Population sizes and the status of endemic and restricted-range bird species on Sangihe Island, Indonesia

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Summary

The island of Sangihe, Indonesia, was visited in 1998–99 with the aim of producing population estimates of the island's endemic and other restricted-range bird species, some of which were poorly known and thought to be at risk of extinction due to habitat change. The study focused on the last remaining patch of primary forest, on Mount Sahendaruman in southern Sangihe, home to three critically endangered endemic species: Cerulean Paradise-flycatcher *Eutrichomyias rowleyi*, Sangihe Shrike-thrush *Colluricincla sanghirensis*, and Sangihe White-eye *Zosterops nehrkorni*. Population densities were estimated from primary forest and secondary habitats across Sangihe to assess species dependency on primary habitat. Twenty of 24 restricted-range, globally threatened or endemic taxa were recorded and density estimates were calculated for 15 of these. The endemic Red-and-blue Lory *Eos histrio* is extinct on Sangihe as a result of lowland forest loss. Six species (Nicobar Pigeon *Caloenas nicobarica*, Sulawesi Dwarf Kingfisher *Ceyx fallax*, Golden Bulbul *Ixos affinis*, *E. rowleyi*, *C. sanghirensis*, and *Z. nehrkorni*) were either not recorded or have very small populations and are critically endangered on Sangihe; two species of *Tanygnathus* parrot are also facing local extinction on the island. The major threat to all these species is the destruction of primary forest; larger species are also threatened by hunting. The remaining endemic and restricted-range species (Blue-tailed Imperial Pigeon *Ducula concinna*, Sangihe Hanging-parrot *Loriculus catamene*, Sangihe Scops-owl *Otus collari*, Lilac-cheeked Kingfisher *Cittura cyanotis* and Elegant Sunbird *Aethopyga duyvenbodei*) were more widespread and occurred in secondary habitats. I recommend that *L. catamene* and *A. duyvenbodei*, currently treated as globally endangered, be reclassified as near-threatened and vulnerable respectively because of their large populations and tolerance of disturbed habitats. Species with wide global ranges that are represented by endemic subspecies have the greatest tolerance for disturbed habitat. The widespread deforestation of Sangihe has had serious consequences for many bird species and today the island supports the most threatened assemblage of single-island endemic species in Indonesia. Species-specific research to determine the status and ecology of *E. rowleyi, C. sanghirensis* and *Z. nehrkorni*, and monitoring of the Sahendaruman forest are desperately needed as a basis for future conservation efforts.

Introduction

Sangihe island (03°35′N, 125°32′E) is part of the northern volcanic range of Indonesia, an area dominated by young and active volcanoes, and lies on a narrow submarine ridge extending from Sulawesi, through Sangihe and the Talaud islands, to the Philippine island of Mindanao. The island is close to the

Table 1. Endemic, threatened and restricted-range bird species recorded on Sangihe

Species	Endemic	Status
Philippine Scrubfowl *Megapodius cumingii*	SS	-
Slender-billed Cuckoo-dove *Macropygia amboinensis*	SS (ST)	-
Nicobar Pigeon *Caloenas nicobarica*	-	NT
Blue-tailed Imperial Pigeon *Ducula concinna*	-	RR
Grey-cheeked Green Pigeon *Treron griseicauda*	SS	-
Red-and-blue Lory *Eos histrio*	E (ST)	EN
Sangihe Hanging-parrot *Loriculus catamene*	E	EN
Sangihe Scops-owl *Otus collari*	E	RR
Lilac-cheeked Kingfisher *Cittura cyanotis*	SS	RR, NT
Sulawesi Dwarf Kingfisher *Ceyx fallax*	SS	RR, NT
Red-bellied Pitta *Pitta erythrogaster*	SS	-
Hooded Pitta *Pitta sordida*	SS	-
Pied Cuckoo-shrike *Coracina bicolor*	-	RR, NT
Sulawesi Cicadabird *Coracina morio*	SS	-
Golden Bulbul *Ixos affinis*	SS	-
Black-naped Oriole *Oriolus chinensis*	SS	-
Cerulean Paradise-flycatcher *Eutrichomyias rowleyi*	E	CR
Sangihe Shrike-thrush *Colluricincla sanghirensis*	E	CR
Asian Glossy Starling *Aplonis panayensis*	SS (ST)	-
Brown-throated Sunbird *Anthreptes malacensis*	SS	-
Black Sunbird *Nectarinia aspasia*	SS	-
Elegant Sunbird *Aethopyga duyvenbodei*	E	EN
Yellow-sided Flowerpecker *Dicaeum aureolimbatum*	SS	-
Grey-sided Flowerpecker *Dicaeum celebicum*	SS	-
Sangihe White-eye *Zosterops nehrkorni*	E	CR

E, species endemic to Sangihe; E (ST), species endemic to Sangihe and Talaud; SS, subspecies endemic to Sangihe; SS (ST), subspecies endemic to Sangihe and Talaud; RR, restricted-range species (ICBP 1992); CR, Critically Endangered; EN, Endangered; NT, Near-threatened (IUCN 2000).

northernmost limit of Wallacea, and has a depauperate avifauna lacking many species found on Sulawesi (White and Bruce 1986). Nevertheless, six bird species are endemic to Sangihe and a seventh, Red-and-blue Lory *Eos histrio*, is endemic to the Sangihe island group and the Talaud islands. Thirteen species have subspecies that are endemic to the island, with a further three endemic subspecies shared with Talaud (White and Bruce 1986, Coates and Bishop 1997, Lambert and Rasmussen 1998, Rozendaal and Lambert 1999, Rasmussen *et al.* 2000). Eleven restricted-range species have been recorded (Table 1). Sangihe, together with the Talaud islands, has been classified as one of Indonesia's 24 Endemic Bird Areas and thus a priority area for the conservation of global bird diversity (Stattersfield *et al.* 1998).

By the late nineteenth century forest loss on Sangihe was already significant. Platen noted that habitat loss had forced *E. histrio* to retreat to the central mountains (Meyer and Wiglesworth 1898) and Hickson (1889) commented that Tahuna was already surrounded by deforested hills. By the 1920s forest loss was widespread and the island dominated by plantations of coconut, clove and nutmeg (Heringa 1921).

Consequently, the first modern assessment of the island's endemic species concluded that widespread deforestation had led to the probable extinction of one endemic (Cerulean Paradise-Flycatcher *Eutrichomyias rowleyi*) and that other

endemic taxa were severely threatened (Whitten *et al.* 1987). More detailed studies (Riley 1997a, Lambert 1999) led to six of the endemic species on Sangihe being classified as critically endangered or endangered with global extinction, primarily because of deforestation (BirdLife International 2001).

The objective of this study, therefore, was to identify which of these species were most at risk and to provide information to support concurrent conservation efforts. Previous research had identified the Mt Sahendaruman forest as a key area (Riley 1997b, Lambert 1999), and the current study focused on surveying this site in detail. To understand fully the importance of this forest to endemic taxa, research was also carried out in secondary habitats, including plantations, secondary scrub and small isolated blocks of disturbed forest (usually no larger than 2–3 ha), across central and northern Sangihe. The study aimed to further knowledge of the ecological requirements and distributions of endemic taxa, leading to a detailed assessment of their present status, including population sizes, and the threats faced by them. In addition, key sites for conservation on the island were to be identified and baseline surveys conducted to produce simple information of use when developing conservation strategies and future monitoring work on Sangihe.

Study area

The island is *c.* 92 km long and between 6 and 40 km wide with a surface area of *c.* 700 km^2 (BPS 1999) and a steep topography; the north of the island is dominated by Mt Awu (1,340 m), an active volcano, and in the south the extinct volcanic caldera of Mt Sahendaruman rises to a peak of 1,031 m on Mt Sahengbalira (Figure 1).

There are currently no strictly protected areas (nature reserve, wildlife reserve, national park) on the island, although there have been several proposals for a *c.* 5,000 ha conservation area in the vicinity of Mt Sahendaruman (FAO 1982, Sujatnika and Jepson 1995). A 4,268 ha area centred on Mt Sahendaruman is currently designated Protection Forest *Hutan Lindung* on account of its watershed value and is under the jurisdiction of the Department of Forestry. There are two other areas of Protection Forest on the island: one of 4,884 ha covering the slopes of Mt Awu, and one of 1,105 ha named Mt Otomata in the centre of Sangihe (*Dinas Kehutanan* Manado unpubl. 1998). Of the three areas, only Mt Sahendaruman Protection Forest has any primary forest remaining.

The average temperature on Sangihe is 25–28 °C with little seasonal variation, the average rainfall is 2,928 mm per year, with a distinct wet season in October to January, and the average relative humidity is 85% (BPS 1994).

Methods

Surveys were conducted between 19 August 1998 and 1 March 1999 under the auspices of Action Sampiri, the Sangihe and Talaud Conservation Project, consisting of up to four staff members from the U.K. and a total of 15 students and graduates from Sam Ratulangi University. The Indonesian Institute of Sciences (LIPI) sponsored all three projects. Sixteen sites were surveyed (Figures 1 and 2, Table 2).
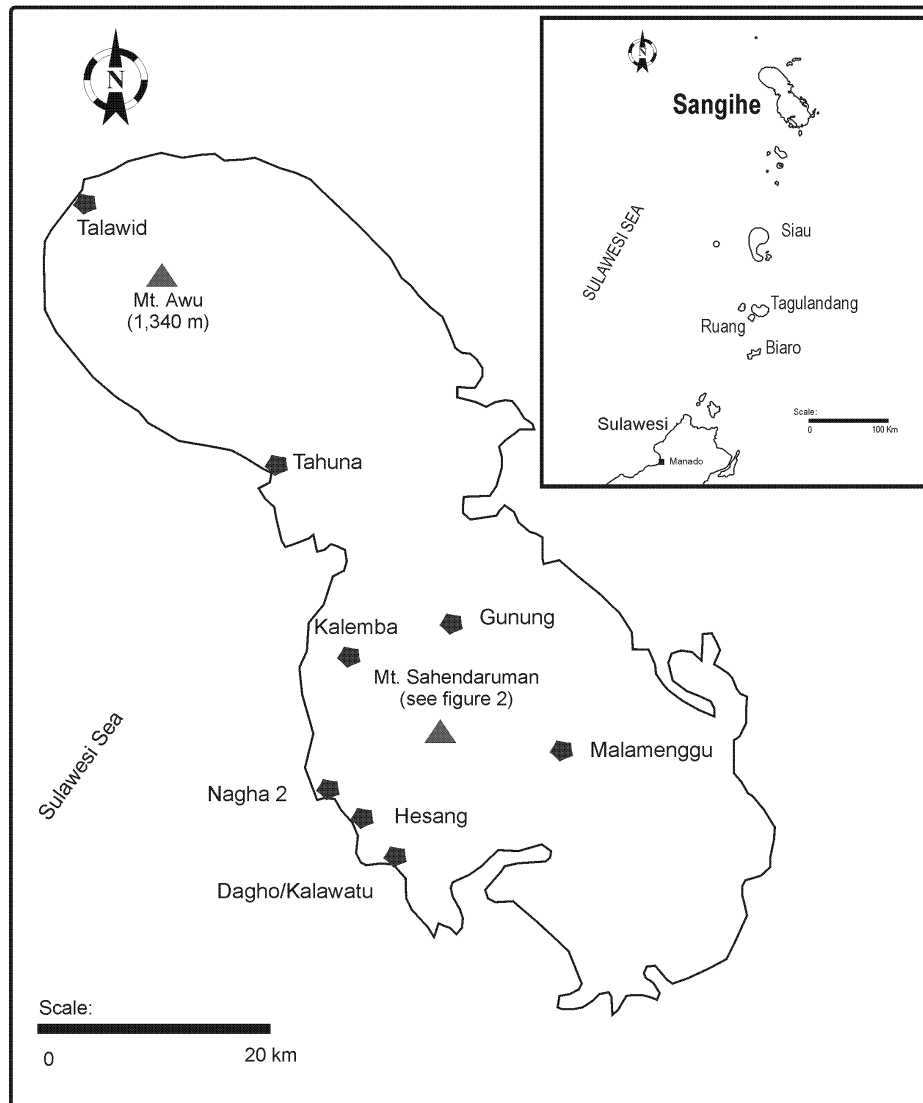
Figure 1. The Indonesian island of Sangihe, showing research sites.

Bird censusing

The variable circular plot (VCP) survey method (Reynolds *et al*. 1980) was the most appropriate form of distance sampling to estimate density in this study for two main reasons. First, forest areas on Sangihe are in steep terrain and sometimes virtually inaccessible; coupled with dense vegetation growth this prevents surveys using transects (see Bibby *et al*. 1992). Second, surveys required a method that could be used in different areas, including those with less steep terrain and more open habitat.

The field methods used during the survey were based on those used during

Table 2. Details of survey sites and census data for point count survey on Sangihe, October 1998–February 1999

Site	Co-ordinates	Census dates	Primary forest		Secondary habitat	
			Census stations	Altitude range (m)	Census stations	Altitude range (m)
Batukakiraeng	03°29′74N 125°33′66E	10/98, 2/99	18	700–945		
Batungbakara	03°32′00N 125°31′00E	10/98, 11/99	7	610–915		
Gunung	03°35′45N 125°32′30E	2/99			28	185–670
Hesang	03°32′00N 125°30′50E	10/98			4	45–75
Kalaengbatu	03°28′30N 125°30′75E	11/98			15	60–640
Kalemba	03°32′29N 125°31′81E	11/98	3	655–700	16	350–730
Kentuhang	03°31′99N 125°31′25E	10–11/98, 2/99	13	410–820	64	200–790
Lilipang	03°29′00N 125°32′00E	2/99	5	580–825	9	380–520
Lumahedo	03°27′00N 125°31′00E	11/98			7	110–260
Malamenggu	03°30′26N 125°34′38E	10/98, 2/99	4	730–915	21	520–820
Nagha 2	03°27′47N 125°30′25E	11/98			8	60–150
Sahengbalira	03°31′50N 125°30′80E	10/98, 12/98	30	440–1035		
Tahuna	03°36′45N 125°30′60E	2/99			18	75–550
Talawid	03°42′66N 125°30′25E	2/99			34	90–580
Tukade Batu	03°30′15N 125°33′40E	10–12/98	22	685–945	8	455–670
Ulung Peliang	03°29′35N 125°31′76E	11/98			21	170–655
Total			102	410–1035	253	45–820

recent studies of bird population densities in Indonesia (e.g. Jones *et al.* 1995, Lambert 1997, Marsden *et al.* 1997). At each survey site, transect routes were set up that followed existing paths or streambeds. Approximately every 150–200 m (in forest) or 250–300 m (in scrub and plantations) along each route a census station was established; in primary forest these stations were marked permanently but in secondary habitats, where the majority of transect routes were walked only once, points were not marked. If the transect followed a well-defined path or stream bed, and it was physically possible to do so in the steep terrain, census stations were placed at a point approximately 50 paces perpendicular to the transect, in alternate directions (Jones *et al.* 1995).

A total of 102 census stations was established in primary forest, of which 59 were surveyed once, 40 surveyed twice, and three stations surveyed three times, a total of 148 point counts. In secondary habitats 253 census stations were counted, six surveyed twice, for a total of 259 point counts. Censuses were carried out on 50 days between 1 October 1998 and 28 February 1999 between 05h15 and 09h30, the time of peak bird activity. No surveys were carried out in adverse weather conditions of rain, low cloud or strong wind.

Stations were surveyed for 10 minutes by two observers. In an effort to reduce bias from different observers (Ralph and Scott 1981) four trained fieldworkers were responsible for collecting the bird census data (J.R., I. Hunowu, Y. Hunowu and J. Mole). The first two observers had spent a total of four months on Sangihe between 1995 and 1998 and the other observers had worked on previous bird surveys. Daily surveys were conducted by random pairs of recorders.

Prior to the start of the systematic surveys, five weeks were spent training, after which all species could be correctly identified from sight and aural cues. To improve the accuracy of distance estimates intensive training involved estimating and measuring distances to trees in a variety of habitats. To improve the accuracy of estimating distances to aural cues, practice point counts were conducted for 10 days; these data have not been used in the analyses in this paper. Training was reinforced by regular re-examination of distance estimation accuracy, for example if gaps of more than 10 days separated field visits.

At each of the census stations the distance to all bird contacts was estimated. If a bird was seen to take flight the distance to the take-off point was estimated. Any flying birds that were not seen to take off were excluded from the estimates of population densities (see Buckland *et al.* 1993). When approaching a station, if any birds were disturbed, it was presumed that these would have been recorded from the station and the distance from the site of disturbance to the census point was recorded.

Further data, including notes on distribution, threats, preferred feeding sites, roosting areas, and nesting behaviour, were gathered using qualitative methods throughout the survey period.

Density and population estimation

Densities, and thus population sizes, of all species for which sufficient information was obtained were estimated using the DISTANCE computer program (Thomas *et al.* 1998). Buckland *et al.* (1993) provide a comprehensive explanation of this method.

The distance data were grouped for analysis to mitigate against the problem of heaping (Buckland *et al.* 1993). For the majority of species, between 5% and 20% of the most distant bird records were truncated. The distance bands used and the actual percentage of records that were truncated differed between species. In each case the data were manipulated to minimize the Akaike's Information Criterion (AIC) for a particular model (Buckland *et al.* 1993).

Groups were entered as clusters for all species. The group size of bird clusters that were heard only and could not be counted accurately was assumed to be the same as the mean group size of that species observed during point counts in that habitat (after Marsden *et al.* 1997).

To calculate precise density estimates using DISTANCE, over 100 observations are needed to model a species's detection function accurately (Buckland *et al.* 1993). Such sample sizes, particularly for rare species or those occurring at low density, were not achievable during the current survey and a number of strategies were used to maximize the precision of estimation, following Marsden (1995) and Marsden *et al.* (1997).

For the commonly recorded species, bird records were entered into DISTANCE in two habitat categories: primary forest and secondary habitats (incorporating data from the secondary forest, secondary scrub, and plantation census stations). For three species that were less frequently recorded – Sangihe Hanging-parrot *Loriculus catamene*, Blue-tailed Imperial Pigeon *Ducula concinna* and Hooded Pitta *Pitta sordida* – data from all points were combined to produce a species-specific but not habitat-specific detection function. In these cases, records from primary forest and secondary habitat were treated as subsets of all records, and separate density estimates calculated based on the pooled detection function (after Marsden *et al.* 1997). For one species – Red-bellied Pitta *Pitta erythrogaster* – recorded on very few occasions, data were combined with a closely related species, *P. sordida*, to create a ''detection function template'' following Marsden (1995).

To calculate total population estimates, species density estimates were multiplied by the total area of habitat available to that species. The area of primary forest on Mt Sahendaruman in December 1998 was estimated to be *c.* 8 km^2 and here species are assumed to be evenly distributed across the entire forest and sampling effort to be representative of the habitat as a whole. The area of Sangihe is taken to be 700 km^2 (BPS 1999) excluding small islands and islets close to the mainland, thus secondary habitats cover 692 km^2. No detailed assessment of altitudinal associations and the specific habitat requirements of species has been made, although where data are available it is mentioned in the species accounts. This may lead to inaccuracies and overestimates where species have more restricted ranges. As such, the total population estimates are seen as very rough indications of the likely magnitude of populations on Sangihe. More specifically they are used to allocate species to a relevant category of threat (IUCN 2000). The status of each species on Sangihe has been assessed by applying the categories, criteria and sub-criteria used to develop the global list of threatened species, whilst acknowledging the problems inherent in this (IUCN 2000).

Taxonomy and English names follow Coates and Bishop (1987). Three recently described endemics Sangihe Scops-owl *Otus collari*, Sangihe Shrite-thrush *Colluricincla sanghirensis*, and Sangihe White-eye *Zosterops nehrkorni* are recognized fol-

lowing Lambert and Rasmussen (1998), Rozendaal and Lambert (1999) and Rasmussen *et al.* (2000). Seven species were encountered during the point counts that have a wide distribution and are not globally threatened and they are not discussed further: Brahminy Kite *Haliastur indus*, Pale-vented Bush-hen *Amaurornis moluccanus* (after Lambert 1998), Emerald Dove *Chalcophaps indica*, Pied Imperial Pigeon *Ducula bicolor*, Common Koel *Eudynamys scolopacea*, Lesser Coucal *Centropus bengalensis* and Collared Kingfisher *Halcyon chloris*.

Habitat recording

The habitat surrounding census stations was classified subjectively as one of six categories, using vegetation structure and species composition characteristics: primary forest, forest edge, secondary forest, secondary scrub, scrub and plantations.

Sangihe has been almost totally deforested and the only extensive area of forest remaining on the island is found at higher altitudes on the steep slopes of the Mt Sahendaruman caldera (03°31′N, 125°30′E). Between August and December 1998 forest boundaries were mapped, suggesting that *c.* 800 ha of closed canopy forest remain. The forest in this area extends along the ridge-tops from Mt Bongkongsio (818 m) to Mt Palenti (827 m) with some small outlying patches, for example on the peak of Mt Sahendaruman (806 m). On the steeper south-facing slopes, the forest extends down in places to *c.* 450 m. On the gentler north- and eastern-facing slopes forest loss has been far greater, with agricultural land reaching the ridge-top in many places. Only in a few isolated valleys, notably below Mt Batukakiraeng (980 m), does forest extend far from the ridge, down to *c.* 650 m (Figure 2).

At lower altitudes – to *c.* 800 m – forest is made up of broadleaf semi-trophophyllous trees, 10–20 m tall, with emergent trees to 35 m. There are abundant lianas and other climbers, and an understorey characterized by many palms *Areca* spp., with occasional tree ferns and screw palms. At higher altitudes, above *c.* 850 m, habitat is dominated by shorter broadleaf semi-trophophyllous trees 5–10 m tall, with emergent trees to 20 m. There are many climbers and epiphytes, with some dense stands of gingers, whilst in some areas, particularly on the ridge-top, screw palms form extensive, single-species canopies. Census stations classified as primary forest were always more than 100 m from the forest border. No attempt was made to distinguish different levels of habitat disturbance – rattan collecting, timber extraction – in the forest, despite the influence of anthropogenic disturbance on bird distributions (e.g. Johns 1986, Lambert 1992, Thiollay 1995).

Five census stations classified as forest edge habitat were located within a corridor of *c.* 100 m width either side of the forest boundary. The habitat at these stations was heterogeneous, four stations were located in primary forest whilst one station was located in a recently opened garden.

Most of the island has been converted to a mosaic of plantations, shifting gardens and other agricultural land and the four remaining habitat types result from anthropogenic activities. No statistically based surveys were performed in these diverse habitats and their classification is entirely subjective. Plantations included a great variety of cultivated landscapes including dense mixed clove *Eugenia aromatica* and nutmeg *Myristica fragrens* plantations, monocrop coconut *Cocos nucifera* plantations with an open grassy understorey, and areas of slash-and-burn
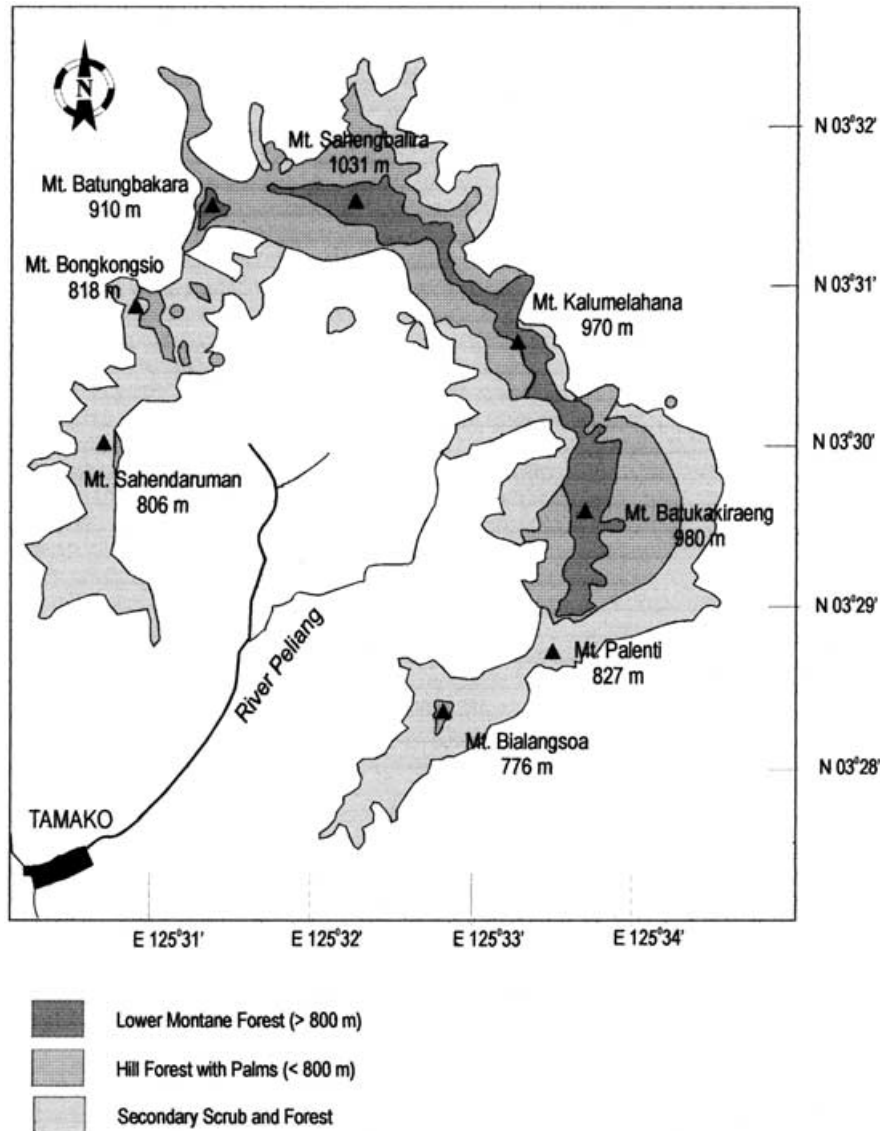
Figure 2. Mount Sahendaruman showing habitat boundaries mapped between August and December 1998.

cultivation. Principal tree crops include coconut, clove, nutmeg, breadfruit *Arto-carpus* spp., durian *Durio zibethinus*, and other fruit trees. Within this mosaic, small slash-and-burn gardens are cleared to plant root crops, banana *Musa* spp. and papaya *Carica papaya*. The flatter areas and gentler slopes are already planted with tree crops, leaving only the steeper slopes for such cultivation.

Patches of secondary forest and scrub occur across the island but are most extensive on Mt Awu, around the periphery of the Sahendaruman forest, and in the centre of the island above Tahuna. Secondary forest was defined as habitat

with a high proportion of medium-to-tall trees including *Albizia falcataria, Homalanthus* sp. and *Ficus cf. minahassae* with an understorey including Sterculiaceae shrubs, bamboo, gingers and tree ferns. Habitat with a greater proportion of tree ferns, a very dense understorey dominated by *Piper aduncum*, Sterculiaceae shrubs, and gingers, few tall trees, and often including areas of *Imperata cylindrica* grassland was classified as secondary scrub; this habitat dominated areas of abandoned gardens surrounding the Sahendaruman forest.

Results

Thirty-one species were recorded during timed point counts, with 28 species encountered in secondary habitat and 21 species in primary forest. Nine species were recorded only in secondary habitat and three species – *E. rowleyi, C. sanghirensis* and *Z. nehrkorni* – were noted only from primary forest. Where sample sizes were too small for population density estimates to be calculated, simple encounter rates were calculated. These are expressed as the average number of encounters with the species at a census station in primary forest or secondary habitat (Table 3).

Sample sizes were large enough for population density estimates to be calculated for a total of 19 species and estimates were possible for 15 species in both habitats. For Golden Bulbul *Ixos affinis* and *C. sanghirensis* density estimates were calculated only from the primary forest data, whilst estimates for *P. erythrogaster* and Brown-throated Sunbird *Anthreptes malacensis* were possible only from the secondary habitat data (Table 4).

Philippine Scrubfowl *Megapodius cumingii sanghirensis*

All records during point counts were made in secondary habitat and *M. cumingii* was very rare in the Sahendaruman forest with just two records of calling birds during the survey periods. The main scrubfowl population was concentrated in plantations and scrub on the foot slopes of Mt Awu and an active nest mound was found here in October 1995 (Riley 1997b). Scrubfowl were very rare in secondary habitat away from here, the sole record a lone bird near Hesang in November 1996. No population estimate could be made but *M. cumingii* is clearly a rare species dependent on a specific habitat on Sangihe. Whilst it is encouraging that scrubfowl can persist in disturbed habitats on the island the small population is presumably at risk from habitat degradation, egg collection, and future volcanic events. Status on Sangihe: Endangered.

Slender-billed Cuckoo-dove *Macropygia amboinensis sanghirensis*

The density data indicate that *M. amboinensis* had a strong preference for primary forest where densities were estimated to be almost seven times higher than in secondary habitats. The total population estimate was small (2,000–6,200 birds) suggesting that the cuckoo-dove's future on Sangihe is threatened. The majority of encounters were with single birds or pairs. The species apparently suffers from hunting pressure on Sangihe, with birds seen in hunters' bags at Kentuhang and Talawid. This together with further loss of the species's favoured primary forest habitat are the main pressures on *M. amboinensis* at present. Status on Sangihe: Endangered.

Table 3: Encounter rates for bird species in primary forest and secondary habitat on Sangihe, October 1998–February 1999

Species	Primary forest K = 148			Secondary forest K = 253		
	n	*i*	*e*	*n*	*i*	*e*
Haliastur indus				2		0.007
Megapodius cumingii				6	7	0.023
Amaurornis moluccanus				5		0.019
Macropygia amboinensis	91	93	0.61	31		0.12
Chalcophaps indica	26		0.17	28		0.10
Treron griseicauda				6	34	0.023
Ptilinopus melanospila	154	185	1.04	130	185	0.50
Ducula concinna	28	40	0.19	31	37	0.12
Ducula bicolor				1	8	0.003
Tanygnathus sumatranus	1		0.006	2		0.007
Tanygnathus megalorynchos				1		0.003
Loriculus catamene	11		0.07	21	28	0.08
Eudynamys scolopacea	43	44	0.29	43	47	0.166
Centropus bengalensis				4		0.015
Cittura cyanotis	16		0.11	74	81	0.28
Halcyon chloris				1		0.003
Pitta erythrogaster	1		0.006	8		0.03
Pitta sordida	13		0.08	22	24	0.08
Coracina morio	1		0.006	4		0.015
Ixos affinis	26	27	0.13	1		0.003
Dicrurus sp.	197	206	1.33	233	246	0.9
Oriolus chinensis	215	227	1.13	215	227	0.83
Eutrichomyias rowleyi	2		0.01			
Colluricincla sanghirensis	14	16	0.09			
Aplonis panayensis	16	28	0.11	16	47	0.06
Anthreptes malacensis				17	21	0.06
Nectarinia aspasia	39	48	0.26	322	396	1.24
Aethopyga duyvenbodei	136	146	0.92	65	76	0.25
Dicaeum aureolimbatum	67	72	0.45	110	125	0.42
Dicaeum celebicum	24	25	0.16	110	113	0.42
Zosterops nehrkorni	1		0.006			

n, Number of contacts; *i*, Number of individuals, if *n* = *I* this column is left blank; *K*, number of point counts in habitat; *e*, encounter rate *n*/*K*.

Nicobar Pigeon *Caloenas nicobarica*

No records during the three survey periods and it appeared to be very rare on Sangihe. Inhabitants of small islands to the northwest of Sangihe provided convincing descriptions of what were presumably *C. nicobarica*, which they claimed to be an occasional visitor to the islands, but numbers were small. It seems likely that a combination of habitat loss and hunting has affected populations throughout the Sangihe archipelago, as has happened elsewhere in Wallacea (Coates and Bishop 1997). Status on Sangihe: Critically Endangered.

Grey-cheeked Green Pigeon *Treron griseicauda sangirensis*

Widely distributed on Sangihe, most common in secondary habitat with remnant forest or other fruiting trees. All records during point counts were from second-

Table 4. Density estimates and population sizes of bird species in primary forest and secondary habitats on Sangihe, October 1998–February 1999

Species	Sahendaruman forest					Secondary habitats					Notes
	Density estimate			Population estimate		Density estimate			Population estimate		
	Mean density	Lower 95% confidence interval	Upper 95% confidence interval	Mean population (birds)	Population range (birds)	Mean density	Lower 95% confidence interval	Upper 95% confidence interval	Mean population (birds)	Population range (birds)	
Macropygia amboinensis	32.4	21.0	49.8	260	170–400	4.7	2.6	8.4	3,300	1,800–5,800	c, d
Chalcophaps indica	7.1	4.2	11.9	60	30–100	4.4	2.7	7.1	3,000	1,900–4,900	e
Ptilinopus melanospila	148.3	113.4	194.0	1,200	900–1,600	47.1	36.4	60.9	32,600	25,200–42,100	a, e
Ducula concinna	3.4	1.5	7.8	30	10–60	1.1	0.5	2.4	760	350–1,700	a, e, f
Loriculus catamene	34.1	16.6	70.2	270	130–560	31.8	15.3	66.0	22,000	10,600–45,700	a, e, f
Eudynamys scolopacea	7.4	4.7	11.7	60	40–100	10.3	6.5	16.5	7,100	4,500–11,400	c
Cittura cyanotis	37.9	17.1	83.5	300	140–670	92.2	60.8	139.8	63,800	42,100–96,700	c, f
Pitta erythrogaster						2.8	1.0	7.8	1,900	700–5,400	b, c, f
Pitta sordida	24.2	11.6	50.6	190	90–400	17.5 8.8	34.8	12,100	6,100–24,100		a, c, f
Ixos affinis	13.3	6.0	29.7	100	50–230						
Dicrurus sp.	155.7	126.4	191.7	1,300	1,000–1,500	59.6	48.6	73.0	41,200	33,600–50,500	d, f
Oriolus chinensis	117.4	88.2	156.4	940	700–1,200	85.8	70.6	104.2	59,400	48,900–72,100	
Colluricincla sanghirensis	79.6	33.3	189.9	640	270–1,500						d, e, f
Aplonis panayensis	17.0	8.3	35.2	140	70–280	23.7	8.0	70.2	16,400	5,500–48,600	e
Anthreptes malacensis						47.4	25.8	86.6	32,800	17,900–59,900	e
Nectarinia aspasia	338.0	215.5	530.0	2,700	1,700–4,200	1,378.7	1,122.3	1,693.7	954,000	777,000–1,172,000	e, f, i
Aethopyga duyvenbodei	1,071.6	828.8	1,385.6	8,600	6,600–11,100	386.3	237.0	629.6	20,100	12,300–32,700	e, g, h
Dicaeum aureolimbatum	566.5	386.7	829.9	4,500	3,100–6,600	415.2	322.4	534.5	287,000	223,000–370,000	e, i
Dicaeum celebicum	72.3	43.9	118.8	580	350–950	356.4	268.8	472.5	247,000	186,000–327,000	e, i

Sangihe island size 700 km²; Sahendaruman forest size 8 km²; secondary habitats size 692 km²; densities are number of individuals/km²; populations < 1,000 birds rounded to nearest 10; populations < 10,000 birds rounded to nearest 100; populations < 100,000 rounded to nearest 1,000; [a] Detection function calculated using data from both habitats then independent density estimates computed. [b] Pitta detection function calculated using data of *P. erythrogaster* and *P. sordida* then density estimate for former computed. [c] Cryptic species under recorded during point counts therefore probably underestimate density. [d] Seasonally vocal species under- recorded during part of survey period therefore probably underestimate density. [e] Mobile species therefore probably overestimate density. [f] Small sample size reduces accuracy of estimate. [g] Density varies considerably between different secondary habitats therefore probably overestimate density. [h] Population sized based on area of occupancy 52 km², see text. [i] Density estimates are very high and may be overestimates because of bias.

ary habitats and throughout the survey period *T. griseicauda* was observed just three times in the Sahendaruman forest. Certain feeding areas were favoured for long periods; a small patch of fruiting trees at Hesang regularly attracted up to 15 birds between November 1996 and October 1998. No population estimate was possible but the population on Sangihe is presumably small. The major pressure is probably hunting, with forest shelters used by hunters found at three sites with fruit trees used by *T. griseicauda* at Kentuhang, Sahengbalira and Malamenggu. Status on Sangihe: Vulnerable.

Black-naped Fruit Dove *Ptilinopus melanospila xanthorrhoa*

The commonest pigeon species on Sangihe and recorded up to altitudes of *c*. 1,000 m. Noted in flocks of up to 30 birds at fruiting trees and observed feeding with *T. griseicauda* and Pink-necked Green-pigeon *Treron vernans*. Density estimates indicated a strong preference for primary forest with densities three times higher than in secondary habitats. The large population estimate (26,100–43,700 birds) suggests that the *P. melanospila* population on Sangihe is secure at present. The main threat to the species is probably hunting, with birds seen in hunters' bags at Sahengbalira and Hesang, and forest shelters used by hunters found at three sites with fruit trees used by *P. melanospila* at Kentuhang, Sahengbalira and Malamenggu. Status on Sangihe: Low Risk: Least Concern.

Blue-tailed Imperial Pigeon *Ducula concinna*

A widely distributed species on Sangihe, to *c*. 1,000 m, most common in primary forest. It has been recorded in flocks of up to 20 birds, but they appear to range broadly and to be nomadic: whilst notably common at Talawid in October 1995 and December 1996, *D. concinna* was scarce at the same site in February 1999. The estimated population on Sangihe was small (360–1,800 birds) and whilst birds occurred at higher densities in primary forest no ecological dependence on the habitat was identified. An important threat is hunting and in some areas hunters suggested that the species has become locally extinct. Whilst this is unlikely given *concinna*'s nomadic behaviour, it is perhaps indicative of a declining population. Forest shelters used by hunters were found at Kentuhang, Sahengbalira, Talawid and Malamenggu, close to fruit trees used by *D. concinna*. Status on Sangihe: Endangered.

Red-and-blue Lory *Eos histrio histrio*

There were no observations during the 1998–99 survey and in February 1999 residents of Talawid, where birds were seen in 1995 (Riley 1995), reported that they no longer see the species in gardens above their village. Given that there have been no confirmed sightings of the lory on Sangihe since October 1995 it must be concluded that the species is extinct on the island. This is a very noisy and conspicuous species, and if a small population survived the birds would be difficult to overlook. It now seems likely that the majority, if not all, of the birds seen in 1995 were escaped, or more likely released, cage birds brought to Sangihe from the Talaud islands.

Eos histrio is the only endemic species to have gone extinct on the island in recent years but a healthy population still survives on Karakelang, in the Talaud islands (Lambert 1997, Riley 1997a). Status on Sangihe: Extinct.

Blue-backed Parrot *Tanygnathus sumatranus*

A maximum of six birds was noted in the Sahendaruman forest in September and October 1998 and *sumatranus* was the more commonly recorded *Tanygnathus* species on Sangihe. The majority of records (80%, *n* = 15) were from the Sahendaruman area but parrots were also noted at Talawid. *T. sumatranus* is active at night and apparently nomadic, presumably dispersing in search of food, and these factors may have reduced encounters with it during point counts. No population estimate was possible from the distance data with a total of just three encounters. However, it is clear that the current population is small and centred on the Sahendaruman forest. This is a conspicuous species and the paucity of records away from Sahendaruman suggests that the total population may number no more than 200 birds. *Tanygnathus sumatranus* is threatened by habitat degradation, particularly the loss of large trees used for nesting and hunting, hunters interviewed at Kentuhang admitted occasionally shooting parrots. Status on Sangihe: Critically Endangered.

Great-billed Parrot *Tanygnathus megalorynchos*

In 1998–99 *T. megalorynchos* was only recorded at Talawid and the population here may be declining – 10 birds in 1995, a maximum of three birds in December 1996, singles in February 1999 – and roost trees have been felled. The lack of recent records from the Sahendaruman caldera is curious; parrots were recorded here in 1995 and in other parts of its range *T. megalorynchos* inhabits primary forest (Coates and Bishop 1997). Given the species's restricted range and the few recent records, the population probably numbered fewer than 50 individuals apparently concentrated around Mt Awu.

This is one of the most highly threatened species on Sangihe. A combination of pressures including habitat loss and degradation, and the absence of large trees suitable for breeding sites suggests that the species's survival on Sangihe is precarious. Status on Sangihe: Critically Endangered.

Sangihe Hanging-parrot *Loriculus catamene*

The population estimate (10,700–46,200 birds) was sufficiently high to recommend that the threat status of *L. catamene* be downgraded. The density estimate figures show that the species had little preference for forest and, as in previous years, this was a widely distributed species occurring up to altitudes of *c.* 1,000 m. Hanging-parrots were most commonly recorded in small groups, with a maximum concentration of 27 birds noted at Lilipang in January 1999. This observation, together with others of large groups (Riley 1998), suggests that *L. catamene* regularly flocks at roosts or favoured feeding sites.

At present *L. catamene* is classified as globally endangered on account of its restricted range, small population and declining habitat quality (IUCN 2000).

Given its relatively healthy population, wide distribution and catholic diet, *L. catamene* no longer fulfils the criteria for a threatened species. The only major threat identified is its inherently small range on an island dominated by an active volcano, and therefore the species's threat status should be reduced to globally near-threatened and its population monitored carefully. Status on Sangihe: Near-threatened.

Sangihe Scops-owl *Otus collari*

No records were made during the point count surveys and no population estimate was possible. Other records confirmed that this is a common and widespread species on the island occurring up to altitudes of *c*. 900 m. Observations in February 1999, of a maximum of 10 birds (four seen) in a *c*. 2 ha patch of mixed plantations with tall fig *Ficus* spp. trees at Gunung, suggested it can occur at high densities in suitable habitat. The maximum number recorded in the Sahendaruman forest was six birds (including a pair mist-netted) at Tukade Batu in November 1998. Three roosting birds, all solitary, were located; one in the crown of a tall coconut in Hesang village in September 1998, one in a low bush in dense scrub above Kalemba in February 1999, and a bird in Ulung Peliang village in February 1999. *Otus collari* can tolerate disturbed habitat and has even been heard calling in the centre of Tahuna. Status on Sangihe: Low Risk: Least Concern.

Lilac-cheeked Kingfisher *Cittura cyanotis sanghirensis*

Population estimates (42,200–97,400 birds) indicated that this is a common species up to *c*. 1,000 m with density estimates showing that *C. cyanotis* has a clear preference for secondary habitat. This is an interesting adaptation; on mainland Sulawesi the species seems to be restricted to primary forest below 1,000 m (Coates and Bishop 1997, Sunarto *et al*. 1999). Status on Sangihe: Low Risk: Least Concern.

Sulawesi Dwarf Kingfisher *Ceyx fallax sangirensis*

There were no sightings in 1998–99 and the sole recent record is of a single bird observed in the Sahendaruman forest in March 1997 (Riley 1997a). The critically endangered status of *C. fallax* is a result of the widespread deforestation of lowland Sangihe and unless further sightings are made soon it must be concluded that the distinctive endemic race of this kingfisher is extinct. Status on Sangihe: Critically Endangered.

Red-bellied Pitta *Pitta erythrogaster caeruleitorques*

This extremely elusive and cryptic species was seen only three times during the survey period. Aural records indicated that it is widely distributed but uncommon, with records from the Sahendaruman forest to *c*. 650 m, the hills above Tahuna, plantations near Kentuhang and mixed plantations and scrub at Talawid. The pitta was notably common at the last site where it favours narrow scrub-covered gulleys amongst plantations.

No density estimate was possible from primary forest and the low densities recorded in secondary habitat resulted in a small population estimate (700–5,400 birds). Given the elusive nature of the species and seasonal variations in calling frequency this may be an underestimate of the true population size. *P. erythrogaster* is not threatened at the present time but the population on Sangihe is probably small and should be the subject of further research. Status on Sangihe: Low Risk: Near-threatened.

Hooded Pitta *Pitta sordida sanghirana*

Widely distributed in all habitats up to *c*. 950 m. The density estimate data suggested it is slightly more common in primary forest but also regularly encountered in secondary habitat. *P. sordida* appeared to favour habitat with a dense ground layer and was not noted in plantations with an open understorey. It was particularly common in plantations with coffee *Coffea canephora* trees interspersed with patches of scrub and secondary forest. The population estimate (6,200–24,500 birds) was probably an underestimate as *P. sordida* is a typically cryptic pitta and usually only detected by its calls. That it is clearly adapted to secondary areas suggests that its future is secure at present; no threats were identified. Status on Sangihe: Low Risk: Least Concern.

Pied Cuckoo-shrike *Coracina bicolor*

This species has not been recorded on Sangihe since a specimen was collected in 1864 (White and Bruce 1986). The sole contemporary record on the island was of a single male bird in September 1995 (Riley 1997b); it is now accepted that an identification error was made regarding this record, which should be withdrawn. On Sulawesi this is a noisy bird, not easily overlooked in areas where it is present (pers. obs.) and, in the light of present evidence, it is recommended that this species no longer be listed for Sangihe.

Sulawesi Cicadabird *Coracina morio salvadorii*

Whilst only recorded on five occasions during the point count survey, *C. morio* was widely distributed on Sangihe and occurred in most habitats to *c*. 900 m. The majority of observations were made in secondary habitat, particularly areas of mixed plantations with tall trees, and birds usually avoided open scrub or monocrop plantations. The low encounter rate during point counts suggested an uncommon species, but *C. morio* can be difficult to observe as it feeds in the crowns of trees and remains undetected unless singing. Males were vocal and easily detected for only a brief period in August–September 1998. After this period *C. morio* became difficult to detect and all records made during point counts were visual. Whilst *C. morio* is widely distributed and no specific threats were identified, its apparently small population should be monitored in the future. Status on Sangihe: Near-threatened.

Golden Bulbul *Ixos affinis platenae*

The population density estimates suggested that this is one of the island's most endangered species. *Ixos affinis* was found only in the Sahendaruman

forest (the sole record from secondary areas was of a bird calling at the forest edge) where the small estimated population (50–230 birds) was patchily distributed up to *c.* 1,000 m. They were recorded regularly in certain areas of the forest – above Malamenggu, Tukade Batu, Sahengbalira – but were apparently absent from others. In part this is explained by seasonal variations in the intensity of vocalizations; at Malamenggu, for example, it was rarely recorded in October 1998 but in February 1999 was vocal and found to be common. Its patchy distribution and seasonal variation in detectability may have led to an underestimate of density, but the species is obviously rare. It is usually seen in small groups of 3–6 birds and the largest group noted was one of 10 at Sahengbalira in December 1998.

The main threat to *I. affinis* is habitat loss and further work is urgently needed to determine the species's true population size, distribution and ecological requirements on Sangihe. The dependence on forest is particularly interesting as two of the most closely related subspecies, *I. a. aureus* of the Togian islands and *I. a. longirostris* of the Sula islands, are both common in plantations and gardens (White and Bruce 1986, Davidson *et al.* 1995, pers. obs.). Status on Sangihe: Critically Endangered.

Drongo *Dicrurus sp.*

A common species in all habitats to *c.* 1,000 m, but the density figures highlighted a marked preference for primary forest. The large population estimate (34,600–52,000 birds) suggested that it is secure on Sangihe and no threats were identified. Status on Sangihe: Low Risk: Least Concern.

Black-naped Oriole *Oriolus chinensis sanghirensis*

Very common and regularly encountered in all habitats to *c.* 1,000 m. Population density estimates suggested that they were commoner in primary forest. It was noted in some areas surveyed – Dagho and Kalawatu – that *O. chinensis* was largely absent. Habitat appeared similar to that in other localities and such local absences may be due in part to hunting. However, the high population estimate (49,600–73,300 birds) shows *O. chinensis* to be secure on the island at present. Status on Sangihe: Low Risk: Least Concern.

Cerulean Paradise-flycatcher *Eutrichomyias rowleyi*

Riley and Wardill (2001) have described in detail the status and conservation of *E. rowleyi*. They suggest that the species is restricted to forested valleys between 475 m and 650 m on Mt Sahendaruman, and that its population numbers at least 19 birds and probably no more than 135 birds. The extremely restricted range, small population size and continued loss of habitat are considered to be the main threats to its survival (BirdLife International 2001). Status on Sangihe: Critically Endangered.

Sangihe Shrike-thrush *Colluricincla sanghirensis*

Since its rediscovery in 1985 it has only been recorded in the Mt Sahendaruman forest and given the lack of suitable habitat elsewhere on Sangihe its global range

is apparently restricted to this forest. This survey suggested that the species's world population is very small (270–1,500 birds) and *C. sanghirensis* is only found in primary or well-established (reported by local villagers to be *c.* 30 years old) secondary forest at altitudes of *c.* 575 to *c.* 1,000 m.

The density estimate figures should be interpreted with caution as they are based on a small sample size (*n* = 14). The figures may also be influenced by apparent seasonality in vocalizations. Shrike-thrushes were only heard singing in February 1999 and the survey period may not have coincided with peak activity and consequently underestimated densities.

The majority of observations (87%, *n* = 63) of this species were of single birds or pairs, but flocks of between five and nine birds were noted on four occasions. More details of the ecology and behaviour of *C. sanghirensis* are provided by Riley (1997a) and Rozendaal and Lambert (1999). With a very restricted range, small population, and dependence on primary forest *C. sanghirensis* is obviously critically endangered. The main threat to the species is habitat loss and, like other endemics restricted to the Sahendaruman forest, the protection of this area is crucial to its survival. Status on Sangihe: Critically Endangered.

Asian Glossy Starling *Aplonis panayensis sanghirensis*

Population density estimates were complicated by the large, ephemeral feeding flocks formed by this species, and their nomadic nature. Both these traits may help to explain the wide range in the estimates of population size (5,600–48,900 birds). However, patterns were discernable and it is clear that *A. panayensis* is a widespread species in all habitats, with flocks of up 120 birds recorded during point counts. It is most common in secondary habitat, particularly areas with remnant forest trees, but was noted up to *c.* 900 m in the Sahendaruman forest. Birds were common around villages and were even seen nesting in houses in Dagho in September 1998. No threats were identified. Status on Sangihe: Low Risk: Least Concern.

Brown-throated Sunbird *Anthreptes malacensis heliocalus*

The density estimates suggested that *A. malacensis* was largely restricted to secondary habitats on Sangihe and no birds were recorded in primary forest during point counts. Moreover, this species was much commoner below *c.* 300 m and there were no records above this altitude during counts. Birds do occasionally reach higher altitudes, in February 1999 a male was seen at *c.* 950 m in primary forest at Sahengbalira, but *A. malacensis* appears to favour low-lying habitats such as clove plantations and mangroves.

The major threat to the species is probably disturbance of mangroves by people collecting firewood or logging trees, but its presence in plantations, and the large population estimate (18,000–59,900 birds) suggests that it is secure at present. Status on Sangihe: Low Risk: Least Concern.

Black Sunbird *Nectarinia aspasia sangirensis*

This seemed to be the commonest species on Sangihe with a very large popula-

tion (779,000–1,176,000 birds). It was found in all habitats and densities are highest in areas of secondary habitat. Status on Sangihe: Low Risk: Least Concern.

Elegant Sunbird *Aethopyga duyvenbodei*

In 1998–99 *A. duyvenbodei* was recorded regularly and the density estimates suggested that it was common in primary forest but that high densities also occurred in secondary areas. In fact, a more detailed analysis of the point count data showed that *A. duyvenbodei* was rarely encountered in secondary habitat away from the Sahendaruman caldera (7.7% of observations, *n* = 65), with encounter rates of only 0.05 observations per point count at distances more than *c.* 2 km from primary forest, compared with 0.35 observations per point count at distances less than *c.* 2 km from primary forest. Therefore, because the higher densities recorded in restricted areas close to primary forest strongly affect the average density figure used to calculate population size in areas where sunbirds are in fact rare, the population estimate for secondary habitats is likely to be a significant overestimate. Further, extremely high numbers of sunbirds were recorded at stations located in Sterculiaceae-dominated scrub bordering primary forest and this will also bias the density estimate.

In an attempt to provide a more acceptable population estimate, I have assumed, for the reasons outlined above, that the area of secondary habitat occupied by *A. duyvenbodei* is *c.* 52 km². This figure is calculated by first assuming the primary forest on Sahendaruman is a rectangle 8 km long and 1 km wide. Given that encounter rates suggest *A. duyvenbodei* is concentrated within *c.* 2 km of primary forest, then the area of secondary habitat occupied is a belt *c.* 12 km long and *c.* 5 km wide (60 km²) with an 8 km² block of primary forest at its core.

The population estimate obtained using this method (18,900–43,800 birds) is obviously much smaller than would be obtained by extrapolating the density estimate for secondary habitat to the entire island. Whilst the method relies on a somewhat arbitrary delineation of *A. duyvenbodei*'s distribution (based on habitat-influenced encounter rates), and overlooks the small but important numbers of birds recorded in northern Sangihe, it better reflects the true status of the species.

Ideally one should calculate population density estimates for each of the four subhabitats lumped under the secondary habitat classification. However, this is not possible for two reasons: first, the sample sizes for the subhabitats are too small to produce reliable results; second, it is impossible to allocate with confidence census stations in marginal habitats given the subjective classifications employed and the lack of detailed habitat maps from Sangihe.

Inaccuracies in the population figures aside, the survey results demonstrate that *A. duyvenbodei* is found mainly around the Sahendaruman forest but that it is not dependent on primary forest. Large concentrations of sunbirds, including juveniles, were regularly recorded in scrub bordering primary forest and birds were also noted in plantations and gardens. Away from this site densities were low, but the sunbird still survives at places where forest was cleared more than 100 years ago. The hills above Tahuna were devoid of forest when S. J. Hickson arrived on Sangihe in the 1885 (Hickson 1889) but *A. duyvenbodei* was observed in February 1999 in steep gullies supporting dense secondary forest. This ability to persist in degraded habitat suggests that the sunbird's future is secure.

Although the large population estimate should be interpreted cautiously it does suggest that *A. duyvenbodei* is not uncommon in certain areas on Sangihe. The key threat is its small range and the concentration of the population around the Sahendaruman caldera. In addition, *A. duyvenbodei* appears to require areas with large trees and tree ferns for nesting and feeding and it occurs at much lower densities in the more heavily managed plantations and gardens which dominate the north and east of the island. It was classified as endangered primarily as a result of its small, severely fragmented range and a decline in the area of occupancy, quality of habitat and number of mature individuals (IUCN 2000). Given the species's small range, the concentration of the population in one area, and the apparent ecological requirements for less intensively managed plantations it should be downgraded to globally vulnerable and its status carefully monitored. Status on Sangihe: Vulnerable.

Yellow-sided Flowerpecker *Dicaeum aureolimbatum laterale*

Commonly encountered in groups of up to 10 birds. Population densities were slightly higher in primary forest but there was no marked preference and *D. aureolimbatum* was very common in secondary habitat. The large population estimate (226,000–377,000 birds) and lack of identifiable threats suggest its future on Sangihe is secure. Status on Sangihe: Low Risk: Least Concern.

Grey-sided Flowerpecker *Dicaeum celebicum sanghirense*

Very common in all habitats with trees on Sangihe and the population density estimates showed a clear preference for secondary habitats with densities five times higher than in primary forest. No threats were identified and the species's large population (186,000–328,000 birds) indicates that it is secure on Sangihe for the immediate future. Status on Sangihe: Low Risk: Least Concern.

Sangihe White-eye *Zosterops nehrkorni*

The status of *Zosterops nehrkorni* has been summarized recently by Rasmussen *et al*. (2000). This is the least known and possibly the most endangered of all Sangihe's endemic birds. It remains unclear why it is so rare, even within the small remaining area of forest on the Sahendaruman caldera. If it had ever occurred in low-elevation forest, one would expect it to be found near the lower limit of presently existing forest. Further work is urgently needed to understand better the factors controlling its populations, and to establish its numbers and full distribution. Status on Sangihe: Critically Endangered.

Discussion

Survey design and the assumptions of distance sampling

For the density and population estimates to be accurate the survey method used on Sangihe must meet the assumptions of distance sampling. Therefore the 1998–99 survey was designed after considering the points raised by Buckland *et al*.

(1993) and the standard methods for monitoring birds using point counts (e.g. Bibby *et al.* 1992, Ralph *et al.* 1995).

An important consideration is that the census stations should be placed randomly with respect to the distribution of birds. In some areas of severe terrain on the Sahendaruman caldera it was not possible to place stations far from ridge tops or valley bottoms. Stations may not, therefore, be random because some bird species, for example *E. rowleyi* and *P. erythrogaster*, apparently favour valleys. Given constraints of time and safety on the survey, this bias is an intractable problem. Whilst the density estimates presented in this paper may be inaccurate because of the non-random placement of points, future surveys and monitoring programmes will face the same problem and population trends will still be revealed.

The number of point count samples necessary to produce statistically robust sample sizes is a further important consideration of survey design (Ralph *et al.* 1995). The current study aimed to assess all species across Sangihe and a total of 407 point counts was surveyed in all habitats. Such a general approach naturally leads to small sample sizes, particularly of species occurring at low densities or in particular habitats. Given the physical difficulties of conducting census work on Sangihe – one field team can survey an average of seven stations a day compared to the 25 suggested by Ralph *et al.* (1995) – and the pressing need for population estimates of very rare species, data based on small sample sizes are presented here. Whilst accepting the problems inherent in using small sample sizes, the density estimate figures are thought to be robust. The standard error as a percentage of mean density varies between 11% and 44% in primary forest and 10% and 56% in secondary habitat, and for the majority of species in both habitats variance is less than 25%, the figure used by Buckland *et al.* (1993) and Marsden *et al.* (1997) to assess the robustness of density estimates. Indeed, to pass the threshold of 60 contacts suggested by Buckland *et al.* (1993) for some of the rarer species on Sangihe would take great commitment. Based on current encounter rates approximately 600, 670, 860 and 10,000 point counts would be required to census *E. rowleyi, C. sanghirensis, L. catamene* and *Z. nehrkorni* respectively to produce robust estimates from the Sahendaruman forest.

Survey design aimed to minimize bias caused by the landscape on Sangihe, but were the three critical assumptions of distance sampling met? The first of these is that birds at the point (distance = 0 m) are detected with certainty. The main factors influencing detectability are habitat and bird behaviour, where cryptic species may go undetected in dense habitats (e.g. Bibby *et al.* 1992, Jones *et al.* 1995). In primary forest or plantations with tall trees it was sometimes difficult to detect birds in the high canopy. However, the 10 minute count period gave sufficient time for complete searches of trees to be made and this assumption was met during the survey. The second critical assumption is that birds are detected at their initial location and that they do not move in response to the observer. In practice this assumption is impossible to meet in bird surveys. Birds are mobile animals and most species respond to humans. On Sangihe, cryptic species, ground or understorey dwellers, and heavily hunted species in particular, regularly move away from surveyors. This problem is likely to have led to underestimates in the densities of species such as *P. sordida, C. cyanotis*, and all pigeon species. The third key assumption is that measurements are exact. Sur-

veyors underwent a period of intensive training and distance estimates were monitored throughout the survey in order to meet this assumption. Initial analysis of ungrouped data showed little evidence of heaping (see Buckland *et al*. 1993) except for aural contacts at distances greater than 100 m. In practice these distant aural records were discarded by truncation and it seems likely that, other than random errors, which may not be a significant bias, distance estimates were accurate.

Accepting that some bias resulting from the survey method not meeting these three assumptions was present, it is important to note that this will tend towards underestimation of densities, and thus populations. The results presented here are therefore still valuable for assessing conservation priorities.

Conservation priorities and future research

The widespread deforestation of Sangihe has had serious consequences for its bird species. The island supports the highest number of threatened single-island endemic species in Indonesia. There has been just one known extinction, the endemic *E. histrio*, but of the remaining 51 resident species, at least eight have very small populations and are critically endangered with extinction on Sangihe in the immediate future (Table 5). Of most concern is the status of the three endemics *E. rowleyi, C. sanghirensis* and *Z. nehrkorni*; all are restricted to just 8 km² of primary forest and have very small populations. Habitat loss is the main pressure on these species with small-scale clearance of forest and adjacent secondary growth by local farmers to create gardens between 0.5 and 1.5 ha in size. This will also affect populations of *C. fallax* and *I. affinis*, which are critically endangered and also found only in forest on the Sahendaruman caldera.

Three other species are critically endangered on Sangihe: *C. nicobarica* seems to be extremely rare on the main island but may persist on small offshore islets, whilst the two species of *Tanygnathus* parrot are threatened by a combination of habitat loss, loss of nesting and roosting trees, and hunting, and only very small populations remain. Of the five species whose Sangihe populations are classified as endangered or vulnerable, three are pigeons that have very low population estimates, whilst a fourth species, *M. cumingii* has specialized nesting requirements. The fifth species, *A. duyvenbodei*, should be reclassified as vulnerable since it can tolerate disturbed habitats.

In general, species with broad global distributions represented on Sangihe by endemic subspecies have adapted to secondary habitats, but just three endemic species and two restricted-range species are regularly recorded in these habitats. The endemic *L. catamene, O. collari*, and *A. duyvenbodei* and the restricted-range *D. concinna* and *C. cyanotis* are widespread across the island and appear to have no ecological dependence on primary forest.

The Sahendaruman forest block is the key site for bird conservation on the island. Any further loss or degradation of primary forest on the caldera will have very serious effects on three critically endangered endemic species and two endemic subspecies. The threats to this forest have been discussed in detail elsewhere (Lambert 1997, Riley 1997a, Wardill *et al*. 1997, Riley and Wardill 2001) and recommendations for its protection made. The current dataset represents a

Table 5. The current status of resident bird species on Sangihe

Species	Population estimate[a]	Status on Sangihe	Criteria
Philippine Scrubfowl *Megapodius cumingii*	< 500[c]	EN	A2cd, B1+B2bcde, C2b
Slender-billed Cuckoo-dove *Macropygia amboinensis*	2,000–6,200	EN	C2b
Emerald Dove *Chalcophaps indica*	1,900–5,000	LC	
Nicobar Pigeon *Caloenas nicobarica*		CR	B1+2abce, C2a
Grey-cheeked Green Pigeon *Treron griseicauda*	< 5,000[c]	VU	A2d, B2cde, C2b
Black-naped Fruit-dove *Ptilinopus melanospila*	26,100–43,700	LC	
Blue-tailed Imperial Pigeon *Ducula concinna*	360–1,800	EN	A2cd, B2bce, C2a
Red-and-blue Lory *Eos histrio*		EX	
Blue-backed Parrot *Tanygnathus sumatranus*	< 200[c]	CR	A2cd, B2bcde, C2b
Great-billed Parrot *Tanygnathgus megalorynchos*	< 50[c]	CR	A1acd, B1+2abcde, C1, D
Sangihe Hanging-parrot *Loriculus catamene*	10,700–46,200	NT	
Common Koel *Eudynamys scolopacea*	4,500–11,500	LC	
Sangihe Scops-owl *Otus collari*	10,000–25,000[c]	LC	
Lilac-cheeked Kingfisher *Cittura cyanotis*	42,200–97,400	LC	
Sulawesi Dwarf Kingfisher *Ceyx fallax*	< 50[c]	CR	A2c, B1+2abcde, C2b,D
Red-bellied Pitta *Pitta erythrogaster*	700–5,400[b]	NT	
Hooded Pitta *Pitta sordida*	6,200–24,500	LC	
Sulawesi Cicadabird *Coracina morio*	< 10,000[c]	NT	
Golden Bulbul *Ixos affinis*	50–230	CR	A2c, B1+2abcde, C2b, D
Drongo *Dicrurus* sp.	34,600–52,000	LC	
Black-naped Oriole *Oriolus chinensis*	49,600–73,300	LC	
Cerulean Paradise-flycatcher *Eutrichomyias rowleyi*	19–135[d]	CR	A2bc, B1+2abcde, C2b
Sangihe Shrike-thrush *Colluricincla sanghirensis*	270–1,500	CR	A2bc, B1+2abcde, C2b
Asian Glossy Starling *Aplonis panayensis*	5,600–48,900	LC	
Brown-throated Sunbird *Anthreptes malacensis*	18,000–59,900[b]	LC	
Black Sunbird *Nectarinia aspasia*	779,000–1,176,000	LC	
Elegant Sunbird *Aethopyga duyvenbodei*	18,900–43,800	VU	B1+2c
Yellow-sided Flowerpecker *Dicaeum aureolimbatum*	226,000–377,000	LC	
Grey-sided Flowerpecker *Dicaeum celebicum*	186,000–328,000	LC	
Sangihe White-eye *Zosterops nehrkorni*	< 50[c]	CR	A2bc, B1+2abcde, C2b, D

CR, Critically Endangered; EN, Endangered; VU, Vulnerable, NT, Low Risk: Near-threatened, LC, Low Risk: Least Concern. Interpretation of criteria codes follows IUCN (2000). [a]Minimum population = min. population primary forest + min. population secondary habitat; maximum population = max. population primary forest + max. population secondary habitats. [b]Min. or max. total population estimate is sum of min. or max. density in secondary habitats x total island area. [c]Population figure based on qualitative estimate only. [d]After Riley and Wardill (2001).

baseline against which changes can be monitored, and only reinforces the urgency of these proposals.

However, further detailed research, in particular monitoring of endemic bird populations, is required. For example, there is still not enough information to produce a population estimate for *Z. nehrkorni* or to accurately assess the species's conservation requirements and this is clearly a priority for research. This paper's findings are based on a dataset that is too small for many of the endemic species, and further studies, particularly at different times of year, or in different microhabitats – forested valleys, for example – would fill in some gaps in our knowledge. Indeed, any future research should be species orientated to reduce the biases identified during the current multispecies survey.

Acknowledgements

References

Bibby, C.J., Burgess, N.D. and Hill, D.A. (1992) *Bird census techniques*. London: Academic Press.

BirdLife International (2001) *Threatened birds of Asia: the Birdlife International Red Data Book*. Cambridge, U.K.: BirdLife International.

BPS (1994) *Sangihe-Talaud in figures, 1993*. Tahuna, Indonesia: Statistics Office of Sangihe-Talaud.

BPS (1999) *North Sulawesi in figures, 1998*. Manado, Indonesia: Statistics Office of North Sulawesi.

Buckland S.T., Anderson, S.R., Burnham, K.P. and Laake, J.L. (1993) *Distance sampling: estimating abundance of biological populations*. London: Chapman and Hall.

Coates, B.J. and Bishop, K.D. (1997) *A guide to the birds of Wallacea: Sulawesi, the Moluccas and Lesser Sunda islands, Indonesia*. Alderley, Queensland: Dove Publications.

Davidson, P., Stones, T. and Lucking, R. (1995) The conservation status of key bird species on Taliabu and the Sula islands, Indonesia. *Bird Conserv. Internatn*. 5: 1–20.

FAO (1982) *National conservation plan for Indonesia, 6. Sulawesi*. Bogor: UNDP/FAO.

Heringa, P. (1921) Rapport over de begroeiing van de Sangi- en Talaud-eilanden. *Tectona* 14: 733–746.

Hickson, S.J. (1889) *A naturalist in north Celebes*. London: Murray.

ICBP (1992) Putting biodiversity on the map: priority areas for global conservation. Cambridge, U.K.: International Council for Bird Preservation.

IUCN (2000) *2000 IUCN Red List of threatened animals*. Gland, Switzerland: IUCN.

Johns, A.D. (1986) Effects of selective logging on the ecological organisation of a peninsula Malaysian rain forest avifauna. *Forktail* 1: 65–79.

Jones, M.J., Linsley, M.D. and Marsden, S.J. (1995) Population sizes, status and habitat associations of the restricted-range bird species of Sumba, Indonesia. *Bird Conserv. Internatn*. 5: 21–52.

Lambert, F.R. (1992) The consequences of selective logging for Bornean lowland forest birds. *Phil. Trans. R. Soc. Lond. B.* 12: 443–457.

Lambert, F.R. (1997) *Field assessment of the conservation status of Red-and-blue Lory* Eos histrio *in Indonesia*. Bangkok, Thailand: IUCN Species Survival Commission.

Lambert, F.R. (1998) A new species of *Amaurornis* from the Talaud Islands, Indonesia, and a review of taxonomy of bush hens occurring from the Philippines to Australasia. *Bull. B.O.C.* 118: 67–82.

Lambert, F.R. (1999) The conservation status of the Red-and-blue Lory *Eos histrio* and other threatened birds of the Sangihe and Talaud islands. *Trop. Biodiv.* 6: 99–112.

Lambert, F.R. and Rasmussen, P.C. (1998) A new scops owl from Sangihe Island, Indonesia. *Bull B.O.C.* 118: 204–217.

Marsden, S.J. (1995) The ecology and conservation of the parrots of Sumba, Buru and Seram, Indonesia. Unpublished PhD thesis. Manchester Metropolitan University, U.K.

Marsden, S.J., Jones, M.J., Linsley, M.D., Mead, C. and Hounsome, M.V. (1997). The conservation status of the restricted-range lowland birds of Buru, Indonesia. *Bird Conserv. Internatn.* 7: 213–233.

Meyer, A.B. and Wiglesworth, L.M. (1898) *The birds of Celebes and neighbouring islands*. Berlin: Friedländer.

Ralph, C.J. and Scott, M.J., eds. (1981) *Estimating numbers of terrestrial birds*. Cooper Ornithological Society Studies in Avian Biology 6. Lawrence, KS: Allen Press.

Ralph, C.J., Sauer, J.R. and Droege, S., eds. (1995) *Monitoring bird populations by point counts*. Gen. Tech. Rep. PSW-GTR-149. Albany, CA: Pacific Southwest Research Station, Forest Service, U. S. Department of Agriculture.

Rasmussen, P.C., Wardill, J.C., Lambert, F.R. and Riley, J. (2000) On the specific status of the Sangihe White-eye *Zosterops nehrkorni* with a taxonomic review of the Black-fronted White-eye *Z. atrifrons. Forktail* 16: 69–81.

Reynolds, R.T., Scott, J.M. and Nussbaum, R.A. (1980) A variable circular plot method for estimating bird numbers. *Condor* 82: 309–313.

Riley, J. (1995) The status and utilization of Red-and-blue Lory *Eos histrio* on the Talaud and Sangihe islands. Bogor, Indonesia: PHPA/BirdLife International Indonesia Programme (Techn. Memo. 10).

Riley, J. (1997a) *Biological surveys and conservation priorities on the Sangihe and Talaud islands, Indonesia*. Cambridge, U.K.: CSB Conservation Publications.

Riley, J. (1997b) The birds of Sangihe and Talaud, North Sulawesi. *Kukila* 9: 3–36.

Riley, J. (1998) Recent observations of the Sangihe Hanging Parrot *Loriculus catamene. Papageienkunde* 2: 1–9.

Riley, J. and Wardill, J.C. (2001) The rediscovery of Cerulean Paradise-flycatcher *Eutricho-myias rowleyi* on Sangihe, Indonesia. *Forktail* 17: 45–46.

Rozendaal, F.G. and Lambert, F.R. (1999) The taxonomic and conservation status of *Pinarolestes sanghirensis* Oustalet 1881. *Forktail* 15: 1–13.

Stattersfield, A.J., Crosby, M.J., Long, A.J. and Wege, D.C. (1998) *Endemic bird areas of the world: priorities for biodiversity conservation*. Cambridge, U.K.: BirdLife International (BirdLife Conserv. Series 7).

Sujatnika and Jepson, P. (1995) *Priority proposed protected areas for the conservation of global biodiversity in Indonesia*. Bogor, Indonesia: PHPA/BirdLife International Indonesia Programme (Techn. Memo. 3).

Sunarto, O'Brien, T.G., Kinnaird, M.F., Supriatna, J. and Basukriadi, A. (1999) Resource partioning among kingfishers in Tangkoko-Duasudara nature reserve, North Sulawesi. *Trop. Biodiv.* 6: 75–86.

Thiollay, J.-M. (1995) The role of traditional agroforests in the conservation of rain forest bird diversity on Sumatra. *Conserv. Biol.* 9: 335–353.

Thomas, L., Laake, J.L., Derry, J.F., Buckland, S.T., Borchers, D.L., Anderson, D.R., Burnham, K.P., Strindberg, S., Hedley, S.L., Burt, M.L., Marques, F., Pollard, J.H. and Fewster, R.M. (1998) *Distance 3.5*. University of St. Andrews, U.K.: Research Unit for Wildlife Population Assessment.

Wardill, J.C., Riley, J., Hunowu, I. and Wangko, M.F. (1997) *A status assessment of the Gunung Sahengbalira protection forest, Sangihe, North Sulawesi*. Bogor, Indonesia: PHPA/BirdLife International Indonesia Programme (Techn. Memo. 19).

White, C.M.N. and Bruce, M.D. (1986) *The birds of Wallacea (Sulawesi, the Moluccas and Lesser Sunda Islands)*. London: British Ornithologists' Union (Checklist 7).

Whitten, A.J., Bishop, K.D., Nash, S.V. and Clayton, L. (1987) One or more extinctions from Sulawesi, Indonesia? *Conserv. Biol.* 1: 42–47.

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