MARIANAS AVIFAUNA CONSERVATION (MAC) PLAN

Long-term Conservation Plan for the Native Forest Birds of the Commonwealth of the Northern Mariana Islands

A Joint Endeavor of:
The Commonwealth of the Northern Mariana Islands' Division of Fish and Wildlife,
The United States Fish and Wildlife Service,
Pacific Bird Conservation,
and
The Association of Zoos and Aquariums

Produced by:
The MAC Working Group

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MAC PLAN OVERVIEW

This document serves as the long-term plan for the Marianas Avifauna Conservation (MAC) Project, its status as of the date on the cover page. The purpose of the MAC Project is to safeguard the unique avian diversity of Rota, Tinian, and Saipan, Commonwealth of the Northern Mariana Islands (CNMI), from potential extinction that could result from introduction of the brown tree-snake (*Boiga irregularis*). The effects of such an introduction have been borne out on the nearby island of Guam; the CNMI does not want them repeated within its jurisdiction.

The MAC Project long term plan is two-fold: 1) the establishment and maintenance of captive populations of potentially affected bird species, through the generous contributions of both space and personnel by the Association of Zoos and Aquariums; and 2) establishment of satellite populations of these species on islands in the Mariana Archipelago deemed "safe" from the brown tree-snake.

Many of the protocols within this document are relatively new and little tested. Thus, this plan in its current state is by default a "work in progress," and revisions and adjustments will be incorporated into future drafts as bugs are worked out and new techniques tested and refined.

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***Note**: This document in its current form does not represent a Federal document of any kind and should not be interpreted as the position or policy of any Federal Government entity.*

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INTRODUCTION

Setting and Rational for the MAC Plan

The Mariana archipelago is a chain of 15 volcanic islands stretching over 466 miles north to south, comprising a land area of 389 square miles (Figure 1). The archipelago is divided into two administrative units; the Territory of Guam and the Commonwealth of the Northern Mariana Islands (CNMI). The Territory of Guam is composed of the island of Guam and the CNMI includes the remaining 14 islands in the archipelago. Rota, Tinian, and Saipan are the only islands in the CNMI with significant human inhabitance (2,527, 3,136, and 48,220 people respectively), while the remaining islands support on average less than 10 individuals (U.S. Census Bureau 2010). The CNMI's climate is marine tropical, hot and humid, and characterized by relatively high and uniform yearly temperatures. The annual mean is 83° F, with a seasonal variation in mean monthly temperature of less than 3.5 degrees. Humidity is high with monthly averages between 79 and 86 percent; the months of greatest humidity are July to November. The mean annual rainfall is approximately 83.8 inches, but varies from year to year, with the wet season generally occurring from July through October.

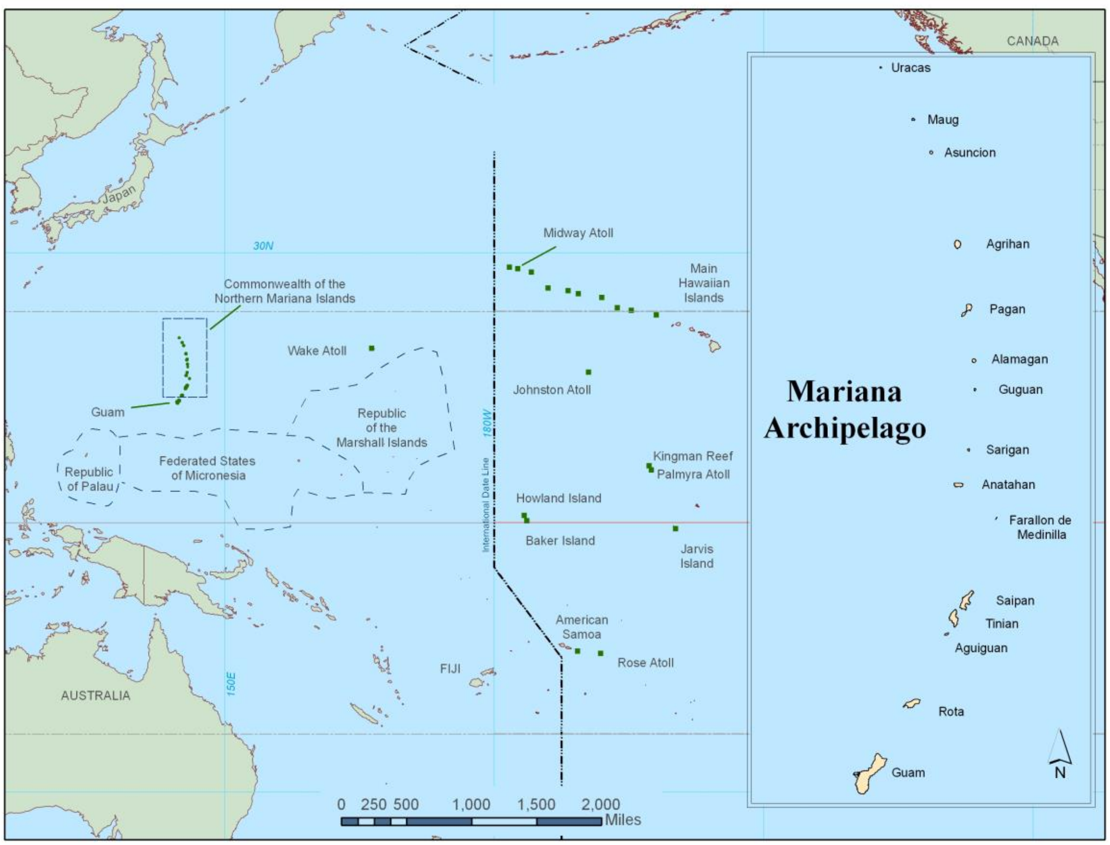

Figure 1. The Northern Mariana Islands.

The CNMI, in cooperation with the U.S. Department of the Interior (DOI), determined that Saipan potentially supports an "incipient" population of the brown tree-snake (*Boiga irregularis*; Colvin et. al. 2005). As of July 2012, there have been 90 credible sightings of the snake in the CNMI (Rota four, Tinian 10, and Saipan 76), and of the 11 captured on Saipan not all have been limited to its ports; three were captured in three different villages away from port areas (Marja Onni, CNMI DFW BTS Program, pers. comm.). This introduced species is believed to be responsible for the extinction or extirpation of nine of 12 species of native forest birds on Guam within the last half-century (Savidge 1987, Wiles *et al*. 2003), and has been determined the single greatest threat to terrestrial ecosystems in the CNMI (Colvin *et al*. 2005). Of the 19 endemic bird species and subspecies that occur in the Mariana Archipelago, DFW has identified 12 species in the CNMI that could potentially be critically endangered by the brown tree-snake on the islands of Rota, Tinian, and Saipan (Appendix A).

Decline of island avian populations as a result of the brown tree-snake introduction appears to be relatively rapid once the snake becomes well established. Based on roadside surveys conducted on Guam over a 20-year period, most species of bird experienced a 90% decline within 8.9 years (Wiles et al 2003). Guam was not able to introduce a propagation program for the Guam Flycatcher (*Myiagra freycineti*), Guam Rufous Fantail (*Rhipidura rufifrons uraniae*), and Guam Bridled White-eye (*Zosterops conspicillata conspicillata*) as they were extirpated or driven to extinction far more rapidly than expected (Wiles et al 2003). However, captive propagation programs were successfully established for the Guam Rail (*Gallirallus owstoni*) and Guam Micronesian Kingfisher (*Todiramphus cinnamomina cinnamomina*).

The brown tree-snake likely arrived on Guam prior to 1950 as a passive stowaway in materiel salvaged from the New Guinea area through the port facility on Manus Island following World War II (Savidge 1987, Rodda *et al*. 1992, Rodda and Savidge 2007). This secretive nocturnal arboreal species occurs in every habitat on Guam, from grassland to forest (Rodda and Savidge 2007). Available evidence indicates that the species first colonized southern Guam and reached the northernmost point of the island by 1968 (Savidge 1987). Within 20 years, the island's snake population reached a peak density of 100 to 120 per hectare (41 to 50 per acres), one-to-two orders of magnitude higher then would normally be expected for large snakes (Rodda *et al*. 1992). By 1988, the brown tree-snake had eliminated most of the native birds on the island (Savidge 1987), as well as many other native and exotic animal species (Fritts and Rodda 1998).

The primary mechanism for the potential spread of brown tree-snakes from Guam to other islands is the transportation of goods; all goods received in the CNMI are shipped through Guam. The majority of these goods are delivered to Saipan from where they are shipped to Tinian and Rota. However, some goods are shipped directly from Guam to Rota. Although efforts to prevent the accidental shipment of brown tree-snakes are being undertaken, not all cargo and goods shipped between islands can be checked. Additionally, the potential establishment of brown tree-snakes on Saipan creates an alternative source of snakes for Rota and Tinian.

As a response to the threat of the brown tree-snake, biologists with the CNMI Division of Fish and Wildlife (DFW) and U.S. Fish and Wildlife Service (USFWS) met with biologists from the Association of Zoos and Aquariums (AZA) to investigate the possibility of developing a captive management program to safeguard CNMI's unique avian species. It was determined that the long-term survival of these species required the establishment of redundant, satellite populations on other islands in the Mariana archipelago that afford safety from the brown tree-snake. This interagency meeting also resulted in the initiation of the Marianas Avifauna Conservation (MAC) Project, developed to identify and implement conservation actions necessary to ensure the persistence of CNMI's avifauna.

Currently within the Marianas, the White-throated Ground Dove (*Gallicolumba xanthonura*), Mariana Fruit Dove (*Ptilinopus roseicapilla*), Collared Kingfisher (two subspecies; *Todiramphus chloris albicilla* and *T. c. orii*), Tinian Monarch (*Monarcha takatsukasae*), Nightingale Reed-warbler (*Acrocephalus luscinius*), Saipan subspecies of the Bridled White-eye (*Zosterops conspicillatus saypani*), Rota White-eye (*Zosterops rotensis*), and Golden White-eye (*Cleptornis marchei*) are found only in the CNMI (Appendix A). The Mariana Crow (*Corvus kubaryi*) can also be included on this list as it is apparently extirpated from Guam (Appendix A; J. Charrier, USFWS, pers. comm.). Although not the primary focus of the MAC Project, the successful reestablishment of many of these bird species on Guam is dependent on the longevity of native bird populations of the CNMI. The establishment of the brown tree-snake on Saipan, and the increased threat of the species' establishment on the islands of Rota and Tinian, serves as a direct threat to the survival of many of the CNMI's endemic bird species.

PREVIOUS AND ONGOING CONSERVATION EFFORTS

The long-term conservation of native species includes (1) the protection of *in situ* populations, (2) the captive propagation of severely compromised species, and (3) the reintroduction of expatriated species (Gibbons *et al*. 1995). Conservation planning and implementation has been ongoing in the Mariana Islands over the last several decades and significant efforts have been undertaken to conserve their native species. Activities and tasks associated with these efforts, especially as they pertain to federally and locally protected bird species and species of concern in the CNMI, have been identified in the CNMI's Comprehensive Wildlife Conservation Strategy (Berger *et al*. 2005), in published recovery plans for the Mariana Crow (USFWS 2005 [revised in 2012]), Rota White-eye (USFWS 2007), Nightingale Reed-Warbler (USFWS 1998a), Micronesian Megapode (USFWS 1998b), Mariana Common Moorhen (USFWS 1991a), Mariana Swiftlet (USFWS 1991b), and in the Brown Tree-Snake Control Plan (BTSCC 1996). Therefore, we will not go into detail in this document. However, a brief overview of the efforts that have been undertaken will provide context for how this plan fits into other planning and conservation efforts.

PROTECTION OF *IN SITU* POPULATIONS

Brown Tree-Snake Control and Interdiction Efforts

The CNMI DFW brown tree-snake interdiction program (i.e., BTS Program) strives to prevent the spread of the snake from Guam to the CNMI (Colvin *et al*. 2005). To meet this objective the BTS Program places a concerted effort into meeting a 90% inspection rate of high risk material at all CNMI ports of entry (both sea and air). The Saipan and Tinian seaports utilize cement containment barriers (Perry *et al*. 2001) in dock areas specifically designed to hold cargo and equipment in a "sterile" environment to facilitate inspections of shipped cargo. DFW intended to initiate construction of a containment facility at the Rota International Seaport in 2009 but this has been delayed due to lack of funds. At the Tinian and Saipan airports, specifically trained detector canines (i.e., "sniffer dogs") are employed to inspect aircraft and any related cargo inbound from Guam for “stowaway” snakes. Although the BTS program currently lacks funds to support a canine unit on Rota, this issue is being addressed. Additionally, the BTS Program implements substantial passive trapping effort to complement all port of entry operations in the CNMI.

To maintain its readiness to respond to credible snake sightings the BTS Program regularly sends staff to Guam for USGS Rapid Response Team Training and Refresher Courses, as funding permits. The CNMI DFW improves these rapid response capabilities by endorsing and utilizing a BTS awareness program that stresses the urgency of immediately reporting snake sighting to the proper officials.

Critical factors that could impact BTS program performance and effectiveness include: 1) budgetary shortfalls due to inflation; 2) an increase in transportation levels (both military and commercial) between Guam and the CNMI; 3) an increase in credible brown tree-snake sightings, which would require an increase in funding to cover personnel and equipment expenses; 4) a short fall in Guam-based USDA-Wildlife Services inspections of CNMI bound cargo, which would require an increase of CNMI inspection services incurring additional personnel and equipment expenses; and 5) an episodic event (e.g., typhoon or tropical storm) that would hamper Guam-based inspection and control, destroy CNMI equipment and/or control tools (traps, etc.), and create additional Guam-based cargo inspections in the form of relief goods and materials.

Control of Other Potential Predators and Avian Diseases

Various potential predators exist on the human populated islands of the CNMI, including rats, feral dogs and cats, and monitor lizards. To date the only control efforts implemented have been for feral cats on Rota; Black Drongo (*Dicrurus macrocercus*) control, however, has previously been investigated and tested on the same island (Lusk 1993, Worthington and Taisacan 1994, USFWS 2007).

Recent research on the Mariana Crow suggests that feral cat depredation is a source of mortality in juvenile and adult crows (Ha *et al*. 2010). Feral cats have also been reported to be important predators of Guam rails released on Rota and on Guam (USFWS 2009). The effect of cats, however, on other native forest birds in the Marianas is largely unknown. Currently, feral cats are found on all of the main inhabited islands of the archipelago and are also reported to occur on some of the northern islands (e.g., Sarigan, Agrihan). Cat control programs have been implemented for both the Mariana Crow and the Guam Rail on Rota, but island-wide control or eradication may likewise be necessary on other islands in the archipelago.

The Black Drongo, which ranges throughout south Asia, was introduced to Rota in 1935 by the Japanese South Seas Development Company as a form of insect control (Baker 1951). The species is known primarily as an insectivore that occasionally takes small birds (MacKinnon and Phillipps 2000, Robson 2000) and one record does exist documenting the predation of a Rota White-eye (Amidon 2000). The increase in drongo numbers on Rota, which appeared to coincide with the decrease in white-eyes on the island in the 1960s, led Craig and Taisacan (1994) to conclude that drongos factored significantly into the decline of white-eyes. However, prior work on Guam indicated that while they often harassed other birds, Black Drongos rarely depredate small passerines and were usually very tolerant to the close proximity of other, smaller birds while both foraging and nesting (USFWS 2007).

Habitat Protection and Management

A number of areas in the CNMI were set aside by legal means as protected areas to conserve and protect terrestrial and marine wildlife species (Berger *et al*. 2005). Of these, nine conservation areas have been established on Rota (three) and Saipan (six) specifically to protect terrestrial wildlife (Table 1; Figs. 2&3). Additionally, the four northern islands of Guguan, Asuncion, Maug, and Uracas (Fig. 1) have been designated by the CNMI as terrestrial conservation areas, to be maintained as "uninhabited places" and "used only for the preservation and protection of natural resources, including but not limited to bird, wildlife and plant species" (Berger *et al*. 2005). Asuncion, Maug, and Uracas are further protected within a 153,235.3 km^2 Marine National Monument (the Marianas Trench Marine National Monument) signed into law by the U.S. Federal Government in January 2009 (White House 2009). Regardless of the protections afforded, enforcement (especially on Rota and in the Northern Islands) is usually insufficient to non-existent because of a lack of local governmental funds necessary to support routine visits.

Various islands in the Mariana archipelago, including Aguiguan, Alamagan, Pagan, and Agrihan (Fig. 1), have been affected by feral ungulates and are in need of habitat restoration. Anatahan was populated by feral pigs and cattle (and still is to some degree) but the island's volcano erupted in 2005 making it unsuitable for species translocation in the foreseeable future (Fig 1). However, ungulate removal is currently ongoing.

The only island in the Marianas from which ungulates have been successfully removed for the purpose of habitat restoration is Sarigan (Fig. 1). Feral animals were introduced to this island at least as early as the 1930s, when between 10 and 20 families lived on the island; all human residents were removed after the Second World War (C. Kessler, USFWS, pers. comm.). Prior to eradication, the feral animals devastated the island's vegetation (Kessler 2002). To improve habitat for the endangered Micronesian Megapode (*Megapodius laperouse*), the CNMI DFW initiated an intensive US Navy and USFWS funded eradication program from 1998 through 2000 to rid the island of all feral goats, pigs, cats, and introduced rats (Kessler 2002). The island has now been free of ungulates since 1999 but rats and cats are still occasionally reported.

PREVIOUS CAPTIVE PROPAGATION EFFORTS

To date, two captive propagation related programs for bird species from the Mariana Islands have been undertaken: 1) the Guam Bird Rescue Project and 2) the Mariana Archipelago Rescue and Survey (MARS) Project. In addition, the recovery plans for the Mariana Crow (USFWS 2012) and the Rota White-eye (USFWS 2007) have identified the potential establishment of captive populations to support conservation efforts as a task needed to recover these species.

Guam Bird Rescue Project

Initiated in 1983 by the Philadelphia Zoo, National Zoo, Bronx Zoo, and Guam Division of Aquatic and Wildlife Resources (DAWR), this project focused on efforts to capture and establish captive populations of the native forest birds of Guam. Ultimately, the goal was the reintroduction of these species to Guam after the brown tree-snake had been controlled.

Through this project, 29 Guam Micronesian Kingfishers were captured in 1984 and 1986 (21 and 8 birds, respectively) and transferred to zoos in the continental Unites States for captive

Table 1. All protected areas with a terrestrial component on Rota and Saipan, CNMI (as per Berger *et al*. 2005; refer to Figs. 1 and 2 for locations).

Conservation Area	Location	Area (ha^2)	Type / Purpose
Sabana Heights Wildlife Conservation Area	Rota; Sabana plateau	1521	Terrestrial; for wildlife conservation
Mariana Crow Conservation Area	Rota; cliffs along eastern coast	444	Terrestrial; for wildlife and sea bird conservation and especially the Mariana Crow
Wedding Cake Mountain Wildlife Conservation Area	Rota; Taipingot Peninsula on southwest end of island	121	Terrestrial; for protection of all wildlife, plants and soils
American Memorial Park (AMP)	Saipan; At AMP just north of Garapan	16	Terrestrial; for protection of wildlife
Saipan Upland Mitigation Bank (SUMB)	Saipan; upland areas of Marpi region on north end of island, encompassing the Marpi Commonwealth Forest	424	Terrestrial; to provide “credits” for sale to developers as mitigation for the “take” of Nightingale Reed Warblers and for preservation of wildlife
Megapode Conservation Area	Saipan; upland area of Marpi region, north of the SUMBA	24	Terrestrial: for preservation of wildlife, especially Micronesian Megapode
Bird Island Wildlife Preserve	Saipan; lands on Saipan island to the west of Bird Island	114	Terrestrial; for preservation of wildlife
DLNR/DFW Lake Susupe Conservation Area	Saipan; parcel on northwest shore of Lake Susupe	6	Terrestrial; for preservation of wildlife
Kagman Wildlife Conservation Area	Saipan; lands on eastern side of Kagman Peninsula	173	Terrestrial; for preservation of wildlife

breeding before the species was extirpated from Guam (Bahner 1988, Hutchins *et al*. 1996). Initial efforts to breed the Guam subspecies in captivity were successful. However, once the captive population reached 60 individuals, mortality at all life stages increased and reproductive success decreased (Hutchins *et al*. 1996). One problem associated with reproductive success has been difficulty with forming successful breeding pairs. Fewer than half of the kingfisher pairs successfully produce offspring (Baltz 1998) and the sex ratio has consistently been skewed towards males since the late 1980’s (Hutchins *et al*. 1996).

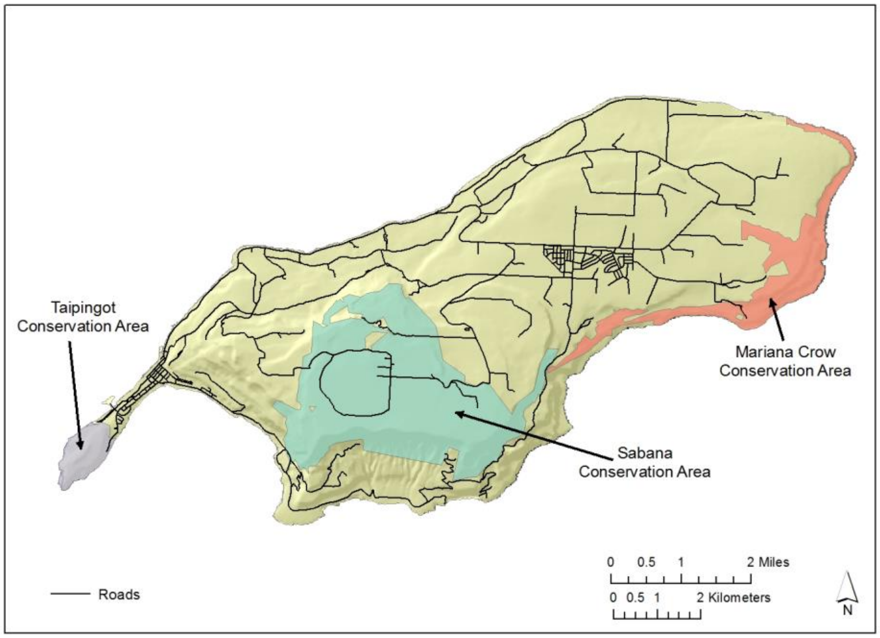

Figure 2. Established terrestrial conservation and protected areas on Rota, CNMI (refer to Table 1 for details).

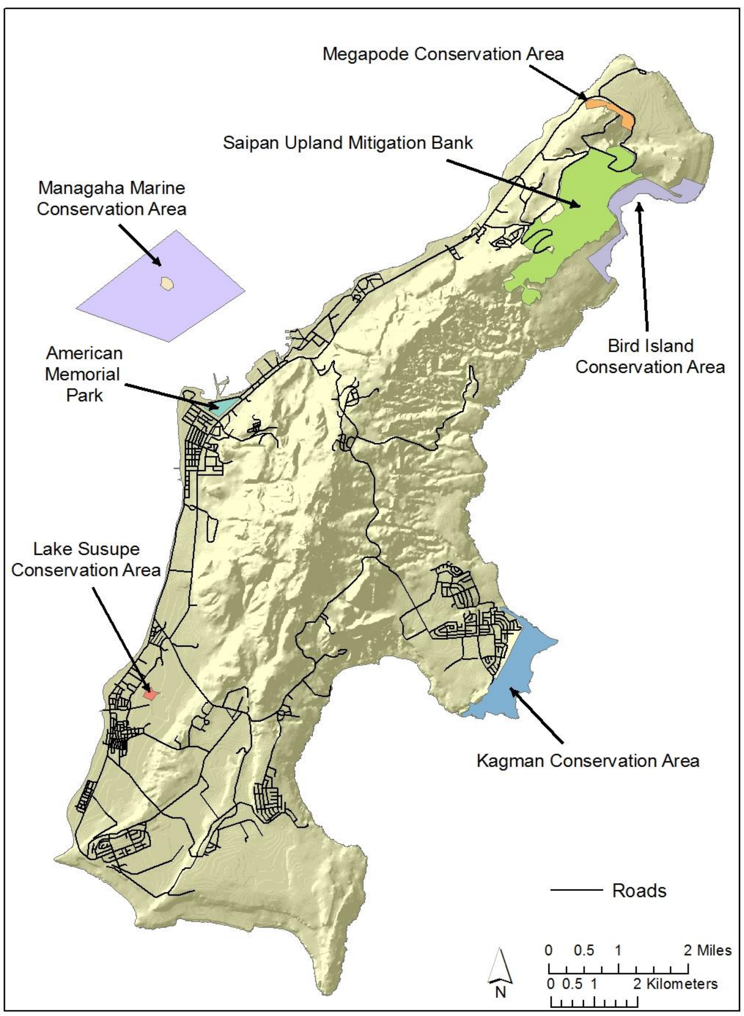

Figure 2. Established terrestrial conservation and protected areas on Saipan, CNMI (refer to Table 1 for details).

To deal with these and other problems, extensive efforts to increase the captive population and maintain genetic diversity of the Guam Micronesian Kingfisher, and address potential problems with the program as a whole have been undertaken (Hutchins *et al*. 1996, Bahner *et al*. 1998). In the last several years the results of many of these efforts have come to fruition as the captive population nears an early goal of 100 individuals. As of February 2007, the population consisted of 98 individual kingfishers in 14 captive breeding facilities, including a facility on Guam (Bahner and Bier 2007). Unfortunately the Guam subspecies still exists only in captivity and its successful re-establishment is still likely far in the future.

Twenty-one Guam Rails were brought into captivity (as eggs, chicks, and adults) between 1983 and 1986 (Table 2). Ten rails were transferred to the National Zoological Park's Conservation and Research Center and the Bronx Zoo in 1984, while the remainder stayed on Guam for captive breeding (Derrickson 1986). As of June 2008, there are approximately 158 Guam Rails in captivity on Guam and in mainland zoological institutions combined (Table 2; USFWS 2009). Captive propagation efforts for the Guam Rail have been very successful and experimental reintroductions were attempted on Guam in 1998 (16 rails released) and 2003 (46 rails released) (Beauprez and Brock 1999a; P. Wenninger 2008, Guam DAWR, pers. comm.). Efforts to establish an experimental population on the island of Rota have also been ongoing since 1989 (Table 2; Witteman and Beck 1990).

Table 2. Timeline of notable Guam Rail captive propagation and translocation efforts to Rota, 1983 – June 2008.

Date/Year	Notable Action or Milestone
1983 - 1986	21 rails (eggs, chicks, and adults) brought into captivity
1984	10 rails transferred to the National Zoo
1989	Establishment of a rail population on Rota initiated
1998	16 rails reintroduced to Guam
2003	46 rails reintroduced to Guam
June 2008	Total captive rail population reaches 158

Attempts to captive breed the Guam subspecies of the Bridled White-eye and Rufous Fantail, along with the Guam Flycatcher, were initiated in 1983 but abandoned in 1984 due to the virtual disappearance of these species in the wild (Beck 1984). One Guam Broadbill and Rufous Fantail were captured in 1983 but both died in 1984 (Beck 1984). Both species were last seen on Guam in 1984 and are now extinct (Wiles *et al*. 1995). No Bridled White-eyes were captured and this subspecies was last seen on Guam in 1983 (Beck 1984).

Marianas Archipelago Rescue and Survey (MARS) Project

The MARS project was initiated in 1993 to develop techniques to capture, acclimate, transport, and captive propagate Mariana Crows, Rota White-eyes, and Mariana Fruit Doves. The latter is not federally listed but is considered endangered by the IUCN because of its limited distribution and the introduction of the brown tree-snake. This project was a cooperative effort among the USFWS, the CNMI DFW, and nine AZA affiliated institutions: the North Carolina and National Zoological Parks, the Houston, Louisville, and Philadelphia Zoological Gardens, the Memphis Zoological Garden and Aquarium, and the Honolulu, San Diego, and St. Louis Zoos.

As part of the MARS project, 10 Mariana Crows (five males and five females) were collected from Rota in 1993 (seven birds), 1994 (one bird), and 1995 (two birds). Eight birds were transferred to the National Zoological Park's Conservation and Research Center and the remaining two were housed at the Houston Zoo. Nesting attempts were observed at both institutions but only the pair at the latter institution successfully produced offspring, one of which survived to adulthood. Based on the recommendations of the National Research Council, six of the crows were released on Guam in 1997 (NRC 1997), and the remaining three were kept in captivity (two birds at the Houston Zoo and one at the National Zoological Park's Conservation and Research Center). The pair of crows kept at the Houston Zoo continued to produce only unsuccessful clutches. Currently only two Mariana crows are in captivity in the mainland United States, both are males and both are held at the National Zoological Park's Conservation and Research Center (ISIS 2010). All six crows transferred to Guam were successfully released on Guam but only two survived to breed (DAWR 2003). Both birds are presumed dead and neither produced offspring.

The MARS project also collected 20 Rota White-eyes in 1993 (three birds) and 1995 (17 birds), only five of which were female. All of these birds were transferred to the National Zoological Park's Conservation and Research Center. As of November 2005, the captive population consisted of only six males; the last female died earlier that year (S. Derrickson, pers. comm. 2005). Of the six males, the last two survivors were eventually sent to the Memphis Zoo where they served in an educational exhibit until their deaths in 2010. Eggs were produced by three females but only two produced fertile eggs or offspring, and no parent-reared birds reached maturity. One male was successfully hand-reared and is currently part of the captive population at the National Zoo. Diet was found to be the principal challenge with rearing viable offspring as chick mortalities were related to abnormal bone development (S. Derrickson, pers. comm. 2005). However, efforts to manipulate calcium, vitamin levels, and ultraviolet light to address this problem were not successful.

Finally, 16 fruit doves were collected on Rota in 1993. Of the 16 birds collected, nine were males and seven were females (two males and one female from this original group are alive as of this writing). These birds were housed at the St. Louis Zoological Park, North Carolina Zoological Park, Philadelphia Zoological Gardens, and Memphis Zoological Garden and Aquarium. As of 1997, the captive population of wild caught fruit doves consisted of 17 individuals (nine males, six females, and two unknown). Eleven captive hatched Mariana fruit doves have been produced at two institutions (Memphis and Philadelphia) since 1996. Plans for collecting additional Mariana fruit doves to sustain the genetic integrity of the captive population were proposed in 1997. In 1998, 20 additional fruit doves were captured on Rota and added to captive stock, of which only five males survive. As of December 2003, there were 45 fruit doves in captivity in 14 institutions as a result of the MARS project. However, in 2006 the MAC Project collected 20 additional fruit doves from Saipan (of which seven males and four females survive) bringing the total current captive population of the species to 65 individuals held amongst 18 AZA institutions.

Guam DAWR Avicultural Intervention Plan

Concurrent with the early efforts of the MARS Project to propagate captive Mariana Crows, Guam DAWR implemented their own such effort in 1994. The intent of this plan was to avoid predation of crow eggs by brown tree-snakes while still allowing the natural parents to rear the chicks (USFWS 2005). Specifically, one egg was to be taken from each active nest on the island. These eggs were artificially incubated and the resulting chicks were initially hand reared at DAWR facilities before they were returned, pre-fledging, to their source nests (USFWS 2005).

Between 1994 and 2007, staff from DAWR pulled 43 eggs produced by active Mariana Crow pairs on Guam. Of the 43 eggs, 14 (33%) hatched in captivity and seven produced crows that were released on Guam in 1997 and 2005 (Guam Division of Aquatic and Wildlife Resources, unpubl. data). In 1994, one nestling was returned to the nest two days after hatching, but was found dead two days later. The necropsy report indicated the chick was in very good medical health and the cause of death was most likely due to falling from the nest (K. Brock, formerly of Guam Division of Aquatic and Wildlife Resources, unpubl. data). Another nestling was returned to the nest in 2003 but was found on ground 16 days later and brought back into captivity.

PREVIOUS TRANSLOCATION AND REINTRODUCTION EFFORTS

Efforts to translocate and reintroduce native birds in the Mariana Islands have focused on reestablishing Guam Rail and Mariana Crow populations on Guam and the establishment of an experimental population of Guam Rails on Rota. In addition, the recovery plans for the Mariana Crow (USFWS 2012), the Nightingale Reed-warbler (USFWS 1998a and 2010b), and the Rota White-eye (USFWS 2007) have identified reestablishing populations on islands where the species was extirpated as goals for the long-term conservation of these species.

Guam Rail Translocation and Reintroduction

As of June 2008, 918 Guam Rails were released on Rota as part of an effort to establish an experimental population on that island (Witteman and Beck 1990; Beck 1991; Brock and Beck 1995; Beauprez and Brock 1996; 1997; 1998; 1999b; Medina and Aguon 2000, p. 176; P. Wenninger 2008, Guam DAWR, pers. comm.). Breeding has been documented and Guam Rails have been observed several years post-release in some regions of the island (P. Wenninger 2008, Guam DAWR, pers. comm.). In 2007, approximately 60 to 80 rails were believed to be persisting in the Duge and Apanon areas of Rota (P. Wenninger 2007, Guam DAWR, pers. comm.). Additional releases and intensive cat control, however, are needed as cat predation is believed to be the primary factor preventing the establishment of a self-sustaining population on the island.

In addition to releases on Rota, there have been two releases of Guam Rails on Guam since the species was listed. In 1998, 16 rails were released in “Area 50” in northern Guam (Beauprez and Brock 1999a). A temporary brown tree-snake barrier was constructed around Area 50 and snake populations within were reduced through management and control. Breeding by rails was documented; however, the small population was believed to have been extirpated by feral cats and other predators (Beauprez and Brock 1999a). In 2003, 44 Guam Rails (some of which were radio-tagged) were released in a snake-reduced area of the Northwest Field Naval Munitions Area on Andersen Air Force Base (P. Wenninger 2008, Guam DAWR, pers. comm.). Of the rails released with radio transmitters attached (*n* = 26), over 80% were preyed on by feral cats (P. Wenninger 2008, Guam DAWR, pers. comm.). Efforts to reduce cat predation were limited due to difficulty obtaining approval to control cats in the area. No native rails are believed to be persisting in the wild on Guam at this time (P. Wenninger 2008, Guam DAWR, pers. comm.).

Mariana Crow Translocation

In 1995, Guam DAWR proposed to translocate a Mariana Crow chick from Rota to Guam to facilitate the social development of captive-reared chicks resulting from DAWR's avicultural intervention plan (USFWS 2005). It was further suggested to move individual nestlings from Rota to Guam to supplement the latter's declining population (USFWS 2005).

Between 1999 and 2003, 13 nestlings and 14 eggs were collected from nests on Rota and brought to Guam for captive rearing and eventual release (USFWS 2012). Of the 13 nestlings, 12 (92%) were successfully raised and released on Guam. Of the 14 eggs, 10 (71%) hatched and four of the nestlings produced were likewise eventually released on the island. One of the remaining captive hatched nestlings had physical deformities and was considered non-releasable while the other five died in captivity. In addition, one adult and one juvenile Mariana Crow were confiscated on Rota by the USFWS and transferred for release on Guam in 1999 (USFWS 2012).

Eighteen crows (10 Males and eight females) were translocated from Rota and released on Guam as part of this DAWR program (DAWR 2004). The last known, surviving crow (a male named Kahit) from this effort was most recently observed in the Munitions Storage Area (MSA) at Andersen Air Force Base, Guam, on 19 July 2011 (N. Johnson, SWCA Environmental Consultants, Guam, pers. comm. 2012); this bird has not been seen since. The last known detection of a crow on Guam was in the same area on 16 August 2011, and was presumably the same bird (N. Johnson, SWCA Environmental Consultants, Guam, pers. comm. 2012). It is uncertain whether this bird still persists on Guam.

Prior to this, in October 2008, Kahit had been seen with another male (Taksunok) in the MSA, the last time the latter bird had been detected (SWCA 2008, J. Quitugua, Guam DAWR, pers. comm. 2012). Five other crows had last been seen in the area in mid-September of the same year (SWCA 2008, J. Quitugua, Guam DAWR, pers. comm. 2012). After October 2008, the military implemented further restrictions to the MSA and DAWR staff could not enter to monitor the crows. The fate of all other birds released on Guam is unknown (SWCA 2012, J. Quitugua, Guam DAWR, pers. comm. 2012) but with the disappearance of Kahit the species is likely extirpated from the island.

MAC PLAN PROJECT PROPOSAL

CONSERVATION PRIORITIES

In response to the threat of the brown tree-snake to its native bird populations, the CNMI has determined that a regional conservation effort is necessary to protect these species. This endeavor will incorporate existing conservation efforts related to the brown tree-snake and native bird populations, and will likewise identify additional actions to safeguard the native species of the CNMI. Preventing the establishment of the brown tree-snake on the islands of Tinian and Rota, and eradicating snake populations established on Saipan, are key components to the success of this effort.

This project is intended to provide the avifauna of the Mariana archipelago with the best possible chances for long-term survival, with the objectives of preserving, maintaining, and establishing self-sustaining populations of native birds secure from the threat of the brown tree-snake. To rapidly address this threat, the CNMI has asked institutions with the AZA for assistance with long-term conservation efforts aimed at protecting native avifauna on Saipan, Tinian, and Rota. The CNMI has specifically requested the following assistance:

- Development of techniques to capture, acclimate, hold, transport, and breed in captivity all of the bird species found in the CNMI.
- Establish captive populations of selected species that can be used as a source population for possible reintroduction back to Guam or Islands in the CNMI where brown tree-snakes have been controlled or eradicated.
- Translocate birds to islands in the Mariana archipelago that are free of the brown tree-snake to establish self-sustaining, satellite populations.
- Identify when additional populations, either captive or wild, should be established.
- Develop public education programs that will assist the conservation of local avifauna.
- Develop a fund raising program to assist conservation efforts.

Priorities for conservation will be determined and set through cooperation between the CNMI and the USFWS. CNMI biologists will take the lead on all species that are not U.S. federally listed, while the USFWS will be responsible for those that are. The focus of combined efforts will be species that are locally or federally listed and/or species that have very limited distribution (Table 1). Representatives from the CNMI, USFWS, and AZA will cooperate to establish long-term project direction and will revise the MAC Plan as needed to reflect changes in the project's direction.

CAPTIVE PROPAGATION

In general, the ultimate goal of a captive propagation program associated with endangered species conservation is the prevention of species extinction by sustaining, enhancing, or reestablishing wild species populations (Olney *et al*. 1994, Seal 1986). To this end, successful avian captive propagation programs should strive for at least three methodological goals: 1) the creation of viable, self-sustaining captive populations; 2) the maintenance of a diverse, healthy gene pool, which is especially important during periods of high risk; and 3) the production of species for reintroduction into their native habitat and range (Gee 1995).

Conservation Significance for the CNMI

The management, maintenance, and propagation of species in captivity will serve as insurance populations against: 1) extinction of the species on Saipan, Tinian and/or Rota as a result of introduction of the brown tree-snake; and 2) the long-term failure of the conservation introduction program. If satellite populations for any species established in the Mariana archipelago fail to be self-sustaining or otherwise fail as a result of unforeseen stochastic events inherent to the region (e.g., volcanic eruption, typhoon, etc.), populations of those species will exist and be perpetuated at AZA affiliated institutions on the U.S. Mainland. In the case of extinction resulting from brown tree-snake introduction, captive populations would serve as a source for later species re-introduction efforts after the brown tree-snake is eradicated from affected islands in the CNMI.

Ultimately, captive propagation serves to round out conservation introduction as a conservation and management tool. Captive management programs provide the conservation biologist with an opportunity to learn more about a given species and develop captive techniques that may aide in its conservation. Not only does propagation help to insure against failed satellite population establishment, it also serves as an effective marketing tool for solid public relations. Birds held and propagated at AZA affiliated institutions are intended to serve as important ambassadors for the MAC Project, introducing the CNMI's avian conservation issues to a broad audience of potential supporters on the U.S. mainland, if not the world.

Advantages and Disadvantages

Captive propagation has the advantage of bypassing the initial high-risk stage of an individual's life history in the wild and can aid species populations to more readily expand in size (Derrickson and Snyder 1992, Maxwell and Jamieson 1997). It can also increase the overall productivity of birds because removal of eggs or young from parents may induce repeated breeding attempts (Derrickson and Snyder 1992, Maxwell and Jamieson 1997). Captive propagation, however, can lead to lower recruitment rates into breeding populations as experience-based, species-typical behavioral patterns are seldom stimulated in captive situations, leaving some captive bred animals unable to cope with their natural environment (Hutchins *et al*.1995, Snyder *et al*. 1996, Maxwell and Jamieson 1997).

MAC Project Captive Propagation Efforts to Date

The MAC Project has targeted six species for which to develop captive management techniques, all of which have been brought into captive management at more than 20 AZA affiliated institutions to date (Table 3). These species are locally protected and not currently Federally listed as Threatened or Endangered (i.e., T&E). If necessary, and if requested by the USFWS, the MAC Project is willing to likewise develop captive management techniques and protocol for the three listed Endangered Species discussed elsewhere in this plan; Mariana Crow, Nightingale Reed-warbler, and Rota White-eye. Further information pertaining to husbandry protocol and techniques for the six target species is included in the species profiles in Appendix B.

Table 3. The current status of captive propagation efforts by CNMI species at AZA affiliated institutions on the U.S. mainland.

Species	**Year Program Initiated**	**Current No. of Zoos**	**Current Pop.**	**Target Pop.**
Mariana Fruit Dove	1993	18	65	100
White-throated Ground Dove	2006	15	68	75
Rufous Fantail	2009	2	4	50*
Tinian Monarch	2009	1	3	50*
Bridled White-eye	2006	4	30	200
Golden White-eye	2007	6	41	100

*Feasibility yet to be determined

As detailed previously, the Mariana Fruit Dove captive program was originally initiated in 1993 under the now defunct MARS Project and was taken over by the MAC Project in 2006. With 20 additional fruit doves captured under the MAC Project in 2006 there are currently 65 in captivity at 18 institutions (Table 3). The Mariana Fruit Dove is a relatively difficult fruit dove species to breed in captivity and some wild caught individuals never completely adapt. This leads to a lack of breeding. Fruit doves can be selective in terms of mate choice and birds may have to be re-paired several times before finally accepting a mate. In addition, the species is somewhat territorial and can be aggressive toward other similar sized dove species.

The current captive population of fruit doves has a skewed sex ratio of 42 males to 23 females. Thus, the AZA has recommended that 10 additional wild caught females be added to the population to better increase genetic diversity and help gender balance the population. This population has been relatively stable, however, fluctuating between 60-70 birds. The MAC Project has set goal of 100 fruit doves (Table 3) as the optimum number to maintain a secure captive population (which is managed by Herb Roberts, Memphis Zoo).

The MAC Project began the White-throated Ground Dove captive program in 2006. The establishment of the current founder population was achieved through three capture events on Saipan, with 14 doves caught in 2006, two in 2007, and five in 2008. Unlike fruit doves, White-throated Ground Doves breed readily in captivity. The largest obstacle thus far to their captive management is inter-specific aggression by ground doves towards other columbids, which tends to limit available housing space at cooperating AZA institutions. After a very successful breeding record the current captive population for the species is 68 individuals held at 15 institutions with a target population of 75 (Table 3). To maintain genetic diversity and to address a sex ratio imbalance the AZA has recommended bringing six additional wild caught females into captivity. To achieve the MAC Project’s goals for the species, recruiting additional holding zoos will be critical to maintain a White-throated Ground Dove population (which is managed by Gary Michael, Louisville Zoo) in captivity long term.

The Rufous Fantail captive program (Table 3) was initiated in 2009 when four birds from Saipan were brought into captivity at the Honolulu Zoo. In both 2010 and 2011 an additional 12 birds were captured and housed at three AZA institutions. These 24 fantails suffered high mortality during quarantine periods at their respective zoos and it was determined that the majority of deaths was caused by metabolic issues (symptoms suggested a deficiency of vitamin D or E). Veterinarian advisors with AZA are developing protocols to improve MAC Project captive diets during the acclimation period. Currently, the captive population of Rufous Fantails consists of two birds held each at Honolulu Zoo and Riverbanks Zoological Gardens, Columbia, South Carolina. The Rufous Fantail is very territorial and contending with social spacing is critical to its captive management. Thus, a small number of additional birds will be brought into captivity for continued refinement of basic husbandry.

The MAC Project began the Tinian Monarch captive program (Table 3) in 2009 when 24 birds were captured and placed in six AZA institutions. Although an additional 23 birds were brought into captivity in 2010, only three birds remain in captivity and all are housed at Memphis Zoo. The Tinian Monarch is very territorial and has proven to be an avicultural challenge. Birds kept in isolation have fared well, while those placed in close proximity to one another usually died within a short period of time. Mortality in these situations has been attributed to stress related complications (e.g., aspergillus infection). This species requires isolation until they are well acclimated to captivity, after which males and females are slowly introduced. To facilitate this approach male enclosures are set up first, with females later placed in adjoining enclosures. Once pairs are established they will be kept together for a full year. Thus far, the Memphis Zoo has experienced nest building by Tinian Monarchs but no eggs have been laid. The MAC Project will capture a small number of monarchs to further refine avicultural techniques.

The target captive population for the Rufous Fantail and Tinian Monarch is at least 50 birds each (Table 3), although the feasibility of this number is yet to be determined. Due to the extreme territoriality of these species, determining space needs is critical to prevent high mortality. Captive management protocols are currently being developed for both species. If during this process it is determined not practical to maintain captive populations of the Rufous Fantail and Tinian Monarch, emphasis will be placed on their translocation instead. Both of these species are managed by Peter Luscomb of Pacific Bird Conservation

The Bridled White-eye captive program began in 2006 when 38 birds were captured on Saipan and distributed between two AZA institutions. In 2010, 30 additional birds were captured on Tinian and placed in three additional zoos; the current captive population is 30 birds held among four AZA institutions with a target population of 200 (Table 3). The Bridled White-eye has proven easy to maintain in captivity but difficult to breed with only two young hatched at one institution and a clutch of fertile but unhatched eggs in another. In response, the Toledo Zoo initiated research to determine the cause of low reproductive success and to establish guidelines for breeding the species in captivity. After this institution shares its findings (which are forthcoming) the MAC Project will capture additional wild birds to determine if a successful captive breeding environment can be created for the species.

The MAC Project brought the Golden White-eye into captive management in 2007 with a starting population of 24 birds and an additional 24 added in 2008; there are currently 41 Golden White-eyes held among six AZA institutions (Table 3). The species is easy to maintain in captivity, but individuals have exhibited significant aggression toward other species when housed in communal aviaries. Golden White-eyes have bred successfully at four institutions, and as knowledge is acquired pertaining to the species' captive breeding requirements, more institutions will be recruited to house additional populations. The target population for the species is 100 birds, a goal that will require at least six additional institutions and likely two more capture events over the next 10 years. Both Golden White-eyes and Bridled White-eyes are managed by Anne Tieber, St. Louis Zoo.

TRANSLOCATION / CONSERVATION INTRODUCTION

Translocation is the action or process of intentional and planned release of plants or animals to the wild to establish, re-establish, or augment a population (Griffith *et al*. 1989, IUCN 1996, Wolf *et al*. 1996, Pierre 2003). Perhaps more accurately relative to the CNMI, translocation can be used to remove a species from an overwhelming local threat or to create a satellite population on another island where it may be safe from extinction by an introduced predator (Griffith *et al*. 1989, IUCN 1996, Clarke and Schedvin 1997, Whittaker *et al*. 2007). In a sense, the long-term intent of such an action is to create genetic reserves for native species whose source populations are potentially threatened with extinction. Such translocation of rare, native species can be quite costly and can be subject to intense public scrutiny (Griffith *et al*. 1989).

Conservation Significance for the CNMI

Translocations of small numbers of endangered, threatened, and sensitive species, even to areas of excellent habitat quality, tend to have low chances of success (Griffith *et al*. 1989). Thus, sources (e.g., Griffith *et al*. 1989, Ballou 1993) assert that translocation be considered long before it becomes a last resort for such species—before densities (and thus genetic diversity) become low and populations enter a state of decline. With the possible establishment of the brown tree-snake on Saipan, and the increased threat of the species' establishment on Tinian and Rota, it is important that secondary or satellite populations of potentially vulnerable bird species be established in areas determined to be safe, preferably before the genetic diversity of these populations decreases. (Work by Reynolds *et al*. [2008, 2011] does indicate, however, that low genetic diversity in donor populations may not affect the ultimate success of translocation of some island species).

The Bridled White-eye was introduced/translocated from Saipan to Sarigan in 2008, with a follow up translocation from Tinian to Sarigan in 2009 (Radley 2008 and 2009). Because of its abundance the species was used as a research model for testing and developing translocation techniques and protocols that will be applied to six other locally and federally threatened and endangered avian species of limited range and under threat by the brown tree-snake in the Northern Mariana Islands (MAC Working Group 2008, Radley 2008 and 2009; Table 4). Some of these species have been given high alert status by the IUCN (2012) and are included in Table 4 (although the Mariana Crow is included in the table, it is currently not being considered for translocation by the MAC Project; refer to *Proposed Conservation Introduction Scenarios*, p. 29).

Table 4. Current range in the Mariana archipelago, and IUCN Alert Status (IUCN 2012), for forest landbird species of concern (those given status of Vulnerable [VU] or higher) in the CNMI. All but the Mariana Crow are considered within this plan for translocation by the MAC Project.

Species	Current Range in the Marianas	IUCN Alert Status
Mariana Fruit Dove	Rota, Aguiguan, Tinian, and Saipan	Endangered (EN)
Rufous Fantail	Rota, Aguiguan, Tinian, and Saipan	Least Concern (LC)
Tinian Monarch	Tinian	Vulnerable (VU)
Mariana Crow*	Rota	Critically Endangered (CR)
Nightingale Reed-warbler	Saipan and Alamagan	Critically Endangered (CR)
Rota White-eye	Rota	Critically Endangered (CR)
Bridled White-eye	Aguiguan, Tinian, and Saipan	Endangered (EN)
Golden White-eye	Aguiguan and Saipan	Critically Endangered (CR)

* = not currently considered for translocation by the MAC Project

Advantages and Disadvantages

When considering release programs of threatened and endangered species, translocation of wild caught birds is generally more successful than release of captive reared (e.g., Griffith *et al*. 1989, Snyder *et al*. 1994). However, sources (e.g., Griffith *et al*. 1989, Lovegrove 1996, Veltman *et al*. 1996, Wolf *et al*. 1996 and 1998) also conclude that translocations are ineffective or fail when too few individuals, with an unbalanced sex ratio, are released. Veltman *et al*. (1996) also indicates that introduction effort (i.e., repeated translocations over time of a species to a given location) and management by humans also played a crucial role in translocations of various species of bird in New Zealand and the world over.

Reviewing the success of 45 separate releases of Saddlebacks (*Philesturnus carunculatus*) between islands in New Zealand, Lovegrove (1996) concluded that one of the primary reasons for failure was that too few birds, with an unbalanced sex ratio, were translocated and released. All releases of 15 or more birds on islands lacking predators were determined to be successful (i.e., resulted in self-sustaining populations of the target species), at least in the short term—in some cases predators arrived later and then became an issue (Lovegrove 1996). Between October and November 2001, 31 Seychelles White-eyes (*Zosterops modestus*) were translocated from the island of Conception to the island of Frégate in the Seychelles (Rocamora *et al*. 2002). The capture methods employed (i.e., the use of tape playback, which attracted more male than female) resulted in a skewed sex ratio of 21 males to 10 females (Rocamora *et al*. 2002, Hardcastle 2005, J. Hardcastle, TNC, pers. comm.). Interestingly, though, Rocamora at al. (2002) reported in May 2002 a breeding population of 40 to 45 white-eyes on Frégate that exhibited the highest success and productivity figures ever recorded for the species (66% of breeding attempts were successful with 0.71 young fledged per breeding adult). Nonetheless, an additional six females were captured and introduced to Frégate in 2003 to help correct the skewed sex ratio (Rocamora *et al*. 2003).

In early October 2004 and 2005 a total of 42 Laysan Teal (*Anas laysanensis*) were translocated from Laysan to Midway Atoll, northwest Hawaiian Islands (Reynolds *et al*. 2008). The sex ratio of 20 birds translocated in 2004 was discovered to be heavily skewed towards males (14:6) but was improved with 22 individuals added to the Midway population in 2005 (10:12) (Reynolds *et al*. 2008). With 17 of 18 females attempting to nest, and an effective population of 13 females, 67 juveniles survived to fledge from 46 nests in the first two breeding seasons (Reynolds *et al*. 2008). Despite being skewed towards males and exhibiting a relatively low effective population, between 2007 and early 2010 the Laysan Teal population on Midway Atoll was estimated to have increased 91% from 247 (95% CI, 233-260) to 439-508 (Reynolds *et al*. 2011).

In a survey of 134 avian translocation efforts worldwide between 1973 and 1986, Griffith *et al*. (1989) indicated that releases of 40 or more birds into good quality habitat generally resulted in self-sustaining populations. Griffith *et al*. (1989) also suggested that increases in success associated with the release of larger numbers of birds became asymptotic; releases of greater than 80 to 120 birds did little to increase translocation success. Phylogenetically based, partial reanalysis of data in Griffith *et al*. (1989) indicated that the number of animals released remained a consistent factor in the success of translocation programs irrespective of analytical technique (Wolf *et al*. 1998). Although populations have been established from small numbers of translocated animals, adverse demographic and environmental stochastic effects are indeed more prevalent in smaller populations (Wolf *et al*. 1998). The minimum viable number of animals released, however, will be dependent upon the unique circumstances surrounding each translocation effort (Wolf *et al*. 1996).

MAC Project Translocation Efforts to Date

Since 2008 the MAC Project has successfully executed four translocations to the Northern Island of Sarigan (Table 5). In May 2008, 50 Bridled White-eyes were introduced to Sarigan from Saipan followed by 50 more from Tinian in 2009 (Table 5; Radley 2008 and 2009). This second translocation was undertaken only after the 2008 effort was determined to be successful (Table 5; Radley 2009).

In 2010 and 2012, point-transect distance surveys for Bridled White-eyes on Sarigan indicated that the population was well established and growing (Table 6; Radley 2012). The 2010 surveys yielded 32 detections from 41 stations (mean = 0.78 detections per station; range = 0 – 8) for which program Distance 6.0 (Thomas *et al*. 2009) was employed to estimate a density of 1.3 birds/ha (95% CI 0.4 – 2.8) and an abundance of 77 – 495 (mean = 234.2) individuals (Table 6). Surveys in 2012 produced 108 detections from 24 stations (mean = 4.5; range = 0 – 9) in 179 ha of forest, an 82.7% increase in mean detections from 2010 to 2012. Density in 2012 were estimated at 16.8 birds/ha (95% CI 10.6 – 24.8) with an abundance of 1897 – 4302 (mean = 3004.5) individuals (Table 6). This represented more than a 12 fold increase in both density and abundance from 2010 to 2012.

Table 5. Translocation of Bridled White-eyes, Golden White-eyes, and Mariana Fruit Doves to Sarigan, CNMI, 2008 through 2012.

Year	Species	No. Translocated	Source Island
2008	Bridled White-eye	50	Saipan
2009	Bridled White-eye	50	Tinian
2010	*No Translocation Executed*		
2011	Golden White-eye	24	Saipan
2012	Golden White-eye Marianas Fruit Dove	50 10	Saipan Saipan

Table 6. Density (D) and Abundance (N) estimates for point-transect distance surveys conducted for Bridled White-eyes on Sarigan, 2010 and 2012.

Year	Estimates	Lower 95% CI	Upper 95% CI
2010	D = 1.3/ha N = 234.2	0.4 77.0	2.8 495.0
2012	D = 16.8/ha N = 3004.5/ha	10.6 1897.0	24.0 4302.0

In 2011 and 2012, the MAC Project translocated 74 Golden White-eyes and 10 Mariana Fruit Doves to Sarigan (Table 5; Radley 2011). The Mariana Fruit Doves were translocated in 2012 to help enhance a very small founder population of the species that managed to self-colonize the island prior to 2006 (Martin *et al*. 2008). Post-translocation monitoring in 2012 revealed that birds from the previous year's translocation effort had both bred and dispersed across suitable habitat on Sarigan (Radley 2012).

Avian Pathogen and Disease Assessments

Disease, which has a profound influence upon individual fitness, plays a major evolutionary role in the maintenance of biodiversity (May 1988, Scott 1988, Cunningham 1996). The effects of disease on one species can impact others by direct or indirect interactions, a consequence that may be amplified in a small island community of avian populations (Cunningham 1996). Thus, apart from the immediate effects on individual species, the introduction of an exotic (i.e., non-endemic) disease may have broad, long-term, and unforeseeable effects upon an entire ecosystem (Cunningham 1996).

The exposure of species to exotic diseases and pathogens is a critical issue that is often encountered when *ex situ* conservation measures (i.e., conservation introduction or translocation) are undertaken (Thorne and Williams 1988, Woodford and Rossiter 1996, Silva-Knott *et al*.

1998, Leighton 2002). Not only is there a risk of introducing a disease, but the same population may be exposed to pathogens and parasites at the translocation site that may pose a serious detriment to the entire translocation and conservation effort (Cunningham 1996, Woodford and Rossiter 1996, Leighton 2002).

As disease is an inherent part of translocation programs (as well as captive breeding and reintroduction programs), quantitative assessments disease risk is an important part of developing such conservation strategies (Ballou 1993). A number of sources (e.g., Cunningham 1996, Ballou 1993, Woodford and Rossiter 1996, Leighton 2002) recommend that individual animals intended for translocation be screened for pathogens and necropsies be performed when possible. In June 2007, the MAC team issued a letter of inquiry (which included copies of all known literature pertaining to avian disease in the Mariana Islands; i.e., Silva-Knott *et al*. 1998, Savage *et al*. 1993, and Fontenot *et al*. 2006) to the USFWS's Avian Disease Recovery Working Group (ADRWG) for recommendations pertaining to disease testing in the Northern Mariana Islands. The letter contained three specific concerns relative to the translocation needs of the MAC project:

1. What diseases does the Working Group believe would present the greatest cause for concern on behalf of the MAC Project's planned translocation work? To stay within a reasonable frame of both time and cost, the MAC Project is looking for something akin to a list of the top five diseases for which surveying should be considered.
2. What would the Working Group recommend as detection methods to be used for the suggested target pathogens?
3. Given the nature of translocation plans, would the Working Group recommend testing equally the donor (Saipan) and recipient (Sarigan) populations, or focus testing specifically on the donor population?

Given the lack of knowledge of wildlife diseases in the Marianas, the ADRWG asserted that the greatest known risk to the endemic avifauna of Saipan (along with Rota and Tinian) is the brown tree-snake, not disease. The ADRWG further suggested that the priority of the MAC Project at this point be placed on determining how to 1) safely translocate birds to Sarigan and other islands, or in lieu of this 2) minimize the damage that the brown tree-snake can cause to the native avifauna of Saipan, and 3) implement an effective monitoring program on Sarigan to gauge the success of translocations and to follow up on mortalities to determine their cause.

While the priority should be the establishment of redundant populations, the ADRWG also recommended that all captured birds be screened and appropriately treated for internal and external parasites as warranted. Some members of the working group, however, felt that unless known parasites of pathological importance were encountered, prophylactic treatments could be counter-productive by disrupting the gut flora of healthy birds.

As no data exist on endemic diseases in the Mariana Islands, the ADRWG felt it would be useful to run routine, non-invasive diagnostic tests on all future captured birds to establish baseline values for Saipan's avifauna to help target any proposed anti-parasite and bacterial treatments. The guidelines of the ADRWG will be followed and birds scheduled for translocation will either be 1) treated for a detected disease prior to translocation, or 2) excluded from translocation and released at the place of capture after treatment, as needed. The second approach will be taken if the seriousness of the disease detected during screening warrants it.

The overall objective of the MAC Project's veterinary team will be to perform disease and health assessment and provide veterinary and triage care, as needed, during the capture, transport, and translocation of focal avian species. The veterinary team's primary role in MAC Project is to work with captive species managers to develop husbandry and management protocols that minimize mortality, maximize the longevity of species in captivity, and maximize reproduction to ensure self-sustaining captive populations.

Post Translocation Monitoring

Post-translocation/release monitoring is an integral component of translocation based conservation management (e.g., Scott and Carpenter 1987, IUCN 1996, Sarrazin and Barbault 1996, Woodford and Rossiter 1996, Fisher and Lindenmayer 2000, Pierre 2003). Monitoring of released individuals all too often does not occur, leading to the unknown status and fates (and causes thereof) of many translocated populations (Wolf *et al*. 1996, Woodford and Rossiter 1996, Fisher and Lindenmayer 2000, Pierre 2003). This lack of data and necessary documentation in turn leads to poor understanding of variables affecting the success or failure of translocation efforts, providing no information on which to base future decisions and methodological adjustments (Scott and Carpenter 1987, Woodford and Rossiter 1996, Clarke and Schedvin 1997).

Appropriate post-translocation monitoring will be executed after each translocation event. The duration and timing of monitoring will depend upon the amount of available funds, the availability of aircraft and pilots at the CNMI's sole helicopter transport agency, *Americopters Inc*., and the distance of the target island from Saipan (*Americopters'* base in the CNMI). It is possible to land small, fixed wing aircraft on Pagan via a short, rough dirt airstrip. This will be used if possible and as necessary to facilitate not only translocations to that island but also to Alamagan, Agrihan, and Asuncion (Fig. 1); the latter two are north of Pagan and prohibitively distant from Saipan for access by helicopter.

To facilitate monitoring, radio-transmitters, serially numbered aluminum leg bands, and color bands will be employed as necessary (for identification purposes, all birds will be both number and color banded prior to translocation). In most cases post-translocation monitoring may consist of radio-tracking tagged birds, searching for and identifying color banded individuals, searching for nests and unbanded juveniles or other individuals, and assessing established populations through point-transect distance surveys (providing data for analysis in Program DISTANCE [Buckland *et al*. 2004, Thomas *et al*. 2009]), or other suitable survey and analysis methodologies.

SUITABILITY OF NORTHERN MARIANA ISLANDS FOR CONSERVATION INTRODUCTION

ISLAND CHARACTERISTICS

Saipan, Tinian, and Rota, all of which will serve as the source populations for translocation efforts, are by no means pristine oceanic island ecosystems. These three islands, which constitute a large portion of the southern arc of the Mariana Archipelago, are volcanic in origin but are all nearly covered with uplifted limestone from ancient coral reefs (Table 7; Berger *et al*. 2005). The covering limestone creates a flat, "layer-cake" topography with numerous caves both above and below sea level. These three islands (along with Guam and Farallon de Medinilla) exhibit the oldest and most developed reefs in the Mariana Islands, all of which are generally most developed on the western (i.e., leeward) sides of the islands, and some of which protect white sand beaches (Berger *et al*. 2005).

Apparently populated by migrants from Indonesia approximately 5000 years ago, the prehistoric landscape of the Marianas was mostly wooded with scattered villages and gardens (Bowers 2001). The sea was an important source of food and the settlements were mostly located near shore, with any smaller interior villages situated along main, well-traveled pathways (Bowers 2001).

The Marianas first became known to the western world when Megellan discovered them on 6 March 1521, eventually making landfall on what is now Guam (Engbring *et al*. 1986, Bowers 2001). Over the following centuries, before coming under U.S. rule after the Second World War, Saipan, Tinian, and Rota fell under the administrations of and colonization by Spain, Germany, and Japan, respectively. Through this succession of cultural occupations of the three islands came various landscape, floral, and faunal modifications on each, including the introduction of exotic species of plants and animals and various domesticated livestock (Bowers 2001). The Japanese, however, brought about a complete change in the landscape of the three islands by clearing all arable land of native forest, plotting them to fields, and planting most with sugar cane (68% of arable land on Saipan, 80% on Tinian, and 33% on Rota), converting each island primarily to sugar plantations (Engbring *et al*. 1986, Bowers 2001).

The landscape of Saipan, Tinian, and Rota was further altered with the onset of Japanese military preparations during the Second World War, with the clearing of land for airfields, infantry barracks and other military installations and infrastructure (Bowers 2001). The U.S. assault on the Marianas began with Saipan on 15 June 1944, followed by Tinian and then Guam; Rota was bypassed by direct military invasion but was shelled and bombed heavily (Engbring *et al*. 1986, Bowers 2001). As a result of the U.S. invasion, which was preceded by heavy aerial bombardment and naval shelling, Saipan and Tinian were virtually denuded with only tiny pockets of native forest remaining intact (Engbring *et al*. 1986). Despite sever depletion of many populations of birds during the war, none are known to have become extinct as a result of it (Engbring *et al*. 1986).

Table 7 presents a breakdown of pertinent details of all islands in the Mariana archipelago except Guam. Although early translocation efforts have been focused on Sarigan (MAC Working Group 2008, Radley 2008, 2009, 2011, and 2012), five other islands will be considered as future destinations for further efforts; Guguan, Alamagan, Pagan, Agrihan, and Asuncion (Table 7). Anatahan is currently not included in the list of target islands because a devastating eruption in 2005 caused extensive habitat destruction and denuding. Maug has been excluded from consideration because of its distance from Saipan, its difficulty of access, and its limited area of appropriate habitat. Factors to consider in relation to alternative islands include associated logistics and costs incurred with increasing distance from the source islands, and the presence and abundance of suitable habitat (dependent upon species to be translocated), a factor

Table 7. Morphological, physiological, and demographic characteristics of islands of the Commonwealth of the Northern Mariana Islands (Berger *et al*. 2005).

Island	Lat/ Long	Area (sq. km)	Nat Forest (ha)	Coco. Forest (ha)	Mix. Forest (ha)	Other Forest (ha)	Total Forest (ha)	Human Pop.	Feral Animals	Volc. Active	Notes
Maug	20° 01' N 145° 13' E	2.1	-	-	-	-	-	0	No	No	No historical eruptions recorded.
Ascuncion	19° 40' N 145° 24' E	7.4	76	56	173	-	305	0	No	No	Erupted explosively in 1906; steam venting observed in 1992.
Agrihan	18° 46' N 145° 40' E	47.4	-	800	1250	250	2300	10 to 12	Yes	No	Erupted in 1917, fumarolic activity in 1990.
Pagan	18° 06' N 145° 46' E	47.7	-	-	900	820	1720	20 to 30	Yes	Yes	An eruption in 1981 resulted in evacuation of the island.
Alamagan	17° 35' N 145° 51' E	11.2	230	120	-	-	350	20 to 25	Yes	No	Past eruptions violently explosive; thick pyroclastic flow covers most of the island. Fumerolic activity continues.
Guguan	17° 19' N 145° 51' E	4.0	140	-	-	-	140	0	No	No	Most of shoreline steep cliffs. Erupted in 1882 and 1884.
Sarigan	16° 42' N 145° 47' E	5.0	90	133	-	-	223	0	No	No	Extinct volcano; no historically recorded activity
Anatahan	16° 22' N 145° 40' E	32.3	750	-	300	-	1050	0	Yes	Yes	Very active, with ash plumes and frequent earthquakes. Plume on 6 April 2005 reached 50,000 ft.
Saipan	15° 12' N 145° 45' E	122.9	490	1236	-	3590	5316	48,220	Yes	No	Ancient volcano capped with uplifted limestone
Tinian	15° N 145° 38' E	101.8	694	116	-	1758	2568	3,136	Yes	No	Ancient volcano capped with uplifted limestone
Aguiguan	14° 51' N 145° 34' E	7.0	281	0	-	6	287	0	Yes	No	Ancient volcano capped with uplifted limestone
Rota	14° 10' N 145° 12' E	95.7	4,947	448	-	309	5,704	2,527	Yes	No	Ancient volcano capped with uplifted limestone

weighing heavily on the success or failure of some translocation efforts (e.g., Griffith *et al*. 1989, Armstrong and McLean 1995, Veltman *et al*. 1996, Wolf *et al*. 1998, Mumme and Below 1999).

The islands that constitute the northern arc of the Mariana archipelago (here in referred to as the "Northern Islands"; Fig. X) are approximately five million years of age; relatively young when compared to the 35-40 million years of the southern arc (Bloomer *et al*. 1989). All are historically or prehistorically active volcanoes (Table 7) that lack uplifted limestone strata and that exhibit little or no fringing coral reefs. Four of the Northern Islands support known populations of feral animals (primarily goats, pigs, cattle, dogs and cats) including three of the target islands; Alamagan, Pagan, and Agrihan (Table 7). Much of the native and secondary forests on these islands have been damaged or otherwise altered as a result of feral ungulate presence. Introduced rodents (primarily Rattus spp.) occur on all of the islands.

AVIAN SPECIES / ISLAND COMPATIBILITY

Proposed Conservation Introduction Scenarios

There have been relatively few and limited scientific research expeditions to the islands in the Mariana archipelago north of Saipan (i.e., Anatahan north to Maug). Information pertaining to forest, habitat characteristics, and ecological health of potential destination islands is limited. This leads to difficulty in making sound decisions about where in the archipelago species should be translocated, decisions that could have a profound effect on the success of the MAC Project's conservation introduction efforts. Although Yamashina (1940) commented on the avifauna of Asuncion after a visit in the late 1930's, little is known of how extensively this island (along with the remainder of the Northern Islands) has been scientifically surveyed prior to the 1970s (Amidon *et al*. 2011, USFWS 1998a,b, and 2010a). By far the largest terrestrial research endeavor in the archipelago has been a U.S Department of Defense (DoD) funded USFWS survey of all the Northern Islands, including Aguiguan, Anatahan and Uracus (USFWS 2010a). This survey was named the Marianas Expedition Wildlife Surveys or MEWS (USFWS 2010a). Although the vast majority of resources were used to survey Pagan, the island that DoD has the greatest interest in for the purpose of training Marine forces stationed on Guam, the remainder of the islands were systematically surveyed to determine the status of the Micronesian Megapode (Amidon *et al*. 2011).

Prior to these surveys, DFW undertook or participated in a number of visits to the Northern Islands to assess the ecological status of their flora and fauna (e.g., Cruz *et al*. 2000a-f, Cruz *et al*. 2003, Fancy *et al*. 1999, Ohba 1994, Stinson 1994). Aside from Cruz *et al*. (2000a-f, 2003) and Fancy et al. (1999) the majority of these visits were brief and constituted little more than biotic inventories and determinations of species presence or absence (Clapp 1983, CNMI 1983, Lemke 1983, Pratt 1983, Glass and Villagomez 1986, Reichel *et al*. 1987, 1988, and 1989, Rice *et al*. 1990, Rice and Stinson 1992, Lusk 1993, Stinson 1994, and Ohba 1994). In 2006, DFW surveyed Sarigan to assess its suitability as a target island for the MAC Project's conservation introduction endeavors (Martin *et al*. 2008), and in 2008 the agency surveyed Asuncion (Williams et al. 2009), in part for the same purpose and in part because it had been missed during early DFW surveys by Cruz et al. (2000a-f).

To take a step further, DFW contracted the Institute for Bird Populations (IBP; Point Reyes Station, California) for a mark/recapture demographic study of Saipan's native forest landbird population, thus initiating the Tropical Monitoring of Avian Productivity and Survivorship

(TMAPS) Project (Pyle *et al*. 2009, 2010, and 2012, Saracco *et al*. 2008). This study was originally intended to determine the most suitable habitats for landbird species on Saipan. Such information would facilitate the most appropriate matching of species with islands and therefore increase the likelihood of success of future translocations. The results of TMAPS work would also provide information to accurately identify the sex of individual birds (Radley *et al*. 2011), facilitating an even sex ratio of individuals captured for translocations and increasing the long-term success of such efforts.

Although the U.S. DoD has shown particular interest in Pagan, the island will not be excluded at this point in time from consideration as a target for species translocation. At the time of this writing it is unclear to what extent, or even if, the DoD will actually use the island for their purposes. The original plan put forth by the DoD's Joint Guam Program Office (JPGO) has changed considerably since the 2010 MEWS (USFWS 2010a) and various proposed projects within have not and will not happen for non-environmental reasons. Due to its extant dirt airstrip, Pagan would provide an easier target island for translocation, both logistically and cost-wise. The large area of suitable forest habitat on the southern portion of the island (which the DoD suggested the intention of leaving untouched) would likely result in successful translocation efforts. One concern, however, is the semi-active volcano on the northern portion of the island, and another the possible transport and introduction of the brown tree-snake to the island by Marines based on Guam. Thus, Pagan will currently be considered for translocation with possible future revisions to these plans as deemed necessary by changing political or natural events.

Table 8 serves as an outline of where in the Mariana archipelago the CNMI's seven species of concern will be translocated. This outline is open to revision and modification if determined necessary at a later date. The decision of where to introduce which species was based on the results of an impromptu Estimated Supportable Population (ESP) Assessment (Appendix C), findings of the 2012 MEWS (USFWS 2010a), and the direct, first-hand experience of P. Radley and F. Amidon with the six target islands (Table 8). The ESP (Appendix C) was useful but incomplete because of the lack of native forest cover data for Agrihan and density confidence intervals (CI) for the Rota White-eye.

Mariana Fruit Dove – A very small, self-established population of this species was discovered on Sarigan in 2006 (Martin *et al*. 2008) and individual birds were observed during MAC Project work on the island in both 2008 and 2009 (Radley 2008 and 2009). In 2012 10 fruit doves were introduced to Sarigan from Saipan (Table 5) to augment the already occurring population and in 2013 an additional 30 will be introduced. As the Mariana Fruit Dove is detected most readily in native and secondary forest cover on Saipan (CNMI DFW, unpublished data), satellite populations of the species will be established on Guguan and Agrihan (Table8).

Rufous Fantail – This species tends to be a habitat generalist and, across cover types, was the species caught in highest numbers by the TMAPS Project on Saipan (Pyle *et al*. 2009, 2010, and 2012, Saracco *et al*. 2008). Thus, it is likely that this species will do well on any of the six target islands (Table 8). Satellite populations of the Rufous Fantail will be established on the three islands nearest Saipan; Sarigan, Guguan, and Alamagan.

Table 8. Proposed target islands in the Mariana Archipelago for establishing satellite populations of the seven focal species taken into consideration by the MAC Plan.

	Sarigan	Guguan	Alamagan	Pagan	Agrihan	Asuncion
Marianas Fruit Dove	X	X			X	
Rufous Fantail	X	X	X			
Tinian Monarch		X		X	X	
Nightingale Reed-warbler				X	X	
Bridled White-eye	X	X		X		
Rota White-eye					X	X
Golden White-eye	X		X			

Tinian Monarch – This species tends to thrive best in native forest but also requires space because of its territorial nature (Camp *et al*. 2012, Marshall and Amidon 2011). Although the habitat cover on Pagan and Agrihan are not pristine examples of native forest in the archipelago, the relatively large size of the two islands will allow for more territorial pairs in what native and secondary cover exist. Guguan will also serve as a target island (Table 8) for satellite population establishment as the quality of the native forest it supports is exceptional, albeit rather limited in size.

***Mariana Crow* –** This species will not be considered here at this time and is thus not included in Table 8. The decision of where and when to translocate the Mariana Crow is the direct responsibility of the USFWS, Honolulu, Hawaii, with consultation from the Mariana Crow Recovery Team, and the CNMI. Discussions between USFWS and the Recovery Team indicate that, because of the lack of an island in the Mariana archipelago of suitable size with enough necessary habitat, the species will likely be introduced to an island outside of the Marianas. No location for a satellite population of the species has been determined as of this writing. When translocation of the Mariana Crow is executed the MAC Project will assist in the fullest capacity possible and as requested.

Nightingale Reed-warbler – The Nightingale Reed-warbler Recovery Plan calls for the establishment of satellite populations on three islands additional to the species' current range of Saipan and Alamagan; Rota, Aguiguan, Tinian, Anatahan, Pagan, and Agrihan are suggested possibilities (USFWS 1998a). Historically, within the CNMI the species occurred on Pagan and Aguiguan, and prehistorically on Tinian (Steadman 2006, USFWS 1998a). Rota and Tinian will not be considered here as they fall outside the scope of the MAC Plan in terms of preventing extinction by the brown tree-snake. Aguiguan and Anatahan will likewise be excluded from consideration at this point in time because of sever habitat degradation caused by large numbers of feral goats on the former (a population that currently exists unchecked), and by a devastating volcanic eruption in 2005 on the latter.

As Pagan and Agrihan (Table 8) are large enough and support appropriate habitat (*Hibiscus tiliaceus*, with a small area of tangantangan on the latter) the MAC Project will establish satellite populations on both these islands. Although Tinian Monarchs (also to be established on both islands; Table 8) and reed-warblers do not occur sympatrically, the two species use different habitats for foraging and nesting.

***Bridled White-eye* –** In 2008 and 2009 a satellite population of this species was established on Sarigan (Table 5). This species tends to be a habitat generalist and is detected in high numbers in all cover types on Saipan, Tinian, and Aguiguan (CNMI DFW unpublished data). The species was also captured in high numbers across Saipan by the TMAPS Project (Pyle *et al*. 2009, 2010, and 2012, Saracco *et al*. 2008). Satellite populations of the Bridled White-eye will also be established on Guguan and Pagan (Table 8).

Rota White-eye – As of this writing, this species is restricted to higher elevation wet forests on Rota (USFWS 2007). Although time may show that the perception of this species' association with wet forest has no basis, the MAC Working Group feels it is safe to err on the side of caution for the purpose of this plan. Based on first-hand observations, only Agrihan (the highest peak in Micronesia) actually supports this type of forest in any abundance, followed to a lesser degree by Asuncion. Thus, satellite populations of Rota White-eyes will be established on these two islands (Table 8). As the Rota White-eye is not sympatric with the Bridled White-eye (a close relative of the former) in the Mariana Islands, populations of the two species will not be established on the same islands. The Rota White-eye is likewise not sympatric with the Tinian Monarch (also to be established on Agrihan) but the two species are not closely related. Additionally, the monarch and Bridled White-eye are sympatric in the Marianas, the latter of which occupies the same foraging niche as Rota White-eye. Thus, there is little cause for concern with both species occupying the same island.

***Golden White-eye* –** In 2011 and 2012 a satellite population of this species was established on Sarigan (Table 5). The Golden White-eye is detected in highest numbers in native and secondary forest (CNMI DFW, unpublished data) and is captured in highest numbers at mid-canopy in the same cover type (Pyle *et al*. 2009, 2010, and 2012, Saracco *et al*. 2008). Although Guguan, Agrihan, and Asuncion are good candidates for translocation of the species, these islands have already been chosen for satellite populations of the Tinian Monarch and the Rota White-eye. The Golden White-eye is not sympatric with either species, shares a similar foraging niche with the monarch and is related to the Rota White-eye. Although the Golden White-eye is naturally sympatric with the Rota White-eyes congener in the archipelago, the Bridled White-eye, the MAC Working Group feels it necessary to err on the side of caution. Thus, the only other island suitable for establishing a satellite population of the species is Alamagan (Table 8).

Proposed Conservation Introduction Timeline

MAC Project effort on Sarigan to date suggests that establishing a species on its designated target island will take two separate translocations, generally over two consecutive or closely spaced years. This is dictated in part by the number of birds that can be translocated at one time, a factor determined by the carrying and load capacity of the aircraft available to the project at the Marianas' sole helicopter charter company (*Americopters Inc*., Saipan). At this pace, establishing each island's full suite of species populations (Table 8) will be completed in 2032, with at least one satellite population of each MAC Project focal species established by 2020 (Table 9). Further augumentation of established populations will be considered on an "as needed" basis, based upon future monitoring. The timeline of events depicted in Table 9 is tentative and fully negotiable on a year-to-year basis as the project commences, and is up for revision at any time by MAC Project PI's when deemed necessary.

Table 9. Timeline for conservation introductions of all species by the MAC Project to islands in the Mariana archipelago.

Timespan (yrs)	Species Translocated	Target Island
2008 and 2009*	Bridled White-eye	Sarigan
2011*	Golden White-eye	Sarigan
2012*	Golden White-eye and Mariana Fruit Dove	Sarigan
2013*	Mariana Fruit Dove and Rufous Fantail	Sarigan
2014*	Rufous Fantail	Sarigan
2015 and 2016	Tinian Monarch and Bridled White-eye	Guguan
2017 and 2018	Rota White-eye	Agrihan
2019 and 2020	Nightingale Reed-warbler	Agrihan
2021 and 2022	Tinian Monarch and Mariana Fruit Dove	Agrihan
2023 and 2024	Rota White-eye	Asuncion
2025 and 2026	Tinian Monarch and Bridled White-eye	Pagan
2027 and 2028	Nightingale Reed-warbler	Pagan
2029 and 2030	Golden White-eye and Rufous Fantail	Alamagan
2031 and 2032	Mariana Fruit Dove and Rufous Fantail	Guguan

* = translocation completed

Depending upon access allowed to the MAC Project by the U.S. DoD from 2017 through 2030, relatively easy and cost-effective access to Alamagan and those islands further north (Pagan, Agrihan, and Asuncion) will be afforded using Pagan as a staging area. Pagan supports a small, rough dirt airstrip that could facilitate MAC Project access to other translocation target islands via fixed-wing aircraft. From Pagan the other nearby islands of Alamagan, Agrihan, and Asuncion can easily be reached by helicopter. Utilizing Pagan's airstrip may serve to speed up translocation to the more northern islands in the archipelago and may help to reduce costs because of the prohibitive weight capacities associated with available helicopters. Supplies and personnel can be flown by fixed-wing to Pagan and staged there for translocations to Alamagan, Agrihan, and Asuncion, all of which would then be executed by helicopter from Pagan.

MAC PROJECT PARTNERS AND ROLES

The MAC project is intended as a cooperative effort among the Commonwealth of the Northern Mariana Islands (CNMI), the U.S. Fish and Wildlife Service (USFWS), Pacific Bird Conservation (PBC), and the Association of Zoos and Aquariums (AZA). The DFW Wildlife Section Supervisor and Wildlife Biologist/Ornithologist are the overall project coordinators and are responsible for identifying conservation priorities for all CNMI avifauna. The DFW Wildlife Biologist/Ornithologist is additionally responsible for planning and undertaking all Conservation Introduction and species translocation work. Designated Wildlife Biologists with USFWS in Hawaii are accountable for coordinating all work specifically associated with U.S. federally listed species in the CNMI. Peter Luscomb and Herb Roberts, co-founders of PBC, jointly oversee, organize, and coordinate all work done by AZA institutions, and both serve as AZA liaison with the CNMI and USFWS.

CNMI Involvement

Aside from overseeing the project as a whole, CNMI wildlife staff will be responsible for coordinating all aspects of "on site" conservation efforts. CNMI staff will acquire all appropriate permits for the holding and handling of non-endangered species and will assist AZA staff with logistics of fieldwork on the Mariana Islands (i.e., transportation, lodging, providing specific biological information on wild birds for captive management efforts, attaining access to capture and release sites, and assisting with field work).

When possible and time permitting, CNMI staff will participate in all avian field capture operations and captive management efforts, while zoo staff develop protocols for all procedures associated with the project. Once the captive program has demonstrated success in maintaining healthy, reproducing and self-sustaining captive populations, a final report will be developed detailing all effective procedures. If at any time CNMI decides to develop captive facilities on Saipan or another island, AZA staff will assist in their design and captive avian management program.

The action and process of establishing satellite populations of species to other islands (i.e., physically transporting and releasing the individual birds to targeted islands) will be the responsibility of CNMI staff biologists, primarily coordinated by the Wildlife Biologist / Ornithologist. Likewise, all necessary follow-up monitoring of translocated bird populations will be conducted by the CNMI.

USFWS Involvement

The USFWS will deal with any actions concerning all U.S. federally listed species (e.g., Nightingale Reed-Warbler, Rota White-eye) on the Mariana Islands, and will be responsible for permitting and assisting in funding any endangered species recovery actions.

AZA Involvement

The initial priority of cooperating AZA institutions will be to develop and refine the necessary techniques to facilitate conservation actions benefiting the avifauna of the Mariana Islands. Translocation and captive breeding are identified as the conservation strategies with highest priority for species within the archipelago. However, before these strategies can be implemented, necessary techniques must first be developed and refined in terms of capturing, holding, and acclimating birds to captivity, and transporting them where needed. Although these specific techniques have previously been developed and used for other species (e.g., Seychelles White-eye [Rocamora 2002, Rocamora *et al*. 2003], New Zealand Saddleback [Lovegrove 1996, Pierre 2003]), the flexibility for evaluation and modification of these procedures is necessary to ensure that mortality is minimized and health of captive birds optimally maintained.

An avian or wildlife veterinarian will be part of the designated AZA field team and will be responsible for monitoring the health status of all birds in captivity, of which detailed records will be maintained. Any birds that do not adapt readily to captive conditions will be released. All procedures will be evaluated constantly and revised as needed to ensure the continued, optimal health of all captive birds. It is intended that the AZA develop written protocols for any and all avicultural aspects of the project, which will be reviewed and agreed upon by all parties prior to their execution.

AZA Field Participation

Participating zoos will organize a team of field workers to travel to the CNMI for live bird collection, consisting of a project coordinator, trapping crew, husbandry crew, veterinarian and support crew. A basic acquisition team will consist of seven members: four individuals involved with capture procedures, one to care for captive birds, one veterinarian, and one support person. CNMI staff will be encouraged to participate and work alongside zoo staff in capture and handling procedures.

The selection of a crew for field collection procedures will be determined by the project coordinator, and will be based upon individuals' bird capturing and handling experience and abilities to contribute to the overall trip objectives. Individuals who have not been selected but are interested in participating in the field operations may have the opportunity, provided that they; 1) receive prior approval from the project coordinator, who will determine their task assignment; and 2) are able to cover all their travel expenses along with their share of expenses such as housing, food, equipment, and materials.

Although CNMI staff will coordinate all translocation work, PBC will develop protocols for all on the ground translocation efforts identifying trapping methods, holding procedures, transport, and activity sequencing. PBC will likewise provide all equipment necessary for translocation procedures (e.g., holding and transport boxes).

Development of Captive Populations

For each species to be held in captivity, PBC will identify a "species coordinator" responsible for overseeing all aspects of its captive management. The designated coordinators will locate and identify AZA institutions and individuals best qualified to hold and propagate the targeted species. Prior to collection, species coordinators will be responsible for developing "biological profiles" for the species they oversee, with assistance from DFW and USFWS. Captive management will be based upon the best available data for each species held. Husbandry protocols will be developed that define basic standards in animal care, from housing and feeding to medical care. All persons wanting to participate with a given species must agree to follow these specified protocols.

The primary responsibility of the species coordinator will be to monitor the captive population of the species under their supervision to ensure that the developed protocols are functioning to maintain optimal health standards. In cooperation with an avian/wildlife veterinarian, the coordinator will review all mortality and health data at least semiannually to determine if there are any negative trends or health concerns in the population, adjusting protocols as necessary. All persons involved with management of the affected captive population will be kept informed of all concerns and any recommended changes to the protocol.

All birds collected will be banded with a sequentially numbered aluminum leg band. Relevant accession and de-accession information will be recorded in the International Species Inventory System (ISIS) using the Animal Record Keeping System (ARKS), and all birds and offspring will be recorded as belonging to the CNMI. A health management program will be developed to monitor captive populations to ensure that all practical steps are taken to minimize the chances of their exposure to disease, which could potentially compromise future reintroduction options (Woodford and Rossiter 1996, Leighton 2002).

Captive breeding is a targeted objective for this project the species coordinator will thus work closely with participating institutions to develop a breeding strategy. The specific objective of breeding efforts will be to identify the factors that are instrumental in stimulating species reproduction while determining those that inhibit reproduction. Over the course of a year, variables such as housing, environmental conditions, and nutritional and social management of all species in captivity will be focused on and controlled in an effort to attain successful breeding. Once the ideal breeding “arrangement” has been determined, at least two zoos will be identified to implement that breeding program.

The director of each zoo that participates in this project will be required to sign a document committing staff and resources to properly manage their assigned/requested target species (90 days advanced notice is necessary if they wish to withdraw from this agreement). Committed zoos will be required to submit biannual reports detailing the status of populations in their care, participate in active communication on the project internet list-serve, display CNMI conservation educational materials (provided by CNMI) for any species they use in exhibits, and assist only when possible in covering expenses necessary to capture and acquire birds for their captive programs.

Interagency and Participant Communications

An AZA Internet list-serve will be developed for communication between participants of the MAC project. Species coordinators will be responsible for sending notices to all zoos maintaining birds from CNMI, requesting that they submit status reports of their captive populations. The coordinators will compile these data, reviewing mortalities, health concerns, and reproductive activities (adjusting any husbandry protocols as needed), and submit this information to MAC participants via the established list-serve in the form of biannual status reports for each species. Project coordinators, in turn, will compile annual reports concerning the status of all relevant captive populations and submit them to both the CNMI and USFWS. The CNMI DFW will annually compile and submit a report to the AZA concerning the status of both wild and translocated populations.

Public Education and Community Activism

Although this program has yet to be fully implemented, zoos that accept and receive birds from CNMI for public exhibition will be responsible for developing interpretative educational programs to inspire and encourage their visitors to support conservation in the Northern Mariana Islands. MAC project coordinators will identify specific areas in which assistance is needed for conservation efforts, and each zoo will be requested to establish a funding program such as establishing visitor donation containers. The MAC Project is currently working to recruit an educational liaison to design and implement this program.

Facilities, Equipment, and AZA Investigator Roles

Holding facilities on Saipan for captive birds include, as needed, the DFW Wildlife/BTS wet lab and specifically built MAC Project aviary at the DFW Compound, and extra rooms at the Summer Holiday Hotel in Garapan. On Tinian and Rota, rooms at available island hotels or other accommodation will be secured for on-site holding facilities. Species specific holding cages will be set up and maintained in these work spaces. In 2012, a 40 foot modified and retrofitted shipping container was purchased from *KwikSpace Guam Inc*. (Hagåtña, Guam) to serve as storage for all MAC Project equipment and supplies and as an impromptu workspace, if necessary.

When on-site, a primary keeper will be assigned to oversee the daily care of captive birds under the supervision of the Principal Investigator and the veterinarian. Suitable holding facilities at AZA affiliated institutions on the U.S. mainland will be provided by each participating zoo. The Memphis Zoo, the Honolulu Zoo, the St. Louis Zoo and the Louisville Zoo have been identified as initial quarantine and placement centers from which participating institutions will receive the birds of which they've agreed to manage captive populations. A placement list is underway currently.

Peter Luscomb will be primarily responsible for coordinating all MAC Project collection-based fieldwork. He will purchase all needed supplies and provide oversight and guidance on techniques used for capture. He will also monitor workers at all trapping locations daily (or designate someone to do so if he cannot) and decide when to relocate to a new collection site if necessary. Herb Roberts will be responsible for coordinating all MAC Project captive husbandry work. This includes the daily care and housing of captured birds while on Saipan, determining appropriate transportation techniques, monitoring and assessing the captive populations on the U.S. mainland, and making appropriate recommendations regarding husbandry and breeding. There will be some overlap in responsibilities of the Principal Investigators.

PROJECT FUNDING AND INFRASTRUCTURE

Attempts will be made primarily by PBC (P. Lucsomb and H. Roberts) to acquire grant money to support field collection. If such monies are secured, they will support all costs associated with the basic acquisition team and their efforts. Zoos receiving birds as part of this project will be responsible for any shipping costs that are incurred. If sufficient grant funds necessary to cover total expenses are not secured, all project costs exceeding available funds will be recovered by applying an associated collection fee to all AZA institutions receiving birds from CNMI. The project coordinator will be responsible for the administration of all funds designated to the MAC project and will provide a detailed account of all expenditures.

As new ideas and technologies become available to facilitate certain aspects of the MAC project, it may be necessary to augment and adjust some predetermined budget requirements. There may be unforeseen expenses in certain areas of the project overall that will be addressed and implemented as needed (e.g., post-release monitoring methods, bird holding and handling facilities).

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MARIANAS AVIFAUNA CONSERVATION (MAC) PLAN

APPENDICES

Appendix A. List of species of greatest conservation concern in the Commonwealth of the Northern Mariana Islands

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- Mariana Fruit Dove (*Ptilinopus roseicapilla*)
- White-throated Ground Dove (*Gallicolumba xanthonura*)
- Rufous Fantail (*Rhipidura rufifrons*)
- Tinian Monarch (*Monarcha tatatsukasae*)
- Mariana Crow (*Corvus kubaryi*)
- Nightingale Reed-warbler (*Acrocephalus luscinia*)
- Bridled White-eye (*Zosterops conspicillatus*)
- Rota White-eye (*Zosterops rotensis*)
- Golden White-eye (*Cleptornis marchei*)

Appendix C. Estimated Supportable Population (ESP) Assessment

APPENDIX A

List of species of greatest conservation concern in the Commonwealth of the Northern Mariana Islands

Appendix A. List of species of greatest concern for conservation in the Commonwealth of the Northern Mariana Islands (Pratt *et al*. 1987, Berger *et al*. 2005, Wiles 2005, Steadman 2006).

Common name ***Scientific Name***	**Marianas Distribution and Status**	**Local, Federal, or International Listing and Protection Status**	**Reasons for Concern**
Mariana Mallard *Anus oustaleti*	Guam – Extinct		
Micronesian Megapode *Megapodius laperouse laperouse*	CNMI, except Rota, questionable on Tinian	Locally protected Locally listed as Threatened or Endangered Federally listed as Endangered	*M. l. laperouse* found only in the Mariana Islands. Rare or extirpated on the four southern Mariana Islands. Numbers declining on northern islands due to impacts from feral animals.
Guam Rail *Galliralus owstoni*	Guam - Extirpated	Federally listed as Endangered	
Mariana Common Moorhen *Gallinula chloropus guami*	Guam, Tinian, and Saipan; occasional on Rota	Locally protected Locally listed as Threatened or Endangered Federally listed as Endangered	Numbers have been reduced due to wetland habitat loss and predation.
White-throated Ground Dove *Gallicolumba xanthonura*	Guam and CNMI, except Asuncion; very unlikely on Maug, and Urucas	Locally protected	Not federally listed, so does not qualify for Section 6 Endangered Species funding. Easily preyed upon.
Mariana Fruit Dove *Ptilinopus roseicapilla*	Guam (extinct), Rota, Aguiguan, Tinian, and Saipan; recently detected on Sarigan, translocated there from Saipan in 2012 and 2013.	Locally protected	Not federally listed, so does not qualify for Section 6 Endangered Species funding. Now rare due to over-hunting; however, declaration as the official bird of the Commonwealth may have resulted in less hunting pressure in recent years.
Mariana Swiftlet *Aerodramus bartschi*	Aguiguan, and Saipan; extirpated from Rota and Tinian	Locally protected Locally listed as Threatened or Endangered Federally listed as Endangered	Objectives for de-listing in Recovery Plan have not yet been met.
Guam Micronesian Kingfisher *Todiramphus cinnamomina*	Guam - Extirpated	Federally listed as Endangered	
Collared Kingfisher *Todiramphus chloris albicilla*	CNMI, except Rota, Anatahan, Guguan; very unlikely on Maug and Urucas	None	Not federally listed, so does not qualify for Section 6 Endangered Species funding.

Appendix A. List of species of greatest concern for conservation in the Commonwealth of the Northern Mariana Islands (Pratt *et al*. 1987, Berger *et al*. 2005, Wiles 2005, Steadman 2006).

Common name ***Scientific Name***	**Marianas Distribution and Status**	**Local, Federal, or International Listing and Protection Status**	**Reasons for Concern**
Collared Kingfisher *T. c. orii*	Rota	None	Not federally listed, so does not qualify for Section 6 Endangered Species funding.
Guam Rufous Fantail *Rhipidura rufifrons uraniae*	Guam - Extinct		
Rufous Fantail *R. r. mariae*	Rota	Locally protected	Not federally listed, so does not qualify for Section 6 Endangered Species funding. Potential easy prey for snakes if they enter the Commonwealth.
Rufous Fantail *R. r. saipanensis*	Aguiguan, Tinian, Saipan	Locally protected	Refer to *R. r. mariae*
Tinian Monarch *Monarcha tatatsukasae*	Tinian	Locally Protected	At risk of extinction if the brown tree-snake becomes established there. May be effected by future US military activities on the island.
Guam Flycatcher *Myiagra freycineti*	Guam - Extinct		
Mariana Crow *Corvus kubaryi*	Guam (extirpated) and Rota	Locally protected Locally listed as Threatened or Endangered [b] Federally listed as Endangered[c]	Dramatic decline in numbers in last 20 years. Section 6 Endangered Species funding is insufficient.
Nightingale Reed-warbler *Acrocephalus luscinia*	Saipan and Alamagan, likely extirpated on Aguiguan, extirpated on Guam	Locally protected Locally listed as Threatened or Endangered Federally listed as Endangered	Numbers are declining on Saipan, status uncertain on Alamagan. The Saipan Upland Mitigation Bank (SUMB) was established for this species.
Bridled White-eye (Guam subspecies) *Zosterops conspicillatus conspicillatus*	Guam - Extinct	Federally listed as Endangered	
Bridled White-eye (Saipan subspecies) *Zosterops conspicillatus saypani*	Aguiguan, Tinian, and Saipan. Established on Sarigan in 2008	None	Not federally listed, so does not qualify for Section 6 Endangered Species funding – this subspecies is afforded no protection. Potential easy prey for snakes.

Appendix A. List of species of greatest concern for conservation in the Commonwealth of the Northern Mariana Islands (Pratt *et al*. 1987, Berger *et al*. 2005, Wiles 2005, Steadman 2006).

Common name ***Scientific Name***	**Marianas Distribution and Status**	**Local, Federal, or International Listing and Protection Status**	**Reasons for Concern**
Rota White-eye *Zosterops rotensis*	Rota	Locally protected Locally listed as Threatened or Endangered Federally listed as endangered	Occurs only on the island of Rota, range now restricted to Sabana Heights. Numbers have declined by an estimated 90% since 1982. USFWS funding insufficient for designation of critical habitat.
Golden White-eye *Cleptornis marchei*	Aguiguan and Saipan. Established on Sarigan in 2011.	Locally protected [a]	Not federally listed, so does not qualify for Section 6 Endangered Species funding. Little is known about natural history or habitat requirements.

[a] "Locally protected" species are protected under the current Division of Fish and Wildlife Non-Commercial Fishing and Hunting Regulations. Hunting for any of these species is prohibited.
[b] Species which are "Locally listed as Threatened and Endangered" are protected under local CNMI law, specifically, the Fish, Game and Endangered Species Act, 2 CMC §§ 5101 *et seq*. and under the regulations promulgated thereby.
[c] Federal listing statuses, under the Endangered Species Act, include: Endangered, Threatened and Candidate.

MARIANAS AVIFAUNA CONSERVATION (MAC) PLAN

APPENDIX B

Species Profiles

Appendix B: Species Profiles

Mariana Fruit Dove (*Ptilinopus roseicapilla*)

Compiled by: Shelly Kremer, USFWS, Honolulu, Hawaii, Herb Roberts, Memphis Zoo, Memphis, Tennessee, and Paul Radley, CNMI Division of Fish and Wildlife, Saipan

Order: Columbiformes
Family: Columbidae
Subfamily: Treroninae
Local or Chamorro Name: *Totut*

SPECIES OVERVIEW

Description: A sexually monomorphic forest dove with pearly gray head, neck, breast, and upper back; remaining upper parts bright green. The cap and malar stripe are rose red. Under parts variegated with purple transverse bar below breast, orange flanks, yellow belly, and pinkish orange undertail coverts. Tail band is pale gray. Juvenile plumage (rarely seen) is entirely green (Pratt, 1987). Adult females resemble males but are slightly smaller with a greener neck, and the purple transverse bar below the breast tends to be less prominent, the yellow belly less bright (Herb Roberts, unpubl. data).

Table 1. Morphometrics of the Mariana Fruit Dove on Saipan (all measures and weights in millimeters and grams, respectively; R = range).

Sex	Wing (R)	Tail (R)	Culmen (R)	Tarsus (R)	Mass (R)	Source
Male (n = 32)	127 (122-133)	80 (75-84)	14 (13-15.3)	25 (24-27)	90 (81-103)	Baker 1951
Female (n = 10)	124 (121-130)	76 (75-79)	13 (12-13.7)	24 (22-25.5)	92 (85-99)	Baker 1951
Male (n = 11)	125 (119-131)	-	-	-	85.3[a] (74.7-92.2)	Radley *et al*. 2011 and unpub. data
Female (n = 6)	122.5 (118-127)	-	-	-	88.5[b] (78.1-107.3)	Radley *et al*. 2011 and unpub. data

[a]Based upon n = 10 males
[b]Based upon n = 4 females

Distribution: The Mariana Fruit Dove is endemic to the Mariana Islands and considered common on Saipan, Tinian, Rota, and Aguiguan. Total population for the species was reported in 1982 as approximately 2,541, 3,075, 292, 3,535 individuals, respectively (Enbring *et al*. 1986). Later DFW and USFWS bird surveys of these islands yielded mean abundance estimates for the species 9,723 on Saipan in 2007 (95% CI 7,129 – 13,050; Camp *et al*. 2009), 2,269 on

Tinian in 2008 (95% CI 1,858 – 2,845; Camp *et al*. 2012), and 855 on Aguiguan in 2008 (95% CI 687 – 1,093; Amidon *et al*. *in review*) The species was extirpated from Guam in the 1980s by the introduced brown tree-snake (*Boiga irregularis*; Wiles *et al*. 2003). Subsequent analysis by Ha (2006) of Rota island-wide surveys (1982 – current), Rota White-eye VCP surveys (2002-2005) and Rota BBS surveys (2000-2005) showed a significant decline in the fruit dove population on the island. Analysis of the Saipan BBS data, however, shows a significant increase in the species population from 1991 – 2010 (Kremer *et al*. *in review*).

Habitat: Craig (1996) documented fruit doves using primarily native forest on Saipan for nesting and foraging, while at times occurring in secondary forest and disturbed habitats. Baker (1951) reported the species most commonly in secondary growth and scrub forest, but also fairly common in undisturbed forest. On Guam the species inhabited ravine and coastal forest with nine records in mangrove swamp (Drahos 1977). Rarely found in coastal strand dominated by coconut forest or in savanna (Jenkins 1983), fruit doves tend to concentrate their activities in upper to mid-level canopy (Craig 1996).

Food and Feeding Habits: The species is primarily a canopy frugivore but will also feed on leaves, flowers, and seeds of a wide variety of plants (Table 2). Fruit doves have been observed to exhibit agonistic behavior towards conspecifics that approach their vicinity to feed on fruits (Villagomez 1987). Marshall (1949) observed that fruit doves "feed in the upper parts of trees and procure food by walking along horizontal twigs, reaching up and to the side to pick fruit. Birds generally alight perching crosswise on a twig or branch, then turn and move off along it. They can turn entirely around and move in the opposite direction. When a group begins to feed they appear to become less wary but will flush from the backside of a tree when a human observer approaches."

Behavior: Fruit doves are often observed flying over forest canopy for distances greater than 100 m, suggesting that they are not territorial in nature (Craig 1996). The species is secretive, usually solitary, difficult to see due to their bright green plumage (Jenkins 1983), and have been observed to sit quietly in thick vegetation (Baker 1951). Individuals frequently call back and forth to each other, the initial song often evoking a chorus of vocalizations by many others. Fruit doves fly only occasionally but always in a swift and direct manner, usually covering short distances of 20-30 meters at treetop level (Jenkins 1983). Marshall (1949) observed that the species "has two tricks to avoid being seen once they have flown into a tree. Either they freeze for up to 15 minutes upon alighting or they alight and repair to further concealment into the tree and then freeze."

Breeding: Peak breeding for the species is from April through August, with nesting likely occurring year round (Jenkins 1983, Pratt 1984, Villagomez 1987). Claridge (1987) found fruit dove nests on Rota in January, February, April, May, June, July, August and September.

Nesting: Fruit dove nests are very loose in construction, generally composed of 40-50 small twigs 1-2 mm in diameter, usually placed in the forks of tree branches and on mats of vines (Jenkins 1983). Stinson (1993) reported a mean nest height of 2.5 m (range = 1-5 m, SD = 1.16 m; n = 21). On Guam, Jenkins (1983) reported a mean nest height of 2.8 m (range = 1-7 m; n = 15). Claridge (1987) likewise reported finding nests at heights of 1-2 m from the ground.

Table 2. List of food plants used by the Mariana Fruit Dove in the Mariana Islands (Jenkins 1983, Villagomez 1987, Craig 1996).

Plant Species	Leaves	Seeds	Flowers	Fruits
Carica papaya				X
Cestrum diurnam	X			X
Eugenia spp.				X
Ficus spp.				X
Glochidion marianum		X		X
Guettarda speciosa				X
Hibiscus tiliaceus		X		X
Jasminum marianum				X
Lantana camara				X
Melanoplepis multiglandulosa				X
Momordica charantia		X		X
Muntingia calabura		X		X
Passiflora foetida		X	X	X
Pithecellobium dulce				X
Premna obtusifolia		X		X
Psychotria spp.				X
Scaevola taccada		X		X
Triphasia trifolia				X

Plant species generally used for nesting include: *Ficus prolixa, Pemphis acidula, Psychotria mariana, Leucaena leucocephala, Cynometra ramiflora, Guamia mariannae, Eugenia palumbris, Elaeocarpus spp., Hibiscu spp., Premna obtusifolia, Intsia bijuga, Maytenus thompsonii, Mangifera spp., Pithecellobium dulce, Triphasia trifolia, Avicennia alba*, and *Casuarina equisetifolia* (Jenkins 1983, Claridge 1987, Villagomez 1993). Nests are found in native limestone forest, strand forest or scrub, forest edges, and in mixed agro-forest (Villagomez 1993). Stinson (1993) reported mean estimated canopy closure at next sites as 54% (range = 10-90%, SD = 22.5; *n* = 18) and estimated forest canopy height at 9.8 m (range = 5-30 m, SD = 6.13; *n* = 19).

Eggs, incubation, hatching, growth and development: Fruit doves usually lay one egg but clutches of two have been recorded (Claridge 1987, Villagomez 1993). Eggs are sub-elliptical in shape and off-white to creamy in color with a rose tint (Villagomez 1993). Claridge (1987) reported egg measurements of 21.5 mm by 29 mm (*n* = 2) while Jenkins (1983) reported one measuring 31.0 mm by 22.4 mm. The roles of sexes in nest related activities in a natural setting is unknown but only one member of a pair appears to incubate, brood, and care for the young (Jenkins 1983). In captivity, however, both males and females have been observed to incubate eggs and rear young (Herb Roberts unpubl. data). Young are initially fed a milky substance ("pigeon's milk") derived from the lining of the parent's crop, and later a regurgitated mash of partially digested berries and nuts (CNMI-DFW).

Incubation in the wild lasts 12 days with fledging at 16-18 days (Drahos 1977), while incubation in captivity is 17-18 days with fledging at 14-18 days (Herb Roberts, unpubl. data).

BASIC HUSBANDRY

Acquisition and Acclimation: Mist netting is the most effective means of capturing Mariana Fruit Doves, with nets monitored every 15 minutes to minimize stress on captured birds. After removal from the net, birds should be transferred to a holding crate for transfer to a primary holding facility; it is prudent to take weights and measurements during this transfer period. Dependent on the size of the holding cage, several Fruit Doves may be housed together as the unfamiliarity of the holding environment tends minimize aggression. Newly captured doves will voluntarily eat only rarely and tube feeding up to twice daily may be necessary. After transfer to quarantine facilities fruit doves can be slowly weaned to a captive diet with purple colored berries such as blueberries, blackberries, or wild elderberries; pelleted foods should be dyed using juices from these berries or dark grape juice. Within six weeks most birds will take a regular captive diet. Once on a captive diet, birds can be placed in holding institutions but should be monitored for weight loss and food consumption as relocation may cause some individuals to cease feeding.

Banding and Weighing: During the initial stages of captivity weights should be taken daily; captive weights can range from 58 to 98 grams. Weight will be influenced by age and condition, with mass in the high 60's to low 80's (grams) the norm (captive acclimated doves tend to weigh slightly more). An initial weight loss of a few grams should be expected. Bands (usually USGS BBL size #3A or 3B) should be applied either at capture or prior to transfer to on-site holding facilities. If the latter, some method must be in place to identify location, time, and date of capture for each bird before placement in a communal holding cage.

Holding Temperature: Mariana Fruit Doves, although not cold hardy, can tolerate temperature ranges from mid-50° F (12°-13° C) to slightly over 100° F (37° C), with a comfort zone of 75°-85° F (23°-29° C).

Light: Natural lighting is preferable for fruit doves but caution must be taken to insure adequate shade if held outdoors. Most zoos use a combination of skylights and artificial lighting, the best available combination of both being optimal. In small exhibits, where close proximity to artificial light is possible, broad-spectrum fluorescent lights that simulate natural light should be used. Length of photoperiod can vary from 12-14 hours daily if controlled.

Food and Feeding: A high quality pelleted food should be the basis of a fruit dove captive diet and should comprise at least 50% of total diet. Pellets can be lightly soaked in water to improve their palatability. The remainder of a captive diet should consist of seasonally available fresh fruit that is diced into cubes approximately 6-7 mm in diameter. Apples, bananas, mango, papaya, pears, plums, peaches, grapes, strawberries, blueberries, and blackberries are all accepted by birds and should be dusted with a vitamin supplement.

Housing and General Environmental Considerations: Mariana Fruit Doves exhibit a few behaviors that should dictate what will constitute a suitable captive environment. Typical of all pigeons and doves, they use a fast, straight-line escape flight that makes large space exhibits with glass barriers unsuitable. Any wire barriers should initially be treated to increase visibility until birds become familiar with them. Single birds (to prevent intra-specific aggression) can be kept in glass-fronted exhibits with shallow depths (1.5-2.4 m), which limits potential flight speed and minimizes impact if a bird does strike the glass.

Exhibit plantings should provide shelter and nesting locations for fruit doves, which are highly arboreal and appear most comfortable when perched 3 m or higher within vegetation. Fruit doves will adjust to lower ceilings as long as available plants provide good perching and camouflage to the highest point. Fruit doves appear most relaxed when able to look down on human caretakers or visitors.

The species is usually most suited to a well planted typical mixed species flight aviary, where individuals tend to ignore and be ignored by non-columbid species. No absolute rules exist pertaining to which species are compatible with Mariana Fruit Doves, but occasionally an individual male will show aggression towards a fruit dove of another species.

Mariana Fruit Doves will drink from shallow pools and have been observed drinking water from leaves after rainfall. They tend to appreciate a light shower and will bath when presented with the opportunity. An automated irrigation or mister system serves this purpose well in most aviaries or exhibits.

Captive behavior: As mentioned previously, intra-specific aggression by fruit doves is very likely when kept in close quarters. However, two or three males are capable of residing together in a planted space with dimensions of approximately 6.1m W by 15.2 m D by 6.1 m H. Mild aggression in the form of displacement is likely but usually nothing more. If a female is present, however, no more than one male should co-habit an exhibit with her.

Mariana fruit doves should be conditioned to a captive diet prior to release into a flight exhibit. Once they are familiar with the diet and the container it is presented in, they will fly to feeding stations 1-1.5 m above the ground.

Pair Formation, Nesting, and Chick Rearing: Both sexes call during pair formation but male fruit doves call more frequently. Calls appear to serve the double purpose of identifying territory and attracting a mate, and are a precursor to pair-bonding. As male doves tend to pursue females somewhat aggressively in early courtship, the female should be acclimated the captive environment several weeks prior to male introduction. This will allow her to outmaneuver the male as necessary. After an initial introductory period, the pair will often be in close proximity to one another and will occasionally allopreen. As fruit dove pairs are constantly aware of human presence, copulation is seldom observed and there is no evidence that the male feeds the female during courtship (Herb Roberts, pers. comm.).

The male fruit dove typically searches for suitable nest sites, which the female later inspects and either accepts or at times chooses one of her own. The female undertakes nest construction with materials procured by the male (*Ficus benjamina* twigs are often preferable). Fruit dove nests are often very fragile and easily destroyed, perhaps due to limited access to suitable materials. Observation of the nest building activities will often indicate site preferences. Nest sites should be reinforced with small-gage wire mesh or a shallow woven basket with preferable dimensions of approximately 15.2 cm W by 15.2 cm D by 7.6 cm H (the lower H allows an incubating bird to better detect approaching danger). Nest material can be added to the structure and a soft liner such as burlap is recommended for the bottom.

Both adults tend to incubate in a captive setting, the female generally for longer periods than the male (the latter tends to incubate for periods of less than 2 hours). Observations of captive individuals indicate that the male provides a "break" in the morning and late afternoon, while the female incubates overnight.

Both parents also provision the chick. For the first few days the chick is fed solely on "pigeon's milk" or "crop milk", a nutrient rich exudate produced in the crop lining. After this period, the chick is fed decreasing amounts of crop milk and increasing amounts of solid food. Young tend to stay in the nest for 12-14 days before spending another 2-3 days on the nest's edge or lip, after which they leave but do not travel far. Juvenile fruit dove wing feathers are functional but the remaining plumage is incomplete, with breast and back feathers in evidence but head and tail feathers rudimentary. Head to tail length is approximately 6.4-7.6 cm. Growth is rapid and by 6-8 weeks of age young begin self-feeding and are approximately 2/3 the size of an adult. Color is a dull green with breast feathers lighter than the remaining plumage.

Rarely a fruit dove pair will re-nest while a chick is fledged but still dependent upon them. At this point, it may be necessary to remove the chick for hand rearing and separate the pair for a few weeks to re-establish a normal breeding cycle.

Banding Offspring: Juvenile fruit doves should be banded when fully weaned from the adults and will accept and adult sized band (i.e., USGS BBL size # 3A or 3B). At this point in time, if deemed necessary juveniles can also be removed from the exhibit they share with the adults.

Management of Juveniles: Juveniles may be left with the adults until courtship and nesting behavior begin, at which point males will likely attempt to drive the juvenile away. This time span can vary greatly but three to four months is typically the norm. Pulling juveniles earlier usually results in the pair resuming breeding behavior and there have been atypical occurrences of parents re-nesting before the juvenile is weaned. As some species of fruit dove will continue to feed the juvenile when not incubating (an undesirable condition), it may be necessary to pull the juvenile and finish hand rearing it to independence.

Juveniles usually cease feeding when it is initially separated from the adults and is placed in a holding facility. Weight should be monitored and if loss continues for 3 days, force-feeding is required; once daily should be sufficient. After approximately a week the juvenile will usually begin to eat on its own. If there is a similar aged juvenile already in holding the new bird can be placed with this "experienced" juvenile, resulting in a faster transition. Juvenile Beautiful Fruit Doves (*Ptilinopus pulchellus*), Jambu Fruit Doves (*Ptilinopus jambu*), and Mariana Fruit Doves have served as teacher birds at AZA institutions, but the use of adults should not be attempted because the risk of aggression is too high. Juveniles begin to assume adult coloration at six months to one year of age and sexual maturity occurs between 11 months to slightly over a year. Multiple juveniles may be housed together until the onset of sexual maturity.

Health Management: Once acclimated, Mariana Fruit Doves are hardy birds with few health related issues; some captives have been known to live more than 14 years. However, they are susceptible to mycobacteriosis and sarcocystosis infections.

Exposure to Mycobacteriosis (also known as Avian TB, which is usually shed through feces) can be minimized by preventing wild birds from accessing holding cages that have been kept outdoors. Sarcocystosis, which has been documented primarily at southern U.S. zoos, is generally spread by North American or Virginia opossums (*Didelphis virginiana*) through fecal deposit and oral ingestion. Although a roofed enclosure provides some protection, the organism can also be spread indirectly via insects; a very fine mesh insect screening is required when used on enclosures in infected areas of the country. If doves are held within indoor enclosures the risk of infection is greatly reduced.

Birds that exhibit symptoms of Avian TB, such as unexplained weight loss or cessation of reproductive activity, can be diagnosed via liver biopsy. There is currently no definitive treatment for Avian TB. Although not highly contagious, the sick individual should be quarantined from the captive population and euthanasia may be recommended depending upon holding circumstances.

Although Sarcocsytosis can be treated using standard coccidia treatments, one of its most common manifestations is acute pneumonia and infected birds may die before exhibiting symptoms. Fecal screens for endo-parasites should be run quarterly with birds treated appropriately, and physical exams should be done annually.

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Appendix B: Species Profiles


F. Amidon

White-throated Ground-Dove
(*Gallicolumba xanthonura*)

Compiled by: Shelly Kremer, USFWS, Honolulu, Hawaii, Gary Michael, Louisville Zoological Garden, Louisville, Kentucky, and Paul Radley, CNMI Division of Fish and Wildlife, Saipan

Order: Columbiformes
Family: Columbidae
Local or Chamorro Name: *Paluman apaka*

SPECIES OVERVIEW

Description: A sexually dimorphic, robust, short-tailed forest dove. Morphometrics for both sexes are outlined in Table 1 and plumage for both is described as per Baker (1951) unless otherwise noted.

Table 1. Morphometrics for the White-throated Ground Dove on Saipan unless otherwise noted (all measures and weights in millimeters and grams, respectively; R = range).

Sex	Wing (R)	Tail (R)	Culmen (R)	Tarsus (R)	Mass (R)	Source
Male (*n* = 43)	146 (139-153)	102 (97-111)	22 (21-23)	32 (31-33)	130 (119-154)	Baker 1951[a]
Female (*n* = 31)	136 (131-141)	94 (90-98)	20.5 (20-21.5)	30 (28-32)	118 (96-150)	Baker 1951[a]
Male (*n* = 45)	140.6 (127-153)	-	-	-	114.6[b] (89.3-139.7)	Radley *et al*. 2011 and unpub. data
Female (*n* = 52)	133.6 (125-142)	-	-	-	103.53[c] (78.5-126.1)	Radley *et al*. 2011 and unpub. data

[a] Source does not indicate from where in Marianas measures were taken
[b] Based upon *n* = 38 males
[c] Based upon *n* = 48 females

***Adult Male*:** The forehead, face, chin, throat, and upper breast white, lightly washed with a pale buff. The crown, occiput, sides of head, and nape are rusty brown to dark brown, the remainder of the upper parts dark bronze-olive. The feathers of mantle and upper wing coverts are broadly edged with metallic purple-violet, the primaries, under wing coverts and axillaries are brown. The tail, lower breast, under parts, bill and feet are dark brown.

***Adult Female*:** Resembles adult male but smaller and with underparts between "ochraceous-tawny" and "cinnamon brown" in color. Head and neck are darker with more rufous than underparts while the remainder of upper surface resembles underparts but with striking olive green sheen, especially on upper wing-coverts. Primaries are brown but outer webs lighter and the tail is rufous brown with a broad black sub-terminal band. The iris of the female is grey or brown with a grey orbital skin. Although less common, an alternate female plumage resembling the adult male plumage has been documented and is described as follows: breast is light drab tinged with light brown and darkening anteriorly; the crown resembles that of normal female although darker and becoming lighter and grayer on neck and nape; the shoulder and wing-coverts compare favorably with that of adult male although lighter and with yellowish tinge; the back is bronzed olive-green as in normal female but the mantle exhibits a few purplish feathers characteristic of the male; abdomen area is "olive brown" with buffy brown edges to the feathers.

***Juvenile/Immature*:** The immature male resembles the adult male but the head and nape are darker brown; the throat and upper breast may be browner and less white. Young males have more noticeable rufous tips on the feathers than females. The immature female resembles the adult female, but with more rufous coloring; the olive-green sheen on feathers is reduced or absent.

Distribution and Status: The White-throated Ground Dove is known to occur on the islands of Asuncion, Agrihan, Pagan, Alamagan, Guguan, Sarigan, Anatahan, Saipan, Tinian, Agiguan, and Rota in the Mariana archipelago. A population was found on Guam but was extirpated in the 1980s by the brown tree snake (*Boiga irregularis*; Wiles *et al*. 2003). The species also occurs on the Micronesian Island of Yap.

Population estimates of ground doves for each island are presented in Table 2. Subsequent analysis of data from all island-wide surveys (1982 – current), Rota Bridled white-eye VCP surveys (2002-2005), and BBS surveys (2000-2005) indicate a stable to decreasing trend of the species' populations on Rota (Ha 2006). Analysis of Saipan BBS data indicates a significant increase in ground-dove populations between 1991 and 2010 (Ha 2005, Kremer *et al*. [*in review*]).

Habitat: Ground doves **o**ccurs in native, secondary, agricultural, and tangantangan (*Leucaena leucocephala*) forests, and in habitat mosaics that include open fields. Craig (1996) reported ground doves more frequently in native forests than disturbed habitats, and Jenkins (1983) found the species absent from savanna, wetland, and coastal strand habitats. Ground doves use a range of forest strata, most of their time spent in either the canopy (45%) or on the ground (30%; Craig 1996).

Food and Feeding Habits: The species is primarily frugivorous but will consume seeds and some leaves and flowers of a wide variety of plant species (Table 3). Craig (1996) observed ground doves foraging for seeds and probing leaf litter on the ground and feeding on the fruits of native trees, including papaya (*Carica papaya*). Although other species of ground doves from the same genus are forest understory herbivores, the White-throated Ground Dove appears to be a microhabitat generalist (Craig 1996). Stophlet (1946) observed a female ground-dove picking at the underside of a leaf and assumed it was gleaning insects. There are no other references or documentation of ground-doves foraging for or consuming insects.

Table 2. White-throated Ground Dove Population estimates throughout the species' current range.

Island	Population Estimate	Date	Source
CNMI			
Rota	2417	1982	Engbring *et al*. 1986
Aguiguan	855	2008	Amidon *et al. in review*
Tinian	1,462	2008	Camp *et al*. 2012
Saipan	11,800	2007	Camp *et al*. 2009
Anatahan	26	2002	Cruz *et al*. 2000[d]
Sarigan	N/A*	2000	Cruz *et al*. 2000[c]
Guguan	54	2000	Cruz *et al*. 2000[a]
Alamagan	83	2000	Cruz *et al*. 2000 [b]
Pagan	379	2010	Marshall and Amidon 2010
Agrihan	377	2000	Cruz *et al*. 2000[e]
Asuncion	None detected	2008	Williams *et al*. 2009
Federated States of Micronesia			
Yap	195	1984	Engbring *et al*. 1990

* Counts were too low to determine an island wide population estimate for Sarigan.

Behavior: The ground dove is secretive, solitary, and seldom found in pairs outside of the breeding season (Drahos 1977). The species is often observed flying high over forest canopy, leading Kibler (1950) to suggest that these long flights may indicate widely separated feeding grounds. Data collected by the CNMI DFW suggest that the species is territorial, often foraging singly on the forest floor and stopping to chase away conspecifics (Villagomez 1987). However, ground doves have been observed in groups of 8-15 on three different islands (Saipan, Aguiguan, and Rota; Villagomez 1987), and they appear to tolerate conspecifics that are greater than 10m away; males that approach other males within that distance are generally chased off (Villagomez 1987). Agonistic behavior was observed within sexes but not between.

Territorial interactions between males are common throughout the year and involve males fighting one another in feet-first attacks directed the head and neck (Jenkins 1983). Birds often become entangled during these fights and tumble down through the vegetation before separating and alighting on exposed perches where they exhibit prancing displays, slowly flapping their wings and exposing the pure white of their neck and breast in one another's direction (Jenkins 1983). Females have been observed perching quietly in the area during these interactions (Jenkins 1983).

Breeding: Ground doves likely breeds year round, peaking between April and August (Craig 1996, Stinson 1993, Villagomez 1987). Drahos (1977) reported a peak season between January and June for Guam. Vocalizations tend to increase from April-July (Craig 1996) and Stinson

Table 3. List of food plants used by the White-throated Ground Dove (Jenkins [1983], Villagomez [1987] and Craig [1996]).

Plant Species	**Leaves**	**Seeds**	**Flowers**	**Fruits**
Aglaia mariannensis				X
Atrocarpus mariannensis				X
Bidens pilosa				X
Callicarpa spp.				X
Carica papaya				X
Cestum diurnam	X			X
Ficus spp.				X
Flagellaria indica				X
Freycinetia reineckei				X
Glochidion marianum		X		X
Guettarda speciosa				X
Hibiscus tiliaceus		X		X
Macaranga thompsonii				X
Melanoplepis multiglandulosa		X	X	X
Messerchmidia argentea		X	X	X
Momordica charantia		X		
Muntingia calabura		X		X
Pandanus spp.	X			
Passiflora foetida		X		X
Pithecellobium dulce				X
Planchonella obovata				X
Polyscias grandifolia				X
Premna obtusifolia			X	X
Scaevola taccada		X		X
Triphasia trifolia				X
Triumfetta procumbens				X

(1993) reported that 14 nests were found on Saipan between April and September. Baker (1951) reports finding nests on Guam only in the first half of the year and Marshall (1949) hypothesized on the basis of physiological data that the ground doves breed year round. Jenkins (1983) on Guam reports observing: " (1) an adult carrying nesting material in late May, (2) courtship and mating in September and mid-November, (3) recently fledged males in immature plumage in September and November, (4) territorial interactions between adult males year round, and (5) paired birds in all months of the year." A Guam Division of Aquatic and Wildlife Resources biologist also reported an active nest in August 1964 (Jenkins 1983).

Mating usually takes place on a bare horizontal limb in a tall tree. The female alights on the limb and begins to walk along it toward concealment into the leafy part of the tree. The male then flies to the same branch and utters, as he alights, a long snarl which can be represented as "*crrrreeeeeek*". She will often remain stationary and allow the male to preen her head and neck.

The male mounts three to four times, each event lasting 20-30 seconds. As copulation occurs the male will grab nearby small twigs and branches in a ritualized fashion. When the male mounts the female she often utters a short, raspy soft call, quite unlike the usual moaning call of the species. After this point the pair will separate and begin the whole sequence over again, the whole procedure lasting 4-5 minutes, after which the birds perch quietly in different parts of the same tree (Marshall 1949; Jenkins 1983).

Nesting: White-throated Ground Doves build a bulky nest in the canopy of littoral scrub or forest. Nests have been found in *Cynometra spp.*, *Elaeocarpus spp.*, *Guettarda spp.*, *Erythrina spp.*, *Ficus prolixa*, *Artocarpus spp.*, *Pandanus dubius*, *Bambusa spp*., *Leucaena leucocephala*, and *Hibiscus tiliaceus* (Stinson 1993; Baker 1951; Drahos 1977; Jenkins 1983). Nest sites have been recorded in limestone forest, near roadside in limestone forest, and agro-forest (Stinson 1993). Stinson (1993) reported a mean nest height of 6.6m (range = 5-8 m; n = 5), mean estimated canopy cover of 37% (range = 10-60%; n = 5), and an estimated forest canopy height of 8.8 m (range = 5.8-12 m; n = 5).

Eggs, incubation, hatching, growth and development: Ground dove clutch size varies from 1-2 eggs (Stinson 1993 and Jenkins 1983). Baker (1951) reported that both male and females participate in nest construction and incubation and D. Aldan reported a nesting ground dove that exhibited a broken wing display on Pagan (Stinson 1993).

BASIC HUSBANDRY

The species was introduced to captivity in 2006 with the collection of fourteen live specimens on Saipan. A general plan for the care of ground doves in captivity is based upon field experiences and captive management experiences at the Louisville Zoo. The Memphis and St. Louis Zoos are partner institutions with Louisville in the development of a protocol to maintain and propagate the species.

Acquisition and Acclimation: Mist netting is the most effective means of capturing White-throated Ground Doves. Net sites are chosen based upon observation of birds and the determination or best guess of their routine patterns of activity. Not only should nets be set high in routine flyways, but they should also be placed low where birds often move secretively on the ground and walk through or across low vegetation from branch to branch. Ground doves are often solitary, resulting in the need for a capture team to move often and add nets frequently as new birds are detected.

Nets should be checked every thirty minutes to minimize stress on captured individuals, but during the heat of the day they should be checked every 15 minutes. A netted bird is removed in a manner to minimize feather loss and transferred immediately to a darkened carrier with a padded ceiling to reduce the likelihood of head trauma. At the holding facility, birds are weighed, measured, and banded. Depending on the size of the holding cage multiple immature and mature ground doves, including multiple males, can be housed together for short duration. However, immature and mature birds are generally housed as separate groups during long term maintenance.

Holding pens should be covered with a curtain, drape, or other similar material to provide a visual barrier between doves and caretakers. Newly captured doves usually do not eat voluntarily in the short-term an must be tube fed once or twice per day to maintain capture weight. Upon arrival at long term holding facilities stateside caretakers are encouraged to offer a wide variety of colorful fruits, insects, and colorfully dyed sweet-pelleted foods to stimulate self-feeding activity.

Banding, Weighing, and General Handling: Ground doves will be weighed, measured, and banded upon transfer from the field capture site to the on-island animal holding area. Table 1 provides a basis for defining normal morphological characters. Doves are typically weighed daily during the initial transition period to captivity. A long term expectation is that body weight will be higher in a stable captive bird than a wild counterpart. As birds are likely to be infrequently handled during their captive lives, it is desirable to obtain a weight whenever handled.

The length of time a bird is hand-held for banding or other activity should be monitored and last no longer than several minutes; procedures lasting longer should be performed under anesthesia. During handling, the bird should be carried upright and the head covered. When long health-related procedures have been performed, the bird should be returned to a dry and warm pen that has been outfitted with a heat lamp.

Captive Environment Temperature and Humidity: The White-throated Ground Dove occurs in a naturally warm and humid environment. The minimum and maximum temperature range for the species is approximately 60°-100° F (15°-37° C), while the suggested desirable range is 70°-85° F (21°-85° C). Desired humidity level is 50% or greater.

Captive Lighting: The White-throated Ground Dove is a species of tropical forest and edge habitats. Thus, outdoor settings at holding facilities should be partially shaded and indoor areas eliminated with a full-spectrum artificial lighting system. Desired day length is approximately 13 hours year round but a dim night-light is suggested to reduce potentially traumatic "blind" night fright in dark housing situations.

Foods and Feeding: The species is managed as an omnivore in captivity although it is described in the field as primarily a frugivore. Similar to related species of the genus *Gallicolumba* in captivity, ground doves show some preference for high fat and high protein foods. In mixed-species displays, individuals will often eat insects and high fat foods such as peanut butter. Caretakers should be mindful of this captive behavior in choosing cagemates and designing captive diets.

A low-iron and low-potassium pelleted food is a desirable basis for a daily captive diet. At Louisville Zoo, colorful pelleted food with high sugar content is preferred. Fresh or fresh frozen fruits and vegetables low in vitamin C (e.g., apple and pear) and potassium should make up about 50% of the daily diet. Papaya fruit and its seeds are a preferred fruit by captive birds, but because it is relatively high in vitamin C it should be fed in small quantities relative to apples. Fresh or fresh frozen sweet peas and other legumes are suggested as a good source of plant protein. Insects can be offered in a low percentage quantity of the daily diet for variety and enrichment. Canned fruits and vegetables should not be used.

A mineral and vitamin supplement designed for birds (and with a low vitamin C component) should be used daily on all foods. It is desirable to determine a favorite food item for each individual bird in order to use the food as a vehicle to deliver medications. The soft-bodied larva of the greater waxworm moth (*Galleria mellonella*) has served this purpose at Louisville Zoo.

Pest Management: Pests can be a problem in the management of the White-throated Ground Dove. Invertebrates include roaches that contaminate diets, eating surfaces, and the aviary in general, biting ants that can attack nestling birds, and several mosquito species that carry the West Nile Virus. Vertebrate pests include mice and rats that can eat eggs and young in the aviary, and in the case of rats, kill adult birds. In the U.S., opossums (*Didelphis virginiana*) and raccoons (*Procyon lotor*), attracted to the birds, their odors, and presence of insects around the aviary, can be problematic in numerous ways including stressing and killing captive birds. In particular however, defecation by these species near aviaries (especially by the opossum) can result in the spread of Sarcocystis disease through contamination of the aviary by infected insects. Sarcocystis is a serious health threat to Old World pigeons and doves. Lastly, raptors such as the Cooper's Hawk (*Accipiter cooperii*) are known to perch upon mesh-topped aviaries and kill birds within that fly within reach near the ceiling of the pen.

The White-throated Ground Dove is best managed indoors with an active pest control program is in place. Because Sarcocsystis is spread from mammal by insects an active live-trapping program, particularly for opossums, should be used even when housing birds indoors. A suitable indoor environment will have a preferable positive air pressure relationship to the out-of-doors, reducing the possibility of mosquito entry into the facility. Predator-proof barriers above and below ground should be installed at outdoor facilities and the ceiling of outdoor flights should have a double layer of mesh. Trapping and removal of rodents should be ongoing and use of roach and ant poisons should be in place. The trapping and removal of native wildlife may be necessary and must be undertaken in compliance with state and federal regulations.

CAPTIVE BREEDING

Housing: As a group, Gallicolumbid doves are generally non-aggressive and sedentary birds, traits that allow for considerable variation in housing arrangements. Housing space will typically fall into one of three categories; 1) simple holding, 2) single pair that are sole exhibit occupants, and 3) single pair in a multi-species exhibit. In whatever setting, the most important enclosure measurement is height compared to length and width. A pen height of 2.1 m is generally recommended and 3.7 m or greater is recommended for a sexed pair of doves.

Temporary Holding**:** An enclosure measuring 0.9 m W by 1.8 m D by 2.1 m H is the minimum space sufficient for temporarily holding two to three ground doves. The number of doves in the enclosure will be dictated by compatibility. Multiple adult males should only be maintained in this size of pen for a short-term period of up to approximately three months, and may need to be housed individually. Groups of immature and female birds are likely to be compatible in this environment for a longer period. If wire mesh is used for a small enclosure, the mesh should be 1.3 cm wide to reduce rodent access and the inside of the top should be padded with foam or fabric to prevent head injuries. Feeding and watering stations should be placed both at ground and mid-level to ensure access by all birds and several perches should be available throughout to prevent competition. Perches should be appropriately sized to accommodate foot-grasping. Substrate should either be a washable surface or litter that can be changed frequently.

***Potential Nesting Pair*:** There is considerable acceptable variation in this category. When first introducing a pair an enclosure with minimum dimensions of 1.8 m W by 3.7 m D by 3.7 m H is advised. This will allow for sufficient room for both birds to feel secure until the pair bond is formed. Enclosure type can be a simple wire structure as described above or a more elaborate exhibit. Regardless, suitable perching and multiple feed stations should be provided. If breeding is desired, tall live plants and nest platforms at approximately 3.3 m (under a 3.7 m tall ceiling) above ground should be provided in secluded areas. Plant litter composed of leaves and twigs should be available on the ground for birds to build their bulky nests or to add to artificial nests. The pen substrate should be of a soft material such as earth, mulch or wood shavings.

As Columbids tend to fly in a fast, straight line when startled, glass fronted exhibits should not exceed a depth 3.0 m. Shallow exhibit depth prevents speed build up and usually prevents serious injuries to birds.

***Potential Nesting Pair in Mixed Species Aviary*:** Most zoos have some variation of a large, mixed-species flight exhibit. Such exhibits usually lend themselves well to housing and breeding Columbid species as they are typically spacious, heavily planted, and contain a water feature. Gallicolumbid doves in particular cohabit well with a large variety of bird species, including other genera of pigeons and doves. If the exhibit is large enough, it might be possible to exhibit more than one Gallicolumbid species together, but such experimentation should be closely monitored. However, no more than one pair and their juvenile offspring of White-throated Ground Doves should be kept in such an enclosure; intra-specific competition can be quite aggressive. Doves are not strong nest defenders hence should not be housed with nest predator species such as jays or toucans.

Reproductive Behavior: Participating institutions should be prepared to hold at least two pairs of ground doves, any offspring, and single-sexed groups. This will allow for re-pairing if necessary. Frequently two individuals will not be productive even though they may be compatible. After a reasonable amount of time to allow for acclimation (1 year) non-productive birds should be re-paired.

Courtship behavior in Gallicolumbid doves follows the basic columbid pattern. At Louisville Zoo, male White-throated Ground Doves call infrequently and typically from a location where the white breast is visible. Both sexes incorporate a series of wing raises with allopreening and a female guttural call as part of the courtship display. The female also makes an insect-like buzzing call during copulation. The female ground dove chooses a nest location and the male will supply her with a variety of nesting materials; twigs, leaves, and coarse grasses tend to be favored. Nests at Louisville Zoo have been consistently built large, thick, and at least 4.6 m from the ground and are approximately 30.5 cm by 30.5 cm and several centimeters thick. Old nests, nests of other species, and artificial nests will often be accepted.

During incubation (duration ~16 days) the male ground dove will add twigs and leaves daily to the nest typically in the very early morning and late afternoon when the female is on the nest; both sexes incubate, males typically by day, females by night. Clutch size is 1-2 and most often the latter. Fledgling White-throated Ground Doves emerge from the nest at about 18 days and typically remain high and near the nest for days before venturing into the surrounding area.

Parental care is provided by both sexes. Both adult ground doves produce “crop milk”, a high protein, high fat substance consisting of sloughed epithelial cells from the crop lining. For the first few days of the chick's life this is its sole food. After approximately day 4, parents begin to regurgitate ingested food items mixed in with the crop milk. Eventually, prior to weaning, all food will consist of recently ingested food items that are regurgitated by the parents.

Weaning and self-feeding occurs at approximately 50 to 60 days of age. Young male White-throated Ground Doves begin to develop patches of burgundy contour plumes and a grayish-white throat area at approximately 45 days of age. The adults will usually tolerate weaned juveniles long after re-nesting occurs, which can on rare occasion occur as early as eight days of age for the chick. At this time, the male begins to build a new nest along with maintaining the current one. When the juvenile is about twelve days old, the female will occupy the new nest leaving the juvenile(s) in the old nest unbrooded at night. Within 24 hours of the incubation of a new clutch, the juvenile is no longer brooded at all as the male assumes responsibility for relieving the female at the new nest during the day and he roosts close to her during the night. During this period, the non-incubating adult loafs with the first juvenile and feeds it in the daytime. Juveniles should be removed from the enclosure by 6 months of age and juvenile doves of various ages may be safely housed together. Sexual maturity in White-throated Ground Doves is likely reached sometime between 8 to 12 months of age.

If hand rearing is determined necessary the species manager (Gary Michael) can provide a recommended protocol. Hand rearing is a lengthy and time-consuming process and should be taken only as a last resort.

Health—General Care by Avicultural Staff: The most important contributing factors to maintaining a healthy collection of birds is the level of avicultural skill administered, and communication between caretaker and supervisor. The staff must be constantly aware of what constitutes normal physical and behavioral characteristics of each individual of each species. Staff must also be aware of the environmental conditions that the birds live in. Any change or abnormalities observed by the caretaker must be communicated to the supervisor and health care provider. It is paramount that the animal caretaker be well trained and be attuned to his or her animal charges, as well as to the physical captive environment.

The manifestation of illnesses may be subtle unless the condition is acutely serious. The caretaker should be responsible for reporting daily about the bird's appetite, level and type of activity, stool production and general quality, plumage condition, respiratory condition, posture when at rest, and mobility. Some of the parameters used to detect illness may be indicators of normal circannual events such as molting or nesting. Some may represent changes in the normal physical environment such as temperature or humidity levels. The early detection of abnormalities in the bird's health by the animal caretaker is key to the successful diagnosis and treatment of an individual bird.

Health—Care by Health Provider: The initial symptoms of an illness, the diagnostic techniques employed, the description of maladies and common diseases, and the treatment of disorders and diseases will not be described in these guidelines. Instead, the health care provider and aviculturist are encouraged to refer to the following applicable printed materials.

General Avian Text (includes a chapter on Columbiformes)

Ritchie, B.W., G.J. Harrison, L.R. Harrison (eds.). 1994. Avian Medicine: Principles and Applications. Wingers Publishing, Inc., Lake Worth, FL.

Zoo Medicine Text (includes a chapter on Columbiformes)

Kirk-Baer, C.L. 1999. Comparative Nutrition and Feeding Considerations of Young Columbidae. *In*: Zoo and Wild Animal Medicine, Current Therapy 4 (Fowler, M.E., and R.E Miller, eds.). W.B. Saunders Co., Philadelphia, PA 1999: 269-277.

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Appendix B: Species Profiles

Rufous Fantail (*Rhipidura rufifrons*)

Photo by Eric Kershner

Compiled by: Shelly Kremer, USFWS, Honolulu, Hawaii, Peter Luscomb, Pacific Bird Conservation, Honolulu, Hawaii, and Paul Radley, CNMI Division of Fish and Wildlife, Saipan

Order: Passeriformes
Family: Corvidae
Subfamily: Dicrurinae
Tribe: Rhipidurini
Local or Chamorro Name: *Naabak*

SPECIES OVERVIEW

Description: A small, sexually monomorphic, monarchid flycatcher (Jenkins 1983), with cinnamon forehead and crown that contrast with black orbital rings and white malar stripes. The anterior chin is white becoming black towards the posterior along the throat and upper breast. Lower breast is spotted brown and white, underwings grayish to buff, abdomen, sides, flanks, and tibia all darker brown than the head. The lower back and base of tail bright rufous, rectrices tipped with white. The bill is black and the feet and irides are dark brown. Immature birds resemble adults, but head, neck, and scapulars are rufous edged, and the black feathering of the chin and throat are edged with white (Pratt *et al*. 1987; Jenkins 1983). Molt begins in July and continues through the fall (Baker 1951). Morphological measurements for both sexes are outlined in Table 1.

Table 1. Mean morphological measurements of the Rufous Fantail (measures and weights are in millimeters and grams, respectively; R = range).

Sex	Wing (R)	Tail (R)	Culmen (R)	Tarsus (R)	Mass (R)	Source
Male (*n* = 7)	68 (68–69)	81 (80–83)	13.3 (13–13.5)	17.3 (16.2–18.4)	9 (9–10)	Baker 1951
Female (*n* = 6)	64 (62–66)	76 (72–81)	12.7 (12.4–13.4)	17.9 (17.2–18.1)	8.8 (7.2–9.6)	Baker 1951
Male (*n* = 122)	66.8 (52-70)	-	-	-	8.1 (7.0-9.1)	Radley *et al*. 2011 and unpub. data
Female (*n* = 176)	64.2 (58-69)	-	-	-	7.8[a] (6.5-9.5)	Radley *et al*. 2011 and unpub. data

[a] Based upon *n* = 172 females

Distribution: Two subspecies are common on Saipan, Tinian, Aguiguan (R. r. saipanensis) and Rota (R. r. mariae), while the Guam subspecies (R. r. uraniae) is believed to be extinct. Another subspecies (*R. r. versicolor*) is found on the island of Yap, with an additional 14 subspecies occurring through Australasia (Pratt *et al.* 1987, Clements *et al*. 2012). The population of Rufous Fantails on Saipan, Tinian, Aguiguan, and Rota was reported in 1982 to be approximately 2,194, 1,634, 455, and 1,049, respectively (Engbring *et al.* 1986). Point-transect distance surveys conducted at the same stations on Saipan in 2007, and Tinian and Aguiguan in 2008 yielded abundances of 52,318 (95% CI 39,703 – 70,057), 68,884 (95% CI 61,297 – 77,069), and 10,939 (95% CI 8,248 – 14,671), respectively (Amidon *et al*. *in review* , Camp *et al*. 2009, Camp *et al*. 2012). Subsequent analysis of data from Rota, including the Enbring island-wide Variable Circular Plot (VCP) surveys (1982–2004) and Rota Bridled White-eye VCP surveys (2002-2005), show a significant decline in Rufous Fantails populations (Ha 2006). However, Breeding Bird Surveys (BBS) on the island from 2000 to 2005 show no change in overall abundance for Rufous Fantail populations. Analysis of the Saipan BBS data, however, shows a significant increase followed by a significant decline in the species population from 1991 – 2010 (Kremer *et al*. *in review*).

Habitat: Rufous Fantails occur in native limestone forest and disturbed habitats, including beach strand and suburban areas (Craig 1996). Baker (1951) noted a preference of fantails for forest and scrub communities, Marshall (1949) documented their abundance in woodland understories, and Strophlet (1946) recorded them in riparian communities on Guam. The species, however, does appear to be largely absent from swordgrass savannah (Craig 1996). Sachtleben (2005) reported nesting densities to be almost evenly distributed among forest types with densities ranging from 0-16/km^2 in native/mixed forest, and 0-25/km^2 in non-native forest, depending upon the month of survey.

Food and Feeding Habits: The species **c**ommonly forages both in the canopy and mid/lower strata (Craig and Beal 2001). Fantails are insectivorous and hawk for insects from perches, primarily catching prey on the wing (Jenkins 1983). Flights are usually horizontal and several insects are usually taken before the bird alights (Marshall 1949). Jenkins (1983) also observed fantails gleaning insects from branches among the foliage, and Craig and Beal (2001) documented them foraging equally both from leaves and in an aerial manner, specializing in sallying and hovering. Rufous Fantails often follow Golden White-eyes (*Cleptornis marchei*) and Bridled White-eyes (*Zosterops conspicillatas*) to capture insects flushed by the foraging activities of these two species (Jenkins 1983; Craig 1996).

Behavior: Fantails are extremely active birds, constantly flitting about in the understory searching for food (Jenkins 1983). Although agile in the understory, flight appears labored when crossing forest openings or roadways, birds undulating slowly at low altitudes of only 1-2 m (Jenkins 1983). They are frequently found in pairs or in small groups of three to five individuals, which are most likely family groups (Craig 1996). Fantails tend to continually spread their long, fan-like tails (Jenkins 1983), almost never completely fold their wings, and frequently exhibit hostility towards one another (Marshall 1949). Color banding showed that groups remained at single locations, and at such locations males engaged in singing duels with neighbors and responded aggressively to taped playbacks of fantail songs. Individuals appear to defend all-purpose territories and observations of interspecific aggression include supplanting perched

Bridled White-eyes, chasing foraging Golden White-eyes near fantail nests, and chasing foraging Micronesian Honeyeaters (*Myzomela rubrata*; Craig 1996, S. Kremer, unpubl. data). The species appears to have no pattern of diurnal activity levels, including singing (Craig and Beal 2001).

Breeding: Craig (1996) documented active fantail nests on Saipan in January, February, March, April, October, and November, while Pyle *et al*. (2012) reported birds on the island in breeding condition every month of the year. Jenkins (1983) reported breeding from January to April and in June and November on Guam.

Nesting: Fantail nests are compact, usually built around a branch or fork of a tree, and are composed of fine grasses, *Casuarina* needles, hair-like matter, and spider webs, all of which is held together by a mucous-like secretion (Jenkins 1983). Nests are usually supported by two to three branches but have been found supported by only one or up to four (Sachtleben 2005, unpubl. data). Nests have been document built from 0–2.3 m from the trunk of the tree (mean = 0.6 m; Sachtleben 2005, unpubl. data).

Sachtleben (2005, unpubl. data) reported the following nest measurements on Saipan: mean inner nest cup diameter of 42 mm (range = 37–46 mm; *n* = 49); mean outer cup diameter of 51 mm (range = 44–55 mm; *n* = 49); mean depth of cup of 22 mm (range = 17–30 mm; *n* = 52); mean nest height of 46 mm (range = 31–60 mm; *n* = 52); mean length of nest "tail" of 64 mm (range = 0–147 mm; *n* = 51). Jenkins (1983) reported that nests on Guam were about 37 mm in outer diameter.

Jenkins (1983) documented nests in *Hibiscus tiliaceus* and *Leucaena leucocephala* on Guam. Sachtleben (2005, unpubl. data) reported the following nesting trees on Saipan: *Aidia cochinchinensis* (*n* = 6), *Albizia lebbeck* (*n* = 2), *Cynometra ramiflora* (*n* = 9), *Eugenia* spp. (*n* = 4), *Guamia mariannae* (*n* = 22), *Leucaena leucocephala* (*n* = 36), *Maytenus thompsonii* (*n* = 1), *Melanolepis multiglandulosa* (*n* = 1), *Ochrosia mariannensis* (*n* = 1), *Pithecellobium dulce* (*n* = 2), *Psychotria* spp. (*n* = 1). On Rota, nests were also found in *Hernandia labyrinthica* (*n* = 1), *Merrilliodendron megacarpum* (*n* = 2), and *Piper guahamense* (*n* = 2) (Amidon, unpubl. data).

On Saipan, mean nest height was 2.1 m (range = 0.5–6.5 m; n = 101) while the mean height nest trees was 4.4 m (range = 0.8–12.6 m; *n* = 100; T. Sachtleben 2005, unpubl. data). The most common nest predators on Saipan are believed to be Micronesian Starlings and Collared Kingfishers and forest type did not affect nesting success/survival (Sachtleben 2005). Sachtleban (pers. comm.) noticed that there was often quite a long delay between nest building and egg lying.

Eggs, incubation, hatching, and growth and development: Fantails typically lay two eggs that are dull white and ringed with brownish spots diffused around the center or nearer their large end (Jenkins 1983). Both adults typically incubate and brood the young (Jenkins 1983). Incubation is 15–17 days and the nestling stage 12–17 days (T. Sachtleben 2005, unpubl data). Jenkins (1983) reported a brood of fantails fledging on Guam in 14-15 days. Both adults feed young but one (sex undetermined) appears to feed more often (Jenkins 1983).

Chick Development: The following is adapted from T. Sachtleben 2005, unpubl. data.

Day 0; hatch at ~1.5 cm long, dark pink/purple skin, either naked or covered with light fuzzy down.
Day 1; 1.5–2 cm long, dark pink/purple skin, usually with light down on the head and often on the body.
Day 3; 2.5–3 cm long, skin color pale to dark pink, wing pins 1–3 mm long with back pins beginning to erupt, still no head pins, and generally still covered in light down on the head and back.
Day 6; ~4 cm long, skin color light to dark pink/purple, wing pins may be 4–8 mm long, back pins 2–3 mm, head pins visible (i.e., just poked through), head is still covered in down. Feathers may barely be erupting from the wing and back pins at this stage of development.
Day 9; 4–5 cm long, dark grey feathers from 4–10 mm long have erupted from pin tracts on wings, rufous feathers 4–5 mm long from the pin tracts on the back, head pins have erupted, as have tail pins (~2 mm). Eyes cracked open but don't seem to open any earlier.
Day 12;~5 cm long, eyes open, and fully feathered although the feathers still look downy, but head pin tracts are still visible.

BASIC HUSBANDRY

Acquisition and acclimation: Mist netting is the most effective means by which to capture Rufous Fantails. Successfully capturing the species will require the use of 25mm mesh nets; birds have a tendency to pass through and get tangled in larger mesh sized nest, causing them undo stress. Nets should be checked every 15 minutes and captured birds should be removed in a manner that minimizes stress and transferred to a cloth “field bag” for transport to the field station. At the field station birds should be weighed, measured, banded, given a quick health assessment and have blood drawn by the veterinarian if the bird is not unduly stressed. The bird should then be placed in a dark and quiet field transport box and be given food and water. Birds in the transport crates in the field will eventually be taken to the MAC onsite aviary where they will be set up in more spacious holding enclosures.

Aviary holding enclosures will be constructed of entirely solid PVC material and are entirely enclosed except for a small row of air vents that are place on the top quarter of the side panels, are covered with mosquito screening. The back wall of the enclosure should be constructed of wire mesh covered with mosquito screening while the front consists of a solid door with two small viewing holes likewise covered with mosquito screening. The aviary enclosure should have two perches, a solid perch placed in its back quarter and a weighing perch in the front quarter. A feeding tray will allow for the cage to be cleaned and fed with minimal disturbance to the birds inside. Fantails can be very territorial so all birds should be housed separately with no visual contact each other.

Newly captured Rufous Fantails should be fed house flies at first and quickly moved to commercially available insects (meal worms, two week old crickets, fruit flies, wax worms). A vitamin deficiency was noticed during quarantine at two AZA facilities in 2009, which caused high mortality (birds died within four days of onset of symptoms, i.e., “star gazing”). Necropsy showed no signs of disease or trauma and indicated that the cause of mortality was metabolic in nature. Deficiencies in vitamin E and B1 both result in the symptom of “star gazing” leading to the need to supplement captive diets of the species with them. Once birds are placed in a natural aviary setting and allowed to eat a variety of insects they appeared to be fine.

Banding and Weighing: Fantails should be are weighed, measured and banded (with USGS BBL size 0) at capture. Refer to Table 1 for expected weight ranges. Birds should be weighed daily while in "holding" boxes in the field, at the on-site aviary, and during transition to a captive institution. Both obtaining weights and monitoring fecal output are good methods to determine a bird's daily heath status whether it is thriving in captivity.

Temperature: Rufous Fantails occur in a naturally warm and humid environment; it is recommended that holding institutions strive to provide a similar climate. Housing birds outside is ideal in the summer as long as shade is provided. Not all institutions will be able to adequately provide this setting, however. Inside aviaries and breeding enclosures should thus be kept at 60°-85° F (18.3°-29.4° C), with ideal temperatures between 70°-80° F (23.9°-29.4° C).

Light: Although natural lighting is always preferred, most institutions employ a combination of both. Optimal photoperiod should be 11 hours in December to 13 hours in June. Ample shade should be provided if fantails are housed outside.

Food and Feeding: Rufous Fantails will only take live insects. Since species captures most of its food on the wing, flies (e.g., fruit flies, Domestic house fly) are an ideal food item. Mealworms, two-week-old crickets, roaches, wax worms, and moths will also be readily taken by fantails. It is important to encourage birds to utilize a variety of insects to ensure that they are receiving a balanced diet. Developing and maintaining a compost pile in the aviary is a good way to encourage the availability of a large variety of insects for captive birds.

Housing and General Environmental Considerations

***Environmental requirements*:** Flycatchers in general need open space in which to fly and maneuver easily and access to cover for instances when they feel threatened. The provision of secluded places in an enclosure is especially helpful with promoting breeding flycatchers tend to be significantly more nervous when nesting.

***Temperature / humidity*:** As mentioned previously, the ideal temperature range is 70°-80° F (23.9°-26.6° C). If temperatures fall below 50° F (10° C) in an enclosure a heat source should be provided. Maximum temperatures of 85° F (29.4° C) can be tolerated for short periods without difficulty. Higher temperatures will induce heat-stress reactions such as labored, open-mouthed breathing. If Rufous Fantails will be exposed to high temperatures within an enclosure, options should be developed to provide cool microclimates. Drip irrigation systems using fine mister heads are ideal as they dispense less than one gallon of water per hour, cost little to operate, and produce a mist that refreshes without saturating the aviary substrate or plants.

A minimum relative humidity level of approximately 55% is appropriate for tropical and semi-tropical bird species. The effects of long exposure to very dry (i.e., conditioned) air are not properly understood. Many bird species, however, appear to do better when provided with both fresh and naturally humid air. Thus, the provision of a humidifier or a simple mister / fogger system is suggested in buildings that do not have a regular inflow of outside air. When misting is used to cool an area during hot weather good air flow is also necessary to facilitate evaporative cooling (Vince 1996).

***Natural light*:** Access to full-spectrum lighting or direct sunlight is beneficial for most bird species. However, if a captive diet is properly supplemented with vitamin D3 the lack of full-spectrum lighting is not necessarily detrimental. Light intensity is very important to both maintain the birds' activity level and to promote healthy plant growth. Light intensity in the enclosure should be at a minimum of 600 foot candles, with peak levels of 1000 foot candles.

Captive Behavior: Rufous Fantails are very active throughout the day and spend most of their time searching for food. If a bird is placed in an out door facility and has access to free flying insects it will hawks them with short aerial sallies. Fantails will also occasionally alight to the ground to glean insects. Although the feeding rates of fantails have not been calculated the Black and Orange flycatcher (*Muscicapa nigrorufa*) exhibits two peak hours of feeding; one in the early morning and the other at days end. The feeding rate for the species averaged approximately 100 insects/hour., which was double the rate at mid-day.

As a rule flycatchers are very territorial, males and females potentially maintain their own territories even during the non-breeding season. Thus, it is important to house Rufous Fantails singly when they are brought into captivity. Introductions for breeding should be done slowly and should typically involve allowing the male to establish a territory within its own enclosure. The female should then be placed in an adjacent cage, within sight of the male, to determine compatibility. Experiments at the Honolulu Zoo indicated that the female spent more time approaching and sitting by the male than vice versa. It is recommended to house the birds side by side for at least two weeks before they are physically introduced to each other. When doing so, the female should be introduced into the male's enclosure and the birds monitored very closely to ensure their safety. If any chasing is noted or if one bird dominates the food plate they should either be separated or a second food platform and visual barriers should be added to the enclosure.

Pair Formation, Nesting, and Chick Rearing: No breeding has yet occurred with the Rufous Fantail in captivity and such information on captive reproduction is currently unavailable. This section will be updated upon successful breeding by the species. In the meantime, chick rearing information for the White-collared Yuhina (*Yuhina flavicollis rouxi*) was developed by San Diego zoo and will be referred to as needed and when appropriate.

Banding Offspring: Chicks should be banded at 30 days of age with a size 0 band.

Management of Juveniles: This information is not yet available.

Health Management: This information is not yet available.

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Appendix B: Species Profiles

Tinian Monarch (*Monarcha takatsukasae*)

Compiled by: Fred Amidon, USFWS, Honolulu, Hawaii, Paul Radley, CNMI DFW, Saipan, and Peter Luscomb, Honolulu Zoo, Honolulu, Hawaii

Order: Passeriformes
Family: Corvidae
Subfamily: Dicrurinae
Tribe: Monarchini
Local or Chamorro Name: *Chickurikan Tinian*

Species Overview

Description: The Tinian Monarch is a small (~15cm in length), sexually monomorphic species of the family Monarchidae (Takatsukasa and Yamashina 1931). Underparts are light rufous, with olive brown upper parts, brown wings and tail, white wing bars, and white rump and undertail (Baker 1951).

Table 1. Morphological Measurements of Tinian Monarch (all measure in millimeters, all weights in grams [USFWS unpubl. data]; R = range).

Sex	Wing (R)	Tail (R)	Culmen (R)	Tarsus (R)	Mass (R)
Male (*n*=33)	70.1 (66.0-73.5)	68.9 (63.0-78.5)	14.9 (13.4-15.8)	23.3 (21.7-25.6)	12.4 (9.4-17.0)
Female (*n*=50)	66.1 (63.0-69.0)	65.4 (61.5-69.0)	13.9 (11.8-15.7)	22.7 (20.8-24.8)	11.5 (7.0-13.5)

Distribution: Found only on the island of Tinian, Commonwealth of the Northern Mariana Islands (CNMI), and considered locally common. Peters (1996) suggests that a now extirpated population may have also occurred on Saipan based on museum specimens. Monarchs were also reported on Aguiguan in the early 1950's but some authorities discount this report as an error (Engbring *et al.* 1986). Gleise (1945) estimated the population on Tinian after WWII to be approximately 40-50 individuals. The total population reported on Tinian was approximately 60,898, 62,863, and 38,449 individuals in 1982, 1996, and 2008, respectively (Camp *et al.* 2012).

Habitat: Monarchs use native limestone forest, secondary forest, and tangantangan forest, highest densities of the species occurring in native limestone (USFWS 1996, Camp *et al.* 2012).

Food and Feeding Habits: Aside from a single observation of a bird eating a small lizard, the Tinian Monarch appears to be entirely insectivorous (Marshall 1949). Although monarchs generally forage singly or in pairs, flocks of 3-5 have been observed. They forage for food by gleaning, probing, hovering, and sallying at mid-level in the forest understory, in shrubs close to the ground, and occasionally on the ground. They perch on relatively slender branches to glean invertebrates from leaf and bark surfaces and tend to forage at mid-level in secondary and tangantangan forest; most foraging occurs at 2-5 meters above ground (USFWS 1996). Marshall (1949) described foraging activity of the species as moving slowly through the foliage, flying after insects, and hovering at the peripheral foliage of the tree. Based on food brought to incubating adult monarchs, prey tends to consist of moths, butterflies, ants, caterpillars, and several long legged insects.

Behavior: Monarchs display a wide range of behavioral responses in and around the nest site ranging from complete passiveness to active aggression (USFWS 1996). Aggressive birds will fly directly from the nest to intercept an intruder. Tinian Monarchs are aggressive towards Collard Kingfishers and Micronesian Starlings throughout most the year. Aerial chases and displays between monarchs and Rufous Fantails can commonly be observed, fantail presence appears to be tolerated overall. Chases and agonistic behavior have not been observed between Bridled White-eyes and monarchs; the species appears to be generally tolerant of other avian species and has been frequently documented foraging within 5-10 m of them.

This species seems generally to tolerate con-specifics and considerable overlap in their home ranges has been noted (USFWS 1996). Flocks of 3-6 have been observed moving quietly through the forest together, but it is unknown if these are family groups. Mated pairs have frequently been seen foraging and traveling within 1-3 meters of one another within their territory during both nesting and non-nesting periods.

Breeding: The Tinian Monarch breeds year round but pronounced seasonality in nesting activity, potentially related to rainfall levels, was noted in a 1994-1995 study (USFWS 1996). The three peaks identified occurred in September, January, and May.

Nesting phrenology among habitat types tends to differ (USFWS 1996). Active nests in one of three stages (building, eggs, or nestlings) were more frequent in limestone forest than secondary forest, and tangantangan forest. Nesting success may also be higher in native forest.

Nesting: Monarch nests are open and cup-shaped and tend to consist of dried *Casuarina equisetifolia* needles, dried leaves, grasses, vine tendrils, spider webs, and feathers. Both male and female take part in construction. Nests are almost always placed at the juncture of vertically oriented supporting branches in the forest understory. Monarchs have been observed reusing old nests (but most were new) and using material taken from a previous nest (USFWS 1996).

Typical mean Tinian Monarch nest dimensions and substrate data include: inner bowl diameter, 51.6 mm; outer nest diameter, 63.8mm; bowl depth, 29.1 mm; nest height, 67.6mm; nest height from ground, 174.6 cm; nest tree height, 246.0 cm; diameter of tree at breast height, 29.2mm; number of branches supporting the nest, 2.7; distance of nest to trunk, 35.8 cm (USFWS 1996).

Over 60% of the Tinian Monarch nests found (*n* = 62) occurred in native tree species (USFWS 1996). The tree species that monarchs most commonly nested in were *Guamia mariannae*, *Leucaena leucocephala*, *Ochrosia mariannensis*, *Aglaia mariannensis*, *Ficus tinctoria*, *Spathodea campanulata* (USFWS 1996). However, nests were also found in *Cynometra ramiflora, Hibiscus tiliaceus, Lantana camara, Melanolepis multiglandulosa*, *Premna obtusifolia*, *Acacia confusa*, *Pithecellobium dulce, Bauhinia monandra*, and unidentified vines (USFWS 1996).

Eggs: Mean clutch size is two with 1-3 eggs being documented. Tinian Monarch eggs are white with pale reddish-brown spots distributed around the surface but generally concentrated at the larger end. Egg length and width were approximately 19.2 mm and 14.4 mm, respectively (USFWS 1996).

Incubation: The incubation period is approximately 15 days and does not begin until after the clutch is complete. Both male and female Tinian Monarchs incubate (USFWS 1996).

Brood Behavior: Once eggs hatch one adult monarch predominately broods while the other brings food to the nest, which is given to both brooding bird and nestlings (USFWS 1996). The sex of the brooding adult is unknown. Brooding decreases as the chicks get older; when they reach five days of age, adults tend to brood less than 50% of the time. Fecal sacs are removed from the nest throughout the nestling period.

Growth and development: Nestlings exhibit light colored skin, blackish bill with a yellow base, and a bright yellow gape. By day nine the young are very active, preening and climbing the rim of the nest with their flight feathers still in sheath. By day 11 nestlings appear fully feathered, with down feathers still around edges of the crown. Fledging occurs at approximately 13 days after which adults feed young for up to eight weeks (USFWS 1996).

Molt: Molting appears to occur after the nesting period in June and July, following the onset of the rainy season (USFWS 1996).

Threats: The primary direct threats to Tinian Monarchs are the loss of native limestone and secondary forest habitats, predation by introduced rats, and disease (e.g., avian pox).

Research Needed: Yet to be determined

Conservation Recommendation: Native forest re-vegetation, predator control, and in-depth analysis of disease impacts, and reinstating of federal and local protective designations.

BASIC HUSBANDRY

Acquisition and acclimation: Mist netting is the most effective means by which to capture Tinian Monarchs. Successfully capturing the species will require the use of 25mm mesh nets; birds have a tendency to pass through and get tangled in larger mesh sized nest, causing them undo stress. Nets should be checked every 15 minutes and captured birds should be removed in a manner that minimizes stress and transferred to a cloth “field bag” for transport to the field station. At the field station birds should be weighed, measured, banded, given a quick health assessment and have blood drawn by the veterinarian if the bird is not unduly stressed. The bird should then be placed in a dark and quiet field transport box and be given food and water. Birds in the transport crates in the field will eventually be taken to the MAC onsite aviary where they will be set up in more spacious holding enclosures.

Aviary holding enclosures will be constructed of entirely solid PVC material and are entirely enclosed except for a small row of air vents that are place on the top quarter of the side panels, are covered with mosquito screening. The back wall of the enclosure should be constructed of wire mesh covered with mosquito screening while the front consists of a solid door with two small viewing holes likewise covered with mosquito screening. The aviary enclosure should have two perches, a solid perch placed in its back quarter and a weighing perch in the front quarter. A feeding tray will allow for the cage to be cleaned and fed with minimal disturbance to the birds inside. Tinian Monarchs can be very territorial so all birds should be housed separately with no visual contact each other.

Newly captured Tinian Monarchs should be fed commercially available insects including meal worms, two week old crickets, wax worms.

Banding and Weighing: Monarchs should be are weighed, measured and banded (with USGS BBL size 0) at capture. Refer to Table 1 for expected weight ranges. Birds should be weighed daily while in “holding” boxes in the field, at the on-site aviary, and during transition to a captive institution. Both obtaining weights and monitoring fecal output are good methods to determine a bird’s daily heath status whether it is thriving in captivity.

Temperature: Tinian Monarchs occur in a naturally warm and humid environment; it is recommended that holding institutions strive to provide a similar climate. Housing birds outside is ideal in the summer as long as shade is provided. Not all institutions will be able to adequately provide this setting, however. Inside aviaries and breeding enclosures should thus be kept at 60°-85° F (18.3°-29.4° C), with ideal temperatures between 70°-80° F (23.9°-29.4° C).

Light: Although natural lighting is always preferred, most institutions employ a combination of both. Optimal photoperiod should be 11 hours in December to 13 hours in June. Ample shade should be provided if monarchs are housed outside.

Food and Feeding: Tinian Monarchs forage by gleaning, probing, hovering, and sallying at mid-level in the forest understory, in shrubs close to the ground, and occasionally on the ground. Monarchs will readily take commercially available insects including meal worms, two - four week old crickets, wax worms. It is important to encourage birds to utilize a variety of insects to ensure that they are receiving a balanced diet. Developing and maintaining a compost pile in the aviary is a good way to encourage the availability of a large variety of insects for captive birds.

Housing and General Environmental Considerations

***Environmental requirements*:** Flycatchers in general need open space in which to fly and maneuver easily and access to cover for instances when they feel threatened. The provision of secluded places in an enclosure is especially helpful with promoting breeding flycatchers tend to be significantly more nervous when nesting.

***Temperature / humidity*:** As mentioned previously, the ideal temperature range is 70°-80° F (23.9°-26.6° C). If temperatures fall below 50° F (10° C) in an enclosure a heat source should be provided. Maximum temperatures of 85° F (29.4° C) can be tolerated for short periods without difficulty. Higher temperatures will induce heat-stress reactions such as labored, open-mouthed breathing. If Rufous Fantails will be exposed to high temperatures within an enclosure, options should be developed to provide cool microclimates. Drip irrigation systems using fine mister heads are ideal as they dispense less than one gallon of water per hour, cost little to operate, and produce a mist that refreshes without saturating the aviary substrate or plants.

A minimum relative humidity level of approximately 55% is appropriate for tropical and semi-tropical bird species. The effects of long exposure to very dry (i.e., conditioned) air are not properly understood. Many bird species, however, appear to do better when provided with both fresh and naturally humid air. Thus, the provision of a humidifier or a simple mister / fogger system is suggested in buildings that do not have a regular inflow of outside air. When misting is used to cool an area during hot weather good air flow is also necessary to facilitate evaporative cooling (Vince 1996).

***Natural light*:** Access to full-spectrum lighting or direct sunlight is beneficial for most bird species. However, if a captive diet is properly supplemented with vitamin D3 the lack of full-spectrum lighting is not necessarily detrimental. Light intensity is very important to both maintain the birds' activity level and to promote healthy plant growth. Light intensity in the enclosure should be at a minimum of 600 foot candles, with peak levels of 1000 foot candles.

Captive Behavior: Monarchs are very territorial and un-paired birds should not be placed in close proximity to one another when held in captivity. High mortality occurred at Honolulu Zoo (Honolulu, Hawaii) and Riverbanks Zoo (Columbia, South Carolina) when birds were kept in cages that allowed visual contact between individual birds. Thus, it is very important that individuals be housed in visual isolation from one another. It is likewise important that Tinian Monarchs be housed singly when first brought into captivity and that introductions for breeding proceed slowly. Such introductions will typically involve allowing the male to establish a territory in his enclosure after which a female is placed in an adjacent cage, within sight of the male, to determine their compatibility. It is recommended to house the birds side by side for at least two weeks before they are physically introduced to each other. When doing so, the female should be introduced into the male's enclosure and the birds monitored very closely to ensure their safety. If any chasing is noted or if one bird dominates the food plate they should either be separated or a second food platform and visual barriers should be added to the enclosure. Once birds are successfully paired they can be held together year round.

Pair Formation, Nesting and Chick Rearing: No breeding has yet occurred with the Tinian Monarch in captivity and such information on captive reproduction is currently unavailable. This section will be updated upon successful breeding by the species. In the meantime, chick rearing information for the White-collared Yuhina (*Yuhina flavicollis rouxi*) was developed by San Diego zoo and will be referred to as needed and when appropriate.

Banding Offspring: Chicks should be banded at 30 days of age with a size 0 band.

Management of Juveniles: This information is not yet available.

Health Management: Proper and adequate Social spacing is critical to maintain the health of the Tinian Monarch in captivity. Birds should be maintained in visual isolation from one another until birds are well established in their captive environment. Maintaining unaccustomed monarchs in close proximity is very stressful for them. After maintaining birds in quarantine for six weeks with no obvious problems, staff at the Honolulu Zoo placed a male and female into a shared aviary of dimensions 1.5 m W by 3.1 m L by 2.4 m H; they were both dead within a day. Although neither bird showed any outward signs of stress, later necropsies indicated that disease, illness, nor organ distress were the cause of death.

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Appendix B: Species Profiles

Mariana Crow (*Corvus kubaryi*)

Compiled by: Fred Amidon, USFWS, Honolulu, Hawaii, Jeffrey Quitigua and Suzanne Medina, DAWR, Mangilao, Guam, Hannah Bailey, Houston Zoo, Houston, Texas, and Chelle Plasse, Disney's Animal Kingdom, Lake Buena Vista, Florida.

Order: Passeriformes
Family: Corvidae
Local or Chamorro Name: *Aga*

SPECIES OVERVIEW

Description: The Mariana crow is the only representative of the Corvidae family occurring in Micronesia (Jenkins 1983), and appears to be most closely related to the house crow (*Corvus splendens*) from southern Asia (R. Fleischer, National Zoo, pers. comm. 2000). Black in color, the adult Mariana crow has a dark green gloss to its head, neck, and back, and a bluish tint to the tail. During molt, a short gray feather-base is visible around the body and neck region and grows lighter toward the head. The Mariana crow has brown eyes, a slender, black bill, and short visible nasal bristles. On average, females weigh less (242 grams, $n = 11$) than males (256 grams, $n = 5$) (Baker 1951), although otherwise the sexes appear outwardly similar. With the exception of the occasional brown gloss to its tail, the immature Mariana Crow closely resembles the adult bird. Wing, tail, and tarsal lengths taken from 31 specimens collected on Guam and Rota are listed in Table 1.

Table 1. Morphometrics for Mariana Crows collected on Guam (R = range; Baker 1951).

Sex	Wing (R)	Tail (R)	Culmen (R)	Tarsus (R)
Male ($n = 9$)	236 (229-244)	165 (158-170)	55 (51-57)	51 (49-52)
Female ($n = 19$)	227 (222-241)	151 (143-166)	50 (47-54)	50 (46-54)

Distribution: The Mariana crow was endemic to the islands of Rota and Guam in the Mariana archipelago. The last Mariana crow from the native Guam population disappeared in 2002 or 2003 (DAWR 2003). The Rota population is currently believed to be less than 60 territorial pairs (Berry *et al.* 2008). In 1999, the population was estimated to be approximately 110 breeding pairs or 234 breeding adults (Plentovich *et al*. 2005). In 1982, the Mariana crow population was estimated to be approximately 1,300 individuals (Engbring *et al*. 1986).

Habitat: Mariana crows were known to utilize secondary forest, coastline forest, ravine forests, agricultural forest, and coconut plantations on Guam and Rota, however, all evidence suggests that crows were (and are) most abundant in primary or mature native limestone forests (Seale 1901, Stophlet 1946, Marshall 1949, Baker 1951, Jenkins 1983, Morton *et al*. 1999). Of 156 nest sites on Rota, 39 percent and 42 percent were in mature and secondary limestone forest, respectively (the remaining 19 percent were in coastal forest; Morton *et al.* 1999). Morton *et al.* (1999) found that breeding Mariana crow densities on Rota averaged one pair per 22 hectares of forested habitat (predominantly native forest) on their six study areas ranging from 50 to 130 hectares in size. Pair densities ranged from a low of one per 37 hectares on Duge, a relatively fragmented forest patch, to as high as one pair per 12 hectares along the coastal terrace above Puntan Saguagahga. Territories were aggressively defended from July through January, although established pairs occupied these areas throughout the year. Although 18 percent of the forested area of Rota is *Leucaena leucocephala* or some other species of introduced tree (Falanruw *et al.* 1989), no Mariana crow nests have been found in anything other than a native tree on this island. Of 161 nest trees found during 1996 to 1999, 63 percent were of 4 species: *Neisosperma oppositifolia*, *Eugenia reinwardtiana*, *Intsia bijuga*, and *Premna obtusifolia* (Morton *et al.* 1999). Individual nest trees averaged 16.9 centimeters diameter at breast height and 8.7 meters high. Canopy cover over nest sites averaged 93 percent and was never less than 79 percent.

Little is known about the foraging habitat requirements of the Mariana crow. Research by Morton *et al*. (1999) indicates that young Mariana crows may prefer immature limestone forest for foraging. Almost 61 percent of locations of banded, pre-dispersal juvenile resightings (n = 398) were associated with immature limestone forest; in contrast, only 49 percent of the study blocks were categorized as immature limestone forest (Morton *et al.* 1999), suggesting Mariana crows were selecting this habitat type. Between 1992 and 1994, 90 percent of perching observations on Rota (n = 115) were in native trees, primarily in mid- to low- heights of the canopy (M. Lusk and E. Taisacan, unpubl. data).

Food and Feed Habits: Mariana crows are omnivorous and their diet includes a wide variety of plants and animals. They have been observed foraging on several invertebrates, including Lepidopteran (butterfly and moth) larvae, grasshoppers, mole crickets, praying mantis, earwigs, and hermit crabs. Skinks, geckos, immature rats, and bird eggs are also a part of their diet (Beaty 1967; Jenkins 1983; Tomback 1986; Michael 1987; R. Beck, unpubl. data; M. Lusk and E. Taisacan, unpubl. data). They have also been observed foraging on the foliage, fruit, seeds, and buds of at least 26 different tree species (Jenkins 1983; Tomback 1986; S. Plentovich, unpubl. data; C. Aguon, unpubl. data).

Mariana crows have been observed foraging in the canopy, subcanopy, understory, in forest undergrowth, and on the ground (Jenkins 1983; Tomback 1986; M. Lusk and E. Taisacan, unpubl. data). On Rota, crows were found to forage at an average of 4.9 meters above the ground, significantly lower than the average canopy height (7.5 meters) of forests in which they were observed foraging (M. Lusk and E. Taisacan, unpubl. data). While foraging, Mariana

Crows will rustle through the leaf litter and tear at bark in search of insects (Tomback 1986; J. Morton and C. Aguon, unpubl. data).

Behavior: Mariana crows make a variety of sounds. Pratt *et al*. (1987) described their vocalizations as a loud "kraa-ah" and quiet "conversational" notes. Pairs also vocalize quietly at their nests with rambling dialogues (NRC 1997).

Mariana crows are typically found in families containing a monogamous pair and one to three offspring. During a 3-year period (1996 to 1999) on Rota, Morton *et al.* (1999) reported an average of 1.2 fledglings per nest for 33 successful Mariana crow nests. Sightings of large groups of Mariana crows have been reported on both Rota (E. Taisacan, Retired, Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife, pers. comm. 1999) and Guam, and were apparently common in the 1980's (Wiles 1998). Such groups typically appeared in late summer, prior to territory establishment for breeding. As many as 66 birds were observed roosting together on Guam during February of the 1984 breeding season, but this may have been a response to abnormally skewed sex ratios resulting from brown treesnake (*Boiga irregularis*) predation on nesting females (Wiles 1998). Large aggregations were not observed on Rota during the late 1990's (Morton *et al.* 1999); most recorded observations were attributable to brief mixing of family groups. Notable exceptions included observations of 16 crows in June 1989 in the Pekngasu region (D. Stinson, Commonwealth of the Northern Mariana Islands Division of Fish and Wildlife [formerly], pers. comm. 1999), nine crows in September 1997 in the Palii basin, and seven crows near Puntan Saguagahga in February 1998 (Morton *et al.*, unpubl. data). Thus, social aggregations are occasionally observed, but the current frequency and causes of this behavior are not fully understood.

Breeding: Mariana crows likely breed year round on Rota. During a 3-year period (1996 to 1999), Morton *et al*. (1999) observed nest initiation as early as July 31 and fledging as late as May 22. June is the only month that active Mariana crow nests were not found. Peak nesting activity occurs from August through February, but the timing can vary considerably depending on typhoon activity during the previous breeding season. In contrast, breeding activity in the remnant Mariana crow population on Guam was truncated, apparently due to nest predation, poor physiological vigor of the adults, and egg nonviability. In recent years (1998 to 2007), nesting by Guam crows was recorded only from October into mid-April (Morton 1996; C. Aguon and J. Quitugua unpubl. data).

Nesting: Mariana crow nests are large open cup nests typically composed of a nest platform and intermediate and inner cups. The nest platform is made principally of flexible *Jasminum marianum* vines and to a lesser extent of twigs from a few other species of trees (Lusk and Taisacan 1996; C. Aguon and J. Morton, pers. comm. 2001). The intermediate nest cup is usually composed of an interwoven mesh of small branches, *Ficus* spp. rootlets, vines of *J. marianum* and *Cocos nucifera* fibers. The nest platform ranges in diameter from about 24 cm to 53 cm while the inner diameter of the nest may be about 15 cm (Lusk and Taisacan 1996). Nests on Guam are usually lined with fine fibers from *Flagellaria* spp. (C. Aguon, pers. comm. 2001).

Nest location and type of trees selected for nesting differs between Guam and Rota. Mariana crows on Rota typically build their nests toward the inner part of the tree canopy. Morton *et al*. (1999) recorded crow nests in 20 species of native trees. These trees are usually about the height of the forest canopy and sometimes shorter. In contrast, Mariana crow on Guam usually build their nests in the outer portions of the tree canopy and choose a small number of mainly emergent native tree species (C. Aguon, pers. comm. 2001).

Eggs, Incubation, Hatching, Growth, and Development: A minimum of 65 days is necessary to build the nest, incubate the eggs, and rear the brood through fledging (Morton *et al.* 1999). Both parents generally participate in all aspects of breeding, although the female incubates most of the time. Nest construction typically takes a week to complete by both parents and develops through three stages with progressively smaller-diameter nest materials: platform, cup, and nest lining (Morton 1996; Lusk and Taisacan 1996). The incubation period is 21 to 23 days and the nestling period is 36 to 39 days (Morton *et al.* 1999). Mariana crows will often reinitiate the nest cycle within 2 weeks after abandoning an empty nest, and within 4 weeks after losing a clutch or brood (J. Morton, USFWS, pers. comm. 2001).

The percentage of nests that produced fleglings between 1996 and 2006 varied from 12% to 50% and Mayfield estimates of nest success ranged from 13% to 41% (Ha *et al.* 2008). Mean clutch size, number of nestlings, and number of fledglings for nests monitored between 1996 and 2006 was 2.59 ± 0.08 SE, 1.42 ± 0.06 SE , and 1.28 ± 0.07 SE, respectively (Table 4; Ha *et al*. 2007; Lainie Berry, University of Washington, pers. comm., 2008). Large clutches (four eggs) have been observed on Rota, but not on Guam. This occurred most frequently (seven of eight observed nests) during the year immediately following Supertyphoon Paka (December 1997). During that year (1998), one female even deposited a second four-egg clutch immediately after losing her first clutch of four eggs (Morton *et al.* 1999).

Although Mariana crows generally produce no more than a single brood per year, nest failure and other factors lead to multiple nest attempts each breeding season. From 1996 to 1999, 32 crow pairs on Rota constructed a mean of 2.2 nests a year (n = 78), nesting as many as seven times in one season (Morton *et al.* 1999). Not all nests resulted in egg laying, however. On average, Rota pairs produced about one nest per year that advanced to the level of egg deposition. Over a 3-year period, of 148 nests with known fates, 18% were only partially constructed, 13% were abandoned after completion, 4 percent had inviable clutches, 28% were depredated, and 16% were destroyed by typhoons (the remaining 22% fledged young; Morton *et al*. 1999). Similarly, on Guam, Mariana crows have been known to attempt nesting seven times in one season (Morton 1996). However, nest failures in more recent years have been attributed to premature abandonment (either as a result of predators or human-induced disturbance), interference by unmated males (due to skewed sex ratios), black drongo mobbing, and possibly senescence (*i.e.*, poor physiological vigor and infertility) (Morton 1996; NRC 1997).

After fledging, Mariana crows will typically remain in family groups until the following breeding season, a period that averaged 241 days (median 197 days) for 15 banded family groups (Morton *et al.* 1999). However, the period of parental attendance after fledging varies widely, from 99 to 537 days. Consequently, although Mariana crows typically produce from zero to one brood a year, exceptions have been documented. One pair on Rota successfully fledged and raised two broods of singletons in one breeding season; in contrast, another pair tended a single juvenile for 18 months, skipping an entire breeding season (Morton *et al.* 1999). This latter consequence of an extended parental attendance period is not uncommon in Mariana crows. Over a 3-year study period, four of 30 pairs were deemed nonbreeders during at least one year due to continued attendance of juveniles produced during the previous breeding season (Morton *et al.* 1999).

We know little about the age of first reproduction or length of reproductive life in Mariana Crows. On Rota, crows are assumed to enter into the breeding cohort at 3.5 years of age, and the oldest known breeding bird was a 13 year old male crow (Morton *et al.* 1999, Ha *et al.*, University of Washington, pers. comm. 2008). However, these estimates may be conservative due to the limited long-term banding work on this species. For example, the longevity record for the American crow (*Corvus brachyrhynchos*), for example, is 14 years, seven months (USGS 2003) and they become sexually mature at the end of their second year (Black 1941, as cited in Verbeek and Caffrey 2002).

Threats: Habitat loss, nutritional deficiencies, human persecution, contaminants, and introduced species such as disease organisms, cats (*Felis catus*), rats (*Rattus* spp.), black drongos (*Dicrurus macrocercus*), monitor lizards (*Varanus indicus*), and brown treesnakes have all been suggested as factors in the population decline of this species. However, the brown treesnake is believed to be the overriding factor in the extirpation of Mariana crow from Guam; habitat loss, human persecution, and feral cat predation are believed to be major factors in the decline on Rota.

Research Needed: High levels of adult and juvenile mortality are believed to be driving the current population decline (Ha *et al.* 2008). Research into those mortality factors is required to effectively manage for the conservation of the species. In addition, factor effecting nesting success and information on habitat selection is needed to better manage the species.

Conservation Recommendation: Feral cat depredation is believed to be a primary source of mortality in adult and juvenile Mariana crows. Therefore, island-wide control or eradication of feral cat populations on Rota is essential to crow conservation. In addition, efforts to address landuse conflicts with the Mariana crow and improve public perception of the species are considered a high priority. Finally, the rapid decline of the population as well as its susceptibility to random catastrophic events requires some form of population intervention. This intervention could take the form of a captive rear and release program on Rota, establishment of a captive population, or the establishment of a rescue population outside the species known range.

BASIC HUSBANDRY

Acquisition and acclimation: Attempting to acquire Mariana crows in the wild is difficult and time consuming. It is recommended to capture adult birds with mist nets early in the morning during the non-breeding months (June to early-August). Capturing juvenile birds should be done with mist nets during the breeding season (late August to May). Collecting nestling crows and eggs should be executed early in the breeding season to allow pairs to re-nest before the end of the breeding season.

The use of kennels or a portable cage is appropriate to transfer crows to holding facilities. The kennel contents should include a towel (or netted mat) and a small perch, which is optional. For nestlings, a portable brooder with an artificial cup is needed for transfer. The artificial cup should be lined with soft tissue and secured in the portable brooder. The brooder should contain a heat source to keep the nestling warm during transport. Transport temperature for nestlings should be maintained at 95°-99° F (35°-37° C; temperatures will depend upon age of the chick, with careful monitoring of chicks behaviors – i.e., panting vs. slow breathing).

Adult birds can be housed in an outside aviary. Depending on the size of the flight cage, four birds can be housed together temporarily. Depending on the age of the nestlings they should be kept in a brooder until ready to be placed outside. Cages should be equipped with a feeding platform, shade cloth, and perches.

Banding and Weighing: Banding should occur when Mariana Crows are placed in the outdoor aviary; three color bands and an USFWS numbered band are typically used. Weight, blood sample, and measurements should be obtained during banding. To reduce stress on the bird, a sock or bird bag can be used to cover its head, but this may not be necessary in all cases. Either surgical gloves can be used when handling birds or ones unprotected hands if adequately washed. Birds should be monitored daily after bands are applied and weights obtained before the first feeding of the day.

Temperature: Adult and juvenile Mariana Crows held on Guam were held in outdoor aviaries. Minimum and maximum preferred temperatures for housing adult and juvenile Mariana crows are unknown. Temperatures of incubators are maintained at 99° F (37.2° C) and wet-bulb temperature is held at 84° F (28.9° C). At the onset of piping, eggs are moved to a hatcher, with temperatures at 98°-100° F (36.9°-37.5° C) and 90° F (32.2 ° C) wet-bulb. Hatchlings are held in a brooder at temperatures similar to those of the hatcher and the temperature is decreased gradually based upon obvious signs of discomfort from the chick. Young are kept in the brooder until they are 10-13 days old or until they to self-thermoregulate.

Light: Mariana crows held on Guam were held in outdoor aviaries covered by shade cloth. Indoor lighting requirements are unknown but if held outdoors some area of the aviary should be left uncovered allowing a bird access to sunlight as desired.

Food and Feeding: Refer to Table 2 for details on chick rearing at the Houston Zoo. Nestlings Mariana Crows are fed once every two hours from day one to day 29, every four hours from day 30 to about day 39, throughout the night if needed (feeding between 06:00 and 18:00 may be sufficient, allowing for the first one to two days if the chick is not progressing well and gaining weight). If the chick is not self-feeding at day 40 it should be fed three times a day between 07:00-21:00 hours until it is (by this time a chick should be self-feeding and should be encourage to do so by leaving food with it – it will be necessary to take into consideration the individual behavior of each bird). The diet for nestlings should include pinky mice, wax worms or bee larvae, and papaya sprinkled with liquid vitamin and mineral supplements. Older nestlings are given additional items such as banana, soursop, breadfruit, grapes, corn, praying mantis, and whole pinkies. Adult crows are fed a commercial nutritionally balanced avian pellet, cooked eggs, grapes, papaya, mice pinkies, lizards, and live mice (a good quality pellet dog food might be substituted for the avian pellet providing the protein level is at least 18-20%).

Housing and General Environmental Considerations: Mariana Crows held on Guam were placed in aviaries with dimensions 5.6 m D by 2.1 m W by 2.6 m H. Each aviary was covered with 0.63 cm mesh wire for snake-proofing and was equipped with perches and feeding platforms. The Houston Zoo found it important to provide perching alternatives in a variety of

Table 2. Suggested chick rearing schedule based upon success at the Houston Zoo.

Age (days)	Feeding Schedule	Housing & Substrate	Brooder Temperature	Development milestone & miscellaneous information
0 - 7	Every 2 hours: sunrise to sunset (~ 8 times a day)	Brooder: nest-bowl lined with soft material	97-98°	Chick should be pink in color, plump (not wrinkled) and peaceful. If lethargic, temperature could be too low. If sprawled out and panting, temperature could be too high.
8 - 14	Every 2.5 hours: sunrise to sunset	Add sticks to nest-bowl to encourage foot development		Slowly drop temperature: generally 1° every 2-3 days. Adjust based on behavior of chick
15 – 21	Every 3 hours (6 times a day)		90-92°	Feather shafts opening, vocalization increases
22 – 30				Weight Gain slows, chick is feathering out
30 - fledge	Every 4 hours; encourage self-feeding	Larger area with more stimulation; provide perching	Ambient temperature (above 85-88°)	Perching on side of nest; fledging ~ 40-45
Post-fledge	3 feedings a day			Encourage self-feeding behaviors (provide live food to stimulate curiosity)

diameters and lengths. If the width of the holding cage makes it difficult to find perching of suitable lengths, rope of natural fibers can be used instead. Deadfall can additionally be placed about the cage floor to provide a variety of resting areas as well as stimulation if live food is placed within nooks and crannies. Enrichment items including puzzle feeders, insect hiding objects, dead and/or rotting bark and vegetation will also provide stimulation. The ideal aviary size for a breeding pair on Guam has not been determined but they have bred at the Houston Zoo in a holding are of dimensions 3.7 m D by 4.9 m W by 3.1 m H.

Captive Behavior: As captive Mariana Crows have been known to attack and kill smaller birds (including wild birds and scavengers, as well as birds in adjacent enclosures) crows should be held in single species aviaries. As a rule, crows are very inquisitive, intelligent, and somewhat destructive birds and tend to require a stimulating environment. Enrichment at the Houston Zoo was provided often (daily if previous day's enrichment items were "spent"). Items offered included logs (especially rotten ones) to break apart, tennis balls, pieces of rope to shred, large bark chips to dig through, mice in cardboard boxes, puzzle feeders, etc.

Pair Formation, Nesting, and Chick Rearing: Little is known about captive breeding of Mariana Crows other than what information was gained by the experience of the Houston Zoo. The crow pair housed there lived together from their pairing in January 1994 until the death of the female in August 2002. The male was removed from the exhibit during nesting on two occasions as he was thought to have consumed eggs and/or chicks (behavior common to corvid species). The male was present, however, in the enclosure when a chick was reared in 1995.

Crow pairs were offered nest baskets filled with hay and placed on platforms in early January. Baskets were approximately 35.6 cm D by 35.6 cm W by 10.2 cm H in dimension while platforms were constructed from weld wire and were approximately 30.5 cm D by 20.3 cm W by 5.1 cm H. All nests were placed approximately 2.1 m above ground level.

Nest building began in February and nesting material was offered to the crows daily, based on the preferences of the birds. The Mariana Crows at the Houston Zoo used sticks (primarily oak), leaves, Spanish moss, cypress bark, ginger stalk (shredded by the crows into soft fibers), cassia, grape vine, palm fibers/fronds, and dried grasses for nest building. A completed nest consists of three distinct elements: an outer framework of coarse sticks, an inner nest of vegetation (e.g., leaves and Spanish moss), and a "bowl" of fine fibers (e.g. ginger stalk fibers). A nest is typically very well defined and tightly constructed. After the outer framework is constructed the female will often sit in the nest while the male delivers further nesting material to her. Nest building is generally accomplished in approximately 8-10 days with completion of the nest lining generally indicating that egg-laying is imminent.

Eggs are typically laid on consecutive days but inter-egg intervals have been observed of 2-4 days. A full clutch for the Houston Zoo pair consisted of two or three eggs. Incubation for captive Mariana Crows was 20-23 days and chicks hatched on consecutive days. The sole chick raised at Houston fledged on day 41 and was removed from the parent's enclosure at approximately 10 months of age (refer to Table 3 for details).

While raising chicks the adults at the Houston Zoo were provided mouse pinkies, anole lizards, and commercial bird-of-prey diet foods (ground horse meat), all of which was sprinkled with dicalcium-phosphate powder.

Banding Offspring: Juvenile Mariana Crows may be banded at day 40 using adult bands. Weight, blood sample, and pertinent measurements should be obtained during banding.

Management of Juveniles: Juvenile crows raised in captivity on Guam have been housed in the same aviary from one to three years. Juvenile birds were never kept in separate aviaries and always shared an eclosure with another. Adult crows were placed in adjacent aviaries when possible to serve as mentors.

Health Management: As a whole, corvids tend to be fairly hardy in captivity. West Nile Virus, however, has recently become a concern for species housed outdoors. Very fine mesh screen to prevent mosquitos from entering enclosures can help remedy this but indoor exhibits are safest in areas where the disease is prevalent. Crows in general are as susceptible to the usual avian diseases (e.g., aspergillosis, atoxoplasmosis, avian tuberculosis, and malaria) as any other species (Fox 2003), and like any species that probes soil for worms, Syngamous (gape-worm) is an issue that can be treated prophylactically.

Table 3. Chick Development Chart (based on 1 captive reared chick at the Houston Zoo).

Age (in days)	Weight (in grams)	Developmental Milestones
1-day pror to Hatch		Egg Candled: chick in air-space (internal pip)
0		Chick hatched, found hatched in early AM, no eggshell found (potentially indicates consumption of eggshell by parents)
6	49	Chick is bright pink
7	63	Eyes not open, no feather tracts present
10		Chick darker in color (no longer bright pink), feather tracts visible under skin
11	127	Eyes starting to open, feather tracts appearing (bluish/black in color)
13	167	Eyes open, feathers emerging
15	191	Chick very vocal and observed looking over the edge of the nest. Feather shaft tips starting to split.
18	223	Chick is very vocal and sitting up on its own
19		Parents are seldom brooding chick
20	241	
21	244	Weight Gain is slowing
27	255	
33		Perching on side of nest
41		Fledged from nest; eyes are steel blue at fledging
~ 10 months		Removed from parental enclosure. Parents were displacing juvenile (juvenile sexed as a hen was also soliciting adult male)

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Appendix B: Species Profiles

Nightingale Reed-Warbler (*Acrocephalus luscinia)*

Complied by: Rachel Rounds and Paul Radley, CNMI Division of Fish and Wildlife, Saipan.

Order: Passeriformes
Family: Sylviidae
Local or Chamorro Name: *Gaga Karisu*


J. Bradley

Species Overview

Description: The Nightingale Reed-warbler is characterized by a horn colored, long and slender bill and overall pale yellowish-buff color (Baker 1951; Pratt *et al*. 1987). The species is pale yellow-buff below, rufous-brown or grayish olive-brown above, with a pale yellow eyebrow (Baker 1951; Pratt *et al*. 1987). Head feathers are "shaggy" in appearance and often held erect and the tarsi and feet are light gray (Pratt *et al*. 1987). Females are similar to the males but are slightly smaller, while immature birds are similar to adults with duller and browner upper-parts and less yellow under-parts (Baker 1951).

Table 1. Morphometrics of Nightingale Reed-warblers in the Mariana Islands (all measures and weights in millimeters and grams, respectively).

Island	Sex	*N*	Wing	Tarsus	Tail	Culmen /Bill	Mass	Source
Saipan	Male	3	85	31.7	81[a]	31.5 (C)	35.6	Johnson 2003
Saipan	Male	19	87	34.8	83	23 (B)	35.9	Craig 1992
Saipan & Guam	Male	11	84	30.5	83	36 (C)	30[b]	Baker 1951
Saipan	Male	12	87.2	-	-	-	33.1	Radley *et al*. 2011 and unpub. data
Saipan	Female	10	82	33.2	78	22.6 (B)	32[c]	Craig 1992
Guam	Female	1	78	28.5	73	37 (C)	27	Baker 1951
Saipan	Female	9	82.4	-	-	-	27.4	Radley *et al*. 2011 and unpub. data

[a] Mean for only two birds – one bird was molting its tail and was not included
[b] Based upon three adult males from Guam
[c] based upon nine adult females

Distribution: The Nightingale Reed-warbler is endemic to the Mariana archipelago and three subspecies are currently recognized: *Acrocephalus luscinia luscinia*, *A. l. nijoi*, and *A. l.*

yamashinae (Mayr *et al*. 1986). The former, *Acrocephalus luscinia luscinia*, was originally found on Guam, Saipan, and Alamagan, but the Guam population was believed extirpated in the 1960s, the last known individual sighted at Agana Swamp in 1969 (Reichel *et al*. 1992). The species was likely extirpated from Guam by the introduced brown tree snake, with habitat loss and other introduced predators also serving as contributing factors (Reichel *et al*. 1992).

In 2007, the Saipan population of Nightingale Reed-warblers was estimated at 2,742 (range = 1,686 – 3,956; Camp *et al*. 2009), a decline of 35% from the 1997 population estimate of 4,225 (USFWS 1998a), and 43% from 1982 estimate of 4,837 (Enbring *et al*. 1986). Camp *et al*. (2009) estimated that reed-warbler densities on the island have decreased by more than half from 1982 to 2007. Additionally, USFWS (1998a) found declines of reed-warbler numbers in developed parts of the Saipan and an increase in numbers in the more undeveloped northern areas of the island. However, reed-warblers are distributed over the entire island and are only absent from heavily developed or populated areas (DFW 2009; USFWS 1998b).

Point –transect distance surveys for the reed-warbler on Alamagan in 2010 place the population at a mean of 946 individuals (95% CI 428 – 1,762; Marshall *et al*. 2011). CNMI DFW surveys of the island in 2000 estimated the population at a mean of 1,125 individuals (95% CI 504 – 1,539; Cruz *et al*. 2000a, Marshall *et al*. 2011). Super-typhoon Choi-wan passed directly over Alamagan on 15 September 2009, while super-typhoon Melor passed well to the south on of the island between 1 and 3 October 2009. These two storms, in addition to other super typhoons in the preceding decade, may have caused enough damage to have reduced the already small population size.

Acrocephalus luscinia nijoi, the subspecies status of which USFWS (1998b) questions, has only been reported from Aguiguan and appears to have always been rare on that island (Reichel *et al*. 1992). After conducting surveys work in 1982, Enbring *et al*. (1986) reported a population of 4–15 birds on the island. Currently, Aguiguan's population may be extirpated as no reed-warblers have been observed there since 1995 (USFWS 1998b), despite extensive surveys by CNMI DFW and USFWS in 2000 (Cruz *et al*. 2000b), 2002 (Esselstyn *et al*. 2002), and 2008 (USFWS unpublished data). The disappearance of reed-warblers from the island is probably due to a combination of feral goats, extensive clearing for agricultural development by the Japanese prior to World War Two, and the small size of the island (Enbring *et al*. 1986; Reichel *et al*. 1992).

Acrocephalus luscinia yamshinae was only reported from the island of Pagan (Reichel *et al*. 1992). Currently, this population is presumed extinct as no sightings were reported in the 1970s, 1980s, and 2000 (Reichel *et al*. 1992, Cruz *et al*. 2000c). Habitat suitable for reed-warblers on Pagan had already been severely degraded by feral ungulates prior to a volcanic eruption in 1981, which destroyed the only known remaining habitat for the species on the island (Reichel *et al*. 1992; Cruz *et al*. 2000c). Surveys conducted in 2010 failed to detect the species (Marshall *et al*. 2011).

In addition to these historical records, recent investigations on Tinian have revealed prehistoric evidence of the reed-warbler on that island (Steadman 1999). Given the current and prehistoric distribution of the reed-warbler in the archipelago it is possible that this species may have inhabited additional islands as well.

Habitat: The Nightingale Reed-warbler is common in upland and wetland habitats over most of Saipan (Reichel *et al*. 1992; USFWS 1998b). Upland habitats include tangantagan forests, tall elephant grass (*Pennisetum polystachyon*), bamboo, secondary forests, forest edges, and mosaics of these habitats (Craig 1992; Reichel *et al*. 1992, USFWS 1998b). USFWS (1998c) found reed-warbler densities highest in mixed secondary and tangatangan habitats in a survey of the Marpi Commonwealth Forest. Wetland habitats include native reed (*Phragmites karka*) marshes, marsh edges, mangroves, and wetland/upland econtones (Craig 1992; Reichel *et al*. 1992; USFWS 1998; Mosher 2006). Marshall (1949) reported reed-warblers in dense populations in marsh lands surrounding Lake Susupe, and marshes at Tanapag Harbor. Across Saipan, the reed-warbler tends to be absent from native limestone forest, mature secondary forests, beach strand, and swordgrass savannahs (Craig 1992; Reichel *et al*. 1992; USFWS 1998).

On Alamagan Nightingale Reed-warblers have been found in habitats with partially open overstory and somewhat brushy understory, and in dense swordgrass (*Miscanthus floridulus*); however, none were observed in dense forest over 300 m elevation (Reichel *et al*. 1992; USFWS 1998b). Occupancy analysis of data collected on Alamagan by USFWS in 2010 indicated the reed-warblers occur in 19% of the island's native forest, 49% of its coconut forest, and 69% its of secondary forest (Marshall *et al*. 2011). Cruz *et al*. (2000a) observed Nightingale Reed-warblers foraging throughout the mixed native and coconut forests, often in *Hibiscus tiliaceus*, and found them common in forested areas in the northern and southern parts of island, and at lower elevations; birds were not detected in open areas. These forested areas are among those most highly altered by human intervention, and are also highly impacted by feral animals. Reed-warblers were also heard in the remnant forests inside the volcanic crater. The bird's use of both forest and open patches is similar to what is observed on Saipan (Cruz *et al*. 2000a).

The USFWS (1998b) reported that reed-warblers on Aguiguan had inhabited formerly disturbed areas vegetated by groves of trees and thickets 1-2 meters tall. Craig and Chandran (1992) located Nightingale Reed-warblers in forest edges on the island and Engbring (1986) in native forest. Reichel *et al*. (1992) reported Nightingale Reed-warblers on Aguiguan using native forest with dense canopy. On Pagan, Nightingale Reed-warblers were reported to inhabit lake and wetland edge vegetation almost exclusively (Reichel *et al*. 1992; USFWS 1998b). On Guam, Nightingale Reed-warblers almost exclusively used *Phragmites karka* wetlands (Reichel *et al*. 1992; USFWS 1998), and less frequently tangantangan habitat (Reichel *et al*. 1992), and were most common at Agana swamp (Baker 1951).

Food and Feed Habits: Data are limited concerning the foraging behavior of the Nightingale Reed-warbler. Baker (1951) reported that Seale (1901) found insects and larvae in the dissected stomachs of four reed-warblers. Likewise, Marshall (unpublished in USFWS 1998) also found coccinelid beetles and species' of Hemiptera and Orthoptera in dissected reed-warbler stomachs. In the field, Marshall (1949) observed reed-warblers gleaning lizards, snails, spiders, and large insects from the ground. Mosher (2006) likewise observed nestlings being fed insects (ants, caterpillars, grasshoppers, moths, and praying mantids), spiders, and lizards (skinks and geckos).

Craig (1992) noted the Nightingale Reed-warblers long bill relative to other reed-warbler species and postulated that this was related to a great range in food size and would be advantageous on a food-limited island. Craig (unpublished data as cited in USFWS 1998b) also reported that prey selection included insects of at least 3 cm in length and observed reed-warblers gleaning invertebrates from live and dead leaves and probing dead stubs. Mosher

(2006) suggested that food does not appear to be a limiting factor for the species, labeling it as a generalist insectivore and carnivore.

Behavior: The Nightingale Reed-warbler's song, which may continue uninterrupted for several minutes, resembles that of American thrashers and mockingbirds, and includes trills, warbles, and whistles (Pratt 1987). Pratt (1987) described the species call is a loud "chuck." Marshall (1949) reported reed-warblers mounting tree tops to sing in the evening, and singing constantly on moonlit nights. Males often sing in chorus at dawn, but singing is less frequent during the day (Marshall 1949). A raspy "ch-ch-ch" noise is often made by a breeding pair when around the nest (CNMI DFW unpublished data).

Craig (1992) noted that the Nightingale Reed-warbler is extremely territorial and that it aggressively defends an approximate 1 hectare (9,338 ± 3,433 [SD] m^2; $n = 7$) territory by singing from exposed treetops, interior thickets, or elephant grass stems. The species generally exhibits high site fidelity by males, and low site fidelity by females (Craig 1992). However, females will at times follow territorial males to defend a territory against an intruder (Craig 1992). Male defensive behavior includes song and pursuit, and two have been observed skirmishing on the ground (CNMI DFW unpublished data).

Breeding: The Nightingale Reed-warbler exhibits a bi-modal profile in timing of breeding throughout a typical year. Mosher (2006) found that the occurrence of male reed-warblers with enlarged cloacal proturberances peaked in January and June, and active brood patches were observed in January, May, and June. Mosher (2006) also observed two peak nesting periods during his study on Saipan; January through March and July through September. Active nests were found in all months except November and December, with no nests being initiated after the month of September (Mosher 2006). Pairs that fledged young during a seasonal peak did not re-nest again until the next breeding peak. However, DFW (unpublished data, 2009) did observe a Nightingale Reed-warbler nest initiated in October.

Unlike other species of reed-warbler, the Nightingale Reed-warbler is apparently monogamous (Mosher 2006, Craig 1992). Males defend their mates and nest sites, but not their feeding territories (Mosher 2006).

Nesting: Unless otherwise cited, most available information on Nightingale Reed-warbler nesting comes from research conducted by Steve Mosher on Saipan (e.g., Mosher 2006, Mosher and Fancy 2002). Mosher (2006) states that information in Oustelet (*in lit*), Engbring *et al*. (1986), Craig (unpubl 1988) all generally fit his descriptions.

Females constructed the nest with limited help from the male. Nest construction typically took 3-4 days and nests tended to be either tightly woven and compact or larger and tightly woven with bulky outer material. The nests were open cups, were circular to ovoid in shape, and some had an inner rim with an overhanging lip.

Nightingale Reed-warblers appear to be opportunistic in selection of nesting material. Nests were typically composed of an outer structure of dried vine stems and tendrils of introduced bitter melon (*Momordica charantia*), wild passionfruit (*Passiflora foetida*) and of ironwood (*Casauarina equisetifolia*) branchlets. Nests in tangantangan (*Leucaena leucocephala*) forest

Table 2. Nest measurements (*n* = 66) from Mosher (2006) and Mosher and Fancy (2002). All nest heights provided are from nests that were located in trees. A single nest found in reed wetland was 2.2 m high and 0.8 m below the top of the reeds.

	Mean (mm)	**Range (mm)**
Outer nest diameter	106	83-127
Outer nest height	90	57-177
Cup diameter	65	46-86
Cup depth	45	29-58
Rim width	20	12-28
Rim width at base of cup	28	17-48
Nest height	4.3 m	2.3-10 m
Nest tree height	6.1 m	3.4-25 m

had cup linings composed of tangantangan petioles, while those in mangrove forests were lined with more ironwood branchlets. Reed blades and spider web casing were also used.

On Saipan, reed-warbler nests have been found in native trees including *Ochrosia mariannensis*, *Hibiscus tiliaceus*, *Bruguiera gymnorrhiza*, and *Casuarina equisetifolia*, introduced tree species including *Leucaena leucocephala* and *Pithecellobium dulce*, and in native reed (*Phragmites karka*) wetlands. Nests have also been found by CNMI DFW biologists in stands of the tall, introduced grass *Pennisetum polystachyon* and in *Melanolepis multiglandulosa* (CNMI DFW unpublished data). Mosher (2006) did not find any Nightingale Reed-warbler nests specifically in limestone forest on Saipan.

Nests placed in *Leucaena leucocephala* were generally attached to the main stem/trunk and several lateral branches with at least one branch supporting the nest's bottom. Those in *Ochrosia mariannensis* were supported by the main truck and 3-5 branches while those in *Casuarina equisetifolia* were found in high drooping branches that extended away from the main trunk. Nests observed in *Phragmites karka* wetlands were usually supported by three vertical reed stems and two leaning stems. In all cases there was always a branch or stem supporting the base of the nest, which was usually woven in place by vines.

Reed-warblers appear to have a principal nesting area within a given territory, with nests from previous attempts often in close proximity to each other. No nests were observed to be used more than once, but reed-warblers were observed building new nests on top of old nest structures. Re-nesting often does occur after the initial nest fails.

Eggs, Incubation, Hatching, Growth, and Development: Information here on nesting ecology comes from Mosher's work on Saipan, data for which can be found in Mosher (2006) and Mosher and Fancy (2002).

Nightingale Reed-warbler eggs are sub-elliptical in shape, dull white to cream to ivory buff in color. They are spotted, speckled, and blotched with irregular shaped markings over entire shell, typically with overlapping markings around broader end of the egg. The markings are gray, brown, black, and rust in color with pinpoints up to 2.3mm in diameter. Mean egg length was 23 mm (range = 21–25.8 mm), mean egg width 16.9 mm (range = 15.9–18 mm), and mean egg mass was 3.1g (range = 2–3.8 g); mean clutch size was 2.5 (range = 2–4 eggs), with a mode of two. Brood size ranged from one to three nestlings with a mode of two.

The mean nesting period is 32.5 days +/-1.7 (range = 31–34 days). Eggs are laid on successive days and incubation ranges from 15–17 days. Both male and female incubate but only females develop a brood patch (also observed by CNMI DFW, unpublished data). Nests (n = 22) observed by Mosher (2006) exhibited a success rate of 44% over two years.

Nightingale Reed-warbler nestlings hatch with closed eyelids, dark gray to black skin, no down, and bright yellow gape flanges. Nestlings are fed on average 7.7 times per hour and adults remove fecal sacs from nest. Prior to fledging, nestlings are almost completely feathered except around eyes, ears, chin, and throat; the egg tooth is present on the bill two to three days prior to fledging. Fledging typically occurs 15 to19 days post-hatching and weak flying young leave the nest with poorly developed flight feathers and short tails (also observed by CNMI DFW, unpublished data). At approximately 14 days, the mean mass of nestlings is 28.4g (range = 24–35g), mean wing chord is 50.3 mm (range = 39–58mm), mean exposed culmen is 17.7 mm (range = 15.1–22.9mm), mean culmen nares-to-tip is 10.4 mm (range = 8.4–11.6mm), and mean tail length is 13.3 mm (range = 4–20.5mm). The mean number of tail feathers at 14 days is 10.2 (range = 9–12), with mode of 10.

Juvenile plumage is brown with buff edges, and the breast, belly, vent, thighs, and undertail coverts light yellow to cream, with flanks brownish yellow to buff. Juveniles lack the pale yellow supercilium and black lores that are characteristic of adults.

Threats: Threats to the Nightingale Reed-warbler include habitat loss, habitat degradation from feral ungulates, introduced predators (including the Brown Tree Snake), and the spread of invasive species (USFWS 1998b; Berger 2005).

Habitat loss on Saipan is due to conversion of forested habitat for agriculture, homesteads and other residential development, and tourist-related facilities. Because of development pressures over the last two decades, suitable habitat for the reed-warbler on Saipan has declined (USFWS 1998b, CNMI DFW unpublished data). Habitat loss is also caused by the spread of non-native vines, especially scarlet gourd (*Coccinia grandis*; Berger 2005). Non-native vines can quickly cover forested areas, shading the trees from light and causing the forest to die.

Feral ungulates, goats in particular, have degraded suitable Nightingale Reed-warbler habitat on Aguiguan and Alamagan. Continued grazing on Aguiguan could limit the opportunities for reed-warblers to recolonize or be introduced to the island, while grazing damage on Alamagan may be a cause of reed-warbler population decline there. Habitat loss due to feral ungulates on Alamagan is a severe problem, and could lead to extinction or decline of reed-warblers on the island much as it did on Pagan (Cruz *et al*. 2000a).

Introduced predators including cats (*Felis catus*), rats (*Rattus* spp.), monitor lizards (*Varanus indicus*), and brown treesnakes (*Boiga irregularis)* also play a significant role in reed-warbler population declines. Currently, the brown treesnake is the most serious predation threat to the reed-warbler on Saipan. This species of snake caused the extinction or severe decline of most native birds on Guam (including the reed-warbler) within 35-40 years after its accidental introduction (Reichel *et al*. 1992).

Mosher (2006) found that predation caused nest failure in 75% of failed nests. Predation occurred primarily by rats (71%), cats (5%) and unknown predators (24%). Monitor lizards and collared kingfishers may also predate reed-warbler nests.

Camp *et al*. (2009) found that insectivorous birds such as the reed-warbler were declining on Saipan, indicating that prey availability may a limiting factor for the species population on the island.

Research Needed:
Information on the response of Nightingale Reed-warblers to development and disturbance to aid in development of appropriate avoidance and minimization measures and mitigation.
Research on population dynamics and taxonomy and Population Viability Analysis (PVA) for the population on Saipan.

Conservation Recommendation:
The USFWS (1998b) and Berger (2005) provided a number of conservation recommendations including:

- Interdiction of the brown tree snake
- Feral ungulate control on Aguiguan and Alamagan
- Predator control, especially around nests and in conservation areas
- Eradication of rats, cats, and other predators from Aguiguan
- Establishment of a captive breeding program and translocation of birds to northern islands
- Habitat protection through avoidance and minimization measures and mitigation placed on • development projects
- Conservation of remaining forest and wetland habitats
- Eradication of invasive vines, specifically scarlet gourd, from Saipan
- Reestablishment of the Aguiguan population
- Improved management of terrestrial conservation areas
- Prevention of the introduction of invasive species to the northern islands
- Development of an island-wide habitat conservation plans for all Mariana islands

BASIC HUSBANDRY

Captive management for the Nightingale Reed-warbler is not currently planned and husbandry techniques do not currently exist for the species. If the reed-warbler is to be brought into captivity for propagation in the future, husbandry techniques and protocol will be developed and reported upon at that time.

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Appendix B: Species Profiles

Bridled White-eye (*Zosterops conspicillatus*)

Compiled by: Fred Amidon, USFWS, Honolulu, Hawaii, and Gary A. Michael, Curator of Birds, and Zoltan S. Gyimesi, DVM, Associate Veterinarian, Louisville Zoological Garden, Louisville, Kentucky.

Order: Passeriformes
Family: Zosteropidae
Local Names: *nosa* (Chamorro), *litchogh* (Carolinean)

SPECIES OVERVIEW

Description: A sexually monomorphic forest bird with a white ring of feathers circling both eyes, a characteristic of many members of the avian Family Zosteropidae. The head, back, and wings of the Saipan subspecies (*Z. c. saypani*) are olive green and underparts are pale yellowish-white (Baker 1951). Legs and feet are olive-gray and the bill is blackish gray (Marshall 1949, Baker 1951).

Table 1. Morphometrics of the Bridled White-eye collected on Saipan and Tinian (all measures and weights in millimeters and grams, respectively; R = range).

Island	Sex	*N*	Wing (R)	Tarsus (R)	Tail (R)	Culmen (R)	Mass (R)	Source
Tinian	-	23	51 (50-53)	18 (17-18)	38 (35-41)	12 (12-13)	-	Baker 1951
Saipan	-	6	54 (52-55)	18 (17-19)	37 (35-39)	13 (13-15)	-	Baker 1951
Saipan	Male	77	52.1 (48-61)	-	-	-	7.4[a] (6.0-8.7)	Radley *et al*. 2011 and unpub. data
Saipan	Female	211	51.4 (48-56)	-	-	-	8.0[b] (5.6-11.0)	Radley *et al*. 2011 and unpub. data

[a] Mass based on n=71 adult males
[b] Mass based on n=205 adult females

Distribution and Status: The Saipan subspecies is endemic to the Mariana Islands and is common on Saipan, Tinian, and Aguiguan. The total populations on these three islands, respectively, were reported in 1982 to be approximately 229,000, 241,000 and 7,000 birds (Engbring *et al*. 1986). Later DFW and USFWS bird surveys of these islands yielded mean abundance estimates for the subspecies 534,029 on Saipan in 2007 (95% CI 427,858 – 650,667;

Camp *et al*. 2009), 225,360 on Tinian in 2008 (95% CI 193,080 – 283,200; Camp *et al*. 2012), and 50,205 on Aguiguan in 2008 (95% CI 37,902 – 68,235; Amidon *et al*. *in review*). The Guam subspecies (*Z. c. conspicillatus*) is now believed to be extinct (Wiles *et al*. 2003).

Habitat: The Bridled White-eye is considered a habitat generalist. Although found primarily in forested areas (Stott 1947; Engbring *et al*. 1986; Craig 1989, 1996), they occur in a variety of cover types, including native limestone forest, introduced *Leucaena leucocephala* thickets, *Casuarina* forest, beach strand, swordgrass savannah, and suburban areas. Research on nesting densities in native limestone forest and *L. leucocephala* thickets indicate that the Saipan subspecies nests predominately in *L. leucocephala* thickets, however (Sachtleben 2005).

Food and Feed Habits: While the Bridled White-eye appears to feed primarily on insects, they have been observed also foraging on the fruits of *Momordica charantia*, *Passiflora foetaeda*, *Jasminum marianum*, *Premna obtusifolia*, *Ficus* spp., *Melanolepis multiglandulosa*, *Artocarpus* spp., *Pipturus argenteus*, *Lantana camara*, *Carica papaya*, and *Muntingia calabura* (Engbring *et al.* 1986; Craig 1989, 1996). In 2007, consumption of the fruits of *Coccinia grandis* was evident in the droppings of all Bridled White-eyes captured on Saipan (H. Roberts, Mamphis Zoo, pers. comm.). They also have been observed probing flowers (presumably to feed on nectar) of *Operculina vetricosa*, *Erythrina variegata*, *Pisonia grandis*, *Cynometra ramiflora*, *Premna obtusifolia*, *Psychotria mariana*, *Morinda citrifolia*, *Hibiscus tiliaceus*, and *Albizia lebbeck*; eating the flowers of *Mikania scandens*, *Jasminum marianum*, *Pisonia grandis*, *Cynometra ramiflora*, and *Leucaena leucocphala*; and eating the seeds of *Momordica charantia* and *Bidens pilosa* (Engbring *et al.* 1986, Craig 1989, 1996).

Bridled White-eyes have been observed foraging in 23 species of tree (Table 2) on Saipan, primarily by gleaning insects from leaves and branches in the outer canopy of limestone and *Leucaena leucocephala* forests (Craig 1989, 1996). However, they have also been observed hovering and sallying for insects and probing flowers (likely for nectar), bark, and dead and rolled leaves (Craig 1989). In addition, the subspecies has been observed foraging in the understory of forests, on the ground, and in *Bidens pilosa* and *Miscanthus floridulus* (Craig 1989, 1996).

Behavior: Bridled White-eyes are reported to make several vocalizations. The most common is a call that Pratt *et al*. (1987) describe as a high-pitched *tszeeip*, often rapidly uttered and organized into a loose song. They have also been observed producing a scolding alarm call, often in response to the presence of Collared Kingfishers (*Todiramphus chloris*; Marshall 1946, Craig 1996).

Like many of the white-eyes in the family Zosteropidae, the Saipan subspecies is gregarious and often observed in flocks. These flocks typically consists of family groups of 3 to 5 individuals or larger flocks of 10 to 40 individuals, though larger flocks do often occur at flowering and fruiting trees (Craig 1989, 1996). No interspecific aggression has been noted to be initiated by Bridled White-eyes and the only such interaction described for the species (aside from scolding Collared Kingfishers) was of an individual foraging with a Rufous Fantail (Craig 1996).

Table 2. Plant species utilized by Saipan bridled white-eyes for foraging and nesting.

Plant Type	Species	Status	Foraging	Nesting
Trees	*Acacia confuse*	Introduced	x[a]	
	Aidia cochinchinensis	Native		x[c]
	Albizia lebbeck	Introduced	x[b]	x[c]
	Artocarpus spp.	Native	x[a]	
	Barringtonia asiatica	Native	x[a]	
	Bruguiera gymnorrhiza	Native	x[a]	
	Carica papaya	Introduced	x[b]	
	Ceiba pentandra	Introduced	x[a]	
	Cocos nucifera	Introduced	x[a]	
	Cynometra ramiflora	Native	x[a]	x[c]
	Erythrina variegata	Native	x[a]	
	Eugenia spp.	Native		x[c]
	Ficus spp.	Native	x[a]	
	Guamia mariannae	Native	x[a]	x[c]
	Hernandia spp.	Native	x[a]	
	Hibiscus tiliaceus	Native	x[a]	
	Lantana camara	Introduced	x[b]	
	Leucaena leucocephala	Introduced	x[a]	x[c]
	Maytenus thompsonii	Native		x[c]
	Melanolepis multiglandualosa	Native	x[a]	x[c]
	Morinda citrifolia	Native	x[a]	
	Muntingia calabura	Introduced		
	Neisosperma oppositifolia	Native	x[a]	
	Ochrosia mariannensis	Native	x[a]	
	Persea americana	Introduced	x[a]	
	Pipturus argenteus	Native		
	Pisonia spp.	Native	x[a]	
	Premna obtusifolia	Native	x[a]	x[c]
	Psychotria mariana	Native	x[b]	x[c]
	Randia cochinchinensis	Native	x[a]	
	Samanea saman	Introduced	x[a]	
Vines	*Abrus precatorius*	Introduced		x[c]
	Bauhinia ssp.	Introduced		x[c]
	Coccinia grandis	Introduced		
	Colubrina asiatica	Introduced	x[d]	x[c]
	Dioscorea spp.	Introduced		x[c]
	Jasminum marianum	Native	x[b]	x[c]
	Mikania scandens	Introduced	x[b]	
	Momordica charantia	Introduced	x[b]	
	Operculina vetricosa	Introduced	x[b]	
	Passiflora foetaeda	Introduced	x[a]	x[c]
Herbs	*Bidens pilosa*	Introduced	x[a]	
	Capsicum frutescens	Introduced		x[c]
Grass	*Miscanthus floridulus*	Introduced	x[b]	

[a] Craig 1989; [b] Craig 1996; [c] T. Sachtleben, pers. comm., 2005, [d] H. Roberts, pers. comm., 2007,

Breeding: Bridled White-eyes likely breed year-round with distinct peaks during different portions of the year. Sachtleben (2005) reported nesting on Saipan from February to June with a distinct peak in February and March, while Pyle *et al*. (2012) reported birds on the island in breeding condition every month of the year. Craig (1996) reported breeding in January, February, August, and October and recorded food begging by juveniles year-round. On Tinian, Yamashina (1932) reported collecting three active nests in January.

Nesting: Nests are typically composed of fine roots and fibers, a small quantity of cotton wool, and feathers (Yamashina 1932). Sachtleben (pers. comm., 2005) recorded the dimensions of 87 Bridled White-eye nests on Saipan, reporting a mean nest height of 49 mm (range = 35-70 mm) a mean cup depth of 33 mm (range = 23-41 mm), a mean cup diameter of 40 mm (range = 32-48), and a mean outer nest diameter of 61 mm (range = 51-72 mm).

Bridled White-eyes have been reported building nests on ten tree species, six vine species, and one herbaceous species (Table 2). In 2004, Sachtleben (pers. comm., 2005) documented the site characteristics of 115 Bridled White-eye nests on Saipan, reporting a mean nest height of 2.3 m (range = 0.7 – 5.2 m), a mean nest tree height of 4.3 m (range = 1.2-10.8 m), and a mean distance of nests from the boles of nest trees of 42 cm (range = 0 - 263 cm). Sachtleben (pers. comm. 2005) reported that the mean number of branches used for nest support was 3 (range = 1-7) and that the mean diameter of these branches was 2 mm (range = 1-6 mm).

Eggs, Incubation, Hatching, Growth, and Development: Clutch sizes range from 1 to 3 pale blue eggs (Yamashina 1932). Egg laying ranges from 2 to 3 days and incubation from 9 to 12 days (Sachtleben 2005), and fledging occurs 11 to 14 days post-hatching (Sachtleben 2005). The duration of post-fledging parental care is unknown. Sachtleben (pers. comm., 2005) described chick growth for the Bridled White-eye as follows:

Day 0: Chicks approximately 1.5 cm (1 – 2cm) in length, naked, with light-medium pink skin and two "tufts" of downy feathers on their head (appearance-wise, a cross between horns and eyebrows).

Day 1: Approximately 2 cm long, and naked with medium-dark pink skin. Otherwise, little change from Day 0.

Day 3: Approximately 2.5 cm (2 – 3cm) long, medium-dark pink skin, wing pins 2 – 5 mm in length, head and back pins visible under skin but not erupted or barely so, two tufts on the head either remaining or no longer present.

Day 4: Approximately 3.5 cm long, medium-light pink skin, back pins 1 – 2 mm in length, and wing pins ≥3 mm long.

Day 6: Approximately 3.5 cm (3 – 4 cm) long, wing pins 6 – 7 mm in length, feathers possibly erupted from wing pins greenish and approximately 1 – 2 mm in length. Back pins 2 – 4 mm in length, feathers possibly erupted from back pins greenish and approximately 1 – 2 mm in length, head pins 3 - 4 mm long, white belly feathers in 2 lines, exposed skin light or medium pink, and eyes still closed or cracking open.

Day 8: Approximately 4.5 cm long, fully feathered, olive grey-green, and eyes opened.

Day 9: Approximately 4 – 4.5 cm long, mostly feathered, olive grey-green, eyes opened, and wing feathers dark grey.

Day 10: Approximately 5 – 5.5 cm long, fully feathered, wings dark grey and back grey-green.

Day 12: Approximately 5 – 5.5 cm long, greenish and fully feathered, belly appearing downy, and often perching on rim of the nest. Chicks will force-fledge at this age and fly well.

Threats: The Bridled White-eye is abundant and widespread on the islands of Saipan, Tinian, and Aguiguan, and is not currently considered threatened or endangered by the Federal or Commonwealth governments. The primary threats to the species are newly introduced predators and possible diseases, such as the Brown Treesnake and West Nile Virus, respectively.

Research Needed: Studies of Bridled White-eye population ecology.

BASIC HUSBANDRY

The Bridled White-eye was introduced to aviculture with the collection of specimens on Saipan, May 2006. The flock was divided and distributed between the Sedgwick County Zoo, Wichita, Kansas, and the Louisville Zoological Garden, Louisville, Kentucky. Basic husbandry guidelines were prepared based more so upon the captive management of related species in the genus *Zosterops* than upon the limited experience with captive Bridled White-eyes.

Acquisition and Acclimation: The Bridled White-eye is a flocking species and is best acclimated and maintained in captivity in groups. Being monomorphic and gregarious, the chance of potential pair formation is increased within groups, and the exhibit value to guests of a naturally behaving flock of active, vocal birds is markedly improved over the display of a single bird or pair. Although not recommended, if it is necessary to maintain a single bird, it should be held in a minimum-sized enclosure of 3 ft. x 2 ft. x 2 ft. The side and rear walls should be solid and the ceiling panel padded softly to avoid head and facial trauma. A mirror is recommended to create the illusion of a cagemate for the lone bird. Otherwise, enclosures need to be large enough to accommodate small to large groups, permit flight, and avoid overcrowding; large walk-in type enclosures 1/2inch width aviary mesh are ideal. Regardless of the enclosure type, cover should be provided (e.g., visual barriers in association with perches) so individuals can retreat from flock members as needed. As the species can at times roost and forage close to the ground, live potted plants can provide refuge and foraging opportunities.

Although generally peaceful, Bridled White-eyes can display extreme aggression, a behavior that is not typically observed during short-term acclimation periods. Aggressive behavior is observed more readily between birds maintained in cramped quarters over a long-term period or between territorial nesting pairs and the general flock. Intraspecific agonistic behavior is often expressed subtly; repeated gaping and beak snapping and appeasement display (feathers fluffed, mock begging) are cause for concern. Excessive allopreening resulting in feather loss (usually around the head and neck) may indicate that the enclosure is too small or has too few perches or hiding spots for the number of individuals housed. If behavioral problems persist, the birds may be kept in two smaller groups and then be reacquainted once they are transferred to a larger, more enriched environment.

Banding and Weighing: It is recommended that birds be banded with brightly colored bands in combinations that facilitate identification from a distance. To avoid disturbing family groups and attracting the attention of cagemates to hidden nest sites, nestlings should not be banded.

Birds can be easily trapped in the aviary with food-baited traps and banded with open (butt-end) bands.

Accurate weights are essential to aid in health management. Captured birds should be quickly transferred from the trap to a smooth, soft bag, and then to a scale that measures to 0.1 gram. A less intrusive method of weighing birds in the aviary is to use a postal letter scale with a brightly lit number read-out panel. If a small container of food is placed at the scale, birds will quickly overcome their fear of the instrument, allowing an individual bird's weight to be read from a distance when it lands on the scale. At the Louisville Zoo, captive weight ranged between 6.8 and 9.3 grams, with a mean male weight of 7.9 grams and a mean female mass of 7.7 grams.

Holding Temperature: The recommended minimum and maximum temperatures at which to hold Bridled White-eyes in captivity are 60 and 95 degrees Fahrenheit. At acquisition, white-eyes should be maintained at about 80-85 degrees Fahrenheit. When transferred within a facility, birds should be provided with a heat lamp at the destination. In general, the species benefits from a heated light source while in captivity provided they have free access to and from a basking area. Sunbathing has not been documented in the wild, but captive individuals have regularly been observed basking under heat lamps.

Light: Access to natural light or full-spectrum artificial light is recommended, as intensity and duration influence health and behavior. Captive white-eyes can benefit from exposure to continuous light during the acclimation period until they are observed eating in their new surroundings. This prolonged exposure to light promotes eating and drinking, and allows familiarization with the immediate environment. This is especially important when birds are housed in large enclosures with multiple feeding stations and cover. For long-term management, 12 to 13 hour of light exposure is recommended for breeding.

Food and Feeding: The Bridled White-eye prefers high protein and high fat diets, is a highly active forager and easily conditioned to captive diets. They will readily take to a diet of waxworm moth (*Galleria mellonella*) larvae, peanut butter, and ripe papaya, along with a variety of other foods including appropriately sized commercially available insects, fruits, pelleted foods, and nectar. In nature, Bridled White-eyes have been observed foraging near the ground but will seldom do so in captivity. Thus, food and nectar should be offered on elevated platforms in multiple locations. For ease of later capture, it is recommended that food be regularly presented in some variation of a food trap.

In general, fruit should be diced and pellets moistened in cool water or fruit juice. Papaya can be offered in large slices as it will be shared by flock members. Offering parasite-covered live plants serves not only as another alternative source of food for Bridled White-eyes, but also as a source for passive enrichment as the species naturally forages on foliage for invertebrates. A constant supply of soft-bodied small insects is essential during chick rearing and it is advisable to plan ahead to identify sources to ensure an adequate supply, as the nutritional value of commercially available stock is marginal. Although not highly nutritious, waxworm larvae appear to be a good source of energy for active white-eyes. Calcium and other minerals can be delivered to the birds by lightly spraying water on the larvae and dusting them with powdered supplements. Alternatively, liquid supplements can be injected directly into individual larvae or insect based food with needle and syringe. Food and nectar should be offered twice daily to reduce the risk of spoilage, as unconsumed nectar is a source for bacteria, especially at higher temperatures.

Housing and General Environmental Considerations: White-eyes in the genus *Zosterops* are generally easy to maintain in captivity and are desirable as display birds because of their active, vocal, and non-aggressive nature. However, they are a challenge to breed in mixed-species settings. Bird collection managers seldom have the luxury or inclination to devote exhibit space exclusively to this species for the purpose of breeding. The keys to a successful physical layout for the species are inoffensive cagemates, thick plantings, and areas for pairs to isolate themselves to establish nest territories.

Large planted aviaries are ideal. The various environments these spaces provide allow Bridled White-eyes to display their full range of flock behaviors and are large enough for mated pairs to isolate themselves for nesting. Species in the genus *Zosterops* are inoffensive nesting birds and are readily disturbed from the nest. Thus, regardless of enclosure size, cagemates should not be known to prey upon eggs and chicks of other birds. In more modest-sized enclosures of approximately 400 square feet, small flocks can be maintained but breeding may be reduced as the result of overcrowding amongst flock members. However, with careful observation pairs can be identified and if needed, relocated to single-pair housing for the nesting season to avoid their attempted domination of available resources. Otherwise, social dynamics can become strained and the resulting territorial squabbles can result in nest failure.

General precautions should be taken when introducing Bridled White-eyes to aviary settings. A gradual introduction is recommended and a pen placed within the aviary will provide the new birds the opportunity to adjust and acclimate. The permanent food trap previously described can be used temporarily for this purpose. It is recommended that white-eyes not be introduced into aviaries when resident birds are nesting and after these birds have been observed exhibiting aggression towards their cagemates. Health issues have been documented at the Louisville Zoo during the initial acclimation period. Thus, new birds should be closely observed and initially weighed during this period to evaluate their health while housed in the introduction pen. When introducing white-eyes to glassed enclosures, the glass should be covered to prevent injuries from collision (similar precautions should be taken to protect young during the fledging period). In larger exhibits, white-eyes can distance themselves from visitors and keepers, making detailed observations difficult. Cautions should be taken as birds may choose nest sites at heights within the space that prevent careful monitoring and that place any eggs and fledglings at risk.

White-eyes enjoy bathing and prefer to do so in wet foliage. As birds prefer taller plants and avoid bathing at pools and in small plants on the exhibit floor, tall aviary plantings should be rinsed daily to create bathing opportunities.

Captive Behavior: Captive white-eyes in the genus *Zosterops* are generally inoffensive, active, vocal, and are suitable for inclusion in mixed species aviaries, making them excellent subjects for public display. Most negative behavior associated with captive white-eyes is intraspecific in nature and usually occurs during the nesting season or when too many birds are confined within too small a space. Allopreening is a defining behavioral trait of the genus and may serve to alleviate stress. Birds in cramped quarters or other potentially stressful environments will over-preen flock mates resulting in feather loss, mostly on the head and neck. Intraspecific aggression has been observed during courtship, nesting, and rearing of fledglings.

Pair Formation, Nesting, and Chick Rearing: The formation of pairs and the long-term maintenance of pair bonds are easily observed in captive birds. While Bridled White-eyes have not been bred in captivity, the behaviors of related species are comparable and provide a basis for managing the Saipan subspecies. Generally, a pair will allopreen and move within the flock close to one another, often eat together, and loaf and roost together. Although the captive nesting season has not yet been determined for the Bridled White-eye, captive Japanese (*Zoseterops japonica*) and Oriental white-eyes (*Zosterops palpebrosa*) have been observed nesting throughout the year (G. Michael, pers. comm.). Nests of these two species are built of fine plant fibers, including palms, grasses, and Spanish moss, and animal hair when offered by zoo staff. These species typically locate their nests high above the ground in discreet locations amongst thick live or artificial foliage and both have accepted small, woven artificial nest cups. Based upon the high-flying behavior of Bridled White-eyes observed at the Louisville Zoo, it is likely that they too would nest high within an aviary (G. Michael, pers. comm.). Some species of White-eye have been documented completing entire breeding events, from nest building to fledging young, in less than one month. Pairs tend to choose quiet, densely planted areas for nesting, reducing their chances of being detected and disturbed by flock or cage mates. As white-eyes often abandon their nests, staff should take care to keep disturbances to a minimum.

White-eye chicks leave the nest between 11 and 14 days post-hatching and are usually incapable of flight for several days, making them especially vulnerable to exposure and predation. Young birds generally stay high in dense foliage to safely develop their flying skills and independence. However, some young move low to the exhibit floor area where they are less well tended by shy parents and are at risk of being injured. Thus, the aviary floor and understory foliage should be checked twice daily when chicks are likely to leave the nest, and water features should be emptied to prevent drowning. Optimally, young debilitated birds should be transferred to a brooder to complete further rearing. At this stage, the young birds are easily conditioned to being fed insects, pellets, and fruits from the hand. Once flighted, the youngsters can be banded and reintroduced to the flock through the use of the dual-purpose, permanent food trap and introduction pen.

Banding Offspring: At approximately two months of age, white-eye fledglings should be banded with a combination of open metal and brightly colored plastic bands. Fledglings can easily be captured at the permanent food trap they learn to follow their parents to feed. It is important to use metal bands, as they are less likely to fall off birds' legs as the plastic ones. The brightly colored plastic bands are easily distinguished at a distance, but soften with age and fade in color with exposure to sunlight. The combination of band types provides the caretaker ease in identification and a means to permanently identify individual birds.

Management of Juveniles: Generally, parent birds will actively feed young white-eyes for about two weeks post-fledging. During this time the fledglings begin to flutter amongst lofty perches to develop their flight skills. Because parents appear reluctant to feed offspring on the ground, when necessary young should be placed a minimum of ten feet above the ground on a perch near a regular food station. If parents do not tend to it within one hour, the youngster should be removed, hand-reared, and reintroduced to the flock as previously described.

Generally, however, siblings remain aloft and often perch very close together near their parents and the nest. Thus, it is recommended that young birds be maintained with their parents for a minimum of two months. Birds in the wild likely travel in family groups within flocks and this activity may be important to the social development of the young. At one or two months of age, young birds can be captured at the food trap and banded.

Health Management: Available health information specific to Bridled White-eyes is scant due to the short time the species has been maintained in North American collections. However, existing veterinary information on the health care of other small passerines is likely applicable to this species.

Mortalities have occurred during stressful events (e.g., during shipment to zoos and post-shipment quarantine). One bird was lost as a result of a disseminated bacterial infection (septicemia), while several others have died due to gastrointestinal yeast infections (ventricular candidiasis). Due to the latter condition, it may be prudent to prophylactically treat birds with an antifungal drug during predicted times of stress. Nystatin can be safely dosed to orally treat groups of birds in an aviary. Mortalities have also been associated with air sac mite infections (S. Wilson, personal communication). Affected birds do not necessarily exhibit respiratory cues and may simply be found dead. Treatment can be attempted with ivermectin but infections can be a challenge to eliminate.

Fecal examinations have revealed cestodes (tapeworms) and coccidia. Cestodes are not uncommon in insectivorous passerines and can be treated with praziquantel. Two different species of coccidia (both likely *Isospora* sp.) have been identified in Bridled White-eyes (E.C. Greiner, personal communication). Via blood smear analysis, a red blood cell parasite (*Haemoproteus zosterops*) has also been identified in wild-caught Bridled White-eyes (E.C. Greiner, personal communication). Infections are likely self-limiting and treatment is typically not necessary.

Bridled White-eyes have been safely anesthetized with inhalant isoflurane anesthesia. Blood can be obtained from the right jugular vein for DNA sexing or hematology (see Table 1 for some hematology data for *Zosterops* sp.). Given the small size of these birds, safe venipuncture requires careful blood volume calculation and good post-phlebotomy hemostasis. Adult male Bridled White-eyes at the Louisville Zoo have ranged in mass from 6.8 - 9.3 grams (mean = 7.9 gram), while adult females have ranged from 6.2 - 8.9 grams (mean = 7.7 gram).

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Table 3. Hematology reference ranges for Japanese white-eyes (*Zosterops japonica*) and Oriental white-eyes (*Zosterops palpebrosa*) sampled at the Louisville Zoological Garden.

Test	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**	***N***
Hematocrit (%)	49.84	+/- 5.186	37	59	25
White Blood Cell Count ($x10^3$/µl)	10.23	+/- 4.977	2.6	25.5	23
Heterophils ($x10^3$/µl)	2.656	+/- 3.349	0.315	14.79	23
Lymphocytes ($x10^3$/µl)	4.338	+/- 3.809	0.402	14.34	23
Monocytes ($x10^3$/µl)	0.635	+/- 1.084	0.0	4.973	23
Eosinophils ($x10^3$/µl)	0.103	+/- 0.206	0.0	0.765	23
Basophils ($x10^3$/µl)	2.495	+/- 1.319	0.089	4.802	23

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Appendix B: Species Profiles

Rota White-eye (*Zosterops rotensis*)

Compiled by: Fred Amidon, USFWS, Honolulu, HI

Order: Passeriformes
Family: Zosteropidae
Local or Chamorro Name: *Nosa Luta*

SPECIES OVERVIEW

Description: The Rota White-eye or nosa is a sexually monomorphic forest bird. The name white-eye is derived from the white ring of feathers around each eye. Their plumage is tinged with yellow, and their bill, legs, and feet are yellow-orange (Pratt *et al*. 1987). See Table 1 for average wing, tail, tarsal, and exposed culmen lengths and weights.

Table 1. Morphometrics for Rota White-eyes collected on Rota in 1993 and 1995 (all measures and weights in millimeters and grams, respectively, R = range; S. Derrickson, pers. comm. 1998).

Sex	**Wing (R)**	**Tail (R)**	**Tarsus (R)**	**Culmen (R)**	**Mass (R)**
Male (*n* = 14)	56.5 (53.5-60.0)	38.0 (36.5-40.0)	25.8 (24.4-27.5)	10.7 (9.1-12.5)	9.7 (8.8-10.6)
Female (*n* = 7)	54.1 (50.3-56.5)	37 (35-38.5)	25.8 (24.9-27.3)	10.7 (10.3-11.9)	9.2 (8.4-10.6)

Distribution and Status: Endemic to the island of Rota, Commonwealth of the Northern Mariana Islands. The Rota white-eye was originally classified as one of three subspecies of Bridled White-eye (*Zosterops conspicillatus*) found in the Mariana Islands. Stresemann (1931) described subspecies on the islands of Guam (*Z. c. conspicllatus*); Saipan, Tinian, and Aguiguan (*Z. c. saypani*); and Rota (*Z. c. rotensis*; hereby referred to as Guam Bridled, Saipan Bridled and Rota white-eyes respectively). However, based on recent genetic work (Slikas *et al*. 2000) and observed differences in plumage, vocalizations, and behavior (Pratt *et al*. 1987, Collar *et al*. 1994), the Rota white-eye is treated here as a full species.

This species is currently restricted to forested areas above 150 meters elevation in the Sabana Region of Rota. The total population consists of approximately 1,000 birds (Fancy and Snetsinger 2001) and is believed to have declined from approximately 10,000 birds in 1982 (Engbring *et al.* 1986).

Habitat: Little research has been done on the habitat requirements of the Rota White-eye. Therefore, it is not possible to present a detailed analysis of their habitat needs. General habitat associations, however, can be inferred from survey data and the results of research by Amidon (2000), at least for the Rota white-eye population since 1982.

Since the first island-wide forest bird survey in 1982, Rota white-eyes have been recorded primarily above 150 m elevation in the Sabana region of Rota (Engbring *et al*. 1986, Engbring 1987, Engbring 1989, Amidon 2000, Fancy and Snetsinger 2001, USFWS unpubl. data). Sightings of Rota white-eyes have been recorded in limestone forest, introduced *Acacia confusa* forest, introduced *Leucaena leucocephala* forest, and secondary vegetation (Craig and Taisacan 1994, Amidon 2000, Fancy and Snetsinger 2001, Amidon unpubl. data). However, the majority of the Rota white-eye sightings have been recorded in limestone forest. For example, of the survey stations where Rota white-eyes were detected in 1982 (n = 44; Engbring *et al*. 1986) and 1987 (*n* = 24; Engbring 1987), 89 percent (*n* = 39) of the stations in 1982 and 79 percent (*n* = 19) of the stations in 1987 were classified as limestone forest within 50 meters (160 feet) of the survey station by Falanruw *et al*. (1989). Of the remaining stations with Rota white-eye detections in 1982, 8 percent (*n* = 4) were in areas with mixed vegetation types that included some limestone forest and 2 percent (*n* = 1) were in forest other habitat types (e.g., *Cocos nucifera* (coconut palm) plantation and secondary vegetation). Of the remaining stations with Rota white-eye detections in 1987, 21 percent (*n* = 5) were in areas with mixed vegetation types that included some limestone forest. Further, of the stations with Rota white-eye detections in limestone forest in 1982 (*n* = 39) and 1987 (*n* = 19), over 60 percent of the areas were dominated by mature limestone forest with large diameter trees (> 30 cm dbh), high density, and over 70 percent canopy cover (Falanruw *et al*. 1989). A similar pattern was also observed for the 1996 survey by Fancy and Snetsinger (2001) were 73 percent of the Rota white-eye locations (*n* = 62) were recorded in areas classified as mature limestone forest by Falanruw *et al*. (1989).

In 1998 and 1999, Rota white-eye habitat relationships were assessed within their current range and across the Sabana region as part of a two year study by Amidon (2000). Forested areas with high densities of Rota white-eyes (≥ 2 birds per hectare) had higher volumes of epiphytic plants, such as *Asplenium nidus* and *Davallia solida*, and were primarily composed of *Elaeocarpus joga*, *Hernandia labyrinthica*, *Merrilliodendron megacarpum*, *Pandanus tectorius*, and *Premna obtusifolia* trees. Other tree species that were regularly recorded in Rota white-eye high density areas include *Aglaia mariannensis*, *Artocarpus atilis*, *Ficus prolixa*, *Ficus tinctoria*, *Guettarda speciosa*, *Macaranga thompsonii*, and *Pisonia umbellifera*. Within the Rota white-eye's range, white-eyes were found to be more abundant in areas with higher densities of *Elaeocarpus joga* and high foliage volume. Rota white-eye abundance was also found to have a positive relationship with the abundance of *Merrilliodendron megacarpum*. Across the Sabana, Rota white-eyes were found to be more abundant in areas with high densities of *Hernandia labyrinthica* and where the groundcover species *Elatostema* and *Procris* spp. were present.

Food and Feed Habits: Very little is known about the food habitats of Rota white-eyes. They are believed to feed primarily on insects, however, they have been observed foraging on the fruits of *Pipturus argenteus* and *Macaranga thompsonii* trees and probing the flowers, presumably to feed on nectar, of *Elaeocarpus joga*, *Hernandia labyrinthica*, *Macaranga thompsonii*, *Persea americana*, *Premna obtusifolia*, and *Eugenia thompsonii* trees (F. Amidon, unpubl. data).

Rota white-eyes forage primarily by gleaning insects from leaves and branches of trees (Craig and Taisacan 1994, Amidon 2000). However, they have been observed sallying for insects, probing flowers for insects or pollen, and searching for food in epiphytes and moss (Amidon 2000; F. Amidon, unpubl. data). Rota white-eyes typically forage in the outer layer of canopy trees on perches less than 1.0 centimeter diameter (Craig and Taisacan 1994, Amidon 2000). Of 97 Rota white-eye foraging observations, the majority were reported in *Elaeocarpus joga* (34 percent), *Hernandia labyrinthica* (13 percent), *Macaranga thompsonii* (10 percent), *Merrilliodendron megacarpum* (9 percent), and *Premna obtusifolia* (9 percent; Amidon 2000; F. Amidon, unpubl. data). However, Rota white-eyes were also recorded foraging in *Pipturus argenteus*, *Persea americana*, *Guettarda speciosa* (panao), *Ficus tinctoria* (hodda), *Acacia confusa*, *Aglaia mariannensis* (mapunyao), *Eugenia thompsonii*, *Ficus prolixa* (nunu), *Tarenna sambucina* (sumac-lada), and *Tristiropsis obtusangula* (faniok) trees (F. Amidon, unpubl. data).

Behavior: Rota white-eyes have been observed making several vocalizations. The most commonly observed vocalization is a call that Pratt *et al*. (1987) described as "a low-pitched tsheip." They have also been observed giving a scolding alarm call, often in response to collared kingfishers (*Todiramphus chloris*), and have been observed singing in the upper branches of canopy trees (Amidon 2000).

Like many of the white-eyes in the family Zosteropidae, Rota white-eyes are gregarious and are often observed in small groups. These groups typically consist of 2 to 3 birds (53 percent, *n* = 154) and sometimes included rufous fantails (*Rhipidura rufifrons*; Amidon 2000). Based on observations of frequent food begging and mutual preening or allopreening, Craig and Taisacan (1994) and Amidon (2000) believed that these small groups were composed of related individuals. Larger groups of 4 to 5 birds are observed occasionally (18 percent, *n* = 154) and groups of up to 14 birds are observed very rarely (1 percent, *n* = 154; Amidon 2000). In contrast, Craig (1989) typically observed Saipan bridled white-eyes in flocks of 10 to 40 individuals. Historically, Rota white-eye group sizes were reported to be larger and available evidence indicates that group sizes have decreased as the population declined (Craig and Taisacan 1994, Fancy and Snetsinger 2001).

Breeding: Observations of breeding activity indicate that Rota white-eyes breed from at least December to August (Lusk and Taisacan 1997; Amidon *et al*. 2004). However, the species may breed year-round, as was reported for the Guam bridled white-eye (Marshall 1949, Jenkins 1983), because nesting has been observed in both the wet and dry seasons.

Nesting: Rota white-eye nests are cuplike and typically suspended between branches and branchlets or leaf petioles (Yamashina 1932, Lusk and Taisacan 1997, Amidon *et al*. 2004). However, one nest was observed suspended from *Davallia solida* ferns below the branch of a tree (Amidon *et al*. 2004). Nests appeared to be composed of rootlets, woven grass or *Pandanus* spp. fibers, spider webs, light green moss, and a yellow, cottony material (Yamashina 1932, Lusk and Taisacan 1997, Amidon *et al*. 2004). The inner cup appeared to be of woven grass or *Pandanus* spp. fibers. Nest dimensions have been recorded for 6 nests (Yamashina 1932, Lusk and Taisacan 1997, Amidon *et al*. 2004). Mean nest height was 43.2 mm (range, 36.0-50.0 mm) and mean cup depth was 28.5 mm (range, 25.0-30.0 mm). Mean cup diameter was 43.9 mm (range, 44.6-50.0 mm) and mean nest diameter was 62.6 mm (range, 57.7-70.0 mm).

Rota white-eyes have been reported nesting in the native tree species *Hernandia labyrinthica* (*n* = 9), *Merrilliodendron megacarpum* (*n* = 27), and *Elaeocarpus joga* (*n* = 7), and the introduced tree species *Acacia confusa* (*n* = 3) between approximately 150 and 460 meters elevation (Lusk and Taisacan 1997; Amidon *et al*. 2004; E. Taisacan, pers. comm., 2005; F. Amidon, unpubl. data). Pratt (1985) also reported finding a nest in a *Hernandia* spp. (presumably *H. labyrinthica* based on the location where the nest was found). The mean distance of 23 nests from the ground was 7.7 m (range, 2.5-12.8 m). The mean height of 18 nest trees was 10.1 m (range, 3.3-14.6 m) and the mean diameter at breast height for 19 nest trees was 28.2 cm (range, 2.3-60.2 cm). Mean distances of 19 nests from the boles of the nest tree was 3.0 m (range, 0.8-6.7 m).

Eggs, Incubation, Hatching, Growth, and Development: Both male and female Rota bridled white-eyes incubate, brood, and feed nestlings (Amidon *et al.* 2004). Eggs are light blue and clutch sizes of one to two eggs have been observed (Yamashina 1932, Amidon *et al*. 2004), though clutch sizes of three eggs are possible based on observed clutch sizes for bridled white-eyes on Guam, Tinian, and Saipan (Hartert 1898, Yamashina 1932, Sachtleben 2005). Observations of seven active nests indicate that incubation and nestling periods appeared to be at least 10 and as long as 12 days for Rota white-eyes (Amidon *et al*. 2004). The post-fledging parental attendance period is unknown, but observations of one banded nestling indicate it is at least 8 days (Amidon *et al*. 2004).

Threats: Among the factors that have been hypothesized to threaten the Rota white-eye are: habitat loss or degradation; predation by introduced rats and black drongos, and other predators; the accidental introduction of new predators, like brown treesnakes; avian disease; and random catastrophic events, like typhoons, which may affect the core range of the species and lead to its extinction. Of these factors, habitat loss and degradation and predation by introduction species are currently believed to be the primary factors in the population decline and core range restriction of the Rota white-eye.

Research Needed: Foraging and nesting habitat requirements and sources of mortality.

Conservation Recommendations: Protection of remaining native forest utilized by species is considered essential along with restoration of degraded habitats (specifically areas converted to *Pandanus* spp. thickets). Management of primary sources of nest and adult mortality should also be implemented once those sources are identified through the research above. Establishing additional populations of Rota white-eyes outside their current range (in captivity and/or the wild) should be considered to help protect the species from catastrophic events.

Basic Husbandry

Captive management for the Rota White-eye is not currently planned and husbandry techniques do not currently exist for the species. If the Rota White-eye is to be brought into captivity for propagation in the future, husbandry techniques and protocol will be developed and reported upon at that time.

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Appendix B: Species Profiles

Golden White-eye, *Cleptornis marchei*

Photo: tropical.pete/wikipedia

Compiled by: Paul Radley, CNMI Division of Fish and Wildlife, Saipan, Shelly Kremer, USFWS, Honolulu, Hawaii and Anne Tieber, Staint Louis Zoo, St. Louis, Missouri

Order: Passerformes
Family: Zosteropidae
Local or Chamorro Name: *Canario*

Species Overview

Description: A sexually monomorphic forest bird with head, rump, and underparts light cadmium and back orange-citrine in color (Baker 1951). Wings and tail are brownish with orange-citrine outer edges and whitish inner edges; breast, belly, side, and tail coverts raw-sienna in color (Baker 1951). Orbital ring, under wing-coverts, and axillaries are yellow, and bill and feet yellow-brown (Baker 1951). Morphometrics for Golden White-eyes captured on Saipan are presented in Table 1.

Table 1. Morphometrics for the Golden White-eye on Saipan (all measures and weights in millimeters and grams, respectively; R = range)

Sex	Wing (R)	Tail (R)	Culmen (R)	Tarsus (R)	Mass (R)	Source
Male (*n* = 7)	79 (77-80)	64 (61-66)	19.5 (19.0-20.0)	26 (25-27)	-	Baker 1951
Female (*n* = 5)	73 (72-75)	58 (56-59)	18.0 (17.5-18.5)	24 (23-25)	-	Baker 1951
Male (*n* = 368)	74.6 (64-83)	-	-	-	20.4[a] (14.4-26.0)	Radley *et al*. 2011 and unpub. data
Female (*n* = 286)	70.2 (63-78)	-	-	-	16.2[b] (12.1-25.0)	Radley *et al*. 2011 and unpub. data

[a] Based upon *n* = 350 males
[b] Based upon *n* = 272 females

Distribution: The Golden White-eye occurs only on Saipan and Aguiguan. Engbring *et al*. (1986) estimated the populations for the species in 1982 as 55,500 and 2,300 individuals on Saipan and Aguiguan, respectively. Later DFW and USFWS bird surveys of these islands yielded mean abundance estimates for the species of 71,997 on Saipan in 2007 (95% CI 47,586 – 106,535; Camp *et al*. 2009) and 15,499 on Aguiguan in 2008 (95% CI 10,383 – 22,277; Amidon *et al*. *in review*). On Aguiguan, surveys have been conducted in 1992, 2000, and 2002 (Craig et al. 1992; DFW 2000, 2002). In addition to these historical records, recent investigations on Tinian and Rota have revealed prehistoric evidence of the species on both islands (Steadman 1999).

Habitat: Golden White-eyes occur in all wooded habitats on Saipan, including native limestone forest, introduced *Leucaena leucocephala* thickets, strand forest, and suburban areas; however, they are generally absent from swordgrass savannah (Stinson and Stinson 1994, Craig 1996). Research on nesting densities in native limestone forest and *L. leucocephala* thickets suggests that the species nests predominately in the native forest (Sachtleben 2005). Engbring *et al*. (1986) suggested that Golden White-eyes does well in virtually all woody vegetation types, especially brushy areas that are abundant in plants with small leaves or leaflets.

Food and Feed Habits: Golden White-eyes feed primarily on foliage invertebrates, flying insects, nectar, fruits, and to a lesser extent on flowers, of at least 18 species of plant (Table 2; Craig 1990 and 1996). The species forages by probing and gleaning, predominantly in the top outer portion of trees in both native limestone and tangantangan forests (Craig 1990). They tend to forage on fruits and dead leaves more than live leaves and flowers, and spends more time on all available substrates other than live leaves, especially branches (Craig 1990). Overall, the Golden White-eye is a more generalized forager than the Bridled White-eye (*Zosterops conspicillatus*), and is less specialized in the use of tree zones, foraging surfaces, and foraging methods than the latter (Craig 1990).

Behavior: Flocks of Golden White-eyes exhibit a harsh, raspy *tchup* or *schick* calls and a quick, loud whistle (Pratt *et al*. 1987). The song of the species is an extended rambling warble (Pratt *et al*. 1987), which is often sung in the off-key and, albeit more drawn out, is reminiscent of that of the Warbling Vireo (*Vireo gilvus*) of North and Central America (P. Radley, personal obs.).

The Golden White-eye is a territorial species that tends to forage in family groups; adjacent or overlapping groups will show intolerance and aggression towards one another (Craig 1990). Craig (1996) observed banded males defend territory boundaries against adjacent males and respond, although not vigorously, to playback of recorded Golden White-eye song. Of the four species of small forest passerine on Saipan this species only shows regular interspecific aggression towards Bridled White-eyes (Craig 1990). Craig (1990, 1996) documented only a few instance of Golden White-eyes chasing Rufous Fantails (*Rhipidura rufifrons*), a species that often seeks out the former for assistance during foraging.

Breeding: The Golden White-eye likely breeds year-round with distinct peaks in breeding during different times of year. Sachtleben (2005) recorded nesting from February to June and Craig (1996) recorded breeding activity from January to August and in October. Pyle *et al*. (2012) reported birds on Saipan in breeding condition every month of the year, with a small gap in time from mid-August to early September when no birds were observed exhibiting brood patch or cloacal protuberance.

Nesting: Nests are cup shaped, unlined, and composed of *Casuarina equisetifolia* needles, grasses, vine tendrils, and hairs (Stinson and Stinson 1994). Thalia Sachtleben (pers. comm., 2005) recorded the dimensions of 44 Golden White-eye nests, reporting a mean nest height of 69 mm (range = 47-98 mm), a mean nest cup depth of 42 millimeters (range = 32-53 mm), a mean

Table 2. Tree and vine species used by Golden White-eyes for both foraging and nesting on Saipan (Craig 1990 and 1996, T. Sachtleben pers. comm. 2005)

Plant Type	Species	Foraging	Nesting
Trees	*Aglaia mariannensis*	x	
	Aidia cochinchinensis	x	x
	Albizia lebbeck	x	
	Artocarpus spp.	x	
	Carica papaya	x	
	Cynometra ramiflora		x
	Drypetes spp.		x
	Erythrina variegata	x	
	Eugenia spp.		x
	Ficus spp.	x	
	Guamia mariannae		x
	Lantana camara	x	
	Leucaena leucocephala		x
	Maytenus thompsonii		x
	Melanolepis multiglandualosa	x	
	Morinda citrifolia	x	x
	Muntingia calabura	x	
	Ochrosia mariannensis		x
	Pandanas spp.	x	
	Phyllanthus spp.	x	
	Pithecellobium dulce		x
	Pisonia grandis.	x	
	Premna obtusifolia	x	
	Psychotria mariana	x	x
	Randia cochinchinensis	x	
Vines	*Abrus precatorius*		x
	Colubrina asiatica		x
	Momordica charantia	x	

cup diameter of 53 mm (range = 44-65 mm), and a mean nest diameter of 78 mm (range = 50-95 mm).

Golden White-eyes have been reported building nests on 11 tree and two vine species (Table 2). Thalia Sachtleben (pers. comm., 2005) recorded the nest site characteristics of 74 golden white-eye nests in 2004. The mean distance of these nests from the ground was 3.0 m (range = 1.2 – 5.0 m). The mean height of the nest trees were 5.3 m (range = 0.8 – 11.2 m) and the mean distance of the nests from the boles of the nest tree were 66 cm (range = 0 – 295 cm). The average number of support branches supporting each nest was three (range = 2 – 6) and the average diameter of these support branches was 3 mm (range = 1 – 8 mm).

Eggs, Incubation, Hatching, Growth, and Development: Typical clutch size of the Golden White-eye is two (n = 11; Baker 1951, Stinson and Stinson 1994) and eggs are pale blue, without gloss, and spotted with rufous but more densely at the wider end (Baker 1951). Eggs tend to be 20 mm in length and 15 mm at their widest point (Baker 1951). Stinson and Stinson (1994) found that incubation, which is undertaken by both sexes, typically lasts 14 days and that young fledge from 10 to 14 days after hatching.

Nests were observed every three days (occasionally four) and nestlings could only be aged with certainty if they were found on Day 0 (hatch day) or Day 1. Chick development appeared to be quite variable, and was presumably dependent on the number of young per nest, experience of the parents, and availability of food.

Day 0: Chicks approximately 2 – 2.5 cm in length, naked, with dark-medium pink skin and no down.
Day 1: 2 – 2.5 cm in length, naked, with medium pink skin.
Day 3: Overall length from 3 – 4.5 cm, wing pin length from 2 – 5 mm, with back and head pins either barely erupting or at 1 – 2 mm in length, skin medium-dark pink in color, with eyes closed and no down.
Day 4: Approximately 3.5 – 4.5 cm in length, with wing pins at 6 – 7 mm and back pins at 2 – 3 mm (or back and wing pins visible but ≥1 mm), skin medium – light pink in color.
Day 6: Approximately 4.5 – 5.0 cm in length, with wing pins at 7 – 10 mm and olive feathers erupted from back and wing, head pins at 2 – 4 mm and back pins at 4 – 6 mm, with any exposed skin light-medium in color, and eyes still closed(?).
Day 7: Approximately 4.5 – 5.0 cm in length with exposed skin pale pink in color, wing pins at 6 – 7 mm and back and head pins at 2 – 3 mm.
Day 9: Approximately 5 – 6 cm in length, fully feathered, downy, and often perched on the rim of the nest cup. Feathers turning golden in color, head tracts visible, eyes open, no tail or wing pins <10 mm, with feathers erupted ~10 mm from back pins, but head feathers barely erupted.
Day 10:Approximately 5 – 6 cm in length, some pin tracts still exposed or fully feathered, olive back feathers or feathers golden, feathers erupted from wings 8 – 10 mm in length, and the tail ~ 10 mm long.
Day 12:Approximately 6 – 6.5 cm in length, fully feathered, golden, eyes open, tail ~ 10 mm, and bare throat. Any young force-fledged at this age flew well.

Threats: The Golden White-eye is currently abundant and widespread on Saipan, less so on Aguiguan, and is not currently considered threatened or endangered by the Federal or Commonwealth governments. Because of its limited distribution, however, the species is considered a Bird of Conservation Concern by CNMI DFW. The IUCN (2012) lists the species as Critically Endangered because Saipan my harbor an incipient population of the brown tree-snake (*Boiga irregularis*; Colvin et. al. 2005), which is exacerbated by the white-eyes limited distribution, and Saipan's proximity to Guam, the known stronghold of the invasive tree-snake. The primary threats to the species are newly introduced predators, such as the brown tree-snake, or avian diseases (e.g., West Nile virus, avian pox, etc.).

Research Needed – Studies of Golden White-eye population ecology.

BASIC HUSBANDRY

Acquisition and acclimation: Mist netting is the most effective means by which to capture Golden White-eyes. Nets should be checked every 15 minutes and captured birds should be removed in a manner that minimizes stress and transferred to a cloth “field bag” for transport to the field station. At the field station birds should be weighed, measured, banded, given a quick health assessment and have blood drawn by the veterinarian if the bird is not unduly stressed. The bird should then be placed in a dark and quiet field transport box and be given food and water. Birds in the transport crates in the field will eventually be taken to the MAC onsite aviary where they will be set up in more spacious holding enclosures.

Holding enclosures were originally made out of welded wire and the original intent was to house 2-3 birds together, such as with the Bridled White-eye. However, this approach was determined not optimal. AZA staff next tried the smaller Bridled White-eye holding enclosure, placing one bird in each compartment of the enclosure. This option worked well and is recommended for all future field trapping and onsite holding of this species.

Papaya, mealworms, and waxworms are the food items most readily accepted by Golden White-eyes in captivity. Other items include bananas, oranges, and frozen fruit medleys. Also readily accepted by birds is *Nekton* (Pforzheim, Germany) nectar offered in feeders.

Banding and Weighing: Golden Whtie-eyes should be are weighed, measured and banded (with USGS BBL size 2) at capture. Refer to Table 1 for expected weight ranges. Birds should be weighed daily while in “holding” boxes in the field, at the on-site aviary, and during transition to a captive institution. Both obtaining weights and monitoring fecal output are good methods to determine a bird’s daily heath status whether it is thriving in captivity.

Temperature: Golden White-eyes occur in a naturally warm and humid environment; it is recommended that holding institutions strive to provide a similar climate. Housing birds outside is ideal in the summer as long as shade is provided. Not all institutions will be able to adequately provide this setting, however. Inside aviaries and breeding enclosures should thus be kept at 60°-85° F (18.3°-29.4° C), with ideal temperatures between 70°-80° F (23.9°-29.4° C). North Carolina Zoo reported that Golden White-eyes held there appeared stimulated to breeding by rainfall or regular misting (Wadsworth, pers. comm.). This was likewise true for birds at St. Louis Zoo. Staff there misted breeding pairs three times weekly and found that this did appear to stimulate breeding.

Light: Although natural lighting is always preferred, most institutions employ a combination of both. Optimal photoperiod should be 11 hours in December to 13 hours in June. Ample shade should be provided if Golden White-eyes are housed outside.

Food and Feeding: Captive diet for the species should include a mix of seasonal fruits and vegetables, insects such as mealworms or wax worms, and perhaps a type of small pellet. Most institutions note, however, that pelletized food is not readily eaten. Nectar should be offered (either wet or dry) if captive birds will take it; if offered wet, it should be changed or pulled in the p.m. Enrichment foods can also be popular and can include fruits (e.g., chunks of orange, apple, or kiwi) skewered to a branch. Another option may be corn-on-the-cob with the silk left intact as experience shows that birds like to pull at it. Although not enough is known about the species to make recommendations pertaining to iron storage problems, most institutions take this into consideration when feeding and err on the side of caution and provide iron rich foods.

Housing and General Environmental Considerations: Golden White-eyes tend to be compatible with most other species they are housed with. In aviaries they have been mixed with fruit doves, ground doves, and several passerine species and in larger holding enclosures they have been housed with fruit doves and a mix of passerines and ground birds. Some aggression (i.e., mild chasing) has been noted towards some individual fruit doves and smaller passerines, such as mousebirds and Leiothrix. Golden White-eyes generally nest at lower mid-canopy level than other passerines, which may reduce competition with other species for prime nest sites higher in the canopy strata. The species prefers a well planted aviary and will spend a good deal of time gleaning leaves for insects and will generally keep "busy" in such an enclosure. Enrichment articles or plants should be offered as much as possible in holding enclosures because of the species "busy" or active nature. Offering a variety of choices in nesting material is also beneficial.

Captive Behavior: As noted above, the Golden White-eye tends to stay active indicating that healthy birds will spend a good deal of their time foraging, inspecting plants, and quietly preening. As this species also prefers privacy, stocking its aviary with plenty of mid- to high-canopy level plants and trees is a good strategy. The same result is achieved by providing visual barriers and plenty of plants in their holding enclosure.

Experience has shown that when introducing pairs in holding enclosures, housing birds separately but side by side (within sight but not contact) for two weeks prior yields the best results. Following this "introductory" period, the male should be released into the female's enclosure. If prolonged chasing is observed, or if one bird dominates the food plate, they should be separated or a second food platform and visual barriers can be installed. Another option is to house both a male and female side by side before moving them together into an aviary. Releasing the two into a neutral "territory" that is new to both birds helps reduce aggression.

At least one AZA institution reported a case of apparent serious aggression by a male toward a female Golden White-eye. In this case the male and female were housed together in an off exhibit area in an enclosure measuring 1.2 m W by 2.1 m L by 2.1 m H. After several months the female was found dead in the enclosure although the male had exhibited no signs of aggression. A second female was introduced to the enclosure and approximately a week later she was found dead although no obvious aggression had been observed. This male Golden White-eye is currently unpaired and will only be placed into a large flight. No other instances of serious of major aggression have been reported.

Golden White-eye pairs that are content with each other will perch close to one another allopreening and forage together daily. Birds tend to vocalize in the morning and the early evening but will remain quiet during the heat of the day.

Pair Formation, Nesting, and Chick Rearing: Once pairs are formed, bonded Golden White-eyes will generally forage together and spend time allopreening. By this time many pairs have sought and carried a variety of nesting material, birds tending to prefer to build their own even though an artificial nest is offered. Documented nesting material has included polyester quilt batting, raffia, Spanish moss, fine grade wood, manila, sisal and other rope fibers, twine, burlap, palm (coconut/banana) fibers, cocoa fibers, capybara and other animal hair. Trees commonly selected for nesting in captivity include F*icus benjamini, Ficus binnendijkii alii, Caryota ochlandra, Massangeana cane,* and *Ligustrum* spp. One nest at the Memphis Zoo was built approximately 2 m from the ground suspended by grapevine growing in the enclosure. A second at the zoo was constructed approximately 1 m from the ground in a privet bush. Average time to complete one nest was approximately 36 hours.

One Golden White-eyes pairs at North Carolina Zoo in 2009 built a nest at 1.8 m in an unidentified bush outside at an indoor/outdoor propagation building and another pair at 6.1 m in a planted aviary building. Both pairs chose nesting sites that provided ample moisture/rainfall. The male of one pair incubated the majority of the time, the female "filling in" as needed, while the trend was the opposite with the other pair, the female incubating most. After hatching, both adults at each nest were very attentive and helped to feed young, which can be quite vocal when begging as they get older. After both pairs were done nesting, zoo staff removed their nests and both pairs built second nests in the same location as the previous (in both cases, staff put the nests on the ground in their enclosures so the birds could reuse nesting materials). Zoo staff has noted that the Golden White-eye pair in the planted aviary has shown aggression towards other birds that attempt to nest close to them.

Banding Offspring: Juvenile Golden White-eyes can be banded at approximately 30 days of age with a size 1B metal band. At this time the sex of the bird should be identifiable either by DNA analysis. North Carolina Zoo bands juveniles at approximately 74 days, while Saint Louis Zoo has banded as young as 30 days and as old as 62 days

Management of Juveniles: Young Golden White-eyes can be placed with other non-aggressive bird species at about 30 days of age. Alternatively, juveniles can be housed in an enclosure adjacent to an adult Golden White-eye, which will serve as a mentor to the younger bird. North Carolina Zoo separated their first chick (sexed as female) from the parents at approximately 74 days and introduced it to a mixed species flight, which held mostly small passerines, at approximately 82 days. Whether parent reared or hand reared, juveniles can be introduced to a breeding situation at 10-12 months. North Carolina Zoo reported that a bird hatched in July 2009 was introduced to a male in July 2010; by August 2010 a nest with eggs was found.

Health Management: This information is not yet available.

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MARIANAS AVIFAUNA CONSERVATION (MAC) PLAN

APPENDIX C

Estimated Sustainable Population (ESP) Assessment

Appendix B. Estimated Sustainable Population (ESP) Assessment

Fred Amidon, USFWS, Honolulu, Hawaii, and Paul Radley, CNMI DFW, Saipan,

The following assessment attempts to evaluate the number of individuals of each species that could be supported on each of the northern islands to determine if they meet thresholds for minimum viable populations identified by Brook et al (2006; approximately 1,000 individuals) and Traill et al (2010; approximately 5,000 individuals). These population estimates were derived from density estimates for each species from one or more islands where the species occurs and estimates of the available forested habitat on each of the northern islands. This assessment was completed for all species of focal interest to the MAC Project.

Target thresholds of 1,000 or 5,000 individuals were used for this analysis (Brook *et al*. 2006, Traill *et al*. 2010) and were meant only to serve as rough guidelines, not as definite constraints. Although many islands fall short of these thresholds in potential carrying capacity, the MAC Project will establish multiple populations of most species in the archipelago. In the end the results of this assessment were used only in part for the decision of where each species would be placed in the Northern Islands. More weight was ultimately placed upon the direct, first-hand experience of P. Radley and F. Amidon with the six target islands during their 2010 participation in the Marianas Expedition Wildlife Surveys (MEWS; USFWS 2010a).

Bridled White-eye (Aguiguan) – Good disperser that uses a variety of forest types. Densities on Aguiguan were 78.8 birds/ha (95% CI = 59.5 – 107.1) (Amidon *et al*., in review). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Forest**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	14,105	10,651	19,171	5,516	4,165	7,497	Yes	Translocated in 2008 and 2009
Guguan	170	170	B	13.396	10,115	18,207	13,396	10,115	18,207	Yes	
Alamagan	485	430	B	38,218	28,858	51,944	33,884	25,585	46,053	Yes	
Pagan	1971	234	C	155,315	117,275	211,094	18,439	13,923	25,061	Yes	
Agrihan	2336	-	B	184,077	138,992	250,186	-	-	-	Yes	
Asuncion	316	260	A	14,901	18,802	33,844	20,488	15,470	27,846	Yes	

Bridled White-eye (Saipan) – Good disperser that uses a variety of forest types. Densities on Saipan were 47.13 birds/ha (95% CI = 39.82 – 54.89) (Camp *et al*. 2009). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	8,436	7,128	9,825	3,299	2,787	3,842	Yes	Translocated in 2008 and 2009
Guguan	170	170	B	8,012	6,769	9,331	8,012	6,769	9,331	Yes	
Alamagan	485	430	B	22,858	19,313	26,622	20,266	17,123	23,603	Yes	
Pagan	1971	234	C	92,893	78,845	108,188	11,028	9,318	12,844	Yes	
Agrihan	2336	-	B	110,096	93,019	128,223	-	-	-	Yes	
Asuncion	316	260	A	14,893	12,583	17,345	12,254	10,353	14,271	Yes	

Golden White-eye (Aguiguan) – May be a poor disperser that may require mostly native and secondary forest types. Densities on Aguiguan were 24.3 birds/ha (95% CI = 16.3 – 35.0) (Amidon *et al*., in review). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Forest**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	4,348	2,918	6,265	1,701	1,141	2,450	Yes	Translocated in 2011 and 2012
Guguan	170	170	B	4,131	2,771	5,950	4,131	2,771	5,950	Maybe	Above 1,000 but below 5,000
Alamagan	485	430	B	11,786	7,906	16,975	10,449	7,009	15,050	Yes?	Above 5,000 for just native
Pagan	1971	234	C	47,895	32,127	68,985	5,686	3,814	8,190	Maybe	Above 1,000 for just native
Agrihan	2336	-	B	56,765	38,077	81,760	-	-	-	Maybe	Percent of native forest uncertain
Asuncion	316	260	A	7,679	5,151	11,060	6,318	4,232	9,100	Maybe	Above 1,000 for just native

Golden White-eye (Saipan) – May be a poor disperser that may require mostly native and secondary forest types. Densities on Saipan were 7.12 birds/ha (95% CI = 5.35 – 9.75) (Camp *et al*. 2009). Target Abundance = 1000/5000 Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	1,274	958	1,745	498	375	683	Yes	Translocated in 2011 and 2012
Guguan	170	170	B	1,210	910	1,658	1,210	910	1,658	Maybe	Above 1,000 but below 5,000
Alamagan	485	430	B	3,453	2,595	4,729	3,062	2,301	4,193	Maybe	Above 1,000 but below 5,000
Pagan	1971	234	C	14,034	10,545	19,217	1,666	1,252	2,282	Maybe	Above 1,000 for just native
Agrihan	2336	-	B	16,632	12,498	22,776	-	-	-	Maybe	Percentage native forest uncertain
Asuncion	316	260	A	2,250	1,691	3,081	1,851	1,391	2,535	Maybe	Above 1,000 for just native

Mariana Fruit Dove (Aguiguan) – A good disperser that may require mostly native and secondary forest types. Densities on Aguiguan were 1.3 birds/ha (95% CI = 1.1 – 1.7) (Amidon *et al*., in review). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	233	197	304	91	77	119	Yes	Translocated in 2012 and 2013
Guguan	170	170	B	221	187	289	221	187	289	No	Below recommended 1,000
Alamagan	485	430	B	631	534	825	559	473	731	Maybe?	Below recommended 1,000
Pagan	1971	234	C	2,562	2,168	3,351	304	257	398	No	Below recommended 1,000 in native
Agrihan	2336	-	B	3,037	2,570	3,971	-	-	-	Maybe?	Percentage native forest uncertain
Asuncion	316	260	A	411	348	537	338	286	442	No	Below recommended 1,000

Mariana Fruit Dove (Saipan) – A good disperser that may require mostly native and secondary forest types. Densities on Saipan were 0.66 birds/ha (95% CI = 0.53 – 0.8) (Camp *et al*. 2009). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	118	95	143	46	37	56	Yes	Translocated in 2012 and 2013
Guguan	170	170	B	112	90	136	112	90	136	No	Below recommended 1,000
Alamagan	485	430	B	320	257	388	284	228	344	Maybe?	Below recommended 1,000
Pagan	1971	234	C	1301	1045	1577	154	124	187	No	Below recommended 1,000 in native
Agrihan	2336	-	B	1542	1238	1869	-	-	-	Maybe?	Percentage native forest uncertain
Asuncion	316	260	A	209	167	253	172	138	208	No	Below recommended 1,000

Rufous Fantail – A poor disperser that may require mostly native and secondary forest types. Densities on Aguiguan were 17.2 birds/ha (95% CI = 13.0 – 23.0) (Amidon *et al.*, in review). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	3,079	2,327	4,117	1,204	910	1,610	Yes?	Above 1,000 in native
Guguan	170	170	B	2,924	2,210	3,910	2,924	2,210	3,910	Yes?	Above 1,000 in native
Alamagan	485	430	B	8,342	6,305	11,155	7,396	5,590	9,890	Yes?	Above 5,000 in native
Pagan	1971	234	C	33,901	25,623	45,333	4,025	3,042	5,382	Yes?	Above 1,000 in native
Agrihan	2336	-	B	40,179	30,368	53,728	-	-	-	Maybe?	Percentage native forest uncertain
Asuncion	316	260	A	5,435	4,108	7,268	4,472	3,380	5,980	Yes?	Above 1,000 in native

Rufous Fantail – A poor disperser that may require mostly native and secondary forest types. Densities on Saipan were 4.7 birds/ha (95% CI = 3.9 – 6.0) (Camp *et al*. 2009). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

Island	Total Forest	Native Only	Source	All Forest *N*	All Forest L95%	All Forest U95%	Native Forest *N*	Native Forest L95%	Native Forest U95%	Trans?	Justification and Notes
Sarigan	179	70	B	841	698	1,074	329	273	420	Yes?	Above 1,000 in native
Guguan	170	170	B	799	663	1,020	799	663	1,020	Yes?	Above 1,000 in native
Alamagan	485	430	B	2,280	1,892	2,910	2,021	1,677	2,580	Yes?	Above 5,000 in native
Pagan	1971	234	C	9,264	7,687	11,826	1,100	913	1,404	Yes?	Above 1,000 in native
Agrihan	2336	-	B	10,979	9,110	14,016	-	-	-	Maybe?	Percentage native forest uncertain
Asuncion	316	260	A	1,485	1,232	1,896	1,222	1,014	1,560	Yes?	Above 1,000 in native

Tinian Monarch – Probably a poor disperser that requires mostly native and secondary forest types. Densities were 4.84 birds/ha (95% CI = 3.98 – 5.78) (Camp *et al*. 2012). Target Abundance = ?

Island	Total Forest	Native Only	Source	All Forest *N*	All Forest L95%	All Forest U95%	Native Forest *N*	Native Forest L95%	Native Forest U95%	Trans?	Justification and Notes
Sarigan	179	70	B	866	712	1035	339	279	405	No	Golden White-eye present since 2011.
Guguan	170	170	B	823	677	983	823	677	983		
Alamagan	485	430	B	2347	1930	2803	2081	1711	2485		
Pagan	1971	234	C	9540	7845	11,392	1133	931	1353		
Agrihan	2336	-	B	11,306	9297	13,502	-	-	-	Maybe?	Percentage native forest uncertain
Asuncion	316	260	A	1529	1258	1826	1258	1035	1503		

Rota White-eye – Probably a good disperser that appears to require mostly native forest above 200 meters elevation. Densities were calculated as 1.83 birds/ha (95% CI = 0-11.09) (Engbring *et al*. 1986). Target Abundance = ?

				All Forest			Native Forest				
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	328	0	1,985	128	0	776	No	Bridled White-eye present since 2008.
Guguan	170	170	B	311	0	1,885	311	0	1,885	No	Limited forest above 200 m elevation.
Alamagan	485	430	B	888	0	5,379	787	0	4,769	No	Limited forest above 200 m elevation.
Pagan	1971	234	C	3607	0	21,858	428	0	2,595	No	Limited forest above 200 m elevation.
Agrihan	2336	-	B	4275	0	25,906	-	-	-	Maybe?	Forest available but status unknown.
Asuncion	316	260	A	578	0	3,504	476	0	2,883	No	Limited forest above 200 m elevation

Nightingale Reed-warbler (Saipan) – A good disperser and probably requires mostly secondary forest and forest edge. Densities on Saipan were 0.23 birds/ha (95% CI = 0.172 – 0.282) (Camp *et al*. 2009). Thought to be a different species from that on Alamagan (Saitoh *et al*. 2012). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest				
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**	**Justification and Notes**
Sarigan	179	70	B	41	31	50	16	12	20		
Guguan	170	170	B	39	29	48	39	29	48		
Alamagan	485	430	B	112	83	137	99	74	121	No	Native reed-warbler population present
Pagan	1971	234	C	453	339	556	54	40	66		
Agrihan	2336	-	B	537	402	659	-	-	-	Maybe?	
Asuncion	316	260	A	73	54	89	60	45	73		

Nightingale Reed-warbler (Alamagan) – A good disperser and probably requires mostly secondary forest and forest edge. Densities on Alamagan were 1.95 birds/ha (95% CI = 0.88 – 3.63) (Marshall *et al*. 2011). Thought to be a different species from that on Saipan (Saitoh *et al*. 2012). Target Abundance = 1000/5000 (Brook *et al*. 2006, Traill *et al*. 2010)

				All Forest			Native Forest			
Island	**Total Forest**	**Native Only**	**Source**	***N***	**L95%**	**U95%**	***N***	**L95%**	**U95%**	**Trans?**
Sarigan	179	70	B	349	158	650	137	62	254	
Guguan	170	170	B	332	150	617	332	150	617	
Alamagan	485	430	B	946	427	1761	839	378	1561	No
Pagan	1971	234	C	3843	1734	7155	456	206	849	
Agrihan	2336	-	B	4555	2056	8480	-	-	-	Maybe?
Asuncion	316	260	A	616	278	1147	507	229	944	

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