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Bohayella rodrigodiazi sp. nov.: a new species from Ecuador with an updated key to the New World species of *Bohayella* Belokobylskij (Hymenoptera, Braconidae, Cardiochilinae)

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Abstract

The New World species of *Bohayella* Belokobylskij, 1987 are revised based on morphological data, and a new species of the genus from Ecuador is described: *Bohayella rodrigodiazi* Kang, **sp. nov.** This work includes an updated identification key to species of *Bohayella* in the New World along with images of diagnostic characters. The number of recorded *Bohayella* species in the New World is increased from two to three.

Keywords

Melanism, Neotropical region, parasitoid wasp, taxonomy

Introduction

Ecuador has 228 braconid species recorded (Yu et al. 2016), including two members of the subfamily Cardiochilinae Ashmead, 1900 recorded by Fischer (1958) as *Cardiochiles aterrimus* Fischer and *C. purpureus* Fischer. A small genus of

cardiochilines, *Bohayella* Belokobylskij (Belokobylskij 1987) contains eleven species worldwide. Among these species, two recently described new species occur in lowland and cloud forests of Costa Rica, *B. geraldinae* Kang and *B. hansoni* Kang (Kang et al. 2020). Host records of two Old World species, *B. adina* (Wilkinson) and *B. exiguura* (Huddleston & Walker), were provided by Beeson and Chatterjee (1935), Huddleston and Walker (1988), and Dangerfield et al. (1999). Unfortunately, nothing is known about biology of New World members of the genus. The validity of the genus was corroborated by phylogenetic data in Dangerfield et al. (1999), based solely on morphological data, and again by Murphy et al. (2008) based on molecular data. These data indicate that *Bohayella* species form a monophyletic group. A new species of Ecuadorian *Bohayella* is described herein, the key to species in the New World is updated, and a distribution map for the new species is provided.

Materials and methods

Specimens

Specimens for this project were borrowed from the Texas A&M University Insect Collection (TAMU; College Station, Texas, USA) and University of Wyoming Insect Museum (UWIM; Laramie, Wyoming, USA). Holotype and paratypes of the new species will be housed in TAMU.

Morphological analysis and morphometric characters

Morphological characters were examined using a Leica MZ75 stereomicroscope. Morphometric characters were measured using Adobe Photoshop CS 6 (Adobe Systems, Inc). Numbers in parentheses in a species description indicate 0.01 × the actual size of each body part. The unit of length used in the current work is mm.

Terminology

Morphological terms and terms for wing venation used are largely based on those of Dangerfield et al. (1999) and Sharkey and Wharton (1997). Terms for surface sculpturing follow Harris (1979). Most terms used in the current work can be also confirmed on the Hymenoptera Anatomy Ontology website (http://portal.hymao.org/projects/32/public/ontology/). The following acronyms are used throughout: POL: distance between posterior ocelli, T1: first metasomal tergite, T2: second metasomal tergite, T3: third metasomal tergite, T4: forth metasomal tergite, and T8: eighth metasomal tergite.

Imaging and image processing

Images were initially captured using a Visionary Digital BK Plus imaging system (Dun, Inc.), equipped with a Canon EOS 5DS DSLR camera. Image stacking was performed using Zerene Stacker v.1.04 (Zerene Systems LLC.). Images were edited using Adobe Photoshop CS 6 or Adobe Photoshop CC 2019 (Adobe Systems, Inc), and image plates were generated using the same software.

Results

Taxonomy

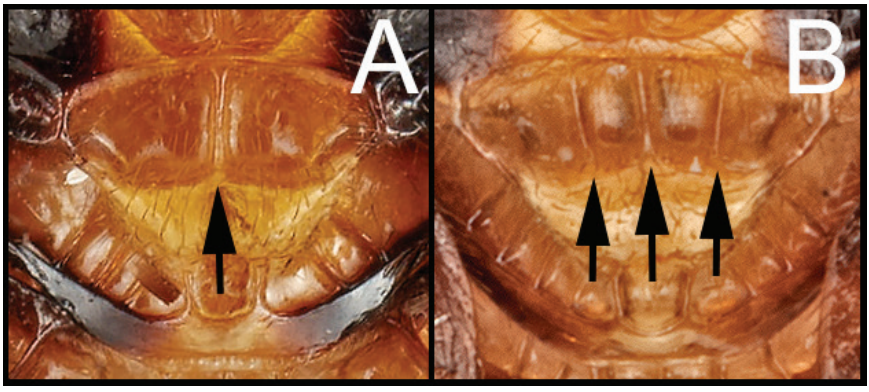
***Bohayella* Belokobylskij, 1987**

Type species. *Bohayella tobiasi* Belokobylskij

Diagnosis. Detailed diagnostic characters were described by Belokobylskij (1987), Dangerfield et al. (1999), and Kang et al. (2020). The genus is easily recognized by the following characters: Body small in size. Eyes with interommatidial setae, length and density of setae variable. Clypeal tubercles absent. Mouthparts short. Occipital carina absent. Mesonotum and mesopleuron strongly sculptured. Scutellum with apical cup-like pit. Epicnemial carina present. Median areola of propodeum fully developed. Metatibia without apical projection. Claws pectinate. Elongate and narrow T1 > 4.00 ×). T2 short and with a ball-like projection medio-basally. Hypopygium short and obtuse apically. Short ovipositor and ovipositor sheath (~0.20 × the length of metatibia).

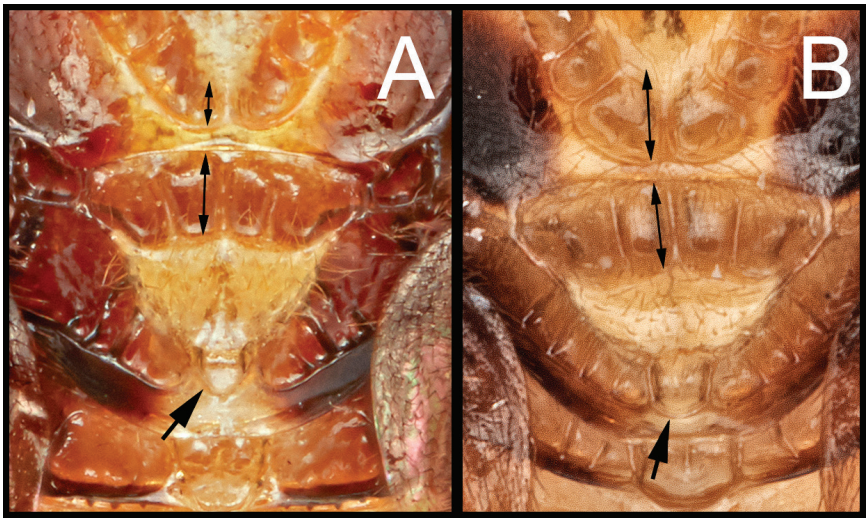
Key to species of New World *Bohayella*

1 A. Scutellar sulcus with a median crenula..... ***B. geraldinae***
– B. Scutellar sulcus with three crenulae **2**



2 A. Median crenula of notauli apparently shorter than median crenula of scutellar sulcus; apical cup-like pit of scutellum with V-shape posterior margin ..... ***B. hansoni***

– B. Median crenula of notauli slightly shorter than median crenula of scutellar sulcus; apical cup-like pit of scutellum with U-shape posterior margin .... ***B. rodrigodiazi* Kang, sp. nov.**



***Bohayella geraldinae* Kang, 2020**

Material examined. ***Holotype*** Costa Rica • ♀; Heredia, 3 km S. Puerto Viejo OTS, La Selva; 100 m; Oct.1992; P. Hanson leg.; Huertos, Malaise trap set by G. Wright. ***Paratypes*** Costa Rica • 1 ♀; same data as for holotype; Nov. 1992 • 1 ♂; same collecting data as for preceding; 10°26'N, 84°01'W; 4, Apr. 1987; H. A. Hespenheide leg.

Diagnosis. Specimens of *B. geraldinae* are distinguished from Old World members by having angled RS and acute apical tooth on claws, and the members of *B. geraldinae* are distinct from the members of *B. rodrigodiazi* sp. nov. by having scutellar sulcus with one median crenula; apical maxillary palpomere as long as penultimate maxillary palpomere; median length of T1 ~5.10 × longer than apical width; T2 medially 0.21 × longer than T1; metasomal tergites generally pale but melanic apically.

Description. See Kang et al. (2020).

Male. See Kang et al. (2020).

Host. Unknown.

Distribution. Costa Rica (La Selva Biological Station).

***Bohayella hansoni* Kang, 2020**

Material examined. ***Holotype*** Costa Rica • ♀; Puntarenas, San Vito, Estac. Biol., Las Alturas; 1,500 m; Jun. 1992; Paul Hanson leg.; traps #1 + #2, Malaise. ***Paratypes***

Costa Rica • 2 ♀; same data as for holotype • 2 ♀; same collecting data as for preceding • 1 ♀; same collecting data as for preceding; 1,700 m; 11, Apr. 1993.

Diagnosis. Members of *B. hansoni* may be distinct from Old World members by having angled RS and acute apical tooth on claws and the members of *B. hansoni* are distinguished from the members of *B. rodrigodiazi* sp. nov. by the following characters: median crenula of notauli shorter than median crenula of scutellar sulcus; apical cup-like pit of scutellum with V-shape posterior margin; metafemur ~0.31 × longer than its length; metabasitarsus cylindrical; median length of T1 4.00 × longer than apical width; T2 melanic; T3 ~2.55 × longer than T2 medially.

Description. See Kang et al. (2020).

Male. Unknown.

Host. Unknown.

Distribution. Costa Rica (Las Alturas Biological Research Station).

***Bohayella rodrigodiazi* Kang, sp. nov.**

http://zoobank.org/CD40E5E1-EF61-4F02-B960-100859706FEE

Fig. 1A–F

Material examined. ***Holotype*** Ecuador • ♀; female, Sucumbíos, Rio Napo, Sacha Lodge; 0°30'S, 76°30'W, 270 m; 4–14, Mar. 1994; Malaise trap; P. Hibbs leg. ***Paratypes*** Ecuador • 1 ♀; same data as for holotype; 78°30'W; 220–230 m; 12–22, Jun. 1995. • 1 ♀; same collecting data as for preceding (Note: According to the GPS coordinates, Sacha Lodge is located near 0°30'S, 76°30'W.).

Diagnosis. *B. rodrigodiazi* sp. nov. can be distinguished from *B. geraldinae* by the following characters: apical maxillary palpomere slightly longer than penultimate maxillary palpomere; scutellar sulcus with three crenulae; median length of T1 ~4.78 × longer than apical width; T2 medially ~0.31 × longer than T1; T4 medially melanic. *B. rodrigodiazi* sp. nov. can be distinguished from *B. hansoni* by the following characters: median crenula of notauli as long as median crenula of scutellar sulcus (Fig. 1D); apical cup-like pit of scutellum with U-shape posterior margin (Fig. 1D); metabasitarsus antero-posteriorly slightly expanded; T1 ~4.78 × longer than apical width; ball-like projection of T2 pale (Fig. 1E); T3 ~1.81 × longer than T2 medially.

Description. Body ~4.95–~5.06 mm. Forewing length: ~4.46 mm. Hindwing length: ~3.50 mm. Antenna length: ~4.84–~5.11 mm. ***Head.*** Antenna 33–34-segmented. Interantennal space with median carina. POL ~1.31 × longer than diameter of anterior ocellus (17:13). Eye sparsely setose with minute setae; length of eye 0.78 × longer than median width of gena in lateral view (39:50). Gena ventro-posteriorly extended into moderate prominence. Width of clypeus 2.04 × longer than height (49:24). Malar space ~1.83 × longer than basal width of mandible (22:12). Mandible bidentate. Maxillary palpus five segmented; apical maxillary palpomere ~1.11 × longer than penultimate maxillary palpomere (21:19). ***Mesosoma.*** Mesoscutum with sharp margin. Notauli broadly converging at base, with eleven crenulae; median crenula of notauli ~0.82 × longer than median crenula of scutellar sulcus

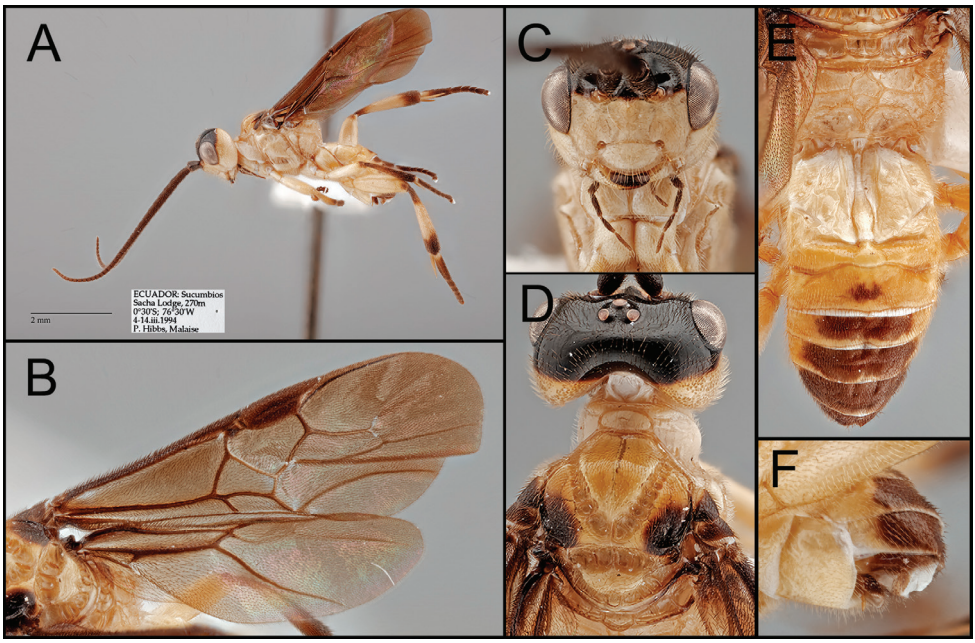


Figure 1. *Bohayella rodrigodiazi* sp. nov. **A** lateral habitus **B** wings **C** anterior head **D** dorsal head and mesonotum **E** dorsal propodeum and metanotum **F** latero-ventral hypopygium.

(18:22). Scutellar sulcus with three crenulae. Apical cup-like pit of scutellum with U-shape posterior margin. Postscutellar depression present. Propodeum rugulose; median areola of propodeum apparent; median transverse carina of the propodeum reaching lateral margin. Pronotum anteriorly smooth and posteriorly crenulate. Mesopleuron dorsally and posteriorly with crenulate margin. Epicnemial carina present medially. Metapleuron anteriorly smooth and posteriorly crenulate. ***Legs.*** Basal spur on protibia ~0.76 × longer than basitarsus (34:45). Basal spur on mesotibia ~0.89 × longer than basitarsus (42:47). Width of metafemur ~0.34 × longer than its length (46:135). Basal spur on metatibia ~0.82 × longer than basitarsus (65:79). Metatarsal claw pectinate. ***Wings.*** Forewing second submarginal cell trapezoidal, ~0.35 × longer than its maximum width (30:86); 3r absent; RS sharply angled at basal third; stigma ~3.31 × longer than medial width (116:35); 1CUa short, 0.26 × longer than 1Cub (13:50). Hind wing 2–1A absent. ***Metasoma.*** T1 with a pair of lateral sutures posteriorly reduced, median length of T1 ~4.78 × longer than apical width (67:14). T2 with a ball-like projection, medially ~0.31 × longer than T1 (21:67). T3 ~1.81 × longer than T2 medially (38:21). Protruded ovipositor sheath ~0.15 × longer than Metatibia and apically setose (26:174).

Color. Body mostly pale; the following areas darker: antenna, vertex, frons, dorsal occiput, labrum, mandible apically, maxillary palpus, labial palpus, lateral mesonotal lobe posteriorly, tegula, margin of metanotum posteriorly, apical protibia, protarsus,

apical mesofemur, mesotibia, mesotarsus, apical metafemur, basal and apical metatibia, apical metatarsus mostly, T4–T8 (one specimen with melanic T3 medially), ovipositor sheath. Wings entirely infuscate, stigma darker.

Male. Unknown.

Host. Unknown.

Distribution. *B. rodrigodiazi* sp. nov. is known only from Sacha Lodge, Rio Napo, Sucumbíos, Ecuador at the elevations of 220m and 270m.

Etymology. This species is named in honor of Dr Rodrigo Diaz, Associate Professor of biological control in the Department of Entomology, Louisiana State University. He is the PhD advisor of the author of this paper (IK) and originally from Quito, Ecuador.

Discussion

Bohayella rodrigodiazi sp. nov. is the third species of *Bohayella* recorded from the New World. The three species of New World *Bohayella* have similar body coloration, but their dorsal metasomal colors are diagnostic and may be correlated to the altitudes of their habitats. Specimens of *B. geraldinae* collected at altitudes of ~100m possess the palest tergites among the three species. Specimens of *B. rodrigodiazi* sp. nov. collected at the altitudes of ~250m have darker tergites than the members of *B. geraldinae* and paler tergites than specimens of *B. hansoni*. Specimens of *B. hansoni* collected at the altitudes above 1,500m possess the darkest tergites of the three species. This corresponds with the observations by Kang et al. (2020) that melanism of New World *Bohayella* species is associated with elevation. This pattern has been noted in other wasps by de Souza et al. (2020), Fernandez-Triana et al. (2014), and Mora and Hanson (2019). Also, melanism correlated with altitudinal gradient has recently been reported in dung beetles by Stanbrook et al. (2021). It is probable that there are a number of undescribed species of *Bohayella* as yet undiscovered in the neotropics.

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References

Beeson CF, Chatterjee SN (1935) On the biology of the Braconidae (Hymenoptera). Indian Forest Records 1: 105–138.

Belokobylskij SA (1987) A new genus of the subfamily Cardiochilinae (Hymenoptera, Braconidae) from the USSR Far East. Zoologicheskiy Zhurnal 66(2): 302–304.

Dangerfield PC, Austin AD, Whitfield JB (1999) Systematics of the world genera of Cardiochilinae (Hymenoptera: Braconidae). Invertebrate Systematics 13(6): 917–976. https://doi.org/10.1071/IT98020

de Souza AR, Mayorquin AZ, Sarmiento CE (2020) Paper wasps are darker at high elevation. Journal of Thermal Biology 89: e102535. https://doi.org/10.1016/j.jtherbio.2020.102535

Fernandez-Triana JL, Whitfield JB, Smith MA, Hallwachs W, Janzen DH (2014) Revision of the neotropical genus *Sendaphne* Nixon (Hymenoptera, Braconidae, Microgastrinae). Journal of Hymenoptera Research 41: 1–29. https://doi.org/10.3897/JHR.41.8586

Hymenoptera Anatomy Consortium (2021) Hymenoptera Anatomy Consortium. http://glossary.hymao.org [Accessed on Oct 2021]

Harris RA (1979) Glossary of surface sculpturing. Occasional Papers in Entomology 28: 1–31.

Huddleston T, Walker AK (1988) *Cardiochiles* (Hymenoptera: Braconidae), a parasitoid of lepidopterous larvae, in the Sahel of Africa, with a review of the biology and host relationships of the genus. Bulletin of Entomological Research 78(3): 435–461. https://doi.org/10.1017/S0007485300013201

Kang I, Shaw SR, Lord NP (2020) Two new species and distribution records for the genus Bohayella Belokobylskij, 1987 from Costa Rica (Hymenoptera, Braconidae, Cardiochilinae). ZooKeys 996: 93–105. https://doi.org/10.3897/zookeys.996.59075

Mora R, Hanson PE (2019) Widespread Occurrence of Black-Orange-Black Color Pattern in Hymenoptera. Journal of Insect Science 19(2): 13: 1–12 https://doi.org/10.1093/jisesa/iez021

Murphy N, Banks JC, Whitfield JB, Austin AD (2008) Phylogeny of the parasitic microgastroid subfamilies (Hymenoptera: Braconidae) based on sequence data from seven genes, with an improved time estimate of the origin of the lineage. Molecular Phylogenetics and Evolution 47(1): 378–395. https://doi.org/10.1016/j.ympev.2008.01.022

Sharkey MJ, Wharton RA (1997) Morphology and terminology. In: Wharton RA, Marsh PM, Sharkey MJ (Eds) Manual of the New World genera of the family Braconidae (Hymenoptera). Special Publication of the International Society of Hymenopterists, No 1, Washington DC, 19–37.

Stanbrook RA, Harris WE, Wheater CP, Jones M (2021) Evidence of phenotypic plasticity along an altitudinal gradient in the dung beetle *Onthophagus proteus*. PeerJ 9: e10798. https://doi.org/10.7717/peerj.10798

Wilkinson DS (1930) New species and host records of Braconidae. Bulletin of Entomological Research 21: 481–487. https://doi.org/10.1017/S0007485300024822

Yu DS, Achterberg C van, Horstmann K (2016) Taxapad, Ichneumonoidea. Vancouver, Canada. http://www.taxapad.com