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# **BRIDLED WHITE-EYE** (*Zosterops conspicillatus*)

ROBERT J. CRAIG<sup>1</sup>

Bird Conservation Research, Inc. P.O. Box 84 Hadlyme, CT 06439 USA and Department of Natural Resources and the Environment University of Connecticut 1376 Storrs Road, Unit 4087 Storrs, CT 06269-4087 USA

PETER PYLE

The Institute for Bird Populations P.O. Box 518 Petaluma, CA 94953

# **INTRODUCTION**

The Bridled White-eye, or Nosa in the Chamorro language, is one of the better studied bird species of the western tropical Pacific's Mariana Islands, although even in this case for the past 20 years there has been limited study beyond population surveys. In addition to periodic studies into its population status, trends and dynamics, investigations have been conducted into its foraging ecology, microhabitat use, social behavior and breeding biology. This member of the wide-spread African-Australasian Zosteropidae has among the highest population densities of any bird species. It is known historically from the islands of Saipan, Tinian and Aguiguan, although a separate subspecies, now extinct, once occurred on Guam.

The diminutive size, greenish back, yellow breast and distinct white eye-ring separate this species from all others within its limited range. Flocks of 50 or more individuals, which in many cases are members of family groups, occupy home ranges but pairs do not defend all-purpose territories. Within home ranges, individuals are supremely versatile foragers and users of habitat, although they are principally gleaners of insects present in the outer canopy of forests. Population densities are by far the greatest in native forest, although birds also occupy a variety of alien wooded habitats and even areas of human habitation. Evidence suggests that, although breeding occurs year-round, nesting peaks in the dry season.

Although still abundant, the species is threatened with extirpation from its range by the possible introduction of the brown tree snake (*Boiga irregularis*)—a non-native predator responsible for the extinction of the Guam population. To aid in its conservation, it has been translocated to the more northerly, uninhabited Mariana Island of Sarigan, where it is prospering. More recently, it has been translocated to Guguan.

## **IDENTIFICATION**

## **Field Identification**

The Bridled White-eye is notable for its diminutive size, greenish back, yellow breast and distinct

<sup>1</sup>Corresponding author. *E-mail address: mail@birdconservationresearch.org.* 

white eye-ring, although juveniles are distinctly less yellow than adults. The small, sexually monomorphic passerine typically occupies the forest canopy.

#### Similar Species

The only other white-eye within the geographic range of the Bridled White-eye is the rather distantly related Golden White-eye (*Cleptornis marchei*), which is much larger, has a weakly whitish eye ring,

yellow-orange plumage and orange beak and legs. Unlike the Bridled White-eye's vocalizations of primarily thin chit-chit-chit notes and whines, the Golden White-eye has a melodious song. The small white -eye of the Mariana Island of Rota, the Rota Whiteeye (Z. rotensis), has a white eye ring but yellowish lores, yellowish green plumage above, bright yellowish plumage below, and an orange bill and legs. Other co-occurring small passerines in the Marianas include the brilliant red Micronesian Myzomela (Myzomela rubrata) and the brown and burnt orange Micronesian Rufous Fantail (Rhipidura versicolor). The similarly sized Caroline Islands White-eye (Z. semperi) of Palau, Chuuk, Pohnpei and the Caroline Islands is similar in appearance and was once considered conspecific with the Bridled White-eye (e.g., Baker 1951). It is brighter greenish-yellow above and yellowish below, although less so than the Rota White-eye. The also similarly sized Dusky Whiteeye (Z. finschii) of Palau has upper parts smoky olivaceous-gray, lores dingy white, auriculars brownish, no white eye ring, underparts pale ashy-gray and wing and tail feathers dark brownish-gray with paler greenish-gray outer edges.

### PLUMAGES, MOLTS AND STRUCTURE

### Plumages

The Bridled White-eye has 9 full-length primaries (numbered distally, from innermost p1 to outermost p9), 9 secondaries (numbered proximally from outermost s1 to innermost s9 and including 3 tertials, s7-s9 in passerines), and 12 rectrices (numbered distally, from innermost r1 to outermost r6 on each side of the tail). Geographic variation in appearance is slight (see Sytematics: Geographic Variation); the following covers both subspecies and is based on plumage descriptions in Marshall (Marshall 1949), Baker (1951), and Pratt et al. (1987), along with examination of Macaulay Library images; see Pyle et al, (2008), Radley et al. (Radley et al. 2011), and Craig (2021a) for information on ageing and sexing this species. See Molts for molt and plumage terminology. Appearance of sexes is similar in all plumages; definitive-like appearance is assumed at the formative plumage in most individuals and definitive appearance is assumed at the second basic plumage in some individuals. Seasonal variation in plumages (e.g., fresh vs. worn) based on timing of molts, which is unknown but may occur year-round based on yearround breeding (see Breeding: Phenology) and/or extended periods of molt observed (see Molts).

**Natal down.** Occurs in the nest. Natal down is undescribed in Bridled White-eye; chicks appear to hatch naked.

**Juvenile (first basic) plumage.** Juveniles are grayer above and paler below than in later plumages (Craig 2021a) and can show dusky streaking to the

crown and underparts. On Guam, a juvenile was observed to be lighter green above and lighter yellow below compared to its parents (Stophlet 1946). The lores also appear paler, not as dusky as those in later plumages (Baker 1951). Juvenile body feathers are weaker and more filamentous (barb density sparser) than in later plumages, especially the undertail coverts, and juvenile primaries and rectrices are thinner and more tapered or pointed at the tips than basic feathers. Iris color of juveniles may also be duller (see Bare Parts).

**Formative plumage.** This plumage appears to be distinguishable in only a proportion of birds when the Preformative Molt is incomplete (Pyle et al. 2008, Radley et al. 2011). An unknown proportion of birds can retain contrastingly worn and narrow juvenile outer primaries, primary coverts, secondaries among s4–s6, and/or outer rectrices following this molt and can be aged as first-year birds. Formative plumage following a complete preformative molt is indistinguishable from definitive basic plumage.

Definitive basic plumage. Definitive basic plumage overall can vary from gravish green to yellowish green even within subspecies; factors for this variation are not known. The crown, upperparts, upperwing coverts, and sides of head vary from mixed green and dusky to uniformly green or greenish yellow; a paler cream to pale yellowish band crosses the forehead above the bill, and the nape is slightly paler greenish, greenish yellow, or gray. A full and broad, prominent white eye ring is a conspicuous plumage feature. The lores are dusky, this color usually extending across the eye ring and sometimes under the eye. Remaining sides of the head are washed green to greenish yellow. Rectrices and remiges are dusky with olive to yellow-olive edging. Underparts are variable, primarily buff to whitish or cream, usually with a dull to bright yellowish wash to the throat (can be absent or very faint), ventral feathering, and undertail coverts, occasionally tinged yellowish elsewhere. Definitive basic plumage is characterized by having all upperwing coverts and remiges uniform in wear and quality, without retained feathers; basic outer primaries and rectrices broad, more truncate (less pointed), and relatively fresh compared with retained juvenile feathers. No differences between sexes have been confirmed; females on Guam have been described as being lighter on the underparts (Baker 1951) but more recent examination of sexed Saipan individuals revealed no consistent differences in plumage (Pyle et al. 2008).

## Molts

Molt and plumage terminology follows Humphrey and Parkes (Humphrey and Parkes 1959) as modified by Howell et al. (Howell et al. 2003). Under this nomenclature, terminology is based on evolution of molts along ancestral lineages of birds from ecdysis



FIG. 1. A Saipan Bridled White-eye juvenile (left) and adult.

(molts) of reptiles (cf. Pyle et al. 2024), rather than on molts relative to breeding season, location, or time of the year, the latter generally referred to as "life-cycle" molt terminology (Jenni and Winkler 2020; see also Pyle 2022). Bridled White-eye exhibits a Complex Basic Strategy (cf. Howell et al. 2003, Howell 2010b), including complete prebasic molts and a partial-to complete preformative molt in the first cycle, but no prealternate molts (Pyle et al. 2008, Radley et al. 2011). Timing of molts may occur primarily in January–June (Pyle et al. 2008) but also may occur year-round following year-round breeding (see Breeding: Phenology); see below for more details.

**Prejuvenile (First Prebasic) molt.** Occurs in the nest. Sequence of juvenile feather development not studied in Bridled White-eye.

**Preformative molt.** Typically occurs within 3 mo of fledging. The preformative molt appears to be partial to complete, with all or some secondaries, rectrices, and primaries retained in some but not all birds. Often 1–3 secondaries among s4–s6 (the last scondaries replaced in sequence) could be the only juvenile feathers retained following this molt (Pyle et al. 2008, Radley et al. 2011; see image under Formative Plumage). The proportion of individuals that undergo a complete preformative molt is unknown.

**Second and definitive prebasic molts.** Prebasic molts are complete and typically may occur 1–3 mo following breeding, although this may be complicated in the Bridled White-eye by potential bimodal

breeding seasons. In some cases molt may be suspended for breeding, as has been observed in other Pacific island species (Pyle et al. 2016). On Saipan, examination of 53 specimens found that 15 collected in active molt all occurred January–April i.e., the dry season, and the remainder were not in active molt, but banding data indicated molt also occurring in April–July (Pyle et al. 2008).

Of 114 Saipan birds banded in 1988–1993, there were 29 instances of individuals displaying molt of flight and contour feathers. Most instances were from September–October, the end of the wet season, which lasts from late June–November, although five were from late June. There were five instances of primarily flight feather molt during the dry season, although two of these were in early June— the end of the dry season (Craig 2021). Similarly, four specimens collected during the wet season in October were all in molt (Baker 1948). These observations may suggest a tendency to segregate the energetically expensive activities of molt to the wet season and breeding to the dry season but that molt timing can also occur year-round.

During complete molts, primaries (and corresponding primary coverts) are often replaced distally (p1 to p10), secondaries are replaced proximally and distally from the central or innermost tertial (s8 or s9)proximally from s1, and rectrices are generally replaced distally (r1 to r6) on each side of the tail, though variation in sequence of rectrix molt may occur. However, odd sequences of retained remiges have been observed in Bridled White-eye, where old

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FIG. 2. A Saipan Bridled White-eye illustrating a distinct white eye ring, black bill and legs and greenish upperparts.

and new primaries in various positions were observed that were not always symmetrical (Pyle et al. 2008); further study on molt sequences needed in this sand other white-eye species. Odd sequences may occur following suspended molts, as noted above.

#### **Bare Parts**

**Bill.** Guam adults had an upper mandible that was olive and the base of the lower mandible was yellow (Marshall 1949). The juvenile was described as having a light yellowish-brown upper mandible (Baker 1951), although photographic evidence from Saipan shows the bill of a fledged juvenile to be similar to that of the adult (R.J. Craig pers. obs.). However, a juvenile Guam bird was also observed to have a bright orange-red bill (Stophlet 1946). Saipan and Tinian adults have an upper mandible that is shiny black but a lower mandible that is lighter gray (Marshall 1949, R.J. Craig pers. obs.).

**Iris.** The iris of Guam birds was described as light brown (Jenkins 1983) or gray (Marshall 1949). That of Saipan birds is rich reddish-brown (R.J. Craig pers. obs).

**Tarsi and toes.** The tarsi and toes of Guam birds are variously described as dark gray sometimes tinged olive green (Baker 1951) or dark olive in both adults and juveniles (Marshall 1949, Jenkins 1983). On Saipan and Tinian, adults and juveniles have bluish-gray feet (Marshall 1949, R.J. Craig pers. obs.).

#### Measurements

Linear measurements. The earliest reported measurements, although the details of measurement procedures are lacking, are for Guam Bridled Whiteeyes. For females, total length =  $109.3 \pm 3.4$  mm, wing length =  $68.1 \pm 26.6$  mm, tail length =  $38.6 \pm$ 0.7 mm, tarsus length =  $20.3 \pm 0.3$  mm, culmen =  $11.6 \pm 0.5$  mm, mid-toe =  $15.3 \pm 0.5$  mm (n = 4), and, for a single male, total length = 108.0 mm, wing length = 58.4 mm, tail length = 38.1 mm, tarsus length = 24.9 mm, culmen = 11.9 mm, mid-toe = 14.7 mm. A single juvenile had total length = 76.2mm, wing length = 38.1 mm, tail length = 14.2 mm, tarsus length = 20.3 mm, culmen = 8.9 mm, mid-toe = 15.7 mm (Seale 1901). Specimens from Guam, again with measurement details lacking, showed that unsexed individuals (n = 43) had a flattened wing length = 56, range = 52-59 mm; tail length = 41, range = 37-43 mm; tarsus length = 19, range = 18-20 mm; culmen = 13.5, range = 13-14.5 mm (Baker 1951).

Specimens of *saypani* (n = 29) had a flattened wing length = 52, range = 50–55 mm; tail length = 38, range = 35–40 mm; tarsus length = 18, range = 17–19 mm; culmen = 12.5, range = 12–13.5 mm. Of these, 23 birds from Tinian had a flattened wing length = 51, range = 50–53 mm; tail length = 38, range = 35–41 mm; tarsus length = 18, range = 17–18 mm; culmen = 12.0, range = 12.0–13.0 mm. Six birds from Saipan had a flattened wing length =



FIG. 3. The Aguiguan Bridled White-eye averaged larger but with lower mass than birds from Saipan...

54, range = 52-55 mm; tail length = 37, range = 35-39 mm; tarsus length = 18, range =17-19 mm; culmen = 13.0, range =13.0-15.0 mm. Birds from Saipan averaged slightly larger than birds from Tinian (Baker 1951).

Captures on Saipan in 1988-1993, with full measurement details provided, showed that males (n = 30) had wing chord =  $50.2 \pm 1.3$  mm, tail length =  $40.2 \pm 2.3$  mm, tarsus length =  $18.2 \pm 1.2$  mm, bill length from proximal nares =  $7.0 \pm 0.4$  mm, bill depth at proximal nares =  $2.6 \pm 0.1$  mm. Females (*n* = 12) had wing chord =  $49.4 \pm 1.2$  mm, tail length =  $40.7 \pm 2.6$  mm, tarsus length =  $17.5 \pm 0.9$  mm, bill length from proximal nares =  $6.9 \pm 0.3$  mm, bill depth at proximal nares =  $2.6 \pm 0.2$  mm (Craig 2021a, R.J. Craig, unpublished data). Captures on Saipan in 2008-2009, using standard U.S. Fish and Wildlife Service procedures, showed that males had wing chord =  $52.3 \pm 1.6 \text{ mm} (n = 64)$  whereas females had wing chord =  $51.5 \pm 1.4$  mm (n = 70) (Radley et al. 2011). Male Saipan captures in 2008 (n = 17) had wing chord = 51–54 mm, whereas females (n = 29) had wing chord = 49–54 mm (Pyle et al. 2008).

Discriminant function analysis demonstrated that means for Saipan Bridled White-eye sexes differed significantly, albeit weakly (n = 114, Wilk's  $\lambda =$ 0.64, P < 0.01; canonical correlation = 0.60), with 90.0% of selected but only 58.3% of unselected grouped cases correctly classified. Based on tests of equality of group means, only wing chord contributed substantially to the function. From the 95% confidence interval, birds with wing length >50.1 mm were males and birds with wing length  $\le 50.1$  mm were females (Craig 2021a).

Captures of largely unsexed individuals on Aguiguan (Fig. 3) in May 1992 (n = 15), using the same procedures as Craig (2021a), had wing chord = 50.3 $\pm$  1.0 mm, tail length = 43.0  $\pm$  1.6 mm, tarsus length =  $17.5 \pm 0.7$  mm, bill length from proximal nares =  $7.6 \pm 0.4$  mm, bill depth at proximal nares =  $2.8 \pm 0.2$ mm. Three of these were males sexed by cloacal protuberance and had wing chord =  $51.1 \pm 0.3$  mm, tail length = 43.1  $\pm$  1.8 mm, tarsus length = 18.4  $\pm$ 0.7 mm, bill length from proximal nares =  $7.7 \pm 0.4$ mm, bill depth at proximal nares =  $2.9 \pm 0.1$  mm. No birds displayed brood patches. Discriminant function analysis demonstrated a significant difference between Saipan and Aguiguan birds. Univariate f tests demonstrated that the Bridled White-eye had significantly larger wing, bill, and tarsus measurements on Aguiguan compared with Saipan (Craig et al. 1993a).

**Mass.** Birds from Guam had a male mass mean = 10.5, range = 9.5–14 g (n = 11) and a female mass mean = 9.3, range = 8–10 g (n = 3) (Baker 1948). Saipan captures from 2008–2009 had a male mass of 7.4  $\pm$  0.5 g (n = 48) and a female mass of 8.0  $\pm$  0.7 g (n = 59) (Radley et al. 2011). Saipan captures from 1988–1993 had a male mass of 8.0  $\pm$  0.4 g (n = 30) and a female mass of 8.3  $\pm$  0.9 g (n = 11). May 1992 Aguiguan captures had a mass of 7.4  $\pm$  0.5 g (n = 14), which was significantly lower than that of birds

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FIG. 4. A Saipan Bridled White-eye foraging in Erythrina variegata flowers.

from Saipan. Three of these were sexed as males and had a mass of  $7.8 \pm 0.4$  g (Craig 2021a, Craig et al. 1993a, R.J. Craig, unpublished data).

## SYSTEMATICS

## Systematics History

The Bridled White-eye was apparently reported from Tinian in 1742, when a beautiful little green bird was described from there in journals of the H.M.S. Centurion (Barratt 1988). The Guam population was first named Dicaeum conspicillatum (Kittlitz 1832–1833, 1835, Lutké, 1836). It was then assigned to Zosterops (also conspicillatum) by Bonaparte {1850-1857), listed as Zosterops conspicillata by Reichenbach (1852) and listed as Zosterops conspicillatus by Momiyama (1922). The subspecies conspicillata was first recognized by Stresemann (1931). The subspecies *saypani* was distinguished by Dubois (1899–1902), although it was listed as a separate species, Zosterops saipani, by Mathews (1930). More recently, saypani also was considered specifically distinct (del Hoyo and Collar 2016, Pratt 2010). However, considering the estimated short period of genetic divergence of the Guam and Saipan populations, ca.10,000 years, these are generally treated as conspecific (Stattersfield and Capper 2000, Dickinson 2003). The Rota White-eye (Zosterops rotensis), Caroline Islands White-eye (Zosterops semperi), and Plain White-eye (Zosterops hypolais)\_were formerly considered conspecific with the Bridled Whiteeye (Baker 1951), although DNA studies indicate that the Bridled White-eye is specifically distinct from them (Slikas et al. 2000, Oliveros et al. 2021).

## **Geographic Variation**

The plumage of Z. c. saypani is similar to Z. c. conspicillatus but it has a fronto-loral band more greenish-yellow, the auriculars olivaceous rather than grayish, the crown greenish rather than gray, the orbital ring narrower, the upper parts brighter olive, the underparts paler yellowish-white and the bill darker. Birds from Saipan resemble closely birds from Tinian and Aguiguan, but Saipan birds may have the upper parts slightly brighter and the underparts slightly more yellow (Baker 1951, Pratt et al. 1987), although Marshall (1949) and Engbring et al. 1986) could find no difference between populations. In Z. c. conspicillatus, the upper mandible is more gravish and the iris is described as light umber, whereas in Z. c. saypani it is described as chestnut (Baker 1951). Discriminant function analysis, albeit with small samples, suggested that Aguiguan birds were larger than those of Saipan (Craig et al. 1993a). Guam birds were larger than Saipan-Tinian birds (Baker 1951, Pratt et al. 1987).

### **Related Species**

This species belongs to a large clade of ca. 40 Indo-Pacific *Zosterops* species (Fjeldsa et al. 2020).



FIG. 5. A nest and eggs of a Bridled White-eye on Saipan.

DNA studies demonstrate that Zosterops conspicillatus is sister to a clade formed by the Dusky Whiteeye (Zosterops finschii) and Yap White-eye (Zosterops oleagineus) (Oliveros et al. 2021). Its relationship to the Rota White-eye (Z. rotensis) is not determined in this study, although Slikas et al. (2000) examined DNA of the Bridled White-eye, Caroline Islands White-eye (Z. semperi), Plain White-eye (Z. hypolais), Yap White-eye (Z. oleagineus) (previously Rukia oleaginea) and Golden White-eye and found substantial genetic divergence (5.7–7.3%) among the first three of these, which formerly were treated as a single species, as well  $6.5 \pm 1.7\%$  divergence between rotensis and the previously considered conspecific populations on Guam, Tinian and Saipan.

## **Fossil History**

Sub-fossils of *Zosterops* bones, all identified as *conspicillatus*, have been uncovered on Rota, Aguiguan and Tinian (Steadman 1999).

# DISTRIBUTION

The subspecies *saypani* is known historically from the Mariana Islands of Saipan, Tinian, Aguiguan, and it has recently been introduced to Sarigan and Guguan. The subspecies *conspicillatus* is extinct on Guam.

## Historical Changes to the Distribution

Sub-fossils of *Zosterops* bones, all identified as *conspicillatus*, have been uncovered on Rota, Aguiguan and Tinian (Steadman 1999). The species *conspicillatus* has not been recorded from Rota historically. The subspecies *conspicillatus* of Guam became extinct in 1984 (Wiles et al. 2003). In 2008–2009, the subspecies *saypani* was translocated from Saipan and Tinian to the more northerly Mariana Island of Sarigan, where it is now breeding successfully (Radley 2012). In 2015–2016, it also was translocated to the Mariana Island of Guguan (BirdLife International 2024).

## HABITAT

An early account of habitat occupancy described the Bridled White-eye as occupying tall trees (Hartert 1898), whereas Stott (1947) found flocks on Saipan in a sugarcane field, in *Casuarina equisitifolia* stands and in semi-wooded hillsides. Another early account described the species as being a habitat generalist although preferring trees and shrubs that have small leaves (Marshall 1949). More recently, habitat has been described as shrubby forests, native *Pandanus* woods and limestone forest as well as introduced tangantangan (*Leucaena leucocephala*) thickets (Pratt et al. 1987).

On Guam, the Bridled White-eye was initially

thought to prefer small bushes at roadsides and other waste places (Seale 1901). Baker (1951) reported it from uplands and in mature native cliffline forests of the northernmost part of the island. Tubb (1966) found it in scrub, Stophlet (1946) found it the volcanic soil-derived grasslands and foothills of southcentral Guam, and King (1962) observed it in coastal strand near Tarague Beach. It was once common in the Agana Swamp and it was apparently also once common in the mixed woodland and second growth of the northern plateau. As the species became rare, it was present primarily in the mature native cliff line forest of extreme northwestern Guam, although it was still seen rarely in coastal strand near Pati Point Beach (Jenkins 1983).

On Saipan, the species was studied in two principal habitats that it occupied: native limestone forest and introduced tangantangan thickets. In these two habitats, it was far more common in the former (Craig 1996, 2021). Limestone forest in the Marpi region is dominated by such native canopy trees as Guamia mariannae, Neisosperma oppositifolia, Ochrosia mariannensis, Melanolepsis multiglandulosa, Cynometra ramifolia, Ficus prolixa, Pisonia grandis, Psycotria mariana, Aidia cochinchinensis Premna obtusifolia, Morinda citrifolia, Guettarda speciosa, Pandanus spp. and Erythrina variegata. In the Talufofo and Mt. Tapotchau regions, such native trees as Artocarpus mariannensis, Cerbera dilatata, Hernandia nymphaeifolia, Hibiscus tiliaceus, Mammea odorata and Barringtonia asiatica are also common. Near the summit of Mt. Tapotchau, birds frequented Pandanus spp. copses. Canopy height is generally restricted to <15 m because of frequent typhoons and understory vegetation is dense (Craig 1989). Such native forests are typical of the relatively xerophytic forest communities of the northern Mariana islands of Saipan, Tinian, and Aguiguan where Bridled White-eyes are abundant inhabitants (Chandran et al. 1993, Craig 1992, R.J. Craig pers. obs.).

Another Saipan location used for studying flocking behavior extended in a 300 m radius surrounding a single mist net station, and included ca. 50% alien thickets of *Leucaena leucocephala*, *Lantana camara*, *Cocos nucifera*, and *Carica papaya* interspersed with elephant grass (*Pennisetum purpureum*) and other weed grasses, although copses of native trees (15%), including *Casuarina equisetifolia*, *Ficus tinctoria*, *F. prolixa*, *Guamia* [=*Meiogyne*] mariannae, *Claoxylon* marianum, *Premna obtusifolia*, *Erythrina variegata*, and *Morinda citrifolia* also occurred. The remainder of the area consisted of residential development, which birds also frequented, and an unvegetated quarry (Craig 2002).

On Aguiguan, population surveys and behavioral studies of birds were conducted in steep limestone escarpments which, unlike level areas, were still vegetated by native forest dominated by such species as *Pisonia grandis, Cynometra ramiflora,* and *Guamia* [=*Meiogyne*] *mariannae.* Unlike on Saipan, the forest understory was open due to intensive brows-ing by feral goats (*Capra hircus*). Birds also were mistnetted and banded in alien thickets principally comprised of *Lantana camara* that were present on level areas formerly cultivated for sugarcane (Craig et al. 1993b, R.J. Craig pers. obs.).

# **MOVEMENTS AND MIGRATION**

## Movements

The Bridled White-eye has not been recorded to move among islands historically, although it is possible that individuals are blown between such nearby islands as Saipan, Tinian and Aguiguan during typhoons. Clearly, however, in the past the species had dispersed among the islands of Saipan, Tinian and Aguiguan, and in the more distant past dispersal occurred either to or from Guam.

## **Dispersal and Site Fidelity**

During a study of flocking behavior, banded birds remained in the study area of 600 m diameter for up to 14.5 months although at least some individuals appeared to range beyond this distance during foraging activities. Small groups of at least three birds were family groups, although larger groups of ca. 50 birds also foraged together and then dispersed into smaller flocks (Craig 2002).

### **DIET AND FORAGING**

## Feeding

Microhabitat for foraging. On Guam, the earliest description of foraging microhabitat (Seale 1901) was of birds using roadside bushes. The favored feeding locations were thought to be to be small Triphasia trifolia bushes that grew by the roadside as well as waste places on the island. On shrubs, they hopped about on the branches, first on one side and then on the other. By the 1940s (Baker 1951), observers found birds to be restricted to certain areas on Guam, where they were found in low trees, including those of high, coastal cliffs. Other localities were in the central part of the island in upland low trees. Stophlet (1946) found them in grasslands on foothills. In 1960, Hartin (1961) found the species to climb on bushes and trees and inhabiting tangantangan and Casuarina equisitifolia. During 1978-1979 (Jenkins 1983), birds fed frequently in large Ficus and Guettarda, two of the larger trees found in the mature native limestone forest at Urano and Ritidian Point. They were once common in the Agana Swamp and were observed once in coastal strand near Pati Point Beach. They appeared to be primarily a canopy-feeder. Foraging occurred mostly among twigs and small branchlets, but birds also occasionally foraged among leaf sprays. In 1981, Engbring and Ramsey (1984) observed them to forage actively in the upper canopy.

In 1931, Coultas (in Baker 1951) described the Bridled White-eye as frequenting gardens and shrubs in villages on Saipan and Tinian, where it climbed over potted plants on the window ledges of dwellings. He thought it no longer a bird of the forest, as there was none to go to. In the 1940s on Tinian (Downs 1946), it occupied low brush or trees and occurred at edges of open fields. Also in the 1940s, Marshall (1949) described foraging habitat as small twigs in all kinds of habitat, but there was a marked preference for trees and bushes that had small leaves or leaflets On Saipan (Stott 1947), it was observed frequenting Casuarina equisitifolia stands, semiwooded hillsides and sugarcane fields . More recently in the Northern Mariana Islands, Engbring et al. (1986) reported foraging microhabitat as teing he upper canopy of mature native forest or scrubby second growth, although urban areas and even dense herbaceous vegetation along fence rows and in fields were occupied.

In native limestone forest on Saipan in 1988 (Craig 1989), the species was found to forage mostly in the top outer portions of trees, where the foliage was most dense. The only other tree zone used extensively was the middle outer zone. Forest edge and forest interior observations did not significantly differ. This same pattern of outer canopy preference also held for observations made in introduced tangantangan thickets, where results also did not significantly differ for edge and interior data. Only eight of 146 (5.5%) observations in limestone forest and 24 of 214 (11.2%) observations in tangantangan thickets came from understory trees. In addition to foraging in trees, birds fed in herbaceous weeds and gleaned from Miscanthus grass leaves while perched on their stems. On occasion, foraging birds used roadsides and lawns.

In both limestone forest and tangantangan thickets (Craig 1989), foraging birds appeared to prefer sunlit areas. In the morning on the west-facing Marpi Cliffs, most foraging birds were at the top of the cliffs— the area first illuminated by sun. Similarly, in the early morning birds fed actively in the sunlit *Leucaena* thickets at the base of these cliffs. However, few birds used *Leucaena* by late morning, when daytime temperatures neared their peak. Numerous thicket-foraging birds were again present in the afternoon, but when thickets became shaded toward evening there were few birds. On the Marpi Cliffs native forest illuminated by late afternoon sun, birds foraged to nearly sunset.

In limestone forest and tangantangan thickets (Craig 1989, R.J. Craig pers. obs.), the species foraged mostly among leaves. It searched buds, fruits, trunks, dead leaves and rolled leaves only infrequently. Birds fed from either upper or lower surfaces of leaves. While foraging among leaves, they reached above and below and also dangled beneath perches. When foraging in trees with large leaves, they sometimes stood on leaf surfaces. This latter behavior was possible because birds averaged only 8.2 g in mass. There were no significant differences in use of foraging surfaces between forest edge and forest interior. Perches 0.25-0.5 cm in diameter were preferred in both limestone forest and tangantangan thickets, with <0.25 and 0.5-<1.0 cm perches used secondarily. Although birds could use larger perches, they did so infrequently. There was no significant difference in perch use between edge and interior observations or an interaction between habitat and edge and interior observations, but a significant difference between habitats in perch use, with birds more frequently choosing larger perches in limestone forest. Birds foraged in the following limestone forest taxa: Guamia [=Meiogyne] mariannae, Pisonia grandis, Cynometra ramiflora, Ficus spp., Premna obtusifolia, Melanolepsis multiglandulosa, Ochrosia mariannensis, Erythrina variegata, Aidia cochinchinensis, Morinda citrifolia and Artocarpus spp. At high elevations on Mt. Tapotchau, they foraged in Pisonia. umbellifera, Pandanus spp. and Claoxylon marianum. Birds also foraged in native and introduced tree species in such environments as beach strand, native mangrove (Bruguiera gymnorrhiza) swamps, strand woodlands dominated by Barringtonia asiatica, Hibiscus tiliaceus and Hernandia sonora, and formerly cultivated areas vegetated by such introduced tree species as Acacia confusa, Samanea saman, Ceiba pentandra, Cocos nucifea and Persea americana.

In 1988-1989 comparisons of foraging microhabitat use by the Bridled and Golden white-eyes (Craig 1990), the two species foraged similarly in native limestone forest and introduced tangantangan thickets. These similarities imply that foraging strategies are not greatly altered in order to use the different habitats. The Golden White-eye foraged predominantly in the top outer portion of trees in limestone forest and tangantangan thickets, although the proportion was significantly less than for the Bridled White-eye. The Golden White-eye foraged for less time on live leaves and longer on dead leaves, fruits, branches and trunks in both limestone forest and tangantangan thickets than did the Bridled White-eye. In limestone forest, the Bridled White-eye chose perches  $(1.1 \pm 2.1 \text{ cm}, n = 64)$  about the same size as the Golden White-eye  $(0.9 \pm 1.1 \text{ cm}, n = 135)$  whereas in tangantangan thickets the Bridled White-eye used smaller perches  $(0.5 \pm 0.5 \text{ cm}, n = 167)$  than the Golden White-eye  $(1.6 \pm 2.0 \text{ cm}, n = 91)$ .

In 1988–1991 comparisons of microhabitat use in limestone forest (Craig and Beal 2001), the species diverged significantly in use of forest zones, with the Bridled specializing in canopy foraging and the Golden using canopy and mid-forest strata. The Bridled White-eye chose to forage in taller trees, i.e., more canopy trees, and specialized more on live leaf and flower foraging surfaces. Moreover, the Bridled White-eye selected smaller perches and gleaned more but used other foraging methods less than the Golden White-eye, which in both cases was more of a generalist. Use of woody vegetation types as foraging perches differed significantly between the white-eye species, although the tree most frequently used by both species was Cynometra ramiflora. Overall, the Bridled White-eye (n = 333) specialized more on C. ramiflora, whereas the Golden White-eye (n = 234) was more generalized in use of vegetation. Both species showed a negative relationship between preference and availability, with more abundant woody species such as Pisonia grandis, Intsia bijuga, and Premna obtusifolia used less and less abundant species such as Psychotria mariana, Aidia cochinchinensis, and Maytenus thompsonii used more than their availability. However, the second most common forest tree, Cynometra ramiflora, showed use by both Bridled and Golden white-eyes to be slightly greater than availability. Foraging between years also differed significantly. Principal differences noted were that the Bridled White-eye foraged less from live leaves, more from other foraging surfaces, and more from smaller perches in 1990-1991 compared with 1988-1989.

On Aguiguan (Craig et al. 1993b), the Bridled White-eye most frequently used the forest canopy and foraged mostly by gleaning from live leaves on 0.25–0.5 cm perches. Aguiguan data differed significantly from 1991 Saipan data only in use of perches, with Aguiguan birds feeding more from larger perches. As on Saipan, the species significantly differed from the Golden White-eye in use of forest zones, with the Bridled White-eye forag-ing more in the forest canopy. Aguiguan birds tended to feed more from live leaves and small perches than the Golden White-eye, which also mirrored find-ings from Saipan.

Food capture and consumption. Early descriptions of behavior from Guam (Seale 1901) stated that in foraging and flight the Bridled White-eye behaved like a goldfinch (Spinus spp.). On Saipan, it was likened to a Bushtit (Psaltriparus minimus) due to its infiltration manner of moving through the vegetation (Stott 1947). Food capture techniques were described by Marshall (1949) as involving prey being taken as birds moved rapidly through foliage while occasionally hawking or hovering in front of a leaf spray. A common attitude in foraging was to use a horizontal body position, with bill, body and tail in line, with birds flicking wings constantly. The species also was described (Baker 1951) as being very active, always moving rapidly through vegetation or flying across open areas to disappear into scrub foliage. During 1978-1979 on Guam (Jenkins 1983), birds were reported to forage in a warbler-like manner as they creeped along branches searching for

prey. In 1982 on Tinian (Engbring et al. 1986), a flock was observed to hawk insects repeatedly 3-10 m above the forest canopy, although more typically birds engaged in foliage gleaning and feeding on fruits. On Tinian, they fed upon the fruits of *Passi-flora foetida* and on Aguiguan they fed upon nectar (Fig. 4) in flowering *Erythrina variegata* trees.

The Bridled White-eye is extremely versatile in its foraging behavior. In 1988 (Craig 1989), the principal foraging method used on Saipan in both native limestone forest and introduced tangantangan thickets was gleaning. Birds hovered and sallied only when chasing invertebrates. They probed flowers, apparently for nectar (n = 8), bark (n = 1), dead leaves (n = 3), rolled leaf (n = 1); and passion fruits (*Passiflora foetida*) (n = 5). When foraging, they searched methodically, inspecting numerous surfaces before seizing prey. There was no significant difference in use of methods between forest edge and forest interior or between habitats. Flocks (Craig 2002) were encountered at heavily flowering (particularly Erythrina variegata and Cynometra ramiflora) and fruiting trees (particularly Ficus spp. and Premna obtusifolia).

In a 1988–1989 comparison of foraging methods of the Bridled and Golden white-eyes (Craig 1990), both species principally employed foliage gleaning in both limestone forest and tangantangan thickets. Probing was a more important method for the Golden White-eye than for the Bridled White-eye in limestone forests and tangantangan thickets. In a 1988–1991 comparison of foraging methods between these species (Craig and Beal 2001), the Bridled White-eye gleaned more but used probing and aerial foraging less than the Golden White-eye, which in both cases was more of a generalist. On one occasion (Craig 1996), a Bridled White-eye was observed to follow a Micronesian Rufous Fantail while foraging

Captive birds of subspecies saypani were observed to engage in the following feeding behaviors (Smith and Wassmer 2016): foraging—birds either searched for food on the ground or gleaned from a perch. In ground foraging, birds walked, hopped, ran or stood on the ground to find prey. They moved rapidly while perch-gleaning with short hops or flights. In food preparation, wax worms were held in the beak and beaten on branches with lateral head movements. Birds ran wax worms through the beak sideways to kill and soften them. Sometimes prey were abandoned after preparation. When eating, food items were grasped in the beak, the head lifted and the item consumed. Fruits were consumed while perched rather than while hovering. On occasion, birds hung upside down to eat fruits.

## Diet

On Guam, insects were thought to form the principal part of the Bridled White-eye's diet (Seale 1901). However, the principal food also was thought to be berries with hard pits 4.5 mm. in diameter. Seeds, fruit, caterpillars, ants and other small insects were reported as eaten, with grasshopper parts and small snails sometimes found in stomachs (Marshall 1949). On Saipan and Tinian, it was believed to be a seed eater (Coultas, in Baker 1951). On Tinian, a bird ate a large, green fuzzy caterpillar (Downs 1946). Guam birds were later described as feeding primarily on insects that were gleaned from twigs or foliage. If fruits and seeds were taken, they were considered to comprise only a small portion of the diet (Jenkins 1983).

On Saipan in 1988 (Craig 1989), the Bridled White-eye fed on foliage invertebrates, flying insects, nectar, fruits and seeds, with invertebrates (ca. 2-22 mm in length) being the most frequently taken food. Birds fed on seeds of herbaceous weeds and took nectar from flowers. However, they ate less fruit than the Golden White-eye (Craig and Beal 2001). The species has been recorded as feeding from the following native and introduced plants (Craig 1996): taking seeds from Momordica charantia and Bidens pilosa, fruit from Momordica charantia, Passiflora foetida, Jasminum marianum, Premna obtusifolia, Ficus spp., Melanolepsis multiglandulosa, Artocarpus spp., Pipturus argenteus, Lantana camara, Carica papaya and Muntingia calabura, eating flowers of Mikania scandens, Jasminum marianum, Pisonia grandis, Cynometra ramiflora and Leucaena leucocephala and taking nectar from Operculina vetricosa, Pisonia grandis, Cynometra ramiflora, Premna obtusifolia, Erythrina variegata, Psychotria mariana, Morinda citrifolia, Hibiscus tiliaceus and Albizia lebbeck. On Aguiguan in 1992 (Craig and Chandran 1993), it frequently fed in Lantana camara, and mist-netted birds had black, watery droppings indicative of feeding upon Lantana fruits. Individuals also were observed taking nectar from Lantana flowers.

## Drinking, Pellet-Casting, and Defecation

Captive birds lower their beak into water or nectar and tilt their heads upwards to swallow, as is typical for many passerines. They also may drink rain water drops off of objects. When feces are passed, the birds spread their vent feathers and undertail coverts and lean forward (Smith and Wassmer 2016).

## SOUNDS AND VOCAL BEHAVIORS

#### Development

Food begging by Saipan juveniles was observed year-round (Craig 1996).

#### Vocal array

**Song.** Song was first described from Tinian as involving of an extended series of siskin (*Spinus*)-like call notes (Marshall 1949). More recently, Guam birds were described as having a relatively complex song consisting of a lilting, buzzy *zeeip-zee-zee-zoo-zip* (Pratt et al. 1987). Males sing with their throats puffed (Smith and Wassmer 2016).

Calls. On Guam, an early account of the Bridled White-eye's voice described flight calls as being like those of the House Sparrow (Passer domesticus) but not as loud or harsh. The high-pitched location notes were reported as being constantly uttered, apparently serving to keep flock members together, and were more intensely given by flock stragglers (Seale 1901). Flocking calls also were described as twittering sounds (Baker 1951) and sounding like insects, with the voice almost a buzz (Hartin 1961). Birds made flocking calls in flight, presumably as a contact note. These chipping calls intensified when a group landed in vegetation, although calls became less frequent as birds began to forage. The chipping call, uttered at various intensities, was the only vocalization heard (Jenkins 1983). In 1981, low volume contact calls were frequent, particularly when groups were moving between trees (Engbring and Ramsey 1984). Birds also were described as making rolling, buzzy call notes best characterized as cheep or tszeeip (Pratt et al. 1987).

On Tinian, a "confusion chorus" heard upon the arrival of a predatory Mariana Kingfisher (*Todiramphus albicilla*) consisted of call notes delivered at maximum intensity and frequency by all flock members. It lasted for ca. one minute, during which time birds remained stationary. They appeared to respond in this manner only to the kingfisher in flight. After a kingfisher perched, the confusion chorus abated and birds resumed foraging (Marshall 1949).

Observations made in 1988 on Saipan showed that while birds foraged in flocks, individuals communicated via series of *chit-chit* notes, although a second group of whining vocalizations were given commonly. These whining notes also were used in agonistic interactions, such as those involving chases between a pair of birds and a third individual, and when birds mobbed Mariana Kingfishers (Craig 1989).

Contact calls recorded on 270 min in January–February 1988 of bird sounds from Saipan limestone forest and *Leucaena* thickets consisted of series of or single high-pitched, elongated *chdddeer* or *chdddeet* notes, which correspond to siskin-like notes described by Marshall (1949), whining, thin, highpitched *eeeer* notes and also shorter, high-pitched *chit* notes. Contact calls recorded over 90 min in January 1989 from Tinian limestone forest and *Leucaena* thickets showed no obvious differences with those from Saipan (R.J. Craig unpublished data). Similarly, birds on Aguiguan showed no noticeable differences in vocalizations with birds from Saipan and Tinian (Engbring et al. 1986, R.J. Craig pers. obs.).

Geographic variation. Boesman (2016)claimed that subspecies saypani has a more extensive vocabulary, including medium-pitched chirps, lowpitched chirps, high-pitched notes, nasal (i.e., whining) notes, and song-like high-pitched phrases, whereas subspecies conspicillatus apparently produced only buzzy and high-pitched notes. However, observations on Guam birds by Pratt et al. (1987) do not support the occurrence of such a limited vocal repertoire. Moreover, review of 360 min of audio recordings of Saipan and Tinian birds did not support the occurrence of medium and low-pitched chirps in this subspecies (R.J. Craig pers.obs.). However, Saipan and Tinian birds appear to differ in voice from those on Guam, with subspecies saypani described as making high-pitched plaintive siskin (Spinus)-like calls and a rough chilp-chilp calls like those of a House Sparrow. The high-pitched calls were absent from the repertoire of subspecies conspicillatus (Marshall 1949). Similarly, Saipan and Tinian birds have been described as having calls that are higher pitched and less buzzy than Guam birds, with chirps often uttered rapidly and organized into a loose song (Pratt et al. 1987).

## **BEHAVIOR**

### Introduction

On Guam, the Bridled White-eye was first described as an active flocking species whose behavior was like that of goldfinches (Spinus spp.) (Seale 1901), titmice (Baeolophus spp.) (Safford 1902), and chickadees (Poecile spp.) (Hartin 1961). It was reported to hop about on branches, first on one side and then on the other (Seale 1901). On Saipan, it was thought to resemble a Bush-tit (Psaltriparus minimus) in its infiltration manner of moving through the vegetation (Stott 1947). It was similarly described as being very active and always moving rapidly through vegetation or flying across open areas to disappear into scrub foliage (Baker 1951). Mees (1969) thought the species' movements were typical for Zosterops. In 1981, Guam birds were found to be inconspicuous and difficult to observe (Engbring and Ramsey 1984). It was characterized as being the only native passerine of the Mariana Islands that was nonterritorial even when nesting (Jenkins 1983), although the Micronesian Starling (Aplonis opaca) also does not appear to defend all-purpose territories (Craig 2021b).

## Locomotion

Captive individuals moved from one place to another by hopping and propelling themselves with their feet. When they flew, they used short and rapid wing beats to move from one place to another (Smith and Wassmer 2016).

### Self-Maintenance

Preening, head-scratching, stretching, sunbathing, bathing, anting, etc. In captivity, birds use their beak to smooth and clean wings, throat, vent and area around the legs. The neck and abdomen are groomed by bending the neck backwards and approaching from above. The breast is groomed by bending the head downwards. The top of the wing is smoothed and cleaned by stretching the wing out, bending the head sideways and approaching from above. The underwing is groomed by lifting the wing and approaching from underneath. Bathing birds flutter on leaf petioles during rain. When sun bathing, birds sit near a heat lamp, puff and preen themselves. Birds use indirect scratching where one wing droops and the foot on the same side is brought over the shoulder to scratch the head. When stretching, a bird fans its tail and extends one leg and wing contralaterally and then extends the opposite wing and leg after retracting the first. In another variation, the bird pulls its wings together along the back. To smooth plumage, feathers are erected from the head downwards towards the vent and then smoothed down rapidly (Smith and Wassmer 2016).

**Sleeping and roosting.** Captive birds sit together for ca. 5 min to rest after bathing or preening. They tuck their heads, close their eyes and perch on one foot. To perch, birds rest on a branch with breast feathers puffed but they remain alert with open eyes. When panting, birds breather with an open beak while perching (Smith and Wassmer 2016).

### **Agonistic Behavior**

On Saipan in 1988, Bridled White-eye individuals were observed to chase and supplant each other on perches, suggesting that dominance relationships existed in flocks. Chases involved bill clattering and whining calls. Wing fluttering appeared to precede attacks. Such observations were typical of behaviors observed year-round. Aggression was detected virtually anywhere where flocks of birds were present. Aggression could not be clearly related to territorial encounters except within several meters of the nest; instead, it most frequently appeared to involve disputes over access to food (Craig 1989, 1996, 2002).

During intraspecific aggression in captivity, a defending bird faces the intruder, stretches out straight with smoothed head feathers, holds wings down while flitting them and vocalizes with cheeps. Only males were observed to give threat displays. A bird flies directly towards another bird in a rapid, straight flight causing the other bird to fly away without a fight. Both sexes displace other birds. Birds make physical contact by bumping breasts and biting each other. One bird may be pinned against a branch. Both sexes engaged in fights. Birds retreat when attacked by conspecifics (Smith and Wassmer 2016).

## **Sexual Behavior**

Evidence of the social nature of individuals on Saipan included observation of one bird preening another, which was probably its mate (Craig 1996). Allopreening was indeed frequent. Moreover, pairs of birds were observed together foraging, gathering nesting material and responding in pairs to playback of calls (Craig 2002).

In captive birds, the courtship display involved a male presenting a piece of nesting material with the beak to a female and fluttering wings quickly. The male also allopreens the female, focusing efforts around the neck, head, contour feathers, hind-flanks and tail. Copulation occurs after a male preens the female. He rapidly mounts her back, balancing himself with his wings and dismounts to her side (Smith and Wassmer 2016).

### Social and Interspecific Behavior

**Degree of sociality.** Flocking was first described on Guam as involving groups of 10-20 individuals (Seale 1901). Stophlet (1946) reported flocks of only 6–7, Baker (1951) reported a group of 12, Tubb (1966) found flocks of 6–10 and Hartin (1961) found flocks of 2–10. In 1976, small flocks of up to 15 birds were found at the northern parts of the island, but by 1978 it was absent from these same areas. Only two flocks of 4–5 birds were present at Ritidian Point and none were found elsewhere (Pratt et al. 1979). Flocks of 3–8, with most commonly groups of 3–5 were found by Jenkins (1983). By 1981, flocks of 3–6 were present (Engbring and Ramsey 1984).

On Tinian, observations immediately after World War II revealed the Bridled White-eye to be common but in flocks of only 2-7 (Downs 1946). On Saipan during the same years, it was reported to be in groups of 3-20 (Stott 1947). In the Mariana Islands in general, flocks of 12-50 were reported (Marshall 1949). In 1982, flock size in the Northern Marianas was 6-12 with a maximum of 50 (Engbring et al. 1986). By the late 1980s on Tinian, flocks of up to 100 individuals were found (Craig 1989). In 1992–1993 study of flocking behavior on Saipan, flocks larger than family groups (ca. 3-5 individuals) were typically 10-40 (= 17.6, n = 25), although larger flocks of at least 50 were encountered. Male-female pairs also fed away from flocks (Craig 2002). An analysis of 1990-1993 Saipan social group encounters revealed that, in native forest, groups of  $8.2 \pm 4.3$  (n = 180) were present in the wet season, whereas 8.4  $\pm$ 4.0 (n = 212) were present during the dry season. In contrast,  $10.1 \pm 3.7$  (n = 58) were observed in disturbed habitats in the dry season (Craig 2021b).

Flock size appears to show some relationship to population density, although estimates of flock size vary widely. Typically, small flocks occur when populations are low and large flocks occur when populations are large (Craig 1989). As on Guam, when the Rota White-eye (*Z. rotensis*) was undergoing a precipitous population decline, maximum flock size dropped from 23 in 1988 to ca. 10 in 1991 (Craig and Taisacan 1994).

Flocks occasionally were observed to fly high above the forest canopy, which indicated a widely separated foraging circuit, although when flying across open spaces from one forage tree to the next, birds were within 3-6 ft of the ground. Each flock made rounds of a fixed forage circuit with individuals flicking their wings constantly (Marshall 1949). In a study of flocking behavior on Saipan in 1992-1993, 97 birds were color banded. Plotted data from 16 recaptures and 135 resightings, including 10 birds resighted  $\geq 5$  times, traced roughly elliptical areas, of which six were ca. 200 m maximum diameter, three were ca. 250 m in diameter and one was 100 m in diameter. Six of the 10 were in roughly overlapping areas, whereas two were in areas encompassing but greater than those of the six. The remaining two were located in portions of areas used by these other birds (Craig 2002).

Flocks on Saipan 1992-1993 showed cohesiveness; i.e., members continuously communicated through contact calls and flew between trees (foraging sites) in groups. On several occasions, perched birds communicated with flock members by tilting the head at 45°, moving the head from side to side and flicking the wings while giving whining calls. Flock departure and arrival occurred over a period of seconds rather than simultaneously, however, as individuals completed foraging at one site before moving to the next. In two instances where larger (ca. 15 birds) foraging flocks were followed, groups remained cohesive for 100-200 m but then fragmented into groups of 3-5 birds, which headed in differing directions. In one instance, an individual flew for ca. 110 m. Flocking was a conspicuous behavior throughout the year and showed little clear change in character. Observations of year-round nesting and inability to find evidence for a pronounced breeding season helps to explain this uniformity in behavior. Moreover, the intensive phase of this investigation lasted from the end of the dry season into the wet season, yet no behavioral alteration was apparent (Craig 1996, 2002, R.J. Craig pers.obs.).

Observations on movements, flock size, and social interactions led to the conclusion that flocks showed characteristics intermediate between permanent membership and site dependent flocks. Small groups of at least three birds were clearly family groups, and may be considered permanent at least to the extent that family groups remain cohesive over time. However, observations of larger groups of ca. 50 birds foraging together and then dispersing into smaller flocks is most consistent with the concept of site dependency, where smaller groups opportunistically converge on dense food resources. Resightings of banded birds also were consistent with a pattern of independent, overlapping home ranges of individuals or small groups. Individuals within such home ranges have the opportunity to converge on attractive food resources and thus form temporary large flocks (Craig 2002).

Nonpredatory interspecific interactions. Aggressive encounters with the Bridled White-eye occurred during canopy foraging. Golden White-eye individuals flew at the smaller birds and partially extended both wings outward towards them. The Golden White-eye also made calls and opened its bills at the peak of wing-spreading. After an aggressive encounter, foraging resumed (Bruce 1978). Of the four small passerines that inhabit Saipan forests, the Golden and Bridled white-eye were the only species to show regular interspecific aggression (n = 20) observations). The Golden White-eye supplanted the Bridled from perches, snapping its bill when landing, chased it, and flew through flocks of foraging birds, which dispersed them. However, the two species also foraged within 2 m of each other. In two instances, a Golden White-eye also appeared to chase a Micronesian Rufous Fantail (*Rhipidura versicolor*) and in another a Micronesian Rufous Fantail chased a Golden White-eye from near its nest. In contrast to this aggression, the Golden White-eye was sought out by the Micronesian Rufous Fantail to assist in its foraging. The Micronesian Rufous Fantail followed 1-2 m behind a foraging Golden White-eye, hawking insects disturbed from leaves. In contrast, the Micronesian Myzomela (Myzomela rubratra) was observed to chase individuals and disperse flocks of Golden White-eyes (n = 4) (Craig 1990, 1996). At the nest, Golden White-eye adults chased away other birds from the nest including the Eurasian Tree Sparrow (Passer montanus), Bridled White-eye and other Golden White-eve individuals (Stinson and Stinson 1994). The Bridled White-eye also was reported to steal nesting material from nests of the Micronesian Rufous Fantail and Tinian Monarch (Monarcha takatsukasae) (Swift et al. 2024).

### Predation

**Kinds of predators.** On Guam, the Guam Kingfisher (*Todiramphus cinnamominus*) was reported to attack flocks of Bridled White-eyes, which set up a confusion chorus at each appearance of a kingfisher. However, no actual capture of a white-eye was observed. On Saipan and Tinian, the Mariana Kingfisher was described as an unrelenting assailant of the Bridled White-eye (Marshall 1949). Also on Saipan, the Mariana Kingfisher was observed to take a probable fledgling from a branch while being vigorously scolded by a pair of white-eyes (Craig 1989). **Response to predators.** On Tinian, the Bridled White-eye called aggressively in response to the presence of flying Mariana Kingfishers, although birds remained stationary (Marshall 1949). Birds on Guam also mobbed the Micronesian Starling (Jenkins 1983). On Saipan, birds mobbed the Mariana Kingfisher (Craig 1989). In addition, birds scolded and chased after a Yellow Bittern (*Botaurus sinensis*) when it flew (R.J. Craig pers. obs.).

## BREEDING

#### Phenology

On Guam, nests were first recorded in February-March (Hartert 1898). In May-July, one nestling and three nests with eggs also were reported (Seale 1901) and in October, 1945 an adult feeding a fledgling was observed (Stophlet 1946). Although (Baker (1951) limited evidence of breeding was found in late May-July, three males taken in June and July had enlarged testes. Similarly, field notes recorded a nest in June (Jenkins 1983). Hence, the subspecies *conspicillatus* appeared to breed yearround (Marshall's (1949), although nesting may have been concentrated in winter-spring (i.e., the dry season) (Baker 1948).

The first recorded nests and young on Saipan were in May-July (Oustalet 1895). Of 18 birds collected on Tinian in September, 1931, half had enlarged gonads (Baker 1951). Yamashina (1932) recorded three nests on Tinian in January, 1932. On Saipan, breeding (Fig. 5) was recorded in January (carrying nesting material), February (nestlings, carrying nesting material), August (eggs, carrying nesting material) and October (carrying food). Moreover, food begging by juveniles was observed yearround (Craig 1996). Hence, breeding appeared to occur year-round (Craig and Beal 2001, Pyle et al. 2012). However, on Saipan evidence of birds being in breeding condition (presence of cloacal protuberance, brood patch, eggs) occurred on 15 of 60 (25%) wet season and 27 of 54 (50%) dry season captures, indicating that, as on Guam, a peak of breeding occurred during the dry season of December-early June (Craig 2021a). Similarly, in 2004, a model based on the densities of located nests predicted that nest densities peaked in late February-early March. However, 2003 data did not verify this trend. In 2004, estimated nest densities generally declined in the native and non-native forest from February-March to April-May survey periods. This decline was more pronounced in nonnative forest, where no nests of any species were found in April-May. (Sachtleben 2005).

### Nest

Nest site. On Guam, nests were placed 3-4 ft from the ground in shrubs and trees (Hartert 1898). Nests also were usually found to be built in the Ingadulus (a common name not known to relate to an extant taxon but possibly Pithecellobium dulce, based on other nests found in this species) tree (Seale 1901) hidden among leaves. The nest was usually placed far out where several branches come together some distance from the ground. One nest was 2.4 m up in a Leucaena leucocephala (Jenkins 1983). On Tinian, a nest was built on a fork of a Yamaichibi (also a common name not known to relate to an extant taxon) tree 2 m from the ground. A second nest was hung like a cradle on a fork of a horizontal branch of *Pithecellobium dulce* 4 m from the ground. A third nest was on a horizontal branch of Pithecellobium dulce 4 m from the ground (Yamashina 1932). Three active Saipan nests were at 2.3-6.0 m above ground in Casuarina equisetifolia and Phragmites karka (Amidon et al. 2004). Another nest with two eggs was 2 m up in a Guamia [=Meiogyne] mariannae (R.J. Craig pers. obs).

Data from nests located in 2003-2004 indicated that Bridled White-eye nest densities ranged from  $0-115/km^2$  in non-native forest and  $0-11/km^2$  in native/mixed forest. Statistical analyses indeed suggested that nest densities were greater in non-native than native forest, with 160 of 198 nests located in non-native forest (Sachtleben 2005). However, this finding is likely to be an artifact of the comparative difficulty of finding nests in the ca. 15 tall native vs. the typically 6 m tall non-native habitats, as the species occurs at far greater densities in native forest and principally occupies the forest canopy there (Craig 1989, 2021b, Craig and Beal 2001). Sachtleben (2005) also documented the characteristics of 115 Bridled White-eye nests on Saipan, reporting nest height mean = 2.3, range = 0.7-5.2 m, nest tree height mean = 4.3 m, range = 1.2-10.8 m, distance of nests from the boles of nest trees mean = 42 cm, range = 0-263 cm, number of branches used for nest support mean = 3, range = 1-7 and diameter of these branches mean = 2 mm, range = 1-6 mm (MAC Working Group 2014).

**Structure and composition.** On Guam, a nest was described as a fairly deep cup, placed in the fork of a branch, woven together with fine grasses and roots, and on the outside ornamented with cobwebs, wool and cottonwool (Hartert 1898). Another was constructed of fine fibers and grass, the outside being covered with green moss, which rendered it almost indistinguishable from below (Seale 1901). Another nest was composed of fine fibers and rootlets woven into a hanging basket (Jenkins 1983).

Of three Tinian nests, their shape was like a cup and were so roughly built that their interior could be seen through their side wall. The chief construction materials were fine roots and fine fibers mixed with a small quantity of cotton wool and feathers. The interior was lined with only a small quantity of fibers (Yamashina 1932). In captivity, subspecies *saypani* builds an open cup nest. Construction begins by both the male and female making loops out of long fibrous materials such as coconut fibers and weaving them into a base. Once the base is made, the male and female alternate sitting in the nest and weaving small cotton-like material through the gaps (Smith and Wassmer 2016).

**Dimensions.** A Guam nest varied in width from 8 to 5 cm (Hartert 1898). Another's size internally was 4.83 x 4.19 with a depth of 2.54 cm, whereas externally it was 7.49 x 5.56 with a depth of 4.45 cm (Seale 1901). A later nest was externally 4–5 cm in diameter by 7–8 cm deep (Jenkins 1983). Three Tinian nests had an outer diameter of 5.5-6.5 cm, height of 4.0–5.5 cm, inner diameter of 4.0-4.5 cm and internal depth of 2.5–3.0 cm (Yamashina 1932).

## Eggs

Size. On Guam, the eggs were first described as pale blue, like all *Zosterops* eggs. They measured 16.9 mm  $\pm$  0.9 mm x 12.9 mm  $\pm$  0.5 (n = 5). Clutches consisted of two and three eggs (Hartert 1898). The eggs, of which there were usually two in each nest, were white with a slight tint of blue and shaped like the eggs of a robin, measuring ca. 16 x.12.7 mm (Seale 1901). Another nest contained two light bluegreen eggs (Jenkins 1983). On Tinian, three nests contained one, two, and three eggs, respectively. They measured mean = 15.2 x 11.4 mm (n = 3). The color of the egg shell was uniformly pale blue (Yamashina 1932).

#### **Parental Care**

No information was said to be available on Guam incubation, nestling or fledgling periods (Jenkins 1983), although a pair was observed feeding a young bird out of the nest in a thicket in October, 1945 (Stophlet 1946). On Saipan, food begging (wing fluttering, crouching and gaping) by juveniles with no evidence of natal feathers was observed frequently. Moreover, pairs of birds were observed together (foraging, gathering nesting material, responding in pairs to playback of calls), as were family groups of three (apparently a male, female, and juvenile as identified by food-begging) (Craig 2002).

In captivity, the male and female of subspecies *saypani* alternate in incubation. Typically, one bird at a time sits in the nest to keep the 1–3 eggs warm for development. A mate begins by approaching the attending parent sitting on the egg. The attending mate leaves once its partner is within several inches of the nest. The newly incubating bird adjusts the

egg with its beak, fluffs its breast, belly and flank feathers and settles its brood patch over the egg. Both sexes also participate in brooding, with attending parents taking turns keeping the chick warm. The brooding parent does not leave until the other comes within close proximity of the nest. The newly brooding bird adjusts the chick with its bill, puffs its breast, belly, and flank feathers and settles its brood patch over the chick. The brooding bird adjusts by shifting side to side several times. Birds stay alert with heads upright and eyes open. Both sexes participate in nest maintenance. Using their beaks, the attending parents grab fecal pellets out of the nest and move them elsewhere, typically during feeding times. Both sexes participate in feeding nestlings. Attending parents prepare live waxworms and maggots, bring them whole and place them in chick's mouth. Parents also deliver smaller items to the nestling, such as fruit flies, bean beetles and fruit pulp (Smith and Wassmer 2016).

**Development.** Egg laying ranges from 2 to 3 days and incubation from 9–12 days and fledging occurs 11–14 days post-hatching (Sachtleben 2005). The duration of post-fledging parental care is unknown. Chick growth as reported by the MAC Working Group (2014) is as follows:

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

Day 1: ca. 2 cm long and naked with medium-dark pink skin; otherwise, little change from day 0.

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

Day 4: ca. 3.5 cm long, medium-light pink skin, back pins 1-2 mm, wing pins  $\ge 3$  mm.

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

Day 8: ca. 4.5 cm long, fully feathered, olive greygreen, eyes open.

Day 9: ca 4-4.5 cm long, mostly feathered, olive grey-green, eves open, wing feathers dark grey.

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

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

In captivity, chicks leave the nest 11–14 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 develop their flying skills and independence. Parent birds actively feed young for ca. two weeks post-fledging. During this time, fledglings begin to flutter among higher perches to develop their flight skills (Sachtleben 2005, MAC Working Group 2014).

# **DEMOGRAPHY AND POPULATIONS**

## **Causes of Mortality**

**Depredation.** After its accidental introduction to Guam from the north Australia-New Guinea-Solomon Islands region, the predatory brown tree snake decimated native bird populations within several decades, with its effects on the tiny Bridled White-eye particularly rapid despite the bird's previous abundance (Savidge 1987, Wiles et al. 2003). Nest predators in the Mariana Islands include the native Mariana Kingfisher, the introduced green tree skink (Lamprolepis smaragdina) and rats (Rattus spp.) (BirdLife International 20524). However, such predators as rats, monitor lizards (Varanus indicus) and cats (Felis cattus) are not known to be major predators of tree nesting birds in the Marianas, although the native Micronesian Starling (Aplonis opaca) is documented to prey upon nests of other forest birds (Sachtleben 2005) and a Yellow Bittern being scolded by white-eyes suggests that this species may act as a predator as well (R.J. Craig pers. obs). Differences in rat species occupying Saipan vs. Aguiguan have been suggested to be related to differing population densities on these islands (Amidon et al. 2014), although no empirical evidence supports this possibility. Causes for the decline of several bird species on Tinian have been suggested to be predation (Camp et al. 2012), although evidence for this is conjectural. Moreover, there is no evidence for a decline of the Bridled White-eye on Tinian.

**Exposure.** Variable circular plot surveys on Rota conducted in 1982–2003 and U.S. Fish and Wildlife Service roadside surveys showed that typhoon frequency or severity might affect the abundance of some bird species (Ha et al. 2012). Typhoon-related nest failures have been documented for white-eye species (Amidon 2000). However, U.S. Fish and Wildlife Service roadside surveys conducted between 1991 and 2010 on Saipan showed no significant relationships between typhoon activity and bird counts (Ha et al. 2018). Now that a Bridled White-eye population is established on Sarigan (Radley 2012), volcanic activity is also a potential cause of mortality, as the nearby island of Anatahan and an undersea volcano are both volcanically active (Brainard 2012).

**Disease.** The Bridled White-eye on Saipan and Tinian were almost universally infected with *Haemoproteus*, a red blood cell parasite, and had microfilariae in an incidence of about 15%. Neither parasite was found in Guam birds (Marshall 1949). Moreover, of 63 Saipan birds collected, two were infected with *Plasmodium* (avian malaria), and 46 were infected with *Haemoproteus*. One bird developed poxlike lesions but the lesions resolved. A potential threat from West Nile virus also exists, as other *Zosterops* have proven susceptible to this disease, although to date this virus has not been detected in the Mariana Islands (USFWS 2007). Fecal examinations have revealed cestodes (tapeworms) and *Coccidia* (MAC Working Group 2014).

## **Population Status**

Numbers and trends. Early reports from Guam described the Bridled White-eye as common (Hartert 1898, Seale 1901). In the 1930s, it was still found to be common along roadways (Bryan 1936). However, by the 1940s birds were restricted to certain areas, although Arvey (field notes) saw them at Mt. Tenjo in July, 1946 (Baker 1951), they were found on the foothills of the Mt. Tenjo area in 1945, and on the edge of forest near Ritidian Point (Stophlet 1946). However, they were missed in roadside counts in 1945 (Baker 1947). Hartin (1961) saw white-eyes frequently in 1960, but found them less common than the Micronesian Myzomela and King (1962) observed them near Tarague Beach. Guam Aquatic and Wildlife Resource notes indicate that the species was found in central Guam in the early 1960's and apparently was common in the Agana Swamp. By the 1970s, it was observed regularly only at the extreme northwestern cliffline near Uruno and Ritidian points. It was rarely seen even in the most undisturbed woods of Northwest Field, only once was present near Pati Point Beach and was by then among the rarest of native birds. It was uncommon along the northernmost cliffs and rare in the most northern areas of Northwest Field. A small group of whiteeyes was seen once in Marbo Annex (Andersen Air Force Base-South), the only plateau record outside Northwest Field. It had one of the most restricted ranges of any native bird and was thought to be near extinction (Jenkins 1983). It was reported as last observed in summer, 1983 (Savidge 1987), although the last confirmed sighting was in 1984. The Pajon Basin was the last area on Guam to support the full ensemble of native forest birds at historical densities, with count results high and relatively consistent for the nine species of forest birds present in 1981 and 1982. Declines were first detected in May 1983, when Bridled White-eye abundance fell sharply. They were well underway by May 1984, when four species had been extirpated and two others were in rapid decline. Average counts of white-eyes per survey were 54.0 in 1981, 49.0 in 1982, 0.8 in 1983 and zero thereafter (Wiles et al. 2003).

In 1981, the population estimate for Guam was 2,220 and the density estimate for Pajon Basin was 1,027/km<sup>2</sup>—the highest density estimate for any species. Before the Bridled White-eye's decline, it was likely among the most abundant species. Although still common in certain regions, it exhibited a distri-

bution more restricted than any other native forest bird. Over 97% of the population resided in less than 2% of the land area on Guam, and there was evidence that the range had diminished from the previous year. Guam Aquatic and Wildlife Resource personnel recorded the species commonly at Pati Point in 1980, but none were found in this vicinity in 1981 (Engbring and Ramsey 1984).

In 1931, Coultas (field notes) found the species to be common on Saipan and Tinian (Baker 1951). In 1945, the population on Tinian was estimated at 500+ (Gleise 1945). Moran (1946) found it common on Saipan and Tinian and Downs (1946) found it to be abundant on Tinian. In 1945–1946, it was described as common on hillsides east of Lake Susupe, Saipan (Stott 1946). Pratt et al. (1979) found it to be the most abundant bird on Saipan and Tinian. In 1977, a density estimate for Saipan based on 7.74 km of survey route was 1,360 birds/km<sup>2</sup> (Ralph and Sakai 1979).

In 1982, the first variable circular plot population survey of all natural habitats on Saipan, Tinian and Aguiguan revealed that the Bridled White-eye was by far the most abundant bird species on these islands. Computed densities were greatest on Tinian, with 2,931 birds/km<sup>2</sup> and a total population of 241,352. There were 2,221 birds/km<sup>2</sup> and a total population of 229,138 on Saipan and 1,930 birds/km<sup>2</sup> and a total population of 10,763 on Aguiguan. In each case, the distribution was island-wide (Engbring et al. 1986).

Using updated analytic methodology to examine data from several island-wide surveys, estimates of birds/km<sup>2</sup> for Saipan were  $4,710 \pm 332$  for 1982 (over twice that of the Engbring et al. 1986 computation),  $5,344 \pm 407$  for 1997 and  $4,713 \pm 387$  for 2007, with a total 2007 population estimate of 534,029. The 25-year population trend showed no significant change (Camp et al. 2009). The most recent estimate for Saipan is  $4,079 \pm 313$  for 2018 (Bak et al. 2024). Using similar updated methodology on Tinian, estimates were  $3,508 \pm 344$  for 1982,  $2,997 \pm 305$  for 1996 and  $3,275 \pm 338$  for 2008, with a total 2008 population of 225,360, and with the 26year population trend showing no significant change (Camp et al. 2012). On Aguiguan, updated methodology yielded density estimates of  $1,798 \pm 280$  in 1982,  $3,787 \pm 712$  in 1995,  $2,427 \pm 306$  in 2000,  $1,933 \pm 200$  in 2002 and  $7,882 \pm 1,233$  in 2008, with a 2008 total population estimated at 50,205. The difference in estimates among years was significant (Amidon et al. 2014). However, the wide differences in estimates among years suggests that surveys conducted by multiple and differing observers with varying experience and perceptual abilities may have obscured any actual temporal change in population size. Additional analysis of 1991-2010 standard U.S. Fish and Wildlife Service roadside surveys demonstrated that the Bridled White-eye was the most abundant species and that no significant longterm trends occurred in counts (Ha et al. 2018).

In a 1990-1993 seasonal variable circular plot study of bird populations in native limestone forest on Saipan, densities were  $6,027 \pm 1,529$  birds/km<sup>2</sup> for the wet season and 6,303  $\pm$  1,172 birds/km<sup>2</sup> for the dry season. In contrast, there were 3,189  $\pm$  707 birds/km<sup>2</sup> for disturbed habitat in the dry season. On Aguiguan in the dry season of 1992, density was estimated at 5,806 birds/km<sup>2</sup> for limestone forest. All these studies were performed by a single observer (Craig 2021). A difference among Saipan habitats in population densities also was noted by Camp et al. (2009). In addition to these surveys, in 1991–1992 standard U.S. Fish and Wildlife Service roadside surveys were conducted quarterly on Saipan. January counts averaged lowest, probably because higher winds at this season reduced the detectability of this canopy species. Like most passerines, variation in counts was relatively low (Craig 1996).

From February 1992 to June 1993 on Saipan, a mark-resighting study of the Bridled White-eye in mixed native and non-native forest used combinations of color bands that permitted identification of individuals in the field. The frequency of banded birds in the population was assessed by determining the proportions of banded vs. unbanded birds at 50 m intervals to 300 m from the banding site. Based on the locations of resightings, banded birds declined in frequency of occurrence, p, from the banding site in an empirically fitted quadratic relationship: p = 1.47x-1.21x + 53.82, where x had values from one for the basal zone (0-50 m from the banding site) to six for the outermost zone (251-300 m). Based on this relationship, a Jolly-Seber estimate of population density was 7770 birds/km<sup>2</sup>. Population densities of this species as determined through this study and variable circular plot surveys are among the highest ever recorded for birds (Craig 1996, 2002).

### **Population Regulation**

A 2004 study showed that the Bridled White-eye had a daily nest survival of 0.904 in the incubation stage and 0.928 in the nestling stage. Daily and overall nest survival rates did not differ between February–March and April–May. Increased nest concealment, including side and canopy cover, appeared to decrease nest survival, with side cover appearing to have the greatest impact (Sachtleben 2005).

Based on 2008–2018 capture-recapture data from six mist net sites on Saipan, population growth rate estimates suggested a population decline in the Bridled White-eye, with survival the largest contributor to annual growth rate. Recruitment was particularly important in driving population growth in years of population increase. Spaced at approximately annual intervals, the mean population growth rate was 0.93, the adult apparent survival probability was 0.71, the recruitment rate estimate was 0.23, the proportionate contribution of survival to population growth was 0.76 and the proportionate contribution of recruitment to population growth was 0.24 (Saracco et al. 2021). Variable circular plot survey and U.S. Fish and Wildlife Service roadside survey data do not support the occurrence of a population decline, however (Camp et al. 2009, 2012, Amidon et al. 2014, Ha et al. 2018).

Cover conversion from forest to anthropogenicdominated habitats on Saipan has been implicated in producing declines in some of Saipan's bird species, although the Bridled White-eye population showed no evidence of decline. Moreover, the invasive nonnative vine Coccinia grandis, introduced to Saipan ca. 1998, has altered bird habitat by smothering woody and other vegetation. Fruit-eating birds may have benefited from the fruit-producing vine's spread (Camp et al. 2009), and fruit comprises a portion of the Bridled White-eye's diet (Craig 1996). Causes for the decline of several bird species on Tinian are thought to be predation and site-specific habitat loss/ degradation, such as that due to the expansion of Tinian airport (Camp et al.2012), although evidence for this is conjectural. Again, however, there is no evidence for a decline of the Bridled White-eye on Tinian. The greater 2008 population on Aguiguan compared with previous years has been attributed to expansion of secondary forest and particularly Lantana camara thickets into abandoned agricultural land (Amidon et al. 2014). Based on mist-netting studies and foraging observations, Lantana is actively fed upon by the Bridled White-eye (Craig et al. 1993b).

# CONSERVATION AND MANAGEMENT

### **Conservation Status**

The Bridled White-eye subspecies conspicillatus is extinct, with the last individuals observed in 1984 (Wiles et al. 2003). The subspecies saypani is listed as near threatened on the IUCN Red List (BirdLife International 2024). However, it is not federally listed as endangered or threatened. Evidence from capture-recapture studies indicate a Saipan population decline (Saracco et al. 2016, 2021). However quantitative population surveys from Saipan, Tinian and Aguiguan show no decline or a possible increase. Still, the species' range is small and threatened by the possibility of introduction of the predatory brown tree snake to islands in its range. This could result in rapid elimination of populations, as it did for land birds on nearby Guam (Wiles et al. 2003). Based on the most recent estimates from transect counts, the current total Saipan, Tinian and Aguiguan population is 809,594 (Camp et al. 2009, 2012, Amidon et al. 2014).

## **Effects of Human Activity**

Habitat loss and degradation. Habitat loss has been cited as a cause of concern for the Bridled White-eye's Saipan and Tinian population. Since the

1980s, considerable uninhabited land on Saipan and Tinian has been developed for residential, commercial and tourist-related purposes (Camp et al. 2009, 2012, Craig 2021b). Moreover, on Tinian airportrelated development has occurred and much of the island is leased by the U.S. military for training purposes (Camp et al. 2012). In contrast, on uninhabited Aguiguan, abandoned agricultural land has reverted to thickets and secondary forest (Amidon et al. 2014), which likely has benefitted the population there. Despite the potential for forest cover reduction to influence populations, the species' ecological versatility (Pratt et al. 1979, Craig 1990) suggests that it is likely to persist in the face of such change, albeit at reduced densities in alien habitats (Craig 2021b). Changing climatic conditions related to fossil fuel consumption also might affect populations, as wet and dry seasons are predicted to be wetter and warmer in the western tropical Pacific (BirdLife International 2024). Survival of the Bridled White eye was positively related to remotely sensed dry season greenness and negatively related to wet-season greenness. Survival also showed evidence of a positive response to overall greenness, thereby highlighting the potentially important role of rainfall regimes in affecting population dynamics of species on oceanic tropical islands. Greater rainfall is associated with increased greenness at all but the highest rainfall levels (Saracco et al. 2016).

Effects of invasive species. Perhaps the most ominous threat to face Bridled White-eye survival is the potential for introduction of the brown tree snake (Rodda and Savidge 2007). Once the snake became established on the southernmost Mariana Island of Guam in the 1940s, most endemic landbirds declined to extinction within ca. 40 years (Savidge 1987, Wiles et al. 2003). Accidental introduction via cargo ships and planes has been the primary dispersal mechanism from Guam. All goods received in the Northern Mariana Islands are shipped through Guam, with most arriving on Saipan. There have been over 70 reports of brown tree snakes on Saipan, including sightings away from port areas (Rodda and Savidge 2007, MAC Working Group 2014). Saipan was feared to have an incipient population. However, based on available evidence and modeling of surveillance efforts, there is presently a low probability that Saipan has an incipient population (Yackel-Adams et al. 2021). In contrast to Saipan, the risk of snake introduction to Aguiguan, Sarigan or Guguan is low, as they are uninhabited.

The invasive non-native vine *Coccinia grandis*, introduced to Saipan ca. 1998, has altered bird habitat by smothering woody and other vegetation. Fruiteating birds may have benefited from the fruitproducing vine's spread (Camp et al. 2009), and fruit comprises a portion of the Bridled White-eye's diet (Craig 1996). In contrast, the demise of *Erythrina variegata* due to invasion of the Marianas by an alien gall wasp (*Quadrastichus erythrinae*; Rubinoff et al. 2010) may negatively impact populations. This large native tree with large flowers and the eighth most important tree in native forests in the 1990s (Craig 1992b), drops its leaves and flowers heavily during the dry season at a time when other tree species flower less. The Bridled White-eye feeds at these flowers during this time (Craig 1996).

### Management

**Conservation areas.** Protected areas have been established by the Commonwealth of the Northern Mariana Islands on Saipan (MAC Working Group 2014) and Aguiguan is set aside as a reserve (Engbring et al. 1986). Additionally, Guguan, Asuncion, Maug and Uracas have been designated as conservation areas to be used only for the protection of natural resources. Furthermore, Asuncion, Maug and Uracas are federally protected within a 153,235 km<sup>2</sup> Marine National Monument (MAC Working Group 2014).

Conservation measures and habitat management. Because of the limited range of the Bridled White-eye and its potential for extirpation from this range by introduction of the brown tree snake, a captive breeding and translocation program has been developed. The captive program began in 2006 when 38 birds were captured on Saipan and placed at two zoos. In 2010, 30 additional birds were captured on Tinian and placed at three additional zoos. The captive population presently numbers 30, and these are held at four zoos. Managers plan for a target captive population of 200. Although the species has been maintained in captivity easily, it has proven difficult to breed, with only two young hatched at one zoo and a clutch of fertile but unhatched eggs produced at another. To improve breeding success, the Toledo Zoo has initiated research to determine the cause of low reproductive success and to establish guidelines for breeding the species in captivity (MAC Working Group 2014).

In May 2008, 50 Bridled White-eyes were translocated from Saipan to Sarigan. In 2009, 50 more were translocated from Tinian. In 2010 and 2012, surveys on Sarigan demonstrated that the population was growing (Radley 2012). The 2010 surveys yielded a density estimate of 1.3 birds/ha (95% CI = 0.4-2.8) and a total population of 77-495 (mean = 234.2) individuals. Surveys in 2012 produced a density estimate of 16.8 birds/ha (95% CI 10.6-24.8) with a total population of 1,897-4,302 (mean = 3004.5) (MAC Working Group 2014). In June 2016, surveys on Sarigan yielded a population estimate of 8,239. In 2015 and 2016, translocations of 96 birds also were made to Guguan (BirdLife International 2024). Translocations are also planned for Pagan (MAC Working Group 2014). However, it is conceivable that a large population of a socially dominant species could interfere with the successful establishment of a translocated subordinate species. For this reason, the socially subordinate Bridled White-eye should be translocated to islands before socially dominant species (Craig and Beal 2001).

To prevent establishment of the brown tree snake on Saipan, cargo arriving from sea and at airports is checked for snakes. Moreover, traps have been installed to catch any snakes that are missed and barriers have been constructed at docks to allow escaping snakes to be contained. Sniffer dogs have been trained to detect snakes at Saipan airport. Port officers have been trained in prevention of snake establishment and educational programs have been developed to increase awareness among the population of the importance of reporting sightings (MAC Working Group 2014).

# PRIORITIES FOR FUTURE RESEARCH

- 1. The highest priority is continued monitoring and implementation of interdiction efforts at ports to prevent the establishment of brown tree snake populations on other Mariana islands.
- 2. As the highest densities of the Bridled Whiteeye are attained in native limestone forest, a second priority is the preservation of this habitat by setting it aside from any encroachment by agriculture, residential or commercial development. In addition, much of secondary forest that is presently dominated by alien species, particularly that adjacent to seed sources in native forest, have the potential to be revegetated by native forest species (Craig 1994). Native birds and Mariana fruit bats (*Pteropus mariannus*) are major dispersers of native seeds (Caves et al. 2013), so further research into facilitating conversion of alien forest into that dominated by native species is needed.
- 3. High feral goat densities on Aguiguan are interfering with reproduction of native trees in the forest and goat reduction efforts yield improvement in native seedling development (Rice and Stinson 1993). Hence, ongoing management of feral goats on Aguiguan is required to maintain high densities of the Bridled White-eye and other native bird species.
- 4. Expand translocation efforts to additional Mariana islands. The Mariana Islands of Alamagan, Pagan, Agrihan and Asuncion, all of which have apparently suitable areas of forest habitat, are also candidates for translocation of the Bridled White-eye. Pagan is presently under consideration for translocation. However, Agrihan and Asuncion are presently slated for Tinian Monarch and Rota White-eye translocation, so there are no plans to translocate the species to these islands (MAC Working Group 2014).

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