Avian malaria on Oahu: evidence of disease resistance in a native Hawaiian honeycreeper

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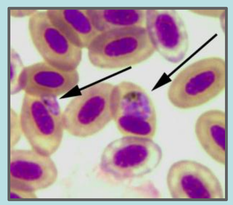
INTRODUCTION

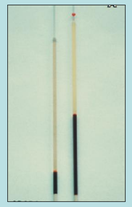
- Host species have two strategies for combating disease: **resistance** (limiting parasite load) or **tolerance** (limits damage done by pathogen)
- Introduced diseases to naïve populations with no evolutionary history with the pathogen often results in high morbidity and mortality of the host
- Avian malaria (*Plasmodium relictum*) and avian pox (*Poxvirus avium*) are introduced pathogens vectored by an introduced mosquito (*Culex quinquefasciatus*), and are known to cause significant mortality in many native Hawaiian forest bird species
- Yet a handful of Hawaiian honeycreeper species are surviving in low elevation forest habitat, including the Oahu amakihi (*Hemignathus flavus*)
- A 2007-2008 study documenting avian malaria in across 6 sites on Oahu of introduced and native forest birds (n=934) found a low prevalence in Oahu amakihi compared to other species

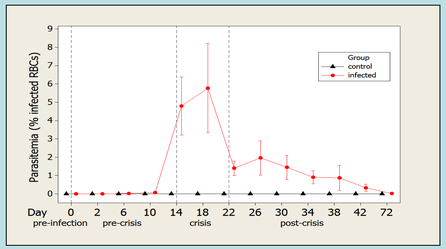
OBJECTIVES

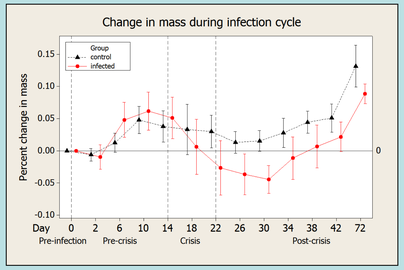
- Experimentally infect Oahu amakihi with avian malaria and track parasitemia and disease pathology for evidence of resistance or tolerance
- Compare results to similar studies in a related species, the Hawaii amakihi (*H. virens)* from the Island of Hawaii

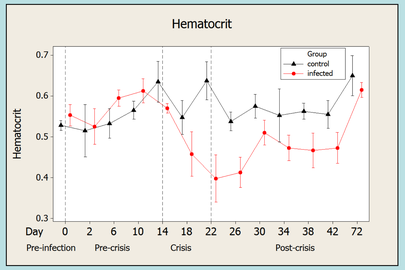
METHODS









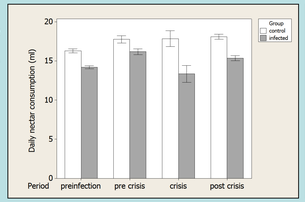


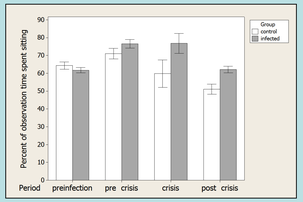
RESULTS

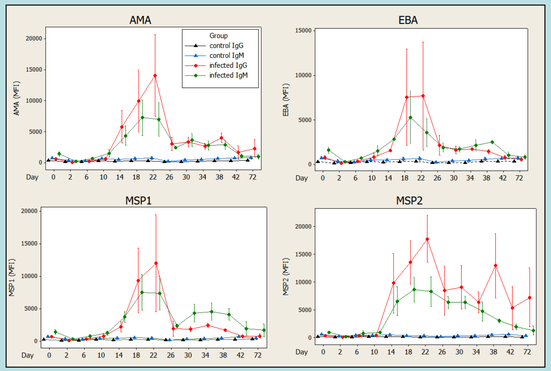
- Infected birds had a mean peak parasitemia of 8.3% (+-1.1%) during days 14-18 post-infection (PI)
- Parasitemia dropped to levels detectable only by molecular methods by day 72 PI
- No mortality occurred during the study

- No difference in mass by group or period (Mixed model ANOVA, Grp<0.52, Per p<0.08, Grp:Per p<0.19)
- Hematocrit significantly lower in infected group (Mm ANOVA, Grp p<0.02, Per p>0.50, Grp:Per p<0.011)

- Infected birds decreased nectar intake during crisis (Mm ANOVA, Grp p<0.08, Per p<0.03, Grp:Per p<0.016)
- Infected birds were less active during crisis (Mm ANOVA, Grp p<0.049, Per p>0.034, Grp:Per p<0.27)



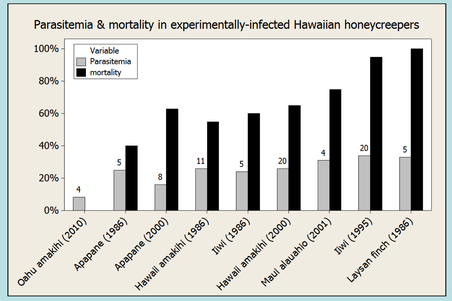




- Immune response of infected birds peaked at day 22 PI, the slowly dropped
- Some persistence shown in IgG for antigen MSP2
- Used *P. falciparum* antigens to detect IgG and IgM *P.relictum* antibodies in birds
- One of the first studies to apply the cutting edge multiplex microsphere assay for serological analyses, primarily used for human health

CONCLUSIONS

- Lowest peak parasitemia detected in experimentally infected Hawaiian honeycreepers, and no mortality recorded
- Low parasite load, limited morbidity, and strong immune response, along with low malaria prevalence in the wild suggest disease resistance
- A population of Hawaii amakihi are surviving in low elevation forests on the Island of Hawaii with high malaria prevalence in the wild and medium peak parasitemia when experimentally infected suggest disease tolerance



Oahu amakihi (*H. flavus*)	Lowland Hawaii amakihi (*H. virens*)
Low malaria prevalence in wild (11%)	High malaria prevalence in wild (35%)
Low peak parasitemia	Medium peak parasitemia
Evidence of resistance	Evidence of tolerance

- Findings suggest two different adaptive strategies have evolved to the same selective pressure of avian malaria

CONSERVATION IMPLICATIONS

- Population sizes and genetic diversity of related Hawaiian honeycreepers must be maintained to allow for disease resistance or tolerance to develop
- Studies of gene expression in resistant and non-resistant species could determine which genes are involved in fighting malaria infection
- Most serological assays done on wildlife are binomial; the animal is either positive or negative for antibodies, while this study provides a quantitative component
- The multiplex microsphere assay used to detect antibodies in human health studies and here would be ideal for work in wildlife disease because it requires only a small blood sample
- Most immunological studies on animals are conducted with cloned model organisms such as mice, and do not accurately represent the varied circumstances of wildlife disease
- Along with the island wide survey of avian malaria on Oahu, this study shows that work done in ecology and immunology can be combined to provide a more accurate representation of wildlife disease than either field separately
- Hawaiian forest birds face a challenging future; understanding how and why a few species have survived where others have not in the face of introduced disease is critical to the conservation of Hawaiian honeycreepers

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