *et al.* 1996) call was heard from 700–800 m elevation at Bedinta and Ambohitsitondroina several times. The species uttering this call was not identified because of the inclement wet weather and lack of time.

Appendix 2. Bird species shared by all inventory sites.

Madagascar Crested Ibis *Lophotibis cristata*
Madagascar Buzzard *Buteo brachypterus*
Madagascar Turtledove *Streptopelia picturata*
Greater Vasa Parrot *Coracopis vasa*
Lesser Vasa Parrot *Coracopis nigra*
Red-breasted Coua *Cou serriana*
Blue Coua *Cou caerulea*
Malagasy Scops-owl *Otus rutilus*
Cuckoo-Roller *Leptosomus discolor*
Ashy Cuckoo-shrike *Coracina cinerea*
Long-billed Greenbul *Phyllastrephus madagascariensis*
Madagascar Bulbul *Hypsipetes madagascariensis*
Madagascar Magpie-robin *Copsychus albospecularis*
Common Newtonia *Newtonia brunneicauda*
Madagascar Paradise Flycatcher *Tersiphone mutata*
Souimanga Sunbird *Nectarinia souimanga*
Long-billed Green Sunbird *Nectarinia notata*
Madagascar White-eye *Zosterops maderaspatana*
Red-tailed Vanga *Calicalicus madagascariensis*
Rufous Vanga *Schetba rufa*
Hook-billed Vanga *Vanga curvirostris*
Blue Vanga *Cyanolanius madagascarinus*
Tylas Vanga *Tylas eduardi*
Crested Drongo *Dicrurus forficatus*

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