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APHID-PARASITOID (INSECTA) DIVERSITY AND TROPHIC INTERACTIONS IN SOUTH DAKOTA

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ABSTRACT

Parasitoid wasps of the subfamily Aphidiinae (Hymenoptera: Braconidae) specialize on aphids (Hemiptera: Aphididae) as hosts. The diversity of known and probable aphidiine wasps from South Dakota is itemized, with representation by 13 genera and 42 species, 43% of which are probably adventitious. The wasps and aphids are central to various combinations of multitrophic relationships involving host plants and secondary parasitoids. Selected native and introduced aphid host taxa were quantitatively and qualitatively collected from diverse native and crop host plants in eastern South Dakota and western Iowa. Wasps were reared to confirm plant association, host aphid association, taxonomic diversity, and native or introduced status of the wasps. *Acanthocaudus tissoti* (Smith) and *Aphidius* (*Aphidius*) *ohioensis* (Smith) were found together on the native aphid *Uroleucon* (*Uroleucon*) *nigrotuberculatum* (Olive), a new host aphid species for both wasps on *Solidago canadensis* L. (Asterales: Asteraceae). The native wasp *Lysiphlebus testaceipes* (Cresson) was repeatedly reared in massive numbers from mummies of invasive *Aphis glycines* Matsumura on soybean, *Glycine max* (L.) Merr. This wasp was also reared from the non-native *Aphis nerii* Boyer de Fonscolombe and the native *Aphis asclepiadis* Fitch, both on *Asclepias syriaca* L. The introduced wasp *Binodoxys communis* (Gahan) was not recovered from any *Aphis glycines* population. Hyperparasitoids from the genus *Dendrocerus* Ratzeburg (Hymenoptera: Megaspilidae), and the pteromalid (Hymenoptera: Pteromalidae) genera *Asaphes* Walker, and *Pachyneuron* Walker were reared from mummies of *Uroleucon* (*Uroleucon*) *nigrotuberculatum* parasitized by either *Acanthocaudus tissoti* or *Aphidius* (*Aphidius*) *ohioensis*. Hyperparasitoids of the genus *Alloxysta* (Hymenoptera: Figitidae) were reared from mummies of *Aphis glycines* and *A. nerii* parasitized by *Lysiphlebus testaceipes*.

Keywords

Aphidiinae, taxonomic diversity, adventitious, new host record, multitrophic associations, *Aphis glycines*

INTRODUCTION

Braconid wasps in the subfamily Aphidiinae (Hymenoptera: Braconidae) are primary parasitoids of aphids. These wasps and those of the unrelated family Aphelinidae are specialists in the parasitization of aphids and are sometimes used as biological control agents for pest species of aphid. The Aphidiinae, as Aphidiidae, had over 400 valid species assigned to it worldwide by Mackauer and Starý (1967) and Starý (1970), but have not been cataloged globally subsequently. Marsh (1979) cataloged 114 species from North America north of Mexico; most of these species lack further taxonomic study. Despite the seemingly low diversity of described species of these wasps, there are a number of known undescribed species. Many provide invaluable biological control for numerous aphid species, and some are used against pests by the agricultural and horticultural industries. Braconid wasps are frequently cited as having high levels of host specificity or fidelity (e.g., Shaw 1995; Mills 2003; Price et al. 2011), meaning that a wasp species uses only a single known or a few closely related species of insect host. Price et al. (2011) stated that 60% of braconid wasps are host specific. In contrast, though some aphidiine wasps have only single recorded hosts, the majority appear to be more widely polyphagous and are known to use several to many aphid species as hosts (e.g., Mackauer and Starý 1967; Starý 1970). Continued examination of the natural history and taxonomy of these wasps demonstrates that intricate webs of host associations involving multiple host plants and variations in habitats, aphids and host plant switching, aphids and primary parasitoid host switching, and parasitoids and hyperparasitoids may be the normal condition. As such, historical attributions of host specificity by aphidiines are likely founded on a lack of in-depth knowledge about individual species and their trophic interactions and life histories.

Comprehensive lists of aphidiine parasitoids and their respective aphid hosts, new host records, as well as more modern taxonomic reviews and revisions (e.g., Kula et al. 2017) for North American genera are generally lacking. Only through the documentation and publication of new host records, new species descriptions, and biological information can we begin to better understand these organisms and the important role they play as parasitoids.

The goal of this report is to itemize the known and probable taxa occurring in South Dakota, document some new host records for certain aphidiine wasps in eastern South Dakota and western Iowa, provide notes on host aphid biology, and offer a brief summary of a few wasps reared from aphids on selected native prairie plants and soybean.

METHODS

Aphidiine wasps were field collected using standard entomological methods for small Hymenoptera, especially gleaning, sweeping and beating of vegetation, Malaise and V-shaped flight intercept traps (V-FIT, Warner 2017) (Figure 1) and yellow bowl traps. Sampled specimens were returned to the laboratory and

processed as described below. Aphid colonies were collected from sites throughout eastern South Dakota and western Iowa from native and agricultural host plants including Canada goldenrod (*Solidago canadensis* L.), common milkweed (*Asclepias syriaca* L.), cup plant (*Silphium perfoliatum* L.), and soybean (*Glycine max* (L.) Merr.) into one-gallon-sized Ziploc® bags. Colonies were processed under a Wild M5 microscope. Parasitized aphids (a.k.a. mummies) were removed from host plants and placed individually into 1.5 mL microcentrifuge tubes. Voucher specimens of aphids were preserved in 80% ethanol (EtOH). After eclosion and emergence from mummies, wasps were preserved in 80% EtOH, then chemically dehydrated according to Heraty and Hawks (1998) and point-mounted for identification. Aphidiine wasps were identified to genus using Smith (1944) and Van Achterberg (1997), and to species by using reference specimens from the University of Minnesota Insect Collection, St. Paul, MN (UMSP), the National Museum of Natural History, Washington, D.C. (USNM), and the Severin-McDaniel Insect Research Collection, Brookings, SD (SMIRC). Voucher specimens of each species of aphidiine parasitoids from our studies will be deposited in the Severin-McDaniel Insect Research Collection at South Dakota State University, Brookings, SD.

Figure 1. Senior author with flight intercept traps; V-FIT on left, Malaise on right.

RESULTS AND DISCUSSION

A review of listings in the most recent catalog of the Hymenoptera for northern North America by Krombein et al. (1979) (as Aphidiidae) and Kula et al. (2017) provided an estimate that Aphidiinae could be represented in South Dakota by no fewer than 13 genera and 42 species (Table 1). Approximately 43% of these species were intentionally or accidently introduced into North America. Most of the species are rarely collected even with dedicated sampling efforts. *Lysiphlebus testaceipes* (Figure 2) is the exception because it successfully and regularly parasitizes the soybean aphid in all fields sampled and is known to parasitize no fewer than 54 aphid species representing 18 genera worldwide (Mackauer and Starý 1967). Other native aphidiines seem not to have transferred to invasive aphid species or use them only occasionally and in low numbers. The role and competitive impact of the introduced parasitoids on the diversity and abundance of the native parasitoids remain unknown. Based on the limited ecological data for most of the aphidiine species known from South Dakota, and that being limited to host aphid information (e.g., Blackman 2018; Favret 2018), it appears that the vast majority of these wasps in our area are associated with aphids that are associated primarily with native prairie forbs and crops. These kinds of multitrophic associations and the limited presence of host plants may help explain the relative rarity of the wasps.

Native prairie and steppe communities are rapidly diminishing in the northern Great Plains in favor of agricultural commodity crops like maize (*Zea mays* L.), soybean, and wheat (*Triticum aestivum* L.) (e.g., Wright and Wimberly 2013). Because of these massive acreage monocultures, plant community diversity is very limited and reduced to habitat islands, which in turn reduces habitat available to native fauna including countless invertebrate species due to decreased area and increased edge effects. In addition, conservation areas set aside in an effort to restore plant diversity are often overtaken by non-native invasive plant species like smooth brome (*Bromus inermis* Leysser), Kentucky bluegrass (*Poa pratensis* L.), and leafy spurge (*Euphorbia esula* L.). These weeds further reduce the occurrence of native prairie plants, their aphids, and the associated parasitoid and hyperparasitoid complexes. These large community shifts directly and significantly impact the insect associations and trophic relationships. Appropriately restored and maintained prairie areas are refuges of biodiversity within a cropland biotic desert and promote faunal biodiversity. Plants like common milkweed, Canada goldenrod and cup plant provide habitat to a wide diversity of aphids and their parasitoids, as well as being essential resources for native pollinators. The study of diverse native ecosystems offers insight into an assortment of multitrophic interactions that cannot be studied in a homogenous system like cropland. The study of interactions between plant, aphid, and parasitoid in native ecosystems can strengthen and improve biological control programs by expanding the knowledge base from which these programs are derived.

Figure 2.* Lysiphlebus testaceipes *emerging from host aphid mummy. Body length 2.0 mm.

Aphids and parasitoids on Canada goldenrod. Two species of native aphidine, *Acanthocaudus tissoti* (Smith) and *Aphidius* (*Aphidius*) *ohioensis* (Smith), were reared from the native aphid *Uroleucon* (*Uroleucon*) *nigrotuberculatum* (Olive) on Canada goldenrod. Reported in South Dakota by Kula et al. (2017), both species of wasp were previously reared from *Uroleucon* (*Uroleucon*) cf. *rudbeckiae* (Fitch) on cup plant. The presence of *U.* (*U.*) cf. *rudbeckiae* colonies in South Dakota is highly variable from year to year in cultivated patches of cup plant. These aphid colonies are typically small, but occasionally develop populations that appear to cause damage to the plants. Colonies of *U.* (*U.*) *nigrotuberculatum* on Canada goldenrod are more commonly found and are typically larger in size than colonies of *U.* (*U.*) cf. *rudbeckiae* on cup plant. Colonies of *U.* (*U.*) *nigrotuberculatum* on Canada goldenrod are often found in areas of partial shade and protected from strong winds. Plants occurring in large clusters in open areas commonly have smaller aphid colonies than on more protected plants. Three hyperparasitoid species, a megaspilid (Hymenoptera: Megaspilidae) *Dendrocerus* Ratzeburg, and the pteromalids (Hymenoptera: Pteromalidae) *Asaphes suspensus* (Nees) (Figure 3), and *Pachyneuron* Walker, were reared in low numbers from mummies of *U.* (*U.*) *nigrotuberculatum* parasitized by either *A. tissoti* or *A.* (*A.*) *ohioensis*. The mummies of these two wasps are indistinguishable.

Figure 3.* Asaphes suspensis*, male, a hyperparasitoid of* Acanthocaudus tissoti *on* Uroleucon *cf.* rudbeckiae *on cup plant. Body length 1.5 mm.

Aphids and parasitoids on common milkweed. The aphidiine *Lysiphlebus testaceipes*, a species ostensibly native to North America, including Iowa and South Dakota, and numerous other regions of the world, was reared from two species of aphid, *Aphis nerii* Boyer de Fonscolombe and *A. asclepiadis* (Fitch) on common milkweed. No other aphidiines were reared from these aphid species. Aphid colonies on common milkweed (Figure 4) were more commonly found in areas protected from wind and direct sunlight. Colonies favored the undersides of leaves until they grew large enough to expand onto stems. Several specimens of an undetermined species of *Alloxysta* Foerster (Hymenoptera: Figitidae), a hyperparasitoid, were reared from mummies of *A. asclepiadis* and *A. nerii* parasitized by *L. testaceipes*.

Aphids and parasitoids on soybean. *Binodoxys communis* (Gahan), the aphidiine parasitoid released throughout the Midwest, including Iowa and South Dakota, for *A. glycines* biological control (Tilmon et al. 2011; Ragsdale et al. 2011) was not recovered from *A. glycines* in soybean fields in eastern South Dakota. The widely polyphagous parasitoid *L. testaceipes* was the only aphidiine parasitoid reared from *A. glycines* on soybean in unsprayed plots. In eastern South Dakota, *A. glycines* colonies did not appear at economic threshold levels of 250 aphids per plant in 2017 until mid to late August. *Lysiphlebus testaceipes* was

present in soybean fields throughout the growing season regardless of aphid density (e.g., 1000). When aphid populations were below the economic threshold, *Aphelinus* spp. (Hymenoptera: Aphelinidae) were the dominant parasitoids of *A. glycine*. A species of *Alloxysta,* possibly the same species as that on *L. testaceipes* on common milkweed, was also reared from *A. glycines* mummies on soybean.

Figure 4. Aphid mummies of* Lysiphlebus testaceipes *on abaxial leaf surfaces of common milkweed. Mummy diameter 2.0 mm.

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Table 1. Taxa of Aphidiinae occurring or expected to occur in South Dakota, from Krombein et al. (1979) and Kula et al. (2017). * = adventitious species, *? = possibly adventitious.

Tribe Ephedrini

Ephedrus californicus Baker
Ephedrus incompletus (Provancher)
Ephedrus lacertosus (Haliday) *
Ephedrus persicae Froggatt *

Tribe Praini

Praon aguti Smith
Praon exoletum palitans Muesebeck
Praon negundinis Smith
Praon occidentale Baker
Praon pequodorum Viereck
Praon simulans (Provancher)

Tribe Aphidiini

Subtribe Lysiphlebina

Adialytus fuscicornis (Ashmead)
Adialytus salicaphis (Fitch) *?
Lysiphlebus flavidus Gahan
Lysiphlebus testaceipes (Cresson) *?

Subtribe Protaphidiina

Pauesia californica (Ashmead)
Pauesia gillettei (Gahan)
Pauesia juniperaphidis (Gahan)
Pauesia procephalic (Ashmead)
Pauesia takomaensis (Smith)
Xenostigmus bifasciatus (Ashmead)

Subtribe Aphidiina

Aphidius avenaphis (Fitch)
Aphidius colemani Viereck *
Aphidius ervi Haliday *
Aphidius hortensis Marshall *
Aphidius matricariae Haliday *?
Aphidius nigripes Ashmead
Aphidius obscuripes Ashmead
Aphidius ohioensis Smith
Aphidius polygonaphis (Fitch)
Aphidius ribis Haliday *
Aphidius rosae Haliday *
Aphidius smithi Sharma & Subba Rao *
Diaeretiella rapae M'Intosh *
Euaphidius cingulatus (Ruthe) *
Lysaphidus multiarticulatus (Ashmead) *

Tribe Trioxini

Subtribe Monoctonina

Monoctonus caricis (Haliday) *
Monoctonus nervosus (Haliday) *

Subtribe Trioxina

Acanthocaudus caudacanthus (Smith)
Acanthocaudus tissoti (Smith)
Binodoxys communis (Gahan) *
Trioxys americeris Smith
Trioxys complanatus Quilis *