New findings of twisted-wing parasites (Strepsiptera) in Alaska

by Molly McDermott[1]

Figure 1: Adult male *Elenchus* sp. collected on Alaska's Seward Peninsula (UAM:Ento:293071). Note front halteres, raspberry-shaped eyes, and forked antennae. Photo by DS Sikes.

Introduction

Strepsipterans are a group of insects with a gruesome life history and an enigmatic evolutionary past. Called 'twisted-wing parasites', they are minute parasitoids with a very distinct morphology (Figure 1). Alternatively thought to be related to ichneumon wasps, Diptera (flies), Coleoptera (beetles), and even Neuroptera (net-winged insects) (Pohl and Beutel, 2013); the latest genetic and morphological data support the sister order relationship of Strepsiptera and Coleoptera (Niehuis et al., 2012). Strepsipterans are highly modified, males having two hind wings and halteres instead of front wings or elytra. Unlike most parasitoids, they develop inside active, living insects who are sexually sterilized but not killed until or after emergence (Kathirithamby et al., 2015).

Strepsipteran life history

Females (in most species) do not undergo a typical pupal phase—after four larval phases, they attain their adult form, lacking eyes, wings, legs, and antennae (Whitfield and Purcell, 2012). They remain embedded in their host throughout their adult life. To attract males, they secrete a pheromone which is detected by elaborate chemical receptors on the male antennae. The sole purpose of a male's 3–6 hour life is to find a female (Kathirithamby et al., 2015). A male mates by rupturing the entrance to the brood canal, located just behind the female's head. This unusual placement allows mating while the female remains within her host (Kathirithamby et al., 2015). A single female can produce 75,000 eggs and 9–10,000 larvae, who move freely in the mother's circulatory system, an arrangement unique to these animals (Kathirithamby, 2002; Whitfield and Purcell, 2012).

Figure 2: Adult female delphacid planthopper collected on Alaska's Seward Peninsula, showing no evidence of parasitism. Genitalia are normal and there are no darkened spots on the abdomen. Photo by M McDermott.

In a 30–40 day process that kills the mother, larvae emerge from the brood canal to seek new hosts. Only these 1st instar larvae and emergent adult males are mobile (Whitfield and Purcell, 2012). Most larvae enter their hosts through the abdomen by secreting an enzyme that softens the host exoskeleton, although there is a recorded case of larvae entering through the host's tarsus (Kathirithamby, 2002; Whitfield and Purcell, 2012). Once inside their host, larvae induce the host to produce a cuticle to protect it from the host immune system, an adaptation that has allowed strepsipterans to parasitize a wide range of hosts (Kathirithamby et al., 2003; Whitfield and Purcell, 2012). The 595 described species of strepsipterans parasitize 34

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insect families, mainly Hemiptera (true bugs) and Hymenoptera (ants, bees and wasps) (Kathirithamby, 2002; Kathirithamby et al., 2015; Whitfield and Purcell, 2012). In a few cases, males and females may parasitize different species, even different orders of insects (Whitfield and Purcell, 2012). The paucity of research on this group makes it likely that there are many undiscovered species (Kathirithamby et al., 2015).

Figure 3: Adult delphacid with two developing strepsipteran males. One parasite (bottom) is close to emergence; the other (top left) is in the pupal phase. Note how the host is prevented from developing any genitalia. Photo by M McDermott.

New Records in Alaska

In the summer of 2013, I worked as a field technician as part of a study conducted by US Geological Survey assessing the distribution and abundance of shorebirds and songbirds in the boreal forest-tundra transition zone of western Alaska (McNew et al., 2013). As an indicator of habitat quality for birds, we collected insects via sweep net from June 28th to July 10th in a variety of subarctic habitats. Upon examination and identification of these insects, Delphacidae (planthoppers, see Figure 2) adults and nymphs were often found to show evidence of strepsipteran parasitism. Evidence ranged from a darkened larval entry point on the abdomen to an adult male emerging head-first (Figure 3). At some sites, delphacids were found to have rates of parasitism as high as 29%. Some hosts had two parasites, engulfing more than half their abdomen (Figure 3). One study site in the interior of the Seward Peninsula had much higher parasitism rates than other sites, although the rate varied greatly along transects (Figure 4).

To determine what ecological variables are related to host prevalence and rates of parasitism, I examined vegetation and landscape characteristics collected at each of the 100 sample points. Delphacid planthoppers were found to be associated with herbaceous plant cover height and abundance, with a slightly higher prevalence on north and northeast facing slopes. Within the Neva Creek study area (Figure 4), higher-elevation sites with gentler slopes and taller grasses and sedges had higher rates of parasitism, even when controlling for planthopper abundance. Interestingly, elevation was a much stronger predictor of parasitism rate than host abundance or herbaceous plant cover.

These results suggest that parasitism rate is not due to host abundance, but varies across the landscape. Considering the extremely short lifespan of the winged male and the miniscule size of mobile larvae, it seems likely that strepsipteran population abundance is restricted by how far they are able to disperse while within their host. It could be that higher elevation sites with gentler slopes are windier, which allows their hosts to travel farther. The high rates of parasitism associated with tall grasses after controlling for host abundance could be explained by a behavioral difference between infected and non-infected hosts, causing infected planthoppers to prefer taller grasses. Alternatively, it is possible that taller grasses provide better conditions for strepsipteran adults to mate or larvae to infect new hosts.

Prior to these collections[2], there were only four records of this order in Alaska, and none from the Seward Peninsula: two in Fairbanks (UAM:Ento:201815, UAM:Ento:217034), one in Delta Junction (UAM:Ento:201812), and one in Sterling (UAM:Ento:100552).

In early 2015, an adult male specimen (Fig. 1) was sent to J. Kathirithamby who identified it as a member of the genus *Elenchus* and possibly a new species. Two adult males were prepared for DNA barcoding this spring, and will be sent out by D. Sikes for sequencing. Although this is an understudied group of insects, there are DNA barcodes published for four described species of *Elenchus* as well as for several unidentified specimens of *Elenchus* (GenBank search, 3/10/16). Genetic results from the Seward Peninsula collections will help to determine if these specimens are one of these four species of *Elenchus* or not, although it will be difficult to determine if this specimen represents a new species or a previously described species that has no genetic data available. Regardless, these collections provide more information about the geographic range and ecology of these fascinating creatures.

[2]UAM:Ento:293071, UAM:Ento:296383, UAM:Ento:296386, UAM:Ento:296387, UAM:Ento:296389, UAM:Ento:296392, UAM:Ento:296393, and UAM:Ento:296396

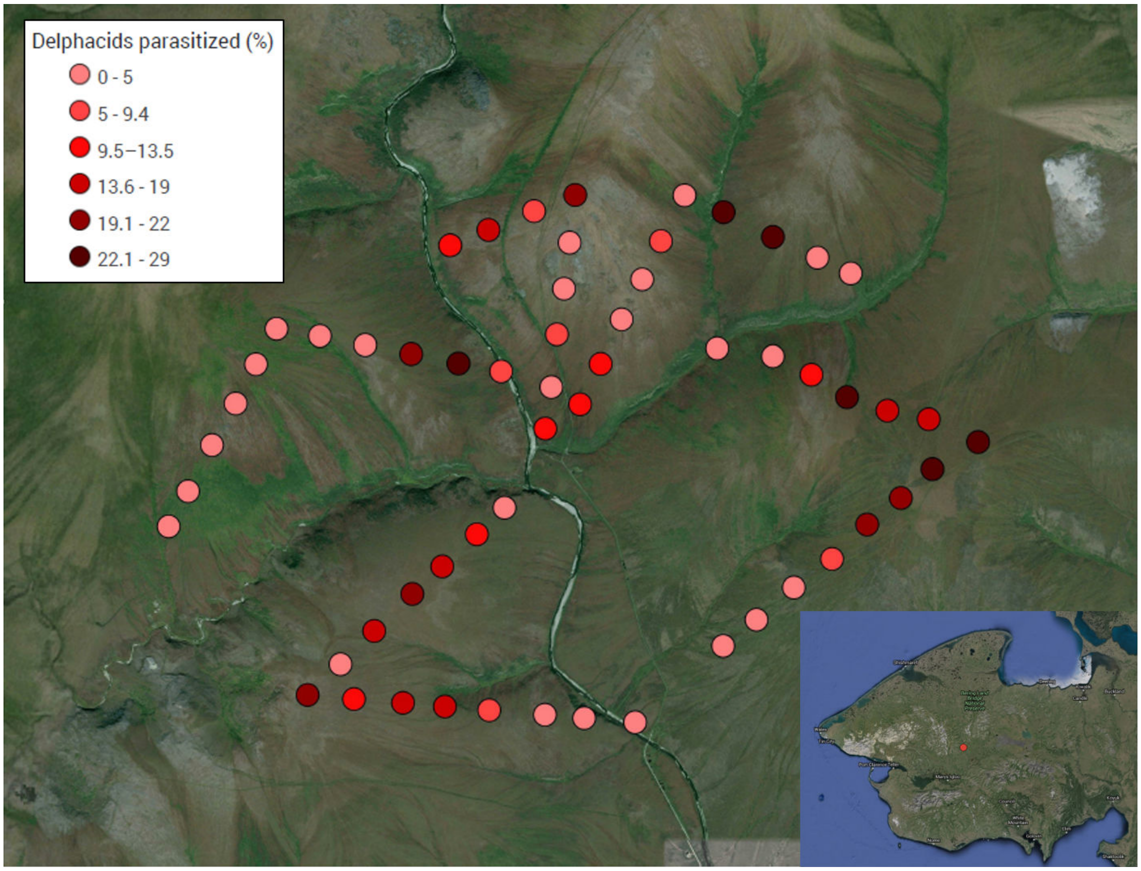

Figure 4: Rates of strepsipteran parasitism around Neva Creek in the interior of Alaska's Seward Peninsula. Each circle represents a plot 500 m in diameter. Within each plot, insects were collected with three randomly placed 50 m transects. Data were also collected on bird abundance, vegetation and landscape characteristics.

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