Micronesica 32(2):181-190, 2000

Population status of the Tinian Monarch (*Monarcha takatsukasae*) on Tinian, Commonwealth of the Northern Mariana Islands

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Abstract—We conducted surveys to evaluate the current population status of the Tinian Monarch (*Monarcha takatsukasae*), an insectivorous forest bird restricted to the island of Tinian, Commonwealth of the Northern Mariana Islands. In 1996, we recounted transects surveyed in 1982 and used the same analysis procedure to compare 1982 and 1996 population estimates. The 1996 population estimate was 55,721 ± 3,846 SE (48,345–63,495 95% CI), which is 57% higher than our estimate of 35,846 ± 2,211 SE (31,668–40,337 95% CI) for 1982. Vegetation density, measured by canopy cover and lateral visibility at each station, has also increased since 1982. Our data suggest that the Tinian Monarch population has increased possibly due to increased habitat availability, but remains at risk both from an accidental introduction of brown tree snakes (*Boiga irregularis*) to the island and stochastic processes.

Introduction

The Tinian Monarch (*Monarcha takatsukasae*), locally known as *Chuchurican Tinian*, is a monarch flycatcher found only on the island of Tinian, Commonwealth of the Northern Mariana Islands (CNMI), in the western Pacific islands of Micronesia. The terrestrial avifauna of Micronesia has a high propor-

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tion (32%) of species endemism. In the Marianas Archipelago, the Tinian Monarch and 11 of 28 other endemic species are believed to have originated from Melanesia (Baker 1951). The Tinian Monarch is widely considered to be endemic to Tinian, however a recent examination of museum specimens indicates that a population may have once existed on the neighboring island of Saipan (Peters 1996).

The Tinian Monarch was listed as an endangered species by the U.S. Fish and Wildlife Service (USFWS) in 1970 based on descriptions of low population numbers after the heavy bombing of Tinian during World War II (WW II) (Glieze 1945). Other incidental reports of the monarch's status followed (Downs 1946; Marshall 1949; Owen 1974; Pratt et al. 1979), but bird populations on Tinian were not systematically quantified until a USFWS survey in l982 (Engbring et al. 1986). The 1982 survey found the Tinian Monarch to be the second most abundant species on Tinian, with an estimated population of 39,338 ± 2,131 SE individuals occurring in forest and shrub habitat throughout the island (Engbring et al. 1986). Monarchs were absent only from unvegetated areas, open fields, and agricultural areas. Engbring et al. (1986) recommended a reassessment of the species' endangered status, and in 1987, it was downlisted to threatened (USFWS 1995a). In 1995, a life history study estimated the population to be 52,904 individuals based on banding data (USFWS 1996), although this study used slightly different estimates in calculating potential monarch habitat than our study.

In 1996, we conducted a follow-up survey of Tinian Monarchs to provide current data on numbers, distribution, and population trend for use in evaluating its threatened status (USFWS 1996) and preparing strategies for long-term management. We present methodologies and results of the 1996 survey and a reanalysis of the 1982 survey.

Study Area

Tinian (15º N, 145º 38' E) is the third largest island (10,172 ha) in the Marianas, lying 5 km southwest of Saipan and 160 km northeast of Guam. Tinian's topography is dominated by low, level terrain, with a few raised limestone plateaus and escarpments. The highest elevation, 178 m, occurs in the southeastern ridge of the island. Tinian's climate is tropical, with a mean temperature of 26º C and mean humidity of 80%. Rainfall averages 203 cm/year, with a wet season from July to October and a dry season from February to April. Tropical storms and typhoons are common during the rainy season.

The majority of human residents live in the island's only town of San Jose at the southwestern edge of the island (island-wide population 2,628 in 1995). The northern 71% of Tinian is leased to the U.S. military (Belt Collins 1994). Approximately 10% of the island is devoted to agriculture, while another 30–50% is used for grazing (Engbring et al. 1986, Belt Collins 1994). Heavy disturbance of the island's native forests began in the 1700s with the importation of livestock by the Spanish (Fosberg 1960), continued with the development of the Japanese sugar cane industry in 1926 (Belt Collins 1994), and culminated during WW II with clearing associated with battles and military construction (Baker 1946). Presently, only 5–7% of the island remains in native limestone forest (Engbring et al. 1986; Falanruw et al. 1989), which is primarily restricted to long, thin strips found along the bases of cliffs. Approximately 38% of Tinian is dominated by tangantangan (*Leucaena leucocephala*) forests (Engbring et al. 1986), which may have been aerially seeded by the military after WW II (USFWS 1995b, 1996). Vegetative composition of the island is described in detail by Fosberg (1960), Engbring et al. (1986), and Falanruw et al. (1989).

Methods

Survey Design

We included 62% (6269 ha) of the island as potential habitat of the Tinian Monarch, including limestone forest, secondary vegetation, and tangantangan thickets. Six habitat types not used by the species (USFWS 1996), strand (beach edge), urban, cultivated, open fields, marsh, and bare ground, were excluded. Additionally, we excluded 2,375 ha of primarily open fields that Engbring et al. (1986) used in their population estimate. To compare survey results between years, we relocated the ten original transects and 216 stations from 1982 as closely as possible by following detailed field notes and maps from that survey (Figure 1). Transects were originally established by a random-systematic method whereby the initial transect was randomly chosen and the remaining transects were separated by 2 km distances and not stratified by habitat type (Engbring et al. 1986). All stations were 150 m apart. We did not stratify the island into different habitat types during data analyses because native forest, where monarchs exist in densities four to five times higher than in secondary and introduced forests (USFWS 1996), compose such a small fraction of points along the randomly placed transects that sample size was not large enough to make meaningful comparisons.

We estimated the Tinian Monarch population using variable circular plot (VCP) survey methodology with 8-minute count periods (Ramsey & Scott 1979, 1981, Reynolds et al. 1980, Scott et al. 1986, Fancy 1997). Detailed discussions of this methodology are found in Buckland et al. (1993) and Fancy (1997). Counts were conducted during the first five hours after sunrise. At each station we recorded starting time, cloud cover, wind, and a visibility index based on vegetation density. We estimated 5 visibility categories based on the following criteria: (1) complete forest canopy and dense understory with < 15 m lateral visibility in all directions; (2) complete or mostly complete forest canopy and 15–50 m lateral visibility in all directions; (3) complete or mostly complete forest canopy and > 50 m visibility in 5–20% of the surrounding area in all directions; (4) fragmented forest and > 50 m visibility in 5 –20% of the surrounding area in all directions; and (5) no forest canopy and > 50 m visibility in > 50% of the surrounding area in all directions. Cloud cover was recorded to the nearest 10% and wind was categorized according to the Beaufort scale. Counts were only conducted during

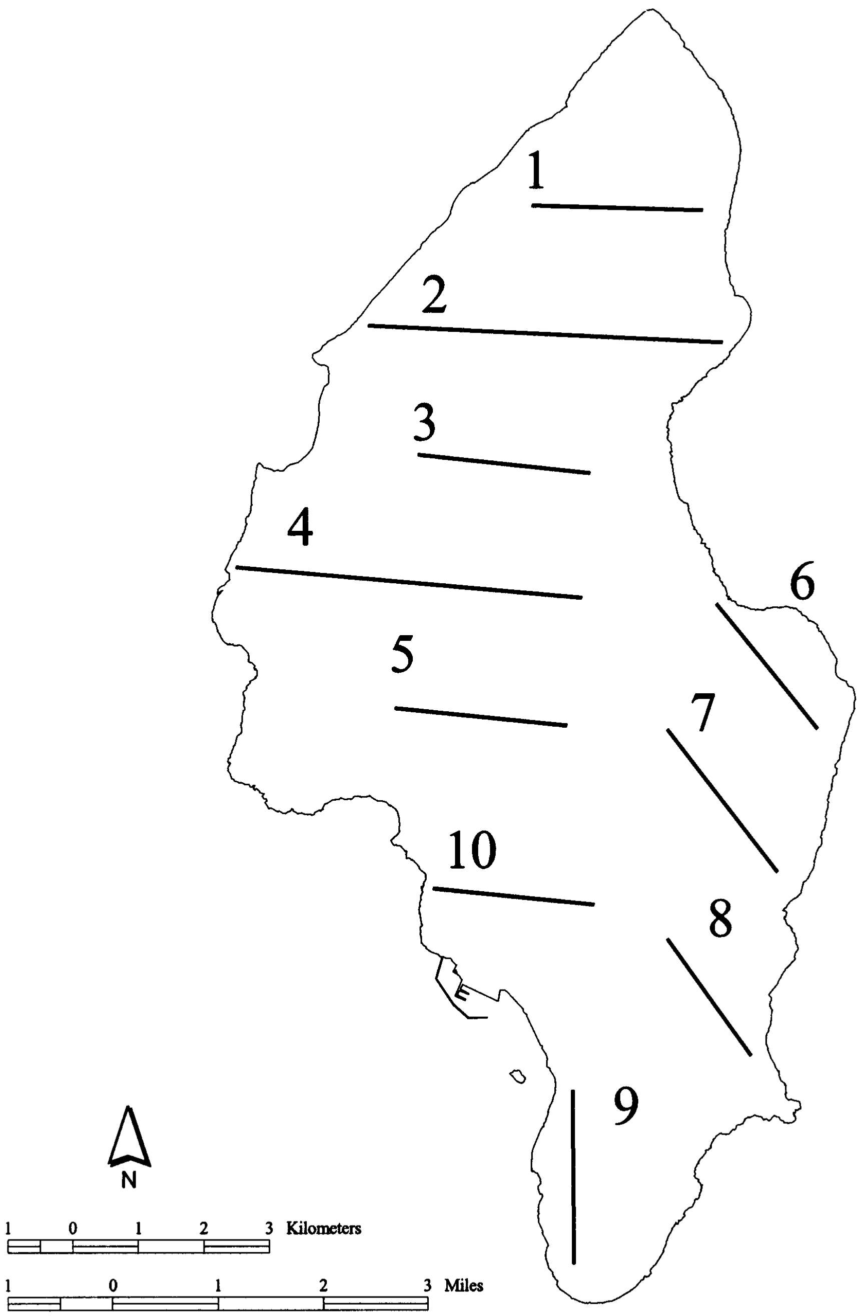

Figure 1. Map of Tinian showing transects sampled in 1982 and 1996.

favorable weather conditions (i.e., no rain and wind at Beaufort scale 4 or below). For each forest bird detected, we recorded species and distance from observer. Prior to the survey, we conducted an intensive three-day training session for experienced VCP counters, similar to that described by Kepler & Scott (1981), to calibrate distance estimations and species identification. Survey dates were August 28 to September 1, 1996, approximately four months later in the year than the 1982 surveys, which were conducted from April 27 to May 8.

Data Analysis

To make results from the 1982 survey comparable to our own, we selected the count data from only one of the two observers at each station from 1982 to be included in data analyses, rather than combining observations at each point as done by Engbring et al. (1986). By taking this approach we could account for all stations in 1982 by selecting only two of the original four observers.

We used the covariate data of clouds, wind, time of day, visibility index, and 5 different observers to adjust the pooled detection distances from 1982 and 1996 according to a reference condition, as if all distances were recorded by the same observer under a specific set of conditions (Ramsey et al. 1987, Fancy 1997). Our reference condition was an experienced observer (MHR) at 0700 hours with no clouds or wind and visibility index 2 (closed forest canopy with open understory).

Detection distances at each station were adjusted by the regression coefficients of the model under the actual conditions when the station was sampled. We pooled all detection distances from 1982 and 1996 to calculate effective detection radius (EDR) and coefficient of variation surveyed under reference conditions with the program DISTANCE (Laake et al. 1994). We calculated variation in the effective area surveyed and population size with 5,000 bootstrap samples from a random normal distribution centered on the mean effective area using the computer program VCPADJ (Fancy 1997). Density was calculated by dividing the number of Tinian Monarchs detected at each station by the mean effective area surveyed. Population estimates were derived by multiplying the size of the study area by density.

Visibility codes were analyzed with a one-sided Wilcoxon rank sum test to determine if vegetation densities had increased between surveys. We chose a more conservative one-sided test to compare visibility codes because stations may not have been at exactly the same location.

Results

Two of the five observers, time of start of count, and visibility index had significant effects on the EDR and were used as covariates (Table 1). Weather variables did not significantly affect detection distances and were excluded from further analyses. DISTANCE selected a half-normal model with polynomial adjustments for the best fit and estimated an EDR of 34.587 m with a coefficient

Table 1. Estimated beta coefficients used for covariate adjustments to effective detection area, percent area adjustments, and significance of multiple linear regression tests for the independent variables relative to standard conditions: observers, visibility classes, and time of day.

Variable	Coefficient	Area Adjustment	P-value
Observer 1 (1982)	-0.243287	78.4%	> 0.12
Observer 2 (1982)	0.531281	170.0	< 0.0002
Observer 1 (1996)	-0.065024	93.7%	> 0.69
Observer 2 (1996)	-0.526166	59.1%	< 0.002
Visibility class 5	1.478328	438.6%	< 0.0001
Visibility class 4	0.853184	234.7%	< 0.0001
Visibility class 3	0.219101	124.5%	> 0.19
Visibility class 1	-0.351252	70.3%	< 0.006
Time of day	-0.134743	87.4%	< 0.002

of variation of 2.46%. Engbring et al. (1986) found an EDR of slightly less than 40 m using a different analysis method for their 1982 survey.

There were 539 monarch detections at 216 stations in the 6,269-ha study area during 1982, with at least one monarch detected at 186 (86.1%) stations. In 1996, we recorded 495 monarchs at 216 stations, with at least one monarch detected at 172 (79.6%) stations. Our reanalysis of the 1982 data resulted in an estimate of 35,846 ± 2,211 SE monarchs (31,668–40,337 95% CI). We estimated 55,721 ± 3,846 SE monarchs (48,345–63,495 95% CI) in 1996, indicating a 57% difference between surveys. Engbring et al.'s (1986) original estimate was 39,338 ± 2,131 SE birds, which included an additional 2,375 ha in their monarch habitat calculations that we did not include in our re-analysis. Density at sampling stations was higher in 1996 (8.85 birds / ha) than in 1982 (5.71 birds/ha; ANOVA, $F = 4.97$, $P < 0.027$).

The median visibility index for both 1982 and 1996 was 2. However, a one-sided Wilcoxon test revealed that the visibility indices were significantly lower in 1996 than 1982 ($P = 0.0005$, $Z = 3.2799$), indicating that thicker vegetation in 1996 resulted in reduced observability distance (Figure 2).

Discussion

We believe that a possible increase in the Tinian Monarch population from 1982 to 1996 can be accounted for by an increase in vegetation density. While the net area of available habitat has changed negligibly over the past 10 to 15 years (USFWS 1996; C. Aguon, R. David, and D. Herbst, pers. comm.), the quality of habitat within this area has probably improved. For example, discussions with biologists familiar with Tinian since the early 1980s confirm our statistical observations that the island's vegetation has grown significantly denser over the past

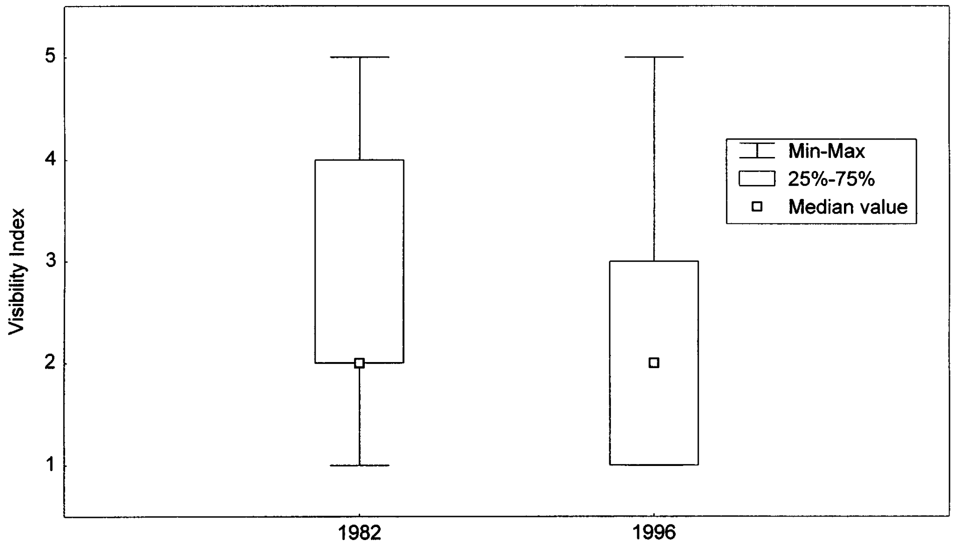

Figure 2. Visibility indices for Tinian VCP surveys.

15 years (C. Aguon, T. Sutterfield, pers. comm.). In 1982, when the initial bird survey was completed, there were approximately 6,000 to 7,000 cattle on Tinian (Micronesian Development Company, pers. comm.). Cattle numbers fell to about 4,000 by 1993 and to about 2,000 by 1996 after a series of droughts (Micronesian Development Company, pers. comm.). A reduction in cattle grazing pressure would likely result in regeneration of understory growth and increased seedling recruitment, which may represent higher quality monarch habitat. Denser vegetation also helps explain the fact that although we detected slightly fewer birds than in 1982, our overall density estimates were higher. Monarchs may also be more vocal during the rainy season from July to October (D. O'Daniel, pers. comm.), making them more easily detected during our survey than in 1982. In addition, if detection distances were overestimated during the 1982 survey, then the monarch population would have been underestimated. The large beta coefficient of 1982 observer 2 (Table 1) indicates that this may have occurred. In comparing surveys from different years in Micronesia, Ramsey (unpubl. data) suggests that differences in observer acuity may account for some differences in population estimates. All of the above factors may have contributed to the lower 1982 population estimate. However, we believe that our results indicate a real increase in bird densities. Based on the results of a banding study conducted in 1995, densities of monarchs were calculated for each habitat type included in our study (USFWS 1996). Extrapolating these densities across our study area yields an independent estimate of 52,993 birds, which is within 5% of our estimate of 55,721 monarchs.

Although the Tinian Monarch population has probably increased since 1982, it should still be closely monitored and receive adequate management to insure its long-term survival. Because of the proximity to Guam and frequency of direct, low altitude flights, and because the monarch is endemic to a single island, it is especially vulnerable to the establishment of the brown tree snake. This introduced predator is responsible for the decline, extirpation, or extinction of all of Guam's native avifauna (Savidge 1987). Although the Tinian Monarch has withstood frequent typhoons over time, the combination of habitat loss from development and the replacement of native forests with alien dominated habitats could present a novel situation in the face of future devastating typhoons. More information is needed on the contribution of breeding success and survival of monarchs in native forest relative to the entire population. Native forest communities, which have higher breeding densities than alien dominated habitats (USFWS 1996), may represent an important breeding source that serves to maintain high densities in neighboring areas that are suboptimal.

To ensure the long-term survival of the Tinian Monarch, we recommend: (1) repetition of the VCP census during April and May to confirm our conclusion that the monarch population is increasing; (2) development of a brown tree snake intervention plan to prevent its establishment on Tinian; (3) protection of adequate habitat, with special emphasis on preserving native forest; (4) population monitoring on a regular basis to detect declines that may be due to the above factors or new factors such as introduced avian diseases which have had devastating effects on the native avifauna of Hawaiʻi (Scott et al. 1986); and (5) preparation of a plan of action in the event of a population decline.

Acknowledgments

This research was funded by the U.S. Department of the Navy, Pacific Division, Naval Facilities Engineering Command. We thank the personnel of the CNMI Division of Fish and Wildlife, Tinian and Saipan offices, for their support in conducting this research. Dan Grout, Scott Krueger, and Jaan Lepson were instrumental in identifying the 1982 transects and David Worthington, Jay Jeffrey, Jason Townsend, Annie Marshall, and Jim Yuen deserve our greatest thanks for cutting transects. Thanks to Steve Fancy of USGS-BRD for useful comments on this manuscript and Rod Low of USFWS for help in producing the map of Tinian.

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Received 7 Oct. 1998, revised 24 Feb. 1999