The Mangrove Communities of Danjugan Island, Cauayan, Negros Occidental, Philippines

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Abstract

The mangroves of the Philippines have declined by 75% over the past 80 years due to a range of anthropogenic pressures. However, there is relatively little information available on mangrove stands in the central Visayas region of the Philippines. This paper represents first detailed inventory of the mangrove resources of Danjugan Island, Cauayan, Negros Occidental, which represents an island with relatively undisturbed mangal communities. The results of the completed inventory of all mangroves of the island suggest that the island supports very diverse (14 true mangrove species identified) and abundant communities that vary with location on the island. These are discussed in terms of the geographic location and potential conservation value.

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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 from twenty-six families are found in the Philippines. 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; Walters 2000).

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. 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 in the Philippines is indicated by a positive correlation between near-shore yields of fish and/or shrimp and relative densities of mangrove areas (Primavera 2000).

However, despite their environmental importance mangroves have suffered considerable degradation in the Philippines because of their relative accessibility and long history of conversion to aquaculture ponds (Primavera 2000). Such conversion in combination with over-exploitation has meant that the Philippines has lost over 70% of its original mangrove forest (Walters 2000) and 50% of the remaining forest cover is deemed to be threatened (DENR/UNEP 1998). 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 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.

Danjugan Island provides an ideal candidate location for such work (Harborne *et al*, 1996; Turner *et al*, 2002). It is a small (approximately 43 hectares), coral fringed island covered in tropical limestone forest, 3km west of Negros Occidental just off the coast of Barangay Bulata in the Sulu Sea (Figure 1). The island has six lagoons, of which two are open to the sea and all but one are surrounded by mangrove stands. Danjugan Island was designated reserve status as the Danjugan Island Marine Reserve and Sanctuaries (DIMRS) by the municipal government of Cauayan and provincial government of Negros Occidental in February 2000. It has three sanctuaries or “no-take zones” within the reserve boundary, which has a total area of 104.2 hectares approximately 50% of the total coastline and reef area of the island. The island has been managed by the Philippines Reef and Rainforest Conservation Foundation, Incorporated (PRRCFI) since 1995 who are adopting an integrated community-based approach to resource management (Ledesma *et al*, 1999). However, the abundant mangrove resources have never been assessed beyond partial species listings completed by PRRCFI staff.

The current study formed part of the wider reaching Danjugan Island Biodiversity Survey whose objective was to survey the flora and fauna of terrestrial and mangal commuities (Turner *et al*, 2002). The specific objectives of this study were to:

1. Quantify the abundance and distribution of each mangrove species on Danjugan Island
2. Compare and contrast the mangal communities at different locations

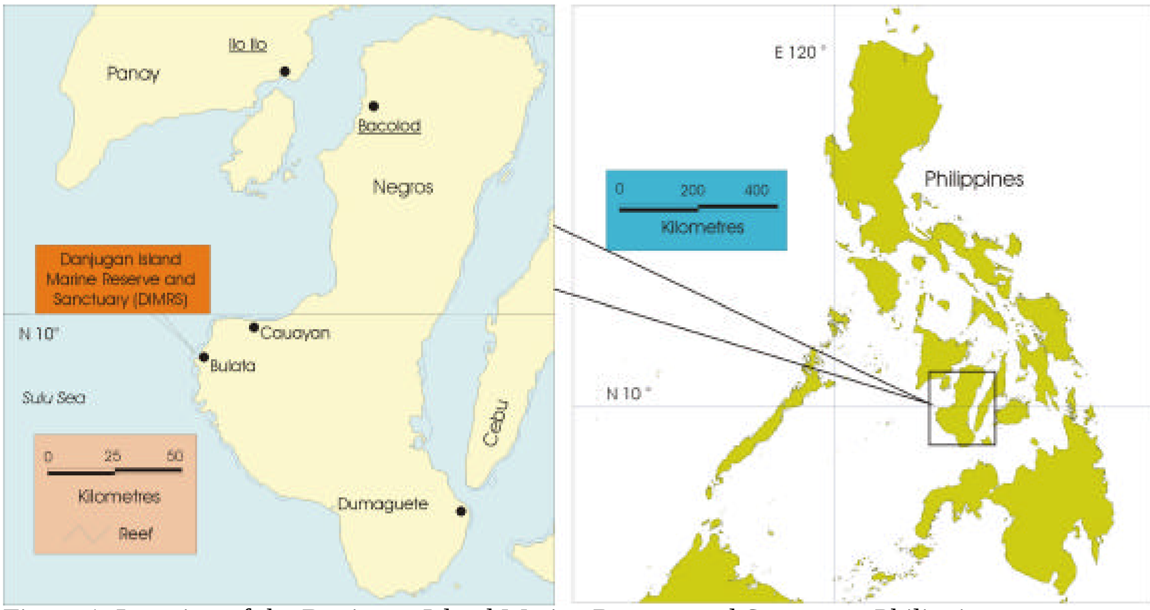

Figure 1. Location of the Danjugan Island Marine Reserve and Sanctuary, Philippines.

Methods

An initial survey of the Island identified a total of seven locations supporting mangrove stands (Figure 2). 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 size classes 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 1969) although a few unidentified species remained, they were included in the inventory in order to illustrate total species richness at each site.

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 $H=\Sigma(P_i*Log_e(P_i))$ (where P_i is the number of individuals of the ith species as a proportion of the total number of all *i*th species); and Pielou's eveness $J=H/Log_eS$ (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).

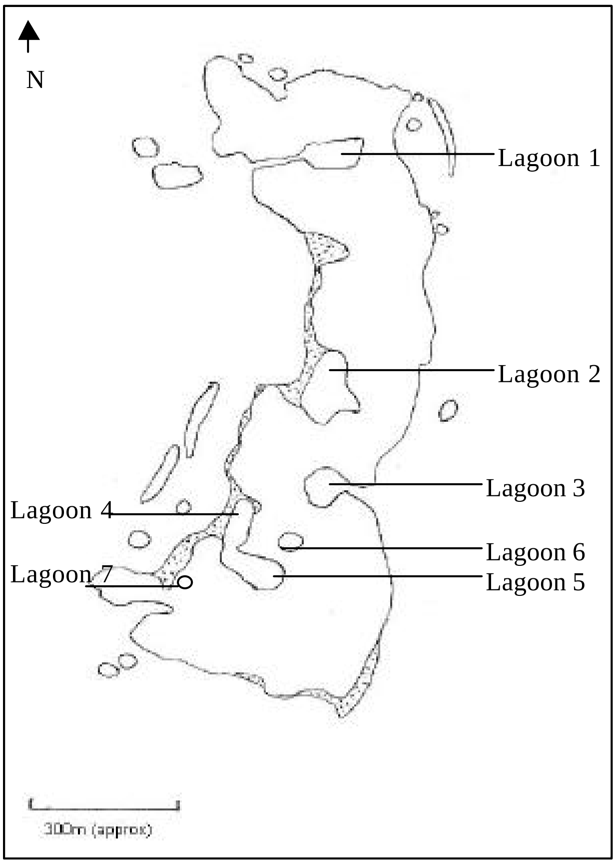

Figure 2. Schematic outline map of Danjugan Island with location of lagoon areas where mangrove stands were identified.

Results

A total of fourteen true mangrove species from eight families and twelve associated mangrove species (or morpho-types) were identified on Danjugan (Table 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 1. Total abundance of true mangrove species in each lagoon on Danjugan Island

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

Rhizophora mucronata was the most common species at both lagoons 3 and 4 (Table 1). However, at lagoon 2, just a single established *R. mucronata* was recorded, with *R. apiculata* being the most common Rhizophoraceae. *Bruguiera gymnorrhiza* 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 frequent 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 2), *Pongomia pinnata* was the most widely distributed, being recorded from each lagoon. *Pemphis acidula* (a threatened species [Domingo Madulid pers.comm.]) 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 2. Presence/absence of identified associated mangrove species located within each lagoon.

Family	Species	Lagoon						
		1	2	3	4	5	6	7
Combretaceae	*Terminalia cattapa*	Y	-	Y	-	Y	-	-
Fabaceae	*Aganopa heptaphylla*	Y	-	Y	-	-	Y	-
Fabaceae	*Pongomia pinnata*	Y	Y	Y	Y	Y	Y	Y
Lecythidaceae	*Baringtonia asiatica*	-	-	Y	-	-	-	Y
Lythraceae	*Pemphis acidula*	Y	-	Y	-	-	-	Y

Distribution, abundance and species richness all varied with location. While lagoons 2 and 4 supported the highest number of individuals (Table 3), lagoons 1 and 3 demonstrated the highest cumulative (true and associated) total species richness (Table 3). For both true species and associated species, lagoon 3 was the most species rich (including morpho-types). 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.

Table 3. Mangrove community metrics for each major lagoon.

Community Metric	Lagoon 1	Lagoon 2	Lagoon 3	Lagoon 4	Lagoon 5
Approx. mangrove stand area (sqm)	2000	5000	3000	2000	1500
True 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 Eveness	0.78	0.72	0.63	0.75	0.69
Associated species richness	4	1	5	1	2
+Morphotype species richness	3	3	4	2	0
*Total Species Richness	13	10	19	9	7

+Morphotype: where resolution to family level or lower could not be achieved.

*Total Species Richness = sum of True, Associated and Morphotype species richness for each location.

The diversity analyses (Table 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 eveness value since it is dominated by 3 species. The analysis of community composition (Figure 3) 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%).

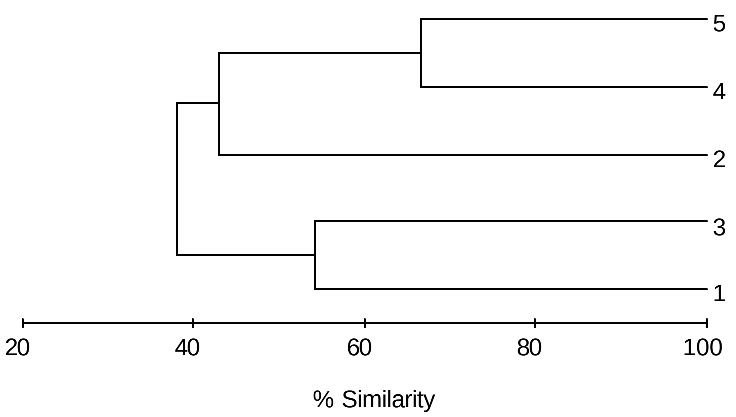

Figure 3. Dendrogram of mangrove community composition at the five lagoons calculated using group-average linking of Bray-Curtis similarities (calculated from √√-transformed data) and labelled according to lagoon location.

Discussion

Danjugan Island has a diverse mangrove flora, comparable in species richness to other sites on Negros where at least fourteen species have been recorded, but fewer than the most diverse sites in the Philippines where as many as 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 recorded abundance and diversity measures within each lagoon may partially be explained by the size of the area sampled (Table 3), however, there is no clear correlation between these factors. Therefore, the reasons for the observed patterns may be explained by three additional factors. Firstly, lagoons 1and 3 are potentially exposed to increased natural recruitment of propagules via transportation on the tidal flow potentially exposing these areas to increased abundance and diversity of propagules. 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 and may have increased levels of disturbance that could promote greater species diversity (Connell 1978).

The intermediate disturbance hypothesis 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 Danjugan.

Such a theory has some foundation based on the observed results from lagoons 1 and 3 which were not dominated by any single species but contained a cross-section of family groups with different 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 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 probable given the lack of opening to the sea from these lagoons. 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 frequent but more widely distributed. 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). This may be explained by the observed general preference for many species in these families for tidal stream and well-flushed areas and hence they were only located in lagoon 3 (Calumpong 1994).

Thirdly, based on historical accounts derived from informal interviews by PRCCFI with local community members of Bulata, the mangrove resources of the islands have been partially exploited. Local communities have been gathering firewood on the island prior to the acquisition of the island by the PRRCFI in 1994. From the interviews it was apparent that lagoons 1 and 3 were more accessible for exploitation and they preferred species like *Avicennia* and *Sonneratia* for firewood while *Rhizophora* species were exploited for construction materials and tannins for food colouring. The degree to which such historical exploitation has influenced the mangal community composition of the different lagoons is difficult to quantify since the target *Avicennia* and *Sonneratia* species are largely absent from the island except for one of the most accessible lagoons (lagoon 3).

The underlying causal mechanisms for the observed ecological patterns clearly require further investigation with respect the role of disturbance, abiotic conditions (e.g. water quality) and anthropogenic exploitation. 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 regeneration patterns of the mangals.

The mangroves of Danjugan 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 PRRCFI who manage Danjugan 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.), thereby creating an alternative income to the coral reef fishery. The lagoons of Danjugan Island thus potentially provide a rich resource for ecological restoration while supporting a diverse habitat of considerable conservation value.

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