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A revision of *Ganaspidium* Weld, 1952 (Hymenoptera, Figitidae, Eucoilinae): new species, bionomics, and distribution

Matthew L. Buffington

1 *Systematic Entomology Lab, ARS/USDA, c/o Smithsonian Institution, National Museum of Natural History, PO Box 30712 MRC-168, 10th & Constitution Ave, NW, Washington DC, 20013*

† *urn:lsid:zoobank.org:author:603275DE-9AE3-40C6-8AD7-6A2AF7485F35*

Corresponding author: *Matthew L. Buffington* (matt.buffington@ars.usda.gov)

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Abstract

The New World eucoiline genus *Ganaspidium* is revised. Species in this genus are parasitoids of some of the most pestiferous species of leaf-mining Agromyzidae (Diptera), including the notorious *Liriomyza trifolii* (Burgess). The following new species are described: *Ganaspidium didionae*, *G. eldiablo, G. flemingi*, *G. kolmaci,* and *G. konzaensis*. *Ganaspidium navajoe* (Miller), **comb. n.**, is recognized as junior synonym of *G. pusillae* Weld (**syn. n.**). *Ganaspidium nigrimanus* (Kieffer) and *G. utilis* Beardsley are removed from synonymy, and together with *G. hunteri* (Crawford), are now in *Banacuniculus* Buffington. Species of *Ganaspidium* are recorded from a wide geographic area within North America, and several species appear to be adapted to arid environments. New distribution data, new host records, and a key to known species are provided.

Keywords

Eucoilinae, *Liriomyza*, Agromyzidae, new species, genus revision, species revision, parasitoid

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Introduction

Weld (1955) established the genus *Ganaspidium* to accommodate the type species *G. pusillae* Weld (Hymenoptera: Figitidae: Eucoilinae) based on specimens sent to the United States National Museum (USNM) from the 'Winter Garden Area' of Texas. This species was reared as a koinobiont endoparasitoid (Godfrey, 1994) of the leaf miner *Liriomyza pusilla* (Meigen) (Diptera: Agromyzidae) taken off black-eyed peas (*Vigna unguiculata* (L.) Walp., Fabaceae) in Monte Alto, Texas. The species that was to become *G. pusillae* was referred to in Weld's (1952) key as 'new genus E'. This genus went ignored until Beardsley (1986) determined that *Eucoila hunteri* Perkins belonged in *Ganaspidium*; and, thus, created the combination *Ganaspidium hunteri*. *Ganaspidium hunteri* was discovered to parasitize multiple species of *Liriomyza* Mik in Hawaii on species as diverse as chrysanthemum, cucumber, tomato, and 'unspecified hosts' (Beardsley, 1986). In a follow-up paper, Beardsley (1988) provided a key to all eucoiline agromyzid parasites recorded at that time from Hawaii and described a third new species of *Ganaspidium*, *G. utilis* Beardsley. This species has been shown to be instrumental in controlling certain pest species of *Liriomyza*, including *L. trifolii* (Burgess) and *L. huidobrensis* (Blanchard) (Johnson 1987; Lynch and Johnson 1987; Mason and Johnson 1988; Rathman et al. 1991; Rathman et al. 1995).

Ganaspidium is easily confused with several closely related genera of Eucoilinae. One paratype of *G. pusillae* is actually *Disorygma pacifica* (Yoshimoto). Several collections I have examined consistently had specimens of *Agrostocynips* Diaz mixed with series of both *Ganaspidium* and *Disorygma* Förster. Miller (1989) assigned two new eucoilines described from North America to the Afrotropical genus *Nordlanderia* Quinlan. Unfortunately, the precise location of the holotypes is unknown, so Buffington (2004) left the following species as *nomina dubia*: *Nordlanderia merickeli* Miller and *N. najavoe* Miller. Comparison of the holotypes of the known species of *Ganaspidium* and many specimens of *Ganaspidium* at the USNM with the scanning electron micrograph images in Miller (1989), however, has allowed me to determine that one of his species belongs in *Ganaspidium*, while the second does not.

Buffington (2004) erroneously synonymized *Ganaspidium nigrimanus* (Kieffer 1907) with *G. utilis* because of the limited material available at the time. This action is now corrected and *G. utilis* is resurrected as a valid species, based on examination of material from the Canadian National Collection of Insects (CNCI, Ottawa, Canada), Texas A&M Insect Collection (TAMU, College Station, TX), the Entomology Research Museum, UC Riverside (Riverside CA), and the USNM (Washington, DC).

In Buffington et al. (2007), *Ganaspidium utilis* and *G. hunteri* were recovered in a clade separated from *G. pusillae*; this clade is sister-group to the Afrotropical lineage *Ealata* Quinlan and Palearctic lineage *Microstilba* Förster. Additional morphological studies of borrowed specimens, as well as those housed at the USNM, revealed that *G. hunteri*, *G. nigrimanus*, and *G. utilis* share very few character states with *G. pusillae*, but do share several states found within *Disorygma* Hartig, *Gronotoma* Förster and *Microstilba*. Because no other eucoiline genus could accommodate these species, Buffington

(2010) described *Banacuniculus* and created the combinations *Banacuniculus hunteri* (Crawford), *B. nigrimanus* (Kieffer) and *B. utilis* (Beardsley). The need for a redefinition of the generic boundaries of *Ganaspidium* is critically needed given that several closely related leafminer-parasitizing genera are typically confused with this genus.

Considering that species of this genus are distributed over a broad geographic range in North, Central, and South America, and its species are parasites of agromyzids of considerable economic importance (Johnson 1987), this paper is presented to help clarify confusion in this important and fascinating genus. This paper contains a redescription of *Ganaspidium* and *G. pusillae*, as well as the description of five species new to science: *Ganaspidium didionae*, *G. eldiablo, G. flemingi*, *G. kolmaci,* and *G. konzaensis*. *Nordlanderia navajoe* Miller, is recognized as junior synonym of *G. pusillae* Weld (new synonym). A key to all known species is included and the biology, when known, is included in each description.

Materials and Methods

List of Repositories

CASC California Academy of Sciences, San Francisco, CA, USA (R. Zuparko).
CNCI Canadian National Collection of Insects, Ottawa, Canada (J. Read).
KSCU Kansas State University, Manhattan, KS (G. Zolnerowich).
TAMU Texas A&M University Insect Collection, College Station, TX, USA (E. Riley).
UCDC Bohart Museum, University of California at Davis, Davis, CA, USA (L. Kimsey).
UCRC University of California at Riverside, Riverside, CA, USA (S. Triapytsin).
USNM National Museum of Natural History, Smithsonian Institution, Washington, D.C., USA (M. Buffington).

Additional sources of specimens. Extensive collections were made available from Texas by Ricardo Hernandez (Department of Entomology, TAMU) and Kansas by Robert Kula (Systematic Entomology Laboratory (SEL), ARS/USDA, Washington, DC) and Gregory Zolnerowich (Kansas State University, Manhattan, KS). Several specimens of *Ganaspidium* were taken via sweep net in Arizona and Nevada by Michael Gates (SEL) and myself during routine collecting trips. Sweeping low, placate vegetation, with a triangular sweep net (Noyes 1982), resulted in a significant number of specimens from each location.

Specimen illustration and observation. Methods for the imaging of specimens using light microscopy follow those of Buffington and van Noort (2007, 2009). An environmental scanning electron microscope (ESEM) was used as well; specimens were shot uncoated in a Philips XL-30 ESEM machine, with lanthanum hexaboride electron source (LaB6). The instrument was operated in low vacuum mode with water vapor as the imaging gas and backscatter imaging with one-half of the diode active. Specimen

mounting and lighting techniques follow Buffington and Gates (2009). Slide mounts were prepared with PVA mounting medium, cured for 72 hours at 43°C. Original drawings were done in pencil, scanned, and digitally edited using Adobe Photoshop CS2 (original drawings prepared by Theadore Buffington). Specimens were examined with a Leica M10 stereomicroscope, illuminated with a pair of fluorescent desk lights. This type of light is essential for the examination of *Ganaspidium*, since these lights produce an extremely diffuse illumination, preventing the obscuring of fine sculpture by glare.

Descriptive format

Diagnoses focus on features that are easily recognizable by other observers, and closely related species that may have similar gross morphologies are distinguished. Terminology for all descriptive characters, as well as phylogenetic characters, are defined in Buffington (2009) and are not repeated here; surface sculpture terminology follows that of Harris (1979). Following the descriptions are summaries of general distribution, biology and comments on nomenclatural issues (when applicable). The species descriptions are generated by a database application, vSysLab (Johnson 2008), designed to facilitate the generation of taxon by character data matrices and to export the data both as text and as input files for other applications. Exact label data is reported for holotypes. A link to a distribution map is included in each species description.

Systematic treatment

Ganaspidium Weld, 1955: 274

Type species: *Ganaspidium pusillae* Weld, by original designation.

Diagnosis. Malar space and ventral clypeal margin with distinct conical protuberances. Notauli absent. Parascutal impression incomplete. Scutellar plate narrow with paired conical protuberances anterior of midpit; midpit positioned in posterior one-third of plate. Setal band at base of syntergum of metasoma complete. Similar to *Disorygma*, *Microstilba,* and *Nordlanderia*, but distinguished by the absence of notauli and the presence of a hairy ring at the base of the syntergum; also similar to *Agrostocynips*, but with the pronotal plate less than one-half the width of the head, the genal carina absent, and the presence of clypeal and malar protuberances. Similar to *Banacuniculus*, but differing in the morphology of the scutellar plate (conical protuberances present in *Ganaspidium*, absent in *Banacuniculus*) and the incomplete parascutal impression (complete in *Banacuniculus*).

Redescription. *Head*. Nearly glabrous with a few scattered setae on lower face, clypeus, inner margins of compound eyes, and gena; ocellar hair patches absent. Ventral one-fourth of lower face with admedial clypeal furrows converging towards the clypeus; point of convergence resulting in the formation of a distinct conical protuber-

ance protruding from anterior margin of clypeus. Orbital furrows absent. Malar sulcus ranging from simple to compound. Malar space smooth to distinctly strigose, with large conical protuberance present. Genal carina absent.

Antennae. Female: 13 segments, moniliform, clavate; segments 3–13 sub-equal in length; rhinaria present only on the last 7 segments. Male: 15 segments; segments 3–15 sub-equal in length; rhinaria present on segments 3–15. Segment 3 modified, curved outwardly, excavated laterally.

Pronotum. Pronotal plate narrow, with setae present along posterior margin; dorsal margin rounded; pronotal fovea open. Lateral pronotal carina absent. Pronotal triangle absent. Pronotal impression absent. Lateral aspect of pronotum smooth, glabrous in most species.

Mesoscutum. Glabrous and smooth. Parascutal impression incomplete. Notauli, mesoscutal keel, parapsidal ridges, and parapsidal hair lines absent.

Mesopectus. Upper and lower part of mesopleuron ranging from completely smooth to longitudinally striate; glabrous. Mesopleural triangle present, faintly indicated (often only visible in the space immediately anterior to the mesopleural spiracle). Mesopleural carina simple; mesopleural hair patch present to absent. Precoxal carina of lower part of mesopleuron present anteriorly and posteriorly, absent ventrally. Surcoxal depression reduced, smooth.

Scutellum. Scutellar plate small, narrow; scutellar midpit positioned posteriorly, typically on posterior one-third of plate (MP, Fig. 1A); rim of plate translucent; dorsal surface of plate with pair of tubercles (TUB, Fig. 1A, B). Dorsal surface of the scutellum reticulate to smooth; rounded posteriorly and laterally; posterior carina present or absent. Laterodorsal and posterior projections absent. Lateral bar as long as wide; ventral lobe absent. Scutellar fovea oval, smooth and deep.

Metapectal-propodeal complex. Posterior one-third to one-fourth of metapectus setose. Spiracular groove with a well-defined dorsal margin and reduced ventral margin. Posterior margin of metapectus smooth, not ridged. Metapleural ridge and submetapleural ridge absent. Anterior impression of metepimeron absent; anterior impression of metepisternum reduced. Anteroventral cavity rounded, setose. Propodeum covered in dense, appressed setae. Lateral propodeal carinae semiparallel, bowed at junction with auxiliary propodeal carinae; auxiliary propodeal carinae distinct. Nucha glabrous, reticulate.

Wings. Hyaline; setose. R complete, pigmented along anterior margin of wing; marginal cell truncate, typically deeper than long (Fig. 1C). Apical fringe short.

Legs. Fore and mid coxa sub equal in size, hind coxa twice the size of either fore or mid coxa. Fore coxa variously setose; mid and hind coxa with distinct anterior and posterior dorsoventral setal bands. Femora with sparse setal lines; tibiae and tarsomeres with dense, appressed setae. Length of hind tarsomere 1 equal to 0.5x the combined length of remaining hind tarsomeres.

Metasoma. Female: Sub equal in size to mesosoma. Base of syntergum with hairy ring, comprised of dense appressed setae and a ring of thin, erect setae; remainder of metasoma glabrous. Micropunctures present on posterior one-third of syntergum and remaining terga. Terga posterior to syntergum gradually directed ventrally, resulting

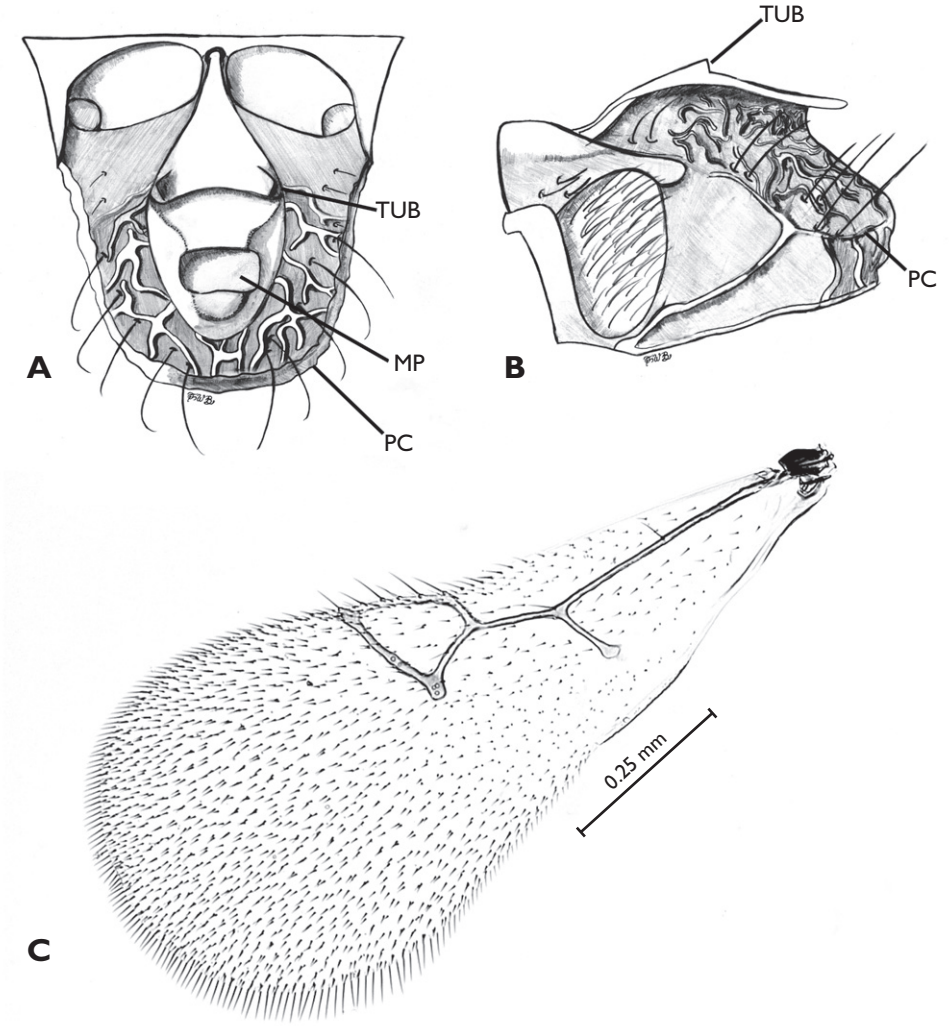

Figure 1. Diagnostic features of *Ganaspidium*. **A** scutellum, dorsal view **B** scutellum, lateral view **C** forewing, dorsal view. All illustrations of *Ganaspidium pusillae*. Abbreviations: **MP** midpit of scutellar plate **PC** posterior carina of scutellum **TUB** tubercles of scutellar plate.

in 70 degree angle between syntergum and remaining terga. Ovipositor with series of sub apical serrations (seen only in large specimens). Male: as in female, with the terga posterior to syntergum abruptly angled ventrally, resulting in 90 degree angle between syntergum and remaining terga.

Distribution. Figure 5.

Neotropical Region: Chile, Costa Rica; Nearctic Region: northern Mexico, continental United States, southern Canada.

Biology. Several species of *Liriomyza* have been recorded as hosts (Weld 1955; Harding, 1965, present study). Species of this genus can be found in nearly biogeo-

graphic region and have been recovered from hosts in 25 families of Asteraceae (CABI 1992). This incredibly broad geographic and host range helps explain the presence of this host from lush agroecosystems to arid desert habitats.

Comments. Miller (1989) described two species of eucoiline wasps that were placed in *Nordlanderia* Quinlan. Although the type specimens for these two species are apparently lost (Miller, pers. comm.), it is clear from the scanning electron micrographs accompanying the original descriptions that these two species do not belong in *Nordlanderia*. One species, *N. navajoae* Miller, bears diagnostic features of *Ganaspidium* and is transferred below; the second species, *N. merickeli* Miller, belongs in *Banacuniculus*, and is formally transferred in Buffington (2010). One paratype of *Ganaspidium pusillae* is actually a specimen of *Disorygma pacifica* (Yoshimoto), reared from *Liriomyza pusilla*. This specimen bears the label "*Disorygma*" in Nordlander's hand.

Species included in *Ganaspidium* Weld

G. didionae Buffington, new species.
G. eldiablo Buffington, new species.
G. flemingi Buffington, new species.
G. kolmaci Buffington, new species.
G. konzaensis Buffington, new species.
G. pusillae Weld, 1955: 274, holotype in USNM. *Ganaspidium navajoae* (Miller), syn. n., holotype lost.

Species formerly placed in *Ganaspidium*, now placed in *Banacuniculus* (Buffington, 2010):

Banacuniculus hunteri (Crawford), Buffington (2010). *Ganaspidium hunteri* (Crawford) Beardsley (1986); *Eucoila hunteri* Crawford, 1913: 310, holotype in USNM.
B. nigrimanus (Kieffer). *Eucoela nigrimanus* Kieffer, 1907:138, holotype in CAS. New combination by Buffington (2004).
B. utilis Beardsley, 1988: 44–46, holotype in BPBM, removed from synonymy; synonymized with *G. nigrimanus* (Kieffer) in Buffington (2004).

Key to species of *Ganaspidium*

Note: Diffuse light, such as that produced by fluorescent lights or fiber optic lights with light dispersing film, is absolutely essential to effectively use this key.

1. Frons smooth, malar space, and mesopleuron smooth (Fig. 2B); if malar space striate, striations restricted to ventral margin and not extending to ventral margin of compound eye; if mesopleuron with some striations, these striations restricted to the postero-dorsal margin of the sclerite **2**
– Frons, malar space and the majority of the mesopleuron distinctly longitudinally striate Figs 3A & B); frons typically striate from mandibular base to ventral margin of compound eye.....***G. konzaensis* Buffington, sp. n.**

2. Dorsal surface of scutellar plate with a pair of distinct tubercles present on the anterior half of the plate (Fig. 1A) **3**
– Dorsal surface of scutellar plate nearly flat, with a slight hump where in other species the scutellar plate tubercles are present (Fig. 4A) .... ***G. kolmaci*** **Buffington, sp. n.**
3. Dorsal surface of the scutellum entirely smooth, occasionally with weak wrinkles along the margin of posterior carina (Fig. 4D) **4**
– Dorsal surface of scutellum distinctly rugulose to strigose, never smooth (Fig. 2B) **5**
4. Posterior margin of scutellum without a distinct carina differentiating the dorsal surface from the postero-lateral surface; dorsal surface of scutellum totally smooth ..... ***G. eldiablo*** **Buffington, sp. n.**
– Posterior margin of scutellum with a distinct and well-developed posterior carina, differentiating the dorsal surface of the scutellum from the postero-lateral surface; dorsal surface of scutellum smooth, with occasional weak wrinkles posteriorly along the posterior carina ..... ***G. flemingi*** **Buffington, sp. n.**
5. Dorsal surface of scutellum distinctly rugulose with a large, distinctly cleft, posterior carina (Fig. 4C); tubercles of the scutellar plate massive, height of tubercle equal to the width of the tubercle base; malar space striate .... ***G. didionae*** **Buffington, sp. n.**
– Dorsal surface of scutellum more delicately sculptured, with fine strigae radiating from the underside of the scutellar plate (Fig. 2 B); posterior carina very thin and not cleft; tubercles of the scutellar plate smaller, height of each tubercle equal to one-half to one-third length of tubercle base; malar space occasionally striate but much more typically smooth ..... ***G. pusillae*** **Weld**

Ganaspidium didionae **Buffington, sp. n.**
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urn:lsid:biosci.ohio-state.edu:osuc_concepts:253200
Figure 4C

Description. Malar sulcus compound. Malar space partially striate, striations extending one-half to two-thirds distance from ventral margin of malar space to base of compound eye. Malar protuberance smooth, elongate, extending beyond length of ventral margin of malar space. Clypeal protuberance elongate, overhanging anterior margin of clypeus. Tubercles of scutellar plate present, distinct, large, length of tubercle equal to or greater than width of tubercle base. Dorsal surface of scutellar plate concave around midpit, two setal bearing pits at base of each tubercle. Carina along posterior margin of scutellum present, distinctly cleft, defining transition from dorsal surface of scutellum from posterior surface. Dorsal surface of scutellum entirely rugulose/wrinkled. Midpit of scutellar plate in posterior half of plate; plate small, revealing dorsal surface of scutellum when viewed dorsally. Mesopopleural setal patch absent. Mesopleuron

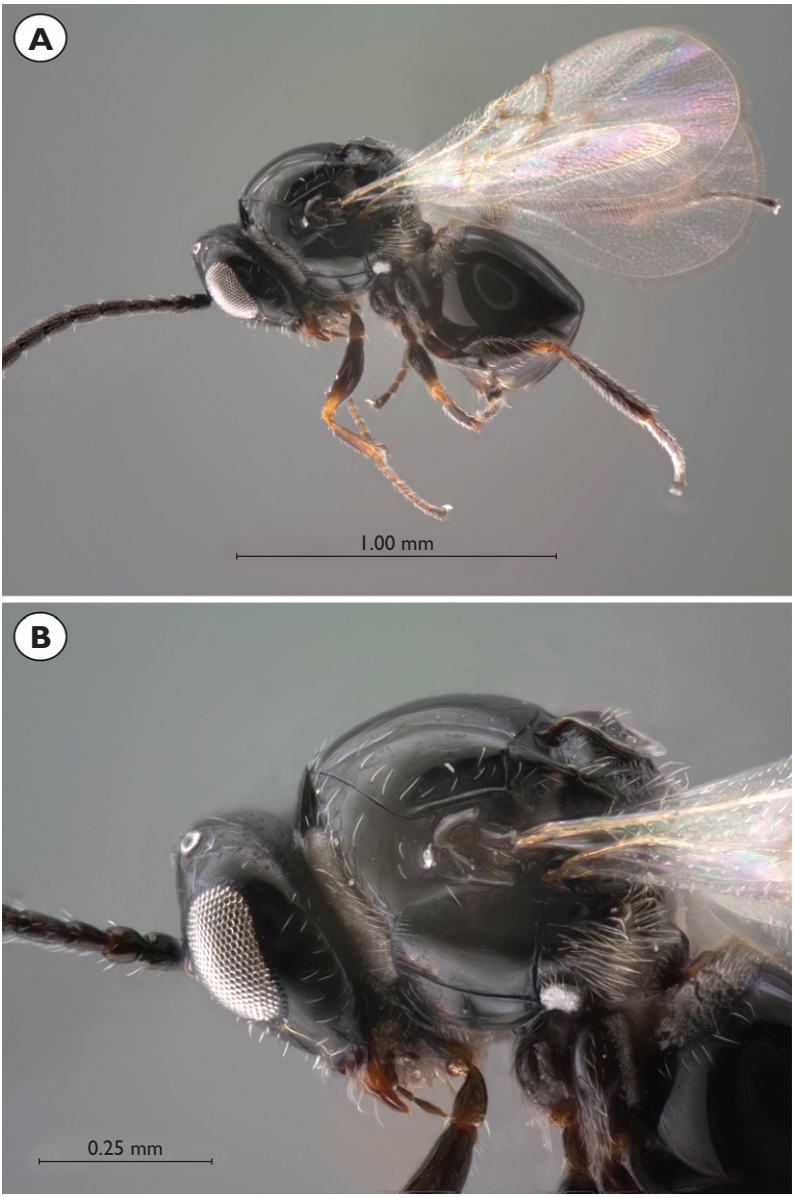

Figure 2. *Ganaspidium pusillae* Weld. **A** habitus, female **B** head and mesosoma, lateral view, female.

entirely smooth; smooth anteriorly, striate along the postero-dorsal margin. Lateral aspect of pronotum anteriorly with some short setae, remainder glabrous. Marginal cell of forewing distinctly deeper than long. Metasoma of sub-equal size to mesosoma in lateral view.

Diagnosis. This species is unique within *Ganaspidium* as it is the only species with a horizontally striate scutellar plate. The strongly reticulate dorsal surface of the scutellum is also rather unique, only shared with *G. konzaensis* and *G. kolmaci*; *G. didionae*

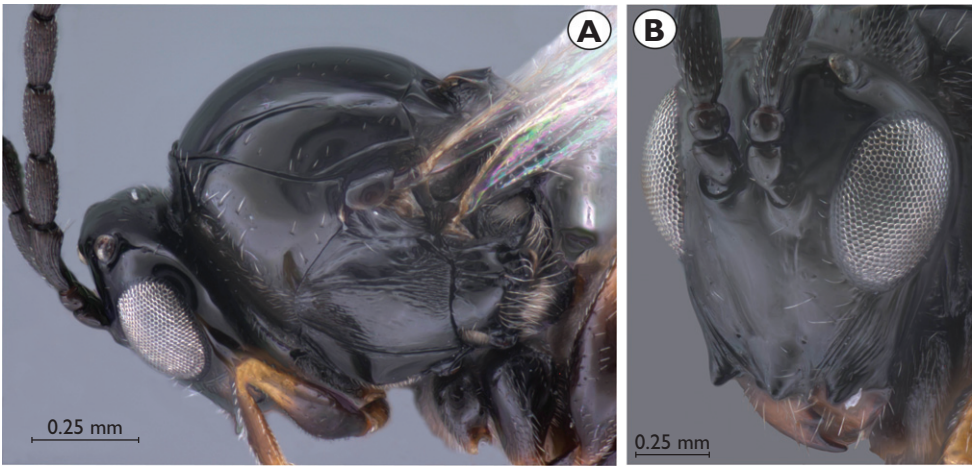

Figure 3. *Ganaspidium konzaensis* Buffington, sp. n. **A** head and mesosoma, lateral view **B** head, ¾ anterior view. Note the striations on both the mesopleuron in 3A and on the malar space in 3B.

is separated from these two by the horizontally striate scutellar plate as well as a limited degree of striation on the malar space (fully striate in *G. konzaensis*) and distinct tubercles on the scutellar plate (significantly reduced in *G. kolmaci*).

Etymology. Named in honor of author Joan Didion. Several fiction and nonfiction pieces by Ms. Didion focus on the desert Southwest of the United States. The gender is feminine.

Link to distribution map. http://hol.osu.edu/map-full.html?id=253200

Material examined. Holotype, male: **UNITED STATES:** *NEVADA.* White Pine Co., 45km SSE Eureka, 19.VII.1995, S. L. Heydon & R. M. Bohart, USNM ENT 00655512 (deposited in UCDC). *Paratypes*: (4 females) **ARGENTINA:** Neuquén Prov., 21km WNW Junín de los Andes, hwy 62, 3km inside park, Lanín National Park, 19.II-24.II.1999, S. L. Heydon & J. Ledford (1 female, USNM ENT 00655516 (UCDC)). **CHILE:** Región Metropolitana de Santiago, 1km W Farellones, 2125m, 11.XII.1994, S. L. Heydon & E. Arias (1 female, USNM ENT 00655464 (UCDC)). **UNITED STATES:** *ARIZONA*. Cochise Co., Chiricahua Mts., Portal, 20.VIII.1958, R. H. James (1 female, USNM ENT 00655432 (CASC)); Pima Co., Santa Rita Mts., G96/045, Box Canyon, 3.VII.1996, M. W. Gates (1 female, UCRC ENT 197002 (UCRC)).

Ganaspidium eldiablo Buffington, sp. n.

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Figure 4D

Description. Malar sulcus compound. Malar space smooth. Malar protuberance smooth, elongate, extending beyond length of ventral margin of malar space. Clypeal

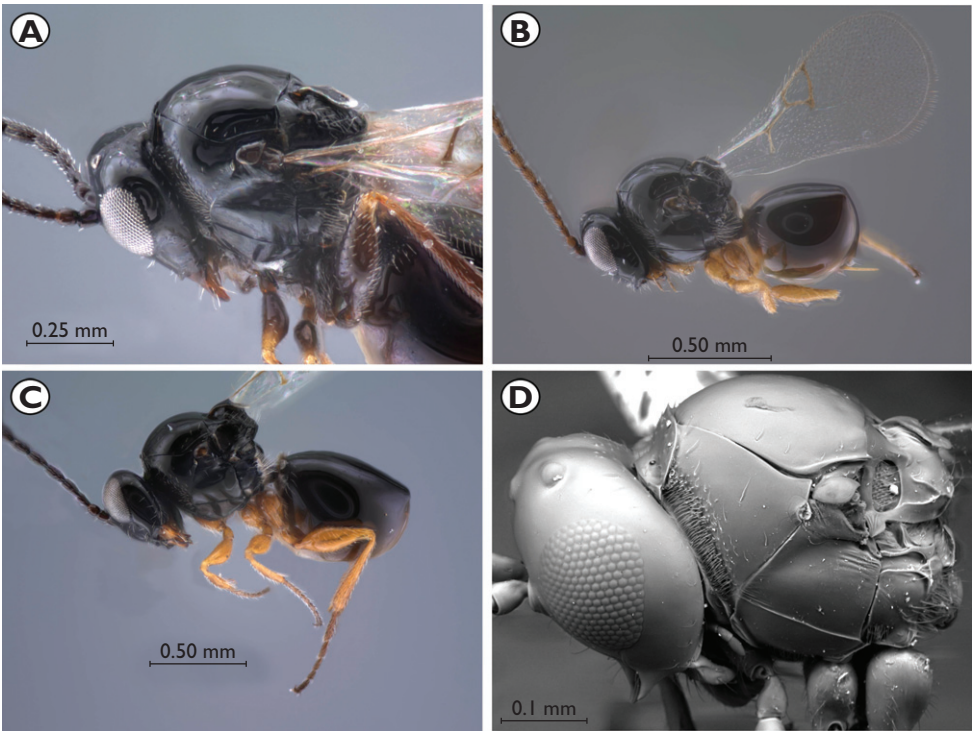

Figure 4. New species of *Ganaspidium*: *G. didionae* Buffington, *G. flemingi* Buffington, *G. kolmaci* Buffington, and *G. eldiablo* Buffington. **A** head and mesosoma, lateral view, of female *G. kolmaci* **B** habitus female of *G. flemingi* **C** habitus female of *G. didionae* **D** habitus female of *G. eldiablo*.

protuberance elongate, overhanging anterior margin of clypeus. Tubercles of scutellar plate extremely reduced, hardly distinguishable. Dorsal surface of scutellar plate concave around midpit, two setal bearing pits at base of each tubercle. Carina along posterior margin of scutellum absent. Dorsal surface of scutellum smooth anteriorly, gently striate posteriorly. Midpit of scutellar plate in posterior half of plate; plate small, revealing dorsal surface of scutellum when viewed dorsally. Mesopopleural setal patch absent. Mesopleuron entirely smooth. Lateral aspect of pronotum anteriorly with some short setae, remainder glabrous. Marginal cell of forewing distinctly deeper than long. Metasoma of sub-equal in size to mesosoma in lateral view.

Diagnosis. This species can be separated from all other *Ganaspidium* by having the dorsal surface of the scutellum smooth anteriorly, striate posteriorly, and lacking the posterior carina of the scutellum. This species is most easily confused with *G. pusillae* and *G. flemingi*, both of which possess a distinct posterior carina of the scutellum.

Etymology. Name refers to the type locality along the 'El Camino Diablo Real' in southwestern Arizona. The gender is neuter.

Link to distribution map. http://hol.osu.edu/map-full.html?id=253202

Material examined. Holotype, female: **UNITED STATES:** *ARIZONA*. Pima Co., 17mi E Papago Well, Camino del Diablo, along wash, Organ Pipe Cactus Na-

Figure 5. General distribution map of all species of *Ganaspidium*.

tional Monument, 29.VIII.2006, sweeping, Gates & Buffington, USNM ENT 00655307 (deposited in USNM). *Paratypes*: (17 females, 4 males) **UNITED STATES:** *ARIZONA*. Pima Co., 17mi E Papago Well, Camino del Diablo, along wash, Organ Pipe Cactus National Monument, 29.VIII.2006, sweeping, Gates & Buffington (14 females, 3 males, USNM ENT 00655297, 00655298, 00655299, 00655301-00655306, 00655308, 00655309, 00655310-00655315 (USNM)). *CALIFORNIA*. Riverside Co., Thousand Palms, 26.IV.1955, W. R. M. Mason (1 female, USNM ENT 00655546 (CNCI)); Riverside Co., Whitewater Canyon, 310m, 2.VI.1998 (1 female, UCRC ENT 196990 (UCRC)). *OREGON*. Lake Co., 13.5mi SW Christmas Valley, 5.VIII.1995, sweeping, J. D. Pinto (1 male, UCRC ENT 196979 (UCRC)). *WASHINGTON*. Grant Co., Potholes State Park, 26.VII.1985, Moss, Finnamore & Thormin (1 female, USNM ENT 00655556 (CNCI)).

***Ganaspidium flemingi* Buffington, sp. n.**
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urn:lsid:biosci.ohio-state.edu:osuc_concepts:253203
Figure 4B

Description. Malar sulcus compound. Malar space smooth. Malar protuberance smooth, elongate, extending beyond length of ventral margin of malar space. Clypeal protuberance elongate, overhanging anterior margin of clypeus; short, not overhanging anterior margin of clypeus. Tubercles of scutellar plate distinct, small, length of tuber less than one-half width of tubercle base. Dorsal surface of scutellar plate concave around midpit, two setal bearing pits at base of each tubercle. Carina along posterior margin of scutellum present, delicate, defining transition from dorsal surface of scutellum from posterior surface. Dorsal surface of scutellum smooth except for faint wrinkles along posterior carina. Midpit of scutellar plate in posterior half of plate; plate small, revealing dorsal surface of scutellum when viewed dorsally. Mesopopleural setal patch absent. Mesopleuron entirely smooth. Lateral aspect of pronotum anteriorly with some short setae, remainder glabrous. Marginal cell of forewing distinctly deeper than long. Metasoma of sub-equal in size to mesosoma in lateral view.

Diagnosis. This species can be separated from all other species of *Ganaspidium* by having an entirely smooth dorsal surface of the scutellum, with only a few gentle wrinkles present along the posterior carina of the scutellum, and having a completely smooth malar space. Most easily confused with *G. pusillae*, which will often have a smooth anterior half, but distinctly wrinkled/striate posterior half of the dorsal surface of the scutellum.

Etymology. Named in honor of Ian Fleming, author and creator of the British secret agent *James Bond 007*, and long time resident of The Bahamas. The gender is masculine.

Link to distribution map. http://hol.osu.edu/map-full.html?id=253203

Material examined. Holotype, female: **BAHAMAS:** Ragged Island Dist., 2008R103, Buena Vista Cay Island, 9.I-14.I.2008, malaise trap/yellow pan trap, L. S. Kimsey, USNM ENT 00655526 (deposited in UCDC). *Paratypes*: (10 females, 1 male) **BAHAMAS:** Ragged Island Dist., 2008R103, Buena Vista Cay Island, 9.I-14.I.2008, malaise trap/yellow pan trap, L. S. Kimsey (1 female, USNM ENT 00655527 (UCDC)). Ragged Island Dist., 2008R103, Buena Vista Cay Island, 9.I-14.I.2008, L. S. Kimsey (2 females, USNM ENT 00655528, 00655529 (UCDC)). **UNITED STATES:** *ARIZONA*. Coconino Co., Moenkopi Wash, 2mi SE Tuba City, 31.VIII.1986, A. S. Menke (1 female, USNM ENT 00653499 (USNM)). *CALIFORNIA*. Inyo Co., Indian Ranch Road, tamarisk / mesquite, warm sulfur springs, 21.III-22.III.2002, A. Owens & J. George (1 female, UCRC ENT 196973 (UCRC)); Inyo Co., white flowers, 14km NW Darwin, 25.V.1994, S. L. Heydon (1 female, USNM ENT 00655496 (UCDC)); Riverside Co., 5mi E Cabazon, 27.IX.1978, G. Gordh (1 female, UCRC ENT 196977 (UCRC)). *IDAHO*. Twin Falls Co., #5A, Hollister, 5.VI.1931, D. E. Fox (1 female, USNM ENT 00653489 (USNM)). *KANSAS*. Geary

Co., watershed, Konza Prairie Biological Station, 16.VIII-26.VIII.2005, malaise trap (1 female, USNM ENT 00655618 (USNM)); Geary Co., watershed, Konza Prairie Biological Station, 27.VI-8.VI.2005, malaise trap (1 male, USNM ENT 00655619 (USNM)). *NEW MEXICO.* Valencia Co., 20mi W Los Lunas, along streambed, Carrizo Creek, 23.VIII.1977, malaise trap, S. Peck & J. Peck (1 female, USNM ENT 00655555 (CNCI)).

Comments. The presence of this taxon in The Bahamas is intriguing. Most eucoiline leafminer parasites from the Caribbean belong to the Zaeucoilini (Buffington, 2009). It is likely that this species is a North American native that has been introduced to The Bahamas via human activity, as has occurred with *B. utilis* and *Disorygma pacifica* (Yoshimoto) in the Hawaiian Islands.

Ganaspidium kolmaci Buffington, sp. n.

urn:lsid:zoobank.org:act:F0845DF2-5656-4366-9FEC-31C25F034005
urn:lsid:biosci.ohio-state.edu:osuc_concepts:253205
Figure 4A

Description. Malar sulcus simple. Malar space partially striate, striations extending one-half to two-thirds distance from ventral margin of malar space to base of compound eye. Malar protuberance smooth, elongate, extending beyond length of ventral margin of malar space. Clypeal protuberance elongate, overhanging anterior margin of clypeus. Tubercles of scutellar plate extremely reduced, hardly distinguishable. Dorsal surface of scutellar plate flat, smooth, setal bearing pits present surrounding midpit. Carina along posterior margin of scutellum absent; present, delicate, defining transition from dorsal surface of scutellum from posterior surface. Dorsal surface of scutellum smooth anteriorly, reticular/strigate posteriorly. Midpit of scutellar plate in posterior half of plate; plate small, revealing dorsal surface of scutellum when viewed dorsally. Mesopopleural setal patch absent. Mesopleuron entirely smooth; smooth anteriorly, striate along the postero-dorsal margin. Lateral aspect of pronotum anteriorly with some short setae, remainder glabrous. Marginal cell of forewing as deep as long. Metasoma of sub-equal in size to mesosoma in lateral view.

Diagnosis. This species can be separated from all other *Ganaspidium* by the presence of reduced tubercles on the scutellar plate. This character requires careful observation because the tubercles are difficult to observe. In all other species of *Ganaspidium*, the paired tubercles are well developed and easily seen in profile (e.g. Fig. 1B).

Etymology. Named in honor the doctors and staff of the Kolmac Clinic, Washington, DC. The gender is masculine.

Link to distribution map. http://hol.osu.edu/map-full.html?id=253205

Material examined. Holotype, female: **UNITED STATES:** UT, Wayne Co., 8mi W Caineville, Moki Ruin, 4920ft, 14.X.2002, sweeping, J. D. Pinto, USNM ENT 00655300 (deposited in USNM). *Paratypes*: (28 females, 18 males) **ARGENTINA:** Neuquén Prov., 21km WNW Junín de los Andes, hwy 62, 3km inside park,

Lanín National Park, 21.VII.1994, S. L. Heydon & J. Ledford (1 female, 1 male, USNM ENT 00655517, 00655518 (UCDC)). **CANADA:** AB, W of Dinosaur Prov. Park, hwy 876, Red Deer River, 5.VII-6.VII.1991, malaise trap, J. H. O'Hara (1 female, USNM ENT 00655560 (CNCI)). AB, flowery prairie, Waterton Lakes National Park of Canada, 8.VII.1991, H. Goulet (2 females, USNM ENT 00655552, 00655563 (CNCI)). AB, montaine prairie, Waterton Lakes National Park of Canada, 6.VII.1991, H. Goulet (1 male, USNM ENT 00655551 (CNCI)). AB, montaine prairie, Waterton Lakes National Park of Canada, 8.VII.1991, H. Goulet (1 male, USNM ENT 00655564 (CNCI)). BC, 57km N Princeton, hwy. 5, pine / grass, Kentucky-Alleyne Park, 10.VII.1986, H. Goulet (8 females, 1 male, USNM ENT 00655550, 00655553-00655554, 00655558, 00655559, 00655561-00655562, 00655565, 00655569 (CNCI)). SK, Dunblane, 10.IX.1959, J. R. Vockeroth (1 male, USNM ENT 00655567 (CNCI)). **NICARAGUA:** Rivas Dept., San Juan del Sur, 11°15'N 85°52'W, 21.VII.1994, L. J. Clark (1 male, USNM ENT 00655505 (UCDC)). **UNITED STATES:** *ARIZONA*. Cochise Co., Chiricahua Mts., swimming pool, Southwestern Research Station (SWRS), 5.V.1980, V. Roth (1 female, USNM ENT 00655547 (CNCI)); Coconino Co., 13mi S Jacob Lake, 6600ft, 26.VI.1993, J. D. Pinto (4 females, 3 males, UCRC ENT 196981-196987 (UCRC)); Coconino Co., pine / aspen / fir, 36km S Jacob Lake, 2650m, 14.VII-15.VII.1967, B. V. Brown (1 female, UCRC ENT 196980 (UCRC)). *CALIFORNIA*. Lake Co., Lakeport, 8.VII-20.VII.1994 (1 male, USNM ENT 00655483 (UCDC)). *NEVADA*. Churchill Co., 61mi W Austin, desert scrub, "Shoetree", hwy 50, 9.V.2002, Buffington & Munro (2 females, UCRC ENT 196974, 56822 (UCRC)); Nye Co., Rock Valley, 20.IV.1976 (1 female, USNM ENT 00655426 (CASC)). *OREGON*. Lake Co., Alkali Lake, 21.VII.1994, S. L. Heydon (7 females, 5 males, USNM ENT 00655476, 00655478, 00655479, 00655480, 00655481, 00655482, 00655489, 00655490, 00655491, 00655493, 00655494, 00655495 (UCDC)); Union Co., Mount Emily, 5mi N La Grande, 15.VII-18.VII.1984, malaise trap, T. R. Torgersen (1 male, USNM ENT 00653503 (USNM)). *UTAH*. Wayne Co., 6mi W Caineville, along Fremont River, 4700ft, 29.VI.1993, J. D. Pinto (1 male, UCRC ENT 196988 (UCRC)). *WASHINGTON*. Whitman Co., Festuca / Symphoricarpos, Colton, 15.VII.1960 (1 male, USNM ENT 00653496 (USNM)).

***Ganaspidium konzaensis* Buffington, sp. n.**
urn:lsid:zoobank.org:act:58ECBA6A-14F8-4763-A41C-C2B3E631DC5C
urn:lsid:biosci.ohio-state.edu:osuc_concepts:253206
Figures 3A–B

Description. Malar sulcus compound. Malar space completely striate from ventral margin of malar space to base of compound eye. Malar protuberance smooth, elongate, extending beyond length of ventral margin of malar space. Clypeal protuberance elongate, overhanging anterior margin of clypeus. Tubercles of scutellar plate present,

distinct, large, length of tubercle equal to or greater than width of tubercle base. Dorsal surface of scutellar plate concave around midpit, two setal bearing pits at base of each tubercle. Carina along posterior margin of scutellum present, distinctly cleft, defining transition from dorsal surface of scutellum from posterior surface. Dorsal surface of scutellum entirely rugulose/wrinkled. Midpit of scutellar plate in posterior half of plate; plate small, revealing dorsal surface of scutellum when viewed dorsally. Mesopopleural setal patch absent. Mesopleuron distinctly striate along the anterior, posterior margins; often entire sclerite striate. Lateral aspect of pronotum anteriorly with some short setae, remainder glabrous. Marginal cell of forewing as deep as long. Metasoma of sub-equal in size to mesosoma in lateral view.

Diagnosis. This species is separated from all other species of *Ganaspidium* by the distinctly striate mesopleuron and fully striate malar space. In some *G. pusillae* and *G. kolmaci*, the postero-dorsal corner of the mesopleuron can be striate, as well as the ventral one-half to one-third of the malar space, but in neither case is the entire surface striate as in *G. konzaensis*.

Etymology. Named for the type locality of the holotype, Konza Prairie Biological Reserve, Geary County, Kansas. The gender is neuter.

Link to distribution map. http://hol.osu.edu/map-full.html?id=253206

Material examined. Holotype, female: **UNITED STATES:** KS, Geary Co., watershed, Konza Prairie Biological Station, 16.VIII-26.VIII.2005, malaise trap, USNM ENT 00655616 (deposited in USNM). *Paratypes*: (4 females, 7 males) **CANADA:** *ALBERTA*. Drumheller, 14.VI.1946, W. R. M. Mason (1 female, USNM ENT 00655568 (CNCI)). **UNITED STATES:** *CALIFORNIA*. Alpine Co., Hope Valley, 11.VII.1972, R. M. McMaster (1 female, USNM ENT 00655484 (UCDC)); Inyo Co., Eureka Valley Sand Dunes, 14.V.1979, N. J. Smith (1 male, USNM ENT 00655485 (UCDC)); Inyo Co., Goodale Creek, 3.IV.1953, H. B. Leech (1 male, USNM ENT 00655427 (CASC)). *COLORADO*. Park Co., 6km S Lake George, along Fish Creek, 21.VII.1994, S. L. Heydon (4 males, USNM ENT 00655471-00655474 (UCDC)); Weld Co., Greeley, 8.VIII.1929, W. J. Zaumeyer (1 female, USNM ENT 00653596 (USNM)). *KANSAS*. Riley Co., Konza Prairie Biological Station, 25.V-29.V.2001, G. Zolnerowich & R. Kula (1 male, USNM ENT 00655615 (USNM)); La Crosse Co., 27.VIII.1960, L. A. Stange (1 female, USNM ENT 00655425 (CASC)).

Ganaspidium pusillae **Weld, 1955**

urn:lsid:biosci.ohio-state.edu:osuc_concepts:251125
Figures 1A–C, 2A–B

Nordlanderia navajoae Miller, 1989, new synonymy

Redescription. Malar sulcus simple. Malar space partially striate, striations extending one-half to two-thirds distance from ventral margin of malar space to base of compound eye. Malar protuberance smooth, elongate, extending beyond length of

ventral margin of malar space; smooth, short, not extending beyond length of ventral margin of malar space. Clypeal protuberance elongate, overhanging anterior margin of clypeus; short, not overhanging anterior margin of clypeus. Tubercles of scutellar plate distinct, small, length of tuber less than one-half width of tubercle base. Dorsal surface of scutellar plate concave around midpit, two setal bearing pits at base of each tubercle. Carina along posterior margin of scutellum present, delicate, defining transition from dorsal surface of scutellum from posterior surface. Dorsal surface of scutellum smooth anteriorly, reticular/strigate posteriorly. Midpit of scutellar plate in posterior half of plate; plate small, revealing dorsal surface of scutellum when viewed dorsally. Mesopopleura setal patch absent. Mesopleuron entirely smooth; smooth anteriorly, striate along the postero-dorsal margin. Lateral aspect of pronotum anteriorly with some short setae, remainder glabrous. Marginal cell of forewing distinctly deeper than long. Metasoma of sub-equal size to mesosoma in lateral view.

Diagnosis. Differs from other species of *Ganaspidium* by having moderately developed tubercles on the scutellar plate, dorsal surface of scutellum smooth anteriorly and delicately sculptured posteriorly, and a complete posterior scutellar carina; other species in the group either lack the posterior carina, have an entirely smooth dorsal surface of the scutellum, indistinct or very well-developed tubercles on the scutellar plate.

Biology. Recorded from *Liriomyza huidobrensis* (Blanchard) (present study), *L. pusilla* (Meigen) (Weld, 1955), and *L. munda* Frick (Harding, 1965).

Link to distribution map. http://hol.osu.edu/map-full.html?id=251125

Material examined. Holotype, female: **UNITED STATES:** *TEXAS*. Hidalgo Co., Monte Alto, 30.V.1953, USNM ENT 00655718 (deposited in USNM). *Paratypes*: **UNITED STATES:** *TEXAS.* Hidalgo Co., Monte Alto, 30.V.1953 (3 females, 1 male, 1 unknown, USNM ENT 00655428, 00655429, 00655430-00655431 (CASC); USNM ENT 00653497 (USNM)). *Other material*: 40 females, 4 males, 110 unknowns) **CANADA:** AB, no date (1 female, USNM ENT 00655566 (CNCI)). AB, W of Dinosaur Prov. Park, hwy 876, Red Deer River, 5.VII-6.VII.1989, malaise trap, J. H. O'Hara (1 female, USNM ENT 00655570 (CNCI)). **MEXICO:** TAMPS, 3mi S Ciudad Victoria, 1.XI.1982, screen sweeping, A. Gonzalez & J. T. Huber (7 females, UCRC ENT 196991-196997 (UCRC)). **UNITED STATES:** *ARIZONA.* Coconino Co., Moenkopi Wash, 31.VIII.1986, A. S. Menke (1 female, USNM ENT 00653487 (USNM)); Pima Co., Tucson, no date, Baker (2 males, USNM ENT 00653502, 00653601 (USNM)); Santa Cruz Co., Sonoita, 25.VIII.2006, malaise trap, E. E. Grissell (1 female, USNM ENT 00655346 (USNM)). *CALIFORNIA*. Inyo Co., Darwin Falls, 21.III-22.III.2002, George & Owens (1 female, UCRC ENT 56867 (UCRC)); Inyo Co., white flowers, 14km NW Darwin, 25.V.1994, S. L. Heydon (1 female, USNM ENT 00655497 (UCDC)); San Bernardino Co., 1.4mi N of crossing of 2N93 Service Road and hwy 38, pine scrub, San Bernardino Mountains, 2450m, 24.VI.1997, M. Buffington (1 female, UCRC ENT 196989 (UCRC)); San Bernardino Co., Helendale, 21.V.1955, W. R. M. Mason (1 female, USNM ENT 00655557 (CNCI)). *COLORADO*. El Paso Co., Colorado Springs, 1.VII.1915 (1

female, 1 male, USNM ENT 00653486, 00653611 (USNM)); Larimer Co., Cameron Pass, 30.VII.1896, Baker (1 female, USNM ENT 00653524 (USNM)). CO, Park Co., 6km S Lake George, along Fish Creek, 7.VII.1992, S. L. Heydon (1 female, USNM ENT 00655468 (UCDC)). *IDAHO*. Woodbury Co., Sioux City, 8.IX.1927, C. N. Ainslie (1 female, USNM ENT 00653517 (USNM)). *KANSAS*. Geary Co., watershed, Konza Prairie Biological Station, 27.VI-8.VI.2005, malaise trap (1 female, USNM ENT 00655617 (USNM)). *NEW MEXICO*. Bernalillo Co., Albuquerque, 18.VI.2000 (1 female, USNM ENT 00653506 (USNM)); Doña Ana Co., Mesilla, no date, C. N. Ainslie (1 female, USNM ENT 00653523 (USNM)); Doña Ana Co., Mesilla, no date (1 female, USNM ENT 00653594 (USNM)). *NEVADA*. 4.VII.1924, Timberlake (1 female, UCRC ENT 196975 (UCRC)). *OREGON*. Klamath Co., 10mi out Medford Road, Crater Lake National Park, ~5500ft, 10.IX.1930, H. A. Scullen (1 female, USNM ENT 00653595 (USNM)). *TEXAS*. 3.VI.1924, Timberlake (1 female, UCRC ENT 196976 (UCRC)); Cameron Co., TAM Veracruz hot pepper, La Feria, 19.IX.2007, Hernandez (1 female, USNM ENT 00655157 (USNM)); Dimmit Co., East Guajalote, pasture 15, 90/077, Chaparral Wildlife Management Area, 30.IX.1990, J. B. Woolley (1 female, USNM ENT 00655345 (USNM)); Hidalgo Co., Jalapeño M hot peppers, Weslaco, 1.IV.2008, Hernandez (5 females, USNM ENT 00655094, 00655095, 00655103, 00655114-00655115 (USNM)); Hidalgo Co., tormenta hot pepper, Pharr, 28.VI.2008, Hernandez (3 females, USNM ENT 00655013, 00655028, 00655033 (USNM)); McLennan Co., cotton, Waco, 21.VII.1949, Glick (1 female, USNM ENT 00653592 (USNM)); Uvalde Co., roadside flowers, 1985-002S, 13mi NW Uvalde, 15.IV.1985, Schaffner (2 females, USNM ENT 00655326-00655327 (USNM)); Zavala Co., cantaloupe, Crystal City, no date (1 unknown, USNM ENT 00653500 (USNM)). *UTAH*. Emery Co., nr. Goblin Valley State Park, Wild Horse Creek, 2.VIII-7.VIII.1997, malaise trap, M. Wasbauer & J. Wasbauer (1 female, USNM ENT 00655452 (UCDC)). *WYOMING*. Sweetwater Co., 11.6mi E Point of Rocks, 30.VII.1983, J. D. Pinto (1 female, UCRC ENT 196978 (UCRC)).

Discussion

Buffington et al. (2007) considered *Ganaspidium pusillae* to be the sister-group to what was referred to then as the *Gronotoma* group of genera. Forshage and Nordlander (2008) resurrected Diglyphosemini Belizin, 1961, and referred to taxa formally included within the *Gronotoma* group, based on Fontal-Cazalla et al. (2002) and Buffington et al. (2007), as members of this tribe; hence, *Ganaspidium* is included within Diglyphosemini. This tribe will be formally circumscribed in a subsequent paper that will be a companion to Buffington (2009). Although the morphology of *Ganaspidium* could be considered rather derived within Eucoilinae (e.g. scutellar plate small, tubercles present on the scutellar plate, mostly Nearctic distribution; Fontal-Cazalla et al. 2002), it appears that these characters are instead autapomorphies for

the genus as a whole. The host preference for Agromyzidae, as well as the presence of conical protuberances on the anterior margin of the clypeus and malar spaces, appears to be the ground plan for the Diglyphosemini; the protuberances are shared with *Banacuniculus*, *Ealata*, *Microstilba*, *Nordlanderia* Quinlan, and *Tobiasiana* Kovalev (Buffington et al. 2007; Buffington 2010). The arid habitats in which some species of *Ganaspidium* appear to thrive is another peculiar aspect of this genus (Fig. 5) and is linked to the broad distribution of *Liriomyza* species (CABI 1992). The shrub *Larrea tridentata* (Sesse' and Moc. Ex DC.) Coville (Zygophyllaceae) possesses a similar distribution to many *Ganaspidium* species (Runyan 1934; Marshall 1995), and may be a critical host reservoir for agromyzids attacked by *Ganaspidium*. Specimens have been swept off what appears to be completely dormant (Runyan 1934) or dead shrubs *L. tridentata* in the Great Basin of North America. Exactly how these wasps survive and what hosts they are utilizing are unknown. Further fieldwork and careful rearing protocols are needed to learn more about this small yet effective natural enemy of agromyzid flies.

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