2008 Technical Report #14

Wildlife and Vegetation Surveys of SARIGAN ISLAND April 13-25, 2006

Conducted By:
CNMI Division of Fish and Wildlife

With Assistance From:
U.S. Fish and Wildlife Service
U.S. Navy
University of Guam, Marine Laboratory
Dr. Ortwin Bourquin

Contributing Authors:
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Photo: Curt Kessler

ABSTRACT

Wildlife and vegetation surveys were conducted by a multi-agency field crew at Sarigan Island from April 13 through 25, 2006. This technical report contains contributions by the researchers concerning the biological resources they studied at Sarigan, including forest resources, forest birds, geckos and skinks, monitor lizards, fruit bats, rodents, coconut crabs and land snails.

Special studies were also made to evaluate the suitability of Sarigan Island to receive translocated native forest birds from the southern islands of the Mariana archipelago. These studies included an assessment of the availability of invertebrates that are potential food sources for translocated birds, and sampling for avian diseases among the native birds at Sarigan.

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Wildlife and Vegetation Surveys of Sarigan Island in 2006: An Introduction

By Gayle Martin

An expedition to Sarigan Island, one of the northern islands in the Marianas archipelago, was carried out in April 2006 to survey wildlife and vegetation resources. Biologists and technicians from the Commonwealth of the Northern Mariana Islands (CNMI) Division of Fish and Wildlife (DFW), the U.S. Fish and Wildlife Service, the U.S. Navy, the University of Guam, and independent volunteers cooperated to complete the surveys. This technical report describes our methods and findings.

Purpose of the Surveys

Introduction of the Brown Treesnake (*Boiga irregularis*) to the island of Guam has resulted in the extinction or local extirpation of nine of the 12 native forest bird species and two of 11 native lizard species, and threatens native fruit bat populations (Colvin et al. 2005). The Brown Treesnake (BTS) has established an incipient population on the island of Saipan, and is the biggest threat to terrestrial ecosystems in the CNMI (*ibid.*). It is imperative that measures be taken to ensure the future of the CNMI's endemic birds. One viable option for conserving endemic birds is to translocate them to the northern islands of the Marianas archipelago before BTS infestation results in their demise on the southern islands of Saipan, Rota and Tinian.

Sarigan Island is a good candidate for receiving translocated birds because: 1) feral animals have been entirely eradicated (Kessler 2002); 2) recovery of vegetation is occurring (Cruz et al. 2000); and 3) transportation cost and time to Sarigan is less than for other more remote northern islands. The Saipan subspecies of the Bridled White-eye (*Zosterops conspicillatus saypani*) is a good candidate species for translocation to Sarigan because: 1) it is the most abundant endemic bird species in the southern islands of the CNMI (Engbring et al. 1986); 2) it is not endangered, but its distribution is limited to only three islands (Berger et al. 2005); 3) white-eyes were the first avian species to become extinct from Guam as a result of BTS infestation (Savidge 1987); and 4) success in translocation of this one species will drive translocation plans for other species in the future.

Before a translocation program of Bridled White-eyes could be instituted for Sarigan, a survey of wildlife and vegetation was needed to determine: 1) if sufficient forest habitat exists to support Bridled White-eyes; 2) if avian diseases are present on Sarigan; 3) the status of predators; and 4) if there are sufficient food resources (invertebrates) to support Bridled White-eyes. The last comprehensive wildlife and vegetation survey prior to this current effort was conducted by DFW on Sarigan in 2000 (Cruz et al. 2000). Since then, vegetation changes have occurred and there was a need to update information on wildlife and vegetation resources.

Project Approval and Funding

A project to conduct these surveys was proposed in August 2005 by the CNMI Division of Fish and Wildlife. The project was approved and funded through the U.S. Fish and Wildlife Service Federal Aid Program, under the State Wildlife Grant, Grant no. T-2-R-1, in September 2005. The project was specifically designed to meet one of the conservation actions outlined in CNMI's Comprehensive Wildlife Conservation Strategy (Berger et al. 2005). A budget of $36,650 was approved for this project, but was augmented with support lent by other agencies.

Collaboration with Other Agencies

Additional support was lent to the effort by coordinating these surveys with other ongoing work of the U.S. Fish and Wildlife Service (USFWS) and the U.S. Navy. This collaborative effort meant that we could expand our efforts. Funding for an additional sailing of the M.V. *Micronesian* was provided by the USFWS, enabling us to send a field party to Sarigan ahead of the surveys to cut transects. Helicopter time was funded by the USFWS and the U.S. Navy, enabling us to take additional equipment and supplies to Sarigan. The ability to sling loads by helicopter meant we could avoid dangerous ship to rocky shore off-loading by inflatable and outboard motor in high surf, and facilitated supplying the "Upper Camp".

Sarigan Island Characteristics

The Northern Mariana Islands are located in the mid-Pacific Ocean, in a region called Micronesia, far from the U.S. Mainland. The Marianas archipelago is made up of 15 islands, spanning 675 km of ocean. Saipan is the capital of the CNMI, where most of the population resides. Guam is the largest island in the archipelago, but is a separate political entity from the CNMI. Sarigan is a volcanic island located approximately 100 miles north of Saipan, (Figure 1).

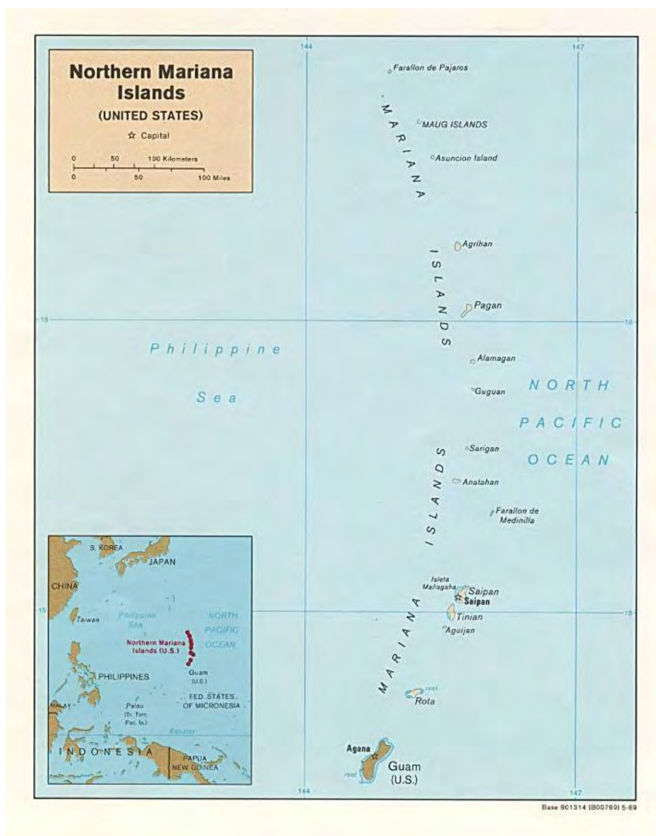

Figure 1. Location map showing Sarigan as being approximately 100 miles north of Saipan.

Sarigan is an extinct volcano, with the highest point being at 549 meters (Berger et al. 2005). The slopes are so steep that hiking is dangerous; in fact, one member of our field party, Ping Kapileo, broke his ankle while cutting transects. Sarigan's

tropical climate is hot and humid, with daytime temperatures ranging from 84° to 90°F., and nights from 70° to 75° F. (*ibid.*). The island is small, 5.0 square miles in area and 3 km across (*ibid.*); one could hike across it in a day, if one didn't mind climbing a lot.

Sarigan's steep eastern and southern slopes are sparsely vegetated with grasses and ferns, whereas the western and northern slopes are more gentle and support native forest and coconut forest (Fancy et al. 1999). Native forest is common in ravines and was estimated in 1997 to cover 29 ha of the island, comprising 18% of the forest area of Sarigan (*ibid.*). Coconut (*Cocos nucifera*) plantations were estimated to cover 133 ha of the island, comprising 82% of the forest area (*ibid.*).

Sarigan's forests have been severely degraded by feral goats and pigs. In 1997, little palatable vegetation was found in the understory of the coconut forest by Fancy et al. (1999). Feral animals were removed through a campaign conducted during 1998, utilizing shooting from a helicopter and on the ground (Kessler 2002). Numbers of plant species, frequency of individual plant species and ground cover increased dramatically within a year after feral animal removal (Cruz et al. 2000).

Acknowledgement of Personnel

An expedition of this magnitude would not have been possible without the dedicated work and expertise of a number of different people. The following individuals (in alphabetical order and by agency) played a part in making these surveys successful.

CNMI Division of Fish and Wildlife

- Ben Camacho – logistical support from Saipan.
- Jess "Gere" Deleon Guerrero – cut transects, kept the inflatable and engine running.
- Alvin Fitial – conducted coconut crab surveys, Mariana fruit bat surveys.
- Nate Hawley – small mammal and reptile surveys.
- Joe "Ping" Kapileo – cut transects, and unfortunately broke his leg doing so.
- Shelly Kremer – mist-netted birds at Upper Camp, collected avian blood and feather samples, performed avian necropsies, conducted bird surveys.
- Gayle Martin (formerly Gayle Berger) –assisted with avian blood sampling and necropsies, conducted vegetation surveys.
- Jess Omar – participated in feral animal control at Anatahan.
- Paul Reyes – small mammal and reptile surveys.
- John Salas – bird and vegetation surveys.
- Pete Teigita – cut transects.
- Peter Tomokane – cut transects.
- Laura Williams – performed bird and vegetation surveys.

Workforce Investment Agency

- VJ Concepcion – cut transects, bird and vegetation surveys.

U.S. Fish and Wildlife Service

- Curt Kessler – cut transects, logistics and helicopter support, megapode capture and banding, Mariana fruit bat count, feral animal eradication at Anatahan.

U.S. Navy

- Scott Vogt – monitor lizard study, coconut crab surveys.

University of Guam Marine Laboratory

- Barry Smith – a professional malacologist from the University of Guam, donated his time for land snail surveys and subsequent data analysis and report writing, and UOG paid his roundtrip airfare from Guam to Saipan.

Volunteers

- Richard Sikkel, a volunteer from Saipan, donated a week of his time to cut transects on Sarigan.
- Robby Kohley of the Institute of Wildlife Studies donated a week of his time to mist-net birds and take blood samples for the avian disease assessment.
- Dr. Ortwin Bourquin's travel from Montana to Saipan was paid by State Wildlife Grant funds, but he donated weeks of his time to conduct the invertebrate surveys and perform the subsequent data analysis and report writing.
- Patrick Santos along with his hunting dog "Diver", from the island of Alamagan, volunteered for feral animal eradication Anatahan Island and assisted with megapode capture and banding.
- Dr. Tina de Cruz, formerly employed at DFW, was paid a small sum for avian data analysis and report writing.

Transportation

- Americopters and Saipan Crewboats are appreciated for taking the field party and all of its supplies, equipment, food and drinking water to Sarigan, and for getting us home safely.

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Sarigan Forest Surveys
1999, 2000 and 2006

By

Laura L. Williams
CNMI Division of Fish & Wildlife

February 2008

SUMMARY

Feral goats and pigs were eradicated from the island of Sarigan in 1997. The CNMI Division of Fish and Wildlife and the United States Fish and Wildlife Service (USFWS) through funding from the United States Navy, established permanent bird and forest survey transects in 1999 to monitor the post eradication recovery. The permanent transects were resurveyed in 2000 and 2006. The objectives of the 2006 surveys for the purpose of this study, were to continue the post feral animal eradication monitoring of the vegetation and to determine the suitability of the habitat for the experimental translocation of a small population of the Saipan subspecies of the endemic Bridled White-eye (*Zosterops conspicillatus saypani*).

The density of trees in the surveyed forested areas increased from 1.48 trees/100m^2 in 1999 to 13.70 trees/100m^2 in 2006. Species richness (number of tree species) also increased from 1999 to 2006 along forested transects and grassland transects from 13 to 15 and 15 to 29 species respectively. The importance value of the dominant tree species *Aglaia mariannensis*, *Cocos nucifera* and *Hibiscus tiliaceus* decreased on permanent forest transects from 1999 to 2006 whereas *Pisonia grandis*, *Morinda citrifolia*, *Ficus prolixa*, *Ficus tinctoria* and *Premna obtusifolia* increased in importance value from 1999 to 2006. The average canopy cover of forested and grassland transects increased from 52% to 77% and 0.4% to 15% between 1999 and 2006 respectively.

The results of these surveys indicate that Sarigan will provide suitable habitat for the translocation of Bridled White-eyes as there has been an increase of foraging tree species, forest area and composition. Fifteen tree species that are known to be utilized by the Bridled White-eye were identified during surveys and opportunistically on Sarigan. The increase in importance value of more tree species combined with the increase in density and canopy cover indicate a trend towards increasing species richness, forest complexity and forest area. These factors combined will increase the usable habitat for Bridled White-eyes.

INTRODUCTION

Sarigan is a 500 ha uninhabited island in the Mariana archipelago approximately 121 miles north of Saipan. In the 1900's under the German administration of the Northern

Mariana Islands Sarigan was a penal colony and coconuts were cultivated for copra production (Kessler 1998). Feral animals are likely to have been introduced to Sarigan during that period however Kessler reports feral ungulates have been continuously present since the 1940's (Kessler 1998) even though humans have not occupied Sarigan continuously since WWII (Kessler 1998). Therefore, the feral ungulate population increased unfettered by any limiting factors. The increasing impact of feral animals led to extensive vegetation damage, loss of native bird and bat habitat, and erosion of top soil (Fancy et al. 1999; Cruz et al. 2000b). A total of 904 goats, 68 pigs and two cats were eradicated by February 1998 (Kessler 1998). Vegetation recovery after eradication was monitored initially by thirteen $1m^2$ permanent plots which sampled different habitat types. Plant species richness increased by 59% within the monitoring plots from seven to seventeen species identified within the first six months post eradication. Density and frequency of all tree species within the plots increased. Some herbaceous species however actually decreased in density and/or frequency as the plots became more diverse (Arriola and Kessler 2001).

In 1999, biologists from the USFWS and the CNMI Division of Fish and Wildlife (DFW) established eight permanent transects with 67 stations every 100 m to monitor vegetation recovery with forest point-centered quarter surveys, and avian populations through Variable Circular Plots surveys (VCP) (Figure 1). Transects 1 through 5 were established in the forests predominantly on the west side of the island. Transects 6 through 8 were established in grasslands, in some cases with very widely dispersed trees, or on lava flow (transect 7). The USFWS conducted point-centered quarter forest surveys on a subsample of 26 stations in 1999 within the forested areas, however surveyed all the stations on transects 6, 7 and 8. They found that native and coconut forests were the dominant forest types (USFWS unpublished data). In 2000, the CNMI DFW conducted VCP bird surveys and forest point-centered quarter surveys along the permanent stations established in 1999. Forest point-centered quarter surveys were conducted at 37 stations, although the most remote, dangerous stations on one of the grassland transects were not surveyed (Cruz et al., 2000b).

The first objective of this survey was to continue monitoring vegetation recovery in correlation with the avian Variable Circular Plot (VCP) surveys. The second objective was to analyze the forest habitat to determine if suitable habitat is available for the translocation of Bridled White-eyes (*Zosterops conspicillatus saypani*). Translocation of the Bridled White-eye and other species is currently being planned by the CNMI Division of Fish and Wildlife in response to the strong possibility of an incipient Brown Treesnake (BTS) population on Saipan (Colvin et al., 2005). To date there have been 76 sightings and 11 captures of BTS on Saipan (Colvin et al., 2005).

METHODS

Forest surveys were conducted from April 20-23, 2006 in conjunction with bird surveys along the seven permanent transects that were established in 1999 by the USFWS and resurveyed in 2000 by the CNMI DFW, (Figure 1). However, due to unsafe conditions

and a lack of vegetation, transect 7 was not surveyed in 2006. Trees were surveyed at every station along seven transects using the point-centered quarter method following the same methodology used in 1999 and in 2000 (Mueller-Dombois and Ellenberg 1974). The lateral distance from point to nearest tree in each cardinal direction was measured, species identified, circumference measured and height estimated for all species 1.75m and greater. Height data was only collected in 2006. Canopy cover was determined using a densiometer (Model-C: Forest Densiometer sold through Forestry Suppliers, Inc.) according to the manufacturer's instructions and ground cover was estimated using the line intersect method (Mueller-Dombois and Ellenberg 1974).
A total of 45 stations on forested transects 1 through 5 were surveyed in 2006 and the data was combined for analysis. Transects 6 and 8 were analyzed together and separately from transect 1 through 5, as they are grass dominated and could not be analyzed similarly to the forest transects.

Data from the 1999 surveys and the 2000 surveys were obtained and re-analyzed along with the 2006 data to ensure consistency and comparability. There were 26 forest stations surveyed in 1999 by the USFWS (unpublished data). In 1999 every other station was surveyed on transects 1-5 and stations 1-11 only were surveyed on transect 5. In 2000, the CNMI DFW surveyed 37 stations (Cruz et al., 2000b). Each station was surveyed in succession along the transects, however transect 8 in the grassland habitat was not surveyed for vegetation.

The data for all years from transects 1-5 were analyzed for tree density, absolute density, absolute frequency, basal area, dominance, importance value and percent canopy and ground cover (Mueller-Dombois and Ellenberg 1974). Absolute frequency was calculated as the number of stations in which a species occurs divided by the total number of stations multiplied by 100. The absolute density (AD) was calculated for the total number of trees supported in a $100m^2$ area and for each individual species within the area. Absolute density of all tree species in $100m^2$ was calculated with the formula AD = area/D^2, where D=the mean distance of all distances to all trees at all stations. In order to determine the density of a specific tree species, the ratio of the number of quarters in which the species occurred to the total number of quarters was calculated. That ratio was then multiplied by the overall absolute density of trees to determine the density of each species per 100 m^2. Basal area (BA) was calculated with the formula $BA=\pi (DBH^2)$, where DBH is the diameter at breast height (1.4m) of each tree measured. Dominance of each species incorporates the average basal area of each species for all individuals surveyed times the species density in the 100 m^2 (as calculated above). The Importance Value (IV) incorporates density, frequency and dominance of each species to determine the overall most important ecological species within a forest. The IV was determined by taking the sum of relative dominance, relative density and relative frequency. Relative values were derived from the ratio of individual species to the sum of all species (Mueller-Dombois and Ellenberg 1974).

The 2006 forest data was used to develop a forest vegetation map. A transect section was designated native forest or coconut forest based on 75% of the vegetation (as determined by the tree species) at each station, either native or coconut trees. If the vegetation

clearly changed from one forest type to another consistently (i.e. dominated by either coconut or native) that section was reclassified to reflect the dominant forest type.

Transects 6 and 8 were grassland, field with trees too widely dispersed to measure distance to the point, therefore density and other forest parameters could not be calculated. The data from these two transects were combined and analyzed for species richness (the total number of species present), absolute frequency, species abundance (total number of each species), and ground and canopy cover. In 1999, there were 16 stations and only transects 6 and 8 were surveyed. In 2000, ten stations on transect 6 were surveyed and in 2006, 15 stations on transects 6 and 8 were surveyed.

Transect 5 between stations 4 and 5, facing north.

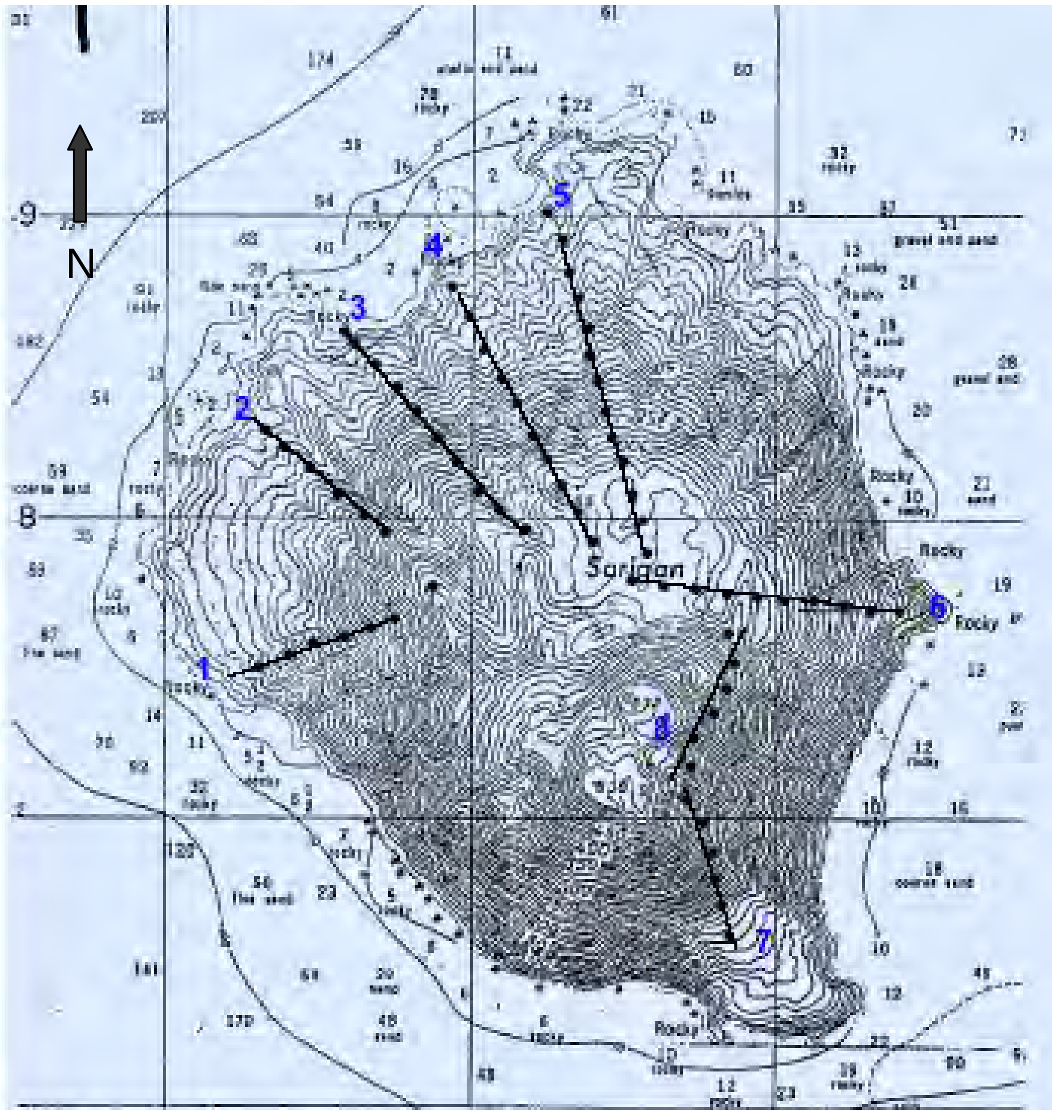

Figure 1. Eight permanent transects established in 1999 for avian and vegetation monitoring on Sarigan. Forest and bird surveys were conducted on these transects in 1999, 2000 and 2006.

RESULTS

The total number of tree species identified in the forested areas (transects 1-5) increased from 13 to 15 between the 1999 and the 2006 surveys, (Table 1). The absolute frequency, which represents the distribution of species, varied widely from 1999 to 2006 depending on species, (Figure 2). *Aglaia mariannensis* had the greatest absolute frequency in 1999. The distribution of *Carica papaya* changed by only a single percentage point, effectively remaining the same over the three years, *Cocos nucifera,*

Ficus prolixa and *Morinda citrifolia* increased from 1999 to 2006, and *Hibiscus tiliaceus* decreased from 1999 to 2006, (Figure 2).

The overall density of tree species more than tripled from 1.48 trees/100m^2 in 1999 to 9.81 trees/100m^2 in 2000. Density of all tree species has continued to increase and in 2006 was 13.70 trees/100m^2, (Table 2). *Cocos nucifera*, *A. mariannensis* and *C. papaya* had the greatest increase in density from 1999 to 2000. *Erythrina variegata* increased in density by more than ten times from 1999 to 2006; density of *Neisosperma oppositifolia* increased by more than seven times from 1999 to 2006; density of *Morinda citrifolia* increased by more than three times from 2000 to 2006, (Figure 3 and Table 2). *Leucaena leucocephala*, *F. prolixa*, *Melanolepis multiglandulosa and Pandanus tectorius* increased moderately from 2000 to 2006. Conversely, *Barringtonia asiatica* was detected only in 1999. *Pipturus argenteus* and *Trema orientalis* were each detected in 2000 and not in 2006, (Figure 3 and Table 2).

The dominance of several native tree species increased from 1999 to 2006 including *C. nucifera*, *A. mariannensis*, *M. citrifolia*, *N. oppositifolia, and P. grandis*, (Figure 4 and Table 3). *Leucaena leucocephala* was not detected in 1999 however was present in 2000 and increased in 2006, (Figure 4 and Table 3). *Hibiscus tiliaceus* varied in dominance (increasing from 1999 to 2000, then decreasing from 2000 to 2006) and decreased in average basal area from 1999 to 2006, (Figure 4 and Table 3). Despite the increase in dominance, the average basal area did not increase much for *A. mariannensis* and average basal area decreased with increasing dominance in *Erythrina variegata*, (Table 3).

Table 1. The number of transects surveyed each year and the total number of tree species (species richness) detected.

Year	**# Stations Surveyed**	**# Tree Species Identified**
1999	26	13
2000	37	14
2006	45	15

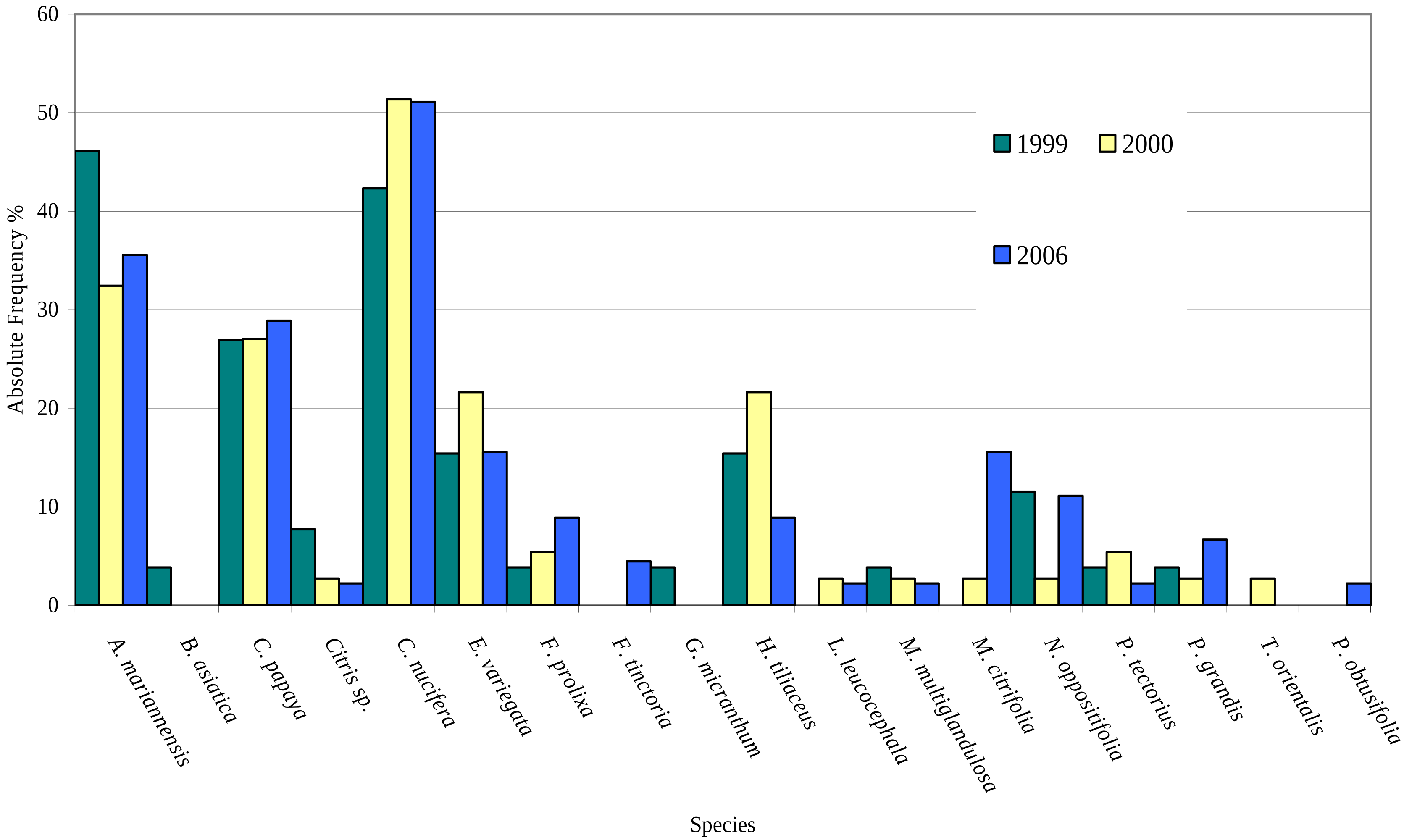

Figure 2. Absolute frequency of tree species in forested areas (transects 1 through 5) on Sarigan in 1999, 2000 and 2006.

Two Micronesian Megapodes in native forest in the middle of transect 5 in between stations 7 and 8.

The importance value, which encompasses frequency, dominance and density, was highest in *C. nucifera*, *P. grandis*, *A. mariannensis* and *E. variegata* in 2006, although this represents a decline for *E. variegata* from 1999 to 2006, (Table 4). The importance value for *A. mariannensis* decreased from 64.54 to 43.88 from 1999 to 2006 and *C. nucifera* decreased from 100.10 to 89.45 from 1999 to 2006 (Table 4). *Hibiscus tiliaceus* has decreased by 50% in importance value between 1999 and 2006, (Table 4). The greatest increases in importance value were for *P. grandis* (17.28 to 46.52) and *F. prolixa* (4.87 to 18.64) from 1999 to 2006, (Table 4).

Several tree species were commonly detected along transects in 2006 but not at stations, or were opportunistically observed in areas not covered by transects including: *Terminalia catappa, Psychotria mariana, Artocarpus altilis, Pipturus argenteus and Cynometra ramiflora.*

The average canopy cover for all forest transects in 2006 (transects 1-5) was 77%± 30%. This is an approximate 20% increase from 2000 when overall forest canopy cover was 52%±12%. The range of canopy cover for forest transects in 2000 was 49% to 76% and in 2006 it was 72% to 92%. Transect 2, which was dominated by coconut forest, had the highest percent canopy cover, at 92%± 4%, an increase of almost 30%. Canopy cover on Transect 6 increased from 0.4% to 15% from 2000 to 2006, (Figure 5).

The total average ground cover increased by 9% for all forest transects (the average ground cover for transects 1-5) from 31% in 2000 to 40% in 2006. The range of ground cover for forests transects in 2000 was 15% to 48% and in 2006 it was 22% to 46%, (Figure 6).

The average height of tree species on transects 4 and 5 which were dominated by native species was 4.96 m and 5.65 m respectively, whereas the average height of trees on transects 1 and 2, which were predominantly coconut forests, were 14.79 m and 11.25 m, (Figure 7).

Cynometra ramiflora (Gulos), found in the native forest along transect 5.

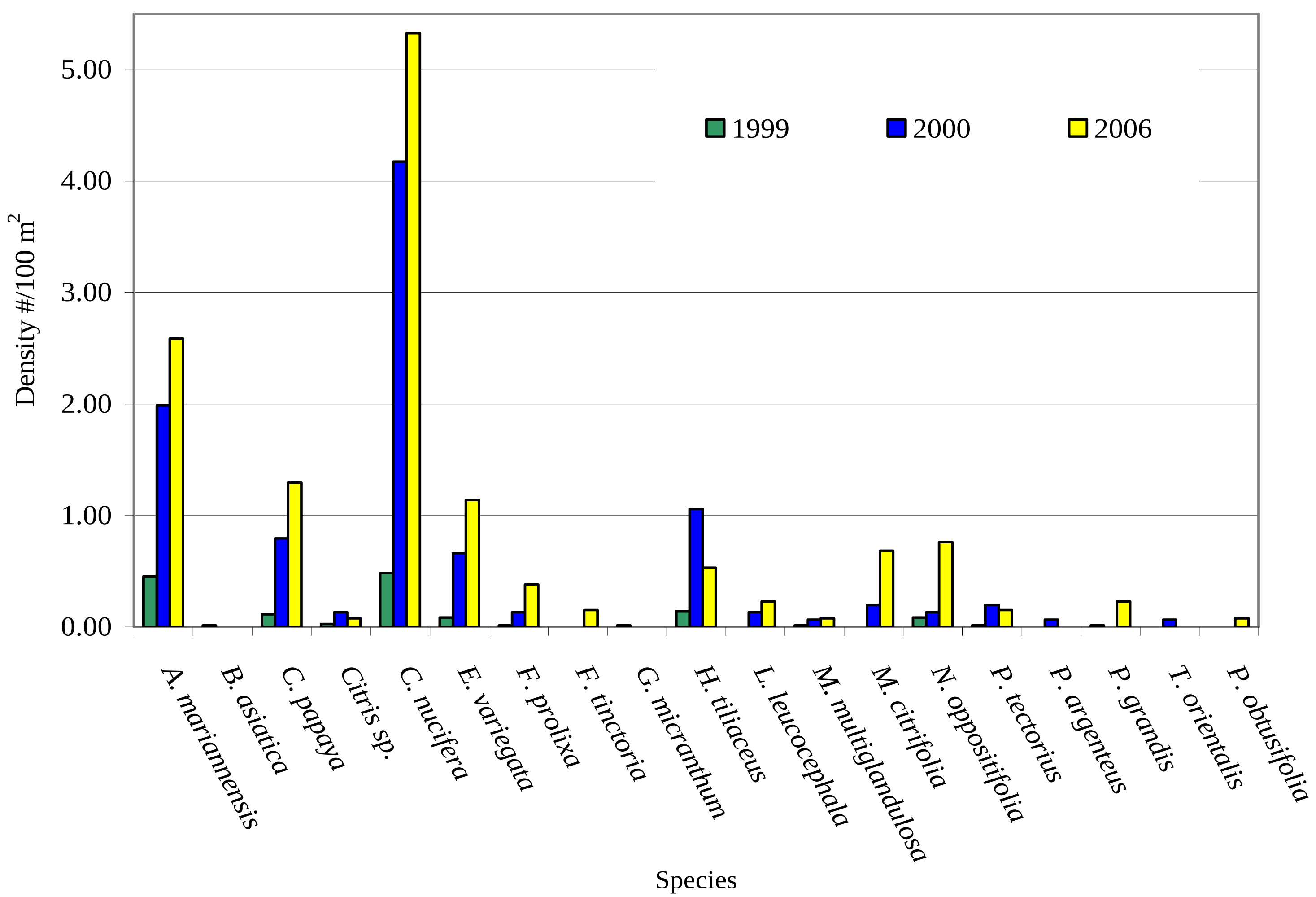

Figure 3. The density of individual tree species per 100 m^2 in 1999, 2000 and 2006 for forested areas (transects 1 through 5) on Sarigan.

Table 2. The density of individual tree species per 100 m^2 and the total overall tree density in 1999, 2000 and 2006 in forested areas (transects 1 through 5) on Sarigan.

Species	Trees per 100m^2		
	1999	2000	2006
A. mariannensis	0.46	1.99	2.59
B. asiatica	0.01	0	0
C. nucifera	0.48	4.18	5.33
C. papaya	0.11	0.80	1.29
Citrus sp.	0.03	0.13	0.08
E. variegata	0.09	0.66	1.14
F. prolixa	0.01	0.13	0.38
F. tinctoria	0	0	0.15
Geniostoma micranthum	0.01	0	0
H. tiliaceus	0.14	1.06	0.53
L. leucocephala	0	0.13	0.23
M. citrifolia	0	0.20	0.69
M. multiglandulosa	0.01	0.07	0.08
N. oppositifolia	0.09	0.13	0.76
P. argenteus	0	0.07	0
P. grandis	0.01	0	0.23
P. obtusifolia	0	0	0.08
P. tectorius	0.01	0.20	0.15
T. orientalis	0	0.07	0
Total for all Trees	**1.48**	**9.81**	**13.70**

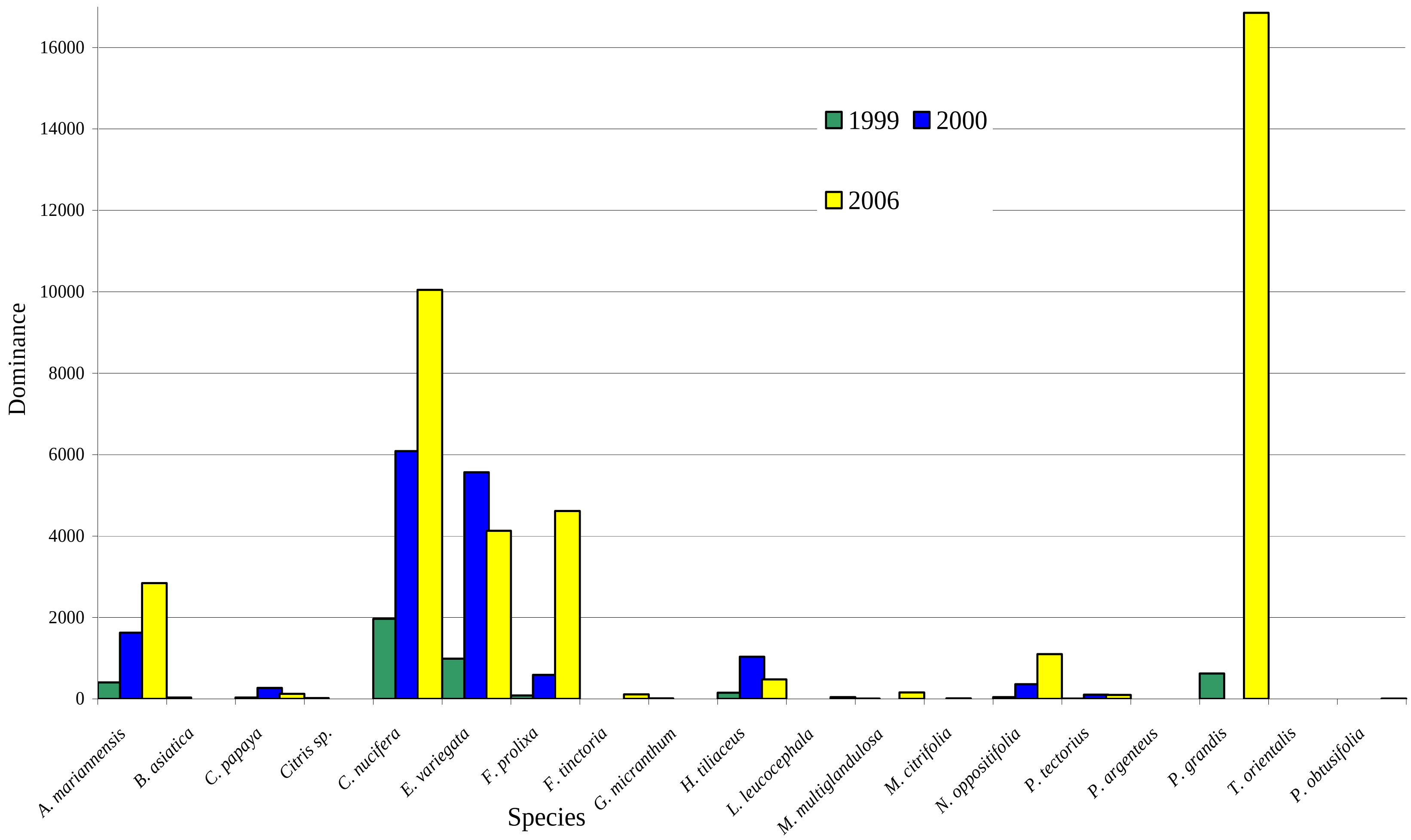

Figure 4. The dominance (D=avg BA*Density) of tree species in forested areas (transects 1 through 5) detected on Sarigan in 1999, 2000 and 2006. (Dominance values for *B. asiatica*, *Citrus* sp., *L. leucocephala*, *P. argenteus* and *P. obtusifolia* are too low in comparison to other species to be detected on graph, please refer to Table 3 for values).

Table 3. The average basal area (BA=π {DBH^2}) and dominance (D=avg BA*Density) of tree species in forested areas (transects 1 through 5) on Sarigan in 1999, 2000 and 2006.

Tree Species	1999		2000		2006	
	Avg BA	Dominance	Avg BA	Dominance	Avg BA	Dominance
A. mariannensis	897.71	408.80	817.93	1626.46	1101.16	2849.57
B. asiatica	2136.16	30.40	0	0	0	0
C. nucifera	4066.23	1967.43	1456.79	6083.36	1885.46	10045.31
C. papaya	277.51	31.59	336.25	267.46	96.10	124.34
Citrus sp.	661.78	18.84	22.24	2.95	5.10	0.39
E. variegata	11596.46	990.16	8396.17	5565.30	3618.46	4131.08
F. prolixa	5761.60	81.99	4467.56	592.25	12134.54	4617.87
F. tinctoria	0	0	0	0	750.64	114.26
G. micranthum	891.88	12.69	0	0	0	0
H. tiliaceus	1055.50	150.21	979.33	1038.62	894.86	476.76
L. leucocephala	0	0	17.78	2.36	210.32	48.02
M. citrifolia	0	0	7.76	1.54	233.31	159.82
M. multiglandulosa	297.32	4.23	191.16	12.67	25.80	1.96
N. oppositifolia	506.07	43.21	2724.72	361.21	1444.13	1099.15
P. argenteus	0	0	27.54	1.83	0	0
P. grandis	43873.15	624.35	0	0	73834.71	16858.93
P. obtusifolia	0	0	0	0	81.53	6.21
P. tectorius	455.04	6.48	516.48	102.70	659.39	100.37
T. orientalis	0	0	4.36	0.29	0	0

Table 4. The importance value (the sum of relative density, frequency, and dominance) of all tree species detected in forested areas on Sarigan (transects 1-5) in 1999, 2000 and 2006.

Tree Species	Importance Value		
	1999	2000	2006
A. mariannensis	64.54	48.28	43.88
B. asiatica	3.69	0	0
C. nucifera	100.10	109.32	89.45
C. papaya	22.66	24.50	24.34
Citrus sp.	6.42	2.84	1.68
E. variegata	36.57	54.05	26.37
F. prolixa	4.87	8.07	18.64
F. tinctoria	0	0	3.64
G. micranthum	3.29	0	0
H. tiliaceus	21.19	29.19	9.56
L. leucocephala	0	2.84	2.91
M. citrifolia	0	3.51	13.25
M. multiglandulosa	3.09	2.23	1.68
N. oppositifolia	12.86	5.13	13.87
P. argenteus	0	2.16	0
P. grandis	17.28	2.16	46.52
P. obtusifolia	0	0	1.69
P. tectorius	3.14	5.62	2.48
T. orientalis	0	2.15	0

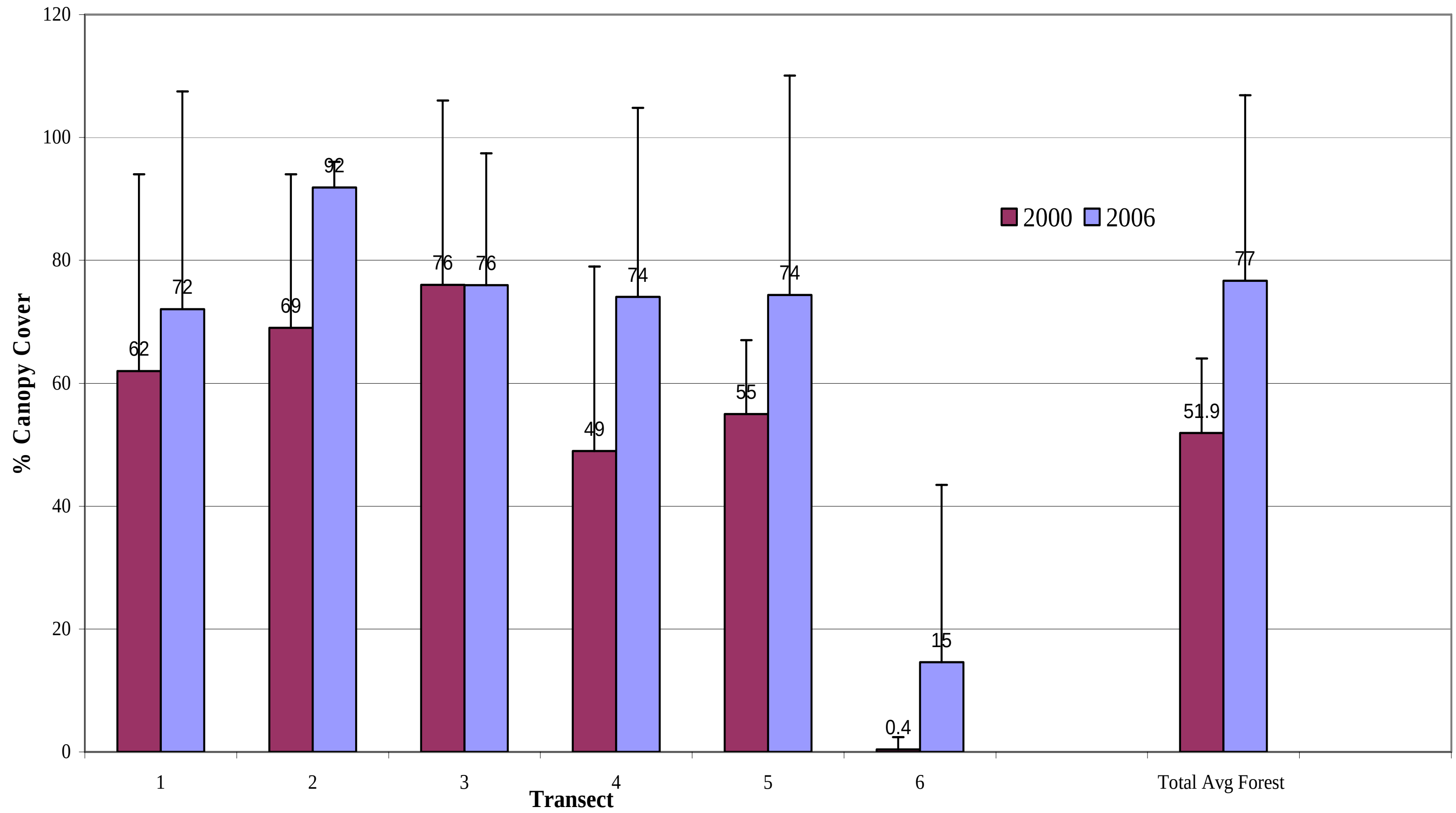

Figure 5. The percent average canopy cover for forested areas (transects 1 through 5) and grassland transect 6 (transect 8 did not have canopy cover) surveyed on Sarigan in 2000 and 2006.

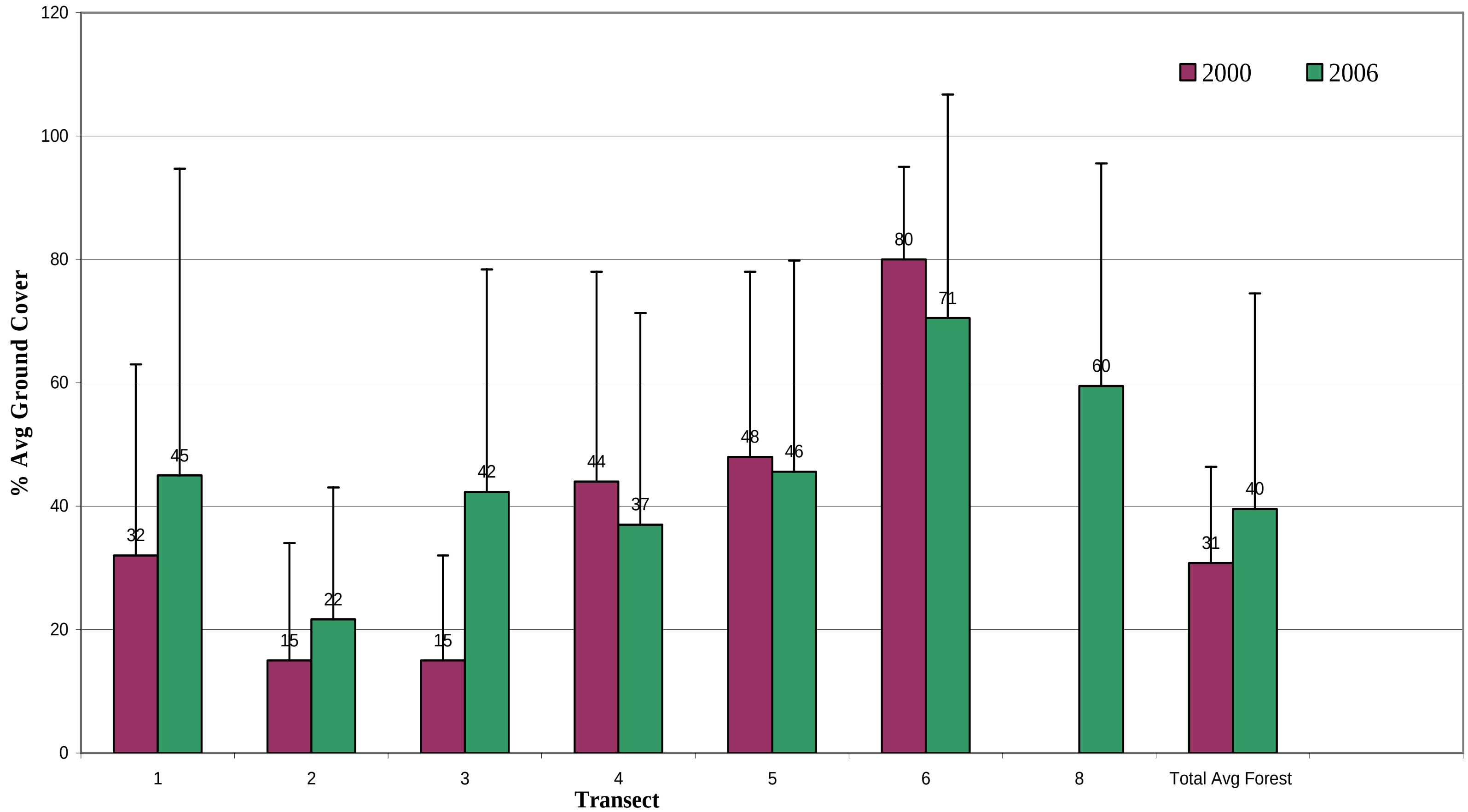

Figure 6. The percent average ground cover in forested areas (transect 1 through 5) and grassland areas (transects 6 and 8) on Sarigan in 2000 and 2006.

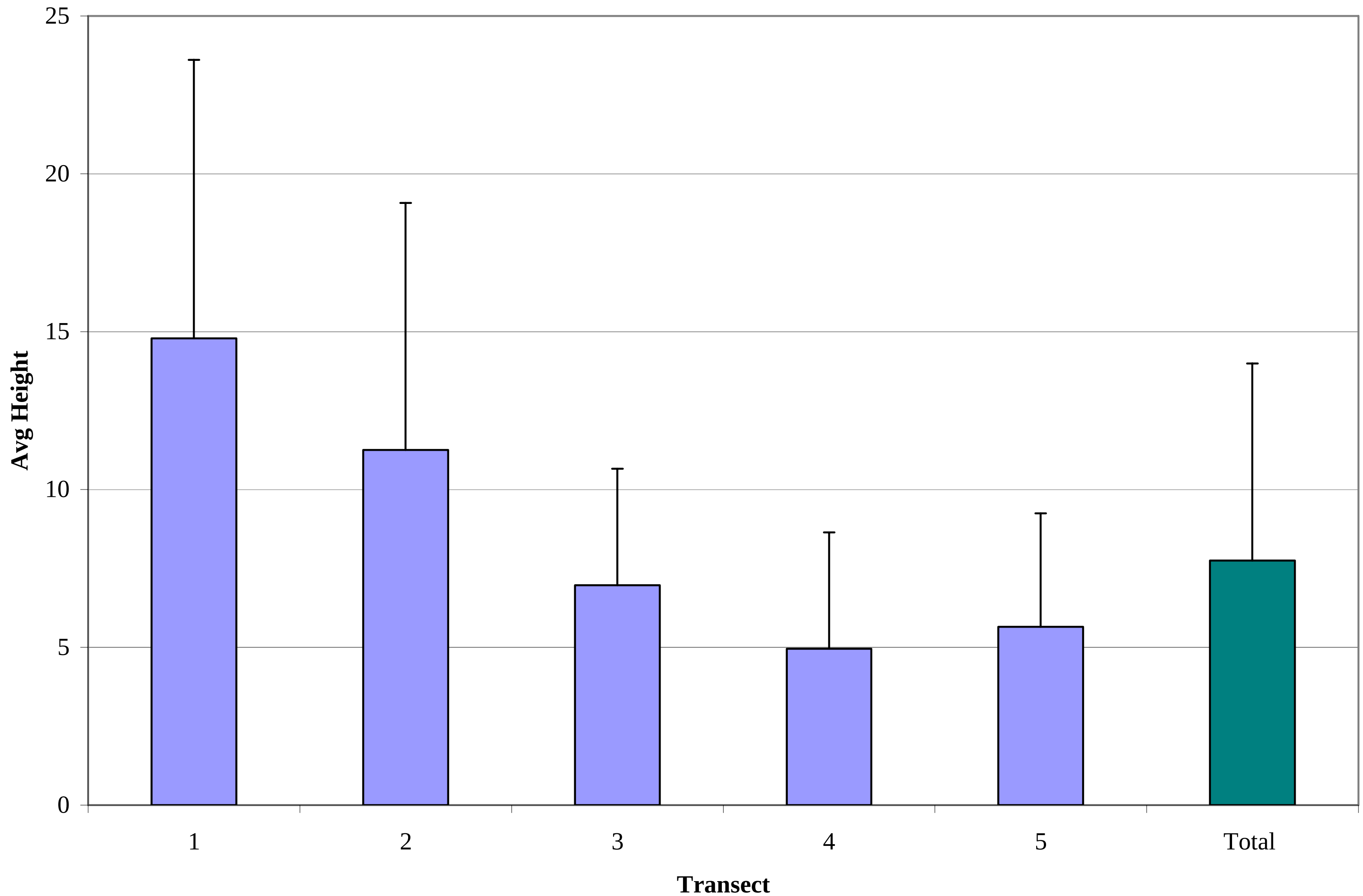

Figure 7. The average height of trees surveyed on each transect and the average height of all trees in all forested areas (transect 1 through 5) on Sarigan in 2006.

There were eight stations with trees on transect 6 all three years. However, the total number of trees detected increased from 15 in 1999 to 19 in 2006 on transect 6, (Table 5). There were six tree species detected along transect 6 in 1999, 2000 and 2006. However, the composition of species varied for each year, (Table 6). The tree species that remain constant along these transects are *C. nucifera*, *F. prolixa*, *H. tiliaceus*, and *N. oppositifolia*, (Table 6).

There were four stations with trees on transect 8 in 2006 and no trees found in 1999. Transect 8 was not surveyed in 2000. The total number of trees detected went from zero in 1999 to ten in 2006, (Table 5). The ten trees were of four tree species in 2006 and the greatest increase in absolute frequency was with *P. argenteus*, (Figure 8).

Table 5. The number of stations with tree detections and the total number of trees in grassland areas (Transects 6 and 8) on Sarigan in 2000 and 2006.

Number of Stations with Trees			
Transect	1999	2000	2006
6	8	8	8
8	0	NS	4
Total Number of Trees			
Transect	1999	2000	2006
6	15	13	19
8	0	NS	10

NS = not surveyed that year

Table 6. The absolute frequency of trees detected in grassland areas (transect 6 and 8) on Sarigan in 1999, 2000 and 2006.

Species	Absolute Frequency Percent				
	Transect 6			Transect 8	
	1999	2000	2006	1999	2006
C. nucifera	20	20	20	No Trees Present	0
Citrus sp.	10	0	0		0
E. variegata	0	10	0		20
F. prolixa	10	10	10		60
H. tiliaceus	10	10	10		20
M. citrifolia	20	0	20		0
N. oppositifolia	10	10	10		0
P. argenteus	0	0	0		80
P. tectorius	0	0	30		0
T. orientalis	0	10	0		0

The flower of tree *Erythrina variegata* (Gaogao). Seedlings, saplings and young trees under 3m are especially common around the central plateau area near the beginning of transects 4, 5 and 6. *E. variegata* is found throughout the island, especially in the center plateau along the southern parts of transect 3, 4 and 5.

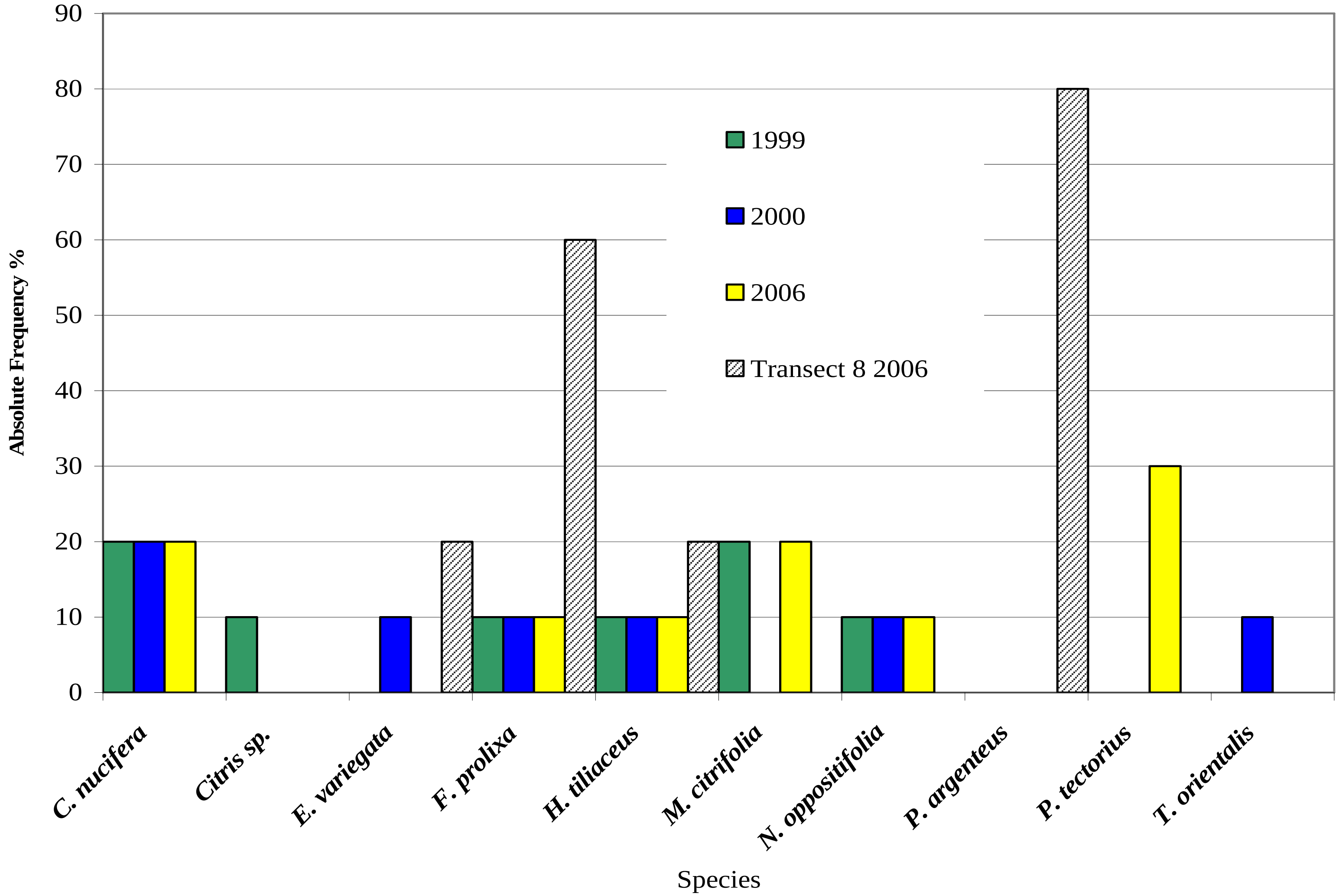

Figure 8. The absolute frequency of trees detected in grassland areas on transect 6 in 1999, 2000 and 2006, and on transect 8 in 2006 on Sarigan.

Native forest was found throughout the area traversed by transect 5 except at the last station, 70% of transect 4 on the southeast incline, and 40% of transect 3. Coconut forest dominated the area of transects 1 and 2 and the coastal parts of transects 3 and 4. The demarcation line between the two forest types occurred between stations on all transects and is easily recognizable in the field. A vegetation map of the approximate location of the vegetation types was drawn based on these data (Figure 9).

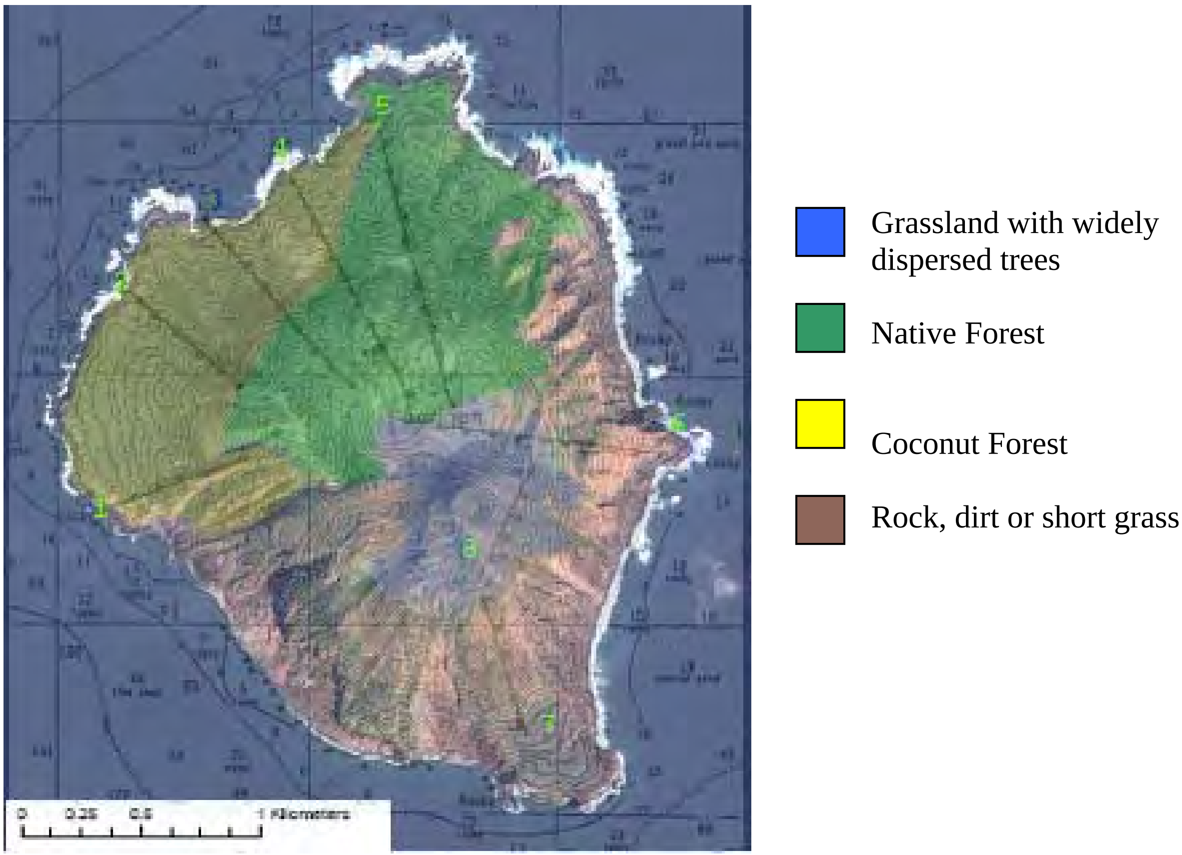

Figure 9. The approximate location of the four major vegetation types on Sarigan based on vegetation data collected at stations along eight transects in 2006.

DISCUSSION

The recovery of vegetation is an ongoing and dynamic process on Sarigan. Based on the three surveys conducted in 1999, 2000 and 2006, species richness (number of tree species) and overall tree density continue to increase. The canopy cover which increased by 20% is a result of the increased tree density. The increased density of tree species likely affected the avian surveys that occurred on the same stations and transects, as changes in bird detections were reported (Cruz 2007, unpublished data). The number of tree species detected during the point-centered quarter surveys will increase over time as there are still rare and localized pockets of species

observed serendipitously during surveys but that were not present at the stations. The four species *T. catappa, P. mariana, A. altilis and C. ramiflora,* observed on Sarigan but not at the stations are all important forest and wildlife food trees. Additionally, there are other significant tree species that have been reported to occur on Sarigan but have yet to be detected during the 1999, 2000 or 2006 research. Trees reported to occur on Sarigan include: *Acacia confusa*, *Grewia crenata*, *Thespesia populnea*, *Polyscias grandifolia*, *Aidia cochinchinensis* (formerly *Randia*), and *Ochrosia mariannensis* (Fosberg et al. 1979).

The changes in absolute frequency, density, dominance and importance value indicates successional changes are occurring simultaneously with vegetation recovery. The utility of the importance value is that it combines all the parameters relative to all the species observed and therefore indicates the overall influence of a species within the community. The individual parameters of frequency, dominance, and density of a species will only indicate a part of the overall ecological influence of a species within the ecosystem. For example, despite the increase in density and dominance of *C. nucifera* and *A. mariannensis* the importance value of these two species has decreased. Conversely, the density and absolute frequency of *F. prolixa*, *F. tinctoria* and *P. grandis* are still comparatively low, however their overall importance value has increased considerably. *Cocos nucifera* and *A. mariannensis* were the most influential, dominant and had the greatest importance value in the forest habitat of 1999. Possibly, *C. nucifera* and *A. mariannensis* were not favored by feral ungulates and therefore had a selective advantage. Now that ungulates are not present these species may no longer have an advantage. Therefore, other species have reached a point ten years after eradication where their influence is detectable within the scope of these survey methods. Given these trends the forest ecosystem in another ten years may be dominated by *P. grandis*, *F. prolixa*, and *F. tinctoria* as they increase in density, become more widespread and therefore increase in importance value. *Erythrina variegata* and *N. oppositifolia* both have not changed in importance value much (in fact *E. variegata* has decreased) however their importance values have remained relatively steady indicating that their influence will continue and possibly that their importance values were not detected well by these survey methods.

Sarigan has suitable habitat for Bridled White-eyes as there is a mix of forest types and tree species they are known to inhabit or utilize. Based on the vegetation map approximately 75-90 ha is native forest. Bridled White-eyes are known to inhabit native forest on all islands where they have been surveyed. Native forest on Tinian (Cruz et al., 2000a) had a mean of 5.75± 2.67 Bridled White-eyes per station. The highest Bridled White-eye densities however were recorded in mixed secondary forest with an average of 10.9 birds per station (Cruz et al. 2000a). In the Saipan Upland Mitigation Bank, which is 490 ha, and a mix of forest types including *L. leucocephala* (41.6%), native (30.3%) and mixed introduced (13.5%), mean detections of Bridled White-eyes per station (n=89) ranged from 7.3-12.0 from 1999 to 2003 (Cruz and Williams 2003). Data on Bridled White-eye abundance in a dominant coconut forest is not available, however Craig (2002) studied flocking behavior on Saipan in a 300 square meter area where 50% of the tree species were *C. nucifera* and *L. leucocephala*. In this area 97 birds were banded and there were 63 sightings of unbanded birds. These observations of Bridled White-eyes in a mixed habitat with a high *C. nucifera* component are comparable to those found at stations in native forests on other islands. Density estimates made using the program DISTANCE v3.5 (Thomas et al. 1998) based on Variable Circular Plot (VCP) (Reynolds 1980) surveys on

Aguiguan in 2002 reported 67.9 Bridled White-eyes per hectare in approximately 130 ha of native forest (Esselstyn et al. 2002). The native forests on Aguiguan and Sarigan are not identical; many of the native tree species are found in different proportions, frequency and density, however, all the tree species found on Sarigan are found on Aguiguan (Fosberg et al. 1979, Esselstyn et al. 2002, Cruz and Williams 2003). Therefore, a very rough estimate of the potential population that could be supported on Sarigan based on the Aguiguan density and the estimate of 75-90 ha of native forest on Sarigan is a total of 5092-6111 Bridled White-eyes.

In addition to the presence of habitat types on Sarigan that are known to support Bridled White-eye populations, there are also specific tree species present on Sarigan that they are known to utilize. Craig (1989, 2002) lists all the tree species Bridled White-eyes were observed foraging in, including: *Guamia mariannae*, *Pisonia grandis*, *Cynometra ramiflora*, *Ficus* sp., *Premna obtusifolia*, *Melanolepis multiglandulosa*, *Ochrosia mariannensis*, *Erythrina variegata*, *Randia cochinchinensis* (currently referred to as *Aidia cochinchinensis*), *Hernandia sonora*, *Morinda citrifolia*, *Barringtonia asiatica*, *Neisosperma oppositifolia*, *Hibiscus tiliaceus*, *Artocarpus* sp., *Acacia confusa*, *Samanea saman*, *Ceiba pendtandra*, *Cocos nucifera*, *Persea americana*, and *Leucaena leucocephala*. Additionally, Craig (1989) reports Bridled White-eyes foraging on the seeds of swordgrass (*Miscanthus floridulus*) and herbaceous species. Most of these species have been observed on Sarigan either in the current or from previous research.

There is every indication that Bridled White-eyes will be successful on Sarigan from a habitat and forest community perspective. Bridled White-eyes are generalists (Craig 1989), indicating that they can tolerate a certain amount of latitude in habitat composition. Bridled White-eyes have certainly been able to flourish in healthy numbers in different habitats on Saipan, Tinian and Aguiguan. Sarigan has adequate forest similar in structure and composition to areas where white-eyes are successful. Additionally, there are specific tree species present on Sarigan that Bridled White-eyes are known to use. The area occupied by forest on Sarigan is expanding and increasing in complexity as evidenced by the increased density and species richness. This trend will continue to provide increasing habitat for Bridled White-eyes.

A small stand of *L. leucocephala* near the Sarigan coastline at the end of transect 4. *Leucaena leucocephala*, a tree used by Bridled white-eyes for foraging and nesting, is increasing in importance value.

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SURVEY OF SARIGAN'S FOREST BIRDS, APRIL 2006

Analysis of Variable Circular Plot Data

by Justine B. de Cruz
for Gayle Martin, Natural Resources Planner
CNMI Division of Fish and Wildlife
June 21, 2007

EXECUTIVE SUMMARY

Systematic forest bird surveys detected 437 birds of seven species on Sarigan in April 2006. Small numbers of the Mariana Fruit-dove were detected for the first time in the native forest, an important occurrence in the period after ungulate eradication (1998 to 2006). One Grey Heron, usually an Asian mainland species, was also recorded.

We analyzed forest bird densities (number of breeding pairs per hectare) and number of detections per station for differences among surveys conducted prior to eradication of ungulates (in 1990 and 1997) and after eradication (in 1999, 2000, and 2006). We also tested these measures of bird abundance for differences among vegetation cover types. Compared with pre-eradication levels, we found that the mean density of Collared Kingfishers and Micronesian Starlings was significantly higher, while the mean density of Micronesian Megapodes and Micronesian Honeyeaters was lower, in the post-eradication period. Considering just post-eradication surveys (from 1999 onwards), the number of Micronesian Honeyeaters detected along survey transects has increased significantly while detections of Collared Kingfishers have tended to decrease. In 2006, detections of Micronesian Starlings were lower than in previous post-eradication years, and their density per hectare was significantly lower than in 1999. Detections of Micronesian Megapodes and White-throated Ground-doves tended to be higher in 2006 than during the 1999 and 2000 surveys, but not significantly so.

Survey points were assigned to three general vegetation classes on Sarigan in 2006: native forest, coconut forest, and all other cover types combined. The density and detection rate of Micronesian Honeyeaters and Micronesian Megapodes in native forest was significantly higher than in coconut forest or in other cover types; their abundances in coconut forest were about the same as in other cover. Collared Kingfisher density

and number of detections in coconut forest was significantly higher than in other cover; its abundance in native forest could not be distinguished from its abundance in coconut forests or other cover types. Micronesian Starlings and White-throated Ground-doves were detected with equal statistical frequency across all cover classifications. Mariana Fruit-doves were restricted to forested cover.

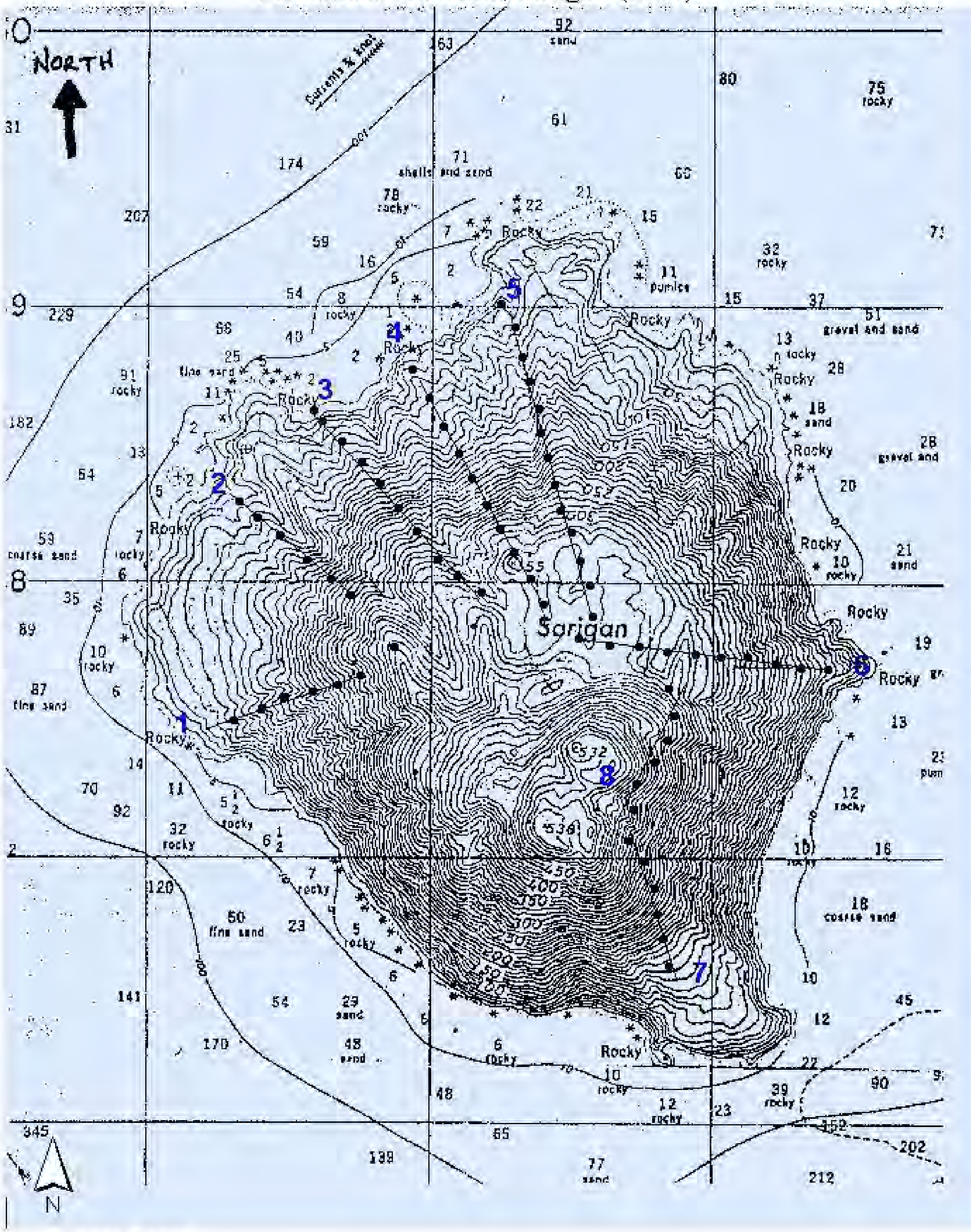
During surveys, Variable Circular Plot methods relied on detecting singing males of each bird species. Although observations reflected only the number of males, it was assumed, as is common with this survey method, that each male was paired with a female. Here, the density and abundance estimates based on the surveys are presented as an estimate of the number of breeding pairs followed by a 95% confidence interval (CI). In 2006, Micronesian Honeyeaters were the most abundant bird on Sarigan, numbering 4,130 breeding pairs (3,121 – 5,467 pairs 95% CI). The 2006 surveys indicated that the island supported approximately 1,772 breeding pairs (1,202 - 2,604 pairs 95% CI) of Micronesian Megapodes; 1,002 breeding pairs (500 – 2005 pairs 95% CI) of Micronesian Starlings; and 141 breeding pairs (91 – 217 pairs 95% CI) of Collared Kingfishers. White-throated Ground-doves were least abundant (47 breeding pairs, 16 – 137 pairs 95% CI); no estimate was made of Mariana Fruit-dove abundance due to small sample size.

INTRODUCTION

Sarigan is a volcanic island of approximately 460 ha rising steeply to 538 m. Ungulates were removed from the island in 1998 after pre-eradication surveys documented the status of avian populations and vegetation in 1990 and 1997. Post-eradication surveys, conducted in 1999 and 2000, have documented the slow recovery of some of Sarigan's populations. The results of avian surveys conducted in April 2006 as part of the post-eradication monitoring effort are the subject of this report.

To calculate avian abundance estimates consistent with past studies conducted on Sarigan, we used the vegetation cover classifications previously described by Fancy *et al*. (1999). These workers determined that most of the north and northwestern slopes were forested (162.5 ha in 1997), with patchy stands of trees on the plateau below the main crater. Of forested areas, Fancy *et al*. (1999) designated approximately 133.4 ha as coconut forest and 29.1 ha as native forest. In 1999, Morton (2000) determined that an additional 170.5 ha of the island were either grass or fern covered. The remaining area of nearly 127 ha was considered unvegetated, consisting of cliffs and steep scoria flows, mainly on the southern exposure.

Permanent Transects, Sarigan (1999)



• **Census Points**

Figure 1. Map of Sarigan with eight permanently marked transects, numerically designated, set up in 1999 by USFWS.

This report relies on the hectarage given above (particularly 162.5 ha of total forest and 333 ha of vegetated area) in calculating avian abundance in different cover types. However, it is likely that vegetation surveys in 2006 will reveal changes in cover classifications as the island continues to recover from overgrazing. When new vegetation cover percentages are known and published, avian abundances in different cover types should be recalculated accordingly. We report on the findings of the 2006 survey below and compare them with the results of prior surveys whenever possible.

AVIAN SURVEY METHODS

Avian baseline pre-eradication surveys were conducted by Craig in 1990 and Craig and Fancy in 1997 (Fancy *et al*. 1999) on two unmarked transect lines using Variable Circular Plot (VCP) point-counts. In the post-eradication period, eight (8) permanently marked avian survey transects were established on Sarigan by the US Fish and Wildlife Service (USFWS) (Fig. 1). In 1999, a CNMI-DFW research team re-surveyed the two unmarked transect lines while the USFWS surveyed the new transects. Avian surveys in 2000 and 2006 were conducted only along the eight permanent transects by CNMI-DFW. All surveys (1990, 1997, 1999, 2000, and 2006) employed VCP counts following Reynolds *et al*. (1980).

As part of the Division's translocation program, CNMI-DFW conducted post-eradication forest bird surveys on Sarigan from 19-22 April 2006 using VCP methodology. Point-counts of avian species were conducted at permanent stations spaced every 100 m along transects established in 1999 (Fig. 1). These transects, which were delineated systematically to sample different cover types, were composed of between 6 and 13 count stations each. Transect number 7 was not surveyed in 2006 for safety reasons and because it was deemed unlikely that many forest birds occurred along it. A survey team composed of Shelly Kremer, Laura Williams, Juan Salas, and Victor J. Concepción sampled a total of 61 stations.

Surveys were conducted from 6:00 a.m. to 10:30 a.m. using 8-minute count durations at each point. Weather conditions (rain, wind, and gusts) were documented following USFWS protocol. Birds were recorded upon detection (visual and/or auditory) and the distance to each was estimated. No taped playbacks were employed and most birds were counted by their song or call notes.

Plant cover type at each point-count station was assessed visually using the dominant vegetation characteristics and classified by observers into one of eight categories:

- Native forest
- Coconut forest
- Coconut/Native forest or Coconut/Hibiscus forest
- Open areas/Rocky lava flows

- Swordgrass/Pandanus
- Mixed secondary forest
- Agro-forest
- Field/Forest edge

To enable comparisons with previous surveys and to help improve sample sizes for comparisons of avian abundance among vegetation cover types, these categories were later assigned to one of three groups: native forest, coconut forest (including coconut/native forest and coconut/hibiscus forest), and all other cover types. Following Fancy *et al*. (1999) and Morton (2000), the extent of native forest was assumed to be 29.1 ha, the extent of coconut forest 133.4 ha, and all other cover types summed to 170.5 ha. For the purposes of population abundance estimates, vegetation classes that supported birds were taken to equal 162.5 ha of forest and 333 ha for the sum of all cover types.

Data from the 1999, 2000, and 2006 surveys were pooled and stratified by year to determine avian abundance estimates using DISTANCE (available at www.ruwpa.st-and.ac.uk/distance/), a software program commonly employed by both the USFWS and National Park Service for analyzing avian point-count data (Buckland *et al*. 1993). DISTANCE calculated an estimate of the number of individuals per hectare (density/ha) as well as an estimate of species abundance over a given area (density/ha multiplied by area) based on transect data where the distance to the observed animal was estimated. During our VCP surveys, the birds detected were generally singing males, so the estimates of density and abundance were calculated for one half of the breeding population, or males only. In this report, consistent with Engbring et al.'s (1986) descriptions, both species density and species abundance estimates are expressed as number of breeding pairs to reflect the assumption that each singing male was mated.

Raw data from 1990 and 1997 could not be included in the present analysis, but the mean numbers of birds detected per station (Fancy *et al*. 1999) were compared directly with the post-eradication results of surveys conducted by CNMI-DFW along two unmarked transects in 1999 (see Cruz *et al*. 2000). Comparisons presented in this report between pre- and post-eradication surveys were based on mean avian densities in different vegetation types where the variance from the mean for 1990 and 1997 was also known. Differences among survey years in numbers of detections per station were compared using multiple regression techniques in Statistica 6 (StatSoft 2003). Differences among mean densities were compared using analysis of variance (ANOVA); post-hoc Tukey or Scheffé tests were applied when differences among means were significant.

The abundance of breeding pairs was estimated for five species of native forest bird: Micronesian Megapode (*Megapodius laperouse*), Micronesian Honeyeater (*Myzomela rubratra*), Micronesian Starling (*Aplonis opaca*), Collared Kingfisher (*Halcyon chloris*), and White-throated Ground-dove (*Gallicolumba xanthonura*). For the first four species, detection distances from 1999, 2000, and 2006 were pooled to estimate the effective area surveyed for each species, then stratified by survey year to estimate species

density (breeding pairs per ha) and abundance (pairs in 333 ha). There have been too few observations of the secretive White-throated Ground-dove during survey periods to produce a robust estimate of its population using Sarigan data by itself. Therefore, data on ground-dove detections from VCP surveys of other northern islands in the archipelago (with similar vegetation) were pooled and then stratified by island and year of survey. Because ground-doves were observed only in forested habitats, their abundance estimate was based on the 162.5 ha of total forested cover on Sarigan. The resulting density and abundance estimates should be treated only as an approximation of White-throated Ground-dove numbers; when the sample size for ground-doves (number of distance detections on Sarigan) increases to >60, these surveys should be re-analyzed using data from Sarigan only.

Comparisons of species density in different habitats on Sarigan were made based on calculations using the analytical tools outlined above. Species distribution and density for 1997 were taken from Fancy *et al*. (1999) and are included here for comparative purposes. Species density calculations for 1999, 2000, and 2006 are based on a DISTANCE analysis of bird detections stratified by three vegetation classifications. Data were not examined for differences in detection distances among observers or among cover types. In previous reports, differences in avian distribution among cover types were calculated on the basis of the number of detections within a 50 m radius of the observer (e.g., Morton 2000, Cruz *et al*. 2000). However, the density-based results reported here should supersede these earlier attempts as the current estimates are more robust.

SURVEY RESULTS

The most noteworthy result of the 2006 forest bird survey was the detection of the Mariana Fruit-dove (*Ptilinopus roseicapilla*); several individuals were heard along Transect 5 in native forest. This is the first documentation of a naturally occurring island colonization event in the Marianas.

Generally, Micronesian Honeyeaters (*egigi*) and Micronesian Megapodes (*sasangat*) were the most abundant species on Sarigan in 2006, and were commonly found in every cover type sampled. Micronesian Starlings (*sali*) and the less abundant Collared Kingfishers (*sihek*) were also common in all but open/rocky or field/forest areas. White-throated Ground-doves (*paluman apaka*) and Mariana Fruit-doves (*tottot*) were rare and found in exclusively forested areas. A Grey Heron (*Ardea cinerea*), an Asiatic species, was seen in the grassy fields of Transect 6 and is a new record for the island (Reichel and Glass 1991).

A. <u>DETECTIONS OF BIRDS</u>

With the exception of the Micronesian Honeyeater, statistical comparisons indicated that the number of avian detections per station did not increase or decrease for any species over the period from 1999 to 2006. Detections of Micronesian Honeyeaters increased

significantly during the post-eradication period (Table 1) while detections of Collared Kingfishers showed a tendency to decline (although the decline was not statistically significant). Most species detections have remained stable over the last seven years, although more species inhabited the island in 2006 than previously (e.g., the Mariana Fruit-dove). The increase in honeyeater detections in 2006 suggests that changes in the island's vegetation since ungulate eradication in 1998 have benefited the species. For example, *Erythrina* tree saplings appear to be colonizing previously well-grazed areas of the island; honeyeaters, which often forage at *Erythrina* blooms, may be able to take advantage of this more than other species. It is expected that other forest bird numbers will gradually increase as habitat conditions improve island-wide.

Collared Kingfisher detections may have declined somewhat over the post-eradication period and their occurrence (number of stations at which they were detected) was also lower (Table 1). This suggests that the kingfisher population may be getting smaller and their distribution over the island more restricted. Although Micronesian Starlings were detected less often in 2006 than in 1999 and 2000, the change was not significant (Table 1, Fig. 2). Other bird populations appeared to be stable with detections of Micronesian Megapodes and White-throated Ground-doves appearing to be slightly higher (but not significantly so) than previously (Fig. 2).

Table 1. Detections of forest bird species on Sarigan during Variable Circular Plot point-count surveys in 1990, 1997, 1999, 2000 and 2006. Analysis of variance test results are for comparisons among 1999, 2000, and 2006 detections per station.

Species	Survey Year	Number Detected	# birds/ station[1]	# of stations occupied[2]	% Occurrence[3]	Test for differences in means
Collared Kingfisher	1990[4]	66	1.32	na	na	
	1997[4]	20	0.65	na	na	
	1999[5]	88	1.33	43	65.2	$F_{3,51}$ = 2.412 P < 0.077
	2000[6]	70	1.30	38	70.4	
	2006[6]	57	0.92	31	50.8	
Mariana Fruit-dove	1990	0	0	0	0	*No test*
	1997	0	0	0	0	
	1999	0	0	0	0	
	2000	0	0	0	0	
	2006	6	0.10	4	6.6	
Micronesian Honeyeater	1990	142	2.84	na	na	
	1997	118	3.81	na	na	
	1999	209	3.17	50	75.8	$F_{3,51}$ = 2.849 P < 0.047*
	2000	167	3.09	49	90.7	
	2006	255	4.18	55	90.2	
Micronesian Megapode	1990	58	1.16	na	na	
	1997	36	1.16	na	na	
	1999	77	1.17	37	56.1	$F_{3,51}$ = 1.035 P < 0.385
	2000	79	1.46	31	57.4	
	2006	92	1.51	41	67.2	
Micronesian Starling	1990	31	0.62	na	na	
	1997	30	0.97	na	na	
	1999	64	0.97	31	47.0	$F_{3,51}$ = 1.555 P < 0.212
	2000	38	0.70	18	33.3	
	2006	18	0.30	18	29.5	
White-throated Ground-dove	1990	1	0.02	1	2	
	1997	1[7]	0.012	1	1.2	
	1999	6	0.09	3	4.5	$F_{3,51}$ = 0.889 P < 0.453
	2000	3	0.06	3	5.6	
	2006	8	0.13	5	8.2	

[1] Number of birds per station is based on the number detected divided by the number of stations, or points, sampled in that year's survey. The number of points sampled was 50 in 1990 (Table 1, Fancy *et al*. 1999), 31 in 1997 (Table 1, Fancy *et al*. 1999), 66 in 1999, 54 in 2000, and 61 in 2006.
[2] The number of stations occupied is the occurrence, or frequency with which the bird was recorded over the course of the survey.

[3] Percent occurrence is the number of stations occupied divided by the number of points sampled multiplied by 100.
[4] Data are published by Fancy *et al*. (1999).
[5] Data are loaned by Morton (2000).
[6] Data are from CNMI-DFW surveys. None of the data in the table are truncated.
[7] Data are from Table 2 in Fancy *et al*. (1999) where points sampled = 86.
* Statistically significant differences in mean detections among years 1999, 2000, and 2006.

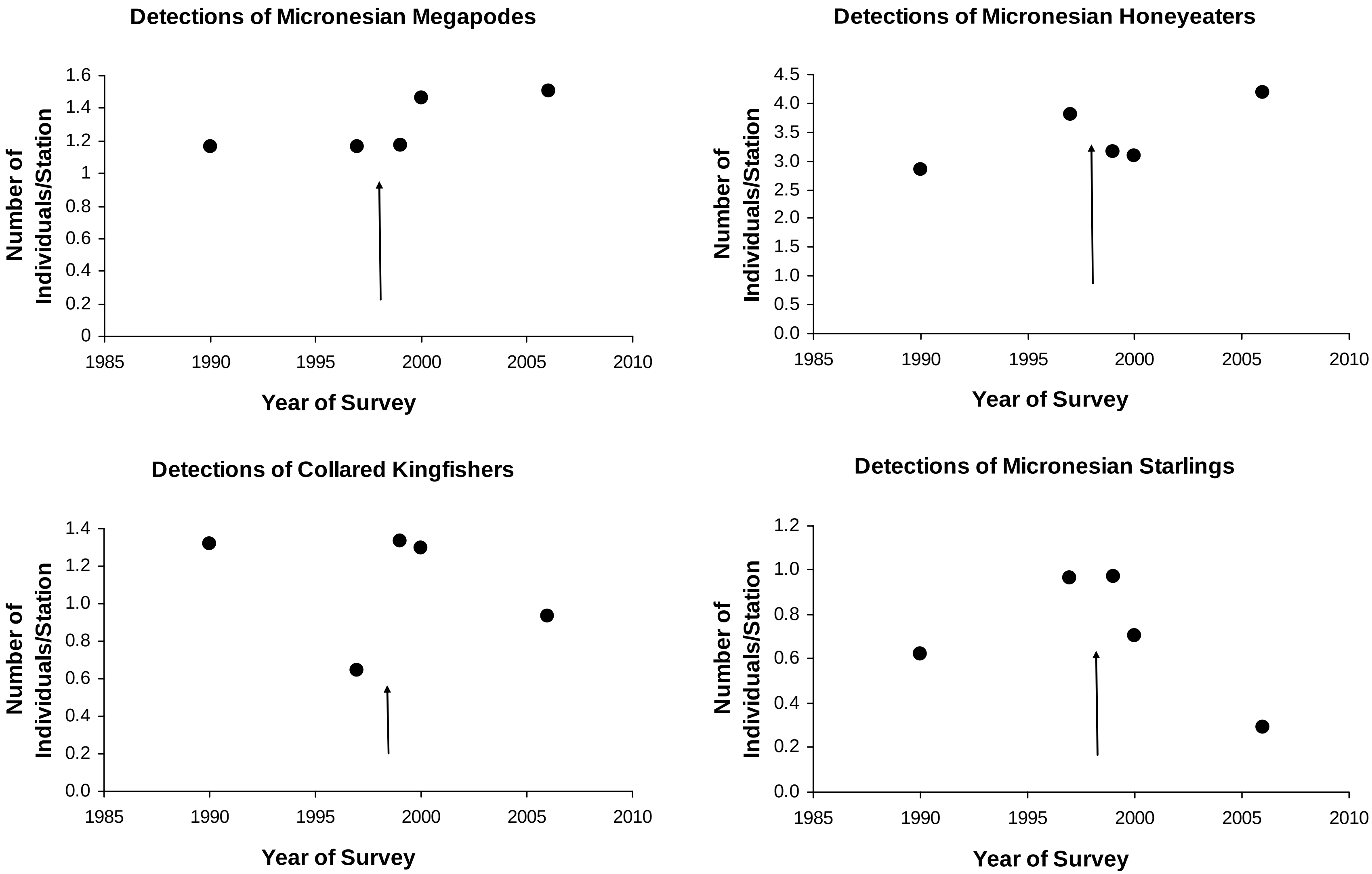


Figure 2. Detections per station of Micronesian Megapodes, Micronesian Honeyeaters, Micronesian Starlings, and Collared Kingfishers on Sarigan from 1990 to 2006. Arrow indicates year that ungulate eradication was completed.

B. AVIAN DENSITY AND ABUNDANCE

The algorithms calculated by the software program DISTANCE described the data on detection distances for 1999, 2000 and 2006 extremely well (Table 2) encouraging a high level of confidence in the resulting density and abundance estimates. No density estimates were made for species with small sample sizes. In 2006, the numbers of breeding pairs per hectare of Micronesian Honeyeaters outnumbered the next most abundant species, Micronesian Megapodes, by two to one. Although honeyeater and megapode densities were slightly higher in 2006 than during the 2000 survey, and kingfisher densities were lower, only starling densities in 2006 were significantly lower than in 1999.

Results of the ANOVA comparison of densities for the four most abundant species across time revealed significant differences in mean densities among survey years (Table 2). Scheffé's multiple comparison test of 1990-1997 densities measured against 1999-2006 densities indicated that Micronesian Honeyeaters and Micronesian Megapodes were significantly more numerous before eradication as opposed to afterward. Conversely, Micronesian Starling and Collared Kingfisher densities were significantly higher in post-eradication surveys compared with pre-eradication ones.

Table 2. DISTANCE estimates of avian density (number of bird pairs per ha) for all years of VCP surveys on Sarigan. ANOVA comparisons of mean densities surpassed the critical value for $P < 0.05$ indicating significant differences among survey years for the species tested. Pre- and post-eradication densities were contrasted using Scheffé tests; the higher period is blocked in color ( ).

Species	Survey Year	Point Estimate of Density/ha (SE)[1]	Lower 95% Confidence Interval	Upper 95% Confidence Interval	Differences among surveys (ANOVA)
Collared Kingfisher	1990[2]	0.38 (0.10)	na	na	$F_{4,258}$ = 18.13 $P < 0.001$
	1997[2]	0.49 (0.15)	na	na	
	1999[3]	0.58 (0.12)	0.39	0.87	
	2000[4]	0.55 (0.11)	0.37	0.80	
	2006[4]	0.42 (0.09)	0.27	0.65	
Mariana Fruit-dove	2006	No estimate			
Micronesian Honeyeater	1990	16.79 (2.12)	na	na	$F_{4,258}$ = 57.93 $P < 0.001$
	1997	16.77 (2.86)	na	na	
	1999	9.45 (1.47)	3.95	12.83	
	2000	8.59 (1.20)	6.53	11.31	
	2006	12.4 (1.77)	9.47	16.42	
Micronesian Megapode	1990	5.25 (0.89)	na	na	$F_{4,258}$ = 24.32 $P < 0.001$
	1997	4.85 (1.24)	na	na	
	1999	3.80 (0.82)	2.49	5.79	
	2000	4.93 (1.17)	3.10	7.85	
	2006	5.32 (1.05)	3.61	7.82	
Micronesian Starling	1990	4.82 (1.42)	na	na	$F_{4,258}$ = 9.24 $P < 0.001$
	1997	5.02 (1.33)	na	na	
	1999	9.35 (2.30)	5.79	15.09	
	2000	5.85 (1.90)	3.13	10.97	
	2006	3.01 (1.08)	1.50	6.02	
White-throated Ground-dove	1990	No estimate			No test
	1997	No estimate			
	1999	0.22 (0.14)	0.07	0.69	
	2000	No estimate			
	2006	0.29 (0.17)	0.10	0.84	

[1] Goodness-of-fit tests indicated that the algorithms fit the distance detection data very well (p = 1.0 would indicate a perfect fit): kingfisher p = 0.99, honeyeater p = 0.87, megapode p = 0.95, starling p = 0.99, and ground-dove p = 0.99 encouraging a high level of confidence in the estimates of density and abundance for 1999, 2000, and 2006.

[2] Calculations are made with data from Table 1, Fancy *et al*. (1999).
[3] Data are loaned by Morton (2000).
[4] Data are from CNMI-DFW surveys.

Although it is of interest to compare avian densities prior to the eradication of ungulates from Sarigan with densities afterwards, there are several reasons why the above results should be treated with caution. In both 1990 and 1997, surveys were restricted to forested areas only, while the 1999, 2000, and 2006 surveys included large areas of other vegetation types as well as forest. Again, prior to 1998, birds could be detected at great distances by both sound and sight because the forest was less dense and the understory almost entirely lacking (L. Williams, CNMI-DFW botanist, pers. comm.). The presence of a regenerating understory during the 1999, 2000, and 2006 surveys limited sight detections and changed the attenuation of sound, thus limiting detections to shorter distances. These and other differences between the two periods of time possibly influenced the estimation of bird densities, which may help to explain some of the puzzling patterns observed in the data. For example, detections of Micronesian Honeyeaters and Micronesian Megapodes after eradication were as high as, or higher than, those prior to the elimination of ungulates (Table 1), so it may be an artifact of the changes in habitat or differences in survey coverage that we found their post-eradication densities to be significantly lower than they were prior to eradication (Table 2).

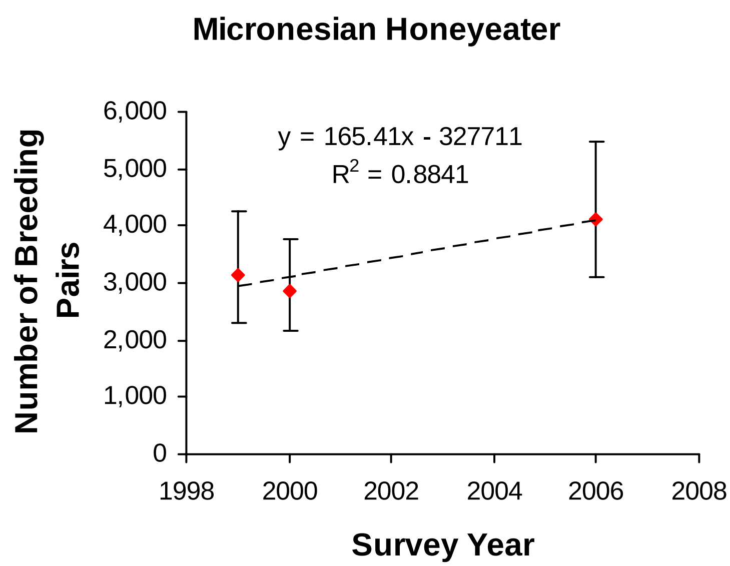
Estimates of species abundance (numbers of breeding pairs in the island-wide population), based on the densities in Table 2, were calculated only for the 1999, 2000, and 2006 surveys. The 1997 abundance estimates were based on the area of forested habitat alone, while the post-eradication abundance estimates were based on both forested and non-forested areas. Consequently, the 1997 abundance estimates were not comparable with the present calculations. For the current analysis, population abundances of honeyeaters, megapodes, kingfishers, and starlings (Figs. 3 & 4) were estimated over a 333 ha area on the premise that these species occurred in fair numbers in most vegetated areas (Fig. 8). The population abundance of ground-doves (Fig. 4) was estimated over a 162.5 ha area because this species appeared to be restricted to forested cover.

Micronesian Honeyeaters were by far the most abundant species on Sarigan in 2006, numbering 4,130 breeding pairs (95% confidence interval 3,121 – 5,467 pairs) (Fig. 3). The species appeared to take advantage of flowering trees in both coconut and native forests, as well as those in pockets of forest scattered through mostly non-forested areas. Micronesian Megapodes were also widespread and common numbering approximately 1,772 breeding pairs (1,202 -2,604 pairs 95% CI). Although densities of honeyeaters and megapodes were lower after eradication (1999-2006) than before it, numbers of both species have been steadily increasing

over the last three surveys. The population abundance trajectories in the 1999-2006 period for both species were positive (Fig. 3).

Micronesian Starlings were the third most abundant species on Sarigan in 2006, numbering 1,002 breeding pairs (500 – 2005 pairs 95% CI), down from a population that was as much as three times larger in 1999 (Fig. 4). Collared Kingfishers numbered approximately 141 breeding pairs (91 – 217 pairs 95% CI); this species has not been abundant on Sarigan in any of the survey years. Population abundance trajectories were negative for both of these cavity-nesting species (Fig 4) and it is possible that they are competing with each other for nesting space, a factor that may be limiting for both populations. However, Micronesian Starlings and Collared Kingfishers are common residents of the entire archipelago and a small downward shift in numbers on Sarigan (that in part may be simply natural variation in their abundance) is not cause for immediate concern.

White-throated Ground-doves were rare on Sarigan in 2006, numbering about 47 breeding pairs (16 – 137 pairs 95% CI). Although no population trajectory could be constructed for this species due to the small number of birds observed (Fig. 4), ground-doves may have benefited from the removal of ungulates and the subsequent recovery of understory vegetation, which would provide better cover from their predators (e.g., cats).



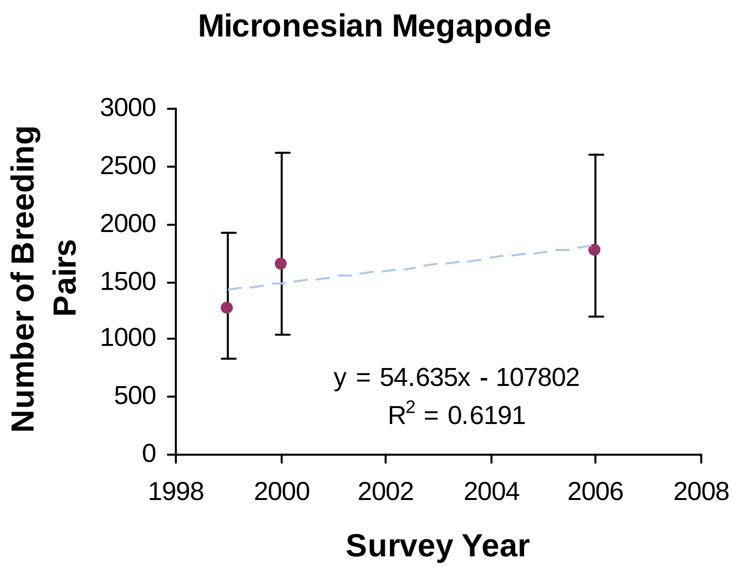
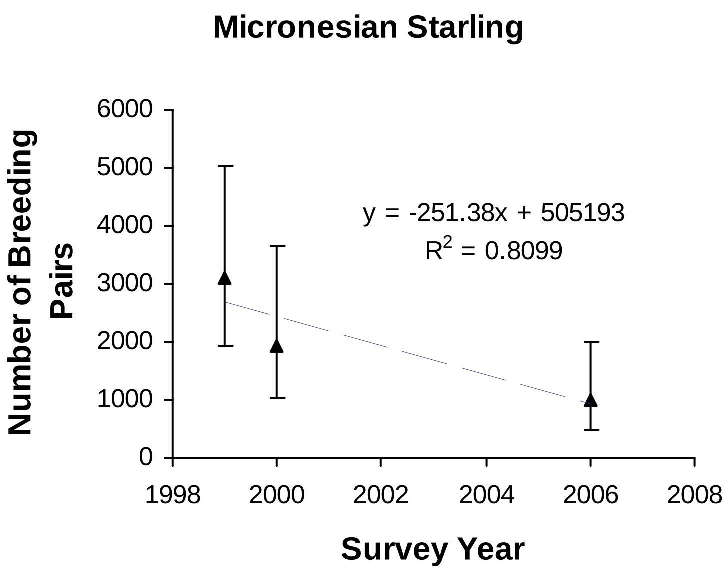
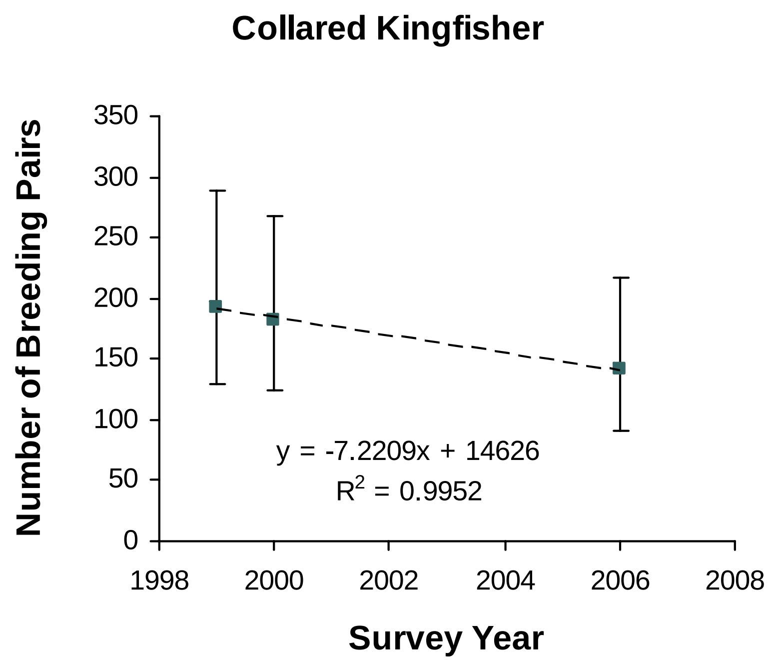


Figure 3. Population abundance estimates for breeding Micronesian Honeyeaters and Micronesian Megapodes on Sarigan from the 1999, 2000, and 2006 VCP surveys. Abundance estimates were made for 333 ha area of vegetated area on Sarigan. Error bars represent the upper and lower 95% confidence intervals around the mean.





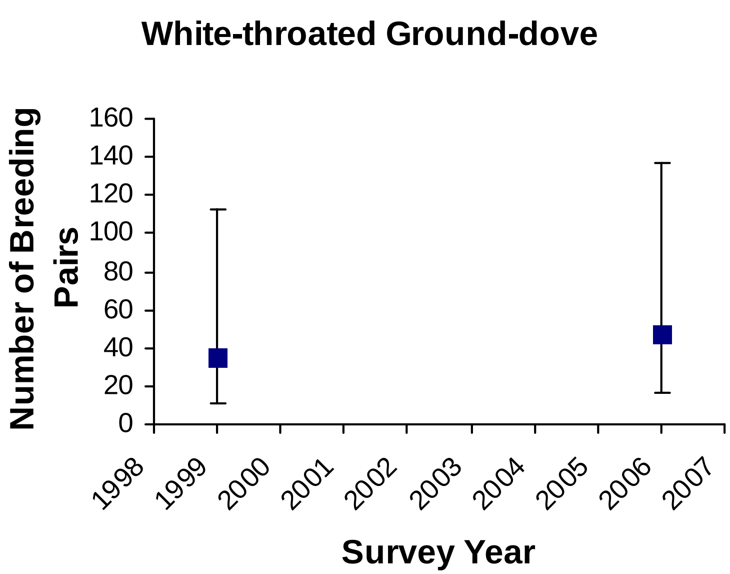


Figure 4. Population abundance estimates for breeding Micronesian Starlings, Collared Kingfishers and White-throated Ground-doves on Sarigan from the 1999, 2000, and 2006 VCP surveys. Abundance estimates for breeding starlings and kingfishers were based on 333 ha of vegetated area island-wide. Abundance estimates for breeding ground-doves were based on 162.5 ha of forest on Sarigan. Error bars represent the upper and lower 95% confidence intervals around the mean.

C. <u>EFFECTS OF DIFFERENT COVER TYPES ON BIRD NUMBERS</u>

Based on the number of birds detected per station in 2006 (Table 3) mixed and native forests were the most important vegetation types on Sarigan (Fig. 7). Coconut forests and field/forest edges were also important, while agro-forests and open, rocky fields supported fewer birds.

Figure 5. Pocket forest at point-count station 4 along Transect 6 in 2006 (photo courtesy of G. Martin).

Transects 1, 2, and 3 extended through what is currently thick coconut forest, or coconut forest mixed with native species, and some stands of nearly pure native forest. Transects 4 and 5 were established through coconut and mixed secondary forest near the coast, native forest at mid-elevations, and native forest with some field/forest interfaces at higher elevations. Transect 6 was set through open fields near the coast and pockets of forest vegetation with expanses of saplings at higher elevations (Fig. 5). Transects 7 and 8 were established over old, completely open lava flows, dominated by grasses and ferns with some pockets of forest (Fig. 6).

Figure 6. Cover types sampled by transects 7 and 8 (photo courtesy of G. Martin).

Table 3. Original vegetation classifications sampled in the field by observers in April 2006.

Cover Type	# of Stations Sampled	Proportion of Total Sampled	# of Species Present	# Birds Detected	# of Birds/station
Open Field/Rocky	11	18%	4	28	2.55
Coconut Forest	17	28%	4	112	6.59
Agro Forest	1	2%	3	3	3.00
Mixed Secondary Forest	1	2%	3	13	13.0
Coconut/Native Forest	6	10%	4	37	6.17
Native Forest	19	31%	6	207	10.90
Field/Forest Edge	6	10%	2	37	6.17

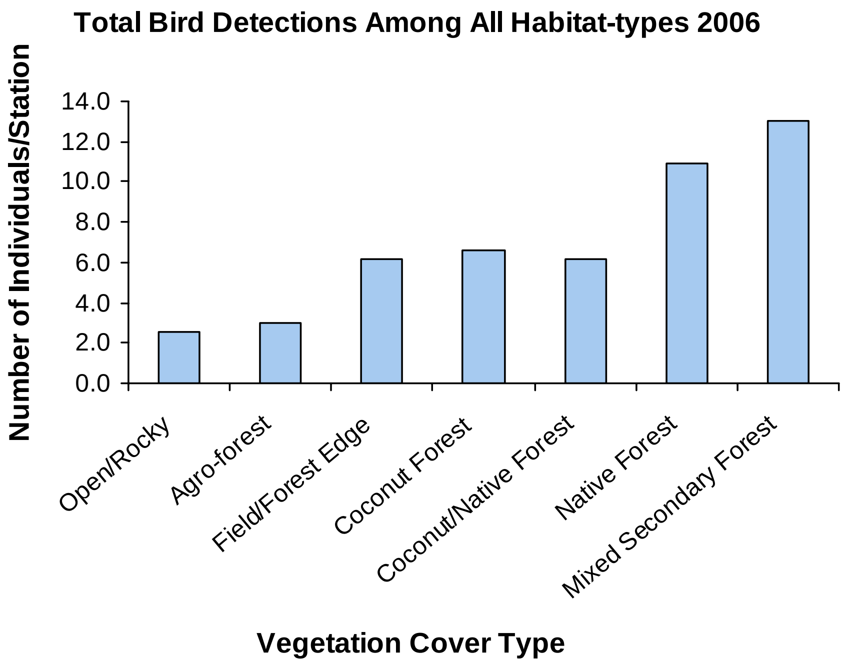


Figure 7. Distribution of avian detections among cover types (as classified in the field) on Sarigan in 2006. Native and mixed forest vegetation covers were more important for forest birds than open and agro-forest covers.

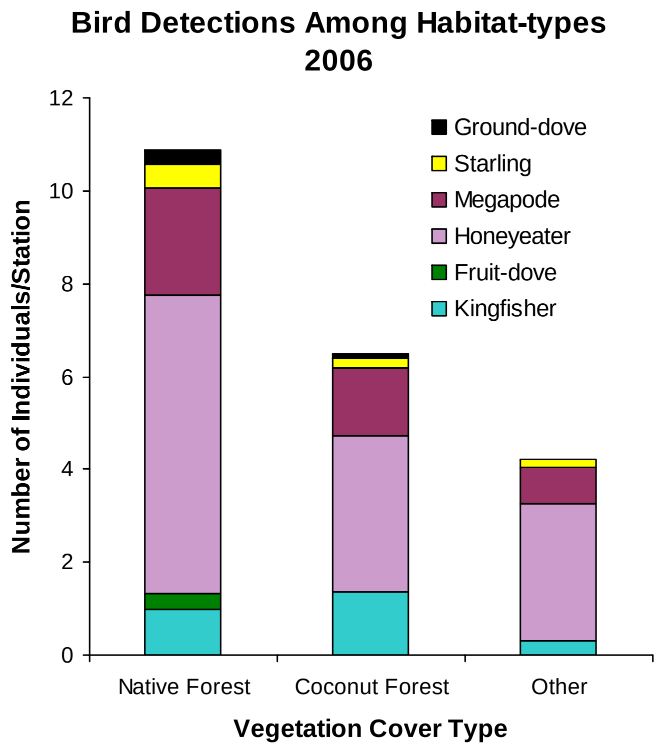


Figure 8. Using three vegetation classifications for purposes of comparing the 2006 survey results with previous surveys, detections of birds in native forest cover outnumbered those in all other cover types combined.

As post-eradication recovery of vegetation continues on Sarigan, cover type classifications used by future observers will need to be reassessed. For comparative purposes, Morton's (2000) categorization of vegetation cover into three broad classifications (coconut forest, native forest, and all other cover types) is followed for the rest of this analysis.

In 2006, more birds were detected in native forest than in either coconut forest or other cover types combined (Fig. 8). Mariana Fruit-doves were detected only in native forest, while White-throated ground-doves were detected in both coconut and native forests. Analysis of variance results combined with post-hoc tests indicated that Micronesian Honeyeaters were detected more often in native forest than in coconut forest, and more often in native forest than in other areas ($F_{2,58} = 10.034$, $P < 0.00018$). Micronesian Megapodes occurred more often in native forest than in other cover ($F_{2,58} = 4.474$, $P < 0.015$) but about equally often in coconut forest and other areas. Collared Kingfishers were detected more often in coconut forest than in other cover ($F_{2,58} = 5.33$, $P < 0.008$). There were no statistical differences in the detections of Micronesian Starlings or White-throated Ground-doves among cover types. The positive response of several species to forest cover suggests that they have benefited from the elimination of ungulates and the subsequent recovery of understory and ground vegetation.

Similar to the differences in number of detections among vegetation classifications, ANOVA tests of the densities of the most abundant species on Sarigan indicated that Micronesian Honeyeater, Micronesian Megapode, and Collared Kingfisher densities were not evenly distributed among the three cover types in 2006. Tukey's post-hoc tests indicated that both Micronesian Honeyeaters ($F_{2,58} = 10.55$, $P < 0.001$) and Micronesian Megapodes ($F_{2,58} = 40.12$, $P < 0.001$) were more numerous in native forest than in coconut forest, and more numerous in native forest than in other areas, although their numbers were about equal in coconut forest and other cover. Collared Kingfishers were more abundant in coconut forest than in other cover ($F_{2,58} = 10.55$, $P < 0.001$) while Micronesian Starling density was evenly distributed among cover types. The two sets of similar results (densities and detections) suggest that in 2006 the four most numerous species were wide-spread in different cover types across Sarigan and were able to take advantage of pockets of forest that occur in otherwise open areas. The results also indicated that honeyeaters, megapodes and kingfishers were more numerous in forested landscapes than in other types of cover.

Micronesian Honeyeaters were significantly more densely packed into native forest than into either other cover type. However, because native forest on Sarigan is limited in extent (covering 9% of the total land area), Micronesian Honeyeater abundance in native forest (614 breeding pairs, 480-786 pairs 95% CI) contributed less than the abundance in coconut forest (1,296 breeding pairs, 882-1,904 pairs 95% CI) to the overall breeding population estimate. Coconut forest covered about 40% of the land area and other vegetation types represented about 51% of island cover. Micronesian Honeyeater abundance in coconut forests was about equal to that in the remaining vegetated area of the island (1,268 breeding pairs, 629-2,555 pairs 95% CI).

Over the period of time that surveys have been conducted, the highest density of honeyeaters has shifted back and forth between native and coconut forests (Appendices A, B & C; Fig. 9). This may reflect a seasonal shift in abundance as honeyeaters move among different vegetation types and elevations in order to forage on flowering trees.

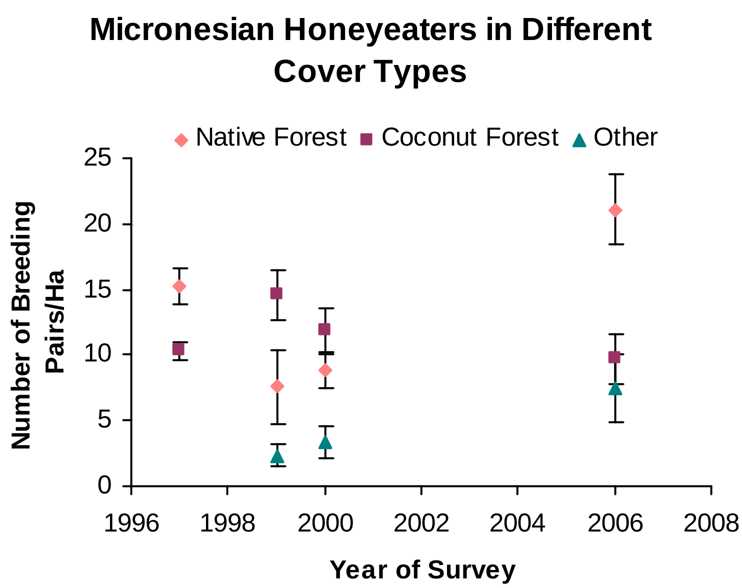


Figure 9. Density of Micronesian Honeyeaters in three general vegetation classifications over time.

Megapodes took advantage of all cover types on island, but in 2006 their density was significantly higher in native forest and in coconut forest than it was in non-forest cover (Fig. 10). Their estimated abundance of 260 breeding pairs (167-404 pairs 95% CI) in native forest, 702 breeding pairs (449-1,099 pairs 95% CI) in coconut forest, and 329 breeding pairs (186-861 pairs 95% CI) in other areas (Appendices A, B & C) indicated that they were common in all vegetation types. Similar to honeyeaters, megapode density has shifted back and forth between native and coconut forests over time (Fig. 10); the species can generally be found more readily in forested areas rather than in other cover types.

Micronesian Starlings were evenly distributed in all vegetation types in 2006. Their estimated abundances in native forest [148 breeding pairs (64-346 pairs 95% CI)], coconut forest [324 breeding pairs (104-1,012 pairs 95% CI)], and other habitats [261 breeding pairs (45-1,506 pairs 95% CI)], appear to be lower than estimates for almost all other years (Appendices A, B & C). However, the broad confidence intervals around the means indicated a greater amount of uncertainty in the point estimates for this

species than for others. Over the years that the VCP surveys have been conducted, the pattern in starling distribution among forests was similar to that noted for both honeyeaters and megapodes; starling densities shifted between the two forested habitats (Fig. 11) over time, possibly reflecting the bird's movements in response to changing food resources.

Although Collared Kingfishers were concentrated in coconut forests as opposed to other cover (Figs. 8 & 12), their densities in these areas were not statistically different from those in native forest. Estimated breeding abundances in native forest [13 breeding pairs (7-25 pairs 95% CI)], coconut forest [86 breeding pairs (53-140 pairs 95% CI)], and other cover types [28 breeding pairs (11-74 pairs 95% CI)] suggest a solid, but small, population that can make use of small pockets of trees and shrubs in otherwise inhospitable environments. Collared Kingfishers tended to be concentrated in coconut forests more frequently than in other cover, possibly because they can find, or build, nesting cavities more easily in old coconut trees than in other vegetation.

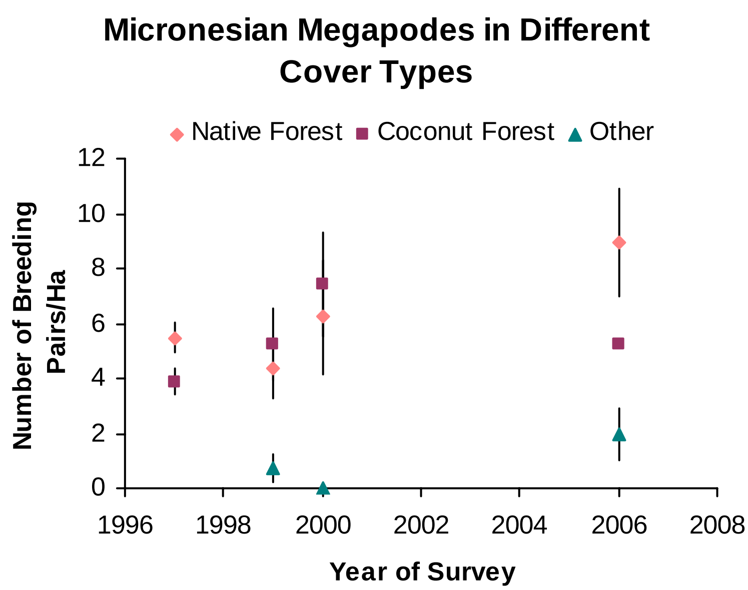


Figure 10. Density of Micronesian Megapodes in three general vegetation classifications over time.

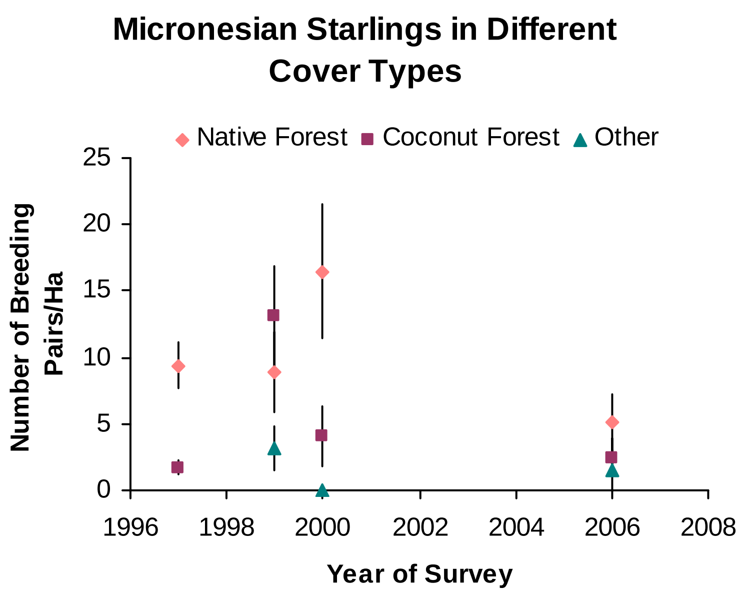


Figure 11. Density of Micronesian Starlings in three general vegetation classifications over time.

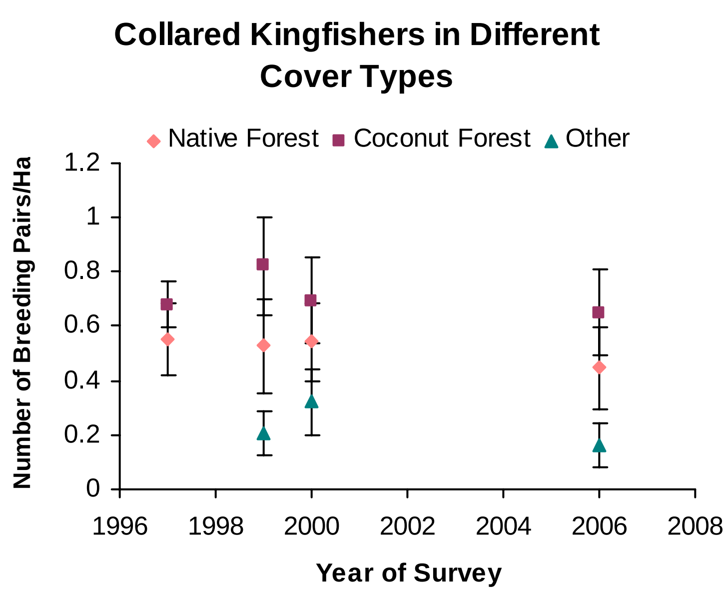


Figure 12. Density of Collared Kingfishers in three general vegetation classifications over time.

CONCLUSIONS

The mean number of breeding pairs per hectare (density) of Collared Kingfishers and Micronesian Starlings has increased on Sarigan since ungulate removal (1999-2006) when compared with pre-removal levels (1990-1997). However, the increasing density of vegetation since the eradication of ungulates, affecting the detectability of birds, combined with an enhanced survey area and number of cover types sampled in the post-eradication period, suggest that results of the 1999, 2000, and 2006 surveys be considered separately from their predecessors. Over the last three surveys the abundance of both Collared Kingfishers and Micronesian Starlings has shown a tendency to decline (the starling significantly so since 1999). In 2006, both species occurred in all cover types on the island, but kingfisher density was higher in coconut forests than in other cover. Although the mechanisms that are producing the above patterns remain unknown, it is expected that forest regeneration following ungulate eradication on Sarigan will have a positive impact on these species in the long-term.

The mean densities of Micronesian Honeyeaters and Micronesian Megapodes in post-eradication years were lower than their pre-eradication levels. However, for the reasons cited above that may have confounded comparisons of avian density, and based on the significantly increasing number of birds detected per station since 1999, it appeared that the Micronesian Honeyeater was responding positively to post-eradication vegetation changes. Although widespread across all cover types on the island, in 2006 both honeyeaters and megapodes occurred more often in native forest than in coconut forest, and more often in native forest than in other cover. Both species’ population tendencies have been positive over the post-eradication period; these trends are expected to persist as habitat conditions continue to improve for these species.

A new species for the island, the Mariana Fruit-dove, was recorded in native forest during the 2006 survey. Mariana Fruit-doves and White-throated Ground-doves were detected only in forested areas. Results suggest that Micronesian Honeyeaters, Micronesian Megapodes and Collared Kingfishers may be detected more readily and be more abundant in forests as opposed to other cover types.

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Appendices

Appendix A. For other than native and coconut forest (170.5 ha), the density (number of breeding pairs per ha) and abundance (density x 170.5 ha) of forest birds during surveys conducted on Sarigan in 1997, 1999, 2000 and 2006.

Species	Survey Year	Number Detected	# birds/ station[1]	Density of breeding pairs per ha	SE	Abundance (95% CI)[2]
Collared Kingfisher	1999	13	0.59	0.21	0.080	35 (16-76)
	2000	16	1.00	0.32	0.121	55 (26-117)
	2006	6	0.32	0.16	0.082	28 (11-74)
Micronesian Honeyeater	1999	23	1.05	2.54	0.859	398 (188-843)
	2000	32	2.00	3.31	1.230	564 (264-1,204)
	2006	56	2.95	7.44	2.570	1,268 (629-2,555)
Micronesian Megapode	1999	3	0.14	0.72	0.535	123 (31-499)
	2000	0	0	0	0	0
	2006	15	0.79	1.93	0.947	329 (186-861)
Micronesian Starling	1999	6	0.27	3.19	1.623	543 (199-1,486)
	2000	5	0.31	--	--	--
	2006	3	0.16	1.53	1.550	261 (45-1,506)

[1] Number of birds per station is based on the number detected divided by the number of stations, or points, sampled in that year's survey. The number of points sampled in other than native and coconut forest habitat was 22 in 1999, 16 in 2000, and 19 in 2006.
[2] 95% Confidence Interval (CI) around the mean.

Appendix B. For native forest (29.1 ha), the density (number of breeding pairs per hectare) and abundance (density x 29.1 ha) of Sarigan's forest birds during surveys conducted in 1997, 1999, 2000, and 2006.

Species	Survey Year	Number Detected	# birds/ station[1]	Density of breeding pairs per ha	SE	Abundance (95% CI)[2]
Collared Kingfisher	1997[3]	32	0.64	0.55	0.133	16 (na)
	1999	20	1.25	0.53	0.172	15 (8-30)
	2000	15	1.15	0.54	0.141	16 (9-27)
	2006	19	1.00	0.45	0.149	13 (7-25)
Mariana Fruit-dove[4]	1997	0	0			
	1999	0	0			
	2000	0	0			
	2006	6	0.32			
Micronesian Honeyeater	1997	183	3.66	15.24	1.402	443 (na)
	1999	41	2.56	7.59	2.79	221 (104-468)
	2000	37	2.85	8.86	1.35	258 (189-351)
	2006	122	6.42	21.10	2.63	614 (480-786)
Micronesian Megapode	1997	49	0.98	5.47	0.455	159 (na)
	1999	19	1.19	4.34	1.049	126 (78-205)
	2000	23	1.77	6.24	2.075	181 (92-359)
	2006	44	2.32	8.94	1.982	260 (167-404)
Micronesian Starling	1997	62	1.24	9.39	1.755	273 (na)
	1999	15	0.94	8.92	3.003	260 (132-509)
	2000	21	1.61	16.97	5.047	479 (258-890)
	2006	10	0.53	5.10	2.195	148 (64-346)
White-throated Ground-dove	1997	0	0			
	1999	3	0.19			
	2000	0	0			
	2006	6	0.32			

[1] Number of birds per station is based on the number detected divided by the number of stations, or points, sampled in that year's survey. The number of points sampled in native forest was 50 in 1997 (as reported in Table 2 of Fancy *et al*. 1999), 16 in 1999, 13 in 2000, and 19 in 2006.
[2] 95% Confidence Interval (CI) around the mean.
[3] Calculations are taken from Table 2, Fancy *et al*. (1999).
[4] No estimate was made of Mariana Fruit-dove or White-throated Ground-dove density or abundance due to the small sample size of observations in native forest.

Appendix C. For coconut forest (133.4 ha), the density (number of breeding pairs per hectare) and abundance (density x 133.4 ha) of Sarigan forest birds during surveys conducted in 1997, 1999, 2000 and 2006.

Species	Survey Year	Number Detected	# birds/ station[1]	Density of breeding pairs per ha	SE	Abundance (95% CI)[2]
Collared Kingfisher	1997[3]	68	0.79	0.68	0.087	91 (na)
	1999	55	1.96	0.82	0.182	110 (71-170)
	2000	39	1.56	0.70	0.156	93 (60-144)
	2006	31	1.35	0.65	0.158	86 (53-140)
Micronesian Honeyeater	1997	286	3.33	10.33	0.703	1,378 (na)
	1999	145	5.18	14.57	1.905	1,943 (1,502-2,515)
	2000	98	3.92	11.83	1.704	1,578 (1,186-2,100)
	2006	78	3.39	9.72	1.871	1,296 (882-1,904)
Micronesian Megapode	1997	120	1.40	3.89	0.461	518 (na)
	1999	55	1.96	5.24	1.330	699 (423-1,154)
	2000	56	2.24	7.41	1.873	989 (600-1,630)
	2006	33	1.44	5.27	0.091	702 (449-1,099)
Micronesian Starling	1997	19	0.22	1.68	0.547	223 (na)
	1999	43	1.54	13.11	3.743	1,749 (998-3,064)
	2000	12	0.48	4.08	2.227	544 (191-1,547)
	2006	5	0.28	2.43	1.447	324 (104-1,012)
White-throated Ground-dove	1997	1	0.01			
	1999	3	0.11			
	2000	3	0.12			
	2006	2	0.09			

[1] Number of birds per station is based on the number detected divided by the number of stations sampled in that year's survey. The number of points sampled in coconut forest was 86 in 1997 (Fancy *et al*. 1999), 28 in 1999, 25 in 2000, and 23 in 2006.
[2] 95% Confidence Interval (CI)
[3] Calculations are taken from Table 2, Fancy *et al*. (1999).
[4] No estimate was made of White-throated Ground-dove density or abundance due to the small sample size of observations in coconut forest.

Herpetological Surveys and Small Mammal Surveys, Sarigan 2006

Nathaniel B Hawley, CNMI Division of Fish and Wildlife

Herpetological Surveys

The purpose of the herpetological surveys on Sarigan was to document and monitor the presence and relative abundance of reptiles.

Methods

Diurnal ground lizards (skinks) were sampled using adhesive mouse traps (Bauer and Sadlier, 1992; Rodda et al., 1993). Three transects were sampled, one in mixed coconut forest (UTM 1847755N 368992E), one in native forest (UTM 1847564N 369997E), and one in grassland (UTM 1847225N 370033E). Ten to fifteen traps were placed flush with the ground every 10 meters along each transect. Traps were run for two consecutive days. Traps were placed in the morning (0830-900h) and run for 5-6 hours. All captured lizards were removed from the sticky trap with vegetable oil and then were measured, weighed and identified before release.

Nocturnal tree lizards (geckos) were also sampled along the native forest transect by stapling one adhesive trap to a tree at between 0.25 - 1.0 meters height every ten meters. Each trap was armed between 1600-1800h and checked the following morning between 0830-1000h. All captured lizards were removed from the sticky trap with vegetable oil and then were measured, weighed and identified before release.

Monitor lizards (*Varanus indicus)* were sampled along the mixed coconut forest transect (UTM 1847755N 368992E) and the native forest transect (UTM 1847564N 369997E). Ten flat loop snare traps, similar to bird of prey traps (Berger and Mueller, 1959) were placed every 15m and baited with approximately one pound of day old fish meat. The loop snare traps were baited at 0800h and run for two consecutive days (48hrs). Each trap was monitored every ten to twelve hours and re-baited if necessary.

Results

Table 1 represents the results of adhesive trapping for diurnal lizards for 2006. The blue-tailed skink (*Emoia caeruleocauda*) was the most abundant skink captured (n=88), accounting for 92.6% of the total skinks captured, were *Emoia slevini* accounted for 7.4% of the total skinks captured. The only species of nocturnal lizard captured during this survey was the Rock Gecko (*Nactus pelagicus*), where three specimens were recorded from the native forest transect. Two *Varanids* were recorded from the native forest transect and it was evident that two additional monitor lizards were captured along the coconut forest transect but had escaped before information could be collected.

Table 1. Results of adhesive trapping to determine diurnal lizard presence and abundance on Sarigan, 19-21 April, 2006.

Habitat	#Traps	#Hours	Trap Hours	#Lizards	Lizards/2006 # Per Tr Hrs
<u>Ground Trapping</u>					
Grassland	30	7.34	220.2	3	0.013
Coconut Forest	20	6.24	124.8	41	0.329
Native Forest	20	6.58	131.6	51	0.388
Total	70		476.6	95	0.285

Table 2. Presence and abundance of lizards trapped on Sarigan, 19-21 April, 2006 with totals from 2000 for comparison.

	Grassland	Coconut Forest	Native Forest	Total (2006)	Total (2000)
Family Scincidae					
Cryptoblepharus poecilopleurus	0	0	0	0	6
Emoia caeruleocauda	2	38	48	88	203
Emoia slevini	1	3	3	7	12
Family Gekkonidae					
Nactus pelagicus			3	3	0
Family Varanidae					
Varanus indicus		1	1	2	3
Totals		76	147	100	224

Discussion

A total of three species of ground dwelling skinks, *Emoia caeruleocauda*, *Emoia slevini* and *Cryptoblepharus poecilopleurus*, have been recorded on the island of Sarigan during previous surveys. However, during this investigation only two species were recorded, *Emoia caeruleocauda* and *Emoia slevini*.

Scott Vogt previously reported a capture rate of 0.02 captures/trap-hour for *E. slevin*i (Cruz et al., 2000) on Sarigan and Grant Beauprez (unpublished data, 2000) reported a capture rate of 0.03 captures/trap-hour in 2000. The 2006 data show a capture rate increase of 0.05 captures/trap-hour (seven *slevini* lizards divided by a total of 131.6 trap hours in native forest)

Paul Reyes removes lizards from a sticky trap. Photo: Nate Hawley

Small Mammal Surveys

Methods
Rats were sampled using Victor rat snap-traps. One transect was sampled in native forest (UTM 1847564N 369997E). Twenty traps were placed on the ground with 25 meter spacing. Traps were run for two consecutive nights. Traps were set in the evening and baited with peanut butter and left overnight. Traps were checked the following morning.

Results
The native forest rat transect did not yield any captures, however *Rattus exulans* was observed near the lower camp area. The only species of rat captured on Sarigan in 1999 and 2000 was *Rattus exulans*.

Discussion
It was reported that rats were more numerous in coconut forest than native forest (Cruz et al., 2000). This was similar to Vogt's findings from 1999 (Cruz et al., 2000). Rat capture rate was 2.6 rats/100 trap-nights (n=3) during the Sarigan 2000 survey by G. Beauprez. Scott Vogt had a capture rate of 3.2 rats/100 trap nights in native forest in 1999 (Cruz et al., 2000). This increase in capture rate may be due to the removal of goats several years ago. With more vegetation producing more seeds and fruit, the rat population may be increasing (Cruz et al., 2000), however this was not evident during the 2006 surveys. Additional trapping needs to be conducted to assess rat abundance on Sarigan because the 2006 surveys were not extensive and were limited to the upper native limestone forest.

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Ground Skink Surveys on Sarigan Island, Commonwealth of the Northern Mariana Islands

By Scott Vogt
January 2007

INTRODUCTION

In 1998 feral goats and pigs were eradicated from Sarigan Island (Kessler 2000). Flora and fauna surveys are performed to document changes due to the removal of the feral ungulates. It is assumed that recovery of the vegetation will positively benefit native wildlife species.

This study documented the changes in ground skink species diversity and abundances from studies conducted between 1997 and 2006.

METHODS

Ground skinks were sampled by adhesive "sticky" traps. Trap lines of 15-20 traps were run from ~08:00 am to ~15:00 pm. Traps were spaced ~5 meters apart. Lizards were removed from the trap with vegetable oil. Lizards were removed and measured for snout to vent length. In 1997 and 1999 all lizards were sacrificed and prepared as voucher specimens. In 2000 and 2006 lizards were released after measuring.

Skink abundance was expressed as number of lizards captured per trapping hour. One trap set for 1 hour represents 1 trap hour. Ten traps set for 5 hours represents 50 trapping hours and so on. The number of lizards captured divided by the number of trapping hours is the capture rate.

Two sites were sampled in 1997, 1999, 2000 and 2006. Site 1 is located ~30 meters to the south of the lower elevation main base camp. This site is in a gulley and the habitat is coconut forest. Site 2 is located on the upper elevations of the island near camp 2, starting at station 1 of transect #5 and following the transect. The habitat is native forest.

RESULTS

Three skink species were initially documented on Sarigan in 1997: *Emoia caeruleocauda*, *Emoia slevini* and *Cryptoblepharus poecilopleurus*.

In 1999 *E. caeruleocauda* catch rates increased in both habitat types and appear to have leveled off in 2006 (Charts 1. and 4.). There was a very large spike in catch rates for this species in the native forest in 2000. The spike is inconsistent with the rest of the data and might indicate some sort of artificial bias for that sampling event. This does not, however, rule out a true population increase of that magnitude in the native forest in 2000. In any case, the catch rates for that forest type leveled off in 2006.

E. slevini has mostly showed increases in catch rates with each sampling event (Charts 2. and 5.). In 2000 in coconut forest there was a drop in catch rates compared to 1999. The catch rates rebounded in 2006 and as with *E. caeruleocauda* in native forest in 2000, the *E. slevini* 2000 coconut forest catch rates appear inconsistent with the rest of the data. Again this might indicate some sort of bias but does not rule out a true population decrease at this time period.

Catch rates for *C. poecilopleurus* declined quickly in the coconut forest and the species has not been documented there since before the eradication (Charts 3. and 6.). It was documented in the native forest in 2000 but was not captured at all (in either habitat) in 2006.

The data show that capture rates for both *Emoia* species is usually higher in coconut forest than native forest.

Chart 1.

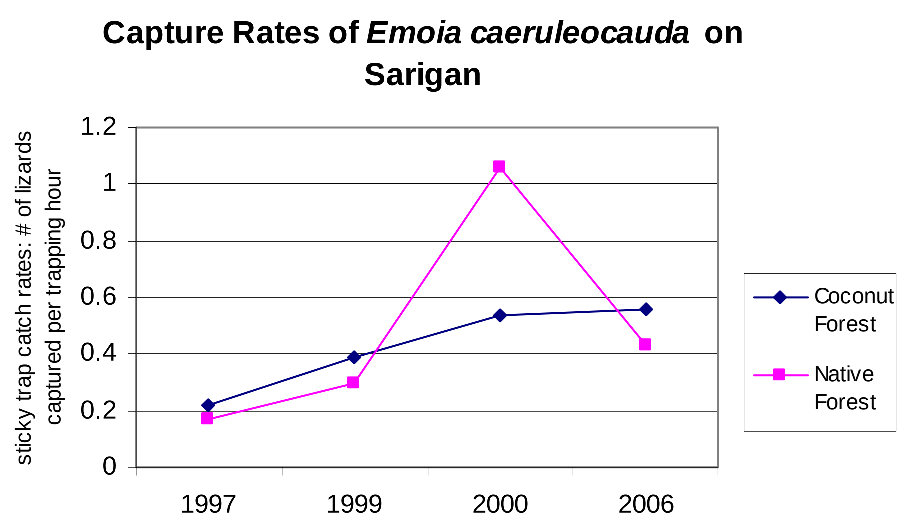


Chart 2.

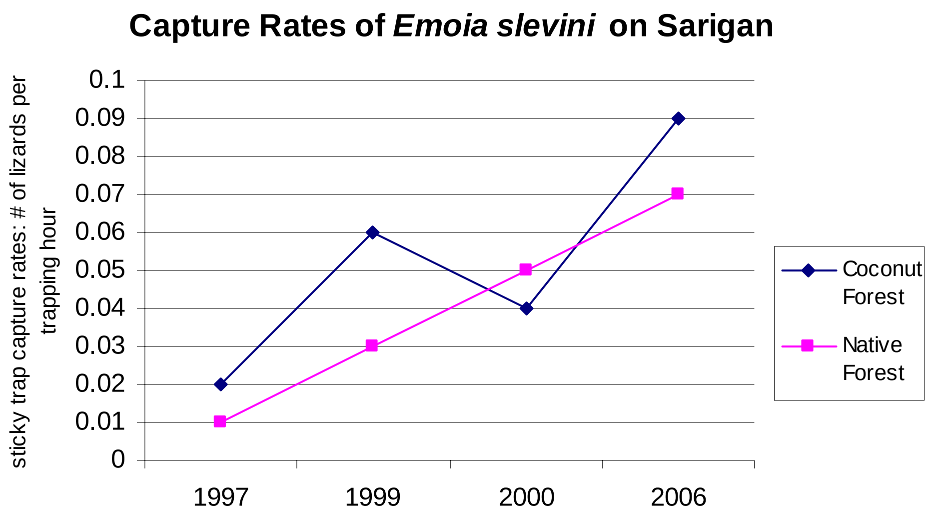


Chart 3.

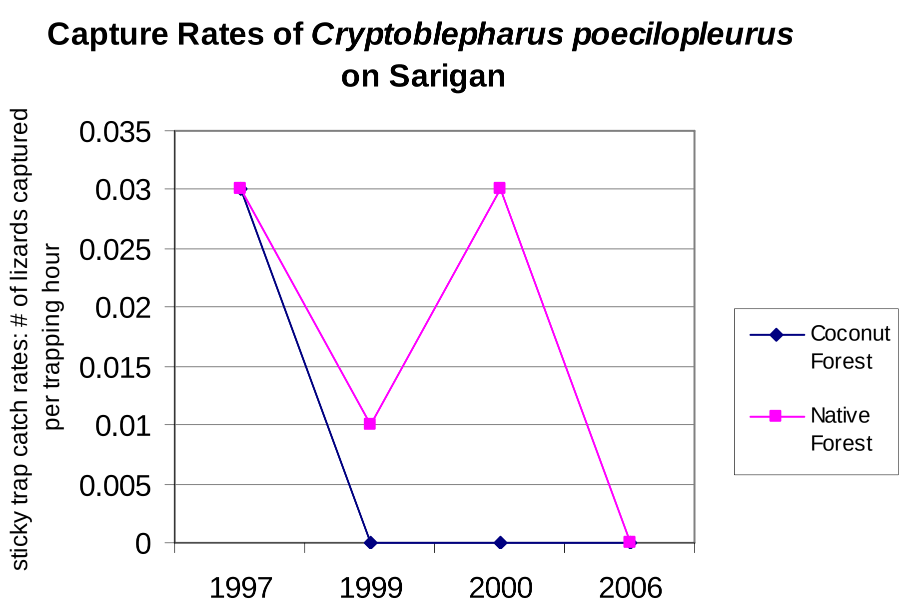


Chart 4.

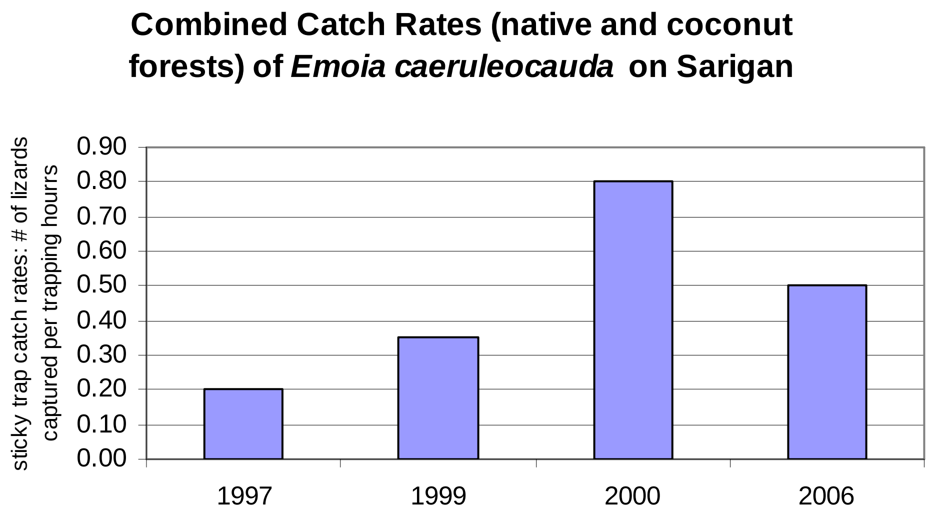


Chart 5.

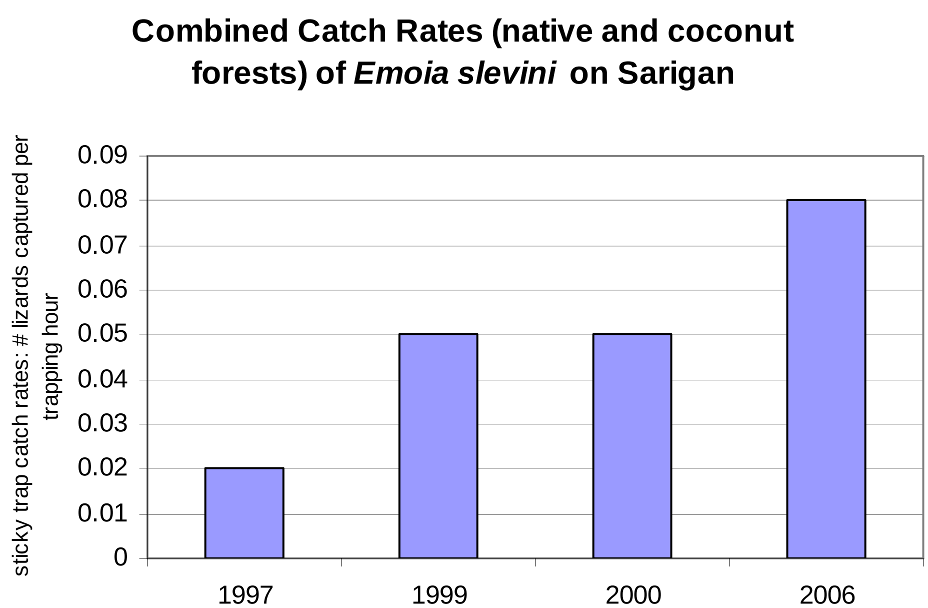
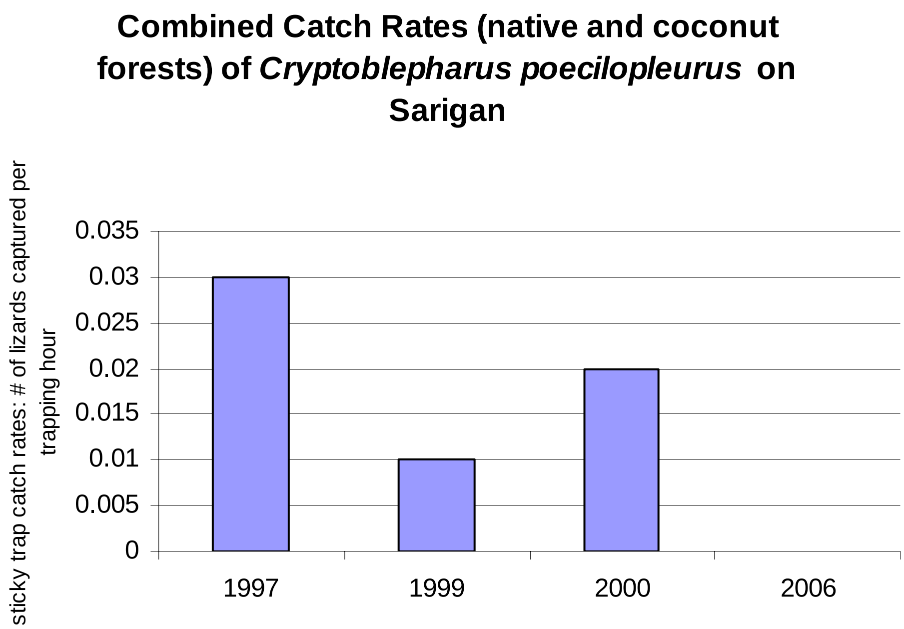


Chart 6.



DISCUSSION

The prediction that eradicating the feral ungulates on Sarigan would be a benefit to the native species has largely been upheld by the ground skink data. True, there has been the decline of one species but the other two species have greatly increased.

Significantly, *Emoia slevini*, the only endemic reptile to the Marianas, has quadrupled its numbers since the eradication. This species is presently known from 5 islands in the chain: Sarigan, Guguan, Alamagan, Pagan and Asuncion. The catch rates for this species are now much higher on Sarigan than any other island in the chain (Vogt unpublished data). Because of this, Sarigan is vital for the survival of this species and could become a source population for future reintroduction efforts.

The decline of *Cryptoblepharus poecilopleurus* is of interest. This species is normally found in coastal beach strand habitat but on smaller islands can be found inland (Vogt and Williams, 2004). This species prefers light sandy or powdery soil and has immovable eyelids (hence the common name "snake-eyed skink") for burrowing or sand swimming (Vogt and Williams, 2004). When feral ungulates were present on Sarigan there was much more exposed loose soil. After the eradication, plant cover and leaf litter increased and the amount of exposed loose soil decreased (Kessler 2000). This could be the reason for the decline in catch rates of *C. poecilopleurus*. Interestingly the re-growth of vegetation occurred much quicker in the coconut forest than the native forest (Kessler 2000). *C. poecilopleurus* catch rates were 0 in the coconut forest one year after the eradication while the catch rates in the native forest did not become 0 until much later. Because sampling did not occur on a yearly basis it is impossible to say exactly

when catch rates would have reached zero. There is also the possibility that the lack of trap captures is the result of a sampling bias brought on by increased vegetation and that *C. poecilopleurus* is still present in these habitats.

It is unknown why the *Emoia* numbers are consistently higher in coconut forest than native forest at this point. The author feels that this is a true abundance difference and not survey bias. The reason for this is that the understory in the coconut forest came back much more quickly and the increased vegetation gave skinks more structure to climb on or over making them less susceptible to capture by ground based sticky traps.

For the same reason, the author feels that the overall increases in catch rates, in the two *Emoia* species, represent true population increases. Indeed, because of this lessened susceptibility to the ground based sticky traps, the magnitude of the population increase could be higher than what the catch rates suggest.

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Monitor Lizard, *Varanus indicus*, Diet on Sarigan Island, Commonwealth of the Northern Mariana Islands.

By Scott Vogt
January 2007

INTRODUCTION

The monitor lizard (*Varanus indicus*) is abundant on Sarigan and is the only large predator on this island. As such this species could be functioning in a key role and exerting major influences over the ecology of this small island.

METHODS

Varanids were sampled on Sarigan on April 17-24, 2006. Varanids were opportunistically shot with a .22 caliber air rifle. Collected lizards were measured for snout vent length, tail length, weighed and sexed. Necropsies were performed to document body fat condition, stomach contents and presence of egg follicles in females.

RESULTS

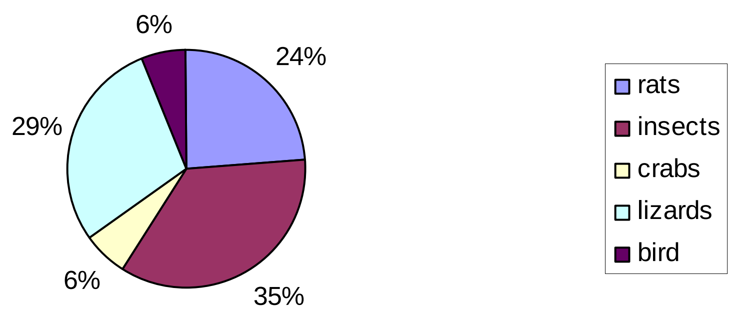
Sixteen lizards were collected: four females and twelve males. One stomach was empty with the rest containing prey items. A total of seventeen natural prey items were identified (Table 1., Figure 1.). In some cases discarded camp food (rice, cooked chicken and fish) were recovered, but not used for the analyses.

Table 1.

Prey item	Number recovered	Frequency
Rats (*Rattus exulans*)	4	24%
Insects (grasshoppers)	6	35%
Crabs (land crab)	1	6%
Lizards (skinks and geckos)	5	29%
Bird (*Megapodius laperouse laperouse*)	1	6%
Total	17	100%

Figure 1.

Monitor lizard prey items on Sarigan: percent of occurance in stomachs



Two of the females had developing egg follicles (9 and 6).

All lizards had very good fat deposits and appeared to be in excellent condition. Two males had the ends of their tail cut off and the wounds had healed over.

The percent frequency of prey items is similar to what was documented with Sarigan monitor lizards in 1998 and 1999 (Table 2.). The difference observed between the years is probably the result of the small sample sizes.

The 1998 and 1999 data also showed a skewed sex ratio with 11 males and 3 females in 1998 and 8 males and 2 females in 1999.

Table 2.

Prey item	1998: (n=14 Lizards) frequency	1999: (n=10 Lizards) frequency
Rats	25%	38%
Insects/grubs	35%	23%
Crabs	15%	23%
Lizards	20%	15%
birds	5%	0%

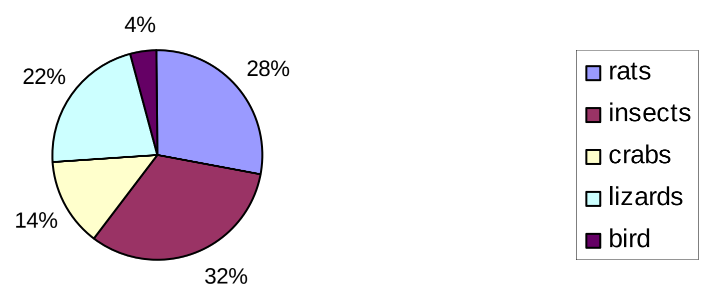
If we combine the numbers for the 3 survey periods (1998, 1999 and 2006), we get the following prey item frequency of occurrence (Table 3, Figure 2.).

Table 3.

Prey item: N=40 lizards	Number recovered	Frequency
Rats (*Rattus exulans*)	14	28%
Insects (grasshoppers)	16	32%
Crabs (land crab)	7	14%
Lizards (skinks and geckos)	11	22%
Bird (1 *Megapodius laperouse laperouse* and 1 unknown)	2	4%
Total	50	100%

Figure 2.

Monitor lizard prey items on Sarigan, 1998, 1999 and 2006 data combined: percent of occurance in stomachs



Males were larger than females with an average snout-vent length of 391mm, 95% ci 361-422 and an average weight of 1100 gms, 95% ci 867-1332. Females had an average snout-vent length of 319 mm, 95% ci 292-346, and an average weight of 500 gms, 95% ci 377-623.

Please see Appendix 1 for the weights and measures of all lizards collected.

DISCUSSION

While the numbers point to a fairly equal distribution between rats, insects and lizards as prey items it must be noted that this is prey numbers. The mass of the prey is not accounted for. If such were the case, rats as prey would assume a much greater importance.

Given this, one should be cautious when discussing rat control on Sarigan. It might not be wise to eliminate or reduce a major prey item of the only large predator on this island, causing it to switch to another prey item (e.g. native birds) to make up the difference. At this point I would only recommend rat control if one could also reduce or eradicate varanids at the same time. Effective varanid control or eradication might not be possible with the tools and techniques presently known. There has been little or no research on exactly how to do large scale varanid control. The toxicant that has been proposed for Brown treesnake control on Guam, acetominophine, might hold promise and should be investigated for varanid control.

Skewed sex ratios in favor of males are common in varanid studies and are thought to arise from survey bias due to different home range sizes between the sexes (De Lisle, 1996). Males are more active and more apt to be collected (De Lisle, 1996). More closely studied populations have shown both equal sex ratios and skewed ratios in favor of males depending on the species (De Lisle, 1996). It is unknown if the Sarigan ratio is natural or the product of survey bias.

Megapode predation was documented in the April, 2006 surveys. A feather and two megapode feet were found in the stomach of one lizard. It is not known if the bird was killed and eaten by the lizard or if the lizard found and ate a dead carcass. It does not appear that megapodes are regularly taken by varanids on Sarigan. The record of a bird being taken during the 1998 surveys is from a small bone that was found in a varanid stomach. The species of the bone could not be ascertained.

Varanids are probably not a native species (Vogt and Williams 2004). Although the exact dates of varanid introductions are unknown, they have presumably been in the Marianas (Steadman 1999) and Sarigan long enough (hundreds if not thousands of years) for megapodes to have evolved defenses against varanid predation (Vogt and Williams 2004). This is demonstrated by the high densities of both species on Sarigan.

Even with occasional predation, at present varanids do not appear to pose substantial risk to the Sarigan megapode population.

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Monitor lizard at Sarigan, April 2006. Photo: Nate Hawley

Appendix 1

April, 2006			
sex	snout-vent length, mm	weight, gms	tail length, mm
m	527	2180	895
f	358	660	685
f	352	740	650
m	350	710	325
			tail cut off and healed over, crab or another Vi?
m	420	1100	535
			tail cut off and healed over, crab or another Vi?
m	332	595	595
m	470	1620	820
m	408	1200	740
m	434	1520	795
m	379	815	711
m	339	525	566
f	282	325	512
		had 6 developing egg follicles	
f	314	540	565
		had 9 developing egg follicles	
m	377	720	680
m	321	495	577
m	236	200	432

February, 1999			
sex	snout-vent length, mm	weight, gms	tail length, mm
f	285	360	510
m	490	2025	825
m	418	1200	731
m	351	640	671
m	379	830	666
m	444	1200	872
m	476	1700	871
m	350	670	691
m	320	565	595
m	215	130	394
f	337	455	550

Scott Vogt with dissected monitor lizards.
Photo: Gayle Martin

January, 1998			
sex	snout-vent length, mm	weight, gms	tail length, mm
f	364	660	615
f	260	260	476
m	493	2200	813
f	NA, missing head	480	570
m	355	750	695
m	520	2450	865
m	442	1600	733
m	390	920	672
m	365	720	686
m	196	105	281
m	482	1950	785
m	469	1650	745

Coconut Crab, *Birgus latro*, Surveys on Sarigan Island, Commonwealth of the Northern Mariana Islands

By Scott Vogt
January 2007

INTRODUCTION

The coconut crab (*Birgus latro*) is an important game species in the Pacific. The Mariana Islands are no exception and crabs are popular at holidays and "fiestas". In the Commonwealth of the Northern Mariana Islands there is a season for crab hunting with size, sex and bag limits. Even with these regulations, the population is overharvested on inhabited islands (as it is in most of its range) (USFWS, 2001; Kessler, 2006).

On the inhabited islands in the CNMI there is the commonly held belief that the uninhabited islands north of Saipan (the Northern islands) hold vast numbers of crabs. However there has been little to no systematic crab surveys performed on these islands and crab abundance and demographics are unknown.

This study is the first time that a scientific methodology was used to measure crab abundance on Sarigan Island.

METHODS

This work was performed in April 17-26, 2006. Crabs were sampled by coconut bait stations. Aged, fallen coconuts were obtained on island. A small hole (~3x3cm) was cut in each coconut to expose the meat. The coconut was then tied with wire to a tree from ground level to ~1 meter high. This constituted one station. Stations were spaced every 20 meters. Stations were checked at night for crabs that came to eat the coconut.

Two lines of twenty stations each were set in the lower elevations close to base camp (camp A). Line 1 ran from base camp on the trail leading to transect #2. Line 2 began at the end of transect 1 and followed the transect trail. The two lines were checked for two consecutive nights. The habitat was coconut forest.

Two other lines were run at the top of the island near camp B in native forest. Line 1 was 14 stations beginning at station 1 of transect 5. Line 2 was 16 stations beginning on the trail between the first stations of transect 4 and 5 and ending in a small gulley ~50 meters east of transect 4. Line 1 was run for 3 consecutive nights and line 2 was run for 2 consecutive nights.

All captured crabs were weighed, measured for thoracic length and width, sexed, marked and released at the capture site. Crabs were marked by attaching plastic "zip ties" at the base of one of the legs. This ensured that crabs were not double counted. Pesola balances and digital calipers were used for the weights and measures.

Abundance was expressed as the number of crabs captured divided by the number of trapping nights (the catch per unit of effort or CPUE). A trap night is defined as one station set for one night. The number of stations multiplied by the number of nights equals the number of trapping nights. So, 20 stations set for 2 nights equal 40 trap nights. The bait station lines near base camp totaled 80 trapping nights and the lines at the top of the island totaled 72 trap nights.

This type of survey is termed an "index" survey. It does not calculate the absolute population numbers but gives an index of abundance, in this case the catch rate.

RESULTS

Thirteen crabs were captured on the bait stations and one was captured off of the bait station lines (near camp B on the top of the island) during the day. The two trap lines near base camp captured two crabs and the two lines near camp B captured 11 crabs. Six crabs were female and 8 were male. The base camp capture rate was 0.03 and the capture rate for the camp B bait station lines was 0.15. See appendix 1 for the weights, measures and summary statistics.

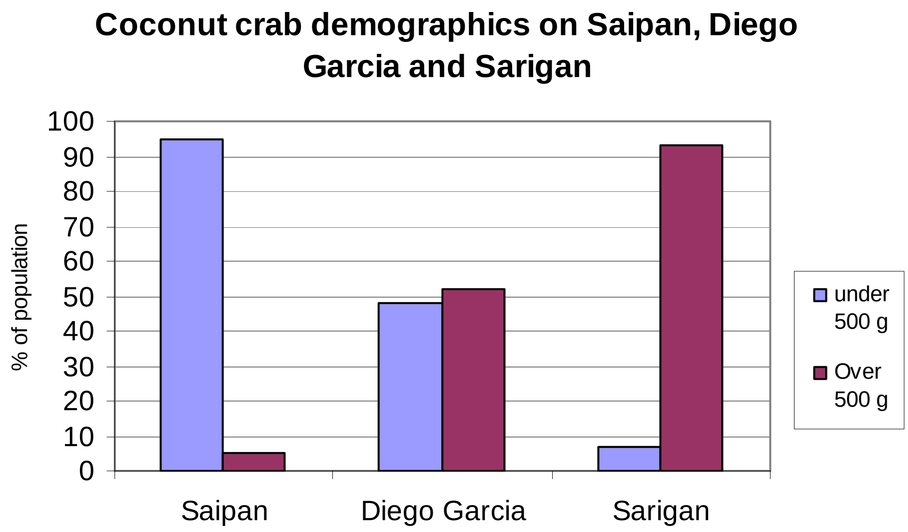
DISCUSSION

It is interesting that there was such a difference in the capture rates between each of the sampled areas. The camp B sites clearly had higher numbers of crabs. Given that coconut forest habitat has greater numbers of coconuts on the ground one would expect more crabs in this type of habitat. It is puzzling why this was not so. Due to its isolation, the Sarigan crab population presumably receives little or no harvest pressure.

Overall the crab numbers on Sarigan appear to be low. Even the higher catch rate in the forest is much lower than one would expect for a lightly harvested population. A comparable bait station line (40 trap nights) in the conservation area (coconut forest habitat) on the Indian Ocean island of Diego Garcia (Vogt, unpublished data) produced a catch rate of 1.78. This is 11 times higher than the highest rate on Sarigan.

The other puzzling fact was the apparent absence of smaller sized crabs, under 500 grams in weight. On Saipan and Guam (Kessler, 2006 and Vogt, 2000), crabs of this size make up over 95% of the sampled population. This is most likely due to overharvest of the larger crabs on these inhabited islands, but the reasons why this size class is almost nonexistent on Sarigan is difficult to explain. In the unharvested population on Diego Garcia, 48 percent of the population was under 500 grams. On Sarigan 7 percent of the sample (1 out of 14) was under 500 grams (Chart 1.). Interestingly Amesbury (1980), found similar demographic profiles for coconut crabs on Guguan and Asuncion.

Chart 1.



It is possible that this discrepancy is the result of some unknown sampling bias or small sample size but the fact that this same technique sampled this cohort (<500 grams) on other islands argues against it. So we can only speculate as to why this cohort is a negligible part of the Sarigan crab population.

One conjecture is that feral pigs eat juvenile crabs (<20 grams) and that the feral pig population kept crab numbers low due to greatly decreased juvenile recruitment, however the feral pig population was eradicated in 1998 (Kessler 2000). One would expect smaller crabs to be noticeably present by now and they are not.

Monitor lizards (*Varanus indicus*) will prey on smaller coconut crabs (S. Vogt pers. exp) and these lizards are very abundant on Sarigan. It is possible that the smaller crabs are being predated by varanids.

Since coconut crab larvae have a marine stage it is possible that the lack of a fringing reef on Sarigan and currents carry away many of the larvae, causing juvenile recruitment into the adult cohorts to be low.

Coconut crab juvenile recruitment was found to be very low in Vanuatu (Fletcher et al. 1991) and successful recruitment of the oceanic larval stages was hypothesized as being dependent on shallow water near the coastline and presence of depository (sand or coral rubble) beaches. Both of these conditions are lacking on Sarigan. The data on Vanuatu suggested that “coconut crabs populations in Vanuatu archipelago probably experience large scale recruitment only every 5-10 years” (Fletcher et al. 1991). It is worth noting that in ~10 years of performing coconut crabs surveys on 5 different islands and having measured and weighed close to 500 crabs, the author has never seen a female with eggs.

Some combination of the above (e.g. low recruitment combined with pig/varanid predation on those crabs that do make it to shore) could be responsible for the skewed demographics of the Sarigan crab population, but these are speculations. More research on this issue and sustainable crab harvesting (e.g. what percentage of the population can be harvested each year) is warranted, especially since this is an important species to the local culture and the belief (quite possibly erroneous) that large numbers of crabs exist in the Northern islands.

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Appendix 1.

Weights and measures for each crab captured and summary statistics

Sex	Thoracic Length (millimeters)	Width (millimeters)	Weight (grams)
Male	72	145	2190
Male	59	140	1705
Male	59	135	1405
Male	57	127	1185
Male	62	150	1885
Male	60	135	1585
Male	49	105	1025
Male	24	46	105
Female	45	107	895
Female	43	85	625
Female	47	99	805
Female	45	96	805
Female	46	109	810
Female	43	98	675
Mean with 95% Confidence Interval	51, 45-57	113, 98-127	1121, 824-1419
Mean for Males with 95% Confidence Interval	55, 45-65	123, 99-146	1386, 944-1828
Mean for Females with 95% Confidence Interval	45, 44-46	99, 92-106	769, 689-849

Top to Bottom:

Alvin Fitial grasping a captured coconut crab at Sarigan, near Camp B (Upper Camp).

Alvin Fitial measuring thoracic length with digital calipers.

Released coconut crab climbing papaya tree. Note one leg marked with a zip tie.

All photos: Gayle Martin

PRELIMINARY ASSESSMENT OF ENDEMIC ARBOREAL SNAILS IN THREE FOREST TYPES IN SARIGAN, WITH NOTES ON GROUND-DWELLING SPECIES

by

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Abstract

Arboreal snails were surveyed in three habitat types in Sarigan from April 19 to April 22, 2006. Population densities of the humped tree snail *Partula gibba* in native forest were the highest ever reported for the species, but densities declined in mixed native-secondary growth forest and mixed coconut-secondary forest. Arboreal *Succinea* sp. reached high densities as well. Broad-leafed native trees were the preferred host species. Demographic structure of tree snail populations in Sarigan was similar to that of Guam tree snails. Seven species of ground-dwelling snails were recorded for the first time in Sarigan, bringing the total fauna to 22 species. Measures should be developed by natural resources agencies to prevent the introduction of snail predators and to conserve land snail populations in Sarigan.

Introduction

Insular biotas, especially those of tropical Pacific islands, have been of particular interest to biogeographers and evolutionary biologists since at least the time of Darwin (Cain, 1984). Both Darwin and Wallace recognized that the distribution of land snails on islands presented a paradox for their concepts of dispersal. Here is a group with seemingly limited dispersal capacity, but land snails are nonetheless ubiquitous and diverse components of island biotas, including the most remote islands (Peake, 1981).

Although dominated by relatively few families, the land snails on islands of the tropical Pacific exhibit spectacular evolutionary radiations (Cowie, 1996). Despite this diversity, native land snail faunas of the Pacific islands are composed almost entirely of narrow-range endemics. The same factors that favored rapid evolution of endemic land snail biotas from colonists dispersing successfully to islands also imposed certain constraints on the resulting populations. Extreme sensitivity to environmental disturbances and high rates of extinction among insular endemic species are consequences of small geographic ranges and small populations (Diamond, 1984; Tracy and George, 1992).

These unique native snail faunas are now disappearing rapidly (Lydeard et al., 2004). In the Northern Mariana Islands, the tree snail *Partula gibba* has disappeared from historical locations in Saipan studied by Crampton (1925) in 1920 and by Kondo in 1949 (Smith and Hopper, 1994). No living *Partula gibba* were found in former habitations in Tinian and Rota, as well (Smith and Hopper, 1994; Smith, 1995). Bauman (1996) recorded at least 39 native species of land snails in Rota, and Kurozumi (1994) recorded at least 16 species on the islands north of Saipan. Sixty-eight percent of the Rota snail species are extinct or declining (Bauman, 1996).

These and other data suggest that overall perhaps 50% of the land snail fauna has disappeared throughout the Pacific islands as a whole, mostly in recent times (Lydeard et al., 2004).

Molluscan conservation strategies (e.g., Killeen et al., 1998) are needed throughout the Pacific islands. Biotic surveys and taxonomic studies are critically important, particularly in poorly inventoried areas. Biologists must provide an accurate picture of the true levels of species richness and extinction so that managers can determine appropriate locations for conservation efforts. Biologists need to identify land snail hotspots to improve or modify management practices to accommodate the needs of molluscs and, if necessary, to guide the establishment of new areas specifically related to molluscs (Lydeard et al., 2004).

The objective of this study is to establish baseline data for arboreal snail populations in representative forest habitats in Sarigan. For the purposes of this report, arboreal snails are tree-dwelling species of the families Partulidae and Succineidae. These data will be useful for wildlife managers in the development of conservation and management programs.

Materials and Methods

Arboreal snails were surveyed in Sarigan from April 19 to April 22, 2006. Three sampling stations were established to collect size-frequency data on arboreal snails. Stations were selected to represent an array of arboreal snail habitat ranging from native forest to mixed coconut grove and secondary forest.

<u>Description of Sampling Stations</u>

Station A (Figure 1) was located in native forest near upper end of Transect 5 of the permanent transects established in 1999 for forest bird surveys in Sarigan (see Cruz et al., 2000). The station was situated in a small grove of trees. A closed canopy extending some 5–10 m above the ground was dominated by *Neisosperma oppositifolia*, *Carica papaya*, *Aglaia mariannensis*, and *Trema orientalis*. A dense understory ranging from 1–2 m above the ground consisted primarily of saplings of *Neisosperma oppositifolia* and *Carica papaya*. Ground cover was sparse, consisting of the ferns cf. *Asplenium nidus* and *Pteris quadriaurita*.

Station B (Figure 1) was situated in mixed native-secondary growth forest, near the upper end of Transect 4 of the permanent bird survey transects. The station was characterized by a semi-closed canopy some 5–10 m above the ground. The dominant canopy tree was *Erythrina variegata*. The understory consisted of saplings of *Erythrina variegata*, *Hibiscus tiliaceus*, *Aglaia mariannensis*, *Ficus tinctoria*, and *Premna obtusifolia*. Ground cover was dense, with *Pteris quadriaurita* and *Piper guahamense* dominant.

Station C (Figure 1) was located in mixed coconut-secondary growth forest on the 300-m elevation contour directly up-slope of Transect 1 of the permanent bird survey transects. An open canopy of *Cocos nucifera* and *Erythrina variegata* trees extended from about 5–15 m above the ground. The understory was comprised of saplings of *Aglaia mariannensis*, *Carica papaya*, and *Neisosperma oppositifolia* and seedlings of *Cocos nucifera*. Ground cover was sparse, with *Pteris quadriaurita* scattered in the quadrat.

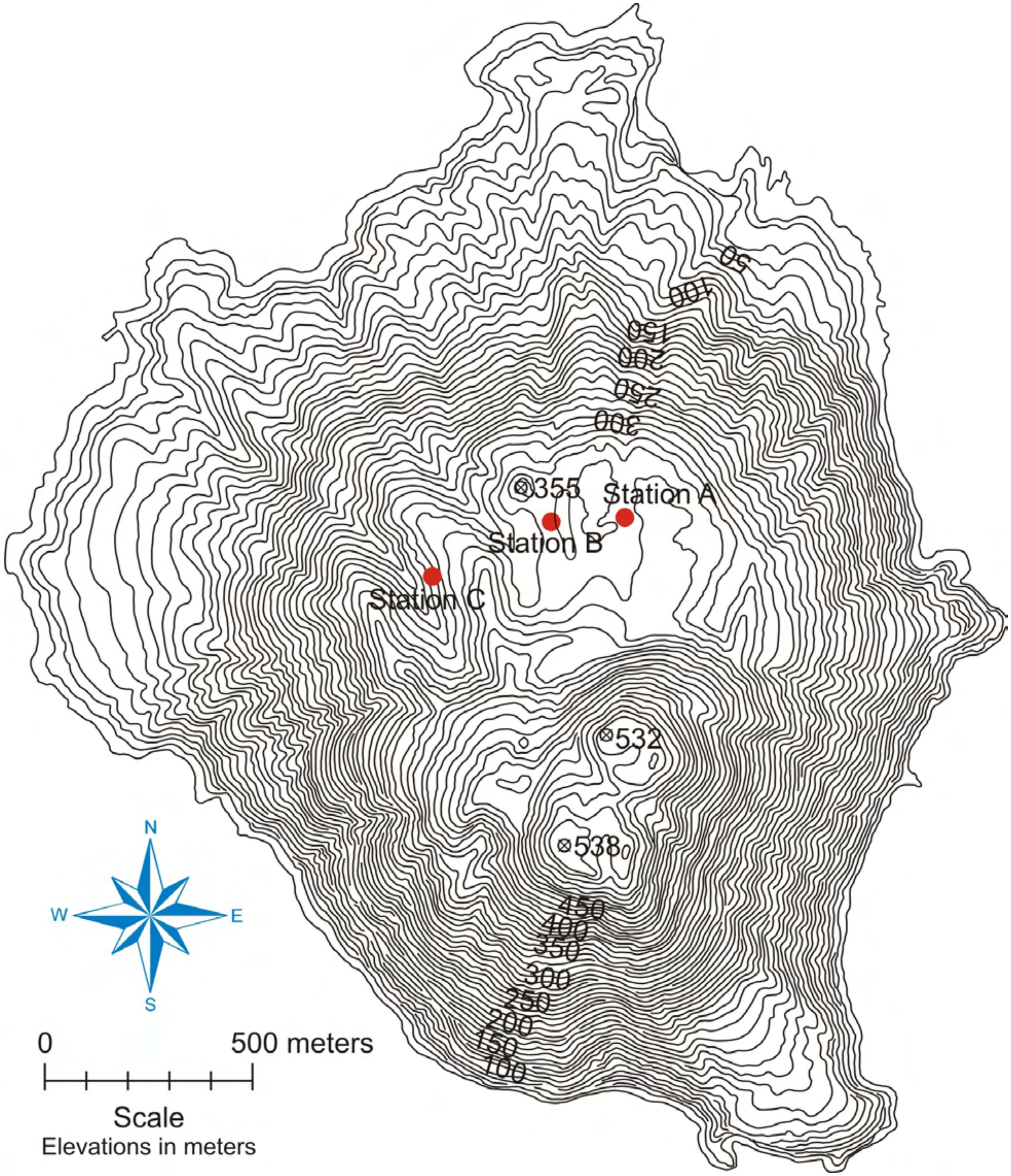

Figure 1. Topographic map of Sarigan showing the locations of sampling stations for arboreal snails. Modified from Cruz et al. (2000).

Sampling Methods

At each station, a 5 m x 5 m quadrat was delineated with a metered transect tape. Within each quadrat, average percent canopy cover was determined from five readings with a spherical densiometer, one in the center of the quadrat, and one at a distance of 1 m from each corner.

All tree snails within 2.5 m of the ground were collected from each individual host tree within the quadrat, and the host tree species was recorded. The axial length of each shell was measured to the nearest 0.01 mm with digital calipers, and the presence or absence of a varical lip was noted. All snails were returned to their original host plant.

Ground-dwelling gastropods were collected from tree trunks, leaf axils, leaf litter, decomposing wood, mosses, and rocks within each quadrat. Specimens were drowned overnight in vials of water and preserved in 75.5% alcohol (Manta Bay® 151 Rum) for future identification.

Results

Arboreal snail populations in Sarigan were dense in forested areas dominated by broad-leafed native trees, but snail densities declined in secondary growth forest and mixed coconut-secondary growth forest, much like bird abundances in these habitats (de Cruz, 2007). Tree snails were particularly abundant at Station A, where 448 specimens of *Partula gibba* and 204 of *Succinea* sp. were encountered within the 25-m^2 quadrat. The numbers of *Partula gibba* declined to 148 and 29 at Stations B and C, respectively; no data were collected on *Succinea* sp. in these quadrat because of time limitations. These data are reflected in the average percent canopy cover which declined from 70.5% at Station A to 36.2% at Station B to 13.3% at Station C. Host plant species are given in Table 1; broad-leafed native trees were preferred host plants.

Size-frequency distributions for *Partula gibba* at the three sampling stations are presented in Figure 2. The size-frequency distribution for *Succinea* sp. at Station A is shown in Figure 3. Box plots of the size data for *Partula gibba* are presented in Figure 4, and for *Succinea* sp. in Figure 5. Box plots provide excellent visual summaries of the smallest observation, the lower quartile (Q1), the median, the upper quartile (Q3), the largest observation, and observations that are considered unusual, or outliers (Tukey, 1977). The box stretches from the lower hinge (defined as Q1, or the 25th percentile) to the upper hinge (Q3, or the 75th percentile) and therefore contains the middle half of the scores in the distribution. The median is shown as a line across the box. Therefore, one-fourth of the distribution is between this line and the top of the box, and one-fourth of the distribution is between this line and the bottom of the box.

Table 2 lists the species of terrestrial gastropods previously reported from Sarigan (Kurozumi, 1994; Kurozumi and Asakura, 1994), plus new species records documented in the present study. Unfortunately, Kurozumi did not provide descriptions or figure specimens of the species that he collected in Sarigan. For several species, he identified specimens to morphospecies, e.g., *Omphalotropis* sp. A and *Omphalotropis* sp. B, and for others he used the plural designation of species, e.g., *Lamprocystis* spp., when he could not distinguish morphospecies. Therefore, it is not possible to determine which, if any, of the species of terrestrial gastropods observed in the present study are synonymous with those reported by Kurozumi, without examining his species in the Chiba Natural History Museum and Institute.

Table 1. Plant species hosting arboreal snails in three habitat types at Sarigan. A filled circle (●) indicates that the snail species was observed on the host plant within the quadrat, and an empty circle (○) indicates that the snail species was not observed on the host plant within the quadrat.

Plant taxa	*Partula gibba*	*Succinea* sp.
Native Forest		
Aglaia mariannensis	●	●
Neisosperma oppositifolia	●	●
Carica papaya	●	●
Asplenium nidus	●	●
Pteris quadriaurita	●	●
Mixed Native-Secondary Growth Forest		
Aglaia mariannensis	●	●
Hibiscus tiliaceus	●	●
Ficus tinctoria	●	●
Carica papaya	●	●
Mikania scandens	●	○
Piper guahamense	●	●
Erythrina variegata	●	○
Mixed Coconut-Secondary Growth Forest		
Aglaia mariannensis	●	●
Cocos nucifera	●	○
Carica papaya	●	●

Despite this limitation, at least 7 new records of gastropod species from Sarigan were encountered in the present survey, bringing the number of terrestrial gastropods recorded from Sarigan to at least 22 species.

Discussion

Populations of partulid tree snails in Sarigan are comparable to populations in similar habitats in Guam. Size-frequency distributions at Stations A and B (Figure 2) are similar to those observed in Guam and Rota (Smith, unpublished data). However, the size-frequency distribution recorded from Station C has not been observed in previous studies. Unfortunately, there was insufficient time to make replicate samples at the three stations to provide estimates of statistical variance in these data.

The population density of *Partula gibba* at Station A is remarkable, exceeding numbers found in previous studies. The greatest pre-reproductive season density of *Partula gibba* previously known was observed during a 3-yr population study at Haputo, Guam, where 430 snails were recorded in a 25-m^2 quadrat in April 1995 (Smith, unpublished data). At the peak of the reproductive season the following month, this number rose to 636 snails—an increase of

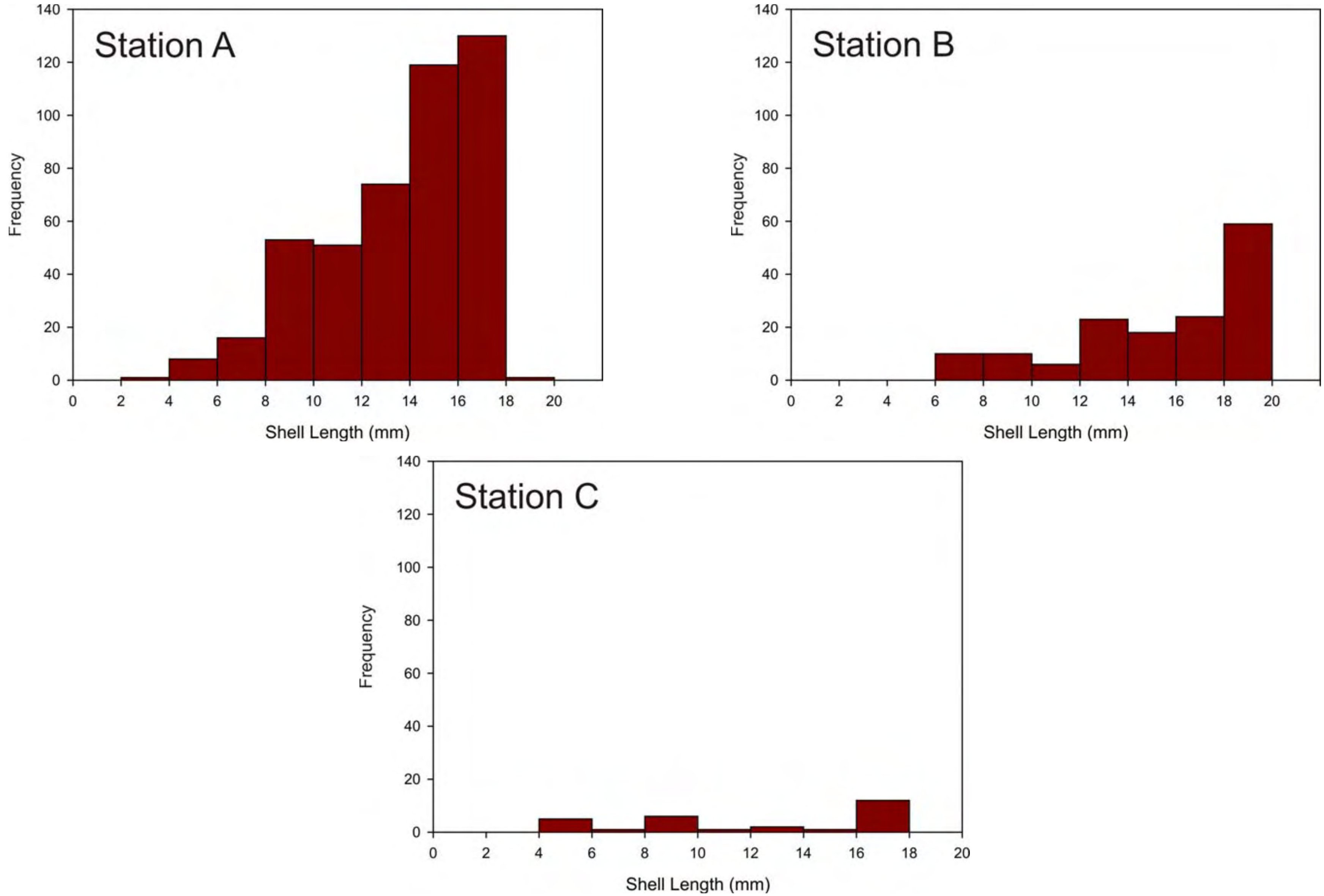

Figure 2. Size-frequency distribution of *Partula gibba* inhabiting a 25-m^2 plot in three habitat types (see Figure 1).

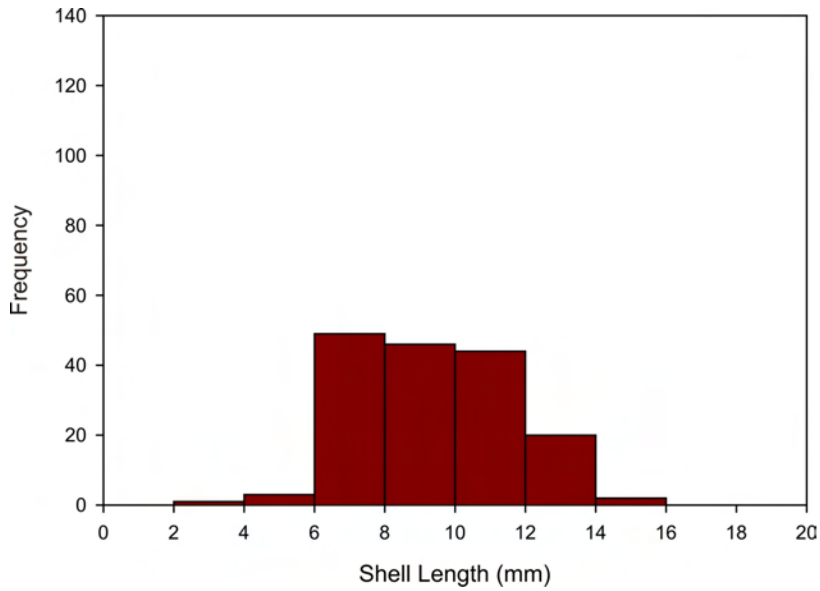

Figure 3. Size-frequency distribution of *Succinea* sp. inhabiting a 25-m^2 plot in native forest at Station A (see Figure 1).

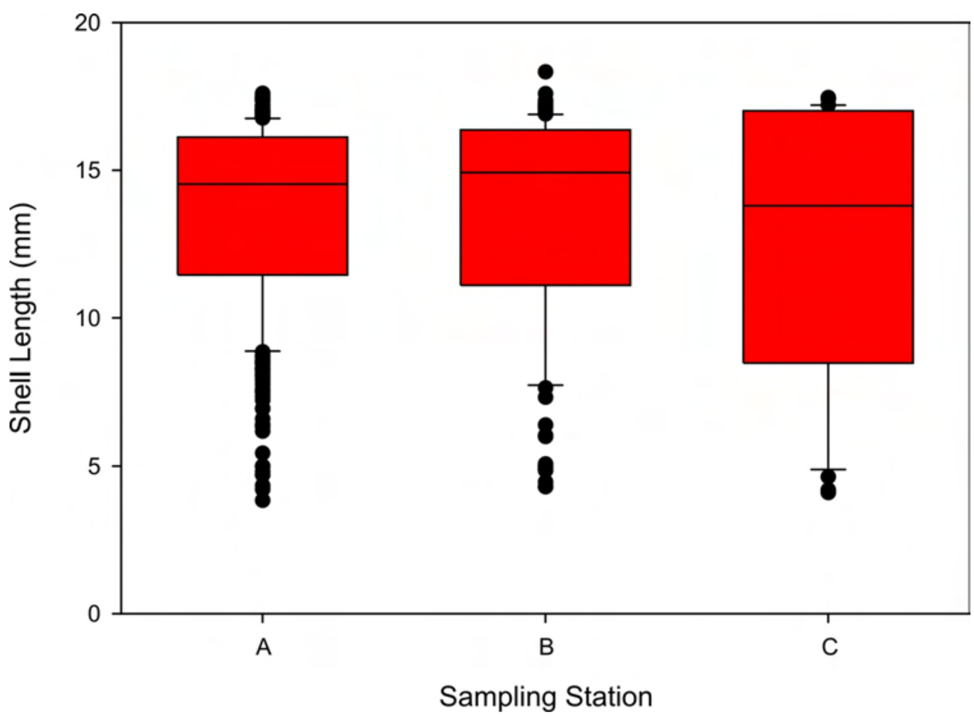

Figure 4. Box plots of shell length of *Partula gibba* in 25-m^2 plots in three habitats in Sarigan.

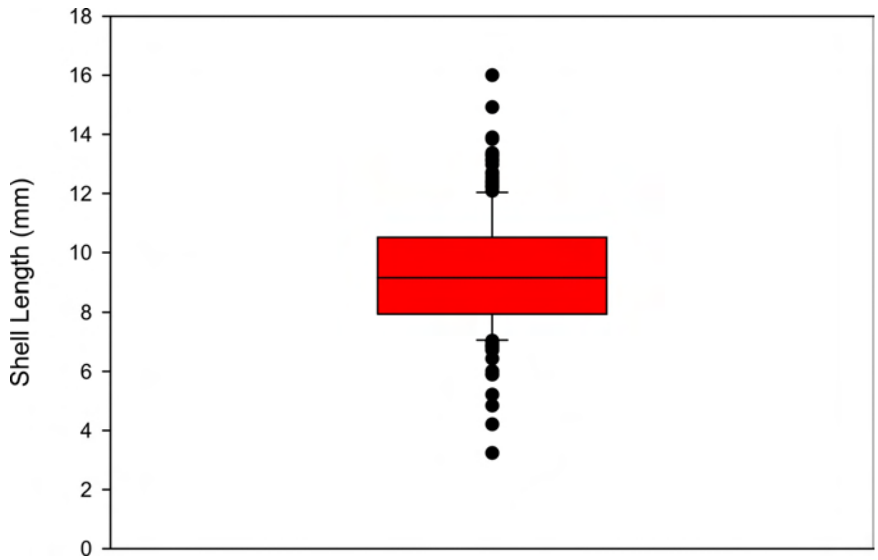

Figure 5. Box plot of *Succinea* sp. shell length in a 25-m^2 plot in native forest in Sarigan.

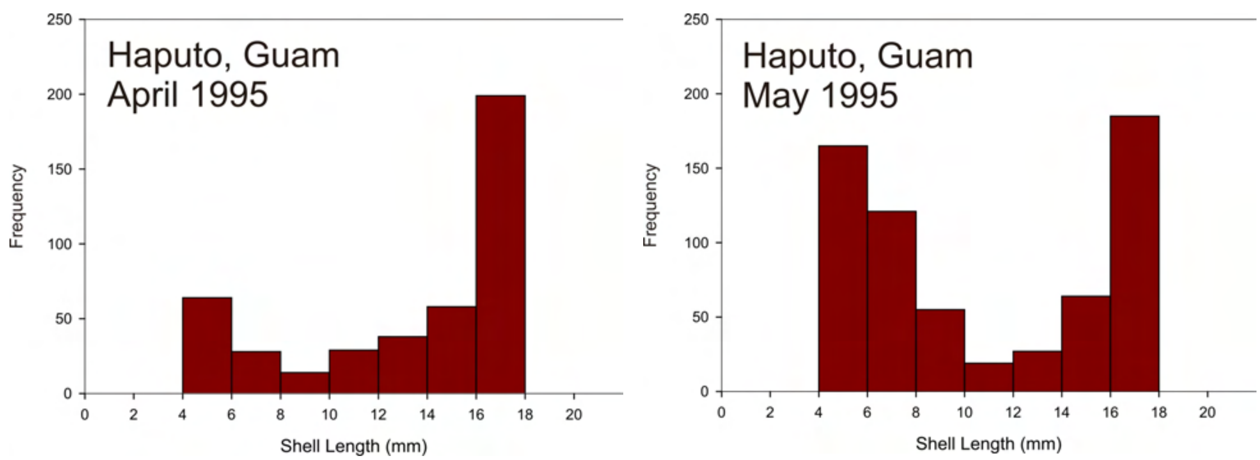

Figure 6. Effect of seasonal reproduction on the size-frequency distribution of *Partula gibba* at Haputo, Guam in April and May 1995. Data from Smith (unpublished).

Table 2. Terrestrial gastropods reported from Sarigan, Mariana Islands.

Taxon	Source
Family Hydrocenidae	
Georissa biangulata Quadras & Möllendorff, 1894	Present Study
Georissa laevigata Quadras & Möllendorff, 1894	Present Study
Family Diplommatinidae	
Palaina taeniolata Quadras & Möllendorff, 1894	Present Study
Family Assimineidae	
"*Assiminea*" *nitida* Pease	Kurozumi and Asakura (1994)
Omphalotropis sp. A	Kurozumi (1994)
Omphalotropis sp. B	Kurozumi (1994)
Omphalotropis erosa Quoy & Gaimard, 1832	Present Study
Omphalotropis cf. *cookei* Abbott, 1949	Present Study
Omphalotropis cf. *semicostulata* Quadras & Möllendorff, 1894	Present Study
Omphalotropis cf. *suturalis* Quadras & Möllendorff, 1894	Present Study
Paludinella conica (Quadras & Möllendorff, 1894)	Present Study
Family Achatinellidae	
Elasmias sp.	Kurozumi (1994); Present Study
Lamellidea spp.	Kurozumi (1994)
Tornatellinops sp.	Kurozumi (1994)
Family Vertiginidae	
Gastrocopta (s.s) sp.	Kurozumi (1994)
Gastrocopta (*Sinalbinula*) spp.	Kurozumi (1994)
Ptychalaea sp.	Kurozumi (1994)
Family Partulidae	
Partula gibba Férussac, 1821	Kurozumi (1994); Present Study
Family Ferussaciidae	
Geostilbia sp.	Kurozumi (1994); Present Study
Family Subulinidae	
Allopeas spp.	Kurozumi (1994)
Paropeas achatinaceum Pfeiffer,1846	Present Study
Family Succineidae	
"*Succinea*" sp.	Kurozumi (1994); Present Study
Family Helicarionidae	
Lamprocystis sp. A	Kurozumi (1994); Present Study
Liardetia spp.	Kurozumi (1994); Present Study

almost 50% in one month! The shift in size-frequency distributions during the reproductive season is striking (Figure 6). In comparison, the data in the present study show no indication of an imminent reproductive season for *Partula gibba* colonies at Sarigan. This suggests that the reproductive season, if one exists, is later in Sarigan than in Guam.

The median sizes of *Partula gibba* at the three stations are similar (Figure 4), suggesting a cohort from the previous reproductive season. Monthly sampling would be required to corroborate this relationship. Size is more variable in the *Partula gibba* colony at Station C, with the distribution skewed towards snails smaller than the median size.

Data presented in Figures 3 and 5 for *Succinea* sp. indicate a normal distribution for these snails at Station A. These are the first population data reported for this species from the Mariana Islands. Previous investigators have recorded presence-absence observations or numbers of individuals collected, not size-frequency distributions or colony densities for *Succinea* sp. Densities of *Succinea* sp. at Station B were so great (see Figure 7) that time limitations precluded collection of size distribution data.

One parameter that is not illustrated by the size-frequency distributions or box plots is the percentages of *Partula gibba* that are mature and immature. Crampton (1916, 1925, 1932) found that an expanded apertural lip of the shell is an external indication of maturity of the reproductive organs for all species, with singular exception of *Samoana fragilis* in Guam and Rota. Immature snails outnumbered mature snails at all three stations. Some 58% of the colony was immature at Station A (259 of 448 snails), and about 52% of the colony was immature at both Stations B (77 of 148 snails) and C (15 of 29 snails).

Figure 7. High density of *Succinea* sp. on *Aglaia mariannensis* at Station B.

These data are within the range reported from previous studies, and they are indicative of species characterized by relatively high natural mortality and low fecundity. Reproductive maturity is generally reached during the first year (Murray and Clark, 1984; Smith, unpublished data), but few offspring are produced. Crampton (1925) estimated that *Partula gibba* produced an average of about 2.54 offspring per year. Although lifespan estimates of at least 5 years were reported for *Partula taeniata* in Moorea (Murray and Clarke, 1984), data for *Partula gibba* in Guam (Smith, unpublished) suggest a lifespan of only about 2 years. When considered together with natural mortality estimates as high as 50% in one population of *Partula taeniata* in Moorea (Murray and Clarke, 1984), partulids must be viewed as *K* selected species (see Krebs, 1985).

No predators of arboreal snails were observed during this study. Known predators of snails in the southern Mariana Islands include the Polynesian rat *Rattus exulans* (Smith, unpublished data) and the triclad planarian *Platydemus manokwari* (Hopper and Smith, 1992). Cruz et al. (2000) reported *Rattus exulans* from Sarigan, and they found that rats were more abundant in coconut forest than in native forest. Although I did not observe any rats and none was captured in native forest during the 2006 survey (N. Hawley, personal communication, July 2007), one specimen of *Partula gibba* (Figure 8) was observed at Station A with a shell repair scar characteristic of that resulting from predation by *Rattus exulans* at Rota (Smith, unpublished data). Large numbers of dead shells littered the ground at Station A (Figure 9), but no middens of shells from rat predation were observed.

Figure 8. *Partula gibba* on the surface of a *Neisosperma oppositifolia* leaf after a brief rain shower. Arrow indicates shell repair scar.

Figure 9. Ground shells and leaf litter at Station A. Note lack of soil and leaf litter moisture.

No land planarians are recorded from Sargian, although Kawakatsu and Ogren (1994) reported two species from nearby Anatahan and a third species from Alamagan and Agrihan. Subsequently, Okochi et al. (2004) found that one of the three species preys upon gastropods in the laboratory. At the time of the present study, the xeric conditions on Sarigan (see Figure 9) did not favor activity by flatworms. Further, *Platydemus manokwari* is active nocturnally (Muniappan et al., 1956), and snail investigations were conducted during daylight hours. Kaneda et al. (1990) reported that although *Platydemus manokwari* was active primarily at night, individuals actively move about, fed, and mated during the day as well under laboratory conditions, if adequate moisture was available.

The monitor lizard *Varanus indicus*, especially younger individuals, may also prey upon arboreal snails, although snails have not been reported in the diet of this species in the Mariana Islands (S. Vogt, personal communication, 2006). Land snails are a preferred natural food of *Varanus albigularis* in southern Africa (Kaufman et al., 1996).

One note of particular interest is the observation of interactions between an isopod species and *Partula gibba* at Station A. The sampling protocol for collecting size-frequency data included removal of all snails from each host plant. During the measurement procedure, snails were held in a specimen jar with a screened lid to supply air for respiration. When I opened the jar to remove snails for measurement of shell length, I noticed isopods emerging from the jar. Further, isopods were observed with *Partula gibba* on surfaces of leaves after a brief rain shower (Figure 10). No isopods were collected and placed in the jars, so their appearance in the

Figure 10. *Partula gibba* with an isopod on the surface of a leaf after a brief rain shower.

specimen jar is puzzling. Possible explanations include some kind of commensal relationship between the isopods and snails. If so, this would be the first known instance of such a relationship. Therefore, this observation merits further investigation. Isopod specimens were collected and preserved, and they are being examined by the leading authority on species from the insular Pacific for comparison with the three species of isopods reported from Sarigan by Nunomura (1992).

New records of ground-dwelling gastropods found in Sarigan in the present study include two hydrocenids, one diplommatinid, at least three assimineids, and one subulinid. Operculate prosobranch species tend to be small (<7 mm), but relatively common under rocks and in the leaf litter. Both *Georissa biangulata* and *Georissa laevigata* (Plate I, Figures A and B) were found under small rocks at Station C. *Georissa laevigata* is easily recognizable by weak, membranous riblets on the upper whorls, gradually fading anteriorly on the body whorl. *Georissa biangulata* is one of two Quadras and Möllendorff species that Bauman could not separate in the material available to him (Bauman, personal communication, 1996), so he synonymized his specimens as *Georissa elegans* (Bauman, 1996). Based upon the Quadras and Möllendorff (1894b) original description, *Georissa elegans* is characterized by "*spira sat elevata*," which clearly is not the case with the specimens from Sarigan. Consequently, I have identified these specimens as *Georissa biangulata*, extending the range of the species from Guam to Sarigan.

The Assimineidae is the most diverse family of terrestrial gastropods in the Mariana Islands, with 26 species recorded from Guam (Smith, 1993; 2003) and 19 species recorded from Rota (Bauman, 1996). This pattern is also found in Sarigan, with the addition of at least three new records of assimineids in the present study. In addition to the two morphospecies reported from Sarigan by Kurozumi (1994), five distinct species were identified in the present study

(Table 2; Plate I, Figures D–H). *Paludinella conica* occurred at all sampling stations. *Omphalotropis erosa* and *Omphalotropis* cf. *cookei* were found in native forest (Station A), while *Omphalotropis* cf. *semicostulata* and *Omphalotropis* cf. *suturalis* was found in mixed coconut-secondary growth forest (Station C). All five species were described from Guam (Quadras and Möllendorff, 1894a; 1894b); Bauman (1996) reported all but *Omphalotropis erosa* from Rota.

Pulmonate species outnumbered prosobranch species. *Elasmias* cf. *quadrasi* (Plate II, Figure A) was widespread on vegetation on the island. Three specimens of *Geostilbia* cf. *philippinica* (Plate II, Figure B) were collected from beneath a rock at Station C. Although the dead specimen of *Paropeas achatinaceum* (Plate II, Figure C) is the first reported for Sarigan, this species is widely dispersed in the tropical Pacific and considered by many to be a tramp or synanthropic species. *Lamprocystis* cf. *fastigata* (Plate II, Figure D) was found at all sites sampled, including the base camp. The record of *Liardetia* sp. (Plate II, Figure E) in the present study is also based upon a dead specimen. Bauman reported *Liardetia* sp(p). from Rota, and noted that the species was not considered to be in decline.

None of the terrestrial gastropods reported from Sarigan is a single-island endemic, although at least 54% (12/22 species) of the fauna are endemic to the Mariana Islands; this figure could increase with elucidation of the Helicarionidae. This observation conforms with Bauman's (1996) statement that land snails of the Mariana Islands tend to have multi-island distributions. This widespread distribution implies the existence of an effective dispersal mechanism (Bauman, 1996) and serves as a hedge against extinction for several species. The 10 non-endemic species may be indigenous, as they are widely distributed in the Pacific. Kurozumi (1994) suggested that *Ptychalaea* sp. may have dispersed naturally from its Ogasawara Islands native range, but it is equally plausible that the species was introduced by humans operating a copra plantation on the island before World War II.

Conclusions and Recommendations

Native forest on Sarigan supports the healthiest arboreal snail populations known from the Mariana Islands. *Partula gibba* attains the highest densities recorded for the species, and *Succinea* sp., which may be extinct in the southern islands, may locally exceed partulids. Although ground-dwelling gastropods were not studied quantitatively, a relatively diverse fauna occurs on the island. These observations lead to the following recommendations for terrestrial gastropods at Sarigan.

1. **No known predators of gastropods should be intentionally introduced into Sarigan for any reason.**

   Population declines and extinctions of native taxa are characteristic of the human-populated Mariana Islands, and Sarigan supports the densest snail populations, if not the most diverse snail fauna, yet reported.

2. **Protocols should be developed to preclude the accidental introduction of the predatory flatworms, especially *Platydemus manokwari*, into Sarigan.**

Such measures should include a government-imposed ban on importing any potted plants from other localities. Department of Agriculture and Department of Forestry personnel should be trained to recognize *Platydemus manokwari* and should be informed that this predator represents a threat to native land snails as great as that of the brown tree snake *Boiga irregularis* to the native birds.Wet corrugated cardboard boxes should not be allowed for transport of cargo to the island from Saipan or even other northern islands. Potted plants and moist corrugated cardboard are thought to have served as mechanisms for the dispersal of the flatworms in other localities, namely Ulong Island, Palau and Aguiguan, Mariana Islands (Smith, unpublished). Although effective steps to prevent the dispersal and establishment of *Platydemus manokwari* may constitute a considerable challenge to government agencies, prevention of invasions is much less costly than post-entry control (Mack et al., 2000; Keller et al., 2007).

3. **Protocols should be developed to preclude the accidental introduction of the black rat *Rattus rattus* from elsewhere in the islands.**

Predation on endemic snails by this species has become a serious problem in the Ogasawara Islands to the north of the Mariana Islands (Chiba, In Press).

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PLATES

Plate I

Figure A. *Georissa biangulata*, under rock, mixed coconut-secondary growth forest (Station C), 300 m elevation; Lot No. BDS-SAR-09; scale bar = 1 mm.

Figure B. *Georissa laevigata*, under rock, mixed coconut-secondary growth forest (Station C), 300 m elevation; Lot No. BDS-SAR-09; scale bar = 1 mm.

Figure C. *Palaina taeniolata*, in leaf litter, mixed coconut-secondary growth forest (Station C), 300 m elevation; Lot No. BDS-SAR-09; scale bar = 1 mm.

Figure D. *Omphalotropis erosa*, on *Carica papaya* leaf, native forest (Station A), 330 m elevation; Lot No. BDS-SAR-02; scale bar = 1 mm.

Figure E. *Omphalotropis* sp. cf. *O. semicostulata*, on *Aglaia mariannensis* leaf, native forest (Station A), 330 m elevation; Lot No. BDS-SAR-03; scale bar = 1 mm.

Figure F. *Omphalotropis* sp. cf. *O. suturalis*, on *Aglaia mariannensis* leaf, native forest (Station A), 330 m elevation; Lot No. BDS-SAR-03; scale bar = 1 mm.

Figure G. *Omphalotropis cookei*, under rock, native forest (Station A), 330 m elevation; Lot No.
BDS- SAR-06; scale bar = 1 mm.

Figure H. *Paludinella conica*, on *Pteris quadriaurita*, native forest (Station A) 330 m elevation; Lot No. BDS-SAR-04; scale bar = 1 mm.

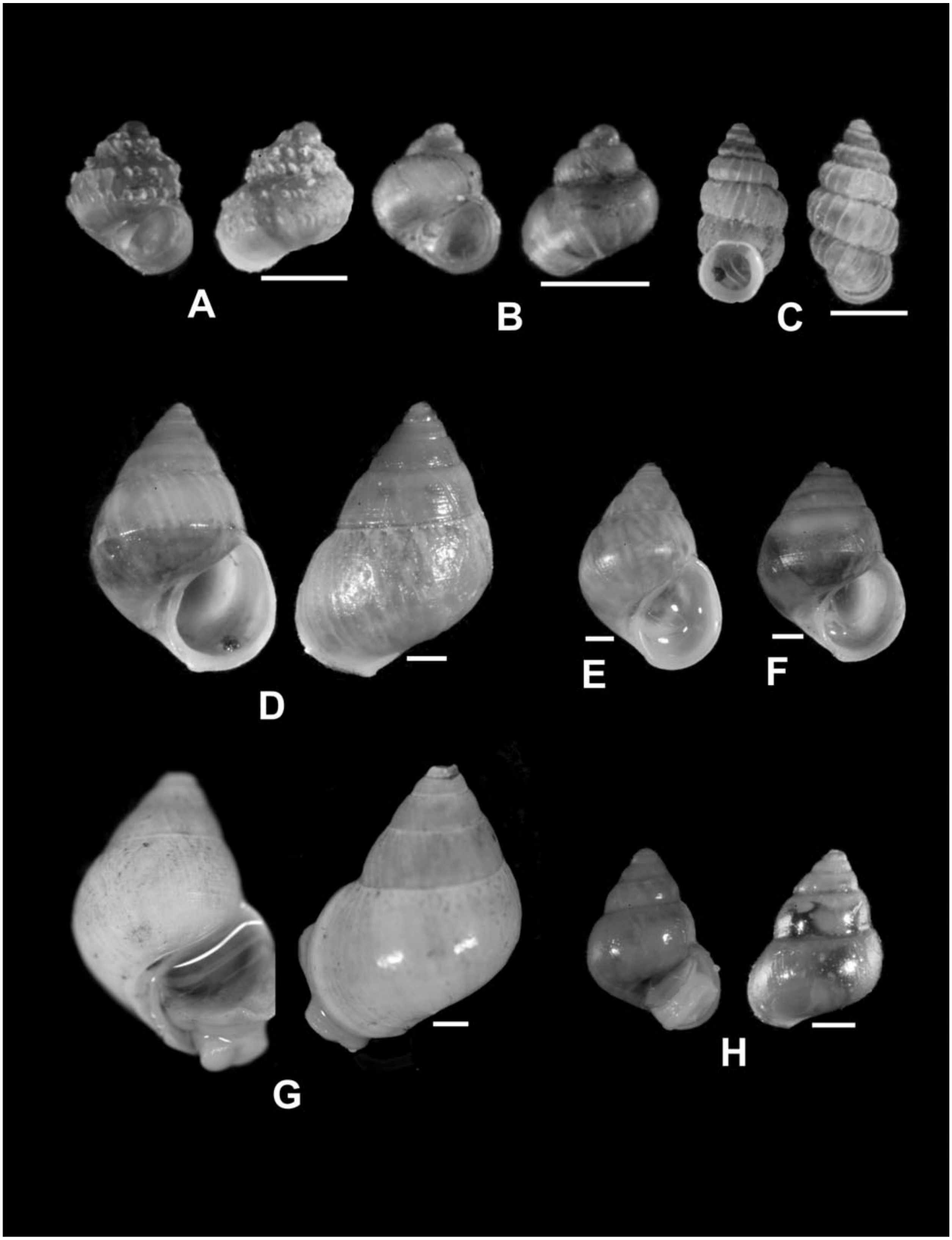
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Plate II

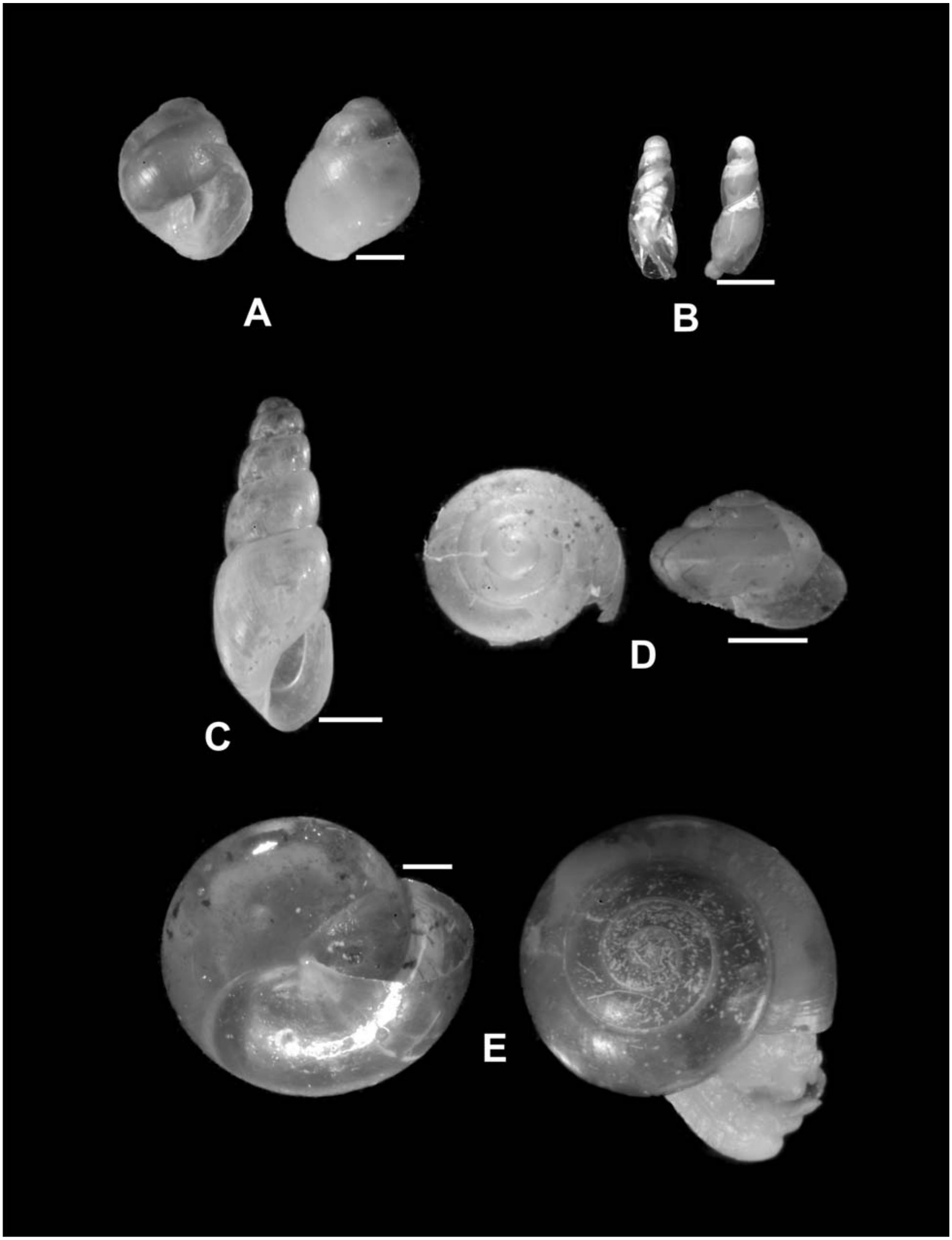
Figure A. *Elasmias* cf. *E. quadrasi*, on *Neisosperma oppositifolia* leaf, native forest (Station A), 330 m elevation; Lot No. BDS-SAR-01; scale bar = 1 mm.

Figure B. *Geostilbia* sp. cf. *G. philippinica*, under rock, mixed coconut-secondary growth forest (Station C), 300 m elevation; Lot No. BDS-SAR-09; scale bar = 1 mm.

Figure C. *Paropeas achatinaceum*, dead, under rock, mixed coconut-secondary growth forest (Station C), 300 m elevation; Lot No. BDS-SAR-09; scale bar = 1 mm.

Figure D. *Liardetia* sp., dead, leaf axil of *Pandanus tectorius*, mixed coconut-secondary growth forest(Station C), 300 m elevation; Lot No. BDS-SAR-09; scale bar = 1 mm.

Figure E. *Lamprocystis* sp. cf. *L. fastigata*, in leaf litter, mixed coconut-secondary growth forest(Station C), 300 m elevation; Lot No. BDS-SAR-09; scale bar = 1 mm.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Availability of invertebrates as potential food items for Saipan bridled white-eyes (*Zosterops conspicillatus saypani*) on Sarigan Island, Northern Marianas, with Saipan Island (Northern Marianas) as a comparison.

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May 2006

Introduction

Following an approved grant proposal to USDI from the Division of Fish and Wildlife (Saipan) for Project T-2-R and T-2-R-1 (September 28, 2005), together with a change to the Conditional Statement in Grant T-2-R-1, which allowed work to be done on Sarigan Island (December 13, 2005; Honolulu Office, Pacific Islands Coordinator, Fish and Wildlife service), I was contracted to carry out data collection and analysis of invertebrate species and abundance on Sarigan Island (Paragraph 6, Grant Proposal). In addition, I was asked to do the same work on Saipan Island to obtain comparative data. After discussions with Gayle Martin and Shelley Kremer (CNMI Division of Fish and Wildlife) a data collection methodology was decided upon. Brief descriptions of both the islands are given in Berger (2005).

Executive summary

A comparative assessment of invertebrate numbers on leaves of ten selected tree species, and in the vicinity of the trees, was carried out on Saipan and Sarigan from 11 April to 4 May, 2006. Potential invertebrate prey items of the Saipan bridled white-eye were identified and the densities were expressed as numbers of invertebrates per leaf area, and per sticky trap. The results indicated that there were enough potential prey invertebrates on Sarigan for a population of approximately 6000 bridled white-eyes to survive there, provided vegetal food items were sufficient. The carrying capacity of Sarigan for white-eyes, and other forest birds, could be increased by applying further management to encouraged expansion of the native forest.

Aim

To compare invertebrate densities in relevant habitats between Saipan (where bridled white-eyes are common) and Sarigan (where no bridled white-eyes occur) and to establish if potential invertebrate food items for the bridled white-eye (and other insectivorous forest birds) on Sarigan were similar to those on Saipan, or at least sufficient to support a viable white-eye population.

Timing and sampling areas

Work was carried out on Saipan from 11-17 April in the Marpi area, eastern boundary (*ca* 80m asl) and the Kalabera Cave area (*ca* 100 m asl); 24 April – 4 May, 2006 in the Marpi area (*ca* 200 m asl), the Papago area (170-200 m asl), Suicide Cliffs area(100 m asl) and on Capitol Hill (*ca* 200 m asl); and on Sarigan from 18 – 24 April, 2006 (NW facing slopes between 35-300 m asl), and on the plateau (330-350 m asl).

Methods

1. Method for determination of leaf area per invertebrate.

The leaves of 10 selected tree species common to Sarigan and Saipan, and occurring in bridled white-eye habitats on Saipan, were sampled for invertebrate presence. Initially the following species were decided on following discussion with the Fish and Wildlife botanist, Laura Williams:

Aglaia mariannensis Merr.
Erythrina variegata var. *orientalis* (L.) Merr.
Ficus prolixa Forst. F.
Ficus tinctoria var. *neo-ebudarum* (Summerh.) Fosb.
Hibiscus tiliaceus L.
Leucaena leucocephala (Lam.) de Wit.
Melanolepis multiglandulosa var. *glabrata* (Muel.-Arg.) Fosb.
Morinda citrifolia L.
Neisosperma oppositifolia (Lam.) Fosb. & Sachet.
Ochrosia mariannensis A. DC.
Pipturus argenteus (Forst. *f*.) Wedd
Premna obtusifolia R. Br.
Psychotria mariana Bartl.ex DC.
Trema orientalis (L.) Bl.

Of this list, the following species had to be omitted from the results because of their scarcity, or non-occurrence, in the sampled areas on one or the other island: *Ficus prolixa*, *Ochrosia mariannensis*, *Psychotria mariana* and *Trema orientalis*. Time was not enough to search for these species and get the sampling done, especially because of the unexpected curtailment of the scheduled work period on Sarigan by four days.

From each of five individuals of each chosen tree species on each island, at least 10 leaves (an exception was *Aglaia*, see below) were collected by pulling one-gallon or two-gallon capacity Ziploc plastic bags over individual leaves or small leaf clusters, which were then clipped off and sealed in the bags. In the case of *Aglaia*, which has compound leaves with three to nine large leaflets, less leaves were collected because of time restraints involving the further analysis. The leaflets of *Aglaia* and *Erythrina* were classed as “leaves” for the purposes of calculating whole leaf areas (Table 6).

Insecticide (“Raid”, S.C. Johnson & Son, Inc; Racine, WI, U.S.A) was sprayed into the bags prior to sealing.

The outlines of each leaf, held as flat as possible, were traced on to paper (with the exception of *Leucaena*, see below), and the area was obtained using a digital planimeter (Charvoz PLACOM KP-90N). For *Leucaena*, which has bipinnately compound leaves with up 460 pinnules per leaf, an average area per pinnule was obtained by sampling and measuring pinnules from three individual plants from Saipan, and pinnules from three individuals from Sarigan. The total single surface leaf areas were then calculated by counting the number of pinnules from each sample and multiplying this by the average pinnule size.

Because of an error in pooling invertebrate and some leaf samples on Sarigan, both the leaf sizes and the invertebrate samples had to be pooled for *Melanolepis* and *Premna*, from both Islands, for comparative purposes. Curtailment of the allocated time on Sarigan prevented the samples being redone.

Invertebrates which were captured with the leaf samples were preserved in 70% isopropyl alcohol (commercially obtained rubbing alcohol). Any invertebrates seen on the leaves, (prior to enclosing these in the bags) but which were not caught in the bags, were noted. Invertebrate samples were pooled for each tree species.

2. Method for establishing general abundance of flying, jumping or hopping invertebrates.

At each site where leaf samples had been taken, a sticky trap ("Sticky Aphid Whitefly Trap", Seabright Laboratories, www.seabrightlabs.com) were hung at between 5 to 8 feet above the ground. The sticky surface area averaged approximately 16.5 square inches per trap. The traps were left for 24 hours, and the invertebrates caught were removed and placed into 70% alcohol for subsequent identification. Removal of the insects from the sticky traps was facilitated by using either of the solvents "Goo Gone" (Magic American products, Cleveland, Ohio, U.S.A.) or "De-Solve-it" Contractors Solvent (Orange-Sol Household Products, Gilbert, AZ, U.S.A.). Invertebrate samples were pooled for each tree species.

Only invertebrates between 2 and 17 mm long were considered as potential food items, and some animals which had hard shells or were protected by other mechanisms (snails, shield bugs, and leaf-footed bugs) were also excluded even at sizes smaller than 17 mm. These were considered to be non-potential food items for bridled white-eyes. The invertebrates were subsequently identified to Classes (Gastropoda), to Orders (except ants) or to family (ants). Time and facilities were not available for more specific identifications. The common names used further in the text to represent the various taxa are as follows:

Snails	Class Gastropoda
Spiders	Class Arachnida, Order Araneae. (mainly web-spinners, family Araneidae)
Crickets	Class Insecta (Hexapoda) Order Orthoptera (all crickets and katydids)
Mantids	Order Mantodea
Cockroaches	Order Blattaria
Termites	Order Isoptera
Psocids	Order Psocoptera
Bugs	Orders Hemiptera and Homoptera, (predominantly Homoptera)
Lacewings	Order Neuroptera
Beetles	Order Coleoptera
Flies	Order Diptera
Moths	Order Lepidoptera
Wasps	Order Hymenoptera, excluding the family Formicidae
Ants	Order Hymenoptera, Family Formicidae

Results and discussion

1. Potential invertebrate food availability.

There is little specific information on the invertebrate food items of bridled white-eyes. Their diet consists of foliage invertebrates, flying insects, nectar, fruits and seeds (Craig 1989), which appears to be the general rule for other similar sized members of this genus (*Zosterops lateralis* – New Zealand, Oliver 1998; *Z. modestus* – Seychelles, Rocamora *et al.* 2002). There is a high degree of diversity and adaptability in the diet of many Zosteropidae (Scott et al. 2003), and there is no indication that the Saipan bridled white-eye is an exception, which enables it to survive in island habitats that are often subject to considerable climatic perturbations.

The term “potential food item” includes invertebrates up to about 25 mm for soft animals like Lepidoptera larvae, but excludes hard shelled animals, such as snails over 10 mm, hard-bodied insects over 15 mm, or insects with scent-related defensive mechanisms (like leaf-footed bugs) over 10 mm. Subsequent work might show that white-eyes are able to exceed such arbitrary diet restrictions.

The invertebrate fauna represented in the collected and observed samples indicate a strong similarity between the higher taxa on the two islands, with one major difference being the high numbers of small snails on Sarigan (Table 1).

Table 1. Ranking of potential invertebrate food items (Saipan n=224 and Sarigan n=134) as recorded from leaves and sticky traps.

Potential food item	**Saipan %**	**Potential food item**	**Sarigan %**
Flies	25.45	Snails	28.35
Beetles	16.96	Flies	20.15
Bugs*	14.28	Beetles	9.70
Ants	10.27	Bugs*	9.70
Wasps	8.48	Moths	8.21
Moths	7.14	Ants	5.97
Spiders	4.91	Wasps	5.97
Crickets	3.57	Spiders	5.97
Psocids	3.57	Lacewings	1.49
Snails	3.57	Crickets	<1
Cockroaches	<1	Cockroaches	<1
Termites	<1	Termites	<1
Egg rafts	<1	Unknown larva	<1
Lacewings	0	Psocids	0

* mostly Homopterans

The high number of snails collected on leaves from Sarigan (including *Partula gibba*, and *Elasmias* sp), which are present but were poorly represented in samples from Saipan, indicate that there is a predation pressure on this group in Saipan, or that conditions are not as suitable on Saipan as they are on Sarigan, or that there never was the same density of snails on Saipan as there were on Sarigan.

The relevant habitat conditions in Saipan appear to be as good, if not better, than those on Sarigan for snails, so the effect of habitat is not considered to have had an impact on snail numbers in Saipan. If the snail numbers were always lower on Saipan, then some reduction pressure must have been, and still is, in operation there. Because of the presence of large numbers of lizards (skinks, geckos and monitors) on Sarigan and Saipan, these significant predators of invertebrates can not have caused any real snail reductions on Saipan, assuming that snails are part of lizard diets. The only other large predators of snails are birds, of which there are a greater number, in greater densities, on Saipan than on Sarigan. If it is found that bridled white-eyes, and other birds, feed on small snails (which I believe is likely, given their leaf-foraging habits), then the low numbers of snails on Saipan may well be a result of predation by birds. If this is so, then there is a huge food resource on Sarigan for such birds.

The use of two different sampling techniques provided different kinds of information, both useful in helping to determine aspects of invertebrate presence/relative abundance. The sticky traps captured taxa

not caught on leaves, while leaf examination yielded taxa not caught on sticky traps. The sticky traps also yielded far more flying insects than were recorded from leaves (Table 2)

Table 2. Invertebrates and their size classes* recorded from Saipan and Sarigan samples.

Taxon	**Leaves**		**Sticky Traps**		
	Saipan	**Sarigan**	**Saipan**	**Sarigan**	**Totals**
Snails	8	46 -11(2), **5(3)**, **3(4)**	0	0	54
Spiders	8 – 1(2)	6 – 2(2), 1(3)	3	2	19
Crickets	5 – 3(2)	1	3 – 2(2), 1(3)	0	9
Cockroaches	0	0	1 (3)	1 (2)	2
Termites	0	0	2 – 1(3)	1	3
Psocids	0	0	8	2	10
Bugs	9 – 3(2), **1(3)**	7 – 1(2), **1(5)**	24 – 3(2)	7 – 4(2)	47
Lacewings	0	1 (3)	0	1 (4)	2
Beetles	5 – 1(2)	9 – 1(2)	33 – 1(2)	4	51
Flies	2	6 – 1(2)	55 – 1(2)	21 – 3(2)	84
Moths	7 – 1(2)	3 – 2(3)	9	8 – 1(2)	27
Wasps	2	0	17	8 – 4(2)	27
Ants	20 – 1(2)	8	3 – 1(2)	0	31
Mantids	**1 (5)**	0	0	0	1
Larva unknown	0	0	0	1 - 1(2)	1
Insect egg raft	1	0	0	0	1
Totals	68	87	158	56	369
Potential food items **	66	78	158	56	358

*Size classes of invertebrates, given in brackets, are: 1= 2-5mm, 2=5.1-10mm, 3= 10.2-15mm, 4=15.1-20mm, 5=>20mm. All numbers without size classes are in size class 1, e.g. Ants 17 – 1(2) means 17 ants of which 16 are in size class 1, and one is in size class 2.
** Numbers in bold are considered non-potential food items.

Invertebrate samples collected from leaves and branchlets by a slightly different method on Rota (Amidon 2000) from 4 tree species (of which only one, *Premna obtusifolia*, was common to the tree species sampled during this study), and collected during April, showed similarities to those from Sarigan and Saipan (Table 3), indicating that the composition of the Mariana Islands invertebrates are similar, but with differences relating to the relative abundance of some of the taxa.

Table 3. Invertebrates* collected from trees on Rota (n=447), Sarigan (n=87) and Saipan (n=68)

Invertebrates	Rota percent of total numbers	Sarigan percent of total numbers	Saipan percent of total numbers
Ants and wasps	42.3	9.2	32.4
Snails	22.1	52.9	11.8
Bugs*	9.8	8.0	13.2
Spiders	8.5	6.9	11.8
Beetles	3.6	10.3	7.4
Unknown	5.8		
Moths/butterflies	2.7	3.4	10.3
Flies	2.5	6.9	2.9
Crickets	2.5	1.1	7.4
Lacewings		1.1	
Mantids			1.5
Egg raft			1.5

*All size classes included.

2. Leaf samples.

The average single-surface of *Leucaena* pinnules was found to be 0.336 cm² (Table 4).

Table 4. The average single-surface area of *Leucaena* pinnules

Sampling area	**Pinnules n**	**Mean single-surface area of pinnules cm²**
Saipan – Marpi	95	0.450
- Marpi	91	0.282
- Papago	115	0.409
Sub-total	**301**	**0.383**
Sarigan 1	83	0.217
2	71	0.270
3	84	0.339
Sub-total	**238**	**0.278**
Total	**539**	**0.336**

Variation of pinnule size appeared to be related to the habitat in which the plants grew (Table 5).

Table 5. Effect of habitat on *Leucaena* pinnule size

Single surface area of pinnules cm^2					
Sheltered and/or shaded			Open		
Sampling area	n	Total cm^2	Sampling area	n	Total cm^2
Saipan	115	47.05	Saipan	91	25.63
Saipan	95	42.74	Sarigan	83	18.04
Sarigan	84	28.52	Sarigan	71	19.27
	294	118.31		245	62.94
Average pinnule area		0.402			0.257

This effect was similar for a number of other species as well. In addition, the compound leaves of some species (cf *Aglaia*), varied in number of leaflets, and most of the sampled tree species had some or many leaves which had been eaten to some degree or another, reducing the overall leaf area. Therefore an alternative method of sampling leaves to arrive at average leaf sizes for all species (as was done with *Leucaena*), instead of using the most time-consuming method of measuring each sampled leaf as was done in this survey, is not considered accurate enough to obtain comparable results. A far less time consuming method would be to weigh the leaf samples (either fresh or dry) and then to equate numbers of associated invertebrates to their weight.

Whole leaf areas for the tree species sampled are given in Table 6.

3. <u>Leaf areas related to potential invertebrate prey items.</u>

Total leaf areas of all samples were very similar from Saipan and Sarigan, and there were overall more potential prey species caught per leaf area on Sarigan than on Saipan (Table 6). This is due to the higher numbers of snails sampled on Sarigan. If snails were removed from the samples, however, the overall potential prey items per leaf area would be greater in Saipan (1 per 2281 cm^2) than in Sarigan (1 per 3278 cm^2).

Table 6: Whole leaf areas and related invertebrate numbers for the tree species sampled in Saipan and Sarigan.

	Aglaia.	Erythr.	Ficus	Hibisc.	Melano. & Premna.	Morind.	Neisos.	Piptur.	Leucaen.	Totals
Leaves n*										
Saipan	173	149	49	52	99	49	40	50	64	725
Sarigan	185	141	51	50	90	50	51	48	48	714
Total leaf area cm²**										
Saipan	19637	22324	4028	19104	20486	19666	10126	6085	10860	132296
Sarigan	11196	21576	5185	16218	27402	14912	15460	12294	6824	131066
Prey items										
Saipan	10	13	2	11	12	11	5	1	1	66
Sarigan	4	7	2	11	23	13	6	9	3	78
Leaf area cm² per invert										
Saipan	1964	1717	2014	1737	1707	1788	2025	6085	10860	2004
Sarigan	2799	3082	2593	1474	1194	1147	2577	1366	2275	1680

*Under-collection of leaf samples resulted from the unavailability of samples, undercounting of leaf samples in the field, or lack of time to correct sample sizes. For *Aglaia* and *Erythrina* the leaflets are counted as leaves.
** Both surfaces of each leaf included

4. Numbers of potential prey invertebrates caught in sticky traps.

Numbers of potential invertebrate prey items of bridled white-eye caught on sticky traps in Saipan and Sarigan are given in Table 7.

Table 7. Numbers of potential invertebrate prey items of bridled white-eye caught on sticky traps Sarigan and Saipan.

	Saipan			Sarigan		
Tree species	Traps n	Inverts n	Inverts per trap	Traps n	Inverts n	Inverts per trap
Aglaia	5	8	1.6	5	4	0.8
Erythrina	5	10	2	5	4	0.8
Ficus	5	20	4	5	4	0.8
Hibiscus	5	13	2.6	5	8	1.6
Melanolepis & Premna	10	38	3.8	9	15	1.7
Morinda	5	17	3.4	5	6	1.2
Neisosperma	4	12	3	5	2	0.4
Pipturus	5	16	3.2	5	9	1.8
Leucaena	5	24	4.8	5	4	0.8
TOTALS	49	158	3.22	49	56	1.14

Although the location of the sticky traps is specifically related to the various tree species, this does not mean that the invertebrates are specific to those trees, but are more indicative of the habitats in which the trees occur. The total catches on Sarigan are less than those on Saipan, since most (57%) of habitats on Sarigan in which the traps were hung in secondary areas in or on the edge of old coconut plantations, which range from almost monotypic, dense stands of adult and young coconut palms to native and introduced plants growing singly or in small groups among adult and young coconuts. Traps in such tree species (e.g. *Aglaia*, *Ficus*, *Neisosperma* and *Leucaena*) caught considerably less invertebrates than those trees growing in extended thickets (*Hibiscus*), or those trees on the plateau, where samples were taken from clumps of native trees in a semi-open habitat, or from forest patches. The samples from Saipan were virtually all caught in or on sheltered edges of native (mostly secondary), forest. The only exceptions were three *Erythrina* trees sampled in a parking area on Capitol Hill.

Conclusion

There are enough potential invertebrate food resources on Sarigan to support a fair population of bridled white-eyes, if there are sufficient vegetal food items present as well. The carrying capacity of Sarigan for white-eyes must clearly be related to suitable habitats, which consists of 29.1 ha of native forest (Anon, undated) and marginal habitats of 133.4 ha of old coconut plantations (Anon, undated) which could carry an estimated one quarter of the numbers of birds in suitable habitats. This gives an effective area of 62.5 ha as far as potential invertebrate food items are concerned. Estimated densities of white-eyes on Saipan in suitable habitats range from 89.2 to 154.8/ha (Berger, 2005), and for the purposes of estimating probable carrying capacity on Sarigan, and arbitrary figure of 100/ha was chosen. Therefore a population of 6250 white-eyes could probably survive on Sarigan.

On Sarigan management aimed at increasing native forests is considered to be the most important conservation activity to ensure survival of white-eye populations. This has already begun by the removal of feral goats and pigs (during 1998 and 1999; Anon, undated), which has stimulated an increase in vegetation growth (Berger 2005). Further active management involving the reduction of coconut palms needs to be considered, and would be best achieved by removing coconut palms and seedlings, concentrating on working down from the high elevations and on the margins and interiors of native forest patches.

Thanks

My thanks are particularly due to Gayle Martin, for her most efficient organization of the trip and equipment, for allowing me to use her home a work-place, for her help in the field and with leaf measurements, and for assisting me with collating some of the results. Without her help and support I would not have been able to finish the work. Thanks to Ted Parker and Kathy Yuknavage for accommodation and hospitality, this was greatly appreciated. Dr. Joaquin Tenorio helpfully allowed me the use of the CREES facilities at the Northern Marianas College for invertebrate identification, for which I am grateful. A digital planimeter was kindly lent to me by Efrain F. Camacho (Consulting Engineer, Saipan) through the efforts of Gayle Martin. Finally, thanks to the staff of the Division of Fish and Wildlife (Saipan), for making my trip such a pleasant one.

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Avian Disease Sampling at Sarigan
Shelly Kremer
September 2006

Introduction
Before a translocation program of Bridled White-eyes (*Zosterops conspicillatus saypani*) can be instituted for Sarigan, a study was needed to determine if avian diseases are present on Sarigan. Blood samples were taken and necropsies performed on forest birds in April 2006 for avian disease assessment.

Study Area
The Upper camp located on the plateau just below the caldera at Sarigan was selected as the best site for mist netting passerines based on its proximity to secondary and native vegetation.

Methods
Mist Nets-
Six to eight mist nets were erected in the morning and evening hours from April 14-20, 2006. Net length and mesh sized varied. The average net length was 9 meters with 60mm mesh size. Nets were opened at sunrise and closed during the hottest part of the day from 12:00-15:00 hours. Nets were re-opened from 15:00 hours until sunset. Each net was assigned a number and open/close times were recorded for each net over the seven day period. Nets were checked every 30 minutes while open. Nets were continually moved to maximize capture effort.

Removal of birds from mist nets was conducted by experienced personnel only. Once birds were removed from the mist nets they were placed in small mesh bags and carried immediately back to the processing site. A standardized Monitoring Avian Productivity and Survivorship (MAPS) banding data sheet was used (DeSante *et al.* 2004). Morphological measurements, age, sex, molt patterns, and other attributes were recorded for each bird captured. Birds were not banded. When possible, birds were released at the capture site; otherwise birds were released from the processing site.

Disease Sampling-
Blood samples were collected using the toenail clipping method. The hallux on the right foot was clipped near the base. Once the toenail began to bleed a small dot of blood was placed on a glass microscope slide and smeared across the slide. Each slide was labeled with a numerical code assigned to each bird, the date and island. Two to three blood feathers were also plucked from the body. If no body feathers were available, an outer rectrice from the tail was plucked. Each feather sample was stored in a small manila envelope with pertinent data recorded on the outside of the envelope.

Birds were collected for necropsy as this is the best method to determine presence/absence of disease. A 37% formaldehyde and seawater mixture was prepared in specimen jars. Necropsies were preformed as outlined in Work (2000).

Results
Total mist netting effort was 212.69 hours (see Table 1). A total of 23 birds were captured with only a single recapture. Twenty-two Micronesian Honeyeaters (*Myzomela rubrata*) and one Collared Kingfisher (*Halcyon chloris*) were captured. Fifty-two percent of the total birds were captured in a single net.

For the Micronesian Honeyeater, fifteen male, three female, and four undetermined honeyeaters were captured. All three females were in breeding condition and only five male honeyeaters showed varying stages of cloacal protuberance. Morphological measurements for both male and female honeyeaters are listed in Table 2. Only 25% of all honeyeaters had no fat reserves with 75% showing some level of fat storage. All but three birds showed signs of flight feather wear. Thirty-five percent of birds showed no body molt and 70% showed no flight feather molt.

Table 1. Mist Netting Effort Results

April 2006	Net Numbers	Net Hours	Total Birds
Day 1	1-6	38.30	1
Day 2	1-7	47.80	2
Day 3	1-8	34.75	6
Day 4	1-8	14.70	3
Day 5	1-8	40.36	5
Day 6	1-8	23.95	4
Day 7	2-8	12.8	1

Table 2. Morphological Measurement (mean, and range in parentheses) for Micronesian Honeyeater on Sarigan

Sex	Wing (mm)	Culmen (mm)	Tarsus (mm)	Weight (g)
Male (n = 14)	73.6 (71-76)	17.23 (16.2-18.1)	23.6 (23.4-24.6)	15.6 (14-18)
Female (n =2)	66 (65-67)	15.4 (15.3-15.5)	24 (22-25.5)	13

For the Collared Kingfisher, only a single female was captured using mist nets, and two more females were collected with a pellet gun. Morphological measurements were collected for a total of three females (see Table 3), two with molting brood patches and one with a smooth brood patch. All three showed sign of body molt and two out of three showed sign of flight feather molt. Two out of three showed no signs of flight feather wear.

Table 3. Morphological Measurements (mean, and range in parentheses) for Collared Kingfisher on Sarigan

Sex	Wing (mm)	Culmen (mm)	Tarsus (mm)	Weight (gr)
Female (n = 3)	112.3 (109-115)	50.1 (18.3-21)	19.8 (18.3-21)	78.6 (73-82)

Twenty blood samples were collected for the honeyeater and one blood sample was collected for the Collared Kingfisher. Three Micronesian Honeyeaters and three Collared Kingfishers were collected for necropsy. All birds caught in the mist nets appeared to be in good health. No lesions, parasites, or lice were observed on any of the species. One honeyeater did exhibit a milky left eye and a single feather louse was seen but not collected on a Collared Kingfisher. Twenty feather samples were collected for the Micronesian Honeyeater.

Honeyeater feather samples were given to Henri Thomassen from Leiden University, Netherlands for genetic analysis, to compare genetic variability between honeyeater populations on several islands including Sarigan, Saipan, and Rota (Thomassen *n.d.*).

Blood samples were sent to the University of California at Davis for analysis. At the time of this writing, no analysis of blood samples has been made, and it is possible that the blood samples may have been destroyed.

Necropsy analysis was conducted by Dr. Thierry Work, U.S. Geological Survey – Honolulu Field Station. There were no significant findings for the Micronesian Honeyeaters, no lesions, internal parasites or evidence of inflammatory processes found. All three kingfishers had internal parasites noted: one with trematodes in the small intestine and two with nematodes in the ventriculus. One of the kingfishers also had a mild inflammation of bacteria in the small intestines.

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Acknowledgments

We would like to thank Robby Kohley from Institute for Wildlife Studies in training and assisting DFW staff in collecting blood samples; Thierry Work from USFWS who provided invaluable information on collecting samples in a remote environment and performed the necropsies; and Dr. Greg Massey of U.C. Davis who also provided information on collecting samples in the field.

Shelly Kremer releases a Micronesian Honeyeater captured in a mistnet.
Photo: Gayle Martin

A male Micronesian Honeyeater captured in a mistnet.
Photo: Shelly Kremer

Robby Kohley takes a blood sample from a Micronesian Honeyeater.
Photo: Shelly Kremer

Brief daily narrative and points of interest
Concerning the
Sarigan Scientific Research Trip.
April 2006
C.C. Kessler

April 13 - left dock at 0001 on board the MV Micronesian. Nine passengers on board.

1. Curt Kessler
2. Jess Guerrero
3. VJ Concepcion
4. Pete Tomokane
5. Pete Teigita
6. Joe "Ping" Iguel
7. Shelly Kremer
8. Richard Sikkel
9. Robby Kohley

Heavy swells made for a rough trip for those landlubbers not use to the sea. These are some of the most dangerous and unpredictable waters in the Pacific. Many people sick. Seas on the starboard bow with much spray and wash over the decks. Gear (about 10,000 lbs – about 4,000 lbs equipment, 4,000 lbs of water, 2,000 lbs aviation and small boat fuel) mostly stored on the aft deck and taking a beating. About mid way the lines securing the gear loosened and we are forced to slow engines and go aft and secure the gear. Most personnel are sick and incapable of helping. Jess Guerro is an exception and although not happy, attends to the task that is required. Rest of the trip goes relatively smoothly but with most hands seasick.

Arrive at Sarigan about 0730. Swells are large and coming from the west into the small harbor area. We wait until about 0830 for the helicopter to arrive. Personnel are ferried to shore by small boat and are stationed in the lower camp, upper camp (moved by helo), on the MV Micronesian, and on the small boat. Communications are by the new marine radios and are working fine giving communications between all points and the helicopter. In the beginning of operations a net is loaded with primarily water but proves to be too heavy for the helicopter. The pilot (Rufus Crowe) is forced to release or "punch" the load which lands in the ocean. The small boat retrieves all items in the net (mostly water containers) but cannot find the net and sling rope which has sunk to the bottom. The net is not that important (although worth about $1,000) as spare nets are available. However the sling rope is the only one we brought and is critical to the continued operation. Luckily the Captain of the Micronesian is a free diver and eventually finds the net in about 60 feet of water and attaches a line to it so that it can be retrieved. Operations are delayed for about one hour but then continue with the delivery to Sarigan of all gear in both the upper and lower camps. Lesson learned is to have an additional sling line available for future trips. Also it is requested of the helicopter company to get a bigger hook on the sling line to better accommodate the new (surplus Navy) cargo nets.

Sling operations go well without further troubles and the helicopter and ship are released at about 1600 and return to Saipan. Shelly and Robby are helicoptered to upper camp and left with

supplies (although they don't discover the comforts that are stored in the camp. For the future, please instruct novices to open all crates and explore contents fully). Communications with upper camp are not established as upper camp personnel are not experienced in radio requirements (line of sight required personnel to hike to plateau edge to contact lower camp. Also requires radio to be on and batteries fresh). First impression of Sarigan is that the island is very overgrown with vegetation and that there are not many fruit bats. Megapodes are common however and are found walking through the lower camp. Main camp tent is erected (Military surplus – twenty man tent) and personnel set up sleeping arrangements. Small boat (Navy surplus – 14' zodiac with 40 hp) is brought up on shore in cove to the north of the helicopter landing pad due to heavy seas and large swells. Landing is rough and boat is too heavy for four men (need at least six).

April 14 - Three personnel stay in camp to set up single side band radio and antenna for communications with Saipan and to establish a kitchen and clean camp area. Other four personnel head out to cut transect #2. Operation is slow going as vegetation is very thick and temperatures are hot. Points on old transect are hard to find and GPS coordinates are old (taken before good accuracy was available) and not accurate. At least one point (rebar found) is 50 meters off the 1999 recorded UTM. Most points (actual rebars) are deemed not findable and transect is cut along the line that is designated by the best available data. This initial transect serves to train personnel in what is expected and how to use the GPS units. For future reference new GPS units are needed and all need to be of the same type. Also sufficient batteries are required as AA batteries turned out to be a limiting factor (also used in the radios). Cutting transects was very rough going. It is easy to get off track in the uniformly steamy green hell of the jungle. Megapodes are common, as are starlings, honeyeaters, and kingfishers. Only 2-5 bats observed while cutting transect. Once we finished the transect (cutting up slope) we headed across slope to the north to try to establish contact with the upper camp. The intention was once we reached the edge of the plateau which the upper camp was on we would then cut a trail back down to camp. We reach the edge of the plateau which is also the start of the swordgrass. We were not able to establish contact with the upper camp and as it was getting late in the day and the men were reaching their endurance limit, it was decided to burn the swordgrass so as to open the trail for tomorrow. Burning of the swordgrass was based on past experience and the prevailing winds and also with the knowledge that the fire would not approach the upper camp. This was done and a trail was cut down to lower camp.

April 15 – Had radio problems in the morning but was able to fix the situation. Believed the antenna wires were touching each other and the tree. At about 0830, all personnel from lower camp headed up the trail to burn area. Reached the burn area and continued cutting the trail to upper camp. Found Shelly and Robby well, with their mist nets in operation and their part of the operation going smoothly. Set-up the large surplus tent (for which Shelly is eternally in my debt) and helped establish a more permanent camp. At about 1330, personnel started to cut transects #3, 4, and 5 from the upper camp to the ocean.
#3 – Kessler, Guerrero, Teigita
#4 – Concepcion, Tomokane
#5 – Iguel, Sikkel
Plan was for personnel of transect #3; the shortest transect, to finish then launch the boat and pick up the other personnel along the ocean. Transect cutting was rough going but personnel

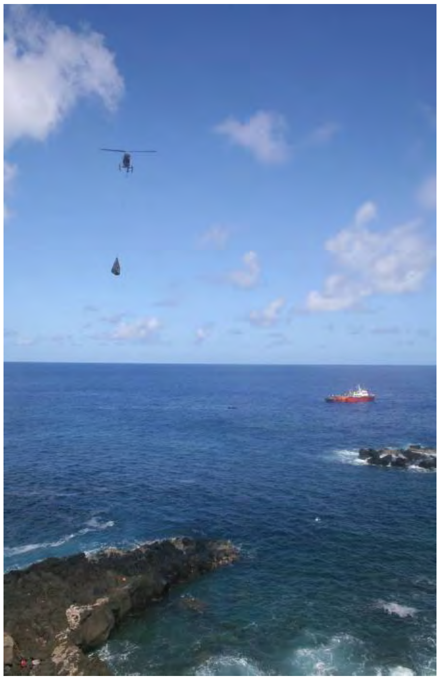
were only required to follow a line and not necessarily find the rebar points. On transect # 3 one worker (who will remain unnamed) cut his knee severely with the machete, proving once again that the most dangerous thing on the island is oneself. The local solution to stop the bleeding was to chew pepper leaf and apply to the cut, although a warning that it would sting was given. This was done which did stop the bleeding; however the stinging was not on the cut but in the mouth while chewing the leaf! Needless to say this person was not allowed to cut anymore and the transect was completed without further incident. Personnel on Transect #4 returned along the seaside cliff line and reported the transect completed. They also reported seeing a group of three birds which were described as swiftlet-like with white on the chest, between transect point 2 & 3 which were later confirmed by Kremer to be barn swallows (*Hirundo rustica)*. Things continued to progress until about 1800 when word was received that Iguel on transect #5 had had a large boulder roll over his leg. Transect #5 follows the north basalt ridge which is composed of tediously balanced boulders stacked to about 70 feet high. Some of these boulders are as large as a small automobile. This area is also the home to some large coconut crabs which apparently had the attention of Mr. Iguel when the incident happened (point # 4 on transect 5). As it turned out (and unknown to us at the time) his leg had been fractured in the region of the ankle. This eventually required us to medivac him out two days latter. The crab, though, was secured for further study. This injury was unfortunate as "Ping" was a hard worker and an important part of the mission and was missed for the rest of the trip. This team reported many megapodes along this transect. Upon picking them up by boat, 8-13 fruit bats were sighted to the north along the ridge.

April 16 – This day being Easter Sunday, no work was assigned and personnel spent the day as they saw fit, mostly fixing their living area and fishing. Fishing was done off the rocks or from our 16' zodiac navy surplus boat. We did both trolling and bottom fishing with an electric reel in about 800 feet of water. Trolling we caught wahoo and skipjack. The skipjack was then used as bait for the bottom fishing. On this day, bottom fishing, we caught gindi, caricari (yellow tail), ahoo, and black jack. Other days we caught grouper, and dog tooth tuna. Fishing combined with the small freezer we had brought greatly increased our ability to supply ourselves with fresh fish. Much of the fish was also smoked to help preserve it. Easter dinner was a great feast to be much remembered.

April 17 – Helo arrived to fly off Iguel for medivac and brought Scott Vogt. Two personnel (Concepcion and Sikkel), head off to the south to cut transect #1. They complete that mission and the boat is used to pick them up on the shore and return them to camp. We had some problem with generator and small boat engine both of which were fixed temporarily. Kessler attempts to capture megapodes for banding without success, although a technique is established.

April 18 – MV Micronesian arrives with second group of people. Sikkel and Kohley leave island. Off loading operation using the helicopter goes well with about 5,000 lbs. of gear brought on island – Rufus Crowe, Pilot. Helicopter stays for operations on Anatahan, Mr. Crowe

heads to Saipan on boat and Mike Cunningham takes his place as pilot.



Offloading of personnel and gear from MV *Micronesian* to shore at Sarigan, by inflatable and helicopter. Photos: Ortwin Bourquin

Personnel brought to the island on this trip include;

1. Jess Omar
2. Alvin Fitial
3. Paul Reyes
4. Barry Smith
5. Gayle Martin
6. Patrick Santos
7. Orty Bourquin

For the rest of the period from **April 19 – 22**, Kessler, Omar and Santos are involved in operations on Anatahan Island. This project is being done jointly with the surveys on Sarigan to take advantage of the camp situation and equipment on Sarigan. The Anatahan project is an eradication of the goats and pigs which at this point is mainly concentrated on removing the last pigs. As part of this, the helicopter flew to Alamagan to acquire one of Patrick Santos's hunting dogs in a hope that it will be effective in tracking down the last pigs on Anatahan. Unfortunately this does not work as well as planned. The main problem that it is too hot on Anatahan for the dog to work, due to the reduced vegetation and ash covering the ground (from the eruption). The ground is so hot that it is burning the dog's pads. A night operation on Anatahan is planned, but permission from EMO is denied due to the potential hazard of the volcano and the night operation must be called off. The continued pressure on the pigs on Anatahan during this period pays off though, and seven pigs are shot. One cat is also shot, which upon examination has in its stomach two rats (*Rattus exulans*), two caterpillars, and a grasshopper. The one pig examined has in its stomach Noni fruit (*Morinda citrifolia)* and *Ficus tinctoria* berries. For more information on the Anatahan trip please refer to that trip report.

While operations on Anatahan were moving along so were the various scientific surveys on Sarigan. All operations seemed to go according to plan without serious injury or mishap.

April 22 - Kessler, Santos and Concepcion did capture one female megapode on Sarigan which was banded with USFWS silver band #725-92610 on the left leg. It also received green over pink bands on the right leg. This bird was caught using a hand held net on an extension pole of the type cliff fisherman use to retrieve their catch. The bird was enticed within range with the use of playbacks on a tape recorder. This was tried again later on in the day without success, although a few attempts with the net were made at megapodes within range. With practice this method shows promise.

April 23 - Kessler and Fitial hiked from the upper camp to the fruit bat colony on the North side. The bat colony was observed with binoculars first at a distance of 300 meters and each observer counted 80 bats. The distance was closed to within 80 meters and again the colony counted by both observes and revealed 120 fruit bats in the colony. This was estimated to range from 120 - 130 bats present. This is interesting because during our stay on the island personnel were asked to come up with a number of bats on the island from personal observations. Most personnel estimated in the 40-80 range, which shows that numbers observed around the island can be deceiving. Also it should be noted that during this hike a fruit dove was heard by Fitial and Kessler as well as other observers in the area. This bird or birds had been heard previously by the transect surveyors.

April 24 - Boat was delayed due to mechanical problems. Scott Vogt and Laura Williams left by helicopter to survey FDM for the Navy then return to Saipan. In camp we cleaned the old containers removing car batteries from past trips (radio power) for proper disposal on Saipan. Crew was busy in preparations for leaving the next day.

April 25 - MV Micronesian returned as did the helicopter with Rufus Crowe pilot. We offloaded all gear and personnel and returned safely to Saipan.

POINTS OF INTEREST:

Camp Supplies & Equipment

Fishing kept us in fresh food with no worry about provisions. In fact the condiments, plates, utensils, and cups were more of a concern. Also the whole effort suffered due to a lack of a cook, and not only to cook, but someone to manage the kitchen and kitchen duties. This post was not filled with a senior member and the camp was lacking for it. The freezer did its job, but the generator was a constant worry for maintenance until we hit the system that worked well. We combined parts from two different units (once again showing the need for backup systems). This trial and error period is normal; however we lacked an assigned engineer. Someone good with machinery and capable of maintaining the generator, lights, small boat engine, and whatever else might be required. We were lucky in that Mike Cunningham (Americopters pilot) and his tool kit were with us.

The surplus military tents worked very well as did the cots. In fact it is important to mention and thank DRMO of Guam, in particular Ms. Mei Highsmith and co-workers for the very valuable help and cooperation they provided in acquiring this equipment. This equipment was collected over two years time and shipped to the CNMI with the help of the CNMI Liaisons office in Guam (Ron Taisican and Dave Pangelinan) for just such a project. Navy surplus equipment used on Sarigan included: tents, cooking utensils, cots, fatigues, tools, boat with engine, water and gas containers, collection equipment, and rope, as well as numerous other items.

Communications were superior this trip and worthy of mention. The acquisition of radios that could communicate with the helicopter, ground, and boat was finally achieved after many years. This was a multi-person effort that has finally produced results. This capability not only improves efficiency, but gives us added protection and safety when afield in remote locations. One unexpected supply shortage in the form of a chronic lack of AA batteries was discovered. The new radios consumed AA batteries rapidly when in constant use and set on high power. Single-side band communications, powered by car battery, once again proved essential.

A piece of field equipment that we could have provided more of was GPS units. Although we had some, they were old and each was different. This required that once someone got used to a particular unit they would always need that unit. For next trip a number of new GPS units with the new high-sensitivity WAAS-capable GPS receiver by SiRF should be acquired.

Fishing

Fishing was permitted, with the idea that when we returned to port it would be split up accordingly so that all families of participants of the trip might share in this bounty. Catch would be split up equally regardless of who actually caught the fish, as all contributed to a successful mission! One of the missed opportunities of this project was not being able to involve DFW-Fisheries. We lacked a fisheries person to document our catch and the trip as a whole would have benefited from the boat expertise of this section.

Fish were plentiful. Photos: Curt Kessler (left) and Nate Hawley (right).

Seas were rough while at Sarigan and at times with heavy swell. This meant that we could not leave the Zodiac (rubber boat) unattended at the mooring in the small harbor. We hauled the boat ashore a number of nights. This was labor intensive and involved pulling the boat and 40 hp Mercury engine (possibly one of the heaviest engines made) through a large swell and over boulders. Being on the small boat pulling out team was always interesting! This operation was a little too much for four people and actually required eight. We did remove the engine and take that up separately, but this was hazardous at its best.   The engine did finally break, and trauma from coming in over the rocks undoubtedly played a role.   Engine problems were a constant source of worry. We did have two engines, but something was always mismatched. The MV Micronesian had an additional spare engine and boat but that had problems when we could not match the fuel hose to the engine. A little standardization in this department for Northern Islands operations is called for.

Helicopter operations

Operations were almost halted due to not having a spare sling rope. Additionally, the sling rope needs a bigger hook to accommodate the new navy surplus cargo nets. Americopters needs to be reminded to acquire this equipment. In the beginning of offloading operations, a cargo net was loaded with water and wood in excess of 700 lbs. The pilot (R. Crowe) had to “punch it” (release it) due to excessive weight and instability. This load was dropped into the ocean close to shore in about 40-60ft of water. The load floated and was recovered (mainly wood poles for the surplus tents and plastic 5 gal water jugs, some of which ruptured on impact). The net and sling rope, weighted down by the swivel and hook, sank and could not be found. Here we lacked another skilled professional on this trip. In the past we have always relied on Northern Island divers to maintain the boats, supervise the ship to shore operations, and act as safety swimmers in emergencies. Sadly we have lost some of our best people and the remaining experts were called away and could not join us. Happily the MV Micronesian’s captain was a mighty sailing man and a free diver. He found the net, dove down, and tied a rope on it. It was recovered,

brought to the helicopter, and operations were underway in less than 2 hours. A good record for Sarigan! It was well that it was recovered because we had just started offloading operations and still had 10,000 lbs of equipment to move! Otherwise, helicopter/offloading operations went well, Americopter pilot Rufus Crowe is always the professional and makes this operation look easy. We offloaded 15 to 20 loads of water, food, fuel, and equipment at about 600 lbs a load. This was to support twenty people and to establish two base camps.

Transects

Again we needed new and standard GPS units. We could not find many of the old rebars from the previous survey. This would require much more searching than we had time for. The GPS coordinates provided were before the improved accuracy and could be as much as 60 meters off. Searching the thick jungle in a 60 meter radius was impractical and time consuming. Therefore, those rebars that could be found were, otherwise transects were cut along a compass bearing. The transects were well cut but needed an additional effort of labeling. Transects were well flagged (except for those areas that we ran out of flagging) but became confusing when intersected by main and minor trails (which were similarly flagged). Some permanent markers and instruction on labeling flagging would have gone a long way to improving this situation.

Sarigan Wildlife

Megapodes (*Megapodius laperouse*) were common and possibly the most common bird on the island (bird surveys will be the deciding factor)! Megapodes appeared thriving and could be found in most areas. Megapodes were filmed at close proximity (http://ibc.hbw.com/ibc/index.html), obviously never having seen humans before. In this aspect Sarigan is very unique and worthy of special consideration (as are all the northern islands). One megapode was caught and banded. It received a USFWS silver band #725-92610 on the left leg and green over pink bands on the right leg. Capture techniques were tried and improved. The birds did not seem to mind the capture nets and did respond aggressively toward playbacks, becoming satisfied after one or two close passes of the tape player.
Kingfishers (*Todirhamphus chloris*), honeyeaters (*Myzomela rubrata*), and starlings (*Aplonis opaca*) were all relatively common on Sarigan. I did not see a white-throated dove (*Gallicolumba xanthonura*). However, I did hear a call that was identified as a Marianas fruit dove (*Ptilinopus roseicapilla)* call. The call was no doubt that of a Mariana fruit dove although without seeing the bird some question will remain. This call was heard by others at both the North ridge and near Camp A (seaside camp). No Mariana fruit doves have historically been recorded from the Northern Islands. If the call was real, then I would agree that more than one dove is resident on Sarigan and more searching is warranted to determine if it is a breeding population. This would have benefits for the CNMI in its efforts to protect bird life from invasive species on the southern islands. Film was also taken of honeyeaters (http://ibc.hbw.com/ibc/index.html). From these pictures it is shown that Micronesian honeyeaters (*Myzomela rubratra*) acquire adult plumage immediately as evidenced by males in adult plumage still having the yellow juvenile gape.

Monitor lizards (*Varanus indicus*) were abundant on Sarigan and could be encountered anywhere during daylight. Scott Vogt established that megapodes are on the lizard's diet (please see his report). Many of the observed lizards were in the 4-5 ft. range.

Dolphins were observed near Sarigan by project members on several occasions. They seemed to be in a group of about 10 and were observed close to the small harbor on the west side by Camp A. These dolphins are assumed to be spinner dolphins (*Stenella longirostris)*.

On Sarigan I encountered an understory of bird nest fern (*Polypodium punctatum?*) with a *Ficus* canopy that was unique. It was in the central native forest and also on the north slope just below the twin peaks. I had never experienced bird nest ferns on Sarigan in that density, 3-4 ft deep and continuous dense cover. When goats were present, the only bird nest ferns were on tree trucks out of the goats' reach. It is good to experience the native vegetation returning. Sarigan lemons were prevalent as ever on the upper plateau and as tasty as rumored. Sarigan has the best lemons of any island!

Native snails (*Partula gibba)* were abundant and very noticeable. Often while hiking in the native forest snails had to be removed from the clothing (please see Barry Smith's report). Coconut crabs (*Birgus latro*) were still noticeably absent (see Scott Vogt's report). I personally observed only two in the native forest on the upper plateau. One of these is a fairly large crab that lives at the containers at Camp B.

A direct colony count of fruit bats on Sarigan was made on April 23, which revealed a population of 120-130. Conservation Officer Al Fitial and I each counted the same number. Previous helicopter surveys of the island showed that this colony, on the north basalt ridge about half way down, was the only colony site in use during this trip. Anatahan at this same period had about 110-130 fruit bats in two colonies. It is interesting to note that it appears that the fruit bats on Anatahan and Sarigan might be the same population. Preliminary data after two years appear to show that as fruit bat numbers on Anatahan fluctuate due to volcanic activity, that the numbers on Sarigan do not increase but follow the same fluctuation pattern (one would expect bats to leave Anatahan during eruption events and move to Sarigan). More data needs to be collected.

Other Islands

Aerial photos of Guguan were obtained during the helicopter trip to Alamagan. These are on file at USFWS-Honolulu. Additionally aerial photos and film were taken of Alamagan, showing the village and inhabitants and also feral cows on the southeast side.

Anatahan operations went very well. We tried a hunting dog from Alamagan which did not work out too well. The terrain was much too harsh for the dog during the daylight hours. We did remove several pigs including at least one sow. This is most likely attributed to our ability to arrive at dawn and dusk and in keeping the pressure on longer than the usual two days. Patrick Santos of Alamagan preformed exceptional service to the project and was a constant source of help and good spirits. Conservation Officer, Jess Omar did his usual outstanding job. His professionalism in the helicopter keeps us all aware of the risks involved and functioning at level above the usual standard of safety.

Anatahan is vegetating quickly and will come back rapidly if the volcano ceases releasing ash. Ravines in which runoff has exposed vegetation are the first areas to grow back. Flies are still present and in annoying numbers. How these insects survive is unknown. Good fruit bat footage was taken and is on file at USFWS – Honolulu. We did shoot one cat which revealed that not

only had cats survived the eruption, but upon opening the stomach that rats (*Rattus exulans*) had survived as well. There is at least one dog still alive on the island also. Terrestrial birds are all gone. On the new black sand beaches, on the north side, a number of Portuguese man-o-war were observed stranded on the beach. These were small, about thumb size. Overall the Anatahan part of this trip was a success and a trip report, photos, and film are on file at USFWS-Honolulu, a copy of which will be given to CNMI-DFW.

Remarkable Discoveries About Sarigan In April 2006

By Gayle Martin

Participants in the April 2006 expedition to Sarigan were interviewed at the end of the trip. Most of the participants had been to Sarigan in previous years, and had seen the island before, during, and after eradication of feral animals. The participants were asked this question: What was the most remarkable discovery you made about Sarigan on this trip? Following are some answers given.

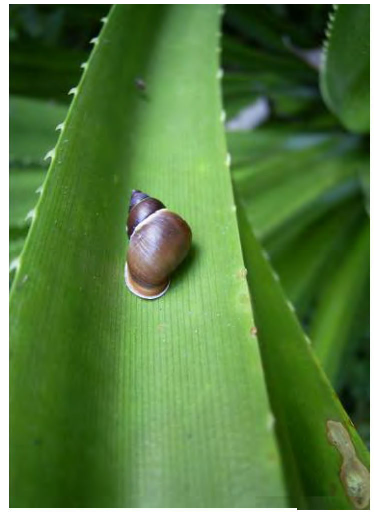
Laura ties her boot while hiking to Upper Camp. Photo: Gayle Martin

"That we found fruit doves. That was shocking. And, that the fruit bats are back up to 120 and are seen on the *Erythrina*. I think they move between islands and their numbers have always been around 100 here, so it's good to see them back up to 120. We lack sufficient surveys to know about inter-island movements." (Laura Williams, DFW Wildlife Section Supervisor, bird and vegetation surveys.)

"I would have expected to catch more coconut crabs at the lower elevations. The fruit doves, if they are really here, that's a biggie. I'm surprised we didn't find any snake-eyed skinks. I suspect it's because there is now an understory; they like sandy soil, and now that's covered. Maybe there are some closer to the coast." (Scott Vogt, U.S. Navy, herp and coconut crab surveys.)

"The crab survey was my first. It was interesting. And, my first time to work with Scott. It was something new for me. Because the first time I came here, it was for the eradication only. Oh, also, the fruit bat count. The crab survey and the fruit bat count were the most impressive things for me. Oh, yeah, the fruit dove! Curt and I heard it. Oh, yeah, and the vegetation here has just gone VOOM! Because during the eradication, there was nothing." (Alvin Fitial, DFW Conservation Officer, coconut crab and fruit bat surveys.)

"For me, it was the astounding abundance of *Succinea* snails. My intention was to look at Partulids. Next time, we'll bring two snail people here, one for *Partula* and one for *Succinea*. I've only seen two *Succinea* individuals in Guam." (Barry Smith, Malacologist, University of Guam, land snail surveys.)



Land snails found at Sarigan: *Elasmius* sp. (left); *Partula gibba* (right).
Photos: Gayle Martin

"All the greenery coming back. Because before, this place was bare. I could see the ridge from here [lower camp]. There were so many flies before. You put something down, and within five minutes there were maggots." (Jess Omar, Conservation Officer, logistics, feral animal eradication at Anatahan, and fishing.)

"That 'Diver' is not a megapode dog. The island is way vegetated. I've hiked more on this trip. The native forest is fantastic. Before, when goats and pigs were here, I found only two birds' nest ferns, now it's everywhere in the native forest. The other thing that is amazing about Sarigan is that we can't get more biologists to come and spend more money to study this place. It is like an ecological puzzle, and the puzzle pieces are big, not fragmented. There are megapodes running around, fruit bats, succession happening right now. The beauty of the wildlife is what amazes me, its innocence. The native forest, it used to be like this", [he picks up dust from the ground]. (Curt Kessler, Wildlife Biologist, U.S. Fish and Wildlife Service, logistics, fruit bat surveys, feral animal eradication on Anatahan.)

"The fruit dove. Cutting transects, the swordgrass is the hardest. Everything is up, or down. Opening those trails is hard, the vegetation is really thick. Megapodes are on almost every transect." (VJ Concepcion, WIA Wildlife Technician, cut transects and bird surveys.)

"The vegetation, the coconuts have grown up. The ocean, so many fish!" (Jess Guerrero, Conservation Officer, logistics, transect cutting and fishing.)

VJ found betel nut.
Photo: Gayle Martin

"Seeing coconut crabs. Nice to see fruit bats flying. The sharks, lots of fish. Lots of nice corals. Cutting trail, it was fun, but it was hard." (Peter Tomokane, BTS program, cut transects and herp / small mammal surveys.)

Juan Salas cooking.
Photo: Shelly Kremer

Orty Bourquin in his laboratory.
Photo: Nate Hawley

"I think this is the first time I cooked so much rice in my life. This is my first green flash. I've never seen it before." (Juan Salas, DFW Wildlife Technician, bird and vegetation surveys.)

"Rediscovering the tropical heat after three years in Montana. I wasn't as geared for it as I thought I was. The other nice thing was discovering the Japanese inscriptions. There are walls, terraces, cisterns, graves – it should all be mapped and preserved. The highlight for anyone would be to see megapodes the way we have seen them here. The Slevin's skink and of course, the moray eel." (Orty Bourquin, volunteered his time to survey insects.)

"There were three big discoveries. Since I'm a bird nerd, the first would have to be the megapode. Their abundance here was amazing to see because they are so rare on Saipan. They are everywhere here, and that's really cool. The second thing would be the coconut crabs. It was amazing to have them come right into camp, and to go with those guys on the transect. They are like aliens from another planet. The third was watching a fruit bat stick his nose into one of those *Erythrina* flowers and then lick his face off. I've never seen anything like that before, it was amazing. And, we have to add "Morton's Transect Of Death" on there. Enough said!" (Shelly Kremer, DFW Ornithologist, avian disease assessment and bird surveys.)

"Lots of megapodes." (Peter Teigita, DFW Conservation Officer, cut transects.)

"It's not like the megapodes, because I've seen them before. The terrain here is amazing, it's very nice." (Paul Reyes, BTS program, herp and small mammal surveys.)

Patrick Santos at Lower Camp cutting a fish.
Photo: Shelly Kremer

"The vegetation has come back. The plants are growing. The mango is big. It was planted here by the people who lived here before." (Patrick Santos, Alamagan resident, feral animal eradication on Anatahan.)

"I don't know if I discovered anything new. I've been all up and down these islands for years. I've been flying for the eradication project with Curt, and have camped up top [on Sarigan] many times. But, I am always awed by what I see." (Mike Cunningham, helicopter pilot, Americopters.)

"What an incredible place! Megapodes running around, even in the burned area. Huge coconut crabs of a brilliant blue color. Monitor lizards hanging out in trees, sunning themselves. Pockets of cool native forest, where skinks dart over rocks, and megapodes can be heard calling. Sharks and big, big sea cucumbers in the water. Sarigan is a recovering paradise." (Gayle Martin, DFW Planner, vegetation surveys.)

Gayle measures diameter
of a coconut tree.
Photo: Gayle Martin

Rock Gecko, *Nactus pelagicus*.
Photo: Shelly Kremer

"The abundance of *Nactus pelagicus* (Rock Gecko) observed in the native forest habitats was a real treat, these geckos were observed during dusk hanging out on trees and the forest floor. Normally I would be looking high and low for these guys, digging through rotten logs and leaf litter." (Nate Hawley, BTS Program Manager, herp and small mammal surveys.)

"Car-sized boulders weighing several hundred pounds can be dislodged by simply stepping on them. The difference between life (a broken ankle) and death is a hair. It's freaking steep and the sword grass is larger than life. But, more seriously, it was nice to see what Saipan, Tinian and Rota used to look like, especially fauna wise." (Richard Sikkel, volunteer, cut transects and helped Ping Iguel get off Transect 5 after a boulder rolled over his leg and broke the ankle.)

Steep slopes of Sarigan viewed from the helicopter.
Photo: Gayle Martin

The crew relaxing at Lower Camp. Left to right: Pete Teigita, Jess Guerrero, Jess Omar, Juan Salas, Alvin Fitial, VJ Concepcion, Curt Kessler.
Photo: Shelly Kremer

Richard Sikkel.
Photo: Shelly Kremer

Scott Vogt and Barry Smith.
Photo: Shelly Kremer

Gayle washing dishes at Upper Camp.
Photo: Shelly Kremer

Above: Patrick, Peter, Paul, John and Jess riding back to the MV *Micronesian*.
Photo: Gayle Martin

Left: Back deck of the MV *Micronesian* loaded up with supplies for the return trip from Sarigan to Saipan.
Photo: Nate Hawley