Territory Selection by Puaiohi:

Influence of food abundance, nest sites, and forest composition and structure

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Introduction

- The Puaiohi, *Myadestes palmeri,* is a critically endangered single-island endemic songbird
- Native to Kauaʻi, Hawaii
- Current population estimated at 200-1000 individuals[1]
- Suitable habitat restricted to high elevation (>1000m) forest in the Alaka'i Wilderness Preserve (Figures 1 and 2)
- Puaiohi mostly nest on vertical cliff walls (Figure 2)
- Puaiohi mainly frugivorous, supplementing diet with insects
- Relative influence of several factors (cliff features, forest structure and composition, and fruit abundance) on Puaiohi space use and distribution is unknown

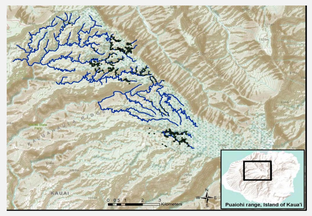


Figure 1. The current range of Puaiohi on the island of Kaua'i.

Figure 2. From left to right: Overlooking the Alaka'i Wilderness; typical stream-side habitat of Puaiohi; young Puaiohi.

Methods

Territory Mapping

•Territories mapped in 2009-2011

•Study streams (Halepa'akai and Halehaha) visited regularly during the breeding season (March-June)

•Delineated territories based on behavioral cues (e.g. counter-singing), color bands or presence of nest

Vegetation and Fruit

•Vegetation and fruit plots surveyed in 2010

•Vegetation plots (100 m^2 circular)

➢25 plots: 14 in territories, 11 out

➢Measured DBH, moss cover on trees, canopy height, shrub cover (%)

•Fruit plots (36 m^2 square)

➢105 plots:40 in territories, 65 out

➢Variables calculated: Individuals of fruit-bearing age (FBA), individuals bearing fruit (FBI), and total fruit in plot

Cliff and Nest Walls

•Cliff walls (140) surveyed in 2009

•123 walls found within territories, 17 outside

•For each wall measured:

➢Height of top and bottom of nest wall above cliff bottom

➢Vertical expanse of wall (Figure 3)

➢Shrub cover (%) and class

➢Wall surface class (categorical: dry to wet)

➢Aspect

➢Tilt class (forward, vertical, back) and tilt degree

➢Distance from wall to stream

Nests

•Nests (96) located from 2007-2009:

•Measured nest height above cliff bottom

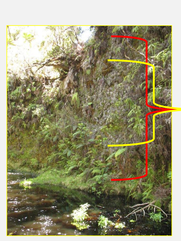


Figure 3. Photo of a typical wall demonstrating the difference between cliff and nest wall area. Cliff wall area highlighted in red and nest wall area in yellow.

Methods

- Used ArcMap 10 to overlay cliff location and survey points onto Puaiohi territories (Figures 4 and 5)

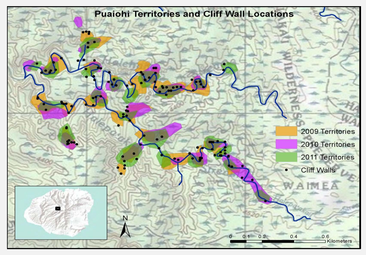


Figure 4. Map of study streams displaying territories and cliff wall locations.

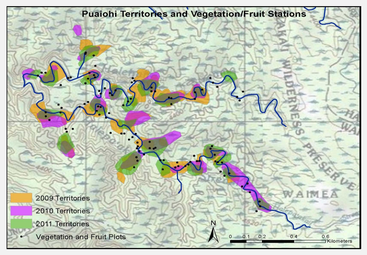


Figure 5. Map of study streams showing territories and vegetation and fruit survey plots.

Statistical analysis

- AIC approach in SAS v9.2 to examine relative importance of variables; did cliffs, vegetation, and fruit separately
- Comparison of cliffs, vegetation, and fruit in and out of territories, and used vs. unused cliffs done in Proc Logisitic
- Factors influencing number of times a cliff was used for nesting was performed in Proc Mixed

Results

Cliff and Nest Walls

•Height of bottom of nest wall and vertical expanse significantly correlated with each other and height of top of nest wall so could not include all variables in models

•Vertical expanse is greater on cliffs inside territories (Figure 6)

•Cliffs with shrub class 1 or 2 more likely to be in a territory; 58% of walls inside territories have shrub cover of 0-25%

•Tendency for cliff walls inside territories to have "vertical" tilt class

Models of Walls in Territories vs. Outside	AICc	Δ AICc	Weight
Cliff VE	96.9	0	0.351
Stream distance	98.3	1.45	0.170
Cliff VE, surface class	98.9	2.06	0.125
Cliff VE, shrub class	99.7	2.78	0.087
Tilt degree	99.9	3.04	0.077
Cliff VE, tilt degree	100.1	3.23	0.070
Cliff VE, tilt degree, surface class	101.2	4.34	0.040
Shrub class	101.4	4.49	0.037
Cliff VE, shrub class, tilt degree	101.9	5.02	0.029
Cliff VE, surface class, tilt degree, stream dist	103.5	6.61	0.013

Figure 6. Model rankings for cliff walls in and outside of territories.

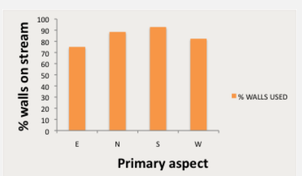


Figure 7. Slight preference for south walls, avoidance of east walls. Rain & wind usually come from the east

Fruit

•The total # fruit bearing individuals of Pukiawe was greater within territories (Figure 6)

•Higher numbers of individuals of fruit bearing age of Kanawao found in territories (Figure 7)

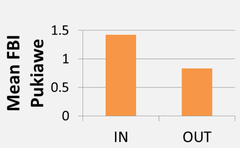


Figure 8. More Pukiawe FBI found inside territories.

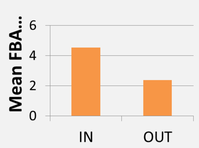


Figure 9. More Kanawao FBA found inside territories.

Vegetation and Forest Structure

•Moss coverage on trees greater in plots within territories (Figure 8)

•Moss coverage on trees positively correlated with mean DBH of trees (r=0.28) and tree density (r=0.33) within plots

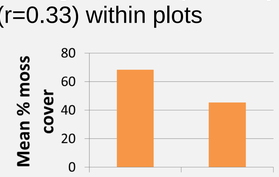


Figure 10. Mean moss cover on trees is higher in plots inside territories.

Discussion

- No territories where there are no cliffs
- Bigger, more barren and vertical walls more likely to be in territories
- Aspect could influence exposure to wind and rain, insolation, and nest temperature; further analysis needed into influence of aspect
- Moss coverage could be indicative of higher moisture or greater invertebrate density
- Fecal samples analyzed for seeds (522 seeds from 36 samples)[2]
- Kanawao significant: third most abundant fruit found in fecal samples, but less available total fruit than other species (Figures 11 and 12)

Species	Mean fruit/plot
Lapalapa (*Cheirodendron platyphyllum*)	332
'Olapa (*C.trigynum)*	135
Pukiawe (*Leptecophylla tameiameiae*)	77
Alani (*Melicope clusiifilia*)	41
Kanawao (*Broussaisia arguta*)	37

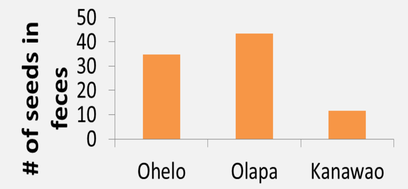
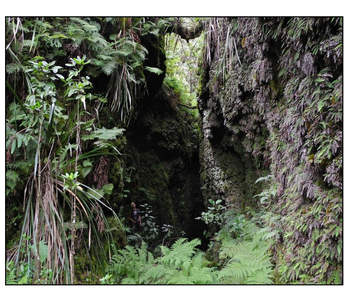


Figure 11. Left to right: top five most abundant fruit found in plots; the three most abundant seeds found in Puaiohi fecal samples.

Figure 12. Left to right: Pukiawe (*L. tameiameiae);* Kanawao (*B. arguta*).

Conclusion

- Location of cliffs influence Puaiohi distribution
- Cliff wall analysis indicated other variables, such as size and shrub cover, are significant, further investigation is needed
- Vegetation features (moss cover on trees) and fruit (*B. arguta and L. tameiameiae)* found to influence Puaiohi space use
- More research is necessary to survey more drainages over a larger area and coordinate fruit surveys with breeding season
- Results have implications for selecting suitable sites for future Puaiohi releases and habitat restoration with suitable plants



Literature Cited

1. Hawaii Division of Forestry and Wildlife. Puaiohi five-year recovery work plan 2010-2015. Unpublished report.
2. Pejchar, L. 2011. Unpublished data

Acknowledgements

We would like to thank our colleagues at U.S. Fish and Wildlife Service, Hawaii Division of Forestry and Wildlife, Pacific Cooperative Studies Unit, Liba Pejchar of Colorado State University, and numerous field assistants for their help in the field.