Using Discriminant Function Analysis to Accurately Sex Maui Alauahio (Paroreomyza montana)

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Introduction

The Maui Alauahio, or Maui Creeper (Paroreomyza montana), is a small insectivorous honeycreeper endemic to the island of Maui. Due to habitat loss and disease, the Alauahio is restricted to two populations on east Maui (Fig. 1); the largest occurs in wet and mesic ohia-dominated forest on the windward slope and the second in exotic-dominated dry and mesic forest on the volcano’s western slope. These populations provide an opportunity to examine behavioral and ecological differences resulting from habitat differences.

Plumage or morphometrics have been used to assign sex to captured Alauahio; however, recent observations suggest past assignments were not always accurate or appropriate for all individuals (e.g., tarsus-by-wing produces 57% unknown or incorrect sex assignments). Our goal was to develop an accurate method to sex Alauahio. The ability to confidently discriminate between male and female Alauahio will allow investigation of a variety of questions related to social structure, parental investment, disproportionate survival, and mating system, which may also aid in the recovery of closely related endangered honeycreeper species.

Methods

Since 1998, Maui Alauahio have been captured as part of ongoing research in Hananui Natural Area Reserve (NAR), on the northeastern slope of Haleakala Volcano, Maui. Mass (g), and wing, culmen, and tarsus length (mm) measurements were taken for each bird. Age was determined using plumage2 for the following classes: Hatch Year (HY), Second Year (SY), After Hatch Year (AHY), and After Second Year (ASY). When possible, birds were sexed by the presence of a pronounced brood patch (BP, N = 7) or cloacal protuberance (CP, N = 31). In 2000-2002 and in 2007-2009, a small amount of blood was taken from the brachial vein of 93 individuals. Genetic sex determination performed on all samples3, and sex was unambiguously assigned to 79 individuals. Genetic sex assignment confirmed assignment by CP/BP for all 10 individuals for which both data were available.

Discriminant function analysis is used to predict an unknown classification variable (e.g., sex) based on known quantitative variables (e.g., morphometrics). The function calculates linear combinations of the known quantitative variables (canonical variables) that explain between-class variation. We examined intersexual and inter-age differences in mass, and wing, culmen, and tarsus length of known sex birds using t-tests to determine their suitability for use in the function.

Results

All four variables (mass, wing, culmen, and tarsus) differed significantly between the sexes (Table 1) but, for the most part, not among age classes.

The only exception was that younger (HY and SY) birds had significantly shorter wings than older (AHY and ASY) birds (F3,109 = 4.81, p = 0.004).

Most conservative function: ASY birds only, N = 99. Correct Assignment = 92.6% males (96/105) and 95.6% females (95/100). Wilk’s Lambda = 0.351, p = 0.0001. Canonical Correlation = 0.805. (Fig. 2A)

Most inclusive function: all age classes, N = 99. Correct Assignment = 84.8% males (85/100) and 95.6% females (95/100). Wilk’s Lambda = 0.528, p = 0.001. Canonical Correlation = 0.687. (Fig. 2B)

Figure 1. Range of Maui Alauahio showing the two disjunct populations

Table 1. Descriptive statistics of the measurements of 107 known-sex Alauahio.

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<thead>
<tr>
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<th>Males</th>
<th>Females</th>
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<tr>
<td></td>
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<tr>
<td>Tarsus</td>
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Figure 2. Canonical plots generated from the two discriminant functions: (A) ASY birds (N = 34). (B) Individuals from all age classes (N = 99). Points and multivariate means (inner circles) are displayed in the two dimensions that best separate the groups (Canonical 1 and 2). The outer circles indicate the 95% confidence limit for the theorized mean. Females are in red and males are in blue according to CP, BP, and DNA data. Large squares indicate individuals which were incorrectly assigned by the function.

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References