Effects of Rodent Predation on Nesting Success of Forest Birds on Kaua‘i

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Introduction

The ‘Akikiki, *Oreomystis bairdi* (Fig. 1) and ‘Akeke‘e, *Loxops caeruleirostris* (Fig. 2), are Hawaiian forest birds added to the endangered species list in 2010 due to apparent population declines since 1970 (Five-Year Recovery Work Plans, DOFAW and USFWS). The biology of both species is poorly understood, but the same factors affecting most Hawaiian forest bird populations (i.e., avian disease, habitat degradation, introduced mammalian predators) are thought to also negatively affect ‘Akikiki and ‘Akeke‘e. Nest predation by introduced mammals, particularly the black rat (*Rattus rattus*), might be one of the most severe impacts to Hawaiian bird nesting success since native birds evolved without mammalian predators. Our first objective was to assess reproductive rates for ‘Akikiki and ‘Akeke‘e. We included five other native forest birds on Kaua‘i (‘Anianiau, *Hemignathus parvus*; ‘Apapane, *Himatione sanguinea*; ‘I‘iwi, *Vestiaria coccinea*; Kaua‘i ‘Amakihi, *Hemignathus kauaiensis*; and Kaua‘i ‘Elepaio, *Chasiempis sclateri*) to more broadly assess the effects of mammalian predators on nest survival. Our second objective was to determine the influence of nest-site characteristics, in particular nest height, on nest survival. Recent studies show that black rats in Hawaii spend most of their time above ground at an average of ~ 3m above the forest floor, and at a maximum height of ~8m (Shiels 2010). We hypothesized that if black rats are largely responsible for nest failures, nest survival should be greater when nest placement is higher. Our third objective was to compare nest survival of the most abundant forest bird in Hawai‘i, the non-native Japanese White-eye (*Zosterops japonicus*), with that of the Kaua‘i ‘Elepaio, which nests at similar heights . The Japanese White-eye evolved with many rodent predators, and we hypothesized that native birds should be impacted more by introduced mammalian predators. We present data summaries and data analysis from the first year of a two-year study.

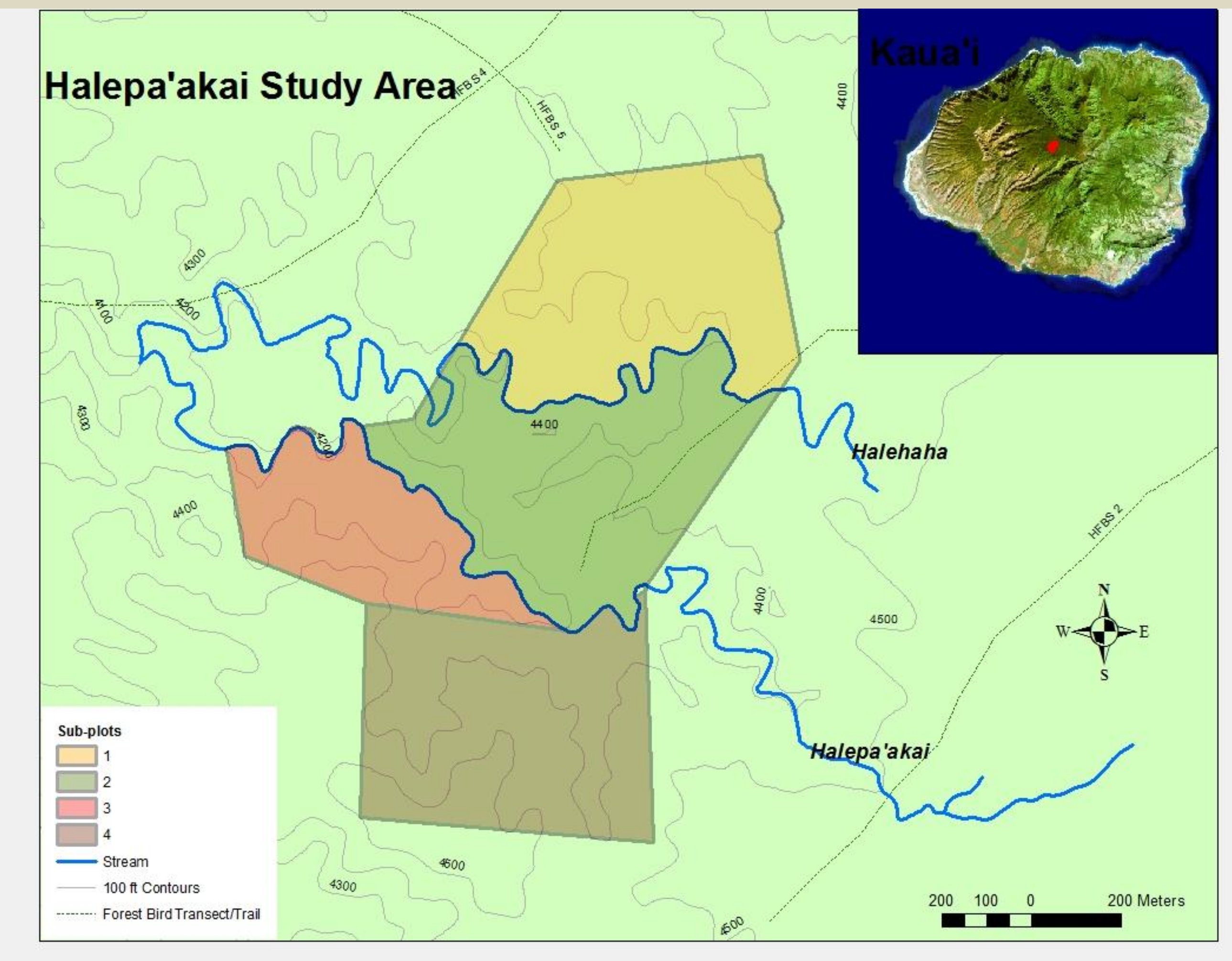

Figure 3. Map of Halepa‘akai Study Area, Kaua‘i Island, Hawai‘i.

Figure 1. Second-Year ‘Akikiki building a nest.

Figure 2. After-hatch-year ‘Akeke‘e perching

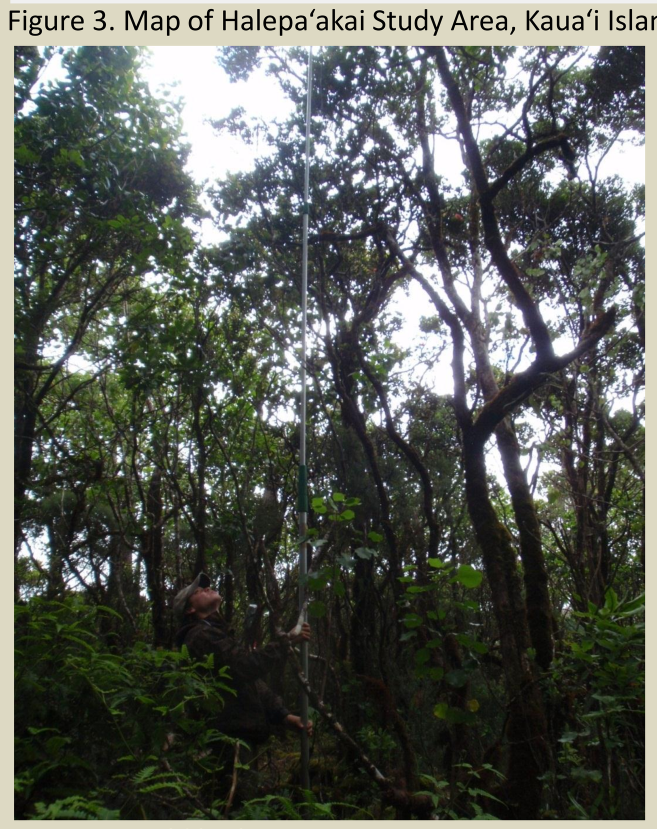

Figure 4. Field biologist peepering a nest

Figure 5. Depredated Kaua‘i ‘Amakihi nest containing rat feces and nestling feathers

Methods

Nest searching, monitoring, and nest-site characteristics

Nest studies were conducted between March and August 2012 within the Alaka‘i Wilderness in the most intact forest remaining on Kaua‘i Island, Hawai‘i (Figure 3) at ~4500 ft in elevation. Nests for all study species were located and monitored every two to three days until termination (fledge or fail). When nests failed, cause of failure was investigated for proof of depredation by:

- Mirror pole for nests <3m
- Peeper camera (i.e., a camera attached to a telescoping pole; see Figure 4) for nests < 9m
- Nest collection when accessible

When nests terminated, the following vegetation data were collected about the nest:

- Nest height
- Nest-tree height
- Nest vertical distance to canopy
- Nest distance to trunk
- Canopy cover around nest
- Vertical vegetation below nest

Analysis

Nesting success and nest survival estimates were derived for each species (except ‘I‘iwi and Kaua‘i ‘Amakihi due to scant nests located) and an estimate was derived for all native species as one group (DSR_{pooled}) . Estimates of nest fates are summarized in Table 1. Nest data were analyzed in Program MARK (White and Burnham 1999). MARK uses a maximum-likelihood approach to estimate daily survival rate (DSR) of nests and provides a generalized linear modeling framework to facilitate investigations of covariate and group effects on DSR (Dinsmore et al. 2002). We used MARK to perform the following:

- Calculated DSR for each species and DSR_{pooled}
- Use DSR to estimate nest survival for the entire nesting period
- Model effects of vegetation on DSR_{pooled} and determine effects by Akaike's Information Criterion (AIC_c) (Akaike 1973, Burnham and Anderson 2002)
- Estimate additive effect of nest height (β) on DSR_{pooled}
- Model Kaua‘i ‘Elepaio and Japanese White-eye in a separate model and use likelihood ratio test (LRT) to investigate differences in DSR for these species

Results

A total of 184 exposure days were used in the analysis. Data summaries including nesting success, nest failures, nest predation, and nest heights for each species are presented in Table 1. DSR estimates are summarized in Table 2. Nest survival varied greatly interspecifically from a low of 0.107 for ‘Apapane to a high of 0.64 for Japanese White-eye. **The endangered ‘Akikiki and ‘Akeke‘e had high nest survival (0.595 and 0.6, respectively) compared to the other species in the study.**

Species	# nests located	# nests failed	# nests fledged	# Unknown fate	# nests depredated	Nesting success	% failures attributed to depredated	Mean nest height (m)	Nest height range (m)
‘Akeke‘e	6	2	4	0	0	0.67	0.00	11.4 ±2.4	8.7-14.5
‘Akikiki	10	3	6	1	1	0.60	0.33	9.0 ±3.2	4.5-16.6
‘Anianiau	13	6	7	0	6	0.54	1.00	7.9 ±1.4	5.8-10.3
‘Apapane	9	7	2	0	0	0.22	0.00	7.9 ±1.95	5.6-11.6
‘I‘iwi	3	2	0	1	1	0.00	0.50	11.2 ±1.5	9.8-12.8
Kaua‘i ‘Amakihi	1	1	0	0	1	0.00	1.00	6.5	6.5
Kaua‘i ‘Elepaio	22	9	13	0	4	0.59	0.44	5.4 ±2.3	1.3-8.4
Japanese White-eye	13	2	11	0	1	0.85	0.50	6.2 ±1.9	3.0-9.7
Total, native birds only	64	30	32	2	13	0.50	0.43		

Table 1. Summary of nest fates and heights determined for each species.

Varying models in Table 3 are listed in order of ascending AIC_c. Simplest model, DSR_{pooled}, was the most parsimonious model. **There were no apparent differences in DSR based on species, date, nest height, or other vegetation variables**, but species and time effects are slightly more strongly supported than other models. The confidence interval for β for the slope of the effect of nest height on DSR_{pooled} (β=-0.063, 1 SE=0.075, CL=-0.210, 0.084) included zero and therefore suggested no effect of nest height on DSR_{pooled}. The LRT conducted between models of DSR for Kaua‘i ‘Elepaio and Japanese White-eye pooled versus DSR grouped by species also showed no difference between models (χ^2=0.047, p=0.828).

Species	DSR ± 95% CI	Nest survival ± 95%CI
‘Akeke‘e	0.99±0.03	0.60±0.37
‘Akikiki	0.99±0.02	0.60±0.32
‘Anianiau	0.98±0.02	0.49±0.26
‘Apapane	0.93±0.06	0.11±0.18
Kaua‘i ‘Elepaio	0.98±0.01	0.57±0.20
Japanese White-eye	0.98±0.03	0.64±0.32
DSR_{pooled}	0.98±0.01	0.50±0.13

Table 2. Daily survival rates and nest survival estimates for each species and for DSR_{pooled}.

Model	AICc	Delta AICc	AICc Weight	# parameters
DSR_{pooled}	211.0276	0.0000	0.19186	1
DSR grouped by species	211.3230	0.2954	0.16552	5
DSR_{pooled}, time	211.9345	0.9069	0.12191	2
DSR_{pooled}, nest height	212.3278	1.3002	0.10015	2
DSR_{pooled}, canopy cover	212.6365	1.6089	0.08583	2
DSR_{pooled}, distance to trunk	212.6779	1.6503	0.08407	2
DSR_{pooled}, vertical vegetation	212.9561	1.9285	0.07315	2
DSR_{pooled}, time, nest height	213.0158	1.9882	0.07100	3
DSR_{pooled}, canopy cover, nest height	213.8283	2.8007	0.04730	3
DSR_{pooled}, canopy cover, nest height, vertical vegetation	215.5268	4.4992	0.02023	4
DSR_{pooled}, nest height, distance to trunk, canopy cover, vertical vegetation	217.1319	6.1043	0.00907	5
DSR grouped by species, time	217.4454	6.4178	0.00775	10

Table 3. Candidate models ranked in order of ascending AIC_c .

Discussion

2012

We found no relationship between nest height or any other vegetative covariate used in the analysis. Japanese White-eye nest survival was higher than Kaua‘i ‘Elepaio and all other species in the study, but the difference between nest survival of Kaua‘i ‘Elepaio and Japanese White-eye was not significant. Although we did acquire estimates for nest survival of two endangered Hawaiian honeycreepers, our sample sizes for these and all species in the study were small and require additional research. ‘Akikiki and ‘Akeke‘e appear to have relatively high nest survival when compared to species in our study and when compared to previously published estimates of Hawaiian forest birds as a whole (0.463±0.041 SE)(Woodworth and Pratt 2009). But, is 60% nest survival sufficient to sustain these populations? What was nest survival of native birds before the introduction of non-native mammalian predators? In our study, at least 43% of nest failures were attributed to mammalian nest predation. We believe this was mostly due to black rats based on the condition of the nest after the depredation even (e.g., small disturbance to nest, scat size) and the location of most nests (i.e., at the periphery of tree canopy on skinny stems).

The future

An artificial nest study was conducted concurrently to this study to determine if nest height had an effect on nest predation rate, but very few predators approached the study plots. Next year, we will modify artificial nests by applying a scent to the nest area in an attempt to better attract predators.

Most of the nests which failed were peepered from 0-3 days and collected at the end of the season. Of the 57% nests failures which could not be positively classified as depredated, only one was peepered and found with intact contents (e.g., dead chicks). All other nests were empty and we do not believe that weather was the cause of any failures. Therefore, it is possible that many other nests were depredated. In 2013, we will put cameras on nests throughout the season in hopes to determine if these empty nests are being depredated, in addition to learning what species are commonly depredating the nests in our system.

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