

First comprehensive avifaunal survey of PK32-Ranobe, a new protected area in south-western Madagascar

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Abstract: We conducted the first comprehensive bird survey of PK32-Ranobe (Atsimo Andrefana Region), a proposed new protected area within the Madagascar Protected Area System. Our cross-seasonal surveys of four sites revealed the presence of 124 bird species, including 56 Malagasy endemics and 8 species endemic to the southern ecoregion. Bird diversity at each site ranges from 53 to 99, these differences being largely explained by differences in wetland bird diversity. Rates of national and regional (Madagascar and the western Indian Ocean islands) endemism are highest among forest-dependent species (77.7/98.1%), and lowest among wetland species (9.8/12.2%). 50 of our records represent new records for the site, and 17 represent range extensions, of which 9 are of wetland species. Literature reviews reveal records of a further six species, giving PK32-Ranobe the most diverse avifauna of any site in the south-west of Madagascar. Based on our survey results, we strongly support the establishment of a protected area that encompasses the full range of vegetation types within the site, and recommend that the wetlands of Ranobe and Belalanda, the gallery forests of the Fiherenana and Manombo river systems and the transitional forest at Ranobe receive the highest priority in protected area zoning and management planning.

Résumé: La zone de PK32-Ranobe (Région d'Atsimo Andrefana), une nouvelle aire protégée proposée dans le Système des Aires Protégées de Madagascar, a été l'objet d'un premier inventaire ornithologique compréhensif. Nos prospections dans quatre sites en toutes saisons ont révélé la présence de 124 espèces d'oiseaux, incluant 56 espèces endémiques à Madagascar et 8 espèces endémiques à l'écorégion du Sud. La diversité des oiseaux varie de 53 à 99 entre les sites ; cette variation peut être surtout expliquée par les différences en diversité d'oiseaux aquatiques. Le taux d'endémisme au niveau national et régional (Madagascar et les îles de l'Ouest de l'Océan Indien) est plus élevé parmi les espèces forestières (77,7/98,1%), et plus bas parmi les espèces aquatiques (9,8/12,2%). 50 des espèces inventoriées représentent les premières observations dans la zone, et 17 représentent des extensions de leurs aires de répartition connues, dont 9 sont des oiseaux aquatiques. Une revue de la littérature indique encore six espèces connues de la zone, rendant l'avifaune de PK32-Ranobe la plus diverse dans le Sud-Ouest de Madagascar. A partir de nos résultats, nous soutenons la mise en place d'une aire protégée qui intègre tous les formations végétales de la zone, et nous recommandons que les zones humides de Ranobe et de Belalanda, les forêts galeries des fleuves Fiherenana et Manombo, et la forêt de transition de Ranobe soient priorisées dans l'aménagement et la planification de la gestion de l'aire protégée.

Introduction

Madagascar's avifauna is characterised by relatively low species diversity, but elevated levels of species and higher taxon endemism. A total of 283 species have been recorded, of which 209 are regular breeders (Hawkins & Goodman 2003). 116 of these species are recognised as endemic (Hawkins and Goodman 2003, Sinclair and

Langrand 2003), representing 40% of all species and 55.5% of breeding species, giving Madagascar the highest proportion of endemic species of any large country in the world. Three families are endemic (the Mesitornithidae, Brachypteraciidae and Bernieridae), while the Leptosomatidae and Vangidae are near-endemic, both having a single species occurring on the nearby Comoros islands. In addition the Couinae and Philepittinae are endemic subfamilies.

The spiny forest ecoregion of southern and south-western Madagascar is one of the most biologically rich in the country, characterised by high species diversity and levels of local endemism. The endemic flora of the region surpasses 1000 species, and approximately 53% of indigenous plant species are locally endemic, with a further 36% of species endemic to Madagascar (Phillipson 1996). High levels of local endemism are also found amongst the reptiles (Glaw and Vences 2007) and birds – the ecoregion has been classified as an Endemic Bird Area (EBA) on the basis of 10 locally endemic species (Stattersfield *et al.* 1998).

The ecoregion is recognised as a high conservation priority for Madagascar (WWF 2002), and suffers the fastest rates of forest loss in the country (Conservation International *et al.* 2007). It was considered under-represented in terms of formal protection (Collar and Stuart 1985, Du Puy and Moat 1996, Seddon *et al.* 2000, Fenn 2003) prior to the expansion of Madagascar's Protected Area System (Système des Aires Protégées de Madagascar, SAPM) which was launched in 2003 (the 'Durban Vision', see Mittermeier *et al.* 2005, GoM 2007). A number of new protected areas (PA) are now being established within the ecoregion under the Durban Vision initiative, including that of PK32-Ranobe, our study site.

This paper presents the results of a multi-season survey carried out in the proposed PK32-Ranobe protected area as part of the Frontier Madagascar Forest Research Programme between August 2002 and December 2004. The objective of the research was to supplement existing data with an intensive survey of the full range of major habitat types within the proposed protected area in order to compile up-to-date baseline data with which to inform conservation prioritisation, planning and management. Inventories were compiled for birds, reptiles, amphibians, mammals, plants and select invertebrate taxa; for a full report of research results for non-bird taxa, see Thomas *et al.* (2005).

Study site

The PK32-Ranobe site, which forms part of the South Mangoky centre of micro-endemism (Wilmé *et al.* 2006), has been long been recognised as a conservation priority area (Domergue 1983, Nicoll and Langrand 1989, Raxworthy 1995, Ganzhorn *et al.* 1997, ZICOMA, 1999, Seddon *et al.* 2000), and since 2006 has been the focus of an initiative to establish an IUCN Category V community co-managed protected area within Madagascar's expanded protected areas system (WWF 2007). The proposed protected area lies to the north of the regional capital of Toliara (Tuléar) on Madagascar's south-west coast, stretching between the Fiherenana River to the south and the Manombo River to the north. It is bordered to the west by the Mozambique Channel, and extends to the eastern edge of the Tertiary limestone Mikoboka Plateau

(see map, Figure 1). The climate is sub-arid, receiving 100-1300 mm of rainfall per annum (Seddon *et al.* 2000). The site is characterised by high habitat heterogeneity, influenced by heterogeneous geology (Du Puy and Moat 1996) and north-south and east-west gradients in rainfall (Rakotomalaza and McKnight 2006). Six distinct terrestrial habitat types can be recognised within an area of approximately 300, 000 ha (WWF 2007): littoral thicket on coastal white sands, spiny thicket on red sands rich in sesquioxides, spiny thicket on limestone, gallery forest, a transitional forest between the spiny thicket of the southern domain and dense dry forest of the western domain, and freshwater and brackish wetlands.

Two published inventories exist of the birds of the PK32-Ranobe area, those of Domergue (1983) and Nicoll & Langrand (1989). 79 species were recorded by these authors, but their surveys were concentrated in relatively small areas and several sub-regions and major habitat types remained un-surveyed. We aimed to supplement these data with intensive wet and dry season surveys of four areas (study locations) within the proposed protected area. 1–4 sites were surveyed at each study location, the details of which are shown in Table 1 below.

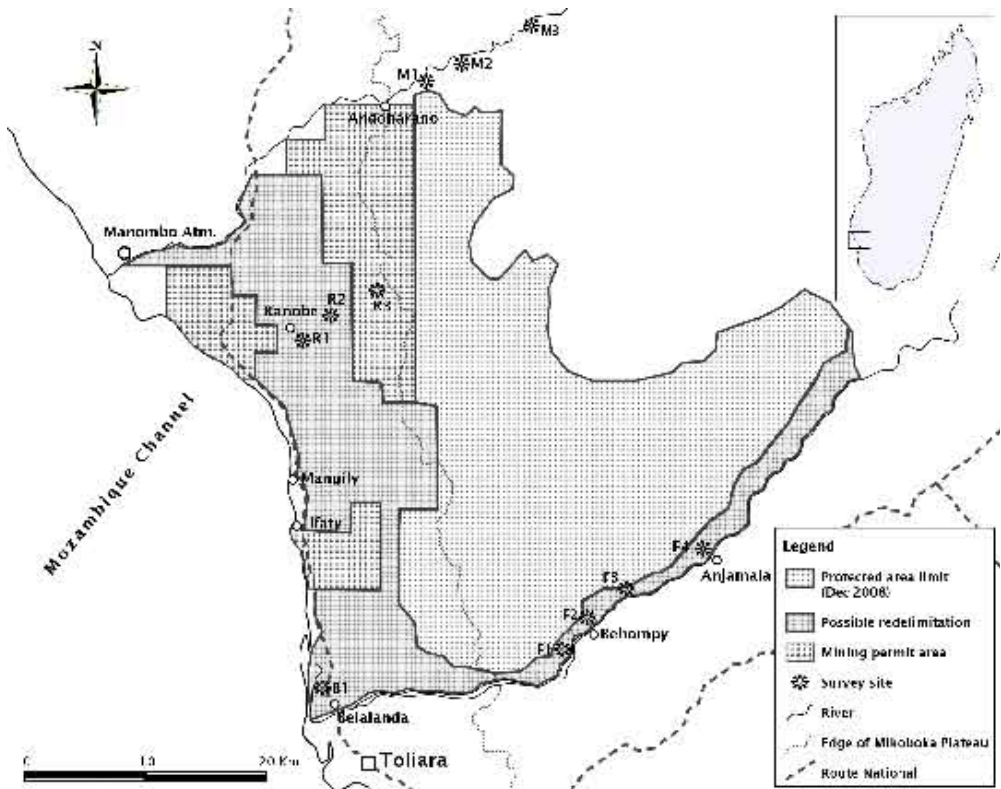


Fig. 1 Map of the survey area

Table 1 Details of survey locations

Study Location	Survey site	Habitat type	Latitude	Longitude	Dates surveyed	Total survey period (days)
Fiherenana River valley	F1	Riparian forest, spiny thicket on limestone	S23° 14' 10.0"	E043° 52' 14.4"	11.08.02-28.08.02, 12.10.02-10.12.02, 05.07.03-28.08.03	135
	F2	Spiny thicket on limestone	S23° 13' 51.0"	E043° 51' 36.6"		
	F3	Riparian forest, transitional forest	S23° 12' 44.2"	E043° 53' 36.1"		
	F4	Riparian forest, transitional forest	S23° 10' 40.2"	E043° 57' 44.8"		
Belalanda Lake complex	B1	Brackish lakes and reed beds	S23° 17' 24.3"	E043° 38' 53.1"	19.05.03-29.05.03, 02.11.03-06.11.03, 20.07.04-27.07.04	24
Ranobe Lake and forests	R1	Freshwater lake and reed beds, transitional forest	S23° 02' 24.6"	E043° 36' 34.2"	14.01.03-28.03.03, 13.04.03-04.06.03, 14.10.03-08.12.03, 16.01.04-08.03.04, 05.07.04-29.08.04	292
	R2	Transitional forest, spiny thicket on red sand	S23° 02' 05.5"	E043° 37' 52.1"		
	R3	Anthropogenic grassland, spiny thicket on limestone	S23° 01' 47.9"	E043° 41' 38.2"		
Manombo River valley	M1	Riparian forest	S22° 48' 21.6"	E043° 44' 02.4"	17.01.04-31.01.04, 21.02.04-05.03.04, 05.04.04-31.05.04, 07.07.04-16.07.04, 11.10.04-04.12.04	151
	M2	Riparian forest, transitional forest	S22° 48' 16.0"	E043° 45' 38.7"		
	M3	Riparian forest, transitional forest, spiny thicket on limestone	S22° 47' 10.0"	E043° 48' 19.0"		

Methodology

We employed two methods to compile a bird inventory at each of the four study sites; timed observation walks and casual observations (Bibby *et al.* 1998)

Timed observation walks

Walks were carried out at times of peak bird activity, between 05:00 and 08:30, and between 16:00 and 18:00. All habitat types occurring within the study sites were surveyed in approximate proportion to the extent of their occurrence.

Casual observations

In addition to formal data collection, all visual bird sightings around base camps or elsewhere were recorded. Such observations are useful to record species that may otherwise go unrecorded using the formal method, such as nocturnal or cryptic species or those occurring at low density.

For taxonomy and nomenclature we generally follow Hawkins and Goodman (2003). This review, however, treats as subspecies a number of taxa that have subsequently been demonstrated to merit full specific status, all of which are species with closely-related sister taxa occurring on the Comoros or Aldabra islands. For these species we follow the revisions accepted by Sinclair and Langrand (2003). The elevation of these taxa to full species raises the number of Madagascar endemics by 9 from the figures given in Hawkins and Goodman (2003); the figures for national endemism quoted within this paper thus represent our own calculations incorporating the new revisions.

Results

We recorded a total of 124 species at the four survey locations, representing 99 genera and 51 families (see Table 3 for complete list with details of recorded locations, habitat utilisation and endemism). 116 of these species breed in Madagascar, representing 55.5% of all Madagascar's breeding species. 56 endemic species were recorded (48.3% of Madagascar's endemic species) while a further 17 species are endemic to the region (defined as Madagascar, the Comoros, Seychelles and Mascarene island groups).

Table 4 below provides rates of national and regional endemism for bird species recorded during this survey, divided by broad habitat categories. Of the 124 species we recorded, 56 (45.2%) are endemic to Madagascar, and a further 17 (13.7%) are endemic to the Madagascar region, giving a total rate of regional endemism of 58.9%. Endemism amongst obligate wetland species is comparatively low, with 9.8% of recorded species endemic to Madagascar and 12.2% endemic to Madagascar and the region. Removing these wetland species from the analysis gives figures of 61.0% national and 80.5%

Table 2 Summary of survey effort

Effort unit	Fiherenana	Belalanda	Ranobe	Manombo	Total
No. of observation walks	61	19	117	57	254
No. of observation hours	116	46.5	225	100	487.5

Table 3 Fiherenana-Manombo Complex bird species list

Latin name	English name	Authority	Fiherenana	Belanda	Ranobe	Manombo	Habitat	Status
<i>Tachybaptus ruficollis</i>	little grebe	Pallas, 1764		X	X		W	
<i>Phalacrocorax africanus</i>	reed cormorant	Gmelin, 1789	X				W	
<i>Ixobrychus minutus</i>	little bittern	Linnaeus, 1766		X			W	
<i>Nycticorax nycticorax</i>	black-crowned night heron	Linnaeus, 1758	X				W	
<i>Ardeola ralloides</i>	squacco heron	Scopoli, 1769	X	X	X	X	W	
<i>Bubulcus ibis</i>	cattle egret	Linnaeus, 1758	X	X	X	X	W, O	
<i>Butorides striatus</i>	green-backed heron	Linnaeus, 1758	X	X	X	X	W	
<i>Egretta ardesiaca</i>	black egret	Wagler, 1827		X	X		W	
<i>Egretta dimorpha</i>	dimorphic egret	Hartert, 1924	X	X	X	X	W	
<i>Egretta alba</i>	great egret	Linnaeus, 1758	X	X	X		W	
<i>Ardea purpurea</i>	purple heron	Linnaeus, 1766	X		X	X	W	
<i>Ardea cinerea</i>	grey heron	Linnaeus, 1758	X		X		W	
<i>Ardea humbloti</i>	Humboldt's heron	Milne Edwards & Grandidier, 1885	X				W	E
<i>Scopus umbretta</i>	Hamerkop	Gmelin, 1789	X			X	W	
<i>Anastomus lamelligerus</i>	African openbill stork	Temminck, 1823			X		W	E
<i>Lophotibis cristata</i>	Madagascar crested ibis	Boddaert, 1793				X	T	
<i>Phoenicopterus ruber</i>	greater flamingo	Linnaeus, 1758		X			W	
<i>Dendrocygna viduata</i>	white-faced whistling duck	Linnaeus, 1766		X	X		W	
<i>Sarkidiornis melanotos</i>	knob-billed duck	Pennant, 1769	X		X		W	
<i>Nettapus auritus</i>	African pygmy goose	Boddaert, 1783			X		W	
<i>Anas erythrorhyncha</i>	red-billed teal	Gmelin, 1789		X	X		W	
<i>Anas hottentota</i>	Hottentot teal	Eyton, 1838		X	X		W	
<i>Thalassornis leuconotus</i>	white-backed duck	Eyton, 1838			X		W	
<i>Aviceda madagascariensis</i>	Madagascar cuckoo-hawk	Smith, 1834				X	W	E
<i>Mithus aegyptius</i>	yellow-billed kite	Gmelin, 1788	X		X	X	T	
						X	REF, O	

Latin name	English name	Authority	Fiherenana	Belandana	Ranobe	Manombo	Habitat	Status
<i>Polyboroides radiatus</i>	Madagascar harrier-hawk	Scopoli, 1786	X		X	X	RF,T	E
<i>Accipiter madagascariensis</i>	Madagascar sparrowhawk	Smith, 1834				X	RF	E
<i>Accipiter francesii</i>	France's sparrowhawk	Smith, 1834	X		X	X	RF, T	RE
<i>Buteo brachypterus</i>	Madagascar buzzard	Hartlaub, 1860	X		X	X	RF, T, O	E
<i>Falco newtoni</i>	Madagascar kestrel	Gurney, 1863	X	X	X	X	RF,S,T,O	RE
<i>Falco zoniventris</i>	banded kestrel	Peters, 1854	X		X		O	E
<i>Falco concolor</i>	sooty falcon	Temminck, 1825			X		O	E
<i>Falco peregrinus</i>	peregrine falcon	Tunstall, 1771	X				S	E
<i>Margaroperdix madagarensis</i>	Madagascar partridge	Scopoli, 1786	X		X	X	RF,T,O	E
<i>Coturnix coturnix</i>	common quail	Linnaeus, 1758			X		O	E
<i>Numida meleagris</i>	helmeted guineafowl	Linnaeus, 1758	X		X	X	O	I?
<i>Monias benschi</i>	subdesert mesite	Oustalet & Grandidier, 1903			X		S	E
<i>Turnix nigricollis</i>	Madagascar buttonquail	Gmelin, 1789	X		X	X	RF,S,T	E
<i>Dryolimnas cuvieri</i>	white-throated rail	Pucheran, 1845			X		W	RE
<i>Porzana pusilla</i>	Baillon's crane	Pallas, 1776		X			W	E
<i>Gallinula chloropus</i>	common moorhen	Linnaeus, 1758		X	X		W	E
<i>Porphyrio porphyrio</i>	purple swamphen	Linnaeus, 1758		X			W	E
<i>Fulica cristata</i>	red-knobbed coot	Gmelin, 1789		X	X		W	E
<i>Rostratula benghalensis</i>	greater painted snipe	Linnaeus, 1758	X		X		W	E
<i>Himantopus himantopus</i>	black-winged stilt	Linnaeus, 1758		X	X		W	E
<i>Pluvialis squatarola</i>	grey plover	Linnaeus, 1758			X		W	E
<i>Charadrius hiaticula</i>	ringed plover	Linnaeus, 1758		X	X		W	E
<i>Charadrius thoracicus</i>	Madagascar plover	Richmond, 1896		X	X		W	E
<i>Charadrius pecuarius</i>	Kittlitz's plover	Temminck, 1823	X	X	X		W	E
<i>Charadrius tricollaris</i>	three-banded plover	Vieillot, 1818	X	X	X		W	E
<i>Tringa stagnatilis</i>	marsh sandpiper	Bechstein, 1803		X			W	E

<i>Tringa nebularia</i>	common greenshank	Gunnerus, 1767	X	X	X	W	E
<i>Actitis hypoleucos</i>	common sandpiper	Linnaeus, 1758	X	X	X	W	RE
<i>Calidris ferruginea</i>	curlew sandpiper	Pontoppidan, 1763	X			W	
<i>Sterna caspia</i>	Caspian tern	Pallas, 1770	X	X		W	
<i>Pterocles personatus</i>	Madagascar sandgrouse	Gould, 1843			X	O	
<i>Streptopelia picturata</i>	Madagascar turtle dove	Temminck, 1813	X	X	X	RF,S,T	
<i>Oena capensis</i>	Namaqua dove	Linnaeus, 1766	X	X	X	O,S	
<i>Treron australis</i>	Madagascar green pigeon	Linnaeus, 1771	X	X	X	RF,T	RE
<i>Alcetroenas madagascariensis</i>	Madagascar blue pigeon	Linnaeus, 1766	X			RF	E
<i>Coracopsis vasa</i>	greater vasa parrot	Shaw, 1811	X	X	X	All	RE
<i>Coracopsis nigra</i>	lesser vasa parrot	Linnaeus, 1758	X	X	X	All	RE
<i>Agapornis cana</i>	grey-headed lovebird	Gmelin, 1788	X	X	X	RF, T, O	E
<i>Cuculus rochii</i>	Madagascar lesser cuckoo	Hartlaub, 1862	X	X	X	RF,T,S	
<i>Cooua gigas</i>	giant coua	Boddaert, 1783	X	X	X	RF, T	E
<i>Cooua coquereli</i>	Coquerel's coua	Grandidier, 1867	X			RF, T	E
<i>Cooua cursor</i>	running coua	Grandidier, 1867		X		S	E
<i>Cooua ruficeps olivaceiceps</i>	green-capped coua	Sharpe, 1875	X	X	X	RF,T,S	E
<i>Cooua cristata</i>	crested coua	Linnaeus, 1766	X	X	X	RF, T, S	E
<i>Centropus toulou</i>	Madagascar coucal	Müller, 1776	X	X	X	All	RE
<i>Tyto alba</i>	barn owl	Scopoli, 1769	X	X	X	T	
<i>Otus madagascariensis</i>	western scops owl	Pucheran, 1849	X	X	X	RF	E
<i>Ninox superciliaris</i>	white-browed owl	Viellot, 1823	X		X	RF	E
<i>Asio madagascariensis</i>	Madagascar long-eared owl	Smith, 1834	X	X	X	RF, T	E
<i>Caprimulgus madagascariensis</i>	Madagascar nightjar	Sganzin, 1840	X	X	X	RF, O	RE
<i>Zoonavena grandidieri</i>	Madagascar spine-tailed swift	Verreaux, 1867	X	X	X	O	RE
<i>Cypsiurus parvus</i>	African palm swift	Lichtenstein, 1823	X	X	X	O	
<i>Apus melba</i>	alpine swift	Linnaeus, 1758	X	X	X	O	

Latin name	English name	Authority	Fiherenana	Belalandia	Ranobe	Manombo	Habitat	Status
<i>Apus barbatus</i>	African black swift	Sclater, 1865			X		S, RF	
<i>Alcedo vinitoides</i>	Madagascar malachite kingfisher	Eydoux & Gervais, 1836	X	X	X	X	RF, W	RE
<i>Ispidina madagascariensis</i>	Madagascar pygmy kingfisher	Linnaeus, 1766	X			X	RF, T	E
<i>Merops superciliosus</i>	Madagascar bee-eater	Linnaeus, 1766	X	X	X	X	RF, S, T, O	
<i>Eurystomus glaucurus</i>	broad-billed roller	Müller, 1776	X		X	X	RF, T, O	
<i>Uratelornis chimaera</i>	long-tailed ground-roller	Rothschild, 1895			X		S	E
<i>Leptosomus discolor</i>	Madagascar cuckoo-roller	Hermann, 1783			X	X	RF, T	RE
<i>Upupa marginata</i>	Madagascar hoopoe	Cabanis & Heine, 1860	X	X	X	X	RF, T	E
<i>Mirafra hova</i>	Madagascar bush lark	Hartlaub, 1860	X	X	X	X	O	E
<i>Phedina borbonica</i>	Mascarene martin	Gmelin, 1789		X	X		O	RE
<i>Hirundo rustica</i>	barn swallow	Linnaeus, 1758			X		O	
<i>Motacilla flaviventris</i>	Madagascar wagtail	Hartlaub, 1860			X	X	O	E
<i>Coraciina cinerea</i>	ashy cuckoo-shrike	Müller, 1776	X		X	X	RF, S	RE
<i>Bernieria madagascariensis</i>	long-billed tetraka	Gmelin, 1789	X			X	RF, T	E
<i>Hypsipetes madagascariensis</i>	Madagascar bulbul	Müller, 1776	X	X	X	X	All	RE
<i>Copsychus albospectularis</i>	Madagascar magpie robin	Eydoux & Gervais, 1836	X		X	X	All	E
<i>Monticola imerinus</i>	littoral rock thrush	Hartlaub, 1860		X			O	E
<i>Monticola sharpei</i>	Forest rock thrush	Gray, 1871	X				RF	E
<i>Acrocephalus newtoni</i>	Madagascar swamp warbler	Hartlaub, 1863		X	X		W	E
<i>Nesillas lantzi</i>	subdesert brush warbler	Grandidier, 1867	X	X	X		S, RF	E
<i>Nesillas typica</i>	Madagascar brush warbler	Hartlaub, 1866	X			X	RF, T	RE
<i>Thamnomis chloropetoides</i>	Thamnomis warbler	Grandidier, 1867	X		X		S	E
<i>Cisticola cherina</i>	Madagascar cisticola	Smith, 1843	X	X	X	X	O	E
<i>Newtonia brunneicauda</i>	common newtonia	Newton, 1863	X		X	X	All	E
<i>Newtonia archboldi</i>	Archbold's newtonia	Delacour & Berlioz, 1931			X	X	RF, S, T	E

<i>Neomixis tenella</i>	common jery	Hartlaub, 1866	X	X	X	X	All	E
<i>Neomixis striatigula</i>	stripe-throated jery	Sharpe, 1881	X	X	X	X	RF,S,T	E
<i>Terpsiphone mutata</i>	Madagascar paradise flycatcher	Linnaeus, 1766	X	X	X	X	RF,T	RE
<i>Nectarinia souimanga</i>	souimanga sunbird	Gmelin, 1788	X	X	X	X	All	RE
<i>Nectarinia notata</i>	Madagascar green sunbird	Linnaeus, 1766	X	X	X	X	RF,O	RE
<i>Zosterops maderaspatana</i>	Madagascar white-eye	Linnaeus, 1766	X	X	X	X	RF,T	RE
<i>Callicalicus madagascariensis</i>	red-tailed vanga	Linnaeus, 1766	X	X	X	X	RF, T, S	E
<i>Schetba rufa</i>	rufous vanga	Linnaeus, 1766	X	X	X	X	RF,T	E
<i>Vanga curvirostris</i>	hook-billed vanga	Linnaeus, 1766	X	X	X	X	RF,T	E
<i>Xenopirostris xenopirostris</i>	Lafresnaye's vanga	Lafresnaye, 1850	X	X	X	X	RF,T,S	E
<i>Falcula palliata</i>	sickle-billed vanga	Geoffroy Saint Hilaire, 1836	X	X	X	X	RF,S	E
<i>Leptopterus viridis</i>	white-headed vanga	Müller, 1776	X	X	X	X	RF,T,S	E
<i>Leptopterus chabert</i>	Chabert's vanga	Müller, 1776	X	X	X	X	RF,S,T	E
<i>Cyanolanius madagascarinus</i>	blue vanga	Linnaeus, 1766	X	X	X	X	RF,T	RE
<i>Tylas eduardi albigularis</i>	tylas vanga	Hartlaub, 1877	X	X	X	X	RF,S	E
<i>Dicrurus forficatus</i>	crested drongo	Linnaeus, 1766	X	X	X	X	All	RE
<i>Corvus albus</i>	pie'd crow	Müller, 1776	X	X	X	X	O	
<i>Acridotheres tristis</i>	common myna	Linnaeus, 1766	X	X	X	X	O	I
<i>Ploceus sakalava</i>	Sakalava weaver	Hartlaub, 1861	X	X	X	X	All	E
<i>Foudia madagascariensis</i>	Madagascar red fody	Linnaeus, 1766	X	X	X	X	All	E
<i>Lonchura nana</i>	Madagascar manikin	Pucheran, 1845	X	X	X	X	O	E
Total No. of species per site			81	53	99	72		
Species total PK32 Ranobe			124					

Habitat codes: RF=riparian forest, S=spiny thicket, T=transitional forest, O=open, W=water (open water, shoreline, reed bed), All=associated with all terrestrial habitats

Status codes: E=Endemic to Madagascar, RE=Endemic to Madagascar region (Madagascar and western Indian Ocean islands), I=Introduced

regional endemism for all terrestrial species. Endemism rates are highest amongst recorded forest-dependent species, of which 77.7% are endemic to Madagascar and 98.1% are endemic to the region. The record of *Alectroenas madagascariensis* is excluded from the above analysis as it is considered a vagrant.

Analysis by sites

Figure 2 shows species-accumulation curves (cumulative species richness as a function of increasing research effort) for the four survey locations. For Belalanda, Manombo and Ranobe these curves reach a plateau, indicating that further survey effort would be expected to generate few additional records, and therefore that our surveys recorded all or almost all of the species present at the site. The species-accumulation curve for the Fiherenana site shows a distinct shoulder at 70 hours, marking a seasonal transition between the two survey periods at this location. That the Fiherenana curve does not reach a clear plateau indicates that further research effort is required at this site.

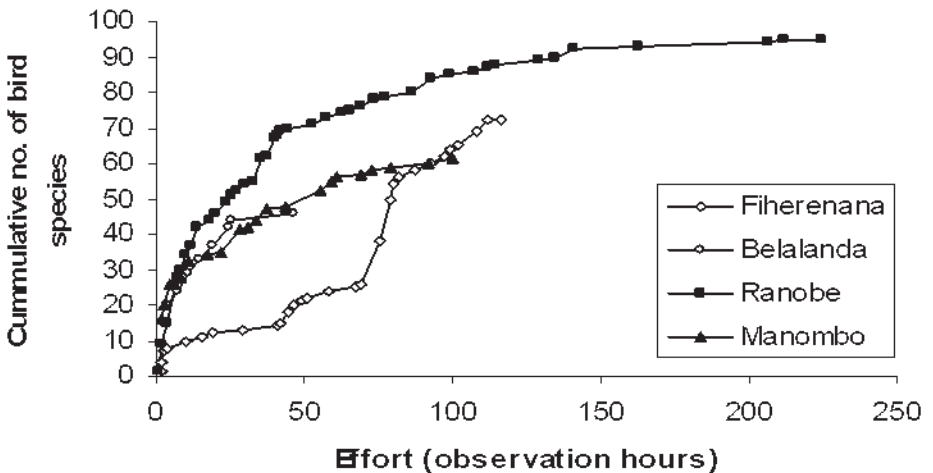


Fig. 2 Species accumulation curves for survey sites

Table 4 Endemism rates by habitat

Habitat	Total No. of species	Number endemics	% endemics	No. regional endemics	% regional endemics	Total % regional endemics
All species	124	50	40.3	22	17.7	58.1
All terrestrial	83	47	56.6	20	24.1	80.7
Obligate wetland	41	3	7.3	2	4.9	12.1
Obligate forest	52	37	71.2	14	26.9	98.1

The number of species recorded per site ranges from 53 (Belalanda) to 99 (Ranobe), see Table 5 below. While research effort was considerably lower at Belalanda than at other sites (see Table 2), the species-accumulation curves above indicate that the comparatively low species diversity at this site is not an artefact of this reduced research effort. Rather, the low diversity at Belalanda is related to the lack of un-degraded thicket or forest habitats around the wetland complex (indeed, only 15 species of non-wetland bird were recorded there). The differences in overall bird diversity between the Fiherenana, Manombo and Ranobe sites are largely explained by differences in wetland bird diversity, the sites harbouring remarkably similar numbers of non-wetland species (62, 67 and 64 respectively). When only forest or thicket dependent species are analysed, the diversity at these sites is even more similar, with 43, 43 and 44 species respectively.

Of the 124 species recorded, only 28 (22.6%) were recorded at all four survey locations, while 30 species (24.2%) were only recorded at one site. These figures are indicative of the habitat heterogeneity of the survey area, and illustrate the importance of including all survey locations in the protected area to ensure full representation of the region's bird diversity within its limits. 17 species were recorded only along the Fiherenana and Manombo river systems, of which 12 (including regionally restricted species such as *Lophotibis cristata*, *Aviceda madagascariensis*, *Accipiter madagascariensis*, *Coua gigas*, *Coua coquereli*, *Ninox superciliaris*, *Ispidina madagascariensis*, *Bernieria madagascariensis* and *Schetba rufa*) were restricted to gallery and transitional forests.

Discussion

Literature review

Comparison of the bird inventories compiled during our survey with published records from PK32-Ranobe (Domergue 1983, Nicoll and Langrand 1989) reveals that 50 of our species records represent new records for the site. The large number of new records is primarily due to the increased coverage in both time and space of our survey; 28 of these records, for example, are of wetland species, and while Nicoll and Langrand (1989) did briefly conduct surveys at Lac Ranobe, they did not survey the brackish wetlands of Belalanda or the Manombo and Fiherenana rivers. Of the other species not recorded previously, many are cryptic or occur at naturally low densities (eg *Aviceda madagascariensis*, *Tylas eduardi*), occur in habitats not surveyed by the authors (eg *Monticola imerinus* which is restricted to littoral thicket), are vagrants or rare visitors to the region (eg *Hirundo rustica*, *Alectroenas madagascariensis*) or have undergone taxonomic revision (eg *Nesillas lantzii*).

Table 5 Habitat breakdown by site

	Fiherenana	Belalanda	Ranobe	Manombo
All species	81	53	99	72
Wetland species	19	28	32	8
All terrestrial	62	15	67	64
Forest species	43	12	43	44

New records include *Acridotheres tristis*, a species introduced into the east of the country in 1875 as a biological control agent against locusts (Hawkins & Goodman, 2003). That the species was not recorded in the area in 1989 is indicative of the continued westward and southward expansion of the species since the initial colonisation event. Indeed, the distribution maps produced in Langrand (1990) indicate that the species, by that point well established across the south, had not yet expanded up the west coast as far as Toliara. The presence of the species at all four study locations may also be indicative of an increase in habitat conversion and degradation in the surveyed areas, as the species is not able to colonise primary forest habitats (Langrand 1990).

Six species were recorded in previous surveys that we did not record; *Tachybaptus pelzelanii*, *Coturnix delagorguei*, *Charadrius marginatus*, *Calidris minuta*, *Asio capensis*, and *Saxicola torquata*. Of these, *Charadrius marginatus* is generally a coastal species and *Calidris minuta* is an uncommon migrant (Langrand, 1990); neither can therefore be considered an important component of the avifauna of the protected area. *Coturnix delagorguei* is a species whose behaviour in Africa is characterised by mass unexplained migrations (Langrand 1990). The absence of this species within the study area during the survey period may therefore be attributable to such movements. While the lack of records of *Saxicola torquata* and *Asio capensis* within the present study is harder to explain, the apparent disappearance from the study area of *Tachybaptus pelzelanii* may be indicative of a worrying national population trend for this species. *Tachybaptus pelzelanii* is a globally threatened (Vulnerable: BirdLife International 2008a) endemic species whose distribution has contracted and population decreased due to competition with the little grebe, *Tachybaptus ruficollis* (Langrand, 1990). The latter species, distributed in Europe, Asia, Oceania and Africa, and represented in Madagascar by the subspecies *T. r. capensis*, is a relatively recent arrival in Madagascar, with the first records originating from the 1920s (Young, 2003). Its expansion since then has been rapid, aided by the introduction of herbivorous fish (*Tilapia* spp.) that limit the growth of aquatic vegetation and thereby alter the structure and ecology of water bodies to the detriment of the endemic *Tachybaptus* species (Langrand, 1990). That *T. pelzelanii* was not recorded during the present survey may indicate its local extinction in the Toliara area, as few other suitable wetlands exist in the region.

Comparison with other areas in the South-west

In addition to our surveys, avifaunal surveys have been conducted in the three other major protected areas of south-western of Madagascar – the Mikea Forest National Park (Raselimanana and Goodman, 2004), Tsimanampetsotsa National Park (Goodman *et al.*, 2002) and the Amoron'i Onilahy protected area (Emmett *et al.* 2003). The inventory of the Mikea Forest, having been compiled from 21 days of survey effort (that did not include surveys of wetlands), cannot be considered complete. In comparison, the Amoron'i Onilahy inventory took place over 15 months and the Tsimanampetsotsa inventory, while based on only 14 days of survey, also included a literature review of historical bird records from the area. The inventory of the Mikea Forest is therefore not strictly comparable with those of the other three sites.

Comparison of these inventories reveals that PK32-Ranobe, with 130 species,

has significantly higher bird diversity than Tsimanampetsotsa (104), Amoron'i Onilahy (79) or the Mikea Forest (63). 18 species recorded in our surveys of PK32-Ranobe have not been recorded in the region's other protected areas, while 10 species have been recorded elsewhere but not at PK32-Ranobe (see Table 6). Note that for the purposes of the present analysis, the PK32-Ranobe inventory also includes a literature review

Table 6 Species records unique to one of the region's protected areas

Species	Fiherenana-Manombo Complex	Tsimanampetsotsa	Mikea Forest	Amoron'i Onilahy
<i>Tachybaptus ruficollis</i>	X			
<i>Phalacrocorax africanus</i>	X			
<i>Ixobrychus minutus</i>	X			
<i>Ardeola ralloides</i>	X			
<i>Ardeola idea</i>				X
<i>Egretta ardesiaca</i>	X			
<i>Anastomus lamelligerus</i>	X			
<i>Mycteria ibis</i>		X		
<i>Phoenicopterus minor</i>		X		
<i>Nettapus auritus</i>	X			
<i>Thalassornis leuconotus</i>	X			
<i>Accipiter henstii</i>		X		
<i>Falco eleanorae</i>		X	X	
<i>Porzana pusilla</i>	X			
<i>Porphyrio porphyrio</i>	X			
<i>Rostratula benghalensis</i>	X			
<i>Charadrius leschenaulti</i>		X		
<i>Calidris ferruginea</i>	X			
<i>Numenius arquata</i>		X		
<i>Calidris minuta</i>	X			
<i>Larus dominicanus</i>		X		
<i>Alectroenas madagascariensis</i>	X			
<i>Cooua verreauxi</i>		X		
<i>Ispidina madagascariensis</i>	X			
<i>Hirundo rustica</i>	X			
<i>Monticola sharpei bensoni</i>	X			
<i>Calicalicus rufocarpalis</i>		X		
<i>Cyanolanius madagascariensis</i>	X			
<i>Xenoprostris damii</i>	X			
Number of species restricted to site	19	8	0	1

of historical records (Domergue 1983, Nicoll and Langrand 1989). Of the 18 species restricted to PK32-Ranobe, 13 are wetland species, emphasising the importance of the Ranobe and Belalanda wetlands for the wetland bird diversity of south-western Madagascar. Of the five remaining species not recorded in the region's other protected areas, two are vagrants or rare migrants (*Alectroenas madagascariensis*, *Hirundo rustica*), one represents a possible range extension (*Monticola sharpei bensoni*), and two represent forest-dependant endemics (*Ispidina madagascariensis*, *Cyanolanius madagascariensis*).

Range extensions

Based on the species distribution maps published in Langrand (1990), 19 of the species we observed were recorded outside of their known ranges. Of these, *Alectroenas madagascariensis* is a species restricted to the humid forests of eastern Madagascar, and is therefore considered to be a vagrant rather than a genuine range extension, while *Hirundo rustica* is a rare migrant to Madagascar, and therefore without a range as such. Records of the remaining species (of which nine are obligate wetland species generally absent from the arid south, while eight are terrestrial endemics) can be considered to represent genuine range extensions. For all nine wetland species (*Ixobrychus minutus*, *Nycticorax nycticorax*, *Ardeola ralloides*, *Egretta ardesiaca*, *Egretta alba*, *Ardea purpurea*, *Scopus umbretta*, *Anastomus lamelligerus* and *Porphyrio porphyrio*), Landgrand's (1990) maps show the western coastal distributions extending as far south as the Mangoky River and Lac Ihotry, approximately 150 km to the north of Lac Ranobe. Our findings therefore further highlight the importance of the Belalanda and particularly the Ranobe wetlands in harbouring the southernmost populations in western Madagascar of a number of wetland species.

Of the non-wetland species that represent range extensions, six (*Margaroperdix madagascariensis*, *Coua coquereli*, *Ispidina madagascariensis*, *Calicalicus madagascariensis*, *Schetba rufa* and *Cyanolanius madagascariensis*) are widespread in the western forests of Madagascar, but were not considered by Landgrand (1990) to occur south of the Mangoky River. The exception is *Tylas eduardi*, a species widespread in the humid eastern forests whose western subspecies (*T.e. albigularis*) is little known and considered by some authors to merit elevation to species (eg Sinclair and Landgrand 2003). *Monticola sharpei bensoni* (a taxon previously considered a full species (Hawkins and Goodman 2003)), was considered by Langrand (1990) to be a breeding endemic to the Isalo massif over-wintering in the forests of Zombitse-Vohibasia and along the Mangoky. BirdLife International (2008b) assert that the subspecies has a relatively broad range in south-central and south-western Madagascar, but our records from the gallery forests of the Fiherenana River may nevertheless represent a new over-wintering site for the taxon.

Species of conservation concern

Table 7 lists the 12 species we consider to be species of conservation concern, based on either local endemism or inclusion in the IUCN Red List of Threatened Species. Stattersfield *et al.* (1998) classify the region as the South Malagasy Spiny

Forests Endemic Bird Area (EBA) based on the presence of ten species whose global distribution is wholly restricted to the area. Eight of these species were recorded in this survey.

The two most important species, based on restricted distribution and taxonomic importance, are the long-tailed ground roller (*Uratelornis chimaera*) and the subdesert mesite (*Monias benschi*). Both of these species represent monotypic genera within endemic families (the Brachypteracidae and Mesitornithidae respectively), and as such contribute greatly to the higher taxonomic diversity of Madagascar's avifauna. Both species are restricted to the Mikea Forest, a narrow coastal strip approximately 30-70 km wide and 200 km long of which PK32-Ranobe represents the southernmost part (Hawkins and Seddon 2003, Langrand 2003). Based on the importance of these two species ZICOMA (1999) declared that in terms of conserving the 'genetic diversity of birds, the Mikea Forest will be considered a supreme priority in Africa'. Both species are classified by the IUCN as Vulnerable (IUCN 2007) on the basis of their narrow geographic ranges and small, declining populations, although Tobias and Seddon (2002) assert that *Monias benschi* does not merit this classification according to IUCN criteria, and recommend downgrading the species. Of the other locally endemic species recorded in our survey, all are common and widespread across the south and classified as Least Concern (IUCN 2007).

Table 7 Species of conservation concern

Species of Conservation Concern	Locally Endemic	Red List Status	Habitat	Sites recorded
<i>Monias benschi</i>	*	VU	S	Ranobe
<i>Coua cursor</i>	*		S	Ranobe
<i>Uratelornis chimaera</i>	*	VU	S	Ranobe
<i>Xenopirostris xenopirostris</i>	*		RF,T,S	Fiherenana, Ranobe, Manombo
<i>Monticola imerinus</i>	*		O	Belanda
<i>Nesillas lantzii</i>	*		S, RF	Fiherenana, Belanda, Ranobe
<i>Thamnornis chloropetoides</i>	*		S	Fiherenana, Ranobe
<i>Newtonia archboldi</i>	*		RF,S,D	Ranobe, Manombo
<i>Accipiter madagascariensis</i>		NT	RF	Manombo
<i>Ardea humbloti</i>		EN	W	Fiherenana
<i>Charadrius thoracicus</i>		VU	W	Belanda, Ranobe
<i>Lophotibis cristata</i>		NT	T	Manombo
Habitat codes: S= spiny thicket, RF= riparian forest, T= transitional forest, W= water, O=open				

Four other Red List species were recorded during our survey, of which two (*Accipiter madagascariensis*, *Lophotibis cristata*) are classified as Near Threatened based on declining populations (BirdLife International 2008c, 2008d). *Ardea humbloti* is an endemic heron that is thinly distributed along the west coast of Madagascar, with an estimated global population of 1,500 (BirdLife International 2008e). We recorded this species only irregularly feeding in the Fiherenana River (four records in October-December 2002, which may represent the same individual, and one record in August 2003), but did not observe any evidence of breeding activity. *Charadrius thoracicus* is an endemic plover that breeds only on permanent or ephemeral wetlands throughout the south and west of Madagascar. It is classified as Vulnerable (BirdLife International 2008f), although recent research into its breeding ecology suggests that it may merit upgrading to Endangered (Zefania *et al.* 2008, Long *et al.* 2008). We recorded this species both at Ranobe (two records in March-April 2003) and at Belalanda (two records including one of ten individuals in April 2003 and one individual in November 2003), where it is sympatric with *C. tricollaris*, *C. pecuarius* and *C. hiaticula*. We could not confirm breeding of this species at either site.

Conclusions and recommendations

A total of 130 bird species have been recorded in the proposed PK32-Ranobe protected area (124 in our survey, and 6 recorded by other authors), making the site the most avi-diverse in the south-west of Madagascar. Our findings therefore highlight the importance of the area for bird conservation, and serve to justify the establishment of the protected area. Our findings also highlight the importance of the range of sites and habitat types in contributing to the overall biodiversity of the PA; with 24.2% of species recorded at only one site, the importance of maximising the coverage of the protected area becomes paramount if the full bird diversity of the region is to receive some formal protection. Of particular importance are the wetlands of Ranobe and Belalanda, which represent the southernmost populations in the west of Madagascar of a number of wetland species, and the transitional forests to the east of Lac Ranobe, the only area in which we recorded *Monias benschi* and *Uratelornis chimaera*. The gallery and transitional forests of the Fiherenana and Manombo rivers harbour a number of species not recorded elsewhere during our survey, including a number of forest-dependent endemics with restricted distributions in the region. Given that only small relict stands of gallery forest remain, we recommend that this habitat be prioritised in the planning and management of the protected area.

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