

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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Richard Dalgetty	Adam Laing	Dominic Swire
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ii. Summary

This report outlines the results of the terrestrial science survey program that was conducted during the course of a four-month expedition between June and September 2001. This was the first collaborative terrestrial survey program between the Philippine Reef and Rainforest Conservation Foundation Inc (PRRCFI) and Coral Cay Conservation (CCC) to be based on Danjungan Island, Philippines. Whilst other researchers have undertaken limited surveys of individual taxonomic groups the work reported here represents the first integrated and quantitative survey of the biodiversity of Danjungan Island.

The project concentrated on two main areas, vegetation and vertebrate surveys. The former has resulted in the production of the first terrestrial habitat map for the island outlining the distribution of the major vegetation types. This has revealed a north-south split in the major habitats and the presence of twelve major habitat types. Further assessment and analysis of selected habitats types was undertaken, revealing for example that the island supports a very diverse mangrove community with at least fourteen true mangrove species and several associated mangrove species (including threatened species) present within the lagoons of the island.

The vertebrate survey work focused primarily on the bird and bat fauna. Over forty bird species from twenty-three families were identified and the results suggest that the diverse array of habitat types support a range of resident (and endemic) and migratory species. The baseline surveys of the bat fauna identified eight species (five Megachiropterans and three Microchiropterans) which represents over 10% of the Philippine bat fauna. Four species of these are new records for the island, and three species are listed as near-threatened or vulnerable to extinction.

This report only represents an initial survey of selected taxonomic groups. However, the findings illustrate that the island is an important site for mangrove communities and a vital refuge for many endemic and migrant bird species. Additionally, for the resident bat fauna it is also a site of national, and for some species global importance. These issues are discussed in the context of the conservation value of the island and the need for further work in order to underpin the sustainable environmental management of the island.

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1. Introduction

1.1. The Philippines

The Philippines is a mega-biodiversity hotspot and has higher percentages of endemism than any other biogeographic province in the whole of the Indo-Malayan Realm. Over 57% of species in the major faunal and floral groups occur nowhere else in the world (Oliver & Heaney 1996). However, these natural resources have come under increasing threat due to changing resource use patterns (e.g. deforestation of watersheds for agriculture) and increased exploitation (e.g. over harvesting of fisheries) (Myers 1988).

The Philippines is consequently experiencing a very high rate of biodiversity loss, indicated by a decline in the quality and area of habitats such as forests, coral reefs and mangroves (Roque *et al*, 2000). Forest coverage has decreased from about 70 percent in 1900 to 18 percent coverage in 1994 (Environment Management Bureau 1996), with only 27 percent of mangrove forest remaining, and 95 percent of coral reefs are in a degraded condition.

Such losses impact on the long-term sustainability of local communities due to their direct and indirect dependence on these natural resources. Negros Island, lying in the central Philippines (Figure 1.1) provides a good case example. On the island itself large tracts of forest cover have been converted to sugar plantation and over 70 percent of the Philippines sugar industry was based on Negros. Such large-scale clearance of natural vegetation means that only 4 percent of the original forest coverage remains, and largely above 800m elevation. Consequently, coastal forest has been cleared for urban development and the mangrove areas of south-western Negros and small coastal islands have all but disappeared largely due to the creation of fish ponds (Roque *et al*, 2000). This in combination with increased fishing pressure has meant that less than 5 percent of living coral reefs in Negros are in excellent condition, a problem that is exacerbated by polluted run-off from industrial operations and sugar mills (Davies 1990). However, on Danjungan Island to the west of Negros (Figure 1.1), natural vegetation and high quality reefs have been maintained and the island provides an ideal mesocosm for research, combining two of the most diverse ecosystems, coral reef and tropical forest, and an opportunity to conserve these natural resources.

1.2. Danjungan Island

Danjungan Island is a small (approximately 43 hectares), coral fringed island covered in tropical forest, 3km west of Negros just off the coast of Bulata in the Sulu sea, and is one of over 7000 islands that make up the Philippine Archipelago. The island has six lagoons, of which two are open to the sea and all but one are surrounded by mangrove stands. However, there is no permanent standing fresh water on the island. The terrain is rugged and characterised by limestone geology, which has permitted the formation of several caves around the perimeter of the island, and a more detailed description of the island is given by Harborne *et al* (1996).

Limited faunal surveys of these small limestone caves has revealed that they provide important havens for cave-roosting bat species, and the island is thought to host at least six species of mega-chiroptera (fruit-bat) (Maro 1994). Much of the previous faunal work has

focussed on the bird fauna and this has suggested that the island is an important refuge for in excess of 70 species, many of which are resident breeding species and some of which are endemic. The only other faunal group previously surveyed was the Lepidopterans, where 22 species of butterfly were listed in an unpublished inventory (Jumalon 2000). Most of the previous faunal work has only resulted in species inventories, with virtually none relating distributions to other biotic and abiotic factors, and no published work on the fauna of Danjungan has thus far been located.

With respect to the islands flora, a diversity of habitats are known to exist, including secondary tropical forest; beach and cliff forests; secondary scrub and grasslands; mangroves; and coastal mudflats. These habitats could provide a vital conservation refuge for several species due to the diminished status of these same habitat types on Negros Island. Previous work had begun to produce species inventories for a number of these habitats (Madulid & Agoo, unpublished). Many of the forested areas appear to be dominated by fig species (*Ficus spp*) and palms (*Areca catecho*, *Cocos nucifera*) and there is clear evidence of prior anthropogenic disturbance with the creation of coconut plantations (Maro 1994). However, no detailed botanical inventory work or habitat mapping has previously been undertaken on the terrestrial habitats of the island.

In 1995 the Philippine Reef and Rainforest Conservation Foundation, Inc (PRRCFI) established the Philippines Reef and Rainforest Project (PRRP) in collaboration with CCC and the World Land Trust to address the problems of reef and forest destruction. The main aim of the PRRP was to protect Danjungan Island via a community-driven reserve in order to protect the natural resources (Ledesma *et al*, 1999). Outcomes of the project included the formal establishment of Danjungan Island Marine Reserve and Sanctuaries (DIMRS) in February 2000, the establishment of People's Organisations (PO's) in the adjacent community, a better understanding and awareness of coastal and reefal resources in the community, and establishment of alternative livelihood projects. However, less focus has been given to the terrestrial resources.

1.3. Danjungan Island Biodiversity Survey

Coral Cay Conservation (CCC) was recently asked (May 2001) by PRRCFI to undertake initial biodiversity surveys within the terrestrial ecosystems of the island in an attempt to initiate the establishment of an ecological baseline for future research and conservation planning. It was proposed that CCC would undertake surveys of the major faunal and floral groups, utilising the established survey techniques employed on the Negros Rainforest Conservation Project (NRCP) in the North Negros Forest Reserve (NNFR) (Turner *et al*, 2001). This work will compliment the marine survey work completed by CCC/PRRCFI that resulted in the island being declared Marine Protected Area (MPA).

The Danjungan Island Biodiversity Survey (DIBS) represents the first integrated and quantitative survey of the biodiversity of the island and will contribute vital information to the on-going conservation and education work of PRRCFI. This represented a unique opportunity to contribute to the understanding of the ecology and conservation issues of this island ecosystem. It is widely acknowledged that a comprehensive assessment of the biological resources is important for effective and sustainable management of the island. Due to the time restrictions of the project (4 month duration) and limited technical support (lack of taxonomic guides and laboratory facilities) detailed taxonomic inventories were not attempted for floral and invertebrate groups. Research surveys were restricted to non-

invasive techniques based primarily on observation and live-capture protocols where no permanent specimen collection or preservation was made. Field research focussed on four major areas: vegetation inventories; habitat mapping; bird surveys; and bat surveys. Ad hoc observations were also made of lepidopterans and herpetiles.

The aims of the PRRCFI/CCC DIBS project were:

- i) To collate and consolidate the current species inventories;
- ii) To provide the first quantitative data regarding the terrestrial fauna and flora;
- iii) To provide distribution data on the major faunal and floral groups;
- iv) To develop a photo-library of the natural history of the island.

1.4. Report Overview

This DIBS report attempts to give the first detailed review of the terrestrial biodiversity of Danjugan, based on the fieldwork completed by CCC volunteers and by other researchers.

The report adopts a hierarchical perspective initially assessing the broad scale habitat distribution and extent through observation based mapping (Chapter 2). The four most dominant vegetation habitats were then assessed through quadrat survey methods in order to compare structural and morpho-species diversity of the different habitats (Chapter 3). Finally, one vegetation habitat (Mangroves) was surveyed in detail, to assess species composition, distribution, diversity and abundance and permit community comparisons between lagoons (Chapter 4).

To compliment the habitat and vegetation assessments, bird surveys (Chapter 5) and bat surveys (Chapter 6) were completed across the island permitting initial analysis of faunal distribution in relation to habitat factors. The findings of the current work are related to existing information and knowledge of the terrestrial habitats on the island and future work is proposed (Chapter 7).

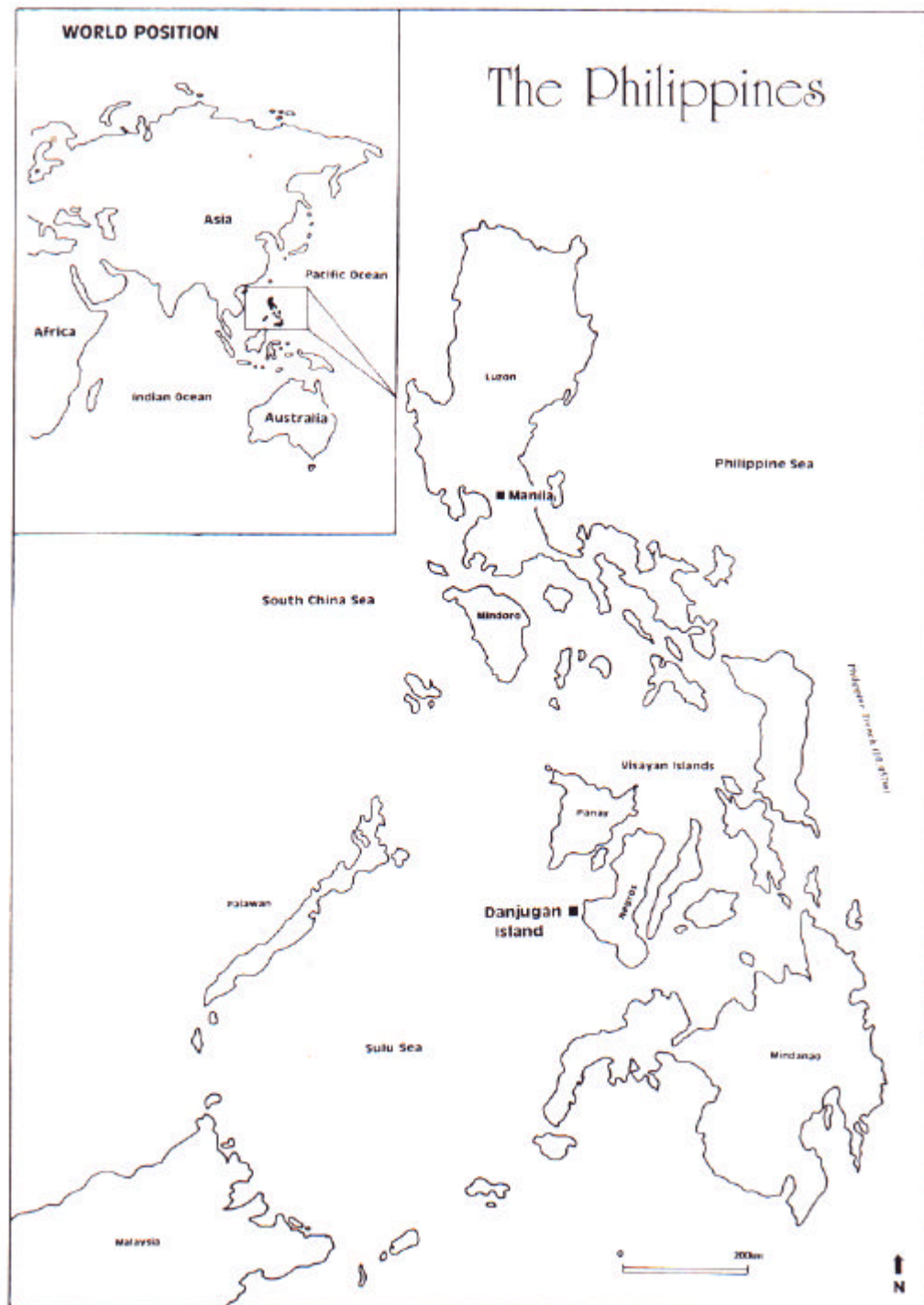


Figure 1.1. Location of Danjugan Island, Philippines.

2. Habitat Mapping

2.1. Introduction

Mapping of biological resources is a valuable tool in aiding the identification of conservation priorities and has an important role in monitoring and planning to minimize the potentially deleterious impacts of proposed projects or policies (Harding 1994). Since ecological communities vary in both space and time, once the distribution and size of major habitat types are known it is much easier to plan priorities and provide information for quantifying past or future change.

Whilst Danjungan Island clearly supports a variety of different habitat types, natural resource assessment and mapping work has to date been focused within the coastal zone (Harborne *et al*, 1996; Ledesma *et al*, 1999). Therefore, the terrestrial habitats (encompassing a wide range of vegetation communities) have only been briefly and qualitatively surveyed for the floral species present (Madulid & Agoo unpublished – Appendix 1). There has been no assessment of the spatial distribution and extent of these different habitat types. Neither has there been any attempt to assess possible relationships in distribution between floral and faunal groups. Hence the island provides an opportunity to produce a baseline habitat map that illustrates the location, extent and spatial arrangement of the major habitat types in relation to natural features such as the lagoons, peaks and ridges. This could then provide a baseline for a more spatially accurate map relating to absolute geographical positioning.

During the initial phase of the project it was observed that one of the major factors influencing vegetation cover and species composition was topography. However, no topographic map was available, so it was obvious that the production of a basic topographic map would complement all the other faunal and floral survey work that had been or was being undertaken by the DIBS project. Further, it was clear that there was a certain amount of inaccurate information concerning the topography of the island, for example the commonly reported presence of a peak of 800 metres on the island (Peters 1997). None of these reports gave the source of this information, so it could not be established whether this was a reference to an erroneous estimate, or an erroneous reference to a more probable estimate of 80 metres.

Habitat mapping is intimately linked with vegetation classification, and vegetation communities (particularly forest environments) are strongly influenced by local gradients in moisture, soil fertility and elevation (Orians *et al*, 1996). Due to the relatively small size of the island, two assumptions were made suggesting that precipitation would not vary greatly between habitats, and the uniformity of the parent geology (limestone) and thus soil type would not significantly affect vegetation communities. It was hypothesized that elevation (and exposure) could be the strongest of the three environmental drivers influencing vegetation community composition and thus habitat distribution.

2.2. Aims

1. To produce an illustrative map of the relative spatial extent and distribution of the major vegetation types on Danjungan Island.
2. To provide summary descriptions of the vegetation within each habitat type.
3. To develop a photographic database of vegetation communities within each habitat.
4. To produce a basic topographic map illustrating the approximate locations of the major peaks and ridges of Danjungan Island.

2.3. Methods

Habitat Mapping

The project used an adapted version of the Phase 1 Vegetation Classification (NCC 1990) where homogeneous vegetation communities are identified and classified according to a number of land cover classes. These classes were modified from UK classes (NCC 1990) to suit the major habitat types encountered on coastal islands in the Indo-Pacific region. Under the standard method habitat ‘parcels’ are delineated using natural boundaries (where possible) or are created by the surveyor and plotted onto existing maps (usually 1:10 000 topographic maps).

In the absence of such a published map, an outline map of the island was derived from Harborne *et al* (1996) and used as the spatial framework within which to undertake the mapping. This map already showed the lagoons, beaches and off-shore rocks and islands. The location and extent of the major habitat types was then superimposed primarily by remote viewing (from vantage points such as peaks, open lagoons, and boats), estimating their positions and extents by relating them to the natural features present on the base map. Less obvious habitat types, and qualitative vegetation descriptions, were established by direct ground surveys on foot. Photographs were also taken both from vantage points and from within the habitats.

Each major habitat type was delineated onto the base map using alphanumeric codes and each major type was further subdivided where observers agreed that significant spatial variation in species composition existed (determined by visual assessment of morpho-species). Each sub-type was also given an alphanumeric code that was then translated into a colour-coded system for the production of the final map.

Topographic Survey

The outline map of the island derived from Harborne *et al* (1996) was again used as the spatial framework within which to undertake the mapping. Following the methods outlined for habitat mapping the approximate location of major peaks and ridges were mapped primarily by remote viewing from vantage points such as other peaks, beaches, open lagoons, and boat-trips around the island, estimating their relative positions by relating them to the other natural features present on the base map.

The height of each peak was then calculated using the technique commonly used by foresters to calculate the height of trees. This is based on the formula:

$$Y = E + \tan X (D)$$

Where:

- Y = altitude of peak
- E = altitude of recorder's eye
- X = angle between horizontal and top of peak
- D = horizontal distance between recorder and peak

Most readings were taken from sea level (+/- 1 metre) to ensure that E was a known variable (0 + height of recorder). X was measured using a clinometer. D was calculated using the trigonometric formula $D^2 = A^2 + B^2$ for calculating the lengths of the sides of a triangle, where A and B were calculated from GPS readings taken from the recording point and from the peak itself. Therefore A was the difference between the north readings of the two locations, and B the difference between the east readings. Universal Transverse Mercator (UTM) position was used for these calculations, to ensure the measurements were in metres, not minutes and seconds. GPS readings could have been used to determine the horizontal distance between two points and to give the altitude directly, but in practice we found the margin of error too great for such small peaks. Where possible, the height of peaks was calculated from more than one spot to indicate the level of accuracy of the estimates.

The calculations described above rely on knowing the horizontal distance between the two points. In the absence of an accurate base map this had to be done using GPS readings from both points. Therefore, peaks that were not visited with a GPS could not be included in this analysis. However, compass bearings were taken from known locations around the island (i.e. from points with GPS readings taken) to several topographic features, in order to provide data that may allow triangulation analysis to locate these points. This data will not be presented here, as problems of GPS inaccuracy and variation need to be overcome before it can be analyzed.

2.4. Results

Habitat Mapping

The habitat surveys identified eleven major habitat types of which four were further divided into sub-types giving nineteen land cover types. The basic habitat map derived from these field surveys is illustrated in Figure 2.1 and an explanation of the habitat coding used is given in Table 2.1. All habitats above the higher tidal limit were included in the map.

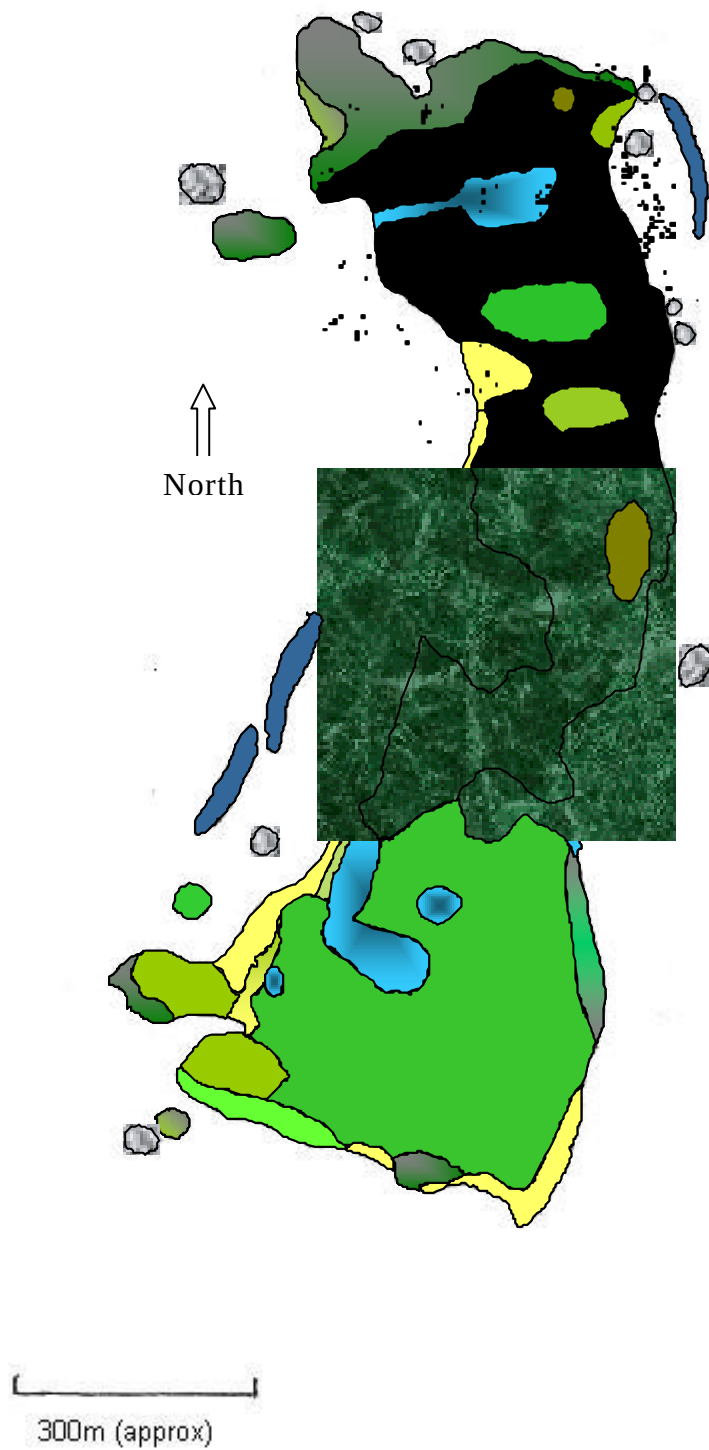


Figure 2.1. The habitat map of Danjungan Island (according to adapted Phase 1 classification). A key to the habitats is given in Table 2.1.

Table 2.1. Habitat types identified during Phase 1 habitat mapping of Danjungan Island, where the relative distribution of these habitat types is given in Figure 2.1.

A High forest	 Relatively undisturbed, <i>Ficus</i> -dominated.
B Mid-height forest	 Logged-over in the past, still with abundance of <i>Ficus</i> , some areas with low- density coconuts.
C Low forest	 On western-headlands, with abundance of "big-leaf-legume"; some areas with extensive <i>Pandanus</i> .  Small island with low forest, <i>Pandanus</i> and cycads.  Clifly area with low forest; <i>Pandanus</i> but without "big-leaf-legume".
D Coconut-dominated forest	 Small temporary freshwater "swamp", in flat area, with bananas, big-leaf <i>Pandanus</i> , saw-palm.  Coconuts and low scrub, abundance of <i>Zingiber</i> .  Coconut and secondary regrowth forest .  Coconut and secondary regrowth forest, with areas of dense "small-leaf-legume", occasional large mangos, and some patches of banana and other cultivated species.
E Coastal-cliff scrub/forest	 <i>Pandanus</i> -dominated but with several other coastal species including <i>Terminalia</i> , <i>Sterculia</i> and cycads; <i>Pemphis acidula</i> abundant near sea-level  <i>Pandanus</i> dominated.  <i>Pandanus</i> spp and "small-leaf-legume".
F Beach forest/scrub	 Coconuts and several coastal species including <i>Pandanus</i> spp, <i>Terminalia</i> , <i>Barringtonia</i>  Area of grasses and low coastal shrubs/trees.
G Beach	 Sandy/coral beaches.
H Cultivated fruit-garden	 Grassy clearing between forested ridges, with planted species such as banana, tea, figs.
J Bare-rock islands	 Little or no vegetation.
K Tidal rocks/corals	 Rocks/corals exposed at low tide.
L Salt-water lagoons	 Lagoon areas (all salt-water) with some mangroves present.

Topographic Survey

The basic topographic map illustrating the approximate locations of the major peaks (x) and ridges of the island is presented in Figure 2.2, and this also gives the locations of sites (s) used for calculating the height of peaks. The site codes correspond to those given in Table 2.2, which gives the GPS readings for each site, and to those in Table 2.3 that gives the calculations of height.

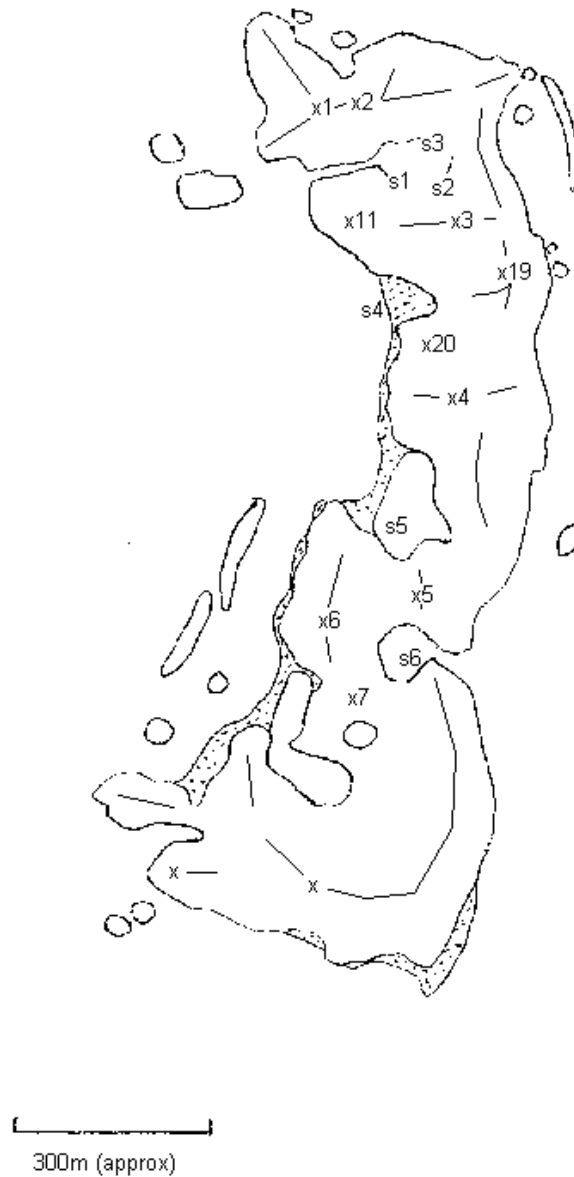


Figure 2.2. Initial topographic map for Danjungan Island, where (x) indicate peaks, (-) indicate ridges, and (s) indicates sites for readings (see Table 2.2).

Table 2.2. GPS readings for sites used in calculating the heights of peaks on Danjungan Island. Site codes correspond to those in Figure 2.2. UTM readings in *italics* indicate that these were not read from the GPS at the time of the reading, but were converted at a later date from the original reading.

Date	Site Code	Northing	Easting	UTM	UTM
29-Sep-01	s1	9° 52.69	122° 22.62	1092010	51431706
29-Sep-01	s2	9° 52.70	122° 22.69	1092031	51431829
29-Sep-01	s3	9° 52.76	122° 22.69	1092132	51431818
28-Sep-01	s4	9° 52.58	122° 22.65	1091809	51431750
28-Sep-01	s5	9° 52.38	122° 22.67	1091441	51431780
26-Sep-01	s6	9° 52.25	122° 22.72	1091195	51431901
29-Sep-01	x1	9° 52.76	122° 22.59	1092130	51431634
29-Sep-01	x2	9° 52.75	122° 22.62	1092118	51431689
30-Sep-01	x3	9° 52.67	122° 22.71	1091959	51431901
30-Sep-01	x4a	9° 52.50	122° 22.73	1091654	51431898
30-Sep-01	x4b	9° 52.50	122° 22.76	1091664	51431943
01-Oct-01	x5	9° 52.31	122° 22.72	1091300	51431876
30-Jul-01	x6	9° 52.15	122° 22.59	1091011	51431639
30-Jul-01	x6b	9° 52.10	122° 22.57	1090919	51431602
29-Sep-01	x7	9° 52.19	122° 22.67	1091103	51431779
28-Nov-01	x11	9° 52.65	122° 22.64	1091934	51431727
27-Nov-01	x19	9° 52.63	122° 22.74	1091900	51431916
28-Nov-01	x20	9° 52.57	122° 22.70	1091790	51431839

Table 2.3. Calculations used to estimate the heights of the major peaks of Danjungan Island. Site codes relate to those given in Table 2.2 and Figure 2.2.

Peak	Site	d	x	e	$y = e + \tan x (d)$	Mean ht (m)
x1	s1	140	24	1.5	63.8	64
x1	s2	219	16	1.5	64.3	
x2	s1	109	17	1.5	34.8	Unreliable
x2	s2	165	17	1.5	51.9	
x3	s3	192	23	1.5	83	76
x3	x1	317	1	64	69.5	
x4a	s4	214	16	1.5	62.9	Unreliable
x4b	s5	164	12	1.5	36.4	
x5	s5	171	12	1.5	37.8	37
x5	s6	108	18	1.5	36.6	
x6	s6	320	9.5	1.5	55	Unreliable
x6b	s6	407	11	1.5	80.6	
x7	s6	153	16	1.5	45.4	45
x11	s3	218	14	1.5	55.8	57
x11	s4	127	24	1.5	58	
x19	s4	189	13	1.5	45.1	45
x20	s4	91	16	1.5	27.6	28

2.5. Discussion

Habitat

The mapping technique employed is a widely used method (Cherrill & McClean 1999) and has resulted in a broad scale map delineating several different habitat types, demonstrating the diversity and distribution of the vegetation communities which most clearly illustrates a north-south split across the island between *Ficus* dominated and coconut palm dominated forest. The other dominant habitat types include the lagoons and scrub forest. It is acknowledged that this is an initial attempt to map the island and the resultant map produced is still relatively basic and approximate. It will require refinement to reduce mapping error and become more ecologically useful.

With respect to the technique used, two basic types of mapping error are possible in habitat mapping, namely misclassification of land cover types and spatial displacement of boundaries (Cherrill & McClean 1995). These are not necessarily independent and thus similar steps can be taken to reduce such errors. With regard to Danjungan, more detailed vegetation surveys (both transect and quadrat based) would not only aid land cover classification but appropriate spatial distribution of transects would reveal more accurately the relative location of transition zones from one land cover type to another. They would also permit changes along environmental gradients (such as elevation) to be more accurately quantified and assessed. Clearly this requires detailed surveys at genus and species level, and appropriate taxonomic support in order to accurately classify land cover types based on community composition (in terms of species presence/absence and distribution), was not available during the current project. However, a limited assessment of structural diversity, both within and between land cover types was undertaken (see Chapter 3).

More detailed vegetation surveys would not only improve the spatial accuracy but also improve the resolution of the map. It was observed that within each habitat type identified there is variation in species composition and structural diversity (see Chapter 3). This was particularly prevalent along elevational gradients where ridge-top vegetation is often very different to that lower down the slope, a phenomenon that has largely been overlooked in the creation of this broad-scale map.

Topography

In the absence of an accurate topographic map, the map figures presented give a useful indication of the approximate locations of peaks and ridges on Danjungan Island. This initial mapping survey can be used to help understand the relationships between topography and habitat types on the island.

The calculations of the heights of major peaks, using basic trigonometric techniques, gave some variable results, with some estimates being very similar, while others differed to such an extent as to make the estimate unreliable. The unreliable estimates tended to be for ridge tops that lacked obvious peaks, thereby reducing the accuracy of the distance estimates that depended on GPS readings from specific points that were hard to distinguish on the ground. However, the reliable estimates show that the highest peaks on the island are in the region of 60 to 80m above sea level, rather than the 800m quoted in a wide variety of literature (Peters 1997).

The data presented here may be used as an indication of the topography of Danjungan, but it is recommended that an accurate topographic map should be acquired or produced to allow detailed analysis of spatially related biological relationships. Such a map could be more accurately derived using basic surveying techniques (Miller 1977) time and resources permitting.

Conclusion

Despite the acknowledged probable inaccuracies of the current maps they can still be a useful tool in assessing the locations and extents of the different habitats present on the island. Coupled with existing qualitative species lists and quantitative structural and species diversity data, the maps may be used to assess distributions of flora and fauna across the island. Should a detailed topographic map be obtained (or developed), this could be over-laid with a broad-scale habitat map (revised to a similar level of spatial accuracy as the topographic map), and smaller-scale habitat variations may be identified and quantified, such as along elevational gradients. However, regardless of the accuracy of the base maps, the problem of delineating habitats that generally exhibit transitional zones will always be present (see Miller 1994). Therefore, a basic approximation of the extents of the habitat types, such as has been illustrated in this report, can often be just as useful for spatial analysis as apparently more accurate maps, so long as its limitations are recognised and managed appropriately (see Openshaw 1989; Aronoff 1991; Næsset 1997).

Ultimately the improved knowledge of habitat distribution and species presence within, and dependence upon these habitats will provide useful information to guide the future conservation management decision-making.

3. Vegetation Survey

3.1. Introduction

Danjungan Island is one of the few islands remaining in the Philippines whose vegetation is still relatively unspoilt and thus supports a range of vegetation communities from mangrove forest to beach scrub and forest over limestone. Each contains a differing array of species with several endemic to the Philippines (Domingo Madulid pers.comm).

The great diversity of vegetation types on Danjungan Island is due to several parameters, from natural variables such as topography and coastal exposure (see Chapter 2) to human-induced variables such as small-scale logging and clearing for coconut plantations. The coconut plantation areas are not managed for coconut production and under the current management the forest areas are being left to regenerate naturally following these past disturbances.

Despite the obvious richness of the flora only a qualitative summary of species present in the various habitat types has been undertaken (Madulid and Agoo unpublished – see Appendix 1). No assessment of the structural and species diversity of the major vegetation types has previously been undertaken.

3.2. Aims

This vegetation survey aimed to quantify and contrast the structural and species diversity of four major vegetation communities on the island identified during habitat mapping (Chapter 2). These included the regenerating (coconut) forest habitat in the south of the island, the *Ficus*-dominated high forest areas to the north of the island, legume-dominated areas on exposed headlands on the western side of the island, and the logged-over mid-height areas in the centre of the island (Figure 3.1).

3.3. Methods

The international standard plot size for tree inventories in mixed tropical forest is 1 hectare, split into twenty-five 20m x 20m quadrats (Dallmeier 1992; Alder & Synnott, 1992). For the purposes of this study a more rapid survey technique was employed, but based on the use of 20m x 20m quadrats for possible comparison with other tree inventories in the Philippines (Madulid 1996). Two survey sites were selected in each of the four habitat types to be assessed. At each survey site 100m of tape was set out along the ground on a north-south bearing (with the exception of Transect 6 which was laid along the direction of the ridge) as a centre line for the transect, and at each 20m interval a perpendicular tape was laid out 10m either side. This resulted in a set of 5 consecutive 20m x 20m quadrats in each transect, a total area of 0.2 ha for each transect. The tree species present were then assessed within each of the quadrats.

As large trees occur at a lower density than smaller trees, a larger area is needed to sample large trees than is required for small trees. Therefore, trees greater than 20 cm dbh (diameter at breast height) were recorded in all five of the quadrats, those greater than 10 cm dbh in 3 of the quadrats, and those greater than 5 cm dbh in a single quadrat. The quadrats within which each minimum-size was used was chosen at random for each transect. The data recorded for each tree was girth (converted to dbh) and morpho-species.

Species-level identifications were not attempted for all specimens during this expedition due to limited taxonomic expertise and support (and lack of appropriate permits for botanical collections).

For each quadrat some further details were recorded, including the presence or absence of selected under-story species, structural indicators such as canopy openness and percentage grass cover, and physical data such as aspect, slope, and slope position. The presence or absence of germinating coconuts was also noted for establishing coconut regeneration in the different sites.

The two *Ficus*-dominated transect sites were located just north of typhoon beach, while the one of the coconut-dominated transect sites was located from the south-west corner of lagoon 5 and the second in the forest south of 3rd lagoon and east of 6th lagoon. The two legume-dominated sites were located on the headlands between Turtle Beach and Tabon Beach, and between Tabon Beach and South-west Bay. The two mid-height logged-over sites were located on the hill between 3rd lagoon and 2nd lagoon, and the hill between 2nd lagoon and Bamboo-bridge trail (see Figure 3.1).

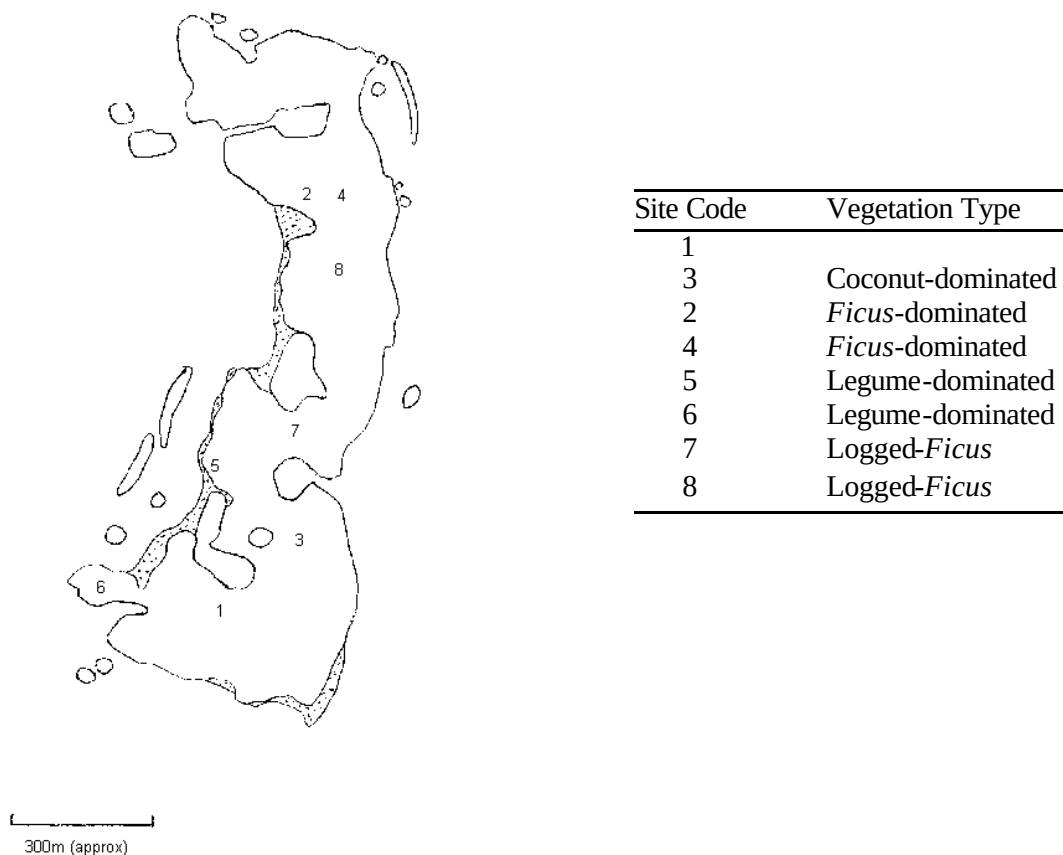


Figure 3.1. Location of vegetation transects on Danjungan Island.

3.4. Results

A total of 950 individual tree stems were assessed within the eight transects and the size class structure and morpho-species diversity of the four habitat types surveyed were quantified (Figure 3.2 & 3.3). Each transect was dominated by small stem individuals (<20cm dbh) and the *ficus* and coconut transects had a greater proportion of larger individuals (>30cm dbh). However, there was considerable within habitat variation in the frequency of smaller size classes, as indicated by the standard deviations (see Appendix 2).

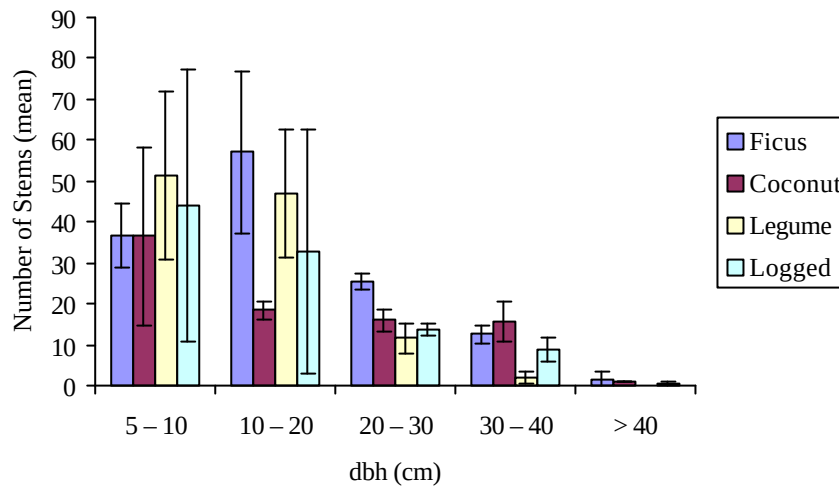


Figure 3.2. Mean number of stems (with SD) recorded in each size-class in each transect (not adjusted for sampling area).

A total of 196 morpho-species were identified across all transects, with the lowest species richness exhibited by the coconut transects. There was a clear difference in diversity with size structure, with a greater diversity of smaller (younger) species.

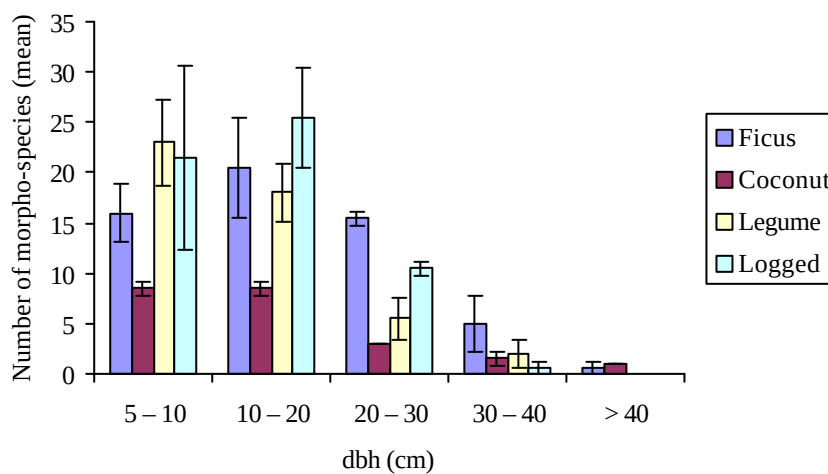


Figure 3.3. Mean number of morpho-species (with SD) recorded in each size-class in each transect (not adjusted for sampling area).

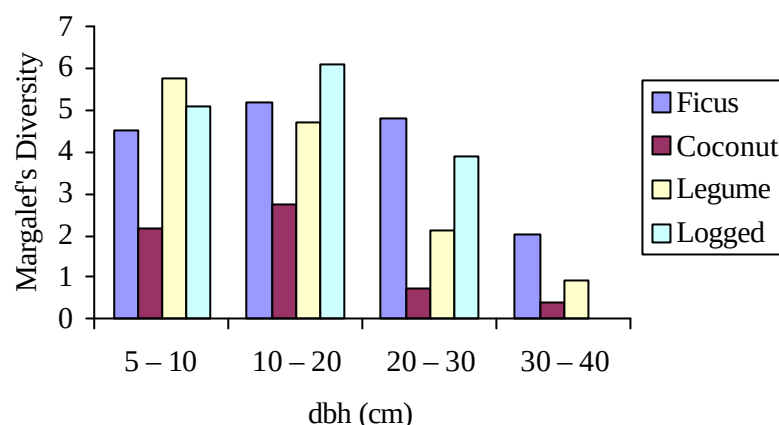


Figure 3.4. Mean species diversity recorded in each size-class in each transect (not adjusted for sampling area).

Species diversity (Figure 3.4) mirrored species richness by decreasing with increasing size class structure. There was also a clear difference between the diversity of the coconut transects compared to the other three transect types, with the former exhibiting lower diversity across all size classes. Differences were not tested statistically due to lack of sufficient replication. No single vegetation type demonstrated higher diversity across all size classes. There was little difference in species evenness across all transects for species below 30cm dbh (Figure 3.5). Results for species above 40cm dbh are not presented since only single species were located in each of the transects. Species evenness generally decreased with increasing size class (above 20cm dbh) particularly for the coconut-dominated transects.

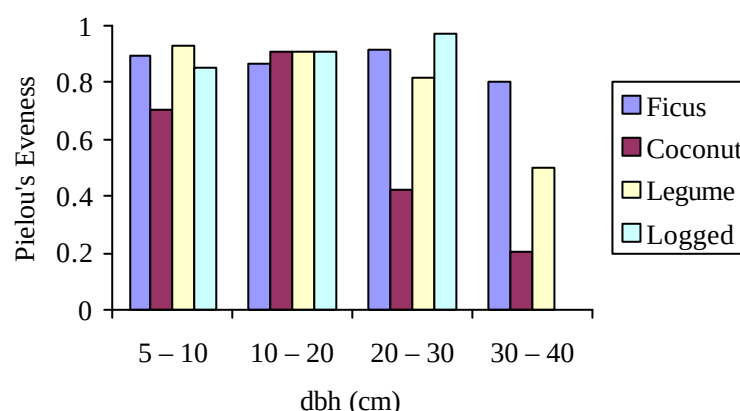


Figure 3.5. Mean species evenness recorded in each size-class in each transect (not adjusted for sampling area).

Whilst the data collected limits species-specific analysis it is apparent that certain species are very restricted in their distribution across the island. For example, *Callophyllum* species (Clusiaceae), previously unrecorded on the island, were restricted to ridge-tops and upper slopes in closed forest. More detailed analysis of species distributions across the island is clearly required.

3.5. Discussion

The results of the study give limited insight into the structure and composition of the different vegetation communities but the coconut-dominated forest was shown to have a different size-class structure and reduced species richness and diversity compared to the other three vegetation communities surveyed. The coconut-dominated forest did have comparable numbers of regenerating stems with the *Ficus*-dominated high forest within the 5 – 10 cm dbh size-class, but significantly fewer in the 10–20cm and 20-30cm dbh size-classes. This distribution is typical of a regenerating stand and should change over time as the regenerating trees continue to grow.

The much reduced species diversity and richness of the coconut-dominated forest may to some extent have resulted from previous anthropogenic influences with regard to land clearance for the coconut plantations. It is likely that the species diversity will increase over time by natural regeneration. Although the observed under-story vegetation of the *ficus* and coconut plots were different in composition, there were indications that the plantation area may be returning to more natural forest status. It was also apparent that coconuts are continuing to germinate in the coconut-dominated forest, but it has not been shown whether these persist in the vegetation community.

With regard to the legume and logged communities, they demonstrated broadly similar size-class distribution to each other and the *ficus* forest though the logged transects resulted in a highly variable data set (Figure 3.2 and 3.3). The legume and logged vegetation communities also had comparable species richness, diversity and evenness values to the *ficus* forest for stems <20cm dbh. However, for stems >30cm all three community metrics were reduced. It could be hypothesized that the absence of larger trees in the legume-dominated forest on the western headlands is due to the harsh environmental conditions of those areas, while in the central areas of the island it is due to logging under the previous management.

Interestingly, the seven largest stems in transect 7 were all dead trees, suggesting that, in addition to the direct impact of removing trees for timber, logging may have indirectly caused the death of the remaining large trees by increasing exposure to wind and sea-spray. This hypothesis is reinforced by the species composition of the ridge-top in this transect, made-up of a few low-growing species adapted to survive in harsh coastal habitats. In the same small area there are large standing-dead trees and logged stumps, implying that the area previously supported high forest.

The size class structure (Figure 3.2) suggests that species diversity is slightly higher in the logged-over mid-height forest than the legume-dominated low forest, again supporting the view that the forest on the western headlands is restricted to some extent by harsh environmental conditions. Species diversity of the logged-over forest is also similar to that of the *Ficus*-dominated high forest suggesting that logging has not reduced species diversity, and that in time the logged-over forest may regenerate naturally to a state similar to its prior composition. However, specific analysis of those species' selectively logged would be required to confirm this prediction.

These findings are preliminary due to the limited transect replication and lack of true species identification. However, it is clear that Danjungan supports a range of different vegetation communities with considerable species diversity that are worthy of future investigation in order aid the habitat mapping process and to assess the importance of the island for floral conservation and thus implement management actions accordingly.

4. Mangroves

4.1. Introduction

The diversity of coastal plants in the Philippines is one of the richest in the world (Calumpong & Menez 1996). One of the most important components of the coastal ecosystem is the mangal community (dominated by mangroves) on the landward side of the coastal zone, usually located within the inter-tidal zone. Approximately sixty to seventy mangrove and associated mangrove species are found in the Philippines, 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). In the Philippines, the most common genera are *Rhizophora*, *Avicennia*, *Bruguiera* and *Sonneratia* (Calumpong & Menez 1996) and at least fourteen species have previously been recorded from Negros Island (Calumpong 1994).

Mangals are one of the most diverse communities in the coastal area, harbouring a variety of fauna and they also provide a range of ecological goods and services. Such services include provisions of nurseries for fisheries, nutrient and sediment buffers for fringing reefs and coastal defence, whereas goods include edible products (e.g. shellfish and crustaceans), fuel wood, construction materials and medicines (Bandaranayake 1998). Their importance to fisheries is stressed by a positive correlation between near-shore yields of fish and/or shrimp, and relative densities of mangrove areas that have been documented in the Philippines (Primavera 2000).

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. A more detailed history on Philippine mangrove communities is given by Primavera (2000). Such conversion in combination with over-exploitation has meant that the Philippines has lost over 70% of its original mangrove forest (Walters 2000) and fifty percent of the remaining forest cover is deemed to be threatened (DENR/UNEP 1997). Many of the larger mangrove areas of south-western Negros and small coastal islands have practically disappeared because of the creation of salt-beds and fish ponds (Roque *et al*, 2000).

It has been suggested that conservation of the country's remaining 100,000 hectares of mangrove should be prioritised and existing stands should be re-evaluated for possible application of community-based management schemes within the context of a wider integrated coastal zone/area management (Primavera 2000). Clearly a precursor to such applied action is identification and baseline assessments of existing mangrove stands within a particular area. Danjungan Island provides an ideal candidate location for such work since the abundant mangrove resources have never been assessed.

The current study undertook an intensive survey of all the lagoons (and other locations), to provide a fully quantitative inventory of the mangrove communities.

4.2. Aims

- 1.To complement the existing inventory of mangrove species on Danjungan Island.
- 2.To fully quantify the abundance and distribution of each mangrove species.
- 3.To compare and contrast the mangal communities at different locations.

4.3. Methods

An initial survey of the island identified a total of seven locations supporting mangrove stands (Figure 4.1). However, it should be noted that the site referred to as lagoon 7 is not a true lagoon, but a small tidal pool between Tabon Beach and South-west Bay. It is included in the initial inventory since it supports mangroves. Each lagoon was then inventoried between August and September 2001 using a total count method (Bullock 1996). The lagoons were surveyed in sections, which corresponded broadly to the north, south, east and west shores of each location. Within each section, a count of all established true mangrove plants was made with all individuals identified to species level. Associated mangrove species were also recorded and identified to species level where practicable, however only presence/absence data is presented. A number of unidentified associated mangrove species were documented as morpho-types (where resolution to family level or lower could not be achieved).

Identifications were made using the available field-guides (Calumpong & Menez 1996, Melana & Gonzales 1996, Lovelock 1964) although a few species remained unidentified they were included in the inventory in order to illustrate total species richness at each site.

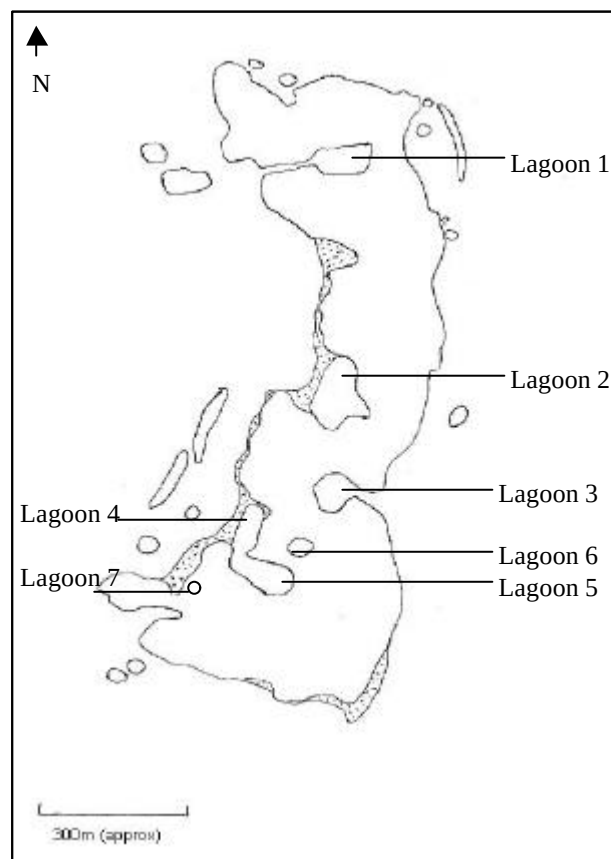


Figure 4.1. Schematic outline map of Danjungan Island with location of lagoon areas where mangrove stands were identified.

For each major location, four measures of local diversity of true species were calculated. These were: total number of species (S); total abundance of individuals; Shannon-weiner diversity $H = -\sum (P_i * \log_e(P_i))$ (where P_i is the number of individuals of the i th species as a

proportion of the total number of all i th species); and Pielou's evenness $J=H/\text{Log}_e S$ (Carr 1996).

Further patterns in community composition were assessed using PRIMER (Plymouth Routines in Multivariate Ecological Research) (Clarke & Warwick, 1994a). Community (species abundance) data were double-square root-transformed to reduce the influence of dominant and rare species. The Bray-Curtis similarity measure was then calculated between every permutation of sample pairs (Clarke & Warwick 1994b). The relationship between samples (lagoons) was displayed using hierarchical agglomerate clustering technique (Figure 4) (Clarke & Green 1988).

4.4. Results

A total of fourteen true mangrove species from eight families and twelve associated mangrove species (or morpho-types) were identified on Danjungan (Table 4.1). A further true species, *Lumnitzera racemosa*, only distinguishable from *L. littorea* by its white flowers, is believed to occur at low-density in lagoon 2 (Vincent Lumbab, pers. comm.), but this could not be confirmed during the present study.

Table 4.1. Total abundance of true mangrove species in each lagoon on Danjungan Island

Family	Species	Lagoon						
		1	2	3	4	5	6	7
Avicenniaceae	<i>Avicennia marina</i>	-	-	45	-	-	-	-
Combretaceae	<i>Lumnitzera littorea</i>	-	193	-	-	-	-	-
Euphorbiaceae	<i>Excoecaria agallocha</i>	4	51	2	-	-	-	-
Meliaceae	<i>Xylocarpus granatum</i>	-	335	-	172	46	-	-
Meliaceae	<i>Xylocarpus moluccensis</i>	23	16	6	4	53	-	3
Myrsinaceae	<i>Aegiceras sp.</i>	-	-	9	-	-	-	-
Palmae	<i>Nypa fruticans</i>	-	-	-	-	-	4	-
Rhizophoraceae	<i>Bruguiera cylindrica</i>	3	-	-	218	67	-	-
Rhizophoraceae	<i>Bruguiera gymnorhiza</i>	1	-	3	13	277	-	-
Rhizophoraceae	<i>Ceriops decandra</i>	1	-	1	-	-	-	-
Rhizophoraceae	<i>Rhizophora apiculata</i>	6	124	24	31	-	-	-
Rhizophoraceae	<i>Rhizophora mucronata</i>	7	1	121	204	4	-	-
Sonneratiaceae	<i>Sonneratia alba</i>	-	-	6	-	-	-	-
Sonneratiaceae	<i>Sonneratia caseolaris</i>	-	-	6	-	-	-	-

Of the classic mangrove family, the Rhizophoraceae, *Rhizophora mucronata* was the most common, and was the dominant species at both lagoons 3 and 4 (Table 4.1). However, at lagoon 2, just a single established *R. mucronata* was recorded, with *R. apiculata* being the dominant Rhizophoraceae. *Bruguiera gymnorhiza* dominated lagoon 5, but only a few individuals were found elsewhere. *B. cylindrica* was never the most dominant species, but was well represented in lagoons 4 and 5, and was also recorded at lagoon 1. Just two individuals of *Ceriops decandra* were recorded, one in each of the lagoons open to the sea.

Within the Meliaceae family *Xylocarpus granatum* was the most common species overall, but was restricted to the three large closed lagoons, whilst *X. mollucensis* was much less frequently recorded but more widely distributed. The remaining true species tended to be established in just a single lagoon, for example *Lumnitzera littorea* in lagoon 2 and *Avicennia marina* in lagoon 3.

Of the associated species (Table 4.2), *Pongomia pinnata* was the most widely distributed, being recorded from each lagoon. *Pemphis acidula* (threatened species) was common in lagoon 3, and present in lagoon 1, but was not recorded from any of the closed lagoons. It should be noted, however, that this species is also distributed widely on low exposed rock all around the coast of the island.

Table 4.2. Presence/absence of identified associated mangrove species located within each lagoon.

Family	Species	Lagoon						
		1	2	3	4	5	6	7
Combretaceae	<i>Terminalia cattapa</i>	Y	-	Y	-	Y	-	-
Fabaceae	<i>Aganopa heptaphylla</i>	Y	-	Y	-	-	Y	-
Fabaceae	<i>Pongomia pinnata</i>	Y	Y	Y	Y	Y	Y	Y
Lecythidaceae	<i>Barringtonia asiatica</i>	-	-	Y	-	-	-	Y
Lythraceae	<i>Pemphis acidula</i>	Y	-	Y	-	-	-	Y

Distribution, abundance and species richness all varied with location. While lagoons 2 and 4 supported the highest number of individuals (Table 4.3), lagoons 1 and 3 demonstrated the highest cumulative (true and associated) total species richness (Figure 4.2). For both true species and associated species, lagoon 3 was the most species rich (including morphotypes). Lagoon 6 supported just one true species (*Nypa fruticans*), a species located nowhere else on the island. This lagoon, and lagoon 7 which also supported just one true species (*Xylocarpus moluccensis*) were both excluded from further analysis.

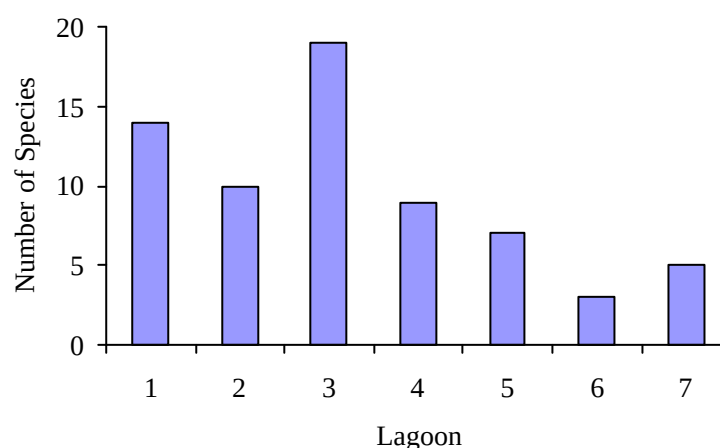


Figure 4.2. Total cumulative species richness for 'true' and 'associated' species within each lagoon.

Table 4.3. Mangrove community metrics (for true species) for each lagoon.

Community Metric	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 4	Lagoon 5
Species Richness	6	6	10	6	5
Total Abundance	44	720	223	642	447
Shannon-Weiner diversity	1.32	0.76	1.66	0.77	0.66
Pielou's Evenness	0.78	0.72	0.63	0.75	0.69

The diversity analyses (Table 4.3) show Lagoon 3 to be the most diverse location with the highest species richness and Shannon-Weiner value. However it also has the lowest evenness value since it is dominated by 3 species. The analysis of community composition using a non-metric multidimensional scaling (NMDS) ordination (Figure 4.3) and a hierarchical agglomerate clustering technique (Figure 4.4) confirmed that lagoons 4 and 5 are most similar to one another (>65% similarity) as are lagoons 1 and 3 (>50% similarity), with lagoon 2 clearly separated from both pairs at a much lower level of similarity (<40%).

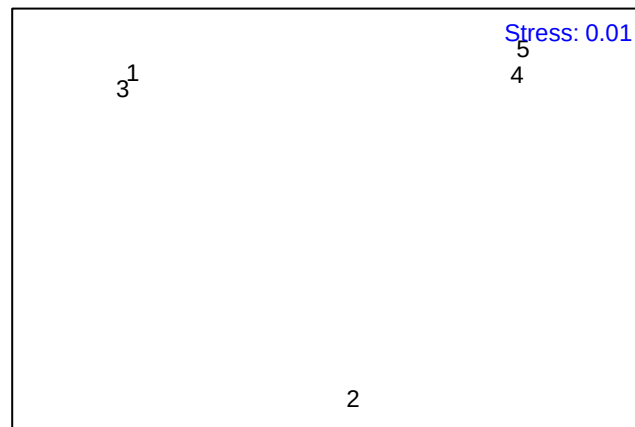


Figure 4.3. NMDS ordination of the five main lagoons, indicating that lagoons 1 & 3, and 4 & 5, are most similar to one another in terms of their community composition.

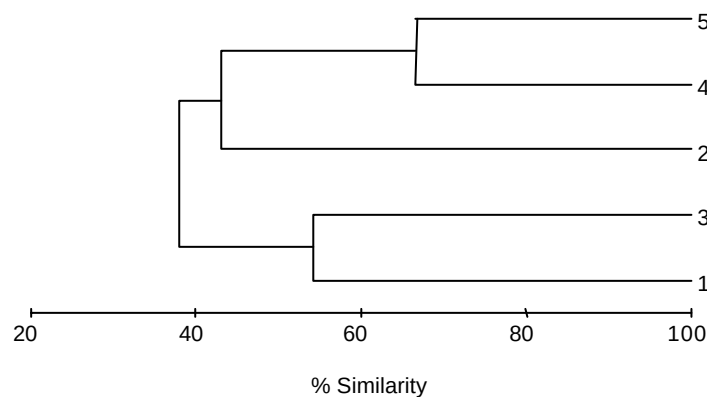


Figure 4.4. Dendrogram of mangrove community composition at the five lagoons, calculated using group-average linking of Bray-Curtis similarities (calculated from $\sqrt{\sqrt{\cdot}}$ -transformed data) and labelled according to lagoon location.

4.5. Discussion

Danjungan Island has a relatively diverse mangrove flora with species richness comparable to other sites on Negros where at least fourteen species have been recorded, and to the most diverse sites in the Philippines where twenty-nine species have been identified (Calumpong 1994). The lagoons have surprisingly different species compositions within their mangrove communities. The two lagoons open to the sea (1 & 3) had the highest species richness while the three enclosed lagoons (2, 4 & 5) had the highest abundance of mangrove stems. The reason for these observed patterns maybe two-fold. Firstly, lagoons 1 and 3 are potentially exposed to increased natural recruitment of propagules via transportation on the tidal flow and secondly it may be that the varying water circulation patterns and tidal flushing into and out of lagoons 1 and 3 presented the widest range of physical conditions which increases disturbance and could promote a greater species diversity, according to the intermediate disturbance hypothesis (Connell 1978).

This suggests that at low levels of disturbance, a few competitively superior species will dominate communities resulting in lower levels of diversity, as found in the 'enclosed' system represented by the other lagoons (2, 4 & 5). Whilst at intermediate disturbance levels, physical, chemical or biological disturbance creates space for new species to colonise, resulting in higher species diversity. Whilst Connell (1978) has shown that diversity is often higher in habitats that are subjected to some disturbance than in undisturbed habitats, this would clearly require further investigation in the context of the lagoons of Danjungan.

Such a theory has some foundation based on the observed results from lagoons 1 and 3 which had few abundant species and contained a cross-section of family groups with differing habitat preferences such as those that prefer tidal streams (e.g. *Sonneratia alba* and *Sonneratia caseolaris*) or deeper mud habitats (e.g. *Rhizophora mucronata*) or landward edges of mangal communities (e.g. *Avicennia marina*). Additionally lagoons 2, 4 and 5 were dominated by just two families, that either prefer fine substrates (e.g. *Rhizophoraceae* spp.) or are typical of more inland areas (e.g. *Meliaceae* spp.). Fine substrates are more indicative of areas with less current, which is likely given the lack of opening to the sea from these lagoons. The predominance of *Rhizophora* species demonstrated similarities with other areas of Negros (Walters 2000) and the Philippines (Calumpong 1994). However, *Avicennia* and *Sonneratia* species were not common in the present study as they have been at other locations (Walters 2000; Calumpong 1994) and this may be explained by the observed general preference for many species in these families for tidal stream areas and hence they were only located in lagoon 3 (Calumpong 1994). Soil/substrate type may also play an important role in determining community composition since the substrate types surrounding the island are rubble, sand silt with few areas classified as mud. As compared to the mangrove forest across mainland Bulata where *Avicennia* and *Sonneratia* species are more numerous.

Based on historical accounts by the local communities of Bulata, lagoons 1 and 3 are more accessible for exploitation. They have been gathering firewood on the island prior to the acquisition by PRRCFI in 1994. From community interviews undertaken by PRRCFI, they preferred species like *Avicennia* and *Sonneratia* for firewood while *Rhizophora* species are exploited for construction materials and tannins for food colouring. This is also one reason why there are relatively fewer *Avicennia* and *Sonneratia* on the mainland. *Rhizophora*

species are more numerous since they are fast growing and the government has been promoting a monospecific reforestation program using *Rhizophora*.

The underlying causal mechanisms for the observed ecological patterns clearly requires further investigation with respect the role of disturbance and abiotic conditions (e.g. water quality) which was not possible during the present study. Additionally, the ecological role of the mangrove communities in lagoons 1 and 3 with respect to habitat provision and trophic support for juvenile fish communities would be worthy of further research particularly in light of the protected area status of surrounding coral communities of the island. Similarly, the size and age structure of existing trees should be more thoroughly investigated, and the number of seedlings inside and outside lagoons should be counted to investigate the potential for further growth of the mangal.

The mangroves of Danjungan are clearly an important conservation resource in terms of their species diversity and the fact that the island harbours relatively high numbers of *Pemphis acidula* which is considered a threatened species due to over-collection for the bonsai trade (Philippines National Herbarium, pers. comm.). Additionally, these communities are not only potentially important for juvenile fish but the Philippine Reef and Rainforest Conservation Foundation Incorporated who manage Danjungan Island have been using the mangrove seedlings of the island to reforest areas on the island and re-seed at the adjacent coastal villages on the mainland. A mangrove and beach forest tree nursery for species such as *Bruguiera*, *Xylocarpus*, *Ceriops* and *Rhizophora* has been established in the second lagoon beach (not assessed in this study). Successful ‘growing-on’ of these seedlings has occurred in the nearby mainland communities, and the long-term goal is to use the re-established mainland mangal as a nursery and habitat for mud crabs (*Scylla* spp.), and thereby create an alternative income to the coral reef fishery. Therefore, the lagoons of Danjungan Island potentially provide a rich resource for ecological restoration and do not only provide habitat for species-rich mangrove forests, but could be used to apply coastal zone regeneration of associated mangals. Future environmental management of the island should be mindful of these values.

5. Birds

5.1. Introduction

The Philippines has one of the highest levels of species endemism in the world. Of the 576 bird species recorded, 192 are endemic (33%). The avian diversity of the Philippines is of global importance and BirdLife International has designated 9 areas of the Philippines as Endemic Bird Areas (EBA) and some as Important Bird Areas (IBA) (Stattersfield *et al*, 1998). An EBA is defined as an area that encompasses the overlapping breeding ranges of restricted range bird species. The EBA in the Western Visayas (which includes Negros Island and Danjungan Island) was listed as one of the 11 highest-ranking (in terms of biological importance and threat level) EBAs worldwide (Brooks *et al*, 1992) and thus a conservation priority.

The Philippines also 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). 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). Some of the decline is attributable to hunting, poaching and more importantly habitat loss, as forests have been cleared through logging and the development of commercial agriculture.

Danjungan Island represents a potential haven for many bird species due to the lack of the aforementioned threats and 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, on Negros and on other islands within the Visayan faunal region. It could therefore be an important area for species that are geographically restricted.

It is widely acknowledged that areas of Negros are biologically poorly known and further field studies should be completed in order to provide adequate baseline data to develop appropriate conservation strategies (Evans *et al*, 1993; Collar *et al*, 1999). In order to assess the relative importance of Danjungan for the avifauna of the Philippines and the Negros EBA it is vital to undertake baseline survey work.

5.1.1. Aims

1. To assess the bird species diversity of Danjungan Island.
2. To assess the relative abundance and distribution of species in relation to habitat type.
3. To compliment previous surveys and other informal observations in order to compile a full species inventory.

The CCC staff and volunteers undertook rapid bird surveys to assess diversity, distribution and relative abundance thus building on the previously completed survey work. Two principle survey methods, MacKinnon Lists and Mist Netting, were employed and these will be discussed separately.

5.2. MacKinnon Lists

5.2.1. Methods

The bird fauna of Danjungan Island was initially 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 of the island, the list length was set at the advised minimum of eight species (Bibby *et al*, 1998) with ten species recorded where possible. A species can only be recorded once on each list but may be recorded on subsequent lists. Surveys were repeated until at least ten lists were made at each survey location. Such data then permits the calculation of species discovery curves and an index of relative abundance (Bibby *et al*, 1998).

Whilst fourteen potential survey locations were identified, MacKinnon lists focused on twelve locations around the island (Table 5.1, Figure 5.1) that were surveyed throughout the duration of the project. Occasionally the 10 species could not be recorded in a single visit; in these cases the site was revisited later in the day or the following day to complete the list.

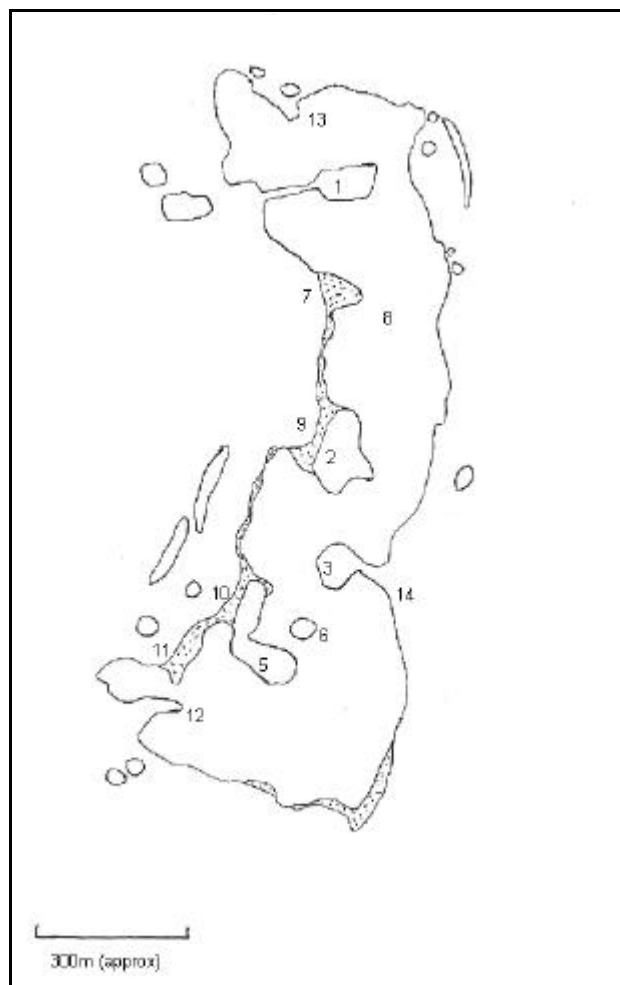


Figure 5.1. Location of MacKinnon surveys on Danjungan Island.

Table 5.1. Locations of Mackinnon List surveys.

Location code	Location	Location code	Location
1	Lagoon 1	8	Bamboo Bridge trail
2	Lagoon 2	9	Turtle Beach
3	Lagoon 3	10	Tabon Beach
5	Lagoon 5	12	South-west Bay
6	Lagoon 6	13	North Wall
7	*Typhoon Beach	14	*South-east Beach

* not included in subsequent data analysis

Whilst surveys were undertaken initially at twelve locations around the island, Typhoon Beach and South-east Beach were excluded from further data analysis for not achieving the minimum number of lists.

5.2.2. Analysis

Species discovery curves were calculated for each survey location by replacing surveyor effort with the number of lists and plotting this against the cumulative total number of species.

An Index of Relative Detectability (IRD) rather than abundance was calculated for each species calculating the proportion of lists on which it appears at each location, and thus the index can vary between 0 (species not recorded) and 1 (species recorded on every list). The term “index of relative detectability” has been used here, 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.

Species diversity metrics were then calculated from the IRDs. Three measures of local diversity were calculated for each survey location and these included: Total number of species (S), Shannon-Weiner diversity $H = -\sum (P_i * \log_e(P_i))$ where P_i is the number of individuals of the i th species as a proportion of the total number of all i th species, and Pielou’s evenness $J = H / \log_e S$ (Carr 1996).

Further patterns in community composition were assessed using PRIMER (Clarke & Warwick, 1994a). The Bray-Curtis similarity measure was then calculated (from IRD data) between every permutation of sample pairs (Clarke & Warwick 1994b). The relationship between survey sites was analysed using a non-metric multidimensional scaling (NMDS) ordination and a hierarchical agglomerate clustering technique (Clarke & Green 1988).

5.2.3. Results

A total of 163 lists were completed and 41 species from 24 families were recorded (see Appendix 3) around the island with the most species rich location being at Bamboo bridge trail, however proportionally more surveys were completed at this location. Species discovery curves (Figure 5.2 & Figure 5.3) indicate similar rates of species discovery at each location for both the eight and ten species lists, with no clear plateau present at any location. The sites were also similar in their overall species richness and the most species poor sites were North Wall and Lagoon 6.

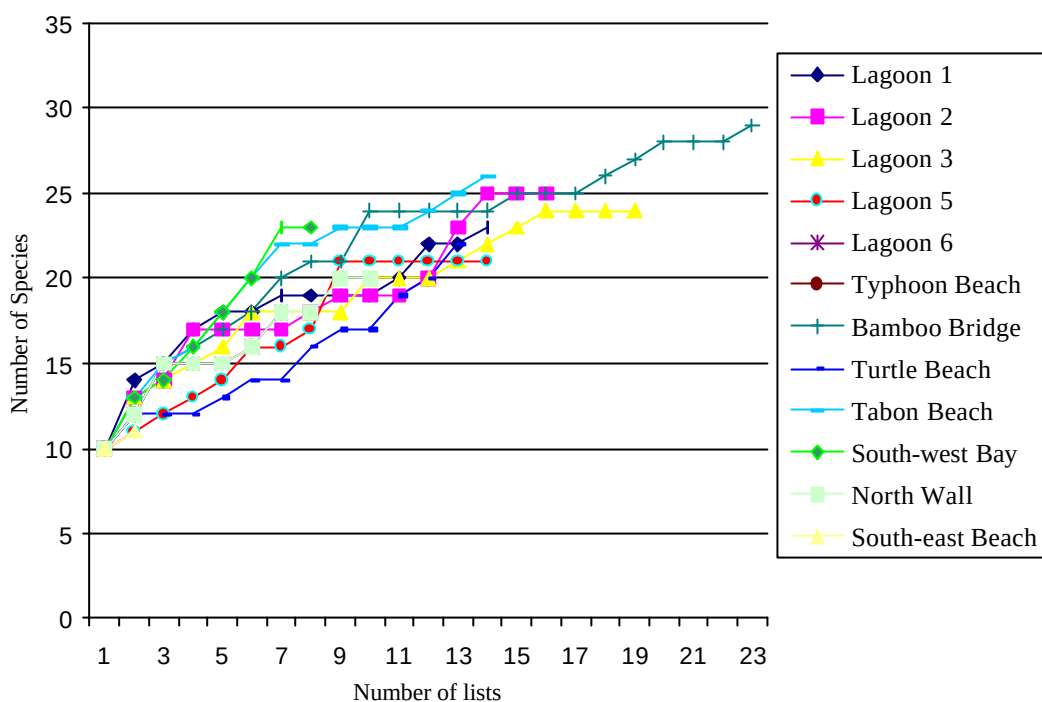


Figure 5.2. Species accumulation curves for lists with ten species.

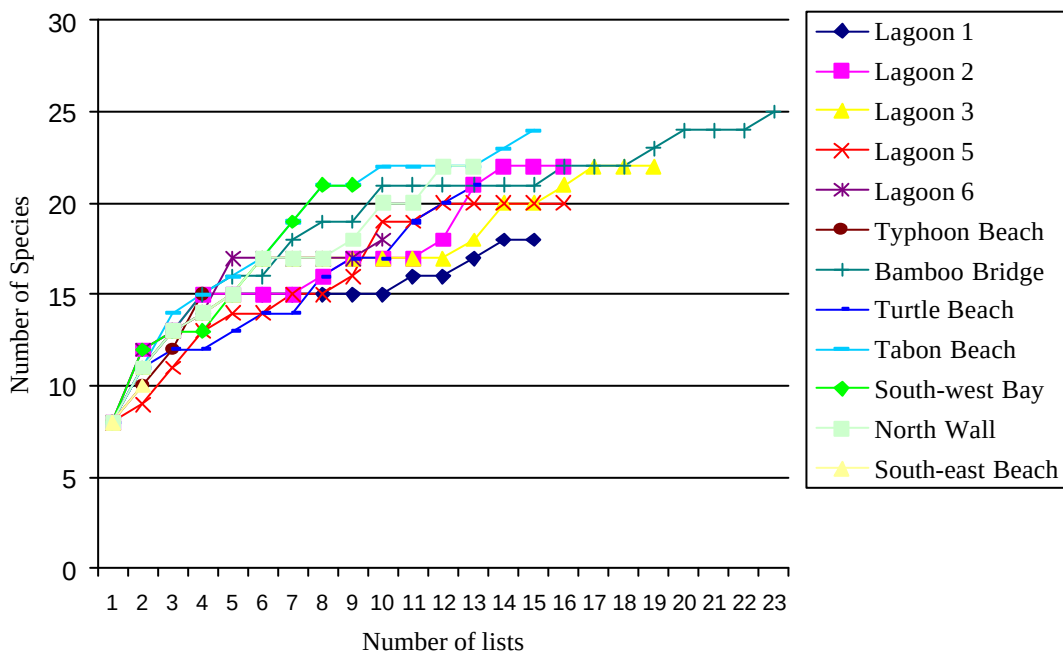


Figure 5.3. Species accumulation curves for lists with eight species.

Table 5.2. Species IRD values by week and by location on Danjugan Island.

	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 5	Lagoon 6	Typhoon Beach	Bamboo Bridge	Turtle Beach	Tabon Beach	South-west Bay	North Wall	South-east Beach
Black-naped Oriole	1.00	1.00	0.94	1.00	0.92	1.00	0.96	0.92	0.86	1.00	0.92	1.00
Glossy Swiftlet	0.92	0.93	0.94	0.94	0.92	1.00	1.00	1.00	0.86	0.88	0.85	1.00
Olive-backed Sunbird	0.69	1.00	0.82	0.82	0.92	1.00	0.87	1.00	0.93	1.00	1.00	1.00
White-collared Kingfisher	1.00	0.93	1.00	0.71	0.75	1.00	0.70	1.00	0.93	0.75	0.92	1.00
Pied Fantail	0.92	0.79	0.82	0.88	1.00	1.00	0.83	0.75	0.79	1.00	0.69	1.00
Asian Glossy Starling	0.77	0.86	0.59	0.65	0.75	1.00	0.87	0.83	0.64	0.75	1.00	0.00
Golden-bellied Flyeater	0.85	0.79	0.82	0.82	0.75	0.00	0.48	0.83	0.86	1.00	0.69	1.00
White-breasted Wood-Swallow	1.00	0.86	0.65	0.41	0.08	1.00	0.61	0.75	0.79	1.00	1.00	1.00
Pink-necked Green-pigeon	0.77	0.43	0.53	0.53	0.08	0.00	0.39	0.92	0.29	0.13	0.54	1.00
Pied Triller	0.31	0.64	0.24	0.47	0.17	0.50	0.52	0.33	0.29	0.50	0.46	1.00
Little Heron	0.54	0.50	0.76	0.53	0.58	0.00	0.04	0.33	0.50	0.13	0.15	0.00
Stork-billed Kingfisher	0.62	0.43	0.71	0.41	0.08	0.00	0.00	0.50	0.50	0.13	0.08	0.50
Oriental Magpie-Robin	0.00	0.14	0.41	0.12	0.50	0.00	0.65	0.08	0.07	0.00	0.08	0.50
Tabon Scrubfowl	0.15	0.21	0.18	0.24	0.33	0.00	0.43	0.17	0.07	0.38	0.31	0.00
White-eared Brown-Dove	0.15	0.21	0.18	0.12	0.25	1.00	0.22	0.08	0.14	0.25	0.08	0.00
Black-chinned Fruit-Dove	0.38	0.21	0.12	0.06	0.08	0.00	0.09	0.33	0.21	0.13	0.00	0.00
Philippine Coucal	0.23	0.07	0.06	0.00	0.17	1.00	0.52	0.00	0.00	0.13	0.00	0.00
Common Sandpiper	0.31	0.07	0.24	0.00	0.00	0.00	0.00	0.33	0.29	0.13	0.00	0.00
White-bellied Sea-Eagle	0.38	0.00	0.00	0.18	0.00	0.00	0.17	0.00	0.14	0.00	0.23	0.00
Rufous Night Heron	0.23	0.00	0.06	0.29	0.50	0.00	0.00	0.00	0.07	0.00	0.00	0.00
Lesser Frigatebird	0.00	0.00	0.12	0.06	0.08	0.00	0.26	0.00	0.07	0.13	0.15	0.00
Spotted Dove	0.08	0.07	0.06	0.00	0.00	0.00	0.09	0.08	0.07	0.00	0.38	0.00
Brown Shrike	0.08	0.07	0.12	0.00	0.08	0.00	0.17	0.08	0.00	0.13	0.00	0.00

Table 5.2. Continued.

	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 5	Lagoon 6	Typhoon Beach	Bamboo Bridge	Turtle Beach	Tabon Beach	South-west Bay	North Wall	South-east Beach
Pacific Swallow	0.08	0.07	0.06	0.00	0.00	0.00	0.09	0.08	0.00	0.13	0.15	0.50
Black-naped Tern	0.00	0.07	0.12	0.00	0.00	0.00	0.00	0.00	0.21	0.13	0.00	0.00
Large-billed Crow	0.00	0.00	0.06	0.00	0.00	0.00	0.09	0.00	0.07	0.25	0.08	0.00
Barn Swallow	0.15	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.07	0.00	0.08	0.00
Common Koel	0.00	0.07	0.00	0.06	0.08	0.00	0.00	0.08	0.00	0.13	0.00	0.00
Common Emerald-Dove	0.08	0.07	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00
Blue Rock-Thrush	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
Tawny Grassbird	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.15	0.00
Black-capped Kingfisher	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.08	0.00	0.00	0.00	0.00
White-browed Crake	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Great Frigatebird	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Common Kingfisher	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Grey-tailed Tattler	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00
Mangrove Blue Flycatcher	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Nightjar sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00
Oriental Cuckoo	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Philippine Leaf-Warbler	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pygmy Swiftlet	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Red-Necked Phalarope	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5.3. Species located over time.

Family	Genus / Species	Common Name	27th Jun - 4th Jul	4th Jul - 11th Jul	11th Jul - 18th Jul	18th Jul - 25th Jul	25th Jul - 1st Aug	1st Aug - 8th Aug	8th Aug - 15th Aug	15th Aug - 22nd Aug	22nd Aug - 29th Aug	29th Aug - 5th Sep	5th Sep - 12 Sep	12th Sep - 19th Sep	19th Sep - 26th Sep	26th Sep - 3rd Oct	3rd Oct - 10th Oct
Accipitridae	<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	-	1	1	-	-	-	-	-	4	2	1	2	1	1	1
Alcedinidae	<i>Halcyon pileata</i>	Black-capped Kingfisher	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Alcedinidae	<i>Alcedo atthis</i>	Common Kingfisher	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Alcedinidae	<i>Eudynamys scolopacea</i>	Common Koel	-	-	-	-	-	-	-	-	-	1	1	1		1	1
Alcedinidae	<i>Halcyon capensis</i>	Stork-billed Kingfisher	3	4	1	1	3	3	4	5	4	5	4	3	3	3	1
Alcedinidae	<i>Halcyon chloris</i>	White-collared Kingfisher	6	4	2	2	7	8	8	12	11	9	11	11	11	7	5
Apodidae	<i>Collocalia esculenta</i>	Glossy Swiftlet	6	3	2	2	9	8	8	10	10	10	13	11	12	11	6
Ardeidae	<i>Butorides striatus</i>	Little Heron (Striated Heron)	4	3	2	1	3	3	1	4	5	2	5	3	8	7	3
Ardeidae	<i>Nycticorax caledonicus</i>	Rufous Night Heron	-	-	1	-	1	1	-	-	2	2	1	2	2	-	-
Artamidae	<i>Artamus leucorhynchus</i>	White-breasted Wood-swallow	4	4	1	1	7	7	7	8	7	8	9	10	9	7	5
Campephagidae	<i>Lalage Nigra</i>	Pied Triller	3	5	1	1	5	5	3	7	3	7	5	4	4	3	2
Caprimulgidae		NightJar Spp	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Columbidae	<i>Ptilinopus leclancheri</i>	Black-chinned Fruit-Dove	2	1	-	1	3	2	4	1	2	1	-	2	1	-	-
Columbidae	<i>Chalcophaps indica</i>	Common Emerald-Dove	-	-	-	-	-	-	-	-	1	-	-	1	-	3	-
Columbidae	<i>Treron vernans</i>	Pink-necked Green-pigeon	4	1	1	1	6	3	5	9	4	3	7	6	5	6	3
Columbidae	<i>Streptopelia chinensis</i>	Spotted Dove	-	-	-	-		1	-	1		1	3	1	2	1	1
Columbidae	<i>Phapitreron leucotis</i>	White-eared Brown-Dove	1	1	-	-	2	3	-	1	1	-	1	4	3	4	-
Corvidae	<i>Corvus macrorhynchos</i>	Large-billed Crow	3	2	-	-	-	-	-	-	-	-	-	2	-	-	-
Cuculidae	<i>Cuculus saturatus</i>	Oriental Cuckoo	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Cuculidae	<i>Centropus viridis</i>	Philippine Coucal	-	-	-	-	4	3	2	-	1	2	2	2	2	2	1
Fregatidae	<i>Fregata minor</i>	Great Frigatebird	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Fregatidae	<i>Fregata ariel</i>	Lesser Frigatebird	-	-	-	-	-	-	1	5	6	1	-	-	-	-	-
Hirundinidae	<i>Hirundo rustica</i>	Barn Swallow	-	-	-	-	-	1	-	-	2	1	-	1	-	1	-
Hirundinidae	<i>Hirundo tahitica</i>	Pacific Swallow	-	-	-	-	-	1	-	-	-	-	1	-	3	5	-
Laniidae	<i>Lanius cristatus</i>	Brown Shrike	-	-	-	-	-	-	-	-	-	-	-	-	1	7	3

Table 5.3. Continued

Family	Genus / Species	Common Name	27th Jun - 4th Jul	4th Jul - 11th Jul	11th Jul - 18th Jul	18th Jul - 25th Jul	25th Jul - 1st Aug	1st Aug - 8th Aug	8th Aug - 15th Aug	15th Aug - 22nd Aug	22nd Aug - 29th Aug	29th Aug - 5th Sep	5th Sep - 12 Sep	12th Sep - 19th Sep	19th Sep - 26th Sep	26th Sep - 3rd Oct	3rd Oct - 10th Oct
Megapodiidae	<i>Megapodius cumingii</i>	Tabon Scrubfowl	2	-	1	1	1	1	2	1	4	3	7	3	5	3	-
Muscicapidae	<i>Cyornis rufigastra</i>	Mangrove Blue Flycatcher	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Muscicapidae	<i>Rhipidura javanica</i>	Pied Fantail	5	3	2	2	8	7	8	11	10	10	12	11	9	7	4
Nectariniidae	<i>Nectarinia jugularis</i>	Olive-backed Sunbird	5	5	2	2	8	5	7	12	8	11	12	12	13	11	6
Oriolidae	<i>Oriolus chinensis</i>	Black-naped Oriole	6	5	2	2	9	7	8	11	10	11	13	12	13	10	6
Phalaropodidae	<i>Phalaropus fulicaria</i>	Rednecked Phalarope	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Rallidae	<i>Porzana cinerea</i>	White-browed Crake	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
Scolopacidae	<i>Actitis hypoleucos</i>	Common Sandpiper	-	-	-	-	-	-	-	3	1	1	1	3	5	3	1
Scolopacidae	<i>Heteroscelus brevipes</i>	Grey-tailed Tattler	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Sternidae	<i>Sterna sumatrana</i>	Black-naped Tern	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Sturnidae	<i>Aplonis minor</i>	Asian Glossy Starling	5	4	1	1	9	6	7	10	10	10	8	6	11	8	5
Sylviidae	<i>Gerygone sulphurea</i>	Golden-bellied Flyeater	-	3	-	2	6	6	4	10	10	11	12	10	13	10	6
Sylviidae	<i>Phylloscopus olivaceus</i>	Philippine Leaf-Warbler	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Sylviidae	<i>Megalurus timoriensis</i>	Tawny Grassbird	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-
Turdidae	<i>Monticola solitarius</i>	Blue Rock-Thrush	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2
Turdidae	<i>Copsychus saularis</i>	Oriental Magpie-Robin	1	-	-	-	1	2	1	-	2	4	2	1	4	10	6

The IRD scores varied between species and location (Table 5.2), with some species common at all locations, e.g. Black-naped Oriole, and some species relative rare across the island, e.g. Brown Shrike. Several species were only rarely located at single locations, e.g. Mangrove Blue Flycatcher and Oriental Cuckoo. Species presence also changed over time (Table 5.3).

Table 5.4. Bird community metrics for each survey location.

Location	Species Richness	Shannon-Weiner Diversity	Pielou's Evenness
1 Lagoon 1	26	10.11	0.91
2 Lagoon 2	27	10.96	0.87
3 Lagoon 3	25	10.17	0.89
5 Lagoon 5	22	9.34	0.91
6 Lagoon 6	21	9.06	0.89
8 Bamboo Bridge Trail	28	11.51	0.89
9 Turtle Beach	24	9.62	0.90
10 Tabon Beach	25	10.52	0.89
12 South-west Bay	23	9.50	0.89
13 North Wall	22	9.12	0.90

There was little variation in community metrics between survey locations (Table 5.4) with all sites having similar species richness and diversity.

Further patterns in community composition were elucidated using multivariate ordination (Figure 5.4) and clustering techniques (Figure 5.5). The low stress value indicates a good spread of data and the dotted line divides those sites located on the north end of the island (right of line) and those located on the south end of the island (left of line).

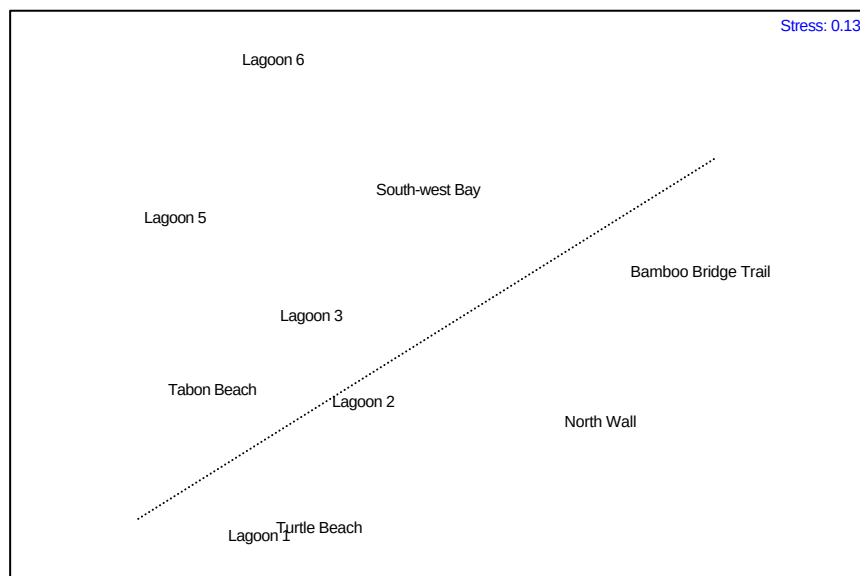


Figure 5.4. NMDS ordination of IRD values for each survey location.

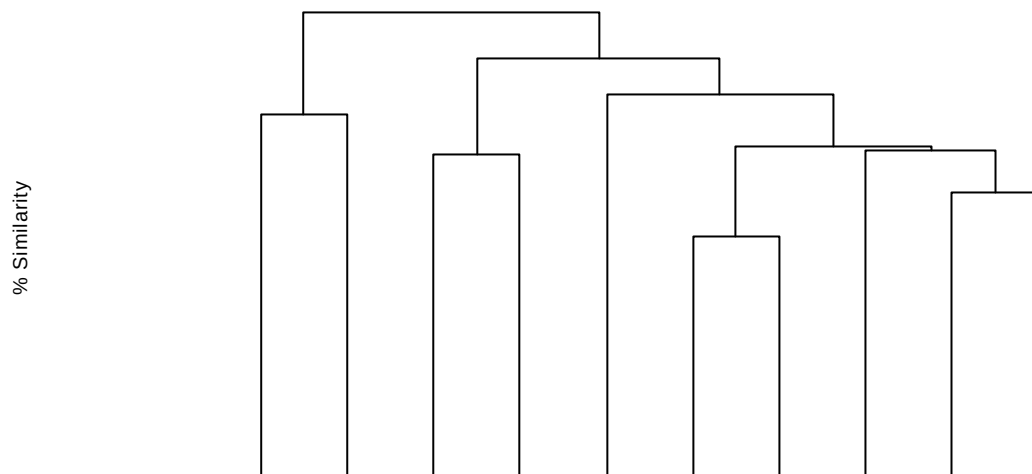


Figure 5.5. Dendrogram of bird community composition calculated using group-average linkage of Bray-Curtis similarities and labelled according to survey location name.

The NMDS suggests that community composition differs on a north-south gradient. Whereas, the cluster reinforces the high level of similarity in community composition between all sites (>75%) but demonstrates that the sites are generally separated by latitudinal location on the island. The sites have been grouped according to their habitat type and proximity to one another.

5.3. Mist Netting

5.3.1. Methods

Standard mist netting techniques were employed (Bibby *et al*, 1998) to survey the less conspicuous species that may not have been detected using the Mackinnon list method. Nets were established using bamboo poles and ropes tied vertically from tree branches we attached combinations of mist nets (38mm mesh, Avinet, USA), each 6 metres in length, at seven locations around the island (Table 5.5). These locations were selected for their accessibility, areas of high bird activity and where species that could not be identified had been sighted.

Nets were opened between 0530 hours and 0630 hours and closed at approximately 1000 hours. Afternoon opening times were 1600 hours to 1830 hours. Occasionally nets were kept open throughout the day. These times were dependent upon weather conditions i.e. recording in heavy rain was avoided. Nets were checked between every 30 minutes to every 2 hours dependent upon previous bird activity. Net records were kept, recording species caught, time, date, location and basic morphology data.

Table 5.5. Location of mist net surveys.

Location Code	Name	Habitat type
1	Bamboo Bridge Trail	Forest clearing
2	2nd Lagoon	Mangrove/Forest edge
3	3rd Lagoon	Mangrove
4	4th Lagoon	Mangrove
6	Scuba Shack/6 th Lagoon	Closed coconut forest
8	Tabon Beach	Coastal scrub/forest
12	Typhoon Hill	High forest

5.3.2. Results

A total of 77 individuals, comprising 11 species were caught at the different locations (Table 5.6). From these catches, average morphology data was compiled for each species caught (Table 5.7).

Table 5.6. Numbers of birds caught in mist nets at different locations on Danjugan Island.

Species	Location												Total
	1	2	3	4	5	6	7	8	9	10	12		
Asian Glossy Starling	-	1	-	-	-	-	-	-	-	-	-	1	
Common Emerald-Dove	-	-	-	-	-	-	-	-	-	-	2	2	
Glossy Swiftlet	-	7	1	-	-	-	1	2	5	-	-	16	
Golden-bellied Flyeater	-	1	-	1	-	-	-	-	-	2	-	4	
Mangrove-blue Flycatcher	2	-	4	-	-	-	-	-	-	-	1	7	
Olive-backed Sunbird	-	4	-	-	2	-	-	-	-	4	-	10	
Oriental Magpie Robin	-	-	-	-	-	-	-	-	1	1	2	4	
Pied Fantail	-	-	1	2	2	2	-	-	1	3	3	14	
Pied Triller	1	-	-	-	1	-	-	-	-	1	-	3	
Stork-billed Kingfisher	-	-	-	-	-	-	1	-	-	-	-	1	
White-collared Kingfisher	-	1	-	3	-	-	5	-	-	3	-	15	
Total	3	14	6	6	5	5	7	2	7	14	8		

Table 5.7. Average (mean) morphology data* for mist netted species on Danjugan Island.

Species	Count	Bill	Tarsus	Wing	Tail	Total length	Weight
White-collared Kingfisher	16	41.60	20.41	104.23	70.53	227.55	63.86
Glossy Swiftlet	16	4.87	11.67	97.82	37.61	94.59	7.00
Pied Fantail	14	14.61	24.99	84.93	93.98	185.27	18.45
Olive-backed Sunbird	10	18.50	16.73	49.51	34.43	108.51	9.00
Mangrove-blue Flycatcher	7	13.80	19.96	71.36	56.16	142.24	18.25
Pied Triller	4	15.23	24.20	89.68	70.50	160.15	22.50
Oriental Magpie Robin	4	14.40	28.00	83.53	87.50	188.43	35.75
Golden-bellied Flyeater	4	9.88	17.25	49.95	33.50	94.63	7.67
Common Emerald-Dove	2	20.50	31.40	142.70	93.70	225.00	160.00
Stork-billed Kingfisher	1	80.70	17.00	154.00	107.20	350.00	210.00
Asian Glossy Starling	1	20.50	28.50	105.60	70.50	202.00	125.00

*All measurements are in millimetres except weight which is given in grams.

5.4. Discussion

Mackinnon Lists

Danjungan supports a diverse bird fauna but the species discovery curves at each location did not reach a clear plateau (which would have suggested no further species to discover). The rising curves may be due to several factors, including the arrival of several migrant species, and an increase in observer skill with increased survey effort over time. The occurrence of other migrant species and passage visitors is supported by the work of others (Appendix 4). The Mackinnon surveys also indicated that there was little difference in the relative diversity of the bird fauna at different locations around the island that is perhaps explained by the limited diversity of habitat types available and overall size of the island. However, the IRD scores have begun to illustrate some patterns in distributions.

The term “index of relative detectability” has been used here, rather than the standard “index of relative abundance” (Bibby *et al*, 1998), as the frequency of a species occurring on a list is dependent on several factors, of which abundance is only one. For example, some species, such as the Black-naped Oriole and the White-collared Kingfisher, are highly visible and audible, and hence easily detectable. Another, the Golden-bellied Flyeater, has a very distinctive song that is easily recognised from a long distance away. Also, some species fly in flocks or are gregarious, so recording only the presence without reference to absolute numbers may result in some of these species being under represented in these results. However, with care, the IRD values can be used to identify interesting trends in species habitat-preferences and movements over time.

The ordination of the IRD data revealed a possible north-south split in the species composition (not evident from diversity metrics) of survey sites that may be partially attributed to proximity to and preference for the dominant habitat types that were coconut-dominated forest in the South and *figus*-dominated forest in the north. This is a very coarse scale analysis and interpretation and is only likely to explain a certain proportion of the variation in the data, since some species recorded are clearly coastal specialists, such as the little heron or common sandpiper, and thus have little dependence on these habitat types.

The cluster analysis revealed a more detailed pattern of relationships between surveys sites with respect to their relative species compositions further suggesting that local habitat type is a key factor influencing species distributions. For example, lagoons five and six are both internal lagoons surrounded by coconut forest and are most similar with respect to their IRD values. Also, North Wall and Bamboo Bridge trail are both surrounded by secondary mixed species forest and are most closely related to one another. This clearly requires more site specific testing of this theory.

Species records also changed over time, during the four-month survey period (Table 5.3) suggesting that the island supports a number of resident species and a number of passage or migrant species. Residents include the White-bellied Sea-eagle, Tabon Scrub-fowl and Rufous Night-Heron, where migrants include the Brown Shrike, Blue Rock-Thrush and Common Sandpiper. The relative changes in the temporal distribution of species may also be explained by increased observer skill and increased surveyor effort overtime at each location.

Mist-Netting

The mist netting surveys have identified far fewer species than the Mackinnon list but have enabled identification of the less conspicuous species on the island, or those species hard to identify via observation alone. For example, the secretive Common Emerald-Dove was first recorded by capture in a mist-net. Further, mist netting is reliable as it allows positive species identification and compliments observation studies by sampling areas where observation studies are less effective. Photographs and morphological measurements have been taken of all species netted.

However, low catch-rates mean the data presented in this report is insufficient to make conclusions about bird distribution or abundances. Also, structural diversity of a habitat impacts catch-rate, with a 2.5 metre high net sampling a larger proportion of the vertical height of mangrove forest or coastal scrub than of higher forest. Therefore, although the results suggest that the Olive-backed Sunbird is netted in mangrove and coastal areas rather than closed forest, this could simply be a function of the variable vertical stratification of the different habitats.

Conclusion

The data derived from the recent study and that compiled from other researchers illustrates that Danjungan island is an important site for many endemic, resident and migratory species. However, in the long-term there is a need to monitor species presence and habitat usage throughout the year in order to accurately inform conservation management activities that are sympathetic to birds.

6. Bats

6.1. Introduction

Bats (Chiropterans) often make up a large proportion of the mammalian diversity of island habitats and this is particularly the case for the Philippines, which has one of the richest mammal faunas in the world. At least 180 species have been recorded, of which 110 are endemic (Heaney 1993; Heaney *et al*, 1997). The Chiropterans are the most diverse order of mammals in the Philippines with 25 Megachiropteran and 48 Microchiropteran species (Heaney & Regalado 1998) and approximately 40% of these are endemic (Heaney 1986). However, it is also recognised that the Philippines Megachiropteran fauna contains a high percentage of threatened taxa as a result of large-scale deforestation and hunting (Mickleburgh *et al*, 1992) but the status of the Microchiropteran fauna is still poorly known (Heaney 1993) despite the identification of many endemic species (Ingle & Heaney 1992).

Consequently, the Chiropterans are also recognised as probably the most poorly known mammalian order in the Philippines (Ingle & Heaney 1992). Island habitats have been identified as particularly important for bats and a priority for conservation efforts on a global scale (Mickleburgh *et al*, 2002), and the Philippines archipelago (and island groups there-in) represents an excellent, if depressing case. 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.

Unfortunately an acknowledged achilles heel is a lack of information (Oliver & Heaney 1996; Heaney & Regalado 1998; Turner *et al*, 2002a). With regard to Chiropterans, whilst new species have recently been discovered, there are concerns that several species may now be threatened and possibly extinct (Ingle & Heaney 1992). Heaney and Heideman (1987) reported that it has not been possible to estimate the number of species of bats in the Philippines that are extinct or endangered because of a lack of basic surveying information, and they suggested that faunal surveys were needed in nearly all parts of the country. More specifically, Mickleburgh *et al*, (1992) stressed (as one of twenty priority global projects) the urgent need to survey the Negros Island area which was ranked eighth highest in the world for Megachiropteran diversity and was listed sixteenth globally for requiring the establishment of protected areas for world fruit bat conservation.

Negros Island forms part of the Greater Negros-Panay Faunal Region of the central Philippines, the most threatened of the Philippines' five faunal regions (Heaney & Regalado 1998). There are at least 42 species of bat thought to be present within this area of which, approximately 25% are known to be endemic to the Philippines (Heaney *et al*, 1998). The major threats to bats already mentioned are echoed on Negros where only 4% of the original tropical forest coverage remains (Heaney & Regalado 1998). This has doubtlessly affected resident bat populations due to their requirement for forest habitat that provides food and roosting sites. Additionally, the restricted areas of forested habitat are still susceptible to local hunting pressure. Whilst habitat preservation would appear a priority (Turner *et al*, 2002a) there is a general lack of information regarding the distribution, status, and ecology of many species in this area and thus detailed surveys of

the bats of the Negros-Panay Faunal Region are required in order to underpin future conservation action.

Research interest and knowledge of Chiropterans in the Philippines has been steadily increasing (see Heaney & Heideman 1987; Heideman & Heaney 1989; Heaney 1991; Ingle & Heaney 1992; Utzurrum 1992; Heaney 1993; Heaney *et al.*, 1998) but very little of this has given any focus to the Negros-Panay Faunal Region. That which has, has tended to be, in the majority, more generalist work on patterns of species richness (Heaney 1993), elevational zonation (Heaney *et al.*, 1989) and the role of fruits bats in seed dispersal in sub-montane rainforest (Hamann & Curio 1999). Little work has focused on diversity, distributions and status of species and there is a clear need to survey areas of remaining habitat that may still support significant bat populations, endemic or otherwise, and thus assess their conservation importance.

Only one previous (unpublished) survey has been completed on Danjungan and this estimated that the island was host to at least 6 species of Megachiropteran (Maro 1994). No other published work on the fauna of Danjungan has thus far been located and the limited faunal surveys of the small limestone caves on the island has revealed that they provide important havens for cave-roosting bat species. Thus it could potentially be an important conservation site since it was recently designated reserve status as the Danjungan Island Marine Reserve and Sanctuaries (DIMRS) by the municipal government of Cauayan and provincial government of Negros Occidental in February 2000. The island has been managed by the Philippines Reef and Rainforest Conservation Foundation Incorporated (PRRCFI) since 1995 (Ledesma *et al.*, 1999).

6.2. Aims

As part of the CCC Danjungan Island Biodiversity Project surveys were carried out to determine the distribution and diversity of the bat fauna on Danjungan Island.

1. To complete an inventory of chiropteran species on Danjungan Island.
2. To assess the relative abundance and distribution of each chiropteran species.
3. To locate and describe roosting sites.

6.3. Methods

Mist-net survey

Mist-nets (38mm mesh, 10m x 2.6m and 6m x 2m) were used at various locations within three of the major habitat types present on the island: beach forest, coconut-dominated secondary forest, and mixed-species forest (Table 6.1; Figure 6.1). A single net was also set just above the sea at the entrance of a lagoon (L3). Other habitat types, such as mangrove and cliff forests, were not sampled due to problems of access at night.

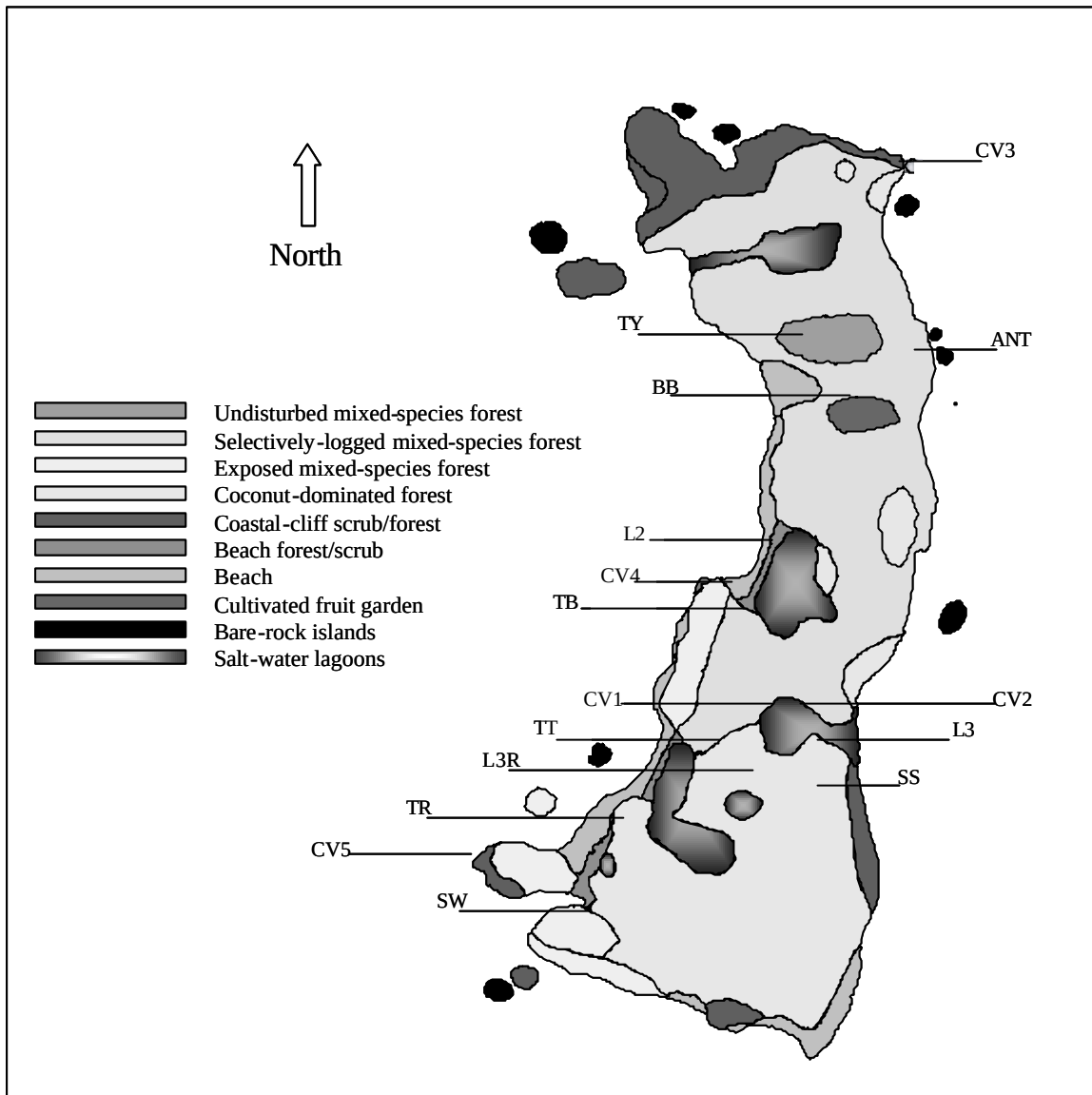


Figure 6.1. Habitat Map of Danjungan Island showing the distribution of major habitat types as described in Table 6.1 with the location of each survey site (Table 6.2).

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 were operated on a pulley system, and when possible were complemented by a low net positioned on the same pulley system (following Ingle 1993). Generally, nets were opened before dusk and closed anytime upto midnight, depending on weather and personnel. The midnight to dawn period was sampled very rarely.

Bats captured were identified using Ingle and Heaney (1992), 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. Fore-arm length was measured using dial callipers, and weight using spring balances. When new species were encountered, ear, hind-foot and total length were also recorded.

For each survey night, the location, weather conditions and time the nets were operational was noted. As nets of 2 different sizes were used, and as they were open for variable lengths of time, net-effort for each location was calculated as hours per square-metre of net.

Table 6.1. The major habitat types of Danjungan Island.

Habitat Type	Description
Undisturbed mixed-species forest	Undisturbed mixed-species forest, with high canopy and an abundance and diversity of <i>Ficus</i> spp.
Selectively-logged mixed-species forest	Mixed-species forest with reduced density of large trees due to history of selective-logging. Species composition influenced by local topography, but generally with abundance of <i>Ficus</i> spp.
Exposed mixed-species forest	Mixed-species forest with low canopy due to exposure to wind and sea-spray, with fewer <i>Ficus</i> but an abundance of <i>Sterculia</i> spp., <i>Mimoidae</i> spp., and <i>Pandanus</i> spp.
Coconut-dominated forest	Even-aged stands of remnant coconut plantations, with areas of other planted species such as mango, banana and a <i>mimoidae</i> spp. Secondary forest regenerating rapidly in most areas, but with low, scrubby undergrowth on ridges and other exposed areas.
Coastal-cliff scrub/forest	<i>Pandanus</i> dominated scrub on steep exposed coastal areas. Also <i>Terminalia</i> , <i>Sterculia</i> and cycads. <i>Pemphis acidula</i> abundant near sea-level.
Beach forest/scrub	Low forest/scrub bordering beaches, with extensive coconut, <i>Pandanus</i> , <i>Terminalia</i> and <i>Barringtonia</i> .
Beach	Beach areas with no vegetation
Cultivated fruit garden	Grassy clearing between mixed-species forested slopes, with planted species such as banana, tea and figs.
Bare-rock islands	Small off-shore rock islands with little or no vegetation
Lagoons	Salt-water lagoons with variety of mangrove habitats.

Cave survey

Caves were located by exploration on foot, and by touring the perimeter of the island by boat. Each cave was surveyed for evidence (visual or audible) of bat presence, either from the entrance or by entering the mouth of the cave. Numbers of bats within caves was estimated by direct observation during the day, or by counting the bats as they left the caves around dusk. Species present within caves was established by trapping either with a hand-net just inside the cave, or with a mist-net just outside the mouth of the cave. If the cave was believed to contain a large number of bats, unmanageable numbers of bats in the net was avoided by setting the mist-net on bamboo poles held by 2 researchers, and lowering it each time a bat was caught. Each bat captured was dealt with as for the general mist-net survey.

Dispersal survey

An initial survey of the Megachiropteran dispersal patterns was conducted from selected vantage points, by counting the number of bats flying in each direction of the compass from half an hour before dusk until the numbers of dispersing bats declined to less than one observation per twenty minutes observation time. Identification of dispersing bats was not possible to species-level, but by noting their general size, and by knowing the species present on the island, they could be identified to species groups.

Table 6.2. The locations of the bat survey points on Danjungan Island.

Code	Forest Type	Site Description
BB	Mixed-species	Grassy clearing between mixed-species forested slopes, along trail to Bamboo Bridge.
TY	Mixed-species	Undisturbed, high-canopy mixed-species forest on hill north of Typhoon Beach
ANT	Mixed-species	On hill west of Typhoon Beach, in mixed-species forest
SS	Coconut	In understory of coconut-dominated secondary forest, just south of lagoon
TT	Coconut	Small clearing along trail from Lagoon 3 to Tabon beach, on the edge of coconut-dominated secondary forest.
TR	Coconut	Ridge east of Tabon Beach, in open coconut-dominated forest
L3R	Coconut	On hill south of lagoon 3, in open coconut-dominated forest
SW	Beach	Beach forest/scrub (<i>Pandanus spp</i> , <i>Terminalia</i> , <i>Barringtonia</i> and coconut.) behind bay south of Tabon beach.
TB	Beach	Beach forest/scrub at southern end of Turtle Beach
L2	Beach	Beach forest/scrub between Turtle beach and mangrove stand of lagoon 2
L3	Entrance to Lagoon 3	Seaward entrance to lagoon between mid-height forest (Abundance of <i>Ficus</i> , scattered coconuts) and coconut dominated forest (see scuba shack).
CV1	Lagoon 3 cave 1	Largest cave on the island. Situated within Mid-height forest, <i>Ficus</i> dominated, low density coconuts.
CV2	Lagoon 3 cave 2	Cave within mid-height forest (see Lagoon 3 cave 1) next to lagoon. Water filled base.
CV3	Sea cave	Two interconnected sea-caves, exposed to the sea. North-west corner of island. Landward side dominated by coastal scrub, coconuts and abundance of <i>Zingiber</i> .
CV4	Turtle Beach cave	Small sea-cave with seaward and beach entrances.

6.4. Results

A total of eight Chiropteran species were recorded on Danjungan Island during this study, of which five were Megachiropteran and three were Microchiropteran species (Table 6.3). Of the 261 bats captured during the general mist-net survey, only 1 was a microchiropteran, *Saccolaimus saccolaimus*, the only record of this species on the island. A further 4 microchiropterans were captured in a net suspended low over the sea at the entrance to lagoon 3, all of which were *Myotis macrotarsus*. The third microchiropteran species, *Taphozous melanopogon*, was not captured during the mist-net survey, but was recorded from three caves, all open to the sea, although only one contained significant numbers (Table 6.7). Morphological data was recorded for each species (Table 6.5).

Table 6.3. Megachiropteran and Microchiropteran species found during the surveys on Danjungan Island with data on their distribution and status.

Megachiropteran Species	Common name*	Distribution*	Status*
<i>Cynopterus brachyotis</i>	Common Short Nosed Fruit Bat	Southeast Asia	Abundant and geographically widespread
<i>Eonycteris spelaea</i>	Cave Roosting Nectar Bat/Common Nectar Bat/Common Dawn Bat	India to Timor	Stable and common in agricultural areas but heavily hunted and vulnerable
<i>Pteropus pumilus</i>	Little Golden Mantled Flying Fox	Endemic to the Philippines	Declining due to habitat destruction but still fairly widespread and stable. CITES II IUCN: Vulnerable
<i>Pteropus hypomelanus</i>	Common Island Flying Fox	Thailand to Australia	Heavily hunted in some areas but stable. CITES II
<i>Rousettus amplexicaudatus</i>	Common Rousette/Geoffroy's Rousette	Thailand to the Solomon Islands	Locally abundant, generally stable but can be subject to intense hunting
Microchiropteran Species	Common name*	Distribution*	Status* ⁺
<i>Saccolaimus saccolaimus</i>	Pouched Bat	India to Timor	Unknown
<i>Taphozous melanopogon</i>	Black-Bearded Tomb Bat	Sri Lanka to Southeast Asia and the Lesser Sunda Islands	Widespread in Southeast Asia, abundant in the Philippines
<i>Myotis macrotarsus</i>	Pallid Large – Footed Myotis	Borneo and the Philippines	Uncommon – dependent on caves

*After Heaney *et al* (1998), ⁺Mickleburgh *et al*, (1992).

Table 6.4. Bats captured per 100 net-effort units during mist-net survey (1 net-effort unit = 1 hour per square metre of net).

Habitat type:	Beach forest			Coconut forest				Mixed-species forest			Lagoon	Total
Location code:	L2	SW	TB	TT	SS	TR	L3R	TY	ANT	BB	L3	-
Net-effort units:	700	540	45	75	56	514	438	300	33	607	63	3370
Net height*:	L&H	L&M	M	L	L	L&H	H	L&H	M	L&H	Sea-level	-
<i>E. spelaea</i>	3.86	0.19	4.44	14.67	-	0.97	20.11	1.67	-	1.32	-	4.36
<i>C. brachyotis</i>	1.43	3.52	6.67	2.67	1.78	0.58	-	1.67	6.15	7.08	-	2.61
<i>P. pumilus</i>	0.29	-	-	-	-	0.97	0.23	0.33	3.08	0.16	-	0.33
<i>R. amplexicaudatus</i>	-	-	-	-	-	-	1.83	-	-	-	-	0.24
<i>P. hypomelanus</i>	-	-	-	-	-	0.58	0.69	-	-	-	-	0.18
<i>M. macrotarsus</i>	-	-	-	-	-	-	-	-	-	-	6.38	0.12
<i>S. saccolaimus</i>	0.14	-	-	-	-	-	-	-	-	-	-	0.03
Total	5.71	3.70	11.11	17.33	1.78	3.11	22.86	3.67	9.23	8.56	6.38	7.86

* L= 1-4m, M= 4-7m, H= 7-10m.

Table 6.5. Megachiropteran morphological data.

Species		Adult male		Adult female		Juvenile	
		Forearm (mm)	Mass (g)	Forearm (mm)	Mass (g)	Forearm (mm)	Mass (g)
<i>P. hypomelanus</i>	range	123.0-141.7	385-410	120.5-131.4	240-360	-	-
	mean	132.35	397.50	124.60	284.00	-	-
	sd	13.22	17.70	5.91	65.90	-	-
	n	2	2	3	3	-	-
<i>P. pumilus</i>	range	94.4-109.0	125-190	89.3-109.5	165-200	-	-
	mean	103.38	161.40	101.32	182.00	-	-
	sd	5.54	24.40	7.53	13.51	-	-
	n	5	5	5	5	-	-
<i>R. amplexicaudatus</i>	range	80.6-85.5	70-120	77.3-89.3	65-75	-	-
	mean	83.05	95.00	83.28	71.25	-	-
	sd	3.46	35.36	5.67	4.79	-	-
	n	2	2	5	4	-	-
<i>E. spelaea</i>	range	55.0-77.9	50-95	57.6-79.2	42-100	47.8-72.3	11.0-65.0
	mean	72.80	68.82	72.56	68.44	59.50	32.41
	sd	2.89	12.94	4.46	17.02	4.52	10.04
	n	30	30	27	27	53	53
<i>C. brachyotis</i>	range	56.5-68.9	27-38	55.9-72.7	28-65	50.0-65.2	15-35
	mean	62.67	33.00	63.50	34.05	58.85	24.70
	sd	3.90	3.40	3.20	6.47	3.60	5.07
	n	10	10	40	40	23	23

The highest diversity of megachiropteran species was found in the coconut-dominated forest, with 2 species recorded only from this habitat (Table 6.4). The remaining 3 species were recorded from all three of the forest types, although *Pteropus pumilus* appeared to be more widespread in mixed-species forest. *Eonycteris spelaea* accounted for over half the bats captured during the mist-net survey, but exhibited high variation in catch-rates across the survey sites. This variation shows a high negative correlation ($r = -0.619$; $p < 0.01$; $n = 10$) with distance from a cave found to contain a roost of over 5000 individuals of this species (Table 7). *Cynopterus brachyotis* was also found roosting in a cave, but in very small numbers and not in proportion to its relative abundance in the mist-net catches. This species was the most widely distributed species, being captured at all but one of the mist net sites. The absence of *C. brachyotis* at this site is probably due to the fact that only a high net was operated, with the species captured almost exclusively in low to mid-level nets. This is in contrast to the other species, with *P. pumilus* and *E. spelaea* being captured in mid- and high-level nets, and *P. hypomelanus* and *R. amplexicaudatus* only in high nets (Table 6.4). Morphological data was recorded for each species (Table 6.6).

Table 6.6. Microchiropteran morphological data.

Species		Adult male		Adult female	
		Forearm (mm)	Mass (grams)	Forearm (mm)	Mass (grams)
<i>Taphozous melanopogon</i>	range	64.3-65.7	22.0-27.0	-	-
	mean	64.70	24.41	-	-
	sd	0.57	2.07	-	-
	n	5	5	-	-
				-	-
<i>Myotis macrotarsus</i>	range	46.5-49.1	10.0-13.1	-	-
	mean	47.73	11.67	47.2	12
	sd	1.31	1.53	-	-
	n	3	3	1	1
<i>Saccolaimus saccolaimus</i>	range	-	-	-	-
	mean	70.2	35	-	-
	sd	-	-	-	-
	n	1	1	-	-

Daytime roost searches found the Pteropidae to be roosting singly or in small groups in the high forest, mid-height forest, and to a lesser extent the low forest on the south-western corner of the island. Both *P. hypomelanus* and *P. pumilus* were observed in the undisturbed mixed-species forest and the selectively logged mixed-species forest regions (see Figure 6.1; Table 6.1). The majority appeared to be roosting north of 'BB' (Figure 6.1; Table 6.2). Daytime searches in the coconut and secondary growth southern region found no Pteropidae bats roosting.

Table 6.7. Estimates of numbers of roosting bats found at each cave during the study period.

Location code	Location	Species	Number trapped	Estimated Numbers	Comment
CV1	Lagoon 3 cave	<i>E. spelaea</i>	53	over 5000	largest cave, near Lagoon 3, with water-filled base; presence of <i>R. amplexicaudatus</i> unconfirmed (see text).
CV2	Lagoon 3 cave 2	<i>C. brachyotis</i>	3	less than 10	smaller cave near lagoon 3, with water filled base and roosting sites in shafts
CV3	N E sea cave	<i>T. melanopogon</i>	1	300 – 500	2 inter-connected caves on north-west corner of island, exposed to the sea
CV4	Turtle beach cave	<i>T. melanopogon</i>	4	less than 10	small sea-cave at southern-end of Turtle Beach, with seaward and beach entrances
CV5	S W sea cave	<i>T. melanopogon</i>	0	less than 10	sea-cave on south-west coast of island, with westward-facing entrance; back galleries closed by storm debris during study-period

The dispersal survey illustrated that both the larger fruit bats (*Pteropus* spp.) and the smaller (mainly *E. spelaea* but maybe also including *R. amplexicaudatus* and *C. brachyotis*) dispersed around dusk, many leaving the island in the direction of mainland Negros or Agutayan island (Figure 6.2). At least 150 individuals were recorded in any single observation period, with all individuals heading in southerly or easterly directions.

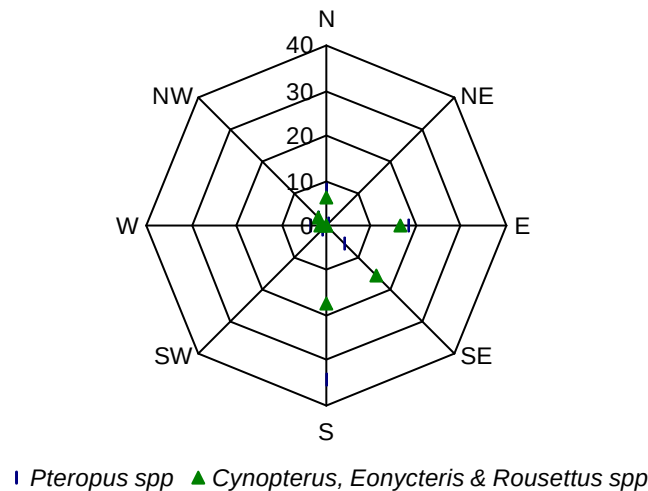


Figure 6.2. Mean dispersal numbers (and direction) of Megachiropteran species from Danjungan island.

The vertical stratification assessment showed *C. brachyotis* flying predominantly at a relatively low height, with *P. pumilus* and *E. spelaea* flying higher (Figure 6.3). Whilst there is less data for *P. hypomelanus* and *R. amplexicaudatus* it would appear that they also fly at higher elevations.

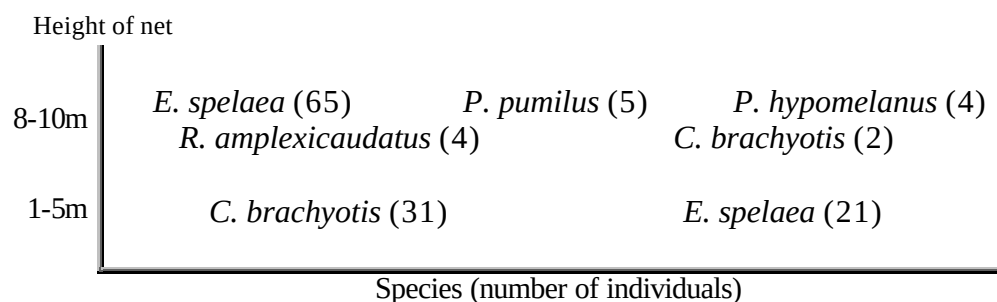


Figure 6.3. Numbers of each species captured (in parenthesis) in nets at different heights during general netting (25 July – 19 Sept), including results from the vertical stratification experiment.

6.5. Discussion

The four-month survey found a total of eight Chiropteran species, and of the five Megachiropterans, one species, *Pteropus hypomelanus*, has not previously been recorded on the island. However Maro (1994) found Jagor's Dog-Faced Fruit Bat (*Ptenochirus jagori*) to be present but this species was not located by the current study. The three Microchiropteran species found in the current survey were not found by Maro (1994) and are therefore considered new species records for the island. Each of the Megachiropteran and Microchiropteran species are discussed individually below and then collectively in terms of the potential conservation value of Danjungan Island.

Megachiropteran Species Accounts.

The Common Nectar bat (*Eonycteris spelaea*) accounted for almost two thirds of all bats caught on Danjungan Island. The species was found to roost in a single cave near lagoon 3. The choice of roost site could be attributed to the size of the cave at Lagoon 3 and this species' preference to roost in large numbers (Utzurum 1992), or the fact that the many other caves on the island are coastal caves and are much more exposed. Another factor that may affect cave roost choice is a probable preference in Philippine roosts for caves with some penetrating light (Mickleburgh *et al*, 1992). Although unconfirmed during this study, distribution data suggests that the population on Danjungan Island is of the sub-species *glandifera* (Heaney *et al*, 1998; Corbet & Hill 1992; Mickleburgh *et al*, 1992), a sub-species 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). Therefore this roost of over 5000 individuals in a single cave may be considered of significant global conservation value.

The second most abundant species on the island was the Common short-nosed fruit bat (*Cynopterus brachyotis*), however despite catching large numbers in the mist nets only a few individuals were ever seen roosting in one small cave at lagoon three. In agreement with previous studies (Mickleburgh *et al*, 1992) our data suggests that this species is not limited to cave roosts as it was found in all areas of the island not just areas local to the cave roosts. It is known to roost in disturbed habitats and is likely to be distributed across the island. There is a possibility that the species may in fact represent an endemic sub species since Kitchener and Maharadatunkamsi (1991) and Schmitt *et al* (1995) considered populations of this species from the Philippines and Sulawesi to represent a separate species, *C. luzoniensis*, but Corbet and Hill (1992) and Koopman (1993) place *luzoniensis* as a subspecies of *C. brachyotis*; further study is needed.

Geoffroy's Rousette (*Rousettus amplexicaudatus*) is known to be abundant in agricultural areas and most commonly roost in caves (Nowak 1994). The catch data of the current study supports this information as the Lagoon 3 ridge is next to former plantation land and also has caves for roosting. This suggests that the unconfirmed sighting of *R. amplexicaudatus* in the cave at lagoon 3 is probably accurate since *R. amplexicaudatus* is commonly found roosting with *E. spelaea* but tends to roost further back, in the darkest regions of caves (Corbet & Hill 1992). *Rousettus* is the only known genus of Megachiropteran that has the ability to ecolocate that enables it to navigate in complete darkness. Further mist netting work outside the cave entrance could confirm its presence. The mist netting work conducted outside the cave yielded over 50 cave roosting *E. spelaea* but the surveys, which began at dusk, may have been too early for the capture of *R.*

amplexicaudatus. The capture of eight *R. amplexicaudatus* occurred after 21:00 and this could be an indication of a later timing of departure from the cave.

The Little Golden-Mantled Flying Fox (*Pteropus pumilus*) is rare and endemic to the Philippines and well known to frequent small islands where it is usually associated with primary and well-developed secondary forest (Heaney *et al*, 1989) and uncommon to rare on larger islands (Heideman & Heaney 1989; Utzurrum 1992). Catch data suggests that densities are quite low although it has been hypothesized that this species forages high in the canopy and therefore it may be more abundant than current catch data suggests (Mickleburgh *et al*, 1992). The presence of this species within the Danjungan Island reserve is very encouraging as it is considered globally vulnerable by the IUCN and is fourth on the conservation priority list for Philippine fruit bats (Mickleburgh *et al*, 1992). Although more frequently captured at the sites in relatively undisturbed mixed-species forest, the species was also netted in reasonable numbers in both the beach forest and the coconut-dominated secondary forest. On a larger-scale, whilst none were observed roosting in the southern region of the island this ability to settle in disturbed areas may be essential to its future survival considering the rate of forest destruction in the Philippines.

The other species of this genus caught, was the Common Island Flying Fox (*Pteropus hypomelanus*), but based on known distribution data it is likely to be the sub-species *Pteropus hypomelanus cagayaus* (Mickleburgh *et al*, 1992). The catch data and observations indicate that this species can be found flying in all areas of the island but was only found roosting in the undisturbed mixed-species forest and the selectively logged mixed-species forest. However, the species is known to fly high above normal netting reach and it appears to be more abundant on the island than the catch-rates suggest.

Microchiropteran Species Accounts.

The Pallid Large-footed Myotis (*Myotis macrotarsus*) is an uncommon species that is dependant upon caves to roost in (Heaney *et al*, 1998) and is currently listed as near-threatened (Mickleburgh *et al*, 1992). This species was caught exclusively in nets hung low across the sea at the entrance to Lagoon 3, as the bats foraged low over water. This hunting behaviour is not unusual for insectivorous bat species as insects often fly low above the water. However all the lagoons on Danjungan contain salt water and are unlikely to be productive hunting grounds for insect. This species was observed skimming the surface of the water, a hunting technique which has been observed in other *Myotis* species that trawl for fallen insects, on the surface of the water, using their hind legs (Jones & Rayner, 1991). It is also possible that *M. macrotarsus* was preying upon small fish near the waters surface. Robson (1994) confirmed that fish were eaten by *M. adversus* of Australia, a species that usually feeds upon insects above the water surface. The fishing bat of central and south America, *Myotis vivesi*, is well documented as feeding mainly upon fish and snatches them from the water using its long feet and enlarged hind claws. *M. macrotarsus* also has large hind limbs and feet and it is therefore not inconceivable that this species has developed a similar feeding technique but further investigation is needed to verify this theory.

The two other Microchiropteran species caught are both from the Emballonuridae (Sheath Tailed bats) family. The Black-bearded Tomb bat (*Taphozous melanopogon*) and the Pouched bat (*Saccolaimus saccolaimus*) are both widespread across South East Asia although not much is known about the latter. *T. melanopogon* was not encountered during the general mist-net survey but was found exclusively at survey locations associated with

limestone sea caves and seen roosting in three sea caves (see Table 6.7) however, some caves, including sea-caves, were surveyed and no bats were present. This supports previous reports (Heaney *et al*, 1998). Philippine populations of *T. melanopogon* were formerly separated as *T. philippinensis*; however Heaney *et al*, (1998) consider the latter to be a subspecies of this widespread species (Corbet & Hill, 1992; Koopman, 1993). *S. saccolaimus* was not seen roosting at all but it may have been present at some of the roosts.

Conclusion

Whilst further survey work on the island would give a clearer indication of the distribution (and roost sites) of all species and an estimate of relative abundances, this preliminary survey demonstrates that Danjungan Island's bat fauna is relatively diverse given the small size of the island. Further research may also bring clarification to the presence of endemic sub-species of *C. brachyotis*, *E. spelaea*, *P. hypomelanus* and *T. melanopogon*. The importance of sub-specific differentiation of polytypic species when conserving endemic biodiversity has previously been stressed for other taxonomic groups on Negros island (Brooks *et al*, 1992; Turner *et al*, 2002c).

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 Danjungan Island is of major national and global significance for bat conservation. Eight of the seventy-three species known to exist in the Philippines (Heaney *et al*, 1998) have been recorded, representing over 10% of the Philippine bat fauna. The island supports a cave-roost of over 5000 *Eonycteris spelaea*, probably of the globally vulnerable sub-species *E. spelaea glandifera*. *Pteropus hypomelanus cagayanus*, and the globally vulnerable *Pteropus pumilus*, both endemic to the Philippines, also roost on the island, amongst the extensive primary and secondary forest, and all 3 species disperse nightly to the mainland. This initial survey has also shown that the island supports cave-roosts of *Taphozous melanopogon* (possibly the endemic *philippinensis* sub-species), and the presence of at least two other microchiropteran species, both of which are not well known, one (*M. macrotarsus* is near-threatened), and both may also roost on the island.

The island, already designated as the Danjungan Island Marine Reserve and Sanctuaries (DIMRS), therefore offers a roosting area for large numbers of the local populations of these species safe from human interference and, for the megachiropterans, from hunting pressures. Further, under the guidance of PRRCFI, a local education programme is already well established as part of the integrated community-based approach to the management of the reserve and its environs (Ledesma *et al*, 1999). Thus, given that the island is already managed in a manner sympathetic to wildlife conservation and sustainable resource-use, the following recommendations specific to the bat fauna may be suggested:

1. Ensure protection and minimal disturbance of the cave-roost of *Eonycteris spelaea*.
2. Ensure continued extensive forest-cover as roosting areas for *Pteropus pumilus* and *P. hypomelanus*.
3. Ensure continued protection and minimal disturbance of all cave roosts.
4. Continue environmental education in the local communities, including issues of bat conservation.
5. Conduct fully quantitative surveys of the island bat populations.
6. Initiate long-term regular quantitative monitoring of populations.

7. Research sub-specific placement of *C. brachyotis*, *E. spelaea*, *P. hypomelanus* and *T. melanopogon* populations.
8. Research feeding behaviour of *Myotis macrotarsus*.
9. Research patterns of dispersal to the mainland of *P. pumilus*, *P. hypomelanus* and *E. spelaea*.
10. Research reproductive biology of all species.
11. Establish levels of hunting pressure on bats on the mainland.

7. Conclusions

7.1. Conclusions

Danjungan Island is clearly an important ecological refuge harbouring a variety of habitats, spanning coastal to forested areas, which in turn support a diverse range of species (based on the taxonomic groups that were studied).

The DIBS was by no means a comprehensive survey of the biodiversity of Danjungan and the results presented and discussed in the preceding chapters should be regarded as provisional due in part to the methods used and due to the short duration of the project. The fauna are likely to change throughout the year due to the presence or absence of certain passage visitors or migratory species. Despite this, the study has clearly achieved its initial objectives, which were:

- i) To collate and consolidate the current species inventories;
- ii) To provide the first quantitative data regarding the terrestrial fauna and flora;
- iii) To provide distribution data on the major faunal and floral groups;
- iv) To develop a photo-library of the natural history of the island.

7.2. Outcomes

The survey work has resulted in the production of the first habitat map for the island with eleven major habitat types identified of which four were further sub-divided into sub-types giving nineteen land cover types in total. More detailed vegetation analysis has not only contributed to species inventories, but specific focus on certain habitat types (e.g. mangroves) has identified diverse communities supporting threatened species and are potentially an important resource for future conservation and ecological restoration strategies on Danjungan and other areas of Negros island.

The delineation of the different terrestrial habitat types on the island has also highlighted the diversity of plant communities and the potential for future vegetation inventory work. Observations suggest that the island supports a wide variety of endemic and threatened plant species.

The development of the habitat map has also complemented the faunal surveys. The bird fauna, which consists of a combination of resident (and endemic), migrants and passage visitors, whose distribution appears to be partially influenced by habitat on a north-south gradient. Over forty bird species from twenty-three families were identified. The surveys of the bat fauna identified eight species (five Megachiropterans and three Microchiropterans), which represents over 10% of the Philippine bat fauna. Four species of these are new records for the island, and three species are listed as near-threatened or vulnerable to extinction.

7.3. Future

The habitat and species inventory work will hopefully provide a useful baseline for future conservation research which is required for all major taxonomic groups and this will in turn support and underpin sustainable management strategies on the island.

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Appendix 1

Vegetation Species List

* List derived from Madulid & Agoo.

+ List derived from current study.

SUNSET BAR*	MANGROVE FOREST⁺
Species Name (Latin)	Species Name (Latin)
<i>Arcangelisia</i> sp.	<i>Aegiceras</i> sp. (True)
<i>Ardisia confertiflora</i>	<i>Aganope heptaphylla</i> (Associated)
<i>Capparis sepiaria</i>	<i>Avicennia marina</i> (True)
<i>Cynometra ramiflora</i>	<i>Barringtonia asiatica</i> (Associated)
<i>Diospyros maritima</i>	<i>Bruguiera cylindrica</i> (True)
<i>Diospyros pilosanthera</i>	<i>Bruguiera gymnorrhiza</i> (True)
<i>Epipremnum</i> sp.	<i>Ceriops decandra</i> (True)
<i>Euphoria didyma</i>	<i>Excoecaria agallocha</i> (True)
<i>Fagraea racemosa</i>	<i>Hibiscus tiliaceus</i>
<i>Ficus</i> sp.	<i>Lumnitzera tiliaceus</i>
<i>Flacourtia</i> sp.	<i>Lumnitzera littorea</i> (True)
<i>Flagellaria indica</i>	<i>Nypa fruticans</i> (True)
<i>Gnetom gnemon</i>	<i>Pemphis acidula</i> (Associated)
<i>Joinvillea</i> sp.	<i>Pongomia pinnata</i> (Associated)
<i>Lepisanthes schizolepis</i>	<i>Rhizophora apiculata</i> (True)
<i>Livistona rotundifolia</i>	<i>Sonneratia alba</i> (True)
<i>Lophopetalum</i> sp.	<i>Sonneratia caseolaris</i> (True)
<i>Macaranga</i> sp.	<i>Terminalia cattapa</i> (Associated)
<i>Passiflora</i> sp.	<i>Xylocarpus granatum</i> (True)
<i>Popowia</i> sp.	<i>Xylocarpus granatus</i>
<i>Pterospermum diversifolium</i>	<i>Xylocarpus moluccensis</i> (True)
<i>Schizostachyum scandens</i>	
<i>Siphonodon celastreus</i>	
<i>Veitchia merrillii</i>	

FOREST OVER LIMESTONE*	FOREST OVER LIMESTONE*
Species Name (Latin)	Species Name (Latin)
<i>Aeschynomene sp.</i>	<i>Linociera sp.</i>
<i>Aglaia sp.</i>	<i>Litsea sp.</i>
<i>Allophyllus sp.</i>	<i>Livistona rotundifoia</i>
<i>Antidesma sp.</i>	<i>Lophopetalum sp.</i>
<i>Arcangelisia sp.</i>	<i>Lunasia amara</i>
<i>Ardidisia confertiflora</i>	<i>Lygodium circinatum</i>
<i>Areca catechu</i>	<i>Macaranga sp.</i>
<i>Aristolochia sp.</i>	<i>Mallotus sp.</i>
<i>Breynia sp.</i>	<i>Melothria sp.</i>
<i>Callicarpa sp.</i>	<i>Mucuna sp.</i>
<i>Canarium sp.</i>	<i>Murraya sp.</i>
<i>Capparis sepiaria</i>	<i>Nauclea orientalis</i>
<i>Cayratia sp.</i>	<i>Oncosperma sp.</i>
<i>Celtis luzonica</i>	<i>Pandanus sp.</i>
<i>Cissus sp.</i>	<i>Passiflora sp.</i>
<i>Cordia sp.</i>	<i>Peltophorum pterocarpum</i>
<i>Cycas revoluta</i>	<i>Pinanga sp.</i>
<i>Cynometra ramiflora</i>	<i>Piper sp.</i>
<i>Desmodim sp.</i>	<i>Pipturus sp.</i>
<i>Diospyros maritima</i>	<i>Pleomele multiflora</i>
<i>Diospyros pilosanthera</i>	<i>Pongamia pinnata</i>
<i>Dischidia sp.</i>	<i>Popowia sp.</i>
<i>Drynaria quercifolia</i>	<i>Psychotria sp.</i>
<i>Epipremnum sp.</i>	<i>Pterospermum diversifolium</i>
<i>Euphoria didyma</i>	<i>Pyrrosia sp.</i>
<i>Fagraea racemosa</i>	<i>Rapanea sp.</i>
<i>Ficus psuedopalma</i>	<i>Rumex acetosella</i>
<i>Ficus spp.</i>	<i>Schizostachyum scandens</i>
<i>Flacourtia sp.</i>	<i>Semecarpus gigantifolia</i>
<i>Flagellaria indica</i>	<i>Siphonodon celastrineus</i>
<i>Garcinia sp.</i>	<i>Syzygium sp.</i>
<i>Gnetom gnemon</i>	<i>Tabernaemontana pandacaqui</i>
<i>Grewia eriocarpa</i>	<i>Taxotrophis ilicifolia</i>
<i>Guioa sp.</i>	<i>Terminalia calamansanai</i>
<i>Guettarda speciosa</i>	<i>Vanda sp.</i>
<i>Hoya sp.</i>	<i>Veitchia merrillii</i>
<i>Leea guineensis</i>	<i>Wrightia lanete</i>
<i>Lepisanthes schizolepsis</i>	

BEACH FOREST*	SECONDARY FOREST / OPEN AREAS*
Species Name (Latin)	Species Name (Latin)
<i>Aristida sp.</i>	<i>Cocos nucifera</i>
<i>Barringtonia asiatica</i>	<i>Dioscorea sp.</i>
<i>Hernandia ovigera</i>	<i>Ficus sp.</i>
<i>Ipomoea pes-caprae</i>	<i>Lantana camara</i>
<i>Messerschmidia sp.</i>	<i>Livistona rotundifolia</i>
<i>Morinda bracteata</i>	<i>Mikania scandens</i>
<i>Pandanus tectorius</i>	<i>Schizostachyum scandens</i>
<i>Premna odorata</i>	<i>Stachytarpheta jamaicensis</i>
<i>Scaevola micrantha</i>	<i>Terminalia catappa</i>
<i>Sesuvium portulacastrum</i>	<i>Voacanga globosa</i>
<i>Sterculia sp.</i>	<i>Vernonia cinerea</i>
<i>Terminalia catappa</i>	
<i>Thespesia populnea</i>	
<i>Vitex trifolia</i>	

Appendix 2

Raw data derived from vegetation transects.

Table 2.1. Number of stems recorded in each size-class in each transect

Dbh (cm)	Area sampled (ha)	<i>Ficus</i> -dominated high forest		Coconut-dominated low- forest	
		Transect 2	Transect 4	Transect 1	Transect 3
>= 40	0.2	0	3	1	1
30 – 40	0.2	14	11	12	19
20 – 30	0.2	27	24	14	18
10 – 20	0.12	43	71	17	20
5 – 10	0.04	31	42	52	21
Total		115	151	96	79

Table 2.2. Number of morpho-species recorded in each size-class in each transect

Dbh (cm)	Area sampled (ha)	<i>Ficus</i> -dominated high forest		Coconut-dominated low- forest	
		Transect 2	Transect 4	Transect 1	Transect 3
>= 40	0.2	0	1	1	1
30 – 40	0.2	3	7	2	1
20 – 30	0.2	15	16	3	3
10 – 20	0.12	17	24	8	9
5 – 10	0.04	18	14	9	8
Total		40	37	18	17

Table 2.3. Number of quadrats with selected understory species in each transect

Species	<i>Ficus</i> -dominated high forest		Coconut-dominated low- forest	
	Transect 2	Transect 4	Transect 1	Transect 3
Germinating coconuts	1	1	5	5
<i>Pandanus</i> (small leaf)	0	0	0	4
<i>Pandanus</i> (big leaf)	1	0	0	1
“Trumpet plant”	3	3	5	5
“Cheese plant” (Araceae)	1	0	0	0
Palm 1 (tall, thin)	3	3	1	0
Palm 2 (thin, stringy bark)	2	0	0	0
Palm 3 (fan leaves)	0	1	1	5
Cycads	0	0	0	0
Tree ferns	0	0	0	0

Table 2.1. Number of stems recorded in each size-class in each transect

Dbh (cm)	Area sampled (ha)	Legume-dominated low forest		Logged-over mid-height forest	
		Transect 5	Transect 6	Transect 7	Transect 8
>= 40	0.2	0	0	1	0
30 – 40	0.2	1	3	5	1
20 – 30	0.2	9	14	14	12
10 – 20	0.12	36	58	43	85
5 – 10	0.04	37	66	37	84
Total		83	141	100	182

Table 2.2. Number of morpho-species recorded in each size-class in each transect

Dbh (cm)	Area sampled (ha)	Legume-dominated low forest		Logged-over mid-height forest	
		Transect 5	Transect 6	Transect 7	Transect 8
>= 40	0.2	0	0	0	0
30 – 40	0.2	1	3	0	1
20 – 30	0.2	7	4	11	10
10 – 20	0.12	16	20	22	29
5 – 10	0.04	20	26	15	28
Total		33	38	40	48

Table 2.3. Number of quadrats with selected understory species in each transect

Species	Legume-dominated low forest		Logged-over mid-height forest	
	Transect 5	Transect 6	Transect 7	Transect 8
Germinating coconuts	0	0	0	0
<i>Pandanus</i> (small leaf)	0	5	0	0
<i>Pandanus</i> (big leaf)	1	3	0	0
“Trumpet plant”	5	5	4	5
“Cheese plant” (Araceae)	0	0	0	0
Palm 1 (tall, thin)	3	3	2	3
Palm 2 (thin, stringy bark)	0	0	0	2
Palm 3 (fan leaves)	0	0	0	0
Cycads	0	0	0	0
Tree ferns	0	0	0	0

Appendix 3

List of bird species recorded on Danjungan Island using MacKinnon Lists.

Family	Genus / Species	Species
Accipitridae	<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle
Alcedinidae	<i>Halcyon pileata</i>	Black-capped Kingfisher
Alcedinidae	<i>Alcedo atthis</i>	Common Kingfisher
Alcedinidae	<i>Eudynamys scolopacea</i>	Common Koel
Alcedinidae	<i>Halcyon capensis</i>	Stork-billed Kingfisher
Alcedinidae	<i>Halcyon chloris</i>	White-collared Kingfisher
Apodidae	<i>Collocalia esculenta</i>	Glossy Swiftlet
Ardeidae	<i>Butorides striatus</i>	Little Heron (Striated Heron)
Ardeidae	<i>Nycticorax caledonicus</i>	Rufous Night Heron
Artamidae	<i>Artamus leucorhynchus</i>	White-breasted Wood-swallow
Campephagidae	<i>Lalage Nigra</i>	Pied Triller
Caprimulgidae		NightJar Spp
Columbidae	<i>Ptilinopus leclancheri</i>	Black-chinned Fruit-Dove
Columbidae	<i>Chalcophaps indica</i>	Common Emerald-Dove
Columbidae	<i>Treron vernans</i>	Pink-necked Green-pigeon
Columbidae	<i>Streptopelia chinensis</i>	Spotted Dove
Columbidae	<i>Phapitreron leucotis</i>	White-eared Brown-Dove
Corvidae	<i>Corvus macrorhynchos</i>	Large-billed Crow
Cuculidae	<i>Cuculus saturatus</i>	Oriental Cuckoo
Cuculidae	<i>Centropus viridis</i>	Philippine Coucal
Fregatidae	<i>Fregata minor</i>	Great Frigatebird
Fregatidae	<i>Fregata ariel</i>	Lesser Frigatebird
Hirundinidae	<i>Hirundo rustica</i>	Barn Swallow
Hirundinidae	<i>Hirundo tahitica</i>	Pacific Swallow
Laniidae	<i>Lanius cristatus</i>	Brown Shrike
Megapodiidae	<i>Megapodius cumingii</i>	Tabon Scrubfowl
Muscicapidae	<i>Cyornis rufigastra</i>	Mangrove Blue Flycatcher
Muscicapidae	<i>Rhipidura javanica</i>	Pied Fantail
Nectariniidae	<i>Nectarinia jugularis</i>	Olive-backed Sunbird
Oriolidae	<i>Oriolus chinensis</i>	Black-naped Oriole
Phalaropodidae	<i>Phalaropus fulicaria</i>	Rednecked Phalarope
Rallidae	<i>Porzana cinerea</i>	White-browed Crake
Scolopacidae	<i>Actitis hypoleucos</i>	Common Sandpiper
Scolopacidae	<i>Heteroscelus brevipes</i>	Grey-tailed Tattler
Sternidae	<i>Sterna sumatrana</i>	Black-naped Tern
Sturnidae	<i>Aplonis minor</i>	Asian Glossy Starling
Sylviidae	<i>Gerygone sulphurea</i>	Golden-bellied Flyeater
Sylviidae	<i>Phylloscopus olivaceus</i>	Philippine Leaf-Warbler
Sylviidae	<i>Megalurus timoriensis</i>	Tawny Grassbird
Turdidae	<i>Monticola solitarius</i>	Blue Rock-Thrush
Turdidae	<i>Copsychus saularis</i>	Oriental Magpie -Robin

All bird species recorded by the DIBS.

Species	Scientific name	Reliability	Comments
Great Frigatebird	<i>Fregata minor</i>	Unreliable	A single sighting on 6/July/01, possibly misidentification of Lesser Frigatebird.
Lesser Frigatebird	<i>Fregata ariel</i>	Confirmed	Observed frequently between 14/Aug/01 and 01/Sept/01, singly or in groups of up to 7 birds.
Little Heron	<i>Butorides striatus</i>	Confirmed	Commonly observed in lagoons and on exposed off-shore rocks or corals at low-tide.
Rufous Night Heron	<i>Nycticorax caledonicus</i>	Confirmed	Frequently observed in lagoons 5 and 6, also recorded from lagoons 1, 3 and 4. During July and August often seen in groups of 2 adults and 2 immatures. By September more commonly seen singly.
Brahminy Kite	<i>Haliastur indus</i>	Confirmed	A single sighting on 13/Sept/01, flying over 3rd lagoon.
White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	Confirmed	Two adults and an immature were sighted throughout the survey period, although were absent between 26/July/01 and 22/Aug/01. They were often disturbed from forest areas around 1st lagoon. The nest above Typhoon Beach was lost during high winds at the beginning of July. An adult was observed perched in the nest-tree on 27 and 28/Sept/01. Kennedy et al (2000) report that the species feeds on a wide variety of prey including fish, sea-snakes, birds and fruit-bats. An early sighting may have been a misidentification of a juvenile White-bellied Sea-Eagle.
Grey-headed Fish-Eagle	<i>Ichthyophaga ichthyaetus</i>	Unreliable	
Crested Goshawk	<i>Accipter trivirgatus</i>	Unconfirmed	A single sighting of a hawk flying over 3rd lagoon, at 10:45 on 26/Sept/01.
Tabon Scrubfowl	<i>Megapodius cumingi</i>	Confirmed	Birds, often in pairs, sighted in most areas of the island. Five chicks were sighted along the beach of South-west Bay in the first week of July. Fresh excavations were observed at the communal nest mound on Tabon Beach, particularly from 20/Aug/01.
White-browed Crake	<i>Porzana cinerea</i>	Confirmed	Two sightings, both at 5th lagoon, 24/Aug/01 and 28/Aug/01. Probably largely over-looked due to secretive behaviour.
Common Sandpiper	<i>Actitis hypoleucos</i>	Confirmed	First sighted 01/Aug/01 (earliest Philippine record 31 Jul in Palawan (Kennedy et al 2000)), then regularly on beaches, exposed rocks, and lagoons 1, 2 and 3.
Grey-tailed Tattler	<i>Heteroscelus brevipes</i>	Unconfirmed	A single sighting on exposed rocks at low-tide off Tabon Beach, 5/Sept/01. (Earliest Philippine record 22 Aug (Kennedy et al 2000)).
Red-necked Phalarope	<i>Phalaropus lobatus</i>	Confirmed	A single individual in non-breeding plumage in lagoon 1, 04/Sept/01. Very tame. A migrant, earliest record in Philippines 2 Sept (Kennedy et al 2000).
Black-naped Tern	<i>Sterna sumatrana</i>	Confirmed	Commonly observed around the island until the second week of July, but not since then. 3 pairs appeared to be nesting on the small rock off Tabon Beach, with a juvenile seen flying on 03/July/01. This implies breeding before July; Kennedy et al (2000) report "Breeding recorded in Jul and possibly Jun".
Pink-necked Green-Pigeon	<i>Treron vernans</i>	Confirmed	Commonly observed throughout the island.

Species	Scientific name	Reliability	Comments
White-eared Brown-Dove	<i>Phapitreron leucotis</i>	Unconfirmed	Often heard but never seen.
Yellow-breasted Fruit-	<i>Ptilinopus occipitalis</i>	Unreliable	Unconfirmed records at the start of the survey period.
Black-chinned Fruit-Dove	<i>Ptilinopus leclancheri</i>	Confirmed	Recorded infrequently throughout the island.
Island Collared-Dove	<i>Streptopelia</i>	Unreliable	An unreliable record from the north of the island.
Spotted Dove	<i>bitorauata</i> <i>Streptopelia</i> <i>chinensis</i>	Confirmed	Most frequently recorded from the north of the island.
Common Emerald-Dove	<i>Chalcophaps indica</i>	Confirmed	Secretive, first recorded from mist-nets 04/Aug/01, then sighted occasionally.
Colasisi	<i>Loriculus philippensis</i>	Unconfirmed	A small green parrot-like bird with a red bill sighted at 0730 on 02/Sept/01, pursued over 3rd lagoon by 2 Glossy Starlings.
Oriental Cuckoo	<i>Cuculus saturatus</i>	Unconfirmed	A single cuckoo sighted at dusk along the trail to Bamboo-bridge, 14/Aug/01. A migrant, previously not recorded in Philippines before 12 Sept (Kennedy et al 2000).
Common Koel	<i>Eudynamys scolopacea</i>	Confirmed	First sighted 30/Aug/01 on Tabon Beach, then regularly for the remainder of the survey period.
Philippine Coucal	<i>Centropus viridis</i>	Confirmed	Seen and heard throughout the island, but particularly in forest surrounding Typhoon Beach.
Philippine Hawk-Owl	<i>Ninox philippensis</i>	Confirmed	Two sightings, in forest near north-east corner of 1st lagoon, 04 and 18/Aug/01. Heard throughout island.
Nightjar sp.	<i>Caprimulgus sp.</i>	Unconfirmed	Nightjars were frequently heard, particularly at dawn. Sighted occasionally at dusk between 2nd lagoon and Turtle Beach, perching on coconut leaves.
Glossy Swiftlet	<i>Collocalia esculenta</i>	Confirmed	Very commonly seen everywhere. 14 individuals were mist-netted flying in and out of the main bat-cave at 3rd lagoon, between 1720 and 1755, 12/Sept/01.
Pygmy Swiftlet	<i>Collocalia troglodytes</i>	Unreliable	Initial records of this species are probably misidentifications of Glossy Swiftlets.
Common Kingfisher	<i>Alcedo atthis</i>	Confirmed	A migrant, first recorded 20/Sept/01, perching on low rocks in 3rd lagoon, then again 02/Oct/01. Also observed in 2nd lagoon, 13/Oct/01.
Stork-billed Kingfisher	<i>Halcyon capensis</i>	Confirmed	Recorded from all lagoons and beaches. Possibly becoming less-frequently seen by the end of the survey period, although still present.
Black-capped Kingfisher	<i>Halcyon pileata</i>	Unreliable	Unlikely to occur on Danjungan Island, according to Kennedy et al (2000) it has not been recorded from Negros, or indeed from most islands in Philippines; it is a rare migrant reported in the Philippines from 20 Sept to Dec.
White-collared Kingfisher	<i>Halcyon chloris</i>	Confirmed	Common and conspicuous throughout island.
Barn Swallow	<i>Hirundo rustica</i>	Confirmed	First sighted 06/Aug/01, then occasionally from then on. A migrant, reported in the Philippines from 29 Jul to 2 Jun (Kennedy et al 2000).

Species	Scientific name	Reliability	Comments
Pacific Swallow	<i>Hirundo tahitica</i>	Confirmed	First sighted 02/Aug/01, then occasionally from then on.
Pied Triller	<i>Lalage nigra</i>	Confirmed	Common but relatively inconspicuous.
Black-naped Oriole	<i>Oriolus chinensis</i>	Confirmed	Very common and conspicuous.
Large-billed Crow	<i>Corvus macrorhynchos</i>	Confirmed	Occasional sightings.
Oriental Magpie-Robin	<i>Copsychus saularis</i>	Confirmed	Recorded throughout survey period, but seemingly becoming more conspicuous at the end of September.
Blue Rock-Thrush	<i>Monticola solitarius</i>	Confirmed	A migrant, first recorded 13/Sept/01 (earliest date given by Kennedy et al (2000) is 21 Sept), then frequently around Turtle and Tabon Beaches.
Golden-bellied Flyeater	<i>Gerygone sulphurea</i>	Confirmed	Very conspicuous melodious song a constant feature of life on Danjungan, throughout survey period. Kennedy et al (2000) state "singing occurs from Jan to Jun and maybe longer".
Philippine Leaf-Warbler	<i>Phylloscopus olivaceus</i>	Confirmed	A pair observed foraging amongst <i>Xylocarpus granatum</i> flowers in 2nd lagoon, 0900, 29/Sept/01. A singleton observed, again in mangroves in lagoon 2, 13/Oct/01.
Tawny Grassbird	<i>Megalurus timoriensis</i>	Confirmed	An unconfirmed record from 5th lagoon, 06/Aug/01, then confirmed sightings from North Bay 18/Aug/01 and Bamboo-bridge Trail, 14/Sept/01.
Mangrove Blue Flycatcher	<i>Cyornis rufigastra</i>	Confirmed	Rarely seen, but mist-netted several times (particularly immatures) in forest areas.
Pied Fantail	<i>Rhipidura javanica</i>	Confirmed	Commonly recorded and netted in all habitats of the island.
White-breasted Wood-Swallow	<i>Artamus leucorhynchus</i>	Confirmed	Commonly recorded throughout the island, often harassing the sea-eagles.
Brown Shrike	<i>Lanius cristatus</i>	Confirmed	First sighted 14/Sept/01, Bamboo-bridge Trail, then regularly recorded throughout the island. A common migrant (Kennedy et al 2000).
Asian Glossy Starling	<i>Aplonis panayensis</i>	Confirmed	Commonly observed in small groups throughout the island. During July appeared to utilise the hollow branch of the large tree on the east shore of 5th lagoon.
Olive-backed Sunbird	<i>Nectarinia jugularis</i>	Confirmed	Common and conspicuous, often seen feeding from flowers of coconut.

Appendix 4

Total bird species list for Danjungan Island including the record of the DIBS and other researchers.

Family	Species Name	Common Name
Accipitridae	<i>Accipiter trivirgatus</i> **	Crested Goshawk
Accipitridae	<i>Haliaeetus leucogaster</i> *	White-breasted Sea Eagle
Accipitridae	<i>Haliastur indus intermedius</i> *	Brahminy Kite
Accipitridae	<i>Ichthyophaga ichthyaetus</i> *	Grey-headed Fishing-Eagle
Alcedinidae	<i>Alcedo atthis bengalensis</i> *	Common Kingfisher
Alcedinidae	<i>Ceyx lepidus margarethae</i>	Variable Dwarf Kingfisher
Alcedinidae	<i>Halcyon capensis gigantea</i> *	Stork-billed Kingfisher
Alcedinidae	<i>Halcyon chloris</i> *	White-collared Kingfisher
Alcedinidae	<i>Halcyon pileata</i> *	Black-capped Kingfisher
Apodidae	<i>Apus p. pacificus</i>	Fork-tailed Swift
Apodidae	<i>Collocalia esculenta marginata</i> *	Glossy Swiftlet
Apodidae	<i>Collocalia troglodytes</i> *	Pygmy Swiftlet
Apodidae	<i>Collocalia vanikorensis amelis</i>	Island Swiftlet
Apodidae	<i>Cypsiurus balasiensis pallidior</i>	Asian Palm-Swift
Ardeidae	<i>Butoroides striatus carcinophilus</i> *	Striated (Little or Mangrove) Herons
Ardeidae	<i>Egretta s. sacra</i>	Eastern Reef-Egret/Heron
Ardeidae	<i>Nycticorax caledonicus major</i> *	Rufous Night Heron
Artamidae	<i>Artamus l. leucorhynchus</i> *	White-breasted Wood-Swallow
Campephagidae	<i>Lalage nigra chilensis</i> *	Pied Triller
Campephagidae	<i>Pericrocotus flammeus novus</i>	Scarlet/Flame Minivet
Caprimulgidae	<i>Caprimulgus sp.</i> *	Nightjar sp.
Columbidae	<i>Chalcophaps indica</i> *	Common Emerald Dove
Columbidae	<i>Ducula a. aenea</i>	Green Imperial Pigeon
Columbidae	<i>Ducula b. bicolor</i>	Green-winged Ground Dove/ Pied Imperial Pigeon
Columbidae	<i>Geopelia s. striata</i>	Zebra Dove
Columbidae	<i>Phapitreron leucotis</i> *	White-eared Brown Fruit Dove
Columbidae	<i>Ptilinopus o. occipitalis</i> *	Yellow Breasted Fruit Dove
Columbidae	<i>Ptilinopus leclancheri</i> *	Black-chinned Fruit Dove
Columbidae	<i>Streptopelia bitorquata dussumieri</i> *	Island Collared Dove / Island Turtle Dove
Columbidae	<i>Streptopelia chinensis</i> **	Spotted dove
Columbidae	<i>Treron pompadora canescens</i>	Pompadore Green Pigeon
Columbidae	<i>Treron vernans</i> *	Pink-necked Green Pigeon
Corvidae	<i>Corvus macrorhynchos philippinus</i> *	Large-billed Crow
Cuculidae	<i>Cacomantis variolosus sepulchralis</i>	Brush Cuckoo
Cuculidae	<i>Centropus viridis</i> *	Philippine Coucal
Cuculidae	<i>Cuculus saturatus</i> **	Oriental Cuckoo
Cuculidae	<i>Eudynamys scolopaea mindanensis</i> *	Common Koel
Dicaeidae	<i>Dicaeum sp.</i>	Flowerpecker sp.
Estrildidae	<i>Lonchura malacca jadori</i>	Chestnut Munia
Fregatidae	<i>Fregata a. ariel</i> *	Lesser Frigatebird
Fregatidae	<i>Fregata minor</i> **	Great Frigatebird
Hirundinidae	<i>Hirundo rustica</i> *	Barn Swallow
Hirundinidae	<i>Hirundo tahitica javanica</i> *	Pacific Swallow

Family	Species Name (Latin)	Common Name
Laniidae	<i>Lanius cristatus lucionensis</i> *	Brown Shrike
Laniidae	<i>Lanius schach nasutus</i>	Long-tailed Shrike
Megapodiidae	<i>Megapodius cumingii pusillus</i> *	Tabon Scrubfowl
Muscicapidae	<i>Cyornis rufigastra philippinensis</i> *	Mangrove Blue Flycatcher
Muscicapidae	<i>Rhipidura javanica nigritorquis</i> *	Pied Fantail
Nectariniidae	<i>Nectarinia j. jugularis</i> *	Olive-backed Sunbird
Oriolidae	<i>Oriolus chinensis yamamurae</i> *	Black-naped Oriole
Oriolidae	<i>Oriolus xanthonotus persuasus</i>	Dark-throated Oriole
Phalaropodidae	<i>Phalaropus lobatus</i> **	Red-necked Phalarope
Pittidae	<i>Pitta sp.</i>	Pitta sp.
Ploceidae	<i>Passer montanus saturatus</i>	Eurasian Tree Sparrow
Psittacidae	<i>Loriculus philippensis</i> **	Colasisi
Psittacidae	<i>Tanygnathus lucionensis</i>	Blue-naped parrots
Pyconotidae	<i>Hypsipetes philippinus guimarasensis</i>	Philippine Bulbul
Pyconotidae	<i>Pycnonotus g. goiavier</i>	Yellow-vented Bulbul
Rallidae	<i>Amaurornis o. olivacea</i>	Plain Bush-Hen
Rallidae	<i>Gallirallus t. torquatus</i>	Barred Rail
Rallidae	<i>Porzana cinerea ocularis</i> *	White-browed crane
Scolopacidae	<i>Actitis hypoleucos</i> *	Common Sandpiper
Scolopacidae	<i>Heteroscelus brevipes</i> **	Grey Tailed Tatler
Scolopacidae	<i>Numenius sp.</i>	Curlew sp.
Sternidae	<i>Sterna sumatrana</i> *	Black naped tern
Strigidae	<i>Ninox philippensis centralis</i> *	Philippine Hawk Owl
		Philippines Glossy Starling /
Sturnidae	<i>Aplonis p. panayensis</i> *	Asian Glossy Starling
Sturnidae	<i>Sarcops calvus melanonotus</i>	Coletto
Sylviidae	<i>Cisticola excilis semifufa</i>	Bright-capped Cisticola
		Golden-headed Fantail Warb /
Sylviidae	<i>Cisticola exilia</i>	Bright Capped Cisticola
		Yellow-breasted Wren Warbler/
Sylviidae	<i>Gerygone sulphurea simplex</i> *	Golden-bellied Flyeater
Sylviidae	<i>Megalurus timoriensis</i> **	Tawny grassbird
Sylviidae	<i>Orthotomus canasteiceps rabori</i>	Philippine Tailorbird
Sylviidae	<i>Phylloscopus borealis</i>	Arctic Willow Warbler
Sylviidae	<i>Phylloscopus c. cebuensis</i>	Lemon-throated Leaf-Warbler
Sylviidae	<i>Phylloscopus olivaceus</i> **	Philippine Leaf-warbler
Sylviidae	<i>Phylloscopus trivirgatus nigrorum</i>	Mountain Leaf-Warbler
Turdidae	<i>Copsychus saularis mindanensis</i> *	Dyal Thrush/Oriental Magpie Robin
Turdidae	<i>Monticola solitarius philippensis</i> *	Blue Rock-Thrush
Turdidae	<i>Saxicola caprata randi</i>	Pied Bushchat

* Records from DIBS project and other previous unpublished surveys.

** Recorded only from DIBS project.

All other records compiled from unpublished species lists generated by local researchers.