Errata added 2002. *Gnetum latifolium = Gnetum gnemon*
Pandanus botryoides = P. simplex?
Pandanus exultatus = P. luzonensis?

Preliminary survey and status report for

Varanus olivaceus *on Polillo Island*

Daniel Bennett

Dept. Zoology, University of Aberdeen, Scotland, AB24 2TZ. email: daniel@glossop.co.uk

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.

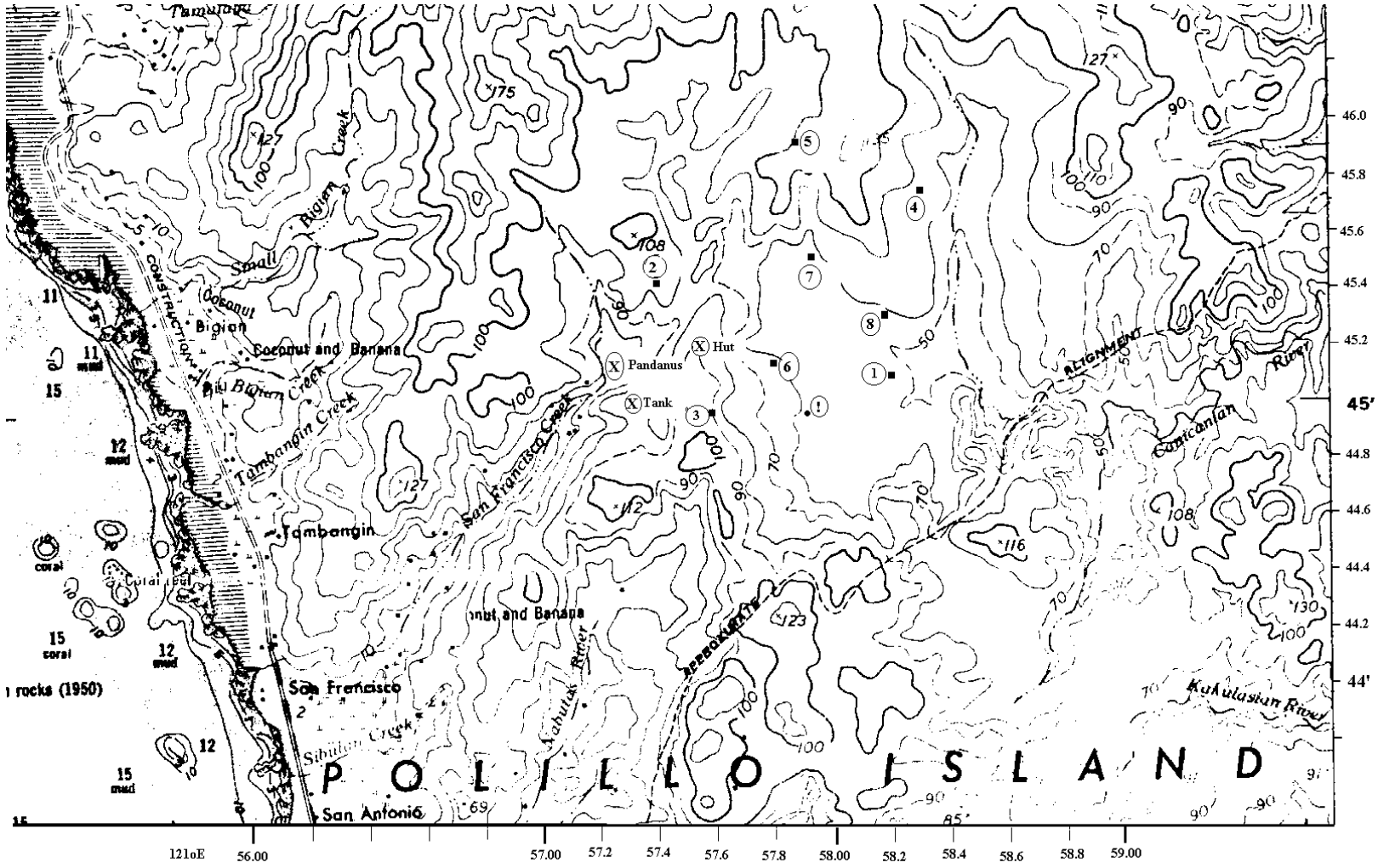

Figure 1. Map of study area showing locations of captures of *Varanus olivaceus* (1-8), Sighting of *V.olivaceus* (!) and other PCQM sites (X). Locations determined by G.P.S.

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 4^{th} 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 (Danfield 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.

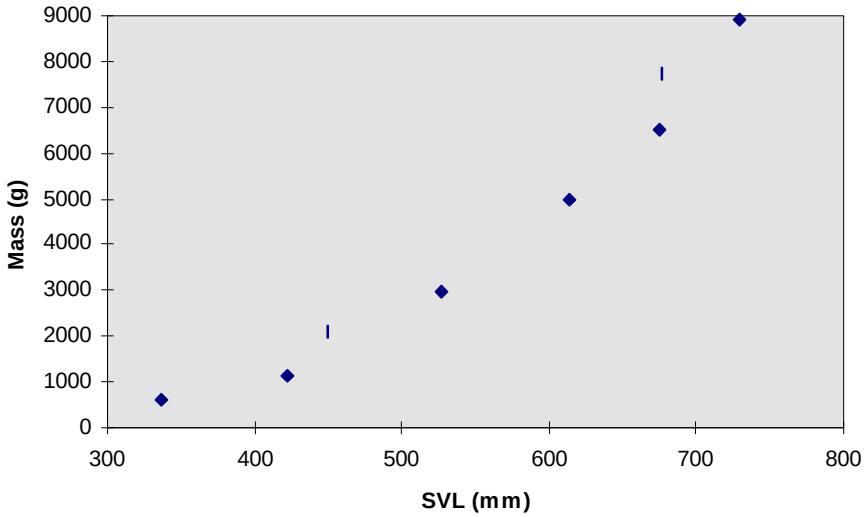

Figure 2. Relationship between snout vent length and mass in *Varanus olivaceus*.

	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)

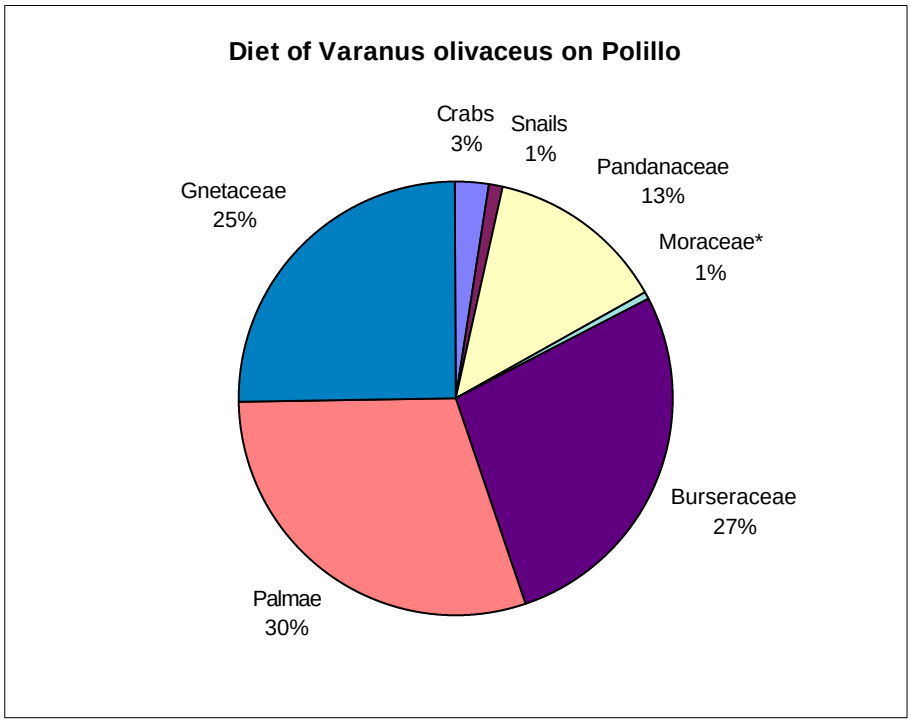

Figure 3. Composition of diet of *Varanus olivaceus* by overall frequency occurrence.

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.

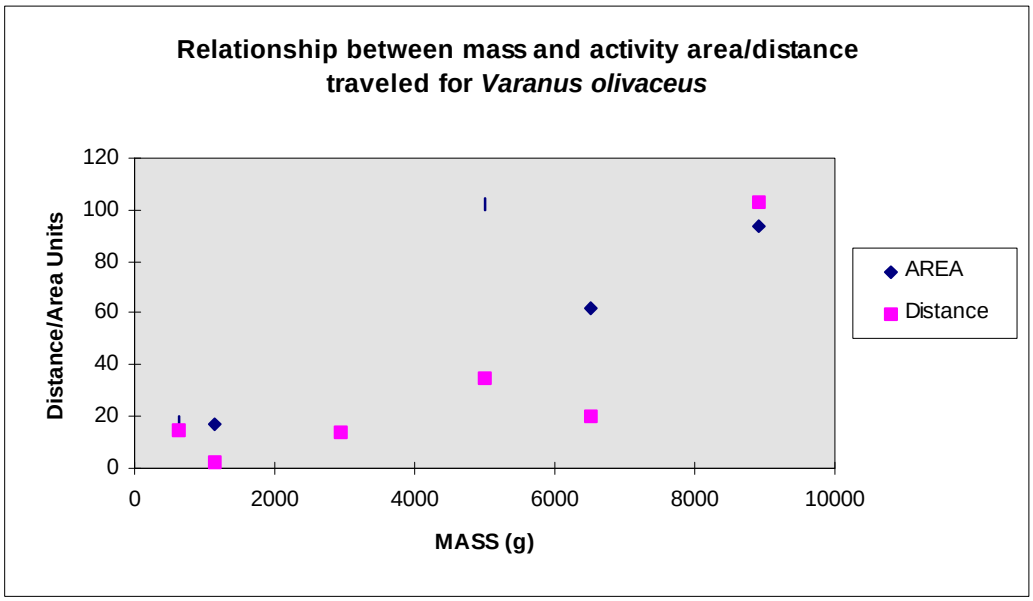

Figure 5. One Distance/Area Unit = 2m/80m^2.

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.

References

Auffenberg,W. 1978. Gray's monitor lizard - status survey. World Wildl. Yrbk. 1977-1978:129-131.

Auffenberg,W. 1988. Gray's Monitor Lizard. University of Florida Press, Gainesville.

Bennett, D. 1999. Expedition Field Techniques. Reptiles and Amphibians. EAC, Royal Geographical Society, London. 95p

Card W. 1994. Double clutching Gould's monitors (*Varanus gouldii*) and Gray's monitors (*Varanus olivaceus*) at the Dallas Zoo. Herpetological Review 25:111-114

Card,W. 1995. Gray's monitor lizard (*Varanus olivaceus*) at the Dallas Zoo. Reptiles. September 1995: 79-85.

Crombie, R.I. 1994. A working list of species of amphibians and reptiles recorded in the Philippines (document of distributional summary by islands). Unpublished manuscript.

Fernando,E.S. & M.L. Castillo 1988 Checklist of species in FBS 21 (taxonomy of forest plants). 4th ed. University of the Philippines, Los Banos. 24p.

Gonzales, J.C.T. 1997. The ecology and distribution of birds in the Polillo Islands, Philippines. MSc. Thesis, University of the Philippines (Los Banos). 134p.

de Guzman, E.D. 1986. Guide to Philippine Fauna and Flora. Volume III. Dipterocarps; Non Dipterocarps. Natural Resources Management Center, University of the Philippines. 414p.

MacDonald, D.W., F.G. Ball and N.G. Hough. 1980. The evaluation of home range size and configuration using radio tracking data. I n C.J. Amlaner & D.W. MacDonald (eds). A handbook on biotelemetry and radio tracking. Permagon Press, Oxford. 667p.

Santos, J.V., E.D. de Guzman & S.E. Fernando 1986. Guide to Philippine Fauna and Flora. Volume IV .Bamboos; Grasses; Palms. Natural Resources Management Center, University of the Philippines. 256p.

Rabor, D.S. 1986. Guide to Philippine Fauna and Flora. Volume XI. Birds, Mammals. Natural Resources Management Center, University of the Philippines. 213p.

Whitford, H.N. 1906. The vegetation of the Lamao Forest Reserve. Philippine Journal of Science 1:373.

Wildlife Conservation Society of the Philippines. 1997. Philippine Red Data Book. Bookmark, Makati. 262p.

Zamora, P.M. & Co, L. 1986. Guide to Philippine Fauna and Flora. Volume II. Economic ferns; Endemic Ferns; Gymonosperms. Natural Resources Management Center, University of the Philippines. 273p.

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*.