

Augmentation of the Puaiohi population through captive propagation and release on the Alakai Plateau, Kauai, Hawaii, USA

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Introduction

The Puaiohi, also known as the small Kauai thrush, is listed as Critically Endangered by IUCN/BirdLife and Endangered by the U.S. Fish and Wildlife Service. It is one of only two remaining Hawaiian species in the genus *Myadestes*, formerly comprising six Hawaiian species. (The Kamao, or large Kauai thrush (*Myadestes myadestinus*), has been considered extinct since 1989). The distribution of the Puaiohi (*Myadestes palmeri*) is currently limited to the upland, wet forests bordering the stream drainages of the Alakai Plateau, on the island of Kauai, Hawaii, at an altitude of approximately 1,050 - 1,500 m. Although endemic to Kauai and always uncommon, the Puaiohi is thought to have been more widespread and flexible in habitat use prior to the arrival of humans (Burney *et al.*, 2001). Historical census data have been



Puaiohi © Robby Kohley/SDZG

variable due to the lack of rigor in surveying effort. Based on limited surveys, the population in the mid-1990s was thought to “conservatively exceed 200 birds” (Snetsinger *et al.*, 1999). Due to its diminished range and ongoing threats, a captive population was determined to be warranted as an assurance against extinction. This captive population subsequently

acted as the source for an augmentation program. The wild Puaiohi population is currently thought to number 300-600 birds (KFBRP, unpubl. data).

Goals

- Goal 1: Establishment of a captive population as an assurance colony to prevent extinction.
- Goal 2: Successful captive propagation, sufficient to provide cohorts for re-introduction.
- Goal 3: Soft release methods to ensure high levels of post-release survivability.
- Goal 4: Augmentation of the remnant Puaiohi population, through long-term survivability and successful reproduction.



Overlooking the Alakai © Richard Switzer/SDZG

Success Indicators

- Indicator 1: Successful development of effective techniques for the collection of wild eggs, artificial incubation, hand-rearing, captive maintenance and captive breeding of Puaiohi.
- Indicator 2: Captive propagation to provide 6 - 12 Puaiohi annually that are "surplus" to the goals of species assurance, constituting release cohorts.
- Indicator 3: Short-term survivability rate of $\geq 50\%$ for 28 days post-release.
- Indicator 4: Follow-up survey data indicating an increase, or at least a halt in the decline, of the wild Puaiohi population; evidence of released birds showing long-term post-release survivability for multiple years; evidence of released birds breeding successfully in the wild.

Project Summary

Feasibility: In the mid-1990s, just as today, the remnant Puaiohi population was under pressure from a wide range of threats, including introduced predatory mammals (e.g. black rats, cats), avian-borne diseases carried by introduced *Culex* mosquitoes (avian malaria, avian pox), and the degradation of habitat by introduced ungulates (e.g. pigs, goats) and invasive plants (e.g. ginger). The majority of the Puaiohi's remnant range is located in the Alakai Wilderness Preserve, on a plateau near Mount Waialeale. Although the wet, upland forest ecosystem of the Alakai is degraded by invasive plants and introduced mammals in some locations, it is still some of the best quality forest in Hawaii and in the Puaiohi's historical range. Within the Alakai, native fruits (e.g. *Vaccinium*, *Cheirodendron*, *Styphelia*) and invertebrates - the two major food types in the wild

Puaiohi diet - are still found. Puaiohi nest primarily in niches on cliff faces running along river drainages. The territoriality of the species may limit the availability of nest-sites. Puaiohi are shy and secretive, presenting a challenge to survey and evaluate the impact of threats. The only total population estimate ever obtained for Puaiohi, from the early 1970s, is 177 ± 96 individuals (USFWS *et al.*, 1983). Research in the mid-late 1990s suggested that the population numbered more than 200 individuals, and the Puaiohi range possibly was expanding from an earlier contraction to only 20 km² (Snetsinger *et al.*, 1999). Further, more wide-spread, surveys indicated there were 300 - 500 Puaiohi in the wild by 2004 (Woodsworth *et al.*, 2009). The altitudinal rise in the "mosquito line" - the elevation limit up to which the *Culex* mosquito and the malaria parasite (*Plasmodium relictum*) can exist - was considered an ever-increasing concern, likely putting further pressure on the Puaiohi's range.

Implementation: Due to the extinction threat to the Puaiohi, the initial goal was to establish a captive, assurance population at the Keauhou and Maui Bird Conservation Centers (KBCC and MBCC) - two captive breeding facilities operated by the Hawaii Endangered Bird Conservation Program, a partnership between The Peregrine Fund, the US Fish and Wildlife Service and the Hawaii Division of Forestry and Wildlife, which was subsequently to be operated by the San Diego Zoo Global. During 1996 - 1997, 19 Puaiohi eggs were collected from wild nests and transferred to a temporary incubation and rearing facility on Kauai. Fifteen eggs were viable and resulted in the hatching of 15 chicks. When robust enough to travel to the Big Island, the chicks were transferred to aviaries at KBCC, as the founders for the captive breeding program (Kuehler *et al.*, 2000). Between 1998 and 2011, the captive breeding program produced a further 420 viable/fertile eggs and hatched 336 more chicks, of which 268 were raised to independence.

Between 1999 and 2012, 225 Puaiohi were transferred to either the Kawaikoi, Koaie or Halepaakai river drainages within the Alakai, constituting 14 release efforts. In preparation for leaving MBCC or KBCC, each bird was given a full veterinary exam to ensure they were fit for release and carrying no pathogens. Birds were transported to Kauai by inter-island plane and then transferred to the remote Koaie or Haleapaakai release sites by helicopter, or by vehicle and on foot to the more accessible site at Kawaikoi. Birds were installed in 2.4 m x 2.4 m x 2.4 m pre-release aviaries, elevated on a predator-proof scaffold approximately 1.5 m above the ground. The area immediately surrounding the aviaries was baited with rodenticide. Up to 6 birds were held in each aviary for a pre-release acclimation period of 7 - 15 days. Native berries and vegetation were provided in abundance. Several days prior to release, each bird was captured, examined, weighed, banded, and whenever appropriate, fitted with a radio-transmitter. Any birds presenting concerns at this point were not released and three birds died in the aviaries before release.

Of the 222 birds released, 176 (79.1%) were released at under one year of age. The mean age at release was 445 days. Each cohort was released by simply opening the hatch, with birds leaving the aviary at their own pace. Supplemental

food was provided in and around the open release aviaries for up to 1 month, to facilitate the birds' transition to wild foraging.

Post-release monitoring:

Whenever possible, birds were monitored using radio-telemetry up to 28 days post-release. The monitoring effort varied according to adaptive management of release methods and availability of personnel. In some years, helicopter surveys aimed to detect birds which had



Puaiohi chicks © Sharon Belcher/SDZG

dispersed long distances. During the initial 1999 release at Kawaiikoi, all 14 birds were monitored to assess survival, dispersal, and home-range establishment - all 14 birds survived up to 56 days post-release (Tweed *et al.*, 2003). In later years, the percentage of release birds with confirmed status at 28 days was as low as 8.3%. Of 222 birds released in total, 122 (55.0%) had confirmed status at 28 days post-release. Of those 122 birds, 80 (65.6%) were recorded as alive. General population surveys have resulted in longer-term observations of 20 released birds - paired up, nesting and raising at least 24 chicks to fledging (Tweed *et al.*, 2006; KFBRP, unpubl. data).

Major difficulties faced

- Although managed by the State of Hawaii as a Wilderness Preserve, the Alakai is operated for multiple purposes, including recreation and hunting. Based on the scarcity of funding and lack of feasibility for ecosystem restoration, minimal effort was made to restore Puaiohi habitat to its pristine state. It is acknowledged that this represented both a less-than-perfect scenario and a challenge in the re-introduction effort. Additionally, throughout the course of this re-introduction program, it appeared that mosquitoes had invaded further into the Puaiohi's remnant range.
- The largest sample group of released birds consisted of those with unknown status at 28 days, represented by 100 birds (45.0%). The thickly forested ridges, peaks and drainages of the Alakai plateau made radio-telemetry a challenge and impacted the evaluation of post-release survival and dispersal.
- There was low detectability of released birds long-term beyond the period of the radio-telemetry effort. Some data exists on the detectability of banded, wild birds, but this only reflects the pairs living at higher densities within the core distribution. This limitation makes it challenging to evaluate the long-term benefit of the released birds on the wild population.
- At the start of the re-introduction effort, little precise data existed on the reasons for range retraction, population and density of the Puaiohi. It is

possible (but by no means certain), that core Puaiohi habitat was at its holding capacity for territories, while habitat at the periphery of the range was being encroached upon by a number of threats. Therefore re-introduction in conjunction with only targeted amelioration of the threats impacting recruitment may have had little benefit.

- By the end of the intensive captive breeding program in 2011, several chicks showed signs of congenital abnormalities, presumed to be related to inbreeding depression. This should not be a surprise, based on more than 5 generations of reproduction descended from only 14 wild founders and their 15 eggs, resulting in a decline in the genetic diversity of the captive flock to only 84%.

Major lessons learned

- The harvest of wild eggs, artificial propagation and productive captive breeding of the Puaiohi provided a valuable source of potential new recruits for the wild population.
- Although the initial captive breeding program was established as an emergency measure to prevent extinction, the re-introduction effort would have benefitted from higher quality and more rigorous data on population, range, ecology, reproductive success, limiting factors, epidemiology of introduced disease, and other threats. This would have provided greater guidance for the re-introduction effort.
- Attempts to augment sinking populations or establish new populations are much more effective if conducted in combination with other measures to ameliorate the limiting factors.
- Similarly, the re-introduction program would have been more effective if other measures had been taken within a holistic approach to ecosystem restoration.

Success of project

Highly Successful	Successful	Partially Successful	Failure
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Reason(s) for success/failure:

- The establishment of the captive assurance colony was highly successful (particularly for a captive passerine program), with 222 birds provided for release.
- Near the midpoint of the reintroduction program, data collected from 2003 - 2006 indicated that there were 300 - 600 Puaiohi in the wild, and continuing research suggests that the population is probably stable (KFBRP, unpubl. data). Even if the population estimates are imprecise due to difficulties in acquiring census data, it can be concluded that, at best, there was an increase in the wild population, and at worst, there was no significant decline in the population. This is within the context of other endemic species in the Alakai declining drastically over the same time-frame.
- Although it is challenging to assess the long-term contribution of released birds to recruitment and population increase, at least 20 released birds successfully bred in the wild.

- The re-introduction program provided the stimulus and momentum for more extensive research of wild Puaiohi and other endemic species in the Alakai, which is currently ongoing.
- Failure to tackle the major threats that are assumed to impact the wild population has resulted in no significant increase in the range of the Puaiohi.

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