

Journal of Melittology

Bee Biology, Ecology, Evolution, & Systematics

The latest buzz in bee biology

No. 13, pp. 1–11

26 July 2013

A new species, *Lasioglossum (Eickwortia) hienae*, from Mexico (Apoidea: Halictidae)

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Abstract. A new species from Colima, Mexico, *Lasioglossum (Eickwortia) hienae* Gibbs & Dumesht, new species, is described and illustrated. *Lasioglossum hienae* is distinguished from related species based on a combination of morphological, geographical, and molecular evidence. A species distribution model is used to predict the potential distribution of the known species of *L. (Eickwortia)*. An identification key is provided.

INTRODUCTION

The bee genus *Lasioglossum* Curtis (1833) is exceptionally diverse in terms of species richness, habitat use, and social behavior (Michener, 1974, 1979, 2000, 2007; Yanega, 1997; Schwarz *et al.*, 2007). *Eickwortia* McGinley, 1999, now recognized as a subgenus of *Lasioglossum* (Michener 2000, 2007), was proposed for two species of high-elevation bees in Mexico and Central America, *Lasioglossum nyctere* (Vachal, 1904) and *L. alexanderi* (McGinley, 1999). *Lasioglossum (Eickwortia)* belongs to the informal group known as the *Hemihalictus* series, which is recognizable by its weak distal wing venation (Michener, 2007). Ascher & Pickering (2013) have included these two species in *L. (Evylaeus)* Robertson, a subgenus we treat in a much narrower sense (Gibbs *et al.*, 2013). The taxonomic limits of *Lasioglossum* subgenera require revision (Gibbs *et al.*, 2012b, 2013), but recognition of the subgenus *L. (Eickwortia)* seems reasonable based on its apomorphic traits, including infusate wings, strongly bidentate mandibles of the females, and slender metasoma of the males.

We are reluctant to describe new species based on few specimens, but in the case of rare bees like *L. (Eickwortia)* this may be necessary, even if only a single specimen is available. Recognition of new species is often a spur towards additional collection efforts and studies that may further elucidate the taxonomic and phylogenetic relationships of species.

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Based on examination of *L. nyctere*, for which the longest series of individuals is available, species of *L. (Eickwortia)* are likely to be highly variable. *Lasioglossum nyctere* body size varies extensively with corresponding allometric changes to head shape and mesosomal sculpture. Such variability might be related to agonistic interactions in social colonies, which has been reported in other species (Pabalan *et al.*, 2000; Packer *et al.*, 2003).

In cases where morphological data are unclear, additional sources of information, such as DNA sequences, can be useful for delimiting species boundaries (DeSalle *et al.*, 2005; Packer *et al.*, 2009; Goldstein & DeSalle, 2011). We describe a new species of *L. (Eickwortia)* from a female specimen collected in Mexico, which is recognized based on a combination of morphological, molecular, and geographical evidence.

MATERIAL AND METHODS

We examined 60 specimens of *L. (Eickwortia)* from across its range from Mexico to Nicaragua for comparison with the new species described herein. Specimens examined came from the following collections: **BBSL**: USDA-ARS Bee Biodiversity and Systematics Laboratory, Utah State University (Logan, UT), **CUIC**: Cornell University Insect Collection (Ithaca, NY), **LACM**: Los Angeles County Museum of Natural History (Los Angeles, CA), **MSUC**: A.J. Cook Arthropod Research Collection, Michigan State University (East Lansing, MI), **PCYU**: Packer Collection, York University (Toronto, Ontario), **SEMC**: Snow Entomological Collection, Division of Entomology, Natural History Museum, University of Kansas (Lawrence, KS), **UNAM**: Universidad Nacional Autónoma de México (Mexico City), and **EMEC**: Essig Museum of Entomology, University of California, Berkeley (Berkeley, CA). These specimens were mostly taken from the sixty-nine specimens used in the original description of *Eickwortia* (McGinley, 1999). The location of the holotype of *L. alexanderi*, which was to be deposited at Lawrence, Kansas after publication but was never returned to that institution, is currently unknown and could not be examined. Based on the type locality, published images, and the original description (McGinley, 1999), it is clearly distinct from the species described herein.

The format of the species description and terminology used follows previous halictid bee studies (*e.g.*, Gibbs, 2009, 2011). Terminology largely follows Michener (2007) for morphological characters and Harris (1979) for surface sculpture. We use the diameter of the median ocellus (OD) as a unit of measurement for setal length. Puncture density is given by width of interspaces (*i*) relative to puncture diameter (*d*). We use the standard abbreviation of 'T' to represent metasomal terga, followed by the appropriate segment number. Measurements were taken using an ocular micrometer on a Zeiss Stemi SV 6 (Oberkochen, Germany) microscope illuminated with a 30 W helical compact fluorescent light bulb (equivalent to 100 W).

DNA barcodes were generated at the Biodiversity Institute of Ontario (Guelph, Ontario, Canada) using standard protocols described elsewhere (Gibbs, 2009, 2011). DNA was extracted from two recently collected specimens of *L. (Eickwortia)*, a specimen of *L. nyctere* and the holotype of the new species, using a single leg of each, taken from the right side of the body. A segment from the 'DNA barcode' region of mitochondrial cytochrome *c* oxidase subunit 1 was amplified from each sample using standard primers (Gibbs, 2009, 2011). Sequences were aligned and compared using analysis tools within the Barcode of Life Data Systems (Ratnasingham & Hebert, 2007). Sequences are available at www.boldsystems.org.

We used geo-referenced records of *L. nyctere* published in McGinley (1999) and supplemented with additional collections to produce distribution maps of that species. Historical specimens without coordinates in McGinley (1999) were geo-referenced using Google Earth (Google Inc.) and online gazetteers (GeoHack and Global Gazetteer v. 2.2). The niche-modelling software Maxent (Phillips *et al.*, 2006) was used to predict geographic ranges of species beyond the observed records. We used eighteen bioclimatic layers and a layer for altitude available from www.worldclim.org when creating our models. We performed ten replicate analyses for cross validation. The results were summarised in a single map using Maxent. The map was additionally modified for clarity using ArcMap v.9 (ESRI, Redlands, California).

SYSTEMATICS

Genus *Lasioglossum* Curtis, 1833

Subgenus *Eickwortia* McGinley, 1999

Eickwortia McGinley, 1999: 112. Type species: *Halictus nycteris* Vachal, 1904, by original designation.

Lasioglossum (*Eickwortia*) McGinley; Michener, 2000: 362.

***Lasioglossum* (*Eickwortia*) *hienae* Gibbs & Dumesh, new species**

ZooBank: urn:lsid:zoobank.org:act:D336B46B-D9D7-472C-BA58-7A4D2FDAB589

(Figs. 1–4, 6, 7)

DIAGNOSIS: Females of *L. hienae* can be distinguished from other Halictidae by the following combination of characters: forewing with vein 1rs-m, and 2rs-m weak [as in *L. (Dialictus)* Robertson, *L. (Evylaeus)*, and *L. (Sphecodogastra)* Ashmead]; anterior third of forewing infusate (Fig. 1); mandible strongly bidentate (Fig. 3); mesoscutum granulate, obscurely doubly punctate (Fig. 4).

Lasioglossum hienae is most similar to *L. nyctere*, but the latter has the mesoscutum tessellate with distinct double punctures (fine punctures separated by 1–2 diameters, coarse punctures separated by 5–10 diameters) (Fig. 5). *Lasioglossum alexanderi* has completely infusate forewings, mesoscutum distinctly singly punctate, and metapostnotum regularly carinulate to posterior rim (*vide* McGinley, 1999).

Additional useful characters for recognizing *L. hienae* include the following: Integument blackish brown (Fig. 1). Off-white, appressed tomentose setae on the pronotal lobe, dorsolateral angle of pronotum, posterior margin of mesoscutum, metanotum, posterior surface of the propodeum and basal portions of T2–T3 (Figs. 4, 6, 7), which sharply contrast with the black integument. Head wider than mesosoma (Fig. 2); compound eyes weakly divergent below (Fig. 2). Pronotal lateral ridge complete; pronotal lobe acutely projected laterally (Fig. 2). Hind wing with distal hamuli organised 3-1-1-1-2 [typically 2-1-2 in *L. (Dialictus)*, *L. (Evylaeus)*, and *L. (Sphecodogastra)*]. Femora slender; inner metatibial spur pectinate, with four long branches (not including apex of rachis). Metapostnotum smooth with virtually no microsculpture (Figs. 4, 6).

The male of *L. hienae* is unknown. Males of *L. nyctere* are similar to females, except they have smaller heads, normal mandibles, and a remarkably slender metasoma. They bear a close resemblance to males of the augochlorine genus *Neocorynura* Schrottky. It is expected that males of *L. hienae* may have similar traits.



Figures 1–2. Holotype female of *Lasioglossum (Eickwortia) hienae*, new species. 1. Lateral habitus. 2. Face. Scale bars = 1 mm.

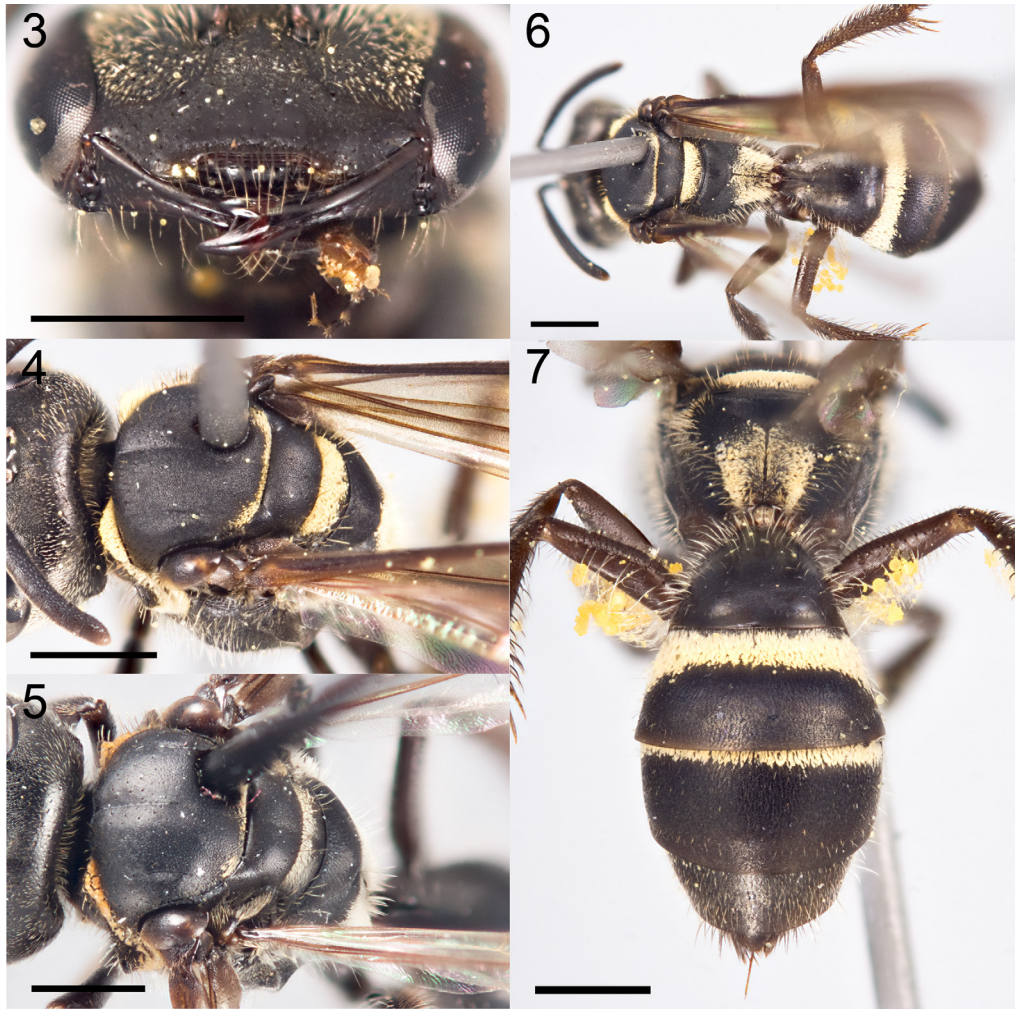
DESCRIPTION: ♀, Length 6.5 mm. Head length 1.95 mm. Head width 2.31 mm. Intertegular distance 1.43 mm.

Color. Entire body blackish brown (Fig. 1), except: Antennal flagellomere 10 reddish brown apically. Tegula dark reddish brown (Fig. 4). Legs dark brown, except medio- and distitarsi reddish brown (Fig. 1). Forewing membrane dusky, anterior margin deeply infuscate (Fig. 1). Pterostigma and venation reddish brown. T2 with margin translucent reddish brown (Fig. 7).

Structure. Head wide (length/width ratio = 0.84) (Fig. 2). Labrum with basal tubercle; apical process broadly triangular. Mandible bidentate, preapical tooth nearly as long as apical tooth (Fig. 3). Clypeus 3x wider than long, extending 2/3 below sub-orbital line (Fig. 2). Compound eyes weakly divergent below, upper ocular distance 0.93x lower ocular distance (Fig. 2). Gena 1.4x wider than compound eye in lateral view, widest at midlength. Hypostomal carinae subparallel. Ocelli unmodified. Vertex broad, extending 1.5 OD above lateral ocellus in frontal view (Fig. 2). Pronotum maximum width 2.13 mm; dorsolateral angle obtuse; pronotal ridge carinate, not interrupted by sulcus; pronotal lobe acutely projecting laterally (Fig. 2). Femora and metatibia slender. Inner metatibial spur pectinate, four-toothed, basal tooth longer than width of rachis. Tegula ovoid (Fig. 4). Forewing with marginal cell very narrowly truncate; submarginal cells three; veins 1rs-m and 2rs-m weak. Propodeal lateral carina not reaching dorsal margin, oblique carina absent (Figs. 6, 7). T1 narrow, 0.7x width of T2; T5 with distinct pseudopygidial area (Fig. 7).

Surface sculpture. Face imbricate except as follows (Fig. 2): Clypeus polished distally. Clypeus, supraclypeal area, and lower paraocular area sparsely punctate ($i = 1-3$ d). Upper paraocular area and frons reticulate. Gena weakly imbricate, punctures sparse ($i = 1-2$ d), postgena imbricate. Mesoscutum coarsely imbricate, granular; punctures very fine, mostly dense ($i \leq 1$ d), difficult to distinguish from background microsculpture, except coarser and sparser on anterior portion ($i = 2-4$ d) (Fig. 4). Mesoscutellum similar to mesoscutum. Mesepisternum with vertical carinulae converging on subpleural signum, coarser ventrally; hypoepimeral area imbricate. Metepisternum transversely carinulate on dorsal third, remainder imbricate. Metapostnotum smooth, weakly imbricate, not shiny (Fig. 4). Propodeum imbricate, lower lateral surface with weak transverse carinulae. Metasomal terga mostly imbricate, apical impressed area coriarius, T1 smoother (Fig. 7); punctures fine, dense ($i = 1-1.5$ d), nearly reaching posterior margin (Fig. 7); T5 pseudopygidial area coarsely punctate ($i = 1-1.5$ d).

Pubescence. Dull white, except tomentum faintly yellowish, largely dark brown on tibiae and tarsi (Fig. 7). Entire body with sparse woolly setae ($1-1.5$ OD), longer on



Figures 3–7. Females of *Lasioglossum* (*Eickwortia*) *hienae*, new species (3, 4, 6, 7) and *L. (E.) nyctere* (Vachal) from Veracruz Prov., Mexico (5). 3. Mandibles. 4, 5. Dorsolateral views of mesosoma. 6. Dorsal habitus. 7. Dorsal view of metasoma and posterior view of propodeum. Scale bars = 1 mm.

metanotum, mesopleuron and lateral portions of metasomal terga (1.5–2.5 OD). Paracocular area with short, subappressed tomentose setae (Fig. 2). Gena with tomentum adjacent to compound eye (Fig. 1). Pronotal lobe and posterior margin with dense tomentum (Figs. 1, 4). Mesoscutum with posterior margin tomentose (Fig. 4). Metanotum almost entirely obscured by tomentum (Fig. 4). Metafemur with well developed scopa (Fig. 7). Propodeal posterior surface obscured by tomentum (Fig. 7), dorsal portion of lateral surface with sparse tomentum. T1 with sparse, erect plumose setae; T2–T4 with dense basal tomentose bands, thickest and most evident on T2 (Fig. 7). Metasomal sterna with plumose scopa (3–4.5 OD).

♂: Unknown.

HOLOTYPE: ♀, Mexico: Colima, Volcán Colima, South Road, W side of river, N19.45166 W103.71814, 1163m, 0.5.x.10, S. Dumesh, PCYU-MEX10-0175 [on white label] / BeeBOL, CCDB-09841 E07, BOWMT150-10 [on green label] / **HOLOTYPE** *Lasio-*

glossum (*Eickwortia*) *hienae* [on red label]. Deposited in Packer Collection, York University. Specimen in good condition except midleg on right side removed for molecular study.

DISTRIBUTION: Only a single female specimen is known, collected from the southern slope of the Colima volcano on the border of Colima and Jalisco Provinces, Mexico (Figs. 8, 9). The specimen was collected at a relatively high elevation (1163 m), as were other specimens in the subgenus (McGinley, 1999) (Figs. 8, 9). The nearest recorded location of *L. nyctere* is nearly 200 km distant. The type locality of *L. hienae* is at the edge of the predicted area of suitable habitat for *L. nyctere* (Fig. 8).

DNA BARCODES: A single partial DNA barcode sequence (407 bp) is available from the holotype specimen of *L. hienae* (GenBank accession: KF199918). A single partial DNA barcode sequence (382 bp) is also available from a specimen of *L. nyctere* from Veracruz Province (near the type locality) (GenBank accession: KF199919). Thirteen nucleotide differences occur over the overlapping 382 bp (= 3.6% genetic divergence). *Lasioglossum hienae* differs from *L. nyctere* in the following sites (relative to standard bee barcodes, *vide* Gibbs *et al.*, 2013): 273(C/T), 363(C/T), 435(C/A), 495(T/C), 543(A/C), 549(C/A), 564(A/G), 570(C/T), 577(C/T), 600(C/T), 603(T/C), 612(C/T), and 621(C/A). Additional sampling is needed to determine what fraction of these 13 differences is fixed between the two species, but this is consistent with species-level differences among closely related bees (Gibbs, 2009).

ETYMOLOGY: We are pleased to name this bee for our friend and colleague Hien T. Ngo in recognition of her studies of tropical native bees and a memorable fieldwork experience in Mexico with the senior author.

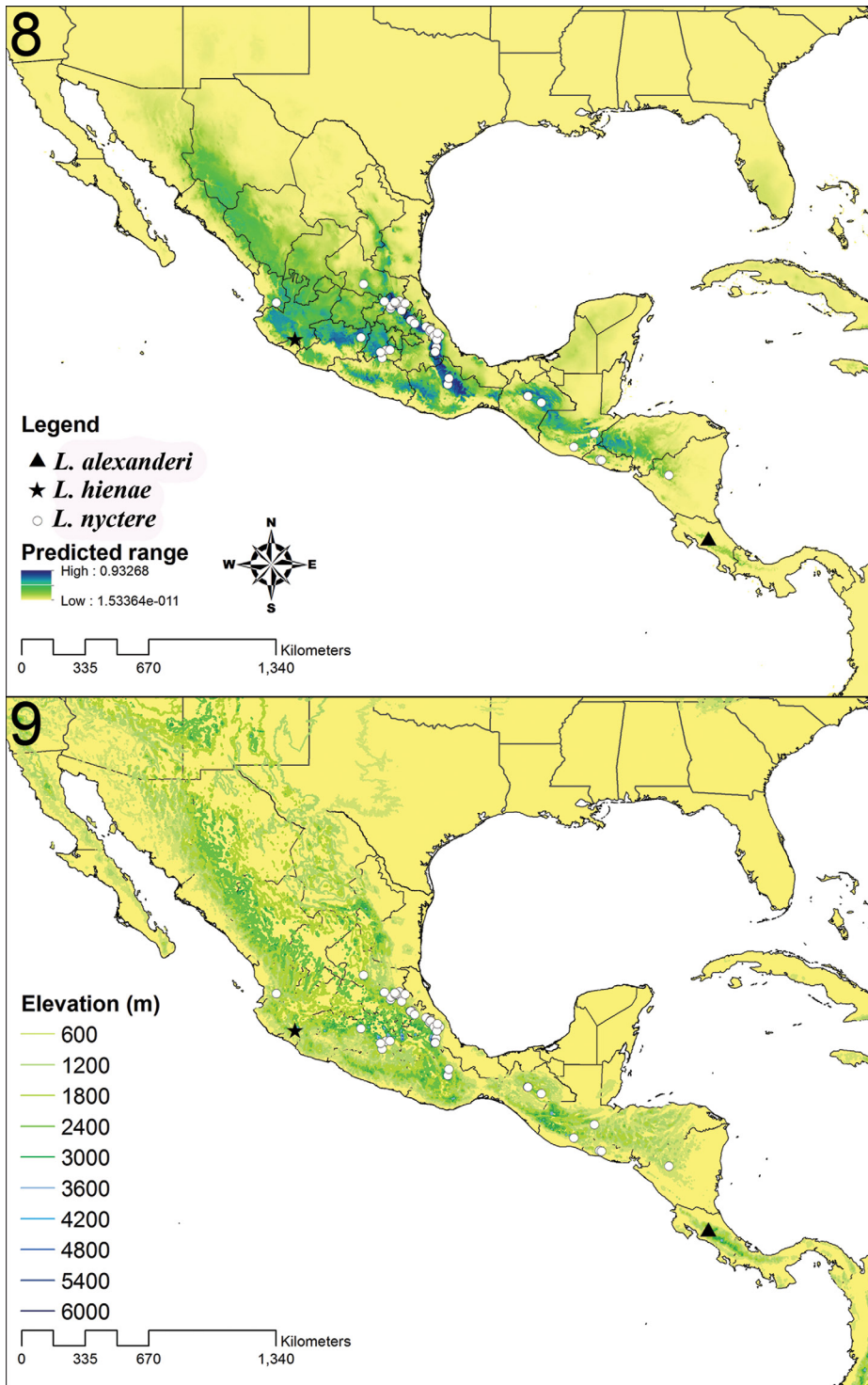
Lasioglossum (*Eickwortia*) *nyctere* (Vachal)
(Fig. 5)

Halictus nycteris Vachal, 1904: 119.

Lasioglossum (*Eickwortia*) [*nyctere*] (Vachal); Michener, 2000: 362.

Lasioglossum (*Eoylea*) *nyctere* (Vachal); Ascher & Pickering, 2013 [online resource; unpublished].

MATERIAL EXAMINED: 60 (52♀♀, 8♂♂). **EL SALVADOR:** Mt. San Salvador (1♀, EMEC). **GUATEMALA:** Escuintla, 6.3 mi. NE (1♂, SEMC). **MEXICO: Chiapas:** Lomata (1♀, EMEC); Municipio Zinacantán, Parajé Navenchauk, 2194 m (1♀, CAS); Municipio Zinacantán, Parajé Vobits, 1371 m (1♀, CAS); Sibakte 'el, Tenjapa, 5500 ft. (1♀, CAS); San Cristóbal de las Casas (1♂, PCYU); **Hidalgo:** Chapulhuacan, 2.4 mi. S, Hwy. 85, 2700' (4♀♀, LACM); Jacala, 10.6 km N, Hwy. 85 (km 192), 1620 m (1♀, SEMC); Jacala, 32 mi. NE, 3950' (1♂, SEMC); Jacala, 38 mi. NE, 3100' (6♀♀, 2♂♂, SEMC); La Placita, Hwy. 85, 8 mi. S Jacala, 5400' (2♀♀, LACM); Otongo, 10 km E, 1110 m (1♂, UNAM); Otongo, 10 km E, 1310 m (1♀, UNAM); San Luis Potosí-Hidalgo border, 19.5 km S (1♀, SEMC); Tamazunchale, S, Hwy. 85 (km 239), 1050 m (1♀, SEMC); Tenango de Doria, El Damó, 1680 m (1♂, UNAM); Tenango de Doria, Cerro El Cirio, 1750 m (1♀, UNAM); Tenango de Doria, La Colonia, 1800 m (1♀, UNAM); Tenango de Doria, Camino a El Texmé, 1250 m (1♀, UNAM); Tlanchinol, 1600 m (1♂, UNAM); Xochicoatlán (1♀, UNAM); **Michoacán:** Moralia, 18 mi. E, 7200 ft. (1♀, SEMC); **Morelos:** Cuernavaca, 6000 ft. (1♀, MSUC); Nayarit: Santa Isabella (3♀♀, BBSL); **Puebla:** Cuetzalán, 3 mi. SW (N. of Zacapoaxtla) (2♀♀, SEMC); Huauchinango, 8 mi. E, 4050' (1♀, SEMC); Olotla, Tuchintlán, 854 m (1♀, SEMC); Teziutlán, 5 km NE, 4600 ft. (1♀, SEMC); Teziutlán, 5 mi. NE, 4700' (2♀♀ SEMC); Teziutlán, 8.5 mi. NE, 4800' (1♀, SEMC); **Querétaro:**



Figures 8-9. Distribution of species of *Lasioglossum* (*Eickwortia*). **8.** Heat map showing predicted suitable range for *L. nyctere* based on maximum entropy analysis. **9.** Heat map indicating elevation gradients.

Jalpán, 43 km E, 1100 m (1♀, SEMC); Jalpán, 43 km E, 1600 m (1♀, SEMC); **San Luis Potosí:** Platanito, W, Hwy. 80 (km 141), 900 m (1♀, SEMC); **Veracruz:** Huatusco (2♀♀, PCYU); Huatusco, 32.2 km S, 1100 m (1♀, SEMC); Jalapa (1♀, MSUC); Jalapa, 2 mi. NW (1♀, LACM); La Guadalupe, 4.2 km S, Hwy. 180 (1♀, SEMC); Las Vigas, 12 km SE (1♀, EMEC); Orizaba (1♀, MSUC); Rio Jamapa, NE of Coscomatepec, 4300' (1♀, SEMC); Xico, Texolo Falls (1♀, SEMC). **NICARAGUA:** Santa Maria de Ostuma (1♀, CUIC).

Key to females of *Lasioglossum* subgenus *Eickwortia*

Note that only the male of *L. nyctere* is currently known.

- 1. Forewing completely infusate; metapostnotum shiny, distinctly carinulate *L. (E.) alexanderi* (McGinley)
- Forewing anterior third infusate; metapostnotum dull, very finely carinulate 2
- 2. Mesoscutum granulate, obscurely doubly punctate (Fig. 4) *L. (E.) hienae* Gibbs & Dumesh, n. sp.
- Mesoscutum tessellate with distinct double punctures (fine punctures separated by 1–2 diameters, coarse punctures separated by 5–10 diameters) (Fig. 5) ... *L. (E.) nyctere* (Vachal)

DISCUSSION

All specimens of *L. (Eickwortia)* are known from relatively high elevations (823–2200 m) from the southern half of Mexico to Costa Rica (McGinley, 1999). This distribution is reminiscent of the high elevation Neotropical halictine genus *Mexalictus* Eickwort (Eickwort, 1978; Packer, 1993; Dumesh, in press). High elevation species in the Neotropics may have narrow physiological tolerances (Kozak & Wiens, 2007), which can limit dispersal. Species with ranges restricted to high elevations may become genetically isolated if individuals cannot traverse lowland regions between mountains (Gutiérrez-Pinto *et al.*, 2012). *Lasioglossum nyctere* and *L. hienae* both occur in the Transverse Volcanic Belt, but this area varies considerably in altitude (Fa & Morales, 1991; Fig. 9). Altitudinal variability across the Transverse Volcanic Belt is related to differences in mean temperature and vegetation patterns (Fa & Morales, 1991), which have frequently led to isolation of insect populations (Halfpeter, 1987). Areas of suitable habitat for montane species can vary over time due to climatic fluctuations such as the ones that occurred during the Quaternary period (Hewitt, 2004). The pine-oak forest ecozone in which *L. (Eickwortia)* are found is susceptible to climate fluctuations (Gómez-Mendoza & Arriaga, 2007). We believe periodic expansions and contractions of suitable habitat for these montane bees could have led to physical isolation and speciation in *L. (Eickwortia)*, as it has been hypothesized for other bee taxa in the Andes (Gonzalez & Engel, 2004).

Describing new species from a single specimen is undesirable, but the addition of molecular data lends increased support to our conclusions. It is possible that there may be additional populations of *L. (Eickwortia)*, perhaps including specimens currently identified as *L. nyctere*, which may be sufficiently isolated and divergent to be considered distinct species. Populations in southern Mexico and Central America are separated from the type locality in the Transverse Volcanic Belt by large distances of low elevation habitat. Specimens show variation both within and between major mountain ranges, but without additional sources of information, such as the mo-

lecular data used here for *L. hienae* or morphological evidence from more specimens, determining if this variation is consistent with species-level differences is premature. Additional sampling at high elevations in Mexico and Central America is needed to better understand the diversity of *L. (Eickwortia)* and other high elevation halictid bees (Engel, 2009; Dumesh, in press).

In his discussion of *Eickwortia*, McGinley (1999) draws attention to two anatomical features of these bees: i) size variation among females and ii) the bidentate mandible. McGinley relates these features to the possibility of social behavior and wood nesting. We find the same enlarged mandible in our species, and agree that this may be related to wood nesting. Similar modifications of mandibles are known from other wood-nesting halictid bees (Eickwort, 1979; Wcislo *et al.*, 2003; Tierney *et al.*, 2008). However, it is conceivable that large mandibles could also be related to intrasexual conflict between females, which has been known to occur in social halictid bees (Smith & Weller, 1989; Pabalan *et al.*, 2000).

Of the subgenus *L. (Eickwortia)*, only *L. nyctere* has been collected in relative abundance. The size variation is extensive (McGinley, 1999), with noticeable allometric size variation particularly in the shape of the head. This variation is consistent with modifications seen in some eusocial halictid bees (Janjic & Packer, 2001). Macrocephaly could be related to intrasexual conflict in females. The carinate pronotum evident in these bees may also serve to protect the sensitive areas between the head and pronotum from biting (Pabalan *et al.*, 2000). Similar modifications of the head and pronotum are evident in many halictid bees (Engel *et al.*, 2012; Gibbs *et al.*, 2012a).

The only way to resolve the remaining uncertainties in the taxonomic diversity, phylogenetic relationships, nesting biology, and social behavior of *L. (Eickwortia)* is to undertake additional studies in Mesoamerica. McGinley (1999) suggests focusing attention on high elevation pine-oak forests (above 823 m), with attention given to Asteraceae (especially the genus *Bidens* Linnaeus). We concur.

ACKNOWLEDGEMENTS

We thank the many curators and collection managers who have facilitated the use and loans of material for research on halictid bee taxonomy. In particular, we thank Chris Dietrich and Dmitry Dmitriev (Illinois Natural History Survey) for assisting in the transfer of material, which included the bulk of known specimens of *L. (Eickwortia)*, and the loan of insect drawers for shipping to the senior author. We appreciate loans of *Eickwortia* from SEMC arranged by Michael Engel and Jennifer Thomas. We thank Sam Droege (USGS Patuxent Wildlife Research Center) for providing recent specimens of *L. nyctere* for molecular study. We appreciate assistance from Ricardo Ayala (UNAM) for collection trips to Mexico, which led to the discovery of *L. hienae*. Images were taken at York University using a Visionary Digital BK Plus imaging system purchased with funds from the Canadian Foundation for Innovation and the Ontario Research Fund through Canadensys using a Canon EOS 40D digital SLR camera and processed with Adobe Photoshop. Molecular studies of halictid bees were supported through funding to the Canadian Barcode of Life Network from Genome Canada, NSERC, and other sponsors listed at www.BOLNET.ca. The senior author's research was funded by the Bradley Endowment at Cornell University, postdoctoral support from Bryan Danforth, and funding from NSF-DBI#0956388 (John S. Ascher, PI). The junior author was supported by NSERC-CANPOLIN and Canadensys grants awarded to Laurence Packer. We thank two anonymous reviewers and Victor H. Gonzalez Betancourt for helpful comments on the manuscript.

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The *Journal of Melittology* was established at the University of Kansas through the efforts of Michael S. Engel, Victor H. Gonzalez, Ismael A. Hinojosa-Díaz, and Charles D. Michener in 2013 and each article is published as its own number, with issues appearing online as soon as they are ready. Papers are composed using Microsoft Word® and Adobe InDesign® in Lawrence, Kansas, USA.

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ISSN 2325-4467