

**THE DIVERSITY AND DISTRIBUTION OF THE BAT FAUNA (MAMMALIA,
CHIROPTERA) OF DANJUGAN ISLAND CAUAYAN,
NEGROS OCCIDENTAL, PHILIPPINES**

Roger O'Malley^{1,2*}, Tony King^{1,2+}, Craig Turner¹, Simon Tyler^{1,2Ψ},
James Benares², Michael Cummings¹ & Peter Raines¹

¹Coral Cay Conservation, The Tower, 125 High Street, Colliers Wood, London, SW19 2JG, UK.

²Negros Rainforest Conservation Project, c/o Negros Forests & Ecological Foundation Inc,
South Capitol Street, Bacolod, Negros Occidental, Philippines.

⁺current address: Projet Protection des Gorilles, BP 13977, Brazzaville, Republic of Congo.

^{*}current address: Aeon Corp, Kumamoto, Kyushu Region, Japan

^Ψcurrent address: 28 Church Street, Braunston, Oakham, Rutland, LE15 8QT

Abstract

The Chiropterans are the most diverse mammalian order in the Philippines and whilst many endemic and threatened species have been documented, they are also probably the least well known order. Negros Island (central Visayas, Philippines) represents one of the ten highest-ranking sites globally for Megachiroptera diversity, and is listed as a priority area for the establishment of protected areas for Megachiropteran conservation. It is also listed as a priority site for survey work. The current study undertook mist netting, roost and observation surveys of the bat fauna of Danjungan Island, off the west coast of Negros Occidental, to inventory the bat species present and to provide base-line ecological information to identify key areas of conservation concern. Eight species - five Megachiropterans and three Microchiropterans - were recorded over the course of the study, representing over 10% of the total Philippine Chiropteran fauna. Four of the species are new records for the island, and three are IUCN Red Listed. The results show that the island provides important cave- and tree-roosting areas for the local populations of several endemic and globally endangered species and sub-species. Already designated with reserve status, and with an environmental education programme established within the local communities, the island may be considered of national and global importance for bat conservation, and recommendations are given for future management.

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 and Heaney 1992).

Consequently, the Chiropterans are also recognised as probably the most poorly known mammalian order in the Philippines (Ingle and 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 and Heaney 1996; Heaney and 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 and Heaney 1996; Heaney and Regalado 1998; Turner *et al*, 2002a). With regard to Chiropterans, whilst new species have recently been discovered (Heaney and Peterson 1984), there are concerns that several species may now be threatened and possibly extinct (Ingle and 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 and 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 and 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 and Heideman 1987; Heideman and Heaney 1989; Heaney 1991; Ingle and Heaney 1992; Utzurrum 1992; Heaney 1993; Heaney *et al*, 1998) but with limited focus on the Negros-Panay Faunal Region. That which has been undertaken on Negros (predominantly in Southern Negros), 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 and Curio 1999). Little work has focused on diversity, distributions and status of species in other areas of Negros 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.

The Negros Rainforest Conservation Project (NRCP) is currently undertaking such work in the North Negros Forest Reserve (Turner *et al*, 2002a) and recently completed similar work on Danjungan Island which lies just off the west coast of Negros Island. 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 but the limited faunal surveys of the limestone

caves on the island has revealed that they provide important havens for cave-roosting bat species. The island has recently been 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, and has been managed by the Philippines Reef and Rainforest Conservation Foundation Incorporated (PRRCFI) since 1995 (Ledesma *et al*, 1999). Therefore, in collaboration with PRRCFI and as part of the CCC Danjungan Island Biodiversity Survey (Turner *et al*, 2002b), surveys were carried out to determine the distribution and diversity of the bat fauna on Danjungan Island, in order to identify conservation concerns and to make management recommendations.

Aims

1. To complete an inventory of chiropteran species on Danjungan Island.
2. To gather basic distributional and ecological data on each species.
3. To ascertain the local, national and global significance of the island with regards bat conservation.
4. To identify key areas of conservation concern for the bat fauna of the island.
5. To make recommendations for the future management of the island with respect to bat conservation.

Materials and Methods

Study Area

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 (Figure 1), 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. There is however, no permanent standing fresh water on the island. The terrain is rugged and characterised by limestone geology, which has given rise to the formation of several caves around the perimeter of the island. 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 (Figure 2; Table 1). A more detailed description of the Danjungan Island environment is given by Harborne *et al* (1996) and Turner *et al* (2002b).

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 1; Figure 2). 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.

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.

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 individuals, the capture of 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 over three nights from four vantage points around Lagoon 3 (L3). Observers counted 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 (usually 1800-1900hrs). 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.

Results

A total of eight Chiropteran species were recorded on Danjungan Island during this study, five were Megachiropteran and three Microchiropteran (Table 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 melanopogan*, 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 7). Morphological data was recorded for each species (Table 5).

The highest diversity of megachiropteran species was found in the coconut-dominated forest, with 2 species recorded only from this habitat (Table 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 4).

Bats captured exhibited no apparent sexual dimorphism in morphological measurements, but there were differences in sex and age ratios between the species (Tables 5 and 6). While juveniles were not recorded for most species, they accounted for approximately half the *E. spelaea* captured, exhibiting a large range of sizes. Several juvenile *C. brachyotis* were also captured, accounting for roughly one third of all captures, but very few adult males were encountered. Conversely, all but one of the microchiropterans captured were adult males.

Daytime tree-roost searches found the two *Pteropus* species to be roosting singly or in small groups in the mixed-species forest in the northern half of the island, and to a lesser extent the exposed forest on the south-western corner of the island (see Figure 2; Table 1). The majority appeared to be roosting north of 'BB' (Figure 2; Table 2). Daytime searches in the coconut and secondary growth southern region found no bats roosting.

The dispersal survey illustrated that both the larger fruit bats (*Pteropus* spp.) and the smaller species (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 3). Upto 150 individuals were recorded in any single observation period (lasting upto two hours), with all individuals heading in southerly or easterly directions.

Discussion

The four-month survey found a total of eight Chiropteran species. 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. Several are of significant conservation concern, based on levels of endemism and global status. Although taxonomic research was out-with the scope of this study, 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), and such considerations will be included within the following individual species discussions.

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 and 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 frequently captured 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 three 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 and Hill 1992). *Rousettus* is the only known genus of Megachiropteran that has the ability to echolocate 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 and 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 recorded on the island, the Common Island Flying Fox (*Pteropus hypomelanus*), is likely to be of the sub-species *P. hypomelanus cagayanus* (Mickleburgh *et al*, 1992), a sub-species endemic to the Philippines. The island was found to support several tree-roosts of the species, all located in mixed-species forest, while captures were restricted to sites in the coconut-dominated forest. Although captured in low numbers, large numbers were observed dispersing from the island at dusk, and the species appears to be more abundant on the island than the catch-rates suggest, probably due to a tendency to fly high above normal netting reach.

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 roosting in three sea caves, one of which contained large numbers (see Table 7). 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 and 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*.

Considering that the seven priorities for the conservation of global bat fauna given by Mickleburgh *et al* (2002) include focusing efforts on 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*, while the extensive primary and secondary forest provides roosting areas for *Pteropus hypomelanus cagayanus*, and the globally vulnerable *Pteropus pumilus*, both endemic to the Philippines. These roosting sites are utilised not only by individuals that forage on the island itself, but also for large numbers of bats that forage on mainland Negros. Further caves support roosts of *Taphozous melanopogon* (presumably the endemic *philippinensis* sub-species). The two other microchiropteran species recorded on the island are not well known scientifically, and one, *Myotis macrotarsus*, is listed as globally near-threatened. The island has already been designated as the Danjungan Island Marine Reserve and Sanctuaries (DIMRS), and therefore offers protection to a roosting area utilised by large numbers of the local populations of these endemic or endangered species, safe from human interference and 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 conservation of 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 *E. spelaea* population, and also of *C. brachyotis*, *P. hypomelanus* and *T. melanopogon*.
8. Research patterns of dispersal to the mainland of *P. pumilus*, *P. hypomelanus* and *E. spelaea*.
9. Research reproductive biology of all species.
10. Research feeding behaviour of *Myotis macrotarsus*.

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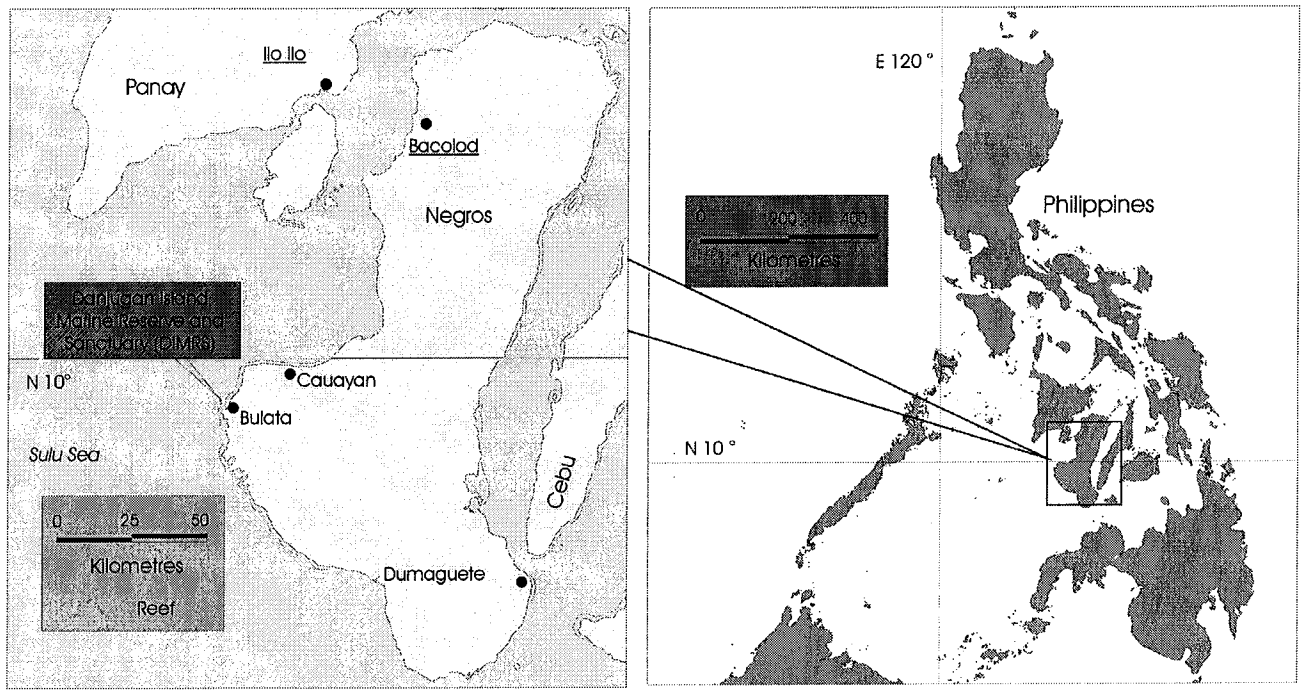


Figure 1.

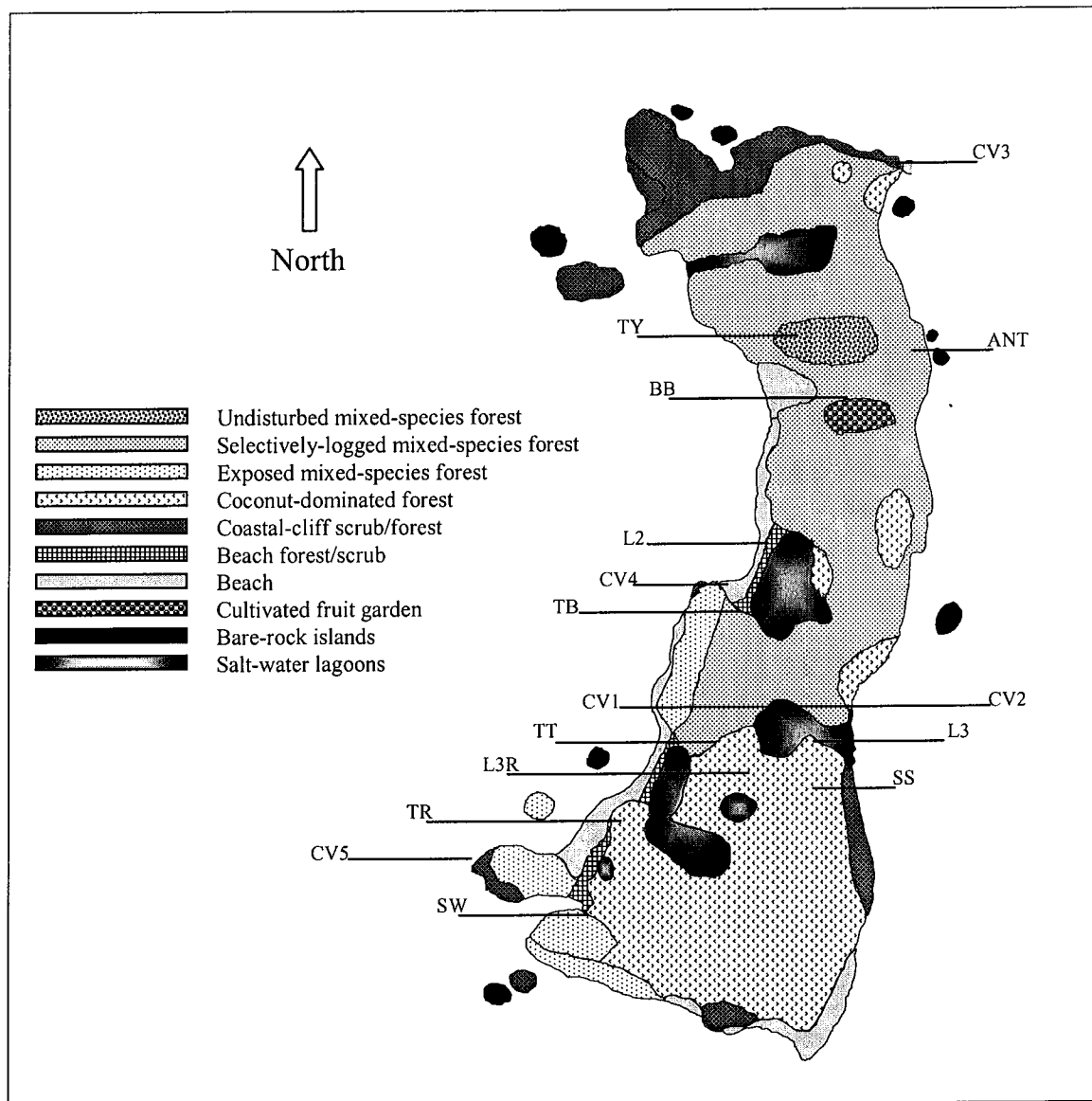


Figure 2.

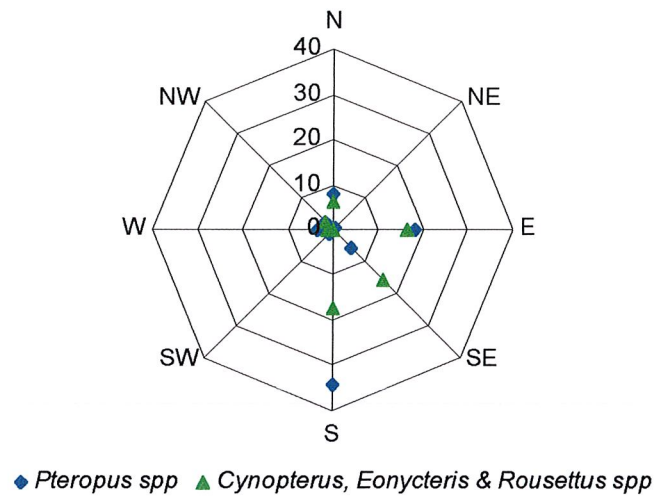


Figure 3.

Figure 1. Location of the Danjugan Island Marine Reserve and Sanctuary, Philippines (Ledesma *et al*, 1999).

Figure 2. Habitat Map of Danjugan Island showing the distribution of major habitat types as described in Table 1 (derived from Turner *et al*, 2002b) with the location of each survey site.

Figure 3. Mean dispersal numbers and direction (over 3 nights) of Megachiropteran species from Danjugan 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>Pandanus</i> spp., and a <i>Mimosoideae</i> sp.
Coconut-dominated forest	Even-aged stands of remnant coconut plantations, with areas of other planted species such as mango, banana and a <i>Mimosoideae</i> sp. 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.

Table 1. The major habitat types of 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).

Table 2. The locations of the bat survey points on Danjungan Island.

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
<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 3. Megachiropteran and Microchiropteran species found during the surveys on Danjungan Island with data on their distribution and status.

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

Species	Adult male				Adult female		Juvenile	
	Forearm (mm)	Mass (g)	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	-

Table 5. Megachiropteran 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	-	-

Table 6. Microchiropteran morphological data

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

Table 7. Summary of caves found to contain bat roosts during the study period (caves found not to contain bats have not been included).