

Previously Undescribed Plumages and Survival Estimates of the Tinian Monarch and Yap Monarch ¹

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Abstract— The Tinian Monarch (*Monarcha takatsukasae*) and Yap Monarch (*M. godeffroyi*) are forest birds in the monarch flycatcher family (Monarchidae) and are endemic to their respective islands. I collected data on the Tinian Monarch during the post-delisting monitoring in 2006 and 2007. I made field observation on the Yap Monarch on 13-14 May 2005. I describe the juvenile plumage of the Tinian Monarch and a predefinitive plumage of the Yap Monarch, neither of which have been described previously. I estimated annual survival of each species using simple methods based on the proportion of adults in the population. Juvenile Tinian Monarchs differ from adults by having a yellow (instead of gray) base to the lower bill, and buff-colored feather tips on the wing bars and rump, instead of entirely white feathers as in adults. First-year birds in formative plumage are similar to older birds but can continue to be identified by the yellow coloration to the bill and molt limits among wing feathers. Predefinitive plumages of male and female Yap Monarchs differ from the black and white definitive basic (adult) plumages by having irregular brownish patches throughout the body that are similar in color to juvenile plumage. The annual survival rate of Tinian Monarchs was 0.89 based on the proportion of adults captured in mist nets. The annual survival rate of Yap Monarchs was 0.89 based on the proportion of adults observed during field surveys. These survival estimates may be overestimates because younger birds are more difficult to observe and capture, but are useful for helping to assess the conservation status of the species.

Introduction

The monarch flycatchers (Monarchidae) constitute a widespread bird family that occurs from sub-Saharan Africa to southeast Asia, Australia, and the Pacific region. One or more monarch species occur on most Pacific island groups, and many monarchs are endemic to a single island or group (Pratt et al. 1987, Cibois et al. 2004, Filardi & Moyle 2005). Some monarchs are common and widespread on their respective island(s), but others have become endangered or extinct due to a variety of threats, including habitat loss and degradation, predation by non-native species, primarily the black or ship rat (*Rattus rattus*), and in some cases, diseases carried by non-native mosquitoes. There is substantial concern about the conservation status of many monarch flycatchers and intensive conservation programs have been implemented for several species (Robertson et al. 1994, VanderWerf 2009, Ghestemme et al. 2019, Blanvillain et al. 2020, Amidon et al. 2021, VanderWerf et al. 2021).

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Some monarch flycatchers have been relatively well-studied, but basic natural history information about some species became known only recently, and there still are gaps in our knowledge about a number of species. For example, in the elepaios (genus *Chasiempis*) of the Hawaiian Islands, the fact that all three species have a two-year delay in plumage maturation, and thus three recognizable age classes, was discovered only 25 years ago (VanderWerf 2001, VanderWerf & Freed 2003).

In many cases, the demographic parameter that is most important in understanding the conservation status of a species is adult survival (Sæther & Bakke 2000). In birds, survival estimates usually are calculated using mark-recapture techniques that require multiple years of banding and subsequent recapture or resighting of marked individuals (Sandercock 2006, VanderWerf 2008, 2009). However, survival can be estimated using other methods that are simpler and less labor intensive. In species that have at least two distinguishable age classes, annual survival can be estimated by the proportion of the adult age class in the population, and this can be measured with visual observations, mist-netting samples, and museum specimens (Hernández-Matías et al. 2011, Ricklefs et al. 2011). Turnover in territory ownership also can be used as a proxy for survival (Hernández-Matías et al. 2011). The assumptions involved in these methods are more restrictive than in capture-recapture methods and are thus more easily violated, and the resulting survival estimates may be biased (Hernández-Matías et al. 2011). Though less reliable than more intensive mark-recapture methods, survival estimates based on these alternative methods can provide a quick method of helping to assess the status of a species.

The Tinian Monarch (*Monarcha takatsukasae*) is endemic to the island of Tinian in the Commonwealth of the Northern Mariana Islands (CNMI). The Tinian Monarch was listed as endangered in 1970 under the U.S. Endangered Species Act (ESA) because its numbers were believed to be critically low due primarily to habitat loss (Baker 1951; USFWS 1970, 1987). An island-wide survey conducted in 1982 found that the Tinian Monarch was widely distributed over the island in all forest types and was the second most abundant bird on the island with an estimated population of 39,338 birds (Engbring et al. 1986). Based on those data, the Tinian Monarch was downlisted from endangered to threatened in 1987 (USFWS 1987). A life history study conducted in 1994-1995 resulted in a population estimate of approximately 52,904 birds, and a second island-wide survey of forest birds in 1996 estimated the population at 55,721 birds (USFWS 1996, Lusk et al. 2000). Because it had remained stable or had increased in number and was not known to be affected by any serious threats, the Tinian Monarch was removed from the endangered species list in 2004 (USFWS 2004). The ESA requires that any delisted species be monitored for at least five years to verify that it remains secure from the risk of extinction, and a post-delisting plan (PDMP) for the Tinian Monarch was completed in 2005 (USFWS 2005). The PDMP was successfully implemented from 2006-2011 and the final results of the monitoring were made public in 2021 (VanderWerf et al. 2007, Amidon et al. 2021). One component of the PDMP was to mist-net, band, and measure monarchs to estimate annual survival, and this allowed me an opportunity to examine individuals closely.

Passerine birds typically undergo a complete prebasic molt annually (Pyle 2022). Nestlings acquire juvenile plumage (now synonymous with "first-basic" plumage) that usually is distinct from later plumages. After fledging, a preformative molt occurs that can vary from partial to complete and, when less than complete, birds in this formative plumage can be identified by differences in shape, wear, and sometimes, coloration, between juvenile and formative feathers. Many migratory passerines also undergo a prealternate molt that results in alternate (or "breeding" plumage), but these are much less common in tropical resident birds (Pyle et al. 2016).

Sexes of the Tinian Monarch are similar, and only a single plumage has been recognized (Fig. 1A; Pratt et al. 1987). During the post-delisting monitoring, I noticed that in some individuals the base of the lower bill and the mouth lining were yellow, and not gray or horn-colored as in most

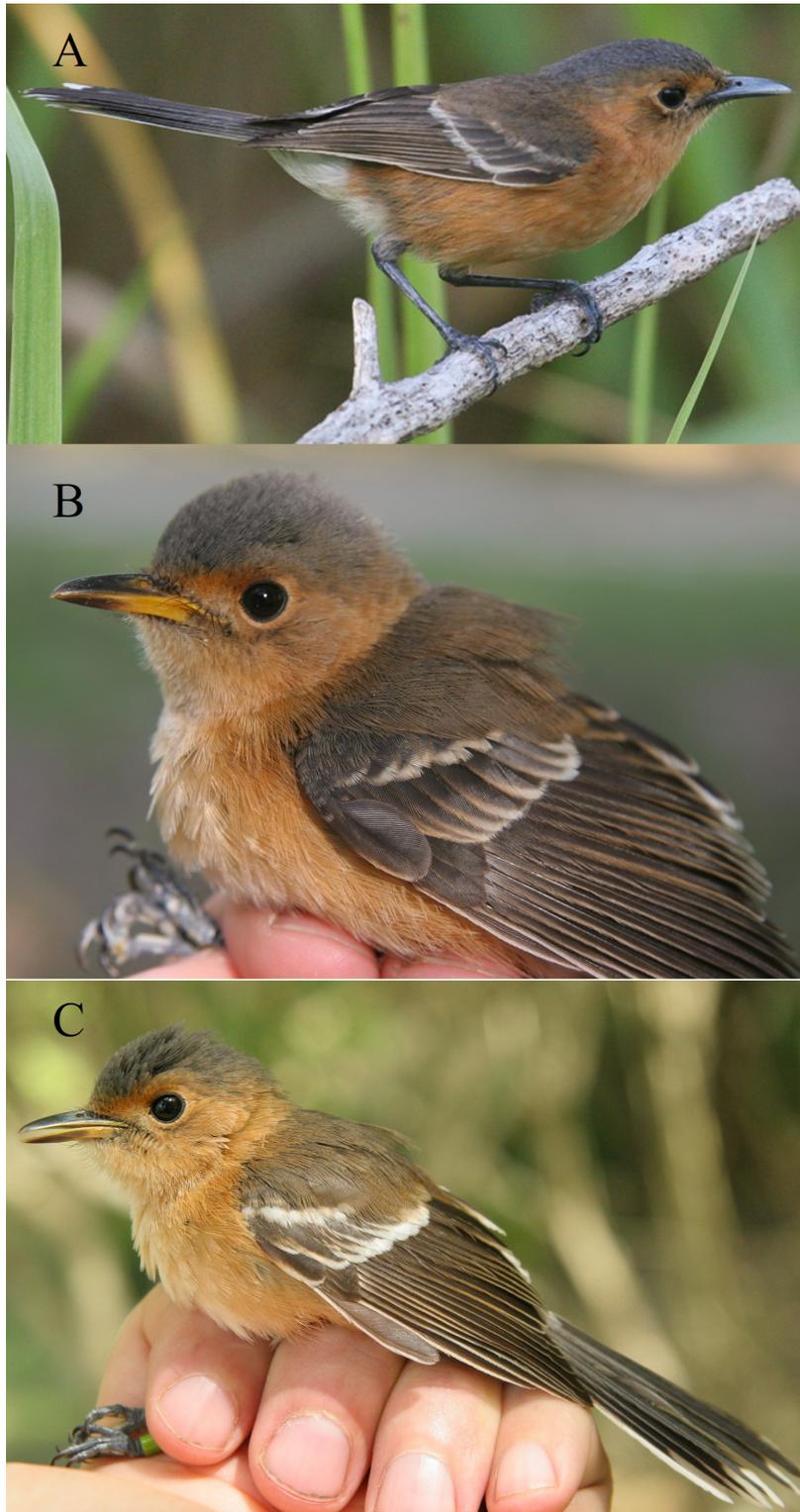


Figure 1. Photos of Tinian Monarchs showing definitive (or adult) plumage (A), and two examples of formative plumage (B, C). All photographs by E. VanderWerf.

individuals. Subsequent observations of nestlings and fledglings revealed that only juveniles had yellow-based bills. I collected additional data on plumage coloration of adults and juveniles, which has not been published previously. The Tinian Monarch account in the Handbook of Birds of the World (Clement 2020a) states that the “female retains dark bill tip of immature plumage for longer than does male” and that the “juvenile is very similar to adult but generally duller brown, with dark upper mandible and yellow lower mandible.” However, this information about juveniles is incomplete and partly incorrect. The juvenile plumage of the Tinian Monarch has not been adequately described previously.

The Yap Monarch (*M. godeffroyi*) is endemic to the island of Yap, where it appears to be common and widespread, but it has never been the subject of any field studies. Yap Monarchs have striking sexual dimorphism, males being white with a black head, wings, and tail, and females being black with a white collar (Fig. 2A,B; Pratt et al. 1987). Yap Monarchs of both sexes have a distinct juvenile plumage very different from that of adults, in which the crown is gray, the back is grayish brown, and the underparts, face, and wing bars are buffy (Fig. 2C; Pratt et al. 1987). During a visit to Yap from 13-14 May 2005, I observed male and female Yap Monarchs that had irregular patches of brownish feathers. The birds did not appear to be molting, and I suspected that these individuals were exhibiting a previously undescribed predefinitive plumage that was a mix of feathers with juvenile and adult coloration. A similar plumage is known to exist in the closely related Truk (or Chuuk) Monarch (*Metabolus rugensis*), in which the molt from juvenile to adult plumage appears to be gradual and irregular, resulting in at least some individuals that retain patches of brownish plumage (Pratt et al. 1987). The predefinitive plumages of the Yap Monarch have not been described previously.

The purposes of this paper are to: 1) describe more formally and in greater detail the juvenile plumage of the Tinian Monarch; 2) describe the predefinitive plumages of male and female Yap Monarchs; and 3) present annual survival estimates for both species based on the proportion of adults in the population, and for the Tinian Monarch to compare survival estimates derived from three different methods.

Materials and Methods

For the Tinian Monarch, I made observations and collected data in 2006-2007 during the post-delisting monitoring of the species, which is described in detail by VanderWerf et al. (2007) and Amidon et al. (2021). That monitoring involved mist-netting and banding of monarchs in three study sites, during which each monarch was banded with a metal leg band and a unique combination of plastic, colored bands for individual identification, measured, weighed, and a small blood sample was collected. Survival of the Tinian Monarch was estimated previously using mark-recapture methods (Amidon et al. 2021) and thus is available for comparison. It proved difficult to determine the gender of some Tinian Monarchs, so survival was estimated for both sexes combined (Amidon et al. 2021).

For the Yap Monarch, I made observations during a two-day visit from 13-14 May 2005. During those days I searched much of the island for monarchs and recorded the location of all individuals I saw or heard, the age and sex of all individuals I saw, and I photographed every individual I could.

I estimated annual survival in both species using the proportion of adults either captured in mist nets (Tinian Monarch) or observed in the field (Yap Monarch). The formula for calculating survival is simply the number of adults divided by the total number of birds (Hernández-Matías et al. 2011). For the Tinian Monarch, I also estimated survival using data on turnover of territory owners, which were reported by VanderWerf et al. (2007) and Amidon et al. (2021). In the turnover method, survival is simply the proportion of territory owners that remained unchanged from one year to the next (Hernández-Matías et al. 2011).



Figure 2. Photographs of Yap Monarchs showing male definitive plumage (A), female definitive plumage (B), juvenile plumage (C), two examples of male predefinitive plumage (D and E), and two examples of female predefinitive plumage (F and G). Photographs A, B, D, E and F by E. VanderWerf. photographs C and G by Peter Kaestner.

Results

TINIAN MONARCH JUVENILE AND FORMATIVE PLUMAGES

The most obvious difference between juvenile and adult Tinian Monarchs is bill color (Fig. 1). In juveniles, the basal half of the lower bill, the tomia, and the mouth lining are yellow (Fig. 1B,C). In adults, the bill is entirely gray or horn-colored, sometimes slightly paler gray toward the tip. In addition, in juvenile plumage the tips of feathers on the wing bars and rump have a variable amount of buff color, instead of being entirely white as in adults. The wing bars are present on the greater and median wing coverts, and in juvenile plumage these feathers can have buff fringes, tips, or both. The formative plumage is similar to the juvenile plumage, but a variable number of the juvenile wing coverts with buff color are replaced in the first pre-basic molt with feathers that are white or nearly so, as in adults. The amount of buff in the wing bars thus is variable, with some individuals having dull or partially dull buffy wings bars (Fig. 1B; only the inner three greater coverts replaced), and others having wing bars that are almost entirely white and not much different from those of adults (Fig. 1C; all greater and median coverts replaced). The coloration of juvenile and formative plumage is otherwise similar to that of the definitive basic plumage of adults, and there is no evidence from captures or images of a prealternate molt in this species.

YAP MONARCH PREDEFINITIVE PLUMAGE

I observed four Yap Monarchs, including two males and two females, that had irregular patches of brownish feathers all over the body. The brownish feathers were similar in color to feathers of the juvenile plumage (Fig. 2; Pratt et al. 1987). The location and extent of the brownish feathers varied among individuals, and in all cases they were distributed unevenly, variously including those of the head, body, remiges, and rectrices, and included areas that are both black and white in adults of both sexes (Fig. 2D-G). Careful examination of the images suggested that the brownish remiges and rectrices were worn juvenile feathers, and none showed evidence of active molt. Replaced remiges included tertials and inner primaries, which would be consistent with an incomplete molt in typical molt sequence (Pyle 2022). I thus suspect that these birds were in formative plumage following a partial preformative molt. This plumage is intermediate in appearance between the juvenile and adult plumages. Further examination of birds in the hand is needed to confirm this, and also to see if some birds in their second year (second basic plumage) can continue to show patches of brown feathers.

SURVIVAL ESTIMATES

In the Tinian Monarch, 105 adults and 12 juveniles were captured in mist nets from 2006-2009 (VanderWerf et al. 2007, Amidon et al. 2021), resulting in an annual survival estimate of 0.89 ± 0.02 in both sexes combined (annual range 0.82-0.92). Annual survival of Tinian Monarchs based on territory turnover averaged 0.65 males and 0.58 in females (Amidon et al. 2021). In the Yap Monarch, I observed 17 adult males and 2 subadult males, and 17 adult females and 2 subadult females, resulting in an annual survival estimate of 0.89 in each sex.

Discussion

The appearance of juvenile and formative plumages Tinian Monarchs is similar in several ways to those of the three elepaio (*Chasiempis*) species in the Hawaiian Islands (VanderWerf 2001), in which the base of the lower bill and tomia are yellow, and the tips to feathers on the juvenile wing coverts, rump, and tail are buff- or rust-colored. The Tinian Monarch is thought to be one of the closest relatives of the elepaios, despite the distance between the islands where they occur (Filardi & Moyle 2005, VanderWerf et al. 2010), so the similarity of their plumages is not surprising. The yellow on the bill in the elepaios gradually fades and becomes gray at about one year of age

(VanderWerf 2020), and it is likely that the bill color of the Tinian Monarch also changes to that of adults in about a year. There is no evidence I know of that female Tinian Monarchs retain a dark tip to the bill longer than in males, as stated in the Handbook of Birds of the World (Clements 2020a). Based on several years of mist-netting and following individual males and females, both sexes have a yellow base to the bill for the same duration (about one year). Moreover, the tip of the bill is dark in all Tinian Monarchs; it is the base of the bill that changes in color. Both sexes also appear to have similar molt sequences, with a partial preformative molt allowing identification of formative birds by molt contrasts among wing feathers through the first year, and no prealternate molt.

The predefinitive plumage of the Yap Monarch appears to be similar to that in the Truk (or Chuuk) Monarch, in that adults of both sexes exhibit irregular patches of brownish coloration that is similar to the color of juvenile plumage. In the Chuuk Monarch, Pratt et al. (1987) illustrated this plumage only for the female, and in eBird the only photograph of predefinitive plumage is of a male (Olah 2019). Examination of this image suggests that the brown feathers (primaries) are juvenile; however, the pattern of molts and plumages in both species is poorly known and more research is needed to clarify whether the brown feathers are retained juvenile feathers, or formative or second basic feathers that are the same color as juvenile feathers. It may be possible to determine this from museum specimens, but it might be necessary to examine the plumage of individual birds in the field over time. In the elepaio, there is a complete second prebasic molt in which all body feathers are replaced, but the resulting second basic plumage is still different from definitive adult plumage. A similar plumage sequence could occur in Yap and Chuuk monarchs.

Comparison of annual survival estimates for the Tinian Monarch obtained by three different methods is instructive. The estimate obtained using mark-recapture methods was 0.78 ± 0.03 (Amidon et al. 2021), and this is likely to be the least biased and most accurate estimate because it requires fewer assumptions. The estimate from proportion of adults captured in mist-nets, 0.89 ± 0.02 , was somewhat higher than the mark-recapture estimate, and the probable cause of this overestimate is that juveniles do not defend territories or mates and are deliberately more secretive, making them harder to capture, thereby resulting in over-representation of adults in mist-net samples. This bias has been shown to affect capture probability in the Hawaii Elepaio (*Chasiempis sandwichensis*), Oahu Elepaio (*C. ibidis*), and Maui Alauahio (*Paroreomyza montana*), and must be accounted for to accurately estimate survival in the juvenile age class (VanderWerf 2008, VanderWerf 2009, Vetter et al. (2012). The survival estimate of 0.89 for the Yap Monarch may be an overestimate for the same reason, perhaps by a similar amount. The survival estimates of Tinian Monarchs from territory turnover, 0.65 for males and 0.58 for females, were substantially lower than the mark-recapture estimate, probably because some turnover was caused by emigration, not mortality. During the monitoring work, we searched for and found a few monarchs that moved to territories outside the study areas, but it is likely that we missed additional individuals that moved even farther away, resulting in an underestimate of survival.

The survival estimates for the Tinian and Yap Monarchs are similar to those reported for other monarch flycatchers. In the Hawaii Elepaio, VanderWerf (2008) reported male and female annual survival rates of 0.87 and 0.81, respectively. For the Oahu Elepaio, annual survival of males was 0.84 without rat control and 0.86 with rodent control), and survival of females was 0.55 without rat control and 0.82 with rodent control (VanderWerf 2009). The relatively high survival rates of the Tinian Monarch and Yap Monarch indicate neither species was seriously affected by predation from rats or other predators, and that the population was likely to have been stable at the time and place where it was measured.

However, other evidence indicates the Tinian Monarch is declining overall. Roadside surveys over much of the island using a prescribed methodology showed a significant decline in Tinian Monarch detections between 1999 and 2010 (Amidon et al. 2021). Furthermore, island-wide population size estimates derived from distance-based methods declined from 55,721 in 1996 to 33,310 in 2008 (Lusk et al. 2000, Camp et al. 2012). The overall decline of the Tinian Monarch

probably has been caused by habitat loss and degradation. Approximately 165 hectares of forest were cleared on Tinian between 2005-2006 and 2010 based on an assessment of satellite imagery, and 69% (114 ha) of this total was potential Tinian Monarch habitat (Amidon et al. 2021).

Continued monitoring of the Tinian Monarch is needed to assess whether the population decline continues, and the extent to which forest clearing and other activities are contributing to the decline. Additional research is needed to determine more details about the nature of the predefinitive plumages of the Yap Monarch, including whether the brownish feathers are retained from juvenile plumage or new, and the number of years for which individuals may exhibit an identifiable predefinitive plumage. Such research also is needed in the Chuuk Monarch. If these plumages are second basic it would represent extended delayed plumage maturation, i.e., birds in predefinitive plumage that are sexually mature and capable of reproducing, as in the elepaios (VanderWerf 2001), or whether these plumages are restricted to the first year (formative plumage) in birds that are sexually immature. This could be ascertained by observations of birds with predefinitive plumage nesting and producing offspring. The predefinitive plumages of the elepaios evolved as a signal of subordination that reduces aggression from dominant adults (VanderWerf and Freed 2003), and it likely serves a similar purpose in the Yap and Chuuk Monarchs. In situations where the population is dense and the habitat is largely saturated with territories occupied by dominant older birds, it is rare for younger birds to have an opportunity to breed. Such opportunities are most likely in secondary forest or other areas where the habitat is suboptimal for some reason, and thus more available to younger, subordinate birds (VanderWerf 2008, Pyle et al. 2020).

Surveys for the Oahu Elepaio showed a male-biased sex ratio and unusually large number of one- and two-year-old females that were breeding, which was an indication of nocturnal nest predation on females by rats (VanderWerf 2009, VanderWerf et al. 2013). If subsequent observations of the Yap Monarch show an increase in the proportion of predefinitive birds in the population, it could be an indication that a threat is causing a decline in adult survival. If observations reveal a scarcity of juveniles at the appropriate season, it could be an indication of low reproductive success (Pyle et al. 2012). Even brief visits to islands like Yap can yield valuable information about the status and potential conservation needs of endemic bird species.

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