2ND DANJUGAN ISLAND BIODIVERSITY SURVEY (TERRESTRIAL)

A COLLABORATIVE PROJECT BETWEEN
THE PHILIPPINE REEF AND RAINFOREST
CONSERVATION FOUNDATION, INC (PRRCFI)
AND CORAL CAY CONSERVATION (CCC)

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I. Acknowledgments

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Finally we would like to thank the CCC staff for carrying out the terrestrial programme and the support of the volunteers.

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III. Summary

This report outlines the results of the terrestrial biodiversity survey programme that was conducted during the course of a six-week expedition between April and June 2004, on Danjugan Island.

This is the second collaborative terrestrial survey programme between Coral Cay Conservation (CCC) and the Philippine Reef and Rainforest Conservation Foundation Inc (PRRCFI) based on Danjugan Island, Philippines. The first terrestrial programme was conducted between June and September 2001 and was the first integrated and quantitative survey of the biodiversity of Danjugan Island (Turner *et al.,* 2002a).

This follow up assessment consolidates previous work from the 2001 project as well as expanding and enhancing the previous data sets. Bird and bat surveys similar to those in 2001 were carried out, allowing results to be compared over the 3-year period and providing for sound comparisons of ecological change. In addition, in depth studies were initiated, focusing on mangrove communities within the lagoons present on Danjugan.

This report presents both survey results of bird and bat fauna and detailed work into the ecological patterns of mangrove distribution across the island's 6 lagoons. Furthermore, detailed assessments of the individuals comprising the mangal community at each lagoon has been made, allowing representative maps of each lagoon and associated mangal communities to be produced. Finally CCC staff set up a mangrove nursery on the island comprising 2000+ seeds of the following species: *Bruguiera gymnorrhiza* and *Xylocarpus granatum*, which is managed by PRRCFI.

The results highlight an increase in the bird inventory record, with several new bird species recorded, including three endemics and two IUCN red listed species; the Pink-bellied Imperial-Pigeon (*Ducula poliocephala*) and the Rufous-lored Kingfisher (*Halcyon winchelli*). Bat species identified included all previously known and recorded species. Mangrove research identifies age classes and dominant species and species distribution mapping of each lagoon.

The results of the latest work confirm that Danjugan Island is an important site for mangrove communities and a vital refuge for many endemic and threatened bird species. These new survey results support previous results, contributing seven new bird species records to the island. Additionally previous results highlighted that the island is of national and global importance for certain bat species for example *Pteropus pumilus*. These issues are discussed in the context of the conservation value of the island and the need for further research to ensure sustainable management of the island.

1. Introduction

1.1 The Philippines

With more than 52,177 described species, of which more than half are found nowhere else in the world, the Philippine archipelago is one of 17 mega-diversity countries. With less than 6 percent of the country's original forest cover now remaining and 634 species currently recognized by the 2003 IUCN Red List of Threatened Species, the Philippines is categorised as one of the 25 global biodiversity hotspots identified (Myers 1988) and one of the few countries to be both a biodiversity hotspot and a mega-diversity region (Philippines Biodiversity Conservation Programme 2004).

Per hectare, the 7000+ islands that make up the Philippines probably harbour more diversity than any other country. However, a growing population coupled with economic and political instability has accelerated habitat and species loss resulting in an unmatched biodiversity crisis in this globally important country (PBCP 2004).

The first steps towards sustainable development and the conservation of biodiversity are the research and understanding of this biodiversity. According to the Protected Areas and Wildlife Bureau (PAWB) of the Department of Environment and Natural Resources (DENR) within the Philippines, the present knowledge of biodiversity in the Philippines is relatively inadequate and acquired mostly from studies done by foreign biologists during the early 1900s (IPAS Final Report DENR).

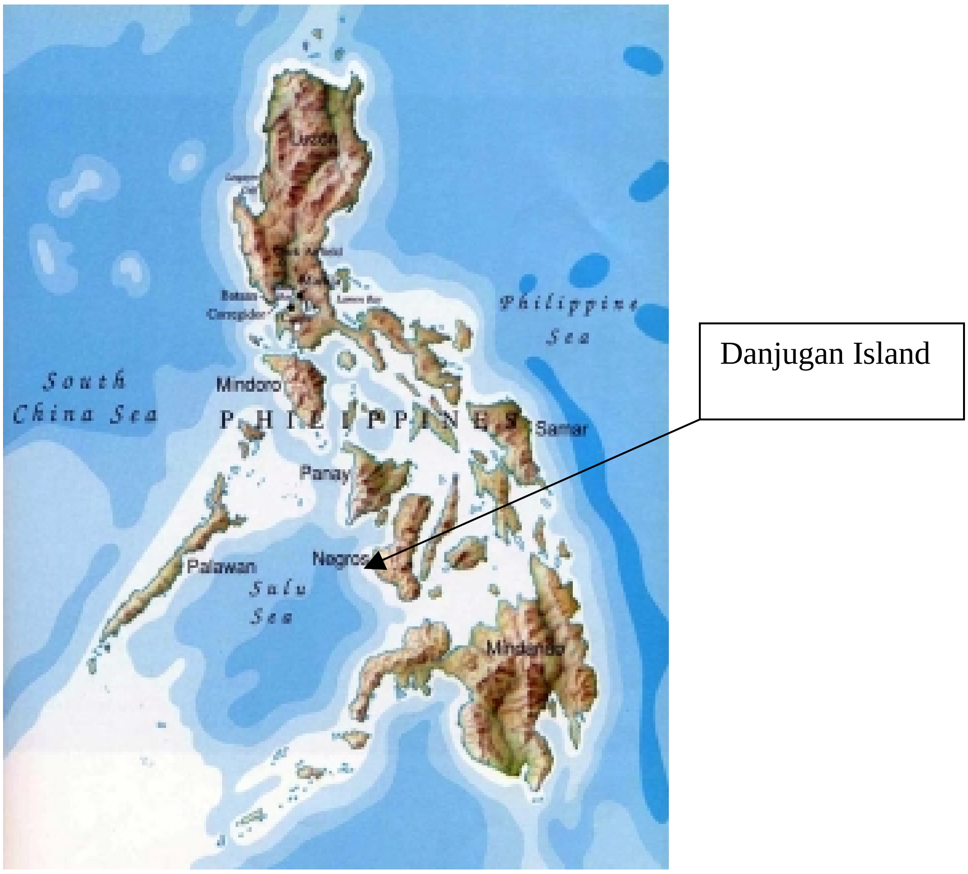

Figure 1.1: Location of Danjugan Island in the Philippines.

1.2 Danjugan Island

The Western Visayas, or Negros Faunal Region, is perhaps the most endangered region within the Philippines. This ecoregion harbours some of the highest levels of endemism, but has suffered a disproportionate share of deforestation, and to compound the problem the area is underrepresented in the national protected area system (Oliver 1996).

Danjugan Island, situated just 3km west of Negros off the coast of Bulata in the Sulu Sea, is a small (approximately 43 hectares) coral fringed island covered in tropical limestone forest. It represents one of the few areas currently under protected status (Danjugan Island Marine Reserve and Sanctuaries (DIMRS) supported by the municipal government of Cauayan and provincial government of Negros Occidental in February 2000) in the Negros Faunal Region.

Danjugan Island's vegetation is still relatively unspoilt and thus supports a range of vegetation communities from mangrove forest to beach scrub and forest over limestone (Turner *et al.,* 2002). The great diversity of vegetation types is due to several parameters, from natural variables such as topography and coastal exposure to human-induced variables such as small-scale logging and clearing for coconut plantations.

Danjugan Island represents an area of high levels of coastal plant diversity and distribution. The diversity of coastal plants in the Philippines is one of the richest in the world (Calumpong & Menez 1996) with approximately sixty to seventy mangrove and associated mangrove species found from twenty-six families. An estimated forty species (from sixteen families) are considered true mangroves (CV-CIRRD 1993; Primavera 2000) which can be defined as those which are restricted to the mangrove community, while associated species may also grow in other habitats (Melana & Gonzales 1996).

However, despite their environmental importance they have suffered considerable degradation in the Philippines because of their relative accessibility and long history of conversion to aquaculture ponds (Primavera 2000). Such conversion in combination with over-exploitation has meant that the Philippines has lost over 70% of it's original mangrove forest (Walters 2000) and fifty percent of the remaining forest cover is considered to be threatened (DENR/UNEP 1997). Danjugan's mangrove communities are therefore considered highly important. However, relatively little is understood about the factors influencing the relative abundance and dominance of even the more common families.

Danjugan Island has 6 lagoons, of which all but one are colonised by mangrove stands. Two of these lagoons (lagoon one on the western side of the island, and lagoon 3 on the eastern side of the island) are open to the sea (see figure 2.1). Abundance and dominance of different mangrove species varies greatly between lagoons. The survey in 2001 (Turner *et al*., 2002) suggested that the underlying causal mechanisms for these observed ecological patterns require further investigation with respect to the role of disturbance and abiotic conditions and of mangrove community structure (King *et al*., 2002).

Research conducted in the first Danjugan Island Biodiversity Assessment (2002) has also documented the importance of both the bird (King *et al.,* In Press) and bat fauna (O'Malley *et al.,* In Press) on the island with two papers currently in press in the Silliman Journal.

1.3 Danjugan Island Terrestrial Surveys

In April 2004, three years after the initial terrestrial assessments, CCC returned to Danjugan Island to implement a six-week follow up terrestrial survey.

Field research focused on four major areas: bird surveys; bat surveys, mangrove ecology and distribution; and lagoon mapping.

The aims of the PRRCFI/CCC project were:

- i) To provide quantitative data regarding the avifauna of the island;
- ii) To consolidate and contribute to species identification of major faunal groups;
- iii) To provide a quantitative analysis of the age structure and community make-up of the mangrove communities at each lagoon;
- iv) To produce accurate maps of each lagoon and associated mangal communities;
- v) Creation of a mangrove nursery.

2. Methods

Ecologically sound forest management, whether for conservation alone or in conjunction with sustainable resource use, will only be successful if the dynamic structure and behaviour of the forest system of interest can be adequately characterised and understood.

Baseline biodiversity surveys (as implemented by CCC) provides an opportunity to assess ecological changes over space and time, and therefore have a central role in many aspects of tropical forest research, conservation and management. All biodiversity baseline surveys completed by CCC are conducted using methods that are globally recognised, robust, peer-reviewed and therefore comparable.

It was proposed that the work conducted on Danjugan would be composed of the following main elements:

1. Bird surveys (consolidation and continual assessment)
2. Bat surveys (consolidation and continual assessment)
3. Habitat mapping of mangrove and associated mangal communities

2.1 Site Location

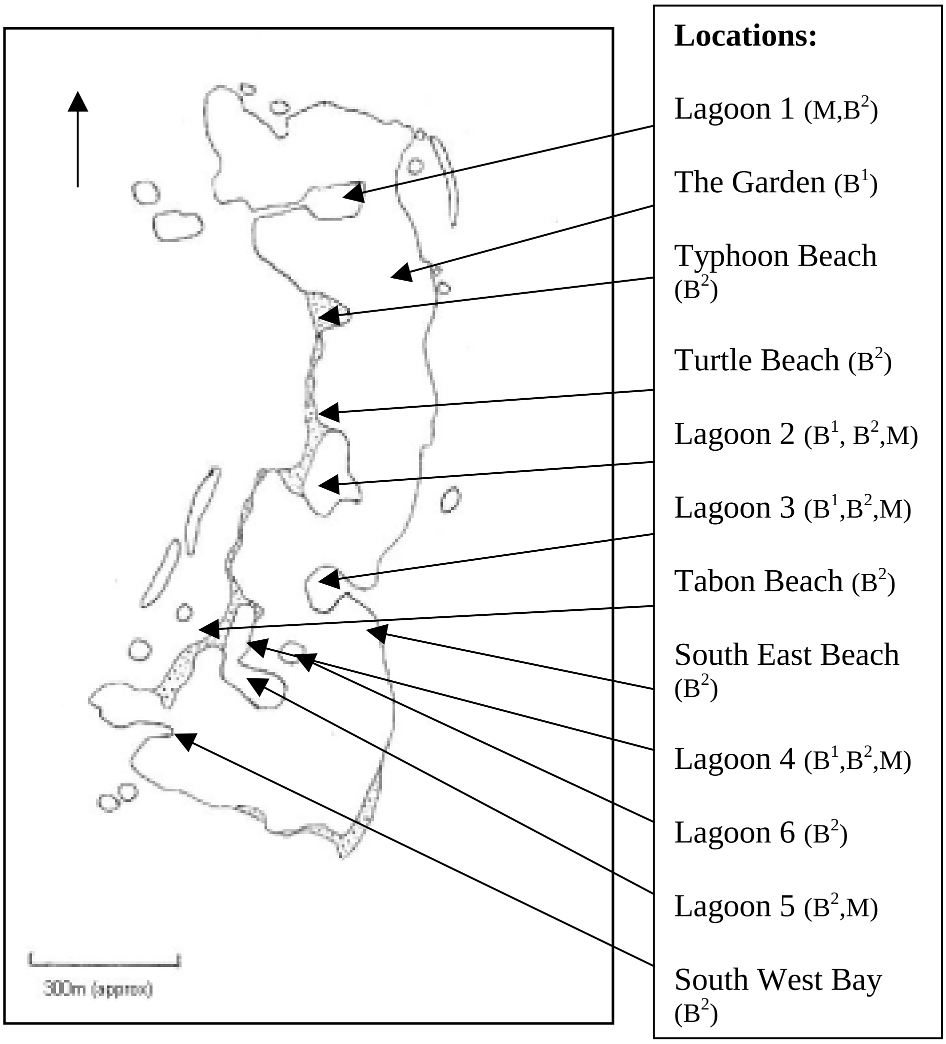

Figure 2.1: Danjugan Island Site Map with survey areas indicated

Where B^1 – Bat survey areas
Where B^2 – Bird survey areas
Where M – Mangrove survey areas.

Habitat types identified during the Phase 1 habitat mapping in 2001 showed variations of habitat type across the island from North to South (Turner *et al*, 2002). Starting in the most Northern point with relative undisturbed *ficus* dominated high forest, to mid-height forest, to more coconut dominated forest inter-dispersed with cultivated gardens. Coastal and cliff forests are also present.

2.2 Bats

Mist Netting

Mist-nets (38mm mesh, 6m x 2.6m) were used at various locations representing different habitat types within the study area. To maximise capture efficiency, nets were established across likely flight-paths such as clearings, along ridges, or by water (Heaney *et al.*, 1989), in a variety of combinations, such as ‘Z’ and ‘T’ formations (Kunz *et al.*, 1996), and at heights ranging from 1m to 10m above the ground. High nets are operated on a pulley system, and where ever possible complemented by a low net positioned on the same pulley system (following Ingle 1993). Nets were opened just before dusk, at 6.30pm and closed at 10pm.

Bats captured were identified using Ingle and Heaney (1992) and Francis (2001), sexed by observation of genitalia and nipples, and aged (to adult or juvenile) by assessment of the ossification of the joints of the digits of the wing. Biometric measurements were obtained using dial calipers. All measurements taken are important for identification purposes.

Mist netting locations included; lagoon 2, lagoon 3, lagoon 4 and the Garden (see figure 2.1). The Garden location is an area of grassy clearings between forested ridges with planted species such as banana and fig.

2.3 Birds

MacKinnon Lists

The bird fauna of Danjugan was surveyed by observation using Mackinnon lists (Mackinnon & Phillips 1993). The observer makes a list of species sighted by recording each new species until a predetermined number of species is reached. Based on preliminary surveys, the list length was set at the advised minimum of 10 species (Bibby *et al.*, 1998). A species can only be recorded once on each list but may be recorded on subsequent lists. Surveys are then repeated until 10 lists are completed at each survey location. Such data then permits the calculation of species discovery curves and an index of relative abundance or detectability (Bibby *et al.*, 1998; Turner *et al.*, 2002).

Ten sites were identified around the island. These were selected to cover the range of vegetation and topographical features of the island. Each of these sites was surveyed throughout the six-week duration of the project.

Table 2.1: Mackinnon List Locations and Habitat Type

*MacKinnon Location	Habitat Type
Lagoon 1	Mangrove lagoon within mid-height forest. *Ficus* abundant
Lagoon 2	Mangrove lagoon within mix of mid-height forest, low forest and with coconut and other fruit tree species
Lagoon 3	Mangrove lagoon within mid-height forest and coconut and secondary re-growth forest
Lagoon 4	Mangrove lagoon within extensive *Pandanus*, low forest and coconut and secondary re-growth
Lagoon 5	Mangrove lagoon within coconut and secondary re-growth forest
Lagoon 6	Mangrove absent lagoon within coconut and secondary re-growth forest
South East Beach	Coastal scrub forest and coconut and secondary re-growth forest
South West Bay	Low forest with 'big leaf legumes' and *Pandanus*
Tabon	Coastal scrub
Turtle Beach	Coastal scrub
Typhoon Beach	Coastal zone surrounded by mid-height forest

*MacKinnon List locations relate to the locations given in Figure 2.1

2.4 Mangroves

The six lagoons within the island were surveyed during the six-week biodiversity assessment period. This involved detailed quantitative assessments of the mangrove communities at each lagoon and their associated mangal communities.

Within each lagoon sample plots were set up at four sites (on north, south, east and west bearings). At each of the sample sites all individuals within a 10 metre radius where analysed. This involved circumference measurements (circumference taken at the top of the root system) and species identification.

Lagoon Mapping

For each lagoon a representative map was established. This was achieved by taking north as zero degrees and moving around the perimeter of the lagoon until reaching 360 degrees (i.e. a complete lagoon was equal to a complete circle). Each lagoon was divided in to distinct sections using natural divisions within the mangrove communtity through visual interpretations. These divisions occurred either where there were no mangrove stands (water present), or where the dominant species or canopy height changed significantly. At each of these changes of division the degrees within the perimeter was noted.

For each defined section the canopy cover and average canopy height was determined. Identification of individuals were made using the available field guides (Calumpong & Menez 1996; Melana & Gonzales 1996; Lovelock, 1964) which then allowed the dominant species and thus the percentage dominance to be determined. In addition, less abundant species were identified, as was the abundance, distribution and average height of saplings within all naturally divided stands. Community composition and age structure analysis could then be determined, illustrating dominance of species in age cohorts.

3. Results

3.1 Bats

A total of four Chiropteran species were recorded on Danjugan Island during this survey period, of which three were Megachiropteran and one Microchiropteran species (Table 3.1). Morphological data was recorded for all species. Results are split in to male, female, adult and juvenile (see Tables 3.3, 3.4, 3.5, 3.6).

Table 3.1: Summary of Mega and Microchiropteran species

Sub order	Family	Species	Location			
			Lagoon 2	Lagoon 3	Lagoon 4	Garden
Megachiroptera	Pteropodidae	*Cynopterus brachyotis*	8	11	-	33
Megachiroptera	Pteropodidae	*Eonycteris spelaea*	72	57	5	5
Megachiroptera	Pteropodidae	*Pteropus pumilus*	13	-	-	4
Microchiroptera	Emballonuridae	*Saccolaimus saccolaimus*	1	-	-	-

Net effort was calculated (Table 3.2) for each mist netting location. The highest diversity of megachiropteran species was found in Lagoon 2, with all species being present. Lagoon 2 also proved to be the only location in where the microchiropteran was caught. Lagoon 4 had the lowest diversity of chiropterans. *E spelaea* accounted for the majority of chiropterans caught at all locations but does show a high variation in the catch rates across the survey sites.

Table 3.2: Bats captured per 100 net-effort units during survey
(1 net-effort unit = 1 hour per square metre of net)

Location	Lagoon 2	Lagoon 3	Lagoon 4	Garden
Net Effort Units	1248	1248	374.4	1166.1
Cynopterus brachyotis	0.64	0.88	-	2.83
Eonycteris spelaea	5.77	4.57	1.34	0.43
Pteropus pumilus	1.04	-	-	0.34
Saccolaimus saccolaimus	0.08	-	-	-
Total	7.53	5.45	1.34	3.60

Table 3.3: Adult Female Morphological Data

Species	Statistical Measures	Mass (g)	Forearm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)	Body length (mm)
C. brachyotis	mean	32.91	63.81	13.58	13.02	6.29	80.71
	St.dev	4.41	2.08	1.23	1.43	1.66	4.53
	range	28-40	60.8-67	11.5-15.2	11.1-15.4	3.2-8.4	75-89
	n	11	14	14	12	12	14
E. spelaea	mean	52.25	69.48	15.16	16.45	14.00	93.71
	St.dev	16.97	5.45	2.85	2.82	3.90	11.86
	range	26-89	57.6-80.1	6.1-19.6	11.6-23.1	5.0-21.0	65.6-109.6
	n	15	20	20	20	20	20
P. pumilus	mean	155	104.5	22.6	31.7	-	128
	St.dev	-	-	-	-	-	-
	range	-	-	-	-	-	-
	n	1	1	1	1	-	1

Table 3.4: Adult Male Morphological Data

Species	Statistical Measures	Mass (g)	Forearm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)	Body length (mm)
C. brachyotis	mean	31.17	59.84	13.88	14.08	6.11	77.82
	st.dev	2.62	7.31	2.40	2.91	2.47	4.49
	range	26-34	41-65.7	9.8-16.9	11.2-22.5	3.4-11.1	69.4-84.3
	n	11	11	11	11	11	11
E. spelaea	mean	59.75	72.47	15.76	17.21	14.30	95.58
	st.dev	18.16	7.89	2.59	2.86	3.30	12.17
	range	28-98	55.5-92.6	10.1-20.9	13.6-24.9	2.6-19.3	70.1-119.9
	n	29	33	33	33	33	33
P. pumilus	mean	174.17	108.52	20.17	33.13	-	145.37
	st.dev	23.03	1.88	1.64	1.64	-	4.28
	range	131-191	106.3-111.2	18.2-22.9	30-34.3	-	138.6-151
	n	6	6	6	6	-	6
S. saccolaimus	mean	-	65.1	13.4	15.6	12.6	91.1
	st.dev	-	-	-	-	-	-
	range	-	-	-	-	-	-
	n	-	1	1	1	1	1

Table 3.5: Juvenile Female Morphological Data

Species	Statistical Measures	Mass (g)	Forearm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)	Body length (mm)
C. brachyotis	mean	33.75	61.56	12	12.82	7.34	77.2
	st.dev	6.75	5.01	4.27	2.77	3.47	6.53
	range	28-41	68.2	4.4-14.6	8.4-16	4.1-11.2	71-87.8
	n	4	5	5	5	5	6
E. spelaea	mean	31.5	60.81	14.92	16.5	11.88	74.80
	st.dev	10.24	4.32	1.90	1.77	2.25	9.28
	range	16.5-60	54.4-70.3	10.6-19.5	13-20.2	6.4-16.5	61.6-99.9
	n	23	23	23	23	23	23
P. pumilus	mean	147	100.3	19.9	32.4	-	146
	st.dev	-	-	-	-	-	-
	range	-	-	-	-	-	-
	n	1	1	1	1	-	1

Table 3.6: Juvenile Male Morphological Data

Species	Statistical Measures	Mass (g)	Forearm (mm)	Ear (mm)	Hind foot (mm)	Tail (mm)	Body length (mm)
C. brachyotis	mean	28.64	63.61	13.76	13.21	5.94	82.96
	st.dev	6.93	3.88	2.57	2.11	3.59	8.88
	range	15-36	57.1-68.2	11.3-19.4	10.4-17	3.7-14	62.1-96.1
	n	9	10	10	10	7	11
E. spelaea	mean	33.98	62.10	14.71	16.22	12.75	77.81
	st.dev	9.93	6.25	1.95	2.09	2.68	9.44
	range	13-76	49.7-76.1	9.4-19.3	10.7-19.7	6.6-19.4	52.4-96.4
	n	52	54	55	55	55	55
P. pumilus	mean	116.25	93.9	19.7	28.73	-	123.78
	st.dev	16.88	4.41	4.31	3.26	-	7.23
	range	101-150	89.4-100	15.5-29	23.9-33.4	-	112-136.3
	n	8	8	8	8	-	9

3.2 Birds

Species discovery curves were calculated for each survey location by plotting the number of lists completed against the cumulative total number of species per survey location (Figure 3.1).

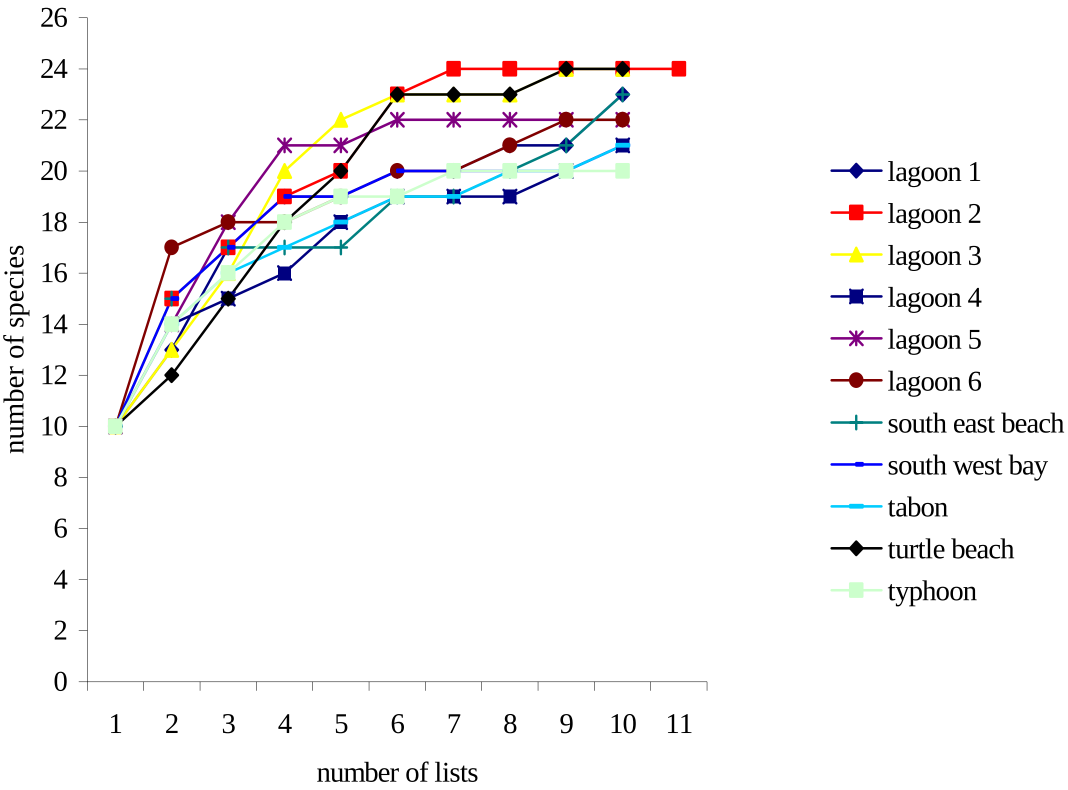

Figure 3.1: Species accumulation curves for each survey location

Species discovery curves (Figure 3.1) indicate similar rates of discovery at each location with plateaus forming in more than one site location. Plateaus indicate that new species discovery is unlikely to a certain degree.

An Index of Relative Detectability (IRD) was determined for each species by calculating the proportion of lists on which each species appears at each location, thus the index can vary between 0 (species not recorded) to 1 (species recorded on every list). The term 'index of detectability' has been used rather than the standard 'index of relative abundance' as the frequency of a species occurring on a list is dependent on several factors, of which abundance is only one.

The IRD values varied between species and species location (Table 3.7). Several species were found to be common at most locations e.g. Pink-necked Green-Pigeon

(*Treron vernans*), Green Imperial-Pigeon (*Ducula aenea*), White-collared Kingfisher (*Halcyon chloris*), Black-naped Oriole (*Oriolus chinensis*) and the White-breasted Wood Swallow (*Artamus leucorynchus*). Other species were found to be rare and only found in specific locations e.g. Rufous-lored Kingfisher (*Halcyon winchelli*) found in Turtle Bay and Lagoon 4; Pied Harrier (*Circus melanoleucos*) found in Lagoon 2 and the Pink-bellied Imperial-Pigeon (*Ducula poliocephala*) found in Lagoon 1.

Similarity values were calculated between samples, in this case the similarity of species discovered (or detected) between each surveyed location using IRD values for each species. This was achieved by using PRIMER (Clarke & Warwick, 1994a) to create a similarity matrix (using Bray-Curtis similarity under 4^{th} root). The results are shown in Table 3.8, which indicate the high levels of similarity. This shows that all survey locations on Danjugan Island have similar species composition, with all locations being over 71% similar, with the highest similarity being over 86% between locations of South West Beach and Tabon.

Table 3.7: Species IRD Values by Location

Family	Common Name	Scientific Name	Typhoon	Turtle	Tabon	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 4	Lagoon 5	Lagoon 6	S-East Beach	S-West Beach
	Plover sp		0	0.3	0	0	0.18	0.2	0	0	0	0	0
Ardeidae	Eastern Reef-Egret	*Egretta sacra*	0	0	0	0.1	0	0	0	0	0	0	0
Ardeidae	Little Heron	*Butorides striatus*	0	0.2	0.2	0.1	0.09	0.6	0.2	0.4	0.2	0.3	0.1
Ardeidae	Rufous Night-Heron	*Nycticorax caledonicus*	0	0	0	0.2	0	0	0	0	0	0	0
Ardeidae	Black Bittern	*Dupetor flavicollis*	0	0.1	0.1	0	0	0	0	0	0	0	0
Accipitridae	White-bellied Sea-Eagle	*Haliaeetus leucogaster*	0.5	0.3	0.1	0.7	0.36	0.4	0	0	0.1	0.3	0.1
Accipitridae	Pied Harrier	*Circus melanoleucos*	0	0	0	0	0.09	0	0	0	0	0	0
Megapodiidae	Tabon scrubfowl	*Megapodius cumingii*	0.2	0.1	0	0.1	0	0	0	0.1	0.3	0	0
Sternidae	Black-naped Tern	*Sterna sumatrana*	0.1	0	0.5	0	0	0	0.1	0	0	0.1	0.3
Columbidae	Pink-necked Green-Pigeon	*Treron vernans*	0.6	0.7	0.3	0.7	0.64	0.7	0.6	0.4	0.3	0.3	0.4
Columbidae	Black-chinned Fruit Dove	*Ptilinopus leclancheri*	0	0	0	0.1	0.18	0.1	0.2	0	0.4	0.1	0
Columbidae	Pink-bellied Imperial Pigeon	*Ducula poliocephala*	0	0	0	0.1	0	0	0	0	0	0	0
Columbidae	Green Imperial-	*Ducula aenea*	0.3	0.1	0.2	0.7	0.55	0.1	0.3	0.5	0.6	0.2	0.3

	Pigeon												
Columbidae	Zebra Dove	*Geopelia striata*	0	0	0	0	0	0	0	0	0.2	0.1	0
Family	Common Name	Scientific Name	Typhoon	Turtle	Tabon	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 4	Lagoon 5	Lagoon 6	S-East Beach	S-West Beach
Columbidae	Pied Imperial Pigeon	*Ducula bicolor*	0	0	0.1	0	0	0	0	0.3	0	0	0
Columbidae	Emerald Dove	*Chalcophaps indica*	0.1	0.1	0	0	0.18	0	0.1	0	0.1	0	0.3
Cuculidae	Philippine Coucal	*Centropus viridis*	0.2	0	0.3	0.6	0.45	0.3	0.6	0.5	0.5	0.5	0.3
Strigidae	Philippine Hawk-Owl	*Ninox philippensis*	0	0	0	0	0	0	0	0	0	0.1	0
Apodidae	Glossy Swiftlet	*Collocalia fuciphaga*	1	1	0.7	0.8	0.82	0.7	1	0.8	0.7	0.8	1
Alcedinidae	Common Kingfisher	*Alcedo atthis*	0	0	0	0.1	0	0.1	0	0	0	0	0
Alcedinidae	Stork-billed Kingfisher	*Halcyon capensis*	0.4	0.4	0.3	0.5	0.18	0.4	0.2	0.2	0.1	0.5	0.2
Alcedinidae	Rufous-Lored Kingfisher	*Halcyon winchelli*	0	0.1	0	0	0	0	0	0.1	0	0	0
Alcedinidae	White-collared Kingfisher	*Halcyon chloris*	0.7	0.6	0.8	0.5	0.27	0.9	0.5	0.2	0.3	0.9	0.6
Hirundinidae	Barn Swallow	*Hirundo rustica*	0	0.1	0.1	0	0.09	0.1	0	0.1	0	0.1	0.1
Hirundinidae	Pacific Swallow	*Hirundo tahitica*	0.5	0.8	0.7	0.1	0.27	0.3	0.2	0.2	0.2	0.5	0.6
Campephagidae	Pied Triller	*Lalage nigra*	0.3	0.3	0.6	0.4	0.45	0.5	0.4	0.8	0.4	0.3	0.5
Oriolidae	Black-naped Oriole	*Oriolus chinensis*	1	1	0.9	1	1	1	1	1	1	1	0.9
Corvidae	Large-billed Crow	*Corvus macrorhynchos*	0.3	0.3	0	0.2	0.18	0.4	0.1	0.5	0.4	0.3	0

Turdidae	Oriental Magpie-Robin	*Copsychus saularis*	0	0.2	0	0	0	0.1	0.3	0.2	0.3	0	0.2
Family	Common Name	Scientific Name	Typhoon	Turtle	Tabon	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 4	Lagoon 5	Lagoon 6	S-East Beach	S-West Beach
Sylviidae	Golden-bellied Flyeater	*Gerygone sulphurea*	0	0	0	0	0	0.1	0	0	0	0	0.1
Sylviidae	Philippine Leaf Warbler	*Phylloscopus olivaceus*	0	0	0	0	0	0	0	0	0	0.1	0
Sylviidae	Mountain Leaf-Warbler	*Phylloscopus trivirgatus*	0	0.1	0.2	0	0.36	0.3	0.2	0	0	0.3	0
Muscicapidae	Mangrove Blue Flycatcher	*Cyornis rufigastra*	0	0	0	0	0	0	0	0.1	0	0	0
Muscicapidae	Pied Fantail	*Rhipdura Javanica*	0.7	0.4	0.8	0.6	0.82	0.3	0.7	0.6	0.9	0.5	0.7
Artamidae	White-breasted Wood Swallow	*Artamus leucorynchus*	0.9	0.9	0.8	1	0.82	0.9	1	0.8	0.8	1	1
Laniidae	Brown Shrike	*Lanius cristatus*	0.1	0	0	0	0	0	0	0	0	0	0
Sturnidae	Asian Glossy Starling	*Aplonis panayensis*	1	1	1	1	1	0.9	0.9	1	1	0.9	0.9
Nectariniidae	Olive-backed Sunbird	*Nectarinia jugularis*	0.7	0.8	0.8	0.2	0.82	0.4	1	0.8	0.9	0.8	1
Dicaeidae	Orange-bellied Flowerpecker	*Dicaeum trigonostigma*	0.4	0.1	0.5	0.2	0.09	0.2	0.4	0.4	0.3	0	0.4
Dicaeidae	Pygmy Flowerpecker	*Dicaeum pygmaeum*	0	0	0	0	0.09	0	0	0	0	0	0

Table 3.8: Percentage similarity of bird communities between locations
(Based on Bray-Curtis similarity under 4th root transformation, calculated from IRD values)

	Typhoon	Turtle	Tabon	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 4	Lagoon 5	Lagoon 6	South-East Bay	South-West Bay
Typhoon											
Turtle	79.34										
Tabon	78.79	78.64									
Lagoon 1	79.85	72.47	71.80								
Lagoon 2	78.08	81.40	78.51	77.45							
Lagoon 3	74.93	83.02	78.88	79.76	84.98						
Lagoon 4	82.35	78.74	81.21	77.30	83.72	81.61					
Lagoon 5	76.37	79.72	78.47	75.20	74.97	77.04	80.20				
Lagoon 6	82.72	78.87	74.34	81.02	81.43	78.57	87.04	82.43			
South-East Bay	77.28	75.37	81.81	74.93	80.90	82.06	81.20	72.68	78.17		
South-West Bay	82.94	78.91	86.14	72.52	79.14	80.63	85.94	79.06	81.27	77.04	

Further patterns of community composition were assessed using PRIMER (Figure 3.2) (Clarke & Warwick, 1994a). The Bray-Curtis similarity measure was then calculated (from the IRD) between the permutations of sample pairs (Clarke & Warwick 1994a). The relationship between survey sites was analysed using a Non-metric Multi-Dimensional Scaling (NMDS) ordination (Figure 3.3) and a hierarchical agglomerate clustering technique (Clarke & Green 1988).

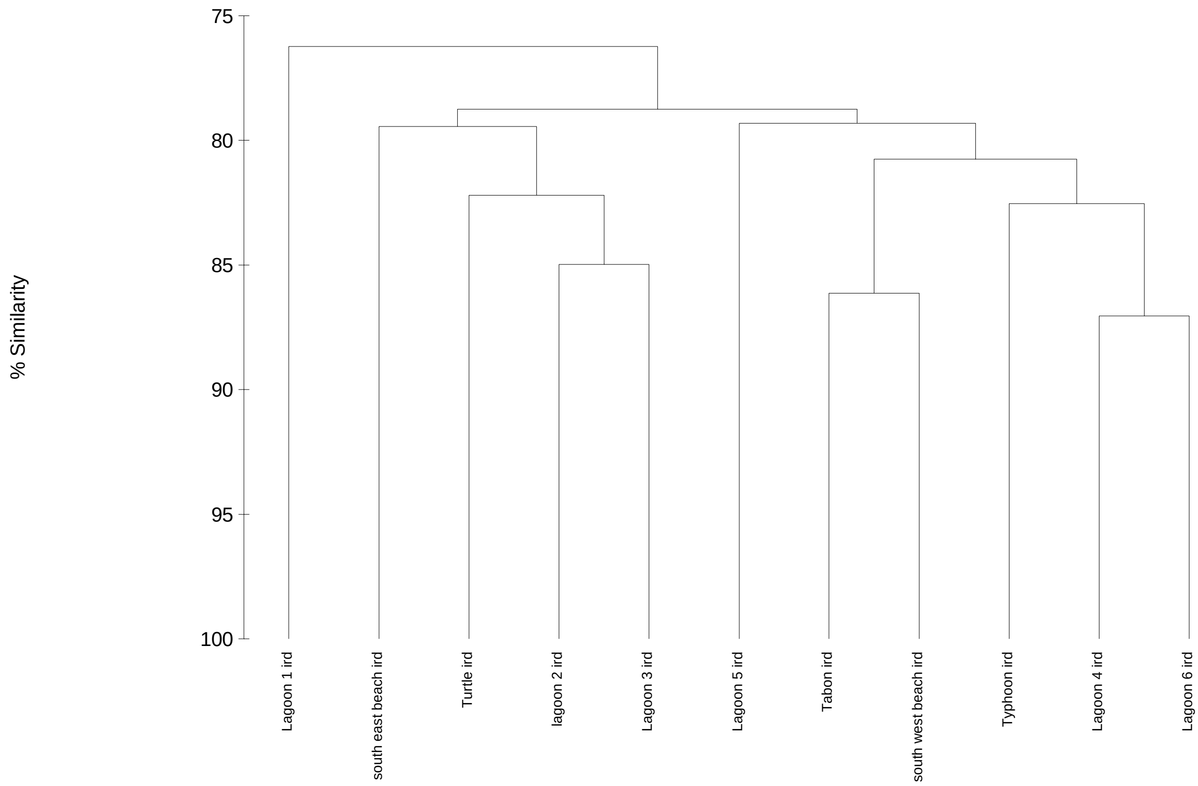

Figure 3.2: Dendrogram of Bird Community Composition
(Calculated using group average linking of Bay-Curtis similarities (4^{th} root transformation) and labelled according to survey location name).

The dendrogram illustrates the similarity matrix (Table 3.8) by assessing the similarities between groups, which highlight the high level of similarity in community composition in all sites (>80%) (Figure 3.2). There are, however, two main groups. Group one consisting of Tabon, South West Beach, Typhoon, Lagoons 4, 5 and 6; and group two consisting of Lagoons 1,2 and 3, Turtle Beach and South East Beach. The locations within these groups are more similar in species composition to each other than between groups.

NMDS analyses these clusters further by creating a 'map' or configuration of the sample sets and placing the sample sets (here these are locations) in 'space'. Physically the nearer the samples are to each other the more similar they are in terms of species composition. (See figure 3.3)

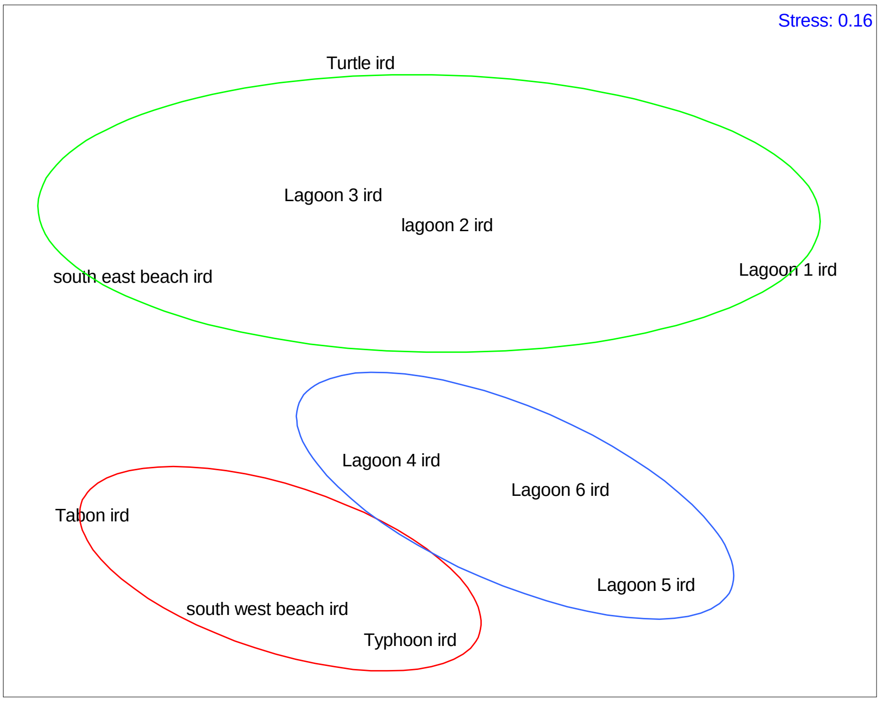

Figure 3.3: NMDS ordination of IRD values for each survey location

The NMDS suggests that community composition differs by location in relation to southwest facing coastal zones and inland lagoon locations. NMDS stresses that a further group can be established, creating three main groups that show highest levels of similarity within them.

The groups are divided by their location on the island. The first group consists of Tabon, South West Beach and Typhoon Beach survey site locations (depicted within the red circle). These are all westerly facing locations that are directly on the coastal zone. The second main groups consist of Lagoons 4, 5 and 6 (within the blue circle). These Lagoons are situated within a coconut-dominated forest to the south end of the island. The last group consists of Lagoons 1, 2 and 3, South East Beach and Turtle Beach (within the green circle). All of these locations are situated within a mixed forest ecosystem of the island.

Further analysis to find which species are responsible for the observed clustering was also achieved. By looking at the overall percentage contribution each species makes to the average similarity within groups, a species list can be formed showing species in decreasing order of their importance in discriminating the sample sets. This gives species that are typical to the group, in the sense that they are found at constant (high) abundances/detectabilty in most samples. These species can then be used as discriminators between groups. This can be achieved through SIMPER (Clarke & Warwick, 2001).

Table 3.9: SIMPER result for Coastal Group
(Where average similarity was 82.6% between South West Beach, Tabon and Typhoon Beach)

Species	Av.Abund[1]	Av.Sim[2]	Sim/SD[3]	Contrib%[4]	Cum.%[5]
Asian Glossy Starling	0.97	5.98	48.07	7.23	7.23
Black-naped Oriole	0.93	5.92	115	7.17	14.4
White-breasted Wood Swallow	0.9	5.81	43.56	7.03	21.43
Glossy Swiftlet	0.9	5.74	17.41	6.94	28.37
Olive-backed Sunbird	0.83	5.62	94.34	6.81	35.18
Pied Fantail	0.73	5.56	115	6.73	41.91
White-collared Kingfisher	0.7	5.42	36.29	6.56	48.47
Pacific Swallow	0.6	5.19	56.51	6.28	54.76
Orange-bellied Flowerpecker	0.43	4.84	115	5.85	60.61
Pied Triller	0.47	4.7	15.11	5.69	66.3
Pink-necked Green-Pigeon	0.43	4.61	21.14	5.58	71.88
Green Imperial Pigeon	0.27	4.21	15.47	5.1	76.98
Stork-billed Kingfisher	0.3	4.21	15.6	5.1	82.08
Philippine Coucal	0.27	4.21	19.8	5.09	87.17
Black-naped Tern	0.3	3.78	6.42	4.57	91.74

[1]Average abundance
[2]Average similarity
[3]Standard deviation of contribution of species to similarity between groups
[4]Percentage contribution of individual species to the overall similarity between groups
[5]Cumualtive contribution of species to overall similarity between groups

Table 3.10: SIMPER result for mixed forest group.
(Where average similarity was 79.23% between Lagoons 1,2,3, Turtle and South East Beach)

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Black-naped Oriole	1	5.57	92.14	7.03	7.03
Asian Glossy Starling	0.96	5.47	56.83	6.9	13.93
White-breasted Wood Swallow	0.92	5.39	39.9	6.8	20.73
Glossy Swiftlet	0.82	5.2	39.43	6.56	27.29
Pink-necked Green-Pigeon	0.61	4.67	10.25	5.89	33.18
White-collared Kingfisher	0.63	4.54	9.05	5.73	38.91
Pied Fantail	0.52	4.41	13.99	5.56	44.47
Olive-backed Sunbird	0.6	4.39	6.69	5.55	50.01
Pied Triller	0.39	4.23	25.52	5.33	55.35
White-bellied Sea-Eagle	0.41	4.19	35.17	5.29	60.64
Stork-billed Kingfisher	0.4	4.14	8.95	5.22	65.86
Large-billed Crow	0.28	3.81	17.43	4.81	70.67
Pacific Swallow	0.39	3.75	6.82	4.73	75.4
Green Imperial Pigeon	0.33	3.42	6.13	4.31	79.71
Little Heron	0.26	3.32	8.67	4.19	83.9
Philippine Coucal	0.37	2.62	1.16	3.31	87.21
Mountain Leaf-Warbler	0.21	2.16	1.14	2.73	89.94
Orange-bellied Flowerpecker	0.12	1.91	1.15	2.41	92.35

The three main species contributors to the mixed forest groups (Table 3.10) are the same as that of the coastal group, however, they do vary in their specific contributions. Additional species that are not present in the coastal groups but are present in the mixed forest group include the White-bellied Sea-Eagle (*Haliaeetus leucogaster*) and the Mountain Leaf-Warbler (*Phylloscopus trivirgatus*).

Table 3.11: SIMPER result for coconut forest groups.
(Where average similarity was 83.22% between Lagoon 4,5 and 6)

Species	Av.Abund	Av.Sim	Sim/SD	Contrib%	Cum.%
Black-naped Oriole	1	5.87	86.86	7.05	7.05
Asian Glossy Starling	0.97	5.76	258.77	6.93	13.98
Olive-backed Sunbird	0.9	5.6	41.24	6.73	20.71
White-breasted Wood Swallow	0.87	5.55	86.86	6.67	27.38
Glossy Swiftlet	0.83	5.43	36.08	6.52	33.9
Pied Fantail	0.73	5.23	34.32	6.29	40.19
Philippine Coucal	0.53	4.93	86.86	5.93	46.12
Pied Triller	0.53	4.67	86.86	5.61	51.72
Green Imperial Pigeon	0.47	4.54	15.79	5.45	57.17
Orange-bellied Flowerpecker	0.37	4.45	20.13	5.35	62.52
Pink-necked Green-Pigeon	0.43	4.45	20.13	5.35	67.87
White-collared Kingfisher	0.33	4.06	15.34	4.88	72.75
Oriental Magpie-Robin	0.27	4.06	15.34	4.88	77.64
Pacific Swallow	0.2	3.92	86.86	4.71	82.35
Little Heron	0.27	3.92	86.86	4.71	87.07
Large-billed Crow	0.33	3.75	5.06	4.5	91.57

It can be seen again that the major contributors to this group are similar to the other two groups, but again varying in species contributions. The Oriental Magpie-Robin (*Copsychus saularis*) is a species that is found in the coconut forest group and not in the other two groups.

These SIMPER results illustrate the distinctions between the groups through species compositions. There is a high degree of similarity between the groups, however individual species percentage contribution changes within the groups and individuals unique to groups can also be highlighted.

The results show that a total of 40 species from 21 families have been surveyed within the six-week period and that a further seven species have been added to the total list for Danjugan Island.

New species added include:

<u>Black Bitten</u> (*Dupetor flavicollis*): recorded only twice throughout the survey period, this species is a resident of the Philippines but is uncommon to the area.

<u>Pied Harrier</u> (*Circus melanoleucos*): recorded only once throughout the survey period. This species is a resident and a migrant of the Philippines but is uncommon to the area.

Pink Bellied Imperial Pigeon (*Ducula poliocephala*): recorded only once throughout the survey period, this species is an endemic to the Philippines and is uncommon only occurring on 15 Philippine Islands, Negros being one of these. This species is becoming rare throughout its range due to hunting pressures and destruction of its habitat (less disturbed secondary and virgin lowland forest). This species was assessed by the IUCN Red List 2003 and considered near threatened.

Rufous-Lored Kingfisher (*Halcyon winchelli*): recorded twice during the survey period this species is endemic to the Philippines where currently 5 races exist. This species is classified as vulnerable (IUCN Red List 2003) and has already been extirpated from some islands. Its ecology remains uncertain although evidence suggests its preference to lowland forests on limestone areas, it may also prefer larger trees. The main threat to this species survival is the continual and rapid deforestation of lowland forests.

Oriental Magpie-Robin (*Copsychus saularis*): recorded on many occasions throughout the survey period. This species consists of two races within in the Philippines, both of which are endemic.

Orange-bellied Flowerpecker (*Dicaeum trigonostigma dorsale*): recorded on many occasions throughout the survey period it is a resident of the Philippines and consists of 11 races, all of which are endemic to particular faunal regions.

Pygmy Flowerpecker (*Dicaeum pygmaeum*): recorded only once during the survey period this species is a Philippine endemic and consists of 5 races within the Philippines.

3.3 Mangroves

For each lagoon the CBH of all individuals was measured in sample plots of 10m radius. The individuals were classified and thus the species abundance per size class (determined by CBH) was determined. Within each lagoon different species are represented in different CBH classes highlighting areas of dominance within the defined grouping. CBH gives an indication of age of species with large CBH generally referring to an older individual and a small CBH referring to saplings.

Within each lagoon species dominance and canopy cover were also assessed developing representative 'maps' of species distribution. Each map illustrates defining features within each lagoon. Additional details of canopy cover, canopy height and dominant species are also given in the associated table. A total of nine species from five families have been documented across the whole island (Table 3.12).

Table 3.12: Mangrove species by location on Danjugan Island

Family	Species*	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 4	Lagoon 5
Combretaceae	*Lumnitzera littorea (LL)*	-	Present	-	-	-
Euphorbiaceae	*Excoecaria agallocha (EA)*	-	Present	-	-	-
Meliaceae	*Xylocarpus granatum (XG)*	-	Present	-	Present	Present
Meliaceae	*Xylocarpus moluccensis (XM)*	Present	Present	-	Present	Present
Rhizophoraceae	*Bruguiera cylindrical (BC)*	-	Present	-	Present	Present
Rhizophoraceae	*Bruguiera gymnorrhiza (BG)*	Present	Present	-	Present	Present
Rhizophoraceae	*Rhizophora apiculata (RA)*	-	Present	-	-	-
Rhizophoraceae	*Rhizophora mucronata (RM)*	Present	Present	Present	Present	Present
Sonneratiaceae	*Sonneratia alba (SA)*	-	-	Present	-	-

* Two letter codes are those used in subsequent analysis.

Lagoon 1

Lagoon 1 is situated in the north of the island with a westerly opening out in to the sea, surrounded by mid-height forest (see figure 2.1).

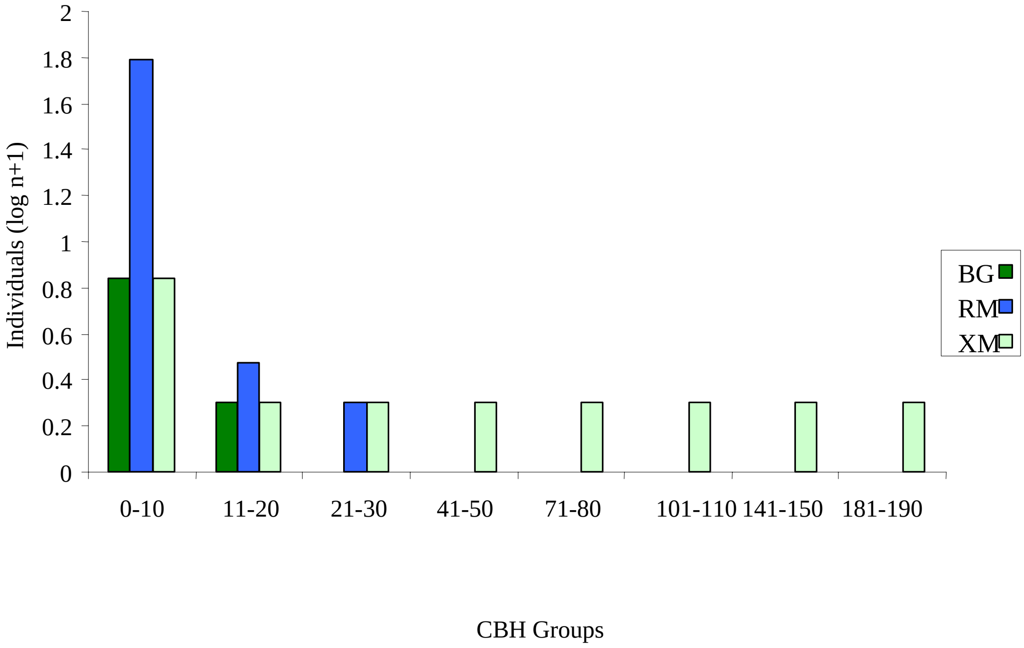

Figure 3.4: Species in CBH Classes (log n+1)

Species *Xylocarpus moluccensis* shows a relatively even distribution throughout all CBH classes in which it was recorded (not a continuous scale on size class axis) with a slightly higher proportion of small saplings. *Rhizophora mucronata* shows dominance at the smallest class and both *Rhizophora mucronata* and *Bruguiera gymnorrhiza* showing no individuals in the higher groupings.

Lagoon mapping demonstrates species dominance within the lagoon area (Figure 3.5). The donut shape represents the perimeter of Lagoon 1, with the mangrove stands being represented by sectors within it. This gives a detailed view of the lagoon showing where dominant stands of mangroves exist. Further details of dominance in relation to percentage cover, canopy height and other mangrove stands are given in Table 3.12.

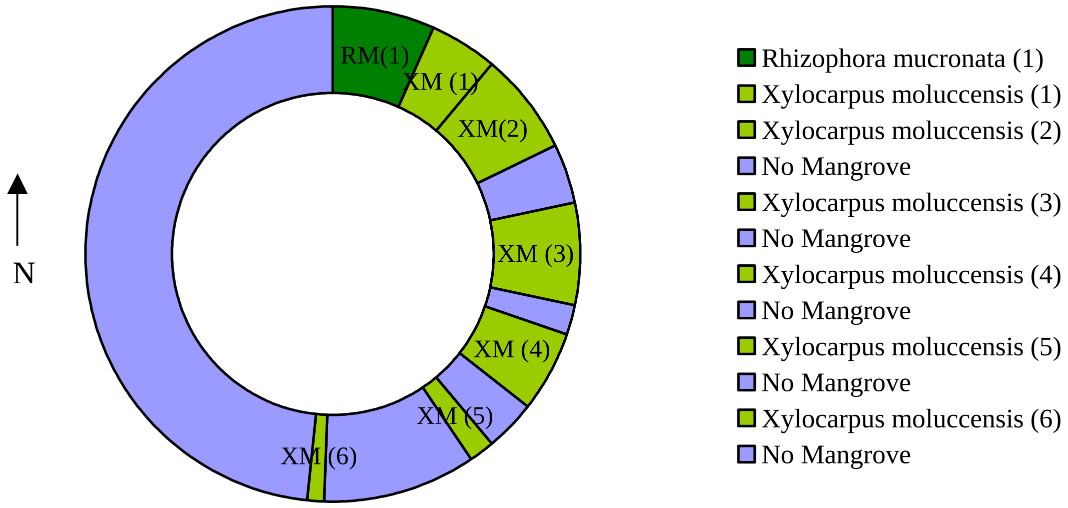

Figure 3.5: Dominant Mangrove Stands Lagoon 1.

Table 3.13: Mangrove Community Composition details of Lagoon 1

Dominant Species	% Canopy cover for mangrove sector	Average canopy Height (m)	Percentage cover of dominant species	2nd most abundant species (%cover)
Rhizophora mucronata (1)	50	3	70	XG - 10
Xylocarpus moluccensis (1)	60	4.5	70	RM - 20
Xylocarpus moluccensis (2)	100	5	60	XM - 20, RM - 20
Xylocarpus moluccensis (3)	70	5	70	RM - 15
Xylocarpus moluccensis (4)	70	2	90	
Xylocarpus moluccensis (5)	90	2.5	100	
Xylocarpus moluccensis (6)	100	4	100	

Lagoon 1 exhibits low species diversity with the major dominant mangrove stand being the species *Xylocarpus moluccensis. Rhizophora mucronata* presents itself strongly in the lower size classes (as saplings) and on several occasions as the second most dominant species present within a defined mangrove sector. The south-west area of the lagoon contains no mangrove stands.

Lagoon 2

Lagoon 2 is situated in the centre of the island, south facing, surrounded by mid-height forest, coconut forest and low forest (see figure 2.1).

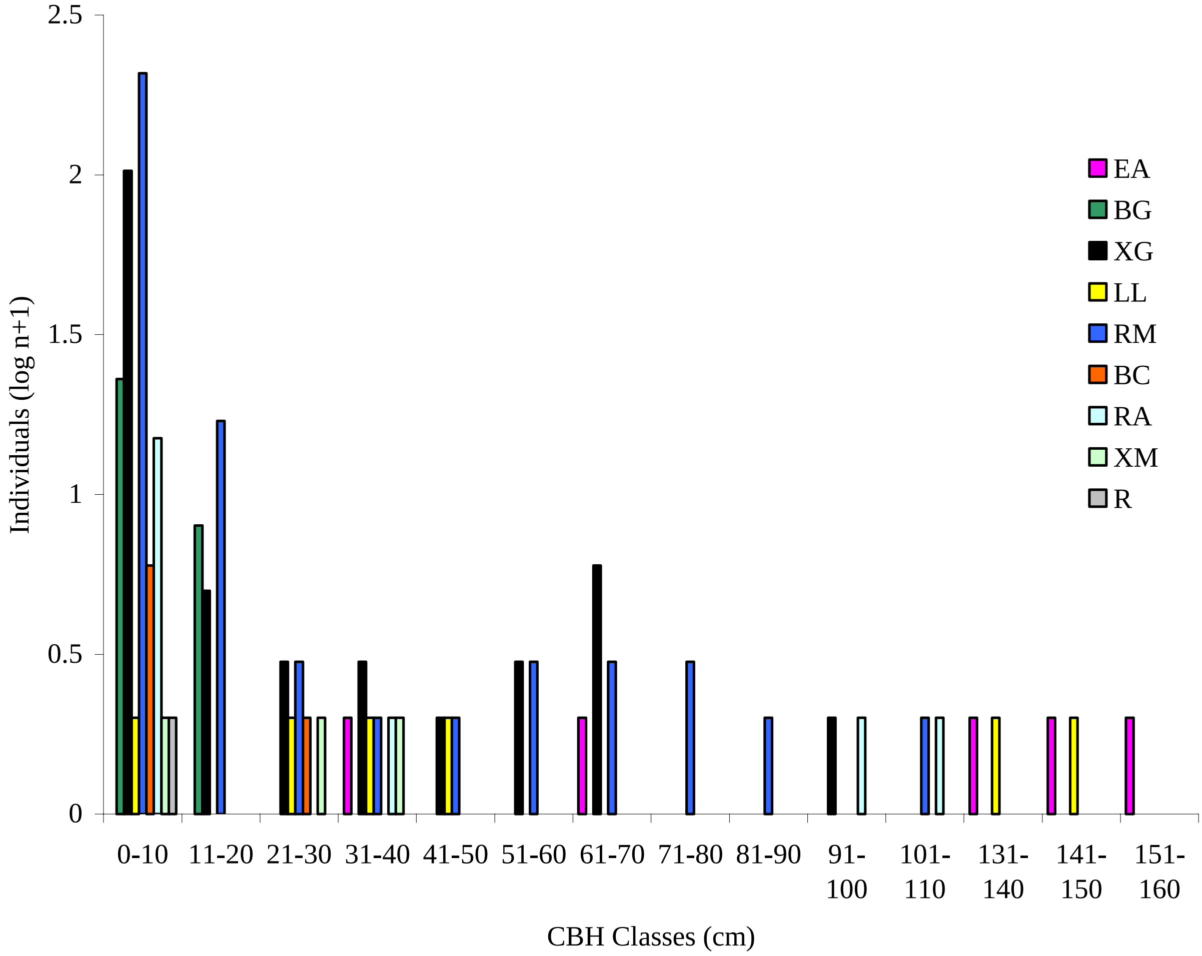

Figure 3.6: Species in CBH Classes (log n+1)

Lagoon 2 shows a much higher diversity of species than Lagoon 1, especially at the lower CBH classes. *Rhizophora mucronata* shows the highest number of individuals in the smaller size categories, but also has presence in some of the larger size groups. Both *Excoecaria agallocha* and *Lumnitzera littorea* show individuals that have the highest CBH.

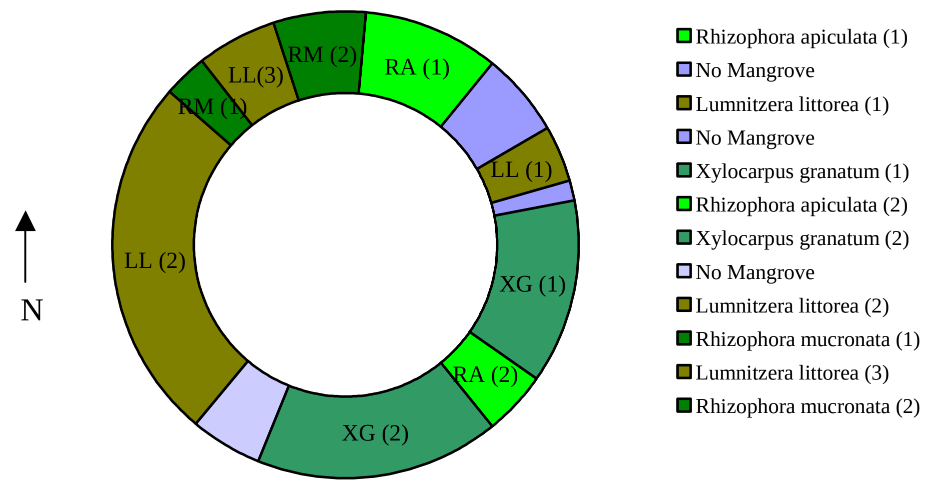

Figure 3.7: Dominant Mangrove Stands Lagoon 2

Table 3.14: Mangrove Community Composition details of Lagoon 2

Dominant Species	% Canopy Cover for mangrove sector	Average Canopy Height (m)	% Cover of dominant species	2nd most abundant species (&% cover)	Saplings
Rhizophora apiculata (1)	75	8	80	RM - 20	
Lumnitzera littorea (1)	100	4	100		
Xylocarpus granatum (1)	50	5	100		
Rhizophora apiculata (2)	100	1.2	100		
Xylocarpus granatum (2)	50	6	30	XM LL- 5	
Lumnitzera littorea (2)	90	8	70	EA- 15, RM - 5	RM – 1.5
Rhizophora mucronata (1)	70	2	90	XM – 5	All saplings
Lumnitzera littorea (3)	90	7	50	XM – 40	RM - 1
Rhizophora mucronata (2)	30	1.4	90		All saplings

The northern most part of this lagoon is dominated by *Rhizophora apiculata*, moving east and then further south, these areas are dominated by *Xylocarpus granatum*, the west area of the lagoon is dominated by *Lumnitzera littorea.*

Lagoon 3

Lagoon 3 is situated on the south east side of the island with a channel connection to the sea. This area is surrounded by mid-height forest and coconut dominated forests.

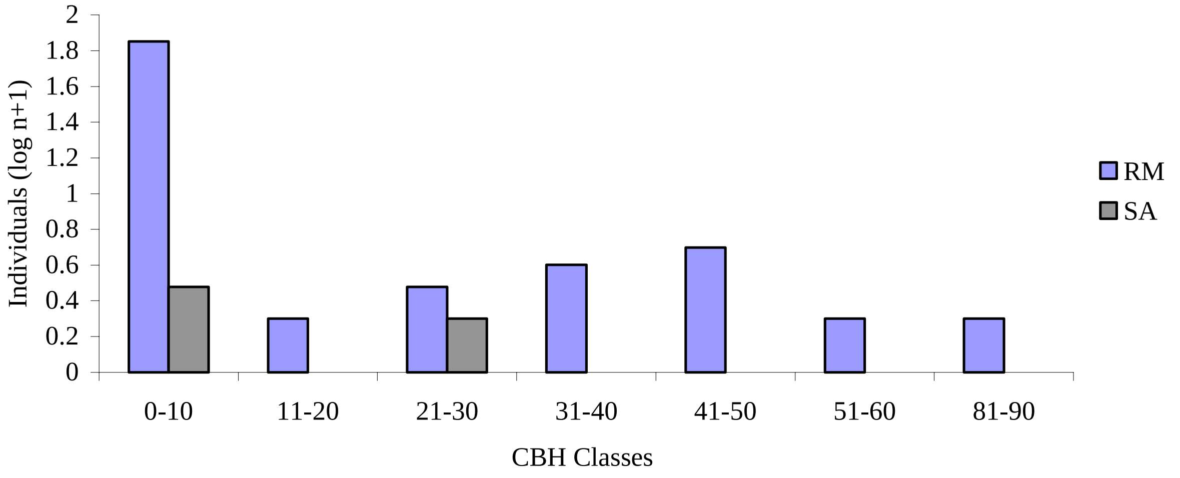

Figure 3.8: Species CBH Classes (log n+1). CBH classes not on a continuous scale.

Lagoon 3 has low species diversity, with only 2 species sampled. Of these *Rhizophora mucronata* shows to be the dominant species over all size classes. *Sonneratia alba* has only two individuals in size class 0-10 cm and one individual in size class 21-20 cm.

Figure 3.9: Dominant Mangrove Stands Lagoon 3

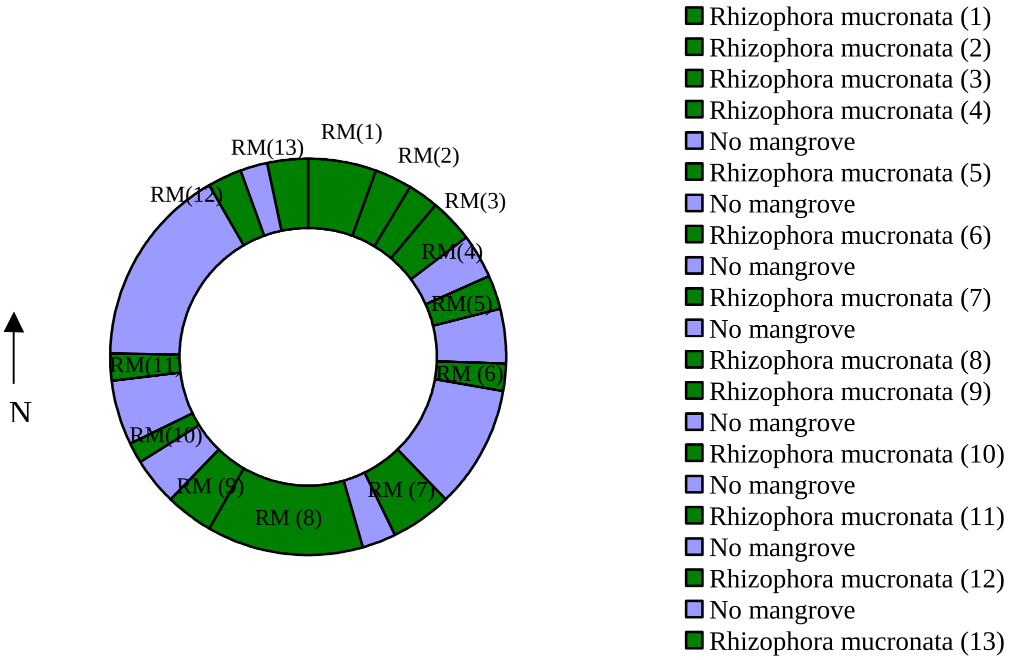

Table 3.15: Mangrove Community Composition details of Lagoon 3

Dominant Species	% Canopy cover for mangrove sector	Average canopy height (m)	Percentage cover of dominant species	2nd most abundant species (with % cover)	Saplings
Rhizophora mucronata (1)	60	4	70		
Rhizophora mucronata (2)	90	4	100		
Rhizophora mucronata (3)	70	5	100		
Rhizophora mucronata (4)	95	6	100		
Rhizophora mucronata (5)	100	3	100		
Rhizophora mucronata (6)	80	1.5	70	BC - 5	all saplings
Rhizophora mucronata (7)	50	5	80		1, RM, 90%CC
Rhizophora mucronata (8)	95	4	100		
Rhizophora mucronata (9)	90	4	60	XG - 40	
Rhizophora mucronata (10)	70	3	50	XG - 40	
Rhizophora mucronata (11)	40	3.5	100		
Rhizophora mucronata (12)	60	3	100		1, RM, 40%CC
Rhizophora mucronata (13)	40	3	100		1, RM, 10%CC

Lagoon 3 is dominated at all age classes and all throughout the lagoon’s natural divisions by *Rhizophora mucronata*. Several other species have been documented within this lagoon but these represent very few individuals.

Lagoon 4

Lagoon 4 is situated in the south west of the island, open to sea and surrounded by coconut dominated forest stands.

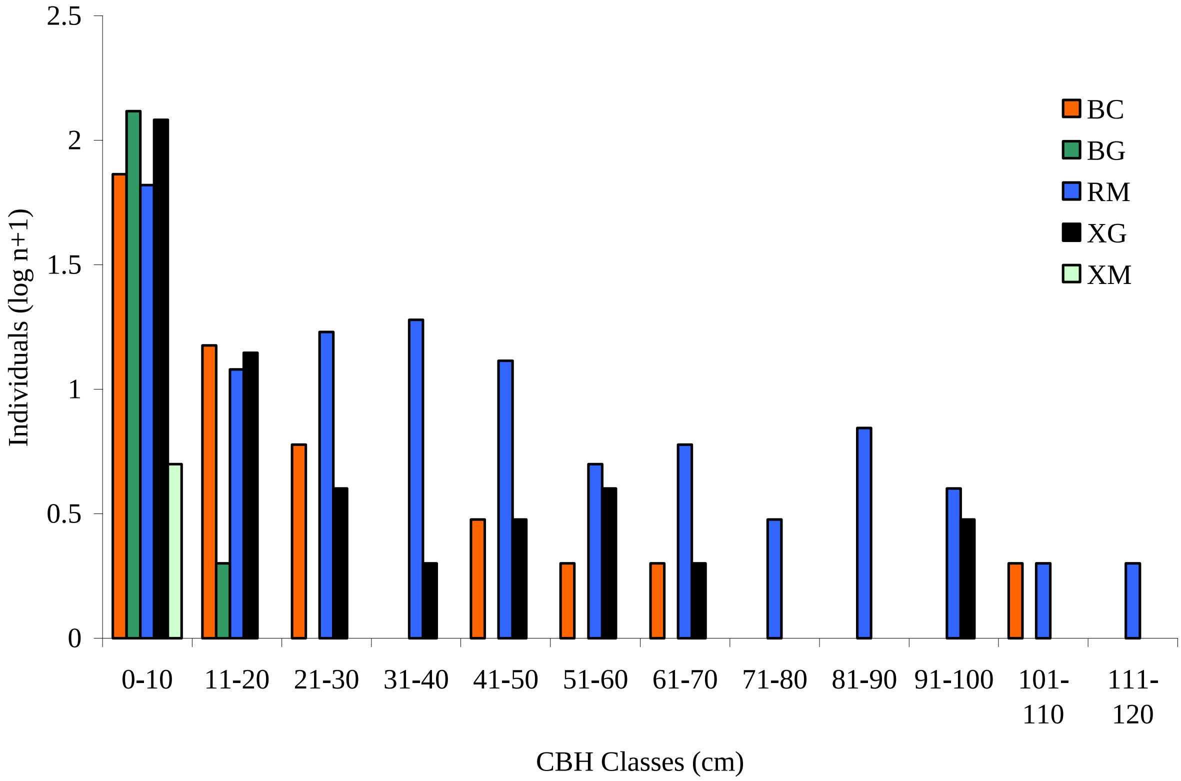

Figure 3.16: Species CBH Classes (log n+1)

Lagoon 4 is dominated by *Rhizophora mucronata* throughout most CBH size classes. There are high numbers of young in species *Bruguiera cylindrica*, *Bruguiera gymnorrhiza*, *Xylocarpus granatum* and *Xylocarpus moluccensis*, however these are not consistent throughout the size groupings.

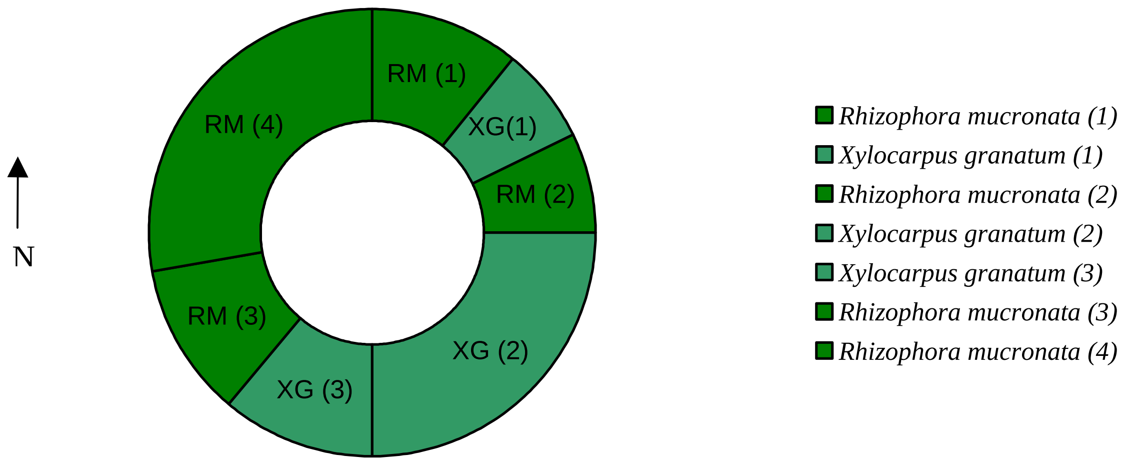

Figure 3.17: Dominant Mangrove Stands Lagoon 4

Table 3.14: Mangrove Community Composition details of Lagoon 4

Dominant species (%)	% canopy cover	Canopy height (m)	2nd abundant sp (%)	Saplings - ht(m), sp
RM - 80	100	6	XG - 15	
XG - 70	60	6	RM - 10	
RM - 55	95	7	XG - 45	1. XG - 60, RM - 30, 20%CC
XG - 80	95	10	RM - 15, BC - 2	1, BC - 60, RM - 20, XG - 10, 60%CC
XG - 100	90	10		0.5, XG - 100, 40%CC
RM - 70	100	15	XG - 30	0.8, RM - 65, XG - 15, 15%CC
RM - 70	100	10	XG - 20, BC - 5	1, RM - 70, XG - 15, BC - 5, 30%CC

Both *Rhizophora mucronata* and *Xylocarpus granatum* are the dominant species present within this lagoon. This includes being consistently high numbers of saplings and throughout all age groups. Other individuals are present but are not dominant in terms of percentage of canopy cover.

Lagoon 5

Lagoon 5 is situated inland of lagoon 4 on the southwest end of the island completely surrounded by coconut dominated forest (figure 2.1).

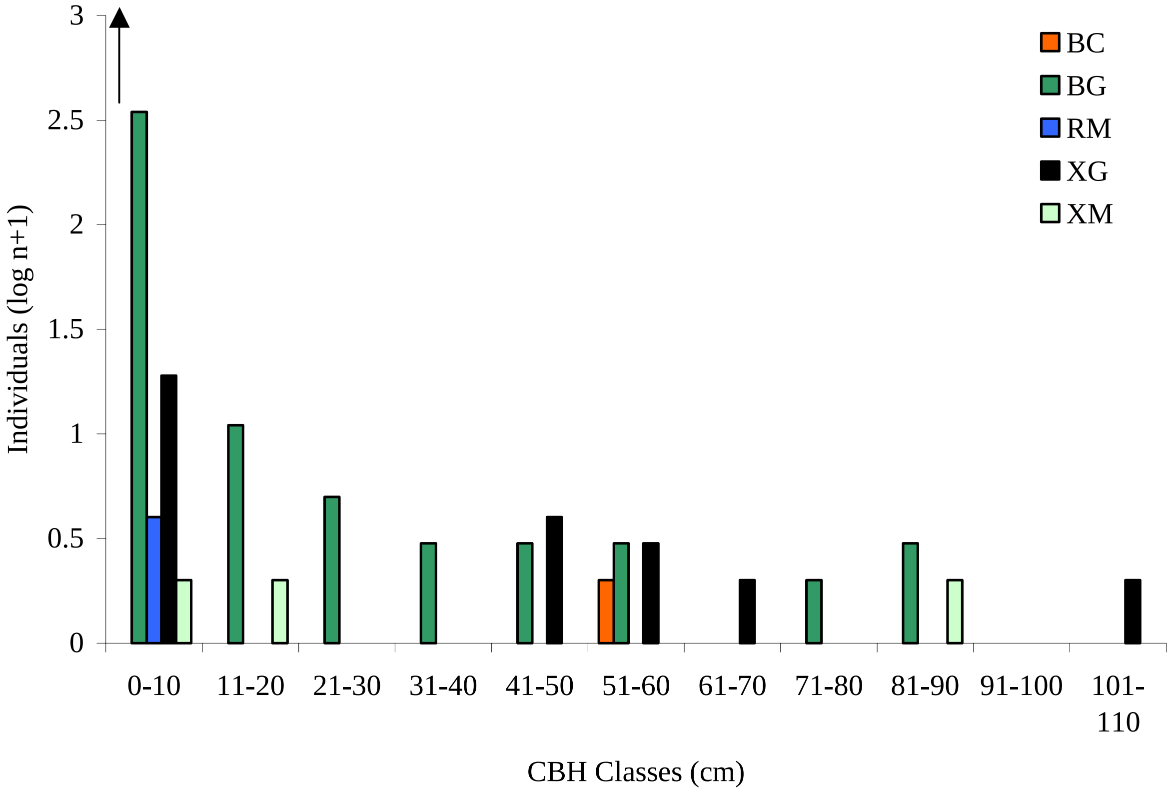

Figure 3.12: Species CBH Classes (log n+1)

Lagoon 5 is mostly dominated by species *Bruguiera gymnorrhiza* with *Xylocarpus granatum* as being the second most abundant species. Small populations of other species exist in several age classes but these seem to be more isolated stands for example *Bruguiera cylindrica*.

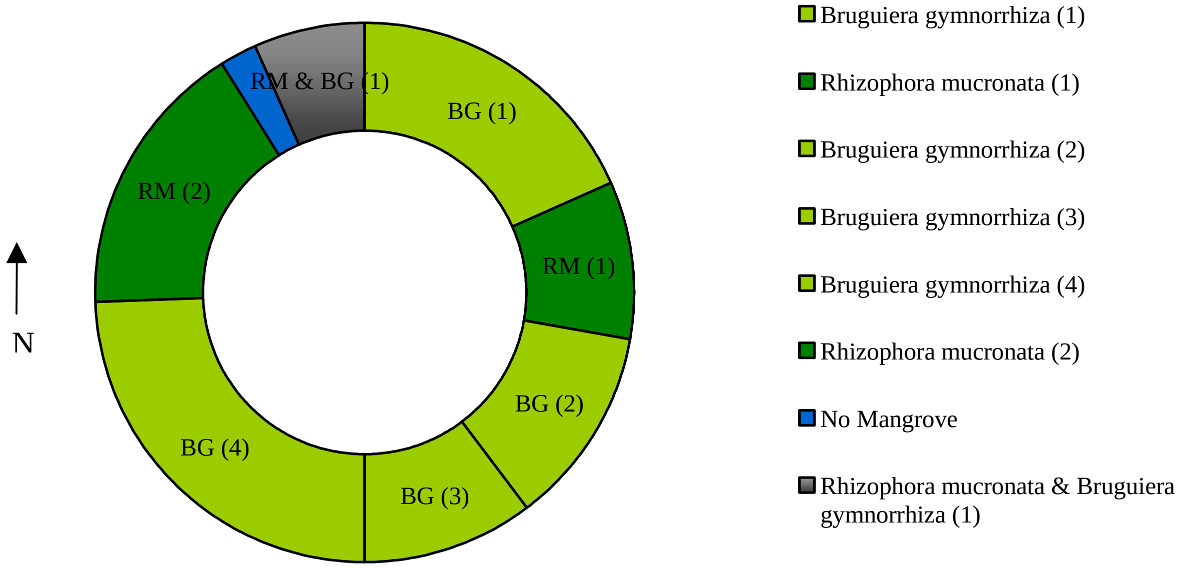

Figure 3.18: Dominant Mangrove Stands Lagoon 5

Table 3.15: Mangrove Community Composition details of Lagoon 5

Dominant Species	% Canopy cover for mangrove sector	Average canopy height (m)	Percentage cover of dominant species	2nd most abundant species (with % cover)	Saplings
Bruguiera gymnorrhiza	95	8	BG - 70	XG - 20	1, RM - 100, 20%CC
Rhizophora mucronata	70	10	RM - 80		
Bruguiera gymnorrhiza	40	13	BG - 70		
Bruguiera gymnorrhiza	20	8	BG - 50		
Bruguiera gymnorrhiza	100	8	BG - 90	RM - 5	1, BG - 90, 75%CC
Rhizophora mucronata	100	7	RM - 75	BG - 5	1.6, BG - 90, 40%CC
Rhizophora mucronata & Bruguiera gymnorrhiza	80	7	RM - 50, XG - 50		1, XG - 50, RM - 50, 40%cc

It can be seen from the analysis that both *Rhizophora mucronata* and *Bruguiera gymnorrhiza* are almost co-dominant within the mangrove stands. At each defined sector of mangrove stands either one is either dominant or the second most dominant species. There are other species present but these species are not playing a significant role in either canopy structure or lagoon definition.

4. Discussion

4.1 Birds

The Philippines has one of the highest levels of threatened species with over 15% of the country's avifauna under threat of extinction (Stattersfield *et al.*, 1998), and many species listed as 'threatened', 'endangered' or 'critical' (Collar *et al.*, 1999) on the IUCN Red List (2003). The Philippines also has the highest proportion of threatened restricted range species in the world. It is estimated that 80% of species are forest dependent (Collar *et al.*, 1999) and presently nearly half the Philippines endemic bird species are threatened by deforestation (Brooks *et al.*, 1997).

Danjugan Island represents a potential haven for many bird species due to the lack of threats and the relative diversity of habitats present on the island. It also supports a variety of lowland forest types that have been lost in many areas within the Philippines particularly on Negros and on other islands within the Visayan faunal region. It is therefore a potentially important area for species that are geographically restricted.

Danjugan Island supports a large number of frugivorous birds, particularly pigeons and doves (Family Columbidae). The Pink-necked Green-Pigeon (*Treron vernans*), found at all survey locations, and the Black-chinned Fruit Dove (*Ptilinopus leclancheri*) both are endemic to the Philippines. A further new species to the island, also endemic to the Philippines, was discovered, the Pink-bellied Imperial Pigeon (*Ducula poliocephala*), which has a current status of near threatened. These results highlight the significance of the island as an important conservation site.

Other endemic species recorded on the island include; Philippine Coucal (*Centropus viridis*), Philippines Hawk Owl (*Ninox philippeanis*), Philippine Leaf-Warbler (*Phylloscopus olivaceus*). Three additional endemic species not found in the 2000 surveys were also recorded: Rufous-lored Kingfisher (*Halcyon winchelli*), Orange-bellied Flowerpecker (*Dicaeum trigonostigma dorsale*) and the Pygmy Flowerpecker (*Dicaeum pygmaeum*).

Of particular note is the Rufous-lored Kingfisher as the current status of this species is listed as vulnerable (IUCN) due to loss of lowland forest. Danjugan Island still contains much of its original forest cover thus being able to support lowland forest bird species.

IRD values can be used to identify habitat preferences of species across the island. Through the use of NMDS location sites of Mackinnon lists can be grouped together through similar species composition. Locations that are close together are more similar to those that are further apart in terms of community composition. This defines three main similar locations on Danjugan Island:

1. Coconut Forest Group (Lagoons 4, 5 and 6)
2. Mixed Forest Group (Lagoons 1,2,3, Turtle Beach and South East Bay)
3. Coastal Group (Typhoon Beach, Tabon and South West Bay)

For all locations within the defined groups achieved by NMDS (coastal groups, mixed forest group and coconut forest group) SIMPER (species contributions to similarity) was used to assess and identify which species primarily account for the observed assemblages. This highlights species that are typical of a group and which are found at a constant high level. The

SIMPER results show that average similarities within the plots are very high (mixed forest groups 79.23%, coconut forest group 83.22% and coastal forest group 82.6%). However, between group similarity, shown on the dendrogram, shows that the island itself has similar species throughout.

Records are liable to change over time due to aspects such as migration routes. These are not assessed here due to the rapid nature of the survey.

The discovery of a further seven species, including endemic species and IUCN Red Listed species supports the management of Danjugan Island as a reserve and as part of an EBA (EBA 152, BirdLife International, 2004).

4.2 Bats

The Chiropterans are recognised as one of the most poorly known mammalian order in the Philippines (Ingle & Heaney 1992) due to high diversity and endemism. The loss of tropical forest and other associated anthropogenic threats (e.g. hunting, urban development) posed to endemic biodiversity have been well documented (Oliver & Heaney 1996; Heaney & Regalado 1998). However this in combination with the high (endemic) species richness and a rate of species discovery which is the highest in the world (Heaney *et al*, 1997) equates to an urgent need for conservation action.

Over the survey period of six weeks, four Chiropteran species were recorded, of which three where megachiropterans and one microchriopteran. The first Danjugan Island Biodiversity Assessment had previously recorded all surveyed species (Turner *et al.*, 2002).

Island habitats have been identified as particularly important for bats and a priority for conservation efforts on a global scale (Mickleburgh *et al*, 2002). The Common Nectar Bat (*Eonycteris spelaea*) was the most common of bats caught on Danjugan (Turner *et al*, 2002). Although unconfirmed, distribution data suggests that the population on Danjugan Island is of the sub-species *glandifera* (Heaney *et al*, 1998; Corbet & Hill 1992; Mickleburgh *et al*, 1992), a subspecies listed as globally "vulnerable" by the IUCN (grade 4 on a scale of 1 – 11 where 1 = Extinct and 11 = Not threatened) (Mickleburgh *et al*, 1992).

Danjugan thus represents a globally important site for bat species conservation. This is confirmed by the continued presence of *Pteropus pumilus* (currently listed as IUCN vulnerable) and is fourth on the conservation priority list for Philippine fruit bats (Mickleburgh *et al*, 1992). This species is endemic to the Philippines, where it is usually associated with primary and well-developed secondary forest (Heaney *et al*, 1989) and is uncommon to rare on larger islands but more common on smaller islands (Heideman & Heaney 1989; Utzurrum 1992).

4.3 Mangroves

A detailed assessment of the mangrove communities surrounding the lagoons was successfully achieved. Details of community structure and composition of each lagoon highlighted the differences in diversity and distribution across Danjugan Island.

The Lagoons show a high variance of community structure and composition within the mangrove communities. Lagoons 1 and 3 show the lowest levels of species diversity and are the only two lagoons that are open directly to the sea. The Lagoons that exhibit the highest species diversity are Lagoons 2, 4 and 5, with Lagoon 2 showing the highest. Lagoon 2 also illustrates the highest number of saplings present represented by eight different species. Lagoon 4 shows the second highest sapling species number and diversity with five species being represented. This work builds on the detailed inventory survey work of Turner *et al* (2002) of the first Danjugan Island Biodiversity Report, and of that of King *et al* (In Press) (Silliman Paper), giving a detailed assessment of age class structure and representative maps of each of the Lagoons present on the island.

Further surveys should include a detailed assessment on the abiotic factors affecting community composition that could not be achieved during this survey period. Previous research (King *et al.*, 2002; Connell 1978) suggests that varying water circulation patterns, tidal movements, disturbance levels and abiotic factors (e.g. salinity, pH, turbidity and temperature) can influence mangrove diversity and other ecological indicators. With a strong grounding in community structure and composition achieved through this survey, an abiotic investigation could well provide further important research.

5. Conclusions

The research carried out in 2004 continues to highlight Danjugan Island as a potential conservation haven. Danjugan represents a refuge for many endemic, rare and threatened species within the Negros-Panay Faunal region and the Philippines as a whole. Most of this region has suffered heavily from deforestation, especially lowland forest, however Danjugan still contains its original cover. Thus Danjugan can support species that have been extirpated from other locations due to habitat loss and support species that are range restricted and forest dependent.

Due to habitat variation and conservation, rare and endangered species are continuing to be discovered on the island. These include, but are not limited to; the Rufous-lored Kingfisher, the Orange-bellied Flowerpecker, the Pink-bellied Imperial Pigeon, and the Little Golden Mantled Flying Fox.

The second Danjugan Biodiversity Assessment met the following objectives:

- Continual expansion of species inventories for both bird and bat fauna;
- The provision of quantitative data to support these inventories;
- In depth assessment of mangrove and mangal species in lagoon communities;
- The provision of detailed maps of the Lagoons present on the island;
- Creation of a mangrove nursery.

5.1 Outcomes

The six-week survey programme has developed further information regarding Danjugan's species inventories as well as including more detailed surveys on mangrove and the associated communities. Specific outcomes include:

- Habitat mapping of mangrove and mangal areas
- More detailed vegetation analysis on mangrove and mangal areas
- An increase in bird species inventory
- Consolidation of bat species inventory
- New species recorded to the island
- Development of mangrove nursery

The development of the nursery is seen as an important development within the PRCCFI programme. Establishing a viable seedling base can be an initial step in the rehabilitation of mangrove communities on the mainland of Negros in areas that have been previously exploited. Mangrove stands, if managed sustainably, can create alternative livelihood schemes based on traditional food sources such as mud crabs (*Scylla* spp.), and provide much needed habitats for fish nurseries as well as serving other important ecological functions (Bandaranayake 1998).

Recommendations that have stemmed from this report have been divided in to two sections; further research requirements and conservation actions. Recommendations made are built on those suggested by Turner *et al.*, 2002a and should be considered in conjunction with these.

5.2 Future Research Recommendations

The habitat and species inventory work will hopefully provide a useful baseline for future conservation research priorities. Additional work on other major faunal groups would be of interest to the area including;

- Investigating invasive species e.g. rat species
- Compiling data on herpetofauna
- Compiling data on invertebrates
- Continual assessment of bird populations taking in to account migratory routes/times
- Continual monitoring of the bat populations
- Continual monitoring of the mangrove populations

As documented in the 2002 reports (Turner *et al.,* The First Danjugan Biodiversity Assessment, 2002) for birds, bats and mangrove populations more specific research, with the help of both national and international experts, would prove to be very insightful.

Considering that the seven priorities for the conservation of global bat fauna given by Mickleburgh *et al.,* (2002) include focusing efforts on taxonomically distinct species, endemic species, islands, caves, education and legal protection, this study has shown that Danjugan Island is of major national and global significance for bat conservation. On Danjugan quantitative surveys need to be established and a population census conducted. Research on specific species (for example, feeding habits, reproductive biology) should also be conducted. Taxonomic research may also prove to be important in establishing sub species (which are significant in conservation status).

Danjugan Island forms part of an Endemic Bird Area (number 152, BirdLife 2004). The islands that contribute to the EBA would once have been completely covered in forest including tropical lowland evergreen rain forest to c.400 m and at higher elevations giving way to mossy forest (Collins *et al.*, 1991; Dickinson *et al.*, 1991). This area has almost been completed deforested (around 4% original cover in Negros) and has caused an increase loss in species which are reliant on lowland forested areas. The habitat is also becomingly increasingly fragmented and species are still under hunting and pet trade pressure.

Danjugan can thus be seen as a haven in supporting species that rely on lowland forested areas and recent findings (including the IUCN Red Listed Rufous-Lored Kingfisher) confirm this. Further research should concentrate on species-specific biology (nesting requirements, breeding times) and also a complete year round study in to include species that rely on Danjugan as a migrant destination.

For continual mangrove research, as stated in King *et al.,* (2002), efforts should be increased to understand the underlying abiotic factors that affect mangrove communities. The development of the mangrove regeneration programme could prove to be an especially important route for the development of sustainable management of mangrove communities not just on Danjugan but also on the adjacent islands within the Negros-Panay faunal region.

5.3 Conservation Recommendations

Bats

Ensure protection and minimal disturbance of roosting sites for all species, especially the cave roosts of *Eonycteris spelaea* and the forest roosts for *Pteropus pumilus*. However, a long term monitoring programme of bat populations should be considered in order to track any ecological changes that are occurring on the island. Further taxonomic and genetic studies should be considered in order to evaluate possible occurrence of sub-species on the island.

As bat populations disperse nightly to the mainland where threats are more prevalent, assessment of the hunting pressure on the mainland is required. This will allow education and conservation initiatives to target specific localities.

Birds

Ensure the continued protection of the lowland forest that supports many resitrcted range species. Minimalise impacts to areas that are important breeding grounds for many species, especially endemic and IUCN Red List species.

A continued assessment on the bird population of the island is needed to monitor any ecological changes that occur on the island over a year including the arrival and departure of the migrant bird population.

Mangroves

Mangroves and their associated communities are the heart of Danjugan Island. Thus these areas must be continually monitored to show any changes that may well be detrimental to species survival. Further research focusing on abiotic factors and more in depth species-specific ecological requirements would greatly increase existing knowledge.

Danjugan should be seen as a conservation success and should be marketed as such. The island has been successfully managed and the observations of endangered and rare species located on the islands prove that this is so. NGOs, interested communities, schools and such like could benefit from visiting the island and learning about all the achievements, the management and the conservation value that it has thus so far contributed to.

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7. Appendix

Simper comparisons between groupings of bird habitats - 1. Comparison between Coastal and mixed forest groups. Average dissimilarity 22.18%

Species	Coastal Av Abund	Mixed Forest Av Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Black-naped Tern	0.3	0.02	1.74	2.32	7.87	7.87
Large-billed Crow	0.1	0.28	1.43	1.48	6.44	14.31
Black-chinned Fruit Dove	0	0.1	1.36	1.91	6.14	20.45
Mountain Leaf-Warbler	0.07	0.21	1.29	1.33	5.82	26.27
Plover sp	0	0.14	1.19	1.18	5.37	31.64
Common Emerald Dove	0.13	0.06	1.06	1.16	4.79	36.43
Orange-bellied Flowerpecker	0.43	0.12	0.93	1.22	4.21	40.64
Oriental Magpie-Robin	0.07	0.06	0.88	0.94	3.99	44.63
Little Heron	0.1	0.26	0.88	1.01	3.97	48.6
Tabon scrubfowl	0.07	0.04	0.87	0.98	3.92	52.52
Barn Swallow	0.07	0.08	0.66	0.8	2.98	55.5
Philippine Coucal	0.27	0.37	0.66	0.88	2.97	58.47
Common Kingfisher	0	0.04	0.65	0.79	2.95	61.42
Black Bittern	0.03	0.02	0.65	0.79	2.94	64.36
Golden-bellied Flyeater	0.03	0.02	0.65	0.79	2.94	67.3
Brown Shrike	0.03	0	0.55	0.68	2.48	69.78
Pied Imperial-Pigeon	0.03	0	0.54	0.68	2.44	72.22
White-bellied Sea-Eagle	0.23	0.41	0.52	1.92	2.35	74.57
Pacific Swallow	0.6	0.39	0.42	1.35	1.88	76.45
Green Imperial Pigeon	0.27	0.33	0.41	2.24	1.83	78.28
Rufous Night-Heron	0	0.04	0.39	0.48	1.77	80.05
Eastern Reef-Egret	0	0.02	0.33	0.48	1.49	81.54
Pink Bellied Imperial Pigeon	0	0.02	0.33	0.48	1.49	83.04
Philippine Leaf Warbler	0	0.02	0.33	0.48	1.49	84.52
Zebra Dove	0	0.02	0.33	0.48	1.49	86.01
Philippine Hawk-Owl	0	0.02	0.33	0.48	1.49	87.49
Rufous-Lored Kingfisher	0	0.02	0.33	0.48	1.47	88.96
Pygmy flowerpecker	0	0.02	0.32	0.48	1.43	90.39

2. Comparison between coastal group and coconut forest group. Average dissimilarity: 19.81%

Species	Coastal Av Abund	Coconut Forest Av Abund	Av.Diss	Diss/SD	Contrib%	Cum.%
Black-naped Tern	0.3	0.03	1.56	1.73	7.89	7.89
Large-billed Crow	0.1	0.33	1.56	1.61	7.88	15.78
Oriental Magpie-Robin	0.07	0.27	1.48	1.47	7.46	23.23
Black-chinned Fruit Dove	0	0.2	1.46	1.32	7.37	30.6
White-bellied Sea-Eagle	0.23	0.03	1.4	1.48	7.09	37.69
Tabon scrubfowl	0.07	0.13	1.14	1.17	5.76	43.45
Barn Swallow	0.07	0.03	0.93	1.05	4.71	48.15
Common Emerald Dove	0.13	0.07	0.92	1.05	4.65	52.8
Pied Imperial-Pigeon	0.03	0.1	0.92	0.92	4.65	57.44
Little Heron	0.1	0.27	0.9	0.94	4.56	62
Mountain Leaf-Warbler	0.07	0.07	0.89	0.84	4.49	66.49
Zebra Dove	0	0.07	0.66	0.67	3.33	69.83
Pacific Swallow	0.6	0.2	0.63	6.82	3.16	72.99
Brown Shrike	0.03	0	0.57	0.67	2.85	75.84
Golden-bellied Flyeater	0.03	0	0.56	0.67	2.81	78.65
Black Bittern	0.03	0	0.56	0.67	2.81	81.46
Rufous-Lored Kingfisher	0	0.03	0.56	0.67	2.81	84.27
Mangrove Blue Flycatcher	0	0.03	0.56	0.67	2.81	87.08
White-collared Kingfisher	0.7	0.33	0.49	2.06	2.46	89.54
Philippine Coucal	0.27	0.53	0.41	3.25	2.08	91.62

3. Comparison between mixed forest groups and coconut forest groups. Average dissimilarity: 21.32%

Species	Mixed Forest Av Abund	Coconut Av Abund	Av.Diss	Diss/SD	Contrib%	Cum %
White-bellied Sea-Eagle	0.41	0.03	1.74	2.13	8.14	8.14
Oriental Magpie-Robin	0.06	0.27	1.35	1.48	6.32	14.46
Mountain Leaf-Warbler	0.21	0.07	1.26	1.34	5.92	20.38
Plover sp	0.14	0	1.17	1.18	5.49	25.87
Tabon scrubfowl	0.04	0.13	1.02	1.16	4.8	30.67
Barn Swallow	0.08	0.03	0.96	1.19	4.51	35.18
Black-chinned Fruit Dove	0.1	0.2	0.95	1.23	4.44	39.61
Common Emerald Dove	0.06	0.07	0.91	1.12	4.27	43.88
Orange-bellied Flowerpecker	0.12	0.37	0.82	1.1	3.86	47.74
Zebra Dove	0.02	0.07	0.74	0.82	3.48	51.22
Pied Imperial-Pigeon	0	0.1	0.7	0.68	3.29	54.51
Black-naped Tern	0.02	0.03	0.65	0.79	3.04	57.54
Common Kingfisher	0.04	0	0.64	0.79	3.02	60.56
Rufous-Lored Kingfisher	0.02	0.03	0.64	0.79	3	63.56
Philippine Coucal	0.37	0.53	0.59	0.62	2.78	66.34
Mangrove Blue Flycatcher	0	0.03	0.53	0.68	2.5	68.84
Green Imperial Pigeon	0.33	0.47	0.46	1.57	2.18	71.02
Stork-billed Kingfisher	0.4	0.17	0.45	1.95	2.09	73.11
White-collared Kingfisher	0.63	0.33	0.42	1.52	1.96	75.07
Pacific Swallow	0.39	0.2	0.39	1.62	1.83	76.89
Rufous Night-Heron	0.04	0	0.39	0.48	1.81	78.71
Large-billed Crow	0.28	0.33	0.34	1.84	1.59	80.29
Little Heron	0.26	0.27	0.34	1.52	1.57	81.87
Eastern Reef-Egret	0.02	0	0.33	0.48	1.53	83.39
Pink Bellied Imperial Pigeon	0.02	0	0.33	0.48	1.53	84.92
Philippine Leaf Warbler	0.02	0	0.32	0.48	1.52	86.44
Philippine Hawk-Owl	0.02	0	0.32	0.48	1.52	87.95
Olive-backed Sunbird	0.6	0.9	0.32	0.95	1.52	89.47
Black Bittern	0.02	0	0.32	0.48	1.5	90.97