Avian Malaria Monitoring in The Nature Conservancy's Waikamoi Preserve

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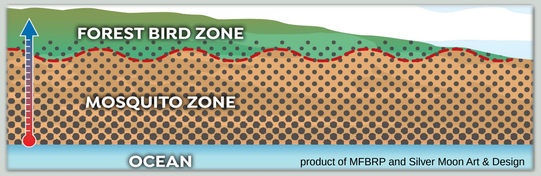
Introduction

Hawaiian honeycreepers have experienced rapid declines in the last two decades due to *Plasmodium relictum (P. relictum)*, a parasite that causes avian malaria transmitted by the Southern house mosquito (*Culex quinquefasciatus, Cx. quinx*).

Due to climate change, particularly warming temperatures and changing rain patterns, mosquitoes are moving higher up the mountain and the disease landscape is changing.



During 2021, we sought to document variation in density and distribution of *Cx. quinx* and the prevalence of *P. relictum* in mosquitoes and birds.

Methods

We sampled at two locations within the western section of The Nature Conservancy's (TNC) Waikamoi Preserve (Fig. 1). The two sites represent the lower (Kiwi) and upper (Pepe) elevational limits of endangered forest bird ranges.

Mosquito trapping was conducted twice during four seasons at each site. Eight trap stations were at each site, placed 50m apart. Each station had two trap types (Fig. 2). Traps were checked daily for presence or absence of *Cx. quinx*.

Gravid water basins and cups filled with fetid water (ovicups) were checked for presence or absence of egg rafts.

Once per sampling season at each site, mist nets were set up to catch birds to collect blood samples for Polymerase chain reaction (PCR) testing for avian malaria. PCR results do not identify whether a positive bird is a current carrier or suffering from avian malaria. The results indicate if a bird has contracted the parasite at any point in its life.

Acknowledgements

This work was made possible by funding from The U.S. Department of the Interior Science Applications Program and the State of Hawai'i Department of Land and Natural Resources-Division of Forestry and Wildlife and support from The Nature Conservancy Hawai'i. We'd like to acknowledge all the field work effort that MFBRP and TNC crewmembers put into this project. We would not be able to do this without their hard work and dedication. Windward Aviation, Haleakalā Ranch, Northern Arizona University, Haleakalā National Park, and Kaua'i Forest Bird Recovery Project also supported this work.

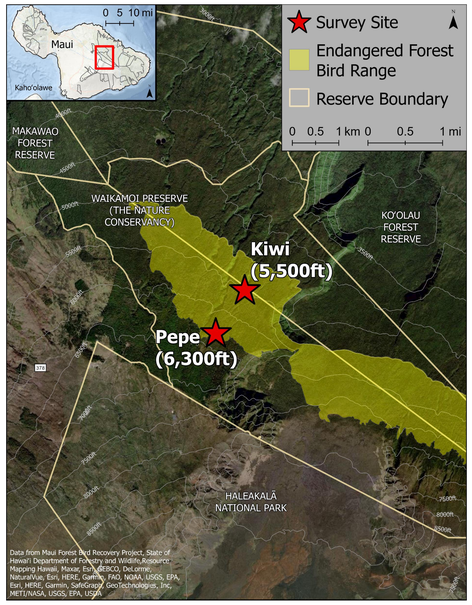


Figure 1. Location of avian malaria monitoring sites within The Nature Conservancy's Waikamoi Preserve - Kiwi (lower site, 5,500ft) and Pepe (upper site, 6,300ft). Mist netting occurred between these two sites. Mosquito trapping occured along the contour line at each site.

Figure 2. Above: Modified Centers for Disease Control and Prevention (CDC) light trap with CO_2 to target female mosquitoes looking for a blood meal. Below: Reiter-Cummings modified gravid trap with fetid water to target female mosquitoes looking to lay eggs.

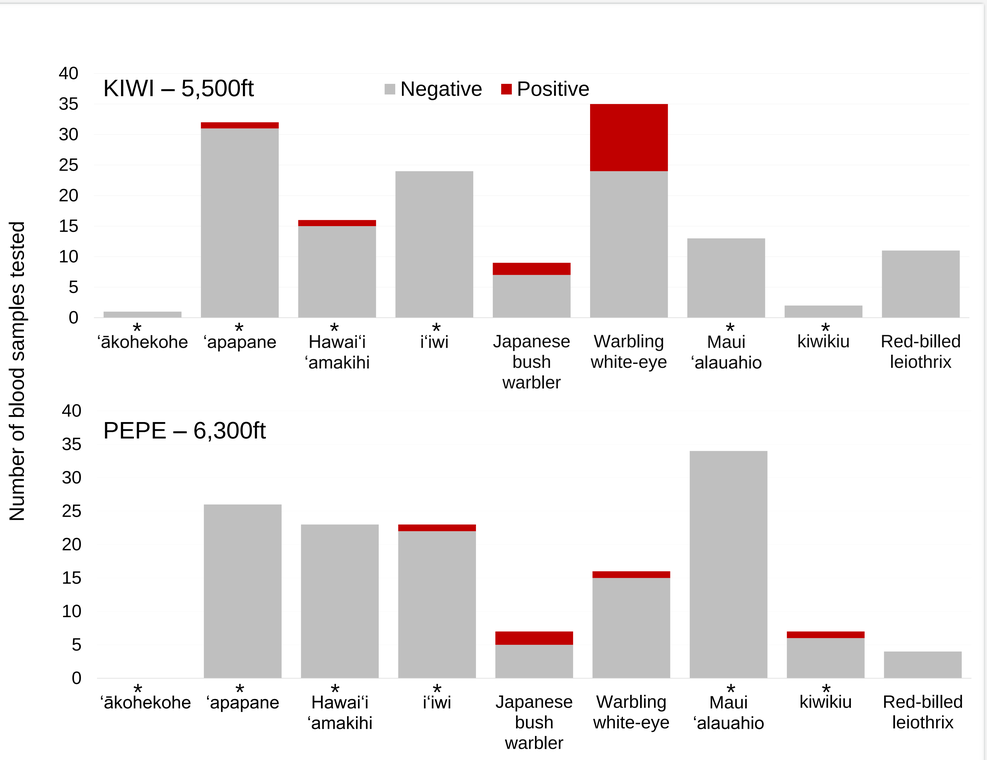


Figure 3. Blood results from polymerase chain reaction (PCR) testing conducted at Northern Arizona University from blood samples collected from native (marked with an asterisk) and non-native birds captured in mist nests from sampling locations at the lower (Kiwi, 5,500ft) and upper (Pepe, 6,300ft) elevational limits of endangered forest bird ranges within The Nature Conservancy's (TNC) Waikamoi Preserve. A positive result means *P. relictum* was present in the sample and a negative result means the parasite was not present.

Results

Cx. quinx were not captured during 826 trap nights. Egg rafts were not detected during 158 ovicup nights.

284 blood samples were collected from six native and three non-native species, including nine kiwikiu and one 'ākohekohe (endangered species).

At Kiwi, 10.5% (15/143) of all bird blood samples were positive, whereas at Pepe 3.5% (5/140) were positive. 19.5% (16/82) of three non-native species were positive, as opposed to 2% (4/201) of six native bird species.

Discussion

No *Cx. quinx* were captured during the duration of our study; however, blood sample results demonstrated that both native and non-native birds were affected by avian malaria.

The absence of mosquito captures does not mean that no mosquitoes are present. The densities could be too low to capture or there may have been adverse climatic conditions when sampling.

Birds may contract disease at lower elevations, where mosquitoes are more abundant, and travel to higher elevations to become a carrier for the disease[1].This is less likely in resident birds, like kiwikiu and Hawai'i 'amakihi, that do not have seasonal migrations.

Pathogenicity and mortality rates are diverse among different bird species[2]. Non-native species are known to have higher tolerance to the parasite and lower mortality rates[2]. Within our results, non-native species had a higher prevalence of avian malaria and malaria prevalence was greater at the lower elevation site than at the higher elevation site. The lower elevation site likely has more exposure to both temporary mosquito invasions and birds traveling lower to denser mosquito populations.

Having reservoirs for the disease and temporary mosquito incursion to Waikamoi can allow the spread of malaria even at the higher elevation site. One kiwikiu and one 'i'iwi sampled above 6,000ft tested positive for malaria, a worrisome finding considering their already restricted range.

Literature Cited

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[2]Samuel, M.D., Woodworth B.L., Atkinson C.T., Hart P.J., and LaPointe D.A. 2015. Avian malaria in Hawaiian forest birds: Infection and population impacts across species and elevations. Ecosphere 6:2- 21.