Description of *Nesophrosyne melemele* sp. n., an Endemic Hawaiian Leafhopper (Hemiptera: Cicadellidae: Deltocephalinae: Opsiini) Associated with *Myoporum sandwicense* (Scrophulariaceae)

Michael D. Denis[1] and **Gordon M. Bennett**[1,2]
[1]Department of Plant and Environmental Protection Sciences, University of Hawaii at Manoa;
[2]Corresponding author, gmb4@hawaii.edu

Abstract. A new species of the endemic Hawaiian leafhopper genus, *Nesophrosyne* (Hemiptera: Cicadellidae: Deltocephalinae: Opsiini), is described: *Nesophrosyne melemele* sp. n. Morphological and molecular characters were used to delineate this species. *Nesophrosyne melemele* is endemic to Kauai and strictly associated with the endemic plant species, *Myoporum sandwicense* (Scrophulariaceae).

The endemic Hawaiian leafhopper genus, *Nesophrosyne* (Cicadellidae: Deltocephalinae: Opsiini), is descended from a single colonization event from the western rim region of the Pacific Ocean (Bennett and O'Grady 2012). *Nesophrosyne* likely shares a common ancestor with the *Orosius* genus (also placed in Opsiini), which is widely distributed throughout Asia, Australia, and African continents (Ghauri 1966, Fletcher et al. 2017). The Hawaiian diversity is derived from an adaptive radiation of species specializing broadly on the endemic Hawaiian flora (Zimmerman 1948, Bennett and O'Grady 2013). Recently, Bennett and O'Grady (2011, 2012) conducted a taxonomic review and molecular survey of the *Nesophrosyne*, describing eight new species representing the first newly described species in the genus in over sixty years. This work revealed that the genus comprises well over 200 species; however, only about a third of this diversity is currently described. Furthermore, many existing species names are questionable and difficult to identify, as historical workers based some descriptions on immatures, females, or only a few individuals (reviewed by Zimmerman 1948, Bennett and O'Grady 2011; also see Osborn 1935, Kirkaldy 1907, 1910). Recent molecular systematic work provided a clearer delineation of morphologically and genetically distinct *Nesophrosyne* species (Bennett and O'Grady 2012). Here we describe one of these new species from Kauai that relies exclusively on the endemic Hawaiian host-plant, *Myoporum sandwicense* (Scrophulariaceae). This species was previously assigned a morphotaxon designation with the provisional identifier, *"N. sp. 126"*. Phylogenetic analysis further revealed that this new Kauai species is sister to the other *Nesophrosyne* that specialize on the same host-plant across the archipelago (Bennett and O'Grady 2012).

Materials and Methods

Insect specimens were field collected under native invertebrate collection and locality access permits furnished by the State of Hawaii, Department of Land and Natural Resources. Specimens were obtained by sweep netting host-plants and preserved directly in 95% EtOH. Specimens were measured and described using a Zeiss Discovery-8 dissection microscope and photographed with Olympus SZX10 and Nikon D7100. Stacked images were merged with Helicon software (Heli-

consoft). For description of the genitalia, specimens had whole abdomens dissected. Genitalia capsules were cleared by incubation in 10% potassium hydroxide at room temperature overnight. After description and measurements, cleared genitalia were stored in glycerol within plastic vials pinned and deposited with specimens. Abdomens were used for DNA extraction (published in Bennett and O'Grady 2012: Accession Numbers: JX417555 [Cytochrome Oxidase II], JX433111 [Cytochrome Oxidase I], JX433284 [16S rRNA], JX433489 [Nuclear Histone 3], and JX433698 [Nuclear Wingless]). Species description followed that established by Bennett and O'Grady (2011), which used the morphological nomenclature outlined in Dietrich (2005) and Oman (1949). All examined material was subsequently deposited in the University of Hawaii Insect Museum, Honolulu, Hawaii, USA.

Results and Discussion

Delimitation of a new species associated with *Myoporum sandwicense*. The designation of a new species status was established based on previous taxonomic and genetic work that reviewed the described material for the *Nesophrosyne* genus (see Bennett and O'Grady 2011, Zimmerman 1948). The species described here does not match existing descriptions and was previously determined to be new with a combination of morphological and molecular characters. Only a single subspecies, *N. giffardi interrupta* Osborn, has been described as associated with the host-plant, *M. sandwicense* (reviewed by Zimmerman 1948). Although no host information was originally given for *N. giffardi giffardi* Kirkaldy, it is also restricted to *M. sandwicense* (Bennett and O'Grady 2012). *Nesophrosyne giffardi giffardi* is morphologically and genetically distinct from *N. giffardi interrupta*. The former has a completely pale clavus, while *N. giffardi interrupta* is darker in color with three articulated pale claval markings (see Zimmerman 1948). Otherwise, the remainder of the forewing is distinctly dark, verging on black, in both subspecies. As has been found for all *Nesophrosyne* species investigated to date, both are single-island endemics restricted to Hawaii island (Bennett and O'Grady 2012). Compared with material examined here for the Kauai taxon, this new species is consistently and almost entirely yellow in coloration. Genetic data further demonstrates that it is indeed a distinct morphotaxon restricted to Kauai; it was previously given the provisional name *"N. sp. 126"* (see supplemental material in Bennett and O'Grady 2012).

Taxonomy

***Nesophrosyne melemele* Denis & Bennett**

Diagnosis. *Length*: male = 2.88 mm, female = 3.58 mm. Yellow colored species. Head and vertex rounded. Frontoclypeus with a dark narrow (stylized) heart-shaped marking. Yellow saddle mark present. Aedeagus with pronounced distal processes, hooking laterally to almost 1/3 length of aedeagal arms.

Description. *Dorsum* (Figure 1A): Yellow colored species. Head rounded with vertex weakly produced. Pronotum predominately yellow with posterior edge light brown, extending 1/2 pronotal length and tapering towards lateral edges. Scutellum yellow; centrally split by diffuse dark vertical triangle that is variable in width and length; further subdivided by thin bowed dark horizontal line curving posteriorly. Forewing cells hyaline to infuscate, darkest forms with cells dark brown colored; veins darkly colored throughout; outer anteapical cell present. Clavus with diffuse yellow saddle mark with anterolateral margins fading to dark brown; yellow color broadening towards

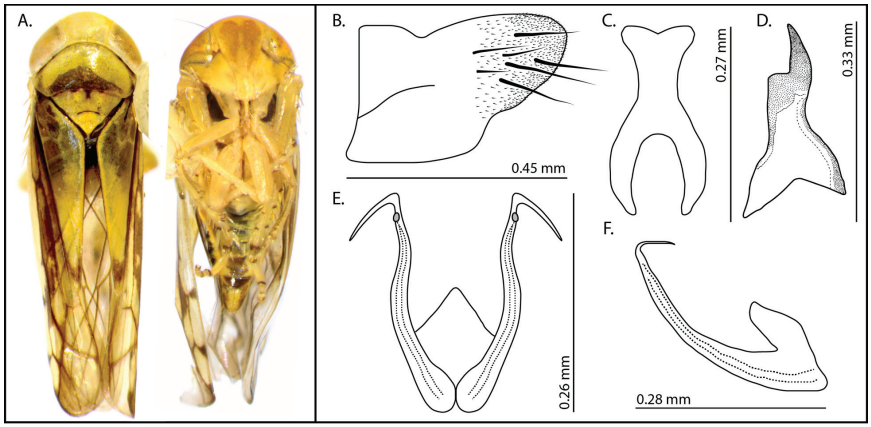

Figure 1. *Nesophrosyne melemele* **sp. n.** endemic to Kauai: (A) dorsal and ventral habitus, (B) male pygofer lateral view, (C) connective dorsal view, (D) style dorsal view, (E) aedeagus posterior view, and (F) aedeagus lateral view.

anterior claval edges.

Venter (Figure 1A): Face with clypellus yellow. Gena and lorum yellow. Antennal sockets yellow. Frontoclypeus broadly dark or brownish; vertex and edges pale, tapering towards posterior base creating a stylized heart-shaped mark on face. Thoracic plates dark. Legs pale. Ventral abdominal segments pale with infused dark bands along anterior edges.

Genitalia (Figure 1B–F): Pygofer bluntly rounded with posterior apex rising to near dorsal edge; dorsal edge flat; ventral lobe reduced with ventral edge angled towards apex; 7 macro setae irregularly distributed. Subgenital plate with dense setae distributed along its lateral edges. Aedeagus with paired aedeagal arms widely splayed, rising conspicuously higher than central apodeme; gonopore preapical; apical processes elongate, extending just above gonopore and hooking to approximately 1/3 length of aedeagal arms. Style with apophysis curved, widening at base; preapical lobe with flat lateral and posterior edges, appearing angular; articulating arm short and triangular; posterior appendages with microsetae. Connective close in length to styles with posterior edge notched; anterior arms bowed and widely splayed with ends hooking mesad.

Distribution: Hawaiian Islands, Kauai, Polihale Beach. Elevation: 3 meters

Measurements: *Body*: male (n = 7) = 2.89 mm (2.7–3.0 mm); female (n = 5) = 3.58 mm (3.2–4.0 mm). *Genitalia:* (n = 4): pygofer = 0.45 mm (0.44–0.45 mm); style = 0.34 mm (0.33–0.35 mm); connective = 0.27 mm (0.26–0.28 mm); aedeagus lateral length = 0.28mm (0.27–0.30 mm); aedeagus posterior height = 0.26 mm (0.24–0.28 mm).

Type material: Holotype: 1 male, Hawaiian Islands, Kauai, Polihale State Park. GPS: 22.29222222, 159.95972222. Elevation: 3 m. Collected on 5-Jan-2010. Host plant: *Myoporum sandwicense*. Coll. G.M. Bennett. Deposited at the University of Hawaii Insect Museum, Honolulu, Hawaii, USA.

Paratype material: 7 males and 5 females with the same locality information and collection date as the holotype mate-

rial (see above). Additional material was also deposited in the University of Hawaii Insect Museum, Honolulu, Hawaii, USA.

Etymology: Melemele is the Hawaiian word for yellow. It was chosen to describe the predominately yellow body coloration observed in male and females of this species.

Notes: *Host plant*: *Myoporum sandwicense*. Previous work referred to this species under the provisional designation as *"N. sp. 126"* (Bennett and O'Grady 2012).

Acknowledgments

We thank two anonymous reviewers for their comments that greatly improved this work. We thank Meng Mao, Kristen Poff, and Jared Bernard for their help with edits on this manuscript. We also thank Michelle Au and Xiushuai Yang for their technical support. Finally, we thank Patrick O'Grady and Dan Polhemus for early advising and help on developing this project.

Literature Cited

Bennett, G.M., and **P.M. O'Grady.** 2011. Review of the native Hawaiian leafhopper genus *Nesophrosyne* (Hemiptera: Cicadellidae: Deltocephalinae) with descriptions of eight new species associated with *Broussaisia arguta*. Zootaxa. 2805: 1–25.

Bennett, G.M., and **P.M. O'Grady.** 2012. Host-plants shape insect diversity: phylogeny, origin, and species diversity of native Hawaiian leafhoppers (Cicadellidae: *Nesophrosyne*). Mol. Phylogenet. Evol. 65: 705–717.

Bennett, G.M., and **P.M. O'Grady.** 2013. Historical biogeography and ecological opportunity in the adaptive radiation of native Hawaiian leafhoppers (Cicadellidae: *Nesophrosyne*). J. Biogeog. 40: 1512–1523.

Dietrich, C.H. 2005. Keys to the families of Cicadomorpha and subfamilies and tribes of Cicadellidae (Hemiptera: Auchenorrhyncha). Fla. Entomol. 88: 502–514.

Fletcher, M., H. Löcker, A. Mitchell, and **D. Gopurenko.** 2017. A revision of the genus *Orosius* Distant (Hemiptera: Cicadellidae) based on male genitalia and DNA barcoding. Austral. Entomol. 56: 198–217.

Ghauri, M.S.K. 1966. Revision of the genus *Orosius* Distant (Homoptera: Cicadelloidea). Brit. Mus. Occas. Pap. 18: 231–252.

Kirkaldy, G.W. 1907. Biological notes on the Hemiptera of the Hawaiian Isles No. 1. Proc. Hawaiian. Entomol. Soc. 1: 135–161.

Kirkaldy, G.W. 1910. Supplement to Hemiptera. pp. 531–599. *In* D. Sharp (ed.), Fauna Hawaiiensis. Cambridge: Cambridge University Press.

Oman, P.W. 1949. The nearctic leafhoppers (Homoptera: Cicadellidae): a generic classification and checklist. Mem. Entomol. Soc. Washington. 1: 1–253.

Osborn, H. 1935. Cicadellidae of Hawaii. Bernice. Bish. Mus. B. 134: 1–62

Zimmerman, E.C. 1948. Insects of Hawaii. Vol. 4. Honolulu: University of Hawaii Press.