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Avifaunal status updates, range extensions and potential new taxa on the lesser Sangihe and Talaud islands, Indonesia

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Abstract. The Sangihe-Talaud Endemic Bird Area harbours one of the highest densities of endemic and threatened bird species in the world. Despite this, there have been no ornithological studies of many of the islands in modern times, and some have no records at all. Using both investigative and more systematic methods, 13 islands were surveyed to gain a comprehensive overview of the resident species. The findings include range extensions for a number of endemic, range-restricted and/or threatened species, as well as completely new regional records. Of particular interest are the seven Nanusa islands, lying north-east of Talaud. Previously there were no published reports for any faunal group here, yet cluster analyses show that these islands have the most unique avifaunal assemblage within Sangihe-Talaud. Most interestingly, there is at least one potential new taxa—an *Erythropitta* that is clearly different from the nearby Talaud Pitta (*Erythropitta inspeculata*). Two new records for Sangihe-Talaud, lemon-bellied white-eye (*Zosterops chloris*) and island whistler (*Pachycephala phaionota*), require further investigation to determine their taxonomic status. Another notable finding was the complete lack of evidence for the continued existence of the Siau scops-owl (*Otus siaoensis*), a Siau island-endemic only known from a single holotype. This study shows that important avifaunal discoveries remain in Indonesia, and that the conservation value of small islands should not be dismissed due to their size or inaccessibility.

Key words. Sangihe, Talaud, Nanusa, Indonesia, avifauna, birds

INTRODUCTION

The Sangihe-Talaud Endemic Bird Area (EBA) has one of the highest densities of threatened and island endemic bird species in the world (Birdlife International, 2017), yet only the largest islands have been surveyed in recent times (Riley, 1997), and not comprehensively during this century. The EBA includes five Important Bird Areas (Birdlife International, 2017), 14 species and 23 subspecies endemic to the islands (Irestedt et al., 2013; del Hoyo et al., 2017), and 18 threatened or near-threatened species (IUCN, 2017). Furthermore, the islands have been chosen as one of six focal areas by the organisation Burung Indonesia (Burung Indonesia, 2017), the Indonesian affiliate of Birdlife International.

The Sangihe islands (Fig. 1) lie on the Sangihe Arc (Morrice et al., 1983), which stretches approximately 500 km from North Sulawesi to Mindanao in the Philippines, and hosts three active volcanoes above sea level. Of these, Karangetang on Siau forms the highest point of the archipelago at 1,762 m. The terrain on the islands is generally steep and difficult to traverse, but the rich volcanic soils have resulted in almost complete conversion of the native tropical forest to agro-forestry matrices, with the most notable crops being coconut (*Cocos nucifera*), nutmeg (*Myristica fragrans*), and clove (*Syzygium aromaticum*) (Badan Pusat Statistik, 2017). Such conversion is not only a recent development, at least on the largest island of Sangir Besar, where deforestation was already widespread by the 1920s (Heringa, 1921). However, patchy remnants of natural forest do remain on the ridges and slopes of most islands. With such substantial anthropogenic impacts, it is unlikely that the bird communities and distributions today are stable, or follow typical biogeographic patterns.

The Sangihe and Halmahera arcs are undergoing the only active arc collision on Earth (Hall, 2008), which has caused the recent uplift (<1MA) of the Talaud ridge above sea level (Moore et al., 1981). Unlike Sangihe, the Talaud islands are not volcanic but largely sandstone and coralline limestone, with the highest point being 608 m at Mount Biala (Riley, 2003). Throughout Talaud there is evidence of a very recent drop in relative sea level, with coral terraces found up to 200 m on Kabaruang (Bader & Pubellier, 2000). Villages and agricultural land are situated around the coast, where coconuts are by far the most dominant crop (Badan Pusat Statistik, 2017). The satellite islands of Salibabu and Kabaruang have been extensively settled and cleared for some time (Holthuis & Lam, 1942), while the remote Nanusa islands to the north-east retain patches of mature forest. The Talaud

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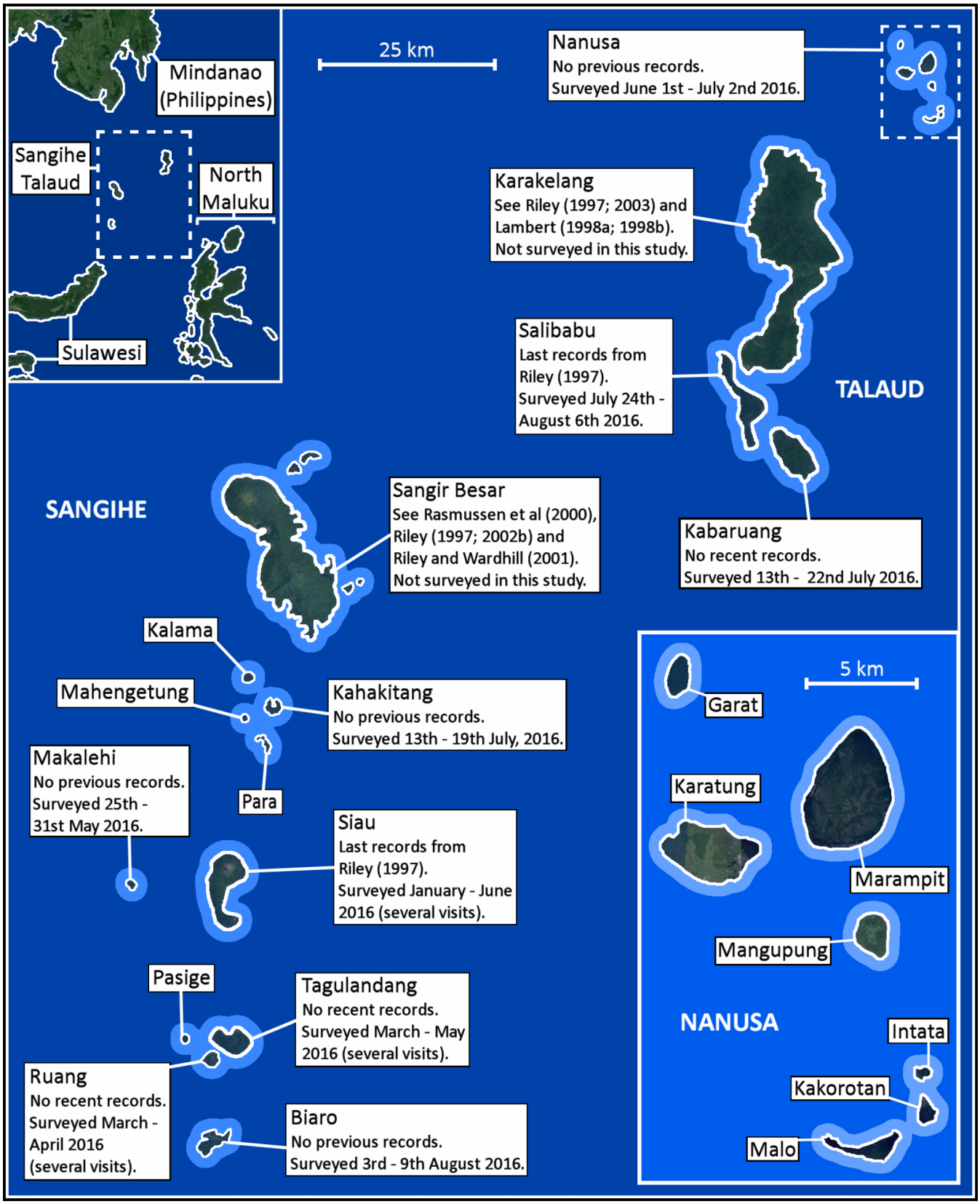

Fig. 1. Map of the Sangihe and Talaud islands, also showing the surrounding landmasses (top-left) and the Nanusa islands (bottom-right). Based on satellite imagery from Google (2017).

Archipelago in general has a lower population density than Sangihe (Badan Pusat Statistik, 2017), and the interior of Karakelang has large areas of relatively undisturbed forest.

In general, Sangihe-Talaud has been afforded little in the way of published ecological research, despite the high levels of endemism and an important biogeographic position between the Philippines, Sulawesi, and Maluku (Fig. 1). The most comprehensive work on the avifauna so far has been from Riley (1997), who conducted surveys on the larger islands between August–October 1995, and also compiled accounts from the handful of collectors, researchers and birdwatchers that have visited the islands since 1866. Riley (2002, 2003) conducted two further studies in 1998–1999 on the status of the island endemics and range-restricted species, and there have also been a handful of publications focusing on individual species (Lambert, 1998a, 1998b; Rasmussen et al., 2000; Riley & Wardill, 2001). Given the infrequency of surveys, it is quite possible that new taxa remain to be described, or may never be described due to the rapid clearing of natural forest and widespread hunting.

This study had two main aims: firstly, to provide much-needed updates for islands that had not recently been surveyed; and secondly, to explore previously unsurveyed islands and make preliminary observations of new records and potential new taxa. As such, thirteen islands were visited between January–August 2016. Investigative methods were used on four of these, while a more systematic approach was used to estimate species richness on nine others.

METHODS

Field surveys. Investigative surveys were suitable for the largest islands visited: Tagulandang, Siau, Salibabu, and Kabaruang (Fig. 1). The size of these islands, steep terrain, and patchy bird distribution made them difficult to systematically survey. However, local knowledge seemed much more reliable than on the smaller islands due to the presence of hunters and trappers, which were familiar with most species. Interviews were conducted using species plates, photos and sound recordings, whereby a general idea of the bird community was formed by the most consistent answers. Knowledgeable locals were hired to find certain species or to locate paths into remnant forest patches. Efforts were made to verify all consistently reported species, gathering photos and sound recordings if possible. The result was likely a comprehensive inventory due to the small habitat patches and low species richness of the islands, though it is possible that some small Passerine species were overlooked. Consistency between reports was checked by asking for the species in the local dialects, and as all small passerines (sunbirds, flowerpeckers etc.) usually have the same name, it was difficult to target these. Some species were not verified first-hand, but considered likely enough and reported often enough to be included in the results.

A different survey method was undertaken on nine other islands: Biaro, Ruang, Makalehi, Kahakitang, Malo, Mangupung, Karatung, Marampit, and Garat (Fig. 1). Local knowledge of avifauna was not as strong on these due to the lack of a hunting culture, and they were small enough to undertake a systematic approach to provide a more complete inventory of resident bird species. Initially the Mackinnon species lists method (Mackinnon & Phillips, 1993) was chosen as a rapid means of producing richness estimates (O'dea et al., 2004), as it does not required randomised sampling or a specific route. Typically this method uses 20- or 10-species lists, but these were far too time-consuming due to a low species richness and low abundances on some islands. Therefore every species 'encounter' was recorded, effectively creating 1-species lists, for which several richness estimators may still be used (Colwell, 2013). Encounters could either be a solitary individual or a conspecific group, whereby the number of individuals were not counted. The next conspecific individual/group was only considered a separate encounter again if clearly not associated with that previously recorded. This served to reduce the risk of double-counting and the detectability bias of gregarious species. Species that were known to be migratory, introduced or dependent on other habitats (e.g., some freshwater rails) were noted but not included in these lists. Only native, resident forest species were targeted, and only if approximately <50 m from the observer and using the forest habitat. Sampling was restricted to closed, natural forest, as opposed to plantations, recent secondary growth or coastal vegetation. On many islands the 'natural' forest was mixed with agroforestry species, predominantly coconut, and occasionally nutmeg and clove. As a rule, an area of forest was only sampled if it appeared to comprise of <50% agroforestry species, and could not yet be considered a plantation. Suitable sample areas were located using high-resolution satellite imagery and 3D terrain available on Google Earth Pro (v7), where the difference between natural forest and plantations can clearly be seen. This continued until all patches of natural forest on an island had been visited, which was evaluated daily by checking GPS tracklogs to ensure that the same routes were not sampled twice. Such sampling took place between 0530–1100, while afternoons were used for scouting other samples sites and investigating different habitat types.

Species richness and hierarchical cluster analyses. Individual-based species richness estimators in EstimateS (Colwell, 2013) were used for the nine islands that were surveyed with the '1-species lists' method. The output (Table 1) included three different estimation methods: Rarefaction + Extrapolation; ACE; and Chao 1 (see Colwell, 2013 for details). For the first method, extrapolation of species richness beyond the original sample size was set to 3× (e.g., 200 encounters extrapolated to 600), the maximum recommended by Colwell (2013). The number of randomisations were increased from 100 to 1,000, while all other settings were left at default, including the use of the 'bias-corrected' formula for Chao 1 as opposed to the 'classic formula'.

Jaccard and Sörensen similarity indices were calculated for all thirteen of the surveyed islands, as well as two additions: Sangir Besar and Karakelang, which are the largest Sangihe and Talaud islands (respectively), and already had comprehensive species records compiled by Riley (1997). A

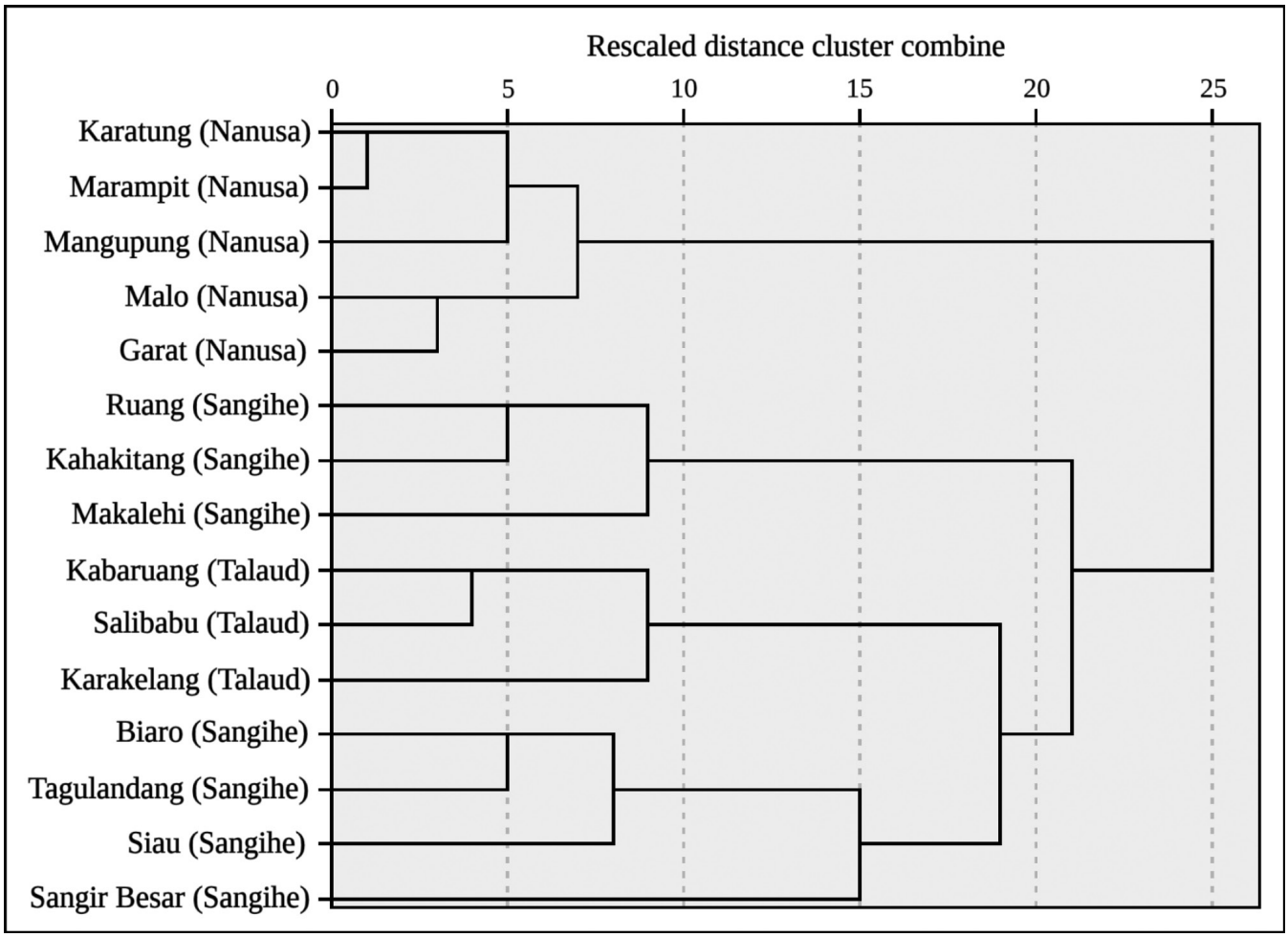

Fig. 2. Dendrogram for a hierarchical cluster analysis using Jaccard similarity index.

number of species or whole taxonomic groups were excluded from the analyses, as they are either migrants, highly nomadic, dependent on the existence of freshwater habitats, or had insufficient data. Two dendrograms (Jaccard similarity index and Sörensen similarity index) were generated with SPSS (v22.0) using the agglomerative method 'complete linkage', as recommended by Jain et al. (1985).

RESULTS AND DISCUSSION

Species richness and hierarchical cluster analyses. Of the nine islands sampled using modified Mackinnon lists, only Garat (Table 1) was estimated to have a higher number of target species (11) than observed (10). Indeed, a single target species on Garat, the Western Koel (*Eudynamys scolopaceus*), was heard but not included in the data as it was at a distance of >50m. Extrapolation as well as rarefaction continued to increase the estimated number of species past the number of observations on only two islands: Karatung and Garat. In the case of Karatung, the increase was not great enough to be rounded to a higher figure. Given these estimation results, it is unlikely that any target species went completely undetected on these islands. See Table 1 for a summarised checklist of all species encountered.

Both the Jaccard and Sörensen similarity indices produced identical clusters, with the only difference being consistently longer chains from the Jaccard index (Fig. 2). Notable clusters included: The larger Sangihe islands, Biaro, Tagulandang, and Siau, along with a more divergent Sangir Besar; the three large Talaud islands in a single group; the smallest Sangihe islands, Ruang, Makalehi, and Kahakitang separated from the two former clusters; and the Nanusa islands in a single group that is separate from all others.

Widespread and abundant species. The Philippine scrubfowl (*Megapodius cumingii*) was found to be common on every island visited, despite being a prime target for hunting and egg collecting. Groups of 2–6 were encountered in all habitat types with sufficient ground cover, most frequently in mature secondary or primary forest. The most abundant species was the black sunbird (*Leptocoma sericea*), except on the Nanusa islands where it was completely absent. While common in every habitat type, it was also most frequently encountered in mature secondary growth or primary forest. At certain altitudes, where *Pandanus* forest began to dominate (e.g., 600–760 m on Tagulandang), it was the only species encountered. The grey-sided flowerpecker (*Dicaeum celebicum*) had a similar distribution, though with a lower abundance and a greater dependence on disturbed, open habitat types. On Ruang, Tagulandang, and Siau, the olive-backed sunbird (*Cinnyris jugularis*) mostly replaced the black sunbird in some settled and heavily degraded areas.

Black-naped fruit-dove (*Ptilinopus melanospilus*) was the most widespread frugivore, occurring on all islands surveyed. However it was only the most relatively abundant in disturbed forest and plantation—in areas of mature forest and lower hunting pressure, imperial-pigeon species (*Ducula*) may repress numbers by competitive exclusion (Hardin, 1960). Slender-billed cuckoo-dove (M*acropygia amboinensis*) was also widespread on almost every island and habitat type, though abundance seemed to be much more sensitive to hunting and trapping pressure. The taxonomy of this species has undergone a number of revisions (Ng et al., 2016), and the Sangihe/Talaud subspecies *M. a. sanghirensis* may now be referred to as the Sultan's cuckoo-dove (*M. doreya sanghirensis*). The appearance and vocalisations of several individuals encountered do not match the standard descriptions of the *sanghirensis* subspecies (Ng et al., 2016; del Hoyo et al., 2017), indicating a highly polytypic race.

Three members of the cuckoo family (Cuculidae) are widespread across the islands: Western koel; channel-billed cuckoo (*Scythrops novaehollandiae*); and lesser coucal (*Centropus bengalensis*). Lesser coucal was only encountered in secondary scrub, so its dispersal has undoubtedly been aided by forest clearance. The western koel and channel-billed cuckoo were encountered in all habitat types, though abundance seemed to be linked with the presence of the slender-billed crow (*Corvus enca*), likely their main host for brood parasitism (del Hoyo et al., 2017). For instance, western koel was only encountered once on both Salibabu and Kabaruang, where the slender-billed crow is seemingly absent.

Biaro, Tagulandang, and Ruang, Sangihe. Biaro has some remaining primary forest along rocky stream beds and steep slopes to the South and centre of the island, giving way to mature secondary forest in more accessible areas. Hills to the East and West have been almost completely converted to plantation, while much of the northern half of the island is reduced to grassland by years of slash-and-burn agriculture. Biaro holds the only sizeable parrot population of all the islands surveyed, perhaps because it lacks a strong hunting culture. The great-billed parrot (*Tanygnathus megalorynchos*) could often be heard passing the port and villages, though their habitat use appeared to be restricted to natural forest fragments. It was reported that these are only occasionally captured, to be kept as local pets or to use the feathers as fishing bait. The species is absent on Ruang and recently extirpated on Tagulandang, where people remember it being abundant and a crop pest only 20 years ago. There were several independent reports that the red-and-blue lory (*Eos histrio*) was common on Biaro just twenty years ago, but is now 'rare' (most likely extinct). This may have been a feral population, but it could have also been one of the last strongholds of the extinct *E. h. histrio* subspecies, which was previously only reported from Sangir Besar (Riley, 1997). Of other species, black-naped oriole (*Oriolus chinensis*) was common, while hair-crested drongo (*Dicrurus hottentottus*) and the range-restricted blue-tailed imperial-pigeon (*Ducula concinna*) were also frequently encountered.

Tagulandang has relicts of primary forest on the slopes and ridges of the central caldera, which has been declared 'hutan lindung' (protected forest) by the local government. Hunting tradition here is well-established, with traps, nets, snares and armed men often encountered in the forest. Abundance of most bird species is now so low that hunters are willing to take costly boat trips to the nearby Ruang. Hierarchical cluster analyses show a similar bird community to Biaro, except for one important exception. Tagulandang hosts perhaps the most significant population of the endangered Siau pitta (*Erythropitta palliceps*), which is also present in small numbers on Siau and possibly Ruang. The species seems tolerant to mature secondary growth and mature plantation, though it is surprisingly unknown to local people, despite its conspicuous plumage. One hunter said that he occasionally caught the bird in his snares, but would release it due to its colourful appearance. It seems that it has not yet been identified as a valuable bird to trade, unlike pittas elsewhere in Indonesia (Shepherd et al., 2015). This is fortunate, as a determined group of trappers could probably clear the small island quite rapidly, extirpating the only sizeable population of the species.

The island of Ruang was evacuated in 2002 due to a large eruption, and many families chose not to return, leaving it with a small human population. However, people from Tagulandang are increasingly using the island for resources, clearing the still-modest natural forest for timber and new plantations. For example, approximately 5 ha of accessible, intact primary forest were found on a scouting trip in June 2015, that by March 2016 had been clear-cut and burned. Selective logging was encountered daily, and fires are frequently set within the forest to clear undergrowth. Despite this, all target species had very high abundances, even close to the villages and plantations. Several species (e.g., pink-necked green-pigeon (*Treron vernans*) and slender-billed cuckoo-dove) were seen courting and nesting on the barren peak, where locals rarely visit and are unlikely to disturb them. A large flock of pied imperial-pigeon (*Ducula bicolor*) feed on the slopes during the day, then return to the nearby mangrove island of Pasige to roost. Curiously, three species present on nearby Tagulandang are completely absent on Ruang—black-naped oriole, hair-crested drongo and blue-tailed imperial-pigeon—despite better habitat quality and lower hunting pressure. There are two potential explanations for this. Firstly, Ruang is grouped with the smaller Sangihe islands in the dendrograms (Fig. 2), so may be below the threshold for island size (c. 14 km^2) for these three species. Alternatively, they may have been present before a cataclysmic eruption in 1871, whereby Hickson (1889) reported "the whole of the forest on the Ruang was completely destroyed". If this is the case, it is interesting that these species have still not recolonised from Tagulandang, which is only separated by approximately 1 km of water.

Siau, Makalehi, and Kahakitang, Sangihe. Almost every accessible part of Siau has been converted to agriculture or an agro-forestry matrix, where in places the plantation is mixed with mature secondary forest. One exception to this is the protected forest on Mount Tamata, the peak of which

Table 1. Summarised checklist of species for islands visited. **Bi** = Biaro; **Ru** = Ruang; **Ta** = Tagulandang; **Si** = Siau; **Mk** = Makalehi; **Kh** = Kahakitang; **Kb** = Kabaruang; **Sa** = Salibabu; **Ml** = Malo; **Mn** = Mangupung; **Kr** = Karatung; **Mr** = Marampit; **Ga** = Garat. **R** = Reported by Riley (1997), and perhaps still present or visiting outside of the study period. **E** = Probably extirpated, though previously reported by Riley (1997) and/or locals. At the base of the table are the target species richness estimations using EstimateS (Colwell, 2013) for the nine smaller islands, and the total number of all species detected. The target species from the nine islands are indicated by an asterisk in the Species column.

Species (del Hoyo et al., 2017) **NT** = Near-threatened; **VU** = Vulnerable; **EN** = Endangered; **CR** = Critically endangered (IUCN, 2017).		**Endemic Subspecies**	**Sangihe**						**Talaud**			**Nanusa**			
			Bi	**Ru**	**Ta**	**Ma**	**Si**	**Kh**	**Kb**	**Sa**	**Ml**	**Mn**	**Kr**	**Mr**	**Ga**
Philippine scrubfowl *(Megapodius cumingii)**		*talautensis*							×	×	×	×	×	×	×
		sanghirensis	×	×	×	×	×	×							
Little grebe *(Tachybaptus ruficollis)*						×									
Rock dove *(Columba livia)*							×						×		
Metallic pigeon *(Columba vitiensis)**											×	×	×	×	×
Eastern spotted dove *(Spilopelia chinensis)*			×	×	×	×	×	×	×	×	×		×		
Slender-billed cuckoo-dove *(Macropygia amboinensis)**		sanghirensis	×	×	×		×	×	×	×	×	×	×	×	×
Zebra dove *(Geopelia striata)**													×		
Nicobar pigeon *(Caloenas nicobarica)**	**NT**												×		×
Emerald-dove sp. *(Chalcophaps sp.)** (see discussion)									×	×	×	×	×	×	×
Grey-capped emerald-dove *(Chalcophaps indica)**			×	×	×	×	×	×							
Pink-necked green-pigeon *(Treron vernans)**			×	×	×	×	×	×	×	×					
Grey-checked green-pigeon *(Treron griseicauda)*		*sangirensis*					×								
Blue-tailed imperial-pigeon *(Ducula concinna)**			×		×		×								
Pied imperial-pigeon *(Ducula bicolor)**			×	×	×	×	×	×							
Green imperial-pigeon *(Ducula Aenea)*		*intermedia*							×	×					
Grey imperial-pigeon *(Ducula pickeringii)**	**VU**	*palmasensis*									×	×	×	×	×

Species (del Hoyo et al., 2017) **NT** = Near-threatened; **VU** = Vulnerable; **EN** = Endangered; **CR** = Critically endangered (IUCN, 2017).	**Endemic Subspecies**	**Sangihe**					**Talaud**			**Nanusa**				
		Bi	**Ru**	**Ta**	**Ma**	**Si**	**Kh**	**Kb**	**Sa**	**Ml**	**Mn**	**Kr**	**Mr**	**Ga**
Black-naped fruit-dove *(Ptilinopus melanospilus)**		×	×	×	×	×	×	×	×	×	×	×	×	×
Swiftlet species *(Collocalia/ Aerodramus)*				×		×	×	×	×					
Lesser coucal *(Centropus bengalensis)*		×	×	×	×	×	×	×	×					
Western koel *(Eudynamys scolopaceus)**		×	×	×		×	×	×	×	×	×	×	×	×
Channel-billed cuckoo *(Scythrops novaehollandiae)**		×	×	×	×	×	×		×					
Oriental cuckoo *(Cuculus saturatus)*			×						R					
Pale-vented bush-hen *(Amaurornis moluccana)*						×								
White-breasted waterhen *(Amaurornis phoenicurus)*					×	×		×				×		
White-browed crake *(Amaurornis cinerea)*					×									
Barred rail *(Hypotaenidia torquata)*			×	×		×	×							
Slaty-legged crake *(Rallina eurizonoides)*			×	×		×								
Red-necked crake *(Rallina tricolor)**										×	×	×	×	
Schrenck's bittern *(Ixobrychus eurhythmus)*									R					
Malay night-heron *(Gorsachius melanolophus)*									R					
Rufous night-heron *(Nycticorax caledonicus)*									R					
Green-backed heron *(Butorides striata)*		×												
Great-billed heron *(Ardea sumatrana)*						×								
Great white egret *(Ardea alba)*				×										

Species (del Hoyo et al., 2017) **NT** = Near-threatened; **VU** = Vulnerable; **EN** = Endangered; **CR** = Critically endangered (IUCN, 2017).	**Endemic Subspecies**	**Sangihe**					**Talaud**			**Nanusa**				
		Bi	**Ru**	**Ta**	**Ma**	**Si**	**Kh**	**Kb**	**Sa**	**Ml**	**Mn**	**Kr**	**Mr**	**Ga**
Intermediate egret *(Ardea intermedia)*					×	R								
Pacific reef-egret *(Egretta sacra)*		×	×	×		×	×		×	×	×	×	×	×
Oriental darter *(Anhinga Melanogaster)*	**NT**					×			×					
Lesser frigatebird *(Fregeta ariel)*		×			×	×	×							
Brown booby *(Sula leucogaster)*					×				R					
Grey plover *(Pluvialis squatarola)*									R					
Pacific golden plover *(Pluvialis fulva)*				×		R								
Little ringed plover *(Charadrius dubius)*		×												
Malay plover *(Charadrius peronii)*				×										
Greater sandplover *(Charadrius leschenaultii)*									R					
Whimbrel *(Numenius phaeopus)*									R					
Black-tailed godwit *(Limosa limosa)*									R					
Common sandpiper *(Actitis hypoleucos)*						×			R					
Grey-tailed tattler *(Tringa brevipes)*				×		R			R					
Bridled tern *(Onychoprion anaethetus)*									R					
Little tern *(Sternula albifrons)*									R					
White-winged tern *(Chlidonias leucopterus)*									R					
Black-naped tern *(Sterna sumatrana)*				×		R								
Common tern *(Sterna hirundo)*									R					
Tyto sp. *(Tyto rosenbergii?)*						×								
Northern boobook *(Ninox japonica)*			×	×	×	×								

Species (del Hoyo et al., 2017) **NT** = Near-threatened; **VU** = Vulnerable; **EN** = Endangered; **CR** = Critically endangered (IUCN, 2017).		**Endemic Subspecies**	**Sangihe**					**Talaud**				**Nanusa**				
			Bi	**Ru**	**Ta**	**Ma**	**Si**	**Kh**	**Kb**	**Sa**	**Ml**	**Mn**	**Kr**	**Mr**	**Ga**
Siau scops-owl *(Otus siaoensis)*	**CR**	endemic species					E								
Osprey *(Pandion haliaetus)*			×				R								
Chinese sparrowhawk *(Accipiter soloensis)*							×								
Japanese sparrowhawk *(Accipiter gularis)*							×								
Brahminy kite *(Haliastur indus)*			×	×	×	×	×		×	×					
Grey-faced buzzard *(Butastur indicus)*							R								
White-bellied sea-eagle *(Haliaeetus leucogaster)*			×	×			×			R		×			×
Rainbow bee-eater *(Merops ornatus)*			×		×		×								
Oriental dollarbird *(Eurystomus orientalis)*					×										
Ruddy kingfisher *(Halcyon coromanda)*					×		×	×							
Talaud kingfisher *(Todiramphus enigma)*									×	×					
Collared kingfisher *(Todiramphus chloris)**			×	×	×		×	×	×	×	×	×	×	×	×
Sacred kingfisher *(Todiramphus sanctus)*			×		×	×		×	×	R					
Spotted kestrel *(Falco moluccensis)*				×			×								
Peregrine falcon *(Falco peregrinus)*							R								
Red-and-blue lory *(Eos histrio)*	**EN**								×	×					
Golden-mantled racquet-tail *(Prioniturus platurus)*		*talautensis*					E		×	×					
Great-billed parrot *(Tanygnathus (megalorynchos)**			×		E		×			R					
Blue-naped parrot *(Tanygnathus lucionensis)*	**NT**	*talautensis*								×					

Species (del Hoyo et al., 2017) **NT** = Near-threatened; **VU** = Vulnerable; **EN** = Endangered; **CR** = Critically endangered (IUCN, 2017).		**Endemic Subspecies**	**Sangihe**					**Talaud**			**Nanusa**				
			Bi	**Ru**	**Ta**	**Ma**	**Si**	**Kh**	**Kb**	**Sa**	**Ml**	**Mn**	**Kr**	**Mr**	**Ga**
Blue-backed parrot *(Tanygnathus sumatranus)*		*sangirensis*							×	×					
Talaud pitta *(Erythropitta inspeculata)*	**VU**	endemic species							×	×					
Siau pitta *(Erythropitta palliceps)*	**EN**	endemic species		×	×		×								
Nanusa pitta *(Erythropitta sp.)** (see discussion)		unknown										×	×	×	
Elegant pitta *(Pitta elegans)*							×	×							
Barn swallow *(Hirundo rustica)*							×			R					
Pacific swallow *(Hirundo tahitica)*			×	×	×	×	×	×	×	×	×	×	×	×	×
Yellow wagtail *(Motacilla flava)*							×			R					
Grey wagtail *(Motacilla cinerea)*							R			R					
Sulawesi cicadabird *(Coracina tenuirostris)*		sanghirana							×	×					
Pied iriller *(Lalage nigra)*													×		
Blue rock-thrush *(Monticola solitarius)*							R			R					
Grey-streaked flycatcher *(Muscicapa griseisticta)*							R								
Rufous paradise-flycatcher *(Terpsiphone cinnamomea)*		*talautensis*							×	×					
Island monarch *(Monarcha cinerascens)**									×	×	×	×	×	×	×
Island whistler *(Pachycephala phaionota)**		unknown											×	×	
Brown-throated sunbird *(Anthreptes malacensis)*		*heliocalus*					R								
Black sunbird *(Leptocoma sericea)**		*sangirensis* *talautensis*	×	×	×	×	×	×	×	×					

Species (del Hoyo et al., 2017) **NT** = Near-threatened; **VU** = Vulnerable; **EN** = Endangered; **CR** = Critically endangered (IUCN, 2017).	**Endemic Subspecies**	**Sangihe**					**Talaud**			**Nanusa**				
		Bi	**Ru**	**Ta**	**Ma**	**Si**	**Kh**	**Kb**	**Sa**	**Ml**	**Mn**	**Kr**	**Mr**	**Ga**
Olive-backed sunbird *(Cinnyris jugularis)**			×	×		×			R					
Grey-sided flowerpecker *(Dicaeum celebicum)**	*sanghirense*	×	×	×		×	×							
	talautense							×	×					
Lemon-bellied white-eye *(Zosterops chloris)**										×	×	×	×	×
Black-naped oriole *(Oriolus chinensis)**	*melanisticus*							×	×					
	Formosus	×		×		×								
Brown shrike *(Lanius cristatus)*						R								
Hair-crested drongo *(Dicrurus hottentottus)**		×		×		×								
Slender-billed crow *(Corvus enca)**		×	×	×	×	×	×							
Asian glossy starling *(Aplonis panayensis)**	*sanghirensis*	×	×	×	×	×	×		R			×	×	
Black-faced munia *(Lonchura molucca)*						R								
Eurasian tree sparrow *(Passer montanus)*		×	×	×	×	×	×	×	×			×	×	

	Sangihe					**Talaud**			**Nanusa**				
	Bi	**Ru**	**Ta**	**Mk**	**Si**	**Kh**	**Kb**	**Sa**	**Ml**	**Mn**	**Kr**	**Mr**	**Ga**
Target species observed—Resident, using natural forest habitat and detected < 50 m from observer.	13	14	–	7	–	12	–	–	11	12	15	13	10
Target species estimate—Expected number of target species from reference sample (rarefaction and extrapolation).	13	14	–	7	–	12	–	–	11	12	15	13	11
ACE Mean—Abundance Coverage-based Estimator of target species (mean among runs).	13	14	–	7	–	12	–	–	11	12	15	13	11
Bias-corrected Chao 1 richness estimator (mean among runs).	13	14	–	7	–	12	–	–	11	12	15	13	11
Total number of species detected	30	27	37	22	47	24	27	29	14	15	23	17	14

is possible to access from the North. The slopes of Mount Tamata host small numbers of Siau Pitta (only recorded once), blue-tailed imperial-pigeon, and great-billed parrot, none of which were recorded elsewhere on the island during the study. Lake Kepetta is also an interesting site for avifauna, despite being largely cleared of forest since the time of Riley (1997). Here a new record for Sangihe-Talaud was made, the near-threatened oriental darter (*Anhinga melanogaster*), as well as two new records for the Sangihe Archipelago, the pale-vented bush-hen (*Amaurornis moluccana*) and white-breasted waterhen (*Amaurornis phoenicurus*), and a new record for Siau, a *Tyto* species. This is most likely to be the Sulawesi masked-owl (*Tyto rosenbergii*), which has already been recorded on Sangir Besar, though the Minahassa masked-owl (*T. inexspectata*) is also a possibility. Two individuals were heard near Lake Kepetta, as well as a single individual on a plantation near Laghaeng.

Four resident species previously recorded on Siau (Riley, 1997) were not encountered: Brown-throated sunbird (*Anthreptes malacensis*); black-faced munia (*Lonchura molucca*); and golden-mantled raquet-tail (*Prioniturus platurus*). The latter is most likely extirpated, as there have been no recent reports. Most importantly, there was no evidence for the continued existence of the island-endemic and critically endangered Siau scops-owl (*Otus siaoensis*), which has not been recorded since the holotype was collected in 1866 (IUCN, 2017). Efforts made to locate the species included interviewing locals, setting mist-nests and actively searching potential habitat. However, satellite imagery does show a tiny, unsurveyed remnant of primary forest on the northern slope of the Karangetang volcano. This is probably only accessible by boat, and could be a potential refuge for any of these species.

The small island of Makalehi is formed by a caldera containing a large freshwater lake, with some degraded forest remaining on the ridge and outer slopes. Bird abundance here is very low, except for the ubiquitous black sunbird and Philippine scrubfowl. Apparently, pied imperial-pigeon used to roost here in large numbers while feeding on Siau during the day, until recent systematic trapping decimated their numbers. The lake itself is still of interest, as it harbours a resident population of little grebe (*Tachybaptus ruficollis*), a first record for Sangihe-Talaud. White-browed crake (*Amaurornis cinerea*) is also present, a first record for the Sangihe Archipelago, while the white-breasted waterhen found was typical of the Philippines subspecies (*A. p. leucomelana*), not the Sulawesi subspecies (*A. p. phoenicurus*).

The natural forest remaining on Kahakitang is mostly mature secondary, though some large trees remain on isolated slopes and along rocky stream beds. The most interesting finding here was the elegant pitta (*Pitta elegans*), with three individuals heard in two locations, 16–17 July 2016. A single individual was also recorded at Lake Kepetta on Siau in May 2016. *P. e. elegans* has already been reported as a non-breeding visitor to the Sangihe islands from Timor (Eaton et al., 2016), and indeed the vocalisations of this subspecies are a close match. From Kahakitang it was planned to visit the nearby island of Kalama, but high winds made the crossing dangerous at the time. Satellite images (Google Earth v7) show that a reasonable area of natural forest remains on the southern and eastern slopes, probably only accessible by boat. If any of the Sangihe endemics are to be found away from Sangir Besar, then Kalama could be the last promising location to investigate, given its close proximity.

Salibabu and Kabaruang, Talaud. Salibabu and Kabaruang are consistently grouped together in the hierarchical cluster analyses, and have almost identical avifaunal assemblages. Neither have the large tracts of primary forest present on the main Talaud island, Karakelang. As such, the forest-dependent and endemic Talaud rail (*Gymnocrex talaudensis*), as well as the endemic Talaud bush-hen (*Amaurornis magnirostris*) appear to be absent. All of the coastal and flat areas have been converted to plantation, though both islands do retain some primary forest in the hilly centres. In the case of Salibabu, this is patchy and highly degraded, and mostly around the highest point of Bukit Ayambana. The primary forest on Kabaruang is slightly more intact, particularly in the Bukit Towo area.

Three species endemic to Talaud were found to be present on both islands. Two individuals of red-and-blue lory were recorded on both Bukit Ayambana and Bukit Towo respectively. It is possible that these individuals dispersed from Karakelang, that they were once captive birds, or that remnant, permanent populations do persist. The endemic, near-threatened Talaud kingfisher (*Todiramphus enigma*) and vulnerable Talaud pitta (*Erythropitta inspeculata*) are relatively common on both islands. The Talaud kingfisher occurs in plantation and forest away from the coastal areas (where it is replaced by the collared kingfisher [*Todiramphus chlori*] and the seasonal sacred kingfisher [*Todiramphus sanctus*]) while the Talaud pitta favours dense plantation or forest. The blue-backed parrot (*Tanygnathus sumatranus*) was also detected on both islands, as was the Talaud-endemic subspecies of golden-mantled raquet-tail (*Prioniturus platurus talautensis*). While the former appears to be rare, the latter was detected in every forest visited, as well as plantations and at forest borders.

Hunting pressure seems to be very high on both islands, indicated by low numbers of the imperial-pigeon species, which are targeted for meat and the wild pet trade. Only one individual of green imperial-pigeon (*Ducula aenea*) was recorded during the entire study, at Bukit Towo, Kabaruang, while other species (pied imperial-pigeon and grey imperial-pigeon) were reported by locals but not detected. Despite the continued presence of some endemics, overall bird abundance is low, and it is difficult to recommend allocating any conservation resources here as opposed to the current efforts focusing on Karakelang (Burung Indonesia, 2017). There are however two findings of potential biogeographic interest. First is the absence of the Everett's white-eye (*Zosterops everetti*), which is normally abundant and tolerant to disturbance, suggesting only a recent colonisation of this species to Karakelang from the Philippines. Second is the

appearance of the emerald-dove (*Chalcophaps*) observed on both Talaud and Nanusa, which lacked the grey cap of the grey-capped emerald-dove (*Chalcophaps indica*). The most likely explanation is that all of those seen (at least six individuals) were immature and have yet to develop the cap, or that some adults in this population never do. Less likely is that these are the brown-capped emerald-dove (*Chalcophaps longirostris*), which would be quite a biogeographic oddity as they are not known from the surrounding landmasses (del Hoyo et al., 2017).

Nanusa, Talaud. Of the seven Nanusa islands, only three are permanently inhabited: Karatung, Marampit, and Kakorotan. Holthuis & Lam (1942) reported that Nanusa was completely deforested, except for the island of Garat. This is certainly not true today, and it is likely that they were unable to see remaining mature forest from the coasts of the two islands they visited (Karatung and Marampit). Significant areas of the islands have been converted to coconut plantation, but patches of selectively logged primary forest of 30–120 ha remain, mostly in areas where rugged coral formations and crevices make such conversion difficult. Karatung has a small patch of mature forest that suffers occasional logging and moderate hunting pressure, but nonetheless appears to host the highest species richness of the Nanusa archipelago (Table 1). Marampit is the largest island with the highest human population (Badan Pusat Statistik, 2017), and retains mature forest in the north-east. The small island of Kakorotan has been completely deforested and converted to plantation, and the residents now travel to Malo or Mangupung to harvest timber and create new plantations. The mature forest on Malo is being rapidly logged due to its closer proximity, while the forest on Mangupung appears to be recovering due to its distance from Kakorotan and an increase in fuel prices. The most pristine forest remaining is on the island of Garat, all of which has been declared 'forbidden' by the local government on Karatung, and is allegedly off-limits for logging and settlements. Despite this, a small house has been built on the southern shore as a base for fishing and harvesting coconut crabs (*Birgus latro*), and occasional signs of logging can be seen along the coast. This is apparently caused by residents from Daempolis village on the west coast of Marampit, which is a point of contention with other villages.

While Garat has the largest, least-disturbed area of primary forest, it appears to have the lowest species richness of all the Nanusa islands, followed by Malo (Table 1). The island whistler (*Pachycephala phaionota*) and a pitta species (*Erythropitta* sp.) occur on Marampit and nearby Karatung, and the latter also on Mangupung, but neither on Garat nor Malo. The most likely reasons are the youth of the islands and their distance from Marampit (Fig. 1), which has the only high ground of Nanusa at 148 m. Neither Garat or Malo reach heights of much more than 15 m, while coral terraces can be seen on Marampit at 75 m (Holthuis & Lam, 1942). Sea levels have dropped by just 4 m since the Mid-Holocene High Stand, 6,000 years ago (Woodroffe & Horton, 2005), but tectonic changes are much faster than eustatic changes in many parts of eastern Indonesia (e.g., Sumosusastro et al., 1989). It is therefore likely that the lower Nanusa islands only emerged in the last few thousand, or tens of thousands of years (Robert Hall, Personal Communication, 2017) based on regional uplift rates. Even above sea level, the lowest islands would still have been at risk of local extinctions by natural disasters. Two tsunamis are known to have occurred in the area, one in 1628 (Satria, 2016), and another in 1917 that destroyed a land bridge between Kakorotan and Intata (Reppie, 2015).

Only two published accounts of Nanusa by naturalists could be found, both of which are dismissive of the islands and were without detailed investigation (Hickson, 1889; Holthuis & Lam, 1942). As such the avifauna of Nanusa has never been commented on, though it is surprisingly different from Karakelang, the nearest island of Talaud. The Nanusa islands are separate from all other Sangihe-Talaud islands in the cluster analyses (Fig. 2), even those of a similar size, indicating a unique assemblage that may be a result of their recent emergence. Areas of mature forest are dominated by high densities of grey imperial-pigeon (*Ducula pickeringii*), particularly on Garat. This species is both range-restricted and vulnerable, and the Nanusa population could be important for its survival. The second abundant, large frugivore is the metallic pigeon (*Columba vitiensis*) most closely resembling the Moluccan subspecies *C. v. halmaheira*, which is only rarely seen on Talaud (Riley, 1997). The near-threatened Nicobar pigeon (*Caloenas nicobarica*) is present but in very low numbers, and was only detected on the islands of Karatung and Garat. It is both an easy target (being largely terrestrial—del Hoyo et al., 2017) and an attractive bird to keep as a pet, and locals report killing or trapping it in large numbers in the past. The only other published record for Nicobar pigeon in Sangihe-Talaud comes from 1879, when it was apparently common in Sangir Besar and Siau (Riley, 1997), though it has since been reported by locals on Karakelang (Riley, 2003).

With no sunbirds or flowerpeckers present, the only small passerine is the lemon-bellied white-eye (*Zosterops chloris*), a first record for Sangihe-Talaud. The vocalisation requires further investigation to establish if it is typical of the nearest subspecies, *Z. c. chloris*. If not, the Nanusa population (which is common in all habitat types on all islands) could represent a new subspecies. Another surprising passerine is what appears to be the island whistler, a first record both for Sulawesi and west of Weber's Line, with the nearest known distribution on small islands in north Maluku (del Hoyo et al., 2017). Differences from previously described and photographed individuals of island whistler include a darker ochre breast (as opposed to light ochre/grey), and a dark brown as opposed to slaty-grey head (see Fig. 3). It seems that there are no previous sound recordings of the island whistler, so it is unknown if the vocalisations recorded on Nanusa are typical of the species. A nest was found at 1 m from the ground with a single egg (see Fig. 3), while the single other report for the species is of 2 eggs in a nest at 2 m (del Hoyo et al., 2017). The whistler was only found to be present on the two central islands, Karatung and Marampit. Another new record for Sulawesi is the red-necked

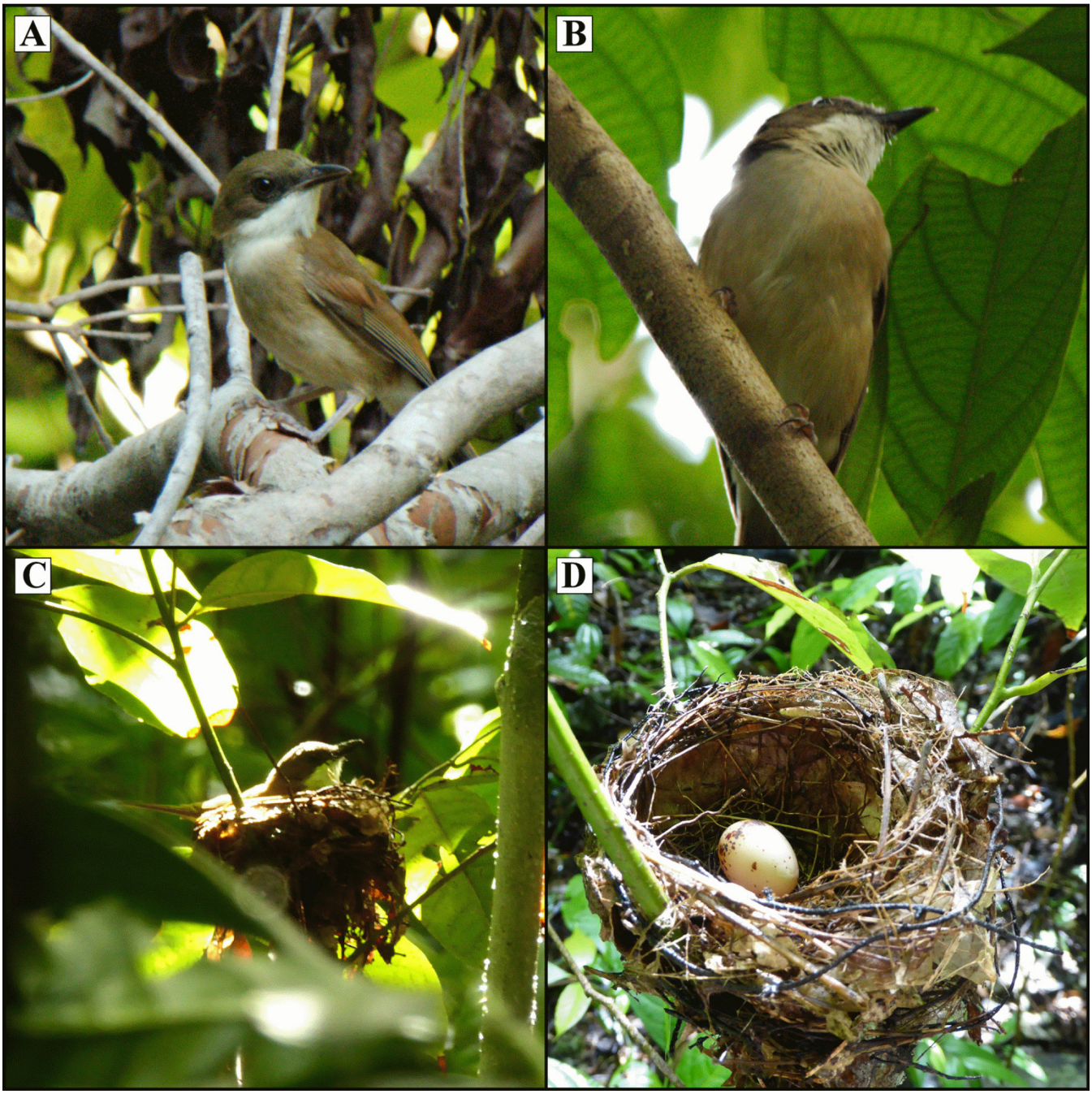

Fig 3. Island Whistler (*Pachycephala phaionota*). A, Individual 1, Karatung, 30 June 2016; B, Individual 2, Marampit, 26 June 2016; C, Individual 3, 26 June 2016; D, Nest and egg of individual 3, Marampit, 26 June 2016.

crake (*Rallina tricolor*), with the closest known population on Moratai (Eaton et al., 2016). It was most frequently encountered in primary and secondary forest on Karatung and Mangupung, and occasionally on Marampit and Malo.

In light of the recent splitting of the red-bellied pitta species-complex (Irestedt et al., 2013), the presence of one that does not resemble the nearby Talaud species (*E. inspeculata*) is of great interest. Most strikingly, the Nanusa Pitta is bright green on the upper/mid-back and shoulders, compared to the uniform blue of the Talaud Pitta. Other differences include an occasional white marking on the outer greater-coverts, a bright yellowish-white stripe on the cap, a more reddish nape, and on some individuals a very dark, almost black face, fading to light brown on the cheeks. Two other possible species are the Moluccan pitta (*Erythropitta rufiventris*) and Philippine pitta (*Erythropitta erythrogaster*), of which the latter has a more superficial resemblance due to the presence of a black bib. Clearly more work is needed for proper classification of this population, which is restricted to small areas of natural forest (primary and mature secondary) only on the central islands of Karatung, Marampit, and Mangupung.

Conclusion. This study shows that important avifaunal discoveries remain in Indonesia, and that the conservation value of islands should not be dismissed due to their small size or inaccessibility. In the case of Sangihe-Talaud, it is likely that several discoveries remain, and there is potential for important conservation work at the species and island level. Conversion and degradation of habitat are continuing

at a rapid pace, and the wild pet trade on many islands is just as rife as elsewhere in Indonesia (e.g., Harris et al., 2016). This necessitates urgent action to describe the potential new taxa mentioned in this study, and develop action plans before they can disappear.

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