Monitoring forest degradation and animal populations in the forests of Central Buton: preliminary results from the pilot study

Edited by Adrian Seymour

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Introduction

Over the last five years Operation Wallacea scientists have shown that the forests of Central Buton have a high conservation value, hosting many endemic species including rare or threatened species on the IUCN red list and species new to science. Like many of the lowland rainforests of Indonesia the forests of Central Buton face a number of threats. Even the central government controlled Lambusango and Kakenauwe Forest Reserves which are officially protected areas are being exploited by illegal loggers, wild animal hunters and rattan collectors. The buffer zones at the edges of the forest reserve are being eroded by forest clearance for agriculture, new settlements and open cast asphalt mining, all of which remove forest habitat and open access to previously remote and relatively untouched areas of the forest.

Operation Wallacea has successfully applied for a World Bank Global Environment Facility (GEF) grant to introduce a new forest conservation management program to the forests of Central Buton in an attempt to alleviate the threats to the forest and the unique biota it holds. Amongst other things, the proposed forest conservation management program involves the division of the forests of Central Buton into a central effectively policed protected forest surrounded by stakeholder controlled production forest. The conservation management program also includes a biological monitoring program so that the effectiveness of the new management program can be assessed.

Research by Operation Wallacea scientists in 2004 has been strongly geared to assessing the feasibility of using forest structure, flagship species and animal communities as measures of success of the management program. The research has focused on assessing different sampling techniques and evaluating the usefulness of the data they generate. Many rainforest biotas are very diverse, often difficult to detect, or occur in low numbers. This presents a number of practical problems for assessing abundance or diversity, such as low encounter rates and problems with species identification. Since the conservation value of a forest is largely determined by the diversity and abundance of unique or vulnerable species living there, the monitoring scheme should be targeted to a selection of these key species, rather than diversity or species richness *per se*. One of the goals of this pilot study is to determine how well we can sample species of conservation concern.

This report is divided into six main sections:

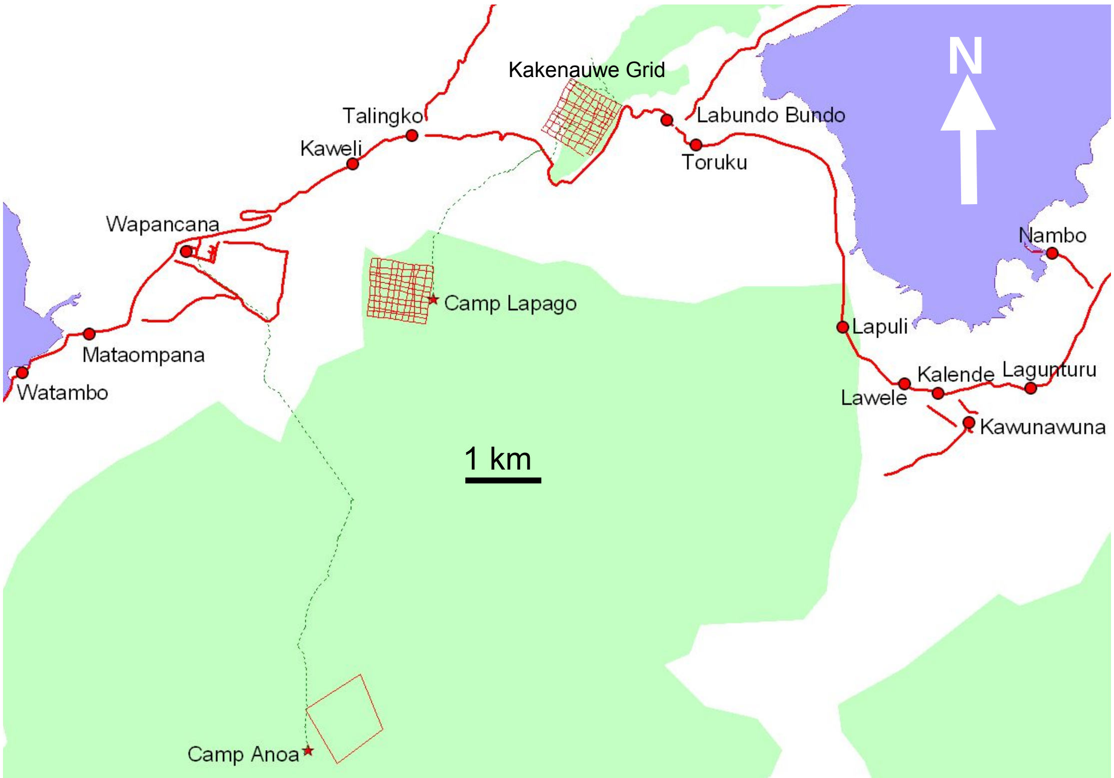
- Description of new sampling nodes.
- Monitoring forest change from satellite imagery and ground surveys.
- Estimating flagship species abundance (Anoa *Bubalus depresicornis*, Buton Macaque *Macaca ochreata brunnescens*, Tarsier *Tarsius spectrum*).
- Characterizing and assessing communities of birds, reptiles and amphibians, butterflies and stream macroinvertebrates.
- Recommendations for GEF biological monitoring.
- Studies not involved with the GEF project (Malay civets *Viverra tangalunga*, small mammals (Rodentia), bats (Chiroptera) and macaque *M. o. brunnescens* behaviour.

Each subsection will present the methods used to assess abundance and/or diversity and some initial findings based on the limited quantity of information that could be synthesized so soon after collecting the data. Each subsection will also include implications of initial findings for the GEF biological monitoring program.

Study sites

Prior to the 2004 field season, Operation Wallacea activity has been largely restricted to three principal study sites called Kakenauwe, Lapago and Anoa (Figure 1). Each of these study sites consists of a 1 km^2 study grid with marked trails separated at 100m intervals. At its nearest point the Kakenauwe study grid is less than one hundred metres from the nearest road and less than a kilometer to the nearest village (Labundo Bundo). The Anoa grid is the most inaccessible of the three study grids and is over six kilometers from the nearest road, and just over seven kilometers to the nearest village (Mataompana). In terms of accessibility, Lapago lies between Kakenauwe and Anoa, and is situated approximately 1.4 km from the nearest road and 1.6 km from the nearest village (Kaweli).

Figure 1. The location of Operation Wallacea study grids in Central Buton. Green areas represent protected forest. Red lines are roads and dotted lines are trails.



The three study grids have GPS way-marked trails, and Lapago and Anoa have well-established base camps associated with them. Although they have been very useful for many scientific projects (and will continue to be used for some projects), they do not provide the best sampling design for monitoring forest disturbance and the abundance of key species for the GEF program because a 1 km^2 study area is too small to sample species that live at low population densities (e.g. Anoa and macaques). In addition, the three study grids cover only a small fraction of the forests of central Buton. For this reason a new sampling design covering a much greater area was trialed in 2004.

'Node camp' sampling

The new sampling design consists of four parallel 3 km transects separated by one kilometre at each sampling node (i.e. 12 km total). Five sampling nodes were established in May 2004, four situated within the Lambusango Forest Reserve, and one within the adjacent limited production forest (Figure 2). By far the most important factor determining the selection of the sampling node location was terrain. Although the steepest areas were avoided for safety and practicality, the sampling transects still cover a wide range of altitudes and topography (Figure 3). In order to minimize our impacts on forest structure, transect trails were cleared as little as possible, though some cutting was necessary for access. Transects were marked at 50 metre intervals with flagging tape and have been way-marked with a GPS, so that repeat samples can be made at identical locations each year of monitoring. One or two additional nodes may be established in the limited production forest when the GEF project starts.

Figure 2. Location of GEF sampling transects (solid blue lines), and access trails (dashed blue lines).

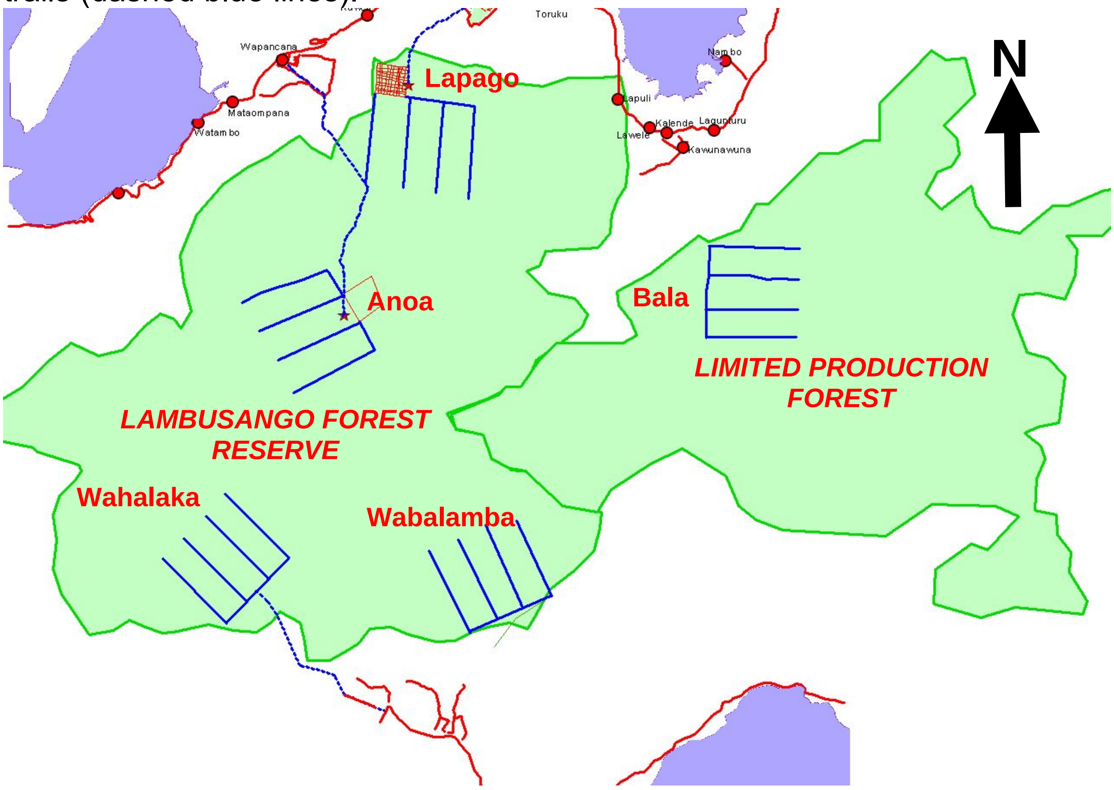
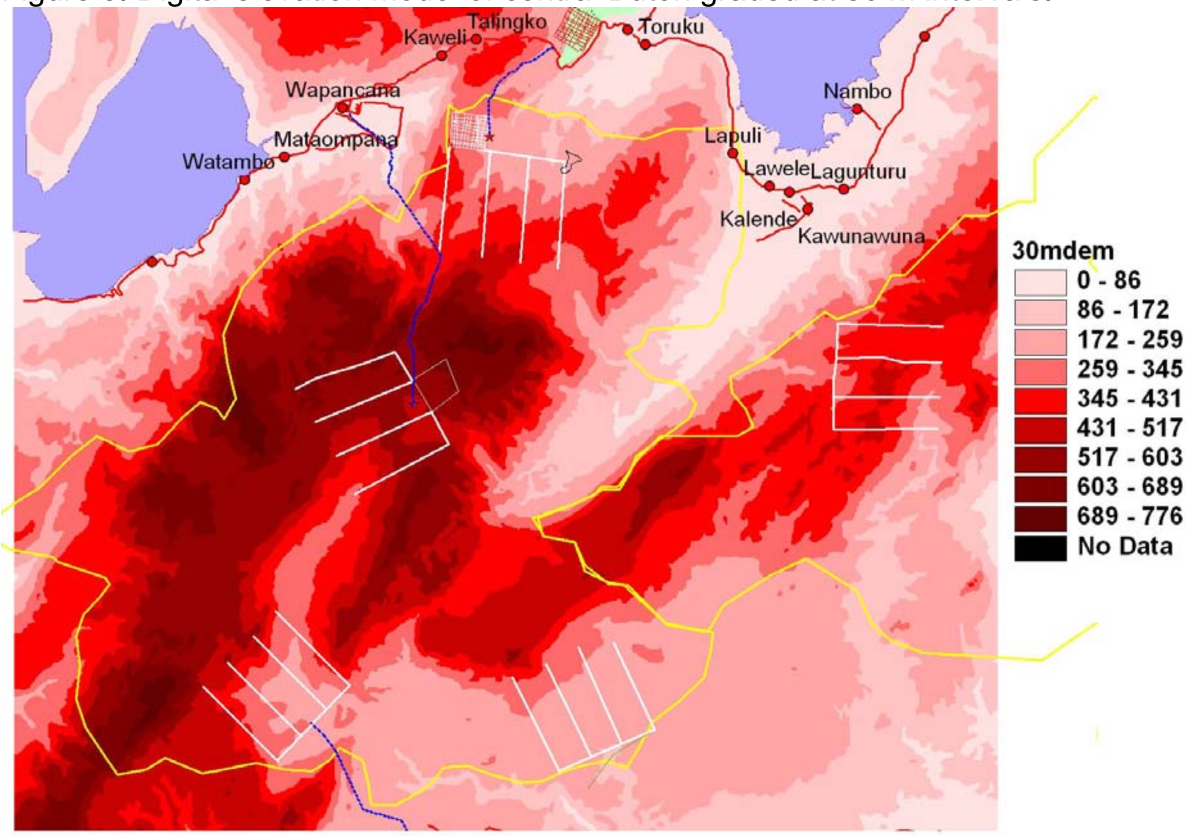


Figure 3. Digital elevation model of central Buton graded at 86 m intervals.



Even after the first visit to the sampling nodes, it was immediately apparent that different nodes were experiencing different kinds of anthropogenic disturbance. The greatest levels of disturbance were found in Wahalaka and Wabalamba in the south of the Lambusango Forest Reserve. Both of these sampling nodes covered some areas of regenerating forest on what appears to be abandoned agricultural land. This sort of forest is characterized by dense understory and the absence of large trees. The Wahalaka sampling node covered areas with dense stands of rattan (a group of spiny palms with fibrous stems that are commercially harvested), which at the time of study were being heavily exploited by significant numbers of rattan collectors. At the Wabalamba study site there was considerable evidence for selective logging within the reserve. Close to the access trail into the Wabalamba sampling node large stocks of pre-cut timber was seen awaiting transport. Selective logging in this area was clearly facilitated by the river Winto, which is large enough to allow cut timber to be floated downstream to a collection point close to a newly constructed dirt road accessible to vehicles. Indeed, rafts of cut timber were observed being transported downstream on many occasions. There was also a high frequency of felled trees. Both Lapago and Anoa sampling nodes also covered areas of regenerating forest from apparently long-abandoned farms (though time since abandonment not known). Somewhat unexpectedly, the Bala sampling node in the limited production forest showed some of the least disturbed forest with a high frequency of large trees, though there was evidence of high levels of rattan collection in the area.

Monitoring forest disturbance

Bruce Carlisle & Jen Dyer

Introduction

In the forests of central Buton there are three main categories of anthropogenic disturbance which include forest clearance for agriculture, new settlements or asphalt mining, selective logging and rattan collection. Forest clearance is the most severe form of disturbance and renders the habitat unsuitable for nearly all forest biota. Selective logging has been shown to have a negative impact on some forest fauna but may actually benefit others (e.g. for butterflies Hamer et al. 2003). Rattan collecting probably has the smallest impact on forest biota, but may have important indirect effects by opening access to previously remote areas via rattan trails. Clearly, a key objective of the biological monitoring program is to estimate how the rate of these different kinds of disturbance changes over the three-year period of the GEF project and beyond.

Two different methods are being employed to estimate changes in forest disturbance: 1) analysis of satellite images of the forest, and 2) direct measures of disturbance on the sampling node transects. These methods are outlined below along with preliminary results.

Analysis of satellite images

Because different types of ground cover reflect different parts of the electromagnetic spectrum it is possible to identify and quantify ground cover types from satellite imagery. High resolution satellite images cover large areas of ground and show considerable detail, making them ideal for detecting even small changes in ground cover over very large areas. However, there are a number of problems associated with this approach. Firstly, satellite images are not always available for the area of interest. Secondly, even when images are available, ground cover may be obscured by cloud cover. This is an obvious problem for analyzing satellite images of rainforests which are frequently obscured by heavy cloud cover. Thirdly, dissimilar ground cover types sometimes look the same on satellite images (low spectral separability), reducing the ability of satellite images to reveal changes in those cover types. A related problem is caused when the same cover type looks different in separate locations (high spectral heterogeneity). For example, similar vegetation types occurring on different slopes or aspects may reflect different parts of the spectrum due to factors such as shading.

Despite these problems, satellite imagery is potentially one of the best tools for monitoring large scale changes. Two good quality satellite images with relatively little cloud cover are available for southern Buton, one taken in 1991 and the other in 2002 making it possible to assess changes in forest cover in the intervening period. From these images it is easy to separate ground cover into two broad ground cover types: forest and non-forest (Figure 4).

Figure 4. Ground cover maps based on satellite images of Buton. Green areas represent forest and yellow areas represent non-forest. White patches are clouds.

1991 2002

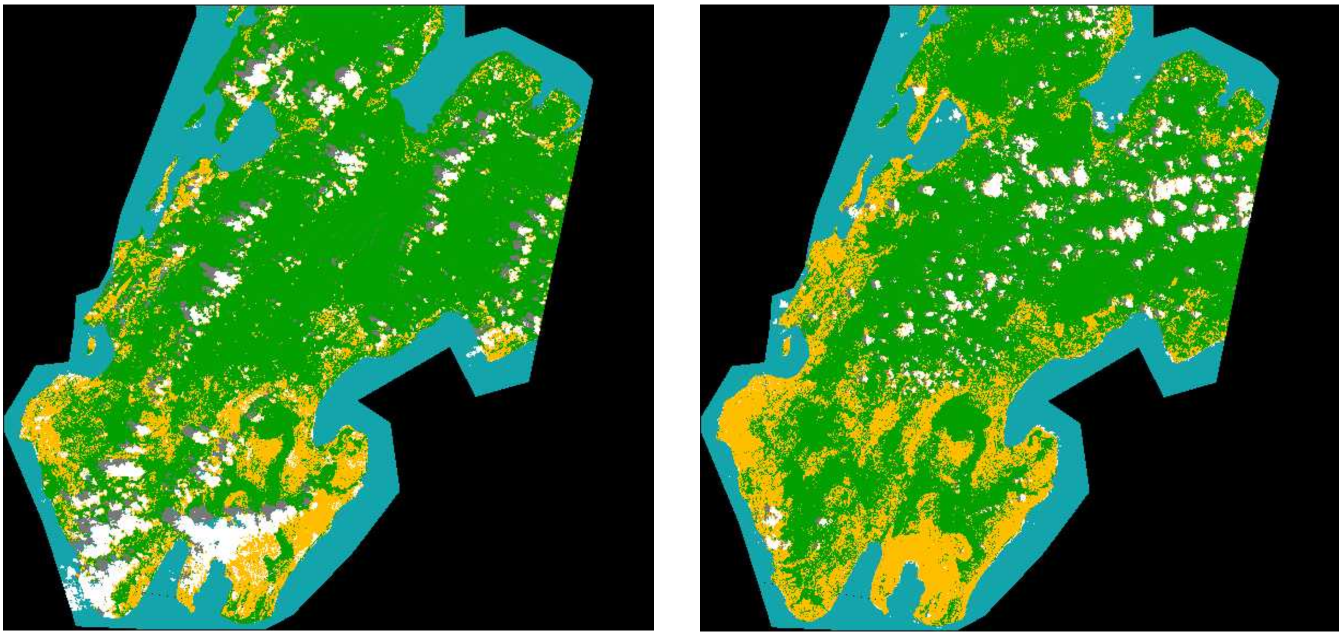
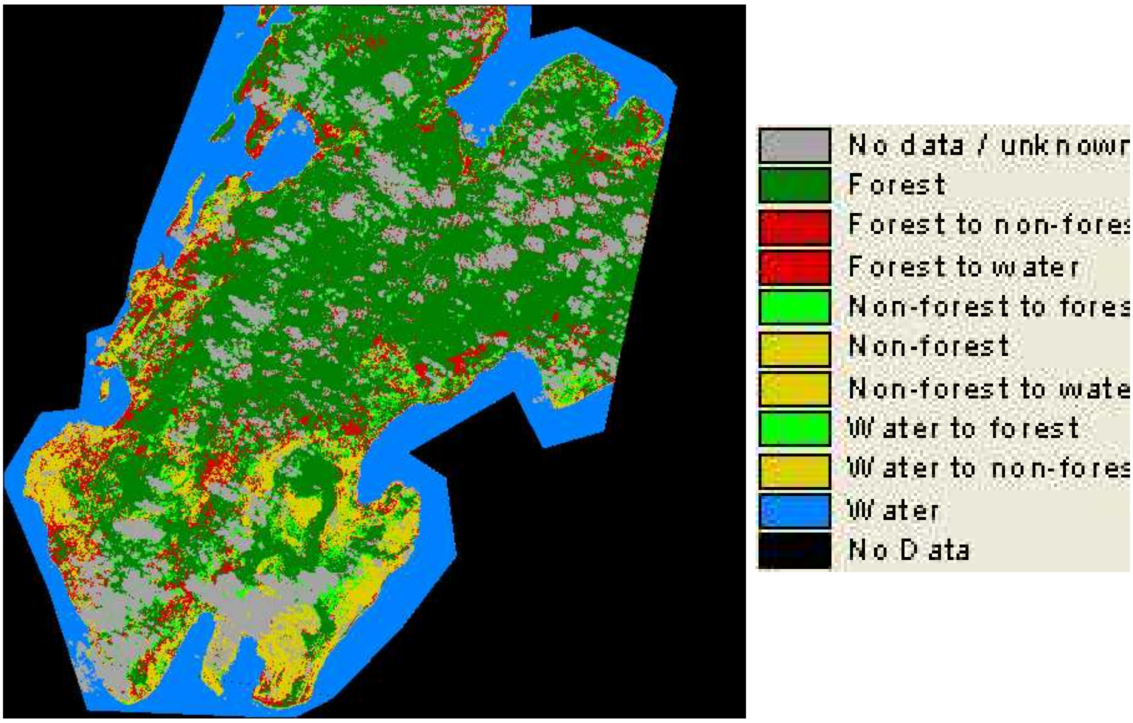


Figure 5. Changes in the ground cover of southern Buton between 1991 and 2003.



Each of these two categories includes many different habitat types. For example, the forest category includes logged forest, regenerating forest, primary forest and plantations. The non-forest category encompasses a wide variety of habitats including agricultural crops, settlements, grassland and bare ground. Comparing the two images in Figure 4 it is possible to quantify changes in forest cover. The two images can be combined to show where the changes have occurred (Figure 5). In between 1991 and 2002, 13% of the land cover of southern Buton has changed from forest to non-forest, an area of 22,809 hectares. This is comparable to the entire area of the Lambusango forest reserve (26,200 ha). A total of 7% of the ground cover has gone from non-forest to forest in the same period, though this forest is likely to have a very different structure than the forest that has been lost. Clearly, a major challenge in the use of satellite imagery to monitor forest change is the development of a method to monitor changes in forest quality. As conservationists, we are particularly interested in monitoring changes in cover of forest types that harbor species of conservation value. In order to do this we need to determine how the reflectance values on the satellite images relate to vegetation structure. This has been the principal goal of the forest structure monitoring project in 2004.

Forest structure sampling methods

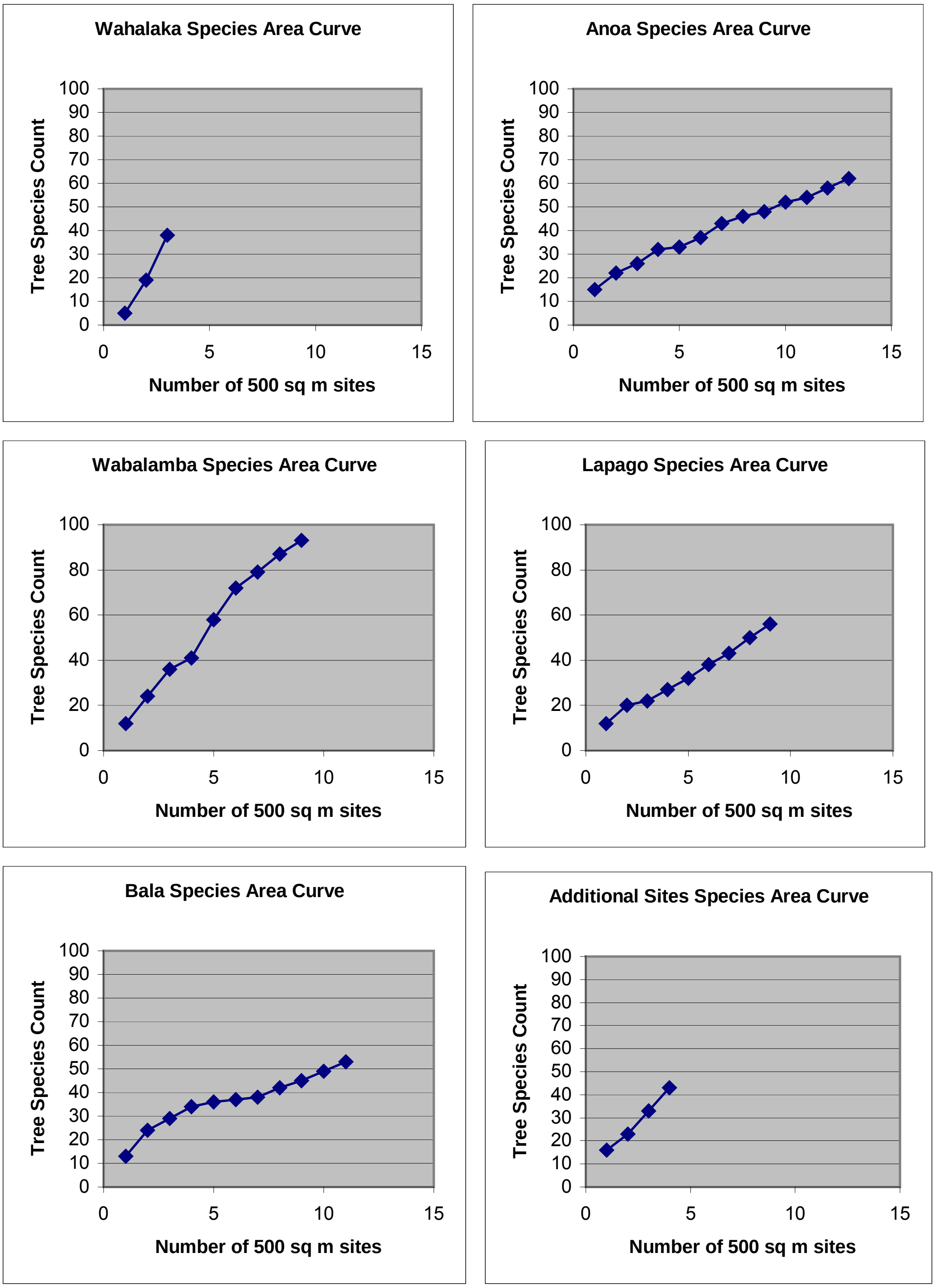
In order to determine the relationship between forest structure and satellite imagery reflectance values, forest structure was sampled at 47 sites in the Lambusango Forest Reserve and the adjacent limited production forest. Sample sites were located along transects on each of the five sampling nodes (Wahalaka, Wabalamba, Lapago, Anoa and Bala) as well as two additional locations off the sampling node transects. All sites were visited in July and August 2004. The location of each site was determined with a handheld geographical positioning system (GPS) so that data from sampling sites could be directly compared with reflectance values on a geo-referenced satellite image. Each site consisted of five contiguous 10m x 10m quadrats. Within each quadrat, the following data were collected:

- Diameter of all trees > 5 cm diameter at breast height (dbh).
- Local species name recorded for all trees > 10 cm dbh.
- Braun-Blanquet scale of % cover recorded for soil, rock, litter, 4 vegetation layers (0m to 1m, 1m to 5m, 5m to 20m, > 20m), and rattan.
- Canopy photo taken to derive % canopy closure.
- Presence/absence recorded for 4 disturbance/non-disturbance indicators (palms, pandans, tree ferns, ferns).
- Details of other disturbance/non-disturbance indicators recorded (number of birds nest ferns and height of lowest, maximum height of bole climbers, abundance of epiphylls, maximum height and depth of moss).
- Maximum height and length of rattan recorded.

Preliminary results

More than 180 local tree names were recorded in 235 quadrats at 47 sites. The species area curves from all sampling nodes showed no evidence of flattening out (Figure 6), suggesting that even more sampling is required to reliably estimate species richness.

Figure 6. Species area curves for trees (> 10 cm dbh) at six sampling locations



The greatest number of tree species was found at Wabalamba (93 species in 0.45 hectares of quadrat), followed by Anoa, Bala, and Lapago. Relatively few quadrats were sampled at Wahalaka and the additional sites, but both show steep species accumulation curves and these sites may have yielded relatively high tree species counts with more sampling effort.

The other data describing forest structure such as vegetation coverage and tree basal areas have not yet been summarized and therefore cannot be presented here. However, all the GIS data are freely available on the World Wide Web at the following URL address:
http://online.northumbria.ac.uk/geography_research/bc_research/butongis. When using these data please cite the following reference:

Carlisle, B., 2002, ButonGIS: GIS data sets of Buton Island, Sulawesi, Indonesia. University of Northumbria.

The data will be analysed to explore the relationship between satellite image reflectance and forest structure. A number of possible relationships will be explored including:

- Green v. Braun Blanquet cover categories.
- Near infra red / Red (a vegetation index) v. basal area.
- Middle infra red v. moisture indicator species.
- Forest accessibility v. species richness.

Measuring disturbance to forest structure along transects

Although the analysis of satellite imagery can reveal changes in forest coverage over large areas, and may also be able to detect changes in forest quality, it may miss out some important aspects of forest disturbance. Since two of the most important sources of anthropogenic disturbance to the forest are selective logging and rattan collection, signs of these activities were recorded on each transect.

Methods

Monitoring logging: Along each transect the locations of felled trees were obtained with a GPS.
Monitoring rattan collection: Each of the 47 sites used in the forest structure survey was scored for the presence of marketable rattan (i.e. with stems of sufficient length).

In addition we counted the frequency and position of points of intersection between rattan trails and each transect (i.e. number of times rattan trails crossed each transect). These measurements can be repeated each year to detect new tree felling and rattan extraction.

Results

A summary of the results is presented in Table 1 below. Sampling effort was not equal at all sites due to time constraints and extent of transects. At Wahalaka only one transect was surveyed for felled trees, and at Wabalamba only the first 500m of transect 4 was surveyed for trees. All four transects were surveyed for felled trees at Lapago, Anoa and Bala. Felled trees were only detected at Wabalamba, where they occurred in high numbers (average 5.2 felled trees per kilometre of transect). The proportion of sampling sites with marketable rattan varied from 0.56 in Lapago to 0.81 in Bala. The frequency of trail-transect intersections was particularly high at Wabalamba. These trails may have been created by the large number of loggers in the area rather than rattan collectors.

Table 1. Summary data for indices of anthropogenic forest disturbance at sampling nodes

Site	Wahalaka	Wabalamba	Lapago	Anoa	Bala
Number of felled trees	0	50	0	0	0
Proportion of sampling sites with marketable rattan	0.67 *n* = 3	0.67 *n* = 9	0.56 *n* = 9	0.67 *n* = 9	0.81 *n* = 11
Number of intersections with trails	22	29	14	8	23

All the above measures can be repeated in following years to detect rates of change in indices of disturbance. Sample sizes (number of sampling sites) may have to increase to detect reasonable levels of change in rattan extraction.

Estimating the abundance of ‘flagship’ species

Flagship species are usually large charismatic animals that are able to attract media attention and funds for their conservation. These species often make good ‘umbrella’ species – species that require large areas of habitat whose preservation would be expected to benefit many other species living in the same habitat. In the forests of central Buton there are several species that make good candidates as flagship species. These are the anoa *Bubalus depressicornis*, the Buton macaque *Macaca ochreata brunnescens*, the spectral tarsier *Tarsius spectrum* and the Sulawesi palm civet *Macrogalidia musschenbroekii*. All five of the species are of conservation concern and are on the IUCN red list. All five species are Sulawesi endemics, and the Buton macaque is only found only on Buton. The tarsiers found on Buton may also represent a distinct species from those of mainland Sulawesi. The anoa is critically endangered and there are probably fewer than 3000 individuals remaining, making this species a high conservation priority. There is still no conclusive evidence the IUCN vulnerable classified Sulawesi palm civet inhabits the forests of central Buton, however local people from several villages occasionally see civets closely matching the description of this species and have local names for this distinct kind of civet (‘musang sangila’ in Labundo Bundo, and ‘musang kilau’ in Kamaru).

In this section we outline methods and initial results of population surveys of anoa, tarsier and Buton macaque at each sampling node. We did not attempt to estimate Sulawesi palm civet abundance because of the extremely high sampling effort needed to determine its presence, let alone abundance (Lee *et al*. 2003).

Estimating anoa abundance

Phil Wheeler

Introduction

Anoa *Bubalus spp.* are dwarf buffalo endemic to the Indonesian island of Sulawesi. Two species are recognised: *B. depressicornis*, the lowland, and *B. quarlesi* the upland anoa. The two species will interbreed when kept together in captivity and it is possible that they represent separate colonisations of Sulawesi by very similar ancestral stock. They are relatives of the Asian water buffalo and Tamaraw but retain a number of primitive characters, most notably straight horns (water buffalo and Tamaraw horns are curved). Anoa are extremely shy animals and are largely restricted to areas of undisturbed rainforest. They have a reputation for aggressiveness and are regarded with fear by many Indonesians. Both species are classified by the IUCN as Critically Endangered. Their populations are estimated at between 2000 and 3000 individuals, and are assessed as having a high probability of extinction in the next 50 years. The two main threats to the species are habitat loss and hunting for meat and trophies.

The islands of Buton and neighbouring Muna are located off the south east tip of Sulawesi. Buton sustains what is probably the last population of anoa outside the Sulawesi mainland. It is unclear whether *B. depressicornis* and *B. quarlesi* are present on the island, but individuals bearing characteristics of both species have been sighted. Muna has been completely cleared of natural forest in recent times, and though it is likely anoa were once present there, they are now certainly extinct. Information on the anoa on Buton is urgently required to prevent the species' extinction there.

The objectives of the anoa project this year were to a) estimate relative abundance at the different sampling nodes, and b) to use these data to obtain a rough estimate of total population size in the Lambusango Forest Reserve and surrounding forests. Estimating anoa densities directly by counting individuals is not feasible because of low encounter rates, so densities have to be estimated indirectly by counting field signs such as tracks and dung. Tracks and dung provide an index of anoa presence though their relationship to actual numbers is not known. Therefore any estimates of density based on field signs must be treated with caution.

Methods

Anoa tracks can be readily distinguished form other ungulates (cows and pigs) in the forest on the basis of size and shape (Figure 7). The tracks of all three species of ungulate were recorded along sampling node transects during the months of July and August 2004. Counts of tracks crossing sampling node transects were made. Where an animal had clearly followed a survey line a single count was recorded. In addition to anoa tracks, counts were also made of anoa dung and anoa sightings. The distance surveyed along each transect is presented in Table 2.

Figure 7. Tracks of Buton forest ungulates. From left to right: Domestic cow, Anoa, pig, pig in deep mud. Babirusa are absent from the island.

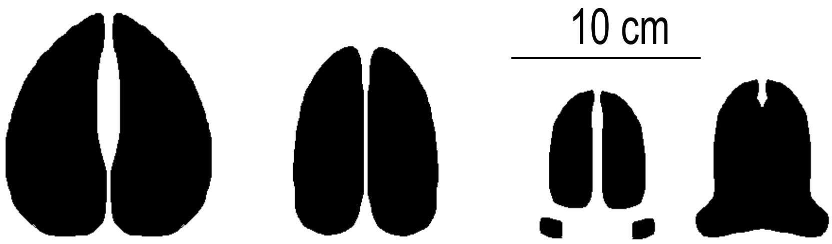


Table 2. Sampling effort (distance walked in km) at each sampling node.

Transect number	Wahalaka	Wabalamba	Lapago	Anoa	Bala
1	3	3	3	3	3
2	3	3	3	3	3
3	3	2.5	3	3	3
4	3	0	3	3	3

In addition to the sampling nodes, a geographically distinct area, the Lawele valley, was reconnoitered for anoa and their field signs.

Results

The frequencies of anoa tracks crossing sampling transects at each node are presented in Table 3. Wild pig tracks were recorded at each node on all transects sampled. Cow tracks were recorded in Wahalaka (all transects), Lapago (the end of transect 4), and Anoa (transects 1,2 and 3). In Wahalaka, cow tracks were associated with recently abandoned farmland. Anoa dung was not recorded on any of the transects. Two anoa were seen in Wahalaka (transect 4).

Table 3. Counts of anoa tracks along each transect at each sampling node.

Transect number	Wahalaka	Wabalamba	Lapago	Anoa	Bala
1	50	19	8	92	57
2	31	33	33	72	73
3	26	41	75	63	42
4	47	-	32	68	39

At all nodes there was some evidence that anoa were avoiding rattan trails (i.e. low occurrence of tracks in the vicinity of rattan trails). This pattern was particularly strong at Wahalaka. However, there was no clear relationship between the number of trails per transect and the number of anoa tracks per transect.

Assessment of Anoa Abundance

Anoa are essentially unstudied and methods for estimating density based on sign surveys are not yet established so it is difficult to assess the number of individuals in the Lambusango population. The world population is estimated at between 2000 and 3000 individuals. Below are a series of estimates of the adult anoa population in the Lambusango area. They are not meant as serious answers to the above question, more as indicators of the order of magnitude of the population. The figures are therefore as reliable as you want them to be!

1. Over the two months (July and August) of the Operation Wallacea season eight anoa have been seen in the Lambusango forest. A further four have been seen being carried out dead by local hunters, three of these from the Lawele valley, where surveys suggest the species is most abundant. Recognising the limited area surveyed by Operation Wallacea in the two month season it would be reasonable to suggest that these 12 individuals potentially represent ten percent of the Lambusango anoa population, giving a ball-park figure for the population of 100 – 150 adults.
2. The Lambusango forest comprises 260 km^2. The 2004 study transects make up a 3km square, so assuming a boundary zone of 1km at each end and on each side, one set of study transects makes up an area of 25km^2, hence Lambusango contains around ten such areas. Using a series of conjectures based on

sightings, dung counts and track counts I have come up with the following estimate for anoa numbers on each of the transect sets:

SITE	NUMBER
Wahalaka	6
Wabalamba	4
Lapago	5
Anoa	9
Mean Density	6
Total Population	60

3. Assuming you are likely to hear or see an anoa within 50m either side of a transect, the following are estimates of densities based on my actual sightings. Note they are heavily skewed towards one site.

SITE	AREA SURVEYED	DENSITY
Wahalaka	1.2km2	0.6km-2
Wabalamba	0.85km2	0km-2
Lapago	1.2km2	0km-2
Anoa	1.2km-2	0km-2
Lawele valley	0.8km2	5km-2
Mean Density		1.14km-2
Total Population		296

4. Reports from hunters suggest that in a good year a hunter will catch 5 anoa; in a bad year they will catch none. Assuming an average of 2.5 anoa per year per hunter, and estimating 20 villages around Lambusango have a hunter or group of hunters, 50 anoa will be going out of the reserve per year. Assuming that a pair of anoa produce one calf per year, and that the hunting levels are sustainable, there should be 50 pairs of anoa in the reserve (i.e. 100 adults). However, I don't believe current hunting levels to be sustainable so either there are fewer than 100 adults or not all adults breed, both of which are possible.

So reasonable estimates for the anoa population based on available data range between 60 which is surely pessimistic given the actual number of sightings and 300 which is likely too optimistic. I would personally favour an estimate of 100 -150 individuals for the Lambusango reserve i.e. around 5% of the world population.

Anoa Hunting in Lambusango

Anoa are hunted in order to provide small but significant amounts of money for local people. Animal protein other than fish and chicken is rare in the Lambusango area and this provides the market for anoa meat. Over the two months of the Operation Wallacea 2004 season eight adult anoa have been seen in the Lambusango forest. A further four have been seen being carried out dead by local hunters, three of these from the Laweli valley, where surveys suggest the species is most abundant, and one from the camp Anoa area. Anoa are usually trapped with leg snares tied to a simple pitfall trigger that is usually attached to a bent over sapling. An anoa stepping into the snare will step into the small pitfall, release the trigger and be pulled up by the sapling, tightening the leg noose. When the hunters return to their traps they endeavour to lasso the horns, restrain the beast and cut the tendons in the lower leg forcing the animal to sit down. The neck is then cut. Animals are butchered in the forest, the backbone removed and only the meat, limbs, innards and head carried out.

Hunting Levels

A good month will produce two or three anoa, and in a good year they may trap five – hunting is not a full-time occupation, and bad months and bad years produce no animals. This level of hunting, if representative of villages around the Lambusango area means that perhaps upwards of 30 animals are being removed from the Lambusango forest each year. I believe that current patterns of anoa distribution suggest strongly that hunting at this level is unsustainable; what I regard as reasonable estimates of population size in the Lambusango area could not produce sufficient young to sustain themselves under this pressure.

In the 2004 Operation Wallacea season two leg snare traps were removed from the camp Anoa area, one apparently set to catch a cow resident in the area, the second, which had clearly successfully caught an animal, was found on a stretch of transect devoid of anoa signs. Over the 2003 season several traps set around the Lapago area were removed. Monitoring of tracks in the Lapago area from one season to the next has shown that one adult present in an area where anoa traps were found in 2003 was absent in 2004. This may or may not be a result of hunting.

In addition a group of Balinese hunters were seen entering the forest on the trail leading to camp Anoa. These men carried spears and had a group of 15-20 dogs with them. It is understood that they hunt for pigs, though one report from a local guide stated that these same men had been seen walking out of the forest with a dead anoa some days previously.

Vulnerable areas

Preliminary data suggest strongly that accessibility of areas of forest to people is the main factor governing anoa distribution in Lambusango. With this in mind the most vulnerable area of Lambusango is currently the Lawele valley where new settlements are being established right up to the reserve boundary, and the flat topography mean there are few barriers to humans accessing the valley's upper reaches. It is my suspicion that the fact that the Lawele river runs dry for much of the year up to the top of the valley has prevented people camping in the forest there and exploiting resources thereabouts. There is a permanent water source at the head of the valley and it is only a matter of time before it is discovered by local people looking for new areas to exploit. The current path running up the valley, likely a result of rattan collection, honey collectors and hunters stops around three kilometres from the water source. There was very little evidence that people had recently been in the forest at the top of the valley. The area is still home to high densities of anoa, and these may provide an incentive for people to explore further.

Increasing encroachment in the south of Lambusango from asphalt mining and its accompanying roads has made that part of the reserve much more accessible. Anoa are present in the area but at relatively low densities, and human trails run well into the forest, and exploitation of the area seems likely to increase.

The third vulnerable area is the north western section of Lambusango where, despite steep topography, rattan collection has resulted in trails running through much of the forest. Anoa signs there are already substantially lower than would be expected given the topography and remoteness of the area.

Value of Anoa

Conversations with hunters and local people familiar with anoa hunting suggest that a large anoa will fetch of the order of 500,000 Rupiah. The skulls are not particularly sought after, possibly because they are clear evidence of illegal activity, and there is at least one report of a long-time anoa hunter from Lawele who has a substantial skull collection he is unable to dispose of. Furthermore anoa meat is not regarded highly, and hunters' claims that they are trying to catch cows rather than anoa are, in part, probably true. An adult cow will fetch 3,000,000 Rupiah, six times the price of a large anoa. However, cows are certainly the rarest ungulates living wild in the Lambusango forest, and leg snares set to catch them are still more likely to catch anoa.
The number of farmed cattle in villages around Lambusango seems surprisingly small, especially considering the amount of rough grazing land available in farmland left fallow. This may be because of the high investment required to purchase cattle and ignorance of cattle husbandry. A government scheme to increase cattle farming was mentioned by one of the local guides where two cows are given to a farmer as a start-up project. Presumably these are inseminated by a local bull and when they produce offspring one is returned to the government scheme, the net result being that the scheme maintains its cattle numbers and the farmer now has cattle to raise. Why this scheme is not operating in the Lawele area is unclear. Though there are rarely 'magic bullets' to solve problems in species conservation, support for cattle husbandry around Lambusango will surely reduce the incentives for anoa hunting in the area. Even if it does not stop local people hunting anoa it may reduce hunting to a sustainable level. I would recommend that the instigation of such a scheme in the areas most vulnerable to hunting be a priority for future conservation efforts in the Lambusango forest.

Estimating Buton macaque abundance

Andrew Smith

Introduction

There are 19 species of macaque worldwide, seven, over a third of which are endemic to Sulawesi (Fooden, 1969). They have radiated to become the most abundant large mammal within the forests of Sulawesi, with more species than on any other comparable area of land (Whitten *et al,* 1987; Reed *et al,* 1997; Rosenbaum *et al,* 1998; Kinnaird, WCMC web site). It is likely that the Sulawesi macaques are descendants of the pig-tailed macaque *M. nemestrina* found in Sumatra and Borneo. These animals probably reached Sulawesi by rafting or island hopping during the low sea levels of Pleistocene glaciation (Fooden, 1969; Whitten *et al,* 1987), possibly at two separate locations or times (Evans *et al,* 1999). The ancestor species then radiated out to colonise the whole island in a continuous distribution (Fooden, 1969; Whitten *et al,* 1987). Although the precise taxonomy of the Sulawesi macaques is disputed, there are seven distinct morphological forms. The most recent taxonomic revision accepts four species, with the Buton macaque, *M. o. brunnescens* being considered a subspecies of the booted macaque, *M. ochreata* (Groves, 1980).

Sulawesi macaques are found in lowland and hill forest (Mackinnon, 1986), and have been sighted as high as 2000m, but are probably not common above 1500m (Whitten *et al,* 1987). Pythons, *Python reticulatus* and *P. molurus,* are their only predators other than humans, who hunt them as crop-pests over most of the island and occasionally for food (Whitten *et al* 1987). The main threat to Sulawesi macaques is habitat loss through deforestation due to agriculture, logging, transmigration camps (MacKinnon, 1986; Whitten *et al,* 1987; Rosenbaum *et al,* 1998). More than 67% of productive wet lowland forest on Sulawesi has been lost over two decades (Whitten *et al,* 1987; O'Brien and Kinnaird, 1996). Diversity of fruit tree species is likely to decline after logging, and food resources become lower in quality and quantity (Rosenbaum *et al* 1998). Sulawesi crested black macaques, *M. nigra,* have been shown to occur at significantly lower densities in logged than primary forest (Rosenbaum *et al* 1998). Behavioural observations of this species living in secondary forest suggest that they travel further, socialise less, and eat less fruit than conspecifics in better quality primary forest with minimal disturbance and canopy-sized trees (O'Brien and Kinnaird, 1997; Rosenbaum *et al,* 1998).

In comparison to other Sulawesi macaques very little is known about the distribution or conservation status of the booted, *M. ochreata ochreata*, and Buton macaques *M. o. brunnescens.* Moreover there are few captive Buton macaques, and no captive breeding programme. The Buton macaque is endemic to the islands of Buton and Muna. Both islands have undergone extensive de-forestation in recent years, due to logging and farming, and these macaques are consequently under threat. Muna has lost the majority of its primary forest, and the largest population of macaques survives on Buton. The Lambusango and Kakenauwe forest areas in central Buton island represent a substantial remaining stand of forest and may support the largest remaining population of this endemic species.

Any macaque species that do not have at least 10% of their remaining habitat protected, or a population of at least 5,000 animals should be considered endangered. Reserves should be large enough to contain viable populations and maintain genetic diversity (MacKinnon, 1986). Data relating to abundance of a species are vital when evaluating its status. The survival prospects of a species are dependent on the number of areas supporting self-sustaining populations and on the sizes of the populations in these areas. Reliable data on distribution and population sizes are necessary to stimulate conservation action in the form of creating new protected areas or improving protection of those already in existence (Brockleman & Ali, 1987). Further, in order to assess accurately the success of conservation measures, such as the creation of protected areas, it is essential that comparable estimates of primate densities be obtained over time, *i.e.* the instigation of a long-term monitoring programme.

Threatened species and sub-species such as the Buton macaque should be monitored within reserves and managed to maintain adequate populations (MacKinnon, 1986). Information on the ecology and behaviour of the Buton macaque, in addition to that on population, is essential for successful management plans to be designed to conserve this endemic primate (O'Brien *et al,* 1997). Further, specific data on habitat requirements, minimum areas for conservation, diet, and details of appropriate social and breeding systems, and conflict with people are necessary for the implementation of such plans (Sutherland, 1998). Consequently this project aims to collect data on the population and distribution of Buton macaques within the study area. The data will enable a comparison of the ecology of macaques living both in the naturally occurring forest types, and in areas with varying levels of anthropogenic disturbance of within the Lambasango protected area.

Methods

The line-transect method was utilized since it facilitates rapid surveys of large areas (MacKinnon, 1986). Estimation of the density of a sample population within a defined area then enables estimation of the total population based on extrapolation to a larger area (Struhsaker, 1981). Line transect surveys have the advantage of providing information about animal abundance and distribution over a relatively short time period (Struhsaker, 1981), and are an effective method for estimating animal populations inhabiting very different geographic areas (Whitesides et al., 1988). Population estimates were carried out at three sampling nodes, Anoa, Lapago, and Bala.

At each site, transects were walked in turn, with two repeat walks at Anoa and Lapago to reduce the potential for the spatial location of fruiting trees and other factors to bias the population counts. Survey walks began between 0700h and 0800h, as macaques (and other diurnal animals) are typically most active, and hence detectable, in the morning. Transects were walked as quietly as possible so as not to disturb any animals. A speed of circa 1.25 km/hr is maintained, taking five minutes to walk each 100m section.

For each census walk, the following information was recorded:

- Study site
- Transect ID number
- Date

For each sighting of monkeys, the following information was recorded:

- Position along transect
- Number of macaques sighted
- Perpendicular distance from transect to first monkey sighted

Analysis of data obtained from population censuses will take advantage of DISTANCE software, which may be used to analyse various types of distance sampling data (Thomas *et al*, 1998).

Results

Counts of macaques along each transect are presented in Table 4 below. Data from the Bala sampling node are not included. At the Lapago and Anoa sampling nodes groups of macaques were recorded on six different occasions during sampling walks (does not include return journey along same transect). An average of 4.5 ± 3.3 (s.d.) macaques were seen per group. In addition, groups of macaques were seen on three occasions when going back along the transects. The return journey was not considered a valid sampling walk because of the possible effect of observers on macaque presence during the outward walk. At both Lapago and Anoa, macaques were observed on three out of four transects (includes data from return walks).

Table 4. Frequency and location of macaque sightings during outward transect walks at Lapago and Anoa sampling nodes.

Site	Transect	Date	Number of macaques	Distance from transect (m)	Distance from start transect (m)
Lapago	4	19-Jul	0		
Lapago	3	20-Jul	0		
Lapago	1	21-Jul	0		
Lapago	2	22-Jul	9	35	450
Lapago	4	25-Jul	0		
Lapago	3	26-Jul	0		
Lapago	1	27-Jul	0		
Lapago	2	28-Jul	0		
Anoa	4	02-Aug	0		
Anoa	1	03-Aug	4	35	450
Anoa	1	03-Aug	1	0	1350
Anoa	3	04-Aug	0		
Anoa	2	05-Aug	0		
Anoa	4	07-Aug	2	50	250
Anoa	1	08-Aug	8	25	1350
Anoa	3	09-Aug	3	30	2700
Anoa	2	10-Aug	0		

Discussion

Clearly the current sampling effort is insufficient to yield data on density estimates. DISTANCE sampling requires in the order of fifty encounters to estimate the distance function needed to estimate density. Even if transects from all the nodes were sampled, it is unlikely that enough data would be obtained to estimate density. Given the need to minimize detrimental effects to the forest caused by increased access to hunters, loggers and rattan collectors via sampling transects, it is undesirable to radically increase the number or length of transects. However, it may be possible to improve density estimates using DISTANCE sampling by increasing the frequency of repeat walks at each transect by increasing the number of observers and/or days available for surveying. Sampling would benefit by increasing the time elapsed between repeat transect walks in order to help account for spatio-temporal biases (e.g. the occurrence of fruiting trees) that may dominate the data obtained from very short sampling periods.

Estimating tarsier abundance

Christine Lillie

Introduction

The tarsier is one of the smallest primates, with a head and body length of 9.5- 11cm, only half as long as its entire hind limb, which is modified for leaping up to 6m. The most characteristic feature of the tarsier is its large eyes, each larger than both its brain case and stomach. Three species of tarsier are known to exist on Sulawesi mainland (*Tarsius dianae, Tarsius spectrum* and *Tarsius pumilus).*

The IUCN red list (www.redlist.org) classifies the conservation status of these species as follows:
T. spectrum- Lower risk, near threatened
T. dianae- Lower risk, conservation dependent
T. pumilus- Data deficient

However, based upon the biogeographic subdivision of other faunal groups, such as macaques and toads, further taxonomic subdivision of Sulawesi tarsiers is likely. There is growing evidence that there may be a constellation of tarsier species that parallels the set of eight closely related Sulawesi macaque species (Niemitz, 1991). Recent studies on duetting behaviour indicated the existence of a new species of tarsier on the Togian Islands in Tomini bay, Sulawesi (Nietsch, 1999). Tarsiers were only recently discovered on Buton Island, South east Sulawesi in 1999 (Burton, 2001). Preliminary analyses of their duet calls indicate pronounced differences to mainland tarsiers, including *T. dianae* and *T. spectrum*, suggesting that the Buton tarsiers may be a distinct species (Nietsch, unpublished. Data in Burton, 2001).

Tarsiers are generally widely distributed and relatively common in Sulawesi, due to a broad insectivorous niche and lack of any significant predators (only snakes, civets and owls) (Gursky, 2001). Major threats to all species are thought to be habitat loss and degradation, which is human induced and ongoing (www.redlist.org). However, information on tarsier ecology and habitat requirements is very limited, with only 10 publications on all aspects of their ecology, none of which are specifically on habitat requirements or effects of habitat degradation. (Crompton, 1986; Dagosto, 2001; Gursky, 1998; 2002; 2002; 2002; 2003; Merker, 2000; Neri-Arboleda, 2002; Nietsch, 1987).

There is a lack of basic ecological information on tarsier habitat requirements. Tarsiers have frequently been seen in disturbed habitats, sometimes in greater abundance than in undisturbed habitats (Fleagle, 1999), understanding this is crucial to assessing the impacts of disturbance on tarsiers. The objectives of this study were to examine the habitat associations of tarsiers near their roost sites and to assess the relative population density in different sampling nodes in order to gain a greater understanding of the effects of disturbance on tarsier populations.

The study attempts to estimate population density at four sites affected by varying degrees of disturbance (Wahalaka, Lapago, Anoa and Bala) and compare them to estimates of previous tarsier studies.

It is predicted that higher densities of tarsiers will be recorded in the more disturbed sites. *T. spectrum* is particularly abundant in secondary forest and scrub (Fleagle, 1999).

Sulawesi tarsiers perform distinctive duet calls regularly at dawn in the vicinity of their sleeping trees and sometimes also at dusk (MacKinnon, 1980). Contact calls are also frequent between group members as they gather at their shared sleeping site at dawn. These vocalisations provide a method for calculating population densities.

Methods

Study area

Buton is the largest of the islands found to the South east of mainland Sulawesi. It is a relatively large island (4,505 sq km), very close to the mainland and has a limited road network. It has many of the mainland species and has maintained much of its forest habitat, due to a high proportion of inhospitable terrain, unlike the mainland and the neighbouring island of Muna, which is much flatter and more easily accessible for logging.

The research was carried out on Buton between June and September 2004. Counts of calling tarsiers were made along the first kilometre of sampling transects at Wahalaka, Lapago, Anoa and Bala.

Data collection

The dawn transect walk would commence at 0530 at 0m and finish at 0610 at 1000m. At any point when a tarsier call was heard, a bearing of the location of the call would be taken along with an estimated distance to the calling tarsier. The exact position on the transect at which the call was first heard was marked with flagging tape. The perpendicular distances from the estimated position of each calling tarsier and the sampling transect were estimated from the bearing and distance to calling tarsiers. The time of the call and the number of tarsiers calling were also recorded. The maximum distance at which a calling tarsier was detected was 50m; calling tarsiers beyond 50m were probably undetectable. Repeat transect walks were undertaken when possible, with a maximum of 12 walks per site (3 repeats per transect – completed at the Anoa site) and a minimum of four successful walks in total.

The habitat structure within a 10 × 10 m quadrat around the estimated position of each calling tarsiers was measured. In addition, habitat structure was also measured in a sample of randomly placed 10 × 10 m quadrats within a 100× 1000 m strip centred along the length of the transect. A maximum of ten of these 'random' quadrats were sampled at each transect.

The same habitat data were collected for both 'random' and 'tarsier' quadrats. Measurements included measures of canopy and vegetation cover at various levels (measured on the Braun-Baunquet scale), average tree circumference and height of the tallest tree. A previous study (Lillie, 2003, unpublished) found a correlation between lianas and tarsiers, so the number of lianas was also recorded. In addition we scored each quadrat for the presence of key plants such as birds' nest ferns, pandans, palms, moss and epiphylls, which are thought to be good indicators of past clearance, light levels and humidity. Additional information such as tree fall and other notable characteristics, for example, proximity to a likely sleeping site (like a large strangler fig), overabundance of a certain plant, any rivers or streams in the area were also recorded.

Analysis methods

DISTANCE sampling can be used to estimate the density of individuals when the probability of detecting an individual is less than one and changes with distance from the observer. In order for DISTANCE sampling to provide reliable estimates of density the following assumptions must be met (Buckland, 1993):

- Objects on the transect line are always detected.
- Objects are detected at their original location, prior to movement in response to observer.
- Distances and angles are measured accurately.
- The object of interest must be identified correctly

All of these conditions are satisfied in the present study.

Preliminary Results

Time constraints have prevented any formal analysis of the data and the small sample sizes may limit the statistical power of the data. However some preliminary observations can be reported. The frequencies at which calling tarsiers were detected in each sampling node are presented in Table 5. Tarsier counts between transects within sampling nodes varied considerable. For example, one transect at the Lapago site (at which two repeats were carried out for each transect) yielded as many as 17 tarsier calls whilst as few as eight calls were detected at other transects. Habitat types, vegetation and terrain also varied between transects. The vegetation structure within tarsier habitat quadrats appeared to vary in some respects (vegetation cover, presence and absence of certain 'indicator' plants), but appeared consistent in other respects such as the abundance of vertical substrate supports (e.g. lianas, thin trees and bamboo). However, these observations need to be confirmed with statistical analyses of the data.

Table 5. Frequency of tarsier encounters and sampling effort at each sampling node.

Sampling node	Number of tarsier encounters	Number of repeats of each transect
Wahalaka	7	1
Lapago	23	2
Anoa	20	3
Bala	22	2

Discussion

There were enough encounters with calling tarsiers to estimate the detection function needed to estimate density in the DISTANCE program. However, it is not certain whether there is sufficient data to make statistical comparisons of tarsier density between sampling nodes. Another factor that may complicate comparison between sites is seasonal bias. The Wahalaka node was sampled during the wet season, whilst the other sites were sampled in dry weather heralding the start of the dry season. Heavy rainfall may influence tarsier distribution, activity and the ability to detect their calls. Although eleven mornings were available for sampling at each sampling node, problems with utilising every available morning included heavy rain (creating conditions in which it is both difficult to hear and tarsiers are less likely to be active and calling) and getting lost and missing the prime calling time on the transect.

Assessing the ability to monitor changes in the conservation value of animal communities

Introduction

Due to their geographical isolation, even during the last glaciations when sea levels dropped leaving land bridges between many islands in the Indonesian archipelago, Sulawesi and neighbouring islands show high levels of species endemicity. Some of these endemic species show very limited geographical ranges and are therefore vulnerable to even small-scale habitat loss or change. Even species with relatively wide geographical ranges may be of conservation concern if there is evidence that they are declining in a significant proportion of their range. Given the large-scale destruction of forest in Indonesia, forest specialist species may be declining in many parts of their range.

Four taxonomic groups were short-listed for inclusion in the GEF biological monitoring program:

- Birds.
- Butterflies.
- Stream macroinvertebrates.
- Herpetofauna.

Previous surveys by Operation Wallacea scientists on Buton have revealed 126 bird species including 42 Sulawesi endemics in the Lambusango and Kakenauwe Forest reserves. One species, the yellow-crested cockatoo *Cacatua sulphurea* is listed by IUCN as Endangered. There were a further 2 bird species (milky stork, *Mycteria cinerea* and snoring rail, *Aramidopsis plateni*) recorded that were in the IUCN Vulnerable category. There were a further 9 species of bird recorded in the Near Threatened category including the pale-bellied whiteye, *(Zosterops consobrinorum)* which has a world distribution restricted to just SE Sulawesi.

Sulawesi and its surrounding islands host approximately 557 species of butterfly, including 239 endemics (Vane-Wright & de Jong, 2003). From previous years' studies, Operation Wallacea scientists have found 175 species of butterfly in the Lambusango and Kakenauwe Forest Reserves, including 30 Sulawesi endemics.

Operation Wallacea scientists have been studying the herpetofauna of the Lambusango and Kakenauwe forests for several years, during which a species identification guide has been developed. Surveys have revealed high snake diversity (28 species - 48% of all terrestrial snakes found on Sulawesi) and eleven newly described species, including:

- 3 snakes (two from the genera *Calimaria* and one *Typhlops)*.
- 2 geckos (*Gehyra* sp. one of a complex of poorly understood species and probably new and *Hemiphyllodactylus* which is the first specimen of the genus from Sulawesi - only previously known from Sunda shelf).

- 4 skinks (one *Lygosoma* sp, two *Sphenomorphus* sp which are the first records from Sulawesi and one *Mabuya* sp. a genus for which there is only one previous record of an undescribed species from central Sulawesi).
- 2 frogs *Oreophryne* sp (confirmed as new species and a paper in preparation and *Rhacophorus* sp which is currently being described Iskander and Gillespie).

Rhacophorus georgii a forest interior species of frog which was thought to have been extinct since the early part of the century, was also recorded in 2001 from the Lambusango reserve. Tadpoles of this species were also seen in water bowls in hollow tree trunks. The only known populations in the world of the 11 new species and the previously considered extinct species, *Rhacophora georgii* are found in the Lambusango and Kakenauwe forests, making these forests of international importance for herpetofauna alone.

There has been very little work on stream macroinvertebrates on Buton or elsewhere in Sulawesi, and there is a high potential for discovering new species and exploring a novel ecological system. In addition, stream macroinvertebrates have been used as indicators of water quality and habitat change in catchment areas in many countries. However, their value as environmental quality indicators has not yet been evaluated in tropical rainforest streams.

The principal objective in the study of these taxonomic groups in 2004 is to assess the feasibility of using these taxa to monitor the conservation value of the forest. For some groups, such as butterflies and herpetofauna, this includes evaluating different sampling techniques. For all groups, the data will be assessed for their ability to estimate the abundance or presence of species of conservation concern (i.e. those with restricted geographical range, threats to habitat etc.). In some groups (birds and herpetofauna) local field guides have already been developed, but in other groups (butterflies and stream macroinvertebrates) there are no local field guides, and in many cases it is impossible to identify species in the field. One of the challenges for these groups is the development of field guides to facilitate the rapid identification of species during the course of the GEF biological monitoring program.

Estimating butterfly diversity and abundance

Maarten Hilbrant, Ben Wallace & Katie Reeve-Arnold

Introduction

Although butterflies are amongst the most conspicuous fauna in tropical rainforests, there are a number of problems associated with monitoring their abundance. A number of techniques have been used to sample butterflies in tropical forests including Pollard walks (fixed width line transects), baited traps (e.g. Van Sommeren traps) and capture mark recapture in study quadrats. All of these methods have sampling biases, with a tendency to under-represent canopy specialists. Even baited traps placed high in the canopy will catch biased samples consisting of those species with a preference for the particular bait used. For example, Van Sommeren traps are most commonly baited with rotting fruit and samples are strongly biased to the fruit-feeding guild of butterflies.

The timing and duration of sampling can also influence the composition and abundance of butterflies sampled. Weather conditions such as cloud cover and rainfall can have an important influence on butterfly activity, so sampling must be able to account for biases caused by variable weather conditions. This is usually done by attempting to sample under a set of standard conditions, usually on bright still days. Season can also have an important affect on butterfly availability even in the tropics. Indeed, seasonality may be particularly important for some forest specialists. Ideally, sampling should be carried out at different times of year to account for such biases.

The objectives of this study were to: 1) assess sampling techniques, 2) determine feasibility of monitoring species of conservation concern, 3) assess the temporal variability of butterfly samples at each site, 4) compare composition of butterfly communities both within and between sampling nodes, 5) explore the relationship between habitat structure and diversity and the abundance of key species, and 6) develop a field guide for identifying the butterflies of Lambusango and Kakenauwe Forest Reserves.

Methods

Although all three observers (M. Hilbrant, B. Wallace, K. Reeve-Arnold) used both Pollard walks and fruit-baited butterfly traps to sample butterfly communities, sampling effort and location differed between observers. Overall sampling effort at each sample location is summarized in Table 6 below. M.H. and B.W. concentrated sampling effort on the first kilometre of the sampling node transects, whilst K.R.-A. concentrated sampling effort along parallel 1 km transects on the study grids (see Study sites). In addition to butterfly sampling, all three observers carried out habitat surveys to characterize forest structure along sampling transects.

Pollard Walks
All recorders walked 1 km transects either along sections of sampling node transects (M.H. and B.W.) or along study grid transects (K.R.-A.). All butterflies see within 10m of the transect line were recorded. Descriptive names were given to species that couldn't be identified. Pollard walks were made at a speed of approximately five minutes per 100m section of transect (e.g. 3 m s^{-1}). However, B.W. also included five minute stops at each 100m interval and K.R.-A. included five second stops at 10 metre intervals. M.H. did not employ stops during Pollard walks.

B.W. conducted Pollard walks along the first kilometre of each transect at Anoa and Bala sampling nodes, whilst K.R.-A. conducted Pollard walks along four parallel 1 km transects separated by at least 200m on the Anoa, Lapago and Kakenauwe study grids. M.H. carried out a selection of Pollard walks along a selection of transects at the Wahalaka, Lapago, Anoa and Bala sampling nodes.

Butterfly traps
These traps consisted of a vertical tube of green mosquito netting approximately 90 cm long and 25 cm wide, closed at the top end and open at the bottom. A thin horizontal plywood board approximately 25 cm in diameter was suspended from the bottom of the tube leaving a small gap of around 2.5 cm between the board and the bottom of the net. A small cup of fruit bait was placed on the board inside the mosquito netting. The bait consisted of 2 day old fermenting banana, sugar, yeast and water mix.

Table 6. Sampling effort for butterflies. Transect sampling effort measured as number of transects sampled × number of days each transect sampled. All transects 1 km long unless otherwise stated. Trapping effort measured in number of trap-days. * trapping occurred during rainy weather. ** two different trap designs compared during dry conditions.

Site	M. Hilbrant		B. Wallace		K. Reeve-Arnold	
	Transects	Traps	Transects	Traps	Transects	Traps
Wahalaka transects	1 × 1	5	-	-	-	-
Lapago transects	1 × 1	224* 16**	-	-	-	-
Lapago grid	-	-	-	-	4 × 4	60
Anoa transects	1 (2.7km) × 2 1 × 2	0	4 × 3	120	-	-
Anoa grid	-	-	-	-	4 × 4	60
Bala transects	1 × 2 1 × 1	0	4 × 3	120	-	-
Kakenauwe grid	-	-	-	-	4 × 4	60

M.H. set 5 traps opportunistically placed for a single day at the Wahalaka sampling node, and set a further 26 traps in pairs at 100m intervals along the first 1300m of transect 3 of the Lapago sampling node. At each 100m interval one trap was placed at

ground level and the other was placed approximately 10m up into the canopy. These traps were checked daily for four days.
B.W. set 10 traps at 100m intervals along the first one kilometre of all transects on the Anoa and Bala sampling nodes. These were checked daily for three days before being removed and re-set on the next transect. Traps were re-baited daily and set approximately 1.5m from the ground.

K.R.-A. set five butterfly traps on each of the four 1 km transects at 200 m intervals (i.e. a total of 20 traps). The traps were set and baited on day one of the study at each site, checked on days 2, 3 and 4. All individuals caught were recorded, marked and released.

Forest structure surveys
All observers carried out surveys of forest structure along Pollard walk transects, though each observer used slightly different techniques.

M.H. estimated percentage vegetation cover at three heights (0-2m, 2-5m, >5m) within a 10m radius from each 50m interval along each transect sampled with a Pollard walk.

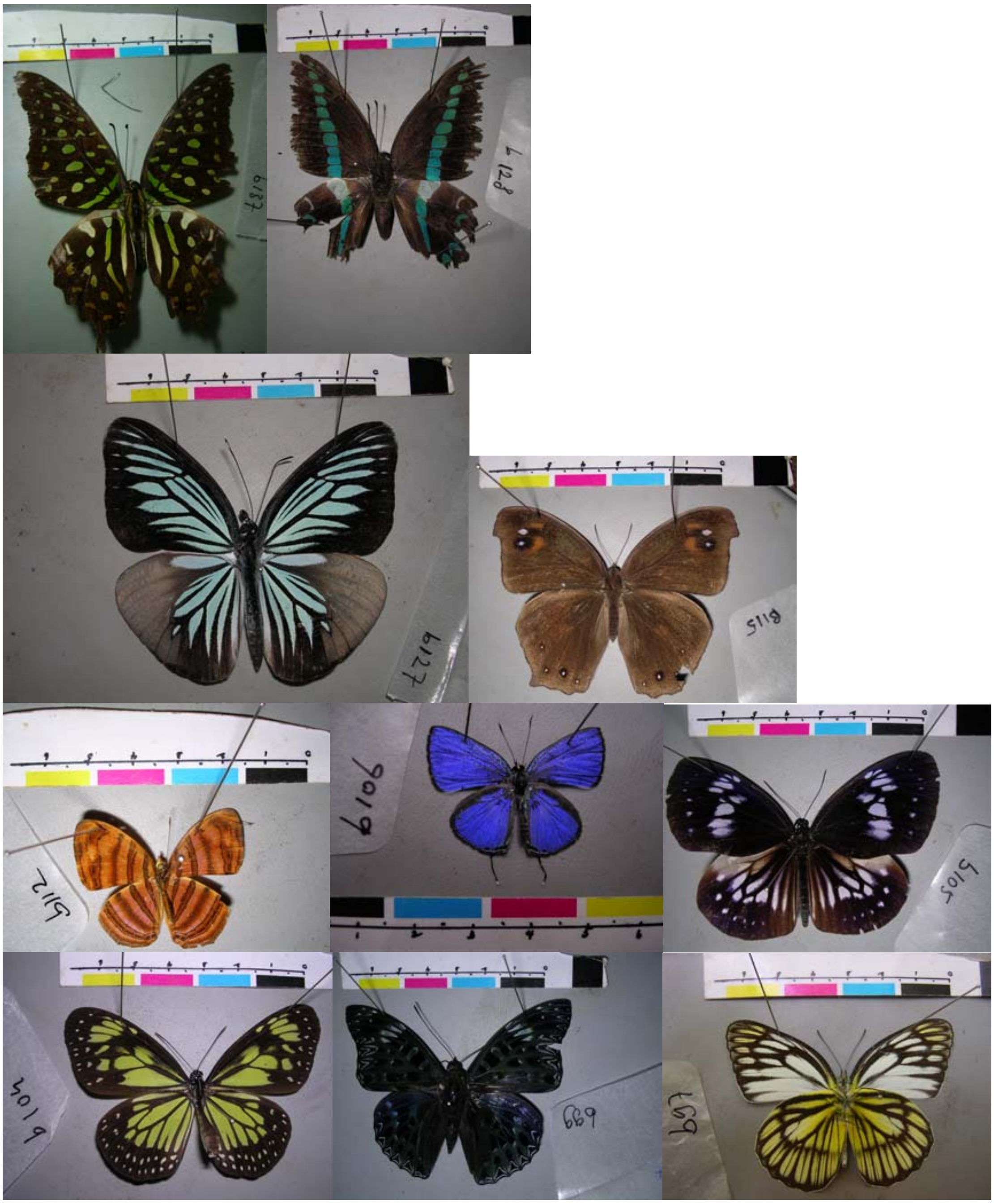
B.W. and K.R.-A. sampled forest structure within a 10m × 10m quadrat, and used the Braun-Blanquet scale to estimate percentage cover at ground level, 1-5m, 5-20m, and >20m. The average basal area of the nearest 20 trees greater than 5 cm in diameter was estimated. Each quadrat was scored for the presence of key plant 'indicator' species including pandans, ferns and palms (including rattans). Also measured was the height of the lowest birds nest ferns (lower indicates a more moist conditions), and the height and depth of moss cover on trees (higher and deeper moss cover also indicates more moist conditions). In addition the steepness of the terrain was noted as were any special features (such as dry river beds, valleys, ridges etc). The number of fallen trees along the transect lines were recorded, as were the number and size of canopy gaps. Gap size was measured using the following scale: 1 = approximately 2-5m squared gap; 2 = approximately 5-10m squared gap and 3 = approximately >10m squared gap. The weather conditions were noted for each transect walk.

B.W. sampled vegetation in quadrats placed at 100m intervals along each transect. At the Anoa study grid K.R.-A. sampled vegetation in quadrats spaced at 200m intervals. The sampling intensity was increased to quadrats at 100m intervals (i.e. 11 quadrats per transect).

Results and discussion

Due to time constraints none of the data have yet been synthesized or analysed, so very little can be reported at this stage. However, a few comments on sampling problems can be made. Pollard walks resulted in fairly high encounter rates (> 50 individuals per km walked), but obviously omitted canopy specialists. On the other hand, traps caught low numbers of butterflies (<< 10 individuals per trap day), and this is thought to be partly due to high butterfly escape rates due to poor trap design. Clearly, trap design needs to be refined and standardized. Identification was also a problem. M.H. attempted to address this by building up a photographed reference collection of adult butterflies. So far 166 specimens have been collected and photographed (Figure 8). Although some species can be identified from photographs, others, particularly from the families Lycaeanidae and Hesperidae, can only be identified from microscopic examination of the specimens themselves. These await export permits so that they may be correctly identified.

Figure 8. A selection of butterflies from the photographed reference collection.



Estimating herpetofauna diversity and abundance

Björn Lardner

Introduction

Aim

To evaluate the effectiveness and limitations of DISTANCE sampling of reptiles, as a potential part of the upcoming GEF programme for monitoring the fauna of the Lambusango forest reserve, Pulau Buton.

In the autumn of 2004, a GEF funded programme focusing on the Lambusango forest reserve of Pulau Buton, Sulawesi Tenggara, will be launched. In the following three years, studies will be performed to monitor the effects of different forest management regimes on a variety of organisms. Reptiles was listed as one of the groups that might be useful as indicators of forest change over time. I here report on a pilot study that was designed to test whether reptiles are indeed suitable group for this purpose. Since the forest streams adjacent to the camp sites were surveyed for frogs at night (although in a less rigorous way than the forest transects), notes on amphibians encountered at the sites are also included.

Objectives

1) To perform DISTANCE sampling of reptiles along line transects, and to evaluate the method's effectiveness and limitations;

2) To provide species lists of reptiles and amphibians of the sites surveyed, and an 'encounter likelihood analysis' for these species, given the current sampling effort and time available per site.

Methods

As part of the Operation Wallacea programme, four sampling nodes within the Lambusango Forest Reserve and neighbouring limited production forest were visited for ca. 9 days each (Camp Wahalaka, Camp Lapago, Camp Anoa and Camp Bala), and an additional survey was conducted in the Kakenauwe Forest Reserve.

Due to the limited time available at each site, pitfall trapping was considered unsuitable; instead, 'DISTANCE sampling' was chosen as the inventory method. This is basically a line transect survey where animals encountered (seen) on or along the trail are recorded. The key feature of DISTANCE sampling is however that for each observation, the actual perpendicular distance from the animal in focus to the transect centerline is noted. For each species, the distribution of distance measures on both sides of the transect line (plotted as a bar histogram) will reveal the actual *width* of the effective transect (Thomas *et al*. 2002). This information allows actual population densities (number of animals of a given species per unit area) to be calculated.

I also attempted a complimentary inventory technique at one of the sites (Lapago): leaf litter removal quadrats. This was done by marking out plots of 5 x 5 metre, and then by hand removing all the leaf litter in an attempt to find small and cryptic amphibians and reptiles that might dwell in the litter. A total of seven such plots were surveyed with the aid of volunteers, the duration of which was over 20 'person hours'. No animals were however found by this method, and it was therefore considered too ineffective to motivate proceeding with it at the other sites.

Given that many animals were encountered outside the formal transect surveys (for example, when tracking back after a transect survey), a list of observations made during the entire stay at each camp site will be compiled for the final report. This can give additional information on the likelihood of encountering species that are not seen often enough to allow any proper population density estimates. This list will also include observations done during the night in the forest as well as along the streams adjacent to the camp sites.

Initial results

The five sites visited differed in that only three of them (Lapago, Anoa and Kakenauwe) had a grid system of trails, whereas the remaining two (Wahalaka and Bala) only had a set of line transects (4 transect lines, each 3 km long; transect lines parallel and separated by 1 km). For the vast majority of reptiles, independent data can be sampled over much smaller scales than the 3 x 3 km area that these transect lines covered.

For effectiveness, in ***Wahalaka*** I thus attempted to set up a system of shorter transect lines, covering an area of ca 200 x 300 m (total transect length 1200 m). While I planned to survey this transect system repeatedly to gain data on observation repetability, adverse weather conditions (heavy rain for much of the time) and a medical problem caused sampling efforts to be way too low to allow any analysis of reptile densities. Thus for Wahalaka, only a list of species encountered is provided (Appendix 1).

In ***Lapago*** a total of 18 km of transect lines were walked during the day. (Night forest transect surveys proved extremely unproductive and are not reported on specifically; observations from these merely enter the species list.). The only species that was encountered in large enough numbers to generate a population density estimate with a reasonably narrow confidence interval (requiring at least 50, preferrably over 80 observations; Buckland *et al*. 1993) is the small forest skink *Sphenomorphus variegatus* (Table 7).

In ***Anoa*** a total of 29.8 km of transect lines were walked during the day. Also here, the only species that was encountered in large enough numbers to generate a population density estimate with a reasonably narrow confidence interval was the skink *Sphenomorphus variegatus* (Table 8).

In ***Bala***, only three of the four transects were surveyed (one of them twice); the total distance being 10.7 km (including the "pseudoreplicate" of one transect). As for the previous sites, *Sphenomorphus variegatus* was the only species common enough to qualify for a solid population density analysis (Table 9). Even if all four transects had been surveyed, the total transect distance would have been merely 12 km (1.3 km more than the present data is based on) - thus, the conclusion would most certainly have been the same.

Table 7. Reptiles (and amphibians) encountered during day transect surveys in Camp Lapago 19 - 28 July 2004.

Species	Number of Individuals	Individuals per km transect	Individuals per hour transect
Sphenomorphus variegatus	73	4.04	2.67
Eutropis rudis	16	0.89	0.59
Oreophryne sp. nova	8	0.44	0.29
Skink sp.	5	0.28	0.18
Sphenomorphus cf. *temmincki*	5	0.28	0.18
Eutropis sp. nova	4	0.22	0.15
Bufo celebensis	3	0.17	0.11
Dendrelaphis pictus	2	0.11	0.07
Rana cf. *chalconota*	2	0.11	0.07
Ahaetulla prasina	2	0.11	0.07
Skink cf. "stout" *S. temmincki*	1	0.06	0.04

Table 8. Reptiles (and amphibians) encountered during day transect surveys in Camp Anoa 2 - 11 August 2004.

Species	Number of Individuals	Individuals per km transect	Individuals per hour transect
Sphenomorphus variegatus	69	2.32	1.94
Sphenomorphus cf. *temmincki*	22	0.74	0.62
Eutropis rudis	5	0.17	0.14
Eutropis sp. nova	4	0.13	0.11
Oreophryne sp. nova	3	0.10	0.08
Rhabdophis chrysargoides	2	0.07	0.06
Tropidolaemus wagleri	2	0.07	0.06
Psammodynastes pulverulentus	1	0.03	0.03

Rana cf. *chalconota*	1	0.03	0.03
Limnonectes modestus	1	0.03	0.03

Table 9. Reptiles (and amphibians) encountered during day transect surveys in Camp Bala 19 - 23 August 2004.

Species	Number of Individuals	Individuals per km transect	Individuals per hour transect
Sphenomorphus variegatus	48	4.49	4.44
Eutropis rudis	24	2.25	2.22
Sphenomorphus cf. *temmincki*	8	0.75	0.74
Skink sp.	2	0.19	0.18
Eutropis sp. nova	1	0.09	0.09
Varanus salvator	1	0.09	0.09
Psammodynastes pulverulentus	1	0.09	0.09

Finally, transect surveys of totally 14.3 km were performed on the existing trail grid in the ***Kakenauwe Forest Reserve***. Also here, an effort comparable to the 12 km of transects available at new nodal camps (such as Wahalaka and Lawele) will only generate sufficiently good density estimates for *Sphenomorphus variegatus* (Table 10).

Table 10. Reptiles encountered during day transect surveys in Kakenauwe Forest Reserve between 30 August and 07 September 2004.

Species	Number of Individuals	Individuals per km transect	Individuals per hour transect
Sphenomorphus variegatus	67	4.69	4.72
Eutropis rudis	40	2.80	2.82
Skink sp.	7	0.49	0.49
Sphenomorphus cf. *temmincki*	4	0.28	0.28
Eutropis sp. nova	4	0.28	0.28
Elaphe jansenii	1	0.07	0.07

Four amphibian individuals and five reptile individuals have been collected for identification / reference (4 *Rana* cf. *chalconota*, 2 *Gehyra* sp.; 2 *Cerberus rynchops*, and 1 *Typhlops* sp.).

Preliminary conclusion & discussion

It stands clear that Distance Sampling will only yield a population density estimate with a sufficiently narrow confidence interval (to be useful) for the forest skink *Sphenomorphus variegatus*. This assumes that the sampling effort is similar to the one used here. For all other species, the number of observations is lower than 50 individuals per site; thus the confidence intervals will likely be so large (see Buckland *et al*. 1993) that the density estimate is not useful for monitoring changes in populations over a time span of merely a few years.

The final report will also test what effect weather and time of the day has on the observation rates of the different skink species. This is of paramount interest, since Distance Sampling rests on the assumption that *all* individuals on the actual transect centerline is detected. We know already now that this assumption is violated to some extent: some animals are most likely not active on the surface, but (in case of skinks) hiding under the leaf litter or in holes, or - for some arboreal taxa - higher in the trees than allow observations of them. Hopefully a more detailed analysis can help assess how much the assumption is violated, and what species are most severely affected by this. After conducting such an analysis, I can address the question - suggested by the encounter rates per kilometer - if the common skinks *Sphenomorphus variegatus* and *Eutropis rudis* are indeed less common at Camp Anoa than at the other sites. If so, this *might* simply be due to the rather high altitude of Anoa - the temperatures there tended to be somewhat lower than compared to the other sites.

What can (and will) be done is to summarize the number of observations of each species for each camp (both during formal transects and during the remaining time at a site) to see what species - given a similar effort and / or time, and equal weather conditions - are likely to be observed (using a binomial test, contrasting the observed numbers with no observation at all).

Appendix 1. Species list of amphibians and reptiles encountered at the five forest reserve sites visited 2004 as well as LaBundo-Bundo village including surroundings. Sites are coded as follows: Wa = Wahalaka (05°22'S, 112°50'E); Lp = Lapago (05°13'S, 112°52'E); An = Anoa (05°17'S, 112°51'E); Ba = Bala (05°16'S, 122°57'E); Ka = Kakenauwe Forest Reserve (05°11'S, 122°54'E); La = LaBundo-Bundo village and surrounding coastal area.The first four sites are all within the Lambusango Forest Reserve area.

Site:	Wa	Lp	An	Ba	Ka	La
Amphibians						
Bufo celebensis	X	X	X	X		
Oreophryne sp.*	X	X	X	X		
Limnonectes cf. *grunniensis*	X	X	X	X		X
Limnonectes cf. *modestus*	X	X	X	X		X
Rana cf. *chalconota* **	X	X	X	X		X
Rhacophorus cf. *monticola*	X	X	X	X		
Rana canrcivora						X
Reptiles						
Varanus salvator		X		X		X
Cyrtodactylus jellesmae		X	X			X
Gehyra sp.		X			X	
Hemidactylus frenatus						X
Draco sp.*		X		X	X	X

Emoia atrocostata						X
Eutropis multifasciata					X	X
Eutropis rudis	X	X	X	X	X	X
Eutropis sp.***		X	X	X	X	
Lamprolepis smaragdinum						X
Sphenomorphus cf. *temmincki*	X	X	X	X	X	
Sphenomorphus variegatus	X	X	X	X	X	
Sphenomorphus tropidonotus				X	X	
Typhlops sp.***					X	
Ramphotyphlops braminus						X
Xenopeltis unicolor						X
Cylindrophis melanotus		X				
Python reticulatus	X		X	X	X	X
Ahaetulla prasina		X		X	X	X
Chrysopelea paradisi celebensis						X
Boiga irregularis		X				
Boiga dendrophila gemmicincta						X
Cerberus rynchops						X
Calamaria sp.****	X					
Dendrelaphis pictus		X				X
Elaphe erythrura celebensis						X
Elaphe janseni					X	
Psammodynastes pulverulentus	X	X	X	X	X	
Oligodon waandersi		X		X		
Rhabdophis chrysargoides	X	X	X	X		
Xenochrophis trianguligera		X	X			
Tropidolaemus wagleri			X			
Cuora amboinensis		X		X		
Site:	Wa	Lp	An	Ba	Ka	La

* Probably a new, yet not formally described taxon.
** Probably a distinct (new) taxon; I will continue studying the systematics of this and related forms.
*** A taxon awaiting formal description.
**** Either *C. brongersmai* or *C. nuchalis*; ID will be attempted later from photos.

It may be noted that no streams were surveyed within the Kakenauwe area (most if not all streams in the area were probably dry due to the well-progressed dry season), therefore the lack of amphibians at this site.

Estimating bird diversity and abundance

Henry Ali Singer & Alwyn Craven

Introduction

The Wallacea region is well known for its highly distinctive biogeography. The area forms a boundary between two primary zoological regions, the oriental and Australasian and the avifauna reflects influences from both these regions. Deep sea trenches have caused the region to be separated from the large land masses surrounding it for a considerable period of time which has resulted in uniquely high levels of endemism across many of the taxa present. In particular, the Sulawesi subregion, including Buton has the highest degree of endemicity of any other comparable land area on earth, with birds reflecting this to the highest degree (Coates and Bishop 1997). Buton island is known to support 232 land and freshwater bird species (Baltzer 1997) including 52 Sulawesi endemics, 19 near threatened species and two endangered species as classified by the IUCN (IUCN, 2002), making it an extremely important site for bird conservation.

Unfortunately, much of the forest in the region is under-threat from logging and habitat destruction. On the Lambusango reserve where the study sites were located the main threats are forest clearance, selective logging and rattan collection. At present the reserve is designated as a protected area, which only offers a relatively low level of protection. One of Operation Wallacea's objectives is to increase the level of protection for the Lambusango reserve using a donation from the GEF and by implementing a novel management plan to ensure the areas future protection.

Bird communities are well known to be good indicators of levels of both natural and human disturbance and habitat degradation (Furness and Greenwood 1993). Operation Wallacea has been studying the avifauna of Buton every year since 1995. In particular, the point count method has been used extensively in the Lambusango reserve since 2001. Previous studies on the Lambusango reserve (e.g. Gregory 2002) have shown dissimilarity between bird community composition on sites of differing disturbance, with a slight trend towards a maximum diversity with limited disturbance. Monitoring the bird communities within the reserve and looking at how disturbance and habitat change may influence bird diversity and abundance, particularly of restricted range species should provide valuable data on which to base the future management of the reserve.

During May and June 2004 five study areas were set up on the reserve, each chosen to represent areas with differing levels of both natural and human disturbance, past and present. Three of these study areas, Anoa, Bala and Lapago were used to monitor the avifaunal species diversity, composition and abundance. Some initial data was also taken from a fourth site called Wahalaka but the weather conditions were found to be unsuitable.

Aim

To determine the effect of forest disturbance on species diversity, species composition and population densities of the avifauna of the Lambusango Forest Reserve.

Objectives

- To determine whether the total number of species differs between the three sites.
- To determine whether the species composition differs between the three sites.
- To determine whether the population densities of certain species differs between the sites.
- To classify the habitats both between and within sites using vegetation surveys and to link this to levels of human disturbance.
- To find how the avifaunal abundance and diversity can best be linked to different habitat classes and at what scale this is most effective.
- To look for certain restricted range species which may only be present in the most undisturbed areas and which may be used as indicators of important habitat to protect.

Methods

Study site

The study was conducted during the months of August and September 2004. Three study areas were used, located in three different areas of the Lambusango reserve. These were Anoa, Bala and Lapago. In each there were four 3km transects spaced at 1km intervals and running in parallel to each other. Point counts were conducted at 400 metre intervals along each transect. Six point counts were completed for each transect going from 0 to 2000 meters. Point counts were repeated at each transect.

Bird counts

The point counts were conducted between 5.30 and 8.00 am during which time the dawn chorus is at its most vocal. Each point count lasted for ten minutes with an additional two minute settling period prior to starting to reduce the observer influence. The time of each point count was recorded and the weather conditions were noted down. The compass bearing and estimated distance from each bird identified by sight or call was recorded. If several birds were calling from the same location, the estimated number of birds was recorded. The counts were always conducted by two observers, one of which was always an experienced observer.

The data collected on species, number and distance from the observer will be analysed using DISTANCE software to generate population density estimates.

Some group size data was collected during morning and afternoon walks at various sites, this will be combined with data collected from previous years to give an estimate of group sizes for social species heard calling together.

Vegetation surveys

Vegetation surveys were carried out at the site of each point count. At each site five 10m by 10 m quadrats were measured out along a 50 m transect line with the centre of this line bisecting the centre of the point count.

In each quadrat the following data were collected:

- % Sky
- % Bare ground
- % Bare rock
- % Litter cover
- % Vegetation cover < 1 m.
- % Vegetation cover 1 - 5 m.
- % Vegetation cover 5 - 20 m.
- % Vegetation cover > 20 m.

(All percentage covers measured on the Braun-Blanquet scale).

- A count of the number of birds nest ferns and an estimate of the height of the lowest.
- An estimate of the abundance of epiphylls.
- An estimate of the maximum thickness of moss and the maximum height to which it was growing.
- A note on the presence or absence of rattan and the maximum height to which it was growing.
- The height of the tallest tree calculated using a clinometer and an estimation of the distance from the observer to the base of the tree.
- The gradient, the aspect and the terrain position.
- The circumferences of all the trees greater than 15.7 cm in circumference.
- The presence or absence of Pandanus, ferns, tree ferns and palms.
- A general site description.

This habitat data will be grouped at several different levels in order to characterise and compare the habit differences both between sites and within sites.

Initial Results

Habitat surveys

The three areas of forest studied, Anoa, Bala and Lapago show several differences. Anoa is the most difficult to access by humans. It has the highest altitude and the coldest temperatures. Human disturbance happened a long time ago in Anoa as shown by the presence of large palm trees. The habitat data suggests that the atmosphere at Anoa is moister with more bird's nest ferns and a greater height and thickness of moss.

Bala contains some of the closest forest to primary rainforest. The trees are taller with the largest circumferences. Tree ferns were only found in the Lawele transects. However Lawele has better access than Anoa and taller and more abundant rattan suggesting that it may currently be the most disturbed by rattan collectors.

Lapago has the easiest access for humans and its location is the closest to human habitation. The trees are shorter than at the other two sites suggesting that logging may have been more common at this site. Chainsaws were heard most frequently at Lapago. There is probably the most potential for human disturbance at Lapago, however the rattan is less tall and plentiful than at the other two sites. Lapago is at the lowest altitude and as a result has slightly warmer temperatures.

A much more detailed analysis of the habitat data is needed before any proper conclusions can be drawn.

Bird surveys

During the period between June and September 2004, 60 bird species were recorded in the Lambusango reserve. Of these 60 species, 46 were recorded during point counts. At Anoa 46 species were recorded in total and 38 recorded during point counts. At Lapago 51 species were recorded in total and 39 recorded during point counts. At Bala 46 species were recorded in total and 36 recorded during the point counts.

Of the 46 species recorded during point counts, 31 occur at all three sites, 3 are unique to Lapago, 3 unique to Bala but none are unique to Anoa.

Of the total 60 species, 30 are endemics, 20 species are endemic to the Sulawesi subregion, 8 species are endemic for Sulawesi and the Sula Islands, one species is endemic for South east Sulawesi and one species is endemic for Indonesia.

Four species were recorded that are classified by the IUCN as 'near-threatened'. These are Jerdon's Baza *Aviceda jerdoni*, Sulawesi Hawk eagle *Spizactus lancolatus*, Pied Cuckoo Shrike *Coracina bicolour* and the Sulawesi white eye *Zosterops consobrinorum*. The yellow Crested Cockatoo *Cacatua sulphurea* classified by the IUCN as endangered was not recorded this year although it had been in 2002 and several years before.

Jerdons Baza and the Sulawesi Hawk Eagle were only recorded once each, on the Lapago and the Bala transects respectively. Both the Pied Cuckoo Shrike and the Sulawesi White eye were found to be common in the reserve, each was recorded on every transect line. This should enable good density estimates for these two species to be calculated.

The initial results show that there are some differences in abundance between sites for certain species. For example the Pied cuckoo shrike and the Sulawesi White Eye were both more abundant on the Anoa transects than at either other site.

A much more detailed analysis of the results is needed before any definite conclusions can be drawn.

Recommendations

To continue monitoring bird diversity and abundance in the lambusango and Kakenauwe reserves using the point count method.

To expand the bird project into new areas such as:

- The study of species home range and behaviour using radio telemetry.
- The use of sonographic analysis to study more about bird calling patterns.
- A more detailed study of the conservation needs of the endemic and threatened species on Buton.

Estimating stream macroinvertebrate diversity and abundance

Kate Hoyle & Fiona Culhane

Introduction

Macroinvertebrates form many of the key links in aquatic food chains, and their diversity and abundance are therefore crucial to maintaining a balanced, functioning and healthy river ecosystem (Chessman 1995). Benthic macroinvertebrates are widely used as a bioassessment tool for the monitoring of stream condition and water quality. The technique is based on the use of biological responses to characterise the status water resources and evaluate changes in the environment associated with anthropogenic perturbance.

While observed changes in macroinvertebrate community structure may be used to monitor affects of anthropogenic disturbances, there are many structuring forces influencing macroinvertebrate community dynamics, and the recognition of the existence of natural variability in the ecological features of undisturbed aquatic systems is essential (Resh et al. 1995). Stream dwelling macroinvertebrates are distributed according to environmental factors that operate at different spatial scales. Macroinvertebrate assemblages are related to a wide range of factors including geographic region, land use, stream size and order, geomorphology, hydrography and fluvial processes, physico-chemical variables and biological interactions. It is therefore difficult to identify human-induced stresses on stream fauna assemblages without a prior understanding of the natural template which may be constraining communities.

Macroinvertebrate community monitoring has been included as an element within a proposed project aimed at conserving forest biodiversity and monitoring effects of forest disturbance within the proposed 60 000 ha Lambusango Forest Management Area on the island of Buton, southeast Sulawesi. Large-scale anthropogenic disturbance or pollution of rivers within the existing reserve would be expected to be unlikely, however activities such as rattan collection and soaking and selective timber harvesting may be expected to have localised effects including alteration or loss of riparian vegetation, alteration of substratum characteristics and sedimentation. In Indonesia as a whole, the approach to water resources management has been based largely on physical and chemical assessment, with little knowledge of ecological conditions or impacts (Walsh et al. 2002). Over the last decade a small number of studies have begun using benthic macroinvertebrates to assess river conditions in Indonesia (eg Sudaryanti et al. 2001; Walsh et al, 2002), however these have all been conducted in East Java. There has been very little investigation of lotic macroinvertebrate communities on Buton, and information about distribution or ecology is extremely limited. This survey of macroinvertebrates in three rivers within the Lambusango Forest Reserve is a first step towards addressing this knowledge gap.

Objectives

1. To collect baseline data on macroinvertebrate community structure in three catchments and Odonata community structure in five catchments in and around the Lambusango Forest Reserve and establish a working reference collection of taxa encountered.

2. To investigate the potential for macroinvertebrate communities to be used as a monitoring tool for assessing forest disturbance within the proposed Lambusango Forest Management Area.
3. To assess the feasibility of sampling methods for any ongoing macroinvertebrate community monitoring program in the proposed Lambusango Forest Management Area.

Two separate studies were carried out; one examined the complete marcrobenthos community (Kate Hoyle), the other focused on the aquatic larval stages of Odonata (dragonflies and damselflies). Although these two studies have similar objectives, and share similar sampling techniques, samples were taken from different sites. Where necessary different accounts will be given for general macrobenthos and Odonata in the sections below.

Methods

Study area

Macrobenthos

Sampling was conducted during July and August 2004 on three rivers within the Lambusango Forest Reserve, Buton. Sites were located up and downstream of temporary node camps set up by Operation Wallacea for the purpose of biological monitoring within the reserve and for the purposes of this report sites have been named to correspond with these camps: Wahalaka Upstream (WU), Lapago Upstream (LPU), Lapago Downstream (LPD), Anoa Upstream (AU) and Anoa Downstream (AD). Sampling details are outlined in Table 11. At WU and AU, two riffle and two edge samples were taken from a 100m reach of stream. Two riffle and two edge samples were also taken from LPU and LPD, however at each site one pair of riffle and edge samples were taken from two separate 100m stream reaches due to a lack of suitable sampling habitat in a single 100m reach. Only one riffle and one edge sample were taken from AD due to time restrictions.

Odonata

Methods

In total seven catchment areas were sampled. These included:

Anoa base camp river (Forest).

Anoa transect 4 river (Forest).

La Pago base camp river (Forest).

Bala base camp river (Forest).

River Tondo - transect 1 and 2 Bala node (Forest).

Wakangka river (Padi).

La dunkula river (Cultivated land near Labundo bundo village).

Sampling

Macrobenthos

A habitat assessment was conducted at each 100m sampling reach, consisting of a general site description noting important features, site diagram and standard set of habitat variables outlined in Table 12. Map-derived data including altitude, stream order, distance from source and upstream catchment area will also be compiled for each site.

Table 11. Macroinvertebrate sampling details within the Lambusango Forest Reserve.

Site	Habitat	Replicate	Sample date	Sample code
Wahalaka Upstream	Riffle	1	13/7/04	WUR1
Wahalaka Upstream	Edge	1	13/7/04	WUE1
Wahalaka Upstream	Riffle	2	14/7/04	WUR2
Wahalaka Upstream	Edge	2	14/7/04	WUE2
Lapago Upstream	Riffle	1	19/7/04	LPUR1
Lapago Upstream	Edge	1	19/7/04	LPUE1
Lapago Upstream	Riffle	2	20/7/04	LPUR2
Lapago Upstream	Edge	2	20/7/04	LPUE2
Lapago Downstream	Riffle	1	21/7/04	LPDR1
Lapago Downstream	Edge	1	22/7/04	LPDE1
Lapago Downstream	Riffle	2	21/7/04	LPDR2
Lapago Downstream	Edge	2	21/7/04	LPDE2
Anoa Upstream	Riffle	1	2/8/04	AUR1
Anoa Upstream	Edge	1	2/8/04	AUE1
Anoa Upstream	Riffle	2	4/8/04	AUR2
Anoa Upstream	Edge	2	4/8/04	AUE2
Anoa Downstream	Riffle	1	3/8/04	ADR1
Anoa Downstream	Edge	1	3/8/04	ADE1

Macroinvertebrates were sampled over 10m of riffle or edge habitat using a kick net with 320 x 280 mm opening and 1mm mesh. For riffle samples, the substratum was disturbed by kicking to dislodge macroinvertebrates while holding the collecting net immediately downstream of the feet. Edges were sampled by sweeping the same net from open water towards the bank, stirring up deposits of silt and detritus on the stream bed in the process. All samples were sorted completely in the field. Net contents were emptied into white sorting trays and all macroinvertebrates were picked out and preserved in 70% ethanol for identification in the laboratory. With the exception of Oligochaeta (class), Acarina (order) and Turbellaria (class) macroinvertebrates were identified to the lowest taxonomic level possible using available keys, usually morphotypes within family or subfamily, and a reference collection established.

Analyses of spatial patterns were conducted using simple biological measures such as number of individuals and number of taxa, and a multivariate analysis of similarity of community composition (still to be completed).

Odonata

At each site four samples were taken (two from riffle and two from edges). The samples were standardized 5 minute kick samples in riffle areas and net scrapes along the edges of pools. At the Bala base camp river eight samples were taken (four riffle and four edge) at different points along the stream.

Table 12. List of habitat variables measured for each 100m sampling reach.

Variable	Comment
Riparian vegetation	General description; density and thickness estimates
Overhanging vegetation	% cover over 100m study reach
Trailing vegetation	% cover over 100m study reach
Aquatic vegetation	% cover over 100m study reach
Woody debris	% cover over 100m study reach
Stream width	Taken at 0, 50 and 100 m over study reach
Channel width	Taken at 0, 50 and 100 m over study reach
Maximum depth	Taken at 0, 50 and 100 m over study reach
Reach habitat area	Proportion riffle, pool and run in study reach
Substrate composition	Adapted Wentworth classification; Proportion bedrock, boulder, cobble, pebble, gravel, sand, silt/clay in study reach
Velocity ranking	Number of categories present: fast deep, fast shallow, slow deep, slow shallow

Preliminary results

Habitat

Macrobenthos

None of the sites sampled showed obvious evidence of significant anthropogenic disturbance, with the exception of localised sections of stream intersected by track crossings at all camps where minor alterations of substratum and erosion of stream banks were observed. Although the rainforest at each node was not considered primary, with the surrounding land showing evidence of historical or current human activity (B. Carlisle, pers. comm.), riparian vegetation at each of the sampling sites generally appeared undisturbed.

At the point of sampling, the river at Wahalaka node camp was approximately 10m wide, with relatively deep riffles interspersed with a majority of run and very little pool habitat. Each of the four velocity categories outlined in Table 12 was present in the 100m study reach. The stream bed consisted of predominantly cobble, some boulder and smaller amounts of pebble, gravel and sand. The riparian vegetation was primarily intact rainforest of sparse – moderate density with a small cleared patch at a crossing immediately downstream of WUR2. Overhanging vegetation covered approximately 50% of the stream reach, with 10% or less of trailing or aquatic vegetation or woody debris. Wahalaka was sampled following more than 7 days of moderately heavy rainfall; WUR1 and WUE1 were sampled in less than ideal conditions while the river was in spate, while WUR2 and WUE2 were sampled the following day when the river had dropped substantially.

At the Lapago Upstream site, LPUR1 and LPUE1 were sampled approximately 500m upstream of a section of river characterised by tufa bedrock waterfalls interspersed with relatively wide, deep pools, while LPUR2 and LPUE2 were sampled approximately 50m upstream of this section. Moderate rainfall had been experienced in the week prior to sampling; however the river level was low at the time of sampling and flow ceased several days after sampling. Both 100m study reaches were approximately 6m wide and 0.2m deep, dominated by pool habitat interspersed with slow, shallow riffles and runs. Only two velocity categories, slow shallow and slow deep were present in both reaches. Riffle sample substrates were dominated by cobble, while edges were characterised by a gravely substrate. Riparian vegetation consisted of intact sparse-moderate rainforest at both reaches, although overhanging vegetation provided 75% cover at LPUR1 and LPUE1 and only 40% cover at LPUR2 and LPUE2. Aquatic vegetation cover was less than 5% at LPUR1 and LPUE1, while algae comprised 50% cover in the LPUR2 and LPUE2 sample reach. In both reaches trailing vegetation comprised less than 5% cover and woody debris 20% cover.

The Lapago downstream site was located in a slow flowing, relatively shallow section of river immediately surrounded by primarily intact sparse-moderate rainforest vegetation. LPDR1 and LPDE1 were sampled approximately 500m upstream of LPDR2 and LPDE2. At the LPDR1 and LPDE1 study reach, overhanging vegetation was approximately 50%, with higher level canopy vegetation absent from a substantial section of one bank due to tree falls. Overhanging vegetation cover in the LPDR2 and LPDE2 study reach was 70%. Trailing vegetation, aquatic vegetation and woody debris provided minimal cover in both reaches. The LPDR1 and LPDE1 study reach was approximately 6m wide and dominated by run habitat with equal smaller areas of riffle and pool. The substrate was dominated by 40% cobble and gravel respectively, and all velocity categories except fast deep were present. At the LPDR2/E2 sampling location, equal amounts of run and pool dominated the reach habitat area, with only 15% riffle, while the substrate was comprised of 70% gravel, some cobble and small amounts of tufa bedrock and boulder. Fast deep was the only absent velocity category in this study reach.

Sampling at Anoa took place at an approximate altitude of 500m, roughly 300m above both Wahalaka and Lapago. The site was located on a small tributary very close to its source, and the stream was dry approximately 100m above the most upstream sampling point. Both the Anoa upstream and downstream sites were surrounded by intact rainforest with a visibly denser riparian understorey than at Lapago or Wahalaka, although trailing and aquatic vegetation cover was still 15% or less at both sites. River level was quite low at the Anoa upstream site, with an average stream width of 3.9m and depth of 0.2m. This site consisted of 50% pool and roughly equal areas of riffle and run and a substrate dominated by cobble, followed by smaller amounts of gravel, pebble, boulder and bedrock. The Anoa downstream site was located among a series of tufa waterfalls and deep wide pools, in a section of river with more substantial flow. The riffle habitat was not typical of previously sampled riffles, the sample taken in a narrow side channel adjacent to a pool and across the top of a small tufa waterfall. The side channel consisted of cobble-sized pieces of tufa rock stuck together, which disintegrated to sand/silt when kick sampled. The edge sample was taken along the undercut banks of the pool, above a mainly gravel/silt substrate.

Odonata
The study sites included five forested catchment areas, one catchment area with a significant area of padi fields, and one catchment area with a significant area of cultivated land (mostly coconut and cashew groves). More detailed habitat descriptions (large-scale and local) of river sampling sites will be available with the final report.

Macroinvertebrates

Macrobenthos

The diversity of macroinvertebrate stream fauna on Buton is relatively high, with a total of 100 different taxa (including morphotypes within families) identified from three rivers within the Lambusango Forest Reserve. Of these, the Coleoptera and Diptera were the most diverse orders, with 11 (provisional IDs included) and 14 families and/or subfamilies respectively, not including morphotypes. Among the Odonata, 5 Zygopteran and 4 Anisopteran (including the family group Libellulidae/Corduliidae) families were detected, while 9 Trichopteran and 5 Hemipteran families were identified. Ephemeropterans were common but predictably less diverse, with three families identified while two Plecopteran families were found in low numbers in riffle samples only at Wahalaka, a result which is both unexpected and as yet unexplained. It should be noted that identification has taken place on Buton with a lack of available lower taxonomic level information or expertise on Indonesian macroinvertebrates and it is likely that further examination of samples would reveal more taxa than have been identified currently. It is also likely that a number of the taxa collected are endemic to Sulawesi and/or undescribed species.

Table 13. Numerically dominant taxa in each of the three rivers surveyed (initial data inspection).

Wahalaka	Lapago	Anoa
Atyidae A Athericidae A Philopotamidae A Leptophlebiidae spp Libellulidae/Corduliidae spp Platystictidae A Simuliidae spp	Atyidae A Baetidae A Calamoceratidae A Hydropsychidae B Leptoceridae A Leptophlebiidae spp Libellulidae/Corduliidae spp Platystictidae A Psephenidae A Simuliidae spp	Atyidae A Baetidae A Hydropsychidae B Leptophlebiidae spp Libellulidae/Corduliidae spp Psephenidae A Simuliidae spp

At the river level (sites and habitats pooled), a total of 59 taxa were identified from Wahalaka (4 samples in total), 77 from Lapago (8 samples in total) and 75 from Anoa (6 samples in total). It should be noted that the WUR1 and WUE1 samples from Wahalaka were likely to have been depressed due to the condition of the river at the time of sampling. Table 13 lists the taxa considered numerically dominant at each site, although this is based only on a preliminary visual inspection of the data. Figure 9 provides an initial indication of the distribution of taxa across rivers. The majority of the 100 taxa identified (41) occurred at all three sites and this group included all of the taxa listed in Table 13. Nineteen taxa occurred at Lapago and Anoa but not Wahalaka, with smaller numbers at Lapago and Wahalaka but not Anoa (7) and Anoa and Wahalaka but not Lapago (3). Anoa contained the highest number of taxa not found in either of the other two rivers (12), followed by Lapago (10) and Wahalaka (8).

Initial comparisons of number of taxa and number of individuals at a sample level are presented in Figure 10 and Figure 11. In general, riffle samples produce a higher number of taxa than edge samples. Initial observations in the field however suggest that edge samples, as expected, produce a different macroinvertebrate community structure, with numerous taxa not encountered in riffles.

Figure 9. Number of taxa occurring in only one river (A = Anoa; LP = Lapago; W = Wahalaka), in two out of three rivers, or in all three rivers surveyed (total number of taxa encountered = 100).

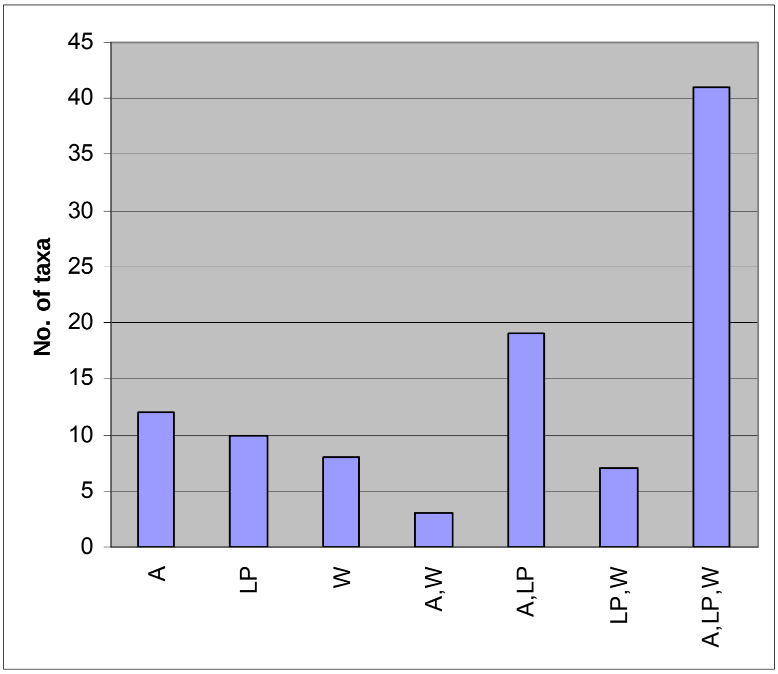
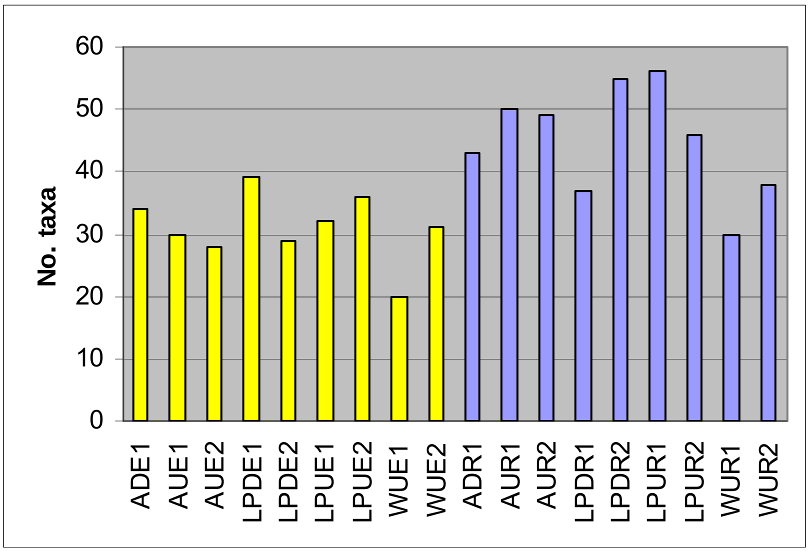
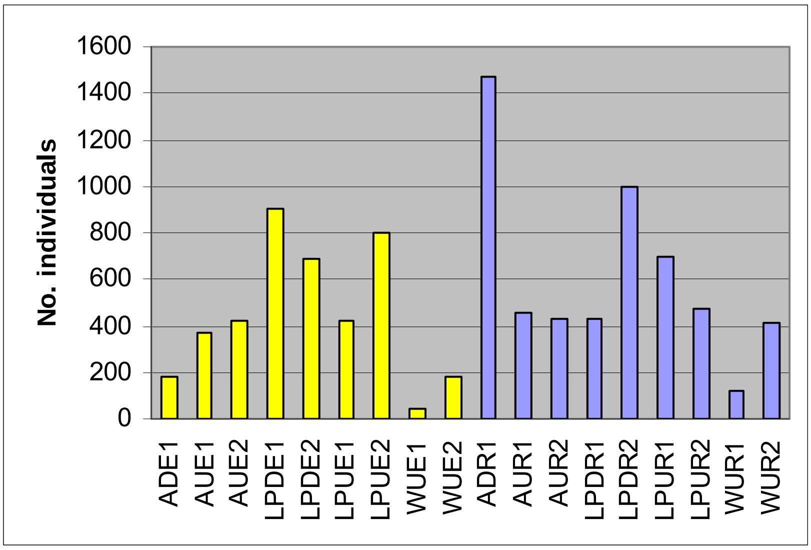


Figure 10. Number of taxa collected in each sample.



Other than the lower taxa numbers encountered at WU1, number of taxa for both edge and riffle samples appears relatively comparable across sites. Within sites, there is little variability between AU1 and AU2, while variability between replicates at LPD and LPU (taken from separate 100m stream reaches) is more substantial, especially for riffle samples. Number of individuals is generally lower in Wahalaka samples, again most likely due to the unfavourable weather conditions experienced prior to sampling. Once again variability is low between Anoa upstream samples, with all samples containing approximately 400 animals. The Anoa downstream riffle sample contained an unusual abundance (over 1000 individuals)of Simuliidae (black fly larvae) while the Lapago upstream and downstream edge samples all contained between 250-550 Atyidae (shrimp), accounting for much of the variation in total number observed. The high number of individuals at LPDR2 and LPDR1 cannot be explained by the unusual dominance of any one taxa group, and corresponds with a high number of taxa for each sample.

Figure 11. Number of individuals collected in each sample.



Odonata

A total of 808 odonate specimens were collected from the following families:

Zygoptera- Coenagrionidae

Chlorocyphidae

Protoneuridae

Calopterygidae

Platystictidae

Anisoptera- Libellulidae

Aeshnidae

Gomphidae

Megapodagrionidae

Additional analyses

Comparisons of macroinvertebrate community composition between sites will be investigated in through multivariate analysis of similarity. Data on environmental conditions at each site may be related to community structure depending on the outcomes of this analysis.

Further comments and considerations

Species of conservation concern

At this stage the presence of species of conservation concern is not known, however diversity of taxa (100 taxa from 18 samples over 3 rivers) is high; as noted, there are likely to be endemics and undescribed species.

Use of macroinvertebrate monitoring as an indicator of forest disturbance

Macroinvertebrate community structure within the Reserve would be expected to show a response to altered land use, including forest disturbance– eg Walsh et al. (2002) attributed variance in macroinvertebrate community composition between rainforest and plantation sites to land use in a small stream in East Java. However this was alteration at a large scale. Rivers within the Lambusango Reserve appear to be in near-reference (undisturbed) condition – only localised minor disturbance of habitat was observed at camps near track crossings or at crossings of rattan trails within the forest. The ability to detect initial impairment as opposed to detecting substantial degradation would rely on finding biological measures that are most sensitive to particular stressors (sedimentation, habitat modification as opposed to toxic or organic pollution). At this stage such indicators have not been identified. Also, detecting variation between sites or change over time is different to identifying causes – there is currently very little known about natural ecological causes of variation between or within sites, and nothing is known about seasonal or interannual variation. Baseline data from this survey will be explored further, however the lack of temporal or spatial replication currently means that inferences about causes of variation will be weak. Future ecological or ongoing community diversity studies would be interesting in themselves and will contribute further information upon which biological assessments can be based. Further taxonomic work may identify rare/endemic species, or species with particular forest associations/requirements (eg Gomphidae larvae were detected at Lapago and Wahalaka – a tall forest canopy is generally a habitat requirement for adults in this family).

Feasibility and factors influencing sampling

Current survey required a minimum of two people to collect and sort two samples in the field per day (picking all specimens from a sample). For the purposes of monitoring or for gathering biodiversity information a greater number of replicates (3-4) per site are recommended. Variation between replicates was low at Anoa upstream, but high at Wahalaka (due to influence of heavy rain) and at Lapago (possibly due to necessarily greater distances between replicates). A larger number of sites would also be ideal (either for biodiversity or forest monitoring); current downstream camp sites could be scrapped and the possibility of sampling on transects explored. Due to limitations on sampling time and the time required for ID in the lab, a greater number of sites/replicates would probably require the adoption of a “rapid” sampling method – a standard approach to rapid macroinvertebrate sampling is to restrict number or organisms picked (either by number of individuals or sorting time in field). For example, pick 200 animals/sample – shown to be sufficient to ensure adequate taxon recovery (Sudaryanti et al 2001). This approach relies on trained, unbiased pickers (i.e. effort directed to picking less common and cryptic taxa as opposed to only abundant or obvious taxa), and analysis may be restricted to presence/absence data as density data would be less reliable.

Sampling period will be restricted by season – sampling is not feasible in the wet season and there appears to be a brief window period at the start of the dry season before smaller seasonal streams dry up. No sampling days were “lost” to rain, but sampling after heavy rain gives unreliable results.

Recommendations for the GEF biological monitoring program

Much of the data has yet to be analysed so there is limited scope for making recommendations at this stage. In particular, data from the butterfly monitoring scheme has yet to be synthesised, and there is still no indication of the sample sizes for species of interest (i.e. endangered species, endemics and late succession forest specialists). However, there are some clear messages that can be obtained from even this cursorial glimpse of the data:

1. Using line transect methods to sample herpetofauna only yields sufficient information to confidently estimate the density of a common species of skink *Sphenomorphus variegatus*. This species occurs in all kinds of forest, and is likely to be a poor indicator of forest change. At the current level of sampling effort (10.7 to 29.8 km transects) insufficient data is gathered to obtain reliable density estimates for any other species. The skink *Eutropis rudis* was common in Kakenauwe, and there may be sufficient data to estimate density, but confidence limits are likely to be wide. Therefore, it is recommended that herpetofauna be dropped from the GEF monitoring program, at least in its current form.
2. Only six out of 17 transect walks from two sampling nodes revealed observations of Buton macaques. At the current level of sampling, there is insufficient data to estimate the density of macaques. Increasing the distance or number of transects is not practical (or desirable), but repeat walks of the same transects may provide sufficient information to estimate the distance function required for estimating density. Although macaques have conservation value, they are not likely to be sensitive indicators of forest disturbance, given that many troupes inhabit the vicinity of farms. It is recommended that either sampling effort is increased considerably or that monkey monitoring is dropped from the GEF monitoring program.
3. Direct measures of forest disturbance (tree loss, rattan trail formation, rattan extraction) should be continued, and possibly extended. Creating a GIS map of rattan trails throughout the proposed Lambusango Forest Management Area would be invaluable. Once a map was developed these could be used to extend these direct measures of forest disturbance from the transects to standard trail routes in selected areas. It is recommended that a project dedicated to rattan trail mapping be set up and that direct monitoring of forest disturbance be expanded to sampling along sections of mapped rattan trails.
4. Estimating anoa activity/abundance using their tracks has yielded useful information with the current levels of sampling effort and should be repeated each year of the monitoring program.
5. The stream macroinvertebrates sampled are likely to contain species of conservation concern (e.g. endemics, undescribed species), though specimens require further examination to confirm this. Species that may be indicators of forest disturbance have not yet been identified. Separating the anthropogenic and non-anthropogenic effects on species composition and abundance will require further research.

6. Point counts of birds may yield sufficient data to estimate densities of species of conservation value such as the Pied Cuckoo Shrike *Coracina bicolour* and the Sulawesi white eye *Zosterops consobrinorum*. More analyses need to be carried out to determine the confidence limits of density estimates at each site. Bird censuses should be included in the GEF biological monitoring program. Density estimates may benefit from additional sampling effort (e.g. extra field ornithologists and an increase in the length of transects surveyed from 8 to 12 km per site).

Studies of animals not short-listed for GEF monitoring

In addition to the studies directed to the GEF biological monitoring program, Operation Wallacea scientists ran a number of other projects in 2004. These included three projects building or continuing long-term ecological data-sets (small mammals, civets and Kakenauwe insectivorous bat project), two behavioural studies (macaque feeding behaviour and macaque crop-raiding behaviour) and a new project exploring the geographical variation in call frequency of insectivorous bats on the Wakatobi Islands.

Figure 12. Spiny rat (Maxomys sp.) being released during capture mark recapture study

Figure 13. Tagged Malay civet in cage trap

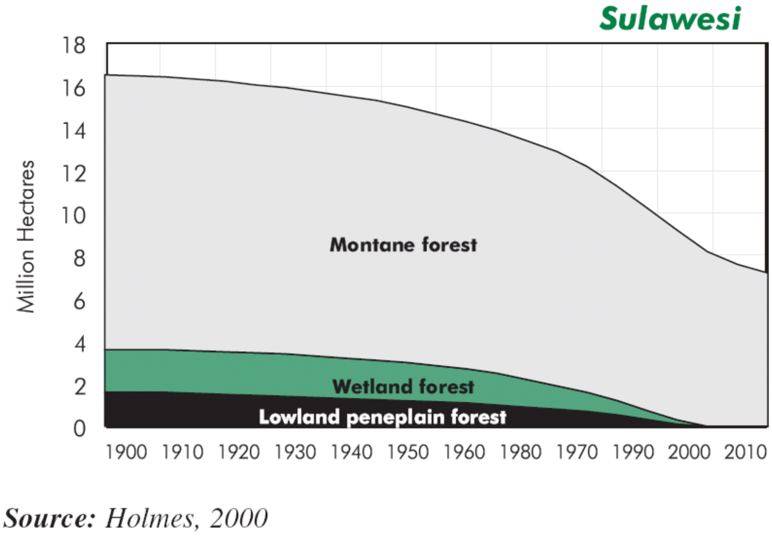
Estimating the abundance and diversity of a small mammal population

Introduction

Forest decline

On Sulawesi, 20% of the forest area was lost between 1985 and 1997 alone, and this figure does not account for the quality of the forest remaining, which may be heavily disturbed. Forest habitat in Sulawesi is subject to many anthropogenic pressures, including timber extraction (on both commercial and small scales), harvesting of other natural resources (e.g. rattan), road building and an increase in the number of introduced species, all of which have been exacerbated by transmigration of refugees into previously unsettled areas (Whitten *et al.* 2002). Forest cover in the study region on Buton Island is still relatively high, but this is partly due to the proportion of land on slopes unsuitable for agriculture.

Figure 14. Estimated loss of lowland and other dominant forest types in Sulawesi between 1900 and 1997 and projected forest loss expected by 2010, assuming continuation of current deforestation trends. This indicates that lowland forest area in Sulawesi has already been reduced to statistical insignificance. *Adapted from Barber et al. (2002).*



Sulawesi's richest forests, the lowland rain forests, have now been almost entirely destroyed (Barber *et al.* 2002), and lowland dry forest, the most valuable type of Indonesian forest for both logging and biodiversity conservation, is essentially defunct as a viable resource in Sulawesi (Holmes 2000 - see Figure 14). This is a major conservation concern as Sulawesi is a unique region, and its lowland forests support a highly distinctive fauna and flora.

Sulawesi rodents: Endemism & vital ecological roles

Sulawesi supports a surprising number of mammal species for an island of its size. One reason for this is that Sulawesi has been the centre of an extraordinary radiation of Murid rodents (Musser 1987). There may be up to 40 species of rats and mice on Sulawesi, making up around one third of the total mammalian fauna, and over half of the endemic species (Musser 1987). If only the non-volant species are considered, a startling half of all Sulawesi mammal species are Muridae. These endemic murids display a combination of primitive and unique characters, and some genera are morphologically highly specialised. This suggests that much of the murid fauna has evolved in isolation on Sulawesi for a significant amount of time, and is likely to have descended from an ancient group of Asian mainland rodents that is now largely extinct (Musser 1987).

It is thus clear that on Sulawesi at least, all rats and mice should not be dismissed as the pest species they are so commonly assumed to be in other regions. None of the Sulawesi endemic murids are commensal, or are known to be large-scale agricultural pests (Priston, pers. comm.). On the contrary, the endemic rats appear to be predominantly restricted to forests, both lowland and montane, whereas the introduced murid species occur in areas of human habitation (Musser 1987). Given the rate of loss of their forest habitat, and the introduction of non-native species, the fate of the Sulawesi endemic murids is now uncertain, and is of conservation concern.

In addition to having intrinsic conservation value due to their endemicity, the small mammals of Sulawesi play a vital role in forest ecosystem processes. There are relatively few studies on the function of small mammals in rainforest systems; however those which have taken place indicate that small mammals not only provide a prey base for various carnivore species but may also function as pollinators, seed dispersers and seed predators. For example, on Sulawesi, Musser (1990) has observed that many of the endemic rats consume fig fruits; however most digest the only the pulp, with the seeds passing through intact in the faeces. In contrast, the pygmy tree mouse *Haeromys minahassae*, Sulawesi's smallest endemic rodent, discards the fig pulp and eats only the seeds. The larger rodents thus act as seed-dispersers to such fig species, whereas *H. minahassae* is a seed predator.

Whether in their role as seed dispersers or predators, rodents may have an impact on critical issues such as tree diversity (Asquith *et al.* 1997). Some species have extremely hard fruit which need to be opened by rodents (e.g. Perez *et al.* 1997) and other tree species need seeds to be buried by scatterhoarding rodents (e.g. Leigh *et al.* 1993). Even trees which are generally known as self-dispersing or wind-dispersing may be affected by rodent species. For example, many dipterocarps are wind-dispersed, but the nutritious seeds are commonly harvested by rodents which store them in spatially scattered caches (Ashton 1988). Such cached seeds may be in better environments for germinating and developing than unharvested seeds (Jansen & Forget 2001). Burial by rodents may also be accompanied by the inoculation of mycorrhizae, and species dependent on such fungi for improved seedling growth may benefit (Janos *et al.* 1995). Some rodents will even harvest seeds from the dung piles of larger mammals and bury them (Janzen 1982). Thus, although rodents do not carry seeds very far, and will consume part of their food reserves later, they may have a positive net effect on the survival of seeds and could be important agents for secondary seed dispersal in Sulawesi tree species.

The small mammal fauna of Buton's forests is thus of importance to forest management and conservation, but to implement effective conservation strategies we must understand key ecological issues and ecosystem processes. The ecological factors determining distribution of tropical species and organisation of tropical communities are complex, and studies of community structure and dynamics in rainforest mammal fauna are in their infancy. This is particularly the case for small mammal species with little obvious charismatic or commercial value, and progress may be further hindered by the difficulties inherent in conducting such studies; small forest mammals tend to be cryptic, traps and baits selective and their environment highly complex.

Gaining an understanding of the ecology of Sulawesi endemic small mammals is not only important for the conservation of those species. Many studies have shown that the richness, distribution and abundance of coexisting small mammal species are affected by the availability of microhabitats which can be characterised by specific quantifiable variables. Small mammal species with distinct microhabitat preferences may act as effective indicator species, as they can be highly sensitive and quick to respond to disturbance.

Aims
The main aims of this season's work were to evaluate the relative distribution of endemic Sulawesi rodent species to each other and to microhabitat properties at the terrestrial and scansorial levels of the forest. An additional aim was to investigate any relationship between small mammal captures and environmental variables such as rainfall.

Objectives

- To explore spatial distribution patterns of rodent species using live-trapping on the ground and in the scansorial level of the forest.
- To investigate any microhabitat preferences of the rodents at both the terrestrial and scansorial levels by characterising the microhabitat at each trap station and relating this to captures.
- To quantify trapping-revealed home ranges and associations for individuals of the endemic murid B. andrewsi.
- To trial the use of hair funnels as an alternative method to live trapping for assessing distribution of mammal species.

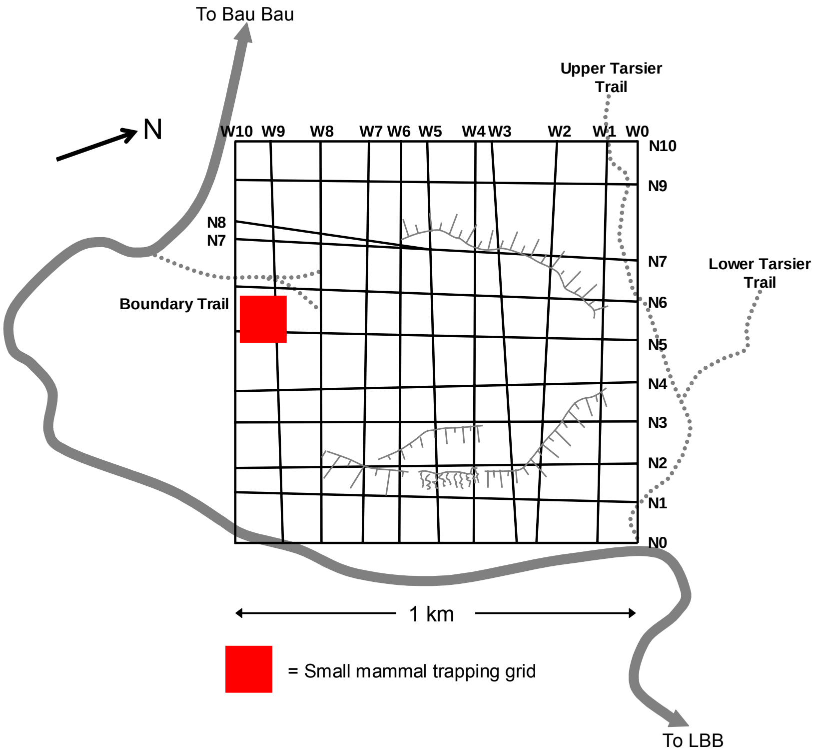
Methods

Study site
This study was carried out in the Kakenauwe Forest Reserve (810 ha) on Buton Island, Sulawesi (5°15'S, 122°50'E). Within this reserve Operation Wallacea has previously established a 1x1km research grid with cleared cross-transects at approximately 100m intervals (Figure 15).

The reserve includes both steep slopes and plateaus; on slopes, soils are shallower, resulting in a tendency for the trees to be slightly stunted, often leaning and falling naturally (O'Donovan pers. comm.). This has produced a more open canopy in these areas.

The Kakenauwe grid is located at around 300m above sea level and so falls within the definition of lowland forest (<1000m altitude); in this case secondary semi-evergreen rain forest. Although the Kakenauwe site shows clear evidence that selective timber extraction has occurred in the past, there has been little sign of logging activity between 2001 and 2004. This site is close to a road and is subject to edge effects as areas adjacent to the road have been cleared for farming.

Figure 15: Kakenauwe research grid. *Redrawn with permission from field map prepared by T. Kingston, 2001.*



Meteorological data

Rainfall and daily maximum and minimum temperature were recorded throughout the trapping period. A wireless digital rain gauge (RGR122, Oregon Scientific) was set up in a suitable open area in Labundobundo village; this recorded total daily rainfall. A digital max-min thermometer was placed in a well shaded area at a height of approximately 1.5m above ground on the small mammal trapping grid. The maximum and minimum temperatures were recorded at approximately 08:00 every day.

Trapping methods

A 120x120m grid was laid out in the Kakenauwe research grid running from the W10N6 intersection (see Figure 15). This location was selected to roughly overlay a botanical research hectare; in this area the majority of trees over 30cm DBH are individually tagged and have previously been measured and identified at least to genus level.

The grid consisted of 49 (7x7) trap stations, with an inter-station distance of 20m. This spacing was based on the habitat type and the likely home range size of the target species. Each trap station was marked with flagging tape and a large ‘Type B’ Elliott aluminium box trap (46x15x15cm. Elliott Scientific Equipment, Melbourne, Australia) was placed in a suitable location on the ground and a small ‘Type A’ Elliott trap (33x10x9cm) in the scansorial level (1-4m above ground level). Scattered at random stations across the grid were a further 20 locally modified Tomahawk cage traps (49x16x16cm. Tomahawk Live Trap Company, Wisconsin, USA); these were also set at 1-4m above ground (in an attempt to target squirrels which are known to have a preference for mesh traps as opposed to box traps). The number of traps used therefore totalled 118, 49 on the ground and 69 at the scansorial level.

Trapping took place predominantly in the dry season, commencing on the 6th July with a 3 night trial session to assess bait performance. In previous seasons a mix of peanut butter and oats was used; in 2004, to cut costs, locally purchased peanuts were ground up and mixed with the oats. A section of ripe banana was also placed in each trap along with the bait mix in 2004. The bait appeared no less successful than that used previously and so this mixture was used throughout the subsequent trapping. After the bait trial, five 5-night trap sessions were completed, ending on 13th August. This gave a total of 2,950 trap-nights trapping effort (3,304 including the bait trial).

Previous work had shown that the target rodents were primarily nocturnal, and that shrews were unlikely to be caught given the bait being used; therefore the traps were checked once daily at 07:30, whilst the day was still relatively cool. Any traps lacking sufficient bait were re-baited, and those which had been disturbed were re-set in their original location.

Any small mammals caught were removed from the trap into a mesh bag for weighing and were then run into a wire mesh handling tube. In the tube the animals could be safely handled whilst they were identified and sexed. Morphometric measurements were recorded, including hind-foot, ear and tail length. Other features which allow differentiation between very similar species were also noted. Small sections of fur were clipped to enable each individual to be recognized if re-captured (Gurnell & Flowerdew 1994). After processing, each animal was released at the trap station at which it was caught.

Mammal taxonomic nomenclature follows that of Corbet and Hill (1992) and Nowak (1999).

Microhabitat characterisation

In order to obtain data on the potential microhabitat preferences of the rodents, a microhabitat characterisation was carried out at each of the 49 trap stations. A 5x5m quadrat was marked out with rope, with the terrestrial trap at its centre and the quadrat's corners oriented towards North, South, East and West. The microhabitat variables recorded within each quadrat are shown in Table 14. These were predominantly based on variables and methods used in previous microhabitat studies (for example Dueser & Shugart 1978; 1979; Lambert & Adler 2000).

Hair funnel trial

Hair funnels are devices designed to capture mammalian hair on a sticky medium. Any hairs gathered can then be identified to genus or species level by microscopy, therefore the use of hair funnels can provide an indication of the distribution of mammal species without the intensive effort involved in live-trapping.

As a trial for potential larger scale use in the future, eight hair funnels (Universal Hair Funnel, Faunatech, Victoria, Australia) were set up at four sampling nodes

Table 14. Microhabitat variables recorded at each trap station.

	Variable	Methods
1	Canopy cover	Canopy cover recorded by digital photograph taken from above centre of 5x5m quadrat.
2	Light level	Light level recorded at the centre of the 5x5m quadrat using simple analogue light meter then calibrated to Lux.
3	Tree number	Number of all trees ≥ 15cm circumference at chest height (CBH) in 5x5m quadrat.
4	Tree circumference	Mean circumference of all trees ≥15cm CBH in 5x5m quadrat.
5	Tree base type	Base type of all trees >15cm CBH in 5x5m quadrat: 1 = round, 2 = furrowed, 3 = buttress, 4 = multiple/stilt, 5 = strangler fig.
6	Tree bark type	Bark type: 1 = flaking, 2 = very smooth, 3 = moderately rough, 4 = deeply ridged.
7	Tree bole climbers >1cm diameter	Bole climbers: if tree supports no bole climbers >1cm in diameter = 0, if tree supports bole climbers >1cm diameter = 1.
8	Liana number	Number of lianas crossing the diagonals of the 5x5m quadrat between ground level and a height of 3m.
9	Liana circumference	Number of lianas (see above) in the following categories: 1-5cm, 5-10cm and >10cm.
10	Shrub layer (1-5m) vegetation density	Estimate by eye of vegetation density in shrub layer on Braun-Blanquet scale: 1 = 0 to 5%, 2 = 5 to 20%, 3 = 20 to 50%, 4 = 50 to 75%, 5 = >75%.
11	Mid-story (5-20m) vegetation density	Estimate by eye of vegetation density in shrub layer on Braun-Blanquet scale: 1 = 0 to 5%, 2 = 5 to 20%, 3 = 20 to 50%, 4 = 50 to 75%, 5 = >75%.
12	Canopy layer (>20m) vegetation density	Estimate by eye of vegetation density in shrub layer on Braun-Blanquet scale: 1 = 0 to 5%, 2 = 5 to 20%, 3 = 20 to 50%, 4 = 50 to 75%, 5 = >75%.
13	Percentage exposed karst	Mean % exposed karst, visually estimated in 1x1m quadrats within the main quadrat.
14	Percentage leaf litter cover	Mean % leaf litter, visually estimated in 1x1m quadrats within the main quadrat.
15	Leaf litter depth	Mean of estimates of predominant leaf litter depth 1x1m quadrats within the main quadrat: 0 = paper-thin or absent, 1 = <1cm depth, 2 = >1 cm litter depth.
15	Percentage vegetation cover to 0.5m above ground	Mean vegetation density from 0 to 0.5m above ground, visually estimated in 1x1m quadrats within the main quadrat.
17	Log number	Number of logs ≥15cm in diameter at the centre point which pass through the 5x5m quadrat.
18	Log length	Mean length of logs ≥15cm in diameter passing through the 5x5m quadrat.
19	Log diameter	Mean diameter at the midpoint of logs ≥15cm in diameter passing through the 5x5m quadrat.
20	Log decay	State of decay: 1 = freshly felled or fallen, 2 = moderately decayed, 3 = decayed to a large extent, 4 = almost wholly decayed and collapsed, 5 = totally decayed, forming a soil mound.
21	Connectivity of tree, log or liana supporting scansorial trap	Connectivity of scansorial trap support: 0 = largely isolated from neighbouring trees, 1 = only weak contact with neighbouring trees by small tips of branches or foliage, 2 = < 5 connections with neighbouring trees by substantial branches and lianas, 3 = > 5 connections with neighbouring trees by branches and lianas.

(Wahalaka, Lapago, Anoa and Bala) for seven nights at each site. The funnels were baited with peanut butter and banana and placed in a variety of locations likely to be used by small mammals. The sticky inserts from the funnels were removed at the end of each session, and any hairs adhering to the cards were carefully removed and stored. On return to the UK the hairs will be compared to a reference collection built up over previous seasons' trapping.

Data analysis

The trapping produced data on captures that could be categorised by trap station, trap type, trap height, species, sex and weight.

As animals had been uniquely marked, it is possible to estimate population size using models which utilise full capture histories. Summary tables of individual capture histories will be created for each species of rodent trapped on each grid. The summary data were initially processed in 'Simply Tagging' (Version 1.31, PISCES Conservation Ltd., Lymington, UK) which offers a range of analytical techniques to estimate population size from mark-recapture methods. Since trapping this season was carried out over a relatively long period of time, it was assumed that the populations were open; population estimates were therefore calculated for each species using a simple Jolly-Seber open population model only. Other more robust and complex open population estimation models will be fitted to the data on return to the UK using MARK (MARK 2001, http://www.cnr.colostate.edu/~gwhite/mark/mark.htm)

Where overall captures or recaptures were very low, precluding the use of mark-recapture population estimates, a very simple catch-per-unit effort measure will be used to allow comparison of species numbers.
Trapping-revealed home ranges will be estimated for individuals with multiple captures (n>4) using BIOTAS (1998-2001. Ecological Software Solutions, Sacramento, USA. http://www.ecostats.com).

The microhabitat assessments produced a set of variables for each trap station. For microhabitat variables where multiple measures were taken within each 5x5m quadrat, (e.g. tree circumference, % cover, vegetation density), a mean value will be obtained for each trap station. In addition, log lengths and diameters will be combined to give an approximate index of log area in the vicinity of the trap stations. These values, along with single value data (e.g. tree number) will be analysed in SPSS for Windows (Version 11, SPSS Inc., Chicago, Illinois).

Both univariate and multivariate techniques will be used to identify significant differences in microhabitat between sites and between individual grids. As there are likely to be significant intercorrelations between the microhabitat variables, a principal components analysis (PCA) will be carried out to attempt to reduce the dimensionality of the data for subsequent analysis. Discriminant function analysis (DFA) will be used to investigate relationships between species and microhabitat. Finally 'CANOCO' (Version 4.0, Plant Research International, Wageningen, The Netherlands) software will be used to carry out a redundancy analysis (RDA) on the species and microhabitat data.

Results

Over the 3,304 trap-nights, there were a total of 205 captures, consisting of 35 individuals of 5 species (Table 15). All species trapped are endemic to Sulawesi on at least the level of genus. Species trapped consisted of Andrew's shrew-rat (*Bunomys andrewsi*), Hellwald's spiny rat (*Maxomys hellwaldii*), Musschenbroek's spiny rat (*Maxomys musschenbroekii*), Sulawesi giant rat (*Paruromys dominator*) and an endemic *Rattus* not yet positively identified to species (most probably *R. xanthurus* or *R. bontanus*) (Figure 16 and Figure 17).

Figure 16: Left: Andrew's shrew rat (*Bunomys andrewsi*). Right: Musschenbroek's spiny rat (*Maxomys musschenbroekii*) © N. Grimwood 2004.

Figure 17: Left: Hellwald's spiny rat (*Maxomys hellwaldii*). Right: Endemic *Rattus sp.* (*Rattus xanthurus* or *Rattus bontanus*) © N. Grimwood 2004.

Table 15: Small mammal captures after 3,304 trap-nights' effort.

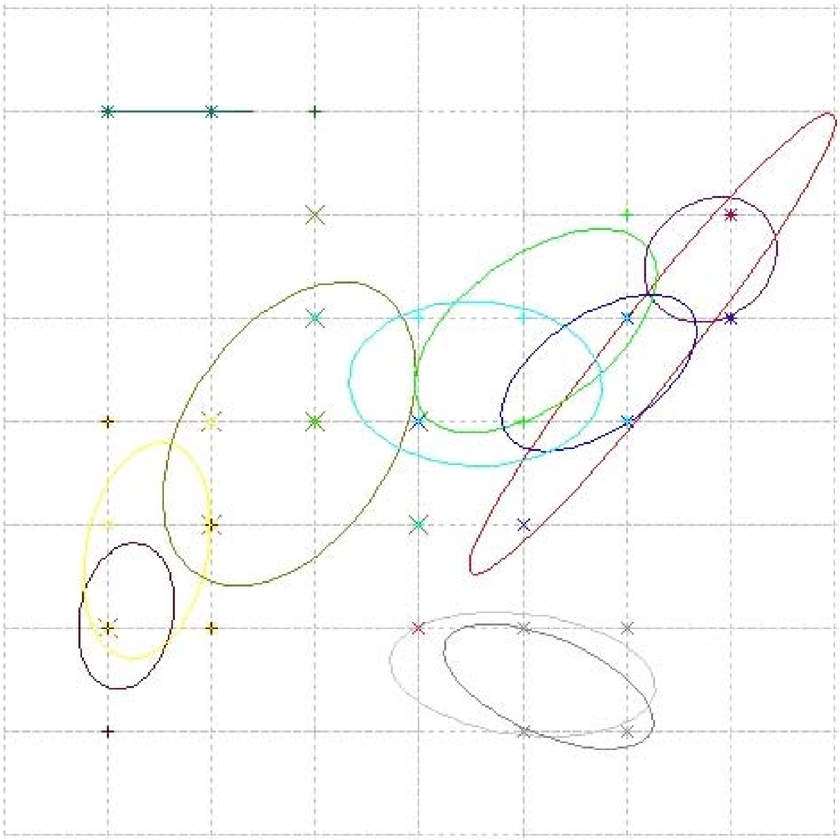
Species	Individuals	Scansorial captures	Terrestrial captures	Total captures
Bunomys andrewsi	16	1	157	158
Maxomys hellwaldii	9	5	24	29
Maxomys musschenbroekii	1	2	0	2
Paruromys dominator	1	0	1	1
Endemic Rattus sp.	8	11	4	15
Total	**35**	**19**	**186**	**205**

Trap efficiency of the terrestrial Elliott traps was 11.5% but only 1% for the scansorial Elliotts. In the previous season, it was shown that the two sizes of Elliott trap do not differ significantly in the size range or species composition of animals captured; any differences in trap efficiency during this study are therefore due to trap placement. Trap efficiency of the scansorial Tomahawk traps was 3%.

Trap-revealed home ranges and distribution patterns of *Bunomys andrewsi* and *Maxomys hellwaldii*.

Trapping-revealed home ranges will be estimated for individuals with sufficient multiple captures (n>5) using BIOTAS (Ecological Software Solutions). For example, Figure 18 shows an initial distribution of B. andrewsi individuals. Trap locations where males were captured are indicated by an x and female captures by a +. The home ranges shown are frequency ellipses at the 50% confidence interval, calculated using the Chi-squared probability function in BIOTAS. From a simple visual inspection it can be seen that females appear to have more well separated ranges than males, and that male ranges overlap those of females and of other males. For each individual the range area will be calculated, and BIOTAS may also be used to analyse spatial distribution patterns, associations and habitat use of the trapped individuals.

Figure 18: Trapping-revealed home ranges (frequency ellipses, 50% CE) of *B. andrewsi* individuals with captures >5. Capture locations are indicated by crosses; x = male, + = female.

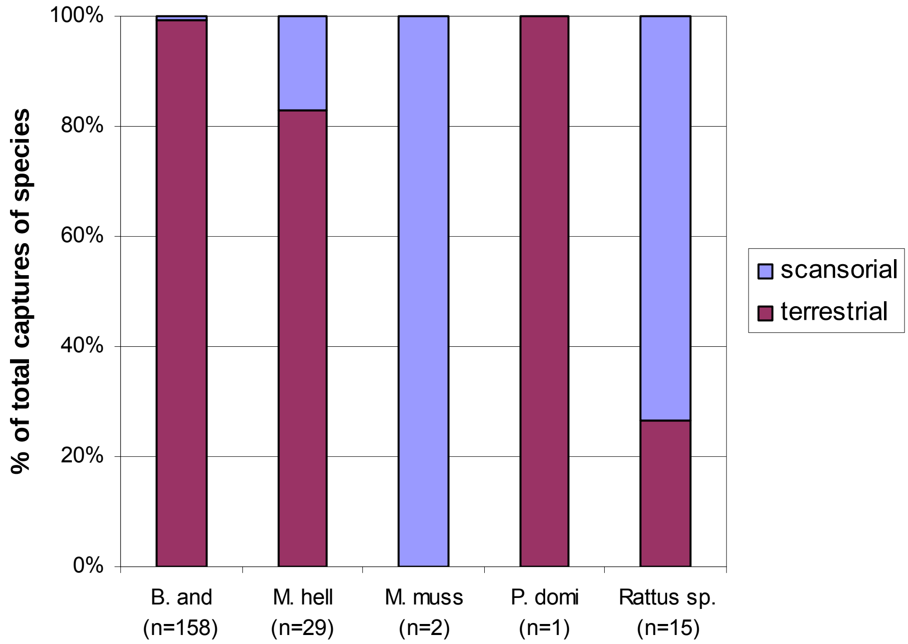


Comparison between scansorial and terrestrial trap capture rates and community composition.

Trap efficiency of the terrestrial Elliott traps was 11.5% (% of traps per night with captures) but only 1% for the scansorial Elliotts. In the previous season, it was shown that the two sizes of Elliott trap do not differ significantly in the size range or species composition of animals captured; any differences in trap efficiency during this study are therefore due to trap placement. Trap efficiency of the scansorial Tomahawk traps was 3%.

Despite low capture numbers for some species, there did appear to be some vertical stratification of the murid fauna. Of 157 captures of *B. andrewsi*, only one (0.6% of captures for that species) was above ground level, whereas for the endemic *Rattus* species 73% of captures were at the scansorial level. For *M. hellwaldii*, 17% of captures were scansorial; this is a surprising finding as this species was previously thought to be exclusively terrestrial.

Figure 19: Relative use of the terrestrial and scansorial trapping levels by small mammal species.



Microhabitat characterisation

Microhabitat data was collected for all trap stations. It was not possible to analyse this data in the field, so results are not presented here.

Hair funnel trial

32 hair funnel cards were collected, eight from each of the four sites sampled. After 7 nights at Wahalaka no mammal hairs were found on the cards. This may have been at least partially due to the very high rainfall at the time of sampling, rendering the adhesive cards less sticky. At Lapago and Anoa two of the eight cards at each site produced only one or two hairs. The funnels at Lawelli are still in situ at the time of writing.

From these results, it appears unlikely that hair funnels will be an effective alternative to trapping for assessing mammal species distribution unless a very large number (probably no less than 100) of funnels can be deployed. However, the method could still be a useful adjunct to a trapping programme, for example to sample the canopy layer where live-trapping is unlikely to be feasible.

Long term monitoring of insectivorous bat species in the Kakenauwe Forest Reserve, Buton Island

Tigga Kingston, Stephen Rossiter & Juliana Senawi

Introduction

Insectivorous bats are a highly diverse yet vulnerable component of mammalian diversity in Old World forests. These bats are characterized by ecomorphological specializations that equip them to forage in the forest understorey, but may greatly constrain their ecological flexibility. They are ill-suited for prey detection and capture in more open habitats that arise from disturbance events, and as a consequence they are likely to experience a severe decline in diversity as forest habitats degraded. The objective of this long-term programme is to monitor the populations of insectivorous bats in the Kakenauwe Forest Reserve as the surrounding forest is fragmented and lost.

Methods

Bats were captured using four-bank harp traps (Francis 1989) positioned across trails. Up to eight harp traps were used each night, ca. 50 m apart, and each trap was set for a single night, then moved to a new position in the forest until the entire trail system was been trapped. Traps were set at dusk, attended every 15-30 minutes until 10 pm and then left open over night and rechecked at dawn (following the peaks in bat activity at dusk and dawn). Captured bats were held individually in cloth bats and identified following Medway (1982), Payne and Francis (1985) weighed, measured and banded with unique wing bands (Kunz 1996), and released at the capture point within 12 hours.

Preliminary results

This was the fifth year of trapping with harp traps in the KFR and the fourth year on the KFR grid. Trapping was conducted from 13th August to 5th September, but unseasonally heavy rains precluded trapping on several nights. As a consequence trap effort was lower than in previous years and amounted to 116 harp trap night. 154 bats comprising nine species (*Emballonura monticola, Hipposideros cervinus, H. cineraceus, Rhinolophus celebensis, R. euryotis, R. philippinensis, Kerivoula hardwickei, Kerivoula papillosa, Murina florium*) were captured, including 32 recaptures. The effort this year brings the total captures in the KFR to 1475 records and 16 insectivorous species.

Insectivorous bats of the Wakatobi Islands

Tigga Kingston & Stephen Rossiter

Introduction

The primary objective of the project was to determine the extent of geographic variation in echolocation call frequency across the islands for four widespread species that use constant frequency (CF) echolocation (*Hipposideros dinops, Hipposideros cervinus, Rhinolophus euryotis, Rhinolophus celebensis).* Call frequency in CF bats can not only determine the size and type of prey that each species can detect, but also plays a role in intraspecific communication. Variability in call frequency across the region can consequently influence the evolution of isolated populations.

Methods

A survey of the bats of the Wakatobi Islands was undertaken from 10 – 29 August. Approximately one week was spent on each of three main islands: Tomea, Kaledupa and Wangi Wangi, with additional trapping conducted on Lintea Selatan and Kapota. As the target species roost primarily in caves, the majority of the field work involved locating and surveying caves. Bats were captured at caves using hand nets, mist nets and harp traps, and individuals were identified, measured (forearm) and weighed, and sex and reproductive condition assessed (Table 17). Echolocation call frequency was recorded using a Pettersen D960 bat detector, using 10x time expansion to download to a professional Sony Walkman (WMD6C). Six calls from each individual will be analysed and the mean values for each species compared across islands to determine the extent of geographical variation in call frequency.

Preliminary results

Over 50 caves were explored in the three weeks, those with bats are listed in Table 16. Preliminary analyses suggest that frequency does differ among islands for all species, and that the direction of change (use of higher or lower frequencies) across the islands differs from species to species. These data are currently being analysed in detail and will be written up as a publication in 2005.

Table 16. Species recorded at caves in the Wakatobi Islands.
Roce - *Rousettus celebensis,* Dosp – *Dobsonia sp.*, Ptsp – *Pteropus sp.,* Emsp - *Emballonura sp,* Miau – *Miniopterus australis*, Misc – *Miniopterus schreibersii*, Rheu - *Rhinolophus euryotis,* Rhce - *Rhinolophus celebensis*, Hidin – *Hipposideros dinops*, Hice – *Hipposideros cervinus,* Hici – *Hipposideros cineraceus,* Mesp – *Megaderma spasma*. x -- < 5 individuals sighted, X -- 5-20 individuals estimated, XX large colony > 20 individuals.

Island	Local Name	Coordinates	Roce	Dosp	Ptsp	Emsp	Miau	Misc	Rheu	Rhce	Hidin	Hice	Hici	Mesp
Tomea	Gua Teelasiahu	S 05º 43.593’ E 123º 53.979’	x											
	Gua Airport	S 05º 45.676’ E 123º 54.791’								x				
		S 05º 45.335’ E 123º 54.827’	x											
		S 05º 43.637’ E 123º 55.462’			x									
		S 05º 43.274’ E 123º 55.150’	X			x								
		S 05º 43.775’ E 123º 55.381’	XX			X								
		S 05º 43.795’ E 123º 55.841’				X								
		S 05º 45.047’ E 123º 59.012’				XX								
Lintea Selatan	Gua Kondu	S 05º 48.575’ E 123º 56.113’	XX			XX				XX	XX	XX	XX	
		S 05º 49.231’ E 123º 56.131’				x								
		S 05º 49.192’ E 123º 56.162’				X								
		S 05º 49.142’ E 123º 56.201’				X								
		S 05º 48.489’ E 123º 55.905’	x			XX								
Kaledupa		S 05º 30.041’ E 123º 42.833’	XX											
	Gua Waogo	S 05º 30.008’ E 123º 44.746’												x
	Gua Tee Ruku-ruku	S 05º 29.730’ E 123º 42.667’	x											
	Gua Wansola	S 05º 34.865’ E 123º 47.959’	XX				XX	X	XX	XX	XX	XX	x	
	Gua Kalaa			XX										

Island	Local Name	Coordinates	Roce	Dosp	Ptsp	Emsp	Miau	Misc	Rheu	Rhce	Hidin	Hice	Hici	Mesp
Wangi Wangi	Gua Teemeintuu	S 05º 20.124’ E 123º 32.628’				x					x			
	Gua Contibu	S 05º 20.110’ E 123º 32.660’								x				
	Gua Honiki	S 05º 19.409’ E 123º 34.195’	X X	X		x				x				
		S 05º 22.112’ E 123º 34.037’	X X											
		S 05º 20.914’ E 123º 33.556’	X X						x	X				
	Gua Karisi	S 05º 21.017’ E 123º 34.286’				X X				x	X X			
	Gua Losi	S 05º 21.242’ E 123º 34.606’	X X						X X	X X				
	Gua Bau	S 05º 18.870’ E 123º 36.889’	X X	X X		X X				X	X X	x		
	Gua Lakabea	S 05º 18.817’ E 123º 36.885’				x			x	x				
		S 05º 16.806’ E 123º 32.037’	X X	X X		X								
Kapota	Gua Kabinta	S 05º 21.304’ E 123º 30.276’	X X	X X			X		X X		X X			

Table 17. Species captured in the Wakatobi Islands.

Species	Tomea	Lintea Selatan	Kaledupa	Wangi Wangi	Kapota	Total
Rousettus celebensis	3			2		5
Dobsonia viridis			2			2
Hipposiderops dinops		33	26	64		123
Hipposideros cervinus		26	28			54
Hipposideros cineraceus		21				21
Rhinolophus celebensis		84	68	17		169
Rhinolophus euryotis			59	53	26	138
Miniopterus australis			7			7
Miniopterus schreibersii			3			3
Megaderma spasma			2			2
Total	3	164	196	136	26	525

The ecology of the Malay civet Viverra tangalunga *on Buton*

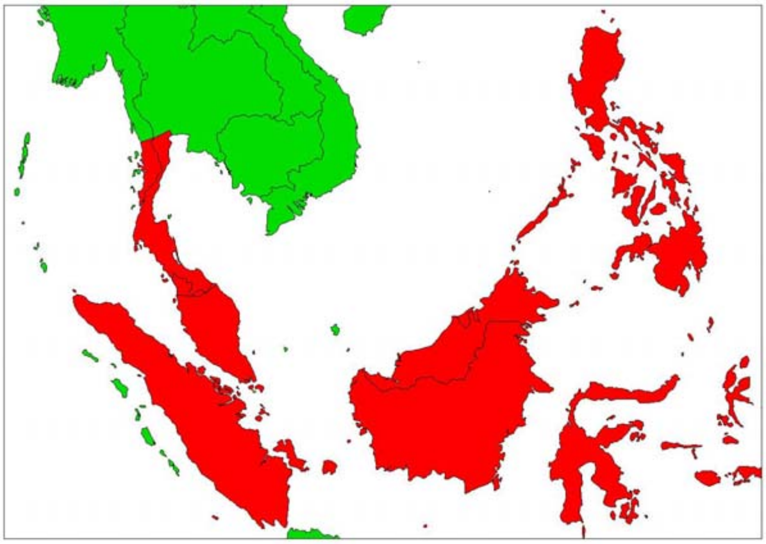
Adrian S. Seymour

Introduction

Sulawesi has an impoverished mammalian carnivore fauna (Musser, 1987) comprising just three species of civet: the endemic Sulawesi palm civet *Macrogalidia musschenbroekii*; and two introduced species the Malay civet *Viverra tangalunga*; and common palm civet *Paradoxurus hermaphroditus* (Suyanto *et al.*, 1998).

The Malay civet is found on the Malay Peninsula, Sumatra, Borneo, Sulawesi, Maluku Islands, and the Philippines (Corbet & Hill, 1992; Kanchanasakha, Simcharoen & Than, 1998; Suyanto *et al.*, 1998; Figure 20) where it occurs in a wide variety of habitats including forests, secondary habitats, cultivated land, and the outskirts of villages (Wemmer & Watling, 1986; Nowak, 1999). Malay civets are solitary, omnivorous and are primarily terrestrial (Kanchanasakha *et al*., 1998).

Figure 20. Geographical distribution of the Malay civet *V. tangalunga*.



The Malay civet was introduced to several islands throughout Southeast Asia, including Sulawesi, to be farmed for *civetine* (a substance that was commonly used commercially in producing perfume) or to control rodent populations (Nowak, 1999). Although the Malay civet is a widespread species little is known about its natural history and ecology in countries where it is native or has been introduced. A number of field studies have been conducted on Borneo (Macdonald & Wise, 1979; Nozaki *et al*., 1994; Heydon & Bulloh, 1996; Colon, 2002), where it comprises part of a much wider carnivore assemblage (22 species), including eight species of civets (Suyanto *et al.*, 1998). On Borneo, the Malay civet also shares its habitat with a number of larger carnivore species including the clouded leopard *Oncifelis nebulosa*, the Malay sun bear *Helarctos malayanus* and the golden cat *Felis temminckii* all of which are likely to be dominant in antagonistic interactions with Malay civets. Indeed, intraguild predation between carnivores has been shown to have important consequences for the behaviour and abundance of the subordinate competitor (Palomares & Caro 1999), though this has never been demonstrated in tropical rainforest habitats. Competitive interactions may depend on landscape and habitat structure, which can influence the rate of encounter between competitors.

On Buton, the Malay civet is the most abundant terrestrial predator in its size class (>1 kg), and probably plays an important role as a predator of small terrestrial vertebrates. It has very few competitors on Buton; the only other large terrestrial predators (> 1kg) are monitor lizards *Varanus salvator*, pythons *Python reticulatus* and possibly the endemic Sulawesi palm civet (presence not yet confirmed). Given the importance of dominant competitors on carnivore ecology in some habitats (Palomares & Caro 1999), we may expect to see differences in the behaviour and ecology of Malay civets on Buton compared to those on Borneo. One of the aims of this study was to compare the ecology of the Malay civet on Sulawesi, in an area where no other mammalian carnivore species were known to exist (with the possible exception of *Macrogalidia musschenbroekii*), with published data of morphometrics and ranging behavior of Malay civets on Borneo, where this species is a member of a larger carnivore guild.

Between 2001 and 2003 radio-tracking data for eight civets were obtained (Jennings et al. In review), and these data provided some useful information on home-range size, diel activity and habitat use. However, the number of animals collared and tracked simultaneously was limited by time constraints, and there may have been insufficient trapping effort to catch all animals in the study area, making it difficult to draw any conclusions about how they distribute themselves relative to one another (spatial organisation).

In 2003 a trapping grid was set up to address the problems posed by radio-tracking (i.e. small sample sizes and incomplete capture of all animals on the study grid), and to initiate a capture mark recapture program (CMR) designed to shed light on Malay civet survival, dispersal and home range stability. There is still very little known about the processes driving the population dynamics of civets, and there are few, if any, long-term studies exploring time series of any rainforest carnivores. The CMR also estimates civet density in a 2 km^2 study grid and eventually lead to a time series of abundance to describe the population dynamics over a long time period.

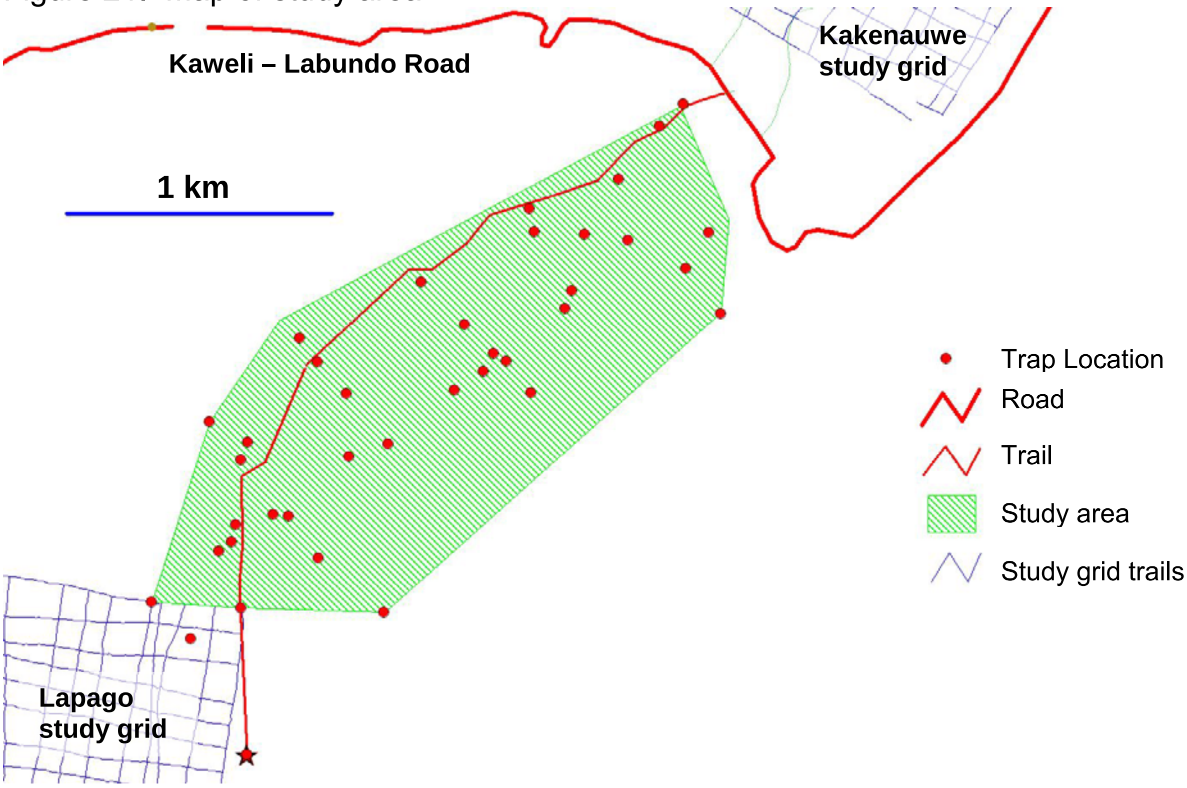
In this report I present the initial findings of the 2004 trapping season (second year of trapping).

Methods

Study site

Research was carried outside the northern border of the Lambasango Forest Reserves, central Buton Island (5˚ 10′ S, 122˚ 54′ E) (Figure 21). The habitat consisted of lowland forest on karst coral limestone of quaternary age. Sulawesi forests are not dominated by any one tree family and there is a virtual absence of dipterocarp trees (Whitten *et al*., 2002). Within these reserves there was considerable variation in the major tree species and families found at different sites and there was some evidence of disturbance from local selective logging and rattan collection.

Figure 21. Map of study area



Trapping

A total of 20 cage traps (140 x 40 x 40cm) were set in 38 locations from June to September 2004. Traps were baited with salt fish and checked daily in the mornings. In order to reduce trauma during immobilisation a "squeeze panel" was used to restrict the civet's movements inside the cage. When the animal was pressing against the cage it was injected intramuscularly with a mixture of Ketaset (Ketamine HCl, Parke, Davis & Co., Detroit, Mich.) and Rompum (Xylazine HCl, Bayer). Most civets were ataxic within 5 minutes and remained so for at least 20 minutes. While under anaesthetic the civets were weighed and measured. Each animal was sexed and aged based on body size and condition of the teeth. The age categories were: juvenile (not full size and still had milk teeth), young adult (almost full size but not sexually mature), adult (full size and showing signs of reproductive activity), and old adult (showing signs of decline in weight and health and pronounced tooth wear). Reproductive status was determined by checking the condition of the nipples in females and testicles in males. The following body measurements were taken: head and body length, tail length, neck circumference, right ear length, right hind foot length, right fore-footpads (length and width), right canine length (upper and lower). Coloured plastic tags were clipped onto both ears. All animals were placed back into the trap and allowed to fully recover for 2-3 hours before being released.

Initial results and discussion

A total of 21 civets were caught (16 males and 5 females) in 865 trap nights (Table 18). There appeared to be a strong male bias in the sex ratio of trapped animals in 2004. There were a total of 101 capture events with a mean capture frequency of 4.2 ± 3.1 (s.d.) captures per individual. Most civets were caught more than once suggesting that they had home ranges centred on trap sites (Table 19). 54.5% of males and 37.5% of females that were caught in 2003 were recaptured in 2004 (Table 20). Civets were caught in all except two of the traps. Recaptures were highly clustered and usually occurred in a trap adjacent to the initial capture location.

Table 18. Summary of civet captures in 2003 and 2004 studies on the musang study grid.

Year	Trap effort	Number of individuals caught: Males		Number of individuals caught: Females	
		Young adult + juvenile	Adult	Young adult + juvenile	Adult
2003	384	5	6	2	6
2004	865	3	13	0	5

Table 19. Frequency of resident (captured ≥ 2 times) and 'transient' civets (captured only once).

Year	Resident	'Transient'
2003	12	2
2004	15	5

Table 20. Proportion of civets caught in 2003 that were recaptured in 2004 by population class. (*n* indicates sample sizes for each class)

Class	Residents	Transients	Adults		Young adults + juveniles	
			Males	Females	Males	Females
Proportion recaptured in 2004	0.5	0.5	0.66	0.17	0.4	1.0
n	12	2	6	6	5	2

The data await further analysis including estimating trap-revealed home range sizes, estimating home-range overlap and analysis of morphometrics. These analyses will be presented in a scientific journal some time in 2005.

Aspects of the ecology , behaviour and conservation of the Buton Macaque Macaca ochreata brunnescens

Nancy Priston, Sarah Carroll, Matthew Taylor, Rhiannon Todd, Lauryn Kime, Emma Ball, Nick Zarb, Sarah Dye & Juliet Wright

Introduction

The Buton macaque, *Macaca ochreata brunnescens,* is found only on the islands of Buton and Muna. The majority of Muna has been deforested, and the last stronghold of the species is on Buton. Large-scale habitat destruction on Buton through logging and farming has reduced potential habitat for these medium sized mammals. There is a paucity of information available regarding the behaviour and ecology of the Buton macaque and indeed the wild Sulawesi macaques in general (Kohlhass 1993, Reed *et al.* 1997 cited in O'Brien & Kinnaird 1997). Information on the ecology and behaviour of Buton macaques, in addition to that on population, is essential for successful management plans to be designed to conserve this endemic primate (O'Brien *et al.* 1997). Further, specific data on habitat requirements, minimum areas for conservation, diet, and details of appropriate social and breeding systems are necessary for the implementation of such plans (Sutherland 1998). Data on key food resources and habitat features are essential to allow recommendations of areas suitable for conserving macaques. In addition, macaques are seed dispersers, and as such are important agents of forest regeneration. Knowledge of food resources is essential in understanding habitat and food resource needs of these macaques for their continued survival.

Macaques often come into conflict with local farmers through the damage they cause to crops. This can result in the macaques being trapped or poisoned, and the farmers losing a potentially significant proportion of their crops. Information on both the actual severity of this problem and the perceptions of local farmers and people is required to look at ways to reduce this conflict. This project also aims to increase our knowledge of these areas and to investigate the degree to which the pet trade affects this species.

Objectives

- Gather information on the behavioural ecology of the Buton macaque, including aggression and feeding.
- Compare the use of habitat in crop and forest areas, and compare the behaviour of macaques in these habitats.
- Compare levels of aggression (as an indicator of stress) in troops living in different habitats and with a zoo troop of *Macaca nigra.*
- Investigate the frequency with which macaques raid crops, which crops are taken, and the influence of human activity in fields as a deterrent.
- Investigate the extent of the pet trade in macaques both now and in the past and assess the impact on wild populations of any such trade.

The Sulawesi Macaques

The Sulawesi[1] Macaques are a unique radiation within the macaques, 7[2] of the 19 species exist on this island's relatively small area and are endemic (Fooden 1980, Groves 1980, Rosenbaum *et al.* 1998). The Buton Macaque *Macaca brunnescens* inhabits the islands of Buton and Muna. Its taxonomy has been debated and it has been classified as a sub-species of *M. ochreata* (Groves, 1980) which inhabits the south-easterly corner of Sulawesi, off which these islands lie. *M. brunnescens* is distinguished by a brown dorsal colour, shorter, mat fur and a shorter face than *M. ochreata* (as described by Fooden 1969, 1980, Groves 1980, Hamada *et al.* 1988). The separation of these species can be no more than 10, 000 years, owing to the emergence of these islands in the Holocene (Groves 1980). In light of this fact and in view of personal observations, which seemed to indicate no distinguishing brown coloration Groves' classification of *Macaca ochreata brunnescens* will be used in this study.

Figure 22. Dominant Adult male in fields, showing lack of brown dorsal colouration

Sulawesi macaques are found in lowland and hill forest (Mackinnon 1986), and have been sighted as high as 2000m, but are probably not common above 1500m (Whitten *et al.* 1987). Pythons *Python reticulatus* and *P. molurus,* are their only predators other than humans, who hunt them as crop-pests over most of the island and occasionally for food (Whitten *et al.* 1987). The main threat to Sulawesi macaques is habitat loss through deforestation due to agriculture, logging, transmigration camps (MacKinnon 1986, Whitten *et al.* 1987, Rosenbaum *et al.* 1998). More than 67% of productive wet lowland forest on Sulawesi has been lost over two decades (Whitten *et al.* 1987, O'Brien & Kinnaird 1996). Diversity of fruit tree species is likely to decline after logging, and food resources become lower in quality and quantity (Rosenbaum *et al.* 1998). Sulawesi crested black macaques, *M. nigra,* have been shown to occur at significantly lower densities in logged than primary forest (Rosenbaum *et al.* 1998). Behavioural observations of this species living in secondary forest suggest that they travel further, socialise less, and eat less fruit than conspecifics in better quality primary forest with minimal disturbance and canopy-sized trees (O'Brien & Kinnaird 1997, Rosenbaum *et al.* 1998).

[1] Formerly Celebes

[2] 4 – 7 species/sub-species are recognised by differing authors [see Chivers, 1986, Fooden, 1969, 1980, Groves, 1980, Whitten 1988]

In comparison to other Sulawesi macaques very little is known about the distribution or conservation status of the booted, *M. ochreata ochreata*, and Buton macaques *M. o. brunnescens*. Moreover there are few captive Buton macaques, and no captive breeding programme. The Buton macaque is endemic to the islands of Buton and Muna. Both islands have undergone extensive de-forestation in recent years, due to logging and farming, and these macaques are consequently under threat. Muna has lost the majority of its primary forest, and the largest population of macaques survives on Buton. The Lambusango and Kakenauwe forest areas in central Buton island represent a substantial remaining stand of forest and may support the largest remaining population of this endemic species.

Threatened species and sub-species such as the Buton macaque should be monitored within reserves and managed to maintain adequate populations (MacKinnon 1986). Information on the ecology and behaviour of the Buton macaque, in addition to that on population, is essential for successful management plans to be designed to conserve this endemic primate (O'Brien *et al.* 1997). Further, specific data on habitat requirements, minimum areas for conservation, diet, and details of appropriate social and breeding systems, and conflict with people are necessary for the implementation of such plans (Sutherland 1998).

Consequently this project aims to collect data on habitat use, behavioural ecology, and diet of three groups of macaques, one of which is a known crop-raiding group to enable a comparison of crop-raiding macaques with non-crop-raiding macaques living within the Lambusango and Kakenauwe protected areas. The data will also enable a comparison of the ecology of macaques living in different types of forest, as the Kaweli group inhabit a matrix of heavily logged secondary forest and agricultural land, the group at Kakenauwe a later-stage secondary forest, and the third group at Lapago inhabit higher canopy, secondary forest.

Human Wildlife Conflict

The human perception of primates is often one of contradiction, typified by extremes. Whilst for many cultures primates are a symbol of religion and are sacred e.g. Hindus of India, in others such as Japan, they are mythical creatures viewed as cunning and devious. However for most of the world's subsistence and plantation farmers living in close proximity to these animals, they are a significant crop pest. In many cultures these views overlap resulting in both a love and loathing of them such that they may be worshipped at a temple but shot on the field next door. Cultural tolerance alone is protecting many species of primate, but as this begins to wane in the face of increasing human populations, demographic movements and habitat destruction, it is vital that the conflict that exists be understood. Conservation depends on local perceptions, economy and social factors and it is within these limitations that it must work and against this background that this project has been set.

Human-wildlife conflict is of increasing concern in all parts of the world and has been the focus of recent conservation efforts (see for example Bell 1984, Else & Lee 1986, Hill 1998, Hoare 2000, Infield 1988, Naughton Treves 1998, Newmark *et al*. 1994). With increasing human populations, especially in the developing world, more human and wildlife populations are coming into direct competition (Eudey 1986, Strum 1987a, b, 1994, Tchamba 1996).

In subsistence agricultural societies the nuisance value of wildlife, from crop damage and livestock depredation, is often pronounced in people's minds (Ranjitsinh 1984). People feel threatened by wildlife, both in terms of crop loss and personal safety (Eley & Else 1984, Hill 1999, Malic & Johnson 1994, Priston 2001). Such losses can be enormous, both in direct economic terms and through indirect costs on time and energy devoted to protection and re-planting after damage (Hill 1998, 1999), as well as the cost of potential conflicts between activities and less time to complete other work. (Lee & Priston submitted). Estimates of damage reach 90% in some areas (Mishra 1984), representing an annual value of $500 per farmer which, though of little national importance, causes the individual farmer much suffering (Barnes 1996).

Primates dominate amongst pests that damage crops, particularly around African and Asian reserves, being responsible for over 70% of the damage events and 50% of the area damaged (Naughton Treves 1998). Because of their intelligence, opportunism, adaptability and manipulative abilities some species can easily turn to crop foraging and make formidable crop-raiders. The human and non-human primate niches overlap extensively making competition much higher between the two and posing many management problems (Strum 1987a).

One fundamental factor is the cultural attitude of people towards primates. Levels of tolerance, acceptance and even demand for interactions vary with cultural context (Biquand *et al.* 1992, Gautier & Biquand 1994). For Hindus the monkey is sacred and in parts of Northern India, Indonesia and other areas, they are worshipped, protected and provisioned by the villagers. Whilst showing remarkable tolerance, people are understandably still reluctant to share their crops (Eudey 1994, Malic & Johnson 1994, Southwick *et al.* 1961a, b, Strum & Southwick 1986).

Traditional methods to prevent primate crop-raiding have limited success. The dexterity, deceptive skills, and intelligence of some primates make containment and control costly, inefficient and ultimately ineffective (Maples *et al.* 1976, Strum 1986, 1987a, 1994).

Indonesia has the fifth largest human population in the world (Atmosoedarjo *et al.* 1984) and nowhere is there a greater variety and diversity of primates than in South and Southeast Asia (Roonwal & Mohnot 1977). Sulawesi itself is one of the most distinctive islands with 127 indigenous mammals, 79 of which are endemic (Whitten *et al.* 1988). Legal protection of species and forested land is poor. As with almost every other primate species, the Sulawesi macaques are facing loss of habitat due to subsistence farming and logging, as well as subsistence hunting and "pest" control measures in some areas (O'Brien & Kinnaird 1997, Rosenbaum *et al.* 1998). Macaques are adaptable and opportunistic and thus can cope with these problems better than some species (Richard *et al.* 1989), but even within Sulawesi population declines of 75% have been witnessed (*Macaca nigra*) (Rosenbaum *et al.* 1998). An understanding of their foraging behaviour is essential to the formation of a suitable management strategy.

The Buton macaque is only one of several pests who damage crops, yet they typically receive much of the blame (Priston 2001). Richard *et a.l* (1989) proposed categorisation of certain macaques as “weed macaques” based on their “differing abilities to tolerate and even prosper in close association with human settlements.” These macaques may choose to raid crops and/or human dwellings because benefits gained by eating readily available, highly nutritious and digestible foods outweigh any risks associated with human contact. Benefits such as better health, higher reproductive rates, and increased time for socialising have been shown to result from this type of strategy when used by vervet monkeys *Cercopithecus aethiops* in Africa (Strum 1994). Other researchers have taken this idea further by questioning whether primates are capable of diversionary strategies to outwit farmers guarding their crops. Maples *et al.* (1976) studied crop-raiding baboons and found that, while their behaviour in the field may have appeared to be a deliberate strategy to maximise crop-raiding success, their behaviour was actually reflected by the shape of the margins between forest and farm. In addition, the type and frequency of raids were directly affected by factors including degree of farmer vigilance and crop availability. On Buton Island, some farms suffer heavy damage by macaques while others are never or rarely raided. Similar conclusions to those found by Maples *et al.* (1976) may apply to Buton Island, wherein type and frequency of crop raiding may be predicted based on factors such as farmer vigilance, state of crop availability and the geography of the farms.

Pet Trade

All the Sulawesi macaques are protected by law, however, the illegal trade in these endangered species is still common (MacKinnon 1986), despite all the Sulawesi macaques being listed in appendix II of CITES (Convention on International Trade in Endangered Species of Flora and Forna) (CITES 2004).

The information available on macaques as pets now seems to be a little dated as much of the research was carried out in the 1980’s, this research suggested that the keeping of macaques as pet was quite a widespread practice, with 100 being kept in the Dumonga Valley alone (MacKinnon 1986). There appears to be a sizeable gap in the research here. Not only is much of the information available outdated it also focuses mostly on international trade and policy something which has become more common since the ban on exports of the Indian rhesus macaque (MacKinnon 1986). The focus on international trade seems to be the norm when looking at the illegal pet trade, and examples of this global bias can be found readily (Wright 1999) which looks at the nest poaching of parrots in the Caribbean for the US market. This again indicates a research area that has not really been focused on, this study will focus on the local level not just on an international scale.

Methods

Behavioural data

Three groups of macaques were habituated to the presence of human observers, one in the forest bordering the village of Kaweli, one at the Kakenauwe study site, and one at the Lapago study site. Behavioural data were collected from all three study groups. The macaques at Kaweli crop raid and their behaviour was recorded both in the forest and when crop raiding. The macaques were located and then followed opportunistically for as long as possible throughout the day. General behaviours were recorded using instantaneous scan sampling every 10 or 20 minutes, and specific behaviours were recorded using both *ad libitum* recording and continuous focal sampling.

The following age-sex categories were used: alpha adult male, adult male, adult female, sub-adult, juvenile, infant.

Behaviours were categorised and recorded as follows:
- Foraging: searching for food, i.e. moving slowly with attention directed towards a potential food source. It includes digging for tubers and insects – i.e. extractive foraging. Where possible the food being foraged for was noted.
- Carrying food: carrying food. Whether the macaque was bi- or tripedal was noted.
- Feeding: ingestion or manipulation of foods, i.e. eating or handling prior to eating. Where possible the food being eaten was noted.
- Locomotion: walking or running from one place to another. Bipedal or tripedal locomotion was noted.
- Climbing: any arboreal movement, including swinging, jumping and climbing.
- Resting: sitting or lying, and not engaged in any other activity e.g. grooming or vigilance.
- Autogrooming: macaque grooming itself.
- Allogrooming: macaque grooming another individual.
- Allogroomed: macaque being groomed by another individual.
- Vigilant: actively paying attention to the surroundings, visually scanning the general environment or focussing on a specific area.
- Playing: characterised by an open mouthed play face. E.g. chase play, rough and tumble etc.
- Fighting: aggressive interactions between individuals or groups usually accompanied by loud vocalisations. Characterised by open mouth threats and submissive grimaces.

This provided data on the amount of time that the macaques spent engaged in the various non-social and social behaviours. These will be compared between groups, and between the various age-sex categories.

Aggressive behaviour

All instances of aggression were recorded, including the type and the amount of time spent engaged in the act. Any aggressive vocalisations were also recorded.

Crop raiding census

Focal farm watches were conducted on 8 farms in Kaweli, from 6:30am until 4:30pm for four weeks. This allowed the average frequency of crop raids, any temporal or spatial patterns, the effect of human activity in the farms, types pf crop raided and whether macaques have a preference for particular crops to be assessed.

The farms were mapped and the following information recorded:
- Size and shape of farms and which margins are forested.
- Distance from farm edge to forest (the margin).
- Adjoining land use.
- Positions of guarding huts and any monkey deterrents.

- Crops grown on each farm and their state of availability to primates (on a weekly basis).
- Weather (daily).

Whilst monitoring farms, the following data were recorded using continuous sampling to link frequency and duration of raids with amount of farmer vigilance:

- Start time and duration of each raid.
- All human activity.
- Presence and activity of dogs.
- Other external noises.

When macaques raided, detailed observations were made of the animals' behaviour, the crops eaten and the amount. This information can be used to assess factors which affect the frequency of crop raiding by macaques. Behavioural data were recorded using 2-minute scan sampling, noting the following:

- Age/sex/class of each monkey present during raids.
- Number of monkeys raiding and whether subdivision is occurring.
- Spatial distribution of troop in farm and along farm boundaries.
- Behaviour.
- Locomotion in the field.
- Time spent on margin versus on field.

Patrol Study
In addition to the crop raiding census a similar study was conducted to investigate the success of human patrols as a deterrent to monkeys. The same information was recorded as for the crop-raiding census (i.e. all human activity and monkey activity recorded). On alternate days the farm was patrolled once every hour for 10 minutes. Farms were accurately mapped and divided into a grid system so that movements of macaques within the farm could be plotted.

Pet Trade Survey
Data was collected over an eight week period in nine villages after permission was granted by the Headman of each village. The six villages chosen where – Wakangka, Lingkungan Restubuana, Watumotobe, Wawoncusu, Suandala, Lawele, Talingko, Nambokidi and Mata. These villages are believed to be representative of the Central Buton area as a whole because they represent a range of communities both Muslim and Hindu.

A mixed qualitative and quantitative interview technique accompanied by straight, covert observation was used. Whilst in the field, two surveys were conducted. Firstly, households within each village were selected at random and one individual from each household was interviewed. Thirty six questions were asked to each respondent beginning with easy, quantitative, demographic questions, followed by a series of structured open-ended questions allowing respondents to reveal their knowledge of the primate pet trade. Each interview took between 20 – 40 minutes to complete and a minimum of 20 interviews were conducted in each of the six villages.

The second survey was designed specifically for individuals who either owner or had owned a pet primate in the past. The same questions used in the main survey were also asked but an extra section was added. This section was composed of a series of closed quantitative questions about the primate pet such as its age, species and origin, followed by a less structured, guided approach designed to gain as much information on the trade in primates as possible. Interviews lasted between 30 – 90 minutes. During both types of interview the individual respondent was allowed to determine the shape and structure of the interview with interesting points being followed up with further questions.

Informal conversations were also conducted with primate pet owners in Bau Bau. No formal questioning took place, rather data on species, origin, age, cost and condition was collected by asking the owner these basic questions or observing the captive animals. Interviews with various government officials were also arranged. These interviews consisted of thirty one questions and tended to last between 90 - 120 minutes. These interviews used a guided approach that enabled follow up questions to be asked if and when appropriate depending on the individuals' field of knowledge and experience.

Initial Results

Behaviour

Aggression study

Due to unforeseen factors the observations of the macaque troop at Lapago had to be abandoned due to poor visibility. This consequently has reduced the comparison to Kaweli and Paignton zoo (to be conducted on return to UK).

- The highest frequency behaviour is walking with it taking up 21.9% of a macaques day between 06.30-16.15. Within this time, macaques were engaged in threatening behaviour 2.3% of the time, with the majority of this taking place inside the forest although this figure did not reach significance (F= 0.446, P = 0.646). This could be confounded by the fact that the macaques spend a considerable amount more time in forest area (59.9%) compared to farm (22.9%) or shrub (6.7%).
- The raw data suggests that adult males are more aggressive than the other members of the troop although this also did not reach significance. (F=0.565, P=0.644).
- The macaques were more aggressive during the afternoon period than the morning or evening (F=4.650, p=0.021).

Comparison of Kaweli and Kakenauwe Troops

At time of writing not all data was inputted and complete analysis had not taken place. However some initial results have been produced.

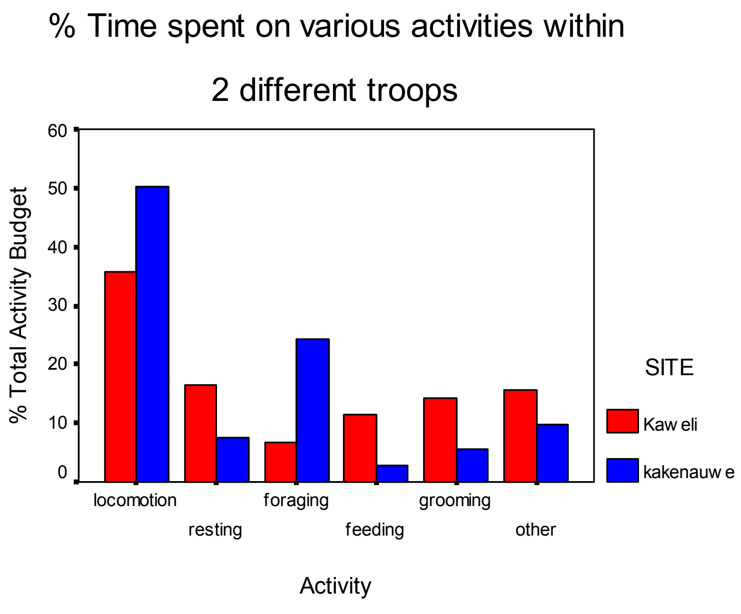
Table 21. Sampling effort in the two study sites

Site	No. days study	No. scans in study period
Kaweli	11	685
Kakenauwe	9	558

Initial analysis showed a significant difference in activity budgets between the different sites of Kaweli and Kakenauwe (Pearson Chi-Square=125.4, df=5, P<0.001). Figure 23 shows the percentage of time spent in each activity by macaques at the two sites. As shown macaques in Kaweli spent most of their time (35.6%) in locomotion (59.4% walking, 6.6% running, 26.2% climbing, 7.8% jumping) followed by resting 16.4%, other activities including playing, aggression, sexual activities, vigilance 15.6%, grooming 14.2% (52.6% social, 47.4% solitary) feeding 11.5% and 6.7% foraging. Within the site Kakenauwe the majority of time was also spent in travelling 50.1% (51.7% walking, 11.7% running, 31.7% climbing, 5.0% jumping) followed by foraging 24.2%, other 9.7%, resting 7.5%, grooming 5.6% (40.0% social, 60.0% solitary) and feeding 2.8%.

Of all the play activities seen 92.5% were seen in Kaweli. This troop spent 9.7% of their time in play activities with the juveniles representing 93.5% of this figure. The alpha male and adult females showed no instances of participating in any play activities, the juveniles however spent almost a quarter of their time engaged in play, 20.4%. In Kakenauwe only 1.5% of their time was spent in play however juveniles once again engaged in this activity the most being 80.0% of the macaques seen exhibiting play activities. Unlike Kaweli macaques only a small percentage of their time was spent in play 3.9%. The statistics produced showed a significant difference between the two troops, (Pearson Chi-Square = 141.7, df = 5, P<0.001).

Figure 23. Clustered bar chart showing activity budgets for *Macaca ochreata brunnescens* at Kaweli and Kakenauwe.



Both troops used both terrestrial and arboreal substrates. Significant differences were seen between the troops and also within the troops regarding time spent on the ground and in the trees. The "ground" was considered as when a monkey was seen either on the ground or a fallen log, any other position was counted as an arboreal position. Between the troops the significant difference (Pearson Chi-Square = 16.9, df = 1, P<0.001) can be seen in Figure 24. As can be observed the troop in Kaweli spent most time in terrestrial positions, 60.9% compared to the 47.6% that Kakenauwe macaques spend on the ground. Kakenauwe macaques spend approximately half of their time on the ground and half in the trees, 47.6% and 52.4% respectively. A two-way contingency table analysis was also conducted to examine the relationship between age and substrate usage within the two troops. At Kaweli adults spent 72.0% of their time in terrestrial positions and 28.0% of their time in trees compared to young macaques, (including infants, juveniles and subadults), which spent 53.1% on the ground and 46.9% of time in arboreal positions. This difference was significant and can be seen in Figure 25 (Pearsons Chi-Square = 24.8, df = 1, $P < 0.001$). The troop in Kakenauwe also showed a significant difference (Pearsons Chi-Square = 17.9, df = 1, $P < 0.001$) which can be observed in Figure 26. As in Kaweli the young were seen to spend the most time in the trees. 64.1% of the young's time was spent in trees compared to 35.9% of their time on the ground whilst the adults spent 58.2% of time in terrestrial positions compared to 41.8% of time in arboreal positions.

Figure 24. Cluster bar chart showing terrestrial versus arboreal at each of the study sites.

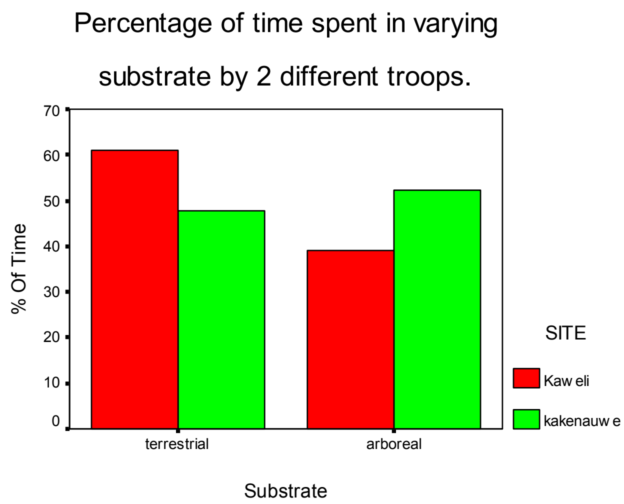


Figure 25. Clustered bar chart showing degree of terrestriality/arboreality for adults and young in Kaweli.

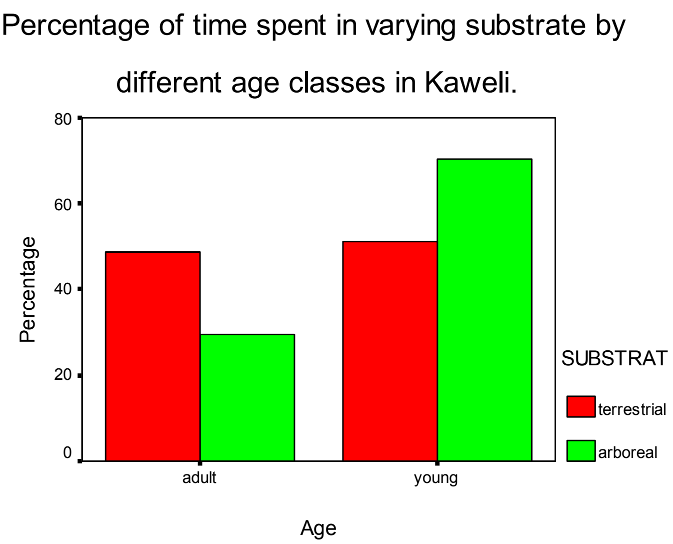
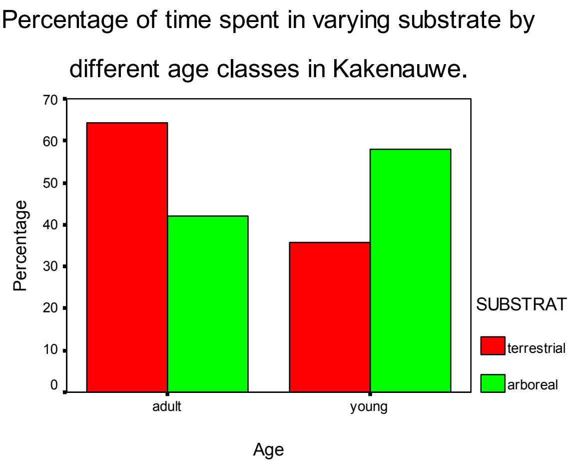


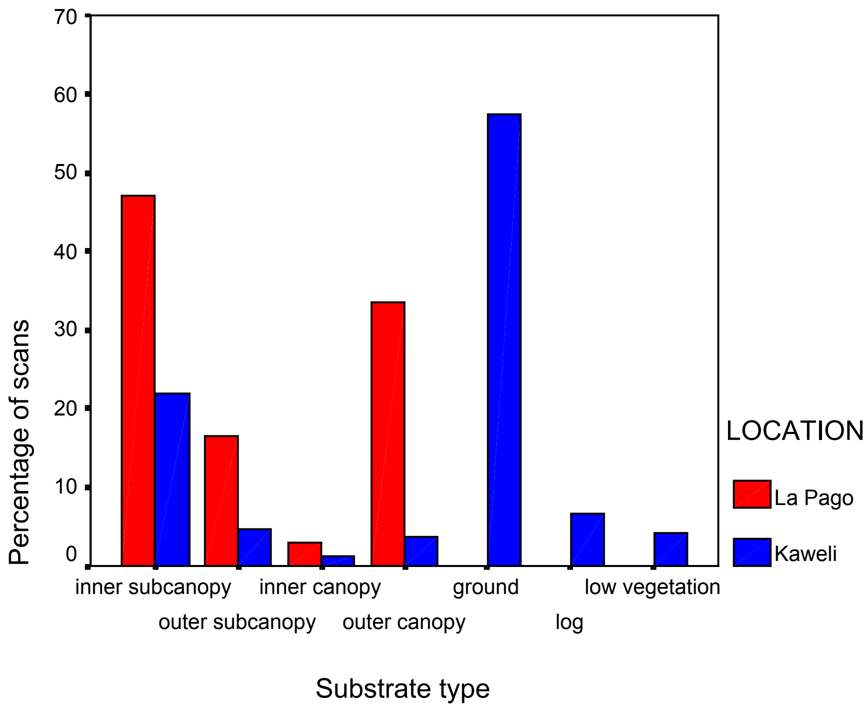
Figure 26. Clustered bar chart showing degree of terrestriality/arboreality for adults and young in Kakenauwe.



Comparison of Lapago and Kakenauwe Troops

From the initial results it is evident that there are some significant differences between the habitat use and activity budgets of the two troops. When analyzing the results of substrate used by the macaques between Lapago and Kaweli, there are very clear differences. The Macaques at Kaweli were found to be more terrestrial, spending 57.4% of their time on the ground. In contrast to this, the troop at Lapago spent 0% of their time on the ground and remained in the inner sub canopy for 47.1% of their time, whereas the Kaweli troop spent only 22% in this substrate.

Figure 27. Substrate use by macaques at Lapago and Kaweli

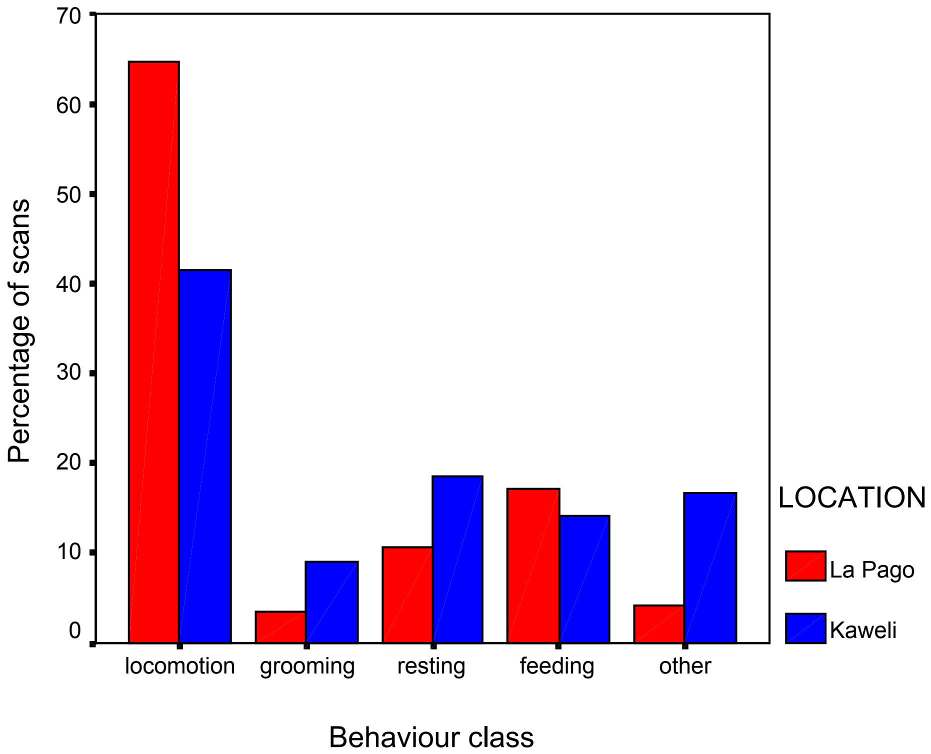


From this we can assume that the deforestation, creating secondary forest and agricultural land, has a significant effect on what substrate the primates' use (Figure 27). With less trees and lower vegetation, as the canopies are not very dense and therefore do not shade the ground which enables lower plants to grow, the macaques at Kaweli are encouraged to spend more time at lower substrate levels.

From Figure 27 we can determine that the troop from Kaweli is largely terrestrial, as opposed to the troop at Lapago, which is seen as entirely arboreal.

From the data collected on the activity budgets of the macaques, it is possible to see that the Lapago troop spent more of their time (64.7%) travelling, than the Kaweli troop (41.5%). The Kaweli group also spent more time resting (18.75) than the Lapago group (10.6%). The Kaweli group was also more social than the Lapago group, whereby the Kaweli troop spent 37.4% either grooming or being groomed and the Lapago troop a mere 12% (Figure 28).

Figure 28. Comparison of macaque behaviour in Lapago and Kaweli.



Therefore, from this very brief analysis, it is possible to note the basic differences between the troops than inhabit these very different habitats.

Crop Raiding Survey – Focal Farm Watches

From the data collected so far it is clear that the Buton macaque is far more likely to raid a farm if there is easy access from the forest. The distance of the farm from the village does not appear to be such an important factor concerning the likelihood of a raid. For example, although the farms Jonaidin and Ruhuni are a large distance from the village they are also cut off from the forest and few raids have been observed for these farms. The monkeys have not once been observed actually entering these two farms.

Fences around the farms showed to do little to prevent the incidence of a raid as they were low enough for the macaques to easily jump or climb over. The macaques showed similarity in the points at which they entered and exited the farm. Adult males were the first individuals to enter the farm during 75% of the first true raids. This dropped to 20% for a second true raid. Maximum raid duration varied between 1 and 35 minutes and monkeys have appeared to raid whilst humans are present, often returning even after having been chased off. The macaques have only been recorded taking sweet potato.

Crop Raiding Survey – Patrol Study

From data collected to date, upon which no statistical analysis has taken place.

- Patrolling reduces the incidence of crop raiding (Farm Darmin was raided 3 times on patrol days, 6 times on non-patrol days, Farm Dauer never on patrol days, 5 times on non-patrol days.).
- Patrolling reduces the average length of raids.
- On patrol days the total time spent inside the farm by monkeys was less than 10% of the total time spent inside by monkeys on non-patrol days.
- On patrol days monkeys never entered the farm less than 45 minutes after the patrol had finished (indicating that patrols every 45 minutes rather than each hour might be more effective).
- Monkeys mainly raid sweet potato, only being observed taking papaya once, on a non-patrol day.
- Monkeys mainly raid in the afternoon.

Pet Trade Survey

At this time full analysis using both SPSS statistical tests and qualitative methods has yet to occur but initial observations are stated below:

- The primate pet trade is far less extensive and obvious in Buton then it is in other areas of Indonesia, such as Java. This is likely to be due to the absence of large cities on the island. The rural communities of Buton see little need to buy primates when they can catch them themselves from their own farms or from the surrounding forest.
- 30% of all respondents interviewed had or have recently had a primate pet, suggesting that the keeping of primates as pets may well be having a significant impact on wild populations of macaques.
- The capture of primates in Buton tends to be accidental. Macaques are frequently reported as being trapped in jungle fowl traps.
- Many infant monkeys are reported as being captured by hand when adult female monkeys drop their young when being chased away from farms. Many macaque owners claimed to feel pity for the abandoned monkeys and therefore decide to keep the youngsters as pets.
- When asked about perceptions of macaques, the majority claimed they disliked wild monkeys, the most frequent reason being because macaques damage crops. However, the response towards captive macaques tended to be positive because tame macaques are entertaining, can be excellent children’s toys, can effectively remove head lice and can act as guards to both houses and farms.

- The only area in Buton where a trade in primates was noticeably apparent was in Bau Bau. This may be because primates are more of a novelty in urban areas where inhabitants have no reason to hate the macaques for damaging their crops. When a random search for primate owners was conducted around Bau Bau the majority of owners revealed that they had purchased their macaque but no specific selling location was identified. Several owners also mentioned that people from outside of Bau Bau had offered them large amounts of money for their primate pets. Amounts offered ranged from Rp 150,000 for one macaque to Rp 4,000,000 for a family of five.
- There appears to be huge confusion both within the communities and between the government officials over the laws associated with macaques. Although Article 21 forbids people to capture, injure, kill, keep, transport or trade any protected animal, the majority of people still believe that it is legal to keep a primate as a pet. Even government officials believe that provided people apply for a licence from the KSDA it is legal to keep a macaque as a pet. None of the primate pet owners interviewed had licences.

Final Reports (to be completed by June 2005)

Matthew Taylor, University of Exeter – 'The effect on behaviour on the Buton macaque of having to continually adapt due to deforestation in comparison to the stable environmental conditions in Paignton zoo.'

Lauryn Kime, University of Cardiff - "An investigation into the behaviour and habitat usage of two troops of macaques (*Macaca ochreata brunnescens*) in tertiary and secondary forest in Buton, South-east Sulawesi"

Rhiannon Todd, University of Leicester - 'The effect of human disturbance on the activity budgets and habitat use of the Buton macaque *(Macaca ochreata brunnescens)'*

Nicholas Zarb, University of Oxford – 'An investigation into the effect of human patrolling of farms on the crop raiding behaviour of the Buton Macaque (*Macaca ochreata brunnescens*).'

Emma Ball, University of Leicester – 'A comparison of the degree of crop raiding exhibited by the Buton macaque (*Macaca ochreata brunnescens*) on varying farms surrounding Kaweli village, Buton Island, SE Sulawesi'

Juliet Wright, University of Manchester - The Impact of the Primate Pet Trade on Macaque Species in Buton

Sarah Dye,University of Birmingham - An assessment of the pet trade in Buton Macaques on Buton Island, South East Sulawesi

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References

Ashton, P. S. 1988. Dipterocarp biology as a window to the understanding of tropical forest structure. Annual Review of Ecology and Systematics 19:347-370.

Asquith, N. M., S. J. Wright, & M. J. Clauss. 1997. Does mammal community composition control seedling recruitment in Neotropical forests? Evidence from Panama. Ecology 78:941-946.

Atmosoedarjo, S., et al. 1984. National Parks and Rural Communities. National Parks, Conservation and Development: The Role of Protected Areas in Sustaining Society: Proceedings of the World Congress on National Parks, Bali, Indonesia 11-22 October 1982. J. Mackinnon. Washington, D.C., Smithsonian Institution Press: 237 - 244.

August, P. V. 1983. The role of habitat complexity and heterogeneity in structuring tropical mammal communities. Ecology 64:1495-1507.

Baltzer, M. C. 1997. Ornithological surveys and conservation priorities in Buton island, South East Sulawesi, Indonesia. Unpublished report for Operation Wallacea.

Barber, C. V., E. Matthews, D. Brown, T. H. Brown, L. Curran, & C. Plume 2002. The State of the Forest: Indonesia.

Barnes, R. F. W. 1996. The Conflict between Humans and Elephants in the Central African Forests. Mammal Review 26(2/3): 67 - 80.

Bell, R. H. V. 1984. The Man-Animal interface: An Assessment of Crop-Damage and Wildlife Control. Conservation and Wildlife Management in Africa: The Proceeding of a Workshop Organised by the US Peace Corps at Kasungu National Park, Malawi. E. McShane-Caluzi, US Peace Corps: 387 - 416.

Biquand, S., et al. 1992. The Distribution of Papio hamadryas in Saudi Arabia: Ecological Correlates and Human Influence. International Journal of Primatology 13(3): 223 - 243.

Bowman, J., G. Forbes, & T. Dilworth. 2000. The spatial scale of variability in small-mammal populations. Ecography 23:328-334.

Brockleman, W. Y. & R. Ali. 1987. Methods of surveying and sampling forest primate populations. In: Marsh, C. W. & R. A. Mittermeier (eds.). *Primate Conservation in the Tropical Rain Forest*. pp. 23-62. Alan R. Liss. Inc., New York.

Buckland, S.T., Anderson, D.R.,Burnham, K.P. & J.L. Laake. 1993. *Distance sampling: estimating abundance of biological populations*. Chapman and Hall, London.

Chessman, B.C. 1995. Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification and a biotic index. Australian Journal of Ecology 20:122-129.

Coates, B. J. & K.D. Bishop. 1997. *A guide to the birds of Wallacea*. Dove publications, Australia.

Colon, C.P. 2002. Ranging behaviour and activity of the Malay civet (*Viverra tangalunga*) in a logged and an unlogged forest in Danum Valley, East Malaysia. Journal of Zoology 257: 473- 485.

Corbet, G. B. & J. E. Hill 1992. *The mammals of the Indomalayan region: A systematic review*. Natural History Museum Publications; Oxford University Press.

Crompton, R.H. 1986. Locomotion and habitat utilization in free ranging *Tarsius bancanus*. Primates 27: 337-355.

Dagosto, M. 2001. Positional behaviour and social organisation of Philippine tarsiers (*Tarsius syrichta*). Primates 42: 233-243.
Dueser, R. D., & H. H. Shugart. 1978. Microhabitats in a forest-floor small-mammal fauna. Ecology 59:89-98.
Eley, D. & J. G. Else. 1984. Primate Pest Problems in Kenya Hotels and Lodges. International Journal of Primatology 5(4): 334.
Else, J. G. & P. C. Lee. 1986. Primate-Human Conflict. Primate Ecology and Conservation: Vol. 2 of Selected Proceedings of the Tenth Congress of the International Primatological Society. P. C. Lee. New York, Cambridge University Press. 2: 213 - 214.
Emmons, L. H. 1999. Of mice and monkeys: Primates as predictors of mammal community richness. Pages 171-188 in J. G. Fleagle, C. H. Janson, and K. E. Reed, editors. Primate Communities. Cambridge University Press, Cambridge.
Eudey, A. A. 1986. *Hill Tribe peoples and Primate Conservation in Thailand: a Preliminary Assessment of the Problem of Reconciling Shifting Cultivation Objectives. Primate Ecology and Conservation*: Vol. 2 of Selected Proceedings of the Tenth Congress of the International Primatological Society. P. C. Lee. New York, Cambridge University Press. 2: 237 - 248.
Eudey, A. A. 1994. Temple and Pet Primates in Thailand. Revue D'Ecologie (Terre & Vie) 49: 273 - 280.
Evans, B. J., J. C. Morales, J. Supriatna, and D. J. Melnick. 1999. Origin of the Sulawesi macaques (Cercopithecidae: *Macaca*) as suggested by mitochondrial DNA phylogeny. Biological Journal of the Linnean Society 66: 539-560.
Fleagle, J.G. 1999. *Primate Adaptation and Evolution*. 118-120. Academic Press, London.
Fooden, J. 1969. Taxonomy and evolution of the monkeys of Celebes (Primates: Cercopithecidae). Bibliotheca Primatologica 10:1-148.
Furness & Greenwood. 1993. *Birds as monitors of environmental change*. London: Chapman and Hall.
Gautier, J.-P. & S. Biquand. 1994. Primate Commensalism. Revue D'Ecologie (Terre & Vie) 49(3): 210 - 212.
Gillingham, S. & P. C. Lee. 1999. The Impact of wildlife-related benefits on the conservation attitudes of local people around the Selous Game Reserve, Tanzania. Environmental Conservation 26(3): 218 - 228.
Gregory, A. 2003. Evaluating the effect of disturbance on rainforest bird communities of Buton, SE Sulawesi, Indonesia. Unpublished B.Sc. dissertation submitted to Operation Wallacea.
Groves, C. P. 1980. Speciation in *Macaca*: The view from Sulawesi. In: *The Macaques*. Lindberg, D. G. (Ed). Van Nostrand Reinhold, New York. P.84-124.
Groves, C. P. 1980. Speciation in *Macaca*: The view from Sulawesi. In: The Macaques. Lindberg, D. G. (Ed). Van Nostrand Reinhold, New York. P.84-124.
Gurnell, J. & J. R. Flowerdew 1994. Live Trapping Small Mammals - A Practical Guide. The Mammal Society, London.
Gursky, S. 1998. Conservation status of the spectral tarsier *tarsius spectrum*: Population density and home range size. Folia Primatologica 69: 191-203.
Gursky, S. 2000. Effect of seasonality on the behaviour of an insectivorous primate, *Tarsius spectrum*. International Journal of Primatology 21: 3, 477-494.

Gursky, S. 2002. Determinants of gregariousness in the spectral tarsier (*Tarsius spectrum).* Journal of Zoology 256: 401-410
Gursky, S. 2002. Predation on wild spectral tarsiers (*Tarsius spectrum)* by a snake. Folia Primatologica 73: 60-62.
Gursky, S. 2002. The behavioural ecology of the spectral tarsier (*Tarsius spectrum).* Evolution and Anthropology 11: 226-234
Gursky, S. 2003. Lunar philia in a nocturnal primate. International journal of Primatology 24: 351-367.
Hamer K.C., Hill JK., Benedick S., Mustaffa N., Sherratt T.N., Maryati M. & V.K. Chey. 2003. Ecology of butterflies in natural and selectively logged forests of northern Borneo: the importance of habitat heterogeneity. Journal of Applied Ecology 40: 150 - 162.
Heydon, M.J. & P. Bulloh. 1996. The impact of selective logging upon sympatric civet species (Viverridae) in Borneo. Oryx 30: 31-36.
Hill, C. M. 1998. Conflicting Attitudes Towards Elephants Around the Budungo Forest Reserve, Uganda. Environmental Conservation 25(3): 244 - 250.
Hill, C. M. 1999. Conflict of Interest Between People and Baboons: Crop Raiding in Uganda. International Journal of Primatology 21(2): 299 - 315.
Hoare, R. 2000. African Elephants and Humans in Conflict: the Outlook for Co-existence. Oryx 34(1): 34 - 38.
Holmes, D. 2000. Deforestation in Indonesia: A review of the situation in 1999. The World Bank, Jakarta.
htttp://www.Opwall.co.uk/2002%20forest%20structure%20summary.htm
Infield, M. 1988. Attitudes of a Rural Community towards Conservation and a local Conservation Area in Natal, South Africa. Biological Conservation 45: 21 - 46.
IUCN. 2002. *Red list of threatened species.* www.nature-conservation.or.id/redlistm.html
Janos, D. P., C. T. Sahley, and L. H. Emmons. 1995. Rodent dispersal of vesicular-arbuscular mycorrhizal fungi in amazonian Peru. Ecology 76:1852-1858.
Jansen, P. A., and P. M. Forget. 2001. Scatterhoarding rodents and tree regeneration in French Guiana in M. Théry, editor. *Nouragues:* Dynamics and Plant-Animal Interactions in a Neotropical Rainforest. Kluwer Academic Publishers, Dordrecht, the Netherlands.
Janzen, D. H. 1982. Removal of seeds from horse dung by tropical rodents: Influence of habitat and amount of dung. Ecology 63:1887-1900.
Kanchanasakha, B., Simcharoen, S. & Than, U.T. (1998). *Carnivores of Mainland South East Asia*. Siam Tong Kit Printing Co. Ltd., Bangkok.
Kohlhaas, A. & C.H. Southwick. 1996. Macaca nigrescens*: Grouping Patterns and Group Composition in a Sulawesi Macaque*. In Fa, J. E. and Lindburg, D. G. (eds.) Evolution and Ecology of Macaque Societies, Cambridge: Cambridge University Press.
Lee, P. C. & N. E. C. Priston (submitted). Perceptions of Pests: Human Attitudes to Primates, Conflict and Consequences for Conservation. Commensalism and Conflict: The Primate-Human Interface. J. D. Paterson. Winniipeg, Manitoba, Hignell Printing.
Lee, R.J, Riley J., Hunowu I., & E. Maneasa. 2003. The Sulawesi palm civet: expanded distribution of a little known endemic viverrid. *Oryx* 37: 378-381.

Leigh, E. G., S. J. Wright, Jr., & E. A. Herre. 1993. The decline of tree diversity on newly isolated tropical islands: A test of the null hypothesis and some implications. Evolutionary Ecology **7**:76-102.

Macdonald, D.W., & M.J. Wise. 1979. Notes on the behavior of the Malay civet *Viverrra tangalunga* Gray. Sarawak Mus. J. 48: 295-299.

MacKinnon, J. & K. MacKinnon. 1980. The behaviour of wild spectral tarsiers.International Journal of Primatology 1: 4.

Mackinnon, K. S. 1986. The conservation status of Indonesian primates. *Primate Eye* 29: 30-35.

MacKinnon, K. S. 1986. The conservation status of non-human primates in Indonesia. In: *Primates – the road to self-sustaining populations.* Benirschke, K. (Ed). Springer-Verlag. PP 99-126.

Malic, I. & R. L. Johnson (1994). Commensal Rhesus in India: The Need and Cost of Translocation. Revue D'Ecologie (Terre & Vie) 49(3): 233 - 244.

Maples, W. R., Maples, M. K., Greenhood, W. F. & M.L. Walek. 1976. Adaptations of crop-raiding baboons in Kenya. American Journal of Physical Anthropology 45 pp.309-316.

Marsden S.J. 1998. Changes in bird abundance following selective logging on Seram, Indonesia. Conservation Biology 12: 605 - 611.

Merker, S. & M. Muhlenberg. 2000. Traditional Land Use and Tarsiers – Human Influences on Population Densities of *Tarsius dianae.* Folia Primatologica 71: 426-428.

Mishra, H. R. 1984. A Delicate Balance: Tigers, Rhinoceros, Tourists and Park Management vs the Needs of the Local People in Royal Chitwan National Park, Nepal. National Parks, Conservation and Development: The Role of Protected Areas in Sustaining Society: Proceedings of the World Congress on National Parks, Bali, Indonesia 11-22 October 1982. K. R. Miller. Washington D.C., Smithsonian Institution Press: 197 - 205.

Musser, G. G. 1990. Sulawesi rodents: Species traits and chromosomes of *Haeromys minahassae* and *Echiothrix leucura* (Muridae: Murinae). American Museum Novitates 1989:1-17.

Musser, G.G. 1987. The Mammals of Sulawesi. In: *Biogeographical Evolution of the Malay Archipelago*: 74-95. Whitmore, T.C. (Ed.). Clarendon Press, Oxford.

Naughton Treves, L. 1998. Temporal Patterns of Crop-raiding by Primates: Linking Food Availability in Croplands and Adjacent Forest. Journal of Applied Ecology 35: 596 - 606.

Neri-Arboleda, I., Scott, P. & N.P. Arboleda. 2002. Home ranges, spatial movements and habitat associations of philipine tarsiers (*Tarsius syrichta*) in Corella, Bohol. Journal of Zoology 257: 387-402.

Newmark, W. D., et al. 1994. The Conflict between Wildlife and Local People Living adjacent to protected areas in Tanzania: Human Density as a predictor. Conservation Biology 8(1): 249 - 255.

Nietsch, A. 1987. The ecological niche of the Sulawesi tarsiers (*Tarsius spectrum*). International Journal of Primatology 8: 5, 483.

Nietsch, A. 1999. Duet vocalisations among different Populations of Sulawesi Tarsiers. ??: 567-583.

Nowak, R. M. 1999. *Walker's Mammals of the World* (II). The Johns Hopkins University Press, Baltimore and London.

Nowell, K. & P. Jackson. 1996. *Wild Cats: Status Survey and Conservation Plan.* Gland, Switzerland: IUCN.

Nozaki, E., Azuma, S., Sasaki, H. & H. Torii. 1994. Home range of the Malay Civet (*Viverra tangalunga*) in Teluk Kaba area, Kutai National Park, East Kalimantan, Indonesia. Kyoto Univ. Over. Rep. Spec. Num. 85-94.

O'Brien, T. G. & M. F. Kinnaird. 1996. Changing populations of birds and mammals in north Sulawesi. Oryx 30:150-156.

O'Brien, T. G. & M. F. Kinnaird. 1997. Behavior, diet, and movements of the Sulawesi crested black macaque (*Macaca nigra*). International Journal of Primatology 18**:** 321-351.

O'Donovan, G. 2002. *Operation Wallacea website*. Retrieved from the World Wide Web on 19/2/03. htttp://www.Opwall.co.uk/2002%20forest%20structure%20summary.htm

O'Brien, T. G. & M. Kinnaird. 1997. Behaviour, Diet, and Movements of the Sulawesi Crested Black Macaque (*Macaca nigra*). International Journal of Primatology 18: 321 - 351.

Palomares, F. & T.M. Caro. 1999. Interspecific Killing among Mammalian Carnivores. American Naturalist 153: 492-508.

Parry, D. & B. Campbell. 1992. Attitudes of Rural Communities to Animal Wildlife and Its Utilization in Chobe Enclave and Mababe Depression, Botswana. Environmental Conservation 19(3): 245 - 252.

Pearl, M. 1992. *Conservation of Asian Primates: Aspects of Genetics and Behavioral Ecology that Predict Vulnerability*. In Fieldler, P. L. and Subodh, K. J. (eds.), Conservation Biology – The Theory and Practice of Nature Conservation Preservation and Management, London: Chapman and Hall.

Perez, C. A., L. C. Schiesari, and L. C. Dias-Leme. 1997. Vertebrate predation of Brazil-nuts (*Bertholletia excelsa*, Lecythidaceae), an agouti-dispersed Amazonian seed crop: A test of the escape hypothesis. Journal of Tropical Ecology 13:69-79.

Pirta, R. S., et al. 1997. The Management of the Rhesus Monkey *Macaca mulatta* and Hanuman Langur *Presbytis entellus* in Himachal Pradesh, India. Biological Conservation 79: 97 - 106.

Priston, N. 2001. Assessment of crop damage by *Macaca ochreata brunnescens* in Southeast Sulawesi – a farmer's perpective. Unpublished Ph.D. thesis, Dept of Biological Anthropology. University of Cambridge, England.

Ranjitsinh, M. K. 1984. Keynote Address: *The Indomalayan Realm. National Parks, Conservation and Development: The Role of Protected Areas in Sustaining Society*: Proceedings of the World Congress on National Parks, Bali, Indonesia 11-22 October 1982. K. R. Miller. Washington, D.C., Smithsonian Institution Press: 148 - 153.

Reed, C., T. G. O'Brien and M. F. Kinnaird. 1997. Male social behaviour and dominance hierarchy in the Sulawesi crested black macaque (*Macaca nigra*). International Journal of Primatology 18:247-260.

Resh, V.H., Norris, R.H. and Barbour, M.T. 1995, Design and implementation of rapid assessment approaches for water resource monitoring using benthic macroinvertebrates. Australian Journal of Ecology 20: 108-121

Richard, A. F., Goldstein, S. J. & R.E. Dewar. 1989. Weed macaques: the evolutionary implications of macaque feeding ecology. International Journal of Primatology 10: 569-594.

Roonwal, M. L. & S. M. Mohnot 1977. *Primates of South Asia: Ecology, Sociobiology and Behaviour*. Cambridge, Massachusetts, Harvard University Press.

Rosenbaum, B., T. G. O'Brien, M. Kinnaird & J. Supriatna. 1998. Population densities of Sulawesi crested black macaques (*Macaca nigra*) on Bacan and Sulawesi, Indonesia: Effects of habitat disturbance and hunting. American Journal of Primatology 44:89-106.

Southwick, C. H., et al. 1961a. A Population Survey of Rhesus Monkeys in Northern India: II Transportation Routes and Forest Areas. Ecology 42(4): 698 - 710.

Southwick, C. H., et al. 1961b. A Population Survey of Rhesus Monkeys in Villages, Towns and Temples of Northern India. Ecology 42(3): 538 - 547.

Struhsaker, T. T. 1981. Census methods for estimating densities. In: Subcommittee on Conservation of Natural Populations (eds.). *Techniques for the Study of Primate Population Ecology*. National Academy Press, Washington D. C.

Strum, S. C. 1986. *A Role for Long-term Primate Field Research in Source Countries. Primate Ecology and Conservation*: Vol. 2 of Selected Proceedings of the Tenth Congress of the International Primatological Society. P. C. Lee. New York, Cambridge Univeristy Press. 2: 215 - 220.

Strum, S. C. (#1987a. Almost Human: A Journey into the World of Baboons. New York, Random House.

Strum, S. C. 1987b. The Pumphouse Gang Moves to a Strange New Land. National Geographic. 172: 552 - 601.

Strum, S. C. 1994. Prospects for Management of Primate Pests. Revue D'Ecologie (Terre & Vie) 49(3): 295 - 306.

Strum, S. C. & C. H. Southwick. 1986. Translocation of Primates. Primates: The Road to Self-sustaining Populations. K. Benirschke. New York, Springer-verlag New York Incorporated: 949 - 957.

Sudaryanti, S., Trihadiningrum, Y., Hart, B.T., Davies, P.E., Humphrey, C., Norris, R., Simpson, J. & L. Thurtell. 2001. Assessment of the h\biological health of the Brantas River, East Java, Indonesia using the Australian River Assessment System (AUSRIVAS) methodology. Aquatic Ecology 35: 135-146.

Sutherland, W. J. 1998. The importance of behavioural studies in conservation biology. Animal Behaviour 56:801-809.

Suyanto, A., Yoneda, M., Maryanto, I., Maharadatunkamsi & J. Sugardjito. (1998). *Checklist of The Mammals of Indonesia*. LIPI & JICA, Indonesia.

Tchamba, M. N. 1996. History and Present Status of the Human/Elephant Conflict in the Waza-Logone Region, Cameroon, West Africa. Biological Conservation 75: 35 - 41.

Thomas, L., Buckland, S. T., Burnham, K. P., Anderson, D. R., Laake, J. L., Borchers, D. L. & A. Strindberg. (2002). Distance Sampling. Pp. 544 - 552 in: El-Sharaawi, A. H. & Piegorsch, W. W. (Eds). *Encyclopedia of Environments*, vol. 1. John Wiley & Sons, Chichester.

Thomas, L., J. L. Laake, J. F. Derry, S. T. Buckland, D. L. Borchers, D. R. Anderson, K. P. Burnham, S. Strindberg, S. L. Hedley, M. L. Burt, F. Marques, J. H. Pollard, & R. M. Fewster. 1998. *Distance 3.5*. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK.

Vane-Wright, R.I. & R. de Jong. 2003. *The butterflies of Sulawesi: annotated checklist for a critical island fauna*. Zoologische Verhandelingen 343.

Wallace, A. R. 1869. The Malay Archipelago: The Land of the Orang-utan and the Bird of Paradise: A narrative of travel with studies of man and nature. Macmillan and Co.

Walsh, C.J., Gooderham, J.P.R., Grace, M.R., Sdraulig, S., Imron Rosyidi, M. and Lelono, A. 2002. The relative influence of diffuse- and point-source

disturbances on a small upland stream in East Java, Indonesia: a preliminary investigation. Hydrobiologia 487: 183-192.
Wemmer, C. & Watling, D. 1986. Ecology and Status of the Sulawesi Palm Civet *Macrogalidia musschenbroekii* Schelgel. Biological Conservation 35: 1-17.
Whitesides, G. H., J. F. Oates, S. M. Green & R. P. Kluberdanz. 1988. Estimating primate densities from transects in a west African rain forest: a comparison of techniques. Journal of Animal Ecology 57: 345-367.
Whitten, A. J., M. Mustafa and G. S. Henderson. 1987. *The Ecology of Sulawesi.* Gadjah Mada University Press.
Whitten, T., G. S. Henderson, and M. Mustafa 2002. The Ecology of Sulawesi. Periplus Editions, Hong Kong.