APPENDIX 1

A SURVEY OF MARIANA FRUIT BATS ON SARIGAN, MARIANA ISLANDS

PERIOD COVERED: July 1999

INTRODUCTION

A survey of Mariana fruit bats (*Pteropus mariannus*) was conducted on Sarigan, Mariana Islands from 2-7 July 1999. Field work was done as part of a broader inventory of wildlife and vegetation performed by the CNMI Division of Fish and Wildlife and the U.S. Fish and Wildlife Service. The objectives of the bat survey were to estimate the size of the island's population and to gather behavioral information for comparison with other bat populations in the island chain. Sarigan is entirely volcanic with a land area of 5.0 km^2, and is characterized by steep topography and a maximum elevation of 538 m. Forest coverage is about 35%, with coconut forest (140 ha) dominating over native forest (35 ha). The rest of the island is occupied by grassland, fern cover, or bare ground.

RESULTS AND DISCUSSION

Station Count Results

Evening counts of flying fruit bats were made at four stations offering broad views of the surrounding terrain (Figure 1). Counts began from 1730-1800 hr and lasted until darkness at about 1930 hr. Observers used 7 or 10X binoculars to view animals. The counts provided information on the numbers of bats feeding and moving through each count area and were useful in searching for colonies, based on the presence of sizable numbers of bats dispersing from particular locations. A brief summary of each station count is given below, with the numbers of animals seen presented in Table 1.

Station 1 - This count site was located on the island's west shore and provided an extensive view of the steep hillsides and cliffs along the southwest coast. About 25% of the area was forested, with two-thirds of this being coconut forest. Modest numbers of bats were recorded during the count (Table 1). Half of these entered or departed via the northern side of the count area, while most others remained in the area. No colonies or flyways were detected.

Station 2 – This count was made from the northwest coast near the main camp and gave a broad view from the shoreline up to a high hilltop. The entire area was covered in coconut (90%) and native (10%) forest. Moderate numbers of bats were recorded, most of which entered or departed from the east or remained in the area (Table 1). No colonies or flyways were detected. The goat eradication team started a large grass fire that burned across the summit of the hill during the count. The fire lasted about 30 minutes, produced loud cracking sounds and much smoke that blew to the southwest, and perhaps affected the count results.

Station 3 – This count site was placed at 350 m elevation on a hilltop overlooking the vicinity of the old basaltic lava flow at the north end of Sarigan and was covered in *Chrysopogon* grassland (60%), native forest (30%), and coconut forest (10%). The site showed considerable bat activity, with the largest numbers recorded for any station (Table 1). About half of the animals were concentrated along the west side of the lava flow and

suggested to the observer that a small colony was perhaps present (this was erroneous based on other observations made during the week). Most of the bats in this portion of the count area eventually departed to the west or south. Most other bats were sighted east of the lava flow and again, many of these animals departed to the west.

Station 4 - Located on the east side of the island at mid-slope (about 200 m elevation), this count provided a view extending from the shoreline to the top of the island's tallest peak. It was conducted to determine if sizable numbers of bats were dispersing into the forested northern third of the island from the south end. *Chrysopogon* grass with a few scattered coconut trees (60%) and *Nephrolepis* ferns (40%) comprised most of the area. Nineteen bats were recorded, with 11 of these flying northward through the count area from the south (Table 1). Thus, no evidence of large bat numbers in the south was noted.

Colony Counts

Although only one person was primarily devoted to making fruit bat observations during the trip, the remaining 12 field staff provided useful supplemental data, especially on the locations of bat colonies. During their various activities, the overall field crew achieved excellent coverage of the northern half of Sarigan. The southern half of the island with its difficult terrain and fields of dense swordgrass was visited less extensively, primarily to search for goats and to conduct vegetation surveys. It seems unlikely that any major colonies were overlooked during the trip and that most smaller groupings of bats were eventually encountered by team members.

Nine colonies or smaller aggregations of fruit bats (defined as $\geq$ 3 animals) were recorded during the study, with a possible tenth colony also located (Table 2). All groups of bats were small, numbering from three to an estimated 24 animals (Table 2). Only three sites held more than 15 bats. Five sites (Groups 2, 5, 6, 7, 8, and 9) were occupied at the end of the survey on 6-7 July and held a combined estimate of 51-63 animals. An additional suspected colony was identified downslope from Group 2, but was not visited on 7 July because of time constraints. Flying bats circled this site repeatedly during observations of Group 2, indicating the possible presence of a group of perhaps 10-25 animals. Based on counts of known groups, plus the likely presence a few additional undetected groups, an estimated 75-100 fruit bats were likely present in colonies or small aggregations on Sarigan during the survey period.

Previous authors have also reported small colony sizes of just 15 to perhaps 40 animals on Sarigan (Wiles et al. 1989, Zoology Unlimited LLC 1998, Fancy et. al. 1999). This contrasts notably with the larger colonies of several hundred or more bats that are typical for *P. mariannus* on some other Mariana islands, such as Guam, Rota, Anatahan, and Pagan (Wiles 1987,Wiles et al. 1989, Stinson et al. 1992, Marshall et al. 1996).

Three aggregation sites (Groups 1, 3, and 4) were used only temporarily during the survey period, however, two of these (Groups 3 and 4) were unintentionally flushed by an observer's presence, which may have resulted in their permanent abandonment. Group 1 was not disturbed, but used its roost site for only 1-2 days. The bats in all three groups may have joined other aggregations by 6-7 July.

Six of the nine aggregation sites occurred in northeastern Sarigan, while two others were found in the southern part of the island and another was near the center. All were located at elevations of about 100-350 m. Five groups roosted in either single or clumps of several coconut (*Cocos nucifera*) trees that were sparsely distributed on steep hillsides with short *Chrysopogon* grasslands. Small isolated patches of native forest held three aggregations, while only one colony occurred in an extensive stand of native forest. No groups were

located in the closed canopy coconut forest occupying the north and west sides of the island. Aggregations used the following roost trees: *Cocos nucifera* (7 trees), *Ficus prolixa* (1), and *Pandanus tectorius* (1).

Limited observations of groups revealed that most were probably composed of harems. Group 5 was viewed in detail for one hour with a 20-60X spotting scope. Two probable harems were present, with nine females and one male identified among the 20 visible bats. The two roost trees likely held separate harems, with harem size estimated at 14-16 bats in one tree and 6-8 bats in the second tree. The male was observed interacting with a female and climbing among roosting perches in a manner resembling harem-male behavior seen on Guam (G. Wiles, unpubl. data). Group 3 was viewed briefly as its members flushed from the tree. An adult male and four females were identified among the seven bats present. Nearly all of the bats present in Group 4 were females with young when that colony was flushed. Fancy et al. (1999) reported seeing an all-male aggregation of 15 bats in 1997.

Abundance and Behavior of Non-Colonial Bats

Solitary roosting and flying fruit bats were regularly seen in all habitats with trees throughout Sarigan, except near the southern end where adequate observations were not made. Pairs of animals were also occasionally encountered. The abundance of non-colonial individuals appeared to be greatest in native forest on the northeastern side of the island and in scattered coconut trees on grassy hillsides along the eastern coast. Both habitats offered either numerous viewpoints or sparse tree cover, making it easy to sight bats. Solitary animals were encountered less often in coconut forest, but detectability was reduced in this plant community because of denser vegetation and fewer viewpoints.

Solitary bats were fairly active throughout the day. Flying individuals were recorded in good numbers at all hours, including the middle hours of the day, and made frequent changes in roosting sites. Some of this activity was due to observer presence and possibly to the general disturbance caused by other team members during their various field activities.

The number of solitary fruit bats on Sarigan was difficult to quantify for a variety of reasons, including poor visibility in closed canopy forests and the high mobility of some individuals. However, based on numbers seen during evening station counts and general daytime observations, a rough islandwide estimate of 75-100 bats is reasonable.

Considerable time was spent making careful observations of bats roosting solitarily to determine the sex ratio and percent of females with young in this segment of the population. Sex and the presence or absence of young were determined for 18 individuals, with a ratio 10 males: 8 females (55.6% male) noted; three of the eight (37.5%) females held non-volant young. Sex ratio data from flying bats were unreliable because adult males with their highly visible genitalia were easier to identify and were possibly more active than females. Precopulatory courtship behavior was observed once between a non-colonial male and female with a medium-sized baby. The male flew in and landed near a female roosting in a coconut tree, courted her unsuccessfully for about 2.5 minutes, and then flew off.

Total Population Estimate

Based on estimates of 75-100 fruit bats in colonies and small aggregations and similar numbers of solitary individuals, Sarigan's fruit bat population was estimated at about 150-200 animals during the count period. This figure is similar to two previous estimates made for the island. Wiles et al. (1989) reported a minimum of 125 animals in 1983-1984, while Fancy et al. (1999) estimated 170 bats (95% confidence interval of 101-238 bats) in 1997.

These counts suggest that the island's bat population has remained fairly constant since the early 1980s. The lack of significant changes in the population's size also gives some very preliminary evidence that large movements of bats among the Northern Mariana Islands may not be a regular occurrence.

Reproduction

Females with babies were commonly observed throughout the survey while roosting and flying. More than half of the females recorded in colonies or small aggregations possessed young, as follows: Group 2, the only identified female had a baby; Group 3, four of six females had babies; Group 4, an estimated 10 of 12 females had babies; Group 5, six of nine identified females had babies; and Groups 8 and 9 combined, five of an estimated 20 females had young. Based on these data, 28 of 50 (56%) colonial females possessed young. Additionally, three of eight (37.5%) females seen roosting alone carried babies. The reproductive data for animals roosting in groups may be biased towards a higher percentage of females with young than in fact was present. Sufficient time was not available to observe all individuals in each group, which is the most desirable method for obtaining true female-young ratios. During incomplete observations, females with babies are sometimes more easily identified because the young usually form a noticeable bulge under their mothers' wings, they often receive additional grooming from the mother, and the extra activity of the babies often helps the observer recognize their presence. Females without young are often less active while roosting and therefore require more time to identify. Based on these considerations, probably 30-50% of the females on the island possessed young during the survey period.

During the survey, 11 babies were classified by size, as follows: one small, nine medium, and one large.

Food Use

Based on direct observations and other evidence (dropped fruit, chewed pellets, and fecal analyses), 20 feeding records were obtained during the survey. Fruit bats used the following foods: the fruits of *Terminalia catappa* (10 occasions), *Neisosperma oppositfolia* (3), *Pandanus tectorius* (2), and *Ficus* sp. (1), the flowers of *Cocos nucifera* (3), and probably sap from the flower stalk of *Cocos nucifera* (1). Additionally, C. Kessler and H. Gideon reported seeing bats making heavy use of *Erythrina variegata* flowers in January and February 1998.

Bats visited our camp on the northwest side of the island each night to eat *Terminalia* fruit. Feeding sign was regularly recorded under other *Terminalia* around the island. Although *P. tectorius* is uncommon on Sarigan, its drupes were heavily fed on in both instances where ripe fruit were found. Despite deliberate searching, no evidence of feeding was located under numerous large *Ficus* trees with ripening fruit, however, *Ficus* seeds were collected from a single fecal splat found beneath the roost of a solitary animal. The dropping was examined with a dissecting microscope on Guam. The seeds were not identifiable to species, but came from *F. tinctoria* or *F. prolixa.*

On 7 July at 1930 hr, four fruit bats were seen clustered around the crown of a coconut tree, where a set of older flower stalks protruded upward. Although the stalks no longer possessed flowers, the bats' activity suggested that the stalks were exuding some type of edible liquid (probably sap) from multiple openings. A dominant bat occupied the stalks, while the other three animals hung 50-100 cm away on separate fronds watching the dominant individual feed. The bat nearest the center (50 cm away) tried several times to approach the crown and insert its head among the stalks, but was rebuffed each time by

brief snarls from the dominant animal. The two outermost bats departed after 9-12 min, and were followed soon after by the dominant individual. The remaining bat immediately moved to the crown and began clambering about to lick different parts of the stalks. It frequently changed positions and returned to relick certain locations that had already been visited. The number of animals involved and the resource defense displayed by the one individual suggests that a desirable food was present.

Uneaten fruits from a variety of species were commonly found on the ground beneath parent trees during the survey. This suggests that Sarigan's bat population was not large enough to consume all available food resources during this particular time period. Only one record of a flying bat carrying a fruit in its mouth was made during the entire survey. This indicates that most bat feeding was taking place in or near the crown of the parent tree.

Evidence of Illegal Hunting

Although fruit bats are protected throughout the CNMI, there is concern that considerable illegal hunting may be taking place on many of the northern islands (Marshall et al. 1996). For example, bat poaching was reported on Sarigan in January 1998 (Zoology Unlimited LLC 1998). Surprisingly little evidence of bat hunting was found during the survey. Fewer than five expended shotgun shells with the small shot appropriate for killing bats were found by four team members who hiked large portions of the island. Additionally, bats appeared relatively tame, indicating that they are not heavily persecuted by people.

Insect – Fruit Bat Interactions

One of the more interesting behavioral observations made during the survey was the large number of fruit bats being bothered by small flying insects. Many roosting bats, which hung with their wings wrapped around themselves, were noticed making repeated rapid shallow flicks of their outer wing. On 6 July, while viewing a male bat at a distance of only 5-7 m on the old lava flow, the observer was inundated by 100-200 small flying insects swarming around and delivering occasional bites to his head and arms. Continued observation revealed that the male bat was also bothered by the same insects and that his wing flicking behavior was in response to their irritation. During 10 minutes of observation, he performed 22.1 wing flicks, 1.3 head-neck shakes, 0.3 body adjustments, and 0.1 leg shakes per minute. A second bat seen in Group 6 on 7 July made 15.0 wing flicks and 1.0 head-neck shake per minute in response to the insects during a second 5-minute period. The irritation seemed great enough to prevent bats from settling into a deep sleep. Bats exhibited wing flicking in all habitats, although several colonies on the eastern and more windswept Chrysopogon-dominated ridges did not seem to be bothered. Later conversations with entomologists from the University of Guam suggested that the insects were possibly a type of biting midge (R. Muniappan, pers. comm.).

It is interesting to speculate whether insect problems may have been responsible for the roosting patterns and site selection of the bats seen in the survey. Animals may have been trying to avoid the insects by choosing the more open and breezy conditions associated with the scattered coconut trees on the northeastern side of the island. The insects may have also been responsible for the frequent movement between roost trees seen in some solitary bats.

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