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MES Analytical Essay

Efforts to save endemic Hawaiian Avifauna

The eerie, fluting song echoes in my ears. The recording I am listening to comes from a small, brownish bird with a long, slightly decurved bill. This individual perches high up in one of the many Ōhiʻa lehua trees that cover the unique landscape of the Alakai Swamp. His song seems to weave through the branches, hitching a ride on the mist that blankets everything. The bird is a male Kaua'i ʻōʻō, a species endemic to the island of Kaua'i and the last species within a family of birds called mohos (Mohoidae). He ends a phrase and waits a few moments for his mate's response, but he is met with silence. This bird was observed with his mate six years earlier, the two being last known individuals of their species. This recording, captured in 1987, was the last time a Kaua'i ʻōʻō was ever heard.

The ʻōʻō used to be common and widespread across Kaua'i, but invasive, disease-carrying mosquitoes drove the species to higher elevations and suboptimal nesting habitat (Pratt, 1994). After many decades of surveys, BirdLife International and the IUCN officially declared the species extinct in 2016, marking the first entire family of birds to go extinct in modern times. The mohos were just one group to fall victim to the increasingly prominent threat of avian malaria.

When European ships arrived on the shores of Hawaii, sailors unintentionally released vector-carrying *Culex* and *Aedes* mosquitoes that had stowed away in the ship's freshwater supply (Winchester and Kapan, 2013). With no native mosquitoes on the islands before their introduction, the avifauna had no biological defenses against these new pathogens. Just a single bite from an infected mosquito is enough to infect and kill a bird. In the modern era, most of Hawaii's remaining endemic bird species are listed as endangered (American Bird Conservancy, 2010). As climate change causes temperatures to increase, all of these species will be threatened by vector-carrying mosquitoes, with infections at middle to lower elevations becoming more common and extreme (Liao et al., 2017)**.** Unless urgent action is taken to reduce or eliminate malaria-transmitting mosquitoes, Hawaii is likely to lose most - if not all - of its endemic avifauna.

In a recent report by the US Fish and Wildlife Service, US Geological Survey, and the Office of Native Hawaiian Relations, three potential conservation strategies were outlined. These conservation methods are directed towards all endemic Hawaiian birds, but were considered specifically in regards to the preservation of four highly endangered endemic avifauna species: the ‘Akikiki (*Oreomystic bairdii*), the ‘Akeke’e (*Loxops caerulerostris*), the Kiwikiu (*Pseudonestor xanthophrys*), and the ‘ākohekohe (*Palmeria dolerei*) (Paxton et al., 2022).

Wolbachia **Incompatible Insect Technique (IIT)**

The first method listed in this report is perhaps the most promising conservation strategy. The Incompatible Insect Technique (IIT), which utilizes an endosymbiotic bacteria called *Wolbachia* has been heavily researched in recent years due to its application towards mitigating human-infecting strains of malaria in addition to animal strains and other mosquito-transmitted diseases. Normally, the bacteria is passed on to the mosquito’s offspring if the strains of *Wolbachia* are compatible during insect reproduction. However, if the two strains don’t match, the bacteria will initiate Cytoplasmic Incompatibility, which renders the female’s eggs infertile (Atyame et al., 2015). In IIT, male mosquitoes are infected with an incompatible strain of *Wolbachia* and released in high numbers. This is repeated multiple times in order to keep the “sterile” mosquitoes in the population. With each subsequent generation, the mosquito population is reduced. In March 2023, Hawaii’s Department of Land and Natural Resources approved this method for use in high elevation forest habitat in east Maui (governor.hawaii.gov, 2023). Subsequent releases of mosquitoes will be initiated until the population is at a desired low level. While this doesn’t eradicate the mosquitoes from Hawaii or eliminate the threat of avian malaria, the hope is that it reduces the mosquito population enough to allow for native birds to bounce back or for the reintroduction of captive bred birds.

Despite a solid understanding of *Wolbachia*, this method has drawbacks. As mentioned, it does not eradicate the disease or its vectors, so infections of avian malaria will still be present, just less frequent. With an annual cost ranging from $5,950,000 to $6,150,000 per year, this endeavor is expensive and will require continuous financial support. Other sources, such as Dodson et al., 2014 claim that *Wolbachia* infection may lead to an increased rate of other mosquito-borne pathogens such as West Nile Virus (Dodson et al., 2014). However, this must still be confirmed by other published articles. Lastly, this is not necessarily a long term solution, since new mosquitoes may still be unintentionally transported into the country via tourism and shipping (Samuel et al., 2011).

Captive Breeding Programs

The second method proposed is the use of captive care facilities for endangered species, which - in combination with the use of Wolbachia IIT - may be the best combination to protect the endangered species. Individually, this technique seems to have the most positive reception, from both international zoos, who could provide financial stability, and native Hawaiians. The most positive benefits that captive care centers offer is protection from avian malaria and other factors that could induce mortality. Additionally, having birds in a captive care center under human supervision grants more time to implement *Wolbachia* IIT, without risking extinction. The San Diego Zoo Wildlife Alliance (SDZWA) has two facilities in Hawaii that have historically been successful in caring for some of Hawaii's endemic species. Oftentimes, the success of these captive care facilities is mixed, with it being a good option for some species and less effective for others. The vast array of avifauna in Hawaii means that each species resides in a unique habitat and displays different behaviors. It would be nearly impossible to maintain a suitable environment for every species within one of these facilities, especially if long-term care was expected or plans to initiate captive breeding efforts are proposed. Risks of domestication, or human reliance, are high unless very specific precautions are taken, especially around highly intelligent or social species such as the Hawaiian Crow. Additionally, if a species has a small population, it is easy for genetic diversity to be lost or greatly reduced in captive breeding programs, making the species less resilient upon release (Snyder et al., 1996).

In conclusion, it seems that it is dependent on the species whether or not captive care may be a useful conservation tool. Ultimately, short-term housing may be most effective while mosquito numbers are in the process of reducing due to *Wolbachia* IIT treatments. This program may also be the most beneficial if used in conjunction with another option.

<u>Captive Translocation</u>

An alternative option to captive care facilities is captive translocation, or relocation elsewhere permanently, or for a period of time. This may be a better option for complexly social birds such as the ‘akeke’e, which has historically not done well in captive care facilities but still needs protection from avian malaria. Captive translocation allows the protected species to avoid removal from the natural world - instead, the individual bird is moved to an area outside of its natural range. If the presence of malaria-infected mosquitoes is high in its native range, relocation may allow the bird time to recover while *Wolbachia* IIT treatments are taking place. Longer-term relocations may be organized as well in hopes that a new population could begin establishing itself in that location, which could increase genetic diversity.

As with many cases, introduction of a new species can be incredibly risky. Hawaii itself has seen a number of species grow wildly out of control upon introduction, such as the asian mongoose. Mortality during transport is also a factor worth considering, especially if the species population is already critically low.

Conclusion

Many Hawaiian honeycreepers still teeter on the brink of extinction, with some estimated to have only two to five years left before they are gone for good. However, the development of *Wolbachia* IIT, when used in conjunction with other methods, may be just what these endangered, endemic birds need. Perhaps future research will determine a method to eradicate avian malaria, but in the meantime, the most that can be done is to minimize its effects. If a variety of successful conservation techniques are employed, with each species' unique needs taken into consideration, there may still be hope for Hawaii's endemic honeycreepers.

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