Zootaxa 1427: 1–36 (2007)
www.mapress.com/zootaxa/

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

Phylogenetic analysis of the genera of endemic Hawaiian sap beetles (Coleoptera: Nitidulidae) based on morphology with redescription and key to the genera of endemic Hawaiian Nitidulidae

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Abstract

The endemic Hawaiian sap beetles were originally placed in 13 genera in 1908; *Apetasimus*, *Apetinus*, *Cillaeopeplus*, *Cyrtostolus*, *Eunitidula*, *Eupetinus*, *Gonioryctus*, *Goniothorax*, *Nesapterus*, *Nesopeplus*, *Nesopetinus*, *Notopeplus*, and *Orthostolus*. *Apetasimus*, *Cyrtostolus*, *Eunitidula*, and *Notopeplus* were described for single species, with additional species later described for *Apetasimus* and three undescribed species known for *Eunitidula* from Oahu, Molokai, and West Maui. *Nesopeplus* and *Nesopetinus* have been previously shown to be junior synonyms of *Prosopeus*. The monophyly of the genera is tested using morphological characters, primarily of the male copulatory sac, in a parsimony framework. The results provide the rationale for reducing the number of endemic genera to six; *Apetasimus* (= *Cyrtostolus* + *Orthostolus* in part), *Cillaeopeplus* (= *Notopeplus*), *Eupetinus* (= *Apetinus*), *Gonioryctus* (= *Eunitidula* + *Goniothorax* + *Nesapterus*), *Orthostolus s.s.*, and *Prosopeus*. *Brachypeplus* (= *Cillaeopeplus*) *gracilis*, a species endemic to Guam, was placed in the formerly Hawaiian endemic *Cillaeopeplus* in 1962. Examination of the types of all species of *Cillaeopeplus* shows no direct connection between *B. gracilis* and the Hawaiian taxa comprising the remainder of *Cillaeopeplus*. *Brachypeplus gracilis* is placed *incertae sedis* in *Brachypeplus* herein. The position of the endemic Hawaiian sap beetles within the nit-

Accepted by D. Pollock: 19 Jan. 2007; published: 19 Mar. 2007

idulid subfamily Cillaeinae is surveyed using exemplar species from 22 of 27 genera placed in Cillaeinae. Undescribed species from eastern Polynesia allied with *Brachypeplus* subgenus *Selis* are proposed as the closest relatives of the Hawaiian endemic sap beetles based on internal and external morphology.

Key words: Hawaii, phylogeny, brachyptery, brachypterous, wing reduction

Introduction

The Hawaiian Islands comprise the most isolated, serially-formed linear archipelago in the World, being 3,200 km from the nearest major landmass (Carson & Clague 1995), providing an ideal situation in which to study evolution of character-based and behavioral traits. Their isolation has resulted in a disharmonic flora and fauna founded by at most 350–400 colonizing insect taxa (Howarth & Mull 1992), 270–280 flowering plants (Wagner, *et al*. 1990), and 161 native species of ferns, providing a maximum number of possible fern colonization events (Palmer 2003). With less than 841 extra Hawaiian colonization events accounting for all of the present insects and vascular plants, most of the biota on a newly emergent island is derived from adjacent islands (Roderick & Gillespie 1998). Newly subaerial islands provide a release for the organisms that colonize them, potentially leading to rapid diversification of form and habit. Diverse arthropod lineages include the Hawaiian *Drosophila* (Carson 1983), *Laupala* and *Prognathogryllus* crickets (Otte 1994; Shaw 1995), *Plagithmysus* longhorned beetles (Gressit 1978), *Orthotylus* plant bugs (Polhemus 2002; Polhemus 2004), *Megalagrion* damselflies (Polhemus & Asquith 1996; Polhemus 1997), and *Blackburnia* (Liebherr & Zimmerman 1998; Liebherr & Zimmerman 2000) and *Mecyclothorax* (Britton 1948, Liebherr pers. comm.) carabid beetles. Among plants the silversword alliance (Baldwin & Sanderson 1998; Carr 1990), and lobelioids (Givnish, *et al*. 1996; Givnish, *et al*. 2000; Givnish, *et al*. 2004; Rock 1919) are best known. The Hawaiian sap beetle (Coleoptera: Nitidulidae) fauna consists of 19 introduced (Ewing & Cline 2004; Ewing & Cline 2005) and 136 described endemic species (Ford 1958; Sharp & Scott 1908) and an estimated 40+ undescribed endemic species, historically believed to have resulted from two or three colonization events. The Hawaiian endemic sap beetles exhibit a high level of island endemism, with 170 of 176 species restricted to single islands, and many species endemic to a particular volcano or ridge.

The first specimen of Hawaiian Nitidulidae described was *Prosopeus subaeneus* Murray (1864). The description was based on a single specimen erroneously believed to have been collected in Caffraria (Cape of Good Hope, South Africa). Examination of the type specimen has revealed the true locality to be the Kilauea region of Hawaii Island (Ewing 2004). The earliest extensive collections of native sap beetles in Hawaii were made by two Englishmen, the Reverend Thomas Blackburn and Dr. R. C. L. Perkins, in the late 19th and early 20th centuries (Liebherr & Polhemus 1997; Manning 1986). The species collected by Blackburn were initially described in a series of papers (Blackburn & Sharp 1885; Sharp 1878; Sharp 1879; Sharp 1881) and completely revised in the Fauna Hawaiiensis using Perkins' more extensive collections (Sharp & Scott 1908).

The origin of the Hawaiian endemic nitidulids has remained obscure. David Sharp (1878) originally proposed two introductions based on the initial Blackburn specimens from the Indo-Malayan and Austro-Malayan subregions. He placed them in two genera, *Gonioryctus* (endemic) and *Brachypeplus* (cosmopolitan) (Sharp 1878). He stated that *Gonioryctus*, under Murray's (1864) scheme of classification, would need to be placed near *Brachypeplus* and *Campsopyga* (the latter a monotypic South American genus), though he believed this to be in error and *Gonioryctus* to be most closely related to *Epuraea*. The remaining endemic species were placed in *Brachypeplus*, which is distributed worldwide but is most diverse in the southern hemisphere. The *Fauna Hawaiiensis* contained descriptions for 134 endemic species placed in 13 genera. *Gonioryctus* was retained and three additional genera were proposed for distinctive groups of *Gonioryctus* species. The species originally placed in *Brachypeplus* were placed into seven new endemic genera and two new monotypic genera, based on new collections, were described. Eleven of the 13 genera, *Goniothorax*, *Gonio-*