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Seasonal Demographics of Landbirds on Saipan: Report on the 2013-14 TMAPS program

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March 31, 2015

Abstract

The Tropical Monitoring Avian Productivity and Survivorship (TMAPS) program was established in 2008 to provide inferences about life history and demographic parameters of landbirds on Saipan, Northern Marianas Islands. Competing objectives and variation in annual funding have necessitated adoption of variable sampling protocols among years. In 2013 we initiated a new sampling design consisting of two annual mist-netting pulses, one in the dry season (Mar-May) and the other in the wet season (Sep-Oct) at the six previously established monitoring stations, each of which is comprised of two net arrays. The principal goals of this effort are to estimate seasonal population sizes and demographic rates. Here we apply closed robust design capture recapture models to this data set to assess population size estimates for dry and wet seasons of 2013 and 2014, as well as estimates of temporary emigration and survival rates between seasons for three target species: Rufous Fantail (*Rhipidura rufifrons saipanensis*), Golden White-eye (*Cleptornis marchei*), and Bridled White-eye (*Zosterops conspiculatus saypani*). For Rufous Fantail, the most strongly supported model was one for which survival was constant across stations and seasons and for which temporary emigration varied between the dry and wet seasons of both 2013 and 2014. The probability of emigrant Rufous Fantails remaining off of the study area between seasons was high, suggesting that once birds leave the study area they tend not to return. For Golden White-eye the top model included survival rates that varied among stations and temporary emigration rates that also varied between the dry and wet seasons of both 2013 and 2014. For Bridled White-eye, we were unable to assess station-specific survival; however, a reduced model estimated relatively high survival, but with confidence intervals that spanned the 0-1 range. Adult population size estimates tended to be higher in 2013 than in 2014, and higher in the dry than in the wet seasons. These results provide new insights into the demography and temporal dynamics of these three species. Overall, we are pleased with the monitoring potential of the study design implemented at Saipan TMAPS stations in 2013, based on the additional precision and model flexibility we encountered by adding data from 2014. We look forward to future analyses that include additional years of monitoring, which will enable incorporation of greater biological realism into demographic inferences, as well as allow testing hypotheses related to when in the life cycle vital rates may limit populations (e.g., transition from wet-to-dry season v. transition from dry-to-wet season).

Introduction

Application of standardized constant-effort mist netting and modern capture-recapture analytical techniques is an effective means of monitoring demographic rates of many landbird species (Robinson et al. 2009). Such an effort was initiated in North America by The Institute for Bird Populations (IBP) in 1989 with the establishment of the Monitoring Avian Productivity and Survivorship (MAPS) program (Desante et al. 1995, DeSante et al. 2004). The MAPS program is a cooperative network of over 1,000 constant-effort mist-netting stations operated across North America that has provided demographic data for > 180 landbird species (DeSante and Kaschube 2009). Similar programs in Europe are central components of national and international bird-monitoring efforts (Peach et al. 2004). The MAPS program was endorsed in 1991 by the Monitoring Working Group of Partners in Flight (PIF) and the USDI Bird Banding Laboratory, and has attracted participation from many U.S. agencies, including the National Park Service, Department of Defense, Texas Army National Guard, USDA Forest Service, and Fish and Wildlife Service, as well as hundreds of independent banding-station operators.

IBP, in collaboration with the Division of Fish and Wildlife of the Commonwealth of the Northern Mariana Islands, established and operated the first six “Tropical MAPS” (TMAPS) stations on the island of Saipan in 2008, and these stations have been operated in each year since that time. The overall goal of this effort is to provide baseline data on trends, vital rates, and habitat associations for populations of up to nine bird species indigenous to Saipan to inform conservation strategies for this insular avifauna. Long-term goals of the TMAPS program on Saipan include: (1) providing annual indices of adult population size and post-fledging productivity (from constant-effort capture data); (2) providing annual estimates of adult population size, survival rates, proportions of residents, and recruitment into the population (from capture-recapture data); (3) relating avian demographic data to weather and habitat; (4) identifying population trends and proximate and ultimate causes of population change; and (5) applying these data to inform management.

In addition to the long-term goals, an initial aim of the TMAPS program was to gather basic information on the timing and extent of breeding and molt, and to better understand how these processes relate to abiotic drivers (rainfall, plant productivity). Due to competing goals, as well as annual variation in funding, the length of the field season during the initial 5 years of the TMAPS program was variable. We operated stations across what was thought to be the the primary breeding season for most species (Apr-Jul), but we also extended the field season into additional months of the year whenever funding allowed, and we were able to complete sampling that extended across a full year between Mar 2011 and Mar 2012. Sampling largely followed the standard MAPS protocol of one day of mist-netting per 10-d period; however, we moved to a monthly 3-d 'pulse' protocol between Jul 2011 and Mar 2012 (to conform to a design more readily analyzed with modern capture-recapture methods). These extenstive sampling efforts have yielded important insights into spatial and temporal variation in breeding (Saracco et al. 2014b) and into the timing and extent of molt (Radley et al. 2011, Junda et al. 2012). But extended annual sampling or year-round banding is expensive, and avoidance of nets over time by birds may result in relatively inefficient demographic monitoring compared to more intensive sampling designs (Ruiz-Gutiérrez et al. 2012). In addition, numbers of captures and recaptures at a typical MAPS station (10 nets distributed over approximately 8 ha) are usually too few to allow application of capture-recapture models that require large samples to provide inferences about demographic parameters at the station-scale. For these reasons, we restructured the Saipan TMAPS sampling in 2013 to conform to a closed robust design model (Kendall et al. 1997, Kendall 1999), whereby two pulses (one in the mid-dry season, one in the mid-wet season) of mist netting are to be completed each year at original station net sites and at an additional array of net sites established at each station (increasing station boundaries in most cases).

In our previous 2013 analysis, we implemented the first closed robust design capture-recapture models to provide an initial assessment of the new sampling protocol (Saracco et al. 2014a); however, the number of parameters that could be estimated from only a single year of data was limited. Here we build on models implemented in the 2013 analysis by adding data from 2014, which allowed estimation of both temporary emigration and survival parameters, as well as population size.

Methods

Study Areas and Field Methods

Six study areas (TMAPS stations) were established across the island of Saipan in land cover types typical of Saipan and neighboring islands Tinian and Rota (see Saracco et al. 2014b) for detail). Ten nets were established at each station across an area of approximately 8 ha (Desante et al. 2014), and these nets were operated annually with various levels of effort since 2008. In 2013, we sampled birds at the original 10 nets established at each TMAPS station plus up to two additional nets within this netting area (hereafter, net array A), as well as at an additional 10-12 nets (net array B) that we established at each station to enhance sample sizes and provide improved station-scale inferences about demographic rates. In all cases except at the Sabana Talofofo (SATA) station (where room for station expansion was most limited), the additional net array increased the overall sampling area of each station.

Sampling at each station was conducted within two 'pulses' of mist netting centered on the mid-dry season (April) and mid-wet season (Oct) in 2013 and 2014. For each net array and pulse, we conducted three consecutive days of mist-netting (four days at LATA in the dry season of 2014 and at MTAP in the wet season of 2014 to make up missed effort). We netted birds at only a single net array on each sampling day, and sampling was structured such that we cycled through net array A at each site before cycling through net array B. This design resulted in both net arrays at each station and pulse being sampled within a period of approximately 1 month, with samples across all stations for a given pulse spanneing a period of approximately 1.6 months (dry season pulse from 19 Mar-7 May; wet season pulse from 20 Sep-10 Nov). Mist-netting effort data (i.e., the number and timing of net-hours on each day of operation) were collected in a standardized manner by recording opening and closing times (to the nearest 10 min) for nets, as well as the time at which each net check commenced. We aimed to operate nets for six morning hours per day beginning 15 minutes after sunrise (on or near 05:30 AST). Inclement weather (mostly high sun and wind exposure) and high capture rates at some sites, however, resulted in variable effort among stations. A summary of mist-netting effort for each station, net array and pulse is presented in Table 1.

With few exceptions, all birds captured in mist nets were identified to species, age (young = 'hatching year'; adult = 'after hatching year'), and sex (based on Pyle et al. 2008, Radley et al. 2011) and banded with United States Geological Survey – Biological Resources Division numbered aluminum leg bands if not already so marked. Band numbers of all recaptures were carefully recorded. We also collected ancillary data on skull pneumaticization, breeding condition, molt, wing length, and subcutaneous fat deposition (Desante et al. 2014).

Capture-recapture models

We applied closed robust design models (Kendall et al. 1997, Kendall 1999) to the 2013 TMAPS capture-recapture data for adult birds (i.e., birds aged "After-hatching-year" or older). The robust design consists of two levels of sampling: primary samples (here represented as the dry season and wet season samples) and secondary samples (individual sampling days for a station within each season). The model assumes population closure within primary samples and an open population between primary samples. We used these models to estimate adult population size at stations during the 2013 and 2014 dry and wet seasons and adult apparent survival rates and temporary emigration rates between sampling pulses. We also provide estimates of time-constant capture and recapture probabilities. All models were run in program MARK (White and Burnham 1999) using the R (R Core Team 2013) package RMark (Laake 2013).

For Rufous Fantail and Golden White-eye, we considered a set of 24 models that allowed for different parameterizations for:

S, adult survival probability over the 6-month time period between pulses;

γ'', the probability of emigrating from the study areas between pulses;

and γ' the probability of an emigrant remaining off of study areas between pulses;

For *S*, we considered time-constant ($\cdot$) parameterizations, as well as models that allowed survival to vary among stations (sta), among year-season combinations (time), and by station and year-season (sta x time). Model parameterizations for temporary emigration included:

(1) no temporary emigration (γ'' set equal to zero);

(2) time-constant random temporary emigration (·); and

(3) annually-varying random temporary emigration (time).

Capture and recapture probabilities were modeled as constant across space and time (·), and adult population size (N) was estimated for each station and season-year combination. For Golden White-eye, we excluded data from station OBYA, as only 9 adults were captured there and no between-pulse recaptures were recorded. For Bridled White-eye recaptures were sparse (only 6 of 138 individuals recorded in multiple seasons), and so we only considered models with time-constant survival and with emigration parameters either time-constant or set to zero (i.e., no immigration). We assessed model support compared to the staion-specific S models based on Aikaike's information criterion adjusted for small samples (AIC_c; Burnham and Anderson 2002) and present results from best (i.e., lowest AIC_c models).

Results

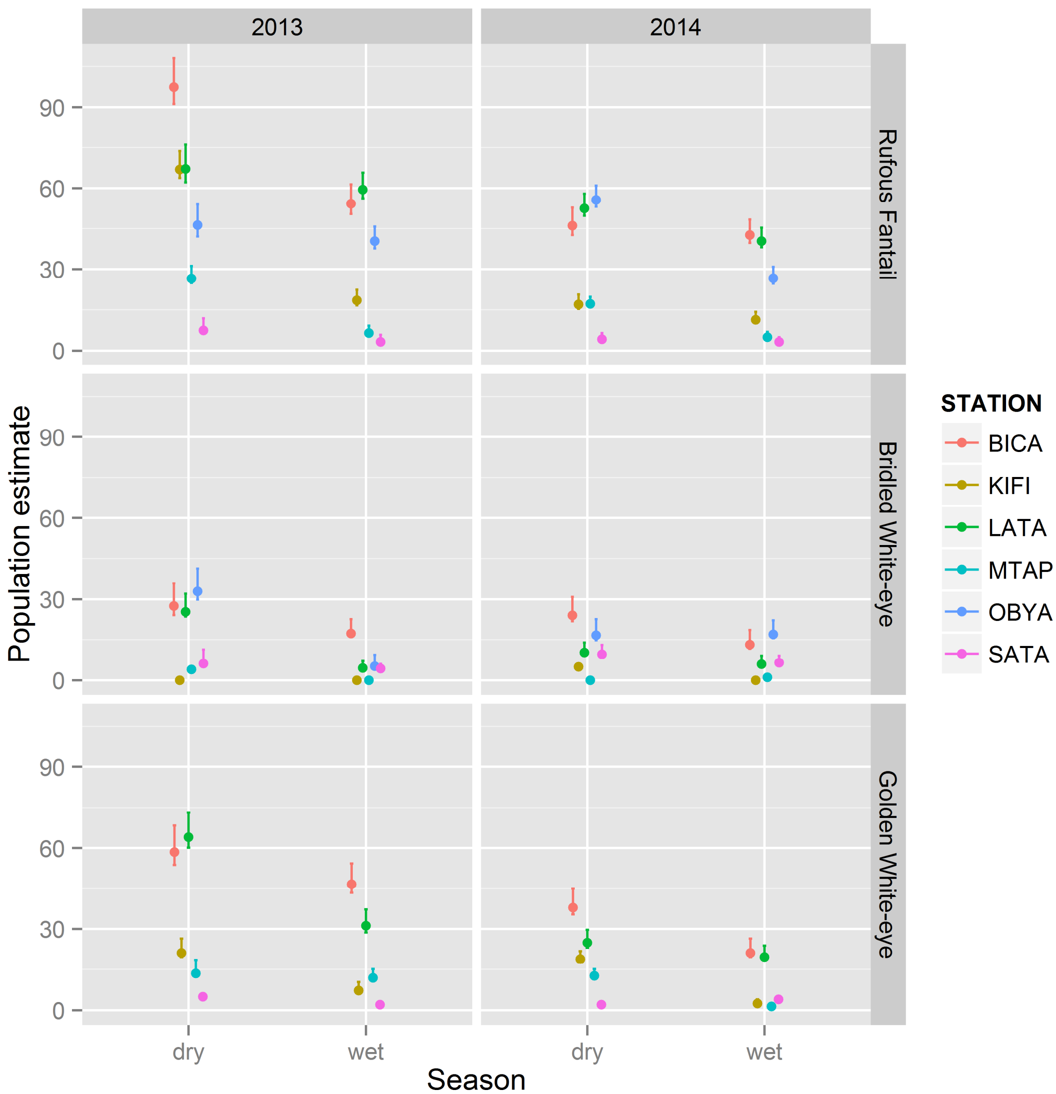
For Rufous Fantail, the most strongly supported model was one for which survival was constant across stations and seasons (6-month survival-rate of 0.696; 95% CI: 0.451, 0.864), and for which temporary emigration varied among seasons (ranging from 0.542 [95%CI:0.377, 0.698] between the dry season of 2013 and wet season of 2013 to 0.721 [95%CI: 0.516-0.819] between the wet season of 2013 and dry season of 2014). The probability of emigrant Rufous Fantails remaining off of the study area between seasons was high (0.671-0.714), suggesting that once birds leave the study area they tend not to return. Initial capture probability within a pulse was much higher (0.463; 95% CI: 0.414, 0.513) than recapture probability (0.087; 95% CI: 0.071, 0.017).

For Golden White-eye there was greater model uncertainty; however, the top model included survival rates that varied among stations and temporary emigration rates that varied among seasons. Survival estimates for Golden White-eye varied from a low of 0.129 (95% CI: 0.027, 0.440) at KIFI to similarly higher survival rates of 0.445 (95% CI: 0.179, 0.747) at BICA and 0.432 (95% CI: 0.187-0.715) at LATA. We were unable to estimate survival for Golden White-eye at OBYA, as only 9 captures and no between-season recaptures of this species were recorded there. Temporary emigration rates for Golden White-eye varied from a low of 0.480 [95%CI:0.167, 0.809] between the dry season of 2013

Table1. Sampling effort at each of the six Tropical Monitoring Avian Productivity and Survivorship (TMAPS) stations on Saipan during 2013 and 2014. Three to four days of mist-netting were completed for each station, net array, and season. Column headings indicate year_pulse_day of pulse.

STATION	ARRAY	2013_1_1	2013_1_2	2013_1_3	2013_2_1	2013_2_2	2013_2_3	2014_1_1	2014_1_2	2014_1_3	2014_1_4	2014_2_1	2014_2_2	2014_2_3	2014_2_4	Name
BICA	1	59.33	72.00	56.00	53.33	54.67	71.33	70.667	71.33	72.00	0.00	56.83	67.67	0.00	0.00	Bird Island Conservation Area
BICA	2	68.00	68.67	62.00	62.67	71.33	72.00	68.000	72.00	54.00	0.00	72.00	72.00	0.00	0.00	Bird Island Conservation Area
LATA	1	70.67	72.00	72.00	64.67	70.00	46.67	8.667	29.33	64.00	55.33	69.33	72.00	0.00	0.00	Laderan Tangke
LATA	2	60.00	70.67	70.67	68.00	48.00	71.33	64.667	69.00	72.00	0.00	60.50	51.33	0.00	0.00	Laderan Tangke
SATA	1	60.00	58.00	60.00	56.67	47.83	58.67	45.333	50.67	50.83	0.00	60.00	60.00	0.00	0.00	Sabana Talofofo
SATA	2	60.00	60.00	60.00	54.33	60.00	60.00	52.667	60.00	12.67	0.00	120.00	0.00	0.00	0.00	Sabana Talofofo
KIFI	1	60.00	56.67	52.67	30.83	58.67	58.00	61.333	64.83	63.67	0.00	55.33	38.33	33.33	0.00	Kingfisher
KIFI	2	58.67	60.00	60.00	56.67	53.33	19.17	52.000	49.50	45.00	0.00	56.67	60.00	0.00	0.00	Kingfisher
MTAP	1	52.00	60.00	60.00	58.00	60.00	59.33	54.000	59.33	58.00	0.00	19.33	31.50	46.67	26.67	Mount Tapochau
MTAP	2	60.00	60.00	60.00	57.33	24.67	58.00	51.500	60.00	58.67	0.00	42.00	48.00	0.00	0.00	Mount Tapochau
OBYA	1	64.00	64.00	64.00	64.00	70.67	45.67	50.667	51.00	43.67	0.00	26.33	62.83	35.33	0.00	Obyan
OBYA	2	56.00	40.00	48.00	47.33	62.00	63.33	53.333	68.00	60.00	0.00	53.67	72.00	20.00	0.00	Obyan

Figure 1. Estimates of station-scale adult population size (±95% confidence limits) during the 2013 and 2014 dry and wet seasons at the six Tropical Monitoring Avian Productivity and Survivorship (TMAPS) stations on Saipan, Northern Marianas Islands.



and wet season of 2013 to 0.788 [95%CI: 0.513-0.929] between the dry season of 2014 and wet season of 2014. Probabilities of an emigrant returning to the study area were 0.452-0.637, although these parameters were estimate imprecisely (95% CIs ranging from 0 to 1). As for Rufous Fantail, recapture probability (0.031; 95% CI: 0.018, 0.050) declined sharply from probability of initial capture (0.478; 95% CI: 0.413, 0.543).

For Bridled White-eye, we were unable to assess station-specific survival, as only 6 of 138 individuals (4%) were ever recorded in multiple seasons. A reduced model with constant survival and temporary emigration parameters suggested that separation of survival and emigration parameters in this species will be difficult. This model estimated relatively high survival (0.710), but with confidence intervals that spanned the 0-1 range. Temporary emigration was estimated to be very high (0.959; 95%CI: 0.659, 0.997), as was the probability of emigrants remaining off of study areas following emigration (0.956; 95% CI: 0.714, 1.000). Recapture probability for Bridled White-eye was again much lower (0.012; 95% CI: 0.004, 0.036) than for probability of initial capture (0.440; 95%CI: 0.355, 0.529).

Adult population size estimates tended to be higher in 2013 than in 2014, and higher in the dry than in the wet seasons (Fig. 1.).

Discussion

These results provide new insights into the demography and temporal dynamics of these species. Additional years of data will enable explicit modeling of seasonal effects, as well as station-specific temporary emigration.

TMAPS sampling protocols on Saipan during the 5-yr pilot program (2008-2012) aimed to address a broad range of goals, including providing basic understanding of the phenology and extent of breeding and molt and providing demographic data. As such, these protocols represented a compromise in approaches, none of which was ideally suited to addressing any particular goal. Although demographic analyses of the 5-yr data set have provided many important insights (Saracco et al. 2014b), the mixture of sampling designs used prior to 2013 resulted in complicated analyses that were always well-matched to meeting demographic monitoring objectives. Revised protocols introduced in 2013 provide a bridge between the 2008-2012 monitoring program (via retention of original net sites) and long-term demographic monitoring protocols that are better matched to available analytical methods. Results through the 2014 season, presented here, suggest great potential for the intensive sampling protocol adopted in 2013 to effectively monitor the population status and demographic rates of target landbird species on Saipan. Although we only consider adult birds here, the same basic methods could be applied to young birds to provide snapshots of age-specific abundances at two periods of the life cycle that, together, may accurately reflect annual productivity (Saracco et al. 2014b).

Population size estimates for each target species were estimated with sufficient precision to detect a variety of differences among stations and pulses, which suggests the overall utility of our approach for monitoring the year- and season-specific status of populations on our study areas. Although stations differ to some extent with respect to sampling area and net density, the increase in net numbers should facilitate spatial modeling that would allow density estimation that would be directly comparable among stations (by scaling abundances to account for differences in areal coverage among stations; (Royle et al. 2013). Survival-rate estimates provided here represent a complex mixture of movement off of study areas (both temporary and permanent emigration) and true survival. As such, these estimates were biased low to some degree. Future analyses with additional pulses of data will offer flexibility in modeling temporary and permanent emigration and survival-rate estimation approximating true survival rates (Kendall et al. 1997, Kendall 1999).

Overall, we are pleased with the monitoring potential of the study design implemented at Saipan TMAPS stations in 2013, based on the additional precision and model flexibility we encountered by adding data from 2014. We look forward to future analyses that include additional years of monitoring, which will enable incorporation of greater biological realism into demographic inferences, as well as allow testing hypotheses related to when in the life cycle vital rates may limit populations (e.g., transition from wet-to-dry season v. transition from dry-to-wet season).

Acknowledgements

We thank the U.S. Fish and Wildlife Service for funding the CNMI Division of Fish and Wildlife through State Wildlife and Pittman-Robertson Wildlife Restoration Grants. We thank Kate Howard ,Victor Koos, Jake Shorty, and Trischa Thorne for collecting the 2013 Saipan TMAPS data, and Karen Coffman, Michael Krzywicki, Aileen Lennon, and Sara 'Ruby' Rozell for collecting the 2014 data. This is contribution no. 498 of The Institute for Bird Populations.

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