

The First Male Specimen of *Blackburnia fulgida* (Coleoptera: Carabidae) Reaffirms the Species' Identity and Phylogenetic Placement

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Abstract. *Blackburnia fulgida* Liebherr was described from a single, teneral female specimen. A subsequently collected, fully sclerotized male specimen confirms the initial diagnosis of the species, and provides information on male genitalic characters. A more complete species diagnosis is presented that includes the male genitalic characters, with those male characters completing the species' matrix representation in a previously published cladistic analysis. These more complete data confirm the species' phylogenetic placement as a member of a Maui Nui clade also including *B. kauwa* Liebherr of West Maui, *B. insociabilis* (Blackburn) of East Maui, *B. fraudator* (Sharp) of Molokai, and *B. filipes* (Sharp) of Lanai. Of these five species, *B. fulgida* is the only one to occur in higher elevation Koa/Ohia Montane Wet Forest characterized by more well-developed mesic soils and large-stature *Acacia koa* trees.

Key words: aedeagus, cladistic analysis, elevational gradient, parsimony, species turnover

Field collecting in support of a taxonomic revision of the precinctive Hawaiian genus *Blackburnia* Sharp (Liebherr and Zimmerman 2000) included discovery of a lone female specimen described as *Blackburnia fulgida* Liebherr. The holotype was collected from under exfoliating bark of an *Acacia koa* A. Gray (Fabaceae), at 1820–1850 m elevation in the Nature Conservancy of Hawaii Waikamoi Preserve, Haleakala volcano, Maui. Here we report the discovery of a complementary male specimen of *B. fulgida*. The new specimen can be diagnosed as *B. fulgida* based on pronotal configuration, setation, coloration, and cuticular microsculpture (Liebherr and Zimmerman 2000). The discovery of a male specimen allows us to describe the male aedeagal characters for the species. Incorporation of these

data in a published cladistic analysis of *Blackburnia* (Liebherr and Porch 2015), affirms the species' phylogenetic placement previously based on only external anatomical plus female reproductive tract characters. *Blackburnia fulgida* is a member of a clade of species distributed on the present-day fragments of Maui Nui; the islands of Lanai, Molokai, and the West Maui and Haleakala volcanoes of Maui island.

Materials and Methods

The male specimen of *B. fulgida* (Fig. 1A) was collected via application of pyrethrin spray to the mossy branches and trunk of an Ohia lehua tree (*Metrosideros polymorpha* Gaudichaud-Beaupré; Myrtaceae), with it and associated specimens collected from a tarp placed under

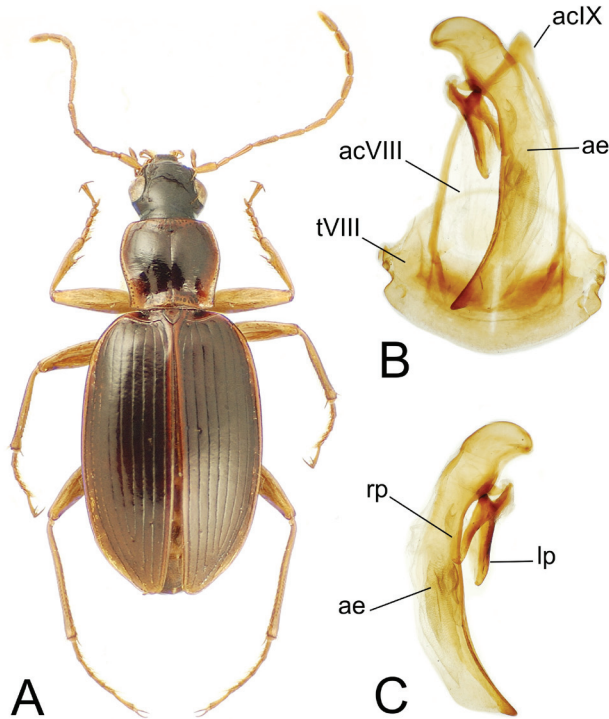


Figure 1. *Blackburnia fulgida* male: A, dorsal view, standardized body length 8.0 mm; B, male aedeagus, dorsal or anatomically left view, in situ with abdominal segments VIII and IX, including the invaginated antecostal margin of laterotergite VIII; C, male aedeagus, right view. Abbreviations: acVIII, antecostal margin of laterotergite VIII; acIX, antecostal margin of laterotergite IX; ae, median lobe of aedeagus; lp, left paramere; rp, right paramere.; tVIII, tergite of abdominal segment VIII.

the branches. Specimens were prepared and eventually determined by JKL. The male was dissected after relaxing in hot distilled water containing a drop of Photo-Flo® detergent. Using minuten nadeln and fine forceps, the aedeagus was removed from the abdomen in association with abdominal segments VIII and IX; i.e. the ninth segment including the invaginated antecostal margin (Deuve 1993), or ring sclerite (Fig. 1B). The genitalic dissection was cleared for 24 hours in cold 10% KOH, neutralized in dilute acetic acid, and then transferred to glycerin for examina-

tion, photography, and ultimate storage in a polyethylene genitalia vial attached to the specimen pin. The *B. fulgida* male and associated specimens are deposited in the Haleakala National Park Entomological Collection (HNPH).

Several measurements are used to characterize the species, including: 1, ocular ratio, or the maximal breadth across the compound eyes divided by the minimum width between the eyes; 2, relative pronotal basal constriction, i.e. maximal pronotal breadth divided by the distance between the hind angles; and 3, standard-

ized body length, or the sum of distances along the body midline, including the distance from the apical labral margin to the cervical ridge posterad the vertex, the length of the pronotum, and the distance from the basal margin of the elevated scutellar triangle to the apex of the left elytron.

Phylogenetic placement of *B. fulgida* is confirmed by scoring character states for 19 male characters (characters numbered 38–56) and adding this information to the 141 taxon, 186 character data matrix used in Liebherr and Porch (2015). The matrix is available at the Research Gate account of JKL in both Winclada (Nixon 2002) format, and as a .ss file compatible with Nona (Goloboff 1999). The cladistic analysis itself was conducted using Winclada running Nona for 5000 and 10,000 iterations of the ratchet (Nixon 1999) at default settings. The resultant trees were hard collapsed to remove branches ambiguously supported under fast or slow optimizations, with the resultant set of trees summarized using strict consensus.

Results and Discussion

Blackburnia fulgida Liebherr, 2000: 452, in Liebherr and Zimmerman 2000.

Diagnosis. The male specimen can be placed as a member of the *Blackburnia* subgenus *Metromenus* Sharp (Liebherr and Zimmerman 2000: 56) based on: 1, its brachypterous condition; 2, presence of dorsolateral sulci on the basal two meso- and metatarsomeres; 3, well developed eyes; and 4, glabrous scape bearing only a single macroseta on the dorsoanterior surface. Within subgenus *Metromenus*, the male specimen affirms the initial species diagnosis (Liebherr and Zimmerman 2000: 452), including: 1, upper body surface glossy, the pronotal disc smooth with only indistinct transverse lines visible within depressed portions of the cuticle; 2, basal pronotal seta present,

lateral pronotal seta absent; 3, apical lobes of metatarsomere 4 short; and 4, pronotum broad basally, $MPW/BPW = 1.14$ (holotype female) to 1.20 (male specimen). The eyes are moderately convex and the head narrow, resulting in ocular ratios of 1.62 for both specimens. The standardized body lengths are both 8.0 mm. For the female holotype this measurement is 0.3 mm greater than that reported in Liebherr and Zimmerman (2000: 452). The only amendment needed to the identification key in Liebherr and Zimmerman (2000: 68) is to note the presence of evident, shallowly margined isodiametric sculpticells on the elytra, those sculpticells difficult to trace in areas of reflected light. More well-developed microsculpture is commonly observed in mature versus teneral adult carabid beetles.

The male specimen is fully sclerotized (Fig. 1A), with the elytra and pronotal margins opaque in contrast to those of the teneral female holotype (Liebherr and Zimmerman 2000, fig. 278a).

Nonetheless, the body of this species is pale, with the dark brunneous pronotal and elytral discs contrasted with the flavous margins, and the legs, including the femora, tibiae and tarsi flavous. This pale coloration differentiates this species from the other Haleakala species, *B. insociabilis* (Blackburn), which is characterized by a piceous body with glossy reflection and brunneous legs. Moreover, *B. insociabilis* is smaller; standardized body length 7.2–7.5 mm (Liebherr and Zimmerman 2000, 457). In addition, the aedeagal median lobe apex of *B. fulgida* is narrowly rounded (Fig. 1C), versus more broadly rounded and parallel sided in *B. insociabilis* (Liebherr and Zimmerman 2000: fig. 280a).

Male genitalia. Antecostal margin of tergite VIII (Deuve 1993) angulate distally, angulate apex slightly broader than lateral arms (Fig. 1B); aedeagal me-

dian lobe lightly melanized, translucent in cleared specimen, lightly spiculate internal sac folds visible through wall of lobe (Figs 1B, C); basal bulb smooth, without sagittal crest; lobe gracile, slightly broadened dorsoventrally near midlength, ventral margin straight near midlength, and ventral surface slightly depressed beyond straight portion before ventral curvature before apex (Fig. 1C; lobe apex narrowed from edge of ostial opening to narrowly rounded, subacuminate tip).

Distribution. The male specimen bears locality information: HI: Maui Is. Haleakala, Waikamoi N.C.P., 1760 m el., 20°47.21'N 156°13.82'W, 12-iii-2002, R. Takumi [Kahoolaa], pyrethrin fog mossy Ohia. The specimen was found in association with one specimen each of *Blackburnia abaxoides* Liebherr, *B. fracta* (Sharp), and *B. sphodrififormis* (Sharp), and 8 specimens of *B. erro* (Blackburn). The newly reported locality is only slightly downhill from the type locality (Fig. 2).

Phylogenetic placement. Cladistic analysis under parsimony using Nona running within Winclada resulted in 1727 equally parsimonious trees of 1137-step length after 5000 ratchet iterations, and 3085 trees of the same length in the 10,000 iteration analysis; sets of equally parsimonious trees of length equal to those previously reported in Liebherr and Porch (2015). Hard collapsing these trees to eliminate all trees ambiguously supported under fast or slow optimizations left 827 unambiguously optimized trees for the 5000 ratchet run, versus 1143 unambiguously optimized trees in the 10,000 ratchet analysis. Strict consensus of trees in both subanalyses collapses 26 nodes, resulting in a 1225-step consensus tree with relationships also identical to that reported by Liebherr and Porch (2015, fig. 2B). In the five-species clade (Fig. 3), *B. fulgida* is adelphotaxon to the three-species clade (*B. insociabilis* (*B. fraudat-*

tor + *B. filipes*)). All of these species are distributed on fragments of Maui Nui, with *B. fulgida* and *B. insociabilis* both distributed on Haleakala, East Maui (Fig. 3). The *B. insociabilis* locality records are widespread from Olinda to Kipahulu Valley, at elevations from 900–1425 m (Liebherr and Zimmerman 2000), whereas the two *B. fulgida* localities range from 1760–1850 m elevation. Within that elevational range, one specimen was collected from underneath a loose bark flap of an *Acacia koa* tree, and the second from a mossy Ohia branch; both situations within the Koa/Ohia Montane Wet Forest (Gagné and Cuddihy 1990). Thus based on available evidence, sympatry between *B. insociabilis* and *B. fulgida* appears to be allopatrically dissected by elevation, with *B. fulgida* found near the upper reaches of the montane forest approaching treeline. Elevational occurrences of the other three species in this clade match that of *B. insociabilis*, with these species occurring within cloud forest habitats at elevations between 605 and 1280 m. That *B. fulgida* can occupy high elevation forest well above 1700 m elevation is made possible by the greater stature of Haleakala. That this species is not known to extend to lower elevation forest conversely suggests that the ecological preference of *B. fulgida* centers on the higher elevation Koa/Ohia Montane Wet Forest that can be characterized by lower levels of rainfall, and also deeper, more well-aerated soils housing symbiotic mycorrhizal *Bradyrhizobium* Jordan bacteria that support *Acacia koa* (Nakao and Kitayama 1996). Haleakala is the only mountain of Maui Nui tall enough to house such high-elevation mixed Koa/Ohia forest. Both Lanai and Molokai lack any habitats of this elevation, and Puu Kukui, West Maui attains 1760 m elevation, but has only limited tracts of low-stature Ohia Montane Wet Forest near its summit (Gagné and Cuddihy 1990). Thus

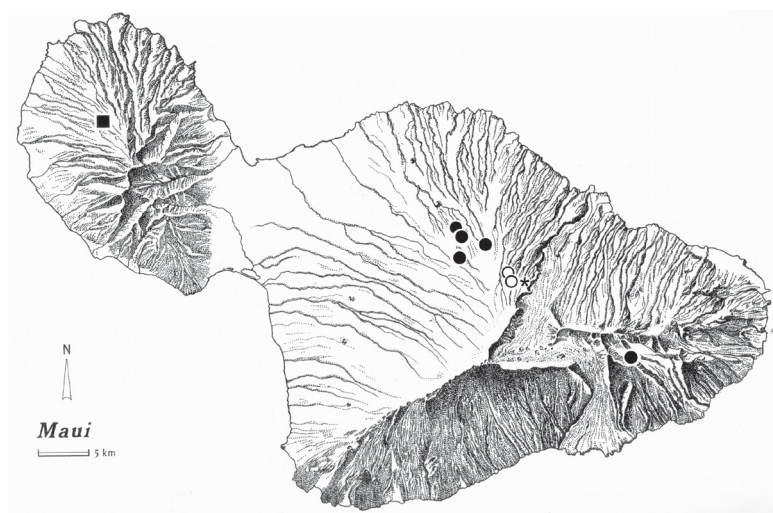


Figure 2. Known localities of the three Maui species in the five-species clade including *Blackburnia fulgida*: *B. kauwa* (■), *B. fulgida* (○), *B. insociabilis* (●). Type locality of *B. fulgida* indicated by asterisk (*).

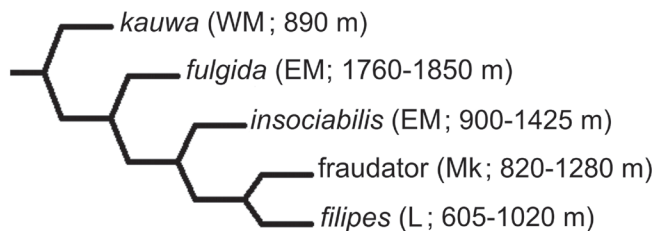


Figure 3. Cladistic relationships among the five species of the monophyletic group including *Blackburnia fulgida*, along with distribution areas, and elevational ranges of collected specimens. Abbreviations: WM, West Maui; EM, East Maui, i.e. Haleakala; Mk, Molokai; L, Lanai.

B. fulgida stands out as a high-elevation specialist among species of this clade.

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