Hydrellia Fly Parasitic Wasp *Trichopria columbiana* Ashmead (Insecta: Hymenoptera: Diapriidae)[1]

Byron R. Coon, Nathan E. Harms, Michael J. Grodowitz, Emma N.I. Weeks, and James P. Cuda[2]

Introduction

Trichopria columbiana (Ashmead) (Insecta: Hymenoptera: Diapriidae) is a native endoparasitic wasp. The wasp is a parasitoid of *Hydrellia* species (Insecta: Diptera: Ephydridae), with multiple implications to biological control. The hydrellia flies are a diverse group with varied ecological roles. Deonier (1971) described 57 *Hydrellia* species in the Nearctic region. The adults of this genus are semi-aquatic, and the immatures are aquatic, feeding on aquatic and semi-aquatic plants (Deonier 1971). Of these 57 species, at least 7 have been described as hosts for *Trichopria columbiana*. In addition, the wasp has successfully moved from its native hosts to exotic *Hydrellia* species (*Hydrellia pakistanae* Deonier and *Hydrellia balciunasi* Bock) that were imported into Florida for biological control of hydrilla, *Hydrilla verticillata* (L.f.) Royle, which is widely regarded as one of the worst invasive weeds worldwide (Holm et al. 1997). Deonier (1971) reported that *Trichopria columbiana* and other parasitic Hymenoptera can negatively impact population densities of *Hydrellia* spp., especially in certain marginal habitats and when parasitoid population densities are high.

Synonymy

According to Hymenoptera Online, there is only one junior synonym for *Trichopria columbiana* (Johnson 2014): *Diapria columbiana* Ashmead 1893.

Distribution

Trichopria columbiana is widely distributed in North America (Bennett 2008) and has been reported from the District of Columbia, Virginia (Ashmead 1893), Michigan (Berg 1950), California (Grigarick 1959), Minnesota (Deonier 1971), Alabama (Grodowitz et al. 1997), Florida (Wheeler and Center 2001), and Texas (Doyle et al. 2002).

Description

The description of the life stages of this species has been modified from Coon et al. (2014).

Eggs

Eggs were dissected from *Trichopria columbiana* ovaries to determine their pre-oviposition morphology. *Trichopria columbiana* eggs, which are hymenopteriform (wasp-like) in shape, were 0.19 mm long and 0.06 mm wide. The chorion (outer membrane) is smooth and thin. As the chorion is transparent, the developing embryo is clearly visible (Figure 1). The second inner membrane, which is

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2. Byron R. Coon, former graduate assistant, Entomology and Nematology Department; Nathan E. Harms, US Army Engineer Research and Development Center; Michael J. Grodowitz, US Army Engineer Research and Development Center; Emma N.I. Weeks, assistant research scientist; and James P. Cuda, professor and Fulbright scholar, Entomology and Nematology Department; UF/IFAS Extension, Gainesville, FL 32611.

likely to be the vitelline membrane, is flexible. A double-membrane egg is characteristic of hydropic eggs (DeBach 1964). Hydropic eggs take up nutrients and water from the host's hemolymph for continued development and typically expand in size (Flanders 1950). *Hydrellia pakistanae* pupae were dissected, and *Trichopria columbiana* eggs were removed from the host 72 hours post-oviposition. These eggs were much larger than those dissected from the female parasitoid; they measured 0.57 mm in length by 0.28 mm in width.

Figure 1. Egg of *Trichopria columbiana* (Ashmead).
Credits: Byron Coon, Argosy University

Larvae

There are three instars; the first instar is 0.49 mm long and 0.14 mm wide. At this stage, the body is segmented and the mandibles are large and sclerotized (hardened). The end of the abdomen has a two-lobed appendage with several teeth on each lobe (Figure 2). This instar moves freely in the hemolymph of the host and is believed to obtain oxygen by diffusion.

Figure 2. First instar larva of *Trichopria columbiana* (Ashmead).
Credits: Byron Coon, Argosy University

The second instar is 0.92 mm long and 0.31 mm wide, and the third instar is 1.50 mm long and 0.52 mm wide. Both the second and third instars are similar in appearance and are grub-like (Figure 3). The abdominal appendage and large mandibles present on the first instar are absent. The head of the later instars has indistinct mouthparts that are not differentiated from the body. The second and third instars obtain oxygen from the host by attaching to the host tracheal system.

Figure 3. Second or third instar larva of *Trichopria columbiana* (Ashmead).
Credits: Byron Coon, Argosy University

Pupae

The pupae are enclosed in a thin case (Figure 4), which is believed to be the last larval exuvium (cast skin). The case is transparent, and the developing adult is visible inside with the red eyes particularly noticeable. Also visible are many small globules, which are believed to be the meconium (fecal material) released by the last instar before pupation.

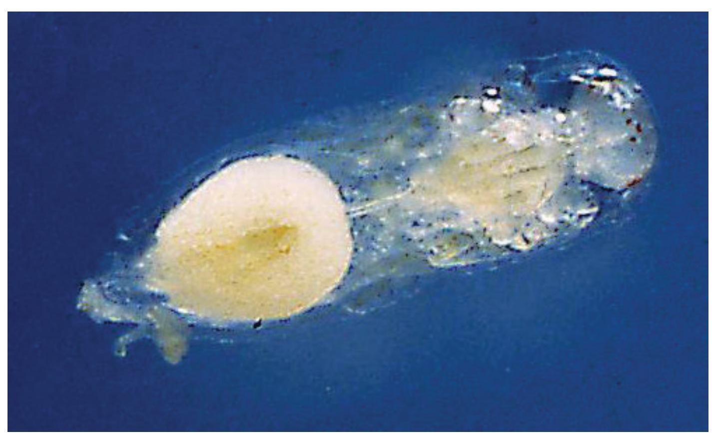

Figure 4. Pupa of *Trichopria columbiana* (Ashmead).
Credits: Byron Coon, Argosy University

Adult

The following description of the adult stage is based on Ashmead (1893). The overall length of the adult wasp is 1–2 mm. The body is shiny and black in color with the base of the antennae and the legs reddish yellow (Figure 5). The head is round and narrows behind the eyes. The thorax narrows anteriorly forming a round neck. The abdomen is oval-shaped. The wings are strongly fringed and clear with pale yellow veins.

Male and female *Trichopria columbiana* can be distinguished easily by the shape of the antennae. The antennae of females have 12 segments and are slightly clavate, or club-like (Figure 5B). In contrast, the antennae of males have 13 segments and are filiform, or thread-like (Figure 5A).

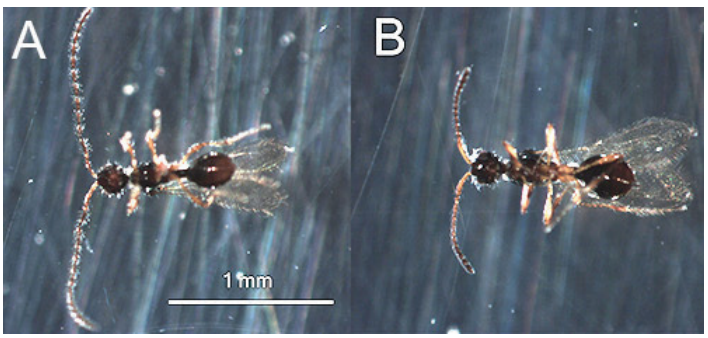

Figure 5. Adults of *Trichopria columbiana* Ashmead; male (A) with filiform or thread-like antennae and female (B) with slightly clavate or club-like antennae.
Credits: Nathan Harms, US Army Engineer Research and Development Center

Life Cycle

The life cycle and biology of *Trichopria columbiana* were studied in detail by Coon et al. (2014) and are summarized below. Four behaviors associated with host location were observed in the laboratory: 1) searching, 2) stem examination, 3) oviposition, and 4) grooming and/or resting. When searching for a host, *Trichopria columbiana* need to access the pupae of *Hydrellia* species, which are usually underwater. The female inserts her antennae into the water first, presumably to detect chemical cues of plant damage or the host insect. When given a choice of hydrilla with *Hydrellia* pupae and hydrilla with *Hydrellia* larvae, 96% of parasitoids selected the hydrilla with *Hydrellia* pupae. Therefore, a suitable host in the appropriate life stage is located using chemoreception. The adult female wasp swims underwater by trapping a bubble of air under her wings, which she uses to breathe. After locating a suitable host, the female inserts her ovipositor into the thorax of the fly, which is close to the cuticle of the puparium. The female parasitoid prefers to lay her eggs in early- to intermediate-stage pupae. However, eggs may also be laid in late instars (Grodowitz et al. 2009).

Dissections of both *Hydrellia pakistanae* and *Hydrellia balciunasi* revealed that *Trichopria columbiana* deposits a maximum of three eggs per host. Each female may lay 14 to 32 eggs in a lifetime. The female deposits her eggs directly into the host hemolymph, and the eggs develop in 1 to 3 days. Development of the first instar requires 1 to 3 days, and only a single larva survives. Apparently, the surviving larva uses its mandibles to kill its siblings, thereby avoiding competition for resources. The estimated stadial lengths (time between molts) for the second and third instars is 2 to 5 and 5 to 8 days, respectively. Development of the larval stage is completed in 13 to 23 days. The pupal stage of *Trichopria columbiana* lasts between 5 and 7 days. After pupation, the adult parasitoid exits the host, which is usually below the water surface, by cutting a hole in the end of the puparium that is not attached to the tracheal system with its mandibles. The adult parasitoid floats to the surface with an air bubble attached to hairs on its abdomen. The bubble of air is believed to have been acquired from the internal environment of the host puparium. This assumption is based on the fact that *Hydrellia* fly adults exit their puparia in a similar way but ascend to the surface enclosed within an air bubble obtained from inside their puparium (Balciunas et al. 2002). Total development time from egg to adult was on average 22 days (14 to 26 days) in the laboratory at 25°C. *Trichopria columbiana* overwinters as an adult in hydrilla at the edge of the water body. The sex ratios that have been recorded in Florida and Texas are female-biased with males being relatively rare. Collection of adults from hydrilla resulted in 14,776 individuals, of which only four were male—a sex ratio of 1: 3694 (male: female).

Hosts

According to Deonier (1971), *Trichopria columbiana* attacks at least seven native *Hydrellia* spp. including *Hydrellia ascita* Cresson, *Hydrellia bergi* Cresson, *Hydrellia cruralis* Coquillett, *Hydrellia griseola* (Fallén), *Hydrellia ischiaca* Loew, *Hydrellia luctuosa* Cresson, and *Hydrellia pulla* Cresson. This parasitoid also attacks the two *Hydrellia* spp., *Hydrellia pakistanae* (Cuda et al. 1997) and *Hydrellia balciunasi* (Grodwitz et al. 1997), that were introduced in the US for biological control of the aquatic weed hydrilla.

Damage

The parasitoid lays eggs in the pupae of *Hydrellia* spp. Once the larvae hatch and begin feeding, the developing *Hydrellia* pupa provides the food source for the larvae. The developing pupa is killed and will not develop into an adult fly. Therefore, *Trichopria columbiana* can reduce populations of *Hydrellia* species including hydrilla leaf mining flies.

Importance for Biological Control

Trichopria columbiana is a parasitoid of *Hydrellia* fly species. Depending on the ecological role of the host species, *Trichopria columbiana* can have a positive or negative effect on biological control.

Some *Hydrellia* species, including the introduced biological control agents *Hydrellia pakistanae* and *Hydrellia balciunasi*, feed on the invasive aquatic weed hydrilla, *Hydrilla verticillata*. After its introduction into the US by the aquarium industry in the 1950s (Langeland 1996), various control methods, including biological control, were developed and used to manage infestations. Classical biological control studies were initiated in the 1970s (Buckingham 1994). These efforts led to the release of four insects in the US, two of which were the leaf-mining ephydrid flies, *Hydrellia pakistanae* and *Hydrellia balciunasi* (Center et al. 1990). Despite successful establishment and range expansion of the Asian hydrilla leaf mining fly, *Hydrellia pakistanae*, population levels of the insect and associated plant damage have remained low (Cuda et al. 2008). However, there is some evidence that past declines of hydrilla in Florida and Texas were associated with local increases in *Hydrellia* fly populations (Grodowitz et al. 2004). Several abiotic and biotic factors have been identified that could adversely affect *Hydrellia pakistanae* populations on a landscape scale (Cuda et al. 2008). One of the potentially limiting biotic factors is parasitism by the native endoparasitic wasp *Trichopria columbiana*.

In Florida, the highest parasitoid activity was recorded in the cooler winter months, October to January, with a peak in January. The average parasitism rate in Florida and Texas was around 20–30% (Coon et al. 2014; Grodowitz et al. 2009). Buckingham and Okrah (1993) concluded that parasitism of the introduced *Hydrellia pakistanae* and *Hydrellia balciunasi* by parasitoids of native *Hydrellia* spp. could be more problematic than interspecific competition between the two introduced biological control agents. Hence, they suggested that parasitism should be carefully monitored. In hindsight, attack of the two introduced *Hydrellia* spp. by *Trichopria columbiana* or other parasitoids of native *Hydrellia* spp. was predictable because the biocontrol agents were not released in an "enemy-free space" (Lawton 1985). When weed biological control practitioners select agents, they should carefully consider the potential for insects to acquire novel parasitoids. This precaution will help avoid reducing biological control agent effectiveness and apparent competition, particularly where species interact through shared natural enemies.

The parasitoid also has been found in *Hydrellia pulla* pupae, with 63% of puparia (out of a sample of 61 puparia) being parasitized during a summer in Minnesota (Deonier 1971). *Hydrellia pulla* feeds on pondweeds (Deonier 1971), such as the large-leaved pondweed (*Potamogeton amplifolius* Tuck.), variable-leaf pondweed (*Potamogeton gramineus* L.), and Richardson's pondweed (*Potamogeton richardsonii* [Benn.] Rydb.), which are all classified as endangered or threatened in their native ranges in the US. For this reason, the parasitoid may protect native pondweeds from herbivory by *Hydrellia*.

On the other hand, *Trichopria columbiana* is a biological control agent itself, providing control of agricultural pests of rice crops. Grigarick (1959) observed 60% parasitism in one sample of *Hydrellia griseola* mining rice plants in California. In that same study, low parasitism of the first generation of *Hydrellia griseola* was observed, but parasitism approached almost 90% in succeeding generations. Deonier (1971) found 38% parasitism by *Trichopria columbiana* and other parasitoids in 132 puparia of *Hydrellia ischiaca,* a pest of wild rice crops.

Monitoring and Management

Adult parasitoids can be extracted from plant material using Berlese funnels. *Hydrellia* pupae can be dissected or isolated and placed in rearing containers to determine parasitism rates.

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