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A new genus of tiger beetle (Coleoptera: Cicindelidae) from the Nearctic and Neotropical realms

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Abstract

The taxonomically problematic tiger beetle species, *Cylindera lemniscata* (LeConte, 1854), has been difficult to place within the Nearctic fauna because of its peculiar morphological characteristics which were noted in its description, and by subsequent workers. Molecular phylogenetic studies of the late 1990s and early 2000s were similarly unable to reach a consensus about its systematic placement. More recently, a densely sampled mtDNA genealogy recovered *Cy. lemniscata* as a monotypic clade that is sister to a larger clade of Nearctic tiger beetles that included species of *Dromochorus* Guérin-Méneville, 1845, *Ellipsoptera* Dokhtouroff, 1883 and *Parvindela* Duran & Gough, 2019. In this present study, morphological characters were assessed for *Cy. lemniscata* and all of the above taxa, as well as members of the genus *Brasiella* Rivalier, 1954 and *Cicindelidia cardini* (Leng & Mutchler, 1916), a poorly known Cuban endemic with markings that are remarkably similar to *Cy. lemniscata*. The consensus of molecular and morphological analyses indicates that *Cy. lemniscata* is not congeneric with any other species, and as such, we erect *Jundlandia* Duran & Gough 2022, new genus, to accommodate this unique taxon. Future molecular work may determine that *Ci. cardini* may belong in *Jundlandia*.

Key words: Cicindelinae, integrative taxonomy, *Jundlandia*, *Parvindela*, taxonomy

Introduction

Until recently, nearly all tiger beetle (Coleoptera: Cicindelidae) taxonomy had been based on morphology (e.g., Dejean 1825; Horn 1915; Rivalier 1950; Ball *et al.* 2011), utilizing characters such as the presence and number of setae on various body sections, the shapes of internal structures of the aedeagus, and the structures of mouthparts. However, phylogenetic studies based on mtDNA and other genetic markers frequently recovered groupings that were incongruous with the traditional taxonomy (e.g., Vogler & Welsh 1997; Galián *et al.* 2002; Pons *et al.* 2004; Gough *et al.* 2019). Recently, there has been an integration of molecular and morphological data which has supported a formal updating of the taxonomy. Well-supported clades have been identified using this integrative framework, both at the species and genus level (Duran & Gough 2019; Duran *et al* 2019, Duran *et al*. 2020, Duran *et al* 2021) and higher-level (Duran & Gough 2020). This approach has been used to resolve the placement of problematic taxa that were *incertae sedis* based on morphology alone (e.g., *Cicindela willistoni,* LeConte, 1879).

The taxonomic placement of the Nearctic species *Cylindera lemniscata* (LeConte, 1854) has been enigmatic from the start. Described as *Cicindela lemniscata* by LeConte (1854), he noted that it was unlike any other North American tiger beetle he had ever seen, given its slender and cylindrical body and unique maculations. LeConte stated that it was the "…only species known to me in which the elytra are ornamented with a vitta equally remote from the suture and the margin". Rivalier (1954) examined the structures of the aedeagus in his revision of the *faune Américaine* and believed *Cy. lemniscata* to be most similar to the New World species that he included in *Cylindera* Westwood, 1831, although *Cy. lemniscata* was seen to represent one end of the continuum of genitalic structures within that group.

Since Rivalier's work (1954), little other morphological work has been done, and all subsequent work has been

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based on molecular data. In Vogler &Welsh (1997), *Cy. lemniscata* was recovered in a clade containing *Brasiella praecisa* (Bates, 1890) and *Apterodela unipunctata* (Fabricius, 1775). In two other studies (Barraclough & Vogler 2002; Vogler *et al*. 2005), *Cy. lemniscata* was recovered in a clade of *Microthylax* Rivalier, 1954, a surprising result. Given this history of incongruent molecular results, Duran & Gough (2019) performed new molecular analyses with three important advances. They: 1) sequenced three gene fragments (*16S*, *COX3* and *CytB*) for newly collected specimens of *Cy. lemniscata*, compared them to GenBank sequences of *Cy. lemniscata* to validate the existing sequence data, 2) more densely sampled closely related genera and species in their phylogenetic analyses, including Palearctic *Cylindera*, Holarctic *Apterodela* Rivalier, 1950 and the Nearctic genera *Dromochorus* Guérin-Méneville, 1845, *Ellipsoptera* Dokhtouroff, 1883, *Brasiella* Rivalier, 1954 and *Parvindela* Duran & Gough, 2019 and 3) employed a maximum likelihood tree-building algorithm, implemented in IQ-TREE v. 1.6.9 (Nguyen *et al*. 2015) with support for nodes assessed with ultrafast bootstraps (Hoang *et al*. 2018) and SH-aLRT tests. This analysis found *Cy*. *lemniscata* contained within a large clade of Nearctic endemics, positioned as sister to the *Parvindela* + (*Dromochorus* + *Ellipsoptera*) clade (Fig. 1).

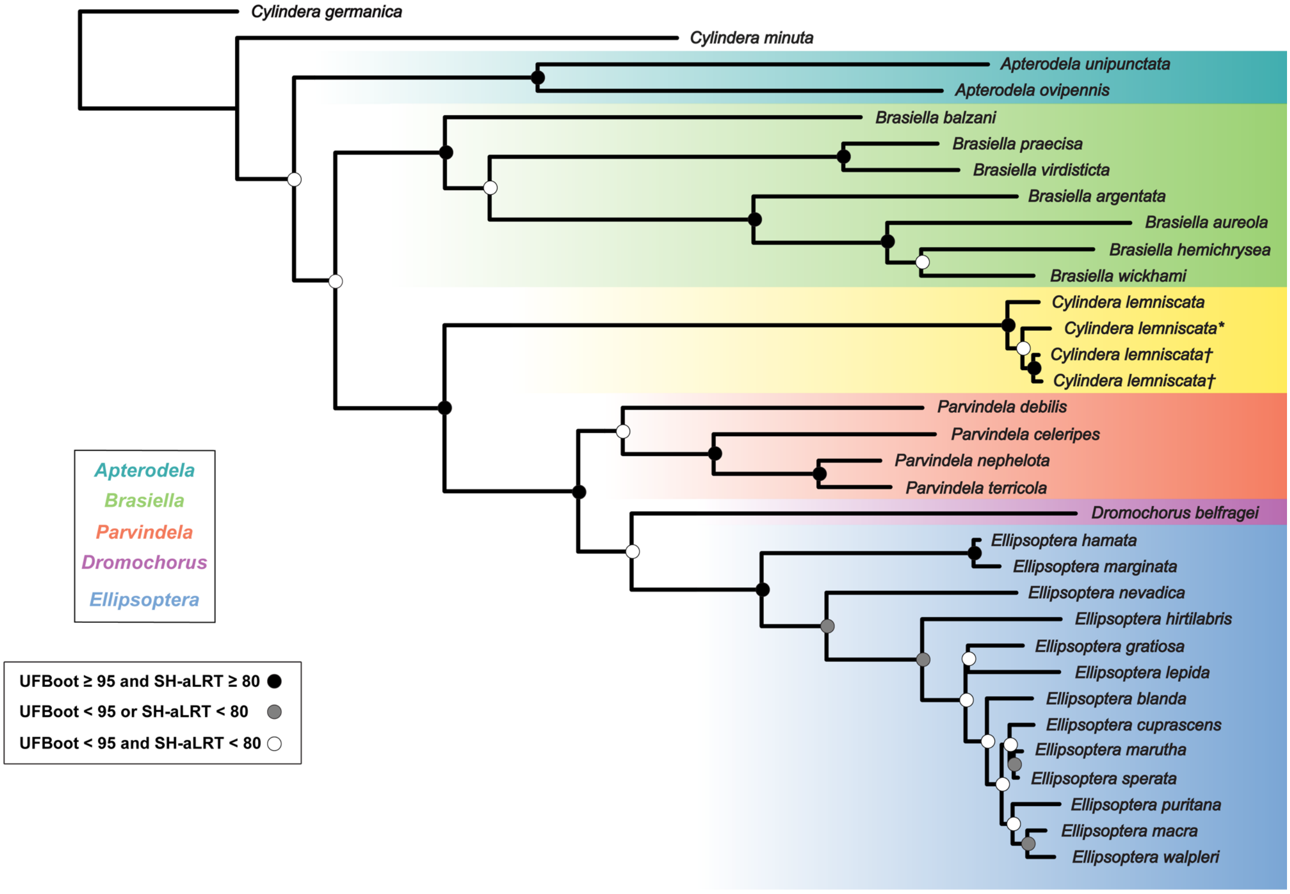

FIGURE 1. Phylogeny of *Cylindera lemniscata* and related taxa. Taxon sampling was informed by Vogler and Welsh (1997), Barraclough and Vogler (2002) and Vogler *et al*. (2005). Topology redrawn from Duran and Gough (2019).

In this study, we examine the morphology of *Cy. lemniscata* and putative close relatives, to determine whether *Cy. lemniscata* possesses unique characters that are distinct from other genera. We included characters that typically vary between genera, such as the presence of setae on the pro- and meso-trochanters (Duran, unpublished). These results were compared to the molecular evidence and the generic distinctiveness of *Cy. lemniscata* was evaluated.

Materials and methods

Material of the following related taxa (inferred from Gough *et al*. 2019, Duran & Gough 2019) was examined for 28 morphological characters (Supplemental Table S1): *Cy. lemniscata, Parvindela celeripes* (LeConte, 1848), *P. cursitans* (LeConte, 1857), *P. debilis* (Bates, 1890), *P. lunalonga* (Schaupp, 1884), *P. terricola* (Say, 1824), *Brasiella* *viridisticta* (Bates, 1881), *B. argentata* (Fabricius, 1801), *B. hemichrysea* (Chevrolat, 1835), *B. wickhami* (W. Horn, 1903), *B. dominicana* (Mandl, 1982), *Dromochorus belfragei* Sallé, 1877, *Ellipsoptera nevadica* (LeConte, 1875) and *E. sperata*. In addition, we compared material of the above taxa to *Cicindelidia cardini* (Leng & Mutchler, 1916). This species was examined, even though it was not sampled in any molecular phylogeny, as it is the only Nearctic or Neotropical species with maculations similar to *Cy. lemniscata*.

Results

Cylindera lemniscata is superficially similar in morphology with species of *Parvindela* based on its small size and cylindrical shape of the thorax. However, *Cy. lemniscata* differs from *Parvindela* species in key respects; it has a polished shining dorsal surface that is deeply and densely punctate, whereas all *Parvindela* have a dull texture and lack deep punctures; *Cy. lemniscata* possesses setae on the protrochanters but lacks setae on the mesotrochanters, unlike species of *Parvindela*, as well as most genera of the Cicindelina subtribe. This lack of mesotrochanter subapical setae is a trait that it shares with *Brasiella*, although it does not closely resemble that group in any other way. Maculation patterns vary in *Brasiella*, but whether they are expanded or reduced in that genus, the general structure and arrangement of spots or lunules never approaches the pattern of *Cy. lemniscata*. Moreover, *Brasiella spp*. possess sparse erect setae on the proepisternal disk (sometimes only on the basal half), whereas *Cy. lemniscata* has a glabrous proepisternal disk with dense decumbent setae present only along the basal suture. No apparent synapomorphies were shared between *Cy. lemniscata* and *Ellipsoptera* or *Dromochorus*.

The poorly known species, *Cicindelidia cardini*, has a remarkably similar maculation pattern to *Cy. lemniscata*, and as such, we assessed whether it could be congeneric with the latter. The authors are aware of only two specimens of *Ci. cardini* (both in the National Museum of Natural History, Washington DC), the type material collected in 1910. Unfortunately, due to the lack of available material for molecular phylogenetic analyses, only morphological comparisons could be made between *Ci. cardini* and *Cy. lemniscata*. *Cicindelidia cardini* was reported to lack setae on all of the trochanters (Leng & Mutchler 1916), but despite the legs being damaged and dirty, examination of the two type specimens indicated that setigerous punctures appeared to be present on the protrochanters, even though the setae were abraded. This set of characters - setae on protrochanters, but missing from mesotrochanters, is uncommon, and in the Nearctic and Neotropical fauna, is only observed in the genus *Brasiella* and in *Cy. lemniscata*. In *Ci. cardini*, the proepisternal disk lacks setae in the female, with a small number of white decumbent setae present at the basal margin. The proepisternum of the male possesses erect white setae throughout the disk as well as around the basal margin. This is in contrast with *Cy. lemniscata*, in which the proepisternal disk is glabrous in both males and females.

Behaviorally, *Cy. lemniscata* shares an affinity for flying to lights at night with *Ellipsoptera* and *Brasiella*. No *Parvindela* species exhibit this trait. Nothing is known about the ecology or behavior of *Ci. cardini*.

Given the above molecular phylogenetic and morphological differences between *Cy. lemniscata* and members of closely related genera, it is necessary to erect a new genus to accommodate this unique taxon. Although there are clear similarities between *Ci. cardini* and *Cy. lemniscata*, including near-identical maculations, the uncommon pattern of setae on the trochanters and red legs and antennae, without molecular data we are unable to move *Ci. cardini* to this new genus, at the present time.

In addition, our morphological examination indicates that *Ci. cardini* is almost certainly not a *Cicindelidia*. No other *Cicindelidia* share the character of setae on the pro- but not meso-trochanters. The characters of trochanter setae are generally conserved at the genus level, with few exceptions (Duran, unpublished). The maculations in *Ci. cardini* are also completely unlike any other *Cicindelidia*. Moreover, *Cicindelidia* species never have red legs, as observed in *Ci. cardini*. As such, *Ci. cardini* becomes *incertae sedis*.

Taxonomy

The electronic edition of this article conforms to the requirements of the amended International Code of Zoological Nomenclature, and hence the new genus name contained herein is available under that Code. This published work and the nomenclatural acts it contains have been registered in ZooBank, the online registration system for the ICZN.

The ZooBank LSIDs (Life Science Identifiers) can be resolved and the associated information viewed through any standard web browser by appending the LSID to the prefix "http://zoobank.org/ ". The LSID for this publication is: urn:lsid:zoobank.org:pub:AFD404A4-1C8C-490D-B082-9F9C333288CA.

Jundlandia Duran and Gough, new genus

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(Fig. 2, 3)

Etymology. The name is derived from the film, Stars Wars: A New Hope. In the film, there is a hot, dry place known as the "Jundland Wastes", a particularly desolate area on the protagonist's home planet of Tatooine. This desert environment is similar in appearance to the some of the more extreme habitats that *Jundlandia lemniscata* inhabits within the Chihuahuan and Sonoran deserts.

Type species. *Cicindela lemniscata* (LeConte, 1854); by present designation

Description. Small size, 7–11 mm. Body shape slender, cylindrical. Head with distinct rugosity. Frons glabrous except for two supraorbital setae near each eye. Genae polished metallic, glabrous. Clypeus glabrous. Labrum long, approximately as long as wide. Antennal scape with a single long erect seta. Pronotum with shallow transverse rugosity, surface polished. Pronotal setae thick white decumbent, restricted to lateral third. Lateral portions of venter with dense white decumbent setae present. Legs variable in color: femora pale testaceous, occasionally with slight metallic surfaces on upper surface or femora strongly pigmented red or green. Protrochanter with a single subapical seta. Mesotrochanter without a subapical seta. Metatrochanter without a subapical seta. Each elytron bears a single cream-colored vitta that possesses a small inward projection on basal third, bending into an apical lunule at the tip; a small number of individuals may have vitta broken into three separate lines. Elytral apices separately rounded in female, very slightly so in male. Small sutural spine present. Microserrations present.

This new genus is supported by recent phylogenetic studies (Duran & Gough 2019) (Fig 1), and it is most closely related to a New World clade comprised of the genera *Ellipsoptera*, *Dromochorus* and *Parvindela*.

Distribution. The monotypic genus has a large distribution in dry grassland and desert biomes within the southwestern United states (Pearson *et al*. 2015) and Mexico (Cazier 1954), mostly in the Nearctic biogeographic realm, but reaching the northern reaches of the Neotropical realm in western Mexico. Specifically, the species ranges from southern California and southwestern Utah to the panhandle of Texas and Oklahoma, south to the southern tip of Baja California and the western Mexico states of Sinaloa and Colima (J. Shetterly, pers. comm. 2022).

Ecology. This genus may be found in a variety of habitats within the Chihuahuan and Sonoran Desert regions, from vegetated to sparely vegetated or unvegetated habitats, near water or in dry areas, from the bottom of washes to uplands.

Jundlandia lemniscata (LeConte, 1854), new combination

? *cardini* (Leng & Mutchler, 1916), incertae sedis

Discussion

The systematic placement of *J. lemniscata* has always been unclear, and the resulting taxonomy has not been stable. In addition to its morphological uniqueness, the most recent molecular phylogeny (Duran & Gough 2019) demonstrated that the species was found in a clade that did not correspond to any named genus. Moreover, in our examination of morphological characters, it is now evident that *J. lemniscata* possesses a unique combination of characters that are different from any of the other related genera (e.g. *Parvindela, Brasiella*). Consequently, we erected a new monotypic genus for the species.

The species described as *Cicindela cardini*, was never well-studied, as it was only known from two worn specimens collected in Cuba in 1910. It bears unusual maculations that are remarkably similar to *J. lemniscata*. Rivalier did not examine the species in his major 1954 revision of the *faune Américaine*. As such, the internal structures of the aedeagus are unknown, and its taxonomic status was not resolved. It remained in *Cicindela s.str.* until Boyd's (1982) checklist of the tiger beetles of North America (including Central America and the West Indies) when he placed *cardini* in *Cicindelidia*, which he considered a subgenus of *Cicindela*. No explanation was given for this placement, and this decision is hard to reconcile with any morphological characters.

Despite the morphological synapomorphies shared between *cardini* and *J. lemniscata* (see Results), we feel that it would be premature to include the former in *Jundlandia* without the additional support of molecular phylogenetic data. Future efforts to locate and collect fresh material may help to resolve the relationships between these taxa.

Our above description for *Jundlandia*, new genus, has been kept broad enough that it could accommodate *cardini*, if future research demonstrated that taxon to be congeneric with *J. lemniscata*. Although the two species share several characters, they also differ considerably in others. The texture of the elytral surface is not similar between the two taxa, with *J. lemniscata* having deeply and densely punctate elytra, forming a glittering shiny overall surface, and *cardini* possessing an impunctate and dull, almost velvety texture. If these taxa are congeneric, it would indicate a great degree of variability in this character.

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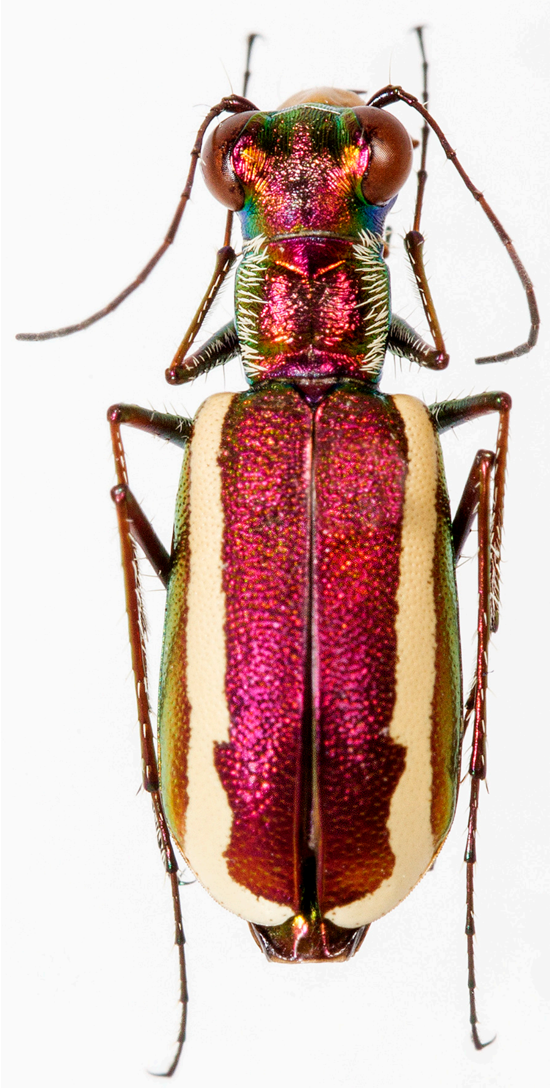

FIGURE 2. Dorsal habitus of former *Cylindera lemniscata*, now *Jundlandia lemniscata*, new combination

FIGURE 3. *Jundlandia lemniscata*, new combination, in situ in Willcox, Cochise County, Arizona.

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