Further Observations of *Varanus olivaceus* on the Polillo Islands.

Daniel Bennett[1] and Katie Hampson.

Abstract
Varanus olivaceus has a patchy distribution through Sibulan watershed reserve and the surrounding forest fragments, with few fragments capable of sustaining the animals permanently. In more isolated forest patches the animals seem to be very rare or absent. The lizard does not occur on any of the smaller islands in the group. Habitat destruction is a serious threat to *V. olivaceus* because loggers preferentially take similar trees to those used by the lizards for shelter. Studies of diet and foraging behaviour suggest differences between this population and those in intact primary forest that we attribute to poor quality, fragmented habitat.

Introduction
The butaan, *Varanus olivaceus*, is a large (up to 180cm, 10kg), frugivorous monitor lizard endemic to the islands of Luzon, Catanduanes and Polillo. Previously we described new, non-destructive methods of catching and studying *V. olivaceus* which we have employed at Sibulan Watershed Reserve on Polillo Island (Bennett 2000, Bennett, Hampson and Yngente 2001). Here we develop those techniques further to investigate the diet and foraging behaviour of animals around Sibulan and conduct preliminary searches for the animal throughout the Polillos.

Methods
Work was conducted between 6 August and 6 December 2001. The main study site is a mosaic of forest and coconut plantations around Sibulan watershed reserve where studies were conducted from 6 August to 15 September and from 4 to 28 November. In addition from September to December other areas of the Polillos were visited and attempts made to determine the presence or absence of butaan (Appendix 1 and Map 1).

Forest patches around Sibulan were searched intensively for evidence of butaan, primarily by looking for faeces on the forest floor and individuals basking on exposed trees). At all other areas visited signs of the presence of lizards (tree scratches, faecal deposits) were noted. Cameras with motion triggers were left at potential refuge and food trees for periods of up to eight days. As a control cameras were also set on trees known to be occupied by butaan at the time.

Individuals were caught opportunistically using a noose attached to a long pole and with trigger sprung traps (Bennett, Hampson and Yngente 2001). Captured animals were weighed measured, examined for injuries and external parasites and released at the point of capture, usually within 60 minutes. Some were fitted with two sets of polyester thread cocoon bobbins (Danfords Ltd, Leigh, England) with 2 or 3 bobbins tied in colour-coded series according to the size of the animal (see Bennett 2000 for full description). The bobbins were wrapped in plastic and attached to the proximal third of the tail with duct tape. Thread trails were subsequently followed at intervals to provide data on tree use, movement and foraging behaviour.

[1] 118 Sheffield Road, Glossop, SK13 8QU, Great Britain. mampam@mampam.com

Faeces were collected during handling and following of known individuals and from unassigned samples picked up on the forest floor. Samples that could have been deposited by other animals were disregarded. The samples were sorted and food items identified. Seeds present were weighed and measured to estimate original flesh weight. Snail and crab limb fragments were considered single items unless they were clearly from more than one individual and no weights were calculated for them.

Results

Details of surveys of *V. olivaceus* around the Polillo Islands are given in Appendix 1. All patches visited outside Sibulan showed fewer signs of butaan activity, with the exception of Balete sapa in northern Polillo.

Around Sibulan eight *V. olivaceus* were caught, examined and released. Five animals were caught in traps and three were noosed in trees. Seven of these animals weighed less than 2kg. Morphometric data is summarised in Table 1.

Table 1. Body size of *Varanus olivaceus*

n = 8	Mean	S.D.	Range
SVL (mm)	388	148	220-690
Mass (g)	1802	2505	192-7800

Forty four fecal samples were collected; 41 from Sibulan area and three from forest near Balete sapa in northern Polillo. Of the Sibulan samples, 17 were from known individuals (collected during handling or subsequent following) and 25 from unidentified animals. Data is summarised in Table 2. In total faeces contained 847 items, of which 824 were seeds. Individual samples contained a mean of 19.7 items (+ 23.6, range 1-88) and 2.2 prey species (+ 1.3, range 1-6). *Pinanga insignis* was the most important fruit by frequency and flesh weight, followed by *Pandanus luzonensis* (similar to *P. botryoides* (Auffenberg 1988 – see Clements this volume), *Canarium hirsutum* and *Canarium luzonicum.* Shell from two species of snails (both unidentified) were found in faeces, but one was predominant. Crab remains were entirely made up of limb parts. A frog is suspected in one very fresh sample because of the presence of ant parts and amorphous slime. The lizard was found in the faeces of a large unknown individual.

Table 2. Composition of 41 fecal samples of *Varanus olivaceus* collected around Sibulan Watershed.

	Frequency occurrence (%)	Estimated total flesh mass (g)	Estimated total mass (g)
Pinanga insignis	66.70%	218	1306
Pandanus luzonensis	52.30%	210	1197
Pandanus simplex	2.40%	2	6
Canarium hirsutum	14.20%	99	270
Canarium luzonicum	9.50%	96	224
Canarium sp.	2.40%	12	28
Caryota	7.10%	6	18
Gnetum gnemon	4.80%	14	27
Ficus sp.	2.40%	*	*

Snails	28.60%	*	*
Crabs	14.30%	*	*
Lizards	2.40%	*	*
Frog(?)	2.40%	*	*
Unidentified arthropods	4.80%	*	*

All faeces contained fruit except one from a juvenile (245mm SVL, 192g) which consisted of two unidentified arthropods and what was probably a frog (represented by amorphous slime and the remains of several ants. Faeces of another juvenile (220mm SVL, 200g) contained two *Pinanga* seeds. *Pandanus* was only present in the faeces of two captured animals (690mm SVL, 7800g; 420mm SVL, 1900g) but all captured butaan produced faeces containing *Pinanga*.

Using faeces with evidence from spool and line data we calculated the total fresh weight of food taken by three butaan over a period of 9-14 days. The largest animal (690mm SVL, 7800g) ate three meals of 192, 434 and 201g over two weeks, a total of 57 *Pandanus* and ten *Pinanga* fruits, ingesting 837g of fruit in total. A young animal (366mm SVL, 1005g) fed entirely on *Pinanga* and snails over a nine day period, ingesting a total of five meals with a total fruit mass of 68g (average of 13.5g per meal). Another (301mm SVL, 425g) fed entirely on *Pinanga* from a single tree over a 12 day period, visiting the tree a total of four times. Both fecal samples recovered from this animal contained 3 *Pinanga* seeds (average of 7.2g per meal). Samples from unidentified individuals represented meals of 11.2 – 215g (mean 90.3g $\pm$65.5).

Five butaan were followed over periods of 2-12 days. One device detached prematurely and three empty spools have already been recovered. Analysis of movement patterns is not warranted at present, because the data set is small and some animals are clearly stressed by their encounter with us. At present the data is most usefully presented descriptively.

The largest animal (69cm SVL, 7.8kg) ran 104m on release, ending up in a tree in an adjacent valley where it remained for two nights. It then walked 80m to a fruiting *Pandanus* which it climbed and fed from, then climbed an emergent tree with thick vines 30m away passing under three fruiting trees (*Pinanga* and *Ficus*) en route. Two or three days later it descended via an adjacent trunk, defaecating at the bottom (*Pandanus, Pinanga* and *Ficus*) and moved to a similar tree on the top of the hill 40m away, apparently without feeding. At this point it had moved 267m on the ground and at least 277m in its last two shelter trees. Three or four days later it descended, defaecated (14 *Pandanus* and two *Pinanga*) and moved 40m to an exposed stump 2.5m high where it probably basked before travelling 140m down hill and taking shelter in a dead tree, where the thread expired.

The smallest animal (24 cm SVL, 190g) moved 77m over the ground and 190m on five different trees over two days, not passing any fruit trees. All trees climbed were emergents and two contained vine thickets. A slightly larger animal (220mm SVL, 200g) spent five nights in each of two trees (a hollow palm stump and a low vine covered tree) located 5m and 14m from a fruiting *Pinanga* tree that the lizard fed from on four occasions. It subsequently revisited the fruiting tree at least twice. Over 11 days this lizard moved 109m on the ground and 158m in trees.

A 42cm (1.4kg) butaan hid in a tall hollow stump overnight before climbing a large emergent *Shorea* tree with vine thickets, a total distance of 21m. It moved 246m in this tree before descending and walking 154m to climb another thicketed tree, where the thread ran out, indicating at least another 100m of arboreal movement.

A 37cm (1.0kg) butaan ran to a vine covered emergent on top of the hill, where it stayed for two nights. It descended and walked 50m in a straight line to a fruiting *Pinanga* tree, defecating along the way (*Pinanga*), It climbed the *Pinanga* tree to feed and went to a hollow stump 30m away, stopping twice en route to dig under roots and a log, leaving a broken snail shell behind. The lizard basked at the top of the stump and climbed another 30m to the top of the hill and into a huge fig tree (CBH 529cm). It moved at least 116m in the tree After one or two nights it descended via a nearby vine and moved 54m (defacating 8 *Pinanga* and part of the snail shell en route) to an emergent tree with vine thickets, where it basked on the east side of the trunk below the crown and then returned to feed on its *Pinanga* tree 12m away. It then moved 82m down the hill and through a swamp, climbed 3m up the trunk of a vine covered tree then apparently changed its mind and moved to another trunk 5m away and climbed into the thickets. When it eventually descended (24m away on the other side of the valley) it had moved 262m on the ground and 270m in trees since being released.

Discussion

The conservation biology of *V. olivaceus* (and *V. mabitang*) is of considerable importance because it is by far the largest and least mobile frugivorous animal in the Philippine Islands. *V. olivaceus* feeds on a very narrow range of fruit and has a narrower dietary niche than any sympatric frugivorous vertebrate. It requires a more or less constant supply of these fruits within walking distance of each other. The lizards are therefore presumed to be much more sensitive to forest degradation and fragmentation than other frugivores.

Very different climatic conditions existed on Polillo during the two study periods of 1999 and 2000, and regularly unpredictable patterns of fruit availability are probably a very important factor in the ecology of the butaan, particularly in disturbed and fragmented areas. Although no data on fruit abundance exists, *Pinanga* was certainly the most common fruit throughout the study periods of 1999 and 2001 at sites around Sibulan watershed reserve. However comparison of faecal material shows a much greater use of *Pinanga* fruit in 2001 compared with the same months in 1999. We hypothesize that the lizards feed on *Pinanga* only when they are unable to find better quality fruit. The flesh to weight ratio of the fruit is low and the fact that it was eaten only rarely in 1999 when other fruit were apparently more abundant suggests it is not a preferred food. Furthermore *Pinanga* were never found in the stomachs of specimens examined by Auffenberg although the palm is apparently particularly common in limestone regions.

Auffenberg stated that *V. olivaceus* takes its fruit exclusively from the forest floor. Spool and line tracking shows that this is not the case on Polillo, where animals habitually climb to feed on suspended fruit and none of the studied animals foraged for fruit on the ground. Fruit falls of the type described by Auffenberg were absent for all species eaten by the butaan, but many prey trees show characteristic scratches on

their bark. We hypothesize that increased competition has led to a shift in foraging strategies on Polillo.

The available evidence suggests that the butaan population on Polillo occupies much poorer habitat than those in the Caramoan area studied by Auffenberg. The total inhabitable area in central Polillo is currently less than $10km^2$ of largely logged, regularly disturbed and heavily fragmented forest whilst Auffenberg (1988) estimated that $400km^2$ of primary forest existed in the Camaroan Peninsular. Trees are much less important shelters for butaan in Caramoa than on Polillo. On Polillo 100% of shelters used are trees; in Caramoa most shelters utilised are rock crevices and cavities (Auffenberg 1988). Shelter trees are rare around Sibulan because they have largely the same characteristics as those targeted by loggers: big (>90cm CBH) emergent (90%) hardwoods (about 87%). Sampling indicates that these trees are still abundant in the watershed reserve but have a patchy distribution over the adjacent fragments, with many areas being almost completely denuded (Clements, this volume). Finally density of crucial fruit resources may be much lower than at Auffenberg's sites. The need for suitable shelter and fruit species in the same vicinity suggests that most hillsides in the study area cannot support butaan and that individuals must move between forest patches to find adequate food. The very small home ranges of butaan recorded by Auffenberg (up to 2.7ha over 108 days) are therefore out of the question for butaan living outside the watershed area. Finally differences in the diet and foraging behaviour of the studied populations can be interpreted as suggesting increased competition for food resources around Polillo, most explicitly by those animals climbing trees for fruit rather than foraging for it on the ground as in Camaroa. We suggest that the Sibulan population is stressed and, unless current logging behaviour is altered or stopped, likely to become extinct locally within 30 years.

The faeces of *Varanus olivaceus* are prominent and unique. Auffenberg recorded only a single sample collected over 22 months of field work in the limestone forests of southern Luzon and Catanduanes. Evidently in these porous substrates faeces are dispersed very quickly but on Polillo they remain on the forest floor for at least several weeks and can be found if sufficient effort is applied. Therefore faeces provide a certain method of assessing the presence of *V. olivaceus* in the lowland dipterocarp areas where it is most endangered. In reasonably easy terrain it takes four people about two hours to search 1ha of forest floor thoroughly, but given the uneven distribution of butaan, area based searches are inefficient. A standardised method where each searcher covers exactly the same distance but is permitted to search at will, would make short surveys reproducible and reduce the amount of effort required to make affirmative discoveries.

Camera traps detected one animal descending a tree (Fig 1). Where cameras were placed on trees known to contain lizards they failed to photograph them, usually because the animal descended by an alternative route. With practise this method may prove fruitful.

Spool and line tracking was unsatisfactory in 1999 because animals appeared not to feed whilst the devices were attached. This has been improved in the present study, with obvious feeding events recorded from four individuals. Although animals were held for shorter periods than in 1999, the main reason is probably that the animals in

the current sample are significantly smaller (and younger) than those of the previous study. Younger (under 1kg) butaan are not intimidated by people and will move about and even descend to the ground in their presence. In contrast adult animals remain hidden, sometimes for weeks, when they are disturbed. Juvenile animals are evidently less stressed by capture than adults and resume normal activity faster after release. Use of spool and line methods to follow *V. olivaceus* work particularly well because the animals' movements are generally too slight to detect with telemetry. All movement is recorded, foraging events can be recognised easily and faeces produced can be found and attributed to the individual with a fair degree of certainty. The main drawbacks of spool and line use are the very short life of the devices (which fall off within three weeks of attachment), and the small amounts of thread used. The use of paired devices (employed as a safeguard against one thread breaking) appears unnecessary because the spools operate correctly even when the lizards jump from the top of tall trees and so the effective total distance could be doubled to record a total of about 2km of movement. The duration of attachment cannot be extended much, because recapturing individuals to remove devices is not practical and so anything fixed to the animal must be certain to come off when the skin is shed.

Fig 1. *Varanus olivaceus* caught on a camera trap, courtesy of Tom Clements.

Butaan, especially large ones, have great difficulty crossing agricultural habitat. Over three study periods (July to September 1999, August to December 2001, April – May 2002) we have found no evidence that butaan ever enter cultivated areas, despite the fact that their habitat is heavily fragmented (with many forest patches completely isolated by coconuts) and many food resources are available in cultivated areas. No followed lizards ever entered this habitat and no faeces have been found there. However local people occasionally see butaan in coconut plantations, and invariably attempt to capture the lizards for food. The lizards are very easy to catch in this environment. At present the animal survives around Sibulan because it can utilise corridors between the watershed reserve and suitable hillsides in the privately owned forest fragments to the northeast. The degree of fragmentation is underestimated on the map, which provides broad outlines of forest/agriculture boundaries. In fact much of the dark green areas are too degraded to provide shelter for butaan and are apparently never visited. Immigration to the area seems unlikely because butaan appear extinct in more southerly fragments and so the Sibulan area represents an essentially isolated population. Auffenberg provided evidence that butaan once occurred on a $4km^2$ island and suggested it was probably the smallest that could support a population of butaan (p126). On that premise the watershed area alone is incapable of sustaining a viable population, but the entire forest mosaic could support it.

The best safeguard against local extinction would be protection of an additional $4km^2$ of adjacent forest fragments together with uncultivated corridors between them. At present this forest is subject to continuous logging. The fact that loggers prefer the same trees as the butaan is not encouraging. The main differences are that butaan use only those covered with vine thickets, and prefer trees close to the top of the hills. Loggers show no preference for vines but generally take trees from lower ground where they are available. As a consequence even highly selective logging destroys butaan resources. One of our capture sites in 1999 had been completely destroyed by 2002 and there was evidence of recent logging at nearly all sites north of the watershed reserve. The lack of a forest guard at the watershed reserve has led to an increase in logging activity within the protected zone, but at relatively low levels.

Perhaps the only encouraging aspect is the attitude of local forest owners. All those we have met are displeased with logging activities, frustrated at the lack of official enforcement and willing to cooperate with forest protection schemes. One suggestion during discussions was protection of individual trees by inserting metal or ceramic spikes into the trunks that would destroy saw blades and thus render the timber worthless. Because targeted trees are rare (average about 15 per ha over all patches) a large area could be covered over a short period and because the work is carried out at the request of owners there are no legal ramifications. Obviously spiking would have to be highly visible and carried out with no actual risk to chainsaw operators. In the absence of any other viable conservation strategy it is worth considering.

Our results demonstrate that it is possible to catch butaan without killing them, and that it is possible to collect some baseline ecological data and carry out reliable population surveys without any interference to the animals whatsoever. **With the exception of camera traps the entire equipment used in the project was valued at little over $20 US**, an achievable budget for local workers. A real test of these

methods would be to employ them in the study of the newly discovered (and apparently extremely rare) *Varanus mabitang* (Gaulke and Curio 2001).

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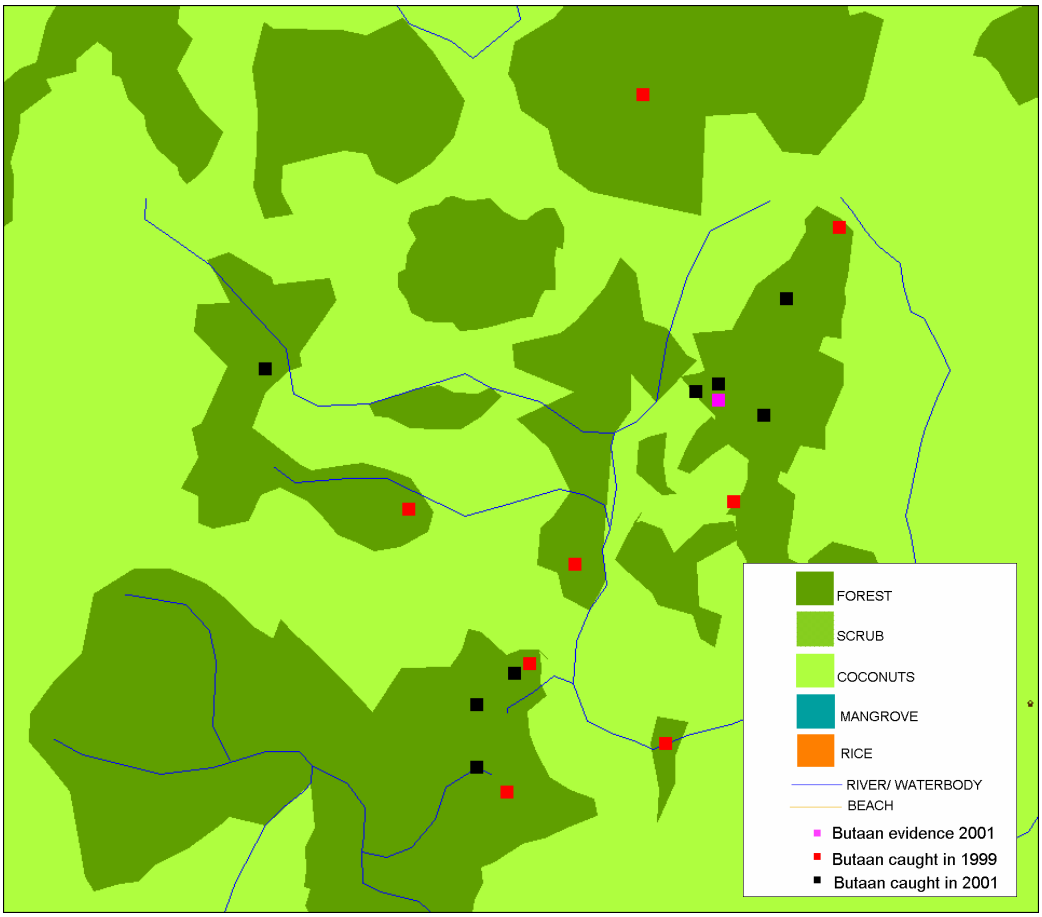
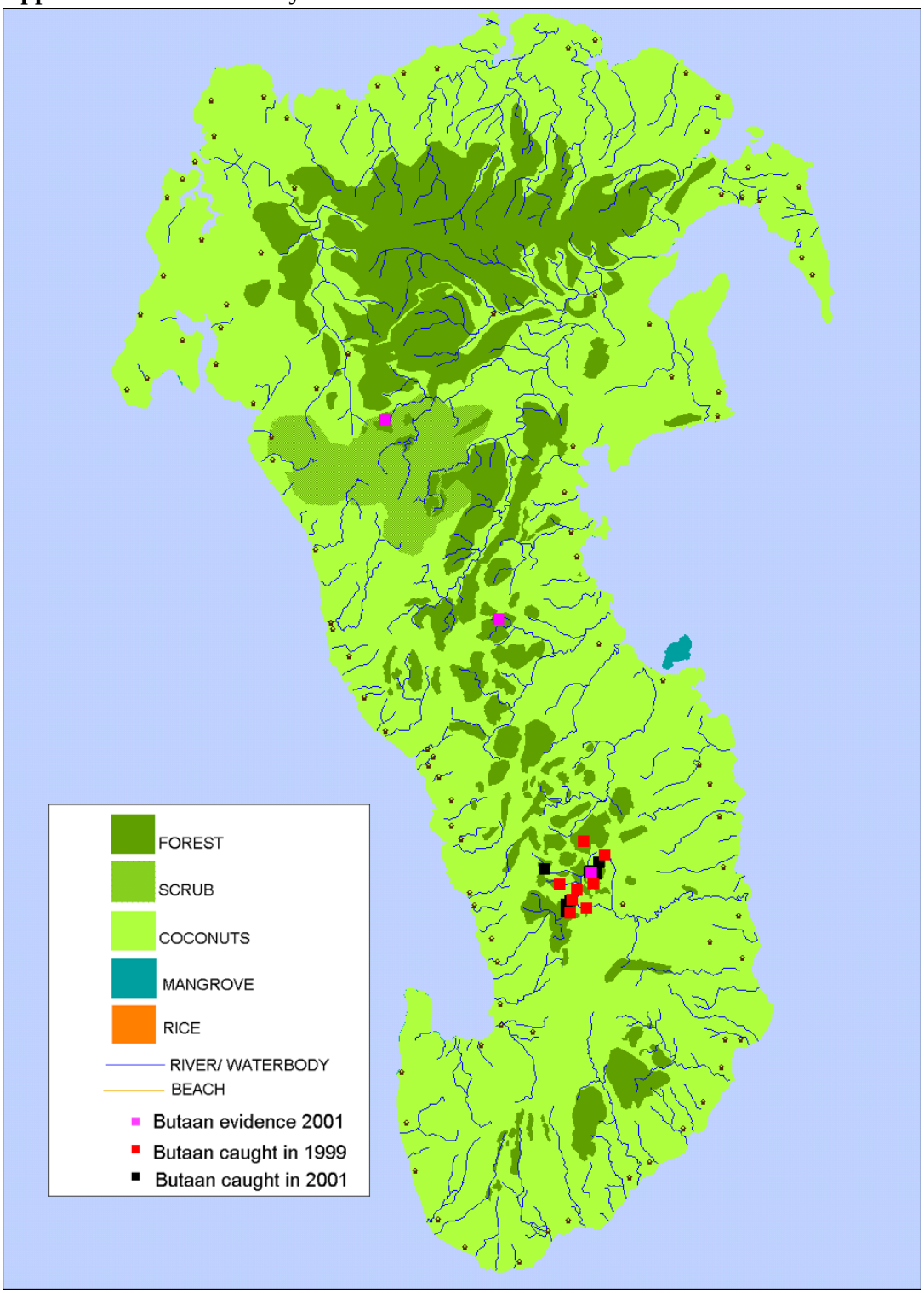


Map 1. Major agricultural and uncultivated habitat blocks around Sibulan watershed reserve. Squares represent animals caught during the study.

Appendix: Informal Surveys for *Varanus olivaceus* in the Polillo Islands



Map 2. Definite evidence of *Varanus olivaceus* on Polillo, 1999-2001.

Patnanugan Island
We found no evidence for the presence of butaan on Patnanungan, despite forest tracts of a similar size to those accommodating butaan on Polillo being present. Despite searching neither faeces nor scratches on trees were found. Furthermore inhabitants interviewed could not distinguish between butaan and biawak. The forest survey indicates forest on Patnanungan has a different structure to forests on Polillo and comparison indicates a paucity of fruiting trees that were important to the butaan on Polillo, notably very few large *Pandanus* and virtually no *Caryota* or *Pinanga*), although *Canarium* trees were quite common.

Jomalig Island
Jomalig is predominantly covered in grassland and marshes, although previously forested. No faeces or scratches were found. The only areas that now contain trees on Jomalig other than coconuts are less than 3 hectares in size, contain fewer than 10 species of trees and are entirely isolated within cultivation and grassland swathes. Individual *Caryota* and *Canarium* trees were found on Jomalig, however it is highly unlikely that any Butaan could survive on the island today due to the isolation of food resources and lack of habitat.

Minasawa Island
Very small island covered entirely by beach forest. No evidence of butaan presence has been found and it is unlikely that an island of this size could support them.

Burdeos
An adult butaan was seen up a tree inside the Burdeos watershed.

Aluyon watershed
No faeces were found during two days spent in Aluyon watershed. Several trees with scratches were found and local residents reported butaan to be present. More direct evidence is however required to substantiate this claim.

Anibawan
Large scratches on *Canarium* trees located along the Anibawan ridge were seen although no faeces were found. Local residents reported the presence of butaan. Direct evidence is required to confirm presence of butaan in Anibawan forest.

Salapakan, Abaca
Local people reported the presence of butaan, and although no faeces were found several scratches were seen on trees. Within the last ten years butaan were undoubtedly present in the Salapakan, Abaca and Moratorium ridges that form much of the extensive 'wilderness area' in the north of Polillo Island. Commercial logging of earlier decades encroached on these areas and local small scale but regular logging is currently degrading forest accessible by the ridge-top logging roads and 'transport' rivers. Consequently the average circumference of trees has been reduced. However food resources and large potential shelter trees were evident and given its virtual contiguity to Lister's forest it seems probable that the butaan is present in this area.

Balete sapa

Neither faeces nor scratches were found in Balete, although it lies within 500m of Lister's patch and would undoubtedly have supported butaan when the forest was continuous. More evidence is required to substantiate local reports of the presence of butaan in this area today.

Listers forest
Butaan are undoubtedly present in this forest as several fresh and older faeces were found. Large shelter trees, and abundant food particularly *Pandanus* were also evident in addition to several scratches on trees such as Catmon, and *Canarium.* This area is currently being logged and many of the trees used by butaan are being selectively cut.

Kalubakis
No evidence was found of recent butaan activity although scratches were seen on trees.

Forest patches surrounding Sibulan.
All forest patches around Sibulan contain butaan at some time of the year.

Mount Malulod
Trees with scratches were found in forest fragments surrounding Mount Malulod, however as these could not clearly be confirmed as Butaan and no faeces were found, it is not possible to determine if Butaan are still present. A local hunter reported catching individuals in the last 5 years.

Summary
Evidently most remaining forest patches are too small to maintain permanent populations of animals. In some resource-poor, isolated fragments the species is locally extinct.