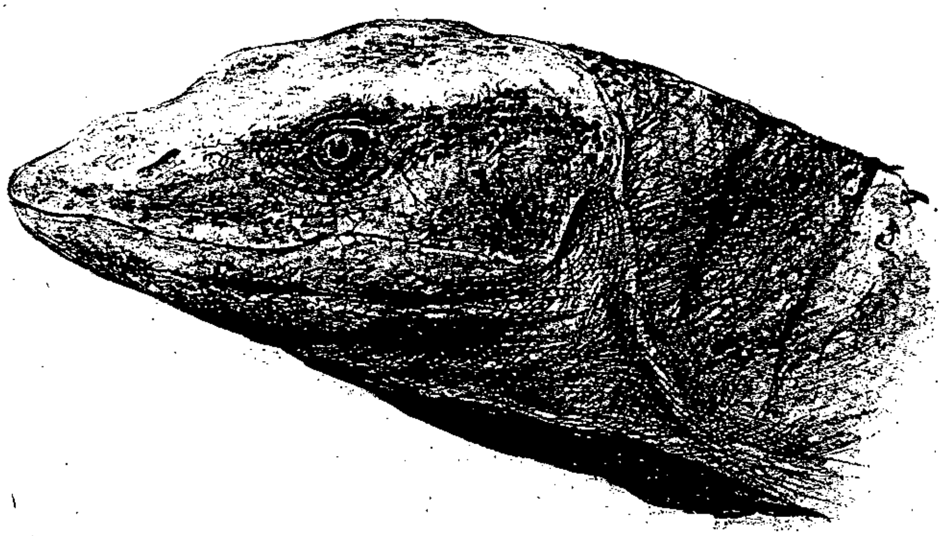
Wildlife of Polillo Island, Philippines.



University of Oxford - University of the Philippines
at Los Banos Polillo '99 Project

Final Report

Wildlife of Polillo Island, Philippines

Oxford University - University of the Philippines at Los Banos

Polillo Project 1999

Final Report

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Cover picture: *Varanus olivaceus* by Katie Hampson

A CIP record for this publication is available from the British Library.

ISBN 0 9526632 5 2

Published by:
VIPER PRESS
118 Sheffield Road
Glossop
SK13 8QU
Great Britain
www.mampam.com

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The Oxford University Exploration Club

Wadham College

The Oxford Society

The Mike Soaper Bursary

The Gilchrist Educational Trust

The Edinburgh Trust

Shell

The Albert Reckitt Trust

The Forest Lodge Garden Centre

Acknowledgements

We would like to express our sincere appreciation to all those whose involvement has been invaluable to the success of this research.

The members of the Polillo '99 project would like to thank Hon. Doris Almeda, Mayoress of the Municipality of Polillo (1998 to present) Province of Quezon, Philippines, Jimmy Passion, the Municipal Council of Polillo, William Azuala, (Division Head Community Environment and Natural resources Office, DENR-Polillo), and all staff at the Polillo Community and Environment and Natural Resources Office (CENRO-DENR), the Municipal Forestry Department (watershed management office) and the Municipal Council of Panukulan. Further thanks to residents and community leaders of Barangay Sibulan and Pinaglubayan, Municipality of Polillo, Municipality of Burdeos and Municipality of Panukulan, Polillo Island.

We are indebted to Vicente Yngente, Remigio Romana, Matthias Bulalacao, Augusto Zafe, Pido Bulalacao, Lito Bulalacao, Dennis Bulalacao, William Bulalacao, Ricky Bulalacao, Eliazer Bulalacao, Christian Zafe, Malou Yngente and family, Marvin and colleagues. Work on Polillo would not have been possible without their support, local expertise and warm hospitality.

We would like to thank J.C.T. Gonzalez, Andre T.L. Dans, Leticia Afuang of UPLB and William Oliver of FFI. We are deeply grateful to them for mediating this research and providing sound advice and encouragement both prior to and during the field period. We are extremely grateful for the opportunity to collaborate with, and for support from, the Polillo Ecology Stewardship Project, which is funded by the North of England Zoological Society (Chester Zoo). Additional funding assistance for this scheme was also kindly provided by FFI, Vogel park Avifauna, Denver Zoological Society, West of England Zoological Society, Royal Melbourne Zoological Gardens and Columbus Zoo. We further wish to acknowledge the British Library of Wildlife Sounds for their support and provision of equipment.

We would all like to further express our thanks to Dr Roger Wilkinson, Chris West and Dr Gordon McGregor-Reid (Chester Zoo), Niel Aldrin D.Mallari (Haribon Foundation), Blaz Hernaez (UPLB), Katharine Gotto and Robin Mitchell (BP Conservation Programme), Roger Sison (The Philippines National Museum), Martin Speight (Oxford University), Pat Wisniewski, Richard Ranft (the British Library of Wildlife Sounds), Sandy Duncan (BP Amoco, Philippines), Michael Riley (the British Embassy, Manila), Liza G.Dans and Juan Cornejo.

Introduction

The South Luzon Faunal region is one of the world's biodiversity hotspots and one of the world's highest priority regions for conservation concern in terms of both numbers of threatened endemic species represented and degrees of threat. High levels of deforestation in the Philippines has put much of the archipelago's fauna at risk. The small island of Polillo has an unusually high amount of endemicity amongst several key vertebrate groups; amphibians, lizards and birds. Polillo harbours several internationally threatened keystone species with highly restricted distributions such as Gray's monitor lizard, the Philippine cockatoo, the Tarictic hornbill, The Giant Golden-crowned flying fox, the Philippine warty pig and the Philippine rusa. Much of the islands fauna is unknown (Phillip Alviolas Bat research this report documented 11 new island records increasing the islands bat species richness by an incredible 48%).

Because of Polillo's conservation importance, a full-time wildlife warden or 'Ecology Steward', Vicente Yngente, the first in the Philippines, was employed in 1997 under the terms of the 'Polillo Island Adoption/ Wardening Scheme' devised by Fauna and Flora International and local wildlife biologists, with sponsorship assistance from the North of England Zoological Society and other international conservation agencies (see below). The level of hunting and deforestation have undoubtedly been reduced and local public awareness of and interest in conservation of the islands wildlife and forests have greatly increased due to his efforts. Further research and implimentation of conservation measures identified in this report are vital, together with continued and increased support for the wildlife wardenship scheme.

Development on Polillo island is recent, but now increasing apace. During the course of our three month study a car ferry was introduced to travel between Polillo and Infanta, Luzon. There is little or no transport infrastructure on the island at present and all the barangays (villages) are therefore situated on the coast apart from Barangay Pinaglubayan close to the watershed. A road from the north to the south of the island is currently being built that will link Polillo town, to Burdeos and Panukulan in the North (the three major towns). There is only one hotel on the island but others are planned. Tourism could have a potentially large impact on island life. The island's economy is based on coconuts, which are adversely affected by the regular occurrence of typhoons and are relatively unprofitable because of the large amount of land needed to produce economically viable amounts of the key export product, copra. All drinking water for the south of the island comes from the Sibulan Watershed Reserve.

Only 200 hectares ($2km^2$) of forest on Polillo Island have formal protection as the Sibulan Watershed Reserve. There are many small and often isolated patches of forest on the island that play an important role in supporting much of the forest wildlife. However these face the imminent threat of encroachment by coconut plantations and caribou logging. Many local residents are unaware of the important wildlife populations on the islands and that many of the animals are found only on Polillo.

A joint team of students from Oxford University and the University of the Philippines at Los Banos conducted fieldwork on Polillo from the 12th of June to the 17th of September

1999, including a five-day study in Baranguay Bati, near Panukulan, North Polillo. Studies were conducted on amphibians, bats, batflies, birds, Lizards, Gray's monitor lizard *Varanus olivaceus,* the water monitor *Varanus salvator marmoratus,* and the stream systems within the Sibulan Watershed Reserve were mapped. The project aimed to facilitate conservation strategies and biological monitoring programmes on the island of Polillo based on

1) Conclusions generated from research focused on threatened and endemic taxa.
2) Provision of equipment for future monitoring and surveying
3) Exchange of techniques among expedition members.

Expedition Members

Katie Hampson Oxford University
Chloe Galley Oxford University
Susan Walker Oxford University
Ben Martynoga Oxford University
Joseph Nicholson Oxford University
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Dennis Bulalacao Polillo Island
William Bulalacao Polillo Island
Remigio Romana Polillo Island
Ricky Bulalacao Polillo Island
Ely Bulalacao Polillo Island
Toto Zafe Polillo Island

ITINERARY

29/6/99 Arrive Manila, extend visas, visit museum, buy supplies, acclimatisation
3/7/99 Meet UPLB counterparts, visit museum and libraries, buy equipment
11/7/99 Arrive on Polillo, meet municipality officials,
13/7/99 Start fieldwork
7/9/99 Depart for Panukulan, North Polillo. Meet mayor of Panukulan and arrange trip to Baranguay Bati.
8/9/99 Depart for Bati, set up camp.
9/9/99 Start field work in Bati
13/9/99 Return to base camp
17/9/99 Depart from Polillo, arrive Los Banos
18/9/99 Complete fieldwork on Mt Maquiling, finish logistical work in Los Banos
19/9/99 Depart Los Banos, meet embassy officials
20/9/99 Depart from Manila

Contents

Preliminary survey and status report for

Varanus olivaceus *on Polillo Island*

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Abstract

A study conducted from July-September 1999 revealed that Gray's monitor lizard, *Varanus olivaceus*, occurs in forested patches on Polillo Island, and may still be common where suitable habitat exists. Eight individuals were captured in a 2.6km^2 area of forest/agricultural mosiac around Sibulan Watershed Reserve. It was demonstrated that there are alternative capture methods to hunting with dogs that reduce the risk of injury to the animals. The population on Polillo is not taxonomically distinct from the Luzon race. *Gnetum*, *Pandanus*, *Canarium*, *Caryota*, *Malasia Livingstona* and *Pinanga* fruits were found in feces, along with small amounts of crustaceans and molluscs. Spool and line tracking indicated that V.*olivaceus* uses trees with a relatively large circumference and spend most of their time in trees on slopes, usually near the top of hills. Activity levels were low compared to other large *Varanus* species and suggested small activity areas, however there was evidence that the animals' behaviour was influenced by capture and handling. *V.olivaceus* is restricted to forest habitats and although food resources are unlikely to be an important limiting factor on population size, the scarcity of remaining forested fragments and the rarity of suitable shelter trees within them contribute to the overall rarity of the animal. The most important local competitor of the lizard is probably the civet cat *Paradoxurus*. The water monitor lizard *Varanus salvator marmoratus* is still common and widespread in most habitats on Polillo, feeding mainly on beetles, crabs and frogs. Future research priorities should include a survey of remaining forest cover on Polillo and attempts to determine age structure of remaining populations of *V.olivaceus* and absolute density of lizards in different forest patches.

Background

Varanus olivaceus is one of the largest lizards in the world and the only member of the Varanidae that is frugivorous as well as carnivorous. First described in 1845, it was thought extinct until 1976 when it was rediscovered on Luzon Island (Auffenberg 1978). The ensuing 22 month project, based in the Caramoan Peninsular, represent the only previous study of the lizard (Auffenberg 1988). Unfortunately the methods used involved sacrificing 110 of 126 study animals and, given the rarity and completely protected status of the lizard, similar investigations of the animal elsewhere have not been performed. The need to develop acceptable methodology for the study of this lizard was therefore considered the most urgent of its conservation priorities.

Auffenberg established the distribution of *V. olivaceus* as southeastern Luzon and Catanduanes Island, stated that the animal probably occurred in more northern parts of Luzon and that "at present there is no evidence that (*V.olivaceus*) occurs on any of the Polillo Island group. Edward Taylor collected there many years ago but failed to get any information or specimens. Furthermore, almost all the forests have been cut for a long time" (1998, page 127). In 1997 the Philippine Red Data Book included Polillo Island in the list of localities for *V.olivaceus*, citing an unpublished list of reptiles and amphibians known from Polillo (Crombie 1994). The only monitor lizard given in that list is *V. salvator marmoratus*. There are no known specimens of *V.olivaceus* from Polillo in museum collections and, prior to this study, no information on the animal's status and ecology on the island.

Aims

The aims of this study were to establish the presence and distribution of *V.olivaceus* in and around Sibulan Watershed Reserve, collect baseline data on the ecology of the lizard (specifically diet, patterns of tree use and activity area), characterise its habitat and investigate alternative methodologies for its capture and study.

Study site

The study site included a small protected forest of about 180ha (Sibulan Watershed reserve) and the surrounding coconut/forest mosiac, covering a total of about $3km^2$ (Figure 1). Elevation was 50-100m above sea level. Work was conducted from 14 July until 16 September 1999.

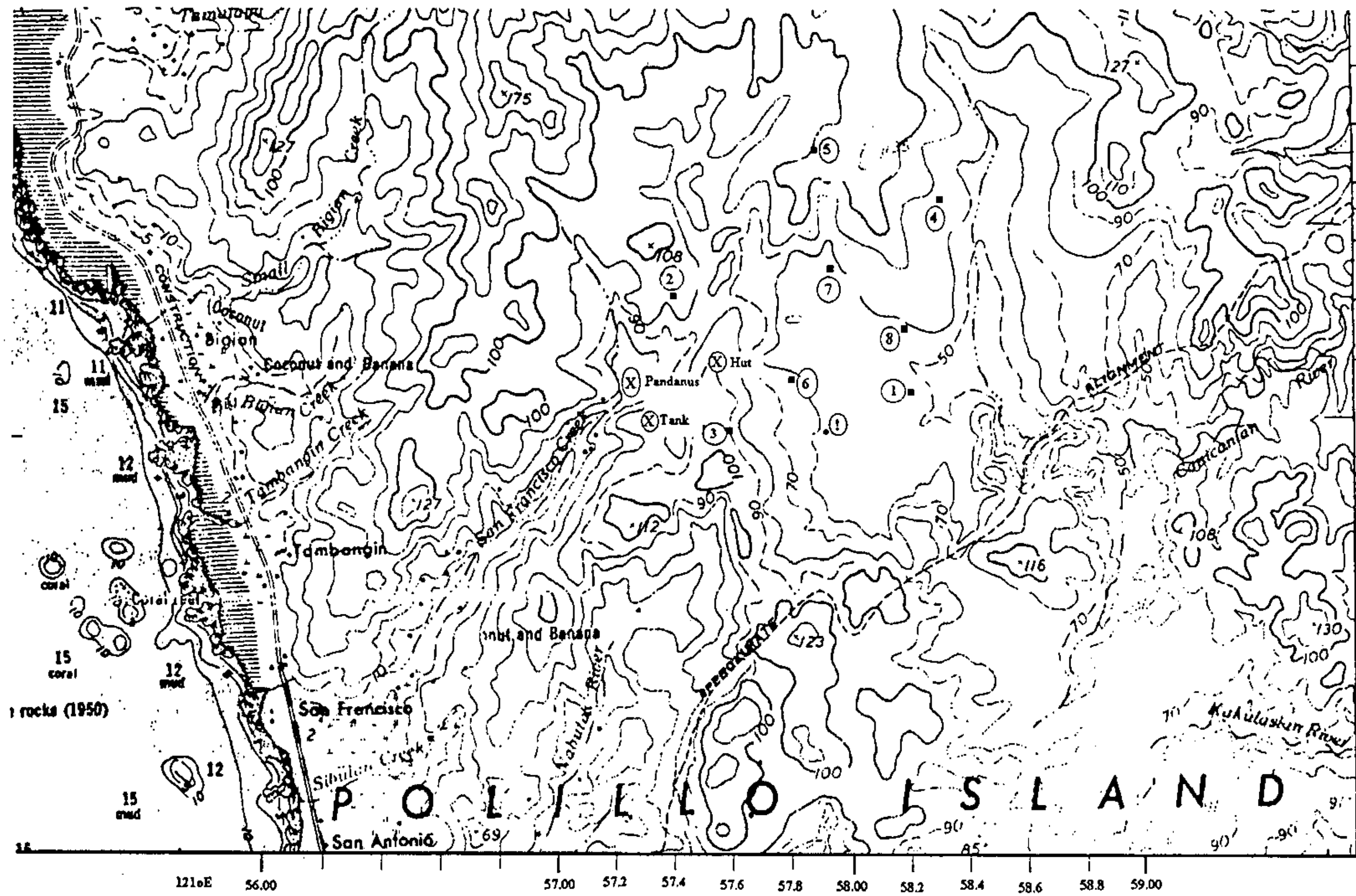

Figure 1. Map of study area showing locations of captures of *Varanus olivaceus* (1-8), Sighting of *V.olivaceus* (!) and other PCQM sites (X). Locations determined by G.P.S.

Methods

Lizards were caught by searching with dogs and with noose traps. Hunting groups consisting of one or two people and up to three dogs. Dogs used were a 5/6 year old pair and a 3 year old male. Forested areas were searched at random. 105 locally made trigger traps were set at two sites, placed along trails and paths on slopes and crests of hills. These traps were unbaited and designed to catch animals by limbs rather than by the neck. They were checked at least three times daily (near dawn, dusk and midday). An adaptation of the same trap was set on the trunk of a tree known to contain a *V.olivaceus* and checked every three hours during daylight.

Animals caught were transported to base camp, where the following characteristics were recorded: snout vent length (SVL), weight, sex, tail length, circumference of head, belly and tail base, recent and old injuries, presence of ectoparasites (removed and being studied by Henry P. Roy Jr, UPLB), colouration, shedding pattern, number of scales at midbody, number of scales from gular fold to insertion of hind limb and number of scales under 4th toe. Details of head scalation were recorded photographically with dorsal and lateral views.

Animals were fitted with spool and line devices consisting of 2-6 polyester thread cocoon bobbins (Danfords Ltd, Leigh, England) each approx 5g and measuring 39 X 15mm, either glued directly to the side of the tail with superglue (3M superglue gel, St Paul, MN, USA) or wrapped in plastic and secured with duct tape. Spools were positioned beyond the maximum reach of the hindlimbs when the animal was held straight. Lizards were released the same day or early the next morning at the exact point of capture. Subsequently thread trails were examined at intervals of 1-3 days. Distance, direction, slope and microhabitats were recorded along the ground, thread in trees was observed through binoculars and collected to give estimates of height climbed and arboreal movement. Distance traveled when released and subsequent movement between trees were calculated, along with a measurement of total activity area, calculated by the least polygon method (MacDonald *et al.* 1980)). The circumference at breast height (CBH) of all trees climbed by lizards was measured to the nearest cm, along with species, approximate height, position in the canopy and absence or presence of vine thickets on trunk or branches.

The diet of *V.olivaceus* was investigated by collecting feces from known individuals during capture or subsequent tracking and from feces of unknown individuals collected on the forest floor. The latter samples were positively identified as *V.olivaceus* on the basis of their distinctive smell and/or the presence of fragments of shed skin. Items recovered from feces were identified to species (for fruits) or order (for animals). Each item was weighed and measured (length, maximum width and volume) and assigned original weights calculated from reference collections made in the vicinity, or from data provided in Auffenberg (1988). Available food resources were inventoried by collecting samples of fruit and seed types found in the forest for subsequent identification at UPLB. Fruits collected were weighed and measured (length and maximum width) and (for some species) volume calculated. Where possible relative measurements of flesh and seed were taken and attempts made to relate fruit size to seed size or degree of ripeness.

To provide a quantitative description of the habitats used by *V.olivaceus*, density, basal area and relative species abundance of trees were estimated at all sites using the Plotless Center Quarter Method. Distance from origin to the nearest tree (or tree stump) with CBH>31cm in the four quadrats of a cartesian grid were recorded together with species, position in the canopy and CBH. Transects were at least 100m long and sampled every 5m. Replicate samples were recorded as such and the distance to next nearest tree measured. Trees were initially identified by local names and subsequently by identification of voucher specimens at Dept. of Plant Science, University of the Philippines, Los Banos (UPLB).

Details of climate (rainfall, maximum and minimum shaded and unshaded temperatures) were recorded from a hill next to base camp at 0900 each morning.

Results

Capture and effort

Around Sibulan Watershed Reserve 22 hunting excursions totaling 119 search hours caught a total of six *V.olivaceus* and 11 *V.salvator*. Two additional *V. olivaceus* were seen but not caught, Numbers of *V.salvator* seen were not recorded. Lizards were only caught on days with sunshine, but there is no relationship between success of searches and climatic variables recorded for that day or the previous day. Only once were two *V.olivaceus* captured on the same day. At Bato 17 search hours resulted in neither captures nor sightings. At Sibulan 105 ground traps were set for 39 days (total effort = 4095 trap days) and caught one *V.olivaceus* (plus nine *V.salvator*, one pigeon and three civet cats (*Paradoxurus philippinensis*). No animals were caught after the 17th day and 88% of traps were still primed at the end of the experiment. A tree trunk trap set on a tree known to contain a *V.olivaceus* caught the animal after 68 hours. Position of capture and trapping sites is given in Figure 1.

Morphometrics

Eight *V. olivaceus* caught had a mean SVL of 554mm (+/-14.2) and a mean mass of 4368g (+/-313.0). Summary of measurements is given in Table 1. Overall sex ratio was 3:1 in favour of males. All animals were in good physical condition; relationship between weight and SVL is given in Figure 2. Seven animals were shedding skin on the limbs and tail and one appeared freshly shed.

Ectoparasites and Injuries.

V.olivaceus had an average of 3 ticks per individual, located mainly around the vent (58%) and between the digits (33%). A report on ectoparasites will be prepared separately (Henry P. Roy, UPLB). Scars were rare on *V.olivaceus* compared with *V.salvator*. Almost all visible scars were on the proximal third of the dorsum. Only the two largest males had broken tail tips.

Diet

Fecal samples were obtained from six of the animals caught and six fecal samples found on the forest floor were identified as being from *V.olivaceus*. Feces contained fruits of nine species belonging to five families, plus fragments of crab and snail shells. Because of their small size and fragmented state, animal prey were excluded from diet analyses. Feces of one individual contained 200-300 tiny (total mass < 2g) *Malasia* seeds. They were treated a single seed in analyses, and flesh weight was not estimated. Mean number of items per sample was 11.2, mean number of species per sample was 1.8. Mean weight of seeds per sample was 35.4g, representing an estimated 22.6g of fruit flesh. Diet according to number of prey items is depicted in Figure 3. Summary of fruit characteristics is given in Table 2. *Pandanus* and *Canarium* fruits were most frequent in samples, followed by species of Palmae and *Gnetum*. By flesh weight *Gnetum* was the most important food (209g), followed by *C. hirsutum* (87g), *Pandanus botryoides* (22g), *Caryota* (8g), *P. exaltus* and *C. luzonicum* (6g each), *Livingstona* (2g) and *Pinanga* (1g).

Movement

Spool and line devices were fixed to seven animals, six of which subsequently yielded data (Table 3). On release animals moved a mean of 63m before climbing a tree and remained in that tree from 2-5 days. Subsequently movement between trees occurred every 1-3 days. Average slope of hillsides covered was 38%. Most movement (over 80% of total) occurred around the top of hills. Lizards moved a mean of 111m on the ground and a mean minimum of 110m in trees during tracking periods of 3-8 days. Mean distance between trees climbed was 34m. There was a positive relationship between both distance moved after release and total activity area with body mass (Figure 5) but the data set is too small to permit further analysis.

Habitat Characteristics

PCQM transects from 13 sites yielded a total of 1100 data points, summarised in Table 3. There were no significant differences in tree spacing and circumference at sites with or "without" *V. olivaceus*. Nor was there any apparent relationship between any of the variables recorded. Dominant tree family overall was Dipterocarpaceae, commonest species was *Shorea negrosensis*.

Fifteen trees known to have been used by *V.olivaceus* during the study period had a mean CBH of 132cm (+/- 57, range 74-252 and a mean height of 24m (+/- 8, range 8-40). 20% of trees used were dead standing trunks or stumps with visible hollows. 90% of living trees used were emergents of 20-40m height. 50% of the trees used had vine thickets. Six species were used, but 64% of trees were *Shorea* ("luaan") or *Trichadenia* ("amlang") There was a significant difference ($P<0.01$, $t = 2.459$, $df = 37$) between the circumferences of trees used by lizards and those of trees measured for PCQM analysis.

	Mean	SD	Range
Tail length	834	207	516-1160
Tail circumference	183	57	96-246
Body circumference	334	97	195-470
Head length	334	21	66-124
Maximum head width	52	13	31-71
Midbody scale rows	191	3	187-196
Lateral scale rows	113	4	107-119
Scales under toe 4	34	2	32-38

Table 1. Measurements (in mm) and scale counts of *Varanus olivaceus* on Polillo.

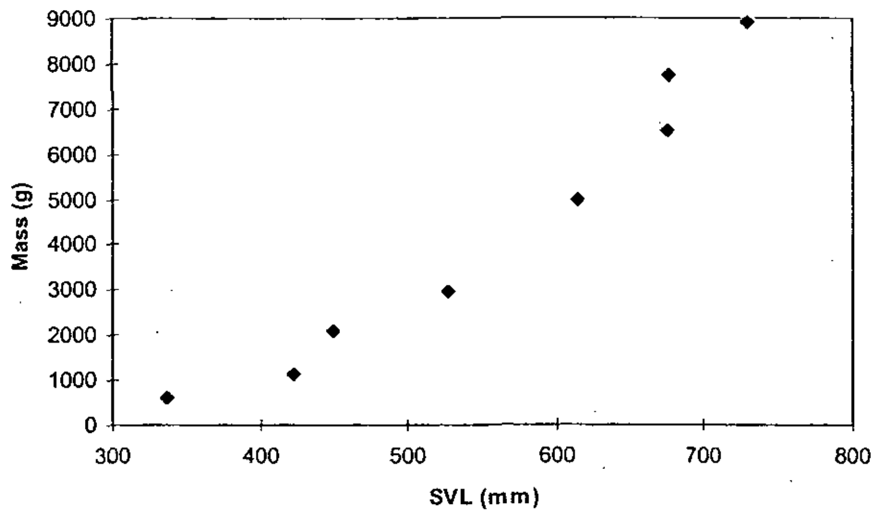

Figure 2. Relationship between snout vent length and mass in *Varanus olivaceus*.

	Total no. items	Frequency	Mean individual seed mass (g)	Estimated individual flesh mass (g)
Canarium hirsutum	51	3	3.8	2.2*
Canarium luzonicum	1	1	8	5.9
Caryota rhumphiana	4	2	4	2.1
Gnetum latifolium	44	2	4.5	4.6
Livistonia rotundifolia	1	1	2.7	2.2
Pandanus exultatus	19	4	7.4	1.2*
Pandanus botryoides	7	1	4.7	0.9*
Pinanga insignis	2	1	2	0.4

Table 2. Characteristics of fruit in feces of *Varanus olivaceus*. * = Estimate from Auffenberg (1988)

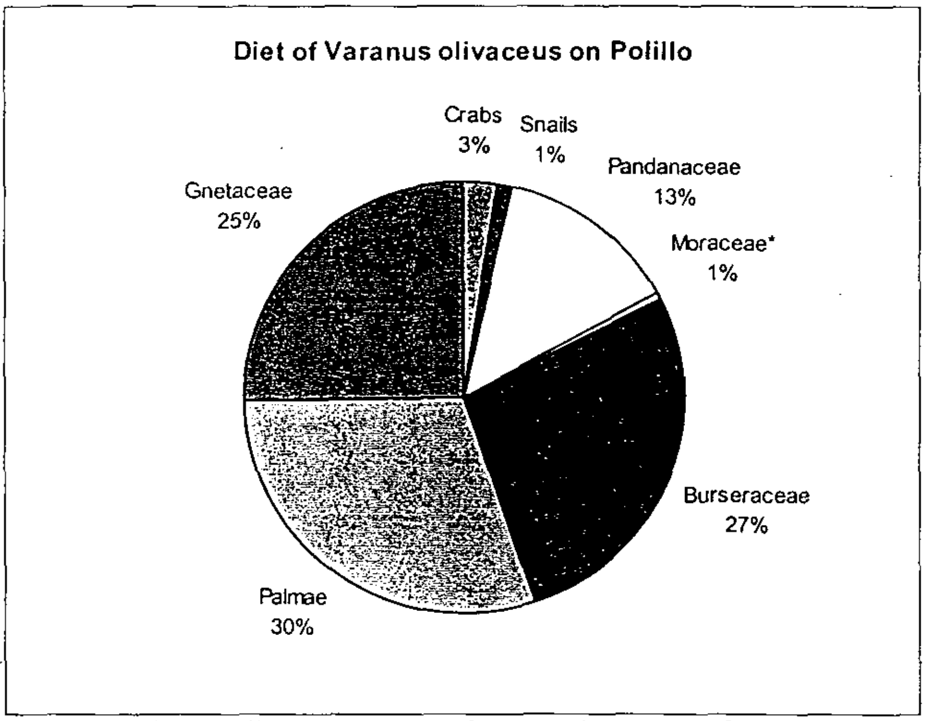

Figure 3. Composition of diet of *Varanus olivaceus* by overall frequency occurrence.

ID	Sex	SVL (mm)	Mass (g)	D_R (m)	D_G (m)	Min D_T (m)	Total activity area (ha)	Mean distance between trees (m)
4	M	730	8900	205	73	195	0.8	24
1	M	675	6500	40	111	28	0.5	N/A
8	M	614	5000	70	219	190	0.8	44
6	M	527	2950	28	43	28	N/A	N/A
3	F	422	1130	4	111	31	0.3	N/A
7	M	337	630	29	106	185	0.1	34

Table 3. Movement of *Varanus olivaceus* from spool and line tracking. D_R = Distance traveled from release point to shelter tree. D_G = Distance covered on ground. Min D_T = Minimum distance moved in trees.

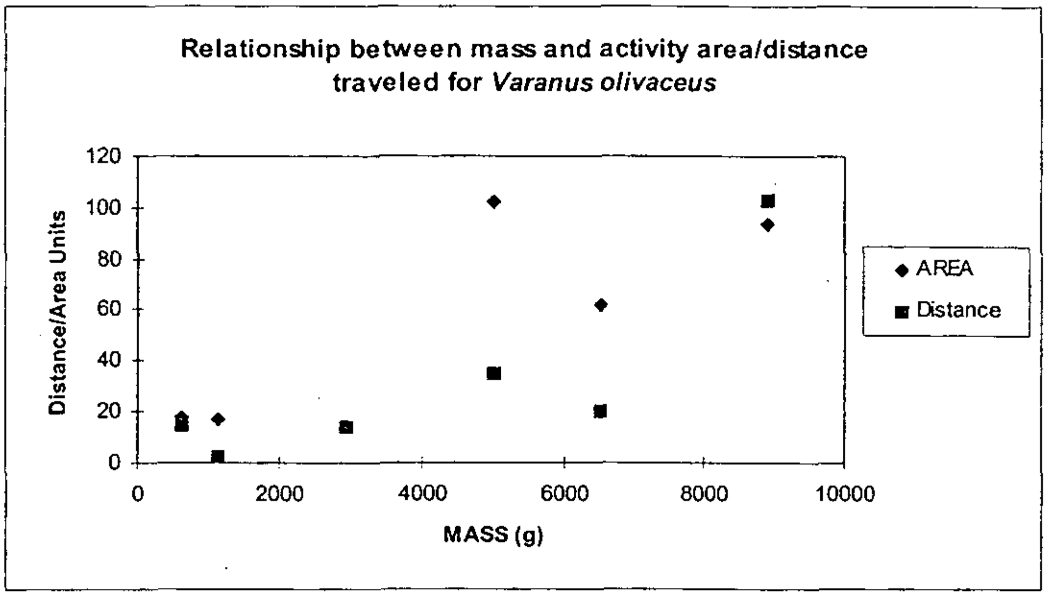

Figure 5. One Distance/Area Unit = 2m/80m^2.

Site	Mean distance (m)	SD	Mean girth (cm)	% Stumps	% Emergents	%Dipterocarps	N
A*	3.21	1.94	72	15	23	28	120
E	3.02	1.97	85	2	7	16	100
H	5.05	3.23	71	1.3	9	1	80
K	2.75	1.55	87	11.3	15	-	80
M	3.28	1.81	69	8.8	-	-	80
O*	3.55	2.55	95	11.3	14	30	80
Q*	3.44	2.69	67	2.5	19	36	80
T*	3.64	2.8	52	3.8	9	0	80
V*	3.01	1.89	76	16.3	23	36	80
W*	2.83	2.01	57	8.8	5	8	80
X*	2.98	1.78	71	8.8	14	18	80
Y*	3.2	2.09	63	1.3	19	28	80
Z	2.78	1.86	62	5	16	6	80

Table 3. Characteristics of tree communities in Sibulan Watershed Reserve Area determined by the point center quarter method. * = *V.olivaceus sites*. For all *V.olivaceus* sites mean distance between trees = 3.23m.

Discussion

The only studies of *Varanus olivaceus* since the publication of Auffenberg's monograph eleven years ago have been concerned with captive breeding (Card 1994, 1995). The lack of follow up field work may be due, in part, to the difficulties of locating animals and the lack of any established and acceptable methodology for investigating its ecology. Despite its large size, *V. olivaceus* is a very shy animal (described as "ashamed" by hunters on Luzon), that spends most of its time in trees. Its cryptic colouration and use of arboreal vine thickets compounds the difficulties of finding them. Auffenberg (1988) considered that *V.olivaceus* could not be caught in traps and relied on teams of local hunters with dogs to catch specimens. Of 126 lizards caught during his study, 61 were injured by dogs (page 262-263). Whilst *V.salvator* recovered from dog bites, infections were the cause of death of all such wounded *V.olivaceus* (p.150). All known injuries caused to animals in this study were inflicted by one dog, three years old and with a full set of teeth. The risk of injury can be reduced by using only older dogs that have incomplete dentition. The use of muzzles was considered, but rejected on the grounds that the dogs would take too long to become accustomed to them. Future studies should consider training dogs to work with muzzles, or not use them at all. Trapping lizards on the ground requires high effort and inevitably results in the capture of many unwanted species. Where trees used by the lizards can be identified, tree trunk traps may yield a higher capture rate and exclude other species. There was insufficient time to test the tree trunk traps adequately, but preliminary results suggest it could be a very useful method for quantitative surveys. Traps baited with ripe fruit set in suitable locations (i.e. among high circumference trees on slopes) have not been tested but trials are warranted. Trapping will remove some of the sampling bias towards the larger animals in the population that previous studies may suffered from (see below) and provide a quantitative measurement of abundance from which sites can be compared.

Although the density estimate for *V.olivaceus* on Polillo is much lower than Auffenberg's estimate for Caramoan (0.61 individuals (1.9 kg biomass) per hectare in prime Caramoan habitat vs. 0.03 individuals per hectare (0.13 kg biomass) in Pollilo forests), yields per unit effort are similar, based on Auffenberg's (1988) statement that a team searching for five hours a day would expect to catch a animal every one or two days (equivalent to at least 0.5 lizards per unit effort). The short time span of the current project and that facts that only one hunting team was used and searches were carried out under almost all weather conditions, often for two or three consecutive days, may contribute to the underestimate of population size. Because of the small amount of suitable habitat available around Sibulan, overall density is likely to be comparatively low. At present nothing is known of the age structure of any population of *V.olivaceus*. Auffenberg (1988) was unable to determine the age of individuals and in any case caught very few juvenile animals. The smallest specimens described by hunters on Polillo were considerably larger than hatchlings, indicating that the youngest age class is not exploited by people. Larger animals are presumably more likely to be caught by dogs and the younger age classes are therefore underrepresented in the sample. Until the number of younger animals in the population can be estimated the conservation status of *V.olivaceus* on Polillo remains unknown. Potential methods of catching juvenile *V.olivaceus* include pitfall traps set along forested ridges and insect-baited traps set in trees (Bennett 1999).

The most important food item of *V.olivaceus* during the study period was *Gnetum latifolium*, representing 35% of total seed mass and 61% of flesh mass. Gymnosperms have not been recorded previously in the diet of *V.olivaceus*, although Auffenberg stated that *Gnetum gnemon* was common in Caramoan. This species is also present on Polillo, but no fruits were observed during the study period. The other genus not previously recorded in the diet was *Pinanga*. It is not listed by Auffenberg (1988) and may not occur in Caramoan. Two species of *Pandanus* (*P.exaltus* and *P.botryoides*) also represent new records. It seems likely that all *Pandanus* species are eaten by *V.olivaceus*, including the 35g fruit of *P.luzonensis*.

Auffenberg (1988) stated that most (perhaps all) of the fruit eaten by *V.olivaceus* were taken from the ground, in a perfectly ripe state. In the present study there was no evidence that any foods had been taken from trees, but was noted that *Pandanus* syncarps often remain intact throughout ripening and fruit decay without falling to the ground. Scratches that probably represent claw marks are present on some *Pandanus* trunks. Auffenberg (1988) reported that *V.olivaceus* tears limbs from crabs that are too large to swallow, and the fragments found suggest that they do the same on Polillo. Snails are probably rarer on the clay soils of Polillo than in the limestone areas investigated by Auffenberg, and were infrequent in fecal samples. However local hunters report that snail shell was commonly found in the animals' guts.

Being able to find and identify feces is a prerequisite of conducting studies on the feeding habits of individuals over any time scale. However feces of *V.olivaceus* could easily be confused with those of the civet cat. There is high overlap in prey items (*Pinanga*, *Caryota* and crabs) and the animals move along at least some of the same trails. Although most fresh *Varanus* feces are easily recognisable by their smell, some samples produced by captive *V.olivaceus* lacked the distinctive smell. In fact these feces smell quite "sweet". The feces of the civet cat may have a sharper smell when fresh but the difference between them was not sufficient to allow them to be distinguished with certainty. For this reason many feces thought to be from *V.olivaceus* were omitted from analyses, and samples from unknown individuals used only when positive identification was made based on strong, unmistakable smell or (once) on the presence of fragments of shed *V.olivaceus* skin. Despite these precautions information about diet from feces must be treated with some reservation. Some taxa (notably amphibians and molluscs without shell) are difficult to detect in feces and small fragments are easily overlooked on the forest floor. Therefore the numbers and quantity of animal prey found in samples may be artificially low.

Auffenberg (1988) described the diet of *V.olivaceus* on Luzon and Catenduanes from a sample of 116 gut contents and 102 fecal pellets, the latter representing four samples taken in the field, the rest taken from the end of the large intestine of dissected individuals. The porous limestone substrate probably made feces difficult to find. In contrast feces of *V.olivaceus* can be found quite easily around Sibulan, especially around suitably sized trees near the top of hills. Further investigations are needed to provide ways of identifying potential samples with certainty.

Some of the food species of *V.olivaceus* occur both in forest and in the surrounding agricultural areas, particularly *Pinanga*, *Livistona*, *Canarium* and *Pandanus* spp. No data is available on fruiting patterns in Polillo, but they appear to differ from those in Camaroan. For example, from mid July no *Pandanus* were eaten by Auffenberg's sample, whilst on Polillo *Pandanus* were fruiting at least until the end of September. PCQM analyses does not give an accurate picture of the abundance of fruit sources for *V.olivaceus* because many (particularly *Pandanus* spp. and *Gnetum*) are less than 31cm CBH. Nevertheless casual observations suggest that *Pinanga* is by far the most abundant of the lizards' food trees and was the most abundant fruit on the forest floor during the study period, although it was rare in the diet. The low amount of flesh per seed may make it an uneconomical food source in many situations. *C.hirsutum* fruits were not found during the study, although the seeds were common in feces. *Caryota rhumphiana* was recorded in the diet of *V.olivaceus* by Auffenberg (1988) together with *C.cumingii* but there are some discrepancies in his report. In table 9.1 *C. cumingii* is reported in 8 samples and *C. Rhumphiana* (sic) in 1. In Table 12.2 *C. rhumphiana* is noted as a food item but *C.cumingii* is not. Page 224 states that *C.rhumphiana* is rarely eaten, but on page 374 *C.rhumphiana* is listed as "an important food of *V.olivaceus*" and *C. cumingii* as "not eaten by *V. olivaceus*, perhaps because of the stinging calcium oxylate crystals in the pericarp". *C.cumingii* was not encountered on Polillo. It was apparent when handling unripe fruits of *C.rhumphiana* that the flesh of this species is also an irritant to the skin. *Canarium. hirsutum* fruits were not found during the study, although seeds were present in feces and a number of trees were examined. Table 9.8 in Auffenberg (1988) gives the mean mass of *C.hirsutum* fruits as 7.1g, of flesh 1.1g and of seed 27.2g. The latter figure is presumably a misprint (likewise *C.vrieseanum* in the same table). Contrary to Auffenberg's (1988) statement that even the largest individuals of *V.olivaceus* are easily manipulated by one person, the larger animals caught on Polillo presented individual handlers with some difficulties. Most could only be easily manipulated when the limbs were tied and the mouth taped. Auffenberg also stated that bites from *V.olivaceus* were "painful and frustrating". Our observations suggest that a bite from a large specimen would cause extensive bone crushing.

Casual observations suggest that *V.olivaceus* has access to abundant fruit foods throughout the forest and in many cultivated areas between at least June and September. Fruiting patterns on Polillo may vary from those reported from the mainland, with many species (notably *Canarium* spp.) apparently fruiting throughout the year. A more important factor in their distribution is the location of suitably sized trees for shelter, which are relatively rare in the Polillo forests. Lack of disturbance from people may also be an important factor in determining preferred butaan areas.

The Polillo population of *V. olivaceus* occupies an isolated position which suggests some degree of taxonomic distinction. However scale counts did not differ from those reported by Auffenberg (1988) for Luzon and Catenduanes specimens, nor were there differences in head scalation. Genetic analysis of the populations should remain a high priority because, under current conditions at least, gene flow from the mainland is highly unlikely. Gene flow probably still occurs between populations on Polillo, through corridors of cultivated or semi cultivated land. Data on movement of *V.olivaceus* on Polillo suggest a low level of activity and small home ranges. Lizards moved greatest distances between release and climbing a shelter tree, thereafter movements between trees were much shorter.The best data on activity area comes from lizard 7, which was first seen on 24 July and was still within 25m of its original position on 4 September, a week after capture and release. The small activity area is in accordance with Auffenberg's (1988) findings from long term telemetry studies. The home range sizes suggested by spool and line data are smaller than those given by

Auffenberg, but not particularly so given the short sampling periods. Both studies indicate very small activity areas that increase with the body mass of the individual.

When released, individuals made essentially linear movements to shelter trees. Distance traveled was usually greater than subsequent movement between trees and larger animals moved further than smaller ones. This suggests that the animals made directly for known shelters along established routes, rejecting the nearest known shelter in favour of a more distant one. Routes often included large areas of ferns, which concealed very obvious pathways probably used by many species of animal. In most cases it was evident that lizards had made substantial movements in trees, and arboreal movement may have exceed terrestrial movement in some cases. Arboreal movement is not connected with foraging, because none of the tree species climbed are food sources. It may represent thermoregulatory shuttling between branches and vegetation thickets.

The primary advantage of spool and line tracking over more sophisticated methods of investigating activity is that it provides a very detailed picture of movement that can give valuable insights into foraging behaviour and particular behavioural events and can give very precise measures of activity areas. Its use here also represents an attempt to find affordable methods of monitoring movement that would permit long term, locally funded studies. The principle disadvantage of the method is that only a small amount of thread can be attached to the lizards. In this study the problem was aggravated by the premature detachment of the devices, which probably represent successful attempts by the animals to pull the spools off. Examination of devices that had become detached revealed a large amount of scuffing on tape from the underneath and sides of the tail, suggesting that the tail is used as a friction brake when descending from trees. Possibly the tape reduces the lizards' ability to control descent. In this case it would be reasonable to suppose that the devices affected behaviour. The problem could perhaps be reduced by placing smaller devices on the flanks, just proximal to the hind legs. The devices were relatively light and were originally considered unlikely to affect behaviour unduly. However it was not possible to create a control to test for possible altered behaviour due to capture or attachment of spool and line devices. In this study not a single act of foraging can be recognised from a total of over 1km of thread left along the ground. Threads sometimes passed close to and underneath fruiting trees, but were never observed to pass through actual fruit falls. Some indications of foraging behaviour were found (e.g. digging under fallen logs and rooting in leaf litter around trees) but the data are too few to draw any conclusions. There is therefore no evidence that any animals fed whilst fitted with spool and line devices and the possibility that the devices affected the animals' behaviour cannot be discounted.

Auffenberg's study of *V.olivaceus* took place in primary dipterocarp forest on limestone slopes. On Polillo the forest is almost entirely secondary, the trees are smaller (mean 72cm CBH) and more widely spaced (mean 3.3m vs 2.5m). The most important difference between the habitats is that the crevices and rock outcrops used by *V.olivaceus* in limestone areas are entirely absent around Sibulan. As a result activity is centered only around trees. Dipterocarp forests tend to have thin, crowded trees with small high crowns and are highly speciose, comprised of 500-2500 tree species, very few of which are widely distributed. The Polillo forest is Lowland Dipterocarp, according to Whitford's (1906) classification. Communities are largely

Shorea dominated, characteristic of igneous landscapes. Few of the common trees species in the *Vitex-Ficus* communities of Auffenberg's limestone study sites occur in the Sibulan forest and the communities are more similar to the Hill Dipterocarp forests dominated by *Shorea* and *Hopea*. Like Auffenberg's area, the forest around Sibulan contains many fruit bearing trees and many vines and shrubs, although there are few bamboos. The most common sentinel trees tend to be *Shorea* or *Trichadenia*, although the latter is relatively rare. Sentinel trees close to the top of hills are often used for basking (and sometimes sleeping) by *V.olivaceus* around Sibulan.

Local people with experience of catching *V.olivaceus* state that females are gravid between April and June and that the animals are very rarely found at the wettest time of the year from October to February. Eggs are said to be laid in tree hollows but no sites were found and the nesting behaviour of *Varanus olivaceus* remains a complete mystery. Some people stated that *V.olivaceus* makes a loud call at night. The sound was recorded (lodged at the British Library of Wildlife Sounds) and traced to a large *Shorea* tree with vine thickets and a hole in the main trunk. Once two calls were heard from trees within 50m of each other. No animals were observed however and the call remains unidentified. It may be a heron or owl (Ranft, pers. comm.).No species of *Varanus* is known to vocalise although there are unconfirmed reports of female *V.dumerilii* vocalising in captivity (Edwards, pers. comm.).

V.olivaceus probably still occurs through most of the other forested remnants on Polillo, though probably at lower densities than in the Sibulan Watershed Reserve area, which was considered a prime site for the lizards by hunters at least until the early 1990s. After a typhoon in 1996 which blew the leaves off the trees eight specimens were sighted in the area in a single day (Yngente pers. comm.). A Polillo Ecology Stewardship Project Status report (1998) listed 15 other locations in the south of Polillo where *V.olivaceus* has been reported. There are no reports of *V.olivaceus* in the limestone areas close to Burdeos, although it is known from clay soils there. At Burdeos a local doctor reported that earlier in 1999 a man had died after falling from a coconut tree in pursuit of a "butaan" (Yngente pers. comm.). There are no definite reports of *V.olivaceus* on the neighbouring island of Patnanugan, but the island is said to still contain tracts of secondary forest and the human population is largely restricted to the coast. Other islands in the group are too small to support viable populations of *V. olivaceus*.

There are no specimens of *V.olivaceus* from Polillo in museum collections. A search of the reptile collection at the Philippine National Museum found three specimens of *V.olivaceus*, two from Catenduanes collected by P.Ross and P.Gonzales, the other (skin only) collected from UP land grant site, Real, Quezon by A.Castro and R.Magana on 2 June 1974. This date is significant because it predates Auffenberg's rediscovery of the species in 1976. The specimen is not catalogued, but is probably the same animal listed by Auffenberg (1988: p 131) as PN 891.

Demand for reptiles from Polillo in the recent past has been for the pet trade (primarily *Hydrosaurus*) and for museum collections (all species). Unidentified groups from Germany and Japan have visited the island in recent years and expressed interest in catching *V.olivaceus*, but as far as is known they were unsuccessful (Yngente pers. comm.). In the past *V.olivaceus* has been hunted on Polillo, apparently for local consumption only. Interest in the animal is exclusively for its highly prized flesh. Auffenberg (1988) stated that only 11% of a 2000g lizard was edible, but the figure is much higher on Polillo. According to local people the intestines of *V.olivaceus* lack the bad smell of the intestines of *V.salvator*, and the entire viscera (except for the gall bladder) is cooked along with the skin and head. Using Auffenberg's figures (1988: Table 2.2) for the relative weight of body parts suggests that 80% of total body weight is available as food when the animals are prepared in this way. Although *V. olivaceus* is completely protected in the Philippines enforcement of protection is non-existent at local level. At present there is a voluntary ban on hunting wildlife in the Sibulan area that is generally supported by the local community and has been reinforced by a bill passed by the Town Council specifically outlawing hunting. Recently very positive publicity about the islands' wildlife on national television has bolstered these efforts. Thus in recent years there has probably been a marked decline in hunting around the watershed area, but hunting certainly still occurs on other parts of the island. Given its secretive nature, the fact that few people know how to catch the animals and the low yield per unit effort, it seems unlikely that hunting is an important pressure on the Polillo population of *V. olivaceus* at present.

Continued logging of the small amount of highly fragmented habitat available to *V.olivaceus* is probably the greatest threat to its continued survival on Polillo. Casual observations suggest that logging occurs regular within the area, often close to the borders of the watershed reserve. Loggers work almost exclusively during the weekends, suggesting that the activity is not their sole occupation. Based on the number of chainsaws heard during the study, an estimated 4 trees per week are removed from the area. Trees targeted have similar characteristics to those used by *V.olivaceus* (sentinels with CBH>80cm), except that the lizards favour trees close to the top of hills or on steeper slopes, whilst preferred logging trees tend to be closer to the bottom of hills. On two occasions evidence of recent logging was found within 50m of points where *V.olivaceus* are known to have been active. Because trees with suitable characteristics for lizards and loggers are rare in the forest there can be no doubt that the selective destruction of larger trees will directly contribute to the demise of *V.olivaceus*, even in areas where the forest as a whole remains intact.

Food resources may not be an important factor in determining its habitat requirements, but the need for relatively intact forest, free from human disturbance, appears essential. It has not been demonstrated that *V.olivaceus* use coconut trees other than when evading predators and this study found no evidence of foraging in agricultural areas. Given adequate food, the lizards probably rarely leave the forest.

Recommendations

For conservation of *Varanus olivaceus* around Sibulan:

1. Efforts should be made to increase local public awareness of the lizard, stressing its unique behaviour and global rarity, and in particular that it is "not the same as biawak".

2. Efforts should be made to dissuade locals from destroying large trees, particularly around the tops of hills.

3. Extending the current Watershed Reserve boundary northwesterly to include a further 80ha of Dipterocarp forest should be considered.

For future research:

1. Extent and condition of remaining forest cover and presence or absence of *V.olivaceus* should be determined for the whole of Polillo and Patnanugan Islands.

2. The annual activity range of *V.olivaceus* and its use of foods from agricultural areas should be investigated.

3. Future studies of *Varanus olivaceus* should use high-effort tree trapping to catch specimens rather than dog hunts. If dogs are used they should either lack canine teeth or be accustomed to wearing a muzzle.

4. A molecular study should be initiated to determine genetic condition of the isolated populations of *V.olivaceus* on Polillo.

Acknowledgments

Thanks for assistance in field to Augusto Zafe, William, Pido, Matias, Lito, Ricky and Eliazar Bulalacao, Chloe Galley, Katie Hampson, Dennis Olaguer and Vicente Yngente and his family. Thanks also to DENR (Polillo), William Oliver, J.C. Gonzales, Letty Aufuang, Doris Almeda, Andres T.L. Dans, members of Oxford University Polillo '99 project (University of the Philippines (Los Banos) and Oxford University) and their sponsors for help and support.

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Appendix 1. List of fruits collected around Sibulan watershed reserve, June-September 1999.

Areca catechu
*Canarium hisutum**
*Canarium luzonicum**
*Canarium ovatum**
*Caryota rhumphiana**
Celtis philippinensis
Dysoxylum
Entada phaserloides
Ficus depressa
Ficus drupacea
Ficus mirahasse
*Gnetum latifolium**
Gonocaryum calleryanum
Kalowmatra elegans
Livistona robinsoni*
Nephilium mutabile
*Panadanus botryoides**
*Pandanus luzonensis**
*Pandanus exultatus**
Parabaena
Phytocryne ruficaulis
*Pinanga insignis**
Pinanga philippinensis
Santol
Sapium luzonicum
Solanum
Syzygium
Tinospora rumphii
Tinosphia

* = Food of *Varanus olivaceus*.

Appendix 2. List of potential vertebrate competitors of Varanus olivaceus around Sibulan Watershed Reserve.

Varanus salvator marmoratus
A common lizard, although it has not been shown to be more abundant than *V.olivaceus* in forested areas, it also inhabits agricultural and coastal areas outwith the activity area of *V.olivaceus*. May show a similarv preference to *V.olivaceus* for trees. *V.salvator* tend to be small on Polillo (mean body length of 30 males was 31cm). Dietary overlap with adult *V.olivaceus* is restricted to crabs, but they are probably important predators of, and have a higher dietary overlap with, juvenile *V.olivaceus*.

Python reticulatus
Only juvenile *P.reticulatus* were found during the study, but the species probably still occurs throughout forested areas. Considered to be one of the most important predators of *V. olivaceus* by Auffenberg (1988).

Paradoxurus hermaphroditus
The civet cats are common in the Sibulan Watershed Reserve area and are probably the most important predators of *V.olivaceus* as well as being competitors for some food sources (*Pandanus*, *Caryota* and *Pinanga* fruits and crabs).

Sus celebensis
The wild pig has been largely eliminated by hunting and the species is said to be most common in grassland habitats close to forest. Evidence of pig foraging (single individuals) was found twice in the Sibulan Watershed Reserve Area. Pigs probably take some of the fruits eaten by *V. olivaceus* from the forest floor but are unlikely to be predators of the lizard nor important competitors at such low densities.

Rattus everetti
Not encountered, but said to be common by locals. Probably an important competitor for *Canarium* fruits.

Macaca philippinensis
Rarely encountered, but apparently still common in the area judging from signs of feeding. They may act as predators of young *V.olivaceus* as well as competitors for food.

Pteropidae:
Pteropus vampyrus (and possibly *Acerodon jubatus*), *Ptenochirus jagori* and *P. hypomelanus Eonycteris spelea, Cynopterus brachyotis* and *Macroglossus minimus* all occur within the habitat of *V. olivaceus* (P. Alveola, pers. comm.). The smaller species are still common, but no evidence was found that bats fed on any of the food plants of *V.olivaceus* during the study period. Dietary overlap is probably higher between *V.olivaceus* and the larger *Pteropus* and *Acerodon* bats, but these species are rarely seen in the area and size of known roosting congregations is very small.

Birds.
Birds are the best studied of the animals on Polillo, having been surveyed by McGregor (1910), Manuel (1956), Gonzales (1997) and Taylor and Hilario (this volume). *Penelopides manillae*, the tarictic hornbill, is still present in the Sibulan Watershed Reserve area, feeding on *Caryota* and *Livistona* (among others) during the study period. However it may now be too rare to be an important competitor of *V.olivaceus*. It is also a potential predator of juveniles. Parrots and cockatoos are now very rare on Polillo. *Cacatua haematuropygia*, *Tanygnathus luzcionenis*, *T.sumatranus* and *Loriculis philippinensis* have all been recorded from islands in the Polillo group but very few were observed during the study period (Taylor, personal communication) and many are probably extinct on the islands. Eleven species of doves have been described from Polillo, most of which are primarily fig eaters and unlikely to have much dietary overlap with *V.olivaceus*.

Notes on Varanus salvator marmoratus *on Polillo Island, Philippines*

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Abstract

Varanus salvator marmoratus appears to be widespread and common in and around Sibulan Watershed Reserve, Polillo Island. The lizard is much smaller than Gray's monitor lizard, *V. olivaceus*, with which it is broadly sympatric, and animals on Polillo possibly have much smaller body size than those from the mainland (Luzon) population. Examination of fecal material, stomach contents and thread from spool and line tracking indicated that the lizards are generalist feeders and that invertebrates and amphibians are important prey items. The Polillo population of *V. salvator marmoratus* shows unusually high tick infestation, which renders the animals worthless for the leather trade.

Introduction

Three subspecies of *Varanus salvator* occur on the Philippines, distinguished from animals elsewhere in Asia by scalation, pattern and colouration (reviewed in Bennett 1998). The animals have been heavily exploited for both meat and leather, and the conversion of forest to agricultural land on a massive scale may be responsible for a decline in lizard populations which has been reported on many islands in the Philippines. Here I present observations on *V.salvator marmoratus* on Polillo Island, gathered during a field study of Gray's monitor lizard, *V. olivaceus*, in and around Sibulan Watershed Reserve between July and September 1999.

Methods

Specimens of *V. salvator* were caught opportunistically by hunting parties looking for *V. olivaceus*, in unbaited, trigger-sprung noose traps set horizontally on the forest floor, and in vertical noose traps baited with parts of marine toads, *Bufo marinus*. Animals caught were marked with notches to the tail crest, examined and released at point of capture. Details of the following characteristics were recorded: snout-vent length (SVL) tail length, sex (determined by hemipenal eversion), weight, circumference of head, belly and tail base, recent and old injuries, presence of ectoparasites, colouration, shedding pattern, number of scales at midbody, number of scales from gular fold to insertion of hind limb and number of scales under 4^{th} toe. Fecal samples and stomach flushings were examined to provide data on diet. Three animals had spool and line devices fixed to their tails before release (see Bennett (this volume) for details) and resultant thread trails were followed at irregular intervals.

Results

Around Sibulan Watershed Reserve 22 hunting excursions totaling 119 search hours caught a total of 11 *V. salvator.* Numbers of animals seen but not caught were not recorded. One hundred and five horizontally set unbaited ground traps were set for 39 days (total effort = 4095 trap days) and caught a further nine specimens. No animals were caught after the 17th day and 88% of traps were still primed at the end of the experiment. Forty two traps days using baited, vertical noose traps (two set for five days, eight set for four days) caught eight specimens. Subsequently the traps were moved and the old bait retained for six days (48 trap days) during which time no animals were caught. When fresh bait was added six animals were caught over ten days (80 trap days). Four animals caught in vertical noose traps were found dead. Four animals were caught more than once in baited traps, replicates have been omitted from the figures given above.

Sex was determined for 34 animals, 28 male and 6 females (ratio: 4.7:1). Morphometrics for both sexes are given in Table 1. For males mean SVL/mass ratio was 2.36 (SD 0.6, range 1.62-3.83), for females 1.83 (SD 0.5, range 0.95-2.45). Summary of scale counts is given in Table 2. Animals had a mean of 4 ticks each (SD 6.9, range 0-29). All animals except the smallest (SVL 268mm) showed very heavy scarring on the ventral surface between the forelimbs. In most individuals this was the site of greatest tick concentrations. The relationship between tick numbers and body length is given in Figure 1. One female (17%) had a damaged tail compared with 34% of males. One male had a lost a hindlimb above the knee, otherwise no major injuries were recorded. This male appeared in good condition (mass/SVL ratio 1.74) and was subsequently followed by spool and line tracking (see below).

Data on diet was obtained from fecal samples of seven individuals and four dissections. Amphibians (including *Rana woodworthi* and *Bufo melanostictus*) were the most common prey type, occurring in 55% of samples, followed by coleopterans (36%), crabs and orthopterans (27% each), reptile eggs (18%) and birds (9%). Two dissected individuals contained fat bodies representing 3.2 and 1.4% of overall body weight. Testes from three dissected individuals accounted for a maximum of 0.6% of body weight. Only in the largest animal (430mm SVL, 1420g) did testes show clear evidence of increased blood supply.

	Mean SVL (mm)	SD	Range	N	Mean mass (g)	SD	Range	N
Males	391	43	335-493	28	961	354	555-1950	30
Females	342	53	268-416	6	645	254	255-1020	6

Table 1. Morphometric data for *Varanus salvator marmoratus* on Polillo

	Mean	SD	Range	N
Midbody	141	7.6	128-157	35
Lateral	90	4.5	84-102	31
4th Toe	28	1.4	25-31	34

Table 2 Scale counts for *Varanus salvator marmoratus* on Polillo

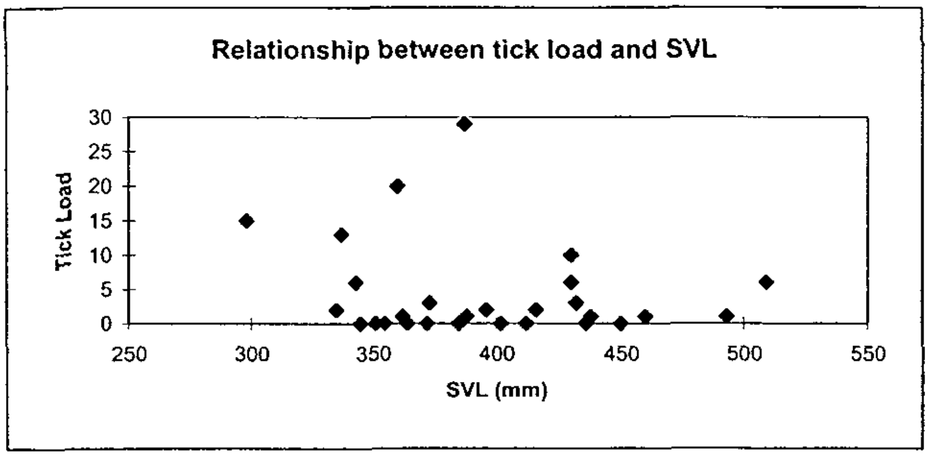

Figure 1. Tick load in *V. salvator marmoratus*

Discussion

V. salvator marmoratus found on Polillo did not differ in scalation from those described by Gaulke (1992) from Calauit Island, although the Polillo animals had a slightly higher lateral scale row count (on Calauit mean=88, range=80-98). They were much smaller than the Caluit animals, which had a mean SVL of 54.5cm. Whether this difference is an artifact of bias from the sampling methods used or a real difference is unclear. Possibly the lizards inhabiting the forested areas are mainly young (immature) and the older animals frequent other (coastal?) regions.

Gaulke (1992) estimated a total population of 913 animals on Calauit Island (3760ha). No such estimate is available for Polillo, but *V. salvator* is still common in forested areas around Sibulan, and probably in both cultivated and uncultivated habitats elsewhere on the island. The relatively high yield of *V.salvator* per unit effort suggests that it is more abundant than *V. olivaceus* in the study area. However the data must be treated with caution considering the low levels of activity of the latter species (Auffenberg 1988) which reduces the likelihood of the animals encountering traps or hunting groups.

Gaulke (1992) noted that *V. salvator marmoratus* on Calauit consume the marine toad (*Bufo marinus*) without ill effects and it appears that the animals on Polillo do the same (V. Yngente, personal communication). The other widespread monitor lizard in southeast Asia, *V. indicus*, is reported to die after eating this amphibian. Whether immunity to the skin toxins occurs in all populations of *V. salvator* is unclear because it has only been reported from the Philippines. Otherwise the diet of *V. salvator* on Polillo is similar to that reported for other populations (Traeholt 1993, 1994a&b, Vogel 1979) and supports the hypothesis that the species acts as an generalist forager, eating any animal it is capable of overpowering.

Cursory observations of the western coast suggests that much of the mangrove cover on Polillo remains intact. Destruction of mangroves has been cited as a cause of the demise of *V. salvator* populations elsewhere (Whitaker and Whitaker 1980, Das 1988). The mangroves are likely to contain large populations of lizards, although this has not been investigated. Exploitation for leather is also considered to be contributed to the species' disappearance in some areas. In the case of the Polillo population it is unlikely that collecting for such purposes will be a threat, because of the unusual amount of tick damage evident on the ventral scales, which probably renders the skins worthless. Tick infestations are heaviest in smaller animals, but the resultant scarring is permanent. Younger animals that lack extensive ventral scars are not accessible by traditional trapping methods and would not yield skins of a commercially acceptable width .

V.salvator is also a popular food item in the Philippines. The animals are hunted for food on Polillo, although apparently only for limited, local consumption. There has been some interest in the animals from mainland restaurant suppliers (V. Yngente, personal communication and although hunting on a commercial scale is unlikely at present, on account of the activities of the Polillo Wildlife Steward, the island may harbour much larger populations than can be found on mainland Luzon and will increase in potential value as mainland populations dwindle. Future studies should therefore investigate the status of populations in coastal areas of Polillo, particularly where mangrove habitat is still abundant.

Conclusions and Recommendations

Polillo Island contains a large population of *Varanus salvator*, an animal of considerable economic importance throughout southern Asia. As in other areas the species is a generalist feeder, consuming a range of vertebrate and invertebrate prey. A combination of relatively low human densities, intact coastal mangroves and scale damage due to heavy tick infestations (which makes the animals' hides worthless) suggest the status of the species is secure at present. Future studies of the animal should concentrate efforts in coastal and agricultural areas. The traditional vertical trigger-sprung traps are not suitable for non-destructive studies of monitor lizards because they catch individuals by the neck, making some mortality inevitable. A suitable alternative is the use of nooses set horizontally on the ground, which trap animals by the limbs.

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AN ACCOUNT OF THE AMPHIBIAN SPECIES FOUND ON POLILLO ISLAND, PHILIPPINES.

The following accounts are based upon both anecdotal observations and information gathered from the intensive surveys comparing amphibian assemblages (discussed later). In some cases illustrations of the feet are provided for reference to webbing and tubercle arrangement, which are useful taxonomic features. Any measurements taken are included for reference (Snout Vent length is abbreviated to SV and the mass is in grams). Information on the calls of most species is provided in the sound analysis section. The species accounts provide an introduction and background to the amphibian assemblage comparisons.

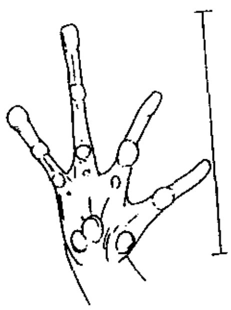
Rana vittigerra
This species is frequently seen and heard in rice paddies and amongst coconut plantations. It was not found to breed in streams, therefore probably requires standing water. It was only found at agricultural sites and therefore identified as an agricultural specialist species. *Rana vittigerra* is found in the Philippines and parts of South East Asia, further work is necessary to clarify the nomenclature and taxonomy of this group.

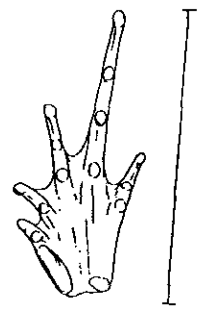
Bufo marinus
The marine toad, known as the Mindoro frog in the Philippines, is found in rice paddies and around human habitation. Originally a forest species from Mexico, this toad has been introduced to different countries around the world as a form of pest control to prevent crop damage, particularly for protection of sugar cane. In different parts of the world it has spread rapidly and devastated native fauna. On Polillo the marine toad was found in exceptionally large numbers, but never in forest. The toad has been on Polillo for at least 15 years, and is found in the North and South of the island. The reason why the marine toad does not live in forest is not known, but it is not due to limited dispersal capabilities. The marine toad was identified as an agricultural specialist species. There was no evidence that the toad affects existing wildlife in forest on Polillo, any effect on agricultural species cannot be determined without knowledge of the native faunal composition before the toads' arrival. It is not known to have replaced any native Philippine amphibians (Alcala and Brown 1998), and it is not found in primary forest elsewhere in the Philippines.

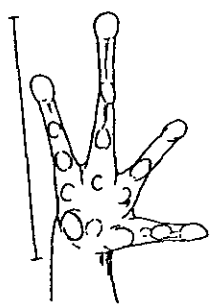
Polypedates leucomystax
The common tree frog is often found on banana trees, hence it's other common name, the banana frog. This species is found most frequently near human habitation and agricultural land, amongst trees and vegetation usually a couple of metres above the ground, but sometimes seen calling in rice paddies perched on the rice stems. A foam nester, it produces large egg masses overhanging shallow water bodies. It was identified as an agricultural specialist species. One adult male was 27g SV 79mm. This species is widespread throughout South East Asia.

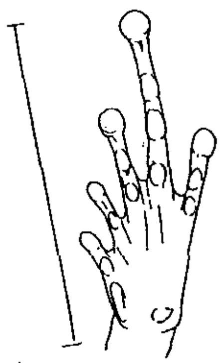
Kaloula picta
The fossorial *Kaloula picta*, (known as the single digit chorus frog) is most active after rainfall. Found by residential areas, rice fields and ponds close to human habitation. This species congregates in large numbers after rain beside water bodies and the chorus of this frog is almost deafening.
Measurements from two frogs are: 8.8g SV 46 mm, 8.5g SV 45mm. Refer to illustrations of feet, but note that *K. picta* has an inordinate amount of variation in the toe webbing (R. Brown. pers. comm.). *Kaloula picta* is endemic to the Philippines.

Kaloula sp.
One individual (4g SV 35mm) was found in primary forest amongst leaf litter at 7.30pm on 17/7/99. A second (3g SV 30mm) was found in a pitfall trap in secondary forest on the evening of 23/8/99. Refer to illustration of tubercles on feet. This species is a new record for Polillo. It is rare and possibly restricted to forest based upon the two sightings. This species does not correspond to any of the other *Kaloula* species that are found on the mainland. The taxonomy of this frog is unclear and requires further investigation.


Right hand of *Kaloula picta*. Scale 13mm


Right foot of *Kaloula picta*. Scale 19mm


Right hand of *Kaloula* sp. Scale 10mm.
Very poorly defined tubercles within palm


Right foot of *Kaloula* sp. Scale 15mm

Limnonectes macrocephalus
A large uncommon frog found in low densities. This species is probably more dispersed because of its predatory lifestyle. Its sit and wait tactics are similar to other large ranid species across Asia e.g. *Hoplobatrachus tigerinus*. It is found in primary forest and also beside large streams in more agricultural habitats. Mean mass 103.4g (n=4, range; 57 to 119.5g), mean SV 121mm (n=4; range 82 to 166mm). The nomenclature of this species

has changed, it has been raised to full species level and placed within the Limnonectes genus (R. Brown. pers. comm.). It is endemic to Luzon, Mindoro and the Polillo Islands.

Occidozyga laevis
Is found in most habitats from agriculture to primary forest, excluding rice paddies and can be in large densities especially in very shallow still water. The pattern on this frog is variable. Sometimes either one or two dorsal stripes are present, and sometimes there is a large light patch behind the head. The call is relatively quiet and these frogs are disturbed from calling very easily. This species is widespread throughout the Philippines and parts of South East Asia.

Rana woodworthi
Woodworth's frog is endemic to a small area of Luzon Island (Laguna and Quezon Provinces) and Polillo. One of the most common frogs on Polillo, particularly abundant in forest and found in agricultural areas in lower numbers.

Rana similis
This frog is commonly seen beside rivers that border forests and rivers within forest. It often sings among rocks or on branches of plants beside the riverbank sometimes a metre or more above the ground. Often heard calling during the daytime in forest. This frog has been designated to full species level (from subspecies *Rana signata similis*) (R. Brown. pers. comm.). A pair found in amplexus weighed 13.25g SV 59 mm (female), and 4.25g SV 40 mm (male).

Rana luzonensis
This frog is seen on leaves or branches up to 2 metres above the ground and occasionally on the ground. *Rana luzonensis* was found beside streams in forest, and fast flowing streams among agriculture that are bordered by trees or bamboo. Females often differ in colouration from the males, sometimes brown or beige in colour. *Rana luzonensis* belongs to the *Everetti* group and has recently been raised to full species level (R. Brown. pers. comm.). It is endemic to Luzon and the surrounding islands.
A pair in amplexus weighed 6.25g (male), 28.5g (female with approximately 900 eggs). Eggs weighed 3.25g.

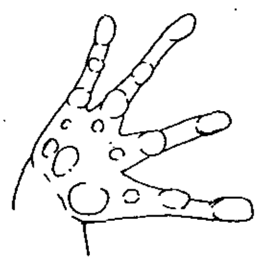
Rhacophorus pardalis
This uncommon frog was found in clustered groups. One group was found amongst bushes beside a temporary pool in a coconut plantation, whereas another group was found in forest. A juvenile was also found in forest at site K, and another in a tree at the paddy field site O (see map of frog survey sites later). Mean mass 7.45g (n=2). This species is found in the Philippines, Borneo and Sumatra.

Rhacophorus appendiculatus
One individual was found on the 9/8/99 during the day in primary forest on a tree trunk (3.8g SV 44.5 mm). No others were found on Polillo. However during a visit to Mt Maquiling, near Mud springs, Los Banos (Luzon Island) several individuals were found

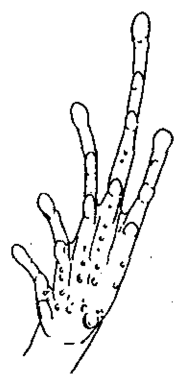
and heard calling. This species is found in the Philippines, the Malay peninsula, Borneo and Sumatra.

Platymantis dorsalis
This is a very common frog, which calls from the ground and low vegetation. It is heard among coconut groves and forest, in contrast to the mainland where it is found more strictly in forest. It has a non-granular belly, and there are no tiny tubercles over the base of the foot. Refer to illustration of feet. Varying patterns and colouration, sometimes prominent dorsal stripes, either a single central or two dorsal, frequently the dorsal stripe is absent. *Platymantis dorsalis* is endemic to the Philippines. Mean mass 2.4g (n=16, range; 0.65 to 5.75g), Mean mass of gravid females 5.4g (n=4, 4.95 to 6.2g)

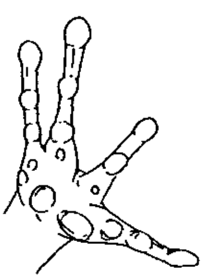
Platymantis corrugatus
This frog is cryptic, calling from beneath dead wood and overgrown plants and its distribution is clustered. This species is found from coconut groves to primary forest. *Platymantis corrugatus* is endemic to the Philippines. Tiny tubercles are visible over base of foot and the belly is granular. See illustrations of feet. Mean mass 3.25g (n=4, range; 3.0 to 3.85g), Gravid female SV 46 mm 10.5g



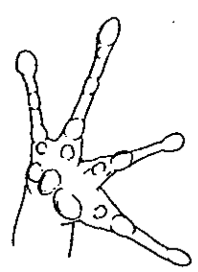
Right hand of female *P. corrugatus.*
Very prominent tubercles on first two fingers



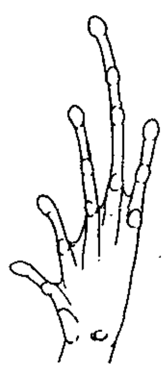
Right foot of female *P. corrugatus.*
Very small granular tubercles beneath feet



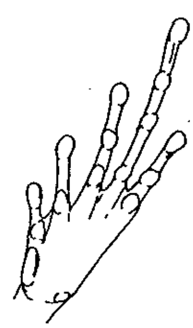
Right hand of *P. dorsalis*



Right hand of female *P. dorsalis*



Right foot of female *P. dorsalis.*

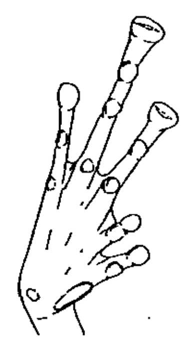


Right foot of *P. dorsalis*, showing prominent projecting tubercles

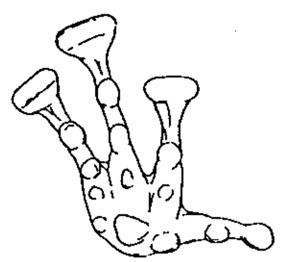
Platymantis sp.

This species has previously been misidentified as the Polillo Forest frog (*Platymantis polilloensis).* It is now known to be a member of the *Platymantis guentheri* group. The most similar frog to it on the mainland is *Platymantis luzonensis*. *Platymantis luzonensis* has a more warty appearance than *Platymantis* sp. The calls of the two frogs are very similar (see the sound analysis section). This frog is potentially a different species from *P. luzonensis*, and possibly endemic to Polillo. Its taxonomy requires further work. DISTANCE transect data was collected for precise estimations of abundance. These frogs were usually heard calling from at least 2m above the ground, therefore are less likely to be found in transects (see assemblage comparisons) than ground dwelling frogs. According to frequency of calling males these frogs are much less common than both *P. dorsalis* and *P. corrugatus* and their habitat is much more restricted to forest. Refer to section on *Platymantis* sp transects. Mean mass 2.0g (n=3 range 0.8g (juvenile) to 3.05g). Mean female mass 7.09g (n=2). Mean SVL 36.6 mm, (n=7, range 23 to 48)

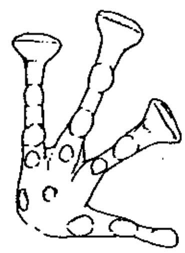
Left foot of *Platymantis* sp



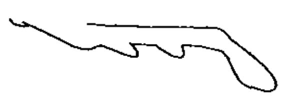
Right foot of female *Platymantis* sp. Large inner metatarsal tubercle, pointed at tip. Very pointed 2nd tubercle on outer toe



Right hand of male *Platymantis* sp.
Male has large tubercle in middle of palm.



Right hand of female *Platymantis* sp. Corresponding tubercle on the female is small. Groove visible across fingertip



Profile of outside finger of right hand:
1 small tubercle at base of hand, 1 small tubercle at base of finger, 2 large tubercles on finger

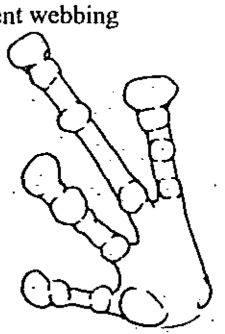
The White frog

A small white frog was found on Polillo. It resembles closely *Platymantis sierramadrensis*, described in 1999 (Brown, W.C., *et al.* 1999). One individual (0.325g SV 19 mm) was found on 14/8/99, 1m above ground on a leaf next to a stream at site K, Sibulan watershed reserve. On the 9/9/99 a white frog (0.5g SV 22 mm) was found calling (call recorded 2140 hours 25°C) from ferns 2m high above a small stream, North Polillo, near Panukulan. On the 11/9/99 a white frog (0.55g) was heard calling from same location as on the 9/9/99, possibly the same individual.

The table below gives descriptions of the hands and feet of *P. polilloensis* from Taylor (1922) and Inger (1954), which resemble closely the drawings of the white frog, (see diagram) and comparative descriptions of *P. sierramadrensis* from (Brown et al. 1999).

Inger	Taylor	*P. sierramadrensis*
Tips of fingers broadly dilate into truncate discs with horizontal circummarginal grooves. First finger shorter than second. A supernumerary tubercle on each metacarpal	Tip of each of the three outer fingers with a strongly dilated pad, nearly twice the width of the digit. Inner finger very small, slender without pad. Subarticular tubercles large, flat, moderately well defined. A single large carpal tubercle. No trace of web	Fingers with minute webs at base; fingers except first with broad disks; fingers with shallow circummarginal grooves. Finger discs broader than those on toes. First finger shortest, third longest and second and fourth approximately equal, subarticular tubercles large, round, low: a row of low, inconspicuous supernumerary tubercles on palm; inner, middle and outer metacarpal tubercles oval, vague, inner and middle about equal in size; larger than outer.
No supernumerary tubercles on the foot. Tips of toes dilated, the discs smaller than those of fingers; web reaching centre of proximal subarticular tubercle on first, second and fourth toes, distal edge of tubercle on third, and between subarticular tubercles on fifth toe. Web extending to disk of fourth toe as a narrow fringe; third toe slightly longer than fifth; first toe, measured from distal edge of inner metatarsal tubercle, less than twice the length of the tubercle; two metatarsal tubercles, the outer one not distinct; without supernumerary tubercles on the foot.	Tips of toes distinctly dilated. Not more than one and one half times the width of the digit. Fourth toe very long. Third and fifth equal, barely reaching third subarticular tubercle from the disc on fourth toe. Inner metatarsal tubercle rather large but ill defined. Outer small, dim.	Terminal phalanges rounded, toes webbed to distal edge of tubercle on first and second, to distal edge of basal tubercle on third, and to midway between tubercles on fifth. Disks of toes narrower than those of fingers, subarticular tubercles rounded, low; platar area smooth; inner metatarsal tubercle elongated, outer vague; dorsum smooth, without tubercles;

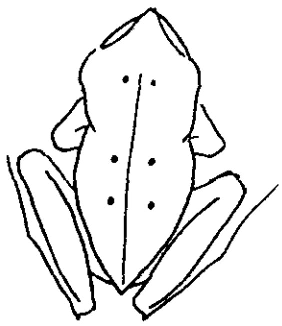
Left hand of white frog showing tubercles and dilated digits
No apparent webbing



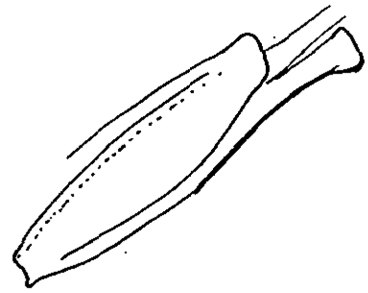
Foot of white frog showing tubercles

Description of white frog	From Taylor 1922: *Philautus polilloensis*	*P. sierramadrensis* from Brown et al 1999.
Prominent tubercle on each eyelid	Single large conical tubercle on upper eyelid near outer middle edge. Inger: Low papilla on upper eyelid	
Very pointed tip to snout	Tip of snout conical. A distinct tubercle on tip of jaw. (Inger: Snout acutely pointed)	
Pupil horizontal	Pupil horizontal	
Small tympanum, one third diameter of eye.	Tympanum rather indistinct, diameter 1 third to 1 fourth of eye. (Inger: Tympanum visible, 1 third diameter of eye.)	
Clear supra tympanic fold, and another fold beneath tympanum, Small fold from tympanum to shoulder	A strong fold above tympanum to near insertion of arm dimly granular. A second fold from a point above and behind tympanum to lower jaw. There is some variation in the folds about the tympanum, some of these specimens show these very dimly. (Inger: A supratympanic fold from eye to axilla).	
Prominent tubercle on heel	A strong tubercle at heel.	Conical tubercle on heel
Pointed anus	A small tubercle on back above anus	
Granular belly	Belly and underside of femur strongly granular. Skin of throat and belly smooth, with numerous minute pit like depressions. No 349 with Pit like depressions in skin of lower jaw not evident, the tubercles on the back are dimmer. (Inger: Belly with coarse granules)	Venter generally smooth, coarsely granular in some specimens
See diagram for tubercle positions and pigmentation	Skin above practically smooth with two small tubercles between shoulders and two pairs on back. (Inger: Skin of back smooth with a few scattered tubercles. No longitudinal ridges). A row of granules from behind tympanum to arm, parallel to supratemporal fold	smooth skin, dorsum smooth without tubercles.
SV: 22 mm 19 mm	SV 27 mm female, 22.5, 20, 19, 17, 15. (Inger: male with vocal sacs 20.3 & 22.6 mm SV)	SV 22.7-25.2; mature males, 25.7 for 1 mature female.
Colour in life:	Colour in life: Between the 7 co types, vary more or less in markings but the colouration is identical	
Darker yellow brown under legs, Yellow beneath thighs and hind legs	Chin and throat yellow with very sparse peppering of brown; underside of leg and foot strongly peppered with brown. (Inger: No areolations on the groin).	
Thin very pale straight stripe down dorsum	Numbers 352 to 354 have a hairline from between the eyes to above the anus	
Above creamy/ off white. Slightly darker pigmented spots as labelled in diagram (dark bar between eyelids and on dorsum), and slightly darker patch on digit. Mask on face from eye to snout	Above creamy white to yellow, slightly pigmented with minute dots of cinnamon brown. No 350 Almost white when taken. A bar of cinnamon between eyes and dim spots about the dorsal tubercles. No 350 The pigment is heavier between the eyes and as far forward as the line between the eyes. Upper eyelids dark gray to blackish. Dim bars on tibia and femur.	pale creamy colour without brown/ blackish markings on body or limbs and without areolations. In preserved specimens, faint scattered brownish flecks are evident on dorsal and lateral surfaces
Thin dotted stripe along upper side of each calf, down leg (see diagram), and off white stripe bordering the outside of every finger	Spots on outer digits of all limbs. The distinct spots on the two outer fingers is very characteristic	
White belly	Underside of hand and belly immaculate	
Iris periphery turquoise		

Schematic drawing to show arrangement of prominent coloured tubercles.



Right leg of white frog: Dotted line along back of leg, and fringe of white borders edge of toe



Head of *Cornufer polilloensis.* (Inger) Head of white frog

Both have pointed snouts, the drawing from Inger does not show tubercle on eyelid but it is given in the description

The description of the white frog corresponds closely to both Inger's and Taylor's descriptions of the original *P. polilloensis* specimens (referred to as *Philautus polilloensis* by Taylor and as *Cornufer polilloensis* by Inger). See accompanying diagrams of the white frog. However the very distinctive turquoise periphery to the iris is not described by Taylor from the original live animals, leaving doubt as to whether the white frog could be *P. polilloensis*. The blue ring seems to be a character uniting all hazelae group species (R. Brown pers. comm.). The description of *P. sierramadrensis* also matches the white frog, but their calls are compared in the sound analysis section and found to be distinct. However the comparison is only between calls from populations of *P. sierramadrensis* in the Northern regions of the Sierra Madre Mountains.

To resolve the identity of the white frog, more specimens are necessary to compare to the original *P. polilloensis* and *P. sierramadrensis* specimens, and more recordings of each of the calls are necessary to confirm without doubt calling pattern and rate differences. Further comparison is necessary between the white frog and Southern populations of *P. sierramadrensis.*

Notes

Eggs presumed to be from a platymantis species were found in a tree hollow. Many gravid *platymantis* individuals were seen however none could be induced to lay eggs or even call when kept in captivity. Several tiny *platymantis* were found but neither in great abundance to locate a hatching site nor with any strong association with water. Further investigations into the natural history and reproductive strategies of these species should be investigated.

AN INVESTIGATION INTO THE AMPHIBIAN ASSEMBLAGES OF POLILLO ISLAND, PHILIPPINES

ABSTRACT

A comparison of amphibian assemblages was made between different habitats and management regimes on the island of Polillo, Philippines. A variety of different techniques were used to estimate density and abundance of amphibian species in agriculture, primary and secondary forest and habitat edges. No one technique was found to be suitable for every species, the advantages and disadvantages of each technique are discussed and recommendations for future studies made. A number of species were found to be agricultural specialist species and forest specialist species. Several species were found in all habitats except the most intensive agriculture. Abundance of frogs tends to increase with distance from agriculture. Highest levels of species richness were observed at central forest sites and forest agriculture boundaries where both forest and agriculture species coexist. The forest specialist species were not found at these boundary areas and should be used as a focus of conservation efforts. 16 amphibian species were found and the calls of 12 species were recorded. Specific research and conservation priorities were identified including the taxonomic determination of three unknown species.

INTRODUCTION

Over half the amphibians species on Polillo are endemic to the Philippines. Several are restricted to the South Luzon Faunal region and *Platymantis polilloensis,* discovered by Taylor in 1922 is found only on Polillo, and has not been found since (Alcala and Brown 1998). Since Taylor's collecting trips in 1920, only Dr R. Crombie (Smithsonian Institution) has conducted formal herpetofaunal investigations on the island, in the early 1990s. Before the Oxford-UPLB project no acoustic guide to the identification of amphibians on Polillo, nor the Philippines was available, despite recent increases in use of such techniques. This project intended to collect baseline data on amphibian species on Polillo, and produce an aural identification guide.

Amphibians sensitivity to environmental variation suggests they may be affected by habitat and landscape alteration (Wyman 1990; Wake 1991, Blaustein et al.1994). In tropical regions forest fragmentation is an important result of human activity and might influence amphibian assemblages through edge effects on environmental parameters (Ranney 1977; Ranney et al 1981; Lovejoy et al 1986; Malcolm 1994). Most of the forest on Polillo has been cut down, and much of what remains is fragmented. 200 hectares of old growth forest is protected as the Sibulan watershed reserve. Studies of amphibian diversity and richness were conducted in and around the watershed to investigate frog assemblages in different habitats from primary forest to intensive agriculture and begin to address the affect of forest fragmentation on particular species.

AIMS

- Investigate the effect of habitat type on frog assemblages by carrying out surveys of density and abundance in agriculture, primary forest, secondary forest and edge habitats.
- To record the calls of amphibians on Polillo to produce an aural identification guide.
- To devise methodology for surveying frogs on Polillo that is simple to use, efficient and robust.

Methodology

Pilot study:
A week's reconnaissance and training period was completed at the start of the project. During this time different methods of searching were assessed, different transect lengths and quadrat sizes tested, species identification practised and potential sites investigated. The methodology used in the main study was refined during this period.

Site selection:
Study sites are shown on the map. There was no suitable map of the area available beforehand, thus selection of sites in terms of distance from primary/ core forest was not possible. The arrangement of habitat type and quality was also unknown. The distance to study sites and terrain of routes prevented their random selection. On the assumption that forest nearest to the centre of the reserve (i.e. furthest from agriculture) would be most representative of the original habitat, sites were chosen in what was considered to be those representative of high quality habitat, through varying levels of disturbance to agriculture. The most intensive agriculture was paddy fields.

The project work was based around water bodies because:

1) Intensive search effort that yielded very few frogs tended to reduce searcher enthusiasm, therefore despite the potential importance of non water body sites, effort was concentrated around water bodies where frog activity was highest
2) Streams were highly abundant in the region, such that finding a non water body site (defined here as at least 25m from a water source) was very difficult, unless work was conducted along hill tops and ridges where terrain was often unworkable.
3) Streams were used as the major navigation routes within the forest, therefore logistically using them as study areas was convenient.

Habitat Characterisation:
In order to compare between sites in a quantitative way, different characteristics were measured that were chosen as indicators of forest quality, or factors that may play a role in the distribution of frogs. The following measurements were taken along a distance of 100m, and 5m either side of the river:

- Abundance of *Pandanus* spp. by their area
- Abundance of dead logs (using a subjective size standard)
- Abundance of bamboo

- Density of ground flora (counting the number of times when walking 200m i.e. 100 down one side of the stream then 100m back on the opposite side, a 1m stick held horizontal at waist height touches under storey vegetation along its length)
- Width of the stream (to within 0.5m)
- Flow of the stream on a scale of 1 to 3
- Canopy cover
- Water parameters -pH, conductivity and Oxygen concentration

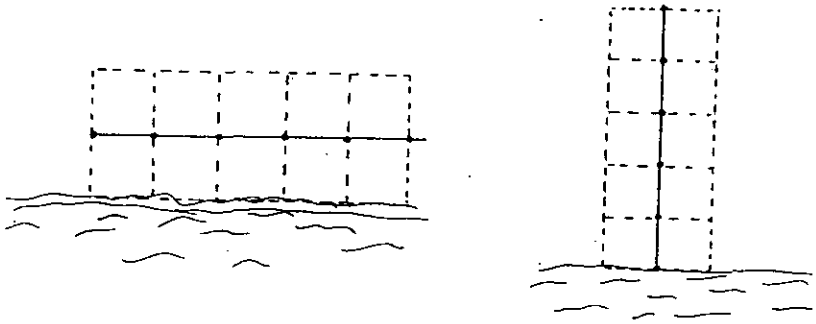
To provide a quantitative description of the composition and structure of forest habitats, density, basal area and relative species abundance of trees were estimated at all sites using the Plot less Centre Quarter Method. Distance from origin to the nearest tree (or tree stump) with Circumference at Breast Height >31cm in the four quadrats of a Cartesian grid were recorded together with species, position in the canopy and CBH, every 5m of the transect. Transects were at least 100m long, 50m on each side of the water body and running perpendicular to it. Replicate samples were recorded as such and the distance to next nearest tree measured. Trees were initially identified by local names wherever possible and subsequently by identification of voucher specimens at Dept. of Plant Sciences, University of the Philippines, Los Banos (UPLB). Details of climate (rainfall, maximum and minimum shaded and unshaded temperatures) were recorded from a hill next to base camp at 0900 hours each morning. The phase of the moon during the study period was recorded.

Amphibian Survey Methods:

Two sites were surveyed each night. At each of the 13 study sites on 4 separate occasions the following were conducted:

1. Transects: Twelve 5m by 2m transects were searched. The species, distance from the water, distance from the start of the transect and height above the ground for every frog within the $10m^2$ was recorded. Six of the transects were directly parallel to the waters edge and six perpendicular to the stream, all 12 beginning at the water's edge.

A 5m length of string, marked at 1m intervals was tied to the transect starting point, to ensure accuracy in measuring distances and consistency between searches. The rough position of the frog within the $10m^2$ transect could be estimated by the 1m markers. Searchers worked from the starting point keeping the string taut, ensuring no disturbance was caused to the area ahead. The diagrams below illustrate how knotted string was used to conduct perpendicular and parallel transects that covered a $10m^2$ area.



2 researchers searched transects simultaneously at each site. Each searched 6 transects; 3 parallel and 3 perpendicular. The searchers worked independently and on opposite sides of the water body to avoid pseudoreplication. Transects were at least 5m apart to prevent active frogs being included in consecutive transects.
Searching began between 6.50 - 7.30pm. Searching was thorough and slow, the time taken to complete a transect was left to the searchers' discretion, given the varying terrains and abundances of frogs. Searchers worked at a pace, where they felt, given more time, unable to find any more frogs within the search area. If a frog was seen to jump from outside the transect area into the area it was not counted, if a frog was seen to jump out of the transect area it was counted. Times to complete a transect varied between 2 to 20 minutes.
The transects were designed to give absolute abundances of every species, to enable patterns in species distributions with distance from the waters edge to be deciphered and to look for signs of clustered distributions.

2. Timed counts: For 30 minutes searchers looked anywhere in the vicinity of the area. No constraints were given to search area dimensions other than that searchers worked on opposite sides of the river from each other to avoid replication. The species of the frogs found were tallied, and the time noted when 10 individuals of 1 species had been found. With the aim of saving time that would be used up by continuing to record the common species (perhaps increasing the possibility of finding more cryptic species). Timed counts are designed to be a simple, rapid and effective technique which gives reasonable relative abundances for avifauna (Bibby 1998). Therefore an adapted version of the technique was tested for assessing frog assemblages.

Ten different searchers carried out the surveys. They were chosen on a rota basis to reduce observer bias, random selection was impossible because of the logistics of the work timetable, frequency of fungused feet and other ailments preventing work. Petzl head torches were used by searchers. Searches were not completed on Sundays and were abandoned when dangerous weather conditions were anticipated. Therefore a total of 48 transects and four hours of timed counts were completed at each site. The advantages and disadvantages of these two techniques are reviewed in the discussion.

Analysis methods:
Species accumulation curves were drawn to assess what proportion of the species present were being sampled. Rank abundance plots were used to assess overall species community patterns and identify habitat specialists. Graphs of species richness and total frog abundance for each site are presented and diversity indices calculated. Ordination using the programme CAP was used to look for patterns in species composition and abundance between sites. Density of each frog species is plotted against distance from agriculture.

Considerations in Design of Methodology:
Of the recommended standard techniques for sampling amphibian populations (Heyer et al 1994) few were considered appropriate for the community being studied on Polillo. Quadrats typically 5m by 5m were rejected because they:

- create too much disturbance (especially given the small size of the watershed reserve)
- require intensive effort to be searched thoroughly
- cannot be repeated in the same location because of the induced disturbance,
- rarely find amphibians unless they are very close to water bodies,
- flush species out of the quadrat before they are found,
- must be repeated many times for statistical analysis

Long transects (100m plus) were rejected because

- As the length of transect increases, the chance of the area being searched thoroughly decreases
- They are affected strongly by observer bias

However a compromise upon both the quadrat and transect design was reached. Small 5m long, 2m wide transects were used that could be searched intensively and repeated many times. Surveying was purely conducted at water bodies, but a small gradient (5m) was used perpendicular from the water bodies to investigate whether on future occasions further work based on the forest floor would be worthwhile.

Considerations about the design of the transects:
Differences in searcher ability are very difficult to overcome and impossible to eliminate. Differences were minimised by the design of the experiment wherever possible. E.g. by keeping the search area small (5m by 2m), by working at the searchers slowest pace (to ensure searchers didn't feel rushed thereby likely to search less thoroughly), by working in one direction (thereby any frogs that jump in front are likely to be seen). A larger search area was considered to increase searcher boredom and apathy, less successful searchers might become disheartened, heightening differences between more successful searchers. (It was assumed that given enough time the searcher will find all the visible frogs no matter what ability the searcher has, given a small enough area). The area searched was small to ensure that if frogs jumped they were likely to be seen. The design was a transect rather than a quadrat to reduce the searcher disturbance and likelihood of frogs escaping before they were spotted. 2m width was considered to be a good field of vision for the observers.

Considerations about the design of the timed counts:
This method tended to be more popular during the reconnaissance period, therefore it was important to consider whether this gave the same relative levels of each species as the transect method (although area is not specified therefore neither relative or absolute abundances can be measured, only frequency of encounters). It was assumed that searchers would try to find as many frogs as possible. A limit to the number of frogs of one species recorded was made, to prevent the tendency to concentrate efforts on one species or productive microhabitat. After trying different limits, 10 frogs of one species

was chosen. In order for appropriate analysis, the number of frogs that would have been found in thirty minutes was extrapolated given the encounter rate for ten frogs.

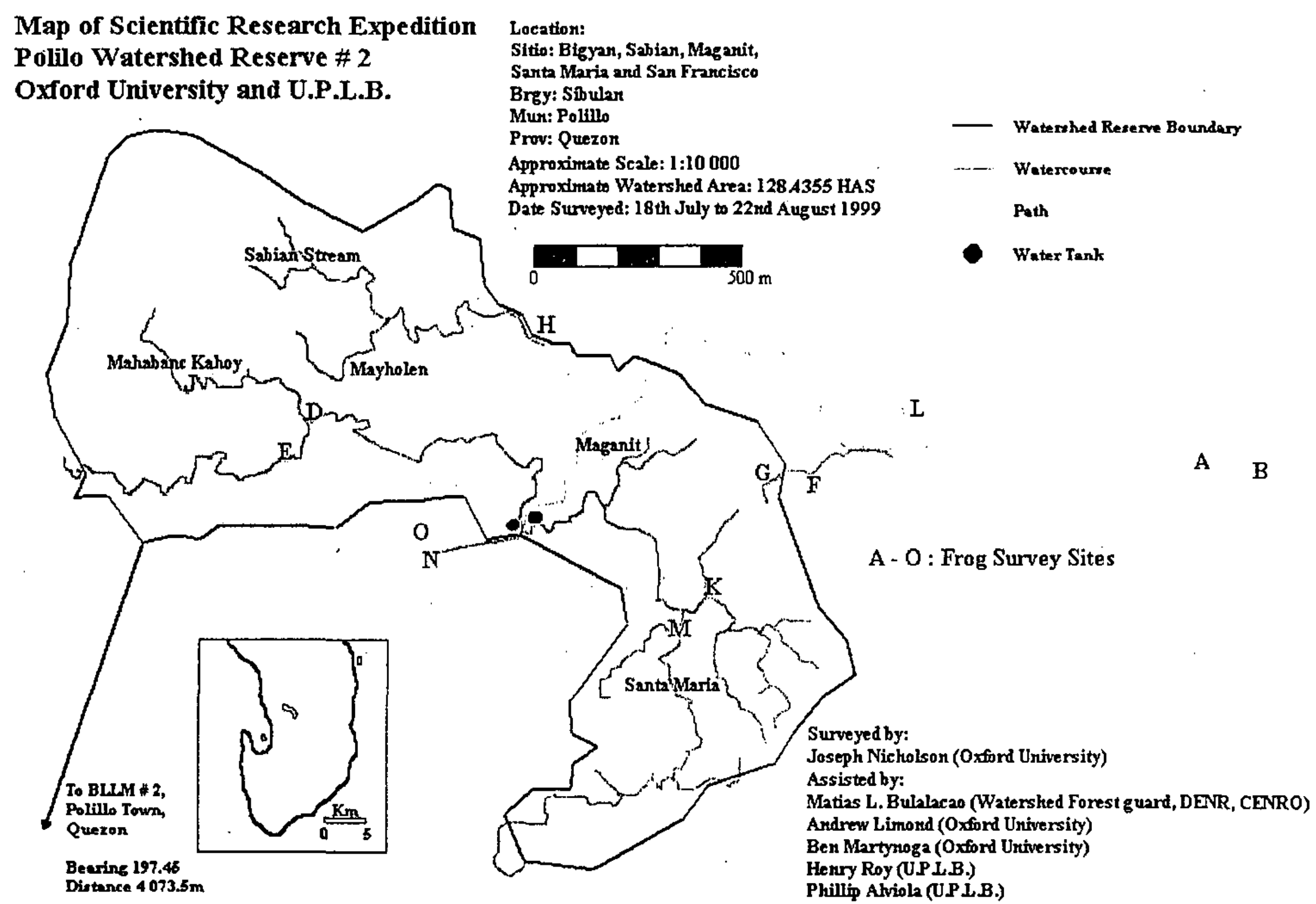
The two search techniques were suspected to collect differing results. E.g. The timed count might not pick up species that are particularly cryptic since this method is possibly less intensive. However the search area and habitats are possibly wider therefore there is more chance of finding animals with lower densities.

Audio strip transects were latterly adopted with appropriate changes for estimating density of *Platymantis* sp. This technique is not appropriate for many of the other species such as *P. dorsalis* which have a high call overlap (high densities of males calling at high rates) (Zimmerman 1994) or others such as *O. laevis* which call in choruses. For *Platymantis* sp. the technique was ideal. However as densities increase, the technique requires more concentration and skill and is more time intensive therefore shorter and shorter transects must be completed.

Description of Study sites:

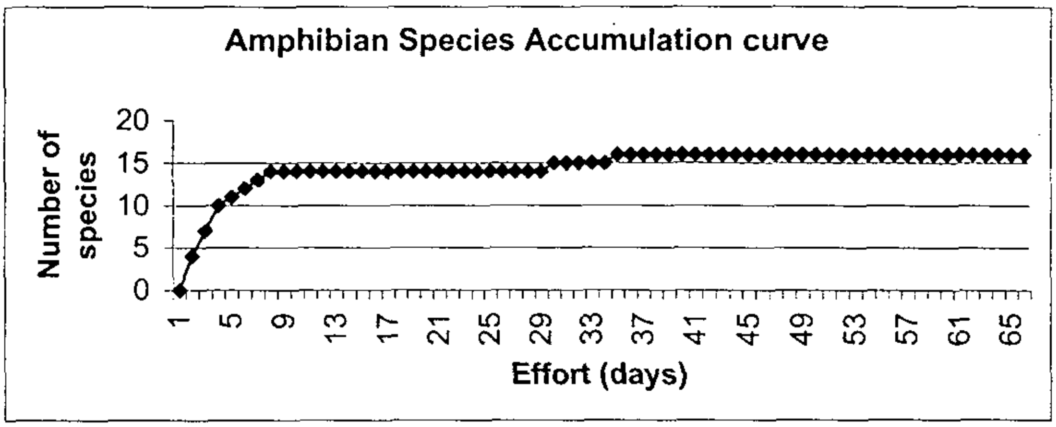
- A- Paddy field bordered by river and coconut plantation. 5 minutes walk to the nearest forest.
- B- Fast flowing river (at least 3m wide in places) within coconut plantation, bordered by a variety of agricultural trees. River passes through forest but nearest forest is at least 5 minutes walk.
- D- Central forest site with a medium sized stream (1 to 2m) with medium flow rate.
- E- Central forest site with a medium sized stream (1 to 2m) with medium flow rate, and *Pandanus* spp. very abundant.
- F- Forest edge site with small (1m) slow stream.
- G- Forest edge site with small (1m) slow stream
- H- Fast flowing river (at least 3m wide in places) within coconut plantation on one side, bordered by a variety of agricultural trees.
- J- Forest site with small stream. Varying terrain (steep sided in places, flat in others) which affects flow rate (varies from fast to slow).
- K- Central forest site with medium sized stream.
- L- Forest edge site with slow stream, widening in some places where the water is still and swamp like.
- M- Central forest site with medium sized stream.
- N- Fast flowing river (at least 3m wide in places) within coconut plantation, bordered by a variety of agricultural trees. River passes through forest. Nearest forest is about 5 minutes walk.
- O- Paddy field site bordered by coconut plantation and forest edge.

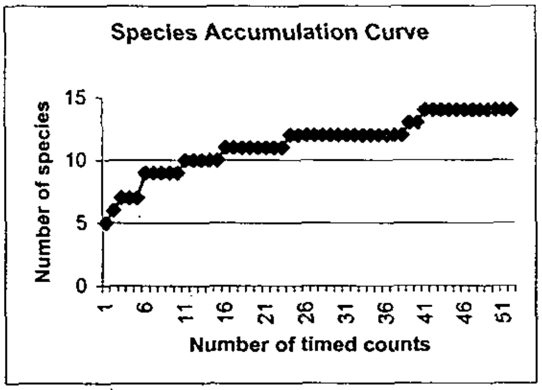
The following map of the watershed and surrounding area shows the position of the frog surveys sites listed above.

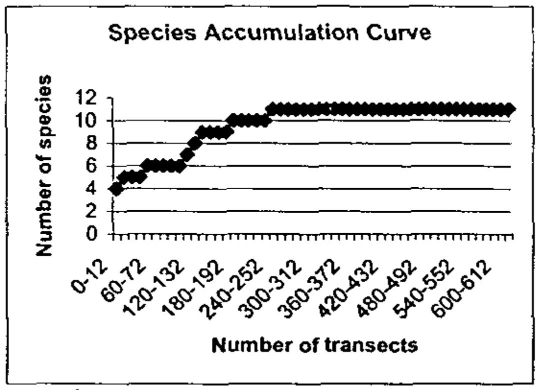


Map of Scientific Research Expedition
Polilo Watershed Reserve # 2
Oxford University and U.P.L.B.
Location:
Sitio: Bigyan, Sabian, Maganit, Santa Maria and San Francisco
Brgy: Sibulan
Mun: Polillo
Prov: Quezon
Approximate Scale: 1:10 000
Approximate Watershed Area: 128.4355 HAS
Date Surveyed: 18th July to 22nd August 1999
0
500 m
Watershed Reserve Boundary
Watercourse
Path
Water Tank
Sabian Stream
H
Mahabanc Kahoy
J
Mayholen
D
E
Maganit
L
G
F
A
B
O
N
A - O : Frog Survey Sites
K
M
Santa Maria
Km
0
5
To BLLM # 2,
Polillo Town,
Quezon
Bearing 197.46
Distance 4 073.5m
Surveyed by:
Joseph Nicholson (Oxford University)
Assisted by:
Matias L. Bulalacao (Watershed Forest guard, DENR, CENRO)
Andrew Limond (Oxford University)
Ben Martynoga (Oxford University)
Henry Roy (U.P.L.B.)
Phillip Alviola (U.P.L.B.)

RESULTS





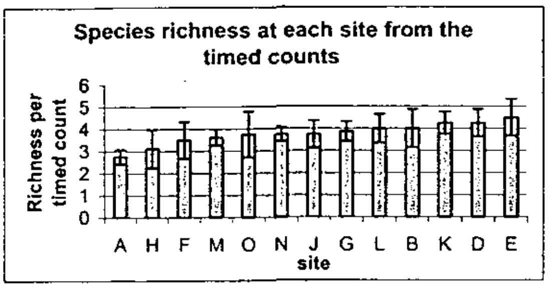


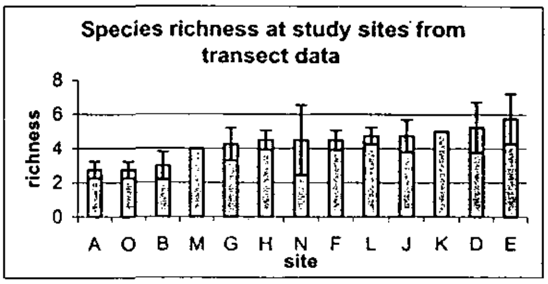
The species accumulation curves compare species richness and rate of species discovery for transect and timed count techniques. The total species richness approaches an asymptote at 16, species were still being discovered after 37 days. The transect technique found 11 of the total 16 species, whereas the timed counts found 14. The two species not found by either technique were seen once and twice respectively (see below and species accounts section). The transect data reached an asymptote one third of the way through the study, whereas the timed count curve continued to rise, although slowly at the end.

Two frog species were only not detected during the surveys; *Kaloula*.sp, a fossorial frog (2 individuals were found, 1 in a pitfall trap after rain, and 1 during the reconnaisance period approximately 5m from the stream) and *Rhacophorus appendiculatus* (found on only one occasion at a site within the watershed reserve). Based on call recognition, the species found regularly at significant distances from water were particularly cryptic, and could often only be located by their call, these were *Platymantis* sp, *P. corrugatus, P.dorsalis*. Individuals of other species were found at a distance from water, such as *R.woodworthi*, but only occasionally compared to their abundance at stream sites.

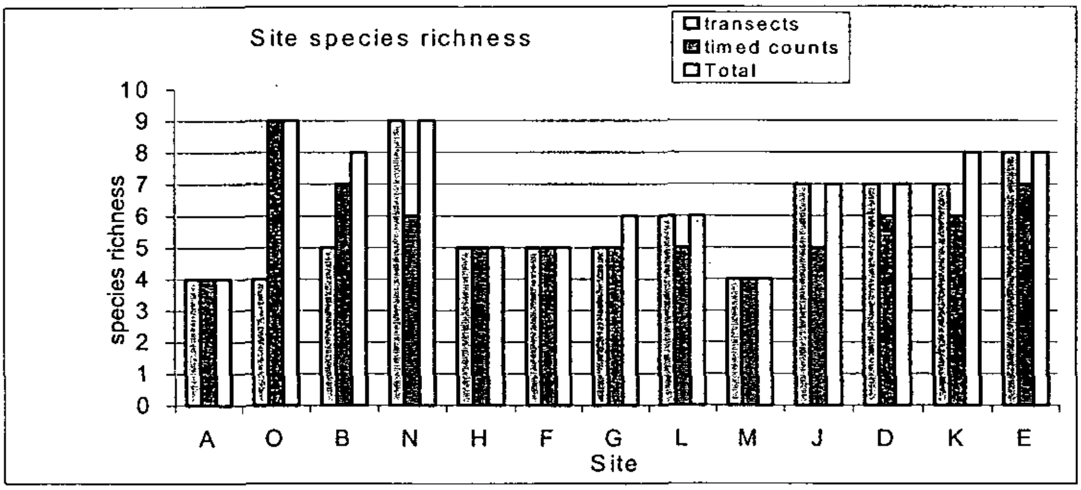
Species richness plotted in rank order for the two techniques does not follow a clear pattern. The forest sites tend to have higher species richness than the paddyfield sites.

Sites are ranked in order of increasing species richness. Differences in the rank order produced by the two techniques should be noted.



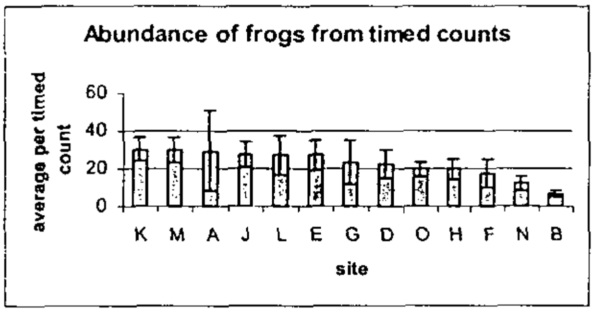


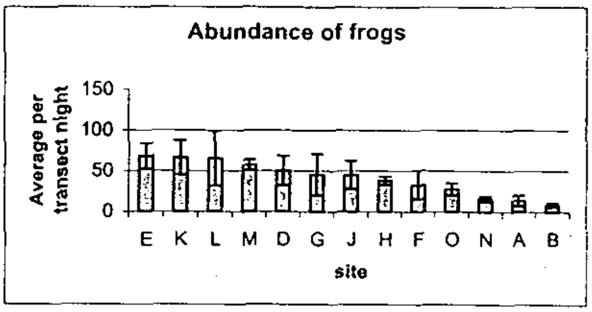
There is no clear distinction between forest and forest edge sites, shown clearly by the diagram combining richness estimates from both techniques with sites ranked from agriculture (A) to the most central forest areas (E). No inference is made about species known to be present but not detected by the sampling techniques.



Sites are ranked in order of their proximity to agriculture. A is a paddy field site and E is the most central forest site.

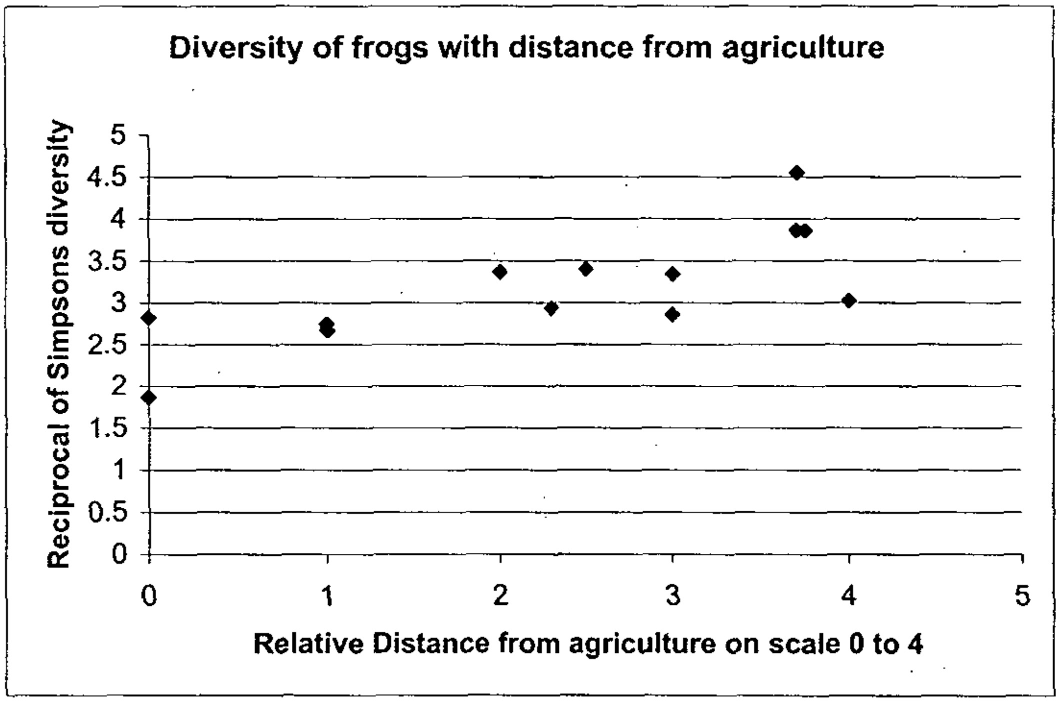
Rank Abundance Plots using both the transect and timed count results in turn have been produced for all the sites (all ranked based upon the rank abundance for site E, (i.e. the site nearest the centre of the watershed reserve). The pattern in species composition and relative abundance between the two methods is very similar. No meaningful measures of abundance can be calculated for the three species found in timed counts but not in transects, although they must be rare, cryptic or clustered in distribution. Further explanation as to their ecology is given in the species accounts section. All the forest sites have similar rank abundance plots. Both B and N which border agriculture show a larger species richness than both the paddy field sites and some of the forest sites. The diagrams on the following page summarise the Rank Abundance plots for the arbitrararily chosen habitat types; Paddy fields (sites A and O), coconut plantation (sites N and B), forest edge sites (sites H, F, G, L) and central forest (sites M, K, J, D, E).

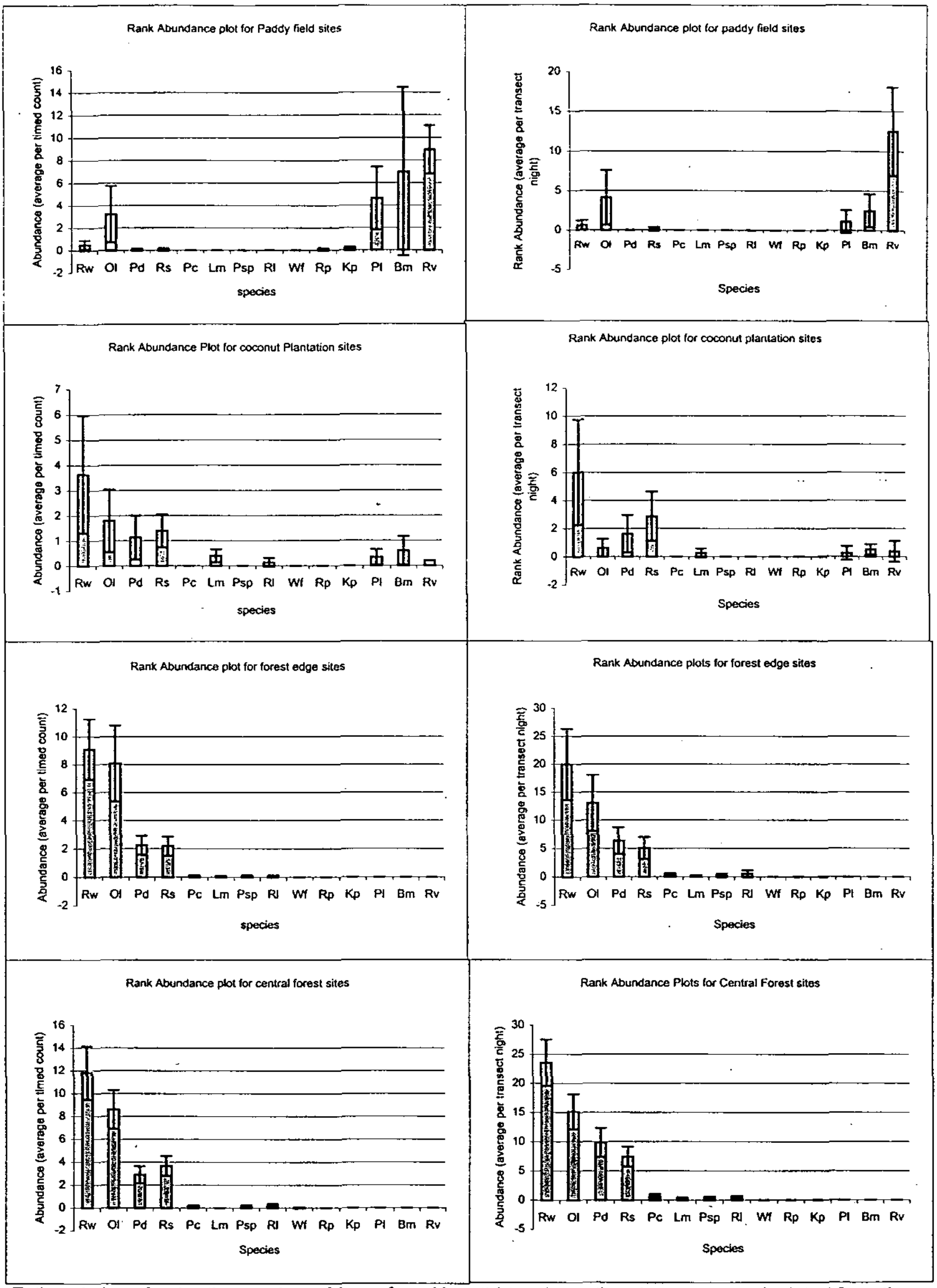




Sites are ranked in order of decreasing abundance of frogs. Changes in order for the two different techniques should be noted.

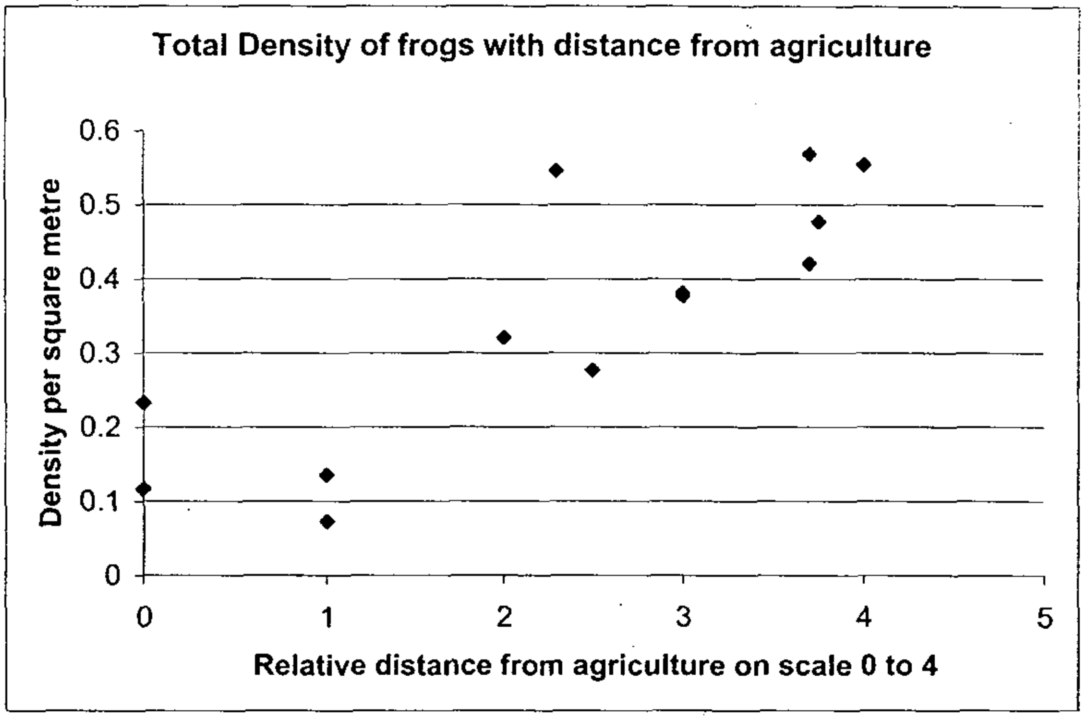
A variety of different diversity indices (Simpson's index, The Shannon Weiner Function, Brillouin's Index of species diversity and Evenness measures) for each site were calculated using the transect results. All indices produced similar patterns of diversity for the sites. Central forest sites were the most diverse, and paddy field sites the least. Sites that bordered agriculture or forest edge were more diverse than both the paddyfield sites and several forest sites.





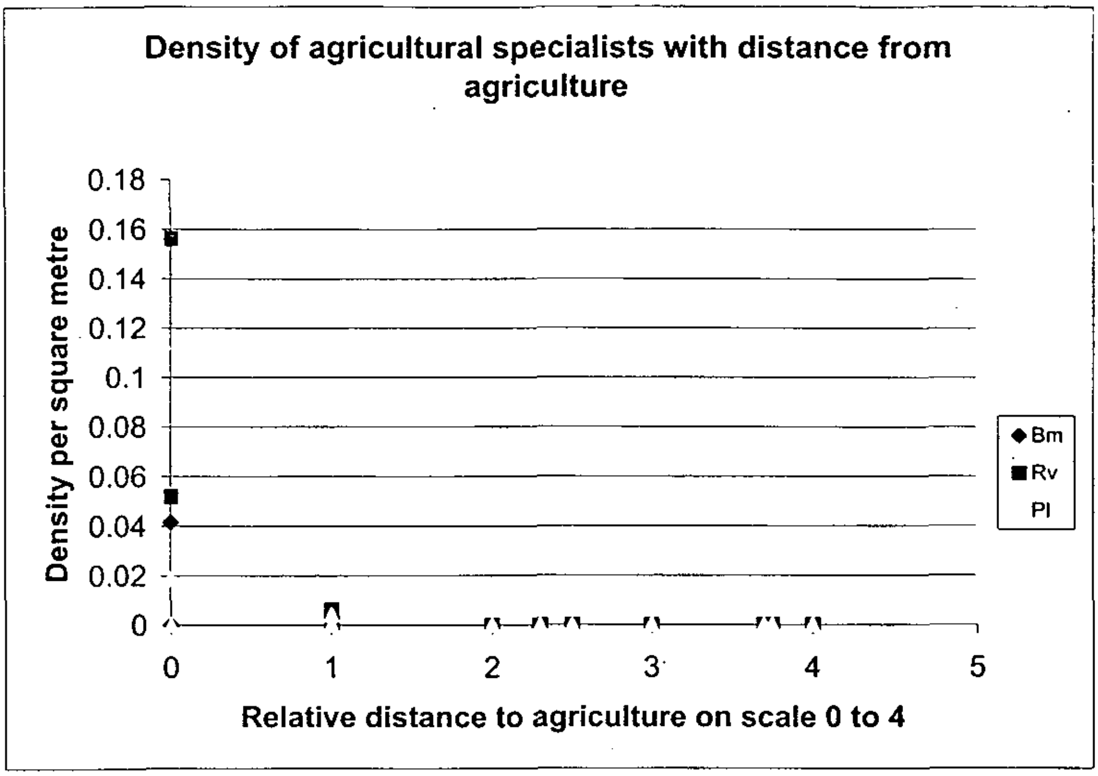
Extrapolations for the the number of frogs found in a thirty minute timed count are calculated from the encounter rate where necessary.

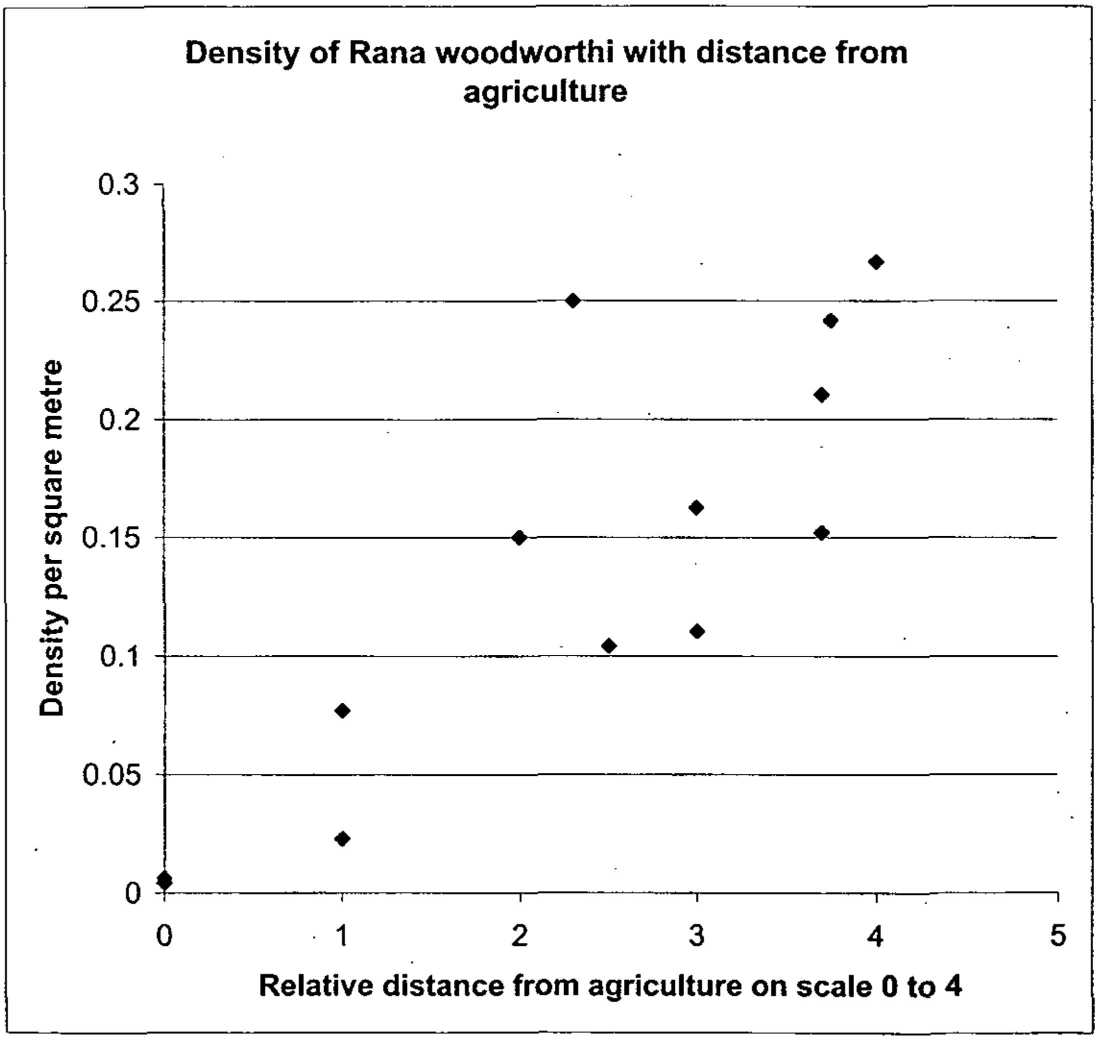
Abundance of all the common species of frog (*Rana woodworthi, Rana signata similis, Occidozyga laevis, Platymantis dorsalis*) increased with distance into forest. Central forest sites have the highest abundances of frogs. Site L is an exception, but it does have characteristics that make it a good frog habitat e.g. still but permanent water and lots of pandanus plants. *Bufo marinus, Rana vittigerra,* and *Polypedates leucomystax* were found exclusively in agriculture. Very few *Platymantis* sp, *Platymantis corrugatus, Rana magna* and *Rana everetti* were found by either technique.

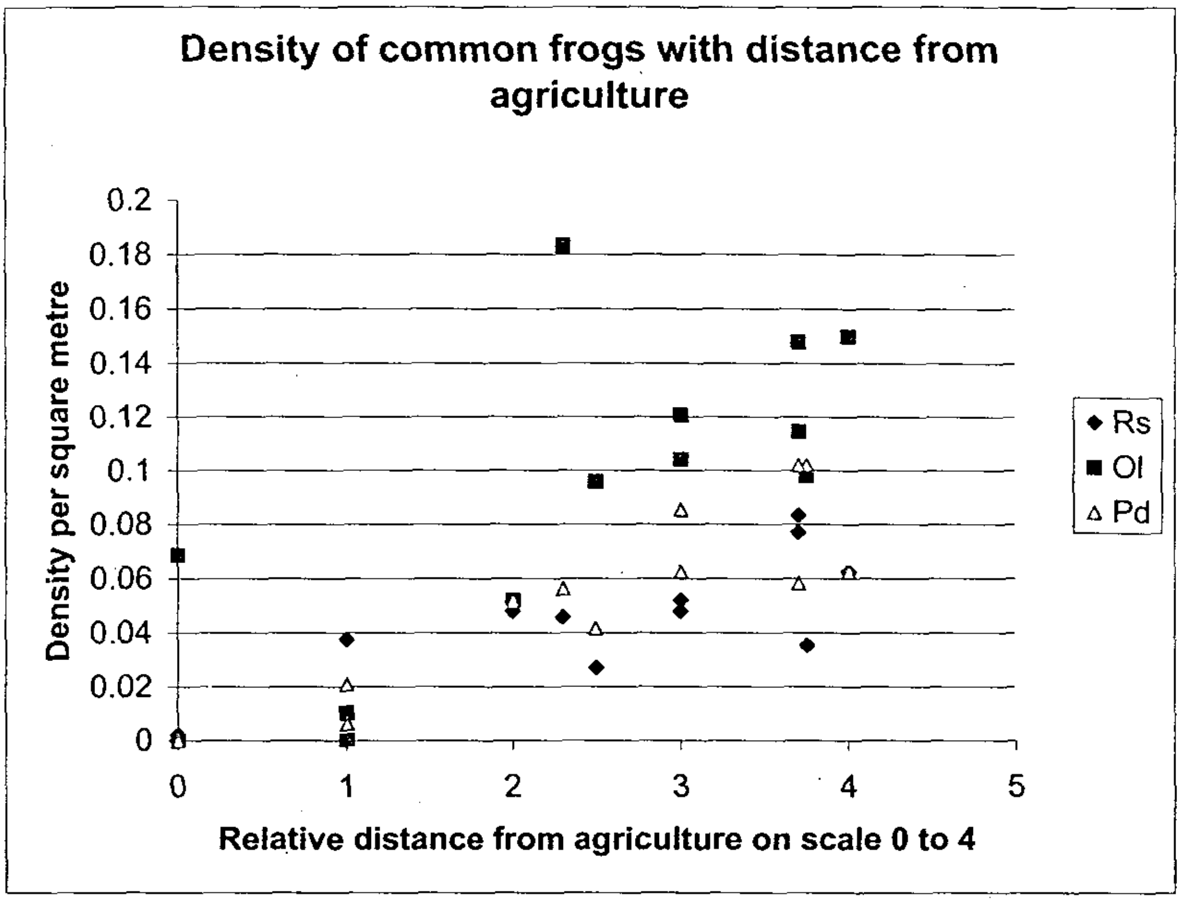


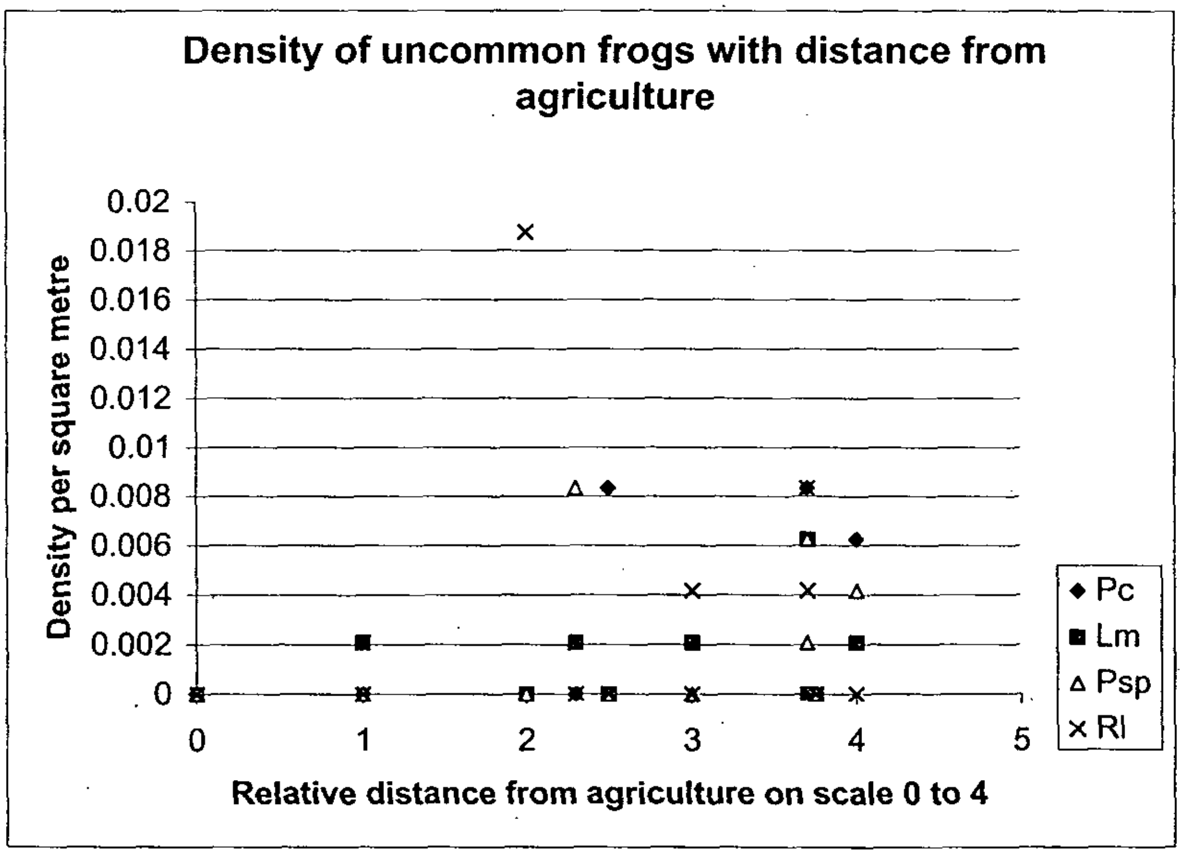
Abbreviations for the amphibian species in all the diagrams are as follows:

Bufo marinus Bm
Rana vittigerra Rv
Rana woodworthi Rw
Rana similis Rs
Polypedates leucomystax Pl
Platymantis dorsalis Pd
Platymantis sp. Psp
Platymantis corrugatus Pc
Limnonectes macrocephalus Lm
Occidozyga laevis Ol
Rana luzonensis Rl
White frog Wf
Rhacophorus appendiculatus Ra
Rhacophorus pardalis Rp
Kaloula picta Kp
Kaloula sp Ksp

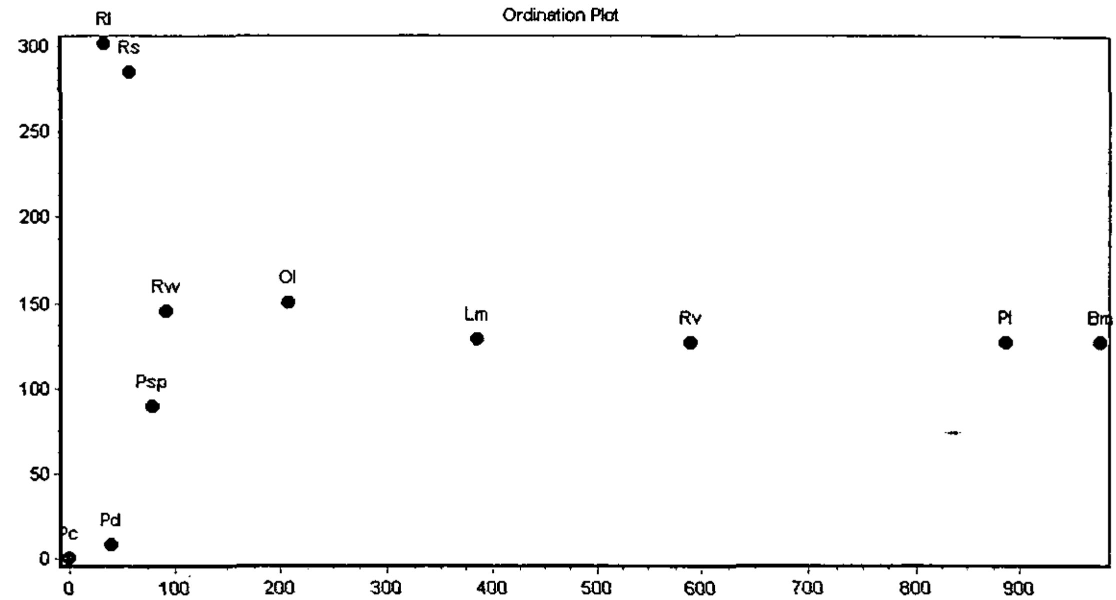

Density of agricultural specialists with distance from agriculture
Density per square metre
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
1
2
3
4
5
Relative distance to agriculture on scale 0 to 4
Bm
Rv
Pl


Density of Rana woodworthi with distance from agriculture
Density per square metre
0.3
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
5
Relative distance from agriculture on scale 0 to 4

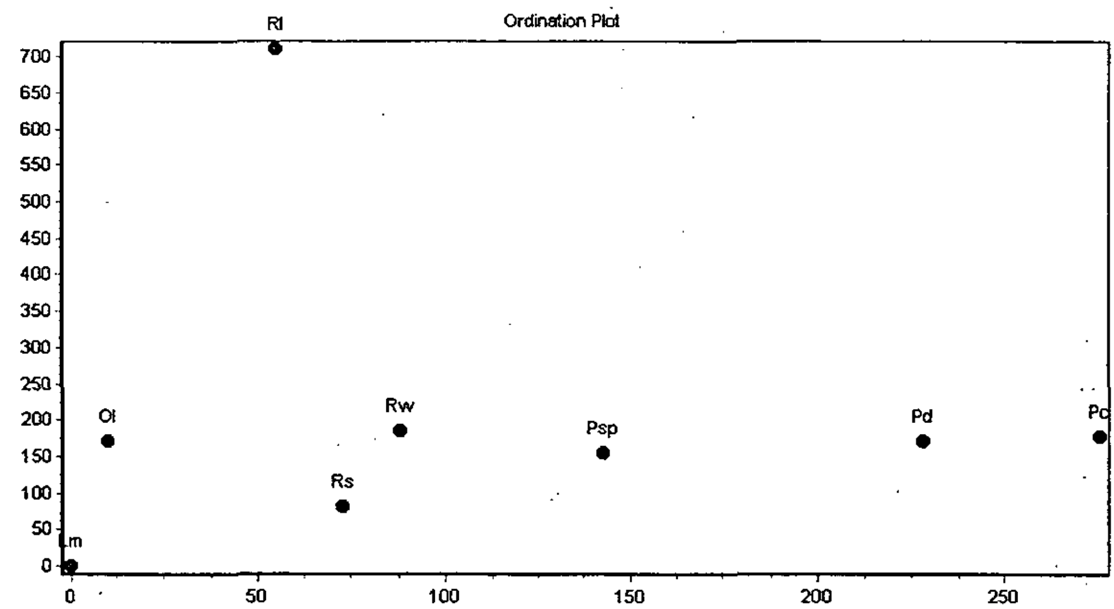

Density of common frogs with distance from agriculture
Density per square metre
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
1
2
3
4
5
Relative distance from agriculture on scale 0 to 4
Rs
Ol
Pd


Density of uncommon frogs with distance from agriculture
Density per square metre
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
0
1
2
3
4
5
Relative distance from agriculture on scale 0 to 4
Pc
Lm
Psp
Rl

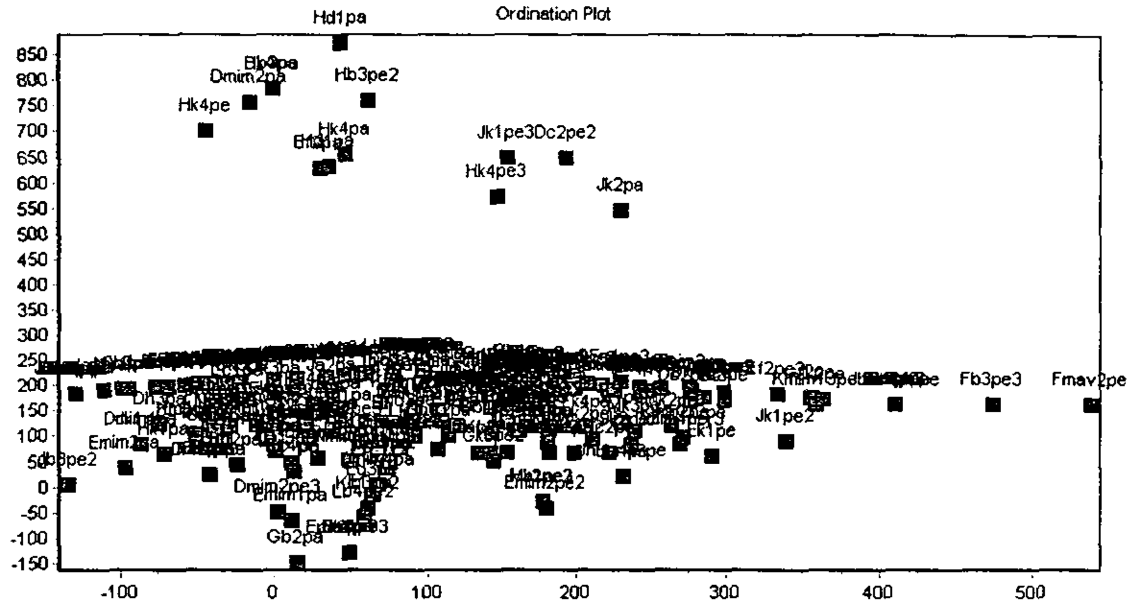
The decorana plot obtained from the complete transect data shows a gradient of ecologically different species. *B.marinus, P,leucomystax* and *R.vittigerra* are the species most indicative of the paddy field/ agricultural sites, (A, O, B and N). The *Platymantis* genus is clustered in the bottom right: *Platymantis* sp., *P.corrugatus* and *P.dorsalis*



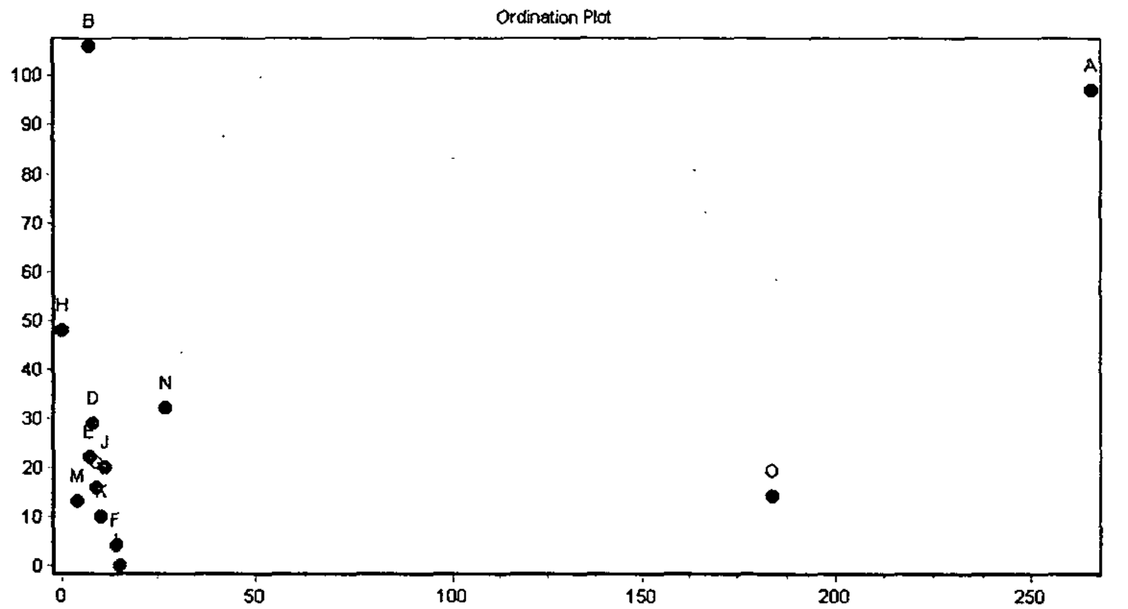
In the plot below uses the transect data but does not include the agricultural sites. The species separate out again.



The plot below shows the individual transects and their separation.



The plot below shows that all the forest sites, both central and edge cluster very closely together, but the agricultural sites separate out.



The community composition changes over the 5m gradient from the waters edge. In particular *O.laevis* was always found very close (within 1metre) to the waters edge. Both *P.leucomystax, R.luzonensis,* and *Platymantis* sp. are found usually at least 1m above the ground, but only *Platymantis* sp. is found at a distance from water.

Discussion

The timed count has more potential to find cryptic species (the 'white frog'), highly clustered species (*R.pardalis*) or those present at low densities (*L. macrocephalus*) because the search area is broader and calling individuals can be located, however no unit of area can be applied. Transect searches must be repeated many more times for an accurate assessment of species richness. Forest site M has one of the lowest species richness according to the transect data, but several species (*P.corrugatus, Platymantis* sp and *L. macrocephalus*) heard or seen were not detected during sampling. All of which are rare, clustered or cryptic species that were rarely detected by the transect techniques.

The species abundance and rank composition produced by both techniques is very similar, suggesting both provide a good representation of species relative abundance. However the timed count method is not applicable for comparisons of frog abundance between certain sites. At site A, a large number of frogs are detected by the timed count, but the transect method produces low density estimates (compared to forest densities), a result of large numbers of marine toads found in agricultural habitats. Discrepancies between the two techniques are a result of differences in the detectability of frogs and because some habitats are more difficult to search or because species found are more cryptic. For rare species sample sizes are too small to make reasonable extrapolations of density estimates.

Species assemblages

Species richness tends to be high at agriculture sites close to forest because of coexistence of agriculture and forest specialist species. Central forest areas appear to be more species rich than edge sites, but too few species are present to judge whether a clear pattern between core and edge forest exists. Therefore species richness is uninformative about species composition and quality. Some species may remain undiscovered on Polillo as suggested by the species accumulation curves; new species were found 37 days into the study.

Local habitat variables influence species richness and composition. There is a clear increase in density of the common forest species with distance from the forest edge, and rarer species may follow this pattern too (as is true for *Platymantis* sp.) or may be influenced by other factors that do not correlate with distance from forest edge (e.g. *R.luzonensis*). Parris (1999) reported a significant relationship between species richness and upstream catchment volume and Inger (1993) found stream width and stream gradient strongly influenced the compositional similarity of assemblages on both a local and regional scale. Stream width and flow may play an important role in the species composition of assemblages on Polillo. Observational trends suggests *R.luzonensis* is more abundant at wider streams, and or streams with a stronger current. In the Decorana plots the strong pull of *R. luzonensis* is very clear, suggesting its habitat requirements are quite different to the other species. In the first Decorana plot the x axis is suggestive of disturbance or proximity to agriculture because that is the axis upon which the agricultural specialists separate from the forest species. Both *Occidozyga laevis* and *Limnonectes macrocephalus* are found in forest and agriculture sites perhaps explaining their position in the Decorana plots.

Because total frog density and abundance increases with distance into forest, larger (and potentially more robust) populations of both sensitive and common species are found within forest compared to edge sites. However some of the edge sites (e.g. site L) have specific local breeding habitat variables that result in high densities of many species. These habitat variables do not necessarily suit all species, which must be understood when planning for conservation. The increase in frog abundance with distance from agriculture might not necessarily be a causal relationship, perhaps simply a correlation of suitable habitat factors with distance into forest). This study compares both abundances of frogs that have a strong dependance on water bodies for breeding as well as terrestrial breeders. It has been shown that edge has an important effect on abundance of a particular terrestrial breeder *Platymantis* sp, which presumably will not be affected to the same extent by water body size as the water breeders. It is important to establish how much of this increase in abundance of water breeders is attributed to distance and how much to factors such as increasing stream width.

Shannon's index is recommended by Hayek (1994) for determining amphibian diversity. Krebs (1999) recommends the reciprocal of Simpson's Index or the exponential form of the Shannon Weiner function to describe heterogeneity depending upon the decision to weight common species or rare species respectively. The sampling procedure did not always detect rare species known to be present. Large sample sizes were obtained for the common species that are probably more accurate. As a result of sampling inadequacies the Simpson's index is probably more appropriate for these amphibian populations than Shannon's index. The transect diversity estimates should be used because they produce accurate abundance estimates comparable between habitats, despite the timed count technique detecting more of the rare species. All the indices produced similar diversity patterns despite each giving different weight to specific properties of the species' abundance distributions.

The diversity pattern can be interpreted many ways. There is a slight trend of increasing diversity with distance from agriculture, but there are also high levels of diversity at the agriculture border forest sites. This could be a result of coexisting agriculture and forest species, at the interface, and increased number of sensitive high quality species (Hambler and Speight 1995) in the central forest. This pattern could be a reflection of sampling inadequacies. As common species increase with distance into forest, rarer species may or may not follow a similar pattern. Rarer species may contribute in unpredictable ways to the overall diversity measures resulting in higher diversity estimates for sites with an overall lower abundance of frogs (such as the interface sites).

I suggest the diversity indices should not be used as a basis for conservation measures in this study because of the difficulty in interpreting their meaning. Species richness is uninformative about species quality and therefore ranks agriculture-forest border sites together with central forest sites that contain rare species, which are not found outside forest. From the rank abundance plots sensitive forest species, and agriculture specialists can be identified, these plots are much more informative on species quality, and the effects of habitat quality. Careful accurate scaling of the plots is required for the general increases in abundances to be detected with distance from agriculture. Species abundance plots against distance from agriculture show this pattern clearly (see diagrams).

The transects identified habitat partitioning within some species. Certain species are rarely found together and when they are, both are at low densities, this may be due to overlap in their habitat requirements. Some species such *P.corrugatus* had clustered distributions, but further intensive work is necessary to quantify spatial distribution. Notably the terrestrial breeders were the only species that were found in abundances away from water bodies.

The importance of habitat structure:
Positions of frogs within transects suggest habitats with greater structural diversity will support higher numbers of species because an increased number of microhabitats is available. Most of the streams and rivers around the watershed that are surrounded by coconut plantation have a mixed variety, mainly of agriculturally important trees, at their edges. The agriculture is monoculture, either coconuts or paddies, therefore not able to support a very diverse community (*Bufo marinus*, and *R.vittigera, Kaloula picta, P.leucomystax*). The stream edges are more structurally diverse and therefore able to support more species rich communities. Stream edges that have low growing bushes and overhanging branches to water bodies provide habitat for some of the more arboreal species such as *R.luzonensis* and *P.leucomystax*,. Even *R.pardalis* was found at paddyfield site O and over a temporary pool amongst agriculture not far from base camp. Sites between agriculture and forest have been shown to have the most species present possibly due to the close proximity of two habitats, allowing agriculture species to mix with some of the 'forest' species (i.e. *Bufo marinus, R.vittigera, Kaloula picta, P.leucomystax, R.woodorthi, R.similis, O.laevis, P.dorsalis* all found at one site).

Fragmentation and corridors:
Vegetation bordering streams allow species to breed in coconut plantations and rice paddies. Streams act as wildlife corridors, especially where they link otherwise unconnected patches of forest and what would otherwise be isolated frog populations. Therefore as a conservation measure these corridors should be preserved together with the surrounding trees and vegetation. This is at present a fortunate consequence of local farming practices around Sibulan.

Without further indepth analysis any minor changes in the frog communities within the forest cannot be detected. Possibly more samples would allow discrimination between sites. Community analysis by decorana suggests all the sites in forest even H which is coconut on one side and forest on the other, support essentially the same communities (despite the likely differences in forest quality/ disturbance levels etc) (differences in overall abundance is possibly due to increased capacity of the breeding habitat). No major differences in the structure of the forest can be identified from the PCQM data at the sites. The decorana plot of the forest sites (excluding site M and K for which tree species data was not collected) would seem to confirm the choice of sites, because edge sites cluster together and central sites cluster together. Therefore in this case Primary forest is differentiated from edge sites and smaller patches of forest by its species composition, not its structure. Presumably there is little difference in the structure of the habitat for the frogs, which would adequately explain why both edge and central forest support the same communities. Further analysis of understorey vegetation and other habitat characteristics are necessary to identify whether they are not different between edge and forest sites, and how they correlate to the frog communities.

Platymantis sp transects

Introduction

The status and distribution of *Platymantis* sp was investigated. Nothing is known about this frog, which has a potentially highly restricted distribution. It has not been found on Luzon, therefore may be endemic to Polillo. The most similar frog on Luzon is *Platymantis luzonensis* however the call of *P.luzonensis* differs from *Platymantis* sp as described in the sound analysis section. A detailed study is required to determine the comparative morphological differences between the two frogs.

Only 10 individuals were found in total from the transects and 7 from the timed counts. This species was also only found at the forest sites, making it one of the rarer frogs. Many of the anecdotal Platymantis sp sightings were 2m or more above the ground. The chance of finding frogs at heights greater than 2m is much less than below 2m i.e. within our field of vision. Discovering the call of *Platymantis* sp made it possible to locate individuals more easily to within 1m square (pinpointing the individual takes much more time and effort). The call also confirmed anecdotal evidence that most individuals call from at least 2m above the ground. Therefore search techniques used previously may not be effective in finding individuals because of their spatial location and habitat preference.

A technique was devised based on detecting the calls of male frogs to estimate absolute densities (density of calling/ breeding males) in forest sites. This provides an opportunity to compare densities to the estimates of the other methods, therefore assess their effectiveness.

AIMS

- Determine the absolute density of *Platymantis sp* in the central area of the watershed forest
- Determine if density changes with distance from agriculture and distance from core forest
- Investigate the effect of forest edge on *Platymantis sp* abundance
- Compare relative abundance for *Platymantis sp* with timed counts and transect estimates
- Produce conservation recommendations based on the results

Methods

Transects were walked along a chosen set navigable route and the distance recorded. For every *Platymantis* sp heard, the distance along the transect and the perpendicular distance to the location of the calling frog was recorded. Initially transects were completed along a gradient, from outside the watershed reserve amongst coconut plantation, towards the centre of the watershed reserve and the potentially least disturbed forest. Transects that entered the watershed from different directions were completed to try and omit any landscape directional gradient biases. Later transects were completed in central sites in the watershed to compare with forest edge estimates. Totally random placement of transects was impractical. Original transect routes were repeated and numbered ribbons were tied to branches within 1m of calling frogs, therefore on a subsequent transect the position could be recognised again.

The Programme DISTANCE (Laake *et al.*, 1993) was used to estimate density. Four different estimator models were used, and the optimum model, with the best fit and the lowest Akaike information criterion (AIC) was selected by DISTANCE. The histograms for best fit of the detection function were examined for potential problems (e.g. input errors, heaped and spiked data) (Brady.L 1993). The forest transects have been split into different sections appropriate to their distance from agriculture, and densities calculated to assess whether densities change with distance from the edge.

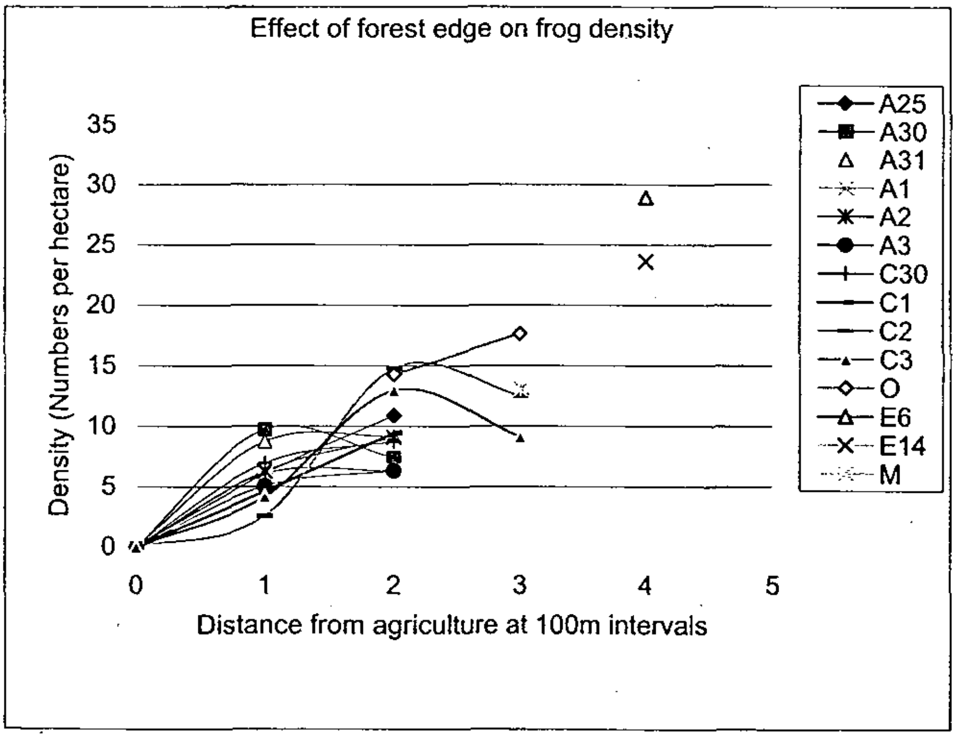
RESULTS

Density estimates are given in individuals per hectare.

Graphs (see appendices) show the distribution of frogs encountered on transects. Clusters of points from different transect nights often correspond to the same calling location, it is not possible to determine if the same frog was calling from that location. The 'edge' transects have been analysed from where the first *Platymantis* sp starts calling from, although the transects started several hundred metres before, to ensure no frogs were overlooked. The third edge transect starts from where fewest frogs were heard calling, because of time constraints.

Forest edge transect A density estimates ranged from 5.2 to 11.8 per hectare (mean 7.85, n=6). Forest edge transect C density estimates ranged from 3..8 to 6.2 per hectare (mean 5.15, n=4). Central forest transect estimates were 13 (transect M, n=1) and 26.2 (transect E, n=2).

Splitting the edge transects up into 200m blocks revealed that densities tended to increase with distance into forest (see appendix for the 1st, 2nd and 3rd 200m density estimates which are also illustrated in the graph below).



Distance from agriculture is plotted by approximate distance from agriculture. The distance to the edge of the forest is used approximated to the nearest 100m , with the edge transects divided up into sections 200m long (see appendix). Each transect is labelled by site (A, C, M, O, E) and by the date (25/8/99, 30/8/99, 3/9/99 etc. For full dates see appendix). Repeated transect nights and transect sites are therefore displayed together. The data legend therefore corresponds to the transect and the day of the month the transect was completed.

Discussion

Highest densities of *Platymantis* sp are found in the central forest areas, in particular site E. This site had the highest diversity indices and was predicted to be the most pristine habitat by all other assessments. *Platymantis* sp were absent in agriculture and found at their lowest densities where forest meets coconuts, with increasing densities with distance from agriculture.

The data set was relatively small and it would be expected that the detection function for an aural cue (such as a calling *Platymantis* sp) would be different to a visual cue. However the chance of detecting a calling frog was high and all transects contained reasonable numbers of frogs such that sensible confidence limits and well fitting detection models were applied. All suggesting the model selected by DISTANCE is realistic.

The densities calculated for one site varies from one transect night to the next. All lie within the appropriate confidence levels of the estimates except for one (see appendix) and most estimates are very similar. This suggests the frog activity changes from night to night, but a reasonable estimate of total density of calling males at a site can be made from one transect night.

Absolute population size cannot be estimated, because male and female survivorships may not be related and because maximum counts of calling males may not be constant proportions of the adult population (Zimmerman 1994). Therefore densities estimated by the aural transects are only for male frogs and are an underestimate of total population densities, whereas males, females and juveniles where found using the timed counts and transects.

Disagreement exists on whether edge has important effects on tropical amphibians (Duellman 1978; Zimmerman & Rodrigues 1990 vs. Gambold & Woinarski 1993; Culotta 1995). My results suggest a significant edge effect whereby frog density does not reach maximum levels until at least 200m or more from the forest edge. The highest densities recorded reach up to 28 frogs per hectare. None of the edge transects reach these densities despite travelling at least 600m into the forest. However other central forest sites (such as site M, density =13 frogs/ hectare), do not approach such high densities. The edge transects A and C are very suitable for this kind of study, but not necessarily typical, because when the forest stops, there is a definite boundary where agriculture replaces forest. Edge transect O is not so clear cut, agriculture and small forest patches are interspersed, which explains the immediately higher densities of frogs at transect O than A and C.

Forest fragments are often much smaller than the 200 edge threshold required to reach maximum densities and so presumably support lower densities than larger forest tracts. The importance of forest for the survival of this species is essential. Individuals were heard calling outside forest (on the 3 hour walk from Polillo town 45 different frogs were heard calling. All were heard in isolation and only amongst patches of trees), but this species is highly restricted to forest habitat. Amphibians vary in dispersal ability (Sinsch 1990), which suggests that species may exhibit differential success in surmounting barriers created by habitat fragmentation (Pearman 1997). The dispersal powers of this frog are unlikely to be large. This species clearly prefers living above 2m from the ground with at least some canopy cover. Without linked patches of forest this species is likely to decline due to isolation and reduced densities resulting from edge effect on small forest patches.

When the frogs are in lower densities calling sites seem to be more constant, as can be seen from the diagrams of transects A and C (see appendices) i.e. nearer to forest edge than in core forest. At high densities there is still evidence for favoured calling sites. It is not possible to say whether the same frogs are calling from the same position on consecutive nights. Possibly lower densities of calling males reduces competition for calling positions. Favoured calling sites may be due to a lack of suitable calling positions sites at edge sites compared to core forest. Pinpointing individual frogs was more accurate when frogs called at low densities, compared to high densities where it takes longer. Reduced clustering of calling positions on consecutive transect nights in forest may be due to increased inaccuracy of pinpointing locations. The labelled ribbons showed that relocating an identical calling position can result in discrepancies in measurements of more than 5m.

Densities per hectare calculated for *Platymantis* sp from the transect data are:

	O	N	M	L	K	J	H	G	F	E	D	B	A
Psp	0	0	0	83	42	0	0	0	0	63	21	0	0

There is no distinction between forest and edge sites from the above data. Some of the central forest sites have densities of 0, whilst some of the edge sites have densities of 83 (affected by finding a frog repeatedly in exactly the same position on two consecutive nights by independent observers). However averaging the densities and assuming all the forest sites have the same densities produces an average density of 26.1 per hectare. Considering that females and juveniles are calculated in that estimate it is probably a reasonable comparison to the estimates generated by DISTANCE. This suggests that transect data would approach accurate density estimates if the sample size increased greatly. However from this study the density estimates from transects are not reasonable, because too few frogs were found.
Platymantis sp is spatially separated from the other *Platymantis* which are all ground dwelling or found amongst shrubs and bushes up to a metre above the ground. The other frogs frequently found above 2m (*P.leucomystax,R.pardalis,R.everetti*) all depend on water to breed and are usually found clustered at the edges of water bodies, whereas the DISTANCE data shows *Platymantis* sp are found at a distance from water.

Sound Analysis

Frog calls were recorded to produce a popular guide to the frogs of the island. All frogs on Polillo can be recognised simply by ear and are not easily confused with the other species on the island. Brief analyses of the calls are provided, for use by other students working on frog calls of the amphibians in the Philippines. All analyses are based upon a very small sample size, in most cases only one, however some species have a repertoire of different types of calls which may not be reflected in analysis. For most species frogs were heard calling frequently and sounded the same. Therefore the calls recorded provide a useful guide for reference, but are not comprehensive. Copies of all recordings have been deposited at the British library of Wildlife Sounds, The National Sound Archive, The British Library of wildlife sounds.

Sound analysis was conducted using the Canary 1.2 package for the Macintosh computer to produce spectrograms (frequency versus time, amplitude represented by shades of grey), Fast Fourier Transform (FFT) spectra (amplitude/ pressure in arbitrary units versus frequency), and oscillograms (amplitude versus time). Reticule measurement cursors were used to give precise measurements. The advertisement calls are described together with numerical data about the temporal and spectral features of the calls. The calls are compared with other species of relevance. Call repetition rate is not such a useful feature as it can increase dramatically for species that call in a chorus, and can be affected by temperature.

To avoid confusion in the description of the calls, definitions for descriptive terms are given below:
The *call* is '...a discrete unit of vocalisation composed of one or more separate bursts of sound and temporally distinct from similar units...'(Zweifel 1985, p.272).

Fig 1.1 A 'call' (of the white frog) made up of 23 chirps

Fig.1.2

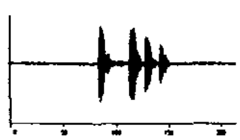


Fig. 1.3

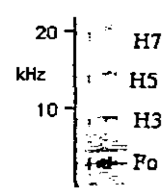
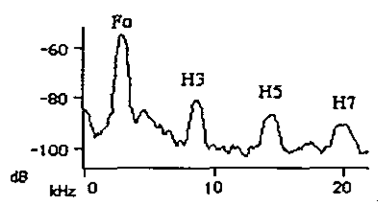


Fig. 1.4



A *pulse* is a physical unit of sound energy, comprising of a number of *waveform cycles* in a simple undivided wave train, rising to a single peak in amplitude and then falling. (P.Olding 1998) Figure 1.2 illustrates a chirp composed of four pulses. Pulses may be produced singly, as groups or as an extended series. Both a single pulse or a brief finite series is termed a chirp (Bennet-Clark, 1989). The envelope shape of the chirp is compared with relevant species.
The *fundamental frequency* is the lowest frequency of vibration, and the *dominant frequency* is that spectral band with the greatest energy output. *Harmonics* are frequency bands that are integer multiples of the fundamental frequency, generated by

different modes of vibration, generally forming a harmonic series, with the fundamental frequency as the first harmonic (Fletcher 1992). Usually the fundamental frequency is the dominant frequency. Cases where the harmonics are of the dominant frequency and not the fundamental are labeled as such. By convention the fundamental frequency is labeled Fo, and the harmonics as H2, H3, etc depending upon their multiple. Figure 1.4 illustrates an FFT spectrum of a single chirp with the associated spectrogram (figure 1.3) showing H3, H5 and H7 each with decreasing amplitude from the dominant frequency.

1.2 The White frog

A white frog was located by its call during a visit to the north of Polillo on 9/9/99 near Panukulan. The frog was calling from ferns approximately 2.7m above the ground overhanging a small stream. Four of its calls were recorded (2140 hours, 25°C), the frog was collected for morphometric measurements (0.5g, SV 22mm) and returned to the same site the following morning. On the 11/9/99 in the same location another white frog was found calling (0.55g SV 22m), possibly the same individual as found on the 9/11/99. (Refer to detailed description of frog).

Each call consisted of a train of chirps illustrated in Figure 1.2.1

Fig 1.2.1 The second call recorded from the white frog

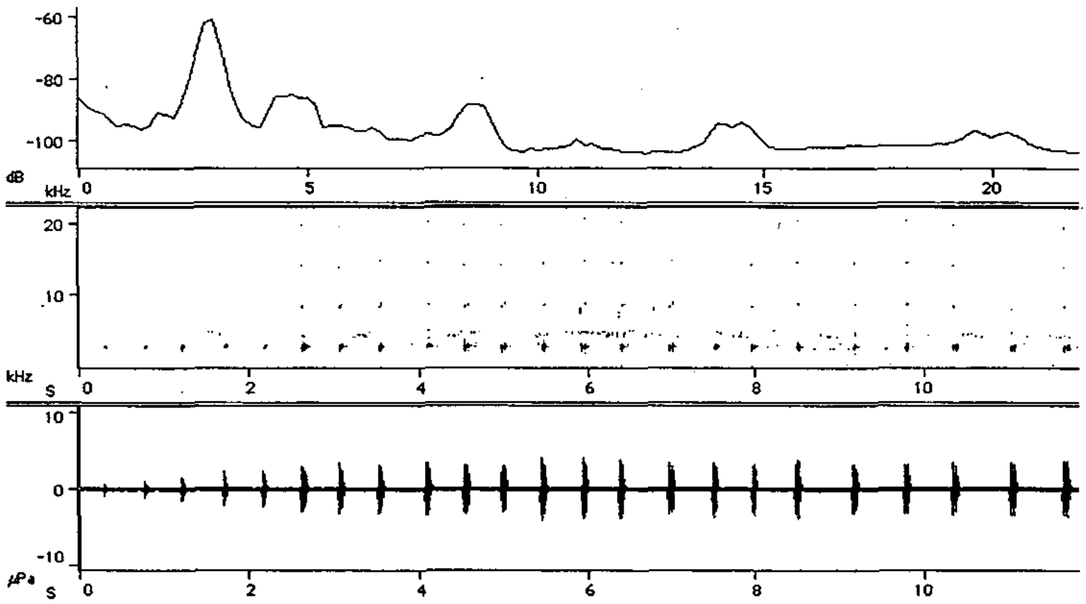


Table 1.2.1

Call	1	2	3	4
Number of chirps/call	12	23	24	23
Call Duration (s)	6.29	11.47	12.25	11.49
Time to next call (s)	82	82	84	-
Dominant frequency kHz	2.8	2.85	2.87	2.89
3H kHz	8.2	8.68	8.57	8.75
5H kHz	13.6	14.05	14.24	14.5
7H kHz	19.1	19.7	19.6	20.04

Table 1.2.1 describes the characteristics of the call pattern from each call in the recording and the dominant frequencies and harmonics from the FFT spectrum. (see fig 1.2.1).

Table 1.2.2 summarises the characteristics of the finer call structure.

The White frog	*Chirp duration (s)*	*Interval (s)*	*Chirp and interval (s)*	*Dominant frequency (kHz)*
Mean	0.069	0.46	0.52	2.77
Standard Error	0.0013	0.0086	0.0109	0.007
Standard Deviation	0.012	0.075	0.096	0.066
Count	82	78	79	82
Confidence Level(95.0%)	0.0027	0.017	0.022	0.0146

The call is repeated at regular intervals approximately every 80-90 seconds, in call groups of approximately 12 to 24 trills. The call rate is 0.65 per min, and the chirp rate is 2.0 per second. Each chirp is composed of a dominant frequency at about 2.8 kHz plus H3, H5, and H7. The 3rd harmonic is approximately 30 dB lower than the dominant frequency, the 5th about 6 dB less than the 3rd and the 7th is 2 dB lower again. It is sometimes not possible to distinguish H5, and H7 depending upon background noise levels. The call takes between 3 and 6 chirps to reach the maximum amplitude and correspondingly similar envelope shape, after which amplitude is relatively constant. The first few chirps have correspondingly different envelope shapes as the call builds up. See figure 1.2.2 for the typical envelope shape of the chirps. Chirps are made up of usually three or four pulses.

Table 1.2.3 summarises the call structure and pattern for a recording of *Platymantis sierramadrensis* donated by Arvin Diesmos.

Table 1.2.3

P.sierramadrensis	Pulse duration (s)	interval duration (s)	Pulse + interval (s)	Dominant frequency (kHz)	H3 (kHz)	H5 (kHz)	H7 (kHz)
Mean	0.057	0.76	0.82	2.8	8.34	13.96	19.5
Standard Error	0.0017	0.04	0.040	0.021	0.034	0.048	0.049
Standard Deviation	0.0059	0.133	0.136	0.074	0.12	0.17	0.17
Count	12	11	11	12	12	12	12
Confidence Level(95.0%)	0.0038	0.090	0.091	0.047	0.074	0.107	0.108

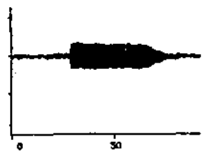
Table 1.2.4

	Pulse duration (s)	interval duration (s)	Pulse + interval (s)	Dominant frequency (kHz)	H3 (kHz)	H5 (kHz)	H7 (kHz)
White frog	0.069	0.46	0.52	2.77	8.5	13.9	19.8
P.sierramadrensis	0.057	0.76	0.82	2.8	8.34	13.96	19.5

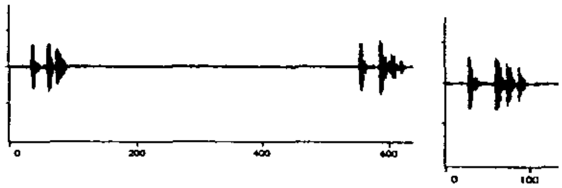
The call of *P.sierramadrensis* consists of the same dominant frequencies and harmonics as the white frog. However the pattern of the chirps is very different. The call of the white frog is made up of a regular pattern, of trains containing 12 to 30 chirps separated by large intervals of between one and two minutes. Chirps are shorter in the white frog than *P.sierramadrensis* and are separated by a smaller interval. The recording of *P.sierramadrensis* is not long enough to determine the number of chirps to a call if such a chirp train exists. The description of *P.sierramadrensis* (Brown, Alcala, Ong, and Diesmos. 1999) states 'the call of this frog sounds like "pek-pek-pek" produced in a forceful manner. Each note ranges from 2500 to 3250 Hz with a duration of 0.05 to 0.06 of a second. The time interval between notes is about 0.53 to

0.64 seconds.' This corresponds to the analysis of *P.sierramadrensis* above except for the time interval, which differs slightly. No pattern to the chirps is described by Brown *et al.* (1999). Each chirp made by the white frog is composed of 3 or 4 short pulses (figures 1.2.2) whereas for *P.sierramadrensis* each chirp is a single pulse (figure 1.2.3), with a longer duration than the white frog pulses. This feature of the frog call is unmistakable and separates the two recordings very distinctly.

Figure 1.2.3



Figures 1.2.2



1.1 *Platymantis* sp

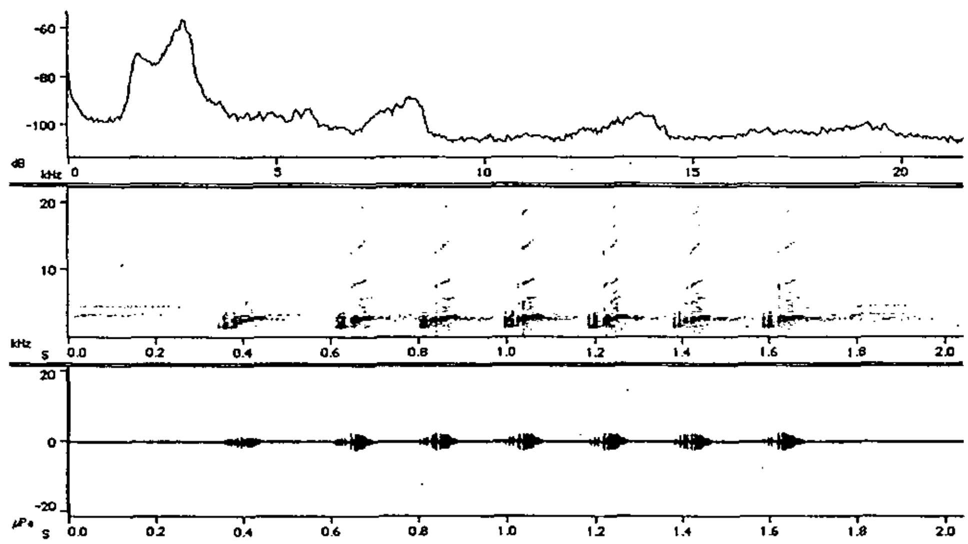
Platymantis sp calls from usually 2m or more above ground. Notes about its distribution and habitat are in the section 'species accounts'.

The call analysis was conducted on two samples of recordings (one from 20/8/99, Sibulan watershed reserve, Polillo Island, 20.30hours, 26°C, the second from 9/9/99, Near Panukulan, north Polillo, 2030hours, 24.8°C). This frog calls at irregular intervals from 11 seconds to a minute apart. The call interval details are given in the table below. The average is 34.8 seconds apart (n=13), but, because of its irregularity call interval is not a useful descriptive characteristic for this frog. On average the call is composed of 6 chirps, see table 1.3.1. Occasionally a single chirp is emitted, but these have been omitted from the calculations of number of chirps per call, because they are not typical. The spectrogram, spectrum and waveform are shown in figure 1.3.1

Table 1.3.3

Platymantis *sp*	No. of chirps per call	Average call length (s)	Call interval (s)
Mean	6.1	1.2	34.8
Standard Error	0.3	0.049	3.86
Standard Deviation	1.27	0.20	13.9
Count	17	17	13

Figure 1.3.3



The FFT spectrums show the call is two tone with two dominant frequencies. The first part of the call has a dominant frequency at approximately 1.7 kHz. The second part of the call has a dominant frequency at approximately 2.7 kHz (13dB louder than the first dominant frequency) with H3 at 7.7 kHz (30 dB lower than the dominant frequency) and weaker H5 and H7 (a further 8 dB lower than H3).

Table 1.3.2 summarises the call characteristics

P.sp	Dominant frequency Hz	Dominant frequency Hz	Chirp duration (s)	Interval Duration (s)	Call period (s)
Mean	1870	2699	0.088	0.13	0.220
Standard Error	22.68	11.15	0.00078	0.0066	0.0065
Standard Deviation	232.4	114.2	0.008	0.061	0.06
Count	105	105	105	88	88

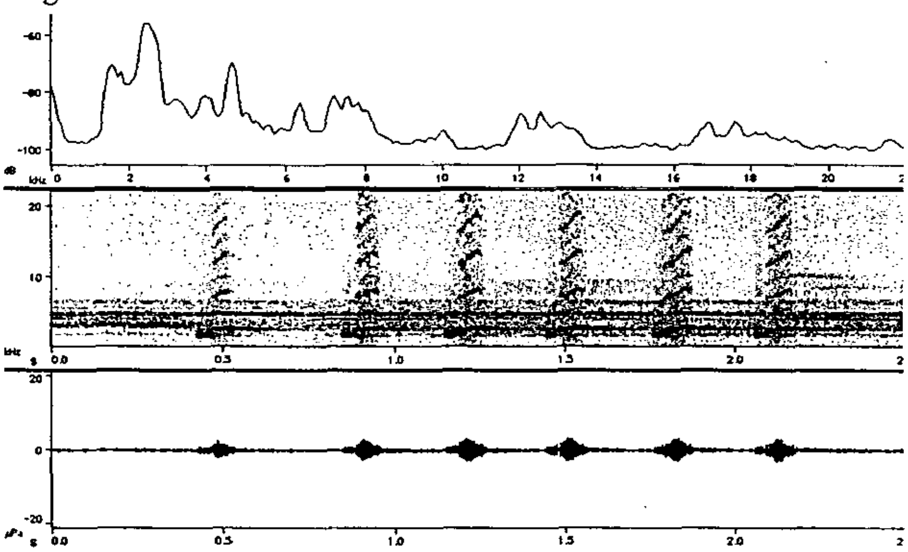
1.4 *Platymantis luzonensis*

This frog calls from heights at least 2m above the ground. The analysis is from two recorded individuals (one donated by Arvin Diesmos, a second recorded on 18/9/99 from Mount Makiling, near Mudsprings, Los Banos, Luzon 25.4°C). The average time between calls is very variable (12-108 seconds, mean 47, n = 11). It is not possible to draw meaningful conclusions for comparisons between call rates.

Table 1.4.1

P.luzonensis	No. chirps per call
Mean	4.7
Standard Error	0.3
Standard Deviation	0.58
Count	3

Figure 1.4.1



There are not enough calls recorded to analyse call length (n=3)

The call of *P.luzonensis* has two tones the first part of the call has a dominant frequency at 1.6 kHz. The second part of the call has a dominant frequency of approximately 2.57 kHz, with a strong H3 (25 dB below the dominant frequency) and weaker H5 and H7. There is a lot noise from the recording between the dominant frequency and 3rd harmonic, which corresponds to the extra peaks on the FFT spectrum.

Table 1.4.2

P.luzonensis	Fundamental frequency (kHz)	Dominant frequency (kHz)	Chirp duration (s)	Interval duration (s)	Call period (s)
Mean	1.626	2.572	0.112	0.20	0.315
Standard Error	0.027	0.019	0.002	0.015	0.015
Standard Deviation	0.107	0.078	0.008	0.05	0.052
Count	16	16	16	12	12

Comparison of *Platymantis* sp to *P.luzonensis*

	Fundamental frequency (kHz)	Dominant frequency (kHz)	Chirp duration (s)	Interval duration (s)
Platymantis sp	1.870	2.699	0.088	0.13
P.luzonensis	1.626	2.572	0.112	0.20

The two groups have essentially the same dominant and fundamental frequencies, those of *Platymantis* sp are perhaps slightly higher. However the chirp length and interval between chirps within the call are shorter for *Platymantis* sp than for *P.luzonensis*. This can be detected whilst listening to the call. The calls of *Platymantis* sp. Were recorded at temperatures above and below the *P.luzonensis* recording therefore differences do not reflect temperature related trends. The number of chirps per call is higher for *Platymantis* sp than for *P.luzonensis*. (mean 6.1 versus 4.7).

Figure 1.4.2

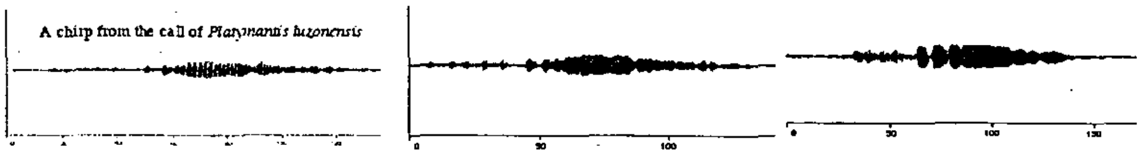
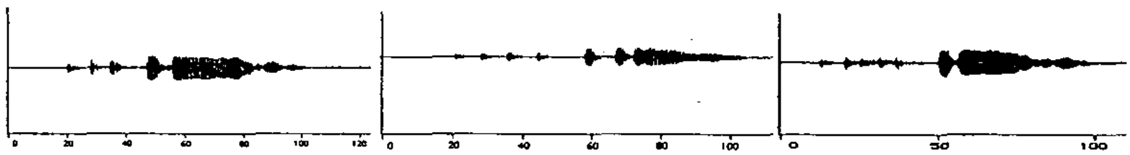


Figure 1.4.3



P.luzonensis (fig 1.4.2) and *Platymantis* sp (fig 1.4.3) both have similar envelope shapes. Each chirp within the call is made up of several pulses. For both species the first half of the chirp is at one dominant frequency and the second half of the chirp at another with harmonics that form a clear upward sweep. For *Platymantis* sp the first half of the call consists of distinct pulses (3, 4, or 5). The second half of the call consists of less distinct, overlapping pulses. The same is true for *P.luzonensis* although the pulses within the first part of the call are less clearly defined.

1.5 *Platymantis dorsalis*

The analyses are based upon the combined characteristics of 4 different recordings

Table 1.5.1

	chirp duration mS	chirp interval mS
Mean	83.4	480.8
Standard Error	2.4	27.7
Standard Deviation	12.21	135.84
Count	26	24

Frogs call during the night and often begin calling in the afternoon stationed on the ground or from low bushes and shrubs, rarely higher than 1.5m from the ground. The call (fig 1.5.2) is composed of short (mean duration 83.4 mS) repetitive (intervals of 480mS) chirps. Sometimes a very quiet click can be heard before the call and occasionally a few chirps are emitted all together as illustrated by figure 1.5.1.
The call starts at approximately 0.5 kHz and rises rapidly in a sharp upward sweep. The main body of the call is concentrated within 2.3 and 3.6 kHz. The dominant frequency is 3.2kHz with H3 (at 9.8 kHz) and a weaker H5. This corresponds closely to the call description given by Brown, Alcala and Diesmos (1997). There is a mistake in their Figure 2, A should correspond to *P.dorsalis* as it is described in the paper, and B to *P.mimulus*.

Figure 1.5.1

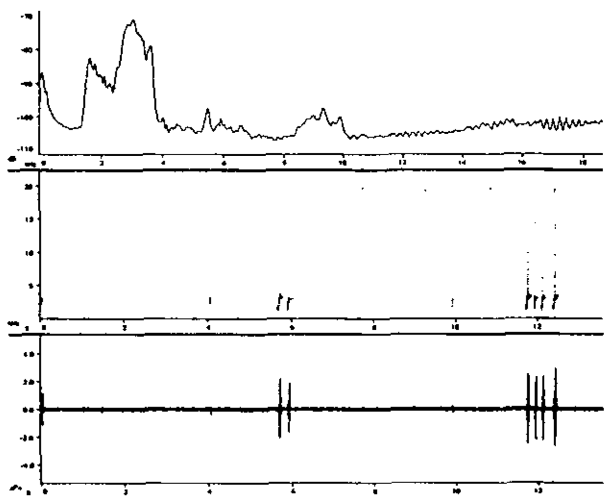
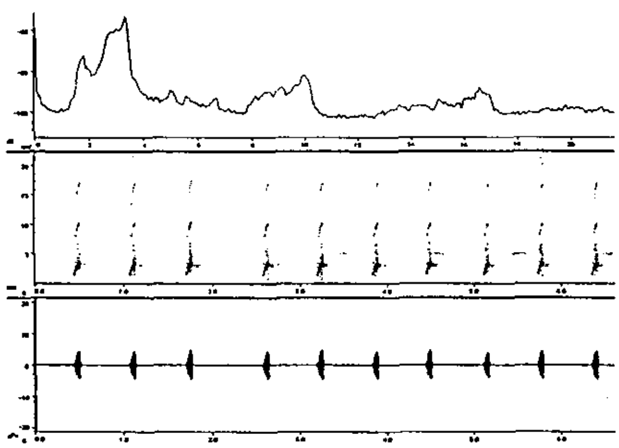


Figure 1.5.2



1.6.1 *Platymantis corrugatus.*

The rate at which this frog called was variable. This species did not call as part of a chorus, however calls recorded early on where repeated at much longer intervals than later on seemingly dependant on the activity of other frogs in the vicinity. When the call reached the maximum calling rate and amplitude the envelope shape was standard. Each call starts at a low frequency of 0.7 kHz and increases in a rapid upward sweep to the dominant frequency of 2.2 kHz. The call is concentrated within 1.6 to 2.9 kHz. There are very weak H3, H5, H7 and H9. The call duration is then approximately 0.25 seconds with intervals between 0.3 and 0.5 seconds

Figure 1.6.1

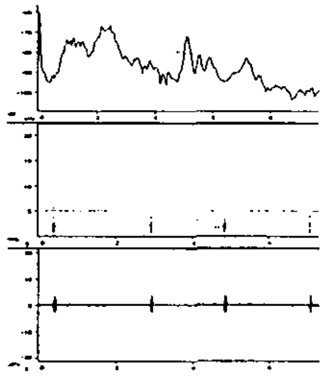


Figure 1.6.2

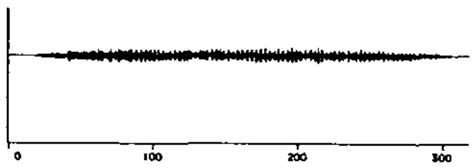
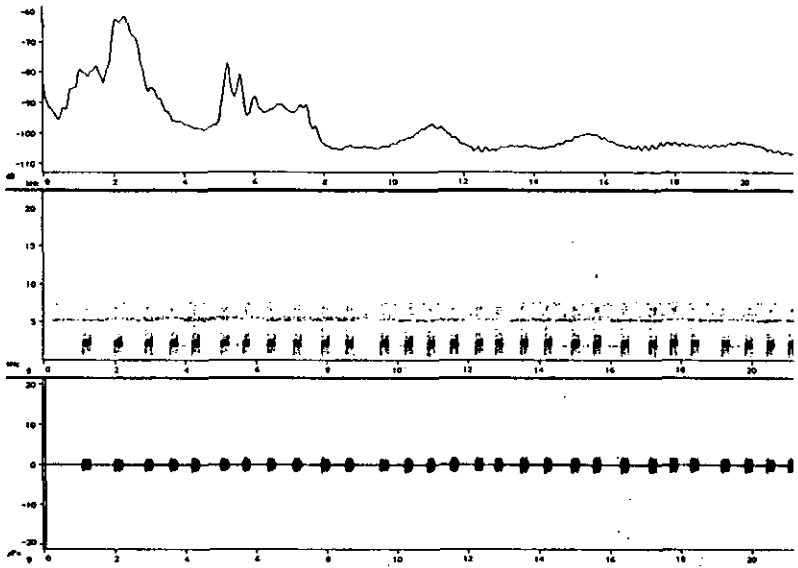


Figure 1.6.3



1.7 *Rhacophorus appendiculatus*
This species was recorded on Luzon, since only a single individual was found on Polillo and none were found calling. The call is concentrated within the frequencies 1.4 kHz to 3 kHz. In figure 1.7.1 there is a lot of background noise between 3 and 5 kHz. The call consists of several rapidly repeated chirps. Within each chirp there are usually two or three pulses, often the first is by far the weakest as illustrated in Figure 1.7.2.

Figure 1.7.1

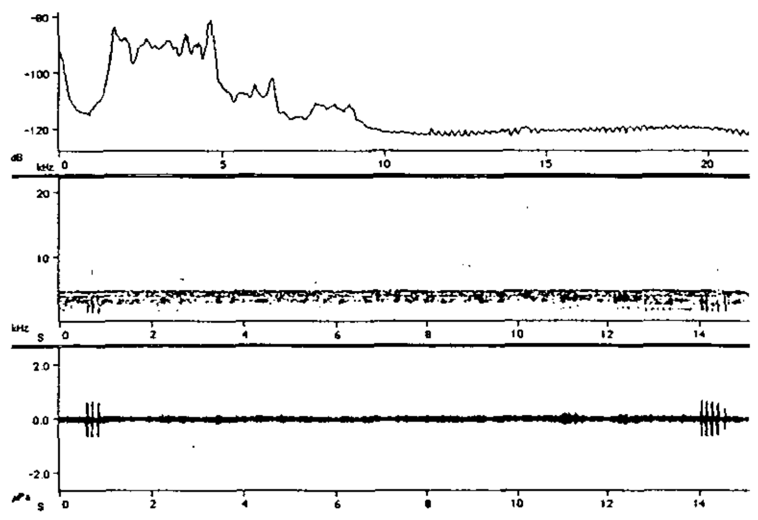
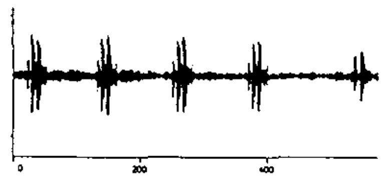


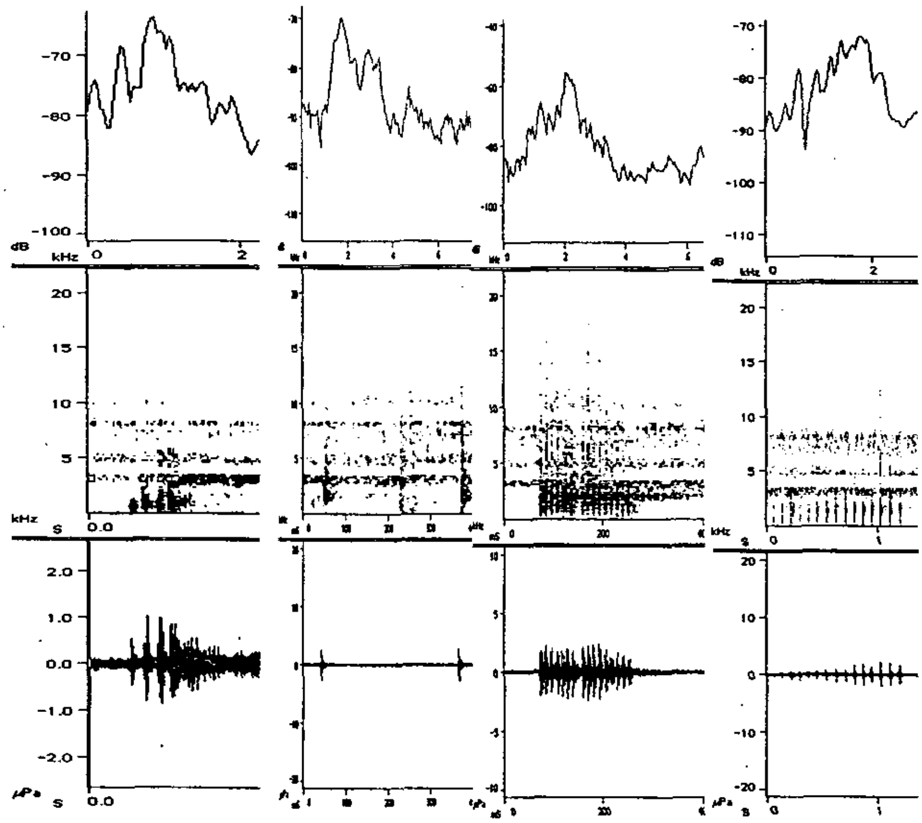
Figure 1.7.2



1.8 *Rhacophorus pardalis*

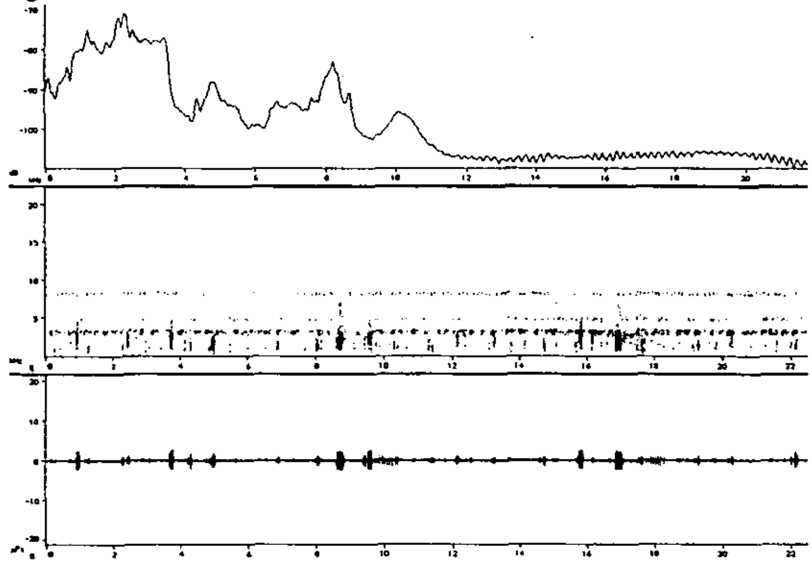
This frog has a very variable call made up of clicks, rattles, trills and gurgling sounds. The call is also very quiet. This frog would not call in our presence so the microphone was set up while recorders waited remotely. Therefore the recording is relatively poor and quiet, and must be separated from the background of other calling frogs, such as *P.dorsalis* and *O.laevis*. I have therefore selected different recognisable call types illustrated below.

Trill click croak rattle



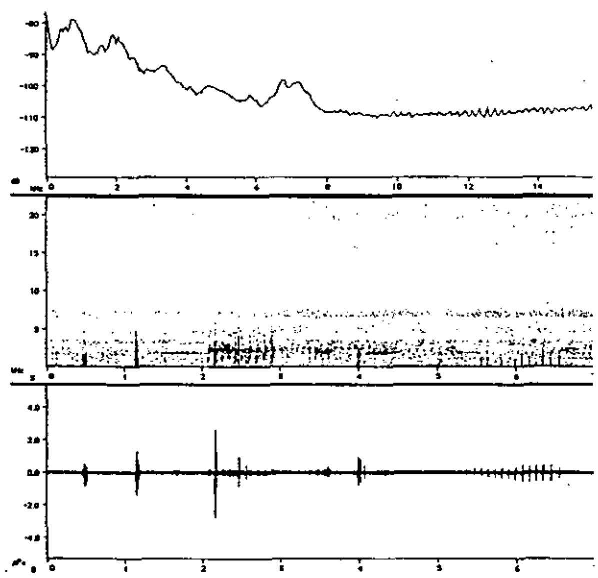
The above diagrams illustrate distinctive aspects of the call repertoire of *R.pardalis*. The call is basically concentrated between 0.5 to 3 kHz, with each of the different noises having their own separate peaks. Figure 1.8.1 illustrates an example of how some of the calls are included in a calling sequence.

Figure 1.8.1



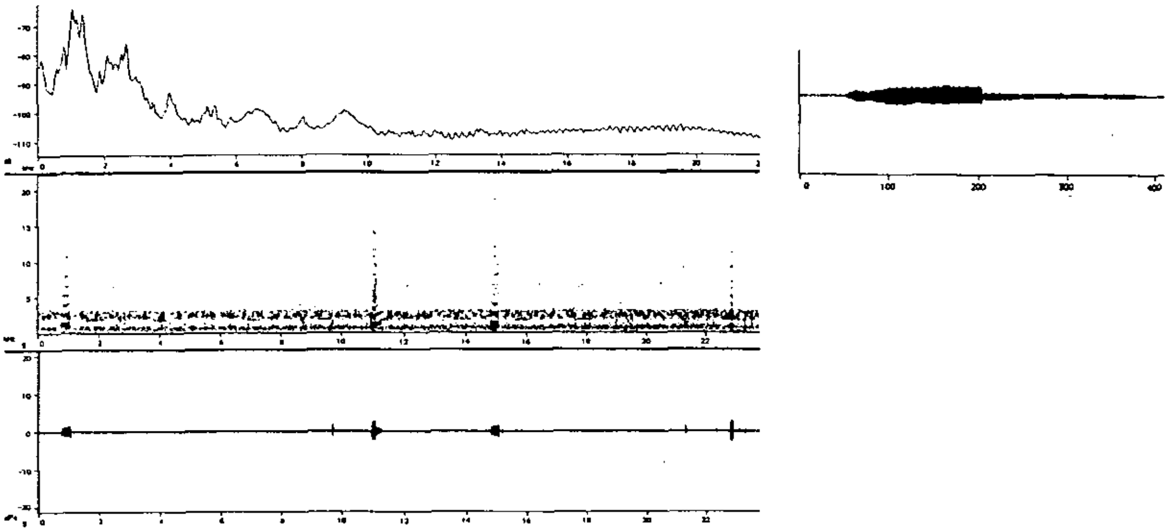
1.9 *Polypedates leucomystax*

The call of *P. leucomystax* is very variable, with a variety of clicks, gurgles and croaks, similar to *R.pardalis*. The dominant frequency for the croaks is approximately 0.75 kHz and all call types are concentrated between 0.3 to 2.7 kHz, which is very similar to *R.pardalis*. For more information on the call of *P.leucomystax* refer to Brzoska, Joermann and Alcala (1986).



1.9 *Rana luzonensis*

A pair were found in amplexus on 14/8/99 (at site H) and brought back to base camp. During the night squeaking was heard from the bag within which the frogs were being stored. The sound was recorded (23.7-24 C). Both animals were released the next day. The dominant frequency of the call is approximately 1.1 kHz and there is H2 (2.2 kHz) and decreasingly weaker H3, H4, H5, H6, and beyond, visible on the spectrogram. The chirp length can vary from 0.05 seconds to over 0.5 seconds. The call of this frog might not be true to the call under natural conditions, therefore recording this species in the wild should be a priority. The envelope shape shows one long changing pulse



1.10 *Rana woodworthi*

The call of *Rana woodworthi* is composed of a train of chirps, sometimes up to 25 chirps in one call. Each chirp is made up of a variable number of pulses, either 1, 2 or 3. The dominant frequency is approximately 2.45 kHz with strong H2 and H3 (both about 20 db lower than the dominant frequency) and weak H4 and H5. The fundamental frequency is approximately 0.97 kHz which can be seen as the lower frequency waves within a single chirp.

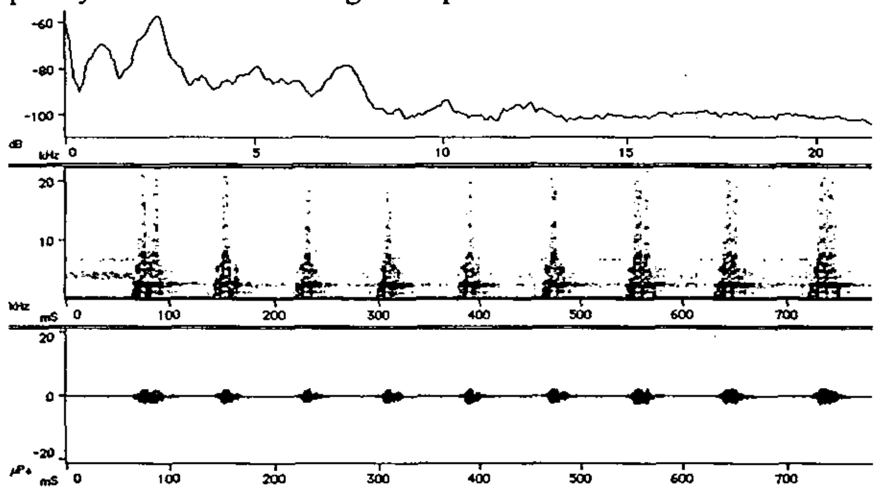


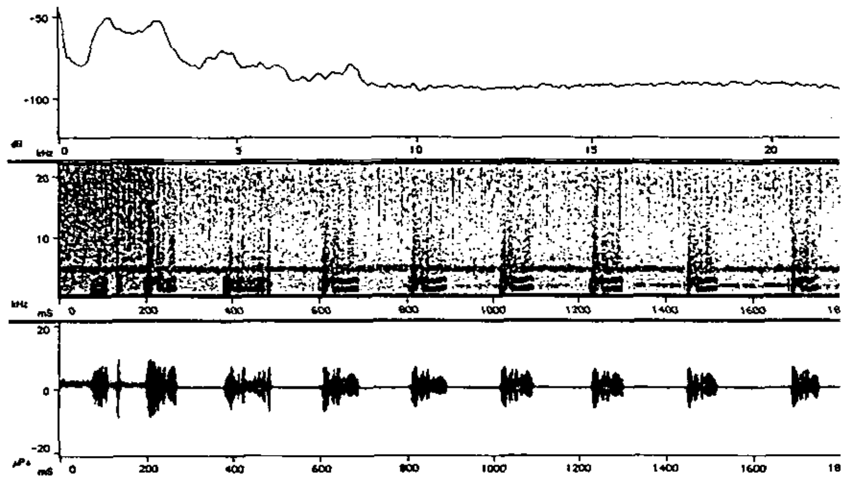
Table 1.10.1

	Chirp duration (s)	Interval duration (s)
Mean	0.03	0.05
Standard Error	0.0011	0.0015
Standard Deviation	0.006	0.008
Count	29	26

1.11.1 *Rana similis*

The call of *Rana similis* is variable consisting of sometimes a single chirp, to a call composed of several chirps (figure 1.11.1). The dominant frequency is 1.35kHz with a strong H2 at approximately 2.7kHz. In this recording chirps were between 0.04 to 0.08 mS long with intervals between chirps of about 0.1mS. However because this frog has a variable repertoire more recordings are needed to quantify the call pattern. The individual chirps do not have a simple structure but are made up of a number (between 1 and 8) overlapping pulses. For more information refer to Alcala, Joermann, and Brzoska (1986).

Figure 1.11.1



1.12 *Rana vittigerra*

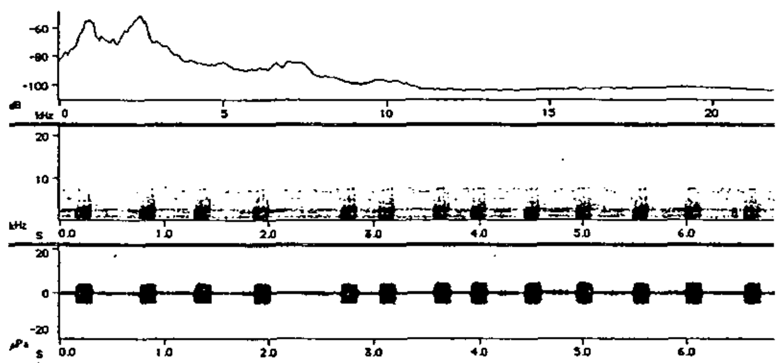
This species was frequently found calling in paddyfields, sympatrically with the marine toad. Its call is also loud. Recorded on 13/7/99, 10.30 pm, in a paddy field, water temperature 27.4°C, air temperature 26.3°C.

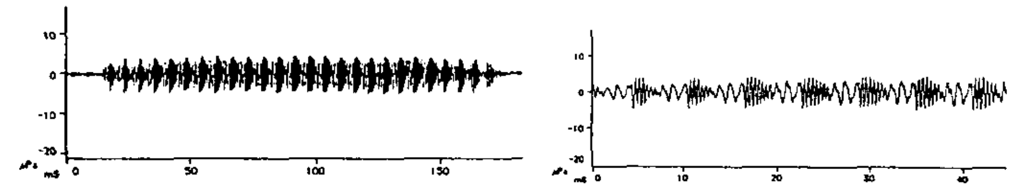
The call duration is typically 0.16 seconds with a varying interval. When in a group these frogs call in a chorus, often calling more regularly and rapidly.

Table 1.12.1

	Call duration(s)	Call interval (s)	Dominant frequency (Hz)	H2 (Hz)
Mean	0.161	0.437	798	2342
Standard Error	0.00058	0.070	8.44	7.17
Standard Deviation	0.0022	0.255	31.59	26.83
Count	14	13	14	14

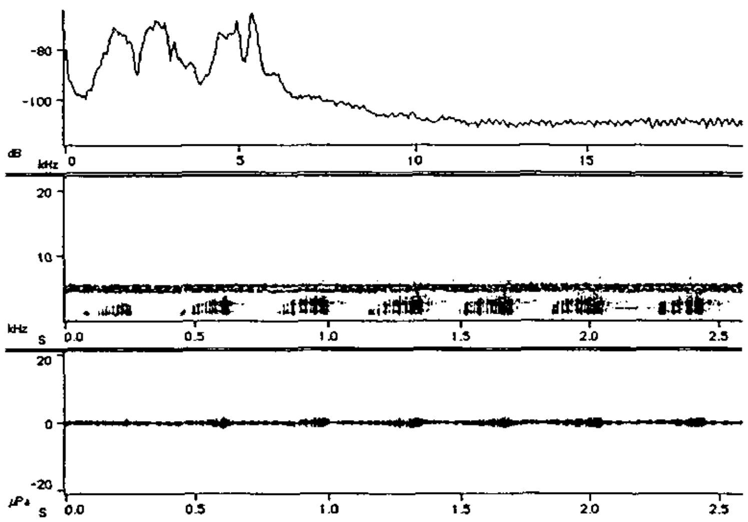
Figure 1.12.1





Each call is made up of 20 to 30 high (2.47KHz) frequency pulses that are separated by 3 wave cycles at a lower frequency (0.88KHz). see above

1.13 *Occidozyga laevis*



The call of *O.laevis* is quiet, with a fundamental frequency at 1.43 kHz and a dominant frequency (approximately 3dB louder) at 2.7 kHz. The third peak on the FFT spectrum is from the constant background noise visible in the spectrogram. The pattern of calling is variable, sometimes a single chirp and sometimes the chirps are repeated usually dependant on the activity of surrounding frogs. Often there are between 4 and 8 chirps to a call. This frog often calls in a chorus, which increases the frequency of call repetition.

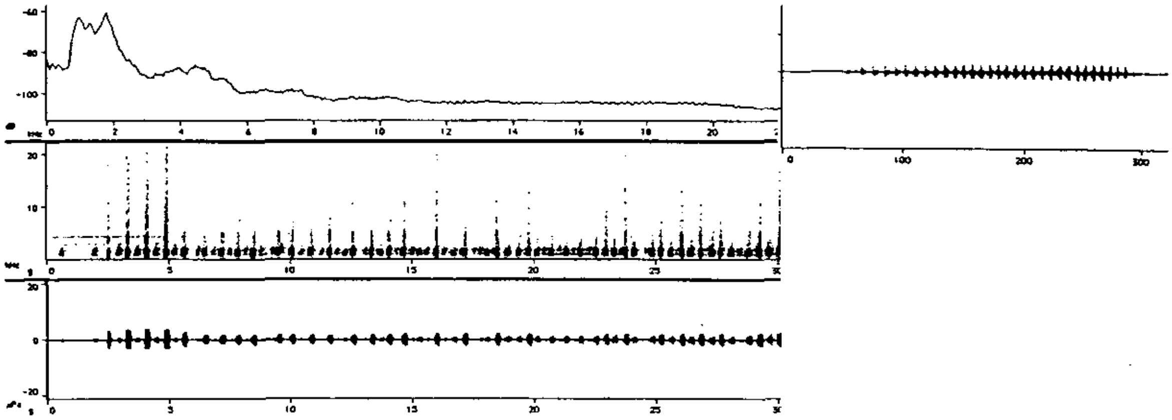
Table 1.13.1

	Chirp duration (s)	Interval duration (s)
Mean	0.137	0.226
Standard Error	0.0076	0.012
Standard Deviation	0.0186	0.027
Count	6	5

1.14 *Kaloula picta*

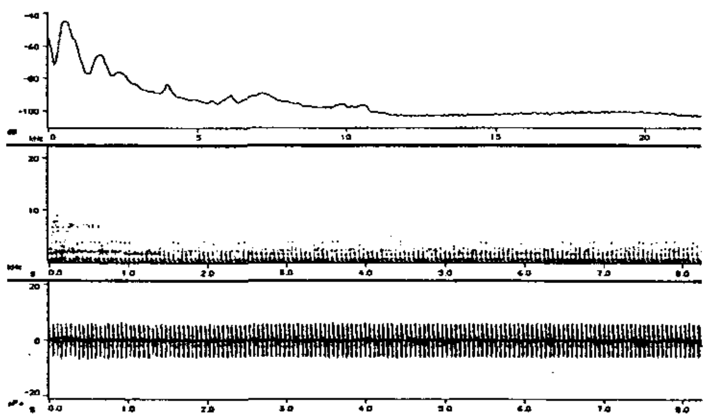
This species was found on Polillo, but the only recording made was on Luzon. The call of this species can be almost deafening in large numbers. The sound analysis is provided as a comparison for future recordings necessary for Polillo specimens.

Figure 1.14.1



The chorus (figure 1.14.1 depicts clearly the constant frequencies used by different individuals). More than one frog is calling. Calls of individuals further from the microphone have a lower amplitude and therefore are lighter on the spectrogram. But all have identical frequencies. The fundamental frequency is approximately 0.9 kHz with an H2. The call repetition rate of this frog can increase dramatically in a chorus. However call duration varies between 0.2 to 0.25 Seconds long. Each call consists of a large number of repeated pulses. See above.

Bufo marinus
The call of this toad is loud and resounding. These frogs were most frequently seen calling in paddy fields often in large numbers. The diagram below illustrates a section of call lasting about 8.2 seconds. Recorded on 13/7/99, 9.30pm, in a paddy field, Water Temperature 27.3°C, Air temperature fluctuating between 26.2°C and 27°C because of a breeze. The toad was in shallow water approximately 3cm deep. In the background are other *B. marinus* and *Rana vittigerra.*)



The call duration of *B. marinus* is often more than 16 seconds. The call has a generally constant amplitude. The dominant frequency is approximately 0.5kHz with a second weaker harmonic at approximately 1.7 kHz evident later in the call. The number of pulses per second is 17.8 (143 pulses in 8.04 seconds n = 143).

Recommendations:

This study identified the use of calls as a useful tool to help distinguish between frogs, particularly within the *Platymantis* genus. Use of genetic techniques would enhance morphological and ecological methods in determining taxonomic status. Furthermore DNA samples and call analysis could be used non destructively and would avoid the collection of rare frogs.

From the results of this study, the following specific research and conservation priorities have been identified:

- Determine the taxonomy of

1. The white frog
2. *Platymantis* sp
3. *Kaloula* sp

- Collect large samples of calls from the frogs on Polillo and compare with large samples collected on Luzon
- Carry out genetic analyses of the species on Polillo and comparable species on Luzon (particularly the aforementioned).
- Determine the wider distribution of frog species on Polillo, using calls to identify the presence of cryptic groups.
- Search for the white frog over different parts of Polillo and determine its habitat requirements.
- Assess the effects of forest fragmentation on supporting *Platymantis* sp populations

- Preserve border vegetation and trees beside streams even when in agricultural land, especially streams linking patches of forest.
- Prevent further destruction of both primary and secondary forest sites which are important habitats and may support populations of rare frog species
- Use frog call recordings as an environmental educational tool
- Conduct investigations into the reproductive ecology of the amphibian species on Polillo

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Acknowledgements

Many thanks to Arvin Diesmos, Dr Rafe Brown, and Dr Ronald Crombie for frog taxonomy advice, Henry Bennet-Clark for introducing me to sound analysis techniques, Clive Hambler and Paul Johnson for advice on ecological methods and analysis, Mike Charleston for computer help and all the team for help with fieldwork.

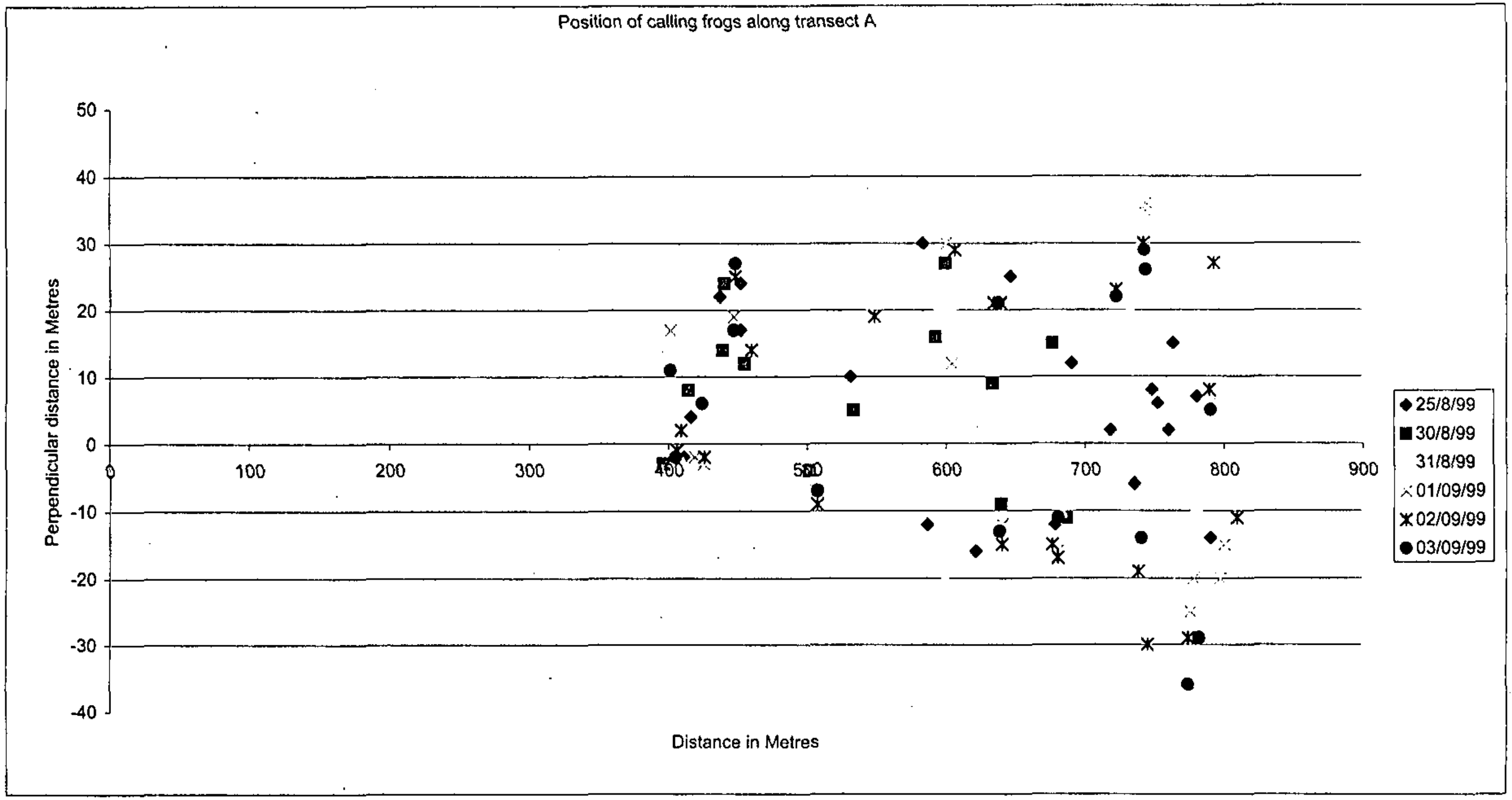
Appendix I

For every site the model chosen by DISTANCE is stated e.g. Hazard/Cosine, the date, the Density D, degrees of freedom and 95% Confidence intervals for the estimate.

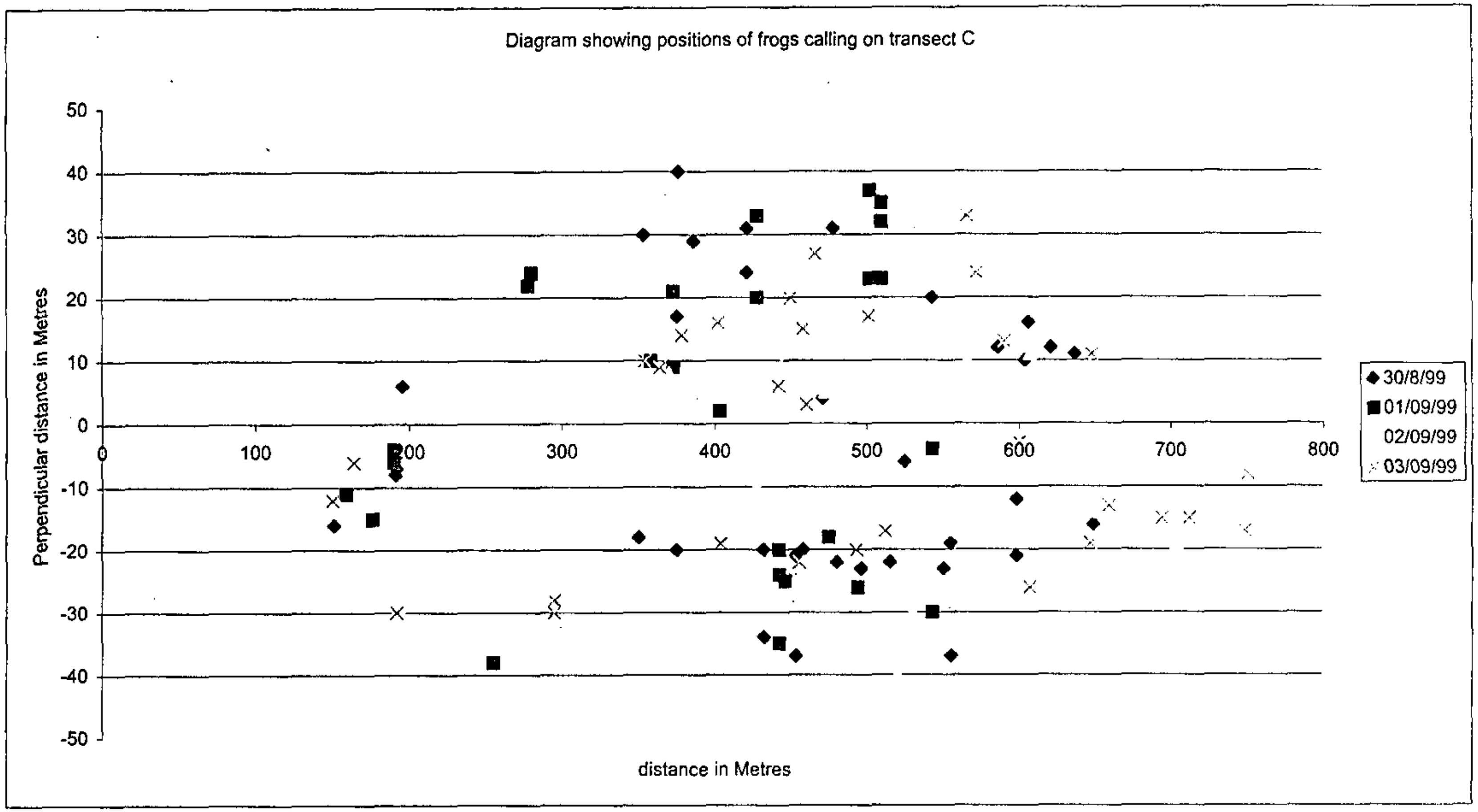
Pooled Estimates:

		Estimate	%CV	df	95% Confidence Interval	
SITE E&M combined						
Hazard/Cosine	D	20.306	21.92	4	11.128	37.054
Edges combined						
Hazard/Cosine	D	7.3304	17.09	3	4.2719	12.579
Site E						
6/9/99 Uniform/Cosine	D	28.947	21.32	22	18.694	44.824
14/9/99 Uniform/Cosine	D	23.611	24.25	17	14.257	39.102
Site M						
6/9/99 Uniform/Cosine	D	13.051	28.05	16	7.2828	23.390
Forest edge O						
28/8/99 Uniform/Cosine	D	16.420	22.36	20	10.358	26.031
Forest edge A						
25/8/99 Uniform/Cosine	D	11.816	29.47	19	6.4592	21.615
30/8/99 Uniform/Cosine	D	8.0247	27.74	13	4.4572	14.448
31/8/99 Uniform/Cosine	D	7.9365	22.36	20	5.0064	12.582
1/9/99 Uniform/Cosine	D	5.9524	23.57	18	3.6519	9.7019
2/9/99 Uniform/Cosine	D	7.9365	22.36	20	5.0064	12.582
3/9/99 Uniform/Cosine	D	5.2910	25.00	16	3.1394	8.9173
Forest edge C						
30/8/99 Uniform/Cosine	D	3.7500	25.82	15	2.1823	6.4438
1/9/99 Uniform/Cosine	D	4.9342	25.82	15	2.8715	8.4787
2/9/99 Uniform/Cosine	D	6.1687	29.55	19	3.3666	11.303
3/9/99 Uniform/Cosine	D	5.5556	22.36	20	3.5044	8.8072
Edges broken down						
Forest edge A						
25/8/99						
1st 220m Uniform/Cosine	D	6.0606	35.36	8	2.7467	13.373
2nd 220m Uniform/Cosine	D	10.909	28.87	12	5.8892	20.208
30/8/99						
1st 150m Uniform/Cosine	D	9.7222	37.80	7	4.0968	23.072
2nd 150m Uniform/Cosine	D	7.4074	40.82	6	2.8341	19.360
31/8/99						
1st 220m Uniform/Cosine	D	8.7413	31.62	10	4.3939	17.390
2nd 220m Uniform/Cosine	D	9.1991	24.25	17	5.5548	15.235
1/9/99						
1st 220m Uniform/Cosine	D	6.0606	35.36	8	2.7467	13.373
2nd 220m Uniform/Cosine	D	6.3131	31.62	10	3.1734	12.559
2/9/99						
1st 220m Uniform/Cosine	D	6.2696	35.36	8	2.8414	13.834
2nd 220m Uniform/Cosine	D	9.0909	28.87	12	4.9077	16.840
3/9/99						
1st 220m Uniform/Cosine	D	5.0505	40.82	6	1.9324	13.200
2nd 220m Uniform/Cosine	D	6.3131	31.62	10	3.1734	12.559
Forest edge C						
30/8/99						
1st 200m Uniform/Cosine	D	6.9444	44.72	5	2.3167	20.816
2nd 200m Uniform/Cosine	D	8.7500	26.73	14	4.9810	15.371
3rd 100m Uniform/Cosine	D	14.865	30.15	11	7.7660	28.453
1/9/99						
1st 200m Uniform/Cosine	D	4.6053	37.80	7	1.9406	10.929
2nd 200m Uniform/Cosine	D	9.4595	26.73	14	5.3849	16.617
2/9/99						
1st 200m Uniform/Cosine	D	2.5862	57.74	3	.46930	14.252
2nd 200m Uniform/Cosine	D	14.828	32.52	14	7.5118	29.270
3rd 200m Uniform/Cosine	D	12.500	24.25	17	7.5479	20.701
3/9/99						
1st 200m Uniform/Cosine	D	4.1667	44.72	5	1.3900	12.490
2nd 200m Uniform/Cosine	D	12.963	26.73	14	7.3793	22.772
3rd 200m Uniform/Cosine	D	9.0909	28.87	12	4.9077	16.840
Edge transect O						
1st 150m Uniform/Cosine	D	14.286	33.33	9	6.8554	29.770
2nd 150m Uniform/Cosine	D	17.460	30.15	11	9.1220	33.421

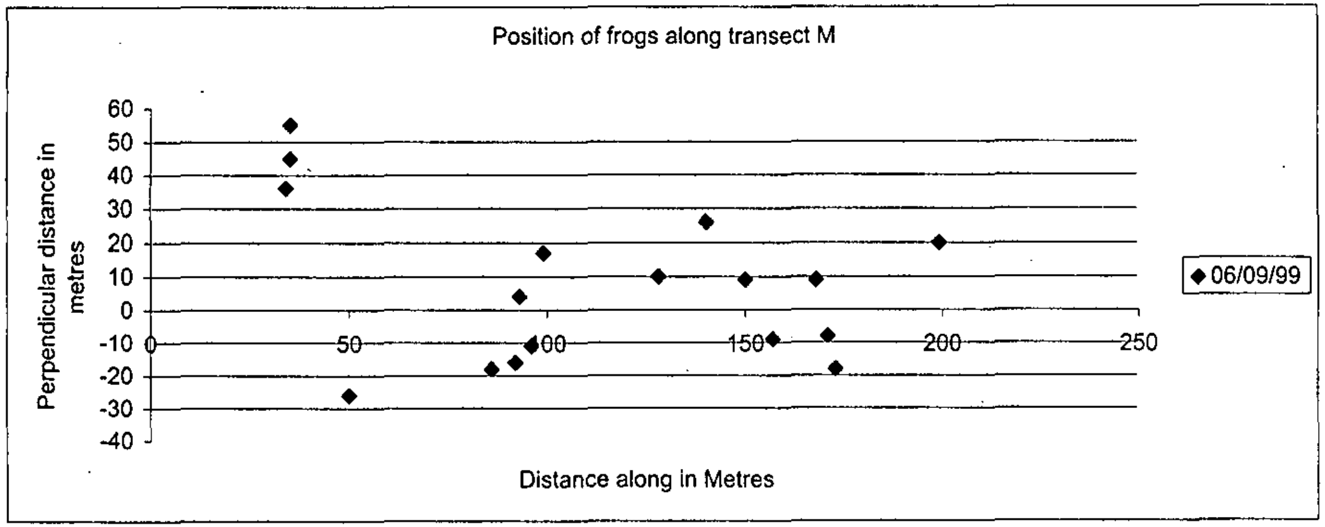
Appendix II



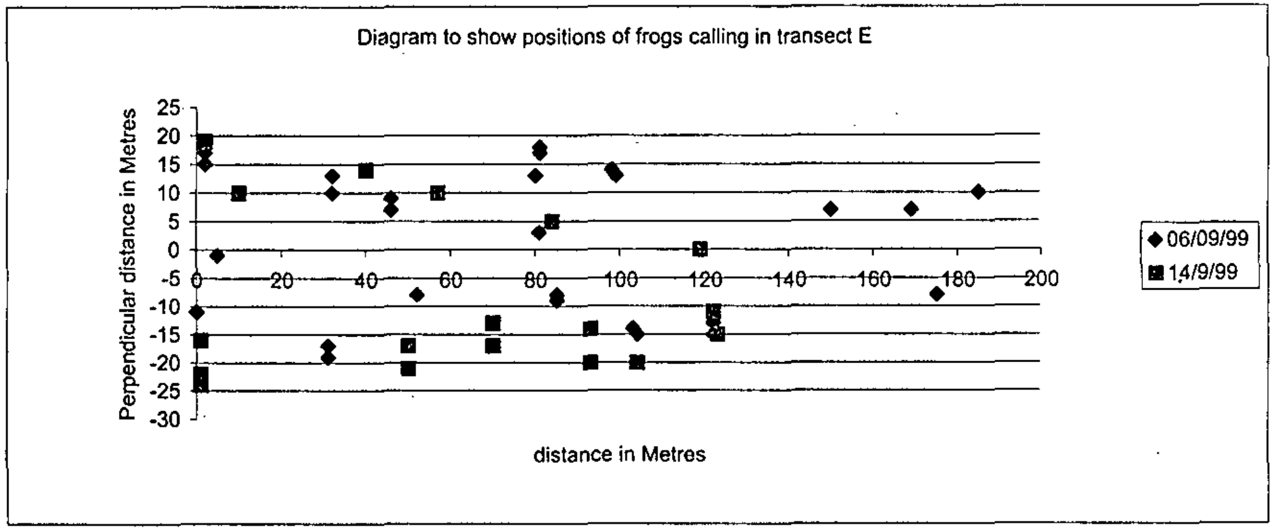
Transect A runs past the pitfalls along the path, beyond site g following the stream. All the transects stop after 810m except for on the 30/8/99 which stops after 700m.

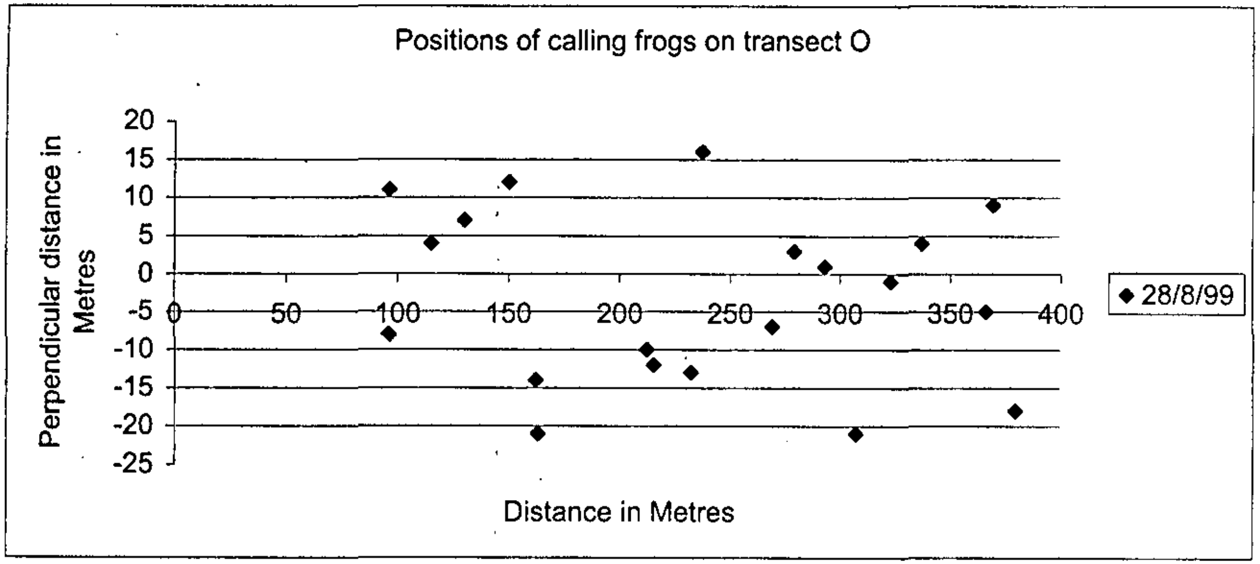


Transect C runs past the tanks into the forest following the stream. All of the transects stopped at 750m apart from on the 2/9/99, which stopped at 650m



Transect M runs through site M and stops after 200m. Transect E runs through site E. The transect on the 14/9/99 stops at 150m, the transect on the 6/9/99 stops after 200m.





Transect O enters the forest from the far side of the watershed, the exact position is unknown.

Appendix III

Densities of frogs per square metre, for every site

	A	O	B	N	H	G	F	L	J	M	K	D	E
Bm	0.042	0	0.004	0.004	0	0	0	0	0	0	0	0	0
Rvl	0.052	0.156	0	0.006	0	0	0	0	0	0	0	0	0
Rw	0.004	0.006	0.023	0.077	0.15	0.163	0.104	0.25	0.11	0.242	0.267	0.152	0.21
Rss	0	0.002	0.038	0.01	0.048	0.048	0.027	0.046	0.052	0.035	0.063	0.077	0.083
Pl	0.019	0	0	0.004	0	0	0	0	0	0	0	0	0
Pd	0	0	0.006	0.021	0.052	0.063	0.042	0.056	0.085	0.102	0.063	0.058	0.102
Rm	0	0	0.002	0.002	0	0.002	0	0.002	0.002	0	0.002	0	0.006
Ol	0	0.069	0	0.01	0.052	0.104	0.096	0.183	0.121	0.098	0.15	0.115	0.148
Psp	0	0	0	0	0	0	0	0.008	0	0	0.004	0.002	0.006
Pc	0	0	0	0	0	0.002	0.008	0	0.002	0	0.006	0.008	0.008
Re	0	0	0	0	0.019	0	0	0	0.004	0	0	0.008	0.004
Total	0.117	0.233	0.073	0.135	0.321	0.381	0.277	0.546	0.377	0.477	0.554	0.421	0.569

LIZARD DIVERSITY PATTERNS ALONG DISTURBANCE GRADIENTS IN POLILLO ISLAND: IMPLICATIONS FOR EFFECTIVE CONSERVATION

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Abstract
An ecological study of the lizard species in Polillo Island (c. 350-400m elevation) was conducted for a period of two months (July-September, 1999). Drift fences in conjunction with pitfall traps and intensive searching that utilizes a plot as sampling area, constituted the sampling techniques employed in the field. Using these two methods to sampling lizard populations, diversity patterns using standard diversity indices (i.e. Shannon-Weaver Indices) were computed and ecological relationships among the different habitats were determined. A total of 783 individuals belonging to 25 species in four genera were recorded from the island. Four of the 25 species are new island records. Of the four groups of lizards, family Scincidae is the most represented taxon, followed by Gekkonidae, Agamidae and the Varanidae to which the endangered and endemic *Varanus olivaceus* belong. Across disturbance gradients, primary forest harbors the most number of species with a total of 11 followed by the secondary growth with eight species and agro-ecosystem with only five.. Species diversity is highest in the primary forest and lowest in the agro-ecosystem. Likewise, endemicity was observed to be highest in the primary and decreases as the species go towards the more disturbed habitats. The trends in the diversity patterns as observed among the lizard fauna on the island largely contributed to the assessment of the existing faunal population. Several conservation measures for the protection and conservation of the species were recommended for the sustainability of the species and their remaining habitats.

Introduction
Made up of more than 7,100 islands and islets, the Philippine Archipelago lies between South China and the Greater Sunda Islands, but zoogeographically it is a fringing archipelago extending northeast from Borneo for nearly a thousand miles (Darlington, 1957). Heaney (1985) divided the entire archipelago into six faunal regions as defined by the extent of the Pleistocene islands – Greater Luzon (this include Luzon island and the adjacent islands of Catanduanes, Marinduque and Polillo), Greater Mindanao, Greater Palawan, Greater Mindoro, Greater Negros-Panay and Greater Sulu. The entire island is home to various floral and faunal assemblages, unique only to the region. At present, more than 1,700 species of vertebrates are found in the Philippines, most of which are island endemics (Dans and Gonzalez, 1998). Among the 224 reptiles that have been recorded from the island, 123 species are lizards, 97 of which are endemic. Gonzalez, 1995).

Although the Philippines is regarded as one of the major centers of biological diversity ("biodiversity") and endemism due to its unique and exceptionally rich biota it is also considered as one of the world's biodiversity "hotspots" for having a markedly high number of threatened plant and animal species. Apparently, this is mainly due to (i) habitat loss as brought about by deforestation and increasing human encroachment on forested areas; and (ii) hunting and illegal poaching of wild animals from the forests. This present predicament has prompted various researchers involved in the study of wildlife species, to dwell on the more pressing issues involved in the understanding of the taxonomic and systematic accounts of most, if not all the entire Philippine faunal population - conservation. It is imperative in any conservation effort to know and identify the different patterns of species distribution as a tool in assessing the existing condition or status of any particular group of organism. Similarly, it is also important to correlate this with the different ecological data that may be obtained or made available in order to recognize salient points that may be equally important in identifying possible threats to the species' survival.

Most of the remaining forests in the country are now basically restricted to a few tracts of mountains and highlands in major protected areas and national parks (Gonzalez, 1997). The Philippine government included these protected areas and national parks as top priority areas for protection. Thus, efforts towards the protection and conservation of wildlife species in these areas are currently in progress. This circumstance further resulted in very minimal attention being given to equally important but smaller islands in the archipelago and Polillo group of islands is among the many places in the Philippines that need immediate attention for conservation efforts. In fact, the paucity of researches done on this island is enough reason to study the fauna of this island. Hence, in an attempt to contribute and help promote future conservation efforts on the island and at the same time provide ecological data on the lizards found on the island, this study aims to accomplish the following:

(i) to determine the species assemblage of the island under varying disturbance gradients;
(ii) to identify the different diversity patterns of lizards on the island using standard diversity indices; and
(iii) to formulate conservation measures as basis for future protection and conservation of the species and their remaining habitat.

History of herpetological studies in Polillo
In retrospect, although there are distributional records of reptiles from Polillo, the history of comprehensive collections on the island is very much limited. In the early 1920s, Edward H. Taylor made noteworthy collections of reptiles from the island and included this among his many Philippine collections. Since then, no attempts have been made to conduct ecological studies on the herpetofauna in the island. The period between 1930 until 1990 marked the "lethargic" years in the study and development of valuable information on the herpetofauna of the island. It was only in 1995 when Ronald I. Crombie of the Smithsonian Institution from Washington, D.C. came on the island that specimens of reptiles were once again collected for purposes of recording and identification. Unfortunately, information generated from such collection is yet unpublished. Nonetheless, based on interviews with some of the local people on the island who were able to work for Crombie during his stay on the island revealed that, he made quite a sizable collection. After Ronald Crombie, no further attempts have been made in conducting surveys or collecting specimens of reptiles from the island.

Description of the study areas
Located some 20-30 kms off the eastern coast of Luzon, the Polillo group of islands (14°50'N, 122°5'E) is among the many distinct islands in the Philippines that is biogeographically situated within the Greater Luzon faunal region (Figure 1). Of the many cluster of islands and islets that comprise the entire Polillo group of islands, Polillo, Patnanungan, Jomalig and Palasan are considered as the major islands while others are simply smaller islands and islets that are scattered around the major islands. Of the four major islands, Polillo has the largest area covering 761 km^2 (618 ha), followed by Patnanungan which has an area of 41 km^2 (89.2 ha), Jomalig with 51.7 hectares and Palasan with less than 50 hectares. The entire island of Polillo has a Type II climate characterized by having no or very short dry season followed by a pronounced wet season that runs between the months of November until January. Prevailing wind directions are the Southwest monsoon ("amihan") which starts in May and ends until September followed by the Northeast monsoon ("habagat") which frequents the island between the months of October until April. Every year, crops, properties and even forests were severely damaged and lost due to typhoons.

For the purpose of this study, the researcher focused her study on Polillo, one of the three municipalities of Polillo Island where the Sibulan Watershed is actually part of. Specific sites visited by the researcher are listed and described in detail below. Other sites that had been visited (i.e. Panukulan) was also noted. Sampling sites are plotted on a map (Figure 2). However, these are only approximations of the areas covered and not the exact locations per se.

Site A1, A2 - *Sitio Mahabang-kahoy, Brgy. Pinaglubayan, Sibulan, Polillo Is., Quezon Province.* Covers part of the agro-ecosystem just outside the eastern boundary of the Sibulan Watershed. It is primarily planted with coconuts and small to medium-sized shrubs (Plate 1). Sampling sites for transect counts cover approximately 3 km. that runs through several streams. Transect counts coupled with intensive searching was carried out on this area for eight days while pitfall traps were left operational for 45 days.

Site S1, S2 - *Sitio Mahabang-kahoy, Brgy. Pinaglubayan, Sibulan, Polillo Is., Quezon Province.* Logged over secondary growth with remnants of primary forests located just along the peripheral boundary Sibulan Watershed on the southeastern flank. It is characterized by moderately sloping hills (approx. 15 to 50 degrees) mostly dominated by small to moderately-sized trees (approx. 7 to 12 m) with traces of Red and White Lauan species. Undergrowth is mainly composed of shrubs and saplings of few dipterocarp species. (Refer to Figure 2)

Site P1, P2 - *Sitio Mahabang-kahoy, Brgy. Pinaglubayan, Sibulan, Polillo Is., Quezon Province.* Primary lowland dipterocarp forest located along the central to the northeastern side of the Sibulan Watershed. The dipterocarps and other hardwood species averaging from 15 to 20 m in height dominate canopy plant species. The undergrowth is mainly composed of various medium to moderately tall plant species with several *anibong, pugahan* and *tukyong* species – these are all palms. Species of rattan are also observed. (Refer to Figure 2)

Methods

Collection / sampling methods

A number of field techniques have been described in sampling lizards. These include noosing, hand-grabbing and pit fall traps (Campbell and Christman, 1982; Karns 1986; and Simmons 1987). More recent innovations involve glue boards (Bauer and Sadlier 1992), refuge tubes, baited lizard sticks (Strong et al 1993) and extraction hooks (Bedford et al 1995) as trapping tools. While these techniques and those that are commonly used by herpetologists in standard trapping or collection activities are efficient, many are expensive and require a long period of time to set up. In the Philippines, although there exists other methods of sampling lizards in the field, one of the most popular and more commonly adapted technique is hand-grabbing. For the purpose of this study, the researcher tried to use at least three methodologies - bucket fencing, transect walk combined with hand-grabbing and intensive searching/plot method.

Bucket fencing or **pitfall traps** coupled with wire mesh as fencing material was used as a collection method in this study. A total of four stations, each having 13 buckets arranged in a more or less straight line distanced at 2.5m apart were positioned in strategic places within the agro-forestry and secondary. Buckets were checked three times a day, sometimes more depending on the weather, to minimize casualties or injuries that may be incurred on species of animals trapped inside each bucket. Bucket numbers, type and the total number of lizard species caught in each bucket were noted. Whenever possible, some important body measurements were recorded for purposes of proper identification. All information gathered were then recorded in field data sheets. This bucket fencing method went operational for 45 days.

Transect walk is accomplished by assigning an imaginary transect of definite length and traversing it for at least seven hours a day for eight days per habitat. Whatever species of lizard encountered during such activity was recorded and its frequency noted. Most often than not, transect walk is simultaneously carried out with opportunistic collection through hand-grabbing. After taking down the important body measurements, each individual is released backed into its original habitat. However, in cases when the researcher has to bring it over to the base camp for photo documentation, the animal/s are being released in the nearby agro-forestry to avoid further stress.

Intensive searching on the other hand, is carried out using a plot, approximately 25m X 20m in area and then search the area for possible presence of lizards by inspecting every rock crevices, dead or rotting logs lying within the assigned plot, every tree trunks, leaf axils and even litter falls. Usually, intensive searching is done together with the transect walk. Both the transect walk and the intensive searching techniques were carried out for 24 days, each habitat being examined for eight days. In order to minimize the disturbance level whenever the researcher tries to carry out sampling activities on a specific habitat, each study area is examined on a regular interval – each habitat is not checked or visited everyday for eight consecutive days but rather, each site is frequented either on a two-day interval period.

Aside from the three field techniques used, other methods by which information or data have been derived were: (i) ethnobiological interviews; (ii) presence of fecal materials or droppings ; and (iii) presence of "roosting" sites.

As aforementioned, whenever possible, body measurements were recorded for every individual caught. Using a Tajima calibrated dial caliper and steel rulers, indicated below are some of the biometric parameters that were measured:

1. Weight (wt) -in grams
2. Total Length (TL) -tip of snout to tip of tail
3. Snout-Vent Length (SVL) -tip of snout to tip of tail
4. Axillary to Groin (AxG) -distance between axilla of forelimb to base of hindlimb
5. Hindfoot Length (HF) -base of hindlimb to tip of longest claw
6. Head Length (HdL) -tip of snout to post. edge of ear
7. Head Width (HdW) -widest point near the angle of the jaw
8. Tail depth and width -widest point near the base, just posterior to the basal, ventral swellings
9. 4^{th} toe lamellae -total number of scansors beneath the digits

Measures for patterns of diversity

Using the bucket fencing or pitfall traps and transect counts, the species composition of lizards between disturbance gradients (i.e. agro-forestry, secondary forest, primary forest) around Sibulan Watershed, Polillo Island was analyzed using diversity and equability indices. Although not foolproof, these ecological indices are a means of combining the species richness and evenness of a species community. For the purpose of this study, the Shannon-Wiener indices were used:

$$\text{Diversity Index } H' = -\Sigma p_I \,.\, \ln (p_I)$$

where p_I is the proportion of species i expressed as a proportion of the total number of individuals of all species, **ln** is the natural logarithm, and Σ represents the **total** p_I **. ln** (p_I) for all species.

$$\text{Equability Index } J = H'/H_{max} = \Sigma\, p_I \,.\, \ln (p_I)/\ln (s)$$

where s = number of species.

Care and handling of specimens

Although proper care and handling of animals were observed in the field, it is quite inevitable however that some of the animals may experience stress which have resulted to death. It is only through this that the researcher was compelled to collect specimens.

For the purpose of this study, the researcher used 10% strength formalin (1 part formalin : 9 parts water) as fixative. Formalin is used to preserve the actual morphological state and color of the specimen, and to prepare the tissues for microscopic examination (Pisani, 1973). To reduce discoloration of specimens, formalin may be buffered by mixing 1 tablespoon of baking soda or borax with each part of 10% formalin solution. All specimens were then allowed to remain in fixative for 24 hours. After fixing with 10% formalin, the specimens were then transferred to alcohol (i.e. 50% strength ethanol or isopropyl alcohol). However, prior this, the specimens were soaked in water for 48 hours to prevent alcohol dehydration.

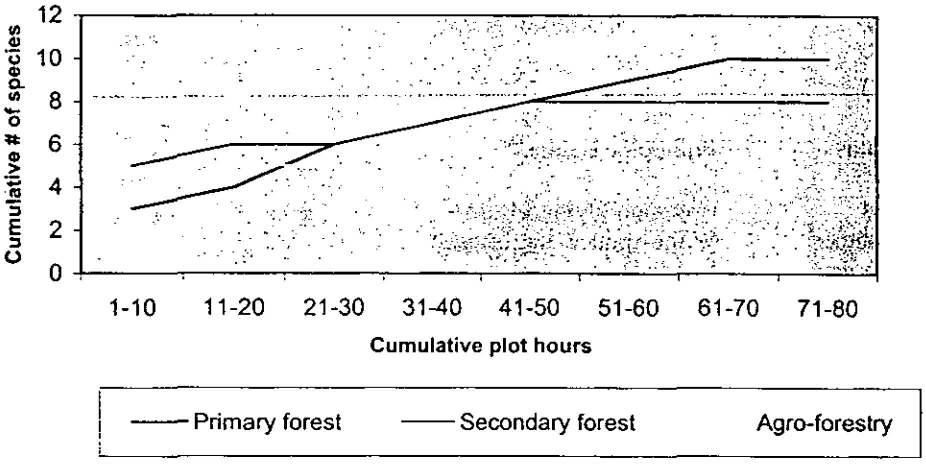
Results and discussion

A total of 25 species of lizards was recorded for both Sibulan and Panukulan Watershed on Polillo Island, although majority was recorded from the former. Table 1 gives a list of all the species accounted during field surveys in a span of two months. Of the 25 recorded species, four are agamids: *Calotes marmoratus sanchezi, Draco spilopterus, Hydrosaurus pustulatus* and *Gonocephalus semperi* (Figures 1,2). An endemic species, the *H. pustulatus* is included as one of the ten species of reptiles on the Red Data List of threatened animals in the Philippines. The White-spotted Anglehead (*G. semperi*) on the other hand, is a new island record. Eight species of geckoes are recorded. Of these, three are regarded as commensal species (*Cosymbotus platyurus, Hemidactylus frenatus* and *Gehyra mutilata*); one island endemic (*Pseudogekko smaragdinus*); and two were unidentified gekkonid species which may possibly be new records for the island. The species of *Lepidodactylus cf. planicaudus* may also prove to be new for the island while the *Cyrtodactylus philippinicus* is a Philippine endemic species. Eleven species belonging to six genera comprise the skink population. It represented almost half of the entire lizard population recorded from the island. *Brachymeles boulengeri boulengeri* is Luzon endemic, being reported only from Luzon, Polillo and Marinduque. Both species of monitor lizards (*Varanus salvator marmoratus* and *Varanus olivacues*) are considered as endemic. The latter, aside from being endemic, is also considered as endangered.

Species composition and diversity patterns along disturbance gradients

Between the three existing habitats that were surveyed, the primary forest yielded the most number of species (11), followed by the secondary forest with only eight species and the agro-ecosystem with five. Table 1 shows the cumulative results on the type of species recorded for both transect count and pitfall traps.

Species effort curve for surveys of lizards using plot method and pitfall traps & bucket fences



Species effort curve for surveys of lizards using plot method and pitfall traps & bucket fences

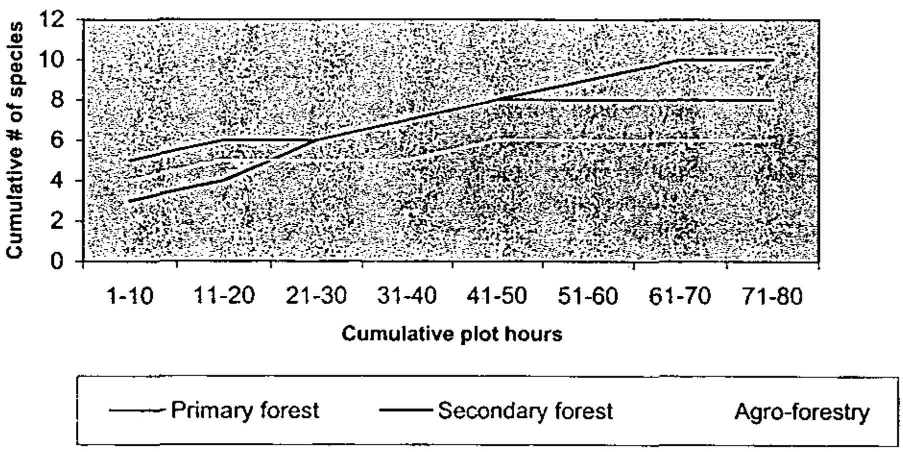


Table 1. Species of lizards recorded from Sibulan Watershed and Panukulan, Polillo Island, Quezon Prov., Philippines (July-September, 1999).

SPECIES	Common Name	Presence			
		Agro	2° forest	1° forest	Pitfall/TC
Family Agamidae (4)					
1. Calotes marmoratus sanchezi	Philippine Calotes*	-	x	x	PL
2. Draco spilopterus	Common Flying Lizard*	x	x	x	PL
3. Gonocephalus semperi	White-spotted Anglehead*	-	-	x	O
4. Hydrosaurus pustulatus	Sailfin Water Lizard	x	-	-	PL
Family Gekkonidae (9)					
5. Cyrtodactylus philippinicus	Bent-toed Gecko*	-	-	x	PL
6. Lepidodactylus sp.	-	-	x	-	O
7. Pseudogekko smaragdinus	Green Smooth-scaled Gecko*	-	x	x	PL
8. Pseudogekko sp. A	-	-	-	x	O
9. Pseudogekko sp. B	-	-	x	-	O
10. Cosymbotus platyurus	Flat-bodied House Gecko	x	-	-	O
11. Hemidactylus frenatus	Common House Gecko	x	-	-	O
12. unknown Hemidactylid	-	-	x	-	O
13. Gehyra mutilata	Tender-skinned House Gecko	x	-	-	O
Family Scincidae (11)					
14. Brachymeles bonitae	Stumb-limb Burrowing Skink*	-	x	-	PF
15. Brachymeles b. boulengeri	Boulenger's Burrowing Skink*	-	-	x	PL/PF
16. Lamprolepis smaragdina	Spotted Green Tree Skink	x	x	-	PL
17. Lipinia pulchella	Yellow-striped Slender Tree	-	x	-	O
18. Mabuya multicarinata	Skink*	x	x	x	PL/PF
19. Mabuya multifasciata	Two-striped Mabuya	x	-	-	PL/O
20. Sphenomorphus jagori	Common Mabuya	x	x	x	PL/PF
21. Sphenomorphus cumingi	Jagor's Sphenomorphus	x	x	x	PL/PF
22. Sphenomorphus coxi	Cuming's Sphenomorphus*	-	x	x	PL/PF
23. Sphenomorphus abdictus	Cox's Sphenomorphus*	-	-	x	PL/PF
24. Tropidophorus grayi		-	-	x	PL
	Spiny Waterside Skink				
Family Varanidae (2)					
25. Varanus salvator	Philippine Monitor Lizard* (R,	-	x	x	O
marmoratus	En)	-	x	x	O
26. Varanus olivaceus	Gray's Monitor Lizard* (R, En)				

Note :
(x) – confirmed presence
(-) – not observed
(*) – Philippine endemic
(R) – rare ; based on RDB,1997
(En) – endangered; based on RDB,1997
(O) – opportunistic collection or data obtained from other sources
(PL) – plot method
(PF) – Pitfall traps

In the agro-ecosystem, the frequently encountered species are members of Family Scincidae (*Lamprolepis smaragdina, Mabuya multicarinata, Mabuya multifasciata, Sphenomorphus jagori* and *Sphenomorphus cumingi*). Next to the skinks are the geckoes, with four species recorded (*Cosymbotus platyurus, Hemidactylus frenatus, Gehyra mutilata* and a gekkonid sp.). Except for the latter, all three species of geckoes are commensal in nature. They are frequently observed in areas associated with human habitation (i.e. houses and shanties which has been used for drying coconuts). The gekkonid sp. A on the other hand, was caught only once on a jackfruit near very near the base camp. Unfortunately, it escaped before the researcher got the chance to preserve it as voucher specimen (note: a picture was taken though, before it escaped). Only two agamid species were caught and recorded in the agro-ecosystem (*Draco spilopterus* and *Hydrosaurus pustulatus*). *D. spilopterus* is highly associated with coconut plantations (Plate 2). However, based on observations they seem to prefer the taller and mature stocks of coconuts (approx. 12- 20m in height) over that of the younger and smaller ones (usu. less than 10m in height). The *Hydrosaurus pustulatus* or the Sailfin Water Lizard is associated with unpolluted bodies of water (i.e.rivers but very seldom on streams) near secondary growth forests (Plate 3). This particular species is considered as the largest among the agamids in the Philippines, next only to the monitor lizards (Family Varanidae). It is however absent in both the secondary and primary forests.

Species of lizards associated with the secondary growth forest include two agamids (*Calotes marmoratus sanchezi* and *Draco spilopterus*); three gekkonids (*Lepidodactylus cf. planicaudus, Pseudogekko smaragdinus* and a *gekkonid sp.*); nine species of skinks (*Brachymeles bonitae, B. b. boulengeri, Lamprolepis smaragdina, Lipinia pulchella, Mabuya multicarinata, Sphenomorphus jagori, S. cumingi, S. coxi* and *S. abdictus*); and two varanids (*Varanus salvator marmoratus* and *V. olivaceus*). All species recorded from the secondary growth forest represented all four families of lizards with the skinks being the most dominant group. Of the two agamid species, *C. marmoratus sanchezi* has been noted by Crombie (1994) to be present only on Polillo but pointed out nonetheless, that this present distribution might be inaccurate because distributional data on *Calotes* species are insufficient and needs further review. Note that it was observed only in the secondary forests and not in the agro-ecosystem or primary forests in Sibulan Watershed. The other agamid species, *Draco spilopterus* was observed on a small to medium-sized tree (approx. 50-60 cm in dbh) over looking a patch of mixed secondary and agro-ecosystem. The endemic *Pseudogekko smaragdinus* is one of the three species of geckoes recorded in the secondary forest and was caught on the leaf axils of a *Pandanus* species found on boundary between the primary and the secondary forest (Plate 4). The other two species of geckoes are *Lepidodactylus cf. planicaudus* and a gekkonid sp. B. Both were only recorded from secondary growths but the former was recorded only from the Sibulan Watershed while the latter was found in Panukulan, the other watershed of Polillo Island, situated on its northern flank. Of the nine recorded species of skinks, the two species of *Brachymeles* (*B. bonitae* and *B. b. boulengeri*) together with the other two species of *Sphenomorphus* (*S. coxi* and *S. abdictus*) are species of lizards which can be found in the secondary but not in the agro-ecosystem while the other five species are simply common to both agro- and secondary growth forests. Not entirely encountered within our transect and pitfall traps, records of the two varanid lizards were basically obtained from ethno-biological interviews and data gathered by one of the members of the expedition team, Daniel Bennett, who is working on monitor lizards at the time this particular study on lizards by the researcher was conducted. For purposes of documentation, the confirmed presence of these two varanid lizards from the island was reported. Another species of skink recorded from the secondary forest is the *Lipinia pulchella.* Fortunately, this skink was accidentally found on a "layasin" tree when the group was just setting camp. For some reasons that may be entirely due to specific habitat or vegetation type, this species was not at all encountered in the Sibulan watershed for the whole duration of the expedition.

Next only to the secondary growth forest in terms of species composition, the primary forest yielded equally substantial number of lizard species with three species specific or found only in this type of habitat and not shared by either agro- or secondary forest. The aforementioned species include *Gonocephalus semperi*, *Cyrtodactylus philippinicus* and *Tropidophorus grayi.* The other ten species are simply shared with the other two habitats except for the two varanid lizards which are not observed in the agro-ecosystem. The agamid lizard, *G. semperi* is a new record for the island. Both Taylor (1922) and Crombie (1994) failed to record this species during the time of their collection on the island.

Assessing the species composition along disturbance gradients, it appears that diversity index value increases as the level of disturbance in each habitat lessens. Table 2 indicates the different values and trends that were observed in the field using the different diversity indices that has been computed. Diversity index for primary forest is 1.4911, followed by the secondary growth with 1.2389 and the agro-ecosystem with only 1.1768. These diversity indices only show that, in the primary forest, more species were recorded and decreased as you go outside the forest towards the more disturbed areas, the agro-ecosystems.

Table 2. Analysis of transect count in the different habitats around Sibulan Watershed, Polillo Island, Quezon Prov., Philippines.

Habitat type	Total no. of ind. Recorded	Total no. of species	Diversity Index (H')	Equability Index (J)
Agro-forestry	248	7	1.1768	.6048
Secondary Forest	271	8	1.2389	.5958
Primary Forest	264	11	1.4911	.6232

In assessing the diversity of a certain habitat, what matters most is the total number of species recorded rather than the total number of individuals encountered. Number of individuals will only give you how often or frequent the species has been observed. Take the case of the secondary forest. Relatively, more individuals were observed while doing sampling activities as compared to the primary forest when less individuals were observed. However, there appears to be more species of lizard that were recorded from the primary than that of the secondary growth. The comparatively higher species diversity in the primary forest, can be attributed to the inherently more available and suitable habitats for lizards compared to the secondary forest. Basically, lizards prefer areas that are characterized by lush and conspicuous looking vegetation that offers enough room for concealing themselves against any predators. Dead forest logs, rock crevices, vines, epiphytes, thick litter fall, humus spiny-edged leaf axils of big *Pandanus* plants, all provide excellent hiding sites for lizards.

The relatively high species diversity for the primary forest may be attributed to the ecotonal relations with agro-ecosystem that borders the forest. Intrusion of species of lizards from the coconut plantations and scrubland, increases the number of species in the primary forest. Colonizing species from non-forested areas may inhabit niches previously vacated by intolerant types. Species diversity in both the secondary and agro-forestry sites is nearly equal. This condition would imply similar ecotonal conditions affecting primary forests can also be observed between secondary and agro-ecosystems.

Based on the evenness indices, data shows that primary forest has the highest equability index (.6232), followed by the agro-ecosystem (.6048) and the secondary forest (.5958). A high equability value implies that there are more individuals equally represented in the species found on each of the other study sites. A low equability index would mean that there are more species found in the site, but with less equally represented species. Perhaps, such values would be indicative of more specialized species being found in habitats with low equability values, and more widespread species are likely to be found on habitats with high equability index.

Bucket fencing vs. Transect walk

Although bucket fencing as a sampling technique for capturing and recording reptiles offer many disadvantages (expensive, difficult to assemble, needs constant checking, moderately destructive because a hole has to be dug out in order to accommodate the buckets), it proved very effective in catching lizards which are not easily captured by hand when walking on transect. Species of *Brachymeles* were trapped inside the buckets. These species of skinks are associated with their burrowing nature. Thus, it would be very difficult to catch them without having to dig into the earth. Furthermore, *Sphenomorphus* species are highly active organisms. You can spot them under heavy forest litter, on holes of dead logs or in rock crevices but seldom are they being caught by hand. They are very agile and easily blend with their surrounding. Using the pitfall traps allow us to capture some of these individuals without any difficulty except when retrieving them from the buckets. Transect counts on the other hand, allows a researcher to explore all possible microhabitats of lizards found within a habitat. It is highly dependent on the ability of the researcher to spot and capture the animal with very minimal amount of stress inflicted on an organism. Area-wise, transect walk is very advantageous for a researcher.

In terms of the total number and kind of species caught in each of these technique, transect walk yielded the most number of species. However, some of the species that were caught in the pitfall traps were not encountered during transect walk and vice-versa. It would be very obvious that upon assessment and comparison, transect counts definitely will yield more species. On the contrary, the researcher thinks that both methods will provide more and valuable amount of data if combined together.

THREATS TO THE LIZARDS AND OTHER WILD FAUNA OF POLILLO ISLAND

By way of carrying out ecological studies, a particular population of organism can be analyzed or assessed. One way of determining how important a study should turn out to be, it must be able to address if not all, some of the pressing issues that may threaten the existing population of that particular group of organism.

Not only lizards, but also all wildlife species, are threatened by environmental factors. Their present population may not be affected by such activities but any future repercussions brought about by such actions can create problems that may threatened their survival. Below is a list of possible threats that may affect the existing population of wild fauna on Polillo Island:

i. Small-scale carabao logging - many of the local people depend on the forest as a source for livelihood. Timber or any forest product is a valuable commodity for them. If this activity remain unregulated by the local government as well as by the people themselves, there would come a time that the forest can no longer sustain the demands by the people for forest products. If left unprotected, the forest will eventually be wiped out. Gone are the trees that provide for them; the pristine, unpolluted and unlimited source of clean water; and even the wild fauna that helps in maintaining "equilibrium".

ii. Encroachment by people into the watershed and other forested areas - continuous and unperturbed encroachment into the forested areas will eventually pose severe repercussions on the following: health, crops and even properties. Without the forests, the areas near the slope of the mountains/hills will experience flooding; farm lands will be flooded which may later affect yield; problems with health and hygiene will increase due to associated diseases brought by development.

These threats can only be abated by (1) Increasing the hectarage or total area covered by the watershed. It is one of the best solution to protect the remaining forested areas. Also, it will allow regeneration of forest species to take place without human interference. Buffer zones may also be considered for this purpose. (2) Encourage the people to practice sustainable use of the forest through careful harvesting of forest products. (3) Form a group that will specifically patrol and check the entire watershed on a regular basis. It would be a great move to involve unemployed but willing to get the job. This job will require hardwork and dedication.

These conservation measures are highly hypothetical but nonetheless, the possibility that some of it might work is something to look forward to. Remember, any conservation effort must be a concerted effort between the concerned party and the stakeholders – the people of the community and the inhabitants of the forest. You can easily talk to them but how about the animals? You just have to know them in order to understand them.

RECOMMENDATIONS

This study was able to generate a list of species of lizards on Polillo Island which can be used as baseline data for further researches on the fauna of the island. However, this data only include information on one island – Polillo and none on the remaining three major islets and satellite island of the entire Polillo group of islands. A lot of data has to be further generated in order to come up with a comprehensive and updated list of all wildlife species on Polillo. The paucity on the ecological studies done on the island should not be looked upon as a hindrance or obstacle in understanding the ecology of these species but rather, it should motivate and encourage future expeditions to be carried out on these group of islands. Below are some of the recommendations that the researcher wishes to convey:

1. To further understand and correlate the species population on this island with the other islands in the Greater-Luzon faunal region, there has to be a comprehensive ecological study between these islands that will employ scientific and standardized methods of sampling.
2. Future studies on lizards and on any other vertebrate group must considered seasonal variations. It is significant to note the underlying biological adaptations of the animal in terms of thermal requirements. It may affect their distributional patterns.
3. The use of several and not just by only one type of sampling method is encouraged by the researcher. Based on this study, it can generate enormous and significant data on the animal's ecology, distribution and behavior.
4. If possible, involve the local people in the conduct of future surveys. It is one way of making them feel that they have a "say" on issues that are happening in their community. Also, it is an excellent means of educating them about the importance of our work and their role in all these.
5. It is very important to also educate the younger generation – teenagers and even those who in the primary level of education. Eventually, all that we are working for will fall into there hands and it is up to them if they would continue working towards conservation.

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Appendix 1. Results of the total number of lizards recorded based on pitfall traps and transect counts in Sibulan Watershed, Polillo Is.

SPECIES	Agro-forestry				Secondary forest				Primary forest		
	Pitfall	Plot method			Pitfall	Plot method			Plot method		
	caught	obs	caught	sub-total	caught	obs	caught	sub-total	obs	caught	sub-total
1. Calotes marmoratus	-	0	0	0	-	1	1	2	-	-	-
2. Draco spilopterus	-	60	13	73	-	9	2	11	-	-	-
3. Gonocephalus semperi	-	0	0	0	-	-	-	-	1	1	2
4. Hydrosaurus pustulatus	-	19	0	19	-	-	-	-	-	-	-
5. Cyrtodactylus philippinicus	-	-	-	-	-	-	-	-	2	1	3
6. Pseudogekko smaragdinus	-	-	-	-	-	14	6	20	11	10	21
7. Brachymeles bonitae	0	-	-	-	2	-	-	-	-	-	-
8. Brachymeles boulengeri	13	-	-	-	29	-	-	-	3	1	4
9. Lamprolepis smaragdina	-	1	-	1	-	3	1	4	1	1	2
10. Mabuya multicarinata	11	130	4	134	4	151	1	152	72	2	74
11. Mabuya multifasciata	-	1	-	1	-	-	-	-	-	-	-
12. Sphenomorphus jagori	15	14	2	16	12	58	13	71	102	26	128
13. Sphenomorphus cumingi	0	4	0	4	3	10	0	10	3	0	3
14. Sphenomorphus coxi	0	-	-	-	1	1	0	1	8	3	11
15. Sphenomorphus abdictus	4	-	-	-	3	-	-	-	4	2	6
16. Tropidophorus grayi	-	-	-	-	-	-	-	-	6	4	10
TOTAL	**43**			**248**	**54**			**271**			**264**

Appendix 2. Results of the relative abundance and diversity index per habitat based on transect counts.

SPECIES	Agro-forestry			Secondary forest			Primary forest		
	p_i	$p_i(\ln p_i)$	$p_i(\ln)$	P_I	$p_i(\ln p_i)$	$p_I(\ln)$	p_i	$p_i(\ln p_i)$	$p_I(\ln)$
1. *Calotes marmoratus*	0	0	0	.0074	-.0363	-4.9090	0	0	0
2. *Draco spilopterus*	.2944	-.3600	-1.2230	.0406	-.1301	-3.2042	0	0	0
3. *Gonocephalus semperi*	0	0	0	0	0	0	.0076	-.0371	-4.8828
4. *Hydrosaurus pustulatus*	.0766	-.1968	-2.5690	0	0	0	0	0	0
5. *Cyrtodactylus philippinicus*	0	0	0	0	0	0	.0114	-.0510	-4.4773
6. *Pseudogekko smaragdinus*	0	0	0	.0738	-.1924	-2.6064	.0795	-.2012	-2.5314
7. *Brachymeles b. boulengeri*	0	0	0	0	0	0	.0152	-.0637	-4.1897
8. *Lamprolepis smaragdina*	.0040	-.0221	-5.5134	.0148	-.0624	-4.2158	.0076	-.0371	-4.8828
9. *Mabuya multicarinata*	.5403	-.3326	-.6156	.5609	-.3243	-.5782	.2803	-.3565	-1.2719
10. *Mabuya multifasciata*	.0040	-.0221	-5.5134	0	0	0	0	0	0
11. *Sphenomorphus jagori*	.0645	-.1768	-2.7408	.2620	-.3509	-1.3394	.4848	-.3510	-.7239
12. *Sphenomorphus cumingi*	.0161	-.0664	-4.1271	.0369	-.1218	-3.2995	.0114	-.0510	-4.4773
13. *Sphenomorphus coxi*	0	0	0	.0037	-.0207	-5.6021	.0417	-.1325	-3.1781
14. *Sphenomorphus abdictus*	0	0	0	0	0	0	.0227	-.0859	-3.7842
15. *Tropidophorus grayi*	0	0	0	0	0	0	.0379	-.1241	-3.2734
$\Sigma p_I (\ln p_i) = H'$			***1.1768***			***1.2389***			***1.4911***

The Distribution and Ecology of Bats in the Polillo Islands, Philippines

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ABSTRACT

The bats of Polillo Island group are described. A total of 25 species of bats were recorded. These include eight fruit bats, one megadermatid, nine rhinolophid and seven vespertilionid. Of the 25 species recorded, 11 are listed as new records for the island. The study employed disturbance gradient surveys in Sibulan watershed, Polillo Island to determine diversity patterns. Trends show that many species are generalist, particularly fruit bats, owing to the small size of the forest and its proximity to disturbed habitats. In addition, new netting techniques were employed: ground netting, sub canopy netting and tunnel trapping. Tunnel trapping proved to be more efficient in capturing bats having an efficiency of 41 and 28-fold than ground and sub-canopy netting respectively. Preliminary assessment shows that foraging behavior plays a great role in discrepancies in capture efficiencies.

INTRODUCTION

The Philippine bat fauna is very diverse, with 71 species recorded, of which 24 species are endemic to the country (Heaney et al, 1997). Studies even at the level of alpha taxonomy and its associated distribution records are lacking, and seven new species have been identified since 1969 and additional four new records (*Murina cyclotis* in 1991, *Pteropus dassymalus* and *Harpiocephalus harpia* in 1992 and *Hipposideros lekaguli* in 1995) in the country during the start of the 1990's (Ingle, 1992 and Heaney et al 1997).

Mistnets have been used in the Philippines for bat surveys since the 1960s, but the method does not work well for microchiropterans. A seven-month study conducted in the Mount Makiling Forest Reserve in 1993 utilized nets that were raised above the ground from three meters to 16 meters and captures were compared with nets set-up at standard heights (0-3 meters). This study enabled inferences on community structure in the subcanopy. Likewise, species composition significantly differed along the different strata in which nets set-up at the subcanopy yielded more species. A study done in the same locality in 1998 also made inferences on the foraging behavior and space-time movement of microchiropterans and made use of a netting technique (tunnel trap) that can capture microchiropterans with relative ease compared with ground nets (Sedlock, unpublished data). Incorporating these new netting techniques into standard field methodologies or protocol will enable a researcher to ensure adequate sampling of bats in a relatively short period of time. In addition, inferences can be made on bat community structure (from subcanopy and below) and their use of natural corridors or flyways.

Primary forest cover in the Philippines as a whole has been reduced from more than 80% of the total land area near the turn of the century to ca. 8% in 1988 (Myers, 1988). Furthermore, impacts of deforestation on wildlife may be particularly severe on small islands, where population and community structure may be less robust (Rickart et al, 1993). This is particularly true on several small islands such as Lubang, Batamnes, Marinduque, Siquijor and Polillo among others, where most of the original forest have been extirpated over the past century. In Polillo, at the turn of the century, McGregor had a first glimpse of what was then a pristine and primeval thick forest, where grasslands and clearings were non-existent (Gonzalez,1997). Today, pressures from industrialization and small-scale farming systems have marginalized the original forest of Polillo at a critical minimum (Gonzalez, 1997).

This paper presents the first synoptic list of mammals from Polillo Island. Previous records from the islands came mostly from collecting trips and inventory of other faunal groups where specimens of bats were taken as "sidetrip", e.g. Crombie in 1994, Taylor in 1922, and McGregor from 1910.

The present study documents diversity of bats based on disturbance gradients and assesses the efficiency of new netting techniques.

METHODOLOGY

Field work were conducted at five site in Polillo island. Most of the field work was conducted along a disturbance gradient in Sibulan forest

Site P1 - Agriculture site, Sitio Sta. Maria, Bo. Pinaglubayan, Polillo Munic. Polillo Is. Seven net-lines were placed on this site, four ground nets, two subcanopy nets and a tunnel trap (net G). Two groundnets (A and E) were set-up traversing a river while rest of the groundnets were placed along a ricefield paddy (net F) and within a coconut grove (net E). Subcanopy nets were hoisted 10 meters above the ground and were placed facing a rice field (net c) and along coconut groves adjacent a sizeable meadow (net B). The tunnel trap (net G) was placed traversing a river with its opening facing the widest junction of the river. This site is about a kilometer east of the watershed boundary and is proximal to a nearest barangay. Much of the vegetation consists of coconut groves and ricefields in between. Fruit trees are uncommon which made up mostly of *Ficus nota*, *F.variegata* and *Antidesma pentandra*. Pioneer plant species are also present in this area like *Tremma orientalis* and *Premna odorata*. Netting effort for ground nets and subcanopy nets are 71 and 32 net-nights respectively while tunnel trapping effort was 12 net-hours.

Site P2- Secondary forest; Sitio Sta. Maria and Mahabang Kahoy, Bo. Pinaglubayan and Sibulan, Polillo Munic. Polillo Is. This site is located within the boundaries of the western part of the watershed. Six net stations were placed in this site. Three ground nets, A ,C and D were set-up along a small trail, ridge tops , and across a creek respectively. Two subcanopy nets (nets B and E) were placed seven meters above the ground and were set up along gaps in the vegetation while tunnel trapping (net F) was conducted adjacent a fishpond that flows through an underground spring. Emergent trees (mostly non-dipterocarp) had small to medium sized buttresses, diameters at breast height of about 0.8 to 1.2 m and reaching heights of 15-25m. Canopy cover is not continuous and is replaced by *Musa* vegetation and occasional bamboo thickets and small-sized meadows. Canopy vegetation mainly consists of *Ficus* spp particularly *minahasse* and *variegata*. An occasional cluster of dipterocarp trees are present although it is restricted along steep slopes of hills of about 25-40 m. These dipterocarps have a rather small dbh (0.2-0.8 m) although saplings are numerous. Epiphytic ferns like *Asplenium*, *Drynaria* and *Freycinettia* were rare to moderate, with their frequency increasing with proximity to the watershed. An open understorey consisted of saplings, small palms (*Calamus*) low ferns, tree ferns (*Cyathea*) and erect terrestrial pandans (*Pandanus*), though the last one is quite rare. Fallen logs are quite common and most of them have medium sized dbh. Exposed rocks or rock formations having crevices are almost non-existent. An occasional clearing can be seen near the southern portion of the watershed and most of them are titled lands. A trail coming from the nearby barrio bisects this site and extends across the watershed to the town. This trail not frequented by the inhabitants of the nearby barrio. A temporary camp was set-up near net C. Netting efforts for ground and subcanopy nets were 64 and 32 net-nights respectively. Tunnel trapping effort accounts for 8 net-hours.

Site P3 - Primary forest; Sitio Maganit, Mahabang Kahoy, and San Francisco, Bo. Sibulan, Polillo Munic. Polillo Is. This site is confined inside the watershed boundary and most of the netting stations are located on a ridge system bounded by steep valleys in intact original lowland forest. Emergents reach heights of about 25-35m with buttress' dbh of about 0.8 to 1.6m. The canopy was 15-25m high and broken by occasional tree falls. Woody vines clinging around large trees are common particularly the large wrist-sized *Entada*. Epiphytes, particularly ferns, were common. Moss was limited to trunks of large trees and fallen logs. Understorey was similar to P3 although medium sized trees and erect pandans are common. Many rivers that serve as potable water source are scattered over the watershed. These rivers, that form numerous tributaries and veins, are Mahabang Kahoy, Sabian, Maganit and Sta. Maria rivers. Eight netting stations are scattered over this site. Three ground nets, C,D, and E were placed along ridge tops, stream, and at edge of forest gaps respectively. Subcanopy nets A and E were likewise placed above a stream and forest respectively. Three tunnel trapping stations (B,G,and H) were placed separately from each other and all them set-up across rivers. Ground and Subcanopy netting efforts were at 64 and 32 net-nights respectively while tunnel trapping accounts for 12 net-hours.

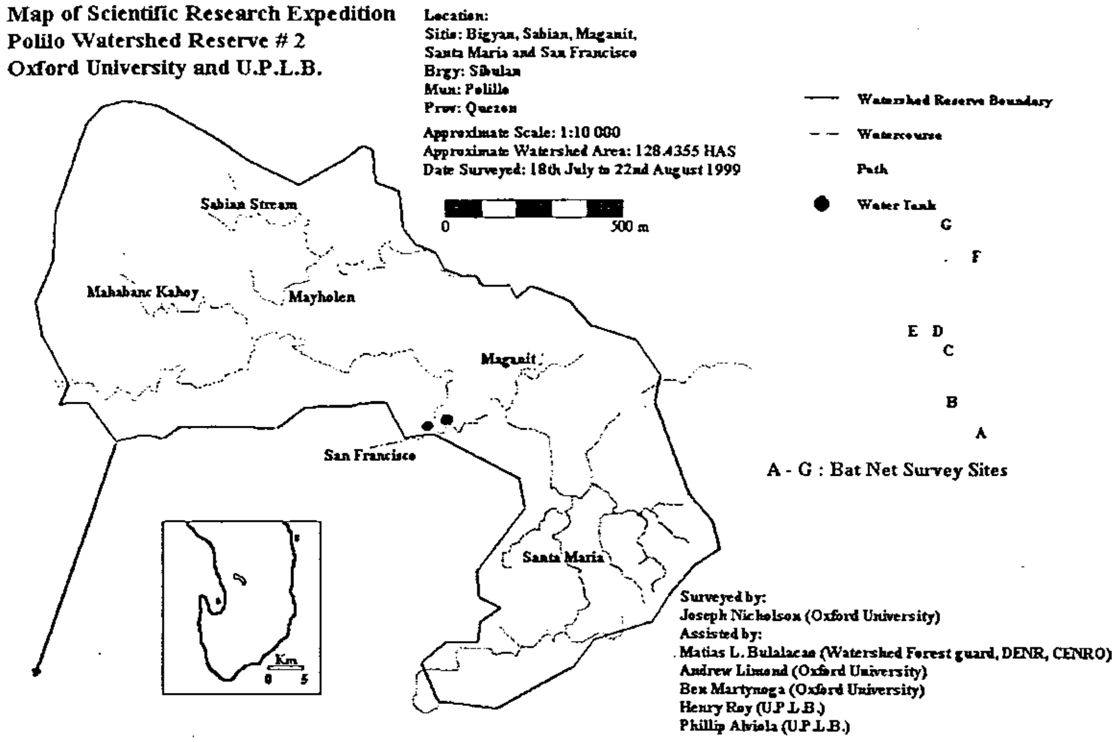
Site P4 - Sitio Kitiwan, Bo. Bato, Panukulan Munic.Polillo is. The site, along its adjacent forest constitutes the main Panukulan Watershed Reserve. The forest is a secondary patch with mixed agricultural crops such as coconut groves, rice paddies and herbaceous shrubs. The secondary patch is confined to the steep hills of about 50 m that surround and form a wall facing the sea. There are few emergents, with heights reaching 20-25 m. Canopy cover is, more often than not, broken except along steep slopes of hills. Much of the original vegetation has been cleared for agriculture. An open understorey consists of an occasional palms (*Calamus*), low and tree ferns, and erectile pandans. *Ficus* density is high although some dipterocarp species were observed although with small dbh. Water source, in the form of creeks, are rare while rivers are absent. The expedition stayed only for five days and netting effort was only confined to ground netting with four stations. Total net-nights was 56.

Site P5 - Bulalon and Mapanghi Caves, Bo. Bulalon, Burdeos, Polillo Is. the Bulalon cave was surveyed last 1974 by UPLB led by Prof. P. Alfonso and Prof. P.L. Alviola III. They stayed for three days and netted four species of insect bats, *Miniopterus australis*, *M.schreibersi*, *Rhinolophus arcuatus*, and *Hipposideros "coronatus"*.The author went back during the span of the expedition surveyed the Bulalon cave and eventually found another cave, apparently missed by earlier researchers, the Mapanghi Cave. These caves are about five kilometers south of the town proper. The Mapanghi cave is nearer with respect to the baranggay, with walking distance of about 300m. The trek to Bulalon cave is much longer, about 30 minutes of negotiating steep hills and valleys. Vegetation uphill from the Bulalon cave was heavily disturbed secondary forest although patches of high woodstands can be seen high portion a hill leading to Bulalon cave. Areas downslope were predominantly agricultural land. Farther west about 500 meters, small limestone formations were observed having jagged edges although for alcoves and can be possible roost site for bats. Roost site of *Acerodon jubatus* was discovered within this vicinity and they were observed to be roosting on a tree of about 15 high.

The largest cave at this locality, locally known as Mapanghi cave, had two main entrance (northwestern and southern). The northwest opening is at the center of a large concavity in the limestone cliff. The height of this opening is about 13 m (outer) and the inner portion is about 10 meters. This entrance leads to a cathedral, with a height and width of 20 m and 50m respectively. Several shallow solution pits were located along the path. The southern opening is about 10 meters and a shallow stream flows through the opening. Along the path coming from the south opening, a long, uphill shaft was seen that leads to the eastern opening about 50 m. The eastern opening is small, about 3 meters in diameter. Sampling of bats were done using hoopnets.

Minasawa

The island of Minasawa, still contains relatively good beach forest in its small five hectare area, due to its protection as a game refuge and bird sanctuary. Large hardwood trees are found in the interior, smaller trees in the periphery with the low canopy dominated by Marang and Dapdap. Colonies of *P. hypomelanus* and possibly *P. vampyrus* roost within these canopy numbering to about 100



B. Netting techniques

Our field studies were conducted using procedures that evolved over time. The primary purpose of surveys of 1996 was to ascertain species richness and diversity of birds as M.Sc dissertation of Gonzalez. Mistnetting of bats became only secondary to that purpose. Standardized field methodologies were not employed so no records of how many nets were set-up, only species richness per island. The present survey had the additional aim of documenting habitat disturbance gradient and employing new mist-netting techniques that were not conceived during the 1996 surveys. Great care was involved in placing nets, number of nights run and the total effort given at each disturbance gradient. Moreover, documentation of ecological parameters such as roost sites was added.

Bats were caught in mistnets set on ridge top, across established trails and streams, or at the edge of clearings in forest, and among fruit trees in agriculture areas. The number of net-nights were standardized more or less so as to permit valid comparison between sites particularly in the disturbance gradient study. For convention, one netnight is equivalent to one 6-meter net left open for 12 hours.

Four types of collecting techniques were employed:

a. Ground mistnetting - 35 mm mesh monofilament mistnets (6 or 12 m long) were set up. These nets were placed 0-3 m above the ground. Total netting effort for the gradient study was 200 net-nights.

b. Sub-canopy netting - this methodology was adopted from Ingle's work in Mt. Makiling during her study about chiropteran vertical stratification. Sub-canopy nets, each consisting of two 12 m nets, one placed above the other, were hoisted by a pulley system or by long bamboo poles. The height of the placement of these nets ranged from 5-10 m depending on the terrain. These nets were placed on natural gaps in the forest or in between two coconut stands in agriculture land. Comparison of this method, in terms of its catching success and type of species captured, with other netting technique was done. A total of 96 net-nights was conducted in this technique with each disturbance gradient having 32 net-nights.

c. Tunnel trap- this methodology was adopted from Sedlock's unpublished work on foraging behavior of microchiropterans. The tunnel trap consists of a series of nets (eight) that are connected with each other, forming a rectangular box configuration. The longer sides and the ceiling consisted two 12 nets (each) placed above the other. One of the shorter sides was left open since no nets were attached, and this serve as the opening. All four corners are supported by poles of about 5-7 meters long, with two of these poles being stationary. Three people manthe contraption, two holding the stationary poles (opening) while the other stays inside the "tunnel". Once a bat goes inside the tunnel the poles are dropped, sealing the tunnel and the bat is caught in a hoopnet. The tunnel trap was placed strategically on sites such as across creek where insect swarms are plenty. Total netting effort for this method was 32 net-hours, 12 each for primary and agriculture sites and 8 for secondary forest.

d. Roost site survey - this procedure was supplementary for the abovementioned techniques so as to document bats that are very hard to observe or capture. Roost site observed by this study included hollow trees, crevices in rock formation, culverts, leaf fronds especially Anahaw (*Livistona*) and caves especially those that formed cathedrals.

RESULTS

Species Accounts

Family Pteropodidae - Fruit bats

Acerodon jubatus (Eschscholtz, 1831)

The globally-threatened golden-capped flying fox is a Philippine endemic and is found through out the country with the exception of the Palawan region. This species is the first record for the islands. It was observed in a roosting site with colonies of about 50 in Bulalon, Burdeos. We did not obtain any specimens nor tried to capture this species since the rocky and loose terrain could not permit it. Our field guide reported numbers close to 1000 and some roost in other places . These bats, while in roost, were observed to display aggressive behavior like "boxing" and squeals when they come into contact with each other.

Individuals observed/captured: Close to fifty individuals were observed, all in Burdeos (P5)

Cynopterus brachyotis (Peters, 1862)

The short-nosed fruit bat is common through out the Philippines and is widely distributed in Southeast Asia. This bat was captured in all sites except in Minasawa Island. This bat was also the commonest species captured in the disturbance gradient study with 73 individuals of which 31 was in agroforest (P1). It was also common in secondary forest (P2) with 24 although it was uncommon in primary forest (P3). Netting

in P4 also proved this bat to the commonest. Four individuals were taken in P4 underneath an Anahaw leaf and likewise was also observed in the Watershed near P2. This bat was caught mostly in groundnets (38) although subcanopy nets proved to be successful also with 25 individuals. Only two individuals were caught inside a tunnel trap.
Individuals caught/observed: Total 73. Site P1 (31); site P2 (24); site P3 (10); site P4 (8).

Eonycteris spelaea (Lawrence, 1939)
The cave nectar bat occurs from India to Timor and is common throughout the Philippines. In our disturbance gradient study it was only captured once, in agriculture site (P1) using the subcanopy nets. It is possible that this species occurs in the caves we visited, so a more thorough examination is required. The lone individual captured was an adult female (measurements are given in table).
Individuals caught/observed: site P1 (1).

Macroglossus minimus (Matschie, 1899)
The dagger-toothed flower bat occurs from Thailand to Australia and is found throughout the Philippines. This is the third most common bat caught in the disturbance gradient sites and is common in agriculture site (P1) with 26 individuals captured. It is quite uncommon in forested areas especially in primary forest (P3) due to paucity of banana stands. Ground nets proved to be the most successful in capturing this species (26) although it was also captured in subcanopy (7) and tunnel trap (1). In Panukulan (P4) a lone individual was captured.
Individuals caught/observed: Total 38. Site P1 (26 indv); site P2 (7); site P3 (4); P4 (1).

Ptenochirus jagori (Peters, 1861)
This species is a Philippine endemic, occurring throughout the archipelago with the exception of the Palawan region. It is the second most abundant bat captured in gradients with 72 individuals. It was most common in agriculture (P1) and primary forest sites (P3) with 29 and 33 individuals each and uncommon in secondary forest (P2) with only 5 individuals. Subcanopy netting was the most successful method in capturing this species with 42 individuals. It was also captured in Panukulan (P4 with 5 individuals) and it may be present in Burdeos. This species was observed to fly very high inside forested areas and this could account for few individuals captured in secondary forest (P2) since subcanopy nets set-up in that site were not high enough (5 meters). Heaney (1989) reported this species to be common in forested areas but ventures out in agriculture lands if there is forest areas present nearby. This conclusion was observed in this study.
Individuals caught/observed: Total 72. site P1 (29); site P2 (5); site P3 (33); site P4 (8).

Pteropus hypomelanus (Mearns, 1905)
This common flying fox occurs from the Maldive Islands to the Solomons. It is widespread in the Philippines, where it is commonly encountered in lowland agriculture areas. This species was observed in great numbers in Minasawa Island about 100 indv and was also seen in mixed colonies with Pteropus vampyrus. It was also observed in Polillo where it can be seen roosting on top of coconut trees usually in group of fours or

fives. Individuals caught/observed: Observed in the Sibulan, Panukulan and Burdeos in Polillo Island. Also observed on Minasawa (about a hundred individuals).

Pteropus vampyrus (Mearns, 1905)
The giant flying fox is widespread in Southeast Asia and is locally common in primary forest in the Philippines (Rickart et al, 1993). This species is a new record for the island and was observed in Minasawa island in mixed colonies with P. hypomelanus. Its presence in Polillo needs to be confirmed where it was reported by villagers to be flying at dusk in Sibulan.
Individuals caught/observed: No individuals caught but observed in Minasawa and probably Polillo island (Sibulan).

Rousettus amplexicaudatus (E. Geoffroy, 1810)
The rousette fruit bat occurs from Thailand to Solomon islands and is found throughout the Philippines. Although it was caught at forested sites (P2 and P3 with 11 and 3 individuals respectively), it was most common in agriculture lands (P1) with 14 individuals. Ground netting was the most successful method in capturing this bat accounting for 18 individuals while subcanopy netting captured 11 individuals. It was not capture in the tunnel trap. A lone individual was captured in Panukulan (P4) in nets set up 0.3 meters from the ground near the waterfalls. In Burdeos (P5), it was observed roosting in Mapanghi cave numbering to about several thousands along with other insect bats. It was not caught though in other islands.
Individuals caught/observed: Total 29. Site P1 (14); site P2 (11); site P3 (3); site P4 (1); site P5 (roosting in caves numbering to about several thousands).

Family Magadermatidae- False Vampire Bats
Megaderma spasma (Linnaeus, 1758)
The false vampire bat occurs from India and is found throughout the Philippines. Only two individuals were captured in the study, both in agriculture site (P1) using a groundnet and in the secondary site using the tunnel trap (P2). It was observed while tending nets to fly real low especially in rivers where it was skimming for prey.
Individuals caught/observed: Total 2. Site P1 (1); site P2 (1).

Family Rhinolophidae- Horseshoe Bats
Hipposideros ater (Templeton, 1848)
The dark leaf-nosed bat is found from India to northern Australia and is widespread in the Philippines. This species is a new record for the island. Three individuals were caught in this study, all of them in the gradient sites. Two individuals were caught in agriculture site (P1) while a lone individual was caught in secondary site (P2). This bat was solely caught by tunnel trapping. In agriculture site, it was caught swooping inside the trap on a partially-dried river bank facing an open area where the river flows while its back facing the front of a drooping tree about 1.5 meters from the ground. In secondary forest (P2), before entering the tunnel, this bat observed to be skimming in narrow creek forming corridors.
Individuals caught/observed: Total 3. Site P1 (2); site P2 (1).

Hipposideros bicolor (Temminck, 1834)
The bicolored round-leaf bat is widely distributed from India to Timor although it is rarely caught in the Philippines. Previous island records in the country includes Luzon (one locality), Mindoro and Palawan so this makes this species a new record for Polillo island and additional record for the country. This bat is one of the rarest bat caught in the study with only a lone individual. It was caught in primary forest (P3) using the tunnel trap. The trap (net B) was placed across a river between two steep hills forming a valley.
Individuals caught/observed: Total 1. Site P3

Hipposideros diadema (Meyen, 1833)
The diadem leaf-nosed bat is widespread from Southern Asia to Northern Australia. It occurs throughout the Philippines in a variety of habitats ranging from agricultural situations to primary forest (Rickart et al, 1993). In Polillo however, it was not caught in primary forest (P3) and most of the captures were from agriculture site (P1) with five individuals and caught in all netting techniques. In secondary forest (P2), two individuals were caught both by ground netting and tunnel trapping. In Burdeos (P4), it was observed roosting in several thousands (Mapanghi cave) hanging in a large cathedral. It was also caught in Patnanungan island.
Individuals caught/observed: Total captured 7. Site P1 (5); site P2 (2); site P5 (several thousands observed). Also recorded in Patnanungan island.

Hipposideros obscurus (Peters, 1861)
This leaf-nosed bat is a Philippine endemic with distribution scattered around the country although there are no previous records from Polillo. This is one of the rarest bat captured in the study - only one individual captured in secondary forest site (P2). Ecological records from other study reported it to be locally common to uncommon in primary and disturbed forest up to 850 m. This species was captured using the tunnel trap that was placed in front of a creek forming a narrow corridor towards the forest. It is speculated that this species inhabits fallen log with hallow interior and may be present in primary forest. None were encountered in other islands.
Individuals caught/observed: Total 1. Site P2

Hipposideros pygmaeus (Waterhouse, 1843)
The pygmy round-leaf bat is also a Philippine endemic with previous records from Bohol, Luzon, Marinduque, Negros and Panay. Also one of the rarest bat caught with 2 individuals, this species is another new record for the island. In the gradient sites, it was netted in primary forest using the tunnel trap. The trap was placed across a river forming a narrow bend 20 meters from the opening of the trap. The river is about five meters wide and is surrounded by a low cliff with dense hard wood vegetation. This species was also caught (by hoopnet) in Mapanghi cave in Burdeos (P5-one individual). It is speculated that the caves are one of the last stronghold for this species in Burdeos.
Individuals caught/observed: Total 2. Site P3 (1); site P5 (1)

Hipposideros sp.
This unknown species was recently discovered being presently housed in Animal Biology Laboratory in UPLB. There were five specimens with their tags placing them

caught in Bulalon caves in Burdeos on a collecting trip last 1974 by Pedro L. Alviola. External measurements didn't conform with Ingle and Heaney's Key to the Bat Families of the Philippines. This species may represent new taxa or new record for the country though further analysis of its cranial measurements is still not finished.
Individuals caught/observe: None. Five were caught in 1974 in Bulalon caves, Burdeos.

Rhinolophus arcuatus (Peters, 1871)
This species occurs from Sumatra to New Guinea. In the Philippines, there appear to be two morphs, differing in body size (Heaney et al, 1997). Individuals captured here in Polillo represent the smaller morph though one individual taken in Mapanghi cave fits the larger size class. This is surprising since the smaller morphs were also captured in the same cave (Measurements in Table). In the gradient sites, 22 individuals were captured making it the most common microchiropteran caught. It is often captured in agroforest (P1) with 17 individuals and less common in forest sites (P2 and P3). The tunnel trap proved to be the most successful technique in capturing this species (19) and it was not caught in subcanopy nets. One dead individual was seen in Bulalon cave.
Individuals caught/observed: Total 22. Site P1 (17); site P2 (2); site P3 (3); site P5 (observed in caves).

Rhinolophus inops (K. Andersen, 1905)
This horseshoe is a Philippine endemic. It was previously recorded in Polillo but was not captured in the present study. Specimens of this species from the island are currently housed in Field Museum of Natural History in Chicago.
Individuals caught/observed: None.

Rhinolophus rufus (Eydoux and Gervais, 1836)
This large species is a Philippine endemic and its status listed as Indeterminate in the Philippine Red Data Book. This beautiful bat is also one of the rarest species caught in the study (2 individuals) and caught only one in the gradient sites. It was caught in primary forest (P3) using a tunnel trap in the same net station with *H. pygmaeus*. One individual was also caught in Bulalon cave (P5). This species seems to be dependent on primary forest and caves.
Individuals caught/observed: Total 2. Site P3 (1); site P5 (1)

Family Vespertilionidae-Vesper and Evening Bats
Kerivoula whiteheadi (Horsefield, 1824)
The Whitehead's wooly bat is found from Southern Thailand to Borneo and the Philippines. Previous records are from Luzon, Minadanao, Palawan and Panay, making this another new record for Polillo island. All three individuals netted were caught in primary forest (P3) using the tunnel trap. Two individuals were caught in tunnel trap that placed in a very narrow creek of about 4 meters and also facing a bend of the creek some 5 meters from the opening. Vegetation surrounding the creek is dense with abundant understorey. It was observed that this species frequents flyways that are narrow particularly creeks and small-sized rivers. Another individual was caught in the same net that captured *R.rufus*.
Individuals caught/observed: Total 3. Site P3

Miniopterus australis (Hollister, 1913)
The lesser bent-winged bat occurs from India to Australia and is found throughout the Philippines. Eleven individuals were captured in the gradient sites of which nine came from agriculture lands (P1) while two are from primary forest site (P3). Tunnel trapping was the only successful technique in capturing this bat except in Bulalon cave (P5) where it was caught using a hoopnet (one individual). It was not recorded on other islands. No caves were seen within the gradient sites and it is possible that in the absence of suitable caves, this species may reside on hollow trunks or rock crevices. A group of individuals were observed to roost underneath Anahaw fronds.
Individuals caught/observed: Total 12. Site P1 (9); site P3 (2); site P5 (1 though was observed to number about several hundreds).

Miniopterus schreibersii (Waterhouse, 1845)
This species of bent-winged bat is very widespread, occurring in Europe, Africa, Asia, and Australia. It is found throughout the Philippines. Three individuals were caught, two of them in agriculture lands in net G (P1) and one in primary forest in net B (P3). Two individuals were also captured in Bulalon caves (P5). Only the tunnel trapping method was successful in capturing this species although hoopnets were also successful in Bulalon.
Individuals caught/observed: Total 5. Site P1 (2); site P3 (1); site P5 (2).

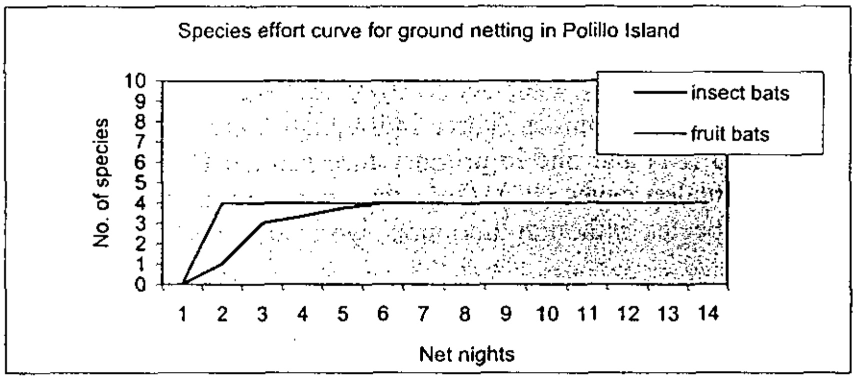
Murina cyclotis (Dobson, 1872)
Recently discovered in the country in 1991, the round-eared tube-nosed bat is distributed from Sri-Lanka, to Hainan and Borneo. Present study in Polillo island group revealed this species to be a new record. Three individuals were netted, all exclusively in primary forest (P3) also suggesting localized habitat requirement. Surveys elsewhere in the country reported this species to be confined to primary and disturbed lowland forest and extends up to lower montane elevations from 250 m to 1500m.
Individuals caught/observed: Total 3. Site P3 (3)

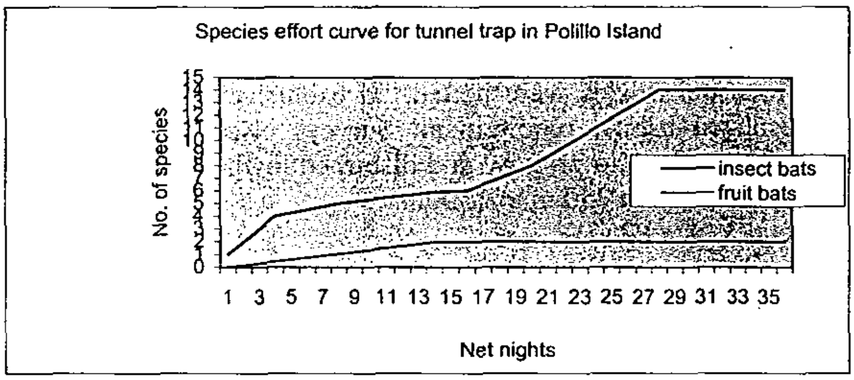
Myotis macrotarsus (Waterhouse, 1845)
The Philippine large-footed myotis occurs from Borneo and the Philippines. This also one of the rarest bat caught- only one individual- in agriculture lands (P1). Ecological studies on other literature suggest it only roosts in caves. Absence of caves in the gradient sites suggests it may reside on hollow trees or crevices. It was only captured in tunnel trap
Individuals caught/observed: Total 1. Site P1 (1)

Myotis muricola (Gray, 1846)
The whiskered myotis occurs from Afghanistan to New Guinea and distribution records in the Philippines is widespread. It is however a new record from Polillo. This bat is the most common microchiropteran caught with 19 individuals and is almost confined in primary forest (P3) with 18 species. One individual was also caught in secondary forest suggesting exclusivity of habitat requirements to forested areas. Of the three netting techniques, tunnel was the most successful in capturing this species with 17 individuals

while two were caught in groundnets and none in subcanopy nets implying low-strata behavior. This species was not caught on other islands.
Individuals caught/observed: Total 19. Site P2 (1); site P3 (18).

Scotophilus kuhli (Leach, 1822)
This widespread Asian house bat is abundant in most urban and agricultural areas. It occurs from Pakistan to Taiwan and Bali. In the Philippines, this bat is found throughout the Philippines although there is no record from Polillo. It was caught underneath a culvert in Polillo town and it is possible that it is also found in the agriculture site (P1). This bat is not recorded in other islands although extensive netting especially with the tunnel trap may prove otherwise.
Individuals examined: Total 1. Polillo town (1).





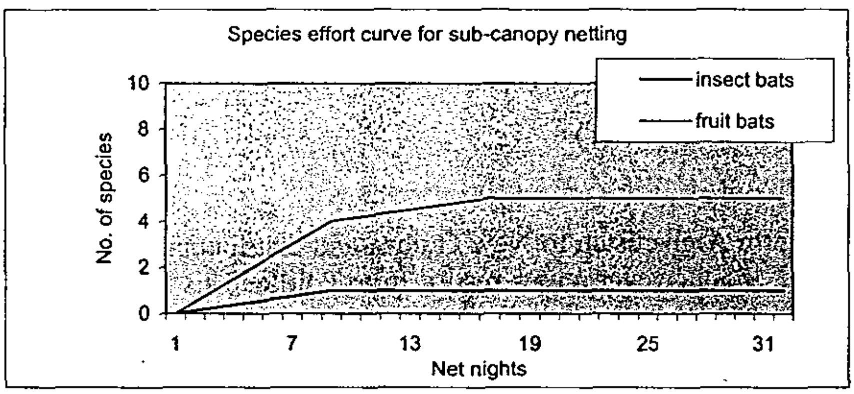


Table 2 .List of bats recorded from Polillo and Minasawa Islands.

Species	Polillo	Minasawa
Pteropodidae		
Acerodon jubatus	X	
Cynopterus brachyotis	X	
Eonycteris spelaea	X	
Macroglossus minimus	X	
Ptenochirus jagori	X	
Pteropus hypomelanus	X	X
Pteropus vampyrus		X
Rousettus amplexicaudatus	X	
Megadermatidae		
Megaderma spasma	X	
Rhinolophidae		
Hipposideros ater	X	
Hipposideros bicolor	X	
Hipposideros diadema	X	
Hipposideros obscurus	X	
Hipposideros pygmaeus	X	
Hipposideros sp.	X	
Rhinolophus arcuatus	X	
Rhinolophus inops	X	
Rhinolophus rufus		
Vespertilionidae		
Miniopterus australis	X	
Miniopterus schreibersi	X	
Myotis muricola	X	
Myotis macrotarsus	X	
Murina cyclotis	X	
Kerivoula whiteheadi	X	
Scotophilus kuhli	X	
Total	**24**	**3**

Table 3 .Species, numbers of bats caught, and number of captures per net-night/hours by three different methods.

Species	Ground net (0-2m)	Catch/ night	Sub canopy (3-10m)	Catch/ night	Tunnel trap	Catch/ hour
Megachiroptera						
Cynopterus brachyotis	**38**	**0.19**	**25**	**0.2604**	**2**	**0.0625**
	0	**0**	**1**	**0.0104**	**0**	**0**
Eonycteris spelaea	**26**	**0.13**	**10**	**0.1042**	**1**	**0.0313**
	25	**0.125**	**42**	**0.4375**	**0**	**0**
Macroglossus minimus	**17**	**0.085**	**11**	**0.1146**	**0**	**0**
	106	**0.503**	**89**	**0.9271**	**3**	**0.0938**
Ptenochirus jagori	**4**		**5**		**2**	
Rousettus amplexicaudatus						
All megachiroperans						
No. of species	**3**	**0.015**	**0**	**0**	**19**	**0.5938**
	2	**0.01**	**0**	**0**	**17**	**0.5313**
Microchiroptera	**0**	**0**	**0**	**0**	**1**	**0.0313**
Rhinolophus arcuatus	**0**	**0**	**0**	**0**	**11**	**0.3438**
Myotis muricola	**0**	**0**	**0**	**0**	**3**	**0.0938**
Myotis macrotarsus	**0**	**0**	**0**	**0**	**3**	**0.0938**
Miniopterus australis	**0**	**0**	**0**	**0**	**3**	**0.0938**
Miniopterus schreikbersi	**2**	**0.01**	**2**	**0.0208**	**3**	**0.0939**
Kerivoula whiteheadi	**0**	**0**	**0**	**0**	**3**	**0.0938**
Murina cyclotis	**0**	**0**	**0**	**0**	**1**	**0.0313**
Hipposideros diadema	**0**	**0**	**0**	**0**	**1**	**0.0313**
Hipposideros ater	**0**	**0**	**0**	**0**	**1**	**0.0313**
Hipposideros obscurus	**0**	**0**	**0**	**0**	**1**	**0.0313**
Hipposideros pygmaeus	**1**	**0.005**	**0**	**0**	**1**	**0.0313**
Hipposideros bicolor	**8**	**0.04**	**2**	**0.0208**	**68**	**2.125**
Rhinolophus rufus	**4**		**1**		**14**	
Megaderma spasma						
All microchiropterans	**129**	**0.645**	**91**	**0.9479**	**71**	**2.1875**
No. of species	**8**		**6**		**16**	

Table 4.The number of fruit bats (Pteropodidae) netted at principal sites in Sibulan Watershed, Polillo, Polillo Is.

Species	Agriculture (P1)			2nd forest (P2)			Primary forest (P3)		
	GN	SC	TT	GN	SC	TT	GN	SC	TT
Cynopterus brachyotis	28	3	0	6	16	2	4	6	0
Ptenochirus jagori	15	14	0	1	4	0	9	24	0
Rousettus amplexicaudatus	9	5	0	7	4	0	1	2	0
Macroglossus minimus	22	4	0	3	3	1	1	3	0
Eonycteris spelaea	0	1	0	0	0	0	0	0	0
Total captures	**74**	**27**	**0**	**17**	**27**	**3**	**15**	**35**	**0**
Total net nights/hours	**72**	**32**	**12**	**64**	**32**	**8**	**64**	**32**	**12**
Netting success	**1.028**	**0.844**	**0**	**0.27**	**0.84**	**0.38**	**0.23**	**1.1**	**0**
Species richness	**4**	**5**	**0**	**4**	**4**	**2**	**4**	**4**	**0**
Overall species richness									
		5			**4**			**4**	

Table 5. The number of microchiropterans netted along disturbance gradients in Sibulan Watershed, Polillo, Polillo Is.

Species	Agroforest (P1)			2nd forest(P2)			Primary forest (P3)		
	GN	SC	TT	GN	SC	TT	GN	SC	TT
Megaderma spasma	1	0	0	0	0	1	0	0	0
Hipposideros diadema	1	2	2	1	0	1	0	0	0
Hipposideros ater	0	0	2	0	0	1	0	0	0
Hipposideros obscurus	0	0	0	0	0	1	0	0	0
Hipposideros bicolor	0	0	0	0	0	0	0	0	1
Hipposideros pygmaeus	0	0	0	0	0	0	0	0	1
Rhinolophus rufus	0	0	0	0	0	0	0	0	1
Rhinolophus arcuatus	1	0	16	1	0	1	1	0	2
Myotis muricola	0	0	0	1	0	0	1	0	17
Myotis macrotarsus	0	0	1	0	0	0	0	0	0
Miniopterus australis	0	0	9	0	0	0	0	0	2
Miniopterus schreibersi	0	0	2	0	0	0	0	0	1
Murina cyclotis	0	0	0	0	0	0	0	0	3
Kerivoula whiteheadi	0	0	0	0	0	0	0	0	3
Total captures	**3**	**2**	**32**	**3**	**0**	**5**	**2**	**0**	**31**
Total net nights/hours	**72**	**32**	**12**	**64**	**32**	**8**	**64**	**32**	**12**
Netting success	**0.042**	**0.06**	**2.67**	**0.05**	**0**	**0.63**	**0.03**	**0**	**2.58**
Species richness	**3**	**1**	**6**	**3**	**0**	**5**	**2**	**0**	**9**
Overall species richness									
		7			6			9	

Table 6 . Summary of parameters listed for three disturbance gradient sites.

Parameters	Agroforest (P1)			2nd forest (P2)			Primary forest (P3)		
	GN	SC	TT	GN	SC	TT	GN	SC	TT
Total captures	77	29	32	20	27	8	17	35	31
Total net nights/hours	72	32	12	64	32	8	64	32	12
Netting success	1.07	0.91	2.67	0.313	0.844	1.0	0.27	1.1	2.58
Species richness	7	6	6	7	4	8	6	4	9
Overall species richness									
		12			**10**			**13**	

DISCUSSION

A. Adequacy of Sampling Effort

Before analyzing the results of this survey, it must be considered how closely current data reflect actual species richness on these islands. Various island surveys done in the past have well considered that the widest possible habitat, elevational range or disturbance gradient must be investigated to ensure adequate sampling of faunas (Heaney et al, 1991 and Rickart et al,1993). In this study, disturbance gradient was considered since elevation in the Polillo island group was not significant enough to merit valid assessment of species richness. Fieldwork done in other locations aside from the aforementioned were side trips in nature and field methodologies employed only managed to ascertain species richness only, thus not included in analysis of data in terms of sampling effort and disturbance gradient. Fieldwork conducted in Sibulan was intensive (though not exhaustive) and comparisons with data from other island surveys of this nature can be tested. Moreover, the present study included surveys in caves and can contribute to cave studies currently being undertaken in other parts of the country (Sedlock, pers com).

The adequacy of sampling may be assessed with species-effort curves that plot the cumulative number of species over sampling time (Rickart et al 1993). This method is usually used to examine the sampling success of a given study and in this case, the comparison of relative success of the different netting methods for two bat groups- fruit bats and microchiropterans. To be a true gauge of sampling success, sampling must be done in the widest possible gradients as possible using field methods that are standardized and diverse, and sampling effort must be long enough (Rickart, 1993) .

On Sibulan watershed, netting in three different disturbance gradients employing three different methods (P1-P3) yielded a total of 19 species of bats, of which five are fruit bats and 14 are microchiropterans. A species-effort curve for ground netting (Figure 1) shows that the total number of fruit bat species was reached well before the midpoint of the survey. Likewise is also evident for microchiropterans. For sub canopy netting (Fig. 2)the total number of fruit bats was also reached midway of the study while species-effort curve for microchiropterans reached within a quarter of the study. The shape of the species effort curve for tunnel trapping (Fig. 3) was different for microchiropterans in which curves reached asymptote late in the study. This suggests that, given the accrual rate for microchiropterans, additional sampling would yield 2-3 additional species.

Curves generated for fruit bats reach asymptote very early in the study and this implies that tunnel trapping is not ideal for fruit bats.

It is concluded from these curves that the surveys in Sibulan were adequate (though not exhaustive) and the data presented herein can give a fairly accurate reflection of the species richness. Nonetheless, data generated from other islands (except Minasawa island) are far too incomplete and employment of these three sampling technique is necessary. In the light of these data, certain generalizations can be made about specific bat taxa and their susceptibility to capture or documentation: (1) Large fruit bats (Acerodon and *Pteropus*) are seldom caught using any of the methods employed and acquisition of these species must be done at roost sites; (2) small fruit bats (like *Ptenochirus* and *Cynopterus*) can be caught readily using any of the netting techniques except tunnel trap, and (3) microchiropterans are not easily caught using ground-netting or subcanopy netting but instead additional method should be employed such as tunnel trapping or collected at roost site.

B. Inventory and distribution of bats

Of the 25 species of bats recorded, 11 species are listed as new records. Prior to this study no detailed inventory had been carried out in the islands and all of the records came from collection trips and given to museums as donations. The number of new records and even the number of species recorded as a whole is unprecedented for a short period of inventory and the number of workers involved. This number is comparable with other medium sized island like Leyte, Bohol, Negros, Panay and other small islands such as Catanduanes, all of which have been relatively studied for a much longer period. The high numbers of species recorded as well as the new island records can be attributed to the variety of netting techniques employed. Studies on other islands only employed simple groundnetting.

Twenty-four of the 25 species were recorded from Polillo. The lone exception is *Pteropus vampyrus* of which identification is not certain.

C. Species composition in different disturbance gradients.

To be able to relate species composition and diversity to different disturbance gradients, assessment of netting effort per gradients is mandatory. It is ideal that sampling effort should be more or less uniform and the same for all study sites in order to generate meaningful comparisons and determine species' habitat associations. In this study, A total of 200 net-nights ground-netting were exerted on all gradient sites in which agriculture site has 72 net-nights, secondary and primary forest have 64 net-nights each. Total sampling effort for subcanopy netting was 96 nets of which all gradient sites had 32 net-nights each. As for tunnel trapping, 32 net-hours was exerted where 12 net-hours were allocated for agriculture and primary forest site and eight net-hours for secondary forest. With these sampling efforts, the present study generally meets the uniformity requirement.

Of the 19 species recorded in all gradient sites, 12 (5 fruitbats and 7 insect bats) were recorded in agriculture lands, 10 (four fruit bats and 6 insect bats) in secondary forest, and 14 species (4 fruitbats and 10 insect bats) in primary forest (Table 4 & 5).

FRUIT BATS- All species of fruit bats were found in all disturbance gradients except for *Eonycteris spelaea* which was found in agricultural lands. *Macroglossus minimus* and *Ptenochirus jagori* are common inhabitants of primary forest (Rickart, 1993). That observation applies to *Ptenochirus jagori* in which it was most commonly found in the primary forest. However, fieldwork done on Luzon by Rickart and Heaney, revealed that this species is absent in agriculture lands and ventures into secondary forest. It is contradictory to the present study's findings wherein this endemic fruit bat is more common in agricultural lands than in secondary forest. The high frequency of *P.jagori* in agriculture lands can be attributed to its proximity to the primary forest and the small area of the forest itself. This species is forced to venture out in disturbed habitats to find suitable places to forages and presence of fruit trees outside forested lands can be a substitute. *Macroglossus minimus* like the rest of the fruitbats recorded, is more common in agricultural lands than in forested areas. However, due to proximity of the forest, these species of fruit bats occasionally forage in forested areas. *Eonycteris spelaea* was found only on agriculture areas though it is possible that it can reside in forested habitats as well. In effect generalizations can be made from these observations: (1) Endemic fruit bats like *Ptenochirus jagori* venture out in disturbed habitats if forested areas are relatively small, (2) Endemic fruit bats can be found in disturbed areas if these areas is proximal to the forest, and (3) Non-endemic fruit bats venture into forested habitats especially primary forest if these forest are proximal to disturbed habitats. Paucity of captures in secondary forest can be attributed to low placement of nets since canopy growth was also low.

MICROCHIROPTERANS - Of the 14 species of microchiropterans caught, *Rhinolophus arcuatus* was captured in all disturbance gradients . In previous survey studies done in different islands this species commonly extends its habitat requirements in all types habitat. Habitat specialists were also observed in this study: one species (*Myotis macrotarsus*) in agriculture lands, one also in secondary forest (*Hipposideros obscurus*) and five (*H. bicolor, H. pygmaeus, R. rufus, Murina cyclotis* and *Kerivoula whiteheadi*) in primary forest. Field notes from previous surveys in other islands have reported *M.macrotarsus* to forage exclusively in agriculture areas. *H. obscurus* is known to inhabit exclusively in forested areas and it is possible that this species is also found in primary forest. All species that exclusively resides on primary forest are forest habitat specialist with exception of *K.whiteheadi* which occasionally forage in agriculture areas. Substantial tunnel trapping in secondary forest would reveal these specialists. There are also species that shares two habitats: 2nd forest and agricultural lands with three species (*Megaderma spasma, H. diadema* and *H. ater*), 2nd forest and primary forest with one (*Myotis.muricola*) and primary forest and agricultural lands with two species (*Miniopterus australis* and *M.schreibersii*). All of these species are generalist with habitat requirements ranging from forested habitats to agricultural lands and with wide elevational ranges with the exception of *M.muricola* in which it resides specifically in forested areas. Of the 19 individuals of this species captured, only one was caught in secondary forest. Nevertheless substantial tunnel trapping would yield several individuals of this species. Although *Megaderma spasma, H. diadema* and *H. ater* are generalist, these species were observed to be more common in agriculture areas and degraded forest (Heaney et al, 1997). Unfortunately, it is still premature to make a generalization about microchirpoteran ecology due to lack of knowledge on their foraging ecology.

D. Comparison of netting techniques

Comparison of netting techniques usually employs standard gauges of measures such as catch success and type of species captured. However, when a certain method differs in standard unit of measurement as in the case of ground netting and subcanopy's net-hours as opposed to tunnel trap's net-hours, calibrations should be made in order generate meaningful comparisons. In ground and sub canopy netting, the smallest unit of measure is the net-night which is equivalent to a single six-meter net exposed for 12 hours whereas in the smallest unit of measure is one hour.

One hundred twenty nine individuals representing eight species were captured using ground netting technique (200 net-nights). Subcanopy netting, with a sampling effort of 96 net-nights accounted for 91 individuals of five species while (32 net-hours) accounted for 71 individuals representing 16 species. Catch success for ground nets, sub canopy nets and tunnel trap were 0.504 bats/night, 0.95 bats/night and 2.22 bats/hour. In order to make valid comparisons, calibrations must be done in hours so that rate of capture can be quantified or visualized more easily. Conversions would be for ground net, 0.054 bats/hour and subcanopy nets 0.08 bats/hour. This means that tunnel trapping is more efficient than ground netting and sub canopy netting by 41- and 28-fold! In reality, it is not possible to man the tunnel trap for 32 straight hours while ground and sub canopy nets can be left unattended. Probable reason for this high discrepancies in catching efficiencies can be attributed to the behavior of microchiropterans. In a certain river or creek, there are many insect bats that forage and are very active at night but they are not caught easily by ground or sub canopy nets due to their ability to echolocate. In the tunnel trap, there is wide space inside the net (usually 12m x 6m) hence the name "tunnel". A skimming insectivorous bat foraging for prey transmits sound and is usually one-directional and thus will not enable to detect the walls of the tunnel trap due to the trap's wideness.

Species composition also significantly varies between the three methods. Tunnel trapping is more successful capturing microchiropterans than fruit bats whereas subcanopy nets capture more fruitbats while ground nets have equal number of species captures of fruit bats and microchiropterans. As mentioned earlier, microchiropterans rarely evade capture of tunnel trap due to its usually one-directional sound transmission and the trap's wide tunnel. Fruit bats easily dodge tunnel traps because they can see the walls of the trap and avoid it. Moreover, most of a fruitbat's feeding behavior are high within the canopy of understorey depending on the height of trees (Ingle, 1993).

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LIST OF THE BATFLIES FOUND IN POLILLO ISLAND

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Family NYCTERIBIIDAE
Subfamily CYCLOPODIINAE

Genus *EUCAMPSIPODA* Kolenati

EUCAMPSIPODA INERMIS INERMIS Theodor

Eucampsipoda inermis Theodor, 1955. Parasitology 45:215. Male, Female.
TYPE: Male, Soribao, Borongan, Samar, Philippines (BMNH).
HOSTS: *Eonycteris spelaea glandifera, Rousettus amplexicaudatus.*
DISTRIBITION: Burma, Java, Malaya, Philippines (Luzon, Catanduanes, Cebu, Leyte, Mindoro, Negros, Samar, Mindanao, Samal, Jolo, Balabac, Busuanga, Palawan, Polillo, new island record), Sumba, Thailand; NE New Guinea.

Specimens examined: On *Eonycteris spelaea*: Quezon-Sibulan, Polillo Island, 1 femaleJuly, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Rousettus amplexicaudatus*: Quezon-Sibulan, Polillo Island, 2 males and 17 femalesJuly –August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

EUCAMPSIPODA PHILIPPINENSIS Ferris

Eucampsipoda philippinensis Ferris, 1924 (in part). Philippine J. of Sci. 24:76.
TYPE: Female, Montalban, Rizal, Luzon, Philippines (STU Palo Alto).
HOSTS: *Eonycteris robusta, Hipposideros diadema griseus, Rousettus amplexicaudatus,* new host record.
DISTRIBUTION: Philippines (Luzon, Leyte, Mindoro, Mindanao Polillo, new island record).

Specimen examined: On *Rousettus amplexicaudatus*: Quezon-Sibulan, Polillo Island, 2 males July –August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

EUCAMPSIPODA SUNDAICA Theodor

Eucampsipoda sundaicum Theodor, 1955. Parasitology 45:213. Male, Female.
TYPE: Male, Farm Caves, Moulmein, Tenasserim, Burma (MCSN Genova).

Eucampsipoda philippensis Ferris, 1924 (in part). Philippine J. Sci. 24:76. figs. 3c, d. (Male). Theodor, 1963. Fieldiana Zool. 42:178. Philippines. Male, Female.

HOSTS: *Eonycteris spelaea glandifera, Rousettus amplexicaudatus.*

DISTRIBUTION: Borneo, Burma, Cambodia, India, Kampuchea, Laos, Malaya, Philippines (Luzon, Leyte, Mindoro, Negros, Mindanao, Palawan Polillo, new island record), Sumatra, Thailand, Vietnam.

Specimen examined: On *Eonycteris spelaea*: Quezon-Sibulan, Polillo Island, I female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

Genus *LEPTOCYCLOPODIA* Theodor
Subgenus *LEPTOCYCLOPODIA* Theodor

LEPTOCYCLOPODIA (LEPTOCYCLOPODIA) FERRARII MABUHAI Maa

Leptocyclopodia (Leptocyclopodia) ferrarii mabuhai Maa, 1975. Pacif. Insects 16: 474. Male, Female.

TYPE: Male, Glan, Mt. Tuduk, Cotabato, Mindanao, Philippines (BBM Honolulu).

HOSTS: *Cynopterus brachyotis luzoniensis, Eonycteris spelaea glandifera, Haplonycteris fisheri, Ptenochirus jagori, ?Macroglossus lagochilus, ? Hipposideros diadema.*

DISTRIBUTION: Philippines (Luzon, Guimaras, Leyte, Negros, Panay, Camiguin, Mindanao, Polillo, new island record).

Specimens examined: On *Cynopterus brachyotis*: Quezon-Sibulan, Polillo Island, 6 males and 6 females July –August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Ptenochirus jagori*: Quezon-Sibulan, Polillo Island,1 male and 3 females July –August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Miniopterus australis*: Quezon-Sibulan, Polillo Island, 1 male July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Rousettus amplexicaudatus*: Quezon-Sibulan, Polillo Island, 1 female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

LEPTOCYCLOPODIA (LEPTOCYCLOPODIA) SIMULANS (Theodor)

Cyclopodia simulans Theodor, 1959. Parasitology 49:291.

TYPE: Male, Mt. Apo,Todaya, Mindanao, Philippines (FMNH Chicago), ex-*Ptenochirus jagori*.

HOSTS: *Ptenochirus jagori,? Cynopterus brachyotis, ?Eonycteris robusta, ? Macroglossus lagochilus, ?Rousettus amplexicaudatus, Eonycteris spelaea*, new host record

DISTRIBUTION: Philippines (Luzon, Bohol, Cebu, Leyte, Mindoro, Negros, Camiguin, Mindanao, Polillo, new island record).

Specimens examined: On *Ptenochirus jagori*: Quezon-Sibulan, Polillo Island, 3 males and 7 females July –August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Cynopterus brachyotis*: Quezon-Sibulan, Polillo Island, 1 female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On Eonycteris spelaea: Quezon-Sibulan, Polillo Island, 1 female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

Subfamily *NYCTERIBIINAE*
Genus ***NYCTERIBIA*** **Latreille**

NYCTERIBIA ALLOTOPA ALLOTOPA Speiser

Nycteribia allotopa Speiser, 1901. Arch. Naturg. 67(1):47. Male, Female.

TYPES: Male, Female, Cave at Lian si Paghe, W Sumatra (BMNH), ex-*Vespertilio* sp. Theodor, 1963. Fieldiana Zool. 42:167. Philippines, Male, Female.

HOST: *Pipistrellus imbricatus, Miniopterus australis,* new host record

DISTRIBUTION: India, Java, Philippines (Palawan, Polillo, new island record), Sumatra.

Specimen examined: On *Miniopterus australis*: Quezon-Sibulan, Polillo Island, 1 male July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

NYCTERIBIA ALLOTOPOIDES Theodor

Nycteribia allotopoides Theodor, 1963. Fieldiana Zool. 42:157. Male, Female.

TYPE: Male, Luangbay Cave, Sitio Tegato, Davao, Mindanao, Philippines (FMNH Chicago).

HOSTS: *Miniopterus australis, M. schreibersi eschscholtzii, Myotis macrotarsus,* new host record

DISTRIBUTION: Burma, Philippines (Luzon, Polillo, Mindanao).

Specimen examined: On *Myotis macrotarsus*: Quezon-Sibulan, Polillo Island, 1 female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

NYCTERIBIA PARVULA Speiser

Nycteribia parvula Speiser, 1901. Arch. Naturg. 67(1):48.

TYPES: 2 Females, Cave Lian si Paghe, W Sumatra (MCSN Genova). Ferris, 1924. Philippine J. Sci. 25:399. Philippines.

HOSTS: (*Chaerephon luzonus*) = *Tadarina plicata luzona, Miniopterus australis, M. schreibersi eschscholtzii, Rhinolophus arcuatus exiguus, Myotis macrotarsus,* new host record

DISTRIBUTION: Burma, India, Java, Malaya, Pakistan, Philippines (Luzon, Polillo, Tablas, Mindanao), Sri Lanka, Sumatra, Taiwan; Afghanistan; Japan, Moluccas, New Guinea.

Specimens examined: On *Miniopterus australis*: Quezon-Sibulan, Polillo Island, 5 males and 4 females July –August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Miniopterus scheibersi*: Quezon-Sibulan, Polillo Island, 2 females August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Myotis macrotarsus*: Quezon-Sibulan, Polillo Island, 1 female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Cynopterus brachyotis*: Quezon-Sibulan, Polillo Island, 1 female August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

Genus *PENICILLIDIA* Kolenati

PENICILLIDIA ACUMINATA Theodor

Penicillidia acuminata Theodor, 1963. Fieldiana Zool. 42:174. Male, Female.

TYPE: Male, Miatan Cave, Katipunan, Zamboanga, Mindanao, Philippines (FMNH Chicago).

HOSTS: *Chaerephonus luzonus, Emballonura alecto, Miniopterus australis, M. schreibersi eschscholtzii.*

DISTRIBUTION: Java, Philippines (Luzon, Lubang, Tablas, Mindanao, Polillo).

Specimens examined: On *Miniopterus australis*: 2 males Quezon-Sibulan, Polillo Island, July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Miniopterus schreibersi*: Quezon-Sibulan, Polillo Island, 1 female August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

Family STREBLIDAE
Subfamily NYCTERIBOSCINAE

Genus *BACHYTARSINA* Macquart
(=Genus *Nycteribosca* Speiser)
Subgenus *BRACHYTARSINA* Macquart

BRACHYTARSINA (BRACHYTARSINA) AMBOINENSIS Rondani

Brachytarsina amboinensis Rondani, 1878. Ann. Mus. Civ. Stor. Nat. Giacomo Doria 12:66.

TYPE: (sex?), Amboina, Moluccas. Jobling, 1951. Trans. Ent. Soc. London 102:235. Philippines (Mindanao).

HOSTS: *Miniopterus schreibersi blepotis* (Temminck), *M. australis australis* Tomes, *M. tristis*, *Rhinolophus arcuatus*, new host record.

DISTRIBUTION: Burma, India, Java, Malaya, Nicobar, Philippines (Luzon, Tablas, Mindanao, Polillo, new island record), Ryukyu, Sri Lanka, Thailand, Taiwan, Timor, Amboina to Australia, New Caledonia, Japan.

Specimens examined: On *Rhinolophus arcuatus*: 2 females Quezon-Sibulan, Polillo Island, July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Miniopterus australis*: Quezon-Sibulan, Polillo Island, 1 male July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

BRACHYTARSINA (BRACHYTARSINA)HOOGSTRAALI (Jobling)

Nycteribosca hoogstraali Jobling, 1951. Trans. R. Ent. Soc. London 102:227 (key), 232/

TYPE: Female, Malabutuan, Caburan, Davao, Mindanao, Philippines (FMNH Chicago), ex-*C.l. luzoniense*.

HOSTS: [Cynopterus brachyotis luzoniense (Peter)]=*Cynopterus brachyotis* S. Mull, *Taphozous melanopogon philippinensis* Waterhouse, *Myotis macrotarsus*, new host record.

DISTRIBUTION: Malaya, Philippines (Mindanao, Polillo, new island record).

Specimens examined: On *Myotis macrotarsus*: Quezon-Sibulan, Polillo Island, 1 female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Rhinolophus arcuatus*: Quezon-Sibulan, Polillo Island, 1 female July, 1999 (H.P.Roy, Jr. and P.A.Alviola).

BRACHYTARSINA (BRACHYTARSINA) WERNERI (Jobling)

Nycteribosca werneri Jobling, 1951. Trans. R. Ent. Soc. London 102:228 (key),238. Male, Female.
TYPE: Female, Central Cave, Cotabato City, Mindanao, Philippines (FMNH Chicago), ex- *H.d. griseus*
HOSTS: *Hipposideros diadema griseus* Meyer, *Eonycteris robusta* Miller.
DISTRIBUTION: Philippines (Mindanao, Polillo, new island record).

Specimen examined: On *Hipposideos diadema*: Quezon-Sibulan, Polillo Island, 1 male and 2 females August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

Genus *MEGASTREBLA* Maa
Subgenus *MEGASTREBLA* Maa

MEGASTREBLA (MEGASTREBLA) PARVIOR PARVIOR (Maa)

Nycteribosca parvior parvior Maa, 1962. Pacif. Insects 4:433. Male, Female.
TYPE: Male, Batu Caves, Malaya (BBM Honolulu).
Nycteribosca gigantea Jobling, 1951. Trans. R. Ent. Soc. London 102:
Palawan and Mindanao records, figs, 1A-E, 6G & H. Maa, 1971. Pacif. Insects Monogr. 28:222. Philippines. Male, Female.
DISTRIBUTION: Borneo, Burma. India, Java, Malaya, Philippines (Luzon, Cebu, Leyte, Negros, Samal, Mindanao, Balabac, Palawan, Polillo, new island record), Sumatra, Sumba, Thailand.
HOSTS: *Rousettus amplexicaudatus and Eonycteris spelaea*, new hosts record

Specimens examined: On *Rousettus amplexicaudatus*: Quezon-Sibulan, Polillo Island, 2 males and 4 females July –August, 1999 (H.P.Roy, Jr. and P.A.Alviola).

On *Eonycteris spelaea*: Quezon-Sibulan, Polillo Island, 1 female July , 1999 (H.P.Roy, Jr. and P.A.Alviola).

AN INVENTORY STUDY OF AVIFAUNAL POPULATION ON THE PRIMARY AND SECONDARY FORESTS OF SIBULAN WATERSHED AREA AND AGROFORESTRY ECOSYSTEMS OF BRGY. MAHABANG KAHOY, POLILLO, QUEZON

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Abstract
An inventory study on the avifauna of Polillo Island, part of the Luzon Endemic Bird Area, was conducted during the period July-September, 1999, thus updating that produced by Gonzalez in 1996. The research was focused within and around the primary and secondary forest of the Sibulan Watershed Reserve and the agroecosystem of Sitio Mahabangkahoy. 30-40 transect hours, mist netting and sound recordings were conducted in each habitat. Informal recordings were also obtained at the coastal site of Bucao and at Panukulan in the north of the island. A total of 86 species were reported in the main study site-50 in the primary forest, 49 in the secondary forest and 69 in the agroecosystem. Five of the seven endemic sub-species were seen: Polillo Tarictic Hornbill *(Penelopides manillae subnigra)*, Polillo White Browed Shama (*Copsychus luzoniensis parvimaculatus*), Polillo Trogon (*Harpectes ardens minor*), Polillo Flameback (*Chrysocolaptes* lucidus grandis) and Polillo Crested Goshawk (*Accipter trivirgatus castroi)*. Eleven globally near-threatened species were observed: *Ixobrychus eurythmus, Ptilinopus merrilli, Centropus unirufous, Ceyx melanurus, Hypothymis helenae, Terpsiphone cinnamomea* (Collar and Andrew 1988), *Anas luzonica, Gallicolumba luzonica, Alcedo cyanopectus, Penelepoides manillae, Irena cyanogaster* (Birdlife International 1994). The presence of *Irena cyanogaster*, *Macropygia phasianella* and *Ptilinopus leclancheri* absent in the 1996 report, wherein they were hypothesized to have undergone local extinction, has been confirmed. New records for the island include *Pitta erythrogaster* and *Rostratula benghalensis.* Trends in species presence and richness have been analysed on a temporal and spatial level. Species diversity and evenness indices were highest in the secondary forest, then the agroforesty ecosystem and lastly the primary forest. An urgent need for further research along the coast has been identified, due to the imminent threat from recreational developments.

Introduction
The Polillo Islands are part of the Luzon Endemic Bird Area (EBA), an area of 108,000 km^2 rising from 0-2700 m.a.s.l. Luzon EBA is threatened severely by habitat loss and ranks sixth in the global critical list of EBAs (Bibby et al. 1992). Three globally threatened and fourteen near-threatened species have been recorded on the Polillo Islands. The Polillo Watershed Reserve in Sibulan, Polillo Quezon is approximately 160 hectares in extent. It contains closed canopy forests and provides a valuable source of potable water for surrounding communities especially the municipal centre of Polillo. Surrounding the watershed area are fractions of secondary growth forest and agroecosystems featuring coconuts and rice paddies.

According to Gonzalez (1997), there have been several expeditions to Polillo. The early collectors were Porter (1903), Ickis (1907) and McGregor (1909)-the latter of whom described several new bird species including the Tarictic Hornbill (*Penelopides manillae subnigra*), which is now considered subspecies. In 1956, Manuel collected several specimens that become neotypes for *Penelopides manillae subnigra* and *Cacatua haematuropygia mcgregori*. His published results were largely based on Burdeos where lowland forest still occurred. Manuel reported resident bird species and described new species including the endemic Polillo race of Philippine Trogon, *Harpectes ardens minor*.

The most recent study on the Polillo islands was conducted in 1996 by Gonzalez- he reported therein 102 species. At the start of this study a cumulative total of 200 species (Status Report: Polillo Ecology Stewardship Project Apr-Sept 1998) had been recorded throughout Polillo's research history. The 1996 study recorded all seven Polillo subspecies: Polillo Tarictic Hornbill *(Penelopides manillae subnigra),* Polillo White Browed Shama (*Copsychus luzoniensis parvimaculatus*), Polillo Blue Naped Parrot (*Tanygnathous lucionensis hybridus),* Polillo Azure-backed Parrot (*Tanygnathous sumatranus freeri),* Polillo Trogon (*Harpectes ardens minor*), Polillo Flameback (*Chrysocolaptes* lucidus grandis) and Polillo Crested Goshawk (*Accipter trivirgatus castroi)* (Figure 1). Gonzalez reported 3 globally threatened and 12 of the 14 near-threatened species recorded on the Polillo Islands.

Objectives

This study aims to update the species account produced by Gonzalez in 1996. In contrast to this previous study based on the entire Polillo Island group the present study is focused predominantly on the Sibulan Watershed area and agroecosystems of Brgy. Mahabangkahoy. Ecological relationships will be established among the three habitats: primary forest, secondary forest and agroecosystem. Short study periods were also conducted at the coastal site of Bucao and at Panukulan in the north of the island. It is hoped that the pending data will have strong implications for conservation management.

IMMEDIATE AIMS:

1. Produce an updated avifaunal inventory based predominantly on the primary and secondary forests of Sibulan Watershed and the agroecosystem of Sitio Mahabangkahoy,Polillo Quezon.
2. Document species presence, species richness and indices of diversity, evenness and similarity. Analyse results on a spatial and temporal basis.
3. Identify areas of conservation concern and provide recommendations for future research

Figure 1:The Endemic Sub-species of Polillo Island

*Copsychus luoniensis,*the White-browed shama is a common bird of the forest undergrowth, below 1000m. It is of particular importance on Polillo due to its designation as a sub-species by McGregor in 1910. *Copsychus luzionensis parvimaculatus* is characterised by its shorter tips to its tail retrices. The question remains as to whether this is a valid conclusion and if it is as to whether it can be supported by further observations; the acoustic characteristics of races of *Copsychus luzionensis* should be examined.

Harpactes ardens, the Philippine Trogon is a 'Fairly common resident of primary forest, occasional in second growth up to 1500m'(Dickinson et al. 1991) The subspecies, *H. ardens minor,* characterised by its darker red feathers and smaller wing of 133cm rather than 145cm was designated by Manuel in 1957.

Penelopides manillae subnigra, the Tarictic Hornbill , a 'Fairly common bird in forest up to about 1000m'(Dickinson et al. 1991). *Penelopides manillae subnigra (*McGregor 1910) is characterised by its larger upperparts and green rather than brown glossed tail.

Mulleripicus funebris, the Sooty Woodpecker, is 'Fairly common in evergreen forest up to about 1000m, occurring in montane oak and pine forest as well. *M. funebris parkesi (*Manuel 1957), restricted to Polillo island is characterised by its smaller white spots on its crown, browner underparts and larger dimensions.

Accipiter trivirgatus, the Crested Goshawk is an uncommon resident not endemic to the Philippines. It occurs in primary forest and secondary growth including residual patches.*A.t. castroi (*Manuel and Gilliard,1952) has a dark blue back, darker more heavily barred underparts and longer wing and tarsus.

Tanygnathus sumatranus, the Blue-backed parrot is a shy forest resident of the Philippines, Sulawesi and neighbouring small islands; it is rare in all areas except the Sulas. *T.s.freeri* the sub species found on Polillo Island (McGregor 1910) has a lighter green crown, a lighter blue back, a yellow collar hind neck and larger dimensions.

Tanygnathus lucionensis, the Blue-naped parrot is an uncommon resident in forests of the Philippines, Talaud islands and islands off north and east Borneo. It is known to occasionally visit farmland and orchards. *T.l.hybridus* (McGregor 1910) is a larger, paler race with less blue on its head.

Methods

The distribution of species in the three habitats: primary forest, secondary forest and agroecosystem, was assessed through walking 3km transects, mist netting, utilizing sound recording techniques and conducting informal ethnobiological surveys.

TRANSECT SURVEYS (Tables 3,4 and 5)
30-40 transect hours between the hours of 05:30-09:30 and 15:00-18:00 were conducted in each habitat. Transects were constructed with the aim of representing the considerable heterogeneities within each of these broad habitat divisions, thus leading to a substantial proportion of each route encompassing the riparian habitat. Consideration was also given to the presence of fruiting trees. The transects were traversed by three observers who recorded species type (based on sound and visual encounters), frequency and where possible activity (flying, foraging behaviour, participation in mixed feeding parties...). The observers were equipped with binoculars. The transect methodology was based upon that of Danielson et al (1991), Miranda (1987) and Gonzalez (1993). Bird identification, to the species and where possible the sub-species level, was based upon the guides by Du Pont (1971) and Dickinson et al. (1991).

The data from the transect area was used for the computation of birds species diversity using the Shannon-Weiner function, H (H=-Spi(logpi), pi=proportion of total sample belonging to the ith species) and evenness indices, E using Pieilou's formula(1966); An index to compare the number of species common to two sites was calculated using the Sorenson's index of similarity, S (S=(A+B)/C2 A=no. species in site A,B=no. species in site B,C=no. species common to both sites). These calculations conform to those adopted by Gonzalez in 1997.

ACOUSTIC RECORDINGS
Acoustic records were made both within and outside the set transect hours (Table 7), providing a vital tool for recording more cryptic species; the method proved invaluable in the primary forest where the habitat had greater three-dimensional properties and visual encounters were relatively scarce.
Equipment: Marantz recorder, microphone and parabolic reflector
Tapes were deposited and copied at the British Library of Wildlife Sounds.

MIST NETTING (Table 6)
Mist netting provided a further means to record the more cryptic species and permitted a finer habitat analysis. Mist nets with an average mesh size of 36 millimetres and height of 2.5 metres were erected between dawn and dusk in each habitat. The various habitat heterogeneities were represented in the netting sites, however forest surveys were limited to sub-canopy birds. Standard biometrics (bill length, bill gape, tail-vent length, total length and weight) were recorded using pesolas and dial calipers; the birds were temporarily marked for mark-recapture purposes. Morphological and colour characteristics were also documented, where appropriate.

OTHER SOURCES OF INFORMATION

The basic protocol for the surveys was complemented by ethnobiological accounts, observations of roosting birds, birds retrieved from traps constructed for the Monitor lizards (*Varanus olivaceus* and *Varanus salvator*) and from bird remains (feathers and bills). Ethnobiological surveys consisted of interviews with the Ecology Steward and residents of communities near the study sites; the presence, frequency and distribution of species, local names, seasonal occurrence and behaviour were among the factors discussed.

MORTALITIES

The mortalities encountered during the study were preserved in 10% buffered formalin and deposited at the Museum of Natural History, University of the Philippines (Los Banos).

HABITAT EVALUATION OF THE AREA

The main study sites were located within the secondary and the primary old growth forest of Sibulan Watershed Area, and the agroecosystems of Brgy. Mahabangkahoy, Polillo Quezon. Characteristic vegetation of each habitat, degree of light penetration, tree morphologies, existence/proximity to a free water source, forest litter density, moss and epiphyte density and substrate type were recorded along the transect route and at netting sites in each habitat. Vegetation was analysed using the Point Center Quarter Method (Afuang and Gonzalez, 1993). Botanical identification was achieved with the help of local guides and UPLB plant taxonomist experts.

Informal surveys were conducted during our brief period at the coastal site of Bucao and in the secondary forest-agroecosystem of Panukulan in the north of the island.

THE PRIMARY OLD GROWTH FOREST

The only old growth lowland forest within the Polillo islands is located within the Sibulan Watershed Reserve, an area that extends for approximately 160 hectares. The area has been damaged severely by the typhoons of 1997 and prostrate trunks with diameters exceeding 100cm remain. Remnant trees have a diameter at breast height of 50-100cm and a height of 30-50m. Dipterocarpaceae predominate with species including *Shorea contorta* (White Lauan), *Shorea negroensis* (Red Lauan), *Dipterocarpus speciosus* (Apitong) and *Hopea malibato* (Daling dingan). Species of Palmae included *Pinanga insignis* (Tokyong), *Areca catechu* (Bunga) and *Caryota rhumphiana* (Pugahan). The Pandanaceae are also represented. Other trees included *Schafflera caudate* (Lima lima), *Ficus nota* (Tibig), Katmon (*Dillenia philippinensis)*, Malanato, Malaruhat, Pelosapis, Malatubig, Malabayabas (*Tristania decorticala)* ,. Dinglas, Narra (*Pterocarpus indicus)*, Balete (*Ficus benjamina)*, Makaasin, Alupag, Mangasenora, Kamagong (*Diospyrus philippensis)* and Malasantol. The understorey features rattans, *Lycopodium,* large gabi plants and ferns.

THE SECONDARY GROWTH FOREST

The secondary growth forest is found both within and adjacent to the Sibulan Watershed Reserve. Selective deforestation was present in the 1960s (Gonzalez 1996). Trees

include *Macaranga bicolor* (Takipasin), *Artocarpus sericicarpus* (Antipolo), *Ficus nota* (Tibig), *Ficus variegata, Nephelium ramboutano* (Bulala), *Trichadenia philippinensis* (Amlang), *Macaranga tanarius* (Bilonga), *Schafflera caudate* (Lima Lima), *Dillenia philippinensis* (Katmon), *Syzygium* sp. (Macaasin), *Litsea ampla, Shorea negroensis* (Red Lauan), *Shorea contorta* (White lauan) and Abaca. The understorey features a leaf litter approximately 3-5cms deep, dead wood, ferns, small pandans, wild gingers and gabi. The stream is mainly shallow with a soft substrate.
The understorey of the secondary forest at Panukulan appeared more dense than that at Sibulan; ferns and wild rattans were apparent. The area has been considerably deforested for agricultural purposes, as described below

AGROECOSYSTEMS
The study site was located at Sitio Mahabangkahoy. The area was logged in the 1960s and 1970s so as to establish coconut (*Cocos nucifera)* plantations and rice; the natural irrigation pattern was altered accordingly. Fruiting trees include the Jack Fruit (*Artocarpus heterophyllus)*, Aratiles, Balimbing (*Averrhoa carambola)*, Guava (*Psidium guavaja)* and Bananas. Water buffalo, horses and cattle are grazed in this area. Bamboo thickets, ferns and cogon grasses are present. A broad river that reacts rapidly to current patterns of precipitation traverses this habitat. Mature fruiting trees frequented by birds overhang the river.

The agroecosystem in Panukulan features rice paddies, sugar cane, cassava, coconuts and bananas.

COASTAL SITE
A short study was also conducted at Bucao and its adjacent island, Tungao. The area has a large tidal range with a vast expanse of sand stretching out towards Tungao being exposed at low tide. The mangroves bordering the shoreline gave way to coconuts. Fish and Sea Cucumbers are harvested in the local waters. Areas of this important habitat have been destroyed for the construction of a hotel-under construction at the time of the study period. The area is under considerable threat from development plans for tourism.

Results and Discussion
A TEMPORAL AND SPATIAL ANALYSIS (Tables 1-5)
A total of 86 (inclusive of primary and secondary information sources) bird species were recorded on the three habitat types of Sibulan Watershed Area and the agroecosystems of Brgy. Mahabangkahoy, Polillo, Quezon. From the list of species recorded by McGregor, Manuel and Gonzalez, 45 species, predominantly migratory and shorebirds are absent from the 1999 inventory. This absence is partly a reflection of the narrower habitat dimensions, smaller geographical area encompassed by this study and temporal differences. Previous accounts have been based on the entire Polillo island group. There are 13 additional records to the inventory produced by Gonzalez (1996). A total of 50 species were recorded from the primary forests, 49 from the secondary and 69 from the agroforestry ecosystem.

The records in Sibulan forest compare favourably to those of Gonzalez in 1996 who recorded 41 species in both the primary and secondary forests (1996); a notable exception is the Blue-backed parrot, *Tanygnathus sumatranus;* an acoustic recording of this species was possibly obtained during the 1999 period however there were no sightings. A notable addition to the 1996 list and a new record for the island is the Red-bellied Pitta, *Pitta erythrogaster,* a ground-dwelling bird caught in a lizard trap. The 1996 agroforestry surveys conducted at Brgy. Agta-Sabang rather than Brgy. Mahabangkahoyn recorded only 25 species; significant temporal and spatial differences prevent a detailed comparative analysis being pursued.

THE AGROECOSYSTEM (Table 3)

The high number of species in the agroecosystem reflects the available resources of this area that are readily exploited by tolerant forest birds and the colonizing non-forest birds (Gonzalez 1997); *Phaenicophaeus superciliosus* is considered to be in this former category and *Lonchura malacca* in the latter. The most abundant species observed during the transect were *Oriolus chinensis* (66), *Hypsipetes philippinensis* (55), *Lonchura Malacca* (38), *Artamus leucorhynchus* (28), *Nectarinia sperata* (66) and *Collocalia sp.* (45); the former two species are arboreal insectivores/frugivores. Gregarious flocks of *Lonchura malacca,* a graminivorous species were observed in the rice paddies together with flocks of *A.leucorhynchus* an insectivorous species. *Nectarinia sperata* an insectivorous/nectivorous species was common around the *Cocos nucifera.* Wading species included the cryptic though highly vocal *Amaurornis phoenicurus. Rostratula benghalensis* discovered in the rice paddy is a new record for the island. The harvest season is reported to attract migratory birds such as *Lanius cristatus. Tanygnathus lucionensis* has also been reported in this habitat when bananas ripen. Common forest edge species included *Dicrurus balicassius, Sarcops calvus, Spilornis holospilos, Accipiter trivirgatus* and *Penelopides manillae subnigra.* According to Hunter (1990), Game species show predilection to edges, where two habitats meet; the benefits of food from the agroecosystem in addition to the shelter and nesting sites within the forest are here exploited. Species reported only in the agroecosystem include: *Ardea purpurea, Egretta intermediata, Bubulcus ibis, Ardea cinerea, Ixobrychus eurthymus, Haliastur indus, Haliaeestus leucogaster, Accipiter virgatus, Gallirallus torquatos, Amaurornis olivacea, Rostratula benghalelsis, Rallus striatus, Ducula poliocephelia, Streptopelia bitorquata, Halcyon smyrnensis, Anthus novaseelandiae, Artamus leucorhynchus, Lanius cristatus, Arachnothera longirosta, Diceaum hypoleucum. Passer montanus* and *Lonchura malacca*

THE FOREST (Tables 4 & 5)

The most abundant species observed during the transects in the primary (p) and secondary (s) forests featured the *Copsychus luzoniensis* (59:55, p:s), *Hypsipetes philippinensis* (46:99, p:s), *Ducula aenea* (48:40, p:s), *Penelepoides manillae* (54:29 p:s), *Sarcops calvus* (29:49, p:s) and *Pycnonotus urostictus* (31:36 p:s). *Oriolus chinensis* was abundant in the secondary (46) though not in the primary (9) forest. Notes on the breeding ecology of *C. luzoniensis,* a terrestrial insectivore were obtained on the 03/09/99 when a fledgling was observed begging to and being fed by an adult. *Penelopides manillae subnigra, Ducula aenea, Phaenicophaeus superciliosus* and

Centropus unirufus were often seen as a mixed flock in the primary forests. *Pitta erythrogaster* and *Hypothymis helenae* were observed only in the primary forest, however the latter was recorded by Gonzalez in the secondary forest. The Rufous Night Heron, *Nyticorax caledonicus* discovered in the primary forest potentially feeds in the rice paddies and has also been sighted at the coastal site of Bucao. *Ptilinopus merrilli, Ptilinopus leclancheri, Eudynamys scolopacea,* and *Aethopyga pulcherrima* were observed only in the secondary forest, the former three species being sighted on a fruiting *Ficus benjaminus* tree in the transect. *Gallicolumba luzonica* was more frequently encountered when roosting than during the formal transect period. The majority of species in the secondary forest were frugivorous and their high numbers reflective particularly of the fruiting *Ficus benjaminus.*

Niche differentiation was most evident within the kingfishers and munias; *Lonchura leucogastra* was recorded in both the primary and secondary forest whereas *L. malacca* was recorded only in the agroecosystem. *Alcedo cyanopectus* and *Halcyon smyrnensis,* riparian species, were both common to the agroecosystem though the range of only the former species extended into the forest. *Ceyx melanurus* a non-riparian species was specific to the forest habitat. The fourth species of kingfisher *Halcyon chloris* was observed at the coastal site of Bucao.

BUCAO AND PANUKULAN

Inventories from the short period at Bucao and Panukulan are shown in figure 2.

PANUKULAN

The short study period in the North of the island could evidently not do this area justice however some interesting observations were made. Two new netting records were obtained, namely, the Fairy Bluebird, *Irena cyanogaster* and the Brown Shrike, *Lanius cristatus.* Direct observations of *Lanius cristatus* hunting were obtained in an area of sugar cane bordering the secondary forest; no equivalent habitat-type was surveyed in the south of the island. *Lanius cristatus* is both a breeder and common winter visitor in the Philippines where it frequents 'open areas, second growth and residential areas' (Dickinson et al. 1991). *Irena cyanogaster* was observed on the forest fringe. It is further interesting to note that no Wattled Bulbuls, *Pycnonotus urostictus* were either caught or observed in this region.

BUCAO

The coastal/mangrove region of Bucao bordered by an area of coconuts was briefly surveyed. This unique habitat, overlooking the small island of 'Tungao '-a fundamental roosting site for Little and Reef Egrets, *Egretta garzetta* and *E.sacra* is under severe threat from coastal anthropogenic developments and has thus been recommended strongly as a region requiring further investigation. It is absolutely vital that the avian (and other) biodiversity of this site is accurately documented with temporal variations being taken into account. The apparent dominating presence of *Nectarinia jugularis* rather than *Nectarinia sperata* is based on limited data and hence should not be extrapolated to draw rigid conclusions about the relative densities of these two species in this coastal habitat. The concept of niche differentiation is nevertheless implied; further relevant is the notable predominance of *N.sperata* rather than *N.jugularis* in the agroforestry of Baranggay Mahabangkahoy. This trend differs from the habitat descriptions offered by Dickinson *et al* 1991, whereby only the former species is associated with mangroves.

Fig.2

INVENTORIES FROM BUCAO AND PANUKULAN, POLILLO QUEZON

BUCAO

Butoroides striatus Striated Heron
Egretta garzetta Little Egret
Egretta sacra Eastern Reef Egret
Egretta intermediata Intermediate Egret
Nycticorax caledonicus Rufous Night Heron
Plurialis dominica Lesser Golden Plover
Numenius pholopus Whimbrel
Actitis hypoleucos Ccommon Sandpiper
Heteroscelus brevipes Grey Tailed Tattler
Sterna bergii Greater Crested Tern
Sterna albifrons Little Tern
Macropygia phasianella Reddish Cuckoo Dove
Strepopelia bitoquata Dwarf turtle dove
Eudynamys scolopacea Common Koel
Centropus viridis Philippine Coucal
Collocalia esculenta Glossy Swiftlet
Halcyon chloris White Collared Kingfisher
Hypsipetes philippinus Philippine Bulbul
Oriolus chinensis Black Napped Oriole
*Artamus leucorhynchus*White Breasted Woodswallow
Aplonis panayensis Asian Glossy Starling
Nectarinia jugularis Olive Backed Sunbird
Rhipidura javanica Pied Fantail

NB: Lists based on primary and secondary evidence
-no *Tanygnathus* actually seen

PANUKULAN

Accipiter virgatus Besra
Accipiter trivirgatus Polillo Crested Goshawk
Phapitreron amethystina Amethyst Brown Dove
Ducula aenea Green Imperial Pigeon
Gallicolumba luzonica Luzon Bleeding Heart
Treron pompador Pompadour's Fruit Dove
Ptilinopus merrili Merrill's Fruit Dove
Chalcophops indica Green Winged Fruit Dove
Tanygnathus sumatranus Blue Backed Parrot
Loriculus philippensis Philippine Hanging Parakeet
Phaenicophaeus superciliousus Red Crested Malkoha
Centropus viridis Philippine Coucal
Harpectes ardens Philippine Trogon
Penelopides manillae subnigra Tarictic Hornbill
Mulleripicus funebris Sooty Woodpecker
Chrysocolaptes lucidus Polillo Flamebacked Woodpecker
Lalage nigra Pied Triller
Hypsipetes philippinus Philippine Bulbul
Pycnonotus urostictus White Eyed Bulbul
Dicrurus balicassius Balicassiao
Oriolus chinensis Black Naped Oriole
Irena cyanogaster Philippine Fairy Bluebird
Corvus macrorhynchus Large Billed Crow
Copsychus luzoniensis White Eyed Browed Shama
Cyornis rufigaster Mangrove Blue Flycatcher
Hypothymis azurea Black Naped Monarch
Tersiphone cinnamomea Rufous Paradise Flycatcher
Motacilla cinerea Grey Wagtail
Lanius Cristatus Brown Shrike
Sarcops calvus Coleto
Nectarinia sperata Purple Throated Sunbird
Diceaum pygmaeum Pygmy Flowerpecker
Diceaum trigostigma Orange Bellied Flowerpecker
Lonchura leucogastra White Bellied Munia

Table 1: Records of Bird Species Found in Polillo Islands: 1910,1956,1996,1999

SPECIES	McGregor 1910	Manuel 1956	Gonzalez 1996	Hilario & Walker 1999
Pterodroma phaeopygia Dark-Rumped Petrel			x	
Calonectris leucomelas Streaked Shearwater			x	
Ardea cinerea Grey Heron			x	R
Egretta garzetta Little Egret	x	x	x	x
Egretta sacra Eastern Reef Egret	x	x	x	*
Egretta intermediata Intermediate egret			x	*
Egretta alba Great Egret			x	
Bubulcus ibis Cattle Egret	x	x	x	R
Butoroides striatus Striated Heron	x	x	x	*
Gorsachius melanolophus Malayan Night Heron			x	
Nycticorax caledonicus Rufous Night heron	x	x	x	BT
Ardea purpurea Purple Heron				x
Ixobrychus eurhythmus Schrenk's Bittern	x		x	x
Ciconia episcopus Wolly-necked stork	x	x		
Dendrocygna arcuata Wandering Whistling Duck			x	R
Anas luzonica Philippine Duck	x	x	x	x
Anas clypeata Northern Shoveler	x			
Pernis ptilorhynchus Oriental Honeybuzzard	x		x	
Haliastur indus Brahminy Kite	x	x	x	R
Haliaeestus leucogaster White Bellied Sea Eagle			x	R
Spilornis holospilus Philippine Serpent Eagle	x	x	x	xN
Accipiter gularis Japanese Sparrowhawk	x			
Accipter virgatus Besra			x	RN
Accipiter trivirgatus Crested Goshawk	x	x	x	x
Butastur indicus Grey Faced buzzard	x			
Megapodius cumingii Tabon Scrubfowl	x	x	x	
Gallus gallus Red Junglefowl	x		x	R
Gallirallus philippensis Buff banded rail			x	R
Gallirallus torquatus Barred rail	x		x	x
Porzana cinerea White browed Crake			x	
Amaurornis olivacea Plain Bush Hen		x	x	x
Amaurornis pheonicurus White Brested Swamphen			x	x
Gallicrex cinerea Watercock		x		
Pluvialis squatarola Grey Plover	x			
Rostratula benghalensis Painted Snipe				N
Rallus striatus Slatty Legged Crake				x
Pluvialis dominica Lesser Golden plover	x			*
Charadrius dubius Little Ringed Plover	x			
Charadrius alexandrinus Kentish Plover	x			
Charadrius mongolus Lesser Sand Plover	x			
Charadrius leslechenaulti Greater SandPlover	x			
Charadrius peronii Malaysian Plover	x		x	
Numenius phaeopus Whimbrel	x		x	*
Tringa totanus Common redshank	x			
Tringa stagnatilis Marsh sandpiper	x		x	
Tringa nebularia Common redshank	x		x	
Tringa ocrophus Green Sandpiper	x			
Tringa glareola Wood Sandpiper	x			
Tringa sp.				R
Actitis hypoleucos Common Sandpiper	x			*
Heteroscelus (T. incanus) brevipes Grey Tailed Tattler	x		x	*
Arenaria interpres Ruddy Turnstone	x			
Gallinago megala Swinhoe's Snipe	x			
Calidris ruficollis Rufous Necked Stint	x		x	
Calidris alba Sanderling	x			
Esacus magnirostris great Thick Knee	x	x		
Glareola maldivarum Oriental Pranticole			x	
Sterna bergii Greater Crested Tern			x	*
Sterna albifrons sinensis Little Tern	x			*

Treron pompadora Pompadour's Fruit Dove	x	x	x	x
Treron vernans Pink necked pigeon				x
Phapiteron amethystina Amethyst brown Dove	x	x	x	xN
Ptilinopus merrilli Cream Bellied Fruit Dove	x	x	x	x
Ptilinopus leclancheri Black chinned Fruit Dove		x		x
Ducula aenea Green Imperial Pigeon	x	x	x	x
Ducula bicolor Pied Imperial Pigeon	x	x	x	x
Macropygia phasianella Reddish Cuckoo Dove	x	x		R
Streptopelia bitorquata Island Collared Dove	x	x	x	x
Streptopelia chinensis Spotted Dove			x	
Chalcophops indica Common Emerald Dove	x	x	x	xN
Gallicolumba luzonica Luzon Bleeding Heart	x	x	x	x
Phapitreron leucotis White Eared Fruit Dove				xN
Ducula poliocephala Pink Bellied Imperial Pigeon				R
Cacatua haematuropygia Philippine Cockatoo	x	x	x	
Tanygnathus lucionensis Blue Naped Parrot	x	x	x	R
Tanygnathus sumatranus Blue backed Parrot	x	x	x	R
Loriculus philippensis Philippine hanging Parrot		x	x	x
Cuculus sparveroides Large hawk Cuckoo		x		x
Eudynamys scolopacea Common Koel		x	x	x
Phaenicophaeus superciliosus Red crested malkoha	x	x	x	x
Centropus viridis viridis Philippine Coucal	x	x	x	x
Centropus unirufus Rufous Coucal	x	x	x	x
Tyto capensis Grass Owl			x	
Ninox philippensis Philippine hawk Owl	x	x	x	N
Batrachostomos septimus Philippine Frogmouth			x	R
Collocalia esculenta Glossy Swiftlet	x	x	x	xN
Collocalia vanikorensis Island Swiftlet			x	x
Collocalia troglodytes Pygmy swiftlet			x	x
Hirundapus celebensis Purple Needle tail			x	
Cypsiurus balasiensis Asian Palm Swift	x	x	x	
Harpectes ardens Philippine Trogon	x	x	x	xN
Alcedo atthis Common Kingfisher	x			
Alcedo cyanopectus Indigo banded Kingfisher	x	x	x	xN
Ceyx melanurus Philippine Dwarf Kingfisher	x	x	x	xN
Halcyon capensis Stork Billed kingfisher	x	x		
Halcyon smyrnensis White Throated kingfisher	x	x	x	xN
Halcyon chloris White Collared kingfisher	x	x	x	•
Eurystomus orientalis Dollarbird	x	x	x	x
Penelopides manillae subnigra Tarictic Hornbill	x	x	x	x
Mulleripicus funebris Sooty Woodpecker	x	x	x	x
Chrysocolaptes lucidus Greater Flameback	x	x	x	x
Pitta erythrogaster Red breasted Pitta				BT
Hirundo rustica Barn Swallow	x			
Hirundo tahitica Pacific Barn Swallow			x	
Coracina striata Bar bellied Cuckoo Shrike	x	x	x	x
Lalage nigra Pied Triller	x	x	x	R*
Pericrocotus divaricatus Ashy Minivet	x		x	
Pycnonotus urostictus Yellow wattled Bulbul	x	x	x	xN
Hypsipetes philippinus Philippine Bulbul	x	x	x	xN
Dicrurus balicassius Balicassiao	x	x	x	xN
Oriolus chinensis Black Naped Oriole	x	x	x	xN
Irena cyanogaster Philippine Fairy Bluebird	x	x		xN
Corvus macrorhynchus Largebilled Crow	x	x	x	xN
Copsychus luzoniensis White Browed Shama		x	x	xN
Phylloscopus borealis Arctic Warbler	x		x	
Cisticola exilis Bright capped cisticola			x	
Cisticola juncidis Zitting Cisticola			x	
Cisticola sp.				R
Muscicapa griseistica Grey Streaked Flycatcher	x			
Cyornis rufigastra Mangrove Blue Flycatcher	x	x	x	xN
Rhipidura javanica Pied Fantail	x	x	x	*(N)
Hypothymis azurea Black Naped Monarch	x	x	x	xBN
Hypothymis helenae Short Crested Monarch		x	x	N

Tersiphone cinnamomea Rufous Paradise Flycatcher	x	x	x	xN
Motacilla flava Yellow Wagtail	x			
Motacilla cinerea Grey Wagtail	x		x	*
Anthus novaseelandiae Richard's Pipit	x	x	x	x
Anthus gustavi Pechora Pipit	x			
Artamus leucorhynchus White Breasted Swallow	x	x	x	x
Lanius cristatus Brown Shrike	x		x	*
Aplonis panayensis Asian Glossy Starling	x		x	x
Sarcops calvus Coleto	x	x	x	x
Nectarinia sperata Purple Throated Flowerpecker	x	x	x	xN
Nectarinia jugularis Olive backed Sunbird	x	x	x	xN
Aethopyga shelleyi Lovely Sunbird	x	x	x	x
Dicaeum trigonostigma Orange Bellied Flowerpecker	x	x	x	xN
Dicaeum hypoleucum Buzzing Flowerpecker			x	R
Dicaeum pygmaeum Pygmy Flowerpecker	x	x	x	x
Passer montanus Eurasian Tree Sparrow		x	x	x
Lonchura leucogastra White Bellied Munia	x	x	x	xN
Lonchura malacca Chestnut Munia	x	x	x	x
Aethopyga pulcherrima Mountain Sunbird				x
Arachnothera longirostra Little Spider Hunter				x
Total no. species	99	71	102	96

R=report by local inhabitant or outside formal study period; also marks possible sound recordings, N=bird caught in net
*=additional record-from Bucao or Panukulan, BT=Lizard Trap

Table 2:List of Bird Species per Area namely Agroforestry(A), Secondary Forests (S), and Primary Old Growth Forest (P) of Baranggay Mahabangkahoy and Sibulan Watershed Area, Polillo Quezon

SPECIES	A	S	P
Ardea cinerea Grey Heron	R		
Egretta garzetta Little Egret	x		
Egretta intermediata Intermediate Egret	R		
Bubulcus ibis Cattle Egret	R		
Nycticorax caledonicus Rufous Night heron			R(BT)
Ardea purpurea Purple heron	x		
Ixobrychus eurythmus Schrenk's Bittern	x		
Dendrocygna arcuata Wandering Whistling Duck		R	
Anas luzonica Philippine duck	x	x	
Haliastur indus Brahminy Kite	R		
Haliaeestus leucogaster White Bellied Sea Eagle	R		
Spilornis holospilus Philippine serpent Eagle	x		R
Accipiter virgatus Besra	x	x	
Accipiter trivirgatus castroi Crested Goshawk	R		R
Gallus gallus Jungle Fowl			R
Gallirallus philippinensis Buff-banded Rail	R	R	R
Gallirallus torquatus Barred Rail	x		
Amauromis olivacea Plain Bushhen	x		
Amauromis pheonicurus White Breasted Swamphen	x	x	
Rostratula benghalensis Painted Snipe	x		
Rallus striatus Slatty Legged Crake	x		
Tringa sp.	x		
Treron vernans Pink Necked Pigeon	x	x	
Treron pompadora Pompadour Green Pigeon	x	x	x
Phapitreron leucotis White Eared Fruit Dove	x	x	R
Phapitreron amethystina Amethyst brown dove	x	x	x
Ptilinopus merrilli Cream Bellied Fruit Dove		x	
Ptilinopus leclencheri Black Chinned Fruit Dove		x	
Ducula aenea Green Imperial Pigeon	x	x	x
Ducula poliocephala Pink Bellied Imperial Pigeon	R		
Ducula bicolor Pied Imperial Pigeon	x		x
Macropygia phasianella Reddish Cuckoo Dove	R		R

Streptopelia bitorquata Island Collared Dove	x		
Chalcophops indica Common Emerald Dove	x	x	
Gallicolumba luzonica Luzon Bleeding Heart		x	R
Tanygnathus lucionensis Blue Naped parrot	R		R
Tanygnathus sumatranus Blue backed Parrot	R		R
Loriculus philippensis Philippine Hanging Parrot	x	x	x
Eudynamys scolopacea Common Koel		x	
Phaenicophaeus superciliosus Red Crested Malkoha	x	x	x
Centropus viridis viridis Philippine Coucal	x	x	x
Centropus unirufous Rufous Coucal		x	x
Ninox philippensis Philippine Hawk Owl	x		R
Batrachostomus septimus Philippine Frogmouth	R		R
Collocalia vanikorensis Island Swiftlet	x	x	x
Collocalia esculenta Glossy Swiftlet	x	x	x
Collocalia troglodytes Pygmy Swiftlet	x	x	x
Harpectes ardens Philippine Trogon		x	x
Alcedo cyanopectus Indigo banded Kingfisher	x	x	x
Alcedo melanurus Philippine dwarf Kingfisher		x	x
Halcyon smyrnensis White Throated Kingfisher	x		
Eurystamus orientalis Dollarbird	x	x	x
Penelopides manillae subnigra Tarictic Hombill	x	x	x
Mulleripicus funebris Sooty Woodpecker		x	x
Chrysocolaptes lucidus Greater Flameback	x	x	x
Coracina striata Bar Bellied Cuckoo Shrike	x	x	x
Lalage nigra Pied Triller	R		
Pycnonotus urostictus Yellow Wattled Bulbul	x	x	x
Hypsipetes philippinus Philippine Bulbul	x	x	x
Dicrurus balicassius Balicassiao	x	x	x
Oriolus chinensis BlackNaped Oriole	x	x	x
Irena cyanogaster Philippine fairy Bluebird	R	x	
Corvus macrorhynchus LargeBilled Crow	x	x	x
Copsycus luzoniensis White Browed Shama	x	x	x
Cisticola sp.		R	
Cyornis rufigastra Mangrove Blue Flycatcher	x	x	x
Hypothymis azurea Black Naped BlueMonarch	x	x	x
Hypothymis helenae Short Crested Monarch			x
Tersiphone cinnamomea Rufous Paradise Flycatcher	x	x	x
Anthus novaseelandiae Richard's Pipit	x		
Artamus leucorhynchus White Breasted Woodswallow	x		
Lanius cristatus Brown Shrike			
Aplonis panayensis Glossy Starling	x	x	x
Sarcops calvus Coleto	x	x	x
Nectarinia sperata Purple Throated sunbird	x	x	x
Nectarinia jugularis Olive-Backed Sunbird	R	x	
Arachnothera longistra Little Spider Hunter	x		
Aethopyga shelleyi Lovely Sunbird	x		x
Diceaum trigonostigma Orange Bellied Flowerpecker	x	x	x
Diceaum hypoleucum Buzzing Flowerpecker	R		
Diceaum pygmaeum Pygmy Flowerpecker	x	x	x
Passer montanus Eurasian Tree Sparrow	x		
Lonchura leucogastra White Bellied Munia		x	x
Lonchura malacca Chestnut Munia	x		
Aethopyga pulcherrima Mountain Sunbird		x	
Pitta erythrogaster Red breasted Pitta			BT
Cuculus sparveroides Large Hawk Cuckoo			x
Total no.species	69	49	50

REPORTED=record from local inhabitant or presence recorded outside formal study period. BT = from trap

Table 3:List of Bird Species recorded per day in the Agroforestry Ecosystems of Baranggay Mahabangkahoy, Polillo, Quezon.

SPECIES	1	2	3	4	5	6	7	8	9	T
Ardea cinerea Grey Heron	R	E	P	O	R	T	E	D		
Egretta garzetta Little Egret	1									
Egretta intermediata Intermediate Egret	R	E	P	O	R	T	E	D		
Bubulcus ibis Cattle Egret	R	E	P	O	R	T	E	D		
Nycticorax caledonicus Rufous Night heron										
Ardea purpurea Purple heron					1					
Ixobrychus eurythmus Schrenk's Bittern		1	2	1	1		3	1	2	10
Dendrocygna arcuata Wandering Whistling Duck										
Anas luzonica Philippine duck		4		2	2		3	3		13
Haliastur indus Brahminy Kite	R	E	P	O	R	T	E	D		
Haliaeestus leucogaster White Bellied Sea Eagle	R	E	P	O	R	T	E	D		
Spilornis holospilus Philippine serpent Eagle	1		1	1					1	4
Accipiter virgatus Besra		1								
Accipiter trivirgatus castroi Crested Goshawk	R	E	P	O	R	T	E	D		
Gallus gallus Jungle Fowl										
Gallirallus philippinensis Buff-banded Rail	R	E	P	O	R	T	E	D		
Gallirallus torquatus Barred Rail			1		1	1			3	
Amaurornis olivacea Plain Bushhen	1	1	2		1		1	2	1	9
Amaurornis pheonicurus White Breasted Swamphen	1						1			2
Rostratula benghalensis Painted Snipe	1									1
Rallus striatus Slatty Legged Crake								1		1
Tringa sp.	1									1
Treron vernans Pink Necked Pigeon	1									1
Treron pompadora Pompadour Green Pigeon		1	2		1			1	3	7
Phapitreron leucotis White Eared Fruit Dove			3	1		2			6	12
Phapitreron amethystina Amethyst brown dove	1			1		1		1		4
Ptilinopus merrilli Cream Bellied Fruit Dove										
Ptilinopus leclancheri Black Chinned Fruit Dove										
Ducula aenea Green Imperial Pigeon		1			1			1	1	5
Ducula poliophelia Pink Bellied Imperial Pigeon	R	E	P	O	R	T	E	D		
Ducula bicolor Pied Imperial Pigeon							1			1
Macropygia phasianella Reddish Cuckoo Dove	R	E	P	O	R	T	E	D		
Streptopelia bitorquata Island Collared Dove				1		1				
Chalcophops indica Common Emerald Dove	1	1	4	5		5	6			22
Gallicolumba luzonica Luzon Bleeding Heart										
Tanygnathus lucionensis Blue Naped parrot	R	E	P	O	R	T	E	D		
Tanygnathus sumatranus Blue backed Parrot	R	E	P	O	R	T	E	D		
Loriculus philippensis Philippine Hanging Parrot	1	1								2
Eudynamys scolopacea Common Koel										
Phaenicophaeus superciliosus Red Crested Malkoha	1	1		2			4	5	3	16
Centropus viridis viridis Philippine Coucal	1	1	2	1	2		2	3	1	13
Centropus unirufous Rufous Coucal									1	1
Ninox philippensis Philippine Hawk Owl									1	1
Batrachostomus septimus Philippine Frogmouth	R	E	P	O	R	T	E	D		
Collocalia vanikorensis Island Swiftlet	1	1	1				2			5
Collocalia esculenta Glossy Swiftlet	1	1	2				4			8
Collocalia troglodytes Pygmy Swiftlet		1		3			2			6
Harpectes ardens Philippine Trogon										
Alcedo cyanopectus Indigo banded Kingfisher	3		2	3	1	1				10
Alcedo melanurus Philippine Dwarf Kingfisher										
Halcyon smymensis White Throated Kingfisher	1	2	4	3	3		4		3	20
Eurystamus orientalis Dollarbird					1		3	2	2	8
Penelopides manillae subnigra Tarictic Hornbill	2	1		2				3	3	11
Mulleripicus funebris Sooty Woodpecker										
Chrysocolaptes lucidus Greater Flameback				1						1
Coracina striata Bar Bellied Cuckoo Shrike	1									1
Lalage nigra Pied Triller	R	E	P	O	R	T	E	D		
Pycnonotus urostictus Yellow Wattled Bulbul	1	1		2	1	1	8	2		16
Hypsipetes philippinus Philippine Bulbul		1	6	5	3	2	28	7	3	55

Dicrurus balicassius Balicassiao	1	3	1	2	6	2	5	4	4	28
Oriolus chinensis Black Naped Oriole	1	5	6	2	12	4	18	8	10	66
Irena cyanogaster Philippine fairy Bluebird	R	E	P	O	R	T	E	D		
Corvus macrorhynchus LargeBilled Crow							4	8	2	14
Copsycus luzoniensis White Browed Shama		1		1	1		2	2	2	9
Cisticola sp.										
Cyornis rufigastra Mangrove Blue Flycatcher					2		2	1	2	7
Hypothymis azurea Black Naped BlueMonarch							2			
Hypothymis helenae Short Crested Monarch										
Terpsiphone cinnamomea Rufous Paradise Flycatcher	1		1	5		1	1	1	3	13
Anthus novaseelandiae Richard's Pipit				1			2	1		4
Artamus leucorhynchus White Breasted Woodswallow		2	4	1		5	5	8	3	28
Lanius cristatus Brown Shrike										
Aplonis panayensis Glossy Starling				1						1
Sarcops calvus Coleto		1	6	5	7	1	2	5	3	30
Nectarinia sperata Purple Throated sunbird	1	2	2	10	13	10	11	6	11	66
Nectarinia jugularis Olive-Backed Sunbird	R	E	P	O	R	T	E	D		
Arachnothera longistra Little Spider Hunter					1					1
Aethopyga shelleyi Lovely Sunbird					1					1
Diceaum trigonostigma Orange Bellied Flowerpecker					1	1	1			3
Diceaum hypoleucum Buzzing Flowerpecker	R	E	P	O	R	T	E	D		
Diceaum pygmaeum Pygmy Flowerpecker							2			2
Passer montanus Eurasian Tree Sparrow				1			3	2	1	7
Lonchura leucogastra White Bellied Munia										
Lonchura malacca Chestnut Munia		1	18	7	1		3	3	5	38
Aethopyga pulcherrima Mountain Sunbird										
Pitta erythrogaster Red Breasted Pitta										
Cuculus sparveroides Large Hawk Cuckoo										

REPORTED=record from local inhabitant or recorded outside formal study period

Table 4:List of Bird Species Recorded Per day in Secondary Forest, Sibulan Watershed Area, Polillo Quezon

SPECIES	1	2	3	4	5	6	7	8	9	T
Ardea cinerea Grey Heron										
Egretta garzetta Little Egret										
Egretta intermediata Intermediate Egret										
Bubulcus ibis Cattle Egret										
Nycticorax caledonicus Rufous Night heron										
Ardea purpurea Purple heron										
Ixobrychus eurythmus Schrenk's Bittern										
Dendrocygna arcuata Wandering Whistling Duck	R	E	P	O	R	T	E	D		
Anas luzonica Philippine duck		2								2
Haliastur indus Brahminy Kite										
Haliaeestus leucogaster White Bellied Sea Eagle										
Spilornis holospilus Philippine serpent Eagle							1			1
Accipiter virgatus Besra										
Accipiter trivirgatus castroi Crested Goshawk										
Gallus gallus Jungle Fowl										
Gallirallus philippinensis Buff-banded Rail	R	E	P	O	R	T	E	D		
Gallirallus torquatus Barred Rail										
Rostratula benghalensis Painted Snipe										
Amaurornis olivacea Plain Bushhen										
Amaurornis pheonicurus White Breasted Swamphen					1					1
Rallus striatus Slatty Legged Crake										
Tringa sp.										
Treron vernans Pink Necked Pigeon		1		2						3
Treron pompadora Pompadour Green Pigeon	1									1
Phapitreron leucotis White Eared Fruit Dove		1								1

Phapitreron amethystina Amethyst brown dove	1	7		9		2	1	4	12	36
Ptilinopus merrilli Cream Bellied Fruit Dove		1								1
Ptilinopus leclencheri Black Chinned Fruit Dove		1								1
Ducula aenea Green Imperial Pigeon	1	3	2	5		6	9	9	5	40
Ducula poliophelia Pink Bellied Imperial Pigeon										
Ducula bicolor Pied Imperial Pigeon										
Macropygia phasianella Reddish Cuckoo Dove										
Streptopelia bitorquata Island Collared Dove										
Chalcophops indica Common Emerald Dove			1		1		1	1	1	5
Gallicolumba luzonica Luzon Bleeding Heart					1					1
Tanygnathus lucionensis Blue Naped parrot										
Tanygnathus sumatranus Blue backed Parrot										
Loriculus philippensis Philippine Hanging Parrot		2		1			1			4
Eudynamys scolopacea Common Koel	1	1		1						3
Phaenicophaeus superciliosus Red Crested Malkoha	2	1	2	2		2	3	3	2	17
Centropus viridis viridis Philippine Coucal	1	3	1	1	1	2	2		4	15
Centropus unirufous Rufous Coucal				1		2	6	6	1	16
Ninox philippensis Philippine Hawk Owl										
Batrachostomus septimus Philippine Frogmouth										
Collocalia vanikorensis Island Swiftlet	1									
Collocalia esculenta Glossy Swiftlet	1	1		1		1	2	2		8
Collocalia troglodytes Pygmy Swiftlet	1					1	2	2	1	7
Harpectes ardens Philippine Trogon	1	1							2	
Alcedo cyanopectus Indigo banded Kingfisher	1				1	2				4
Alcedo melanurus Philippine dwarf Kingfisher		1		1		1				3
Halcyon smyrnensis White Throated Kingfisher										
Eurystamus orientalis Dollarbird		1		1		1		3	3	9
Penelopides manillae subnigra Tarictic Hornbill	1	2		1		4	7	7	7	29
Mulleripicus funebris Sooty Woodpecker	1						1		1	3
Chrysocolaptes lucidus Greater Flameback	1						2	1	1	5
Coracina striata Bar Bellied Cuckoo Shrike			2		1					3
Lalage nigra Pied Triller										
Pycnonotus urostictus Yellow Wattled Bulbul		4	1	6	2	6	2	11	4	36
Hypsipetes philippinus Philippine Bulbul	3	10	9	17	5	15	14	13	14	99
Dicrurus balicassius Balicassiao	1		1	2			3	3	5	15
Oriolus chinensis BlackNaped Oriole	2	3	2	2	1	21	6	6	3	46
Irena cyanogaster Philippine fairy Bluebird				1			1	1		3
Corvus macrorhynchus LargeBilled Crow	1		4	1			1	1	1	9
Copsycus luzoniensis White Browed Shama	4	6	3	7		9	10	11	5	55
Cisticola sp.	R	E	P	O	R	T	E	D		
Cyornis rufigastra Mangrove Blue Flycatcher	1	1	1	3	1				2	10
Hypothymis azurea Black Naped BlueMonarch	1	1	1	3	1				2	10
Hypothymis helenae Short Crested Monarch										
Tersiphone cinnamomea Rufous Paradise Flycatcher		1	2				1			4
Anthus novaseelandiae Richard's Pipit										
Artamus leucorhynchus White Breasted Woodswllow										
Lanius cristatus Brown Shrike										
Aplonis panayensis Glossy Starling				6						6
Sarcops calvus Coleto	1	3		7		9	12	12	5	49
Nectarinia sperata Purple Throated sunbird	1	2		3		3	4	1	1	15
Nectarinia jugularis Olive-Backed Sunbird	1									1
Arachnothera longistra Little Spider Hunter										
Aethopyga shelleyi Lovely Sunbird										
Diceaum trigonostigma Orange Bellied Flowerpecker				1		1			2	4
Diceaum hypoleucum Buzzing Flowerpecker										
Diceaum pygmaeum Pygmy Flowerpecker	1	3						1	4	9
Passer montanus Eurasian Tree Sparrow								1	1	2

Lonchura leucogastra White Bellied Munia										
Lonchura malacca Chestnut Munia										
Aethopyga pulcherrima Mountain Sunbird				1	1					2
Pitta erythrogaster Red breasted Pitta										
Cuculus sparveroides Large Hawk Cuckoo										

Reported=report by local inhabitant or recorded outside formal study period

Table 5:List of Bird Species Recorded per day in Primary Old growth Forests of Sibulan Watershed, Polillo, Quezon

SPECIES	1	2	3	4	5	6	7	8	9	T
Ardea cinerea Grey Heron										
Egretta garzetta Little Egret										
Egretta intermediata Intermediate Egret										
Bubulcus ibis Cattle Egret										
Nycticorax caledonicus Rufous Night heron	B	A	YA	W	A	K	TR	A	P	
Ardea purpurea Purple heron										
Ixobrychus eurythmus Schrenk's Bittern										
Dendrocygna arcuata Wandering Whistling Duck										
Anas luzonica Philippine duck										
Haliastur indus Brahminy Kite										
Haliaeestus leucogaster White Bellied Sea Eagle										
Spilornis holospilus Philippine serpent Eagle	R	E	P	O	R	T	E	D		
Accipiter virgatus Japanese Sparrowhawk										
Accipiter trivirgatus castroi Crested Goshawk	R	E	P	O	R	T	E	D		
Gallus gallus Jungle Fowl	R	E	P	O	R	T	E	D		
Gallirallus philippinensis Buff-banded Rail	R	E	P	O	R	T	E	D		
Gallirallus torquatus Barred Rail										
Rostratula benghalensis Painted Snipe										
Amaurornis olivacea Plain Bushhen										
Amaurornis pheonicurus White Breasted Swamphen										
Rallus striatus Slatty Legged Crake										
Tringa sp.										
Treron vernans Pink Necked Pigeon										
Treron pompadora Pompadour Green Pigeon							1	1	2	4
Phapitreron leucotis White Eared Fruit Dove	R	E	P	O	R	T	E	D		
Phapitreron amethystina Amethyst brown dove		1	1	1	1	6	2			12
Ptilinopus merrilli Cream Bellied Fruit Dove										
Ptilinopus leclencheri Black Chinned Fruit Dove										
Ducula aenea Green Imperial Pigeon	2	3	4	3	7	12	2	4	11	48
Ducula poliophelia Pink Bellied Imperial Pigeon										
Ducula bicolor Pied Imperial Pigeon		1								1
Macropygia phasianella Reddish Cuckoo Dove	R	E	P	O	R	T	E	D		
Streptopelia bitorquata Island Collared Dove										
Chalcophops indica Common Emerald Dove										
Gallicolumba luzonica Luzon Bleeding Heart	R	E	P	O	R	T	E	D		
Tanygnathus lucionensis Blue Naped parrot	R	E	P	O	R	T	E	D		
Tanygnathus sumatranus Blue backed Parrot	R	E	P	O	R	T	E	D		
Loriculus philippensis Phillppine Hanging Parrot						1		1		2
Eudynamys scolopacea Common Koel										
Phaenicophaeus superciliosus Red Crested Malkoha			2		6	7	6	4	6	31
Centropus viridis viridis Philippine Coucal	3	1	1		2	1		1		9
Centropus unirufous Rufous Coucal			2	2	2		6	8	2	22
Ninox philippensis Philippine Hawk Owl	R	E	P	O	R	T	E	D		
Batrachostomus septimus Philippine Frogmouth	R	E	P	O	R	T	E	D		
Collocalia vanikorensis Island Swiftlet	1									

Collocalia esculenta Glossy Swiftlet	1									
Collocalia troglodytes Pygmy Swiftlet	1									
Harpectes ardens Philippine Trogon			2	2		1	2	2	2	11
Alcedo cyanopectus Indigo banded Kingfisher								2		2
Alcedo melanurus Philippine dwarf Kingfisher							1			1
Halcyon smyrnensis White Throated Kingfisher										
Eurystamus orientalis Dollarbird				1						
Penelopides manillae subnigra Tarictic Hornbill	2	2	16	8	11	5	3	2	5	54
Mulleripicus funebris Sooty Woodpecker					1					1
Chrysocolaptes lucidus Greater Flameback			2	5	1	1	1	2		12
Coracina striata Bar Bellied Cuckoo Shrike					1					1
Lalage nigra Pied Triller										
Pycnonotus urostictus Yellow Wattled Bulbul	3	1	2	2		9		5	9	31
Hypsipetes philippinus Philippine Bulbul	2	6	4	1	4		10	8	11	46
Dicrurus balicassius Balicassiao		1	1		6	4	2	1	7	22
Oriolus chinensis BlackNaped Oriole	2	1	1			3	1	1		9
Irena cyanogaster Philippine fairy Bluebird										
Corvus macrorhynchus LargeBilled Crow				1	1		1			3
Copsycus luzoniensis White Browed Shama	3	2	6	5	5	14	4	6	14	59
Cisticola sp.										
Cyornis rufigastra Mangrove Blue Flycatcher					3	3	3			9
Hypothymis azurea Black Naped BlueMonarch					1		1	1	2	5
Hypothymis helenae Short Crested Monarch								1		
Tersiphone cinnamomea Rufous Paradise Flycatcher	1	1	3	2		2	5	1	2	17
Anthus novaseelandiae Richard's Pipit										
Artamus leucorhynchus White Breasted Woodswllow										
Lanius cristatus Brown Shrike										
Aplonis panayensis Glossy Starling			1				3	1		5
Sarcops calvus Coleto	2	3	3		1	7	4	4	5	29
Nectarinia sperata Purple Throated sunbird	1			1	3	5		1	1	12
Nectarinia jugularis Olive-Backed Sunbird										
Arachnothera longistra Little Spider Hunter										
Aethopyga shelleyi Lovely Sunbird			1							1
Diceaum trigonostigma Orange Bellied Flowerpecker	1	2	1	1		1	5		1	12
Diceaum hypoleucum Buzzing Flowerpecker										
Diceaum pygmaeum Pygmy Flowerpecker		1	1			1	1		1	5
Passer montanus Eurasian Tree Sparrow										
Lonchura leucogastra White Bellied Munia							1	1		2
Lonchura malacca Chestnut Munia										
Aethopyga pulcherrima Mountain Sunbird										
Pitta erythrogaster Red breasted Pitta	B	A	YA	W	AK	T	R	A	P	1
Cuculus sparveroides Large Hawk Cuckoo				1						1

Reported=report by local inhabitant or recorded outside formal study period

Table 6:Netting Data

SPECIES	Primary	Secondary	Agro	Bucao	Panukulan
Rostratula bengalensis			1		
Spilornis holospilus			1		
Accipiter virgatus			1		
Phapiteron amethystina			3		
Phapiteron leucotis			3		
Chalcophaps indica		2	13		
Ninox philippensis			1		
Collocalia esculenta			1		
Harpactes ardens	1	2			
Alcedo cyanopectus	1	3	4	2	
Halcyon smyrmensis			2		
Ceyx melanurus		3			
Halcyon chloris				2	
Lalage nigra				3	
Pycnonotus urostictus		5			
Hypsipetes philippinus	4	11	4	4	14
Dicrurus balicassius		2	2		
Oriolus chinensis			3	1	
Irena cyanogaster					2
Copsychus luzoniensis	3	6			3
Cyornis rufigaster		2	2	3	2
Rhipidura javanica				1	
Hypothymis azurea	1	3			1
Hypothymis helenae	1				
Terpsiphone cinnamomea	1	8	3		5
Lanius cristatus					1
Nectarinia sperata		1	1		
Nectarinia jugularis		1		5	
Dicaeum trigonostigma			1		
Lonchura malacca					1
Lonchura leucogaster	3	2			
Species Richness	10	14	17	8	8
Total No. Individuals	15	51	56	21	29
Shannon Weiner Species Diversity, H	0.82	1.03	0.96	0.85	0.7

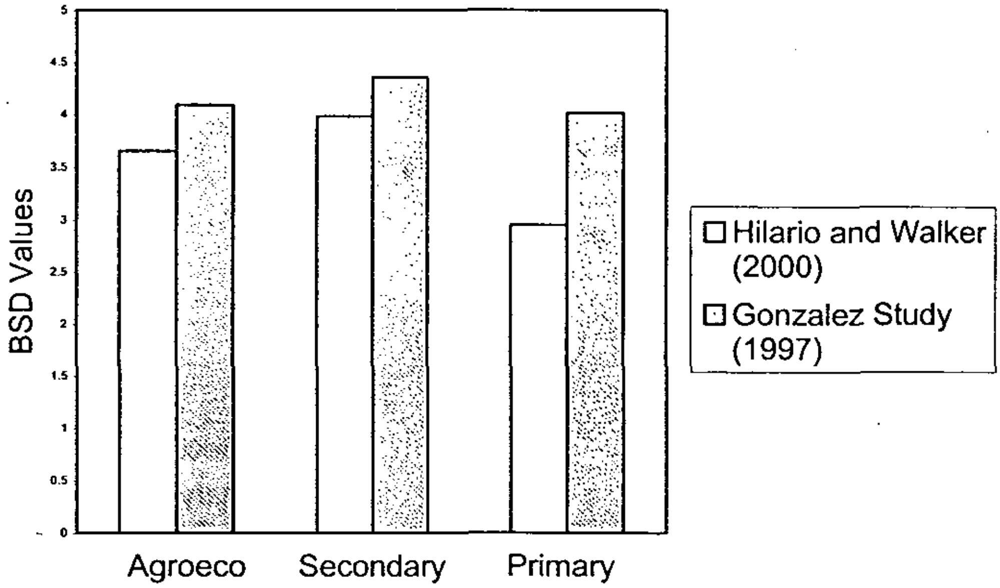
NB: Netting regime consistent in primary, secondary and agroecosystem though only conducted for a short period on an informal basis in Bucao and Panukulan Panukulan-netting conducted on fringe of secondary forest and in area with Pandans and free-flowing water

Table 7. LIST OF SPECIES FOR WHICH ACOUSTIC RECORDS WERE OBTAINED

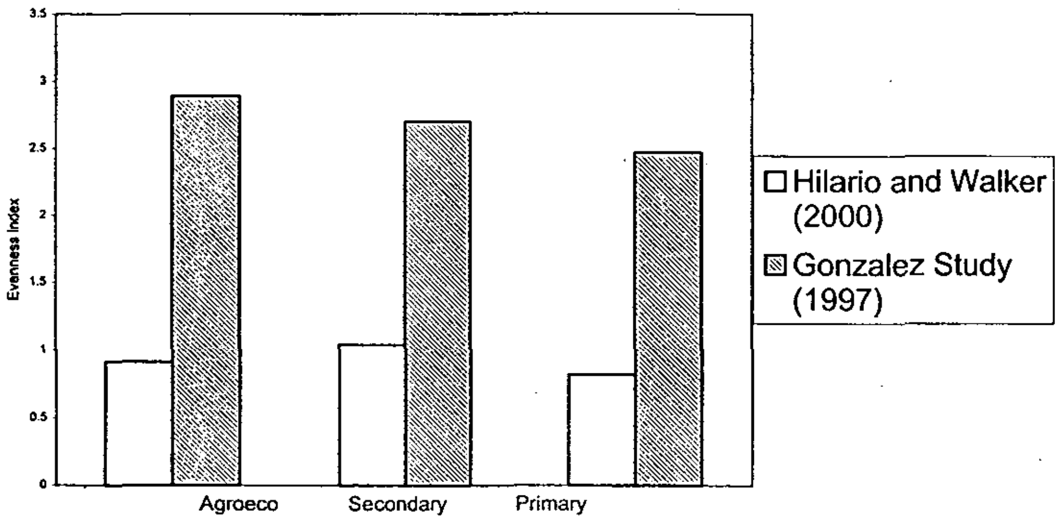
Amaurornis pheonicurus White Brested Swamphen
Phapitreron amethystina Amethyst Brown Dove
Ducula aenea Green Imperial Pigeon
Macropygia phasianella Reddish Cuckoo Dove
Tanygnathus lucionensis Blue Naped Parrot ? (TBC)
Phaenicophaeus superciliosus Red crested malkoha
Centropus viridis viridis Philippine Coucal
Halcyon smyrnensis White Throated kingfisher
Penelopides manillae subnigra Tarictic Hornbill
Chrysocolaptes lucidus Greater Flameback
Pycnonotus urostictus Yellow wattled Bulbul
Hypsipetes philippinus Philippine Bulbul
Dicrurus balicassius Balicassiao
Oriolus chinensis Black Naped Oriole
Copsychus luzoniensis White Browed Shama
Cyornis rufigastra Mangrove Blue Flycatcher
Hypothymis azurea Black Naped Monarch
Artamus leucorhynchus White Breasted Swallow
Sarcops calvus Coleto
Nectarinia sperata Purple Throated Flowerpecker
Dicaeum trigonostigma Orange Bellied Flowerpecker
Pitta erthyrogaster Red Breasted Pitta

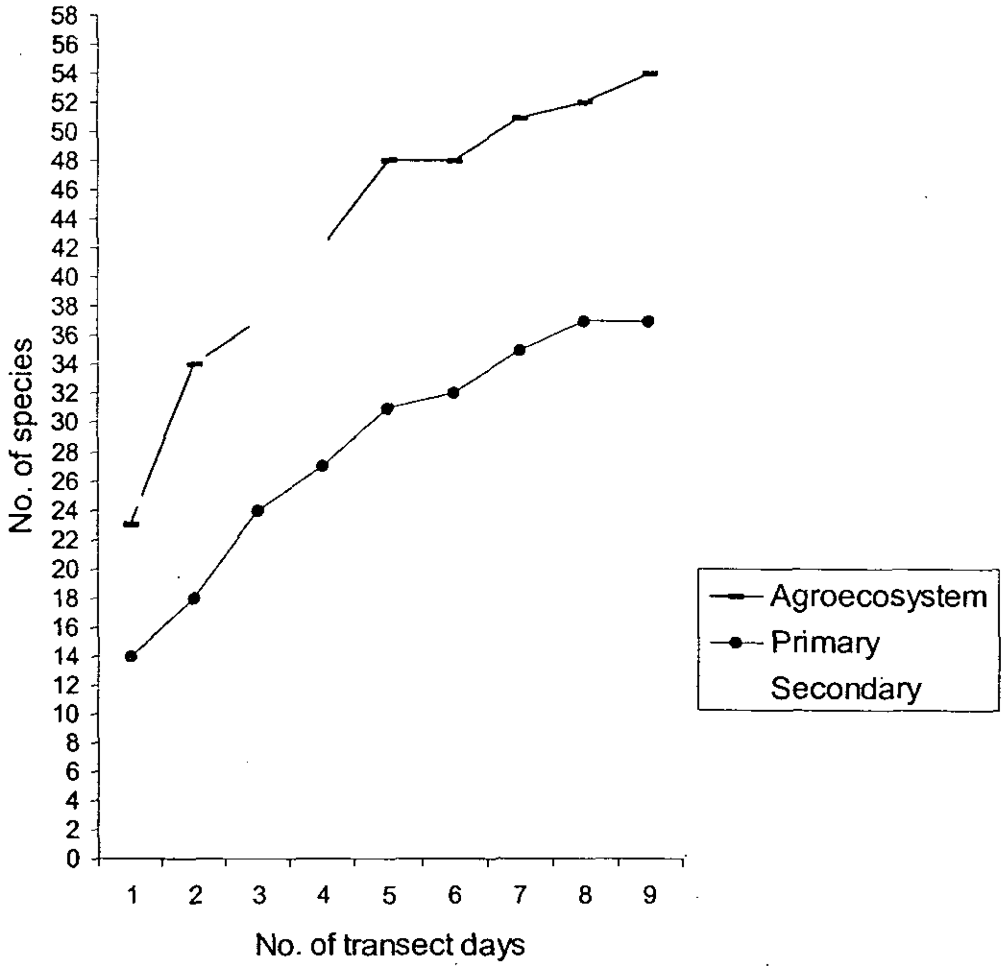
Records donated to the British Library of Wildlife Sounds
TBC=To be confirmed

Graph 1. Comparison of Bird Species Diversity (Shannon-Weiner)Values of Gonzalez (1997) and Hilario and Walker (2000), on the three habitat areas (agroecosystem, secondary and primary forests)



Graph 2. Comparison of Evenness indices of Gonzalez (1997) and Hilario and Walker (2000) on three habitat types (Agroecosystem, primary and secondary forests)





Graph 3.Species Discovery Curve of species on primary and secondary forests of Sibulan Watershed and the Agroecosystems of Brgy. Mahabangkahoy, Polillo, Quezon

INDICES- based on transect data (Graphs 1&2)

Similarity Indices between the three habitats are high. Agroecosystem and secondary forest habitat showed 67% similarity, the primary and secondary forest showed 73% and the agroecosystem and primary showed 72%. The intermixed vegetation of the primary and the secondary forest areas and the highly fragmented nature of the primary forest may have attributed to this high similarity. Further, the presence of frugivorous birds tends to be defined by the presence of fruiting trees rather than purely habitat boundaries. Birds roosting/nesting in the high forest canopy though with a more extensive feeding range and those inhabiting edge habitats further contribute to such high values. An active nest of the Philippine Serpent Eagle, *Spilornis holospilus* was viewed in the primary forest during the study period. Differences between habitats largely reflect the presence of more specialist species such as *Hypothymis helenae,* a sallying insectivore found in the understorey of forests.

Based on the transect the highest Bird Species Diversity (BSD) (Graph 1) was in the secondary forest (4.00148), then the agroforestry ecosystem (3.65203), and lastly, the primary forests (2.949028); the same trend, though over a narrower range of values was reported by Gonzalez in 1997 and the same pattern is evident in indices calculated from the 1999 netting data (Table 6). The low diversity in the primary forest may be partly equated to the effects of forest fragmentation, coupled to postulated lower densities. Habitat degradation in the primary forest, due to human exploitation and natural calamites may have caused typically intolerant species to exploit sub-optimum habitat in the secondary forest.

The highest evenness index (Graph 2) was from the secondary forest, then the agroecosystem and lastly the primary forest. A maximum evenness value refers to the situation where each species is equally represented in terms of its number of individuals. The particularly low index of the primary forest may reflect disturbance. In appreciating that these values fall within a narrow range, are effected by a multitude of variables and are derived from temporally-limited data interpretations should be viewed cautiously. The secondary forest holds both specialist and generalist feeders, which coupled to high habitat heterogeneity limits dominance and competitive exclusion. It is highly possible that species more typical of the primary forest such as *Harpactes ardens* have more recently began to exploit the sub-optimum secondary forest.

ENDEMIC BIRDS AND BIRDS OF CONSERVATION IMPORTANCE

Five of the seven Polillo endemic sub-species were recorded during the study period: *Accipiter trivirgatus catroi, Harpactes ardens minor, Chrysocolaptes lucidus grandis, Copsychus luzoniensis parvimaculatus, Penelepoides manillae subnigra.* The latter four species were all encountered more frequently in the primary than secondary forest. The Trogon was caught in both primary and secondary forest though only recorded during transects in the primary forest; accounts from Gonzalez and ethnobiological studies have not previously recorded the Trogon in the secondary forest. The Polillo Crested Goshawk, observed near the rice paddies with a frog in its talons, is frequently seen by local inhabitants in the agroforestry. A possible sound recording was obtained of *Tanygnathus*

THREATENED AND NEAR-THREATENED SPECIES

11 of the 14 near-threatened species in the Polillo Islands were recorded during the study period:

Ixobrychus eurythmus, Ptilinopus merrilli, Centropus unirufous, Ceyx melanurus, Hypothymis helenae, Terpsiphone cinnamomea (Collar and Andrew 1988), *Anas luzonica, Gallicolumba luzonica, Alcedo cyanopectus, Penelepoides manillae, Irena cyanogaster* (Birdlife International 1994). *Gorsachius melanolophus*, the Malayan Night Heron, observed on Polillo in 1996 was not sighted.

The two threatened species, *Tanygnathus lucionensis* observed in Bucao in 1996, and *Cacatua haematuropgia*, observed in Agta-Sabang in 1996 were also not sighted. According to the Ecology Steward there have been no Philippine Cockatoos seen in Sibulan for the past ten years. The bird's nesting preference for holes in big 'dead' trees made them an easy target for poachers. The emergence of new branches signified the time just prior to fledgling and led to the subsequent capturing of birds for the pet trade; this led to its local extinction. Local reports indicate that *Tanygnathus sumatranus* is seen around Sitio Mahabangkahoy on occasions when banana fruit ripens.

The survey has confirmed the presence of *Irena cyanogaster, Macropygia phasianella* and *Ptilinopus leclancheri* whose absence in 1996 was hypothised to be due to local extinction. *Irena cyanogaster* was first observed in the watershed reserve by J. C. Gonzales and R. Wilkinson in February 1999 (personal communication). This species was most evident in Panukulan near the forest/agroforestry fringe. *Ptilinopus leclancheri* was seen to be feeding on a fruiting *Ficus benjamina*.

NEW RECORDS

The 13 additional records to the 1996 survey were:(n = new record for the island)

Phapitreron leucotis (n), *Ptilinopus leclancheri, Trerons vernans* (n), *Ducula poliocephala* (n), *Macropygia phasianella, Rostratula benghalensis* (n), *Rallus striatus* (n), *Irena cyanogaster, Aethopyga pulcherrima* (n), *Pitta erythrogaster (n), Cuculus sparveroides, Ardea purpurea* (n),and *Arachnothera longirostra* (n). *A.longirostra* is supposedly endemic to Leyte, Bohol, Mindanao and Samar (Dickinson, 1991) however several sightings have been reported in agroforestry sites of Polillo. Sunbirds showed considerable phenotypic variation. *Phapitreron leucotis* has been successfully introduced to Polillo.

The limited plateau of the Species Discovery Curves (Graph 3), in particularly that in the agroecosystem suggests that the number of species has been under-recorded.

CONSERVATION CONCERNS

Deforestation

The establishment of the Polillo Stewardship Program (funded by the North of England Zoological Society) has prohibited hunting and logging in the watershed area; small-scale logging activities were however evident during the study period. The remaining fragmented forest has further been prone to the effects of typhoons.

Tourism

The evident development of tourism including the construction of hotels and recreational fishing ponds in the mangroves signifies a severe threat to avifaunal habitats. The mangroves are further victim to the effects of spreading cultivation, charcoal production and collection of poles for domestic purposes (Gonzalez 1997).

Pesticides in the Agroecosystem

The impacts on wildlife of commercial pesticides used in the agroecosystem surrounding the Sibulan Watershed Reserve remain unknown. Studies in the United States show that organophosphorous and carbonate pesticides, the major constituents of all pesticides today have been related to wildlife die-off(Smith, 1987). Other effects related to pesticide use were lowered reproductive success on species whose major food items consisted of fish, reptiles, amphibians or birds and decrease in eggshell thickness. Birds become contaminated by consuming prey items that have accumulated chlorinated hydrocarbon pesticides (Henny, 1972). Applications even at a recommended rate of a certain organophosphorus and carbonate pesticides may still cause die-off (Smith, 1987).

IDEAS FOR FURTHER RESEARCH

1) Monospecific studies on the globally threatened, near-threatened and endemic birds of Polillo. Species diet requirements and extent of range, are fundamental parameters to be considered given the extent of forest fragmentation.
2) Intensive coastal surveying especially at Bucao to assess accurately the threat posed by coastal developments and tourism. Document seasonal changes and produce guidelines so as to minimize the impact of such developments. Surveys should be extended to include other faunal and floral elements of this habitat. Notes should be obtained on breeding, feeding and roosting sites and where possible specific dietary information obtained.
3) A survey of the frugivores: Focus research around fruiting trees and identify species-specific relationships. Information on fruiting trees is further important for afforestation programmes.
4) *Gallicolumba luzonica*-roosting surveys
   Survey specified patches of forest intensively for roosting birds; reports of *G.luzonica* in the 1999 survey period were mainly obtained in the early evening. Survey design must minimize disturbance since this could otherwise be a very destructve exercise.
5) Detailed observations on *Nectarinia* species. Investigate genetic diversity and consider patterns of speciation. Compare with mainland data.
6) Surveys in the north of the island where comparatively little research has been conducted.
7) Analyse the concentration of pesticides in the abiotic and biotic environment.

RECOMMENDATIONS

It is fundamental that support is continued for the work of the Ecology Steward (sponsored by the North of England Zoological Society) whose achievements in terms of preventing hunting and logging have been remarkable; his role has been absolutely pivotal within the community. The situation in the study region should be considered a template for the future of the rest of the island. The remaining forest is severely fragmented and thus all attempts should be made to reduce further fragmentation. An afforestation program 'RECLAIMING THE FORESTS FOR THE FUTURE', should be considered. It is of great concern that the local people are being ostracized from their forests and their traditional livelihoods being deprived; hunting and logging bans have evidently been crucial however methods of sustainable extraction should not routinely be discouraged. It is fundamental that the intrinsic values of conserving the forest and mangroves are actively recognized by the community and that the needs of the local people are bound within conservation policies.

The impact of tourism and its threats, require prudent planning and the implication of formal conservation policies if it is not to be detrimental to the fauna and flora of the island.

In addition to the above the following recommendation should also be noted:

1) Responsible use of pesticides by the farmers, including restricted seasonal usage and avoidance of overspray. Leave buffer zones, areas which have not been sprayed or sprayed with a less hazardous pesticide, around field perimeters where wildlife tend to feed and nest. Finally, the use of pesticides less hazardous to non-target species, but equally effective against target species will help minimize wildlife mortality (Smith, 1987). 2) Have a cheap alternative for toxic chemicals and fertilizers for agricultural use, especially on agroecosystems that are very near the Watershed Area.

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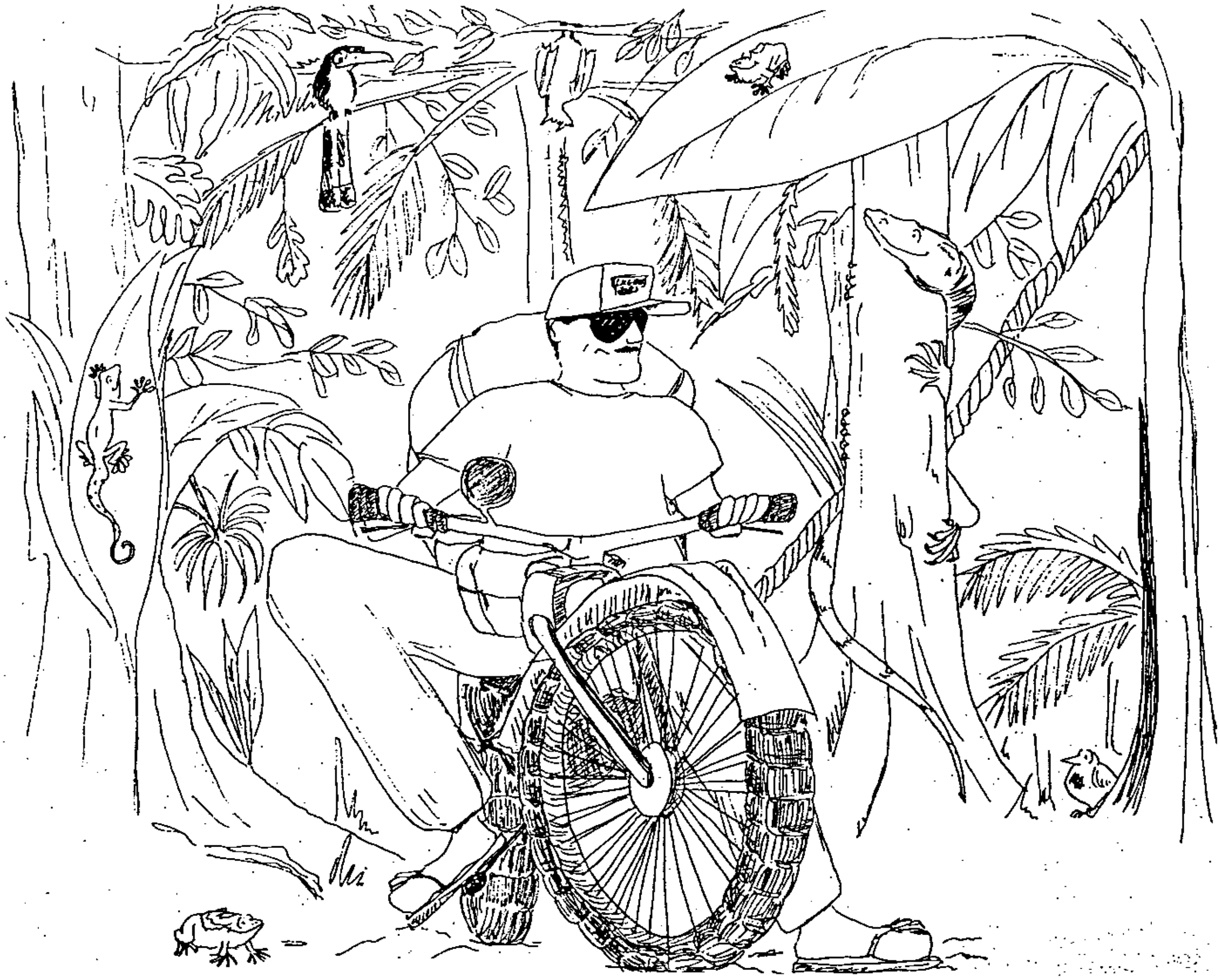
Acknowledgements

Thanks to Vicente Yngente, and our guide Lito Bulalacao whose knowledge and commitment was invaluable, to Prof Juan Carlos T. Gonzalez whose field skills and involvement in the acoustic analyses warrant further recognition and for his thesis 'The Ecology and Distribution of Birds in the Polillo Island, Philippines' (1997), which proved an invaluable reference source material. Further thanks to the writings of John E. Du Pont and E. Dickinson, R. S. Kennedy and K.C. Parkes, whose books 'Philippine Birds, 1971' and 'The Birds of the Philippines, 1991' respectively were consulted regularly; and to the British Ornithologists Union for donation of the latter book. Thanks also to Juan Cornejo for valuable assistance and ornithological expertise and to Dr R. Wilkinson for helpful comments on the manuscript.



Preliminary Analysis of Forest in Sibulan Watershed reserve and surrounding forest patches.

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Introduction

The Plotless Centre Quarter Method (PCQM) was used to provide a quantitative description of habitats at sites where frog surveying was carried out, and *Varanus olivaceus* lizards were caught. This method is aimed at characterising the habitat by estimating density, basal area and relative species abundance of trees.
The identity of many trees was known therefore it was decided that some approximate information could be obtained for the sites (and general area) with regards to their relative level of disturbance, by estimating seral stage and endemicity for these trees. It must be noted that this latter analysis was hindered by the fact that the number of scientific species names which we obtained was a low proportion of the total number of tree types which were measured. However, with this further knowledge of each known tree species (with regards to the habitat and level of endemism), scores were assigned to each site:

1. In terms of a value of endemism; and
2. In terms of a 'pioneer index', which is a relative score for the site in terms of the pioneer stage species within it are found in.

Aims

- To provide data in order that a quantitative characterisation of the habitats can be made, through physical properties of the trees and basal stand;
- To obtain a rough indication of relative level of disturbance of each site;
- To obtain an indication of the importance of the area for conservation in terms of the levels of endemicity of tree species.

Methodology

Obtaining Data

The Plotless Center Quarter Method (PCQM) for each site, involved a transect of at least 80m long, with points at 5m intervals. The transect ran perpendicular to the river at each site and continued for at least 40m up each bank, or to the crest of the hill (whichever was the greatest). At each 5m interval the four nearest trees to the central point were recorded (the nearest one in each of four quarters of an imaginary cartesian grid), circumference at breast height (CBH) for trees of CBH > 31cm, in order to eliminate new growth trees. The CBH, distance from the central point, quarter of the cartesian grid (NW, NE, SE or SW) and local name were recorded for each tree. A voucher specimen was taken and sent (with the local name) to the Department of Plant Sciences at the University of the Philippines (Los Banos) to be identified.
From these measurements decorana plots were produced to group sites in terms of similarity.

Analysis of the tree species

Information was gathered for each species from a variety of sources (Kubitzi K. *et. al.* 1993; Mabberley D. J. 1995; Merrill E. D. 1923-1926; Soepadmo E. & Wong K. M. 1995; Steenis C. G. G. J. van 1958-1989).

The score for endemism was given to each named species by assigning points, according to the extent of its approximate range. From this, each site could then be scored by summing these points and dividing by the number of trees (for which the species name was known). A score of 200 was assigned to species found only in the Philippines; 100 to those found within a restricted range (usually including certain islands of the Indonesia or Papua New Guinea; and 0 to those found throughout Malaya). This enables an estimate to be made, so that a site of 100 points say, can be said to have 50% complete endemism (and 50% species of 0 value), or 100% 'restricted range species' (and 0 % species of 0 value) or a combination of any of these.

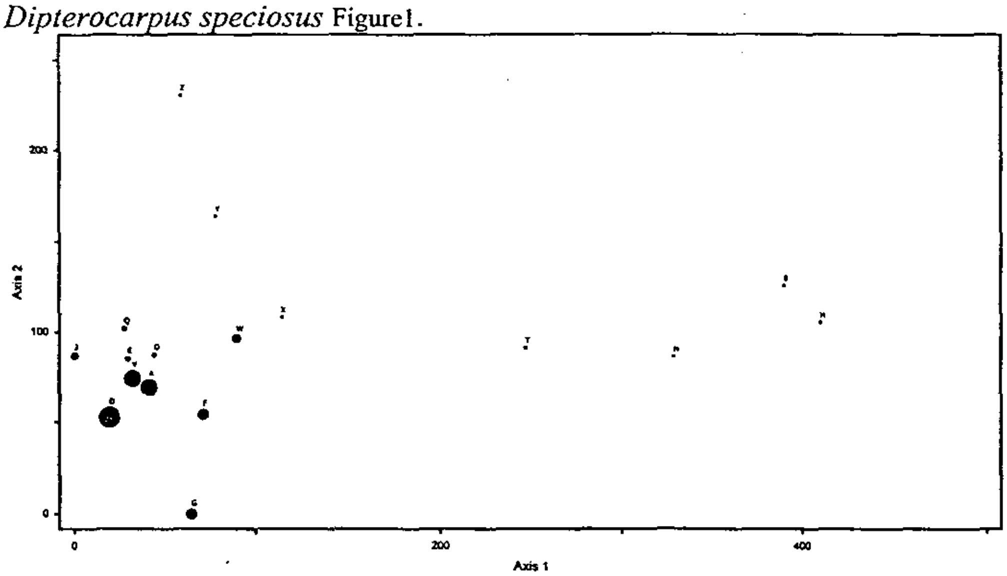
The pioneer index was similarly calculated by allocating known each species to a category according to the approximate seral stage which it inhabits, and scoring 'Pioneer Index' points (and so sites) according to this.

Correlations were drawn from these results.

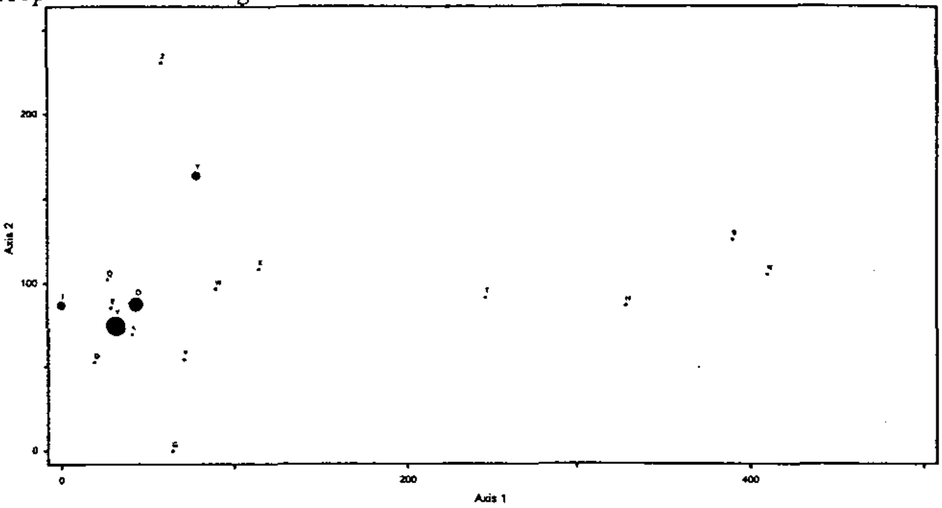
Results

Ordinations using decorana were carried out for the various sites for each of the tree species which were named. Sites seemed to fall into spatial categories as shown. Ordinations shown are for particular species which seem to illustrate well (and probably account for much of the distribution which results. The ordinations are as follows:

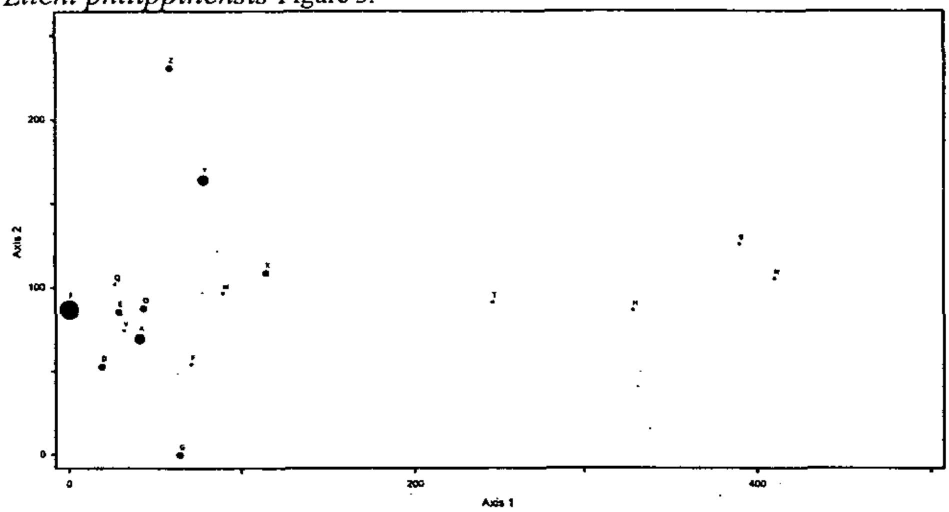
Dipterocarpus speciosus Figure1.



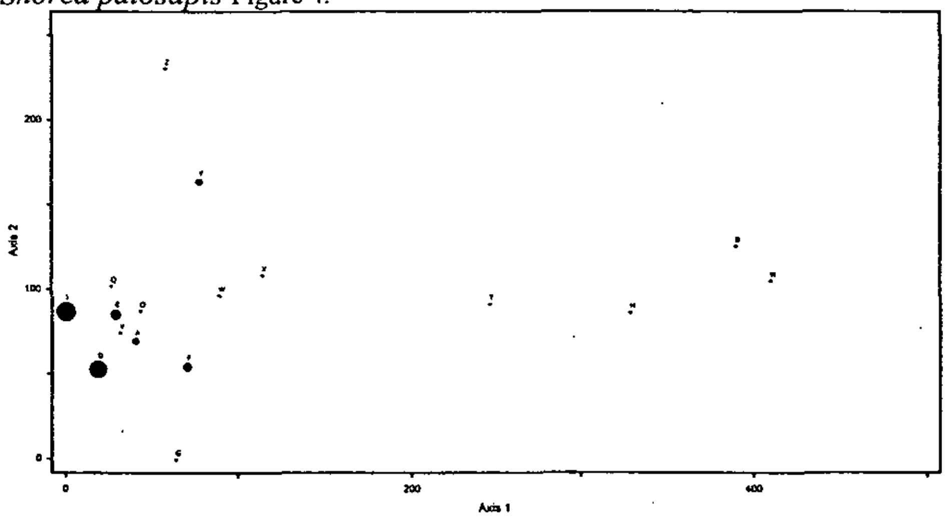
Hopea malibato Figure 2.



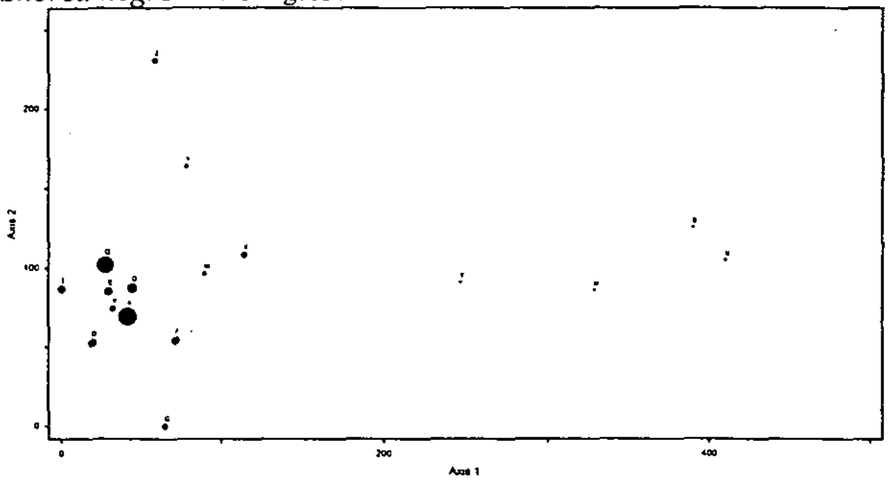
Litchi philippinensis Figure 3.



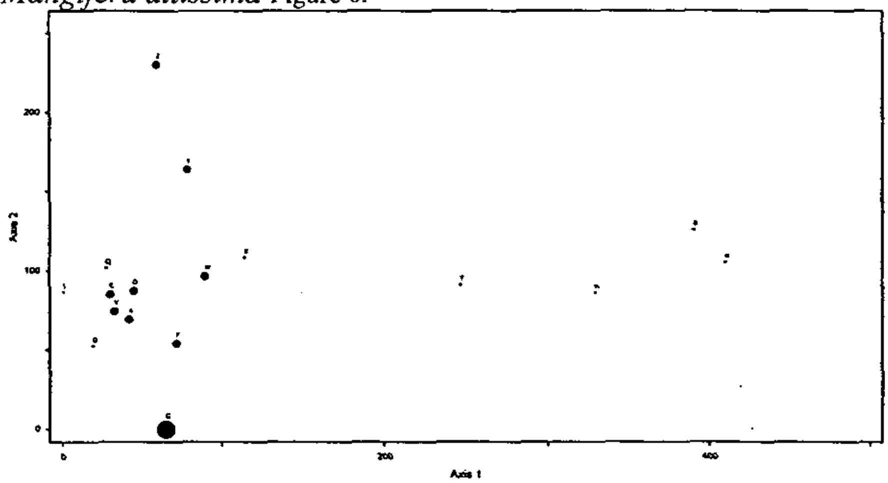
Shorea palosapis Figure 4.



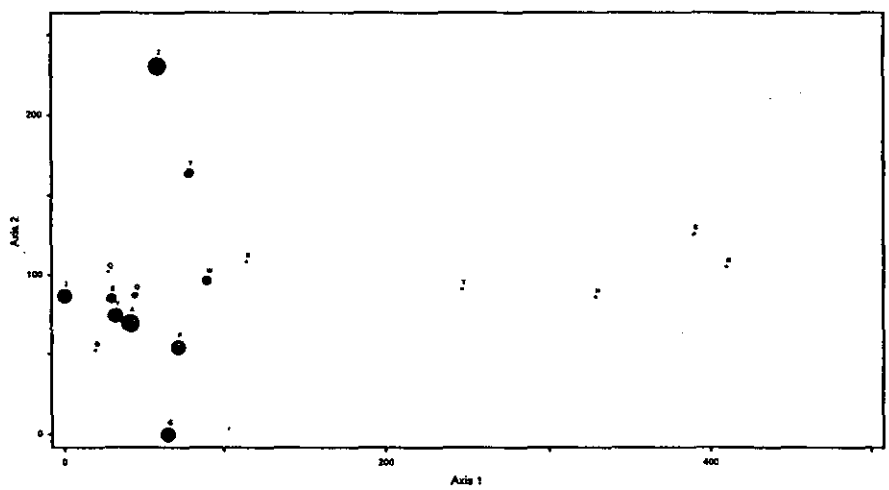
Shorea negrosensis Figure 5.



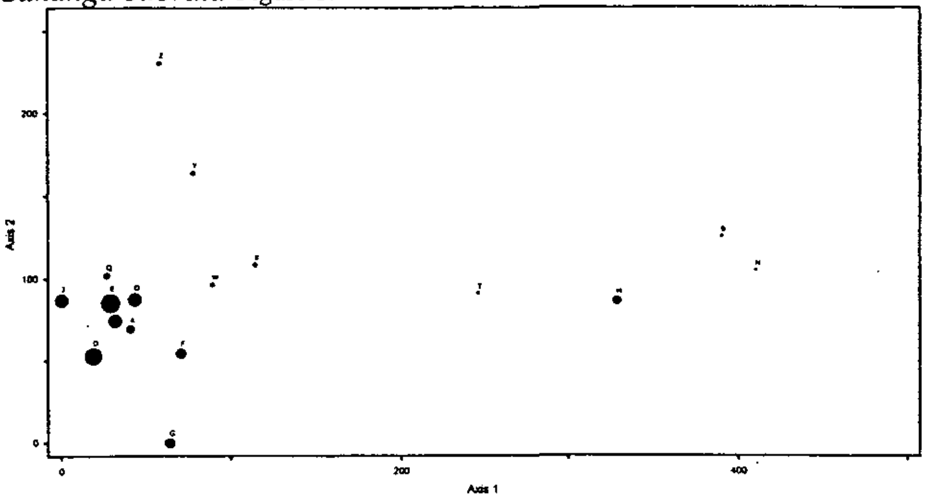
Mangifera altissima Figure 6.



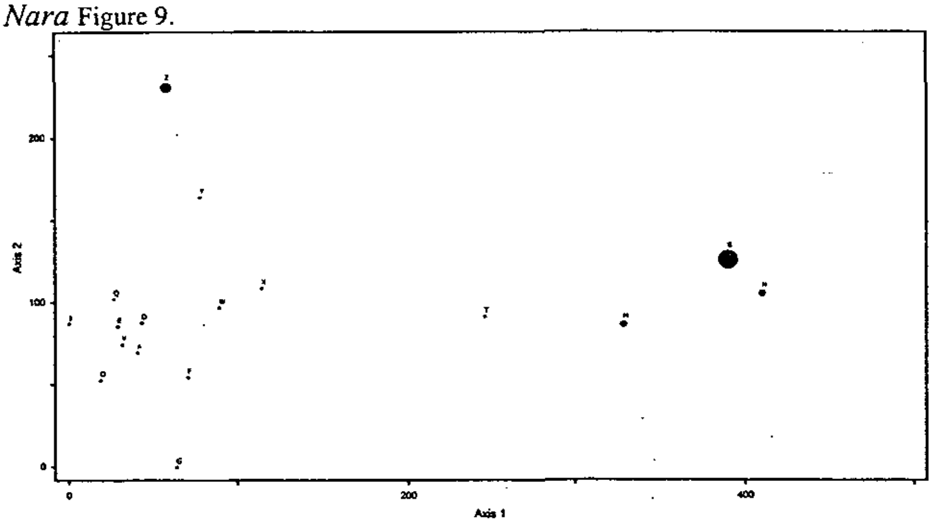
Syzygium nitidum Figure 7.



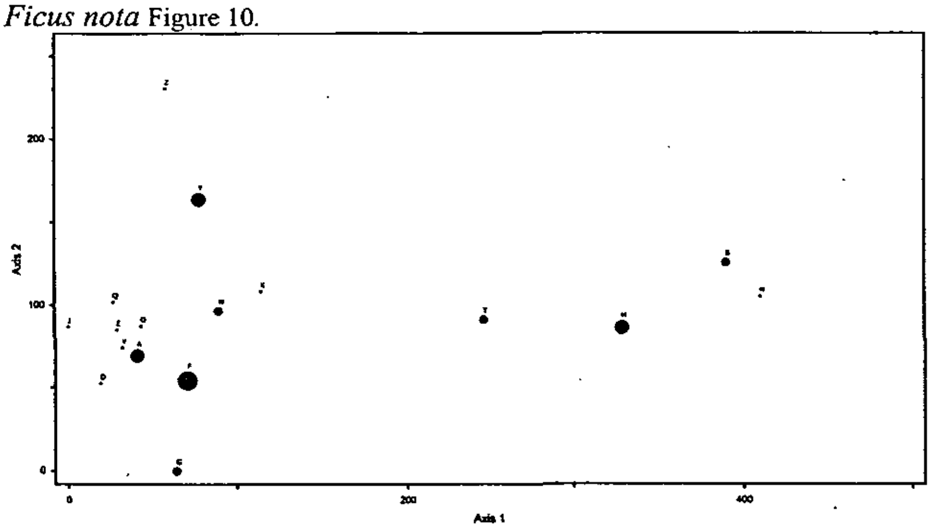
Cananga odorata Figure 8.



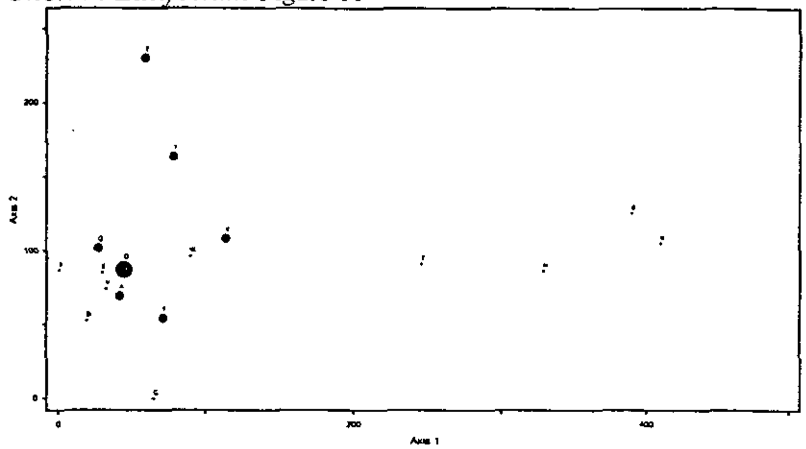
Nara Figure 9.



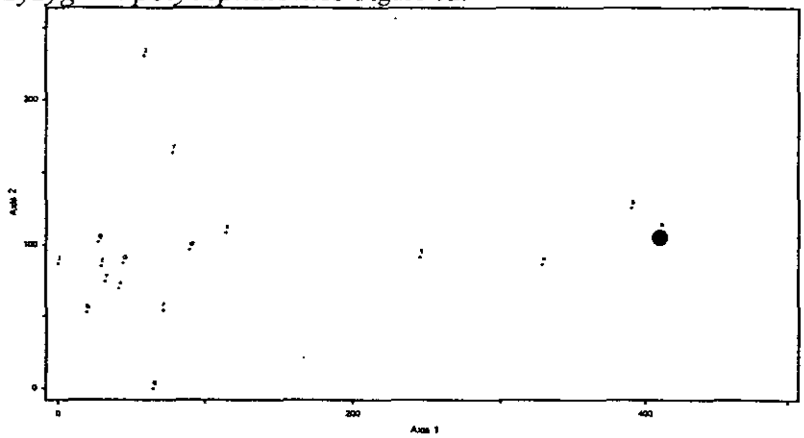
Ficus nota Figure 10.



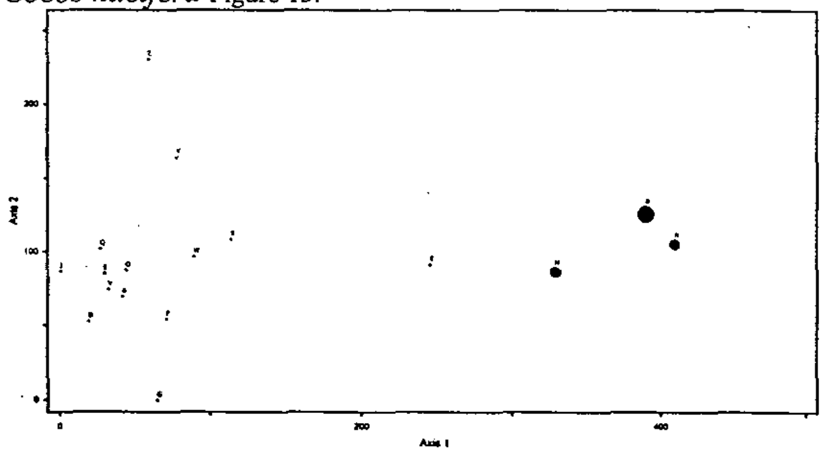
Gnetum Latifolium Figure 11



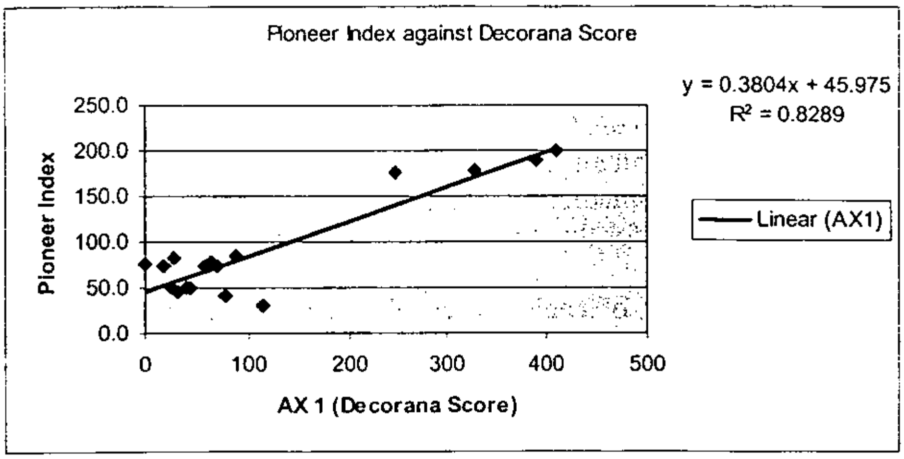
Syzygium polycephaloides Figure 12.



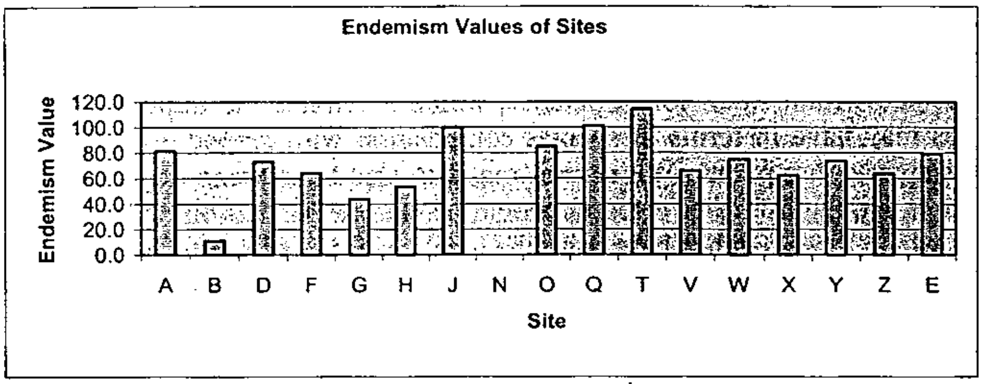
Cocos nucifera Figure 13.



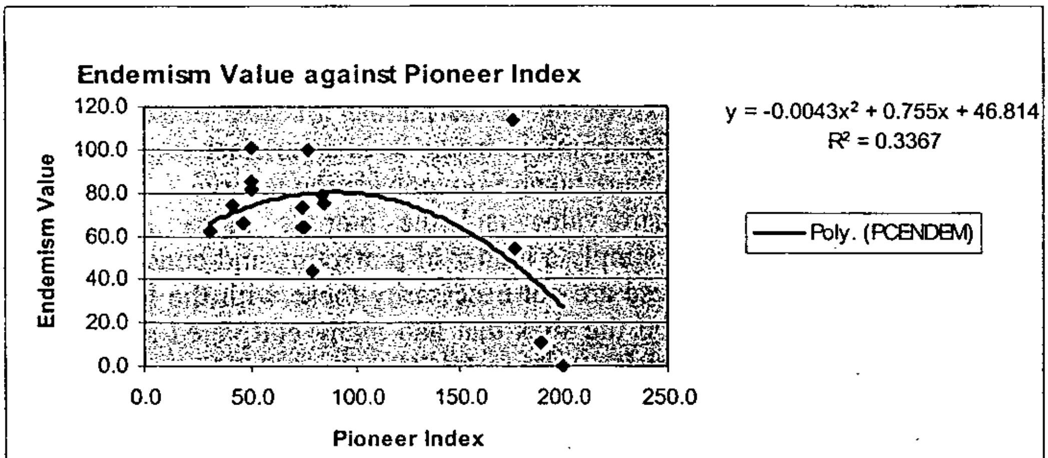
Graph showing the relationship between the Pioneer Index and the Axis 1 obtained form the ordinations. Figure 14.



Graph illustrating the endemism value for each site. Figure 15



Graph showing the plot of the endemism value against the pioneer index. Figure 16.



Discussion

The close correlation (R^2=0.8289) between the 'Pioneer Index' and the 'Axis 1' from the decorana plot indicates that in an ordination involving Axis 1 (such as in figs. 1 to 13) that this axis is a relatively good illustration of grouping the sites according to the relative level of disturbance. Thus clusters of sites which form on this ordination are 'natural' groups in terms of disturbance, due to abundance of certain species found in them. One such cluster (or rather a continuum in this case) is that including sites B, N, H and T, which are likely to be heavily disturbed. The presence of coconut (*Cocos nucifera*) and other cultivated species which appear in sites B, N and H (figs. 13 and 12) supports this hypothesis. Sites H and T seem to fit less well into this cluster. The reason for the position of site T cannot easily be explained, whilst site H has a probable explanation. The river which runs through this site (which thus is the centre of the transects for the PCQM, literally divided the land into cultivation (coconuts) on one side, and forest edge on the other (albeit probably composed of pioneer forest species). This is the reason for the intermediate position of site H and this would perhaps become more clear if the data set for this site was treated as two separate sets.

The graph showing the endemism value of each site enables the results of this to illustrate the conservation value of certain areas of the forests. Out of 17 sites, 13 sites (A, D, F, H, J, O, Q, T, V, W, X, W, Y, Z and E) lie above the endemism value of '50' meaning that these all had (out of the species which were identified) either 25% or more of the species endemic to the Philippines; 50% or more as 'restricted range species' or a combination of this. There are 3 sites which have a value of 100 or more (J, Q and T). Several of the sites of value 50 or more lie outside of the watershed reserve (A, F, H (although on the edge), O, Q, T, V, W, X, Y and Z). These sites were are mostly sites located within small forest patches, which illustrates the importance these small patches may have in terms of species composition with respect to trees. From this, it also suggests that perhaps these sites ought to also have some degree of protection upon them, although further research would need to be carried out in order to find out the use which these patches have with the locals, and the extent of (natural or 'man-made') management / disturbance which they already endure. From the decorana plots, it would appear that they contain species which are typical of fairly undisturbed forest, such as *Mangifera altissima* (fig. 6), *Syzygium nitidum* (fig. 7), *Litsea philippinensis* (fig. 3) or *Shorea* 'blanco' –species also commonly found within 'older' forest within the watershed reserve.

It should not be deduced from this that the watershed reserve holds little value in terms of endemism of the trees. This skewering of the number of sites outside the watershed with high endemism scores (compared to inside it) is an artifact caused by the higher number of sample sites which were taken from outside the reserve.
The correlation between the endemism value and the pioneer index is low (R^2=0.3367) therefore indicates it is not simply a matter of protecting and conserving only the low disturbance habitats, as these are not necessarily those with the highest number of endemic species. As expected the sites that had many cultivated species tended to have very low values of endemicity (for example sites B and N).

Certain species clearly illustrate the important role of a protected area such as the watershed reserve. For example there are several species that are endemic to the Philippines and also are characteristic of undisturbed forest. Examples of those which were also found mainly within the watershed reserve include many *Shorea* species, *Albizzia acle, Calophylum ferugineum* and *Hopea malibato.* Figures 5, 4 and 2 illustrate this –showing that the sites which contain *Hopea malibato, Shorea palosapis* and *Shorea negrosensis*, for example, are often situated within, or very close to the reserve (such as sites J, E, D, F and to a certain extent A). Thus the reserve provides protection to (relatively large) areas of quite undisturbed forest, this illustrates its role in conservation of these endemic species which without the protection would be unlikely to survive.

There are certain species which do not have such a straight-forward distribution. Figure 9 shows the Nara tree (Latin name not obtained). It inhabits mostly cultivated sites (H, B and N) but also site Z, which by considering other tree species seems to be a less disturbed area. Further knowledge about site Z would be needed to resolve this. The Nara tree may have been planted in the forest at Z as a useful agroforestry tree and is able to survive in this type of forest. Alternatively it may be a naturally occurring tree in the sites where it is found, and the examples which remain in the cultivated sites are relic trees, kept for their useful purposes.

Ficus nota (figure 10) shows a similar pattern in that it was found at forest sites (to an even greater extent than the Nara) and also at coconut plantation, site B. Four of the forest sites at which it was found were edge sites, and so again its appearance may either be due to plantation in these edge sites, or as a relic tree in cultivated areas; alternatively it may be primarily a cultivated tree which has 'escaped' into the edge of forest sites, where it has survived, being a pioneer tree.

Site T had the highest recorded level of endemism, yet its ordination position suggets it is disturbed. This could be due to the close proximity of agricultural habitats.

Conclusion

This analysis was limited by the fact that we did not have the complete set of species names of all of the trees that were measured. It is unlikely that there is a bias with respect to the types of trees for which we were able to get scientific names for, compared to those for which we were not (non-identification was largely due to lack of voucher specimen rather than due to non-identification by the Department of Plant Sciences at UPLB). It also enables the relative levels of disturbance to be shown and patterns seen which may not have been so clearly illustrated from the quantitative data alone.

Some forest outside the watershed reserve contains important tree species in terms of endemicity, and some patches appear to be relatively less disturbed –which may be of importance with respect to the fauna which, although was not surveyed here (except for *V. olivaceus*) may well exist. For this reason there is a need for more surveying of fauna in these forest patches and a more extensive (increasing the sampling size, to cover more of the forest) and intensive survey of the flora of the watershed reserve and its surrounding forests.

Appendix

The following names are local names of trees that represent those which were included in the PCQM measurements, but for which we did not obtain the scientific names:

Acli, Anahow, Ba gin, Bahaye, Ballyabas, Balobo, Bamcaro, Banga, Biagambing, Biasacan, Bilanga, Bilocaw, Bitokolin, Boc boc, Bong liw, Bota bota, Camagaay, Camantigi, Colilishaw, Dampol, Danlig, Dingn butaki, Dogoan, Dolotan, Eyeoupad, halupag, Ibanoo / Ibano, Ilang ilang gobat, Lampang, Layasin, Ligas, Lobayo, Madrecacao / Madricacau, Mala byabas, Malabowang (amamaho), Malabuyat, Malacacao, Malacalamias, Malaitmubant, Malatobig, Mercing, Milipili, Mowlowing, Nara, Pako pako, Parabaena, Parisparis, Santol, Santol gobat, Solanum, Talisay, Tamaouyan, Tangili, Yakal blanco, Yimilina.

Although we were unable to identify these trees, this list gives an impression of the extent of variety and diversity of tree types (and probably species) we encountered in (what would be for this purpose) only a small sample of the whole forest.

The following table lists the trees for which scientific names were obtained and therefore subsequently used for analysis according to endemicity and 'pioneer index' (to estimate the seral stage).

Common Names	**Latin Name**	**Family**
Acli, Akli, Acle	*Albizzia acle*	FABACEAE
Batino	*Alstonia macrophylla*	APOCYNACEAE
Bunga, Bonga	*Areca catechu*	PALMAE
Nangca	*Artocarpus heterophyllus*	MORACEAE
Antipolo	*Artocarpus sericicarpus*	MORACEAE
Putat, Potat gobat	*Barringtonia gitengensis*	BARRINGTONIACEAE
Anagee	*Canarium asperum*	BURSERACEAE
Pilaway	*Canarium hirsutum*	BURSERACEAE
Ilang ilang, Elang elang	*Caranga odonata*	ANNONACEAE
Pugahan	*Caryota rhumphiana*	PALMAE
Tapat tapat	*Casearia fuliginosa*	FLACOURTIACEAE
Marisparis	*Champereia manillana*	APILIACEAE
Toug	*Claoxylon sp.*	EUPHORBIACEAE
Marang	*Cleistanthus sp.*	EUPHORBIACEAE
Coconut	*Cocus nucifera*	PALMAE
Catman, Catmon	*Dillenia philippinensis*	DELLINIACEAE
Soupsong aita, Sosongaita	*Diospyros ahernii*	EBERACEAE
Apitong	*Dipterocarpus speciosus*	DIPTEROCARPACEAE
Malasantol	*Dysoxylum arborescens*	MELIACEAE
Tagawi	*Dysoxylum venosum*	MELIACEAE
Bilawang, Bilwang	*Endospermum peltatum*	EUPHORBIACEAE
Malaruhat, Malarohat	*Eugenia elliptifolia*	MYRTACEAE
Capi capi	*Fagraea racemosa*	LOGANICEAE
Tibig	*Ficus nota*	MORACEAE
Palomaria, Tangisang biawak,	*Ficus variegata*	MORACEAE
Boutong manok, Boutong manoc	*Gnetum latifolium*	GNETACEAE
Balotanggintó	*Gonocaryum calleryanum*	ICACIACEAE
Daling dingan	*Hopea malibato*	DIPTEROCARPACEAE
Ipil ipil	*Intsia sp.*	FABACEAE
Laniti	*Kibatalia gitengenis*	APOCYNACEAE

Haloopag, Halopag	*Litchi philippinensis*	SAPINDACEAE
Marang bitokoleen	*Litsea ampla*	LAURACEAE
Anangay, Pilig (on Luzon)	*Livistonia grandifloris*	BURSERACEAE
Takipasin, Tacipasin	*Macaranga bicolor*	EUPHORBIACEAE
Manga manga, Pahotan	*Mangifera altissima*	ANACARDACEAE
Camoling, Kamoling	*Microcus stylocarpa*	TILIACEAE
Bansalagin	*Mimusops sp.*	SAPOTACEAE
Lanotan	*Mitrephora reflexa*	ANNONACEAE
Banana	*Musa sp.*	MUSACEAE
Bankal, Bancal	*Nauclea elmesis*	RUBIACEAE
Bulala	*Nephelium rambutan*	SAPINDACEAE
Anibong	*Oncosperma horridum*	PALMAE
Palosapis	*Palaquium sp.*	SAPOTACEAE
Bagtikan, Danlig	*Parashorea malaanonan*	DIPTEROCARPACEAE
Abucado, Abocado	*Persea americana*	LAURACEAE
Tokyong, Lubia (on Luzon)	*Pinanga philippinensis*	PALMAE
Banot	*Polyalthia galuca*	ANNONACEAE
Goyong goyong	*Polyscias nodosa*	ARALIACEAE
Ispada ispada	*Radermachera pinnata*	BIGNONIACEAE
Barosang, Sipsiping boboyog, Itbe	*Saurauia latibractea*	SAURAURIACEAE
Lima lima	*Schefflera caudata*	ARALIACEAE
White lawaan, White louan	*Shorea contorta*	DIPTEROCARPACEAE
Red lawaan, Red louan	*Shorea negrosensis*	DIPTEROCARPACEAE
Mayapis	*Shorea palosapis*	DIPTEROCARPACEAE
Yakal	*Shorea polysperma*	DIPTEROCARPACEAE
Saripongpong	*Sterculia oblongata*	STERCULIACEAE
Gisgis	*Syzygium jambos*	MYRTACEAE
Macaasim	*Syzygium nitidum*	MYRTACEAE
Lipote	*Syzygium polycephaloides*	MYRTACEAE
Calumpit, Calompit	*Terminalia microcarpa*	CORABRETACEAE
Amlang	*Trichadenia philippinensis*	FLACOURTIACEAE

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Acknowledgements
Many thanks to Mattias Bulalacao for his expert local botanical knowledge and Dr W. Hawthorne for help in Oxford. Thanks also to Blaz Hernaez (UPLB) and Dr N. Brown.

Oxford University Expedition to the Philippines - Polillo '99 Cartography,

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Background Information:
The survey area the expedition worked in was approximately four kilometres northeast of Polillo Town. The survey area is often referred to as 'the watershed' and is designated on most DENR maps and literature as 'Watershed Reserve # 2'.

The soil layer is thin, highly siliciclastic and coarse grained. This facilitates easy weathering allowing deep channels to be eroded by watercourses. These watercourses meander and change path regularly.

Map sources for the research area on Polillo Island are limited to:
1. USC&GS Charts 4277 (1939 reliability good)
2. Aerial Photography November 1948, September 1950
3. NAMRIA 1:50 000 Sheets 3364 I and II, also 3464 III and IV (Polillo, Polillo Islands, Luzon, Philippine Islands) Last reprint by AFP Mapping Centre 1982
4. DENR

Aims:
By gathering cartographic data within the watershed area, it is hoped that an idea of watercourse scale will be established. This would allow the team to conduct research in as many varied locations as possible. The task of mapping watercourses was chosen for the following reasons:

1. Watercourses are easily identified and navigable.
2. Watercourses also provide an indication of relief.
3. Watercourses are an important amphibian habitat.

The production of a small-scale map of the survey area allows the results gathered during fieldwork to be displayed relative to location. This will allow an easier comparison between sites.
It is hoped this will also facilitate further research on the Polillo watershed by future scientific expeditions and allow them to easily identify survey sites used by Polillo '99.

Equipment:
Cartography was not a major objective for the expedition and funding was won for work specifically planned on amphibians, this prevented the purchase of expensive surveying equipment. The equipment used was a compass clinometer, numerous tape measures normally of fifty metre length, waterproof paper and bright marker ribbons accompanied by permanent marker pens. A photographic record was also taken on some occasions.

Method:
The method used proved very similar to that of the local DENR office on Polillo Island.

By identifying a landmark point within the watershed, which would be easily recognised, data could then be collected with respect to that landmark and placed relative to the watershed boundaries. The landmark chosen was the stream junction between the San Francisco River and a stream running between the two watershed reservoir tanks. Ideally, three people were used; one of which was a local guide.

1. One person walked up the watercourse in a straight line. This person held the beginning of the tape measure and marked a point.
2. The Second person held the other end of the tape measure and verified that the tape measure was straight. They read the distance measured to the third person, coiled the tape measure up between measurement points and walked to where the marked point had been made by the first person.
3. The third person measured a bearing from magnetic north from one measurement point to the next and recorded this three figure bearing alongside the measured distance on waterproof paper.

This process was repeated walking normally upstream, the lead person had the responsibility of path cutting and marking the measurement points.
The recorder marked any stream splits, which were passed with bright marker ribbon and an identifying code, which was noted in the results. This split would later be returned to and mapped.

Any gradient encountered was measured with a clinometer and recorded to allow a true horizontal distance to be calculated.

Problems Encountered and Accuracy:
Measurements taken were to the nearest centimetre. The degree of error associated with the results is subsequently based on the approximation of the stream course, the rounding as a result of scaling onto the map and future meanderings of the watercourses with respect to the collected field data.

Further Work required:
Aerial photographs would aid conservation efforts immensely in attempting to identify the fragmented patches of valuable rainforest left.
GIS would facilitate more accurate studies of the area and pin down sites of interest to the conservation community.

Map of Scientific Research Expedition Polilo Watershed Reserve # 2 Oxford University and U.P.L.B.