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**REVIEW OF PARASITOID WASPS AND FLIES (HYMENOPTERA,
DIPTERA) ASSOCIATED WITH LIMACODIDAE (LEPIDOPTERA)
IN NORTH AMERICA, WITH A KEY TO GENERA**

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Abstract.—Hymenopteran and dipteran parasitoids of slug moth caterpillars (Lepidoptera: Limacodidae) from North America are reviewed, and an illustrated key to 23 genera is presented. Limacodid surveys and rearing were conducted during the summer months of 2004–2009 as part of research on the ecology and natural history of Limacodidae in the mid-Atlantic region of the U.S.A. Parasitoid rearing involved a combination of collecting naturally occurring larvae in the field (at least 14 host species) and placing out large numbers of “sentinel” larvae derived from laboratory colonies of three host species. Species in the following families are documented from limacodids in North America as primary or secondary parasitoids (number of genera for each family in parentheses; number of genera included in key but not reared through this research in brackets): Chalcididae ([1]; Hymenoptera: Chalcidoidea), Eulophidae (3; Chalcidoidea), Pteromalidae ([1]; Chalcidoidea), Trichogrammatidae (1; Chalcidoidea), Braconidae (3 [1]; Hymenoptera: Ichneumonoidea), Ichneumonidae (7 [3]; Ichneumonoidea), Ceraphronidae (1; Hymenoptera: Ceraphronoidea), Trigonalidae (2; Hymenoptera: Trigonaloidea), Bombyliidae ([1]; Diptera: Asilioidea), and Tachinidae (3; Oestroidea). We recovered 20 of 28 genera known to attack limacodids in North America. Records discerned through rearing in the mid-Atlantic region are augmented with previously published host-parasitoid relationships for Limacodidae in North America north of Mexico. New records are reported for the following parasitoids (total new records in parentheses): *Uramya limacodis* (Walker) (1), *U. pristis* (Townsend) (5), *Austrophorocera* spp. (6), *Ceraphron* sp. (1), *Alveoplectrus lilli* Gates (1), *Playplectrus americana* (Girault) (10), *Pediobius*

crassicornis (Thomson) (1), *Trichogramma* (1), *Mesochorus discitergus* (Say) (1), *Hyposoter fugitivus* (Say) (1), and *Isdromas lycaenae* (Howard) (5). The male of *Platyplectrus americana* (Hymenoptera: Eulophidae) is redescribed, and the female is described for the first time. Incidental and miscellaneous host-parasitoid associations are discussed, and it is concluded that most of these records are likely parasitoids of contaminants accidentally introduced during the limacodid rearing process. *Triraphis eupoeyiae* (Ashmead), **new combination**, is transferred from *Rogas* (Hymenoptera: Braconidae).

Key Words: hyperparasitoid, parasitic, slug moth caterpillar, *Acharia*, *Acrolyta*, *Alveoplectrus*, *Ascogaster*, *Austrophorocera*, *Baryceros*, *Casinaria*, *Ceraphron*, *Compsilura*, *Conura*, *Cotesia*, *Euclea*, *Hyposoter*, *Isa*, *Isdromas*, *Isochaetes*, *Lithacodes*, *Lysibia*, *Mesochorus*, *Natada*, *Orthogonalys*, *Packardia*, *Parasa*, *Pediobius*, *Phobetron*, *Platyplectrus*, *Prolimacodes*, *Psychophagus*, *Systropus*, *Taeniogonalos*, *Tortricidea*, *Trichogramma*, *Triraphis*, *Uramya*

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Slug moth caterpillars (Lepidoptera: Limacodidae) are mostly polyphagous external foliage feeders on a broad array of deciduous trees and shrubs in eastern North America (Wagner 2005, Lill 2008). Their broad diets, rather distinctive larval morphologies, and often bright coloration make them interesting subjects for ecological and behavioral studies (e.g., Lill et al. 2006, Murphy et al. 2010). Unlike many more mobile caterpillars, limacodid larvae tend to remain on an individual host plant for the duration of their development: typically about two months, going through numerous instars (7–12) depending on the species, with some species requiring more than 100 days to complete development (J. Lill and S. Murphy pers. obs.). Larvae tend to occur in low densities (< 1 caterpillar/m² foliage; Lill et al. 2006, Lill 2008) and can be highly cryptic, especially in early instars, but they produce a rather distinctive pattern of feeding damage

that facilitates their capture. Outbreaks of North American limacodids are reported rarely, but many tropical species are important agricultural pests, particularly in banana and palm plantations in South America and Southeast Asia (Ostmark 1974, Cock et al. 1987, Godfray and Chan 1990). Because many species of Limacodidae possess stinging spines during all or a portion of their larval development (Epstein 1988), the larvae can be a nuisance when they occur in plantations (Ostmark 1974) or on ornamental palms near tourist attractions (e.g., Conant et al. 2002). Their protracted larval development period exposes the caterpillars to attack from a diverse assemblage of larval and larval-pupal parasitoids. However, research to-date on host-parasitoid interactions in Limacodidae has focused almost entirely on biocontrol of pest limacodids in tropical agricultural systems (e.g., Cock et al. 1978) with the notable exception of the massive caterpillar rearing database compiled for tropical forests of Area de Conservación Guanacaste in Costa Rica (Janzen and Hallwachs 2009).

By contrast, the hymenopteran/dipteran parasitoid community that attacks North American limacodids has been described only anecdotally, and concerted rearing efforts are mostly lacking (but see Le Corff and Marquis 1999 and Stireman and Singer 2003a, b for examples where limacodids were reared as part of larger community sampling).

In general, dipteran (i.e., Tachinidae) and hymenopteran parasitoids are essential in regulating native forest macrolepidoptera and are reasonably well studied (LaSalle 1993, McCullough et al. 1999). Conversely, there is little information regarding bombyliid parasitoids (i.e., in *Systropus*) and their roles in regulating native forest macrolepidoptera, likely due to their relative rarity compared to parasitic hymenopterans and tachinids. Most hymenopteran parasitoids of macrolepidoptera belong to the superfamilies Ichneumonoidea and Chalcidoidea, and species of Tachinidae are the most common dipteran parasitoids of microlepidoptera (Askew 1971, Quicke 1997). Two recent studies in North America have focused on Tachinidae and Hymenoptera specifically and their host relationships in eastern North American forests (Strazanac et al. 2001, Petrice et al. 2004). Most research on parasitoids of native forest macrolepidoptera has focused on outbreak species such as fall webworm (*Hyphantria cunea* Drury; Arctiidae), eastern tent caterpillar (*Malacosoma americanum* (F.); Lasiocampidae) (Kulman 1965, Morris 1976, Witter and Kulman 1979), and gypsy moth (*Lymantria dispar* (L.); Lymantriidae) (Barbosa et al. 1975, Elkinton and Liebhold 1990 and references therein). Few studies have documented parasitoids in less abundant/non-outbreak forest macrolepidoptera (including limacodids) (Schaffner and Griswold 1934, northeastern U.S.A.; Raizenne 1952, Ontario, Canada), and fewer still have

focused on Limacodidae (as mentioned above).

Tachinidae and parasitoid Hymenoptera are diverse in forest canopy communities in North America with new host-parasitoid associations being recorded with some frequency (Butler 1993, Strazanac et al. 2001, Petrice et al. 2004). Biologically, tachinids are recorded from 15 arthropod orders (Wood 1987), whereas parasitoid Hymenoptera have been documented from 16 (LaSalle 1993). As a group, parasitoid Diptera have been viewed as secondary to hymenopterans as effective parasitoids (Askew 1971, Quicke 1997); however, both groups are abundant in North American forests where limacodids occur most commonly. North American hymenopteran and dipteran parasitoid-host associations have been cataloged by Krombein et al. (1979) and Arnaud (1978), respectively. A world catalog to Tachinidae is in preparation (JEO), and databases are available for Ichneumonoidea (Yu et al. 2005) and Chalcidoidea (Noyes 2003). Recent large-scale rearings of forest macrolepidoptera by Butler (1993) documented 115 new hymenopteran host associations, and Strazanac et al. (2001) reported 60 new tachinid host associations.

Many of the tachinid and hymenopteran parasitoids reported herein are known to attack lepidopterans (or their primary parasitoids) more generally, but several specialize on Limacodidae, and others are facultative (see *Pediobius*; Peck 1985) or obligatory hyperparasitoids (see *Conura* Spinola; Delvare 1992). Given their specialization on Limacodidae, many of these taxa, particularly certain Chalcidoidea such as *Platyplectrus* Ferrière and *Alveoplectrus* Wijesekara and Schauff, were encountered infrequently in North America (Wijesekara and Schauff 1997). This can be ascribed to the lack of major limacodid pests in North America, the

difficulty of locating/handling their larvae, and the lack of financial resources available to study non-outbreak pests. Most of the parasitoids documented as a result of the rearing portion of this study parasitize early limacodid instars.

The purpose of this study is to review the parasitoids associated with limacodids in America north of Mexico, including introduced limacodids (i.e., *Monema flavescens* Walker) and exotic parasitoids recorded from limacodids elsewhere that could potentially attack limacodids in North America. We assemble these various records herein and add host-parasitoid associations generated from six years of intensive rearing of larval limacodids in the greater Washington, DC metropolitan area (Table 1).

MATERIALS AND METHODS

Collection and Rearing

Beginning in mid- to late-June of each summer of 2004–2009, we searched manually for limacodid larvae on the undersides of leaves of common woody trees at the following field sites near Washington, DC: Little Bennett Regional Park, Plummers Island (Montgomery County, MD), Patuxent National Wildlife Refuge (Prince George’s County, MD), Rock Creek Park (Washington, DC), and the U.S. National Arboretum (Washington, DC). More than a dozen host plants have yielded limacodids, but most of our efforts were focused on searching six common host plants used by most species of Limacodidae: American beech (*Fagus grandifolia* Ehrh.), white oak (*Quercus alba* L.), northern red oak (*Quercus rubra* L.), black gum (*Nyssa sylvatica* Marsh.), black cherry (*Prunus serotina* Ehrh.), and pignut hickory (*Carya glabra* Miller). Additional host plant species were sampled less intensively (Table 1). For each wild-caught larva, we recorded the species,

collection date, and host plant. In addition to these wild-caught larvae, we also conducted a series of field experiments as part of a different project examining tri-trophic interactions in Limacodidae that involved placing out “sentinel” larvae on each of the six common host plants described above at the Little Bennett Regional Park site. These larvae came from laboratory colonies established through a combination of larval and adult (*ex ovo*) collections; thus, larvae were unparasitized when placed in the field. These experimental larvae were left exposed to parasitoid attack in the field for one to several weeks depending on the experiment and then brought back to the lab for rearing.

Collected larvae were reared individually in 16 oz. clear plastic deli containers containing a disk of moistened filter paper to prevent host foliage from drying out. Fresh leaves from the various host plants were replaced as needed (typically twice per week). Larvae showing signs of parasitism were checked routinely for parasitoid larvae/pupae, and emerging adults were either placed in 95% ethanol (Hymenoptera) or frozen (Diptera) for later mounting/pinning and identification. One genus of tachinid flies (*Austrophorocera* spp.) exclusively contains larval-pupal parasitoids, so adults eclosed from overwintering cocoons the following year (pupae were kept in an environmental chamber in moist peat moss during the winter months and then exposed to spring conditions to induce fly pupation and emergence). In addition, several of the hymenopteran parasitoids reared from limacodid hosts late in the season diapaused as pupae and emerged the following summer.

Hymenopteran Parasitoid Preparation and Imaging

Specimens in ethanol were dehydrated through increasing concentrations of

Table 1. Parasitoids reared from host plant/limacodid host pairs in greater Washington, D. C., 2004–2009.

Limacodid Species	Plant Species	Parasitoid Species	Notes
<i>Acharia stimulea</i>	<i>Acer negundo</i> <i>A. saccharinum</i>	<i>Uramya pristis</i>	
		<i>U. pristis</i> <i>P. americana</i> *	
	<i>Asimina triloba</i>	<i>Cotesia empretiae</i> <i>U. pristis</i> <i>Pl. americana</i> *	
		<i>P.s crassicornis</i>	Hyperparasitoid of <i>Pl. americana</i>
		<i>U. pristis</i> <i>A. cocciphila</i> *	
	<i>Carya glabra</i>	<i>Pl. americana</i> *	
		<i>Pe. crassicornis</i>	Hyperparasitoid of <i>Pl. americana</i>
	<i>Fagus grandifolia</i>	<i>U. pristis</i> <i>A. cocciphila</i> *	
		<i>U. pristis</i> <i>Pl. americana</i> *	
		<i>Pe. crassicornis</i>	Hyperparasitoid of <i>Pl. americana</i>
		<i>T. discoideus</i>	
	<i>Lindera benzoin</i>	<i>Pe. crassicornis</i> <i>Ly. mandibularis</i>	Pseudohyperparasitoid through microgastrine.
		<i>Nyssa sylvatica</i>	<i>U. pristis</i> <i>Austrophorocera</i> sp.* <i>Pe. crassicornis</i> <i>Pl. americana</i> *
	<i>Prunus serotina</i>	<i>U. pristis</i> <i>A. cocciphila</i> *	
		<i>Pl. americana</i> *	
	<i>Quercus alba</i>	<i>Pe. crassicornis</i> <i>Co. empretiae</i>	Hyperparasitoid of <i>Pl. americana</i>
<i>U. pristis</i> <i>A. cocciphila</i> *			
<i>Pe. crassicornis</i> <i>Pl. americana</i> *		Hyperparasitoid of <i>Pl. americana</i>	
<i>Co. empretiae</i>			
<i>Quercus rubra</i>	<i>Austrophorocera</i> sp. <i>Ceraphron</i> sp.*	Only egg observed Hyperparasitoid, likely via <i>Pl. americana</i> or <i>Al. lilli</i>	
	<i>Pl. americana</i> *		
<i>Acharia stimulea</i>	<i>Quercus rubra</i>	<i>T. discoideus</i> <i>Pe. crassicornis</i>	Hyperparasitoid of <i>Pl. americana</i>
<i>Acharia stimulea</i>	<i>Quercus rubra</i> <i>Robinia pseudoacacia</i>	<i>Is. lycaenae</i> *	
		<i>Pl. americana</i> *	
<i>Adoneta spinuloides</i>	<i>Carya glabra</i> <i>Fagus grandifolia</i>	<i>Co. empretiae</i> <i>Pl. americana</i> *	
		<i>U. pristis</i> *	
	<i>Nyssa sylvatica</i> <i>Quercus rubra</i>	<i>Pl. americana</i> <i>Pe. crassicornis</i> *	Hyperparasitoid of <i>Pl. americana</i>
		<i>U. pristis</i> *	
		<i>Al. lilli</i> *	
		<i>Pl. americana</i> *	
		<i>T. discoideus</i>	

Table 1. Continued.

Limacodid Species	Plant Species	Parasitoid Species	Notes	
<i>Euclea delphinii</i>	<i>Carpinus caroliniana</i>	<i>Co. empretiae</i>		
		<i>U. pristis</i>		
	<i>Carya glabra</i>	<i>A. einaris</i> *		
		<i>Pl. americana</i> *		
		<i>T. discoideus</i>		
	<i>Fagus grandifolia</i>	<i>U. pristis</i>		
		<i>A. einaris</i> *		
		<i>Pl. americana</i> *		
		<i>T. discoideus</i>		
	<i>Nyssa sylvatica</i>	<i>A. einaris</i> *		
		<i>Com. concinnata</i>		
		<i>T. discoideus</i>		
		<i>Taeniogonalos gundlachii</i>	Hyperparasitoid of <i>Com. concinnata</i>	
		<i>Pl. americana</i> *		
	<i>Prunus serotina</i>	<i>A. einaris</i> *		
<i>U. pristis</i>				
<i>Com. concinnata</i> *				
<i>Pl. americana</i> *				
<i>Quercus alba</i>	<i>A. einaris</i> *			
	<i>Pl. americana</i> *			
	<i>Pe. crassicornis</i> *			
	<i>Trichogramma</i> sp.*	Egg parasitoid		
	<i>T. discoideus</i>			
<i>Euclea delphinii</i>	<i>Quercus rubra</i>	<i>A. einaris</i> *		
	<i>Quercus rubra</i>	<i>Com. concinnata</i> *		
<i>Euclea delphinii</i>	<i>Quercus rubra</i>	<i>U. pristis</i>		
		<i>Al. lilli</i>		
		<i>Pl. americana</i> *		
		<i>Pe. crassicornis</i> *	Hyperparasitoid of <i>Pl. americana</i>	
<i>Isa textula</i>	<i>Diospyros virginiana</i>	<i>T. discoideus</i>		
		<i>Co. empretiae</i>		
	<i>Acer saccharum</i>	<i>U. pristis</i>		
		<i>U. pristis</i>		
	<i>Carya glabra</i>	<i>U. pristis</i>		
		<i>U. pristis</i>		
	<i>Fagus grandifolia</i>	<i>A. lilli</i>		
		<i>T. discoideus</i>		
		<i>U. pristis</i>		
	<i>Quercus alba</i>	<i>Quercus alba</i>	<i>Austrophorocera</i> sp.*	
			<i>Pl. americana</i> *	
<i>Pe. crassicornis</i> *			Hyperparasitoid of <i>Pl. americana</i>	
<i>Is. lycaenae</i>				
<i>T. discoideus</i>				
<i>Quercus prinus</i>	<i>U. pristis</i>			
	<i>Orthogonalys pulchella</i>	Hyperparasitoid of <i>U. pristis</i>		
<i>Quercus rubra</i>	<i>Quercus rubra</i>	<i>U. pristis</i>		
		<i>Ceraphron</i> sp.	Hyperparasitoid of <i>Pl. americana</i> * or <i>Al. lilli</i> *	
		<i>Al. lilli</i>		
		<i>Pl. americana</i> *		
		<i>T. discoideus</i>		
		<i>Is. lycaenae</i> *	Likely hyperparasitoid of <i>Triraphis</i>	
<i>O. pulchella</i>	Hyperparasitoid of <i>U. pristis</i>			

Table 1. Continued.

Limacodid Species	Plant Species	Parasitoid Species	Notes
<i>Isa/Natada</i>	<i>Nyssa sylvatica</i>	<i>Al. lilli</i>	
<i>Isochaetes beutenmuelleri</i>	<i>Fagus grandifolia</i>	<i>U. pristis</i> *	
		<i>O. pulchella</i>	Hyperparasitoid of <i>U. pristis</i>
	<i>Quercus rubra</i>	<i>U. pristis</i> *	
<i>Lithacodes fasciola</i>	<i>Acer negundo</i>	<i>U. pristis</i> *	
	<i>Carya glabra</i>	<i>U. pristis</i> *	
		<i>Pl. americana</i> *	
	<i>Fagus grandifolia</i>	<i>Austrophorocera</i> n. sp.*	
		<i>Pl. americana</i> *	
<i>Lithacodes fasciola</i>	<i>Nyssa sylvatica</i>	<i>Pl. americana</i> *	
	<i>Prunus serotina</i>	<i>Austrophorocera</i> n. sp.*	
		<i>Pe. crassicornis</i> *	Hyperparasitoid of <i>Pl. americana</i>
		<i>T. discoideus</i>	
	<i>Quercus alba</i>	<i>Austrophorocera</i> sp.*	Only egg observed
		<i>Pl. americana</i> *	
	<i>Quercus rubra</i>	<i>Pl. americana</i> *	
		<i>T. discoideus</i>	
<i>Lithacodes fasciola</i>	<i>Quercus velutina</i>	<i>Al. lilli</i>	
<i>Lithacodes/Packardia</i>	<i>Nyssa sylvatica</i>	<i>Pl. americana</i>	
<i>Natada nasoni</i>	<i>Carya glabra</i>	<i>Triraphis discoideus</i>	
	<i>Fagus grandifolia</i>	<i>T. discoideus</i>	
		<i>Is. lycaenae</i> *	
	<i>Nyssa sylvatica</i>	<i>T. discoideus</i>	
	<i>Prunus serotina</i>	<i>Is. lycaenae</i> *	
	<i>Quercus alba</i>	<i>T. discoideus</i>	
	<i>Quercus prinus</i>	<i>Pe. crassicornis</i> *	Possible primary parasitoid
	<i>Quercus rubra</i>	<i>Pl. americana</i> *	
		<i>T. discoideus</i>	
		<i>Is. lycaenae</i>	
<i>Packardia geminata</i>	<i>Fagus grandifolia</i>	<i>U. pristis</i> *	
		<i>Pl. americana</i>	
<i>Parasa chloris</i>	<i>Quercus rubra</i>	<i>Austrophorocera</i> sp.*	Only egg observed
		<i>T. discoideus</i>	
		<i>I. lycaenae</i> *	
		<i>Mesochorus discitergus</i>	Hyperparasitoid of <i>Triraphis</i> ; unconfirmed
<i>Phobetron pithecius</i>	<i>Fagus grandifolia</i>	<i>Pl. americana</i> *	
<i>Prolimacodes badia</i>	<i>Carya glabra</i>	<i>H. fugitivus</i> *	
	<i>Diospyros virginiana</i>	<i>A. imitator</i> *	
	<i>Fagus grandifolia</i>	<i>A. imitator</i> *	
		<i>Pl. americana</i> *	
		<i>Is. lycaenae</i> *	
		<i>Me. discitergus</i>	Hyperparasitoid of <i>Triraphis</i> (unconfirmed)
	<i>Nyssa sylvatica</i>	<i>Austrophorocera</i> sp.*	Only egg observed
	<i>Prunus serotina</i>	<i>A. imitator</i> *	
		<i>T. discoideus</i>	
	<i>Quercus alba</i>	<i>Pl. americana</i> *	
		<i>H. fugitivus</i> *	

Table 1. Continued.

Limacodid Species	Plant Species	Parasitoid Species	Notes
	<i>Quercus rubra</i>	<i>A. imitator</i> *	
		<i>Pl. americana</i> *	
		<i>T. discoideus</i>	
<i>Tortricidia</i> sp.	<i>Quercus alba</i>	<i>Pl. americana</i> *	
	<i>Fagus grandifolia</i>	<i>T. discoideus</i>	
	<i>Prunus serotina</i>	<i>U. pristin</i> *	
	<i>Quercus rubra</i>	<i>U. pristin</i> *	
Unknown limacodid (too small to ID)	<i>Carya glabra</i>	<i>Pl. americana</i>	
		<i>Pe. crassicornis</i>	
Unknown limacodid	<i>Fagus grandifolia</i>	<i>Pl. americana</i>	
Unknown limacodid	<i>Quercus rubra</i>	<i>T. discoideus</i>	

ethanol to hexamethyldisilazane (HMDS) (Heraty and Hawks 1998) before point- or card-mounting. Images of specimens were produced by scanning electron microscopy (SEM) and an EntoVision Imaging Suite. Card- and point-mounted specimens were examined using stereomicroscopes with 10X or 25X oculars and fiber optic light sources. Mylar film was used to diffuse glare from fiber optic light sources to reduce glare from the specimens. Scanning electron microscope (SEM) images were taken with an Amray 1810 (LaB₆ source). Specimens were affixed to 12.7 X 3.2 mm Leica/Cambridge aluminum SEM stubs with carbon adhesive tabs (Electron Microscopy Sciences, #77825-12). Stub-mounted specimens were sputter coated using a Cressington Scientific 108 Auto with gold from at least three different angles to ensure complete coverage (~20–30 nm coating). Wings were removed and slide-mounted in polyvinyl alcohol prior to imaging. Wing and habitus images were captured using an EntoVision Imaging Suite, which includes a firewire JVC KY-75 3CCD digital camera mounted on a Leica M16 zoom lens via a Leica z-step microscope stand. Additionally, a GT-Vision Lw11057C-SCI digital camera attached to a Leica DMRB compound scope was used to feed image

data to a desktop computer. The program Cartograph 5.6.0 (Microvision Instruments, France) was used to merge an image series (typically representing 15–30 focal planes) into a single in-focus, composite image. Lighting was achieved using techniques summarized in Buffington et al. (2005), Kerr et al. (2008), and Buffington and Gates (2008).

Several images (see below) were obtained with a Visionary Digital imaging station. The station consists of an Infinity Optics K2 long distance microscope affixed to a Canon EOS 40D digital SLR camera. Lighting was provided by a Dynalite M2000er power pack and Microoptics ML1000 light box. Image capture software is Visionary Digital proprietary application with images saved as TIF with the RAW conversion occurring in Adobe Photoshop Lightroom 1.4. Image stacks were montaged with Helicon Focus 4.2.1 for images of *Conura nortonii* (Cresson), *C. immaculata* (Cresson), *Orthogonalys pulchella* (Cresson), and *Taeniogonalos gundlachii* (Cresson), as well as habitus shots of *Psychophagus omnivorus* (Walker), *Platyplectrus americana* (Girault), and *Pediobius crassicornis* (Thomson).

Final image plates for hymenopteran and dipteran figures were prepared using

InDesign CS4. Figures 14–17, previously unpublished, were used with the permission of D. M. Wood (Agriculture and Agri-Food Canada, Ottawa). Figures 38 and 43–44 were reproduced from Townes (1970) with permission.

Diptera Imaging

The image of *Systropus macer* Loew was captured with a Nikon Coolpix 8800 and adapters through the ocular of a Leica MZ9.5 stereoscope. Tachinid images were taken with a Canon EOS 40D digital SLR camera mounted on a Kaiser RS1 copy stand. A Canon EF 100 mm f/2.8 macro lens was used for full body images, and a Canon MP-E 65 mm 1–5X macro lens was used for images of body structures. A ring light consisting of 80 LEDs and covered with a reflective dome provided the lighting. Image stacks were montaged using Syncrosopy's Auto-Montage, and the resultant images received further treatment in Adobe Photoshop CS4.

Terminology

Hymenopteran terminology for surface sculpture follows Harris (1979) and for morphology follows Wahl (1993a), Gibson (1997), Sharkey and Wharton (1997), and Deans et al. (2010). Several measurements for chalcidoids were taken, including the following: body length, in lateral view from the anterior projection of the face to the tip of the metasoma; head width through an imaginary line connecting the farthest lateral projection of the eyes; head height through an imaginary line from the vertex to the clypeal margin bisecting both the median ocellus and the distance between the toruli; malar space, in lateral view between the ventral margin of the eye and lateral margin of the oral fossa; posterior ocellar line (POL), the shortest distance between

the posterior ocelli; ocular ocellar line (OOL), the shortest distance between the lateral margin of the posterior ocellus and the eye orbit; marginal vein, the length coincident with the leading fore wing edge to the base of the stigmal vein; stigmal vein, the length between its base on the marginal vein and its apex; postmarginal vein, the length from the base of the stigmal vein to its apex on the leading fore wing edge. Mesosomal and metasomal sclerites were measured dorsally along the midline. The use of “[]” in descriptions denotes structures that are not visible in the specimens upon which the description is based (observed via SEM), whereas their use in the material examined section refer to author notes. For braconids metasomal terga 1, 2, 3, etc. are abbreviated as T1, T2, T3; antennal flagellomeres are abbreviated as F1, F2, F3, etc. The ovipositor of ichneumonids was measured from the structure's base (observed or inferred) to its apex. The ovipositor sheaths must sometimes be separated by a fine needle to expose the ovipositor valves. The juncture of the occipital and hypostomal carina above the mandibular base is measured in posterolateral view; it is sometimes necessary to remove the head to properly measure. Dipteran terminology follows McAlpine (1981).

The portion of the key pertaining to Chalcidoidea is based upon the keys in Gibson et al. (1997). That for Braconidae is based on the keys of Sharkey (1997) and Whitfield (1997). That for Ichneumonidae is based on the key of Wahl (1993b). The diagnosis for *Cotesia* Cameron is based on the key in Whitfield (1997); the diagnosis for *Ascogaster* Wesmael is based on the key in Shaw (1997a). The diagnosis for *Triraphis* Ruthe is based on the diagnoses for *Triraphis* and *Rogas* Nees in van Achterberg (1991), as well as the keys in van Achterberg (1991) and Shaw (1997b).

All binominals for hosts and parasitoids are reported in their current nomenclatural combinations. Although this is not necessarily straightforward in any single publication, we cite the most recent/comprehensive nomenclatural authorities where required. For Limacodidae, nomenclatural references include: Fletcher and Nye (1982), Davis (1983), and Becker and Epstein (1995). Host records from the literature for Tachinidae list the current combination, as well as the combinations under which the hosts and tachinids were originally cited. New host records resulting from the rearing efforts of JTL, SMM and TMS for a particular parasitoid are denoted with * in the text and Table 1. Those newly reported herein from other sources are denoted with ‡. We report new host records at the parasitoid species level only rather than higher taxonomic levels. Thus, if a parasitoid species is newly recorded for a particular host genus or species, we report it as new even if congeneric parasitoids were previously recorded from that host genus or species.

Abbreviations for collections are as follows: AEI (American Entomological Institute, Gainesville, Florida, U.S.A.), ANSP (Academy of Natural Sciences, Philadelphia, Pennsylvania, U.S.A.), BMNH (The Natural History Museum, London, United Kingdom), CNC (Canadian National Collection of Insects, Ottawa, Ontario, Canada), IRSNB (Institut Royal des Sciences Naturelles de Belgique, Brussels, Belgium), MZLU (Zoological Museum, Lund University, Lund, Sweden), MCZ (Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, U.S.A.), MSUC (Michigan State University, East Lansing, Michigan, U.S.A.), NHMW (Naturhistorisches Museum Wien, Vienna, Austria), SEMK (Snow Entomological Museum, University of Kansas, Lawrence, Kansas, U.S.A.), ULQC (Université Laval, Quebec,

Canada), USNM (National Museum of Natural History, Smithsonian Institution, Washington, DC, U.S.A.), and ZMUC (Zoologisk Museum, Copenhagen, Denmark).

RESULTS AND DISCUSSION

Key to Primary and Secondary Parasitoids Known From Limacodids in North America

1. Hind wing modified as haltere (Fig. 1), hamuli absent, mouthparts sponging (Fig. 1) 2 (Diptera)
- 1' Hind wing not modified as haltere, hamuli present (Figs. 92–93), mouthparts mandibulate (e.g., Figs. 39, 82) 5 (Hymenoptera)
2. (1) Abdomen narrow and elongate, > 2.0X as long as broad and swollen apically (Fig. 3). Wings shorter than abdomen. Antennae and proboscis much longer than head
 . . . *Systropus (macer* Loew; Bombyliidae)
- 2' Abdomen stout, less than 2.0X as long as broad (Figs. 1, 11). Wings longer than abdomen. Antennae and proboscis at most as long as head 3 (Tachinidae)
3. (2') Facial ridge bare except for a few small and decumbent setae on lower third or less (Fig. 2). Metathoracic spiracle fringed with plumose hairs of about equal length along both anterior and posterior edges, leaving a V-shaped middorsal opening (Fig. 4). Prosternum bare (Fig. 6)
 . . . *Uramya (pristis* (Walker), *limacodis* (Townsend))
- 3' Facial ridge with row of stout setae on lower one-half or more (Fig. 9). Metathoracic spiracle with posterior lappet much larger than anterior one (Fig. 5). Prosternum haired laterally (Fig. 7) 4
4. (3') Ocellar seta vestigial or absent (Fig. 9). Abdominal terga 3 and 4 each with 1 pair of median discal setae. Bend of vein M obtuse (Fig. 8). Female with sickle-shaped, piercing ovipositor (Fig. 8)
 *Compsilura (concinata* (Meigen))
- 4' Ocellar seta well developed, similar in size to outer vertical seta (Fig. 10). Abdominal terga 3 and 4 without median discal setae (Fig. 11). Bend of vein M almost a right angle (Fig. 11). Female with short, non-piercing ovipositor (Fig. 11)
 . . . *Austrophorocera (cocciphila* (Aldrich and

- Webber), *coccyx* (Aldrich and Webber), *A. einaris* (Smith), *A. imitator* (Aldrich and Webber), *A. n. sp.*)
- 5 (1') Fore wing venation complete, with at least 2 closed cells (Figs. 18, 28, 34) 6 (Trigonaloidea, Ichneumonoidea)
- 5' Fore wing venation reduced, with fewer than 2 closed cells (Figs. 77-78, 96, 113) 17 (Chalcidoidea, Ceraphronoidea)
6. (5) Fore wing with veins C and SC+R touching/fused, costal cell absent (Figs. 63, 65). Metasomal sterna less strongly sclerotized than terga (Figs. 19, 23, 27, 29) 7 (Ichneumonoidea)
- 6' Fore wing with veins C and SC+R separate, costal cell present (Fig. 18). Metasomal sterna and terga equally sclerotized (Figs. 70-73) 16 (Trigonaloidea)
7. (6) Fore wing with vein 2m-cu present (Fig. 28, 35) 8 (Ichneumonidae)
- 7' Fore wing with vein 2m-cu absent (Fig. 56) 14 (Braconidae)
8. (7) Areolet of fore wing closed, large and rhombic (Figs. 20, 26). Ovipositor delicate, needlelike, sheaths thick and rigid (Figs. 19, 22). Female hypopygium prominent and triangular in lateral view (Fig. 22). Male gonoforceps produced into elongate process. Spiracle of metasomal segment 1 near or just behind middle, glymma large and deep (Fig. 21) *Mesochorus (discitergus)* (Say)
- 8' Areolet of fore wing open (vein 3rs-m absent) or closed, if closed then cell obliquely quadrate and petiolate (Figs. 26, 34). Ovipositor always stouter than above, sheaths thin, often curved if ovipositor ~ 2.0X as long as metasomal apical depth. Female hypopygium small and quadrate in lateral view (Fig. 23). Male gonoforceps not produced. Spiracle of metasomal segment 1 beyond middle, glymma small or absent (Fig. 27) 9
9. (8') Ventral posterior corner of propleuron with strongly produced, more or less angulate lobe touching or overlapping pronotum (Fig. 24). Sternaulus about 0.3X as long as mesopleuron (Fig. 30). Clypeus not separated from supraclypeal area by distinct groove (Fig. 32). Areolet of fore wing closed, obliquely quadrate and petiolate (Fig. 26) 10
- 9' Ventral posterior corner of propleuron not developed as distinct lobe, not angulate, at most with weak groove delimiting it from main area of propleuron (Fig. 25). Sternaulus of mesopleuron present and reaching middle coxa (Fig. 31). Clypeus separated from supraclypeal area by groove (Fig. 33). Areolet of fore wing open and pentagonal (Fig. 34) 11
10. (9) Petiole of first metasomal segment long and cylindrical in cross-section; midpoint of petiole with tergo-sternal suture at midline; T1 without trace of glymma (Fig. 28) *Casinaria (grandis)* (Walley)
- 10' Petiole of first metasomal segment shorter and quadrate in cross-section; midpoint of petiole with tergo-sternal suture close to ventral margin; T1 with glymma present as pitlike impression (Fig. 27) *Hyposoter (fugitivus)* (Say)
11. (9') Body color (excluding legs) black with white markings (Fig. 29). Mesosoma with coarse punctures (Fig. 37). Dorsal margin of pronotum with strong swelling at dorsal end of epomia (Fig. 37). Fore wing 5.0-8.5 mm long *Baryceros (texanus)* (Ashmead)
- 11' Body color (excluding legs) ranging from uniformly black/dark brown to having brownish red areas on T2-T3 (Figs. 34-36). Mesosoma with punctures ranging from fine to absent. Dorsal margin of pronotum without strong swelling at dorsal end of epomia. Fore wing 1.9-3.8 mm long. 12
12. (11') Apical 0.3 of clypeus turned inward at 90° (Fig. 43). Vein 2-Cu of hind wing basally incomplete *Lysibia (mandibularis)* (Provancher)
- 12' Apical 0.3 of clypeus flat, not turned inward (Fig. 44). Vein 2-Cu of hind wing complete 13
13. (12') Occipital and hypostomal carinae meeting at mandibular base (Fig. 41) . . . *Acrolyta (nigricapitata)* (Cook and Davis)
- 13' Occipital carina meeting hypostomal carina above mandibular base, juncture separated from base by about 0.2X basal mandibular width (Fig. 42) *Isdromas (lycaenae)* (Howard)
14. (7') Labrum visible through gap between ventral margin of clypeus and mandibles and concave (as in Fig. 39) (cyclostome Braconidae). Epicnemial carina present (Fig. 47); median carina present on T1 and usually extending posteriorly from dorsal carinae; T2 striate to striate-rugose (Figs. 52, 57); fore wing vein 1m-cu basad or in

- line with fore wing vein 2RS (Fig. 56) *Triraphis* Ruthe (*eupoeyiae* (Ashmead), *discoideus* (Cresson), *harrisi* (Ashmead))
- 14' Labrum concealed by clypeus or if visible not concave (Figs. 40 (as in), 60) (non-cyclostome Braconidae). Without combination of characters found in *Triraphis* Cheloniinae, Microgastrinae, 15
15. (14') Occipital carina present, fore wing vein RS reaching wing margin as tubular vein, T1–T3 fused into carapace covering all other terga (Figs. 48, 63). Other characters not in combination found in *Cotesia* (see below) *Ascogaster* (*quadridentata* Wesmael)
- 15' Occipital carina absent, fore wing vein RS not reaching wing margin as tubular vein (Fig. 65), T1–T3 variable (Microgastrinae). Fore wing vein r-m absent, areolet absent (Fig. 65). Ovipositor and sheaths short, weakly extending beyond tip of hypopygium (Fig. 67). Hypopygium evenly sclerotized medially. Propodeum without areola, often with distinct medial longitudinal carina and usually rugose (Fig. 66) *Cotesia* (*empretiae* (Viereck), *phobetri* (Rohwer), *schaffneri* (Rohwer))
16. (6') Antenna black with white or light yellow band at center. Head and mesosoma with black and white pattern. Metasoma and legs mostly orange (Figs. 70–71). Metasoma thin, smooth, impunctate *Orthogonalys* (*pulchella* Cresson)
- 16' Antenna yellowish brown without lighter band at center. Head and body black with yellow markings (Figs. 72–73). Metasoma black and yellow, legs yellow with dark brown to black on femur, tibia dusky in apical third. Metasoma stout, punctate. *Taeniogonalos* (*gundlachii* (Cresson))
17. (5') Fore wing with tubular submarginal vein basally on anterior margin, stigmal vein curving distally (Fig. 77). Female antenna with 7–8 flagellomeres (Fig. 76), male with 8–9 (Fig. 74). Dorsum flat in lateral view *Ceraphron* Jurine (Ceraphronidae)
- 17' Fore wing lacking tubular vein basally on anterior margin (Fig. 78). Other features not as above 18.
18. (17') Hind femur enlarged (< 3.0X as long as broad) (Figs. 79–80). Prepectus reduced to a small sclerite along dorsal margin of mesopleuron (Fig. 83). Gaster petiolate (Figs. 79–80) *Conura* (*comescens* (Cameron), *nigricornis* (F.), *nortonii* (Cresson))
- 18' Hind femur not enlarged (> 3.0X as long as broad). Prepectus larger, triangular (Figs. 87, 109). Gaster indistinctly or not petiolate Eulophidae, Trichogrammatidae, Pteromalidae, 19
19. (18') Legs with 5 tarsomeres. Clypeus shallowly bilobed apically (Fig. 88). Pedicel ~ 2.0X as long as broad, antennal formula 11263 (Fig. 89). Propodeum reticulate-rugose, with median carina incomplete (Fig. 90). Gaster subcircular to short-ovate (Fig. 91) *Psychophagus* (*omnivorus* (Walker))
- 19' Legs with 3 or 4 tarsomeres. Other features not as above Eulophidae, Trichogrammatidae, 20
20. (19') Legs with 4 tarsomeres. Fore wing lacking setal tracks (Fig. 113) Eulophidae, 21
- 20' Legs with 3 tarsomeres (Fig. 94). Fore wing with setal tracks, broad with sigmoid venation and distinctive Rs1 setal track (Fig. 96) *Trichogramma* (*minutum* Riley)
21. (20') Scutellum with one pair of setae (Fig. 95). Submarginal vein with two setae on dorsal surface. Propodeum with paired submedian carinae that diverge posteriorly (Fig. 95) *Pediobius* (*crassicornis* (Thomson))
- 21' Scutellum with two pairs of setae (Figs. 104–105). Submarginal vein with three or more setae on dorsal surface (Fig. 113). Propodeum with single carina, or if with paired submedian carinae then carinae not arcuately divergent (Figs. 104–105) Eulophinae, 22
22. (21') Propodeum with two submedian carinae (Fig. 104). Scutellum with scutellar grooves broad, contiguous with posterior margin (Fig. 104). Hind tibia with one spur *Alveoplectrus* (*lilli* Gates)
- 22' Propodeum with single median carina (Fig. 105). Scutellum with scutellar grooves narrow (Fig. 105). Hind tibia with two spurs. *Platyplectrus* (*americana* (Girault))

Diptera

Systropus Weidemann (Bombyliidae:
Toxophorinae: Systropodini)
(Fig. 3)

Diagnosis.—*Systropus* can be identified in North America using the key by Hall (1981) or Kits et al. (2008; *Melanderella* Cockerell not extant) and can be distinguished from other North American genera (*Dolichomyia* Weidemann) of Systropodini by the following characters: pedicel at least 2–3 times longer than wide (as wide as long in *Dolichomyia*); first flagellomere flattened (cylindrical in *Dolichomyia*); and anal lobe of wing not reduced (extremely reduced in *Dolichomyia*). However, *Dolichomyia* is not known from eastern North America. A third genus, *Zaclava* Hull, is represented by four species known only from Australia. Typically, *Systropus* spp. mimic sphecid wasps and thus are often elongate, largely orange and black with the abdomen long and swollen apically (Fig. 3). The wings are conspicuously shorter than the abdomen, and both the antennae and proboscis are much longer than the head (Fig. 3).

Fauna.—*Systropus* is a large genus containing 154 species most commonly encountered in tropical areas of all continents (Evenhuis and Greathead 1999). The majority of the species are known from the African and Oriental regions (Evenhuis and Greathead 1999). Species from other biogeographic regions have not been treated via comprehensive taxonomic publications. In North and Central America, the 23 described species range throughout tropical and subtropical areas (Painter and Painter 1963, Adams and Yanega 1991), with three found north of Mexico.

Biology.—Specific biology related to host location and oviposition behavior has not been reported for *Systropus* spp.,

although they are documented to oviposit directly onto their hosts by adhering eggs to the host's integument (Genty 1972). In at least one instance, oviposition of black eggs is accompanied by rapid movement of the abdomen of the fly on the host (Genty 1972). *Systropus* spp. are specialists on limacodid larvae and are placed in Toxophorinae, one of only two bombyliid subfamilies containing true endoparasitoids (the other is Anthracinae) (Greathead 1987, Yeates and Greathead 1997). Hosts are known only for *S. macer* in North America (see below). Extralimitally, host associations have been reported from Africa (Hull 1973), Central/South America (Adams and Yanega 1991, Aiello 1980, Dyar 1900), and Asia (Greathead 1987). Adults routinely take nectar from flowers (Robertson 1928, Painter and Painter 1963) and are commonly reported from woodland glades and various habitats in the wet tropics (Painter and Painter 1963, Greathead 1987). Two species are known from Australia (Evenhuis and Greathead 1999).

Literature.—Painter and Painter (1963) revised the *Systropus* of North and Central America treating 23 species, including three found north of Mexico. Extralimitally, Enderlein (1926) keyed 13 species from Southeast Asia, but 48 species are known from the region today (Evenhuis and Greathead 2003). The group has been cataloged along with a full bibliography as part of larger works on Bombyliidae (Evenhuis and Greathead 1999), and these data are now available on the Internet (Evenhuis and Greathead 2003).

North American Records:

Systropus macer Loew (Fig. 3): *Systropus macer* Loew, 1863: 375. Lectotype ♀, MCZ, designated by Evenhuis (1982) (not examined).

Systropus macer is diagnosed in the key of Painter and Painter (1963) by: swollen part of propleura bright yellow,

metasternum solid brown/black, mesonotum with small yellow spots, legs light brown/black, and the caudal edge of the 8th sternum notched/undulating.

Distribution: Northeastern North America (Painter and Painter 1963).

Limacodidae: *Adoneta spinuloides*, *Apoda* sp., *Euclea delphinii* (Boisduval), *Lithacodes fasciola* (H. -S.), *Prolimacodes badia* (Adams and Yanega 1991), *Parasa indetermina* (Boisduval) (Epstein 1997).

Other hosts: No records.

Uramya Robineau-Desvoidy
(Tachinidae: Dexiinae: Uramyini)
(Figs. 1–2, 4, 6)

Diagnosis.—*Uramya* can be identified in North America using the key by Wood (1987) and can be distinguished from *Compsilura* and *Austrophorocera* by the following combination of characters: ocellar seta weak or absent; facial ridge bare except for a few small, decumbent setae on lower third or less (Fig. 2); prosternum bare (Fig. 6); 3 large postsutural dorsocentral setae; metathoracic spiracle fringed with plumose hairs of about equal size along anterior and posterior edges, leaving V-shaped middorsal opening (Fig. 4); scutellum with 3 pairs of strong marginal setae, including pair of strong, crossed apicals; vein M sharply angled at bend (Fig. 1); abdomen with 1–2 pairs of median discal setae on each of tergites 3 and 4 (Fig. 1); female ovipositor short and pointed.

Fauna.—*Uramya* is a New World genus of about 20 described species ranging from Canada to northern Argentina. Twelve species were recognized from South America by Guimarães (1980), and seven species were recorded from North America by O'Hara and Wood (2004); however, there is no recent revision or key available to these species. Janzen and Hallwachs

(2009) recorded several undescribed morphospecies of *Uramya* from Guanacaste (Costa Rica); all were reared from limacodids.

Biology.—Females of *Uramya* are ovularviparous on lepidopteran larvae. Hosts are known for four of the seven species in North America. Two of the four, *U. limacodis* and *U. pristis*, attack limacodids (Arnaud 1978, see below). *Uramya halisidotae* (Townsend) is most commonly reared from *Lophocampa argentata* (Packard) (as *Halisidota argentata*; Arctiidae), but there is a single record from *Malacosoma* sp. (Lasiocampidae) (Aldrich 1921, Arnaud 1978). Stireman and Singer (2003a, b) reared *U. indita* (Walker) from *Norape tenera* Druce (Megalopygidae) in Arizona.

Two South American species have been reared in Venezuela: *U. longa* (Walker) from *Ammalo helops* (Cramer) (Arctiidae) and *U. sibirivora* Guimarães from *Acharia* sp. (as *Sibine*; Limacodidae) (Guimarães 1980). Cruttwell (1969) documented the biology of *U. brevicauda* Curran, reared from *Pareuchaetes pseudoinsulata* Rego Barros (Arctiidae) in Trinidad. Eggs are laid directly on a host and hatch immediately; the first instar penetrates the host's integument within a few seconds. Cruttwell (1969) found that larvae could develop gregariously in lab-reared hosts, but wild hosts were generally parasitized by single maggots continuously throughout the year in Trinidad. Schaffner (1959) reported that the North American species *U. limacodis* and *U. pristis* develop as solitary parasitoids in their recorded hosts (listed below), have one generation per year, and overwinter in the pupal stage. All of the *U. pristis* reared as part of this study followed this pattern.

About 10 morphospecies of *Uramya* were reared from five genera of limacodids (*Acharia* Hübner, *Euclea* Hübner,



Figs. 1–3. Tachinidae and Bombyliidae. 1, *Uramya pristis*, male, habitus (white arrows: (r), haltere; (l), mouthparts; black arrow, discal setae); 2, *U. pristis*, male, head, lateral (arrow, setae absent on facial ridge); 3, *Systropus macer*, female, habitus (arrows: (u), antenna; (l), mouthparts).

Isochaetes Dyar, *Natada* Walker, and *Parasa* Moore) by Janzen and Hallwachs (2009).

Literature.—Aldrich (1921) revised the *Uramya* of the Americas under the generic names *Uramya* and *Pseudeuantha*

Townsend. Twelve species were treated, including only four of the seven species currently recognized from North America. Curran (1930) followed the taxonomy of Aldrich (1921) and provided a key to the three species of *Pseudeuanta* then known from the U.S.A. but excluded without comment *P. johnsoni*. Reinhard (1935) described two additional species, one in *Pseudeuanta* and the other in *Uramya*. Sabrosky and Arnaud (1965) reorganized the species under *Anaporia*, *Pseudeuanta* and *Uramya*, also adding *indita* Walker to *Pseudeuanta* and synonymizing *johnsoni* with *pristis* under *Anaporia*. Wood (1987) synonymized *Anaporia* and *Pseudeuanta* with *Uramya* and keyed the genus among other Nearctic genera. This classification of seven species of *Uramya* in North America was followed in the catalog by O'Hara and Wood (2004). O'Hara and Wood (2004; catalog) provided type and distributional information. North American Records:

Uramya limacodis (Townsend) (Fig. 13): *Aporia limacodis* Townsend, 1892: 275. Holotype ♂, SEMK (O'Hara and Wood 2004) (not examined).

There is no key to the *Uramya* of North America, but the species can be readily separated into three groups. The first comprises *U. halisidotae* and *U. aldrichi*, which are characterized in the male by an unusual taillike projection of abdominal tergite 5 that extends dorsally beyond the male terminalia by about the preceding length of tergite 5. The second group comprises *U. indita* and *U. umbratilis*. These species are recognized easily by their bi-colored wings in both sexes: yellow basally and blackish on apical half (particularly close to veins). The final three species, *U. limacodis*, *U. pristis*, and *U. rubripes*, are more ordinary in appearance although the last (known only from Florida and Texas) is the only species in which the legs and

portions of the abdomen are typically reddish yellow. *Uramya limacodis* and *U. pristis* are the only two species of the genus in North America that have been reared from limacodids. They are typically 7–12 mm long, and only the males are easily distinguished. In males the long slender hairs on the anepisternum, from the central portion of the sclerite to behind the anepisternal setae, are black in *U. limacodis* (Fig. 13) and pale in *U. pristis* (Fig. 12).

Distribution: Saskatchewan to Nova Scotia, south to Wisconsin and Georgia (O'Hara and Wood 2004).

Limacodidae: *E. delphini*[‡] (CNC [North Burgess Township, Lanark County, Ontario, 1973]), *Isa textula* (H.-S.) (Schaffner 1959, as *Anaporia limacodis* ex *Sisyrosea textula*), *Limacodes* sp. (Townsend 1892, as *Aporia limacodis*), *Li. fasciola* (Schaffner 1959, as *Anaporia limacodis*; CNC [North Burgess Township, Lanark County, Ontario, 1971]), *Tortricidia flexuosa* (Grote) (Aldrich 1921, as *Pseudeuanta coquillettii* Aldrich; Johnson 1925, as *Pseudeuanta coquillettii*; Schaffner 1959, as *Anaporia limacodis*).

Uramya pristis (walker) (Figs. 1–2, 4, 6, 12): *Dexia pristis* Walker, 1849: 841. Holotype ♂, BMNH (O'Hara and Wood 2004) (not examined).

See *U. limacodis* for differential diagnostics.

Distribution: Michigan to Quebec and New Hampshire, south to Florida; also Arizona (O'Hara and Wood 2004).

Limacodidae: *Acharia stimulea* (Clemens) (Aldrich 1921, as *Pseudeuanta pristis* ex *Empretia stimulea*; Johnson 1925, as *Pseudeuanta pristis* ex *Empretia stimulea*), *E. delphini* (Coquillett 1897, as *Exorista blanda* (Osten Sacken) ex *Euclea cippus* (Cramer); Johnson, 1925, as *Pseudeuanta pristis* ex *Euclea* “*ceppus*” [= *cippus*] (Cramer)), *I. textula* (Coquillett 1897, as *Exorista isae* Coquillett ex *Isa inornata* (Grote

and Robinson)), *Phobetrion pithecium* (J. E. Smith) (Schaffner 1959, as *Anaporis pristis*). Five additional new limacodid hosts are reported herein (Table 1): *Ad. spinuloides**, *Isochaetes beutenmuelleri**, *Li. fasciola**, *Packardia geminata* (Packard)*, *Tortricidia* sp*.

Other hosts: *Megalopyge crispata* (Packard) (Megalopygidae).

Misidentification: The record by Coquillett (1897) and cited by Arnaud (1978) of *U. pristis* (as *Macquartia pristis*) reared from the arctiid *Lophocampa argentata* (as *Halisidota argentata*) is in error. The tachinid reared was *U. halisidotae* (Aldrich 1921), a well known parasitoid of *L. argentata*.

Compsilura Bouché (Tachinidae:
Exoristinae: Blondeliini)
(Figs. 5, 7–9)

Diagnosis.—*Compsilura concinnata* (Meigen) is the single species of the genus in North America. It is typically 7–8 mm in length but can be as short as 4 mm. It can be identified in North America using the key by Wood (1987) and can be distinguished from *Uramya* and *Austrophorocera* by the following combination of characters: ocellar seta usually absent; facial ridge with row of stout setae on lower one-half or more (Fig. 9); prosternum haired laterally (Fig. 7); 4 postsutural dorsocentral setae; metathoracic spiracle with posterior lappet much larger than anterior one (Fig. 5); scutellum with 4 pairs of setae, apicals crossed and shorter than laterals, subapicals usually divergent; vein M obtusely-angled at bend (Fig. 8); abdomen with 1 pair of median discal setae on each of tergites 3 and 4 (Fig. 8); female with short spines ventromedially on tergites 3 and 4, and sicklelike piercing ovipositor (Fig. 8).

Fauna.—*Compsilura* contains four species, mostly of Old World distribution. *Compsilura concinnata* was introduced

from Europe into North America on multiple occasions beginning in the early 1900s to control a variety of lepidopteran pests, most notably gypsy moth (*L. dispar*) and browntail moth (*Euproctis chrysorrhoea* (L.)) (Boettner et al. 2000).

Biology.—Only *Com. concinnata* has reported host records. This species is extremely polyphagous, attacking many species of Lepidoptera in a variety of families and some species of Hymenoptera (Symphyta) (Herting 1960, Europe; Arnaud 1978, North America; Shima 2006, Japan). Over 180 hosts have been recorded in North America, including a single limacodid, *M. flavescens* (Schaffner and Griswold 1934, Schaffner 1959, repeated in Arnaud 1978; all as *Cnidocampa flavescens*).

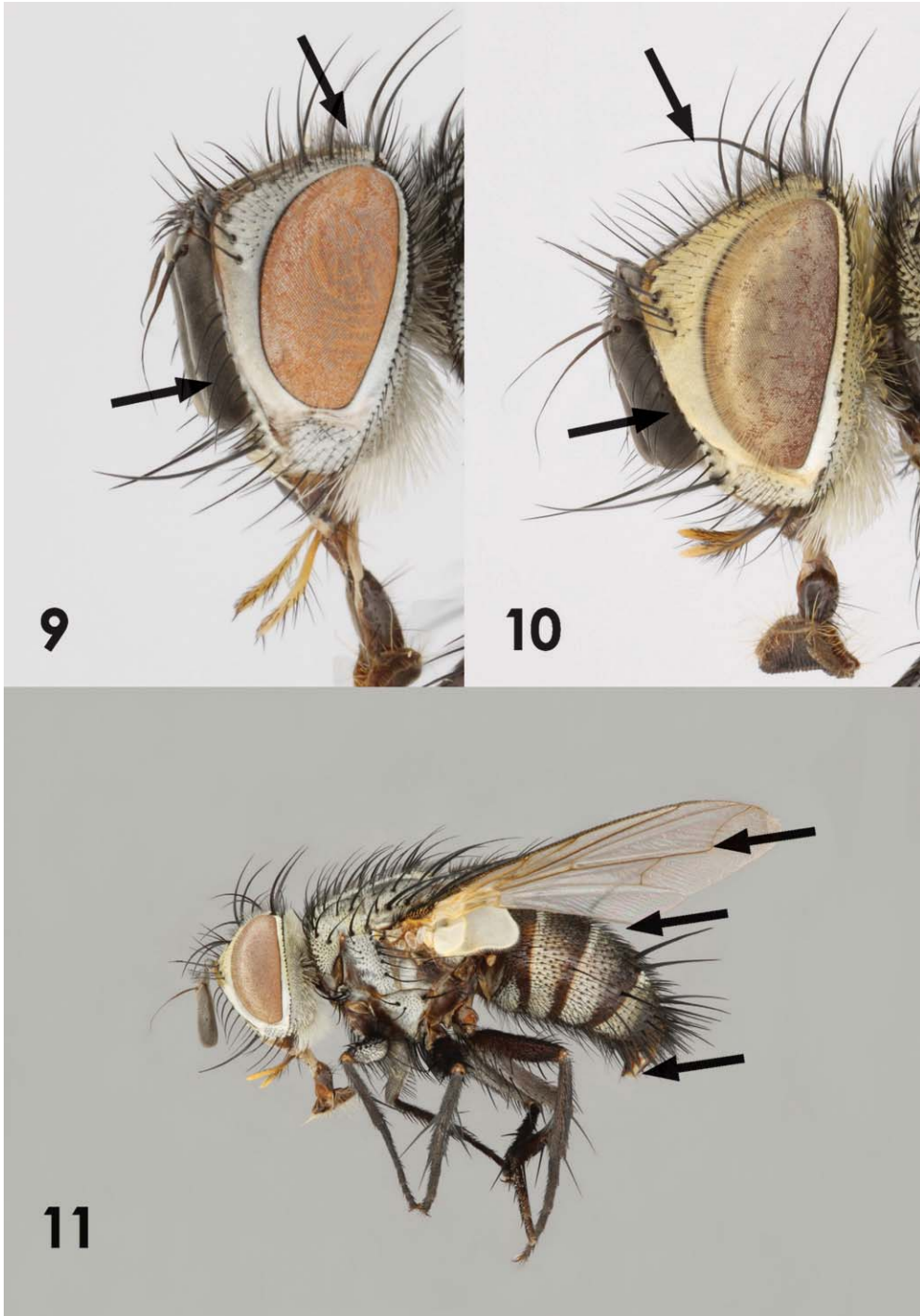
Compsilura species are ovarviparous, injecting eggs with fully developed and ready-to-hatch first instars. In *Com. concinnata*, there is a peculiar adaptation known in few other tachinids: the first instar occupies the narrow space between the peritrophic membrane and the wall of the midgut and remains there throughout most of its three larval instars (Ichiki and Shima 2003). Bouchier (1991) suggested that living in the midgut allows the developing maggot to evade host immune response.

The life history of *Com. concinnata* is varied according to host species and geographic area. There are two to four generations per year, often involving alternate hosts throughout the season. In larger hosts, multiple maggots can develop gregariously. The species overwinters in the larval stage within a host (Culver 1919, Schaffner 1959) or possibly in the pupal stage away from a host (Tothill 1922).

Literature.—Shima (1984) diagnosed *Compsilura* and the single Japanese species *Com. concinnata* in a paper on Japanese blondeliine genera *Blondelia* Robineau-Desvoidy and *Compsilura*. Wood (1985) revised and keyed the



Figs. 4–8. Species of *Uromyia* and *Compsilura*. 4, *Uromyia pristis*, metathoracic spiracle (arrow: posterior lappet); 5, *Compsilura concinnata*, metathoracic spiracle (arrow: posterior lappet); 6, *U. pristis*, prosternum, (arrow: no setae); 7, *Com. concinnata*, female, prosternum (arrow: setae); 8, *Com. concinnata*, female, habitus (arrows: (u), bend of vein M; (m), median discal setae present; (l), piercing ovipositor).



Figs. 9–11. Males. 9, *Compstilura concinnata*, head, lateral (arrows: (u), no ocellar setae; (l), setae on facial ridge); 10, *Austrophorcera* n. sp., head, lateral (arrows: (u), ocellar seta; (l), setae on facial ridge); 11, *A.* n. sp., female, habitus (arrows: (u), bend of vein M; (m), median discal setae absent; (l), non-piercing ovipositor).

Blondeliini of North and Central America and the West Indies. The genus was keyed among other Nearctic Tachinidae by Wood (1987) and among other Palearctic Tachinidae by Tschorsnig and Richter (1998). O'Hara and Wood (2004) provided type and distributional information.

North American Records:

Compsilura concinnata (Meigen) (Figs. 5, 7–9); *Tachina concinnata* Meigen, 1824: 412. Holotype ♀, NHMW (Herting 1972, O'Hara et al. 2009) (not examined).

Compsilura concinnata is the most polyphagous species of Tachinidae. It has recently been implicated in the decline of native species of saturniid moths in New England (Boettner et al. 2000, Elkinton and Boettner 2004). Historical evidence suggests it may have successfully controlled browntail moth, one of the invasive pest species it was originally introduced against (Elkinton et al. 2006).

Distribution: Widespread throughout all biogeographic regions of the Old World (Shima 1984). Introduced into North America and currently known from most of southern Canada and western and northeastern U.S.A. (O'Hara and Wood 2004). The species may still be expanding its range in North America.

Limacodidae: *M. flavescens* (Webber and Schaffner 1926, Schaffner and Griswold 1934, Schaffner 1959; all as *Cnidocampa flavescens*) and *E. delphinii**.

Other hosts: Over 180 species of Lepidoptera and Symphyta in North America (Arnaud 1978, Boettner et al. 2000).

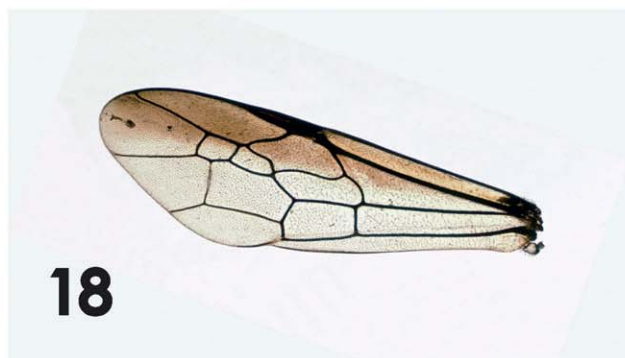
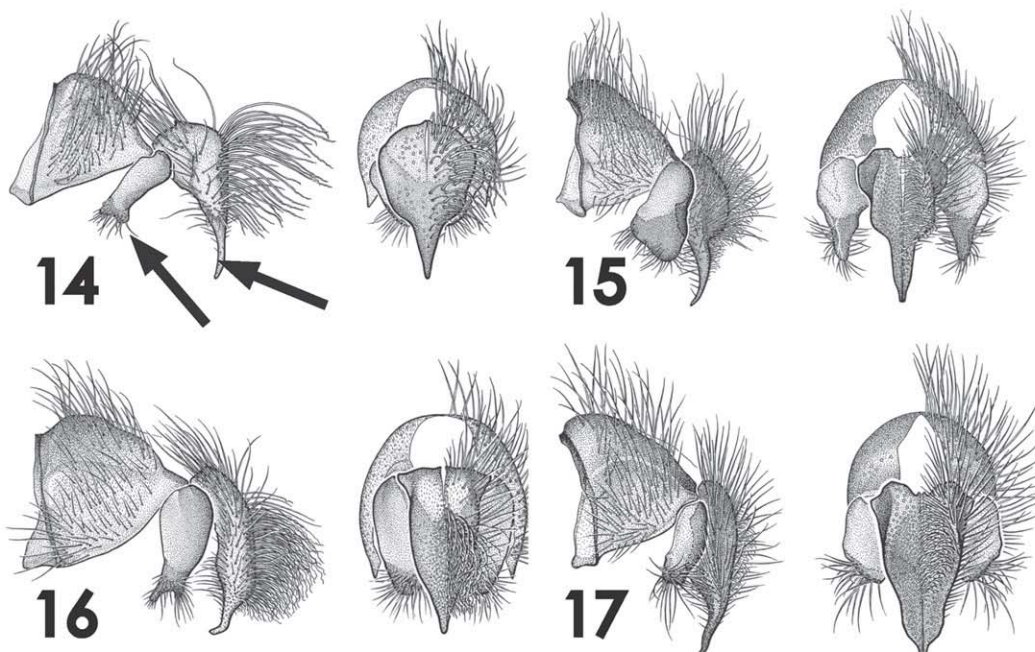
Austrophorocera Townsend
(Tachinidae: Exoristinae: Exoristini)
(Figs. 10–11, 14–17)

Diagnosis.—The genus can be identified in North America using the key by Wood (1987) and can be distinguished

from *Uramya* and *Compsilura* by the following combination of characters: ocellar seta well developed (Fig. 10); facial ridge with row of stout setae on more than lower one-half (Fig. 10); prosternum haired laterally (as in Fig. 7); 4 postsutural dorso-central setae; metathoracic spiracle with posterior lappet much larger than anterior one (as in Fig. 5); scutellum with 4 pairs of setae, apicals crossed and subequal in length to laterals; vein M right-angled at bend (Fig. 11); abdomen without median discal setae on tergites 3 and 4 (Fig. 11); female with non-piercing ovipositor (Fig. 11).

Fauna.—There are 10 described species of *Austrophorocera* in North America (O'Hara and Wood 2004), and at least 15 species are described from the Neotropical Region (Wood and Zumbado 2010), although most of the latter are currently assigned to other genera. Janzen and Hallwachs (2009) recorded about 20 morphospecies of *Austrophorocera* in Guanacaste, Costa Rica, of which only two are referable to named species. There is no modern key to the New World species of *Austrophorocera*. There are five species in the Oriental and Australasian/Oceanic regions (Crosskey 1976, Cantrell and Crosskey 1989), with two of those species reaching the Palearctic part of China (O'Hara et al. 2009).

Biology.—*Austrophorocera* species are oviparous. Eggs are laid directly on a host and hatch within a few days; the first instar then uses its mouth hooks to burrow into the host. Two or three species have been reared in North America (one nominal), and except for one record from a notodontid, the hosts have all belonged to Limacodidae (see below). Janzen and Hallwachs (2009) documented 307 *Austrophorocera* specimens (20 morphospecies, two nominal) reared from 14 genera and > 20 species of Limacodidae in Guanacaste. A widespread species in the Oriental and Australasian regions, *A.*



Figs. 12–18. Species of *Uramya*, *Austrophorocera*, and *Taeniogonalos*. Figs. 12–13. Anepisternum. 12, *Uramya pristis*; 13, *U. limacodis*. Figs. 14–17. Male genitalia, lateral and posterior views, *Austrophorocera* spp. 14, *A. cocciphila* (arrows: (l), surstylus; (r), syncercus); 15, *A. coccyx*; 16, *A. einaris*; 17, *A. n. sp.* Fig. 18. *Taeniogonalos gundlachii*, fore wing.

grandis (Macquart) has been reared from several species of *Thosea* Walker and *Doratifera* Duncan (Limacodidae) (Crosskey 1976, Chadwick and Nikitin 1985), as well as *Heliiothis* sp. (Noctuidae) (Cantrell 1986).

Schaffner (1959) briefly reviewed the life history of *A. coccyx* parasitizing two limacodid species (see below). He reported one parasitoid per host, one generation per year, and larva overwintering in the prepupal stage of the host. Murphy et al. (2009) reported on the undescribed *A.* sp. recorded in the present study, stating that it is a larval-pupal parasitoid that parasitizes the larva and emerges from the host's pupa the following spring. Host pupation appears to be a trigger for development of *A.* sp., because flies have repeatedly been observed to eclose from non-diapausing host cocoons in the one North American limacodid species with a partial second generation, *E. delphinii*.

Literature.—Aldrich and Webber (1924) treated seven of the 10 species of *Austrophorocera* recognized currently from North America as *Phorocera* Robineau-Desvoidy (subgenus *Parasetigena* Brauer and Bergenstamm) in part. Sabrosky and Arnaud (1965) dispersed the species of *P.* (*Parasetigena*) among several genera but kept together six of the seven *Austrophorocera* species in the genus *Palpexorista* Townsend. These authors added three additional species to *Palpexorista* that had been described in *Phorocera* after Aldrich and Webber (1924). Wood (1987) synonymized *Palpexorista* under *Austrophorocera*, a genus formerly known only from the Old World. Thus, the nine species assigned to *Palpexorista* by Sabrosky and Arnaud (1965) were treated under *Austrophorocera* by O'Hara and Wood (2004). A tenth species was added as a new North American record by O'Hara and Wood (2004).

North American Records:

Austrophorocera cocciphila (Aldrich and Webber): *Phorocera* (*Parasetigena*) *cocciphila* Aldrich and Webber, 1924: 53. Holotype ♂, USNM (O'Hara and Wood 2004) (not examined).

Two of the North American species of *Austrophorocera*, *A. cocciphila* and *A. einaris*, are easily distinguished from the other species by having two katepisternal setae instead of three. The male syncercus of these two species is densely setose posteriorly (Figs. 14, 16). The setae are black, and their outer portions have a crinkled appearance. The setae form a thicker and tighter mat in *A. einaris* (Fig. 16) than in *A. cocciphila* (Fig. 14), and the mat in *A. einaris* is positioned more centrally on the more elongate syncercus of that species. The syncercus of *A. einaris* in lateral view is distinctly bent subapically, compared to slightly curved subapically in *A. cocciphila*.

Distribution: District of Columbia, Maryland, Ohio, Tennessee (O'Hara and Wood 2004).

Limacodidae: *Ac. stimulea*.

Other hosts: None known.

Austrophorocera coccyx (Aldrich and Webber) (Fig. 15): *Phorocera* (*Parasetigena*) *coccyx* Aldrich and Webber, 1924: 64. Holotype ♂, USNM (O'Hara and Wood 2004) (not examined).

Austrophorocera coccyx and *A. n.* sp. belong to a group of seven North American *Austrophorocera* species that have three katepisternal setae and a patch of short, fine, wavy yellowish hairs within a depressed area on the basal portion of the posterior surface of the male syncercus. Two of the seven species, *A. pellecta* (Reinhard) (Arizona) and *A. tuxedo* (Curran), are smaller than the rest at about 6–9 mm long; the former has an unusually broad parafacial, and the latter is yellowish on the upper portion of the head (fronto-orbital plate) and the thoracic dorsum.

The remaining five species comprise *A. alba* (Townsend), *A. coccyx*, *A. stolidida* (Reinhard), *A. virilis* (Aldrich and Webber), and *A. n. sp.* These species are moderately large tachinids (about 10–13 mm long except for *A. n. sp.*, which is 8.5–10.0 mm long) and are grayish black in coloration. They are most easily separated by distinct differences in their male syncercus: *A. alba* (and other forms that may represent undescribed species) has the posterior surface of the syncercus expanded laterally at mid-length to form a lobe on either side, and the apical portion of the syncercus is short and narrow; in *A. coccyx* (Fig. 15) the syncercus in posterior view is abruptly narrowed at midlength and tapered to a pointed tip; in *A. stolidida* the syncercus is gently narrowed at mid-length, tapered to a rounded tip, and bears a tuft of dense black setae basally above the area with the short yellow hairs; in *A. virilis* the syncercus is smoothly tapered from base to tip; in *A. n. sp.* (Fig. 17) the syncercus is broadened on lower third and abruptly narrowed subapically to a pointed tip.

Distribution: Ontario to New York, south to Florida, also Arizona and Texas (O'Hara and Wood 2004).

Limacodidae: *Ac. stimulea* (Aldrich and Webber 1924, as *Pho. coccyx*; Schaffner 1959, as *Pho. longiuscula* (Walker)) and *Pho. pithecium* (Schaffner and Griswold 1934, as *Pho. longiuscula*; Schaffner 1959, as *Pho. longiuscula*).

Other hosts: *Datana ministra* (Drury) (Notodontidae).

Austrophorocera einaris (Smith): *Phorocera einaris* Smith, 1912: 119. Holotype ♂, USNM (O'Hara and Wood 2004) (not examined).

See *A. cocciphila* for differential diagnostics.

Distribution: "Michigan to Quebec and Massachusetts, south to Texas and Florida" (O'Hara and Wood 2004).

Limacodidae: *E. delphinii*.

Other hosts: None known.

Austrophorocera imitator (Aldrich and Webber): *Phorocera (Parasetigena) imitator* Aldrich and Webber, 1924: 63. Holotype ♂, USNM (O'Hara and Wood 2004) (not examined).

Austrophorocera imitator and another North American species, *A. sulcata* (Aldrich and Webber), have three katepisternal setae and only black setae posteriorly on the male syncercus. The setae on the syncercus are shorter and more regular in appearance than in *A. einaris* and *A. cocciphila*. The syncercus in both species is slender and evenly tapered in posterior view; in lateral view the apex is slightly clubbed and bent posteriorly in *A. imitator* and tapered to a point and slightly curved anteriorly in *A. sulcata*. The surstylus of *A. imitator* is distinctive among the North American species of the genus in being tightly appressed against, and possibly fused with, the syncercus along its length, giving the appearance on first inspection of being absent.

Distribution: Missouri to Massachusetts, south to Texas and Florida (O'Hara and Wood 2004).

Limacodidae: *Pr. badia*.

Other hosts: None known.

Austrophorocera n. sp. (Fig. 17) Murphy et al. 2009 (*Austrophorocera n. sp.*).

See *A. coccyx* for differential diagnostics.

Distribution: Eastern U.S.A.

Limacodidae: Reported from "Limacodidae" in Murphy et al. (2009) and *Li. fasciola** (Table 1).

Austrophorocera "sp. 1": Stireman and Singer 2003a, b.

Not examined and characters not known.

Distribution: Studied in Arizona.

Limacodidae: *Pa. chloris* (H.-S.) (Stireman and Singer 2003b), *Pro. trigona* (Edwards) (Stireman and Singer 2003a, b).

Hymenoptera

Ceraphron Jurine

(Ceraphronoidea: Ceraphronidae)
(Figs. 74–77)

Diagnosis.—Vertex rounded (Fig. 74), ocellar triangle small, distant from the eyes; median furrow present on the mesoscutum (Fig. 75) (Dessart and Cancemi 1986), and dorsum of the latter flat in lateral view (Austin 1987b). Adult specimens of *Ceraphron*, particularly males, are difficult to identify to species due to their simplified genitalia (I. Mikó pers. comm.) and the dearth and age of published information for the Nearctic Region (Ashmead 1904, Brues 1906).

Fauna.—There is little known about the diversity of *Ceraphron*; no comprehensive treatments have been published regionally or globally. Twenty-four species were recorded from North America by Brues (1906).

Biology.—Species of *Ceraphron* are commonly considered hyperparasitic on primary hymenopteran and dipteran parasitoids based largely on records from the related genus *Aphanogmus* (recorded from Ichneumonidae and Braconidae by Austin (1987b)). Other species of *Ceraphron* have been reared as hyperparasitoids (through Hymenoptera) from both Aphididae (Evans and Stange 1997) and Cecidomyiidae (Franklin 1919), among other hosts.

Literature.—Austin (1987b) recorded a single *Ceraphron* sp. hyperparasitoid from one limacodid rearing from Southeast Asia. Brues (1906) published a key to Nearctic *Ceraphron* and followed this with a key to genera and species of Ceraphronidae (Ceraphronoidea) in Connecticut (Brues 1916). Ashmead (1893) reported on the genera and species of Ceraphronidae known in North America, and Dessart (1981) proposed species groups of *Ceraphron*. The most recent key to the world genera of Ceraphronoidea (incl. subgenera

of *Ceraphron*) was published by Dessart and Cancemi (1986).

North American Records:

Ceraphron sp. (Figs. 74–77): Diagnostics unavailable for North American species.

Distribution: This cosmopolitan genus is widespread in North America.

Limacodidae: Hyperparasitoid that emerged from a primary parasitoid (possibly *Pl. americana** or *Al. lilli**) of *Ac. stimulea* on *Q. rubra*.

Other hosts: Unknown for this species.

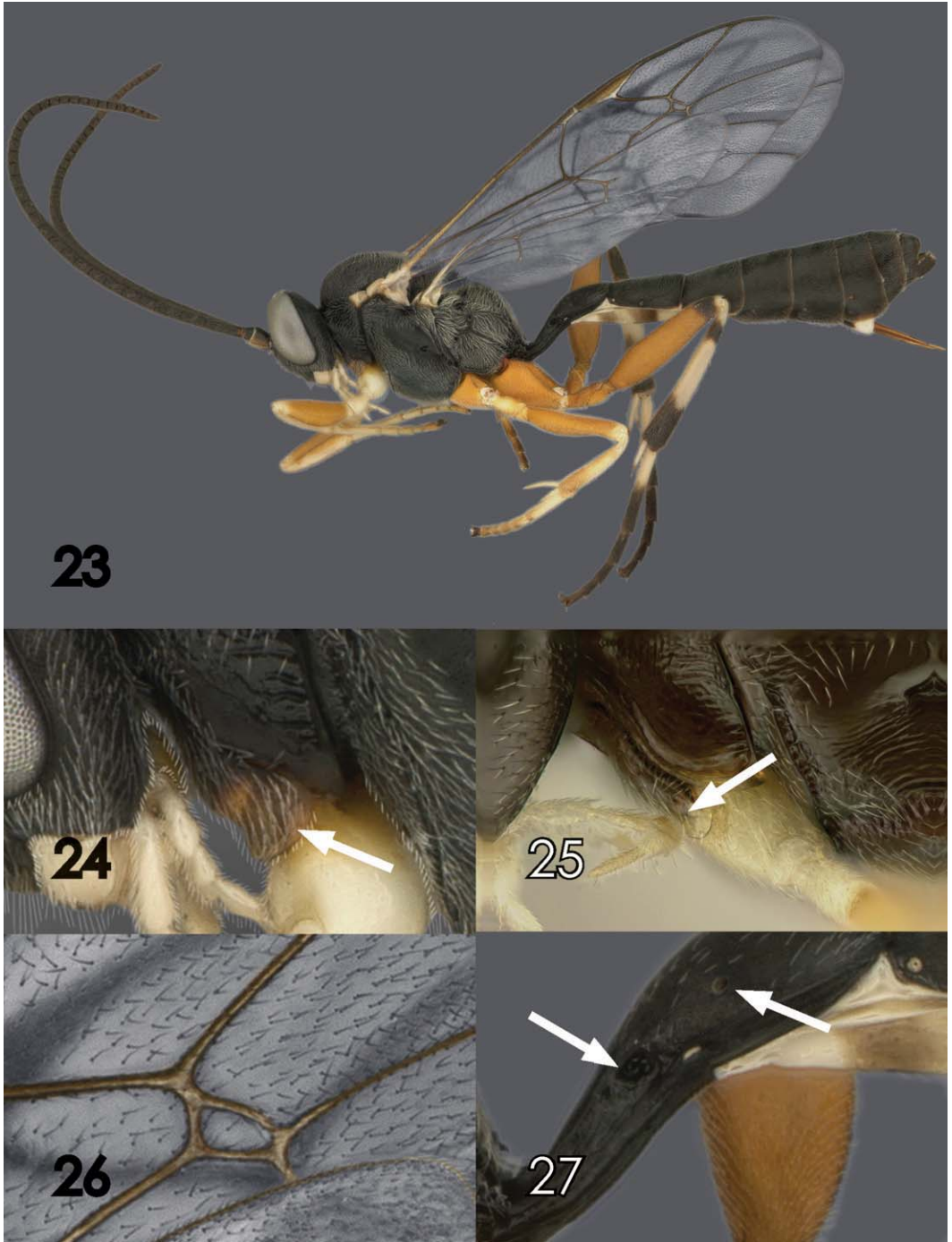
Conura Spinola (Chalcidoidea:
Chalcididae: Chalcidinae)
(Figs. 78–86)

Diagnosis.—*Conura* may be recognized by postmarginal vein longer than stigmal vein (Fig. 78); gaster distinctly petiolate (Figs. 79–80); and propodeal spiracle subvertical to nearly longitudinal.

Fauna.—*Conura* is a large genus of ~ 296 species restricted to the New World, primarily the Neotropical Region (283 species), with only 12 species in the Nearctic (Noyes 2003). Species have been recovered as far north as Alaska and as far south as Chile and Argentina (Noyes 2003). For a discussion of the classification of *Conura* and related genera, see Delvare (1992). Of the known species from the Nearctic, two (*C. nigricornis*, *C. nortonii*) are specialists on Limacodidae and belong to the *nigricornis* group, whose members exclusively attack limacodids. The third (*C. comescens*) is apparently polyphagous, also known as a secondary parasitoid of Hymenoptera through Lepidoptera (see below), and belongs to the *immaculata* group. Delvare (1992) recorded the biology of this group as hyperparasitoids of ichneumonoids through lepidopterans. The members of this group are recognized by the superficial malar sulcus (Fig. 82), interantennal projection a weak carina, shallow scrobal depression (Fig. 81), and



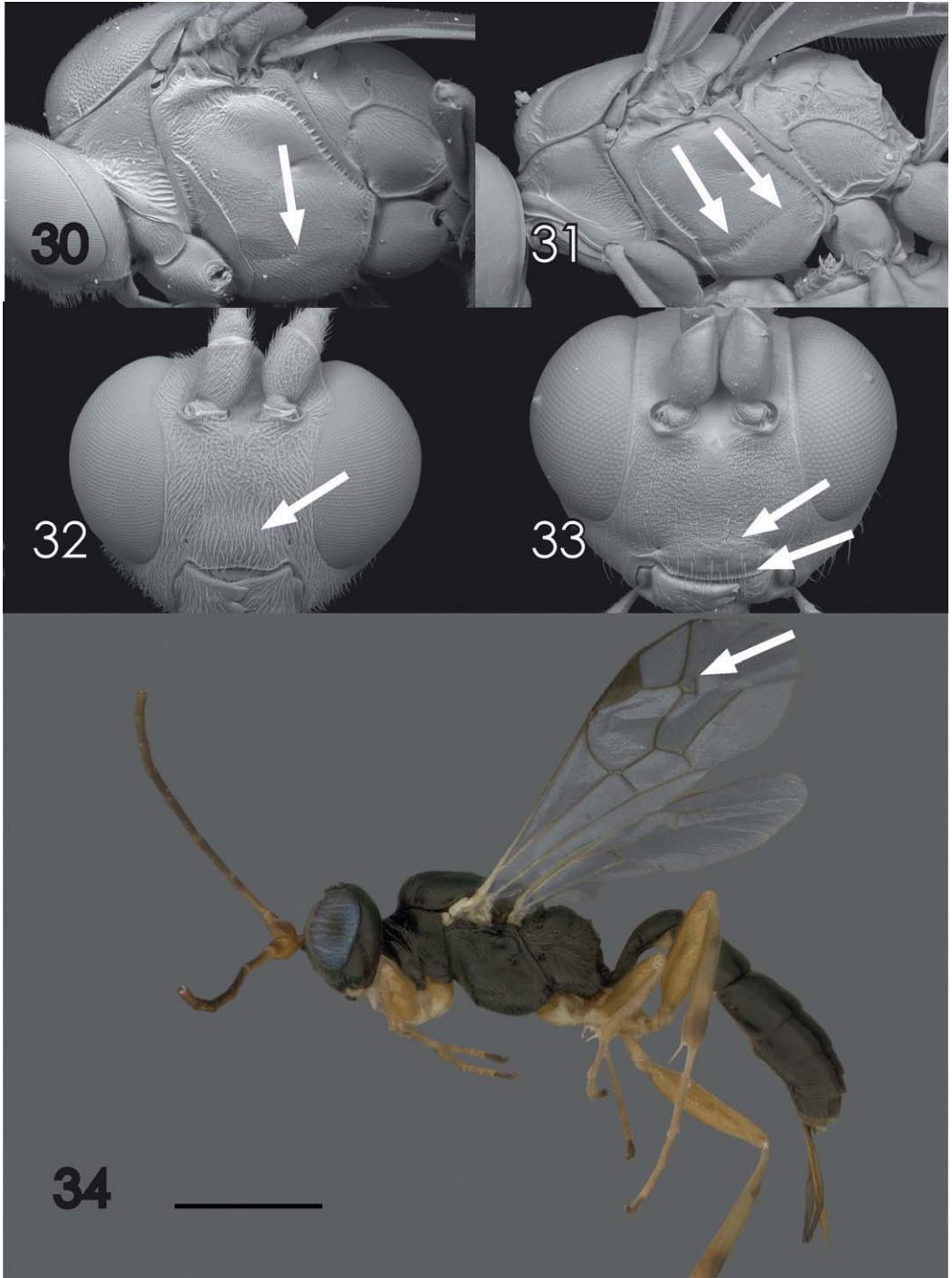
Figs. 19–22. *Mesochorus discitergus*, female. 19, Habitus, scale = 1.0 mm (arrows: (u), areolet; (l), ovipositor sheaths); 20, Aerolet; 21, Metasoma, anterior lateral, scale = 0.5 mm (arrows: (l), glymma; (r), spiracle); 22, Ovipositor and hypopygium (arrow).



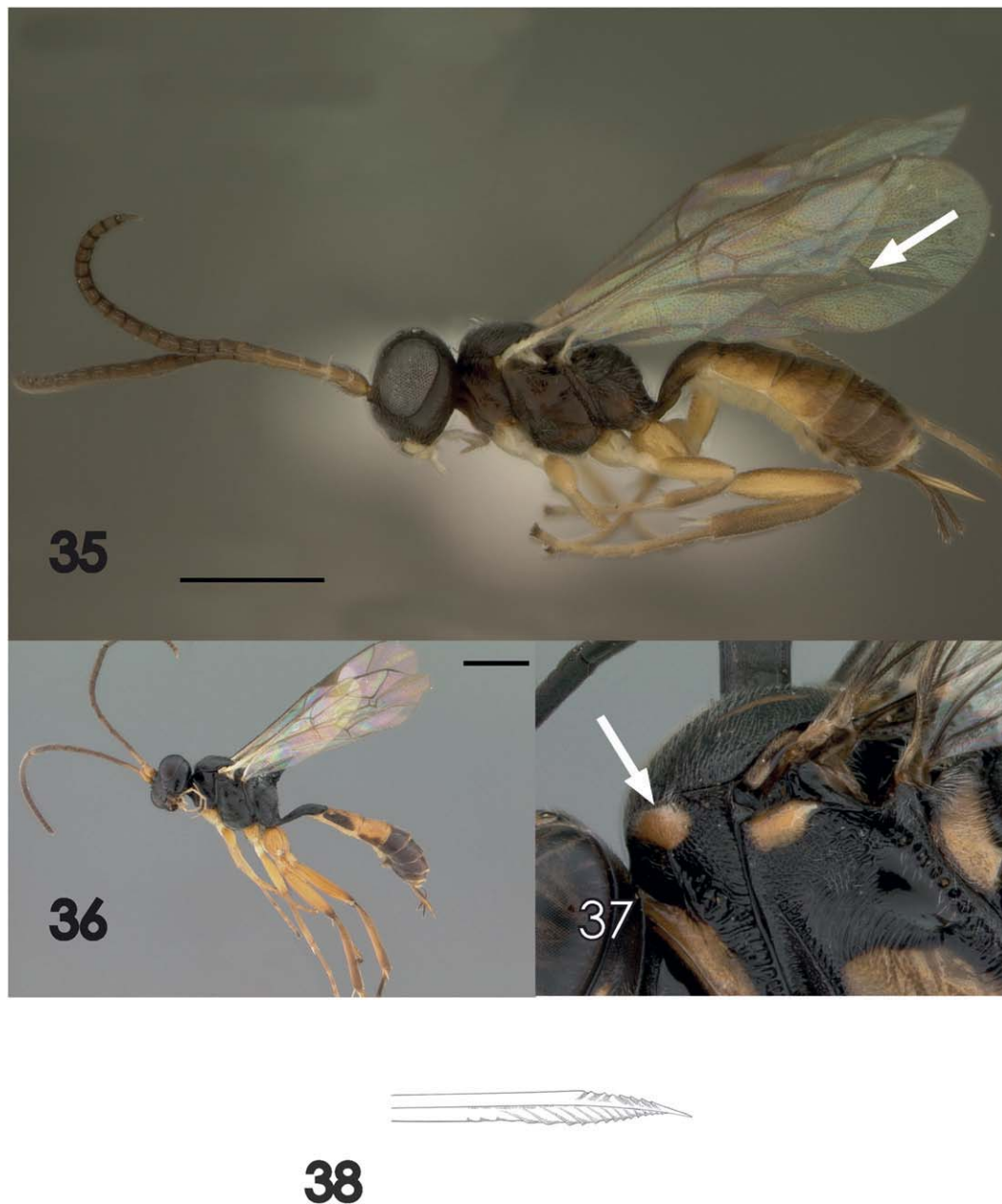
Figs. 23–27. Species of *Hyposoter* and *Lysibia*. Figs. 23–24, 26–27. *Hyposoter fugitivus*, female. 23, Habitus; 24, Propleuron, lateral (arrow); 26, Aerolet; 27, Metasoma, lateral (arrows: (l), glymma; (r), spiracle). Fig. 25. *Lysibia mandibularis*, propleuron, lateral (arrow).



Figs. 28–29. Species of *Casinaria* and *Baryceros*. 28, *Casinaria grandis*, female, habitus, scale = 2 mm (arrow: 2m-cu crossvein); 29, *Baryceros texanus*, female, habitus, scale = 2 mm.



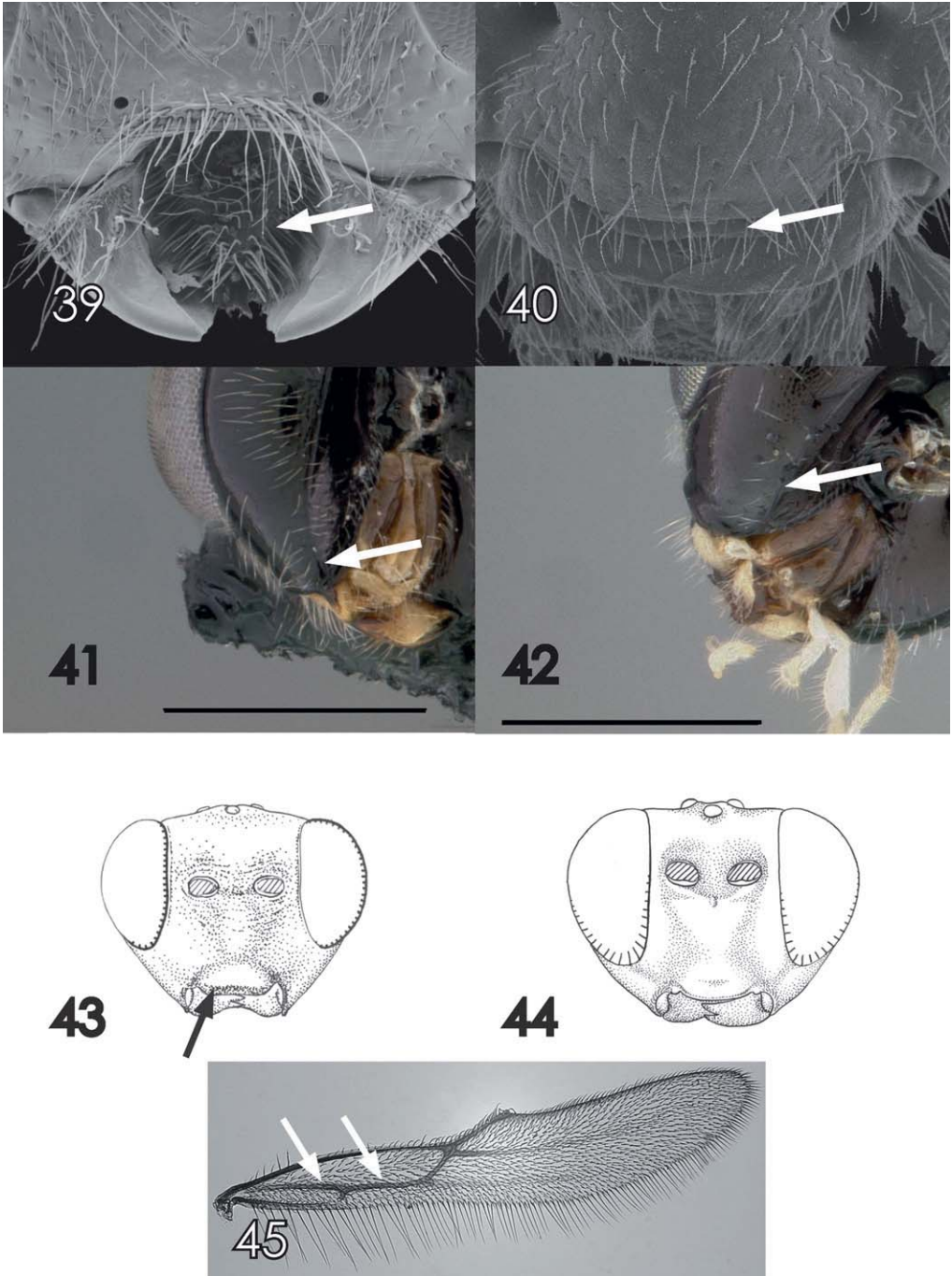
Figs. 30–34. Species of *Hyposoter* and *Isdromas*. Figs. 30, 32. *Hyposoter fugitivus*. 30, Mesopleuron, lateral (arrow: sternaulus); 32, Head, anterior (arrow: no groove). Figs. 31, 33–34. *Isdromas lycaenae*, female. 31, Mesopleuron, lateral (arrows: sternaulus); 33, Head, anterior (arrows: (u), shallow groove; (l), impressed clypeal margin); 34, Habitus, (arrow: aerolet), scale = 1 mm.



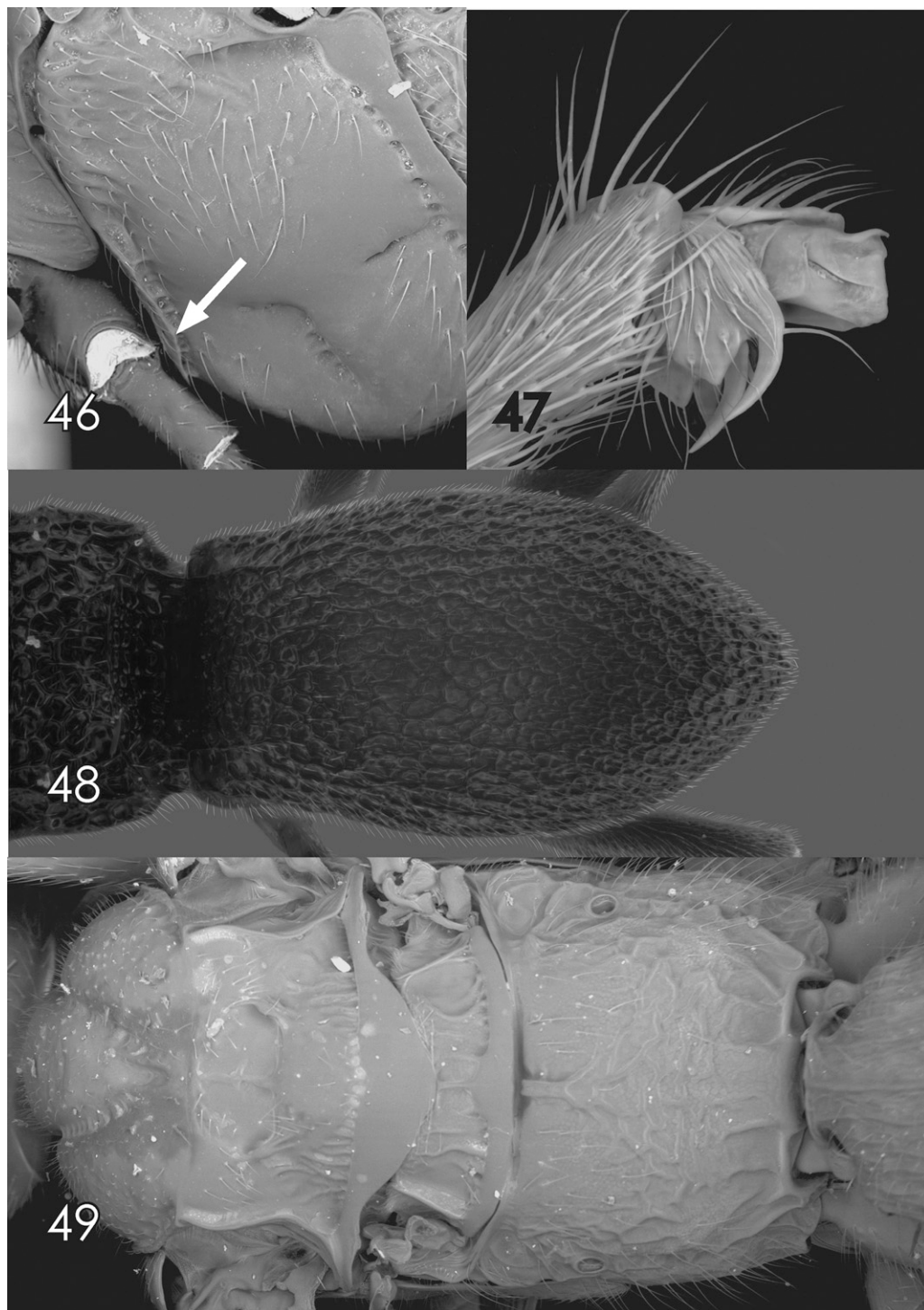
Figs. 35–38. Species of *Lysibia*, *Acrolyta*, and *Baryceros*. Fig. 35. *Lysibia mandibularis*, female, habitus (arrow: vein 2m-cu), scale = 1 mm. Fig. 36. *Acrolyta nigricapitata*, female, habitus, scale = 1 mm. Figs. 37–38. *Baryceros texanus*, female. 37, Mesosoma, lateral (arrow: epomia); 38, Ovipositor tip.

reticulo-rugose to rugose mesoscutum. Burks (1940) defined the *nigricornis* group based on deep and coarse body sculpture, the presence of conspicuous long pilosity

(Figs. 84–85), and a moderately deep scrobal depression with slightly carinate margins. Delvare (1992) refined the definition of this group by noting notauli



Figs. 39–45. Species of Braconidae, *Acrolyta*, *Isdromas*, and *Lysibia*. 39, Cyclostome braconid, hypoclypeal depression (arrow: labrum); 40, Non-cyclostome braconid, head, anteroventral (arrow: labrum); 41, *Acrolyta nigricapitata*, head, posterolateral, scale = 0.5 mm (arrow: hypostomal/occipital carina junction); 42, *Isdromas lycaenae*, head, posterolateral, scale = 0.5 mm (arrow: hypostomal/occipital carina junction); 43, *Lysibia mandibularis*, head, anterior; 44, *Is. lycaenae*, head, anterior. 45, Braconidae, hind wing (arrows: (l), M+CU; (r), 1M).



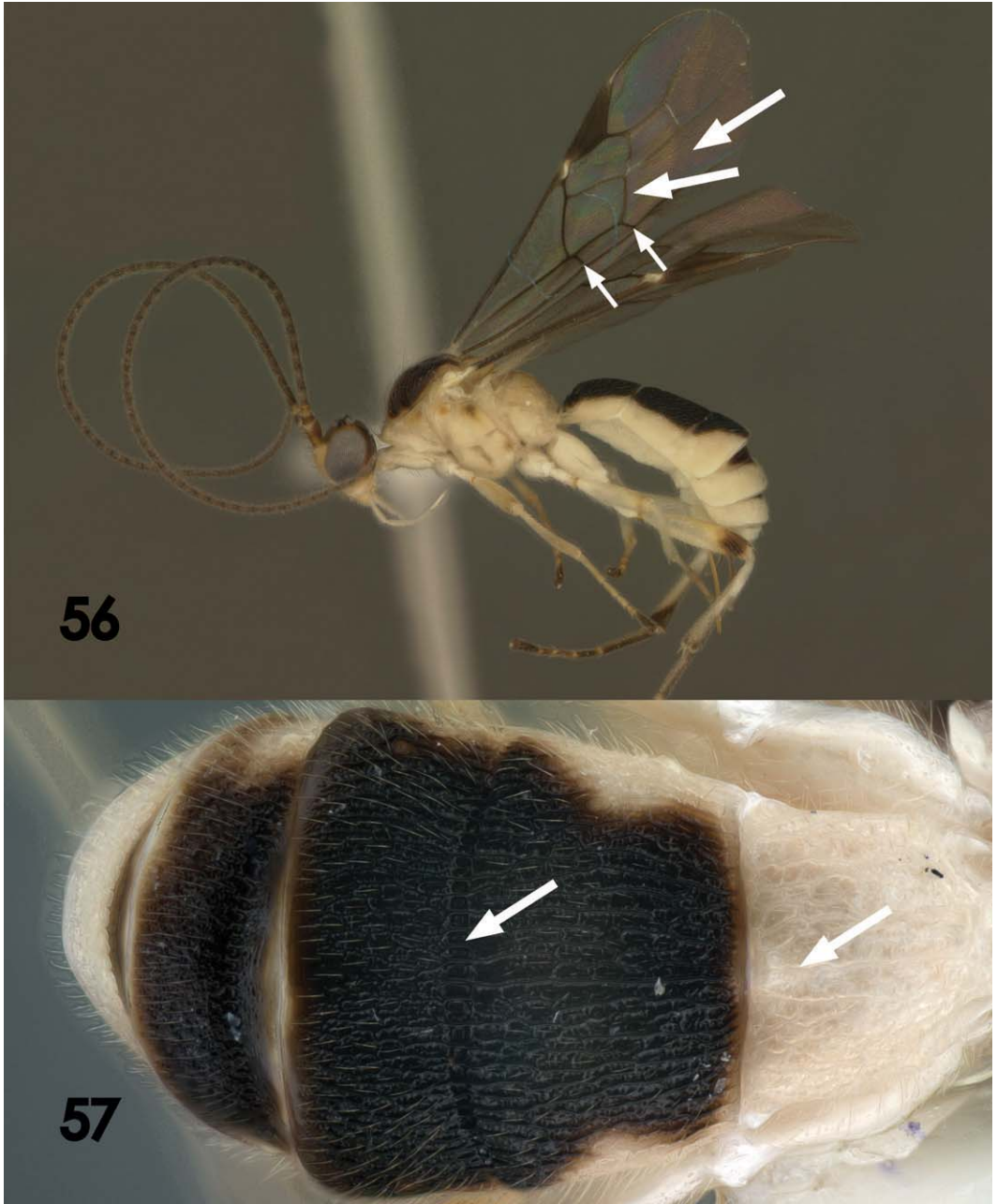
Figs. 46–49. Species of *Trirhaphis* and *Ascogaster*. Figs. 46–47, 49. *Trirhaphis discoideus*, female. 46, Mesopleuron (arrow: epicnemial carina); 47, Tarsal claw. Fig. 48. *Ascogaster quadridentata*, metasoma, dorsal. Fig. 49. Mesosoma, dorsal.



Figs. 50–51. Species of *Trirhaphis*. 50, *Trirhaphis eupoeyiae*, female, habitus; 51, *T. harrisinae*, female, habitus. Scales = 1.0 mm.



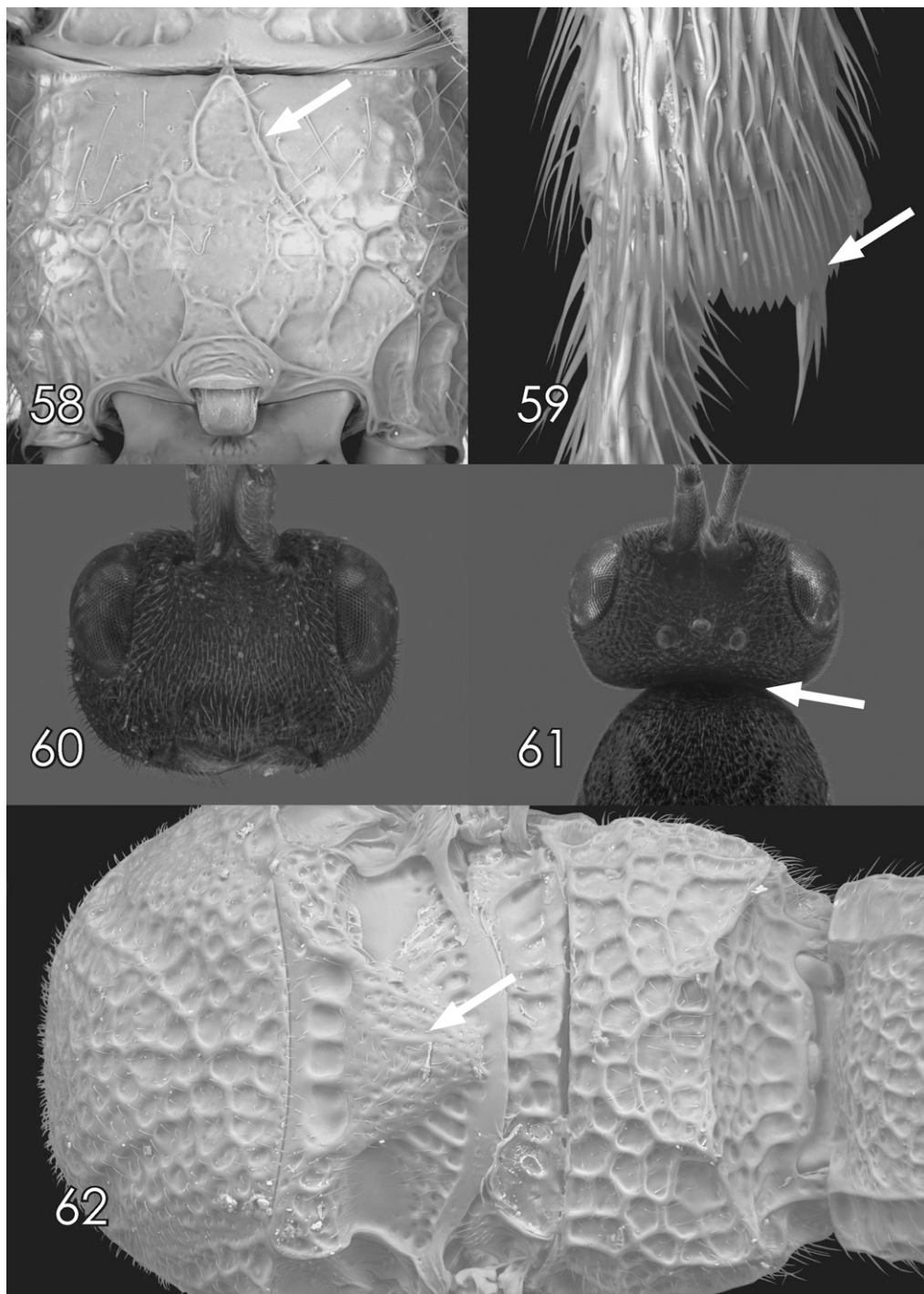
Figs. 52–55. *Trirhaphis harrisinae*, female. 52, Metasoma, anterodorsal (arrows, median carina); 53, Mesosoma, dorsal; 54, Mesosoma, lateral, scale = 0.25 mm; 55, Propodeum.



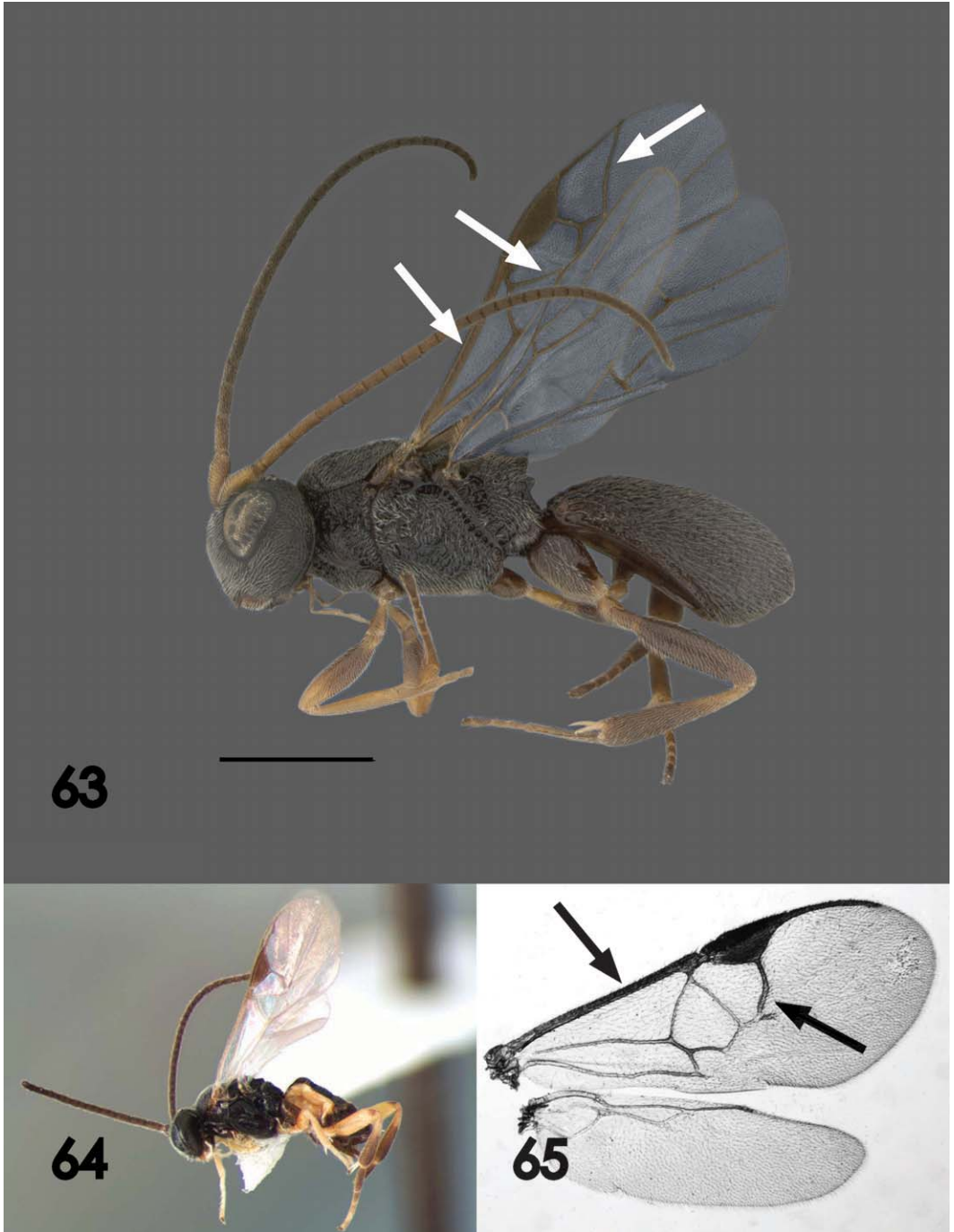
Figs. 56–57. *Triraphis discoideus*, female. 56, Habitus (large arrows: (u), vein 2m-cu absent; (l), vein m-cu; small arrows: (u), 2CUa; (l), 1CUa); 57, Metasoma, anterodorsal (arrow: (l) groove between T2 and T3; (r) median carina).

deep, broad, and crenulate (Fig. 84); pronotum with recurved lamina anteriorly (Fig. 85); and mesopleuron with ventral carina (Fig. 83).

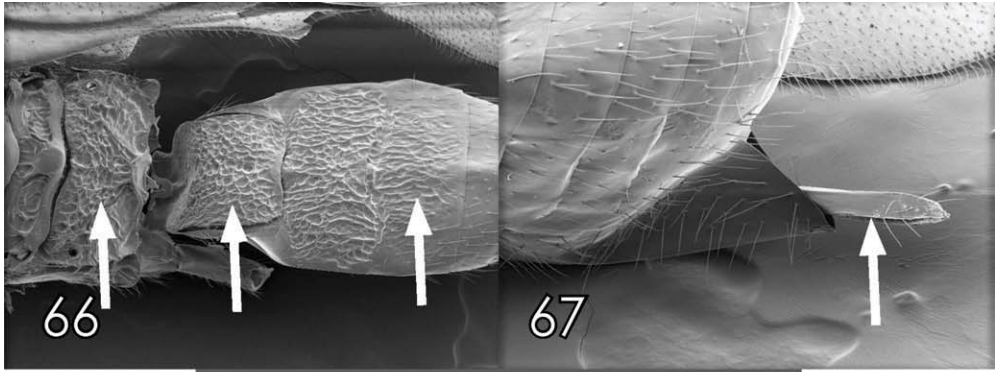
Biology.—Generally, species of *Conura* are documented as parasitoids of larvae and pupae of different insects, mostly of Lepidoptera. However, some species of



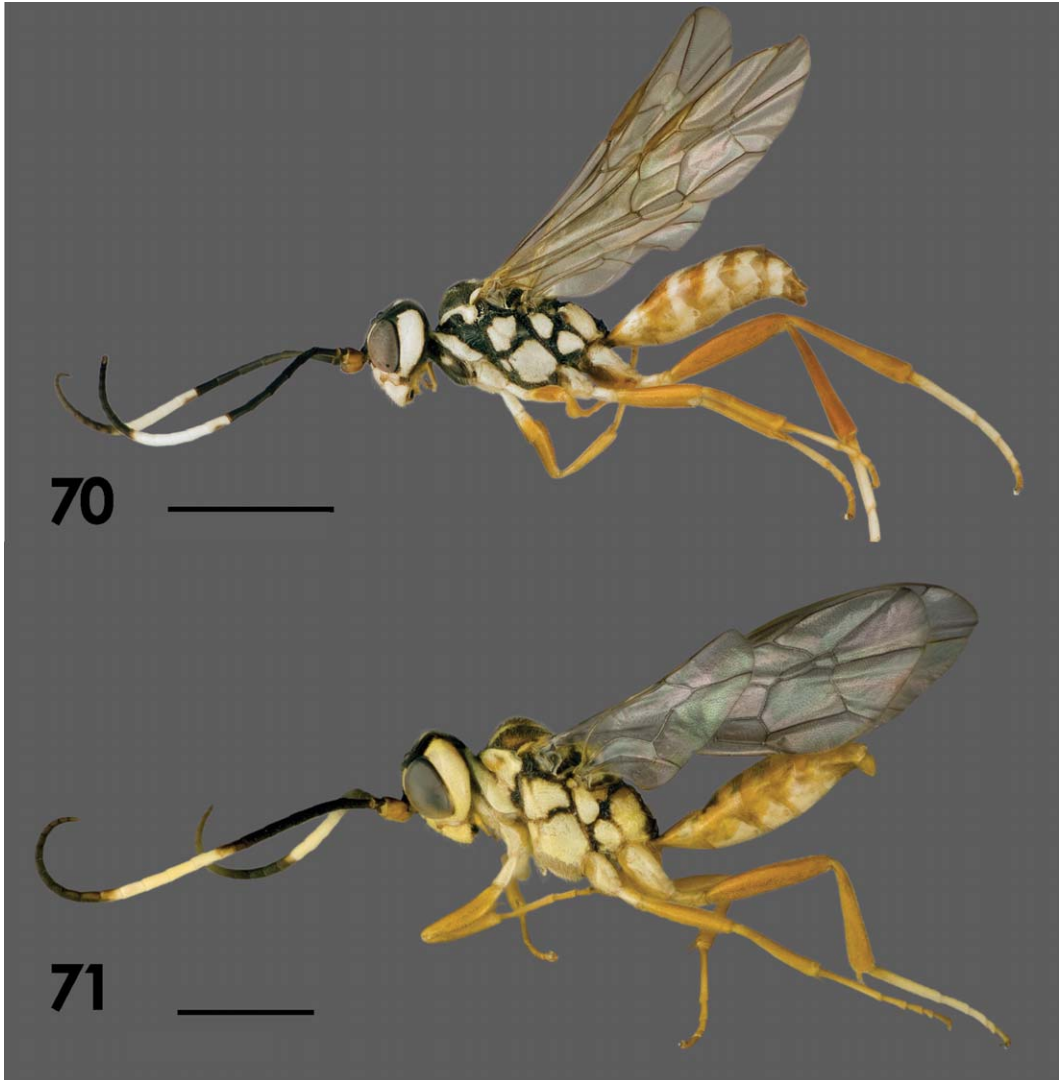
Figs. 58–62. Species of *Trirhaphis* and *Ascogaster*. Figs. 58–59. *Trirhaphis discoideus*, female. 58, Propodeum (arrow: divergent carinae); 59, Hind tibia, apex (arrow: flattened setae). Figs. 60–62 *Ascogaster quadridentata*, female. 60, Head, anterior; 61, Head, dorsal (arrow: occipital carina); 62, Mesosoma, dorsal (arrow: scutellar disc).



Figs. 63–65. *Ascogaster quadridentata* and *Cotesia empretiae*. 63, *Ascogaster quadridentata*, female habitus, scale = 1.0 mm (arrows: (l), vein C+SC+R; (m), vein (RS+M)a; (r), vein 3RS); 64, *Cotesia empretiae*, female, habitus; 65, *Co. empretiae*, wings (arrows: (l), vein C+SC+R; (r), areolet absent).



Figs. 66–69. *Cotesia* spp. 66, *Co. empretiae*, female, propodeum and mesosoma (arrows: propodeal/metasomal sculpture); 67, *Co. empretiae*, lateral metasoma (arrow: ovipositor and sheaths); 68, *Co. phobetri*, female, habitus, scale = 0.5 mm; 69, *Co. schaffneri*, female, habitus, scale = 0.5 mm.



Figs. 70–71. *Orthogonalys pulchella*. 70, Habitus, female; 71, Habitus, male. Scales = 4.0 mm.

Conura are recorded from Coleoptera, Hymenoptera, Diptera, and Neuroptera, and others are known secondary parasitoids of ichneumonoids and tachinids through lepidopterans (Delvare 1992, Bouček and Halstead 1997). Three species that occur in North America are known to attack limacodids, two of these exclusively (see below). Known biologies indicate chalcidid host specialization as solitary parasitoids, but some

smaller species of *Conura* and *Brachymeria* are gregarious.

Literature.—Bouček (1992; key to genera) revised the New World genera, Delvare treated the New World Chalcidini (1992; key to species groups of *Conura*; side group keyed to species), and Burks (1940) offered an earlier treatment of Chalcidini, with keys to genera, species groups, and species.

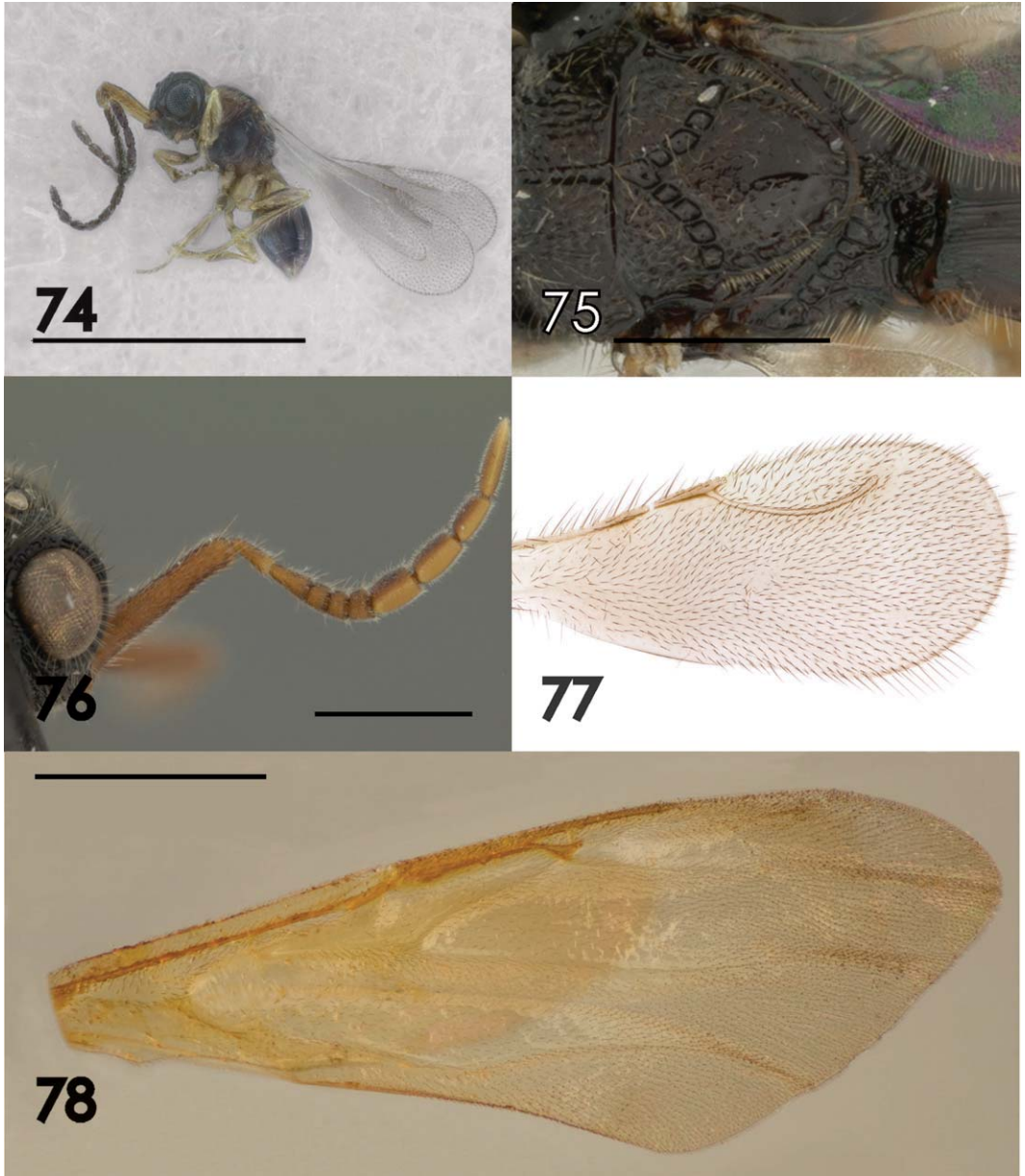
North American Records:



Figs. 72–73. *Taeniogonalos gundlachii*. 72, Habitus, female (arrow: armature); 73, Habitus, male. Scales = 2.0 mm.

Conura nigricornis (F.): *Chalcis nigricornis* F., 1798: 243. Lectotype ♀, ZMUC, designated by Bouček and Delvare (1992) (not examined).

This species belongs to the rarely collected *nigricornis* group (Burks 1940), which contains 14 nominal (at least 16 undescribed) species, all of which are



Figs. 74–78. Species of *Ceraphron* and *Conura*. Figs. 74–77. *Ceraphron* sp. 74, Habitus, male, scale = 0.5 mm. 75, Mesosoma, female, dorsal; 76, Antenna, female, scale = 0.5 mm. 77, Fore wing. Fig. 78. *Conura nortonii*, male, fore wing, scale = 1.0 mm.

known solitary parasitoids of Limacodidae and Megalopygidae (Delvare 1992). This species is yellow with black maculae on the body as reported by Bouček and Delvare (1992: 29), the scutellum has a median groove, and the

frenal carina is present and not fused with the apical margin of the scutellum. The propodeum has distinct lateral teeth (fig. 42 in Bouček and Delvare 1992). Burks (1940) separates *C. nigricornis* from *C. nortonii* by the presence of five

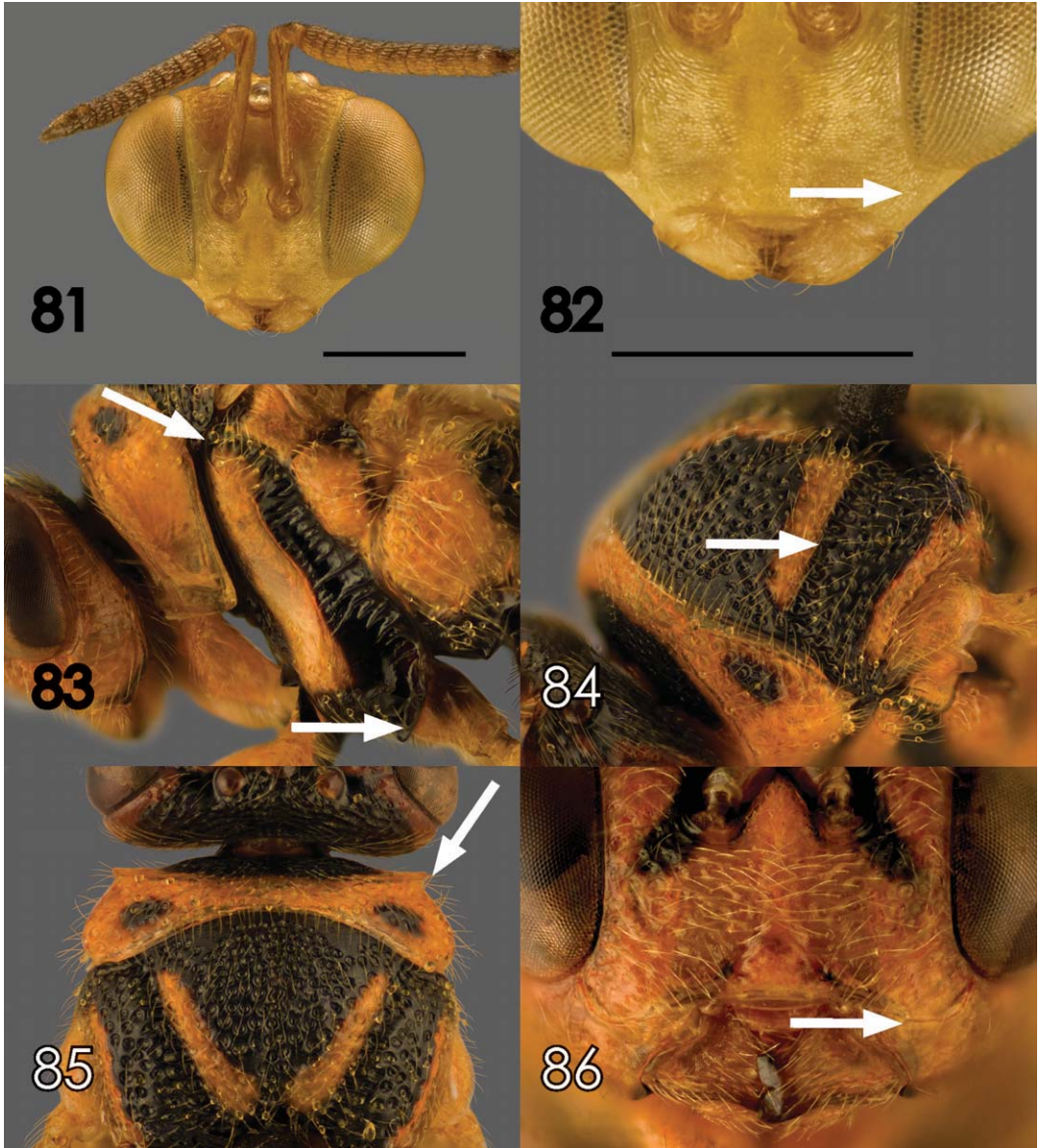


Figs. 79–80. Species of *Conura*. 79, *Conura nortonii*, male, habitus. 80, *Conura immaculata*, female, habitus. Scales = 2.0 mm.

to six hamuli on the hind wing and the presence of an inner tooth on the hind femur as compared to *C. nortonii* (see below).

Distribution: South America (Brazil, Guyana) and eastern U.S.A.

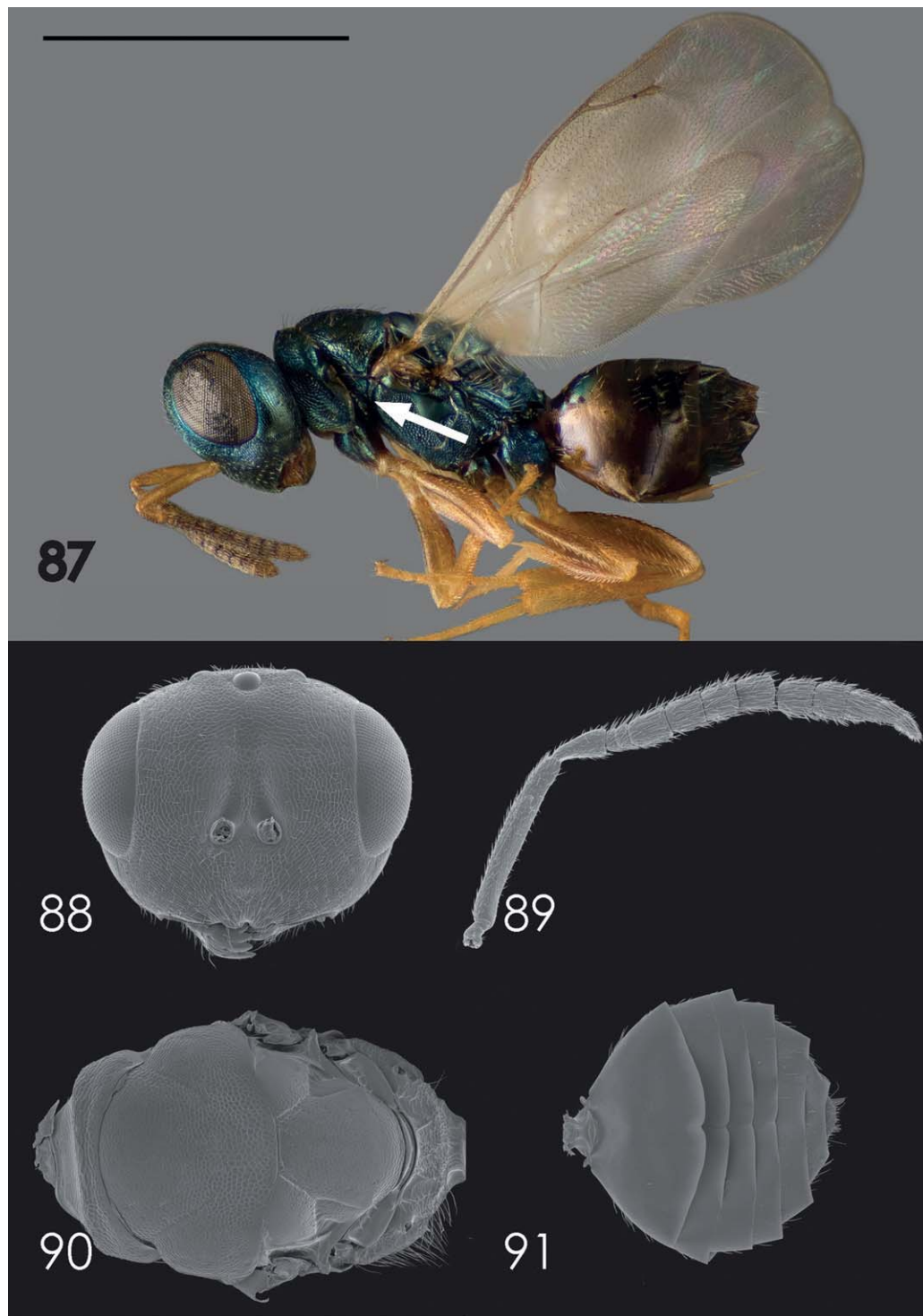
Limacodidae: *Adoneta* sp. (Bouček and Delvare 1992), *Ad. spinuloides* (Peck 1963,



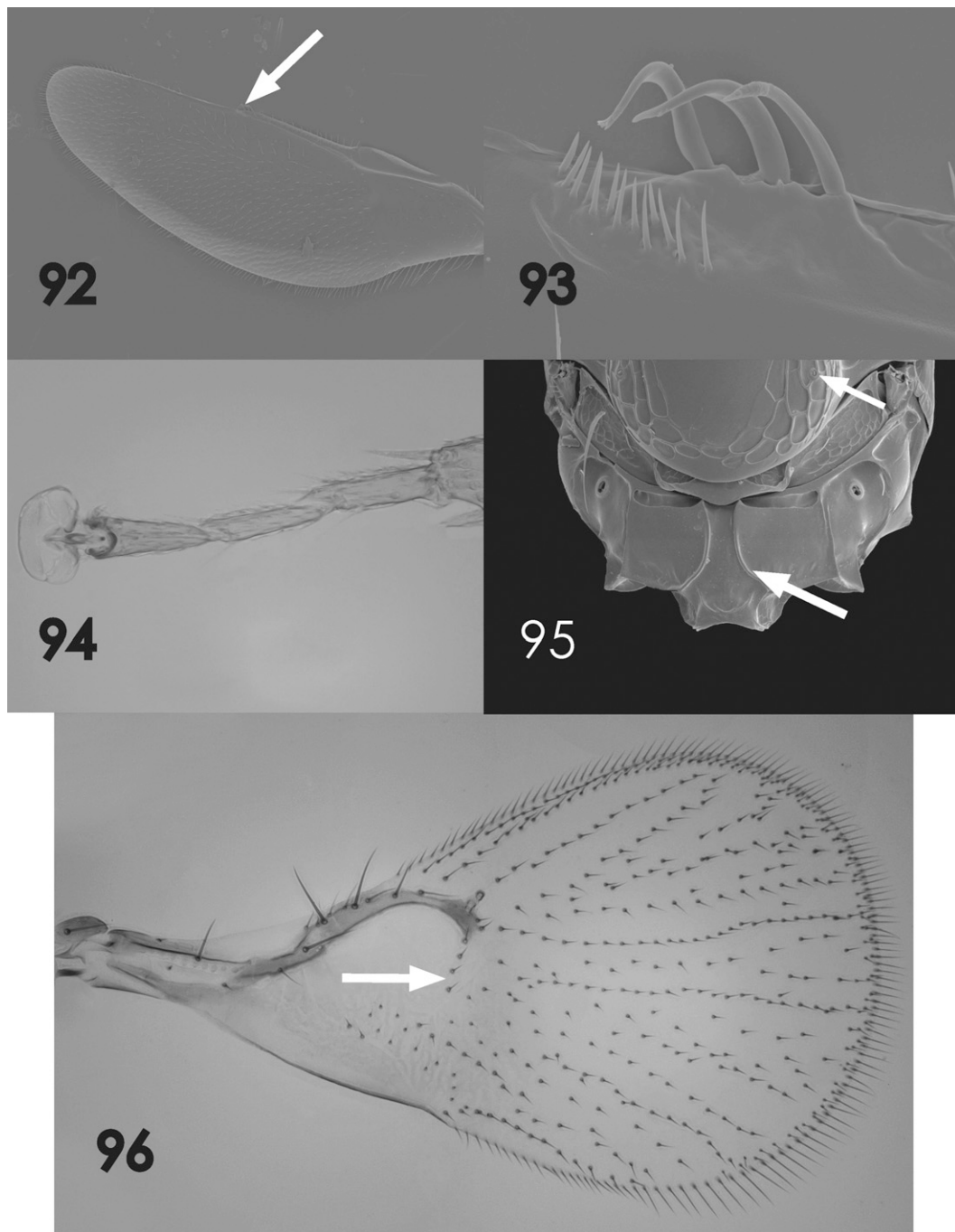
Figs. 81–86. Speceis of *Conura*. Figs. 81–82. *Conura immaculata*, female. 81, Head, anterior, scale = 0.5 mm; 82, Lower face, anterior, scale = 0.5 mm (arrow: superficial malar sulcus). Figs. 83–86. *Conura nortonii*, male. 83, Mesopleuron (arrows: (u), prepectus; (l), ventral carina); 84, Mesosoma, anterodorsal (arrow: notaulus); 85, Mesosoma, anterodorsal (arrow: recurved pronotum); 86, Lower face, anterior (ar-row: malar sulcus).

Herting 1976, Burks 1979), *Apoda* sp. (Peck 1963, Burks 1979, Bouček and Delvare 1992), *Parasa* sp. (Bouček and Delvare 1992), *Pa. indetermina* (Herting 1976, Burks 1979).

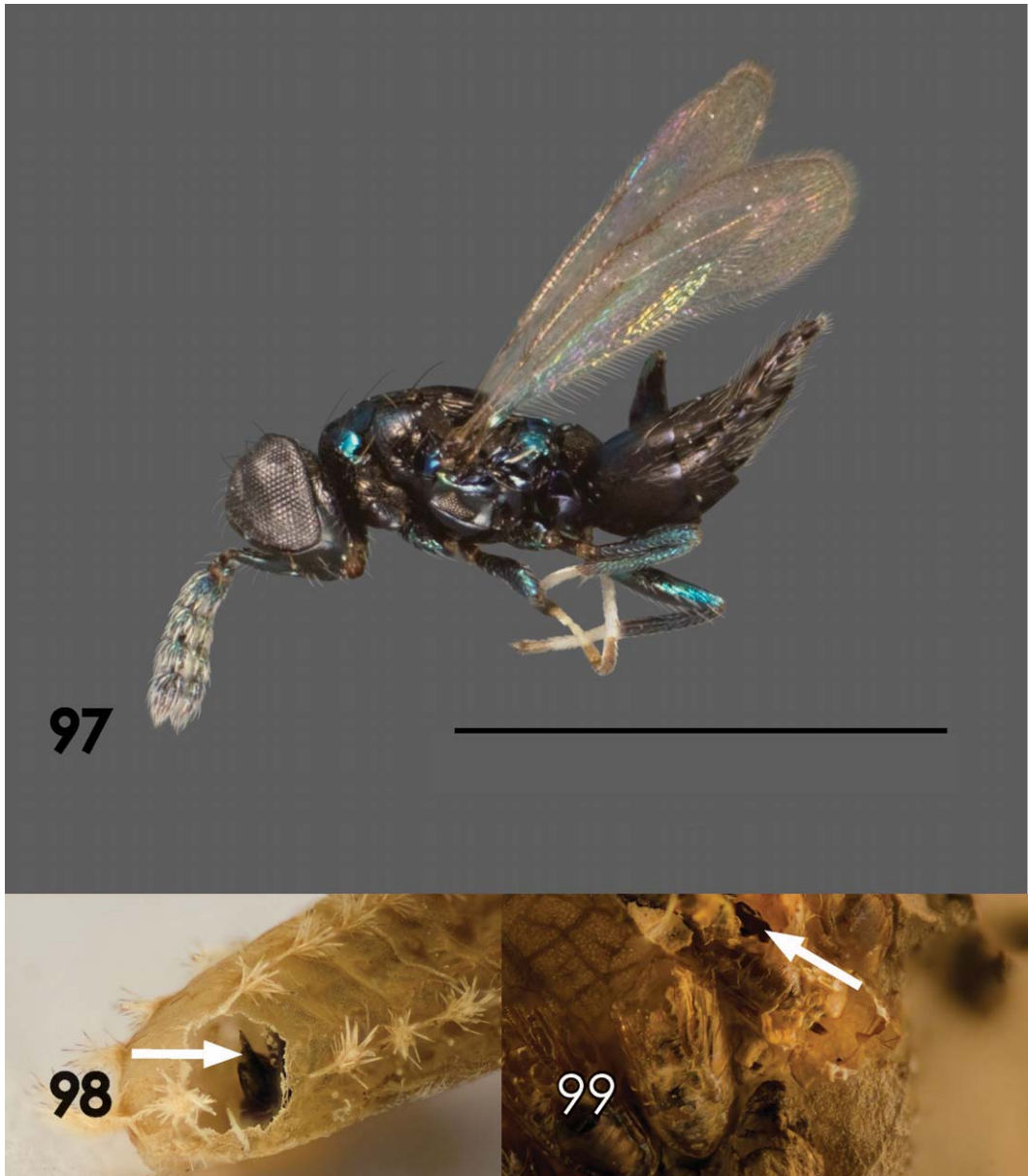
Conura nortonii (Cresson) (Figs. 78–79, 83–86): *Smicra nortonii* Cresson, 1872: 45. Neotype ♂, USNM, designated by Delvare (1992: 239) (examined).



Figs. 87–91. *Psychophagus omnivorus*, female. 87, Habitus (arrow: prepectus), scale = 1.0 mm; 88, Head, anterior; 89, Antenna; 90, Mesosoma, dorsal; 91, Metasoma, dorsal.



Figs. 92–96. Species of *Psychophagus*, *Trichogramma*, and *Pediobius*. Figs. 92–93. *Psychophagus omnivorus*, female. 92, Hind wing (arrow: hamuli); 93, Hamuli. Figs. 94, 96. *Trichogramma* sp., female. 94, Tarsus; 96, Fore wing (arrow: Rs1 setal track). Fig. 95. *Pediobius crassicornis*, female, propodeum (arrows: (u), scutellar setal socket; (l), divergent carinae).



Figs. 97–99. *Pediobius crassicornis*, female. 97, Habitus, scale = 1.0 mm; 98, Pupal remnants (arrow) within limacodid larval cadaver; 99, Pupal remnants (arrow) within pupa of *Platyplectrus americana*.

This species also belongs to the *nigricornis* group. Schaffner (1959) reported that two specimens, one per host, were reared from *Ph. pithecium* cocoons collected in Bolton, Connecticut. The base color of this species is yellow with black maculation, although the neotype in the

USNM is more orange brown (perhaps killed with cyanide) than yellow. Compared to *C. nigricornis*, the propodeum lacks lateral teeth and the scutellum lacks a median groove, although there is minute lamina apically (Burks 1940). *Conura nortonii* has three hamuli on the

hind wing and lacks the inner tooth on the hind femur.

Distribution: Eastern U.S.A., west to Texas (Burks 1940).

Limacodidae: *Apoda* sp. (Peck 1963, Burks 1979), *Ph. pithecium* (Schaffner 1959, Peck 1963, Herting 1976, Burks 1979), *Pr. badia* (Herting 1976, Burks 1979).

Conura camescens Delvare: *Ceratosmicra flavescens* Cameron, 1913: 114. *Conura camescens* is a replacement name for *Conura flavescens* (Cameron 1913) nec (André 1881). Lectotype ♂, BMNH, designated by Delvare (1992: 217) (not examined).

This species belongs to the *immaculata* subgroup of the *immaculata* group (Delvare 1992). Delvare (1992) reported this species from the U.S.A. without further locality information. A specimen from Venezuela in the USNM identified by Delvare has label data indicating *Manduca sexta* (Joh.) as a host [possibly on primary parasitoid]. Two additional specimens, also from Venezuela, indicate *Alabama argillacea* (Hübner), "par. by *Rogas*." This species is reported as a pale brownish yellow with areas of the face, pronotum, mesoscutal sutures, and scutellum in basal half more yellow in color (Cameron 1913). The ~ 13 teeth of the hind femur are black, the basal tooth triangular with the apical teeth closely appressed.

Distribution: New World. (Delvare 1992).

Limacodidae: *Acharia* sp. (as *Sibine*; hyperparasitoid of *Cotesia* sp.) (Delvare 1992).

Other hosts: *Prodenia eridania* (Cramer) (Noctuidae); *Plutella xylostella* (L.) (Plutellidae); *Apanteles* sp., *Cotesia* sp., *Co. plutellae* (Kurdjumov), and *Rogas* sp. (Braconidae) (De Santis 1979, De Santis and Fidalgo 1984, Delvare 1992, Chávez et al. 1993).

Alveoplectrus Wijesekara and Schauff
(Chalcidoidea: Eulophidae: Eulophinae)
(Fig. 104)

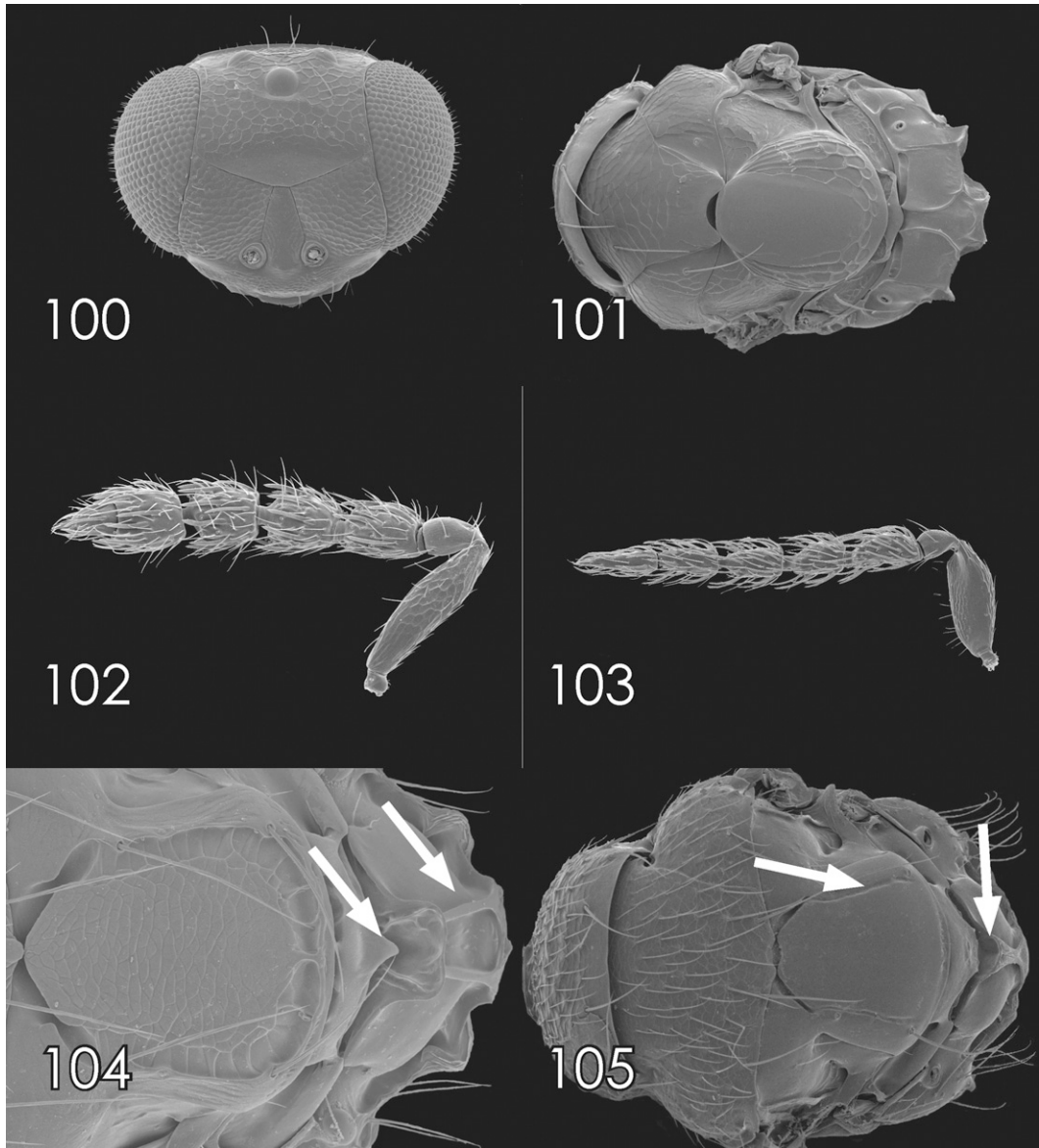
Diagnosis.—*Alveoplectrus* may be recognized by the presence of two submedian carina on the propodeum (Fig. 104), scutellum with lateral grooves broad and continuous posteriorly (Fig. 104), dorsellum produced medially as cuplike carina (Fig. 104), and hind tibia with single elongate spur. The related genus *Platyplectrus* (see below) has a single median carina on propodeum, scutellum with narrow lateral grooves discontinuous posteriorly, dorsellum not produced as triangular point posteromedially, and hind tibia with two elongate spurs (> 0.5X length of hind tarsus).

Fauna.—*Alveoplectrus* is a small genus of four species restricted to the New World, primarily the eastern Nearctic and Neotropical regions (Wijesekara and Schauff 1997, Gates and Stoepler 2010). Species of *Alveoplectrus* were previously placed in *Euplectrus* (Ashmead 1904) or *Euplectromorpha* (see Schauff et al. 1997). The published distribution for *Alveoplectrus* includes Brazil, Costa Rica, and the U.S.A. (Florida) (Wijesekara and Schauff 1997). For a discussion of the classification of *Alveoplectrus* and related genera, see Wijesekara and Schauff (1997).

Biology.—Known biologies indicate host specialization as solitary ectoparasitoids of larvae of Limacodidae. One species, *Al. floridanus* Wijesekara and Schauff, is recorded from label data for undetermined species in USNM indicating Neotropical *Euprosterina elaea* (as *elaesa*) Dyar and *Euprosterina* sp. (Limacodidae) as hosts.

North American Records:

Alveoplectrus floridanus Wijesekara and Schauff: Wijesekara and Schauff, 1997: 105. Holotype ♀, USNM (examined).



Figs. 100–105. Species of *Pedioibius*, *Alveoplectrus*, and *Platyplectrus*. Figs. 100–103. *Pedioibius crassicornis*, female. 100, Head, anterior; 101, Mesosoma, dorsal; 102, Female, antenna; 103, Male, antenna. Fig. 104. *Alveoplectrus lilli*, female, mesosoma, posterodorsal (arrows: (l) dorsellum production, (r) submedian carina). Fig. 105. *Platyplectrus americana*, female, mesosoma, dorsal (arrows: (l) scutellar groove, (r) median carina).

This species is differentiated from *Al. lilli* by the absence of a short, transverse carina beneath the anterior ocellus and the presence of a transepimeral sulcus

(compare with Gates and Stoepler 2010: fig. 2).

Distribution: U.S.A. (Florida) (Wijesekara and Schauff 1997).

Limacodidae: *Ala. slossoniae* (Packard) (Wijesekara and Schauff 1997).

Alveoplectrus lilli Gates (Fig. 104); Gates and Stoepler 2010: 209. Holotype ♀, USNM (examined).

This species is differentiated from *Al. floridanus* by the presence of a short, transverse carina beneath the anterior ocellus and the absence of a transepimeral sulcus (figured in Gates and Stoepler 2010: fig. 2).

Distribution: Eastern U.S.A. (Gates and Stoepler 2010).

Limacodidae: *I. textula*, *Li. fasciola*, *E. delphinii* (Gates and Stoepler 2010), and *Ad. spinuloides**.

Platyplectrus Ferrière (Chalcidoidea: Eulophidae: Eulophinae) (Figs. 105–113)

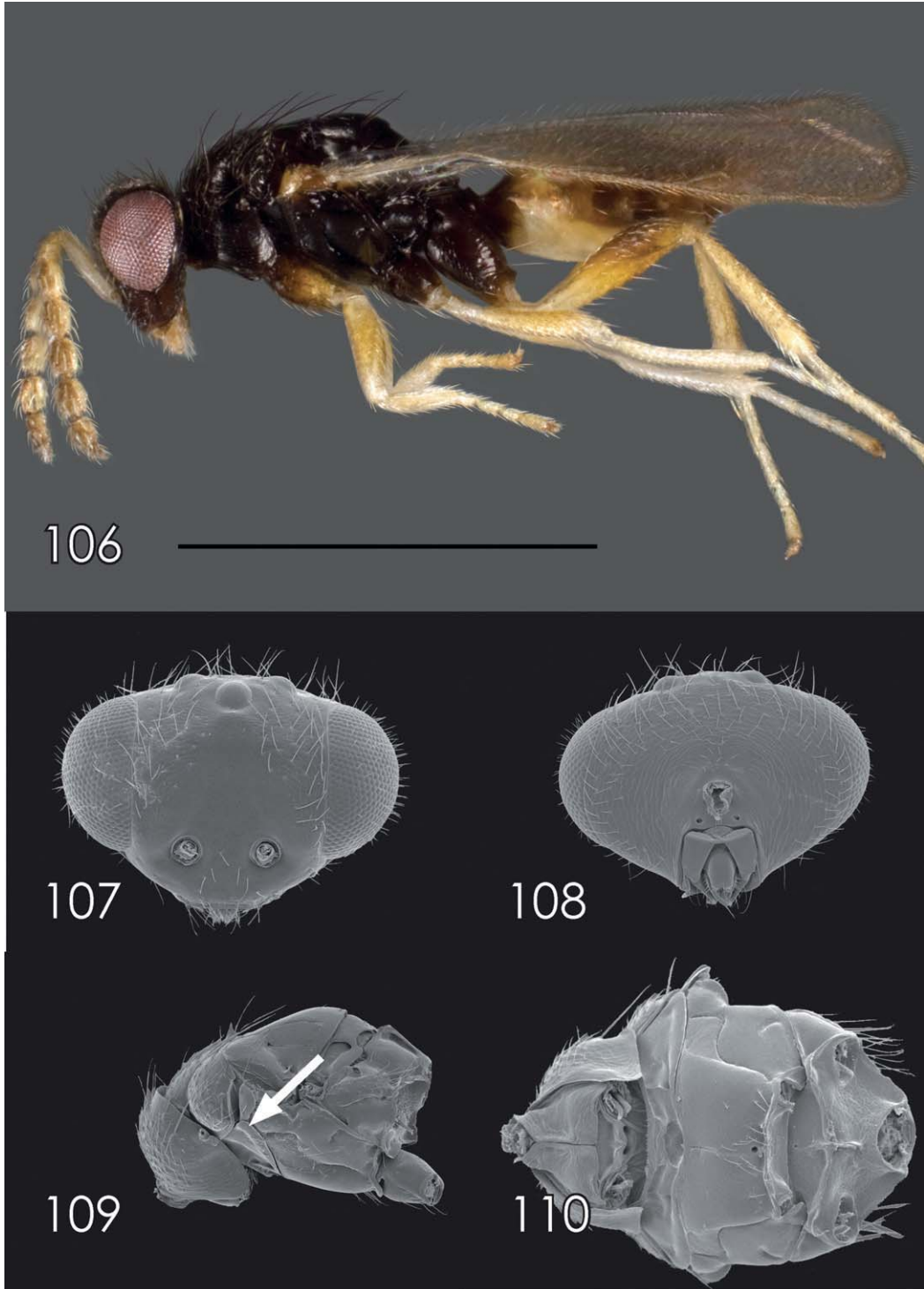
Diagnosis.—*Platyplectrus* is most likely to be confused with *Alveoplectrus* (among parasitoids of limacodids in North America) and *Euplectrus*, although species in the latter genus are not known from limacodids in North America. Species of *Platyplectrus* may be recognized by the following combination of features: single median carina on propodeum (Fig. 105), scutellum with narrow lateral grooves discontinuous posteriorly (Fig. 105), dorsellum not produced (Fig. 105), and hind tibia with two elongate spurs. *Alveoplectrus* has two submedian carinae on propodeum (Fig. 104), scutellum with lateral grooves broad and continuous posteriorly (Fig. 104), dorsellum produced medially (Fig. 104), and hind tibia with single elongate spur. *Euplectrus*, aside from its host preferences, is most similar to *Platyplectrus* in overall coloration and habitus but lacks scutellar grooves.

Fauna.—One species is known from North America of 46 described worldwide. Highest species richness is in southeastern Asia, but several species are known from

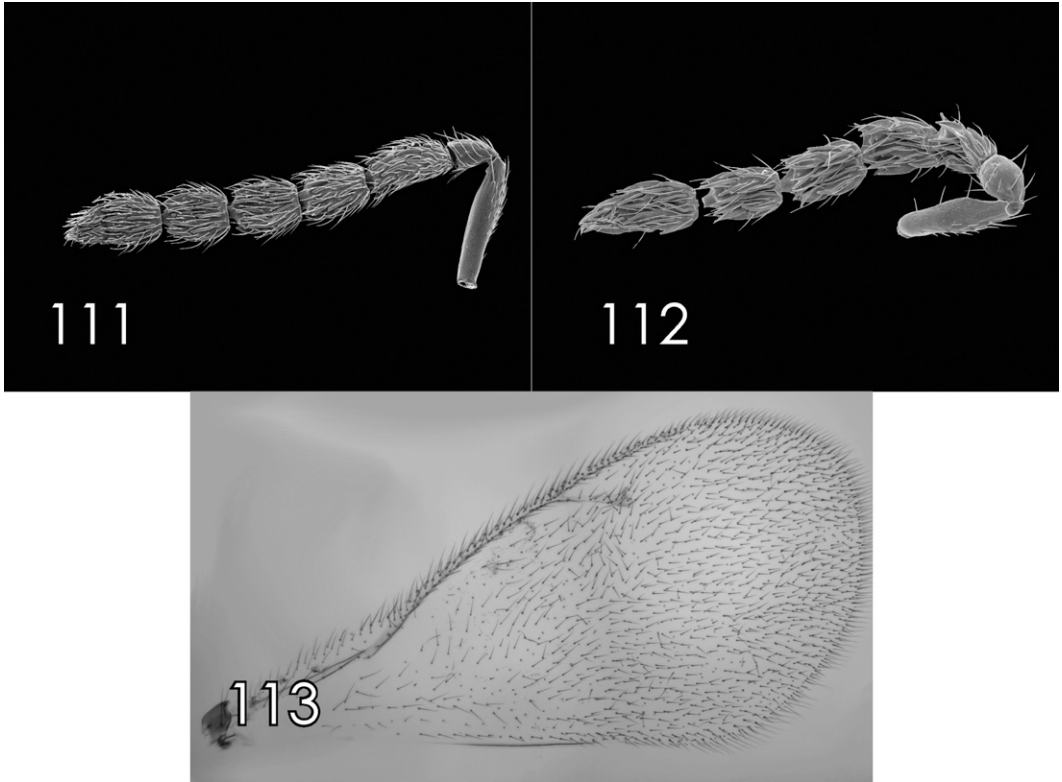
Australia and eastern Europe (Noyes 2003).

Biology.—Known biologies indicate host specialization as solitary or gregarious ectoparasitoids of larvae of Limacodidae. Laboratory studies of the extralimital *Pl. natadae* Ferrière (Gadd et al. 1946) revealed this species engaged in host feeding once for every four eggs laid, and a host used for host feeding was never parasitized. Oviposition occurs on the lateral surfaces below any tubercles of the host after the host is paralyzed with a sting. The egg, positioned externally, is held in place by a pedicel within the host's body. In nature, this species usually lays one or rarely lays two eggs per host with only one larva typically reaching maturity. However, in the present study, the number of eggs per host appears to be size-dependent, with larger hosts (or later instars) yielding as many as 14 mature larvae. A newly eclosed larva migrates to the venter of the host's body where feeding begins immediately and results in the death of the host. Pupation occurs under the host with the host cadaver providing a protective covering (Gadd et al. 1946, M. Gates pers. obs.).

Literature.—Only eight species have associated host records, with five of those records being from limacodids. The widespread *Pl. laeviscuta* (Thomson) ranges from Sweden and China south to Australia and is cited from *Stigmella ruficapitella* (Haworth) (Nepticulidae) (Noyes 2003), but we find no record of it in the original paper (Hansson 1987). *Platyplectrus chlorocephalus* (Nees) is recorded from a zygaenid (*Rhagades pruni* (Denis and Schiffermüller)), and this is perhaps unsurprising given the relationship between Zygaenidae and Limacodidae (Epstein 1996, Wahlberg et al. 2005, Niehuis et al. 2006). The third non-limacodid record published by Zhu and Huang (2004) was based on label data: *Cifuna locuples* Wlkr (Lymantriidae).



Figs. 106–110. *Platyplectrus americana*, female. 106, Habitus, scale = 1.0 mm; 107, Head, anterior; 108, Head, posterior; 109, Mesosoma, lateral (arrow: prepectus); 110, Mesosoma, ventral.



Figs. 111–113. *Platyplectrus americana*, female. 111, Antenna; 112, Fore wing; 113, Antenna, male.

Redescription of *Platyplectrus americana* (Figs. 105–113):

Diagnosis.—*Platyplectrus americana* is the sole representative of the genus in North America and thus will not be confused with congeners. *Platyplectrus* can be differentiated from related eulophid genera by the generic characters outlined above.

Note.—Girault (1916) described this species from a single male. The original description is short, and additional morphological details of the male require documentation, as given below. The female is newly described.

Description.—Female. *Body length:* 2.4 mm (1.2–3.5 mm; n = 20). *Color:* Black except for the following golden—scape, flagellum in ventral half, fore coxa in apical third, legs, apical tarsomere, and basal half gaster dorsomedially (Fig. 106);

brown—dorsal half flagellum, tegula, metafemur in apical half except extreme apex golden, pretarsus, gaster apically, laterally, and ventrally, wing veins; white—basal three tarsomeres.

Head: 1.7X as broad as high, clypeal region transversely impressed along margin, smooth, straight ventrally; malar sulcus fine, slightly curved, malar space 0.53X eye height; mandibles reduced, not touching medially; toruli with upper margin positioned one-half torular diameter above lower ocular line, separated by ~ 2 torular diameters (Fig. 107). Scrobal depression smooth and shallow, shaped as an inverted V. Antenna (Fig. 111) with scape reaching three-quarters distance to anterior ocellus; ratio of scape (minus radicle):pedicel:anellus: F1:F2: F3:F4:club as 27:8:1:16:14:12:12:18; funicular segments with 2

irregular rows of interdigitated longitudinal sensilla and evenly setose; clava apparently bisegmented with fusion complete. Ratio of lateral ocellus:OOL:POL as 7:7:14. [Head posteriorly lacking postoccipital carina, hypostomal carinae present ventrally but faint (Fig. 108).]

Mesosoma (Fig. 105): 1.3X as long as broad; midlobe of mesoscutum 0.9X as long as broad; scutellum 1.0X as long as broad; notauli fine, complete; midlobe of mesoscutum shallowly bilobate posteromedially; scutellum shallowly bilobate anteromedially, sublateral grooves mesad scutellar setae, extending from scutoscuteellar suture to near posterior edge scutellum; scutoscuteellar suture obliterated medially; axilla smooth with few setae posteromedially; lateral surface of prepectus triangular, smooth; [subventral carinae of prepectus steplike, prepectus with ovate depression ventromedially] (Fig. 109). Mesepimeron smooth, femoral depression a sigmoidal sulcus, small linear depression posteromedially. Mesepisternum smooth (Figs. 109–110), convex, defined posteriorly by carina, discrimen medially between mesofurcal pit and anterior margin mesopectus. Dorsellum smooth with posteromedial truncation, subequal in length with propodeum medially, slightly projecting over propodeum medially and excavated submedially (Fig. 105). Metapleuron and lateral areas of propodeum (Fig. 109) smooth; callus setose; propodeum smooth with elevated median carina broadest anteriorly and posteriorly broadly joined to nucha, with fine rugulosity; flangelike carina extending laterally from nucha toward metasomal foramen and spiracle; spiracle about one-third its greatest diameter from dorsellum. All coxae imbricate, smoother laterally. Fore wing with ratio of marginal vein:postmarginal vein:stigmatal vein as 64:45:23 (Fig. 113).

Metasoma: Smooth; petiole ~ 2.0X as broad as long, finely sculptured dor-

sally; Gt1 depressed anterodorsally near petiole occupying about one-third the length of gaster; remaining terga and syntergum smooth; [petiole transverse in dorsal view, smooth; lateral carinae on petiole body meeting ventrally as slightly pointed collar]; measurements of gastral terga along midline as 30:9:9:7:5:7:8.

Male. *Body length*: 1.5 mm (1.2–2.8 mm; $n = 5$). *Color*: As described for female, but with legs and venter of gaster paler, whitish. Sculpture as described for female. Antenna with funicular segments (Fig. 112) minutely pedicellate, each with multiple rows of suberect setae and about 1.0X as long as width of segment; ratio of scape (minus radicle):pedicel:anellus:F1:F2:F3:F4:F5:club as 16:7:1:8:8:8:15; scape with ventral plaque not apparent. Gastral petiole in lateral view roughly cylindrical, roughly trapezoidal in dorsal view, length about 0.8X as long as greatest width.

Variation.—Most variation occurs in coloration and size. Smaller male specimens (< 1.8 mm; range = 1.1–1.8 mm) tend toward a browner coloration rather than black (especially the head and mesosoma) with brownish maculation on the femora only a faint suffusion (especially fore and midfemora) and the fore femur may be entirely golden/whitish whereas the hind femur may approach being entirely dark brown. The whitish maculation dorsally on the gaster may be confined only to that area but can extend laterally and ventrally. Two males are almost golden in body color. For females (range = 1.3–2.3 mm), the coloration patterns seen for males based on size seems to hold true. One specimen is medium brown with white legs, except for brown suffusion on the hind femur; the antenna is whitish. For both sexes, there are exceptions to the size/color trend but typically only at the smaller size range (dark, small specimens).

Type Material.—20471 [red label, handwritten]; *Euplectromorpha americana* ♂, Type, Girault [handwritten] (USNM, examined).

Material Examined.—DISTRICT OF COLUMBIA: Rock Creek Park, collected 9.VIII.2005, J. Lill et al. 05-607, *ex Acharia stimulea* on *Robinia* sp. (1 ♀ USNM); same locality, collected 12.VII.2006, emerged 23.VII.2006, J. Lill, et al., 06-281, *ex* Limacodidae on *Carya glabra* (♂ USNM); same locality, collected 23.VII.2006, emerged 14.VIII.2006, J. Lill, et al. 06-313, *ex Lithacodes fasciola* on *Nyssa sylvatica* (♀ ♂ USNM); same locality, collected 14.VIII.2006, emerged 21.VIII.2006, J. Lill et al. 06-326, *ex Prolimacodes badia* on *Quercus alba* (♀ USNM); same locality, collected 13.VIII.2006, emerged 3.IX.2006, J. Lill et al., 06-336, *ex Acharia stimulea* on *Acer saccharinum* (♀ USNM); same locality, collected 20.VIII.2006, emerged 3.IX.2006, J. Lill et al. 06-387, *ex Euclea delphinii* on *Nyssa sylvatica* (10 ♀ USNM); same locality, collected 20.VIII.2006, J. Lill et al., 06-389, *ex Adoneta spinuloides* on *Nyssa sylvatica* (6 ♀ USNM); same locality, collected 25.VIII.2006, J. Lill et al., 06-408, *ex Lithacodes fasciola* on *Nyssa sylvatica* (3 ♀ USNM); same locality, collected 26.VI.2007, emerged 17.VII.2007, J. Lill et al. 07-120, *ex Lithacodes fasciola* on *Quercus rubra* (♀ USNM); same data, but collected 30.VI.2007, emerged 17.VII.2007, 07-140, *ex Lithacodes fasciola* on *Nyssa sylvatica* (♂ USNM); same data, 07-143, *ex* Limacodidae sp. on *Fagus grandifolia* (♂ USNM); same locality, collected 30.VI.2007, emerged 17.VII.2007, J. Lill et al., 07-144, *ex* Limacodidae sp. on *Fagus grandifolia* (♂ USNM); same data, 07-148 (♀ USNM); same data, 07-149 (♂ USNM); same data, 07-152 (♂ USNM). MARYLAND: Montgomery Co.: Little Bennett Regional Park, collected 25.VII.2007, J. Lill et al. 07-320,

ex Acharia stimulea on *Quercus alba* (1 ♀ USNM); same locality, collected 25.VII.2007, emerged 21.VIII.2007, J. Lill et al. 07-319, *ex Acharia stimulea* on *Prunus serotina* (2 ♀ ♂ USNM); same data, 07-316, (1 ♀ USNM); same data, 07-315, (2 ♀ USNM); same locality, collected 25.VII.2007, J. Lill et al. 07-340, *ex Acharia stimulea* on *Quercus rubra* (1 ♀ USNM); same data, 07-339, (1 ♀ USNM); same locality, collected 25.VII.2007, emerged 21.VIII.2007, J. Lill et al. 07-338, *ex Acharia stimulea* on *Quercus rubra* (1 ♀ USNM); same locality, collected 9.VII.2008, emerged 25.VII.2008, J. Lill et al. 08-152, *ex Lithacodes fasciola* on *Fagus grandifolia* (1 ♀ USNM); same locality, collected 9.VII.2008, emerged 18.VII.2008, J. Lill et al. 08-155, *ex Euclea delphinii* on *Quercus alba* (1 ♀ USNM); same locality, collected 10.VII.2008, emerged 25.VII.2008, J. Lill et al. 08-175, *ex Euclea delphinii* on *Fagus grandifolia* (1 ♀ USNM); same data, 08-175 (1 ♀ USNM); same data, 08-176, (1 ♀ USNM); same data, 08-177, (1 ♀ USNM); same data, 08-178 (1 ♀ USNM); same locality, collected 10.VII. 2008, emerged 28.VII.2008, J. Lill et al. 08-186, *ex Euclea delphinii* on *Carya glabra* (1 ♀ USNM); same locality, collected 10.VII.2008, emerged 21.VII.2008, J. Lill et al. 08-187, *ex Euclea delphinii* on *Carya glabra* (1 ♀ USNM); same locality, collected 11.VII.2008, emerged 25.VII.2008, J. Lill et al. 08-200, *ex Euclea delphinii* on *Quercus rubra* (1 ♀ USNM); same locality, collected 14.VII.2008, emerged 28.VII.2008, J. Lill et al. 08-217, *ex Euclea delphinii* on *Nyssa sylvatica* (1 ♀ USNM); same locality, collected 19.VII.2007, emerged 21.VIII.2007, J. Lill et al., 07-260, *ex Lithacodes fasciola* on *Quercus rubra* (3 ♀ USNM); same locality, collected 19.VII.2007, emerged 4.VIII.2007, J. Lill et al., 07-292, *ex Phobetron pithecium* on

Fagus grandifolia (3♂ USNM); same data, 07-293 (♂ USNM); same data, 07-295 (2♂ USNM); same locality, collected 25.VII.2007, emerged 21.VIII.2007, J. Lill et al. 07-307, *ex Euclea delphinii* on *Prunus serotina* (3♀ USNM); same locality, collected 25.VII.2007, J. Lill et al. 07-351, *ex Acharia stimulea* on *Nyssa sylvatica* (1♀ USNM); same data, 07-346, *ex Acharia stimulea* on *Carya glabra* (1♀ USNM); same data, 07-343 (2♀ USNM); same data, 07-345 (2♀ 2♂ USNM); same data, 07-349, *ex Acharia stimulea* on *Nyssa sylvatica* (1♂ USNM); same data, 07-354 (4♀ ♂ USNM); same locality and date, emerged 21.VIII.2007, J. Lill et al. 07-363, *ex Lithacodes fasciola* on *Fagus grandifolia* (♀ ♂ USNM); same data, 07-367, *ex Acharia stimulea* on *Fagus grandifolia* (♀ ♂ USNM); same data [no emergence date], 07-368 (1♀ USNM); same locality, collected 1.VIII.2007, J. Lill et al. 07-466, *ex Acharia stimulea* on *Quercus alba* (2♀ ♂ USNM); same data, 07-467 (2♀ USNM); same data, emerged 21.VIII.2007, 07-470 (♀ ♂ USNM); same data [no emergence date], 07-471, *ex Acharia stimulea* on *Quercus rubra* (1♀ USNM); same data, 07-489, *ex Adoneta spinuloides* on *Carya glabra* (♂ USNM); same locality, collected 27.VII.2007, J. Lill et al. 07-499, *ex Euclea delphinii* on *Quercus rubra* (1♀ USNM); same locality, collected 3.VIII.2007, emerged 21.VIII.2007, J. Lill et al. 07-558, *ex Prolimacodes badia* on *Fagus grandifolia* (1♀ USNM); same data, 07-561 (♂ USNM); same data, 07-563 (♂ USNM); same data, 07-564 (1♀ USNM); same locality, collected 14.VIII.2007, emerged 1.VI.2008, J. Lill et al. 07-581, same host (1♀ USNM); same locality, collected 31.VII.2008, emerged 11.VII.2008, J. Lill et al. 08-528, *ex Acharia stimulea* on *Nyssa sylvatica* (3♀ USNM); same data but emerged 26.VIII.2008, 08-536, *ex Acharia stimulea* on *Carya glabra* (2♀ USNM); same locality, emerged 2.VIII.2007, 07-996, *ex Euclea delphinii* on *Prunus serotina*, (3♀ ♂ USNM); same data, 07-995, (♂ USNM); same data, 07-997, (1♀ USNM); same locality, [No date], 07-993, *ex Euclea delphinii* on *Nyssa sylvatica* (2♀ 2♂ USNM); same data, emerged 2.VIII.2007, 07-999, *ex Euclea delphinii* on *Quercus rubra*, (1♀ USNM); same data, 07-994, *ex Euclea delphinii* on *Fagus grandifolia* (2♀ USNM); same data, 07-991, *ex Acharia stimulea* on *Quercus alba* (1♀ USNM); same locality, collected 3.VIII.2007, emerged 21.VIII.2007, J. Lill et al. 07-526, *ex Acharia stimulea* on *Fagus grandifolia* (1♀ USNM); same data, 07-522, *ex Acharia stimulea* on *Prunus serotina* (1♀ USNM); same locality, collected 5.VIII.2008, emerged 18.VIII.2008, J. Lill et al. 08-632, *ex Acharia stimulea* on *Nyssa sylvatica* (3♀ USNM); same locality, collected 31.VII.2008, emerged 13.VIII.2008, J. Lill et al. 08-527, *ex Acharia stimulea* on *Nyssa sylvatica* (1♀ USNM); same locality, collected 18.VII.2007, emerged 2.VIII.2007, J. Lill et al. 07-998, *ex Euclea delphinii* on *Quercus rubra* (1♀ USNM); same locality, 23.VIII. 2007, emerged 1.VI.2008, J. Lill et al. 07-672, *ex Prolimacodes badia* on *Quercus rubra* (1♀ USNM); same locality, collected 3.VIII. 2007, emerged 21.VIII.2007, J. Lill et al. 07-524, *ex Acharia stimulea* on *Fagus grandifolia* (1♀ USNM); same locality, collected 14.VII.2008, emerged 1.VIII.2008, J. Lill et al. 08-226, *ex Euclea delphinii* on *Nyssa sylvatica* (♀ ♂ USNM); same data, 08-234 (2♀ USNM); same locality, collected 28.VII.2008, emerged 11.VIII. 2008, J. Lill et al. 08-328, *ex Acharia stimulea* on *Quercus rubra* (3♀ USNM); same locality and collection date, emerged 19.VIII.2008, J. Lill et al. 08-326, *ex Acharia stimulea* on *Nyssa sylvatica* (4♀ USNM); same locality, collected 31.VII.2008, emerged 18.

- VIII.2008, J. Lill et al. 08-525, same host (1 ♀ USNM); same locality, collected 31.
- VII. 2008, emerged 11.VII.2008, J. Lill et al. 08-510, *ex Acharia stimulea* on *Prunus serotina* (3 ♀ ♂ USNM). Plummers Island, collected 18.VIII.2006, J. Lill et al. 06-ak, *ex Acharia stimulea* on *Asimina triloba* (♀ USNM); same data, but emerged 25.VIII.2006, J. Lill et al. 06-am (6 ♀ USNM); same data, but emerged 28.
- VIII.2006, 06-ab, *ex Acharia stimulea* on *Quercus alba* (♀ USNM; 6 pupae beneath host, 4 pupae on leaf); same locality, collected 18.VIII.2006, J. Lill et al. 06-aq-V, *ex Acharia stimulea* on *Quercus rubra* (♂ USNM); same data, but emerged 3.
- IX.2006, 06-ai, *ex Acharia stimulea* on *Asimina triloba* (? USNM; specimen damaged); same data [no emergence date], 06-ae-II, *ex Acharia stimulea* on *Asimina triloba* (♀ ♂ USNM); same data, 06-an-II, *ex Acharia stimulea* on *Quercus rubra* (♀ USNM); collected 3.VII.2007, emerged 17.VII.2007, J. Lill et al. 07-221, *ex Lithacodes fasciola* on *Carya glabra* (♀ USNM); same data, 07-222 (♂ USNM). Prince Georges County: Patuxent NWR, collected 21.VII.2005, emerged 9.VIII.2005, J. Lill et al. 05-501, *ex Lithacodes fasciola* on *Fagus grandifolia*, (2 ♀ ♂ USNM); same locality, collected 17.VIII.2005, emerged 1.
- IX.2005, J. Lill et al. 05-730, *ex Packardia geminata* on *Fagus grandifolia*, (♀ USNM); same locality, collected 17.VIII.2005, emerged 27.VIII.2005, J. Lill et al. 05-742, *ex Lithacodes fasciola* on *Fagus grandifolia*, (♀ USNM); same locality, collected 17.VIII.2005, emerged 30.VIII.2005, J. Lill et al. 05-761, *ex Lithacodes fasciola* on *Fagus grandifolia*, (2 ♀ USNM (5 pupae)); same locality, collected 17.VIII.2005, emerged 10.
- VI.2006, J. Lill et al. 05-779, *ex Proli-macodes badia* on *Fagus grandifolia* (♀ USNM); same locality, collected 1.
- IX.2005, emerged 20.IX.2005, J. Lill et al. 05-899, *ex Lithacodes fasciola* on *Fagus grandifolia* (3 ♀ ♂ USNM); same locality, collected 6.IX.2005, emerged 10.VI.2006, J. Lill et al. 05-916, *ex Lithacodes fasciola* on *Fagus grandifolia* (2♂ USNM (1 pupa)); same data, but emerged 11.VI.2006, 05-921 (2♀ USNM); same locality, collected 11.VII.2006, J. Lill et al. 06-252, *ex Lithacodes fasciola* on *Fagus grandifolia* (♂ USNM); same data, emerged 31.VII.2006, 06-260 (♀ USNM); same data, 06-268 (♀ USNM); same data, emerged 1.VIII.2006, 06-274, *ex Limacodidae* on *Carya glabra* (♀ USNM); collected 30.VIII.2007, emerged 1.
- IX.2007, J. Lill et al. 07-841, *ex Proli-macodes badia* on *Fagus grandifolia*, (1 ♀ USNM); same locality, collected 8.
- VIII.2007, emerged 16. X .2007, J. Lill et al. 07-611, *ex Lithacodes fasciola* on *Quercus alba*, (♀ ♂ USNM); same data, no emergence, 07-608, same host, (4 ♀ ♂ USNM); same locality, collected 14.IX. 2007, emerged 16.X.2007 J. Lill et al. 07-957, *ex Isa textula* on *Quercus alba* (2 ♀ ♂ USNM).
- North American Records:
Platyplectrus americana (Girault) (Figs. 105–113): *Euplectromorpha americana* Girault, 1917: 114. Holotype ♂, USNM (examined).
- Based on the significant new rearing data (Table 1), *Platyplectrus* (and most eulophid parasitoids) preferentially attack early limacodid instars. *Platyplectrus americana* is a solitary/gregarious ectoparasitoid with a single wasp emerging from a host 41% of the time, two emerging 26% of the time, three (12%), four (10%), five (4%), six (4%), and greater than six (4%). The position for larval feeding is as previously described for *Pl. natadae* (Gadd et al. 1946). Pupation occurs beneath the host cadaver (as in Fig. 98; cadaver removed), and the pupa and cadaver are adhered to the substrate with the cadaver providing protection for the parasitoid

pupa. No *in situ* observations for oviposition are yet available for *Pl. americana*.

Distribution: Eastern U.S.A.

Limacodidae: Previously reported from *Packardia geminata* (Gates and Burks 2003). Newly recorded hosts (Table 1) include: *Ac. stimulea**, *Ad. spinuloides**, *E. delphinii**, *I. textula**, *Li. fasciola**, *N. nasoni**, *Ph. pitheciium**, *Pr. badia**, and *Tortricidia* sp.*

Pediobius Walker (Chalcidoidea:

Eulophidae: Entedoninae)

(Figs. 95, 97–103)

Diagnosis.—The following combination of features is diagnostic: propodeum medially with two subparallel carinae (Fig. 95), with distinct plicae; petiole ventrally pointed; notauli incomplete (Fig. 101); antenna with three funiculars and two claval segments (Figs. 102–103).

Fauna.—*Pediobius* is a large genus of 277 species worldwide with 36 known from the Nearctic (Noyes 2003). New World species of *Pediobius* range from central Canada to Argentina. Extralimitally, Cock (1987) summarized the *Pediobius* associated with limacodids in Southeast Asia: *Pe. imbreus* (Walker) (as *detrimentosus* (Gahan)), *Pe. elasmii* (Ashmead), and *Pe. ptychomyiae* (Ferrière). They are recorded from a tachinid, *Apanteles* (*Ap.* sp. and *Ap. parasae*; Braconidae), and *Pa. philepida* Holloway (Limacodidae), respectively. Noyes (2003) summarized additional host records including primary lepidopteran hosts and secondary dipteran/hymenopteran hosts.

Biology.—Most commonly associated with species of Lepidoptera, Coleoptera, Diptera, and Hymenoptera as primary or secondary parasitoids (Peck 1985). Some species are known from spider egg sacs where they may act as secondary parasitoids (Peck 1985). Limacodid host associations in North America are newly reported herein.

Literature.—Burks (1966) published a key to 23 species known from North America, 24 were treated in a catalog (Burks 1979), and Peck (1985) provided a key to 32 species from North America.

North American Records:

Pediobius crassicornis (Thomson) (Figs. 95, 97–103): *Pleurotropis crassicornis* Thomson, 1878: 255. Holotype ♀, MZLU (not examined).

This Holarctic species has a broad host range, but surprisingly, it had not been reported as associated with limacodids previously (Noyes 2003). It has, however, been reported previously from primary parasitoids (Ichneumonidae: *H. fugitivus*, Tachinidae: *Com. concinnata*) that are reported from limacodids herein. It is most commonly recovered as a primary (Lepidoptera) or secondary parasitoid of hymenopterans through lepidopterans. From the rearing results reported herein, *Pe. crassicornis* commonly parasitize *Pl. americana* (Fig. 98). When attacking *Pl. americana*, adult *Pe. crassicornis* emerge from the anterior end of the pupa and escape the limacodid cadaver laterally or dorsally, depending upon the degree of adherence of the limacodid cadaver to the substrate. In the latter case, circular emergence holes are chewed through the dorsum of the limacodid when the margins of the cadaver are tightly appressed to the substrate. It is possible that *Pe. crassicornis* also parasitizes *Al. lilli*. There are a few specimens associated only with the remains of limacodid or other species of primary parasitoid (ichneumonoids), but these records are suspect due to the nature of the emergence hole or the lack of pupal remnants reminiscent of *Pe. crassicornis*. In the former instance, the remains of *Ac. stimulea* are mummified and a very large emergence hole is chewed posterolaterally, roughly equal to 4–5 body widths of *Pe. crassicornis*, and

no pupal remnants are visible inside. In the latter (same limacodid host), microgastrine cocoons associated with *Pe. crassicornis* are empty and appear to have emerged normally, but no primary host remains are associated with them. There is a series of *Co. schaffneri* in the USNM (no label data) bearing a handwritten identification of, "On *Tortricidia testacea* Dyar '97" that has several larvae with cocoons of *Cotesia* adhered. A series of five (formerly seven as two are missing) co-mounted *Pe. crassicornis* appear to correspond with 10 cocoons of *Cotesia*, eight of which bear emergence holes laterally and contain pupal remains. *Pediobius crassicornis* can be separated from other *Pediobius* by the following combination of characters: occipital carina present, frons coarsely reticulate (Fig. 100), male with three funiculars (Fig. 103), scutellum smooth medially (Fig. 95), basal gastral tergum alutaceous.

Distribution: Widespread across North America from the west to east coasts into Canada in the north. Also found in northern Europe and Japan (Peck 1985, Noyes 2003).

Limacodidae: Associated with the following species but appears to be acting as a hyperparasitoid in most instances: *Ac. stimulea*, *Ad. spinuloides*, *N. nasoni*, *E. delphinii*, *I. textula*, and *Li. fasciola*. *Natada nasoni* may serve as a host in one instance as the larva is mummified and an emergence hole is visible posterolaterally, roughly equal to two body widths of *Pe. crassicornis*, and pupal remnants are visible inside.

Other hosts: The numerous hosts are listed by Noyes (2003) and span 22 families across the following four insect orders: Diptera (2), Coleoptera (2), Lepidoptera (10), and Hymenoptera (8). Herein it is newly recorded as a parasitoid of *Pl. americana**, although it is possible that it is attacking

additional taxa (see species treatment above).

Psychophagus Thomson (Chalcidoidea:
Pteromalidae: Pteromalinae)
(Figs. 87–93)

Diagnosis.—Clypeus shallowly bilobed apically (Fig. 88); pedicel ~ 2.0X as long as broad, antennal formula 11263 (Fig. 89); propodeum reticulate-rugose, with median carina incomplete (Fig. 90); gaster subcircular to short-ovate (Fig. 91).

Fauna.—*Psychophagus* contains the single Holarctic species, *P. omnivorus*.

Biology.—This genus has an incredibly broad host range and may act as a primary or secondary parasitoid (Noyes 2003) across four insect orders and 22 families. Most hosts are pupae of Lepidoptera, Hymenoptera, or Diptera (or their dipteran or hymenopteran parasitoids). There is one record of a single species of Limacodidae being attacked in North America among numerous additional host records (see below).

Literature.—Aside from original descriptive work (Walker 1835) and treatment by Graham (1969), Noyes (2003) provides citations of the bulk of the literature (particularly host records) for this species.

North American Records:

Psychophagus omnivorus (Walker) (Figs. 87–93): *Pteromalus omnivorus* Walker, 1835: 204. Lectotype ♂, BMNH, designated by Graham (1969: 473) (not examined).

The sole limacodid host, the exotic *M. flavescens*, was reported by Schaffner and Griswold (1934) and Schaffner (1959). The former recorded this wasp as often hyperparasitic (only other parasitoid recorded therein was *Com. concinnata*), with four to 90 emerging per host and distributed in northeastern North America. The latter reported four specimens of

P. omnivorus from Boston, Massachusetts as a gregarious parasitoid emerging from a limacodid pupa.

Distribution: Holarctic. In North America, primarily eastern U.S.A. and Canada.

Limacodidae: *M. flavescens*.

Other hosts: Primary Parasitoid: Scolytidae (Coleoptera); Diprionidae, Pamphiliidae, Tenthredinidae (Hymenoptera); Arctiidae, Coleophoridae, Lasiocampidae, Lycaenidae, Lymantriidae, Noctuidae, Notodontidae, Nymphalidae, Oecophoridae, Pieridae, Pyralidae, Saturniidae, Tortricidae (Lepidoptera). Hyperparasitoid: Sarcophagidae, Tachinidae (Diptera); Braconidae, Ichneumonidae (Hymenoptera) (see Noyes 2003).

Trichogramma Westwood
(Chalcidoidea: Trichogrammatidae)
(Figs. 94, 96)

Diagnosis.—The family is recognized by the three-segmented tarsi (Fig. 94) and fore wing setation arranged in lines (Figs. 96). *Trichogramma* are recognized by broad fore wing with sigmoid venation and distinctive Rs1 setal track (Fig. 96), among other features not included herein (Pinto 1998).

Fauna.—*Trichogramma* is the largest genus in the family with ~ 180 species worldwide and 68 known from North America (Pinto 1998). They are used extensively in biological control programs of numerous species of pestiferous Lepidoptera in natural and agroecosystems (S. Smith 1996). A comprehensive regional monograph is available (Pinto 1998).

Biology.—Species of Trichogrammatidae are solitary or gregarious parasitoids of insect eggs in several orders (Hemiptera, Coleoptera, Lepidoptera, Diptera, etc.). A single limacodid host is recorded (see below) for North America. Three extralimital records of *Trichogramma* spp. (Hoong and

Hoh 1992, Wei 1996) and *Tr. papilionis* (Nagarkatti) on *Darna pallivitta* in Hawaii (Conant et al. 2006) have been reported. There are also a few extralimital records of *Trichogrammatoidea thosae* Nagaraja attacking limacodids in three genera as summarized by Cock (1987). Most *Trichogramma* species are primarily solitary or gregarious endoparasitoids of eggs of Lepidoptera. The number successfully completing development in a single egg depends upon host size and the proximity of host eggs (Pinto 1998; references therein), and females inject a developmental arrestant during oviposition (Strand 1986).

Literature.—Key to species (Pinto 1998).

North American Records:

Trichogramma minutum Riley (Figs. 94, 96): *Trichogramma minuta* Riley, 1871: 157–158. Neotype ♂, USNM, designated by Pinto et al. (1978) (examined).

Pinto (1998) considers this species to be a “complex of populations whose taxonomic status remains under investigation.” According to Pinto (1998), Peck’s (1963) recognition of only three Nearctic species of *Trichogramma*, and following Girault’s (1911) interpretation of *Tr. minutum*, resulted in recognizing ~ 150 host species in 33 families for this species alone. Given that this vast number of host records and associated research on *Trichogramma* species provided minimal voucher specimen documentation, the bulk of this information is unusable at the species level. Thus, the previously published limacodid rearing record cited below is suspect. Diagnostic genitalic characters for species separation are reported in Pinto (1998).

Distribution: U.S.A., east of 110° longitude (Pinto 1998).

Limacodidae: *Monema flavescens* (Collins 1933).

Other hosts: Pinto (1998) recorded, based on specimens examined and

those reared from field-collected hosts (not literature records), a total of 49 host records from three orders (Hymenoptera (1), Lepidoptera (45), and Neuroptera (3)). None was from Limacodidae.

Trichogramma sp.:

Distribution: Eastern U.S.A., minimally.

Limacodidae: *E. delphinii** on *Q. alba*.

Cotesia Cameron (Ichneumonoidea:
Braconidae: Microgastrinae)
(Figs. 64–69)

Diagnosis.—The combination of the following features is diagnostic (see Whitfield 1997): fore wing with vein r-m absent so that no small “areolet” (tiny second submarginal cell) is present (Fig. 65); propodeum with rugose sculpture and at least some indication of a percurrent medial carina (Fig. 66); anterior two metasomal terga (and sometimes anterior portions of third) sculptured and relatively broad and subrectangular (Fig. 66); ovipositor and sheaths relatively short, with only a few small setae at tip of sheath (Fig. 67).

Fauna.—*Cotesia* is a huge genus containing several hundred described species worldwide, and many more undescribed, although it is best represented in temperate regions. It is one of the largest and most economically important genera of Microgastrinae, with hosts in many lepidopteran (especially macrolepidopteran) families in both natural and agricultural systems. Most available revisions of *Cotesia* are strictly regional, and Muesebeck (1920) is the most recent comprehensive North American treatment. Extralimitally, there are two records of *Apanteles* spp. recorded from *Ph. hipparchia* Cramer and *Ac.* (as *Episibine*) *intensa* Dyar (Genty et al. 1978) in the Neotropical Region; these are most certainly *Cotesia* spp. based on the images of adults and cocoons in Genty et al. (1978).

Biology.—Most *Cotesia* species are gregarious endoparasitoids of macrolepidopteran from many families, with only a few microlepidopteran (e.g., plutelellids) among their hosts. A minority of species develop as solitary parasitoids. Like other microgastrines, species of *Cotesia* typically oviposit into early-instar host larvae, emerging from later instar larvae or prepupae to spin cocoon(s) on or near the host, which soon dies. A few species are capable of ovipositing into eggs (Ruberson and Whitfield 1996). The immune system of the host caterpillar is compromised in part by the introduction, along with the eggs, of symbiotic polydnviruses by the female wasp from her reproductive tract (Whitfield and Asgari 2003).

Literature.—Muesebeck (1920) is the only comprehensive North American treatment of *Cotesia*.

North American Records:

Cotesia empretiae (Viereck) (Figs. 64–67):
Apanteles empretiae Viereck, 1913:
562. Holotype ♀, USNM (examined).

Distinctive among *Cotesia* species in having the body length < 2 mm, first metasomal tergite width subequal anteriorly and posteriorly (Fig. 66; most *Cotesia* have tergite broader posteriorly), the third metasomal tergite with sculpturing over anterior half or two thirds, especially medially (Fig. 66), and the hypopygium sharply angled apically and with ovipositor sheaths strongly exerted, often visible in dorsal view (Fig. 67). The gregarious larvae emerge to spin (separately) 5–15 whitish to pale tan woolly cocoons dorsally (sometimes laterally) on the caterpillars.

Distribution: U.S.A., especially southeastern.

Limacodidae: *E. delphinii*, *Li. fasciola*,
Pa. chloris, and *Ac. stimulea* (Marsh
1979), *Ap. biguttata*, and *Pa. indetermina*
(Whitfield et al. 1999).

Cotesia phobetri (Rowher) (Fig. 68):
Apanteles phobetri Rohwer, 1915: 228.
Holotype ♀, USNM (examined).

This species (Fig. 68) differs from both *Co. emprettiae* and *Co. schaffneri* in having the third metasomal tergite entirely unsculptured; from *Co. emprettiae* it also differs in having the first metasomal tergite broadening posteriorly, and from *Co. schaffneri* it differs in having the hind tibiae and tarsi almost entirely pale orange brown. The gregarious pale buff cocoons are spun separately and positioned dorsally on the host caterpillar.

Distribution: Eastern U.S.A. (contribution from possibly non-conspecific, non-limacodid rearings cannot be ruled out).
Limacodidae: *Ph. pitheciium* (Rowher 1915).

Other hosts: *Halysidota tessellaris* Smith and Abbot (Arctiidae) (Muesebeck 1920) (possibly not conspecific *Co. phobetri*). Several other series reared from *Acronicta* sp. (Noctuidae) and other arctiids have also been identified as this species, perhaps mistakenly.

Cotesia schaffneri (Muesebeck) (Fig. 69):
Apanteles schaffneri Muesebeck, 1931: 4.
Holotype ♀, USNM (not examined).

This species is unique among the three *Cotesia* recorded herein in having the hind tarsi strongly bicolored: the proximal and distal tarsomeres being mostly blackish, whereas the third and fourth (and sometimes also second) tarsomeres are pale orange yellow. Unlike in *Co. emprettiae*, the gregarious pale buff cocoons are spun separately (but appressed together; individually immobile) on the back of the host caterpillar. The parasitized cocoons with the emergence holes on the side are whitish.

Distribution: Nearctic ranging from mid-Atlantic states and Texas in U.S. A.; thus it may be distributed broadly across the eastern and southern U.S.A.
Limacodidae: Unidentified limacodid ("cochliidiid") (Muesebeck 1931),

To. pallida H.-S., *To. testacea*, *Pr. badia*, and *E. delphinii* (specimens in the USNM with host remains).

Ascogaster (Ichneumonoidea:
Braconidae: Cheloninae)
(Figs. 48, 60–62)

Diagnosis.—Carapace without pair of complete transverse grooves, at most grooves present laterally but absent dorsally (Fig. 48); fore wing vein (RS+M) a present; eyes glabrous or virtually so (Fig. 60); ocelli configured in shape of isosceles triangle (Fig. 61); scutellar disc sculptured (Fig. 62).

Fauna.—Described species of *Ascogaster* occur in all zoogeographic regions, but only 12 species are known from the Nearctic (Shaw 1997a). Yu et al. (2005) listed four species in *Ascogaster* placed currently in *Leptodrepana* Shaw. As pointed out in Shaw (1997a), richness is higher in temperate areas than tropical areas of the New World, but richness is lower in the Nearctic than in all other regions except the Neotropical (Yu et al. 2005).

Biology.—As is the case for all chelonines, species of *Ascogaster* are solitary koinobiont egg-larval endoparasitoids of lepidopterans (Shaw 1997a). Host associations reported for *Ascogaster* include 23 families of Lepidoptera, including Limacodidae; most hosts are in Tortricidae (Yu et al. 2005). Host associations reported for species of *Ascogaster* in the Nearctic Region include species in Anthomyiidae, Clusiidae (Diptera), Curculionidae (Coleoptera), Cynipidae, Tenthredinidae (Hymenoptera), Blastodacnidae, Depressariidae, Gelechiidae, Geometridae, Limacodidae, Pyralidae, Tineidae, Tortricidae, and Yponomeutidae (Lepidoptera) (Yu et al. 2005). Non-lepidopteran host records are erroneous since all confirmed hosts for chelonines are lepidopterans

(Shaw 1997a, S. Shaw pers. comm.). Of the remaining 138 putative lepidopteran hosts, only one species of Limacodidae, *M. flavescens*, has been reported (Wilcox 1918).

Literature.—Research relevant to this study published since Yu et al. (2005) includes *As. quadridentata* (Wesmael) reared from the tortricids *Lobesia botrana* (Denis and Schiffermüller) (Carlos et al. 2006) and *Spilonota ocellana* (Denis and Schiffermüller) (Pluciennik and Olszak 2010). The aforementioned hosts were reported previously in multiple publications (Yu et al. 2005). Nazemi et al. (2008) reported *As. quadridentata* from the tortricid *Pammene amygdalana* (Duponchel), an inquiline of the cynipid *Andricus cecconi* Kieffer.

North American Records:

Ascogaster quadridentata (Wesmael) (Figs. 48, 60–62): *Ascogaster quadridentatus* Wesmael 1835: 237. Lectotype ♀, IRSNB, designated by Shaw (1983) (not examined).

This species can be differentiated from all Nearctic species of *Ascogaster*, except *As. shawi* Marsh, using the key in Shaw (1983). It can be differentiated from *As. shawi* using the features that differentiate *As. quadridentata* and *As. provancheri* Dalla Torre in the key by Shaw (1983).

Distribution: All zoogeographic regions except the Afrotropical, although it has been introduced into South Africa and several other countries to control orchard pests, particularly *Cydia pomonella* (Linnaeus). It ranges in the Nearctic Region from Maine south to Georgia and west to California (Yu et al. 2005).

Limacodidae: *Monema flavescens* reported but host plant not mentioned (Wilcox 1918). RRK considers this record possibly valid but has not verified this identification. In terms of rearing protocol, Wilcox (1918) mentioned only

that cocoons were “placed in rearing boxes,” so the record should be confirmed through rearing from a host isolated individually. This host species is likely no longer present in North America based on subsequent searches for it (M. Epstein pers. comm.).

Other hosts: Reported from at least 48 species in six lepidopteran families (Yu et al. 2005).

Triraphis Ruthe (Ichneumonoidea:
Braconidae: Rogadinae)
(Figs. 46–47, 49–59)

Diagnosis.—Third maxillary palpomere not enlarged and flattened, similar in size and shape to distal palpomeres; second labial palpomere not enlarged and vesiculate, similar in size and shape to distal palpomeres; basal carina of propodeum diverging basally to apically (Figs. 53, 55, 58), not complete to apical margin as single mesal carina; inner margin of metatibia with fringe of flattened setae (Fig. 59); metatibial spurs straight and setiferous; pro- and mesotarsus with tarsomeres 2–4 longer than wide (Figs. 50–51, 56); tarsal claws with basal lobe or tooth (Fig. 47); fore wing first submarginal cell uniformly setose, without glabrous patch; fore wing vein 1cu-a not angled as obliquely as fore wing 2CUa (Fig. 56); hind wing M+CU equal to or longer than 1M (as in Fig. 45); metasoma with T1–T4 not carapacelike and covering other terga (Figs. 50–51, 56); T2 without triangular area anteromesally; transverse groove between T2+T3 distinct (Figs. 52, 57).

Fauna.—Described species of *Triraphis* are known from the Nearctic, Neotropical, Oriental, and Palearctic regions (Yu et al. 2005). There are three Nearctic species currently placed in this genus, including *T. eupoeyiae* (Ashmead), **new combination** (see below), but most if not all New World species currently in *Rogas*

belong in *Triraphis* (Valerio 2006, Zaldívar-Riverón et al. 2008). Neither *Triraphis* nor *Rogas* has been revised for the New World; New World richness is estimated at 100–150 species (Shaw 1997b).

Biology.—As is the case for all rogadines, species of *Triraphis* are koinobiont endoparasitoids of lepidopteran larvae and pupate within the mummified remains of their hosts (Shaw 1997b). Reported host associations are larvae in Dalceridae, Limacodidae, Lycaenidae, Lymantriidae, Megalopygidae, Riodinidae, Tortricidae, and Zygaenidae (all Lepidoptera) (Yu et al. 2005, Zalvidar-Riveron et al. 2008). A single record from Cynipidae (Hymenoptera) is obviously erroneous since all confirmed hosts for rogadines are lepidopterans (Shaw 1997b, S. Shaw pers. comm.). Other records of questionable validity are the Palearctic species *T. tricolor* (Wesmael) from the tortricids *Archips rosana* L. (Tobias 1976) and *Tortrix testudinana* Hübner (Reinhard 1865) and the Oriental species *T. sichuanensis* Chen and He from the lymantriid *Euproctis bipunctapex* (Hampson) (Chen and He 1997). Genera in Dalceridae, Lycaenidae, Megalopygidae, and Riodinidae were reported in Zaldívar-Riverón et al. (2008) as containing hosts for species of *Triraphis*; particular parasitoid and host species were not listed. The basis for those records (e.g., rearing protocol) is unknown (i.e., cited as Valerio and Shaw in prep.), although they were noted as confirmed by a rogadine specialist (i.e., S. R. Shaw, University of Wyoming-Laramie). Thus, in terms of published records, species of *Triraphis* are known from hosts in two monophyletic groups (i.e., Limacodidae, Zygaenidae) (Wahlberg et al. 2005, Niehuis et al. 2006).

Literature.—Aside from literature reported in Yu et al. (2005), Zaldívar-Riverón et al. (2004) examined venom gland morphology for Rogadinae, including

Triraphis, and conducted a cladistic analysis based on characters of the venom gland. Quick and Shaw (2005) discussed mummy characteristics for *Triraphis*; *T. tricolor* was the only species mentioned. Valerio (2006) transferred *T. brasiliensis* (Szépligeti) and *T. maculipennis* (Szépligeti) from *Rogas*, but Papp (2004) had already transferred those species to *Triraphis*. Valerio (2006) also indicated *T. pulchricornis* (Szépligeti) as a new combination transferred from *Rogas*, but Papp (2004) had transferred *pulchricornis* from *Rogas* to *Aleiodes* Wesmael. Additionally, Valerio (2006) mentioned eight species of *Rogas* as belonging in *Aleiodes*, but all had been transferred to *Aleiodes* previously (Shaw et al. 1997, Marsh and Shaw 1998, Shaw et al. 1998, Fortier and Shaw 1999). Zalvidar-Riveron et al. (2008) carried out cladistic analyses for Rogadinae, including *Triraphis*, based on DNA sequence data and assessed the evolution of host range and mummy characteristics. Kula et al. (2010) reported the first host records for *T. discoideus*

North American Records:

Triraphis discoideus (Cresson) (Fig. 46–47, 49, 56–59): *Aleiodes discoideus* Cresson, 1869: 380. Holotype ♀, ANSP (not examined).

The body is irregularly yellow and brown and the stigma is usually (96.6%) brown with at most a small yellow area where it meets vein R1a (Fig. 56).

Distribution: Nearctic Region, ranging from Massachusetts to Florida and west to Illinois (Yu et al. 2005).

Limacodidae: Reported from 10 species of Limacodidae sampled collectively from six hardwood tree species in the District of Columbia and Maryland (Table 1) (Kula et al. 2010). See Kula et al. (2010) for additional information on the natural history of *T. discoideus*.

Other hosts: None reported.

Triraphis eupoeyiae (Ashmead), new combination (Fig. 50): *Pelecystoma eupoeyiae* Ashmead, 1897: 113. Holotype ♀, USNM (examined).

The body is primarily orange but with at least the lateral lobes of the mesoscutum brown, and the stigma is yellow with a brown spot directly above vein r (Fig. 50). This species fits *Triraphis sensu* van Achterberg (1991) except the occipital carina is complete dorsally, and the frons is rugose in the holotype. Additionally, several relative features in the diagnosis for *Triraphis sensu* van Achterberg (1991) are difficult to interpret (e.g., size and shape of basal lobe of tarsal claw). It is transferred to *Triraphis* despite the exceptions and problems with interpretation because it shares more features with species in that genus than species in *Rogas sensu* van Achterberg (1991).

Distribution: Known only from Florida prior to this research, but a specimen from Cuba is in the USNM.

Limacodidae: Ashmead (1897) reported the holotype as reared from *Ala. slossoniae*, but a host cadaver is not associated with the holotype. RRK considers this record possibly valid, but it requires confirmation through rearing from a host isolated individually. The cadaver associated with this rearing is deposited in the USNM. In reporting on the biology of *Ala. slossoniae*, Dyar (1897) figured a larva parasitized by *T. eupoeyiae*, indicating that it becomes, “bright red (Plate V, fig. 23) and hardens.” (p. 125).

Other hosts: Label data associated with the specimen from Cuba indicates that it was reared from *Leptotes cassius* (Cramer) (Lycaenidae); host remains are associated with the specimen.

Triraphis harrisinae (Ashmead) (Fig. 51–55): *Rhogas harrisinae* Ashmead (1888) 1889: 632. Holotype ♂, USNM (examined).

The body is entirely yellow to orange, and the fore wing stigma is yellow with at most a light brown spot distad vein r (Fig. 51).

Distribution: Nearctic and Neotropical regions, ranging from New Jersey to Florida west to Missouri and south to Costa Rica. It also occurs in Cuba (Yu et al. 2005).

Limacodidae: Harrison (1963) reported *T. harrisinae* from *Ac. apicalis* (Dyar) on banana; host larvae were isolated individually, and RRK considers this record valid. *Triraphis harrisinae* was not reared from a congener, *Ac. stimulea*, during the course of this research. Marsh (1979) reported *T. harrisinae* from *Li. fasciola*, but there are no specimens of *T. harrisinae* at the USNM purportedly reared from *Li. fasciola*. This record is possibly valid, but *T. harrisinae* was not reared from *Li. fasciola* during the course of this research.

Other hosts: Riley and Howard (1890) first reported it as a parasitoid of *Harrisina americana* (Guérin-Méneville) (Zygaenidae). Additionally, specimens of *T. harrisinae* reared from *H. americana* and undetermined *Acoloithus* Clemens (Zygaenidae) larvae collected in Florida and Illinois were used to start a colony at the University of California-Riverside (Smith et al. 1955). Specimens from that colony were released in California to control *H. metallica* Stretch and apparently established in San Diego (Clausen 1956). See Kula et al. (2010) and references in Yu et al. (2005) for additional information on the natural history of *T. harrisinae*.

Mesochorus Gravenhorst
(Ichneumonoidea: Ichneumonidae:
Mesochorinae)
(Figs. 19–22)

Diagnosis.—*Mesochorus* can be recognized by the following combination of

characters: areolet of fore wing closed, large and rhombic (Fig. 20); spiracle of metasomal segment 1 near or just behind middle (Fig. 21); glymma large and deep (Fig. 21); ovipositor needlelike, about 1.5X as long as metasomal apical depth and without dorsal subapical notch (Fig. 22); female hypopygium prominent and triangular in lateral view (Fig. 22); male gonoforceps produced into elongate processes.

Fauna.—Species of *Mesochorus* occur in all zoogeographic regions (Yu et al. 2005), with about 695 species worldwide, 108 of which occur in the Nearctic Region. Dasch (1971) revised the Nearctic Mesochorinae.

Biology.—Most observations and rearing records indicated that mesochorines are obligate hyperparasitoids of endoparasitic Ichneumonoidea (and, rarely, Tachinidae) which parasitize primary hosts of larval Lepidoptera, Symphyta, and Coleoptera, and nymphal and adult Hemiptera and Psocoptera (Carlson 1979a). Based upon rearing records, many species have a wide host range (Dasch 1971, Carlson 1979a). Ectoparasitic ichneumonids can be utilized as well, based upon rearings of *Mesochorus* from *Phytodietus* and *?Oedemopsis* hosts by M. R. Shaw (Gauld and Bolton 1988: 17). Although there are some records of mesochorines as primary parasitoids (Dasch 1971, Yu et al. 2005), these are likely specimens reared from undetected primary parasitoids (Wahl 1993a). The pitfalls and deficiencies of rearing records were ably discussed by Shaw (1990: 453–455) and are relevant to this matter.

Literature.—The Nearctic *Mesochorus* fauna may be identified using Dasch (1971). Aside from literature reported in Yu et al. (2005), Reis Fernandes et al. (2010) reported two undetermined species of *Mesochorus*: one from an undetermined species of *Hypomicrogaster* Ashmead (Braconidae: Microgastrinae)

through an undetermined species of Olethreutinae (Lepidoptera: Tortricidae), and the other through an undetermined species of Noctuidae (Lepidoptera) presumably parasitized by an undetermined species of *Aleiodes* Wesmael (Braconidae: Rogadinae).

North American Records:

Mesochorus discitergus (Say) (Figs. 19–22): *Cryptus discitergus* Say, 1835: 231. Type ♀ (destroyed, Townes et al. 1965).

There are numerous extremely similar species of *Mesochorus* in the Nearctic, and *discitergus* cannot be separated from them by a short diagnosis. Dasch (1971) divided the 96 species that he treated into 17 species groups with this species placed in the *discitergus* group with two other species: *M. americanus* Cresson and *M. acuminatus* Thompson. Dasch provided information that may be used to separate *discitergus* from other species of *Mesochorus*, but the characters are difficult to interpret by non-experts without access to a large collection. It remains necessary to confirm species identifications by sending them to an expert with access to a well-curated ichneumonid collection (e.g., USNM, AEI, CNC).

Distribution: Worldwide except for the Australian region (Yu et al. 2005).

Limacodidae: The two specimens of *Me. discitergus* in this study emerged (post-erolaterally) from mummified early to middle instar larvae of *Pa. chloris* on *Q. rubra* and *Pr. badia* on *F. grandifolia*; the mummies were probably made by a species of *Triraphis* based on examination of montage images of host remains (JTL). This species has not been reported as a hyperparasitoid through a limacodid, nor was it reared from any other parasitoids in this project.

Other hosts: *Mesochorus discitergus* has been reported as a hyperparasitoid of 31 species of Braconidae and three species of Ichneumonidae (Yu et al.

2005). Records of *Me. discitergus* as a primary parasitoid of lepidopterans are questionable, as discussed above.

Casinaria Holmgren (Ichneumonoidea:
Ichneumonidae: Campopleginae)
(Fig. 28)

Diagnosis.—*Casinaria* may be recognized by the following combination of characters: clypeus not separated from supraclypeal area by distinct groove; ventral posterior corner of propleuron with strongly produced, more or less angulate lobe touching or overlapping pronotum (as in Fig. 24); areolet of fore wing closed, obliquely quadrate and petiolate (as in Fig. 26); metasomal segment 1 with the following: spiracle beyond middle, petiole long and cylindrical in cross-section and with tergo-sternal suture at midline, T1 without trace of glymma (Fig. 28); metasoma laterally compressed; ovipositor not needlelike, about as long as metasomal apical depth and with dorsal subapical notch (Fig. 28).

Fauna.—*Casinaria* is distributed worldwide, with 99 species, 20 of which are recorded from the Nearctic Region (Yu et al. 2005). Walley (1947) revised the Nearctic fauna. In a forthcoming revision of Costa Rican Campopleginae, I. D. Gauld recognizes a species-group within *Casinaria* consisting of *grandis* and two undescribed Costa Rican species. The latter parasitize various species of limacodids in the genera *Acharia*, *Euclea*, *Euprosterna*, and *Natada* based on extensive rearing efforts conducted in Costa Rica (D. Janzen and W. Hallwachs pers. comm; see also <http://janzen.sas.upenn.edu>). Extralimitally, there is one record of *Casinaria* sp. from *Ac.* (as *Sibine*) *megasomoides* (Walker) (Genty et al. 1978) in the Neotropical Region.

Biology.—Like other campoplegines, *Casinaria* species are koinobiont

endoparasitoids of Lepidoptera, with the egg deposited in an exposed host larva and the mature wasp larva emerging before the host pupates (Jerman and Gauld 1988). Species in the following families have been recorded as hosts: Arctiidae, Crambidae, Geometridae, Hesperidae, Lasiocampidae, Limacodidae, Megalopygidae, Notodontidae, Nymphalidae, Oecophoridae, Olethreutidae, and Zygaenidae (Walley 1947, Finlayson 1975, Short 1978, Carlson 1979a, Jerman and Gauld 1988, Janzen and Hallwachs 2009).

Literature.—The Nearctic *Casinaria* fauna may be identified using Walley (1947). Additionally, a species of *Casinaria* was reported from *Ac.* (as *Sibine*) *megasomoides* Walker on oil palm in Costa Rica (Mexzón et al. 1996).

North American Records:

Casinaria grandis (Walley) (Fig. 28): Walley, 1947: 376. Replacement name for *Casinaria texana* Ashmead (1890); Holotype ♀, USNM (not examined).

Casinaria grandis may be distinguished from other Nearctic *Casinaria* by the following characters: large, broad, flat, and centrally concave scutellum; petiolate areolet of the fore wing; gena descending perpendicularly behind ocelli; coarsely rugosopunctate propodeum without carinae; and large size (about 15 mm long).

Distribution: Gulf of Mexico (Florida, Texas, Louisiana; Carlson 1979a). It presumably extends into northern Mexico.

Limacodidae: Reported from *Ac. stimulea* (Carlson 1979a); no specimens could be located in the USNM collection that would verify this record.

Other hosts: None known.

Hyposoter Förster (Ichneumonoidea:
Ichneumonidae: Campopleginae)
(Figs. 23–24, 26–27, 30, 32)

Diagnosis.—*Hyposoter* may be recognized by the following combination of

characters: clypeus not separated from supraclypeal area by distinct groove (Fig. 32); ventral posterior corner of propleuron with strongly produced, more or less angulate lobe touching or overlapping pronotum (Fig. 24); areolet of fore wing closed, obliquely quadrate and petiolate (Fig. 26); metasomal segment 1 with the following: spiracle beyond middle, petiole short and quadrate in cross-section and with tergo-sternal suture close to ventral margin, T1 with glymma present as pitlike impression (Fig. 27); metasoma laterally compressed; ovipositor not needlelike, about as long as metasomal apical depth and with dorsal subapical notch (Fig. 23).

Fauna.—Species of *Hyposoter* occur in all zoogeographic regions. Yu et al. (2005) listed 117 valid species worldwide and 29 for the Nearctic Region. Horstmann (2008) described one new species from the Palearctic Region, and Horstmann (2009) transferred *Hyposoter koentzeii* (Kiss), known from Hungary, from *Omorgus* Förster. *Hyposoter bellus* (Cresson), known from Cuba, was transferred from *Xanthocampoplex* Morley in Gauld and Fernández-Triana (2010). Viereck (1925, 1926) provided keys that include most species known from the Nearctic Region, but a single key to species of *Hyposoter* in the Nearctic Region has not been published. Further, the keys in Viereck (1925, 1926) use characters that are of doubtful utility for species diagnostics (see specific information below).

Biology.—*Hyposoter* spp. are koinobiont endoparasitoids of ditrysian lepidopterans, including some species of Rhopalocera. Egg deposition is in early to middle instar larvae, and the wasp larva usually emerges from the penultimate instar of the host larva. The wasp spins an ovoid cocoon near or under the host caterpillar's remains. The cocoon is sometimes completely covered by the host's

cuticle; this is not, however, mummification as found in rogadoine braconids (see the discussion of rogadoine mummification in Shaw (2006)) in which the host mummy remains intact due to internal pupation by the parasitoid.

Literature.—Aside from literature reported in Yu et al. (2005), Marconato et al. (2008) reported an undetermined *Hyposoter* from two geometrids (Lepidoptera). Reis Fernandes et al. (2010) reported two undetermined species of *Hyposoter* from two geometrids (Lepidoptera). There are no reliable or comprehensive treatments of the taxonomy of the Nearctic *Hyposoter* fauna.

North American Records:

Hyposoter fugitivus (Say) (Figs. 23–24, 26–27, 30, 32); *Banchus fugitivus* Say, 1835: 247. Lectotype ♀, USNM, designated by Cushman (1925) (not found in USNM collection).

Besides the 29 described Nearctic *Hyposoter* species there are numerous undescribed species; in the absence of a formal revision, meaningful diagnosis of *fugitivus* may be misleading. The characters presented in the key, in conjunction with an association with a rearing from a limacodid host in the Nearctic Region, provide the best information at this point to attempt to assign a species name. As with other ichneumonids (e.g., *Mesochorus*) reported herein, final identification should be made by an ichneumonid expert with access to a large collection such as USNM, AEI, or CNC.

Distribution: Transcontinental in the Nearctic (except possibly absent in the southwestern U.S.A.) (Carlson 1979a). Recorded from Brazil (Costa Lima 1962), but not recognized in the Neotropical catalog of Townes and Townes (1966) nor is it present in Costa Rica (I. Gauld et al. unpubl.).

Limacodidae: *Isa textua* on *Acer negundo* L. and *Salix nigra* (Marsh)

(Barbosa and Caldas 2004). It was reared in this study from *Pr. badia** on *Q. alba*. The *Hyposoter* cocoon is completely covered by the skin of the host caterpillar. This is the only described species of *Hyposoter* known to attack limacodids; several undescribed Costa Rican species have been reared from species of *Acharia*, *Euclea*, *Natada*, and *Parasa* based on extensive caterpillar rearing effort in Costa Rica (D. Janzen and W. Hallwachs pers. comm.).

Other hosts: It has been reported from 30 other lepidopteran species in 12 families (Yu et al. 2005); a new record from this study was its rearing from *Meg. crispata* on *Q. alba*.

Baryceros Gravenhorst

(Ichneumonoidea: Ichneumonidae:

Cryptinae)

(Figs. 29, 37–38)

Diagnosis.—*Baryceros* may be recognized by the following combination of characters: clypeus separated from supraclypeal area by distinct groove; ventral posterior corner of propleuron not developed as distinct lobe, at most with weak groove delimiting it from main area of propleuron (Fig. 37); dorsal margin of pronotum with strong swelling at dorsal end of epomia (Fig. 37); areolet of fore wing open (vein 3rs-m absent) and pentagonal (Fig. 29); mesosoma with coarse punctures (Fig. 37); spiracle of metasomal segment 1 beyond middle; glymma absent (Fig. 29); metasoma cylindrical/dorsoventrally compressed; ovipositor not needlelike, about 2.0X as long as metasomal apical depth and without dorsal subapical notch (Fig. 38); body (excluding legs) black with white markings (Fig. 29).

Fauna.—*Baryceros* is a New World genus, with 32 described species; five are found in the Nearctic (Yu et al. 2005).

Townes and Townes (1962) provide a key to the Nearctic fauna.

Biology.—*Baryceros* is placed in the subtribe Baryceratina, with all known host records indicating that the genera of this subtribe are idiobiont ectoparasitoids of Limacodidae (Townes 1970). Three species of *Baryceros* have been reared. *Baryceros euclidis* (Blanchard) has been reared from *Ph. hipparchia* (Cramer) and *Ac.* (as *Sibine*) *nesea* (Stoll), and *B. sibine* (Cameron) has been reared from *Ac.* (as *S.*) *trimaculata* (Sepp) and *Ac.* (as *S.*) *nesea* (Townes and Townes 1966). *Baryceros texanus* is discussed below. A suite of morphological characters appears to be adaptations to attaching limacodid cocoons. One such character is the possession of prominent dorsal and ventral teeth on the ovipositor apex (Fig. 29); characterized by Gauld (1984) as “corkscrew-like,” this specialized structure is used to penetrate the hard limacodid cocoon.

Literature.—Townes and Townes (1962) remains the definitive taxonomic treatment of the Nearctic fauna.

North American Records:

Baryceros texanus (Ashmead) Figs. 29, 39–38; *Crypturus texanus* Ashmead, 1890: 413. Holotype ♂, USNM (not examined).

Baryceros texanus can be differentiated from other Nearctic *Baryceros* by the black and white tergites and the single large white spot on the ventral portion of the mesopleuron (Fig. 29).

Distribution: North America, in U.S.A. from Maryland to Florida, west to Michigan and eastern Texas. Recorded from Sonora, Mexico and is presumably more widely distributed (Townes and Townes 1962 Carlson 1979a).

Limacodidae: *Ala. slossoniae* from southern Florida (Ashmead 1897, Dyar 1897). The USNM collection has a reared specimen from Stock Island (Monroe Co.), Florida; label data state that the

host was a "Lep. larva" on a leaf of *Conocarpus erecta* L. (Combretaceae).
Other hosts: None known.

Lysibia Förster (Ichneumonoidea:
 Ichneumonidae: Cryptinae)
 (Figs. 25, 35, 43)

Diagnosis.—*Lysibia* may be recognized by the following combination of characters: clypeus separated from supra-clypeal area by distinct groove, apical 0.3 turned inward at 90° angle (Fig. 43); occipital carina meeting hypostomal carina above mandibular base (as in Fig. 41); ventral posterior corner of propleuron not developed as distinct lobe, at most with weak groove delimiting it from main area of propleuron (Fig. 25); dorsal margin of pronotum without strong swelling at dorsal end of epomia (Fig. 35); areolet of fore wing open (vein 3rs-m absent) and pentagonal; vein 2-Cu of hind wing basally incomplete (Fig. 35); mesosoma with punctures ranging from fine to absent; spiracle of metasomal segment 1 beyond middle; glymma absent; metasoma cylindrical/dorsoventrally compressed; ovipositor not needlelike, about 1.4X as long as metasomal apical depth and without dorsal subapical notch. Body color (excluding legs) black to dark brown, with eastern Nearctic specimens often having T2–T7 brown and with brownish red areas on T2–T3 (Fig. 35).

Fauna.—*Lysibia* is found worldwide except for Africa and Australia. There are nine described species, with two (*mandibularis* (Provancher) and *tenax* Townes) present in the Nearctic. They may be identified using the key to world species in Townes (1983).

Biology.—Like the majority of species in the Phygadeuontini, *Lysibia* spp. are idiobiont ectoparasitoids of cocooned hosts. They are apparently pseudohyperparasitoids, specializing in microgastrine

cocoons (Townes 1970), including *Co. glomerata* L. (Harvey et al. 2004); Yu et al. (2005) list 33 microgastrine species as hosts. Yu et al. (2005) also list 26 species of Lepidoptera in 14 families as hosts. While some of these host records may be correct (see discussion under *Isdromas*), many likely are the result of faulty record keeping (Shaw 1990). A series of recent papers have been published on the biology and ecology of *Ly. nana* (Gravenhorst) (Harvey et al. 2004; 2006; 2009a, b) attacking *Co. glomerata*.

Literature.—Townes (1983) remains the definitive taxonomic treatment of the Nearctic fauna.

North American Records:

Lysibia mandibularis (Provancher) (Figs. 25, 35, 43): *Hemiteles madibularis* Provancher, 1875: 315. Holotype ♀, ULQC (not examined).

Lysibia mandibularis has the punctures of tergites 2–3 centrally sparse, separated by 1.5–2.5X the length of the setae; *Ly. tenax* has the tergal punctures evenly distributed and separated by about 0.8X the length of the setae.

Distribution: Transcontinental in the Nearctic (Townes 1983).

Limacodidae: The specimens in this study were reared from cocoons of an undetermined gregarious microgastrine parasitizing *Ac. stimulea* on *Lindera benzoin* (L.) Blume.

Other hosts: Yu et al. (2005) list seven species of microgastrines as hosts; four species of Lepidoptera are also listed, but these records are probably erroneous as noted above.

Acrolyta Förster (Ichneumonoidea:
 Ichneumonidae: Cryptinae)
 (Figs. 36, 41)

Diagnosis.—*Acrolyta* may be recognized by the following combination of

characters: clypeus separated from supra-clypeal area by distinct groove, apical 0.3 flat and not turned inward (as in Fig. 44); occipital carina meeting hypostomal carina at mandibular base (Fig. 41); ventral posterior corner of propleuron not developed as distinct lobe, at most with weak groove delimiting it from main area of propleuron (as in Fig. 25); dorsal margin of pronotum without strong swelling at dorsal end of epomia (Fig. 36); areolet of fore wing open (vein 3rs-m absent) and pentagonal; vein 2-Cu of hind wing complete; mesosoma with punctures ranging from fine to absent; spiracle of metasomal segment 1 beyond middle; glymma absent; metasoma cylindrical/dorsoventrally compressed; ovipositor not needlelike, 1.6–1.8X as long as metasomal apical depth and without dorsal subapical notch. Body color of females (excluding legs) ranges from uniformly black/dark brown to having extensive brownish red areas on T2–T4; males have metasomal coloration ranging from having brownish red restricted to the apices of T2–T3, to having brownish red on the apex of T2, all of T3, and the basal area of T4 (Fig. 36).

Fauna.—*Acrolyta* is found in the Afrotropical, Palearctic, Nearctic, and Oriental regions. There are 25 described species, with the following four species in the Nearctic: *alticola* (Ashmead), *mesochori* Ashmead, *nigricapitata* (Cook and Davis), and *washingtonensis* (Cushman) (Yu et al. 2005). No keys are available to separate the species.

Biology.—*Acrolyta* species are inferred idiobiont ectoparasitoids of cocooned hosts, as are other species in the Phygadeuontini (Gauld 1984). Townes (1970) stated that “[p]robably the usual hosts are cocoons of Braconidae and Ichneumonidae.” Yu et al. (2005) list 28 species of braconids as hosts; 13 lepidopteran species in 10 families are also listed (as well as a species of Cynipidae!). While some of the

Lepidoptera may be hosts (see discussion under *Isdromas*), it is likely that these records are due to faulty observations and lax record keeping of the sort discussed by Shaw (1990). Harvey et al. (2009b) reported on the biology of *Acrolyta nens* Hartig attacking *Co. glomerata*.

Literature.—There are no reliable or comprehensive treatments of the taxonomy of the Nearctic *Acrolyta* fauna.

North American Records:

Acrolyta nigricapitata (Cook and Davis) (Figs. 36, 41): *Ischnoceros nigricapitatus* Cook and Davis, 1891: 11. Holotype ♀, MSUC (not examined).

Acrolyta nigricapitata can be distinguished from other Nearctic *Acrolyta* by the following characters: tergite 3 with fine longitudinal striae covering most of surface (tergite 3 without striae); fore and middle coxae light brownish red (fore and middle coxae white); tergite 3 completely brownish red (tergite 3 dark brown/fuscous, ranging from completely so to having anterior and posterior margins narrowly brownish red).

Distribution: Northeastern U.S.A. and southeastern Canada to the Pacific Coast (California and Washington) (Gauld 1984, Yu et al. 2005).

Limacodidae: *Acrolyta nigricapitata* is recorded as parasitizing *Ac. stimulea* in Ashmead (1896: 209), where the only information is as follows: “Described from two specimens labeled No. 295o, reared May 14, 1883, from *Empretiae stimulea*.” It is unlikely to be a primary parasitoid.

Other hosts: Yu et al. (2005) list three braconid species as hosts; a noctuid, *Pseudaletia unipunctata* (Haworth) (= *Mythimna unipunctata*), is also listed, but this record also stems from Ashmead (1896: 210) with only the following entry: “Described from one specimen labeled “parasite on *Leucania unipunctata*, June, 1880.” The USNM

collection has three *nigricapitata* specimens with host records/remains (R. Kula pers. comm.): (1) a specimen without host remains but label data indicating *Ap. melanoscelus* (Ratzeburg) as the host, (2) a specimen with a mounted cocoon and label data identifying it as *Ap. melanoscelus*, and (3) a specimen with an associated cocoon (probably braconid) and no associated information.

Isdromas Foerster (Ichneumonoidea:
Ichneumonidae: Cryptinae)
(Figs. 31, 33–34, 42, 44)

Diagnosis.—*Isdromas* may be recognized by the following combination of characters: clypeus separated from supra-clypeal area by distinct groove, apical 0.3 flat and not turned inward (Fig. 44); occipital carina meeting hypostomal carina above mandibular base (Fig. 42); ventral posterior corner of propleuron not developed as distinct lobe, at most with weak groove delimiting it from main area of propleuron (as in Fig. 25); dorsal margin of pronotum without strong swelling at dorsal end of epomia (Fig. 34); areolet of fore wing open (vein 3rs-m absent) and pentagonal (Fig. 34); vein 2-Cu of hind wing complete (Fig. 34); mesosoma with punctures ranging from fine to absent; spiracle of metasomal segment I beyond middle; glymma absent (Figs. 34); metasoma cylindrical/dorsoventrally compressed; ovipositor not needlelike, about 3.0X as long as metasomal apical depth and without dorsal subapical notch. Body color (excluding legs) usually black; T2–T7 may vary from black to dark brown (Fig. 34).

Fauna.—*Isdromas* contains eight described species worldwide with one species reported in the Nearctic (Yu et al. 2005). Although Townes (1970) estimated that the world fauna consists of at least 60

species, *Is. lycaenae* (Howard) appears to be the sole Nearctic representative.

Biology.—As with most Cryptinae, *Acrolyta*, *Isdromas*, and *Lysibia* are idiobiont ectoparasitoids of cocooned hosts (Gauld 1984). Gauld (1988) points out that many species of Phygadeuontini “are facultative hyperparasitoids and use as hosts whatever is in a particular cocoon be it the cocoon maker or one of its parasitoids.” This is particularly true for the subtribe Acrolytina, to which these genera belong, due to the habit of parasitizing ichneumonid and braconid cocoons (Gauld 1995). This then leads to consideration of two different modes of hyperparasitism (Shaw and Askew 1976): (1) true hyperparasitism in which the hyperparasitoid develops on a primary parasitoid living on or within the primary’s host and (2) pseudohyperparasitism, which involves the pseudohyperparasitoid attacking the primary parasitoid after it has destroyed its host.

This background puts a necessary perspective on the rearing records of *I. lycaenae*. The species has been reported as reared from five species of Braconidae and two species of Ichneumonidae on various lepidopteran hosts (Yu et al. 2005); this would thus be pseudohyperparasitism. *Isdromas lycaenae* has also been reported from nine species of Lepidoptera in seven families (Yu et al. 2005); these could either be instances of primary parasitism or utilization of overlooked primary parasitoids. De Santis (1987) and Lourencão et al. (1989) reported *Is. monterai* (Costa Lima), the only other species of *Isdromas* for which host use is known, as a likely pseudohyperparasitoid of *Protapanteles dalosoma* (De Santis) (Braconidae: Microgastrinae) on *Anacraga citrinopsis* Dyar (Lepidoptera: Dalceridae).

Literature.—The genus may be identified using Townes (1983); *lycaenae* is the only Nearctic representative.

North American Records:

Isdromas lycaenae (Howard) (Figs. 31, 33–34, 42, 44) *Hemiteles lycaenae* Howard, 1889: 1880. Holotype ♀, USNM (examined).

Isdromas lycaenae is the sole Nearctic representative of this genus and may be recognized by the apical 0.3 of clypeus turned inward at 90° (Fig. 43), vein 2-Cu of hind wing basally incomplete, and the dark brown body with paler legs (Fig. 34).

Distribution: In the Nearctic, *Is. lycaenae* is found from Ontario south to the Gulf of Mexico and west to Texas and Kansas. In the Neotropics it is found from Honduras to Argentina (Yu et al. 2005).

Limacodidae: *Isdromas lycaenae* was reared from mummified early to middle instar larvae of *Ac. stimulea** on *Q. rubra*; *I. textula** on *Q. rubra*; *N. nasoni** on *F. grandifolia*, *P. serotina*, and *Q. rubra*; *Pa. chloris** on *Q. rubra*; and *Pr. badia** on *F. grandifolia* (Table 1). The mummies were probably made by a species of *Triraphis* based upon images of the host remains (JTL).

Other hosts: Yu et al. (2005) listed records of *Is. lycaenae* from five species of Braconidae and two species of Ichneumonidae; they also record it from nine lepidopteran species in seven families. Records of *Is. lycaenae* as a primary parasitoid are questionable for the reasons discussed above.

Orthogonalys Schulz (Trigonaloidea
Trigonalidae: Orthogonalinae)
(Figs. 70–71)

Diagnosis.—Antenna black with white or light yellow band in middle; propodeum usually with light markings; metasoma thin, without punctures, usually entirely orange; without female armature; male antenna without tyloids.

Fauna.—Carmean and Kimsey (1998) listed 11 species worldwide, one from

eastern North America, one from South America, and the others from India, Vietnam, Japan, Taiwan, Madagascar, and southern Africa. An additional species was described from eastern North America by Smith and Stocks (2005). Carmean and Kimsey (1998) gave a discussion of the genus.

Biology.—Although some species are collected rather commonly, very little is known about hosts and biology. Seasonal flight activity of *O. pulchella* in eastern North America was recorded in D. Smith (1996). Carlson (1979b) reported *O. pulchella* from a tachinid parasitizing an undetermined species of Lepidoptera. Benoit (1951) recorded *O. hova* Bischoff from a limacodid moth in Madagascar. The first verified host records were reported by Murphy et al. (2009) from tachinids parasitizing limacodids, noctuids, and megalopygids. The female deposits numerous eggs on leaves of angiosperms. The eggs are ingested by caterpillars feeding on the leaves, eclosion occurs in the gut of the caterpillar, and the first instar bores through the gut wall. Further development depends on parasitization of the caterpillar by a parasitoid, in this case a tachinid (Murphy et al. 2009). The other Nearctic species, *O. bella* Smith and Stocks, is known from a single specimen from Great Smoky Mountains National Park, Tennessee.

Literature.—Townes (1956) revised the North American Trigonalidae and separated *Orthogonalys* from other genera. The genus was treated in D. Smith (1996), and seasonal flight data were given for *O. pulchella*. Carmean and Kimsey (1998) gave a diagnosis and description and provided the known distribution and biology of the genus. Murphy et al. (2009) recorded hosts for *O. pulchella*.

North American Records:

Orthogonalys pulchella (Cresson) (Figs. 70–71): *Trigonalys pulchellus* Cresson,

1867: 351. Holotype ♂, ANSP (not examined).

This species and *O. bella* are the only species of *Orthogonalys* in North and Central America. They are illustrated and separated by Smith and Stocks (2005). *Orthogonalys bella*, known only from a female, is almost entirely black, has antennal segments 7–9 white, smaller eyes slightly diverging below and far removed from the posterior margin of the head, tarsal claws with both teeth subequal in size, and the sheath in lateral view broadly rounded at its apex. Figures 58 and 59 show the typical color of *O. pulchella*. There is some variation in the amount of black on the mesosoma and dorsum of the metasoma.

Distribution: Southeastern Canada, eastern U.S.A., Mexico.

Limacodidae: Associated with primary parasitoids of *Iso. beutenmuelleri* and *I. textual*. Most records are from tachinids parasitizing *I. textula* feeding on *Q. prinus* and *Q. rubra*.

Other hosts: *Uramya pristis* parasitizing *Meg. crispata* (Megalopygidae), *Isochaetes beutenmuelleri*, *I. textula*, and *Acrocnicta increta* (Noctuidae) (Murphy et al. 2009). Recorded parasitizing *Com. concinnata* through *Actias luna* (L.) (Kellogg et al. 2003).

Taeniogonalos Schulz (Trigonaloida
Trigonalidae: Trigonalinae)
(Figs. 18, 72–73)

Diagnosis.—Antenna uniformly yellow brown or brown becoming darker apically, never banded (Figs. 72–73); metasoma stout, with punctures, black with transverse yellow stripes; female with armature (Fig. 72); male antenna with tyloids (ventral sensory structures).

Fauna.—*Taeniogonalos* is the most widely distributed of all trigonalid genera. Carmean and Kimsey (1998) listed 34

species worldwide from the Nearctic, Neotropical, eastern Palearctic, Australasian, Oriental, and Afrotropical regions. Most are from eastern Asia and South America. Only one species, *Taeniogonalos gundlachii*, occurs in eastern North America.

Biology.—Species of this genus have been reared from a variety of tachinid and ichneumonid parasitoids of species of Pyralidae, Noctuidae, Saturniidae, Megalopygidae, and Arctiidae. A summary of their biology and hosts was given by D. Smith (1996) and Carmean and Kimsey (1998). Krauth and Williams (2006) recorded *T. gundlachii* from an arctiid, *Euchaetes egle* (Drury), in Wisconsin. Additionally, there is one record from a tachinid parasitizing a detritivore tipulid, *Tipula ?flavoumbrosa* (Gelhaus 1987). The African *Taeniogonalos maynei* Benoit was reared from pupae of *Latoia albipunctata* Holland (Limacodidae) in which it presumably was parasitizing a primary parasitoid (Benoit 1950). In Australia, *T. maculata* (Smith) and *T. venatoria* Riek have been reared as primary parasitoids from pergid sawfly hosts including *Pergagraptia condei* Benson, *Perga dorsalis* Leach, *P. affinis* Kirby, and *Pseudoperga belinda* (Kirby) (Raff 1934; Carne 1969; Weinstein and Austin 1991, 1995, 1996). Oviposition and general biology are similar to that described for *Orthogonalys*.

Literature.—Townes (1956) separated the genus (as *Poecilogonalos*) from other North American genera. The genus was also separated from other eastern North American trigonalids and the seasonal activity of its species recorded in D. Smith (1996).

North American Records:

Taeniogonalos gundlachii (Cresson) (Figs. 18, 72–73): *Poecilogonalos gundlachii* Cresson, 1865: 10. Holotype ♂, ANSP (not examined).

This is the only species of *Taeniogonalos* in eastern North America. Two other species

occur in southern Mexico and Central America. The typical color of eastern North and Central American specimens is shown in Figs. 72–73. Specimens from Cuba are more extensively yellow, especially the head and mesosoma, whereas some specimens from the southern tier of states from Florida to Louisiana are somewhat intermediate in color. Carmean and Kimsey (1998) considered all as a single widespread, variable species. In the literature prior to Carmean and Kimsey (1998), the eastern North American species is cited as *Poecilogonalos costalis* (Cresson).

Distribution: Southeastern Canada, eastern U.S.A. from Massachusetts to Florida west to Wisconsin, Ohio, Louisiana; Costa Rica, Cuba.

Limacodidae: Associated with primary parasitoids of *E. delphinii*.

Other hosts: One specimen reared from a tachinid, probably *Com. concinnata* parasitizing *E. delphinii* feeding on *Nyssa sylvatica*. Recorded parasitizing *Com. concinnata* through *Actias luna* (L.) (Kellogg et al. 2003).

Questionable/Invalid/Miscellaneous Parasitoid Records (North America)

Tachinidae

The following are single records that require confirmation, or in the case of *Chaetexorista javana*, involve an introduced species that is probably no longer extant in North America. Some records may be based on misidentifications or represent rare or accidental host records.

(1) *Carcelia* spp. (Exoristinae: Eryciini):

Adoneta spinuloides (Brauer and Bergenstamm 1895, as *Chaetolyga* sp.), *Ph. pithecium* (Patton 1958, ex “hag-moth”, “*Phobetron pithecium?*”). Both records cited by Arnaud (1978).

(2) *Chaetexorista javana* Brauer and Bergenstamm, 1895 (Exoristinae: Exoristini):

Monema flavescens (numerous records, see Arnaud 1978). *Chaetexorista javana* was introduced into Massachusetts from Japan in 1929 and 1930 for control of the Oriental moth, *M. flavescens* (Dowden 1946). The introduction was successful, but *Ch. javana* has not been reported for many years and is probably now extinct in North America. Similarly, *M. flavescens* is likely extinct in North America also based on subsequent searches (M. Epstein pers. comm.).

(3) *Hyphantrophaga virilis* (Aldrich and Webber, 1924) (Exoristinae: Goniini):

Euclea delphinii (Coquillett 1897, as *Exorista blanda* (Osten Sacken) ex *E. cippus* (Cramer)). The original record by Coquillett (1897) was later cited by Aldrich and Webber (1924, as *Zenillia blanda blanda* (Osten Sacken)), Sellers (1943, as *Z. virilis*), and Arnaud (1978, as *Eusisyropa virilis*).

(4) *Lixophaga mediocris* Aldrich, 1925 (Exoristinae: Blondeliini):

Monema flavescens (Brimley 1938, “reared from twig infested by Oriental moth”; Arnaud 1978 [citing Brimley record]).

(5) *Neomintho celeris* (Townsend, 1919) (Tachininae: Euthelairini):

Packardia ceanothi Dyar (Raizenne 1952, as *Eupelecotheca celer*; Arnaud 1978 [citing Raizenne record, also as *Eupelecotheca celer*]).

Hymenoptera

(Note: None of the taxa listed below appear in Table 1)

(1) *Closterocerus cinctipennis* Ashmead (Eulophidae: Entedoninae):

Associated with *Ac. stimulea* on *Q. rubra* (no host remains), but this species is possibly the result of a contaminant introduced during rearing as they are known parasitoids of microlepidopteran,

buprestid, and agromyzid leafminers; eggs of Chrysomelidae and Tenthredinidae; and “Diptera on *Catalpa*” (Hansson 1994).

(2) *Neochrysocharis diastatae* (Howard) (Eulophidae: Entedoninae):

Associated most frequently with lepidopteran and dipteran leaf/stem miners (Hansson 1995). Five specimens are associated with *E. delphinii* on *Q. alba*, but the limacodid remains offer no indication of parasitization (e.g., emergence holes). We suspect that a leaf miner parasitized by *Neo. diastatae* was introduced during the rearing of the larva.

(3) *Horismenus* sp. (Eulophidae: Entedoninae):

A single male is associated with *Ac. stimulea* on *Q. rubra* (no host remains) but became infected with fungus after emergence, obscuring morphological features. It was run through Burks’ (1971) key to Nearctic species (even though key is written for females) and compared with males of species near which it keyed. It is not conspecific with males of *Ho. latrodecti* Burks or *Ho. carolinensis* Burks. Two extralimital species from the Neotropics, *Ho. clavicornis* Cameron and *Ho. hipparchia* Cameron, attack *Ph. hipparchia* in Guyana (De Santis 1979).

(4) *Aroplectrus dimerus* Lin (Eulophidae: Eulophinae):

This species is known from the Philippines, Taiwan, China, and India and recorded from *Pa. bicolor* (Singh et al. 1988) and *Penthocrates* sp. (Fry 1989). It was released in Hawaii beginning in 2010 as part of a biological control program against the invasive limacodid *Darna pallivitta* (Moore) (HDOA 2010, 2011; Conant et al. 2011). Although neither *D. pallivitta* nor *Ar. dimerus* are currently known from the U.S.A., it is highly likely that the limacodid will be introduced into California given its history of interception at ports of entry

(CDFA 2005, 2006). Were this to happen, it is possible that *A. dimerus* would be introduced also, either accidentally or, later, deliberately.

(5) *Brachymeria euploaeae* (Westwood) (Chalcididae: Chalcidinae):

Recorded from the U.S.A. (but not attacking a limacodid) and as a parasitoid on *Chalcoscelis albiguttata* Snellen in Bhutan (as Butjan) and Maluku Islands (as Moluccas) (Thompson 1954). *Chalcoscelis albiguttata* does not occur in the U.S.A. and has never been introduced (M. Epstein pers. comm.). The recorded distribution for *Br. euploaeae* is in eastern and southeastern Asia and India with the lone U.S.A. record (Thompson 1954) standing out as the single record for the Western Hemisphere. Other host records and associated references are presented in Cock (1987). The Thompson (1954) record indicates that *Br. euploaeae* was introduced into the U.S.A. from Japan to control *Ostrinia* (as *Pyrausta*) *nubilalis* (Hübner). All of the limacodid hosts recorded for *Br. euploaeae* are distributed in eastern and southeastern Asia and India.

(6) *Brachymeria lasus* Walker (Chalcididae: Chalcidinae):

This species is native to the Oriental and Australasian regions but has been introduced into the U.S.A. several times to control the gypsy moth (*L. dispar*; Weseloh and Anderson 1982, ROBO Database 1981–1985), fall webworm (*Hyphantria cunea* Drury; ROBO Database 1981–1985), and range caterpillar (*Hemileuca oliviae* Cockerell; ROBO Database 1981–1985). Known limacodid hosts include *Thosea cinereomarginata* Banks and *Th. sinensis* Walker from the Philippines (Baltazar 1965). This species has a broad host range on small lepidopteran pupae and is facultatively hyperparasitic through hymenopterans and dipterans (Cock 1987).

(7) *Conura immaculata* (Cresson) (Chalcididae: Chalcidinae):

This species is primarily Neotropical but occurs in southern U.S.A., although it is not associated with Limacodidae there. It has been recorded parasitizing *N. subpectinata* Dyar and *Euprosterna elaea* (as *elaeasa*) Dyar (Delvare 1992), primarily Neotropical species, in that region. It is also known as a hyperparasitoid on Ichneumonoidea (Delvare 1992), and Burks (1979) recorded it from *Meteor* sp. (Braconidae) from Cameron County, Texas. The latter specimens and parasitoid pupal remains are housed in the USNM. Lingren (1977) records it as a hyperparasitoid of *Campeletis sonorensis* (Cameron) through *Heliothis virescens* (F.) on cotton in Brownsville, Texas.

(8) *Conura lasnierii* Guérin-Ménéville (Chalcididae: Chalcidinae):

This chalcidid is recorded from Florida in the U.S.A. but is not known from a limacodid host. It has been recorded from *Leucophobeton argentiflua* Hübner in Cuba (Gahan 1934). The moth has never been intentionally introduced into the U.S.A. (M. Epstein pers. comm.). Additionally, *Ala. slossoniae*, a common species in Florida, is closely related to the monotypic *Leucophobeton* and perhaps congeneric (M. Epstein pers. comm.).

(9) *Trichopria* sp. (Diapriidae: Diapriinae):

A single male is associated with *E. delphinii* on *Q. alba* and is likely the result of contamination during the rearing process (see *Neochrysocharis diastatae*, above). Species of Diapriinae are recorded as parasitoids of orthorhaphous (soldier flies, flower flies, etc.) and cyclorhaphous (tachinid flies, muscoid flies, etc.) Diptera (www.diapriid.org/public/site/diapriid/home). The larval cadaver associated with this specimen was thoroughly dissected in search of a tachinid puparium that would have likely served as the host in this instance, but none was discovered. There was no evidence of any

type of emergence from the cadaver during the pre-dissection inspection.

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LITERATURE CITED

- van Achterberg, C. 1991. Revision of the genera of the Afrotropical and W. Palaearctic Rogadinae Foerster (Hymenoptera: Braconidae). *Zoologische Verhandlungen* 273: 1–102.
- Adams, J. and D. Yanega. 1991. The lepidopteran host of a Neotropical bombyliid fly (Lepidoptera: Limacodidae, Diptera: Bombyliidae). *Journal of the Kansas Entomological Society* 64: 443–444.
- Aiello, A. 1980. *Systropus columbianus* (Diptera: Bombyliidae [sic]) reared from a larva of Limacodid moth. *Entomological News* 91: 89–91.
- Aldrich, J. M. 1921. The muscoid genera *Pseudeuanta* and *Uramyia* (Diptera). *Insecutor Inscitiae Menstruus* 9: 83–92.
- Aldrich, J. M. 1925. Two new species of the tachinid genus *Lixophaga*, with notes and key (Diptera). *Proceedings of the Entomological Society of Washington* 27: 132–136.
- Aldrich, J. M. and R. T. Webber. 1924. The North American species of parasitic two-winged flies belonging to the genus *Phorocera* and related genera. *Proceedings of the United States National Museum* 63 (Art. 17) [= No. 2486]: 1–90.
- André, E. 1881. Notes hyménoptérologiques. I. Chalcidites. *Annales de la Société Entomologique de France* (6^e Série) 1: 332–344.
- Arnaud, P. H., Jr. 1978. A host-parasite catalog of North American Tachinidae (Diptera). United States Department of Agriculture. Miscellaneous Publication 1319: 1–860.
- Ashmead, W. H. (1888) 1889. Descriptions of new Braconidae in the collection of the U. S. National Museum. *Proceedings of the United States National Museum* 11: 611–671. doi:10.5479/si.00963801.11-760.611
- Ashmead, W. H. 1890. Description of new Ichneumonidae in the collection of the U.S. National Museum. *Proceedings of the United States National Museum* 12: 387–451. doi:10.5479/si.00963801.12-779.387
- Ashmead, W. H. 1893. A monograph of the North American Proctotrypidae. *Bulletin of the United States National Museum* 45: 1–472. doi:10.5479/si.03629236.45.1
- Ashmead, W. H. 1896. Descriptions of new parasitic Hymenoptera. *Transactions of the American Entomological Society* 23: 179–234.
- Ashmead, W. H. 1897. Two new parasites from *Eupoeya slossoniae*. *Canadian Entomologist* 29: 113–114. doi:10.4039/Ent29113-5
- Ashmead, W. 1904. Classification of the chalcid flies of the superfamily Chalcidoidea, with descriptions of new species in the Carnegie Museum, collected in South America by Herbert H. Smith. *Memoirs of the Carnegie Museum* 1: 225–551.
- Askew, R. R. 1971. *Parasitic Insects*. Heinemann Educational Books, London, England. 316 pp.
- Austin, A. D. 1987a. A review of the Braconidae (Hymenoptera) that parasitize Limacodidae in Southeast Asia, particularly those associated with coconut and oil palm, pp. 139–164. *In* M. J. W. Cock, H. C. J. Godfray, and J. D. Holloways, eds. *Slug and Nettle Caterpillars. The Biology, Taxonomy and Control of the Limacodidae of Economic Importance on Palms in South-east Asia*. CAB International, Wallingford, Oxon, United Kingdom. 270 pp.
- Austin, A. D. 1987b. Ceraphronidae, pp. 181–183. *In* M. J. W. Cock, H. C. J. Godfray, and J. D. Holloways, eds. *Slug and Nettle Caterpillars. The Biology, Taxonomy and Control of the Limacodidae of Economic Importance on Palms in South-east Asia*. CAB International, Wallingford, Oxon, United Kingdom. 270 pp.
- Baltazar, C. R. 1965. A new species of ichneumonfly and a chalcid wasp parasitic on slug caterpillars in Basilan Island. *Philippine Journal of Plant Industry* 30: 109–113.
- Barbosa, P. and A. Caldas. 2004. Patterns of parasitoid-host associations in differently parasitized macrolepidopteran assemblages on black willow *Salix nigra* (Marsh) and box elder *Acer negundo* L. *Basic and Applied Ecology* 5: 75–85.
- Barbosa, P., J. L. Capinera, and E. A. Harrington. 1975. The gypsy moth parasitoid complex in western Massachusetts: a study of parasitoids in areas of high and low host density. *Environmental Entomology* 4: 842–846.
- Barbosa, P. and A. Caldas. 2004. Patterns of parasitoid-host associations in differently parasitized macrolepidopteran assemblages on black willow *Salix nigra* (Marsh) and Box Elder *Acer negundo* L. *Basic and Applied Ecology* 5: 75–85.
- Becker, V. O. and M. E. Epstein. 1995. Limacodidae, pp. 128–132. *In* J. B. Heppner, ed.

- Checklist: Part 2. Hyblaeoidea – Pyraloidea – Torticoidea. Atlas of Neotropical Lepidoptera. Scientific Publishers, Gainesville, Florida.
- Benoit, P. L. G. 1950. Les Trigonaloidae du Congo Belge (Hym. – Terebr.). *Revue de Zoologie et de Botanique Africaines* 43: 216–221.
- Benoit, P. L. G. 1951. La systematique des Trigonaloidae (Hym.) ethiopiens. *Revue de Zoologie et de Botanique Africaines* 44: 141–147.
- Boettner, G. H., J. S. Elkinton, and C. J. Boettner. 2000. Effects of a biological control introduction on three nontarget native species of saturniid moths. *Conservation Biology* 14: 1798–1806. doi:10.1046/j.1523-1739.2000.99193.x
- Bouček, Z. 1992. The New World genera of Chalcididae. *Memoirs of the American Entomological Institute* 53: 49–118, 443–446.
- Bouček, Z. and G. Delvare. 1992. The identities of species described or classified under *Chalcis* by J. C. Fabricius. *Memoirs of the American Entomological Institute* 53: 29.
- Bouček, Z. and J. Halstead. 1997. Chalcididae, pp. 151–164. In G. A. P. Gibson, J. T. Huber, and J. B. Woolley, eds. *Annotated Keys to the Genera of Nearctic Chalcidoidea* (Hymenoptera). Research Press. National Research Council of Canada, Ottawa, Ontario. 794 pp.
- Bourchier, R. S. 1991. Growth and development of *Compsilura concinnata* (Meigan [sic]) (Diptera: Tachinidae) parasitizing gypsy moth larvae feeding on tannin diets. *Canadian Entomologist* 123: 1047–1055. doi:10.4039/Ent1231047-5
- Brauer, F. and J. E. von Bergenstamm. 1895. Die Zweiflügler des Kaiserlichen Museums zu Wien. VII. Vorarbeiten zu einer Monographie der Muscaria schizometopa (exclusive Anthomyidae). Pars IV. F. Tempisky, Wien. 88 pp. ([Also published in 1895. In *Denkschriften der Kaiserlichen Akademie der Wissenschaften*. Wien. Mathematisch-Naturwissenschaftliche Classe, 61 (1894), 537–624.])
- Brimley, C. S. 1938. The Insects of North Carolina. Being a List of the Insects of North Carolina and Their Close Relatives. North Carolina Department of Agriculture, Raleigh. 560 pp.
- Brues, C. 1906. Notes and descriptions of North American parasitic Hymenoptera. II. *Bulletin of the Wisconsin Natural History Society* 4: 143–152.
- Brues, C. 1916. Serphoidea, pp. 529–576. In H. L. Viereck, ed. *Guide to the Insects of Connecticut*. Part III. The Hymenoptera, or Wasp-like Insects, of Connecticut. Chalcidoidea. *Bulletin. Connecticut State Geological and Natural History Survey* 22: 1–848.
- Buffington, M. L., R. Burks, and L. McNeil. 2005. Advanced techniques for imaging parasitic Hymenoptera (Insecta). *American Entomologist* 51: 50–56.
- Buffington, M. L. and M. W. Gates. 2008. Advanced imaging techniques II: using a compound microscope for photographing point-mount specimens. *American Entomologist* 54: 222–224.
- Burks, B. D. 1940. Revision of the chalcid-flies of the tribe Chalcidini in America north of Mexico. *Proceedings of the United States National Museum* 88: 237–354. doi:10.5479/si.00963801.88-3082.237
- Burks, B. D. 1966. The North American species of *Pediobius* Walker (Hymenoptera: Eulophidae). *Proceedings of the Entomological Society of Washington* 68: 33–43.
- Burks, B. D. 1971. The Nearctic species of *Horismenus* Walker (Hym., Eulophidae). *Proceedings of the Entomological Society of Washington* 73: 68–83.
- Burks, B. D. 1979. Torymidae (Agaoninae) and all other families of Chalcidoidea (excluding Encyrtidae), pp. 748–749, 768–889, 967–1043. In K.V. Krombein, P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. *Catalog of Hymenoptera in America North of Mexico*. Vol 1. Smithsonian Institution Press, Washington, D.C. 1198 pp.
- Butler, L. 1993. Parasitoids associated with the macrolepidoptera community at Coopers Rock State Forest, West Virginia: a baseline study. *Proceedings of the Entomological Society of Washington* 95: 504–510.
- California Department of Food and Agriculture (CDFA). 2005. *Darna pallivitta*, p. 21. California Plant Pest and Disease Report 22: 1–76.
- California Department of Food and Agriculture (CDFA). 2006. *Darna pallivitta*, p. 12. California Plant Pest and Disease Report 23: 1–117.
- Cameron, P. 1913. The Hymenoptera of the Georgetown Museum. Part V. Timehri, Guyana 3: 105–137.
- Cantrell, B. K. 1986. An updated host catalogue for the Australian Tachinidae (Diptera). *Journal of the Australian Entomological Society* 25: 255–265. doi:10.1111/j.1440-6055.1986.tb01112.x
- Cantrell, B. K. and R. W. Crosskey. 1989. Family Tachinidae, pp. 733–784. In N. L. Evenhuis, ed. *Catalog of the Diptera of the Australasian and Oceanian Regions*. Bishop Museum

- Special Publication 86. Bishop Museum Press (Honolulu) and E. J. Brill (Leiden). 1155 pp.
- Carlos, C. R., J. R. Costa, C. B. Tão, F. Alves, and L. M. Torres. 2006. Natural parasitism of the grape berry moth, *Lobesia botrana* (Denis & Schiffermüller) at Região Demarcada do Douro. *Boletim de Sanidad Vegetal, Plagas* 32: 355–362.
- Carlson, R. W. 1979a. Family Ichneumonidae, pp. 315–740. In K. V. Krombein, P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. *Catalog of Hymenoptera in American North of Mexico*. Vol. 1. Smithsonian Institution Press, Washington, D.C. 1198 pp.
- Carlson, R. W. 1979b. Superfamily Trigonoidea, pp. 1197–1198. In K. V. Krombein, P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. *Catalog of Hymenoptera in American North of Mexico*. Vol. 1. Smithsonian Institution Press, Washington, D.C. 1198 pp.
- Carnean, D. and L. Kimsey. 1998. Phylogenetic revision of the parasitoid wasp family Trigonalidae (Hymenoptera). *Systematic Entomology* 23: 35–76. doi:10.1046/j.1365-3113.1998.00042.x
- Carne, P. B. 1969. On the population dynamics of the *Eucalyptus*-defoliating sawfly *Perga affinis affinis* Kirby (Hymenoptera). *Australian Journal of Zoology* 17: 113–141. doi:10.1071/ZO9690113
- Chadwick, C. E. and M. I. Nikitin. 1985. Records of parasitism by members of the family Tachinidae (Diptera: Tachinidae). *Australian Zoologist* 21: 587–598.
- Cháves, T. H. A., D. I. A. Díaz, and G. R. A. Briceño. 1993. Introduction to Venezuela and biology of *Cotesia plutellae* Kurdj. (Hymenoptera: Braconidae), parasitoid of *Plutella xylostella* L. (Lepidoptera: Plutellidae). *Manejo Integrado de Plagas* No. 29: 24–27.
- Chen, X. and J. He. 1997. Revision of the subfamily Rogadinae (Hymenoptera: Braconidae) from China. *Zoologische Verhandlungen* 308: 1–187.
- Clausen, C. P. 1956. Biological control of insect pests in the continental United States. United States Department of Agriculture Technical Bulletin No. 1139: 1–151.
- Cock, M. J. W. 1987. Chalcidoidea. Notes on the chalcidoids attacking South-east Asian Limacodidae, pp. 165–179. In M. J. W. Cock, H. C. J. Godfray, and J. D. Holloways, eds. *Slug and Nettle Caterpillars: the Biology, Taxonomy, and Control of the Limacodidae of Economic Importance on Palms in South-east Asia*. CAB International, Wallingford, Oxon, United Kingdom. 270 pp.
- Cock, M. J. W., H. C. J. Godfray, and J. D. Holloway. 1987. *Slug and Nettle Caterpillars: the Biology, Taxonomy, and Control of the Limacodidae of Economic Importance on Palms in South-east Asia*. CAB International, Wallingford, United Kingdom. 270 pp.
- Collins, C. 1933. The Oriental moth (*Cnidocampa flavescens* Walk.) in Massachusetts and the work of its newly introduced parasite. *Journal of Economic Entomology* 26: 54–57.
- Conant, P., A. H. Hara, L. M. Nakahara, and R. A. Heu. 2002. Nettle caterpillar, *Darna pallivitta* Moore (Lepidoptera: Limacodidae). New Pest Advisory No. 01–03. Hawaii Department of Agriculture, Honolulu, HI.
- Conant, P., A. H. Hara, W. T. Nagamine, C. M. Kishimoto, and R. A. Heu. 2011. Nettle caterpillar, *Darna pallivitta* Moore (Lepidoptera: Limacodidae). New Pest Advisory No. 01–03, updated. Hawaii Department of Agriculture, Honolulu, HI.
- Conant, P., C. K. Hirayama, C. M. Kishimoto, and A. H. Hara. 2006. *Trichogramma papilionis* (Nagarkatti), the first recorded *Trichogramma* species to parasitize eggs in the family Limacodidae. *Proceedings of the Hawaiian Entomological Society* 38: 133–135.
- Cook, A. J. and G. C. Davis. 1891. Kerosene emulsion, some new insects. *Bulletin of the Michigan Agricultural Experiment Station* 73: 1–16.
- Coquillett, D. W. 1897. Revision of the Tachinidae of America north of Mexico. A family of parasitic two-winged insects. United States Department of Agriculture. Division of Entomology. Technical Series 7: 1–156.
- da Costa Lima, A. 1962. Insetos do Brasil. 12° Tomo. Hymenópteros. 2a Parte. Escola Nacional de Agronomia (Série Didáctica N° 14), Rio de Janeiro. 393 pp.
- Cresson, E. T. 1865. On the Hymenoptera of Cuba. *Proceedings of the Entomological Society of Philadelphia* 4: 1–200.
- Cresson, E. T. 1867. Descriptions of two new species of *Trigonalys*. *Proceedings of the Entomological Society of Philadelphia* 6: 351–352.
- Cresson, E. T. 1869. List of the North American species of the genus *Aleiodes* Wesmael. *Transactions of the American Entomological Society* 2: 377–382.
- Cresson, E. T. 1872. Synopsis of the North American species belonging to the genera *Leucospis*,

- Smicra* and *Chalcis*. Transactions of the American Entomological Society 4: 29–60.
- Crosskey, R. W. 1976. A taxonomic conspectus of the Tachinidae (Diptera) of the Oriental Region. Bulletin of the British Museum (Natural History). Entomology Supplement 26: 1–357.
- Cruttwell, R. E. 1969. The biology and mode of parasitism of *Uromacquartia trinitatis* Thompson (Diptera: Tachinidae). Commonwealth Institute of Biological Control. Technical Bulletin 12: 20–28.
- Culver, J. J. 1919. A study of *Compsilura concinnata*, an imported tachinid parasite of the gypsy moth and the brown-tail moth. Bulletin of the United States Bureau of Entomology 766: 1–27.
- Curran, C. H. 1930. Report on the Diptera collected at the Station for the Study of Insects, Harriman Interstate Park, N.Y. Bulletin of the American Museum of Natural History 61: 21–115.
- Cushman, R. A. 1925. The synonymy and generic position of two North American ichneumonflies. Proceedings of the Entomological Society of Washington 27: 164–166.
- Dasch, C. 1971. Ichneumonflies of America North of Mexico: 6. Subfamily Mesochorinae. Memoirs of the American Entomological Institute 16: 1–376.
- Davis, D. R. 1983. Limacodidae, pp. 66–67. In R. W. Hodges, ed. Checklist of the Lepidoptera of America North of Mexico. E. W. Classey Ltd and The Wedge Entomological Research Foundation, London, England. 284 pp.
- Deans, A. R., I. Miko, M. J. Yoder, K. S. Seltmann, and The H. A. O. Consortium. [Wed Mar 17 10:45:36 -0500 2010]. Hymenoptera Glossary: <http://purl.oclc.org/NET/hymontology>
- Delvare, G. 1992. A reclassification of the Chalcidini with a checklist of the New World species. Memoirs of the American Entomological Institute 53: 119–441, 443–466.
- De Santis, L. 1979. Catálogo de los himenópteros calcidoideos de América al sur de los Estados Unidos. Publicación Especial Comisión de Investigaciones Científicas Provincia de Buenos Aires. La Plata, Argentina. 488 pp.
- De Santis, L. 1987. Himenópteros parasitoides e Hiperparasitoides de *Anacraga* sp. (Lepidoptera, Dalceridae) en Brasil. Revista Brasileira de Entomologia 31: 97–99.
- De Santis, L. and P. Fidalgo. 1994. Catalogo de Himenopteros Calcidoideos. Serie de la Academia Nacional de Agronomia y Veterinaria No 13: 1–145.
- Dessart, P. 1981. Definition de queleques sous-genres de Ceraphron Jurine, 1807 (Hymenoptera, Ceraphronoidea, Ceraphronidae). Bulletin de l'Institut Royal des Sciences Naturelles de Belgique 53: 1–23.
- Dessart, P. and P. Cancemi. 1986. Tableau dichotomique des genres de Ceraphronoidea (Hymenoptera) avec commentaires et nouvelles espèces. Frustula Entomologica N. S. 7–8(20–21): 307–372.
- Dowden, P. B. 1946. Parasitization of the Oriental moth (*Cnidocampa flavescens* (Walk.)) by *Chaetexorista javana* B. and B. Annals of the Entomological Society of America 39: 225–241.
- Dyar, H. G. 1897. On the white Eucleidae and the larva of *Calybia slossoniae* (Packard). Journal New York Entomological Society 5: 121–126 (plate 5).
- Dyar, H. G. 1900. Life history of a South American slug-caterpillar *Sibine fusca* Stoll. Entomological News 11: 517–526.
- Elkinton, J. S. and G. H. Boettner. 2004. The effects of *Compsilura concinnata*, an introduced generalist tachinid, on non-target species in North America: a cautionary tale, pp. 4–14. In R. G. Van Driesche and R. Reardon, eds. Assessing Host Ranges for Parasitoids and Predators Used for Classical Biological Control: a Guide to Best Practice. United States Department of Agriculture Forest Health Technology Enterprise Team, Morgantown, West Virginia. FHTET-2004–03. 243 pp.
- Elkinton, J. S. and A. M. Liebhold. 1990. Population dynamics of gypsy moth in North America. Annual Review of Entomology 35: 571–596. doi:10.1146/annurev.en.35.010190.003035
- Elkinton, J. S., D. Parry, and G. H. Boettner. 2006. Implicating an introduced generalist parasitoid in the invasive browntail moth's enigmatic demise. Ecology 87: 2664–2672. doi:10.1890/0012-9658(2006)87[2664:IAIGPI]2.0.CO;2
- Enderlein, G. 1926. Zur Kenntnis der Bombyliiden-Subfamilie Systropodinae (Dipt.). Wiener Entomologische Zeitung 43: 69–92.
- Epstein, M. 1988. An overview of slug caterpillar moths (Lepidoptera: Limacodidae) with emphasis on genera in the New World *Parasa* Group. Doctoral thesis, Department of Entomology, University of Minnesota, St. Paul, Minnesota. xi + 149 pp.
- Epstein, M. 1996. Revision and phylogeny of the limacodid group families, with evolutionary

- studies on slug caterpillars (Lepidoptera: Zygaenoidea). *Smithsonian Contributions to Zoology* 582: 1–102. doi:10.5479/si.00810282.582
- Epstein, M. 1997. *Parasa indetermina* (Boisduval) (Lepidoptera: Limacodidae), a new host for *Systropus macer* Loew (Diptera: Bombyliidae). *Proceedings of the Entomological Society of Washington* 99: 585–586.
- Evans, G. A and L. A. Stange. 1997. Parasitoids associated with the brown citrus aphid, *Toxoptera citricida*, in Florida (Insecta: Hymenoptera). Florida Department of Agriculture and Consumer Service, Division of Plant Industry, Entomology Circular No. 384 Gainesville, Florida. 5 pp.
- Evenhuis, N. L. 1982. Catalog of primary types of Bombyliidae (Diptera) in the entomological collections of the Museum of Comparative Zoology, with designations of lectotypes. *Breviora* 469: 1–23.
- Evenhuis, N. L. and D. J. Greathead. 1999. *World Catalog of Bee Flies (Diptera: Bombyliidae)*. Backhuys Publishers, Leiden. xviii + 756 pp.
- Evenhuis, N. L. and D. J. Greathead. 2003. *World Catalog of Bee Flies (Diptera: Bombyliidae)* Web site (<http://hbs.bishopmuseum.org/bombcat/>). [accessed May 2011].
- Fabricius, J. C. 1798. *Supplementum Entomologiae Systematicae*. Proft and Storch, Copenhagen. 243 pp.
- Finlayson, T. 1975. The cephalic structures and spiracles of final-instar larvae of the subfamily Campopleginae, tribe Campoplegini (Hymenoptera: Ichneumonidae). *Memoirs of the Entomological Society of Canada* 94: 1–137. doi:10.4039/entm10794fv
- Fletcher, D. S. and I. W. B. Nye. 1982. *The Generic Names of Moths of the World*. Vol. 4. British Museum (Natural History), London. 192 pp.
- Fortier, J. C. and S. R. Shaw. 1999. Cladistics of the *Aleiodes* lineage of the subfamily Rogadinae (Hymenoptera: Braconidae). *Journal of Hymenoptera Research* 8: 204–237.
- Franklin, H. J. 1919. Seventh report of the cranberry substation from 1917 to 1919. *Bulletin of the Massachusetts Agricultural Experiment Station* 192: 129.
- Fry, J. M. 1989. Natural enemy databank, 1987. A catalogue of natural enemies of arthropods derived from records in the CIBC Natural Enemy Databank, p. 94. CAB International, Wallingford, Oxford, UK. 185 pp.
- Gadd, C. H., W. T. Fonseka, and D. J. W. Rana-weera. 1946. Parasites of tea nettlegrubs with special reference to *Platyplectrus natadea* Ferrière and *Autoplectrus taprobanes* Gadd. *Ceylon Journal of Science (B)* 23: 81–94.
- Gahan, A. B. 1934. Descriptions of some new species of Chalcidoidea from Cuba and Puerto Rico. *Memorias de la Sociedad Cubana de Historia Natural, Habana* 8: 125–134.
- Gates, M. and R. Burks. 2003. Hosts and ranges. *Chalcid Forum* 25: 5 (newsletter).
- Gates, M. W. and T. Stoepler. 2010. A new species of *Alveoplectrus* Wijesekara and Schauff (Hymenoptera: Chalcidoidea: Eulophidae) parasitic on Limacodidae (Lepidoptera). *Proceedings of the Entomological Society of Washington* 112: 207–213. doi:10.4289/0013-8797-112.2.207
- Gauld, I. D. 1984. An introduction to the Ichneumonidae of Australia; with a contribution on Metopiinae by M. G. Fitton. *British Museum (Natural History)*, no. 895: 1–413.
- Gauld, I. D. 1988. Evolutionary patterns of host utilization by ichneumonoid parasitoids (Hymenoptera: Ichneumonidae and Braconidae). *Biological Journal of the Linnean Society, Linnean Society of London* 35: 351–377. doi:10.1111/j.1095-8312.1988.tb00476.x
- Gauld, I. D. 1995. 12.1 Ichneumonidae, pp. 390–431. In P. E. Hanson and I. D. Gauld, eds. *The Hymenoptera of Costa Rica*. Oxford University Press, New York.
- Gauld, I. and B. Bolton. 1988. *The Hymenoptera*. Oxford University Press, London, England. 332 pp.
- Gauld, I. and J. Fernández-Triana. 2010. Type condition and generic placement of Cuban species of Ichneumonidae described by Cresson and collected by Gundlach. *Zootaxa* 2394: 41–50.
- Gelhaus, J. K. 1987. A detritivore *Tipula* (Diptera: Tipulidae) as a secondary host of *Poecilognalos costalis* (Hymenoptera: Trigonaliidae). *Entomological News* 98: 161–162.
- Genty, P. 1972. Morfología y biología de *Sibine fusca* Stoll, Lepidoptero defoliador de la palma de aceite en Colombia. *Oléagineux* 27: 65–71.
- Genty, P., R. Desmier, J. P. Morin, and C. A. Korytkowski. 1978. Les ravageurs du palmier a huile en Amerique Latine. *Oléagineux* 33: 325–419.
- Gibson, G. A. P. 1997. Morphology and terminology. Chapter 2, pp. 16–44. In G. A. P. Gibson, J. T. Huber, and J. B. Woolley, eds. *Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera)*. Research Press, National Research Council of Canada, Ottawa, Ontario. 764 pp.

- Gibson, G. A. P., J. T. Huber, and J. B. Woolley. 1997. Annotated Key to the Genera of Nearctic Chalcidoidea (Hymenoptera). Research Press. National Research Council of Canada, Ottawa, Ontario. 764 pp.
- Girault, A. 1911. On the identity of the most common species of the family Trichogrammatidae (Hymenoptera). Bulletin of the Wisconsin Natural History Society 9: 135–165.
- Girault, A. 1916. Descriptions of miscellaneous chalcid-flies. Insector Inscitiae Menstruus 4: 109–120.
- Godfray, H. C. J. and M. S. Chan. 1990. How insecticides trigger single-stage outbreaks in tropical pests. Functional Ecology 4: 329–337. doi:10.2307/2389594
- Graham, M. W. R. de V. 1969. The Pteromalidae of north-western Europe (Hymenoptera: Chalcidoidea). Bulletin of the British Museum (Natural History). Historical Series (Supplement 16): 1–908 (Natural History).
- Greathead, D. J. 1987. Bombyliidae. A summary of the recorded parasitoids of South-east Asian Limacodidae, pp. 195–196. In M. J. W. Cock, H. C. J. Godfray, and J. D. Holloways, eds. Slug and Nettle Caterpillars: the Biology, Taxonomy, and Control of the Limacodidae of Economic Importance on Palms in South-east Asia. CAB International, Wallingford, Oxon, United Kingdom. 270 pp.
- Guimarães, J. H. 1980. Revision of the South American Uramyini (Diptera, Tachinidae). Papéis Avulsos de Zoologia 33: 191–219.
- Hall, J. 1981. Bombyliidae, pp. 589–602. In J. F. McAlpine, B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds. Manual of Nearctic Diptera, Vol. 1. Agriculture Canada Monograph, Research Branch, Agriculture Canada, Ottawa, Ontario.
- Hansson, C. 1987. New records of Swedish Eulophidae and Pteromalidae (Hymenoptera: Chalcidoidea), with data on host species. Entomologisk Tidskrift 108: 168–173.
- Hansson, C. 1994. Re-evaluation of the genus *Closterocerus* Westwood (Hymenoptera: Eulophidae), with a revision of the Nearctic species. Entomologica Scandinavica 25: 1–25. doi:10.1163/187631294X00018
- Hansson, C. 1995. Revision of the Nearctic species of *Neochrysocharis* Kurdjumov (Hymenoptera: Eulophidae). Entomologica Scandinavica 26: 27–46.
- Harris, R. 1979. A glossary of surface sculpturing. Occasional Papers in Entomology, No. 28. California State Department of Food and Agriculture, Sacramento, California, U.S.A. 31 pp.
- Harrison, J. O. 1963. The natural enemies of some banana insect pests in Costa Rica. Journal of Economic Entomology 56: 282–285.
- Harvey, J., L. M. A. Witjes, and R. Wagenaar. 2004. Development of hyperparasitoid wasp *Lysibia nana* (Hymenoptera: Ichneumonidae) in a multitrophic framework. Environmental Entomology 33: 1488–1496. doi:10.1603/0046-225X-33.5.1488
- Harvey, J. A., L. E. M. Vet, L. M. A. Witjes, and T. M. Bezemer. 2006. Remarkable similarity in body mass of a secondary hyperparasitoid *Lysibia nana* and its primary parasitoid host *Cotesia glomerata* emerging from cocoons of comparable size. Archives of Insect Biochemistry and Physiology 61: 170–183. doi:10.1002/arch.20080
- Harvey, J. A., R. Wagenaar, and M. Bexemer. 2009a. Interactions to the fifth trophic level: secondary and tertiary parasitoid wasps show extraordinary efficiency in utilizing host resources. Journal of Animal Ecology 78: 686–692. doi:10.1111/j.1365-2656.2008.01516.x
- Harvey, J. A., R. Wagenaar, and T. M. Bezemer. 2009b. Life-history traits in closely related secondary parasitoids sharing the same primary parasitoid host: evolutionary opportunities and constraints. Entomologia Experimentalis et Applicata 132: 155–164. doi:10.1111/j.1570-7458.2009.00882.x
- HDOA. 2010. Natural enemy of stinging caterpillar to be released on O’ahu. News Release 10-07. Available from: <http://hawaii.gov/hdoa/news/2010-news-releases/natural-enemy-of-stinging-caterpillar-to-be-released-on-o-ahu>. [accessed May 15, 2011].
- HDOA. 2011. Kaua’i residents asked to report sightings of stinging caterpillar. News Release 11-11. Available from: <http://hawaii.gov/hdoa/news/news-releases-2011/kaua-i-residents-asked-to-report-sightings-of-stinging-caterpillar>. [accessed June 8, 2011].
- Heraty, J. and D. Hawks. 1998. Hexamethyldisilazane – a chemical alternative for drying insects. Entomological News 109: 369–374.
- Herting, B. 1960. Biologie der westpaläarktischen Raupenfliegen. Dipt., Tachinidae. Monographien zur Angewandte Entomologie 16: 1–188.
- Herting, B. 1972. Die Typenexemplare der von Meigen (1824–1838) beschriebenen Raupenfliegen (Dipt. Tachinidae). Stuttgarter Beiträge zur Naturkunde 243: 1–15.

- Herting, B. 1976. Lepidoptera, Part 2 (Macrolepidoptera). A catalogue of parasites and predators of terrestrial arthropods. Section A. Host or Prey/Enemy, 7: 3 Commonwealth Agricultural Bureaux, Commonwealth Institute of Biological Control.
- Hoong, H. W. and C. K. Y. Hoh. 1992. Major pests of oil palm and their occurrence in Sabah. *Planter* 68: 193–210.
- Horstmann, K. 2003. Revisionen von Schlupfwespen-Arten VII. Mitteilungen der Münchner Entomologischen Gesellschaft 93: 25–37.
- Horstmann, K. 2008. Neue westpalaarktische arten der Campopleginae (Hymenoptera: Ichneumonidae). *Zeitschrift der Arveitsgemeinschaft Oesterreichischer Entomologen*. 60: 3–27.
- Horstmann, K. 2009. Typenrevisionen der von Kiss beschriebenen Taxa der Ichneumonidae III. Verschiedene Unterfamilien (Hymenoptera, Ichneumonidae). *Linxer Biologische Beiträge* 41: 673–689.
- Howard, L. O. 1889. The hymenopterous parasites of North American butterflies, pp. 1869–1896. *In* S. H. Scudder, ed. *Butterflies of Eastern United States and Canada*, Vol. III. W. Wheeler, Cambridge, Massachusetts.
- Hull, F. 1973. *Bee Flies of the World. The Genera of the Family Bombyliidae*. Smithsonian Institution Press, Washington, DC. 687 pp.
- Ichiki, R. and H. Shima. 2003. Immature life of *Compsilura concinnata* (Meigen) (Diptera: Tachinidae). *Annals of the Entomological Society of America* 96: 161–167. doi:10.1603/0013-8746(2003)096[0161:ILOCCM] 2.0.CO;2
- Janzen, D. H. and W. Hallwachs. 2009. Dynamic database for an inventory of the macro-caterpillar fauna, and its food plants and parasitoids, of Area de Conservacion Guanacaste (ACG), northwestern Costa Rica (nn-SRNP-nnnnn voucher codes). Available at <http://janzen.sas.upenn.edu>. [accessed 15-June-2010].
- Jerman, E. J. and I. Gauld. 1988. *Casinaria*, a paraphyletic ichneumonid genus (Hymenoptera), and a revision of the Australian species. *Journal of Natural History* 22: 589–609. doi:10.1080/00222938800770401
- Johnson, C. W. 1925. Fauna of New England. 15. List of the Diptera or two-winged flies. *Occasional Papers of the Boston Society of Natural History* 7: 1–326.
- Kellogg, S. K., L. S. Fink, and L. P. Brower. 2003. Parasitism of native luna moths, *Actias luna* (L.) (Lepidoptera: Saturniidae) by the introduced *Compsilura concinnata* (Meigen) (Diptera: Tachinidae) in central Virginia, and their hyperparasitism by Trigonalid wasps (Hymenoptera: Trigonalidae). *Environmental Entomology* 32: 1019–1027. doi:10.1603/0046-225X-32.5.1019
- Kerr, P. H., E. M. Fisher, and M. L. Buffington. 2008. Dome lighting for insect imaging under a microscope. *American Entomologist* 54: 198–200.
- Kits, J. H., S. A. Marshall, and N. L. Evenhuis. 2008. The bee flies (Diptera: Bombyliidae) of Ontario, with a key to the species of eastern Canada. *Canadian Journal of Arthropod Identification* No. 6, March 06, 2008, available online at http://www.biology.ualberta.ca/bsc/ejournal/kme_06/kme_06.html, doi: 10.3752/cjai.2008.06. [accessed 15-June-2010].
- Krauth, S. J. and A. H. Williams. 2006. Notes on *Taeniogonalos gundlachii* Hymenoptera: Trigonalidae) from Wisconsin. *Great Lakes Entomologist* 34: 54–58.
- Krombein, K. V., P. D. Hurd, Jr., D. R. Smith, and B. D. Burks. 1979. *Catalog of Hymenoptera in America North of Mexico*. Vol. 1. Smithsonian Institution Press, Washington, D.C. xvi + 1198 pp.
- Kula, R. R., J. T. Lill, S. M. Murphy, and T. Stoepler. (2009) 2010. The first host records for the Nearctic species *Triraphis discoideus* (Hymenoptera: Braconidae: Rogadinae). *Entomological News* 120: 380–386. doi:10.3157/021.120.0406
- Kulman, H. M. 1965. Natural control of eastern tent caterpillar and notes on its status as a forest pest. *Journal of Economic Entomology* 58: 66–70.
- La Salle, J. 1993. Parasitic Hymenoptera, biological control, and biodiversity, pp. 197–215. *In* J. La Salle and I. D. Gauld, eds. *Hymenoptera and Biodiversity*. CAB International, Wallingford, UK. 348 pp.
- Le Corff, J. and R. J. Marquis. 1999. Differences between understory and canopy in herbivore community composition and leaf quality for two oak species in Missouri. *Ecological Entomology* 24: 46–58. doi:10.1046/j.1365-2311.1999.00174.x
- Lill, J. T. 2008. Caterpillar-host plant relationships recorded from Plummers Island, Maryland (Insecta: Lepidoptera). *Bulletin of the Biological Society of Washington* 15: 75–79. doi:10.2988/0097-0298(2008)15[75:CPRRFP] 2.0.CO;2
- Lill, J. T., R. J. Marquis, R. E. Forkner, J. Le Corff, N. Holmberg, and N. A. Barber. 2006. Leaf pubescence affects distribution and

- abundance of generalist slug caterpillars (Lepidoptera: Limacodidae). *Environmental Entomology* 35: 797–806. doi:10.1603/0046-225X-35.3.797
- Lingren, P. D. 1977. *Campoletis sonorensis*: maintenance of a population on tobacco budworms in a field cage. *Environmental Entomology* 6: 72–76.
- Lourenção, A. L., L. O. de Carvalho, and D. H. de Campos Lasca. 1989. *Anacraga citrinopsis* Dyar (Lepidoptera: Dalceridae) em Mamoneira no Estado de São Paulo. *Bragantia* 48: 109–112.
- Marconato, G., M. M. Dias, and A. M. Penteadó Dias. 2008. Larvas de Geometridae (Lepidoptera) e seus parasitóides, associadas a *Erythroxylum microphyllum* St.-Hilaire (Erythroxylaceae). *Revista Brasileira de Entomologia* 52: 296–299. doi:10.1590/S0085-56262008000200010
- Marsh, P. M. 1979. Braconidae, Aphidiidae, Hybrizontidae, pp. 144–313. In K. V. Krombein, P. D. Hurd, Jr., D. R. Smith, and B. D. Burks, eds. *Catalog of Hymenoptera in America North of Mexico*. Vol. 1. Smithsonian Institution Press, Washington, D.C. 1198 pp.
- Marsh, P. M. and S. R. Shaw. 1998. Revision of North American *Aleiodes* Wesmael (Part 3): the *seriatus* (Herrich-Schaeffer) species-group (Hymenoptera: Braconidae: Rogadinae). *Proceedings of the Entomological Society of Washington* 100: 395–408.
- McAlpine, J. F. 1981. Morphology and terminology—adults. In J. F. McAlpine, B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds. *Manual of Nearctic Diptera*. Volume 1. Agriculture Canada Monograph 27: 9–63.
- McCullough, D. G., S. A. Katovich, D. L. Mahr, D. D. Neumann, C. S. Sadof, and M. J. Raupp. 1999. Biological control of insect pests in forested ecosystems: a manual for foresters, Christmas tree growers and landscapers. Michigan State University Extension Bulletin E-2679: 1–123.
- Meigen, J. W. 1824. Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten. *Vierter Theil*. Schulz-Wundermann, Hamm. xii + 428 pp. + pls. 33–41.
- Mexzón, R. G., C. M. Chinchilla, and D. Salamanca. 1996. The biology of *Sibine megasomoides* Walker (Lepidoptera, Limacodidae): observations of the pest in oil palm in Costa Rica. *ASD Oil Palm Papers* 12: 1–10.
- Morris, R. F. 1976. Relation of mortality caused by parasites to the population density of *Hyphantria cunea*. *Canadian Entomologist* 108: 1291–1294.
- Muesebeck, C. F. W. 1920. A revision of the North American species of ichneumon-flies belonging to the genus *Apanteles*. *Proceedings of the United States National Museum* 58: 483–576.
- Muesebeck, C. F. W. 1931. Descriptions of a new genus and eight new species of ichneumon-flies with taxonomic notes. *Proceedings of the United States National Museum* 79 (Art. 16) [= No. 2882]: 1–16.
- Murphy, S. M., J. T. Lill, and D. R. Smith. 2009. A scattershot approach to host location: uncovering the unique life history of the trigonalid hyperparasitoid *Orthogonalys pulchella* (Cresson). *American Entomologist* 55: 82–87.
- Murphy, S. M., S. M. Leahy, L. S. Williams, and J. T. Lill. 2010. Stinging spines protect slug caterpillars (Limacodidae) from multiple generalist predators. *Behavioral Ecology* 21: 153–160. doi:10.1093/beheco/arp166
- Nazemi, J., A. A. Talebi, S. E. Sadeghi, G. Melika, and A. Lozan. 2008. Species richness of oak gall wasps (Hymenoptera: Cynipidae) and identification of associated inquilines and parasitoids on two oak species in western Iran. *North-Western Journal of Zoology* 4: 189–202.
- Niehuis, O., S. H. Yen, C. M. Naumann, and B. Misof. 2006. Higher phylogeny of zygaenid moths (Insecta: Lepidoptera) inferred from nuclear and mitochondrial sequence data and the evolution of larval cuticular cavities for chemical defence. *Molecular Phylogenetics and Evolution* 39: 812–829. doi:10.1016/j.ympev.2006.01.007
- Noyes, J. S. 2003. Universal Chalcidoidea Database. World Wide Web electronic publication. www.nhm.ac.uk/entomology/chalcidoids/index.html. [accessed 15-June-2010].
- O'Hara, J. E., H. Shima, and C.-T. Zhang. 2009. Annotated catalogue of the Tachinidae (Insecta: Diptera) of China. *Zootaxa* 2190: 1–236.
- O'Hara, J. E. and D. M. Wood. 2004. Catalogue of the Tachinidae (Diptera) of America north of Mexico. *Memoirs on Entomology, International* 18: 1–410.
- Ostmark, H. E. 1974. Economic insect pests of bananas. *Annual Review of Entomology* 19: 161–176. doi:10.1146/annurev.en.19.010174.001113
- Painter, R. and E. Painter. 1963. A review of the subfamily Systropinae (Diptera: Bombyliidae)

- in North America. *Journal of the Kansas Entomological Society* 36: 278–348.
- Papp, J. 2004. Type specimens of the braconid species by Gy. Szépligeti deposited in the Hungarian Natural History Museum (Hymenoptera: Braconidae). *Annals Historico-Naturales Musei Nationalis Hungarici* 96: 153–223.
- Patton, C. N. 1958. A catalogue of the Larvaevoridae of Florida. *Florida Entomologist* 41: 29–39, 77–89. doi:10.2307/3492632
- Peck, O. 1963. A catalogue of the Nearctic Chalcidoidea (Insecta; Hymenoptera). *Canadian Entomologist (Supplement)* 30: 1–1420.
- Peck, O. 1985. The taxonomy of the Nearctic species of *Pediobius* (Hymenoptera: Eulophidae), especially Canadian and Alaskan forms. *Canadian Entomologist* 117: 647–704. doi:10.4039/Ent117647-6
- Petrice, T. R., J. S. Strazanac, and L. Butler. 2004. A survey of hymenopteran parasitoids of forest macrolepidoptera in the central Appalachians. *Journal of Economic Entomology* 97: 451–459. doi:10.1603/0022-0493-97.2.451
- Pinto, J. 1998. Systematics of the North American species of *Trichogramma* Westwood (Hymenoptera: Trichogrammatidae). *Memoirs of the Entomological Society of Washington* 22: 1–287.
- Pinto, J. D., G. R. Platner, and E. R. Oatman. 1978. Clarification of the identity of several common species of North American *Trichogramma* (Hymenoptera: Trichogrammatidae). *Annals of the Entomological Society of America* 71: 169–180.
- Pluciennik, Z. and R. W. Olszak. 2010. The role of parasitoids in limiting the harmfulness of leafrollers in apple orchards. *Journal of Plant Protection Research* 50: 1–8. doi:10.2478/v10045-010-0001-9
- Provancher, L. 1875. Les Ichneumonides de Québec. *Naturaliste Canadien* 7: 309–317.
- Quicke, D. L. J. 1997. *Parasitic Wasps*. Chapman and Hall, New York. 470 pp.
- Quicke, D. L. J. and M. R. Shaw. 2005. First host records for the rogadini genera *Rogasodes* Chen and He and *Canalirogas* van Achterberg and Chen (Hymenoptera: Braconidae) with description of a new species and survey of mummy types within Rogadiniinae s. str. *Journal of Natural History* 39: 3525–3542. doi:10.1080/00222930500392782
- Raff, J. W. 1934. Observations on sawflies of the genus *Perga*, with notes on some reared primary parasites of the families Trigonaliidae, Ichneumonidae, and Tachinidae. *Proceedings of the Royal Society of Victoria* 47: 54–77.
- Raizenne, H. 1952. Forest Lepidoptera of southern Ontario and their parasites received and reared at the Ottawa Forest Insect Survey Laboratory from 1937 to 1948. Canada Department of Agriculture, Science Service, Division of Forest Biology, Ottawa. v + 277 pp.
- Reinhard, H. 1865. Beiträge zur Kenntnifs einiger Braconiden-Gattungen. *Berliner Entomologische Zeitschrift* 9: 243–267. doi:10.1002/mmnd.18650090309
- Reinhard, H. J. 1935. New genera and species of American muscoid flies (Tachinidae: Diptera). *Annals of the Entomological Society of America* 28: 160–173.
- dos Reis Fernandes, L. B., M. M. Dias Filho, M. A. Fernandes, and A. M. Pentead-Dias. 2010. Ichneumonidae (Hymenoptera) parasitoids of Lepidoptera caterpillars feeding on *Croton floribundus* Spreng (Euphorbiaceae). *Revista Brasileira de Entomologia* 54: 263–269. doi:10.1590/S0085-56262010000200009
- Riley, C. V. and L. O. Howard. 1890. Some of the bred parasitic Hymenoptera in the National Collection. *Insect Life* 2: 348–353.
- Robertson, C. 1928. *Flowers and Insects. Lists of Visitors of 453 Flowers*. Science Press Printing Co., Lancaster, PA. 221 pp.
- ROBO (Release of Beneficial Organisms) Database. Introduced Parasites and Predators Released in the U. S. and Territories - by Target Host/Prey, 1981–1985. Biological Control Documentation Center, National Invertebrate Genetic Resources, <http://www.ars-grin.gov/nigrp/menu.html#link1981>. [accessed 5-June-2010].
- Rohwer, S. 1915. Descriptions of new species of Hymenoptera. *Proceedings of the United States National Museum* 49: 205–249. doi: 10.5479/si.00963801.2105.205
- Ruberson, J. R. and J. B. Whitfield. 1996. Facultative egg-larval parasitism of the beet armyworm, *Spodoptera exigua* (Lepidoptera: Noctuidae) by *Cotesia marginiventris* (Hymenoptera: Braconidae). *Florida Entomologist* 79: 296–302. doi:10.2307/3495577
- Sabrosky, C. W. and P. H. Arnaud, Jr. 1965. Family Tachinidae (Larvaevoridae), pp. 961–1108. In A. Stone, C. W. Sabrosky, W. W. Wirth, R. H. Foote, and J. R. Coulson, eds. *A Catalog of the Diptera of America North of Mexico*. United States Department of Agriculture. Agriculture Handbook 276. U.S. Government Printing Office, Washington D.C. 1696 pp.

- Say, T. 1835. Descriptions of new North American Hymenoptera, and observations on some already described. *Boston Journal of Natural History* 1(3): 210–305.
- Schaffner, J. V., Jr. 1959. Microlepidoptera and their parasites reared from field collections in the northeastern part of the United States. United States Department Agriculture Miscellaneous Publications 767: 1–97.
- Schaffner, J. V., Jr. and F. L. Griswold. 1934. Macrolepidoptera and their parasites reared from field collections in the northeastern part of the United States. United States Department Agriculture Miscellaneous Publications 188: 1–160.
- Schauff, M. E., J. LaSalle, and L. D. Coote. 1997. Eulophidae, pp. 327–429. *In* G. A. P. Gibson, J. T. Huber, and J. B. Woolley, eds. Annotated Keys to the Genera of Nearctic Chalcidoidea (Hymenoptera). Research Press. National Research Council of Canada, Ottawa, Ontario. 764 pp.
- Sellers, W. F. 1943. The Nearctic species of parasitic flies belonging to *Zenillia* and allied genera. *Proceedings of the United States National Museum* 93 [= No. 3157]: 1–108.
- Sharkey, M. J. 1997. Key to New World subfamilies of the family Braconidae, pp. 39–45. *In* R. A. Wharton, P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World Genera of the Family Braconidae (Hymenoptera). Special Publication No. 1. International Society of Hymenopterists, Washington, D. C.
- Sharkey, M. J. and R. A. Wharton. 1997. Morphology and terminology, pp. 19–37. *In* R. A. Wharton, P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World Genera of the Family Braconidae (Hymenoptera). International Society of Hymenopterists, Special Publication No. 1. Washington, D. C. 439 pp.
- Shaw, M. R. 1990. Parasitoids of European butterflies and their study, pp. 449–479. *In* O. Kudrna, ed. Butterflies of Europe, Vol. 2. Aula-Verlag, Wiesbaden. 557 pp.
- Shaw, M. R. and R. R. Askew. 1976. Parasites, pp. 240–256. *In* J. Heath, ed. The Moths and Butterflies of Great Britain and Ireland. 1. Micropterigidae – Heliozelidae. Blackwell Scientific Publications and Curwen Press, London. 343 pp.
- Shaw, S. R. 1983. A taxonomic study of the Nearctic *Ascogaster* and a description of a new genus *Leptodrepana* (Hymenoptera: Braconidae). *Entomography* 2: 1–54.
- Shaw, S. R. 1997a. Subfamily Cheloninae, pp. 193–201. *In* R. A. Wharton, P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World Genera of the Family Braconidae (Hymenoptera). Special Publication No. 1. International Society of Hymenopterists, Washington, D. C. 439 pp.
- Shaw, S. R. 1997b. Subfamily Rogadinae s.s., pp. 403–412. *In* R. A. Wharton, P. M. Marsh, and M. J. Sharkey, eds. Manual of the New World Genera of the Family Braconidae (Hymenoptera). Special Publication No. 1. International Society of Hymenopterists, Washington, D. C. 439 pp.
- Shaw, S. R. 2006. *Aleiodes* wasps of eastern forests: a guide to parasitoids and associated mummified caterpillars. Forest Health Technology Enterprise Team/USDA/Forest Service. Morgantown, West Virginia. 121 pp.
- Shaw, S. R., P. M. Marsh, and J. C. Fortier. 1997. Revision of North American *Aleiodes* Wesmael (Part 1): the *pulchripes* Wesmael species-group in the New World (Hymenoptera: Braconidae, Rogadinae). *Journal of Hymenoptera Research* 6: 10–35.
- Shaw, S. R., P. M. Marsh, and J. C. Fortier. 1998. Revision of North American *Aleiodes* Wesmael (Part 4): the *albitibia* Herrich-Schaeffer and *praetor* Reinhard species-groups (Hymenoptera: Braconidae: Rogadinae) in the New World. *Proceedings of the Entomological Society of Washington* 100: 553–565.
- Shima, H. 1984. Study on the tribe Blondeliini from Japan (Diptera, Tachinidae). V. The genera *Blondelia* Robineau-Desvoidy and *Compsilura* Bouché. *Kontyû* 52: 540–552.
- Shima, H. 2006. A host-parasite catalog of Tachinidae (Diptera) of Japan. *Makunagi/Acta Dipterologica*, Supplement 2: 1–171.
- Short, J. R. T. 1978. The final larval instars of the Ichneumonidae. *Memoirs of the American Entomological Institute* 25: 1–508.
- Singh, B. P., R. P. Singh, and V. D. Verma. 1988. New record of *Aroplectrus dimerus* Linn. and *Platyplectrus* sp. as larval parasite of slug caterpillar (*Parasa bicolor* Walk) from U. P. *Farm Science Journal* 3: 199–200.
- Smith, D. R. 1996. Trigonalyidae (Hymenoptera) in the eastern United States: seasonal flight activity, distribution, hosts. *Proceedings of the Entomological Society of Washington* 98: 109–118.
- Smith, D. R. and I. C. Stocks. 2005. A new trigonalid wasp (Hymenoptera: Trigonaliidae) from eastern North America. *Proceedings of*

- the Entomological Society of Washington 107: 530–535.
- Smith, H. E. 1912. A contribution on North American dipterology. Proceedings of the Entomological Society of Washington 14: 118–127.
- Smith, O. J., A. G. Diboll, and H. Rosenberger. 1955. Laboratory studies of *Pelecystoma harrisinae* (Ashmead), an adventive braconid parasite of the western grape leaf skeletonizer. Annals of the Entomological Society of America 48: 232–237.
- Smith, S. M. 1996. Biological control with *Trichogramma*: advances, successes, and potential of their use. Annual Review of Entomology 41: 375–406. doi:10.1146/annurev.en.41.010196.002111
- Stireman III, J. O. and M. S. Singer. 2003a. Determinants of parasitoid-host associations: insights from a natural tachinid-lepidopteran community. Ecology 84: 296–310. doi:10.1890/0012-9658(2003)084[0296:DOPHAI]2.0.CO;2
- Stireman III, J. O. and M. S. Singer. 2003b. What determines host range in parasitoids? An analysis of a tachinid parasitoid community. Oecologia 135: 629–638.
- Strand, M. R. 1986. The physiological interactions of parasitoids with their hosts and their influence on reproductive strategies, pp. 97–136. In J. K. Waage and D. J. Greathead, eds. Insect Parasitoids. Academic Press, London, UK. 389 pp.
- Strazanac, J. S., C. D. Plaugher, T. R. Petrice, and L. Butler. 2001. New Tachinidae (Diptera) host records of eastern North American forest canopy Lepidoptera: baseline data in a *Bacillus thuringiensis* variety *kurstaki* nontarget study. Journal of Economic Entomology 94: 1128–1134. doi:10.1603/0022-0493-94.5.1128
- Thompson, W. R. 1954. A catalogue of the parasites and predators of insect pests. Section 2. Host parasite catalogue. Part 3. Hosts of the Hymenoptera (Calliceratid to Evaniid), pp. 191–332. Commonwealth Agricultural Bureau, Commonwealth Institute of Biological Control, Ottawa. 141 pp.
- Thomson, C. G. 1878. Hymenoptera Scandinaviae 5. *Pteromalus* (Svederus) continuatio. Typis Expressit Haqv. Ohlsson, Lund. 307 pp.
- Tobias, V. I. 1976. Braconids of Caucasus. Nauka, Leningrad. 287 pp. [In Russian]
- Tothill, J. D. 1922. The natural control of the fall webworm (*Hyphantria cunea* Drury) in Canada together with an account of its several parasites. Bulletin of the Canada Department of Agriculture, N. Ser. 3: 1–107 + 6 plates.
- Townes, H. K. 1956. The Nearctic species of trigonalid wasps. Proceedings of the United States National Museum 106: 295–304.
- Townes, H. K. 1970. The genera of Ichneumonidae, part 2. Memoirs of the American Entomological Institute 12: 1–537.
- Townes, H. K. 1983. Revisions of twenty genera of Gelini (Ichneumonidae). Memoirs of the American Entomological Institute 35: 1–281.
- Townes, H. and M. Townes. 1962. Ichneumonflies of America North of Mexico: 3. Subfamily Gelineae, tribe Mesostenini. United States National Museum Bulletin 216: 1–602. doi:10.5479/si.03629236.216.1-3
- Townes, H. and M. Townes. 1966. A catalogue and reclassification of the Neotropical Ichneumonidae. Memoirs of the American Entomological Institute 8: 1–367.
- Townes, H., S. Momoi, and M. Townes. 1965. A catalogue and reclassification of the eastern Palearctic Ichneumonidae. Memoirs of the American Entomological Institute 5: i–v + 1–661.
- Townsend, C. H. T. 1892. An *Aporia* bred from *Limacodes* sp. Psyche 6: 275–276. doi:10.1155/1892/17351
- Townsend, C. H. T. (1918) 1919. New muscoid genera, species and synonymy (Diptera). [concl.] Insector Inscitiae Menstruus 6: 157–182.
- Tschorsnig, H.-P. and V. A. Richter. 1998. Family Tachinidae, pp. 691–827. In L. Papp and B. Darvas, eds. Contributions to a Manual of Palaearctic Diptera (With Special Reference to Flies of Economic Importance), Vol. 3. Higher Brachycera. Science Herald, Budapest. 880 pp.
- Valerio, A. A. 2006. Some taxonomic notes on named *Rogas* Nees species (Hymenoptera: Braconidae: Rogadinae) for the New World. Methods in Ecology and Systematics 1: 37–43.
- Viereck, H. L. 1913. Descriptions of ten new genera and twenty-three new species of ichneumon-flies. Proceedings of the United States National Museum 44: 555–568. doi:10.5479/si.00963801.1968.555
- Viereck, H. L. 1925. A preliminary revision of the Campopleginae in the Canadian National Collection, Ottawa. Canadian Entomologist 57: 176–181, 198–204, 223–228, 296–303. doi:10.4039/Ent57176-7
- Viereck, H. L. 1926. A preliminary revision of the Campopleginae in the Canadian National Collection, Ottawa. Canadian Entomologist 58: 2–8, 30–38, 71–78, 122–130, 143–149,

- 176–182, 196–201, 219–225, 257–260, 276–283. doi:10.4039/Ent582-1
- Wagner, D. L. 2005. Caterpillars of Eastern North America. Princeton University Press, New Jersey. 496 pp.
- Wahl, D. B. 1993a. Cladistics of the genera of Mesochorinae (Hymenoptera: Ichneumonidae). *Systematic Entomology* 18: 371–387. doi:10.1111/j.1365-3113.1993.tb00673.x
- Wahl, D. B. 1993b. Family Ichneumonidae, pp. 395–448. *In* H. Goulet and J. T. Huber, eds. *Hymenoptera of the World: an Identification Guide to Families*. Monograph 1894E. Agriculture Canada Research Branch. Ottawa, Ontario. 668 pp.
- Wahlberg, N., M. F. Braby, A. V. Z. Brower, R. de Jong, M.-M. Lee, S. Nylin, N. E. Pierce, F. A. H. Sperling, R. Vila, A. D. Warren, and E. Zakharov. 2005. Synergistic effects of combining morphological and molecular data in resolving the phylogeny of butterflies and skippers. *Proceedings of the Royal Society Series B* 272: 1577–1586. doi:10.1098/rspb.2005.3124
- Walker, F. 1835. Monographia Chalciditum. (Continued.). *Entomological Magazine* 3: 182–206.
- Walker, F. 1849. List of the specimens of dipterous insects in the collection of the British Museum, pp. 689–1172. Vol. 4. Printed by order of the Trustees [British Museum], London. 483 pp.
- Walley, G. S. 1947. The genus *Casinaria* Holmgren in America north of Mexico (Hymen., Ichneumonidae). *Scientific Agriculture* 27: 364–395.
- Webber, R. T. and J. V. Schaffner, Jr. 1926. Host relations of *Compsilura concinnata* Meigen, an important tachinid parasite of the gipsy moth and the brown-tail moth. United States Department of Agriculture. Department Bulletin 1363: 1–31.
- Wei, C. G. 1985. A preliminary observation on the bionomics of *Miresina banghaasi*. *Kunchong Zhishi (Insect Knowledge)* 22: 76–78.
- Weinstein, P. and A. D. Austin. 1991. The host-relationships of trigonalid wasps (Hymenoptera: Trigonalidae), with a review of their biology and catalogue to world species. *Journal of Natural History* 18: 209–214.
- Weinstein, P. and A. D. Austin. 1995. Primary parasitism, development and adult biology of the wasp *Taeniogonalos venatoria* Riek (Hymenoptera: Trigonalidae). *Australian Journal of Entomology* 43: 541–555.
- Weinstein, P. and A. D. Austin. 1996. Thelytoky in *Taeniogonalos venatoria* Riek (Hymenoptera: Trigonalidae), with notes on its distribution and first description of males. *Australian Journal of Entomology* 35: 81–84. doi:10.1111/j.1440-6055.1996.tb01366.x
- Weseloh, R. M. and J. F. Anderson. 1982. Releases of *Brachymeria lasus* and *Coccygomimus disparis*, two exotic gypsy moth parasitoids, in Connecticut: habitat preference and overwintering potential. *Annals of the Entomological Society of America* 75: 46–50.
- Wesmael, C. 1835. Monographie des Braconides de Belgique. *Nouveaux Mémoires de l'Académie Royale des Sciences et Belles-lettres Bruxelles* 9: 1–252.
- Whitfield, J. B. 1997. Subfamily Microgastrinae, pp. 333–364. *In* R. A. Wharton, P. M. Marsh, and M. J. Sharkey, eds. *Identification Manual to the New World Genera of the Family Braconidae (Hymenoptera)*. International Society of Hymenopterists, Special Publication 1. Washington, D. C. 439 pp.
- Whitfield, J. B. and S. Asgari. 2003. Virus or not? Phylogenetics of polydnviruses and their wasp carriers. *Journal of Insect Physiology* 49: 397–405. doi:10.1016/S0022-1910(03)00057-X
- Whitfield, J. B., R. J. Marquis, and J. Le Corff. 1999. Host associations of braconid parasitoids (Hymenoptera: Braconidae) reared from Lepidoptera feeding on oaks (*Quercus* spp.) in the Missouri Ozarks. *Entomological News* 110: 225–230.
- Wilcox, A. M. 1918. *Ascogaster carpocapsae*, a parasite of the Oriental moth. *Psyche* 25: 17. doi:10.1155/1918/57974.
- Wijesekara, A. and M. Schauff. 1997. Two new genera and three new species of Euplectrini (Hymenoptera: Eulophidae) from the New World. *Proceedings of the Entomological Society of Washington* 99: 101–109.
- Witter, J. A. and H. M. Kulman. 1979. The parasite complex of the forest tent caterpillar in northern Minnesota. *Environmental Entomology* 8: 723–731.
- Wood, D. M. 1985. A taxonomic conspectus of the Blondeliini of North and Central America and the West Indies (Diptera: Tachinidae). *Memoirs of the Entomological Society of Canada* 132: 1–130. doi:10.4039/entm117132fv
- Wood, D. M. 1987. Tachinidae, pp. 1193–1269. *In* J. F. McAlpine, B. V. Peterson, G. E. Shewell, H. J. Teskey, J. R. Vockeroth, and D. M. Wood, eds. *Manual of Nearctic Diptera*.

- Vol. 2. Agriculture Canada Monograph 28. iv + 675–1332 pp.
- Wood, D. M. and M. A. Zumbado. 2010. Tachinidae (tachinid flies, parasitic flies), pp. 1343–1417. *In* B. V. Brown, A. Borkent, J. M. Cumming, D. M. Wood, N. E. Woodley, and M. A. Zumbado, eds. Manual of Central American Diptera, Vol. 2. NRC Research Press, Ottawa.
- Yeagan, K. V. and S. K. Braman. 1989. Life history of the hyperparasitoid *Mesochorus discitergus* (Hymenoptera: Ichneumonidae) and tactics used to overcome the defensive behavior of the green cloverworm (Lepidoptera: Noctuidae). *Annals of the Entomological Society of America* 82: 393–398.
- Yeates, D. K. and D. J. Greathead. 1997. The evolutionary pattern of host use in the Bombyliidae (Diptera): a diverse family of parasitoid flies. *Biological Journal of the Linnaean Society* 60: 149–185. doi:10.1111/j.1095-8312.1997.tb01490.x
- Yu, D. S., K. van Achterberg, and K. Horstmann. 2005. World Ichneumonoidea 2004. Taxonomy, Biology, Morphology and Distribution. DVD/CD. Taxapad, Vancouver.
- Zaldívar-Riverón, A., M. R. Shaw, A. G. Sáez, M. Mori, S. A. Belokobylskij, S. R. Shaw, and D. L. J. Quicke. 2008. Evolution of the parasitic wasp subfamily Rogadinae (Braconidae): phylogeny and evolution of lepidopteran host ranges and mummy characteristics. *BMC Evolutionary Biology* 8: 329. doi:10.1186/1471-2148-8-329
- Zaldívar-Riverón, A., B. Areekul, M. R. Shaw, and D. L. J. Quicke. 2004. Comparative morphology of the venom gland apparatus in the braconid wasp subfamily Rogadinae (Insecta, Hymenoptera, Braconidae) and related taxa. *Zoologica Scripta* 33: 223–237. doi:10.1111/j.0300-3256.2004.00144.x
- Zhu, C. D. and D. W. Huang. 2004. A study of *Platyplectrus* Ferrière (Hymenoptera: Eulophidae) in mainland China. *Journal of Natural History* 38: 2183–2209. doi:10.1080/00222930310001618903