PROC. ENTOMOL. SOC. WASH.
112(2), 2010, pp. 246–257

LELUTHIA ASTIGMA (ASHMEAD) (HYMENOPTERA: BRACONIDAE: DORYCTINAE) AS A PARASITOID OF *AGRILUS PLANIPENNIS* FAIRMAIRE (COLEOPTERA: BUPRESTIDAE: AGRILINAE), WITH AN ASSESSMENT OF HOST ASSOCIATIONS FOR NEARCTIC SPECIES OF *LELUTHIA* CAMERON

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Abstract.—Published host associations are assessed for *Leluthia astigma* (Ashmead), *Leluthia floridensis* Marsh, and *Leluthia mexicana* Cameron, the three known species of *Leluthia* Cameron in the Nearctic Region. *Leluthia astigma* is reported as a parasitoid of *Agrilus planipennis* Fairmaire, emerald ash borer (EAB), infesting *Fraxinus americana* L., white ash, in Delaware County, Ohio. It is the first species of *Leluthia* for which a determined species of *Agrilus* Curtis has been confirmed as a host and the association vouchered. All other hosts reported in the literature for *L. astigma* require confirmation through rearing from an isolated host or documentation of an unequivocal host-parasitoid association. *Leluthia astigma* adults reared from parasitoid cocoons collected in Delaware County, Ohio parasitized and produced F_1 adults in the laboratory on last-instar EAB larvae collected in Ingham County, Michigan. Parasitism of EAB and other natural history data are reported for *L. astigma*, including the first records of *L. astigma* from Kansas and New York.

Key Words: ash, biological control, emerald ash borer, exotic, *Fraxinus*, invasive, natural enemies, Nearctic

DOI: 10.4289/0013-8797-112.2.246

Doryctinae is a large subfamily of Braconidae with 1,335 valid species worldwide listed in Yu et al. (2005). *Leluthia* Cameron currently contains 17 species, with eight, five, three, and one in the Palearctic, Neotropical, Nearctic,

* Accepted by Michael W. Gates

and Australasian regions, respectively (Belokobylskij et al. 2004, Yu et al. 2005, Belokobylskij and Maetô 2006). Species of Buprestidae, Cerambycidae, and Curculionidae (Coleoptera) have been reported as hosts (Wang 2001, Yu et al. 2005). The following three species of *Leluthia* are currently known from the Nearctic Region: *Leluthia astigma* (Ashmead), *Leluthia floridensis* Marsh, and *Leluthia mexicana* Cameron. Hosts and/or host plants have been reported for all three species in the form of published host/host plant lists or statements that certain hosts/host plants are utilized. All reported hosts are wood-boring beetles, including *L. astigma* from five species of *Agrilus* Curtis (Buprestidae). However, Noyes (1994) and Shaw (1994) demonstrated that many host-parasitoid associations in the literature are unreliable, and Noyes (1994) recommended that specialists should verify the validity of associations reported in host-parasitoid lists.

Records of *L. astigma* from species of *Agrilus* in North America are of interest due to the establishment of the exotic invasive pest *Agrilus planipennis* Fairmaire, emerald ash borer (EAB), in North America. Emerald ash borer has killed tens of millions of ash (*Fraxinus* L.) trees in North America and is expected to kill millions more as it spreads throughout the continent (Cappaert et al. 2005). Biological control is considered the primary management tool for EAB in forested areas of North America, and the following species have been reported as parasitoids of EAB in the U.S.: *Atanycolus hicoriae* Shenefelt, *Atanycolus simplex* Cresson, *Spathius floridanus* Ashmead (as *Spathius simillimus* Ashmead) (Braconidae), *Phasgonophora sulcata* Westwood (Chalcididae), *Balcha indica* (Mani & Kaul) (Eupelmidae) (Bauer et al. 2005, 2008; Duan et al. 2009), *Eupelmus pini* Taylor (Eupelmidae) (Duan et al. 2009), and an undescribed species of *Atanycolus* (Cappaert and McCullough in press). Duan et al. (2009) reared *Dolichomitus vitticrus* Townes and one undetermined species each of *Cubocephalus* Townes and *Orthizema* Townes (Ichneumonidae) from green ash (*Fraxinus pennsylvanica* Marsh.) trees infested with EAB but was not able to confirm parasitism of EAB. Additionally, *Oobius agrili* Zhang & Huang (Encyrtidae), *Spathius agrili* Yang (Braconidae), and *Tetrastichus planipennisi* Yang (Eulophidae) have been imported from China and released in the U.S. for classical biological control of EAB since 2007 (Bauer et al. 2008).

Leluthia astigma was reared recently from parasitoid cocoons associated with EAB cadavers dissected from infested white ash (*Fraxinus americana* L.) trees in Delaware County, Ohio. Adult wasps reared from the cocoons parasitized and produced F_1 adults in the laboratory on last-instar EAB larvae from Ingham County, Michigan that were inserted into green ash sticks. The new host record, observations on parasitism in the laboratory, and other previously unreported natural history data for *L. astigma* are reported herein. Additionally, an assessment of the published parasitoid-host-host plant associations for all Nearctic species of *Leluthia* is provided.

Materials and Methods

Through a collaborative effort among U.S. Department of Agriculture Forest Service scientists and a Delaware City Schools teacher at Dempsey Middle School, 7th and 8th grade science students studied EAB at Dempsey Wetlands (40°18.486′N 83°05.087′W), a 15 ha school forest in Delaware, Ohio. Dempsey Wetlands consists of mature forest, old fields, and various successional stages. The mature forest is

Figs. 1–3. Fig. 1. Dempsey Middle School student removing bark from ash. Figs. 2–3. *Leluthia astigma*. 2, Section of white ash isolated for rearing. 3, *L. astigma* cocoon and emerald ash borer cadaver. Arrows: a = cocoon, b = head capsule of cadaver. Scale bar = 2 mm.

dominated by species of *Carya* Nutt. (hickory), *Quercus* L. (oak), and *Ulmus* L. (elm); the early successional areas are dominated by species of ash, *Prunus serotina* Ehrh. (black cherry), and elm. Both green ash and white ash are present and compose 10% of the mature forest trees and 23% of the early successional area trees (K. Knight and J. Rebbeck pers. obs.). The project began in 2006 after the discovery of EAB in a private woodlot adjacent to Dempsey Wetlands in 2005. Parasitoid cocoons were observed in EAB galleries in ash trees at Dempsey Wetlands in January 2008 (KJKG); efforts to rear parasitoids from EAB larvae and parasitoid cocoons started in 2009 (KSK, JR, LSB).

A total of 29 ash trees, consisting of four green ash, 24 white ash, and one undetermined ash species, were felled in December 2008. The main trunk of each tree was cut into 1-m logs. One log from each tree was caged individually to collect emerging insects; the bark was removed from those logs in August and September 2009 after all insects had emerged. The other logs were stored outside until January 2009 when they were brought into the classroom progressively through February 2009 for students to gather data on EAB and collect insects inhabiting the logs. Bark was removed from each log using a drawknife (Fig. 1), and insects found in the phloem were collected. When a parasitoid cocoon or parasitized EAB larva was encountered, the drawknife was used to remove a section of sapwood containing the cocoon or parasitized larva. All parasitized larvae

were identified as EAB at the time of collection (KSK); identifications were confirmed for a portion of those larvae through subsequent examination (DC). All other insects were collected and preserved in 70% ethyl alcohol. Percent cover of EAB galleries was estimated by placing a grid in six locations on each peeled log and counting the number of grid cells occupied by EAB galleries. Logs from which the bark was removed and insects were collected were subsequently caged together in growth chambers; insects that emerged from the logs throughout spring and summer were collected and preserved in 70% ethyl alcohol.

Parasitoid cocoons and parasitized EAB larvae (within a section of sapwood) were isolated individually in 60.0 diameter × 15.0 mm tall disposable polystyrene petri dishes. The petri dishes were incubated at room temperature in a cooler at the USDA Forest Service Northern Research Station laboratory in Delaware, Ohio. The bottom of the cooler was lined with paper towels moistened slightly with water. The petri dishes were checked daily for emergence of adult parasitoids, which were preserved in 95% ethyl alcohol and kept associated with their cocoons and the remains of their hosts for subsequent identification.

Eleven *L. astigma* adults and 35 cocoons were sent to the USDA Forest Service Northern Research Station laboratory in East Lansing, Michigan (NRS-EL) on March 30, 2009 and placed in an incubator at 25°C and 16:8 L:D photoperiod, where daily observations for emergence of adult wasps from cocoons continued (LSB). The 11 adult wasps, plus five additional adults that emerged from the 35 cocoons, all identified as *L. astigma* (RRK), were used to observe parasitism of EAB in the laboratory (LSB). Either an adult female wasp or a female-male wasp pair (F_0) was placed in a 355 ml plastic drinking cup with a snap cap. The cup contained three or four 0.8–1.2 cm diameter × 8.0 cm long, freshly cut green ash sticks, each infested artificially with a last-instar EAB larva. Emerald ash borer larvae used in the exposures were collected from infested green ash trees in Ingham County, Michigan using drawknives. They were identified as EAB in the field and transported alive to the laboratory where they were inserted into ash sticks by peeling up a bark flap on a stick with a knife, cutting an elongate channel in the wood with a linoleum cutter, placing a larva in the channel, replacing the bark flap, and sealing it closed with Parafilm®. A 6.5 cm diameter hole was cut in the cap of each cup and closed over with fine-meshed organdy to provide ventilation. Thirty-seven exposures were carried out April 10–June 22, 2009; they were maintained for either seven or 14 days in a growth chamber at 25°C and 16:8 L:D photoperiod. Food was provided to F_0 adult wasps during exposures as a thin streak of honey on the wall of each cup; a fine mist of water was sprayed on the cap of each cup daily to provide moisture. Most F_0 adult wasps were reused for four exposures, although one female survived through six exposures. F_1 wasps resulting from exposures were allowed to emerge as adults from the sticks. Exposure setups were examined twice/week for emergence of F_1 adult wasps and to observe parasitism in situ by lifting the flaps of bark to view EAB larvae. The sticks were dissected after emergence of F_1 adult wasps ended to determine parasitism prevalence and collect F_1 wasp cocoons; cocoons containing pupae were maintained at 4°C for possible emergence after diapause. All adult specimens of *L. astigma* reared in the NRS-EL laboratory were preserved in 70% ethyl

alcohol for subsequent identification (RRK).

Adult wasps were either air-dried or dehydrated chemically following Heraty and Hawks (1998); they were then point mounted, labeled, and deposited in the Smithsonian Institution National Museum of Natural History, Washington, DC (USNM). Specimens of *L. astigma* were identified to genus and species using Marsh (1997) and Marsh (1967), respectively (RRK). Identifications were confirmed through comparison with all described species of *Leluthia* from the Nearctic Region, including the holotype of *L. astigma*, the holotype and nine paratypes of *L. floridensis*, and the holotype and 40 paratypes of *R. prosopidis* (currently a junior synonym of *L. mexicana*), including a paratype compared previously to the holotype of *L. mexicana*. All of the aforementioned specimens are housed in the USNM. Specimens of *L. astigma* were borrowed from the K. C. Emerson Entomology Museum at Oklahoma State University, Stillwater (OSEC) and the insect collection at West Virginia University, Morgantown (WVUC) to assess the hosts reported for *L. astigma* in Fenton (1942) and Amrine (2002), respectively. Exact label data are reported for all specimens of *L. astigma* examined. All labels are described for the holotype; bracketed semicolons are used to separate lines on each label associated with the holotype. Descriptions of labels for all other specimens are limited to those bearing collecting data; bracketed backslashes are used to separate information on separate labels associated with those specimens.

Data were taken from labels and Andrew Delmar Hopkins' field notes associated with specimens in the USNM (i.e., numbered entries in Hopkins' field notes at the USNM correspond with numbered specimens in the USNM) to determine the occurrence of *L. astigma* in states and provinces from which EAB has been reported (RRK). Data were also taken from the literature, as well as labels and Hopkins' field notes associated with specimens in the USNM, to assess published host associations and determine other potential hosts and host plants for *L. astigma* (RRK).

The image of a section of white ash with a *L. astigma* cocoon and an EAB cadaver was captured using a Nikon COOLPIX S610c digital camera. The close-up image of the cocoon and cadaver and the habitus image of *L. astigma* were captured using a GT Vision EntoVision imaging system that consisted of a firewire JVC KY-75 3CCD digital camera mounted on a Leica M16 zoom lens via a Leica z-step microscope stand. The camera fed a desktop computer where Cartograph 7.0.0.3 and Archimed 5.5.0.1 were used to generate a composite image from a set of images captured at multiple focal planes.

Results and Discussion

Assessment of host associations for Nearctic species of *Leluthia*.—Marsh (1967) reported *L. floridensis* from *Cophes fallax* (Leconte) (Curculionidae) in "citrus." The degree of host isolation is unknown; host remains are not associated with the specimens in the USNM upon which the record was based. Muesebeck (1950) reported *L. mexicana* (as *Russellia prosopidis* Muesebeck) from "mesquite" and mentioned specimens in the USNM with label data specifying *Prosopis juliflora* (Sw.) DC. as a host plant. Host remains are not associated with the specimens. Hopkins' field notes indicate that host plant material was caged for rearing. Adults of one species each of Bostrichidae and Buprestidae and two species of Cleridae emerged from the material

along with *L. mexicana*. Fenton (1942) reported *L. astigma* from *Chrysobothris femorata* (Oliver) (Buprestidae) but did not specify the host plant. Three specimens of *L. astigma* from that study (at least one identified by C. F. W. Muesebeck) are in the OSEC but lack host remains. Beal and Massey (1945) reported *L. astigma* from "American hornbeam and service berry infested almost entirely by *P.* [*Pseudopityophthorus*] *minutissimus*" (Zimmermann) (Curculionidae). Host remains are not associated with a specimen from that study in the USNM. The degree of isolation is unknown for the hosts reported in Fenton (1942) and Beal and Massey (1945). Muesebeck and Walkley (1951) reported *L. astigma* from *Agrilus difficilis* Gory (Buprestidae). The specimens upon which the record was based are in the USNM; Hopkins' field notes indicate that *Gleditsia triacanthos* L. was the host plant. The degree of host isolation is unknown, and the specimens lack host remains. Marsh (1967) reported *L. astigma* from "(?) *A.* [*Agrilus*] *politus* (Say)." The host plant was not specified, the degree of host isolation is unknown, and host remains are not associated with the specimen in the USNM upon which the record was based. Marsh (1967) also reported *L. astigma* from an undetermined species of *Agrilus* based on label data for two specimens in the USNM. Hopkins' field notes indicate that the host plants were an undetermined species of *Acer* L. and *Robinia pseudacacia* L. The specimen reared from a host in the former plant has an associated parasitoid cocoon with the remains of an Agrilinae larva adjacent to it, but the larva could not be identified further because of its poor condition (N. Vandenberg and N. Woodley pers. comm.). Host remains are not associated with the specimen reared from a host in the latter plant. Amrine (2002) reported *L. astigma* from *Agrilus aurichalceus* Redtenbacher infesting *Rosa multiflora* Thunb. and deposited 16 specimens of *L. astigma* in WVUC to document the record. Infested canes were placed together in a rearing cage, and specimens of *L. astigma* and *A. aurichalceus* were collected as they emerged from the canes. The canes were not dissected to recover host remains or determine the presence of other potential hosts, but *A. aurichalceus* was the only beetle that emerged (J. Amrine pers. comm.).

Given the assessment of host associations, hosts reported in the literature for *L. astigma* should be confirmed through rearing from an isolated host or documentation of a parasitoid specimen with host remains adjacent to it in the host's gallery. As host records for *L. astigma* are confirmed, adult specimens, the cocoons from which they emerged, and the remains of their hosts should be deposited in natural history collections to voucher the records as detailed in Shaw (1990, 1994) and Noyes (1994). Vouchering host remains for woodboring insects presents many difficulties. Both the host remains and the parasitoid larva or cocoon may be damaged, destroyed, or lost when bark is removed from logs or when wood chips containing the host remains and parasitoid are removed. Host remains may be partially decomposed and difficult to identify. Parasitoid larvae and cocoons that have been removed from the tree may be difficult to rear outside of the protected environment under the bark due to desiccation if the air is too dry or mold if the air is too moist. Less than half of the parasitoid larvae and cocoons emerged as adults; the high level of parasitoid mortality was likely due to suboptimal rearing conditions.

Host use and other natural history data for *L. astigma*.—Ash trees ranged in EAB infestation from <1% gallery cover to >75% gallery cover. A total of 2,567 EAB larvae or prepupae were found. Forty-five parasitoid cocoons and 10 parasitoid larvae (generally associated with EAB larval cadavers) were collected, resulting in the prevalence of parasitism at 2.1%. Twenty *L. astigma* adults emerged from parasitoid cocoons collected in white ash (Figs. 2–4), and three *L. astigma* pupae were each dissected from their cocoon. All were solitary, and in most instances each cocoon had the remains of an EAB larva adjacent to it. Six additional *L. astigma* adults emerged from the caged logs. *Leluthia astigma* is the first species of *Leluthia* for which a determined species of *Agrilus* has been confirmed as a host given the assessment of host associations for species in the genus (see above). An adult specimen of *L. astigma*, along with its cocoon and associated EAB cadaver placed together in a gelatin capsule on the same pin, have been deposited in the USNM to document the record.

Fig. 4. Lateral habitus of *L. astigma*. Scale bar = 2 mm.

Oviposition experiments carried out at the NRS-EL laboratory resulted in exposure of 151 EAB larvae to 16 *L. astigma* adults (F_0) collected at Dempsey Wetlands. Longevity of F_0 adult female wasps averaged 54 days (range = 21–93 days); F_0 adult male wasps lived an average of 28 days (range = 21–35 days). F_0 adult wasps parasitized 26 of the EAB larvae (17.2%). F_1 wasp larvae were observed feeding externally on nonfeeding EAB larvae; this is direct evidence that *L. astigma* is an idiobiont ectoparasitoid. Fourteen wasps from the F_1 generation emerged as adults, nine remained in their cocoons and were maintained for possible emergence after diapause, and three died as larvae due to injury. Adult wasps from the F_1 generation consisted of three females and 11 males. The larval-pupal period of female and male F_1 wasps averaged 42 days (range = 40–43 days) and 25 days (range = 19–30 days), respectively. The male-skewed sex ratio for F_1 adult wasps resulted from the lack of F_0 adult males in most EAB exposures. No other insects emerged from the ash sticks or were found when the ash sticks were dissected.

Leluthia astigma is broadly distributed in North America (see specimens examined section). The extremes of its geographic distribution are California, USA in the west, Quebec, Canada in the north and east, and Guadalajara, Mexico in the south. It has been reported from the following states and provinces in which EAB has been documented:

Table 1. Estimated occurrence of *L. astigma* (day.month.year) in states and provinces from which emerald ash borer has been reported. Data were taken from labels and Andrew Delmar Hopkins' field notes associated with adult specimens at the USNM. Symbols and abbreviations: * = specimens not reared, coll. = collected, em. = emerged, mi. = miles, SW = southwest.

State/Province	Locality	Occurrence (coll.; em.)
Indiana	Battle Ground	6.v.1978; 29.vi.1978
Maryland	Cabin John	ix.1916*
	4 mi. SW Ashton 39°06.36′N 77°01.30′W	iii.2004; iv–v.2004
Ohio	Milepost 64, Interstate 71 near Octa	21.ix.1987; 29.v.–26.vi.1988
		26.iv.1988; 12.v.1988
	Dempsey Wetlands 40°18.486′N 83°05.087′W	8.ix.2008
		12.i.2009; 30.iii.2009
		13.i.2009; 10.ii.–9.v.2009
		15.i.2009; 24.iv.–1.vi.2009
		unknown; 1.iv.–28.v.2009
Quebec	Old Chelsea	9.viii.1961*
Virginia	Falls Church	26.ix.1913; 1–14.vi.1914
West Virginia	Morgantown	16.viii.1910; 6.iii.1911

Indiana, Maryland, New York, Ohio, Pennsylvania, Quebec, West Virginia, and Virginia (Yu et al. 2005, www.emeraldashborer.info). Data on its estimated occurrence in those states, based on specimens in the USNM, are listed in Table 1. Occurrence data are unknown for one specimen each from New York, Pennsylvania, and Ohio. The specimens from Kansas and New York in the specimens examined section are new records for those states.

Table 2 lists hosts and host plants for *L. astigma* reported in the literature, as well as specified on labels and in Hopkins' field notes associated with specimens at the USNM. All require confirmation but allow for focused exploration to determine the ecological host range of *L. astigma*.

Leluthia astigma is one of several hymenopteran parasitoids of EAB in the U.S. Bauer et al. (2005, 2008) reported *A. hicoriae*, *A. simplex*, *S. floridanus* (as *S. simillimus*), *P. sulcata*, and *B. indica* from EAB at 17 field sites throughout southeast Michigan in 2003 and 2004. Less than 1% of EAB larvae were parasitized throughout the area, and overall, relatively low levels of parasitism persist in most EAB-infested ash stands in Lower Michigan (L. Bauer pers. obs.). Duan et al. (2009) confirmed *B. indica* and *E. pini* as parasitoids of EAB at field sites in Cranberry Township, Pennsylvania and also reared *D. vitticrus* and one undetermined species each of *Cubocephalus* and *Orthizema* from green ash infested with EAB. Only 3.6% of EAB larvae, prepupae, and pupae sampled throughout Cranberry Township were parasitized. Alternatively, 15–56% parasitism of EAB larvae was observed in 2007 for an undescribed species of *Atanycolus* at two sites in southeast Lower Michigan where most ash trees had already died (Cappaert and McCullough In press). Interestingly, this species of *Atanycolus* is absent or rare in EAB natural enemy datasets collected in 10 Michigan and Ohio counties since 2002 and 2003. This finding demonstrates that a parasitoid species usually responsible for negligible EAB mortality might be an important natural enemy of EAB at particular times and/or sites. Continued efforts to rear EAB parasitoids at Dempsey Wetlands and other sites is

Table 2. Host associations for *L. astigma* reported in the literature, as well as specified on labels and in Andrew Delmar Hopkins' field notes associated with adult specimens in the USNM. Symbols and abbreviations: * = based on a specimen with associated host remains and parasitoid cocoon, † = based on specimens with associated parasitoid cocoons, mi. = miles, SW = Southwest. "Mt." is likely an abbreviation for mountain.

Host	Host Plant	Locality (All USA)
Agrilus Curtis	*Acer glabrum* Torr.	Cheyenne Mt., Wyoming[1]
**Agrilus*	*Acer* L.	Salt Lake City, Utah
†*Agrilus*	*Cornus* L.	Tryon, North Carolina
Agrilus	*Robinia pseudacacia* L.	Falls Church, Virginia
Agrilus aurichalceus Redtenbacher	*Rosa multiflora* Thunb.	Milepost 64, Interstate 71 near Octa, Ohio
Agrilus bilineatus (Weber)	*Castanea dentata* (Marsh.) Borkh.	Tryon, North Carolina
Agrilus difficilis Gory	*Gleditsia triacanthos* L.	Woodward, Oklahoma
Agrilus pilosovittatus Saunders	*Wisteria* Nutt.	4 mi. SW Ashton, Maryland 39°06.36′N 77°01.30′W
Agrilus politus (Say)	Unknown	Hummelstown, Pennsylvania
Chrysobothris femorata (Oliver)	Unknown	Stillwater, Oklahoma
Pseudopityophthorus minutissimus (Zimmermann)	*Amelanchier arborea* (Michx. f.) Fernald *Carpinus caroliniana* Walter	Durham, North Carolina
Unknown	"red oak"	Vinton Furnace Experimental Forest, Ohio
Unknown	*Baccharis* L.	Riverside, California
Unknown	*G. triacanthos*	Battle Ground, Indiana
Unknown	*Vachellia farnesiana* (L.) Wight & Arn.	Brownsville, Texas

[1] "Cheyenne Mt., Wyo." is likely a labeling error. The locality is likely either Cheyenne Mountain in Colorado or Cheyenne, Wyoming.

necessary to establish whether *L. astigma* has similar potential.

Specimens examined (excluding those in WVUC and F_1 from NRSEL).—*Holotype male Heterospilus* ? *astigma:* Top label (white; typewritten) = "Collection [;] Ashmead." Second label (white; partially handwritten, partially typewritten) = "AD Hopkins [;] W. Va. [;] Accession [;] No. 6089." Third label (red; partially handwritten, partially typewritten) = "TypeNo [;] 69555 [;] USNM." Fourth label (white; handwritten) = "Type." Fifth label (white; handwritten) = "Heterospilus [;] astigmus [;] ♂ Ashm" (USNM). *Other material examined:* CANADA, QUEBEC: 1 ♂ Old Chelsea,QUE. 9.viii.1961 J. R. Vockeroth [/] Summit of King Mt. 1,150 feet. MEXICO, JALISCO: 1 ♂ Guadalajara Crawford; SONORA: 3 ♂ 10 Mi. E. Navajoa, Son., MEX.VIII-13–1959. Black light trap. WLNutting&FGWerner. USA, ARIZONA: 1 ♀ 1 ♂ 10 mi. E. Continental, ARIZ. Jul. 18, 1961 Werner, Nutting U.V. lt. trp.; 1 ♀ 1 ♂ 8 mi. N. Vail, Pima Co., ARIZ. Aug. 30, 1962 FWerner, WL Nutting U.V. lt. trp.; CALIFORNIA: 1 ♀ Pleasanton, Cal. 8-31-32 [/] A. E. Michelbacher Collector; 1 ♂ on Baccharis [indecipherable handwriting] [/] Riverside Cal. Oct. 15, 27; INDIANA: 1 ♀ Battle Ground Tippe. Co. IND. 6 May 1978 M. & N. Deyrup [/] Emerged indoors from branch of Gleditzia [sic] triacanthos 29 June 1978; IOWA: 1 ♀ Ames, Iowa [/]

Collection Ashmead; 1 ♀ Ames, Ia 7.30.95 [/] Exp Sta [indecipherable handwriting]; 1 ♂ same data as previous except 5/21, 1896 (USNM); KANSAS: 1 ♀ KANSAS: Riley Co. Konza Prairie Biol. Station Kings Creek [/] 39°06.29′N,96°35.77′W 6.vii.-10.vii.2001 Zolnerowich, Kula, Brown Malaise trap; 1 ♂ same data as previous except 27.viii.-4.ix.2001; 1 ♂ same data as previous except 9.x.-16.x.2001; 1 ♂ same data as previous except 23.x.-30.x.2001; 1 ♀ same data as previous except 6.xi.-20.xi.2001 (1 ♀ 2 ♂ KSUC, 1 ♀ 1 ♂ USNM); MARYLAND: 1 ♀ Cabin John Md 9–1916 [/] RMFouts Collector; 3 ♀ 2 ♂ USA: MD: Montgomery Co. 4 mi. southwest Ashton 39°06.36N 77°01.30W iii.04, em iv-v.2004 M. Gates [/] Ex *Wisteria* infested w/ *Agrilus pilosovittatus* Saunders; NEW YORK: 1 ♀ Eire [sic] Co. N.Y 162; OHIO: 1 ♂ Ex red oak Vinton Furnace Ohio. [indecipherable handwriting].3.61; 1 ♀ 1 ♂ OHIO: Delaware Co. Dempsey Wetlands 40°18.486′N 83°05.087′W Dempsey Middle School EAB project coll. 8.ix.2008; 1 ♀ same data as previous except coll. 13.i.2009 em. 10.ii.2009 Tree1408-8a; 1 ♀ same data as previous except em. 11.iii.2009 Tree 1408–8; 1 ♂ same data as previous except em. unknown; 1 ♀ same data as previous except coll. 12.i.2009 em. 30.iii.2009 Tree 1408–6 Specimen DP-04 Preserved OP09–17; 1 ♀ same data as previous except coll. 13.i.2009 em. 31.iii.2009 Tree 1408–5 Specimen DP-05 Preserved OP09–13; 1 ♀ same data as previous except em. 2.iv.2009 Specimen DP-01 Preserved OP09–25; 1 ♀ same data as previous except em. 7.iv.2009 Tree 1408–8 Specimen DP-02 Preserved OP09–26; 1 ♂ same data as previous except em. 7.v.2009 Tree 1408–5 Specimen DP-33 Preserved OP09–21; 1 ♀ same data as previous except em. 9.v.2009 Tree 1408–10 Specimen DP-50 Preserved OP09–30; 1 ♀ same data as previous except coll. 15.i.2009 em. 24.iv.2009 Tree 366–5 Specimen DP-08 Preserved OP09–24; 1 ♀ same data as previous except em. 1.vi.2009 Tree 384–5A Specimen DP-29 Preserved OP09–29; 1 ♀ same data as previous except coll. unknown em. 1.iv.2009 [from caged log] Tree 369–8 Specimen DP-06 Preserved OP09–27; 1 ♀ same data as previous except em. 26.v.2009 Tree unknown Specimen DP-52 Preserved OP09–23; 1 ♀ same data as previous except Specimen DP-53 Preserved OP09–31; 1 ♂ same data as previous except Specimen DP-56; 1 ♂ same data as previous except em. 28.v.2009 Specimen DP-55 Preserved OP09–28; OHIO: 1 ♀ Fayette Co, OH 29 May 1988 J. W. Amrine T. A. H. Stasny near Octa - E. I 71 - mile 64 [/] lab reared from *Rosa multiflora* canes taken 21 Sept 1987; 1 ♂ same data as previous except 31 May 1988; 1 ♂ same data as previous except 1 June 1988; 1 ♂ same data as previous except 3 June 1988; 1 ♂ same data as previous except 4 June 1988; 1 ♀ 1 ♂ same data as previous except 8 June 1988; 1 ♂ same data as previous except 9 June 1988; 3 ♀ same data as previous except 13 June 1988; 1 ♀ same data as previous except 15 June 1988; 1 ♀ same data as previous except 17 June 1988; 1 ♂ same data as previous except 18 June 1988; 1 ♀ same data as previous except 26 June 1988; 1 ♂ same data as previous except 12 May 1988 [/] lab reared from Agrilus spp. infesting canes taken 26 Apr. 88 ex: *Rosa multiflora*; NORTH CAROLINA: 1 ♂ Durham N.C. Aug 9 1943 [/] Ex:-Pseudo minut. [/] J. A. Beal colr.; 1 ♀ 1 ♂ 1457 d Hopk. U.S. [/] TryonNC [/] Cornus [/] W.F.Fiske Collector; 1 ♀ 3100 e Hopk.U.S. [/] Tryon NC [/] Castanea dentata [/] WFFiske Bred (USNM); OKLAHOMA: 1 [gender unknown] Stillwater,Okl IV 23 1936

M. Maxwell; 1 ♀ 1 [gender unknown] same data as previous except IV 26 1936 (OSEC); 3 ♀ 2 ♂ 17700-D7 Hopk. U.S. [/] ex Agrilus difficilis [/] Woodward Okla. 8/13/35 [/] J. A. Beal Colr.; PENNSYLVANIA: 1 ♂ Hnmmelstown [sic] Pa. [/] Champ[?]ain and Knull [/] Parasite of Agrilus politus ?; TEXAS: 1 ♀ Brnsvlle Bred Tex [/] Vachellia farnesiana [/] HSBarber Collector; UTAH: 1 ♀ Prob. pars. on Agrilus sp. [;] Wosatch [sic] Nat. For. Utah. VI.17.35. [/] J. C. Evenden Colr. [/] Hopk. U.S. 21856; VIRGINIA: 1 ♂ 10370a Hopk. U.S. [/] Reared June 1–14 HBKirk [/] Robinia pseudacacia [/] Par Agrilus [/] FallsChurch Va [/] FCCraighead Collector; WEST VIRGINIA: 1 ♂ HarpersFy 10.5 WVa [/] Collection Ashmead; 1 ♀ 7790 f Hopk. W. Va. [/] Morgantown, W.Va.; 1 ♀ 2 ♂ 7791 f Hopk. WVa [/] Morgantown, W.Va. 5.22.96; 1 ♀ 1 ♂ same data as previous except 5.25.96; WYOMING: 1 ♀ 1 ♂ Hopk. U.S. 14573 c [/] Cheyenne Mt. Wyo. 6-6-17 [/] Acer glabrum [/] GeoHofer Colr (USNM).

Acknowledgments

We thank Dempsey Middle School 7th and 8th grade science students and their teacher, Mrs. Deborah Bogard, for dissecting logs and collecting specimens and data. We are grateful to Delaware City Schools for their cooperation. We acknowledge Robert Ford, Tim Fox, Lawrence Long, Kyle Costilow, Joan Jolliff, and Stan McDonald for cutting and hauling ash trees; Joan Jolliff, Deborah Miller, and Bill Morgan for laboratory work; Deborah McCullough and Andrew Tluczek for advice on peeling ash logs; Annemarie Smith, Charles Flower, and Lisa Tabak for helping supervise in the classroom; and the Ohio Department of Agriculture for lending drawknives. We appreciate Natalia J. Vandenberg (Systematic Entomology Laboratory [SEL]) and Norman E. Woodley (SEL) for their efforts in identifying a buprestid cadaver associated with a *L. astigma* cocoon and adult in the USNM. We are grateful to John S. Strazanac (West Virginia University-Morgantown) for examining specimens of *L. astigma* in the WVUC. We thank Thomas J. Henry (SEL), John W. Brown (SEL), and Jeffrey Sosa-Calvo (University of Maryland-College Park) for reviewing the manuscript. The USDA Forest Service Civil Rights Diversity Special Projects Fund provided funding for this project.

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