

Fire Ant Decapitating Flies *Pseudacteon* spp. (Insecta: Diptera: Phoridae)¹

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Introduction

Flies of the genus *Pseudacteon* are members of the family Phoridae, commonly known as scuttle flies, hump-backed flies, and phorid flies (Disney 1994). Phorid flies in the genus *Pseudacteon* parasitize several genera of ants including fire ants in the genus *Solenopsis* (Disney 1994), which includes the invasive red (*Solenopsis invicta* Buren) and black imported fire ants (*Solenopsis richteri* Forel). In 1997, *Pseudacteon tricuspis* Borgmeier was the first species of *Pseudacteon* fly successfully released as a biological control agent for imported fire ants in the US (Callcott et al. 2011). Five other species, *Pseudacteon curvatus* Borgmeier, *Pseudacteon litoralis* Borgmeier, *Pseudacteon obtusus* Borgmeier, *Pseudacteon nocens* Borgmeier, and *Pseudacteon cultellatus* Borgmeier have since been released (Porter and Calcaterra 2013). Eight native *Pseudacteon* species parasitize native fire ants in the United States (Plowes 2009).

Distribution

Pseudacteon flies are parasitoids of ants in many genera worldwide (Disney 1994). About two dozen species parasitize native fire ants in South America (Porter and Pesquero 2001). In the United States, the range of introduced species varies according to their rates of expansion and dates of introduction (Drees and Oi 2015). *Pseudacteon tricuspis* and *Pseudacteon curvatus* are distributed across most of the southeastern US (Callcott et al. 2011). *Pseudacteon litoralis*

populations are occasionally abundant in Alabama (Porter et al. 2011), as are *Pseudacteon nocens* in Texas (Plowes et al. 2012). Both species currently have limited but expanding ranges. *Pseudacteon obtusus* is abundant in a large portion of both Texas and Florida, with smaller established populations in Mississippi and Georgia (Drees and Oi 2015, Plowes et al. 2011, Porter and Calcaterra 2013). *Pseudacteon cultellatus* is the most recently released species and is established at two sites in Florida (Porter et al. 2013).

Description

Eggs

Eggs are approximately 130 µm long by 20 µm wide and torpedo-shaped (Zacaro and Porter 2002).

Larvae

Early instars are maggot-like and transparent, becoming broader, flatter, and cloudy-whitish as they mature (Porter 1998).

Pupa

Early instars are maggot-like and transparent, becoming broader, flatter, and cloudy-whitish as they mature (Porter 1998).

1. This document is EENY680, one of a series of the Department of Entomology and Nematology, UF/IFAS Extension. Original publication date May 2017. Visit the EDIS website at <http://edis.ifas.ufl.edu>. his document is also available on the Featured Creatures website at <http://entnemdept.ifas.ufl.edu/creatures/>.
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Adults

Phorid flies are small to very small with a hump-backed appearance and reduced wing venation (Figure 1) (Triplehorn and Johnson 2005). Female *Pseudacteon* flies have fully developed wings and unique and highly sclerotized external ovipositors (Porter and Pesquero 2001). The ovipositor, an organ used for egg-laying, is different in appearance for each species of *Pseudacteon* and can be used to distinguish one species from another (Figure 2). Males are sometimes smaller than females.



Figure 1. A female phorid fly, *Pseudacteon cultellatus* Borgmeier. Note the humped-back appearance, external ovipositor, and reduced venation typical of phorid flies.

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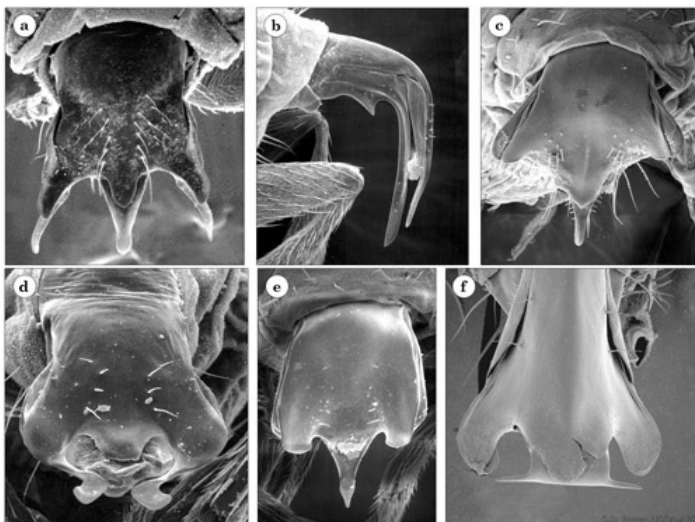


Figure 2. Ovipositors of released *Pseudacteon* species: a. *Pseudacteon tricuspis* Borgmeier, b. *Pseudacteon curvatus* Borgmeier, c. *Pseudacteon litoralis* Borgmeier, d. *Pseudacteon obtusus* Borgmeier, e. *Pseudacteon nocens* Borgmeier, f. *Pseudacteon cultellatus* Borgmeier.

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Biology

Pseudacteon flies have a unique life history. In fire ant attacking *Pseudacteon* flies, the mated female will hover over foraging workers (Figure 3) and strike an ant in the thorax with her ovipositor, depositing an egg into the ant's body (Porter 1998). These strikes are often very fast, occurring in less than a second. After the larva hatches, it moves into the ant's head and consumes mostly hemolymph until just prior to pupation after the third instar. When the larva is ready to pupate it releases a chemical, likely an enzyme, that degrades the membranes that hold the ant's exoskeleton together. The larva then consumes the contents of the ant's head, upon which the head usually falls free of the body (Figure 4). Through a series of repetitive body extensions, the larva forces the deceased ant's mouthparts off the head, though sometimes they do not completely detach (Figure 6). During pupation, the first three segments of the larva's body become sclerotized and fuse into a plate. This plate fills the oral cavity where the ant's mouth parts were previously attached. Within a couple of days, two respiratory structures extend from the sides of the puparium (Figure 5). The adult fly will emerge from the ant's head 2-6 weeks after pupation (Figure 6). The total development time is 4-12 weeks, depending on temperature, and time as an adult represents only about 3-5 days of this time (Pesquero et al. 1995, Porter et al. 1997, Porter 1998).

An interesting mechanism for sex determination exists in several species of *Pseudacteon* wherein sex is determined by the size of the head capsule in which pupation occurs. Large ants result in female flies, and small ants result in male flies (Morrison et al. 1999).



Figure 3. A female phorid fly, *Pseudacteon* sp., hovers over a fire ant worker.

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Figure 4. An ant that has been decapitated as a result of *Pseudacteon* parasitism.

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Figure 5. Two pupae of a *Pseudacteon* fly (dorsal and ventral views) next to a pupa still in its host's head. Note correlation of size and shape to ant host, hardened and darkened anterior portion, and respiratory horns.

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Figure 6. An adult *Pseudacteon litoralis* emerges from an ant head.

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Hosts

Pseudacteon flies released as biological control agents in the United States primarily attack the red imported fire ant, *Solenopsis invicta* Buren, as it is the most prevalent introduced species (Callcott and Collins 1996). *Pseudacteon litoralis* and *Pseudacteon curvatus* also will attack black imported fire ants, *Solenopsis richteri* Buren, and *Solenopsis invicta* × *Solenopsis richteri* hybrids (Callcott et al. 2011, Porter et al. 2011) where they occur. *Pseudacteon* species that are native to North America will attack native fire ants and ants in other genera (Disney 1994; Plowes et al. 2009). All *Pseudacteon* species have been observed to be highly host specific, only attacking ants from a single species or a group of closely related species (Porter and Gilbert 2004, Weissflog et al. 2008). Whereas non-parasitic phorid flies often are found near decaying matter, and some species can become household pests, ant-decapitating *Pseudacteon* flies are not attracted to people or animals (other than ants), decaying matter, carrion, feces, fruits, vegetables, or prepared foods (Porter and Gilbert 2004). *Pseudacteon* flies will only be found around disturbed fire ant mounds.

Biological Control

Invasive imported fire ants have been present in the United States since around 1918 (Callcott and Collins 1996). In their native range of South America, fire ant populations are much lower than in the United States. Porter (1998) surmises that this difference in population density is due to the absence of natural enemies in their adventive range. In addition to the direct impacts of parasitism, the presence of *Pseudacteon* flies has been shown to interrupt fire ant foraging by triggering immediate defensive and evasive behaviors (Porter 1998). The ability of fire ants to recognize *Pseudacteon* flies and their strong reactions to the presence of the flies strengthened interest in use of *Pseudacteon* spp. for biological control. Around 1994, efforts to import *Pseudacteon* flies began with the initiation of two separate research programs; one by the USDA-ARS fire ant research unit in Gainesville, FL and the other at the University of Texas in Austin, TX (Callcott et al. 2011). The first successful release of a *Pseudacteon* fly occurred in 1997 with the release of *Pseudacteon tricuspis* in Florida. From 1997 on, USDA-ARS, the University of Texas, and USDA-APHIS in cooperation with 11 states have released six different species of *Pseudacteon* at numerous sites across the southern US. The biological control of invasive imported fire ants is an ongoing effort that also includes various other parasitoids and pathogens including microsporidians, viruses, and other parasites (Briano et al. 2012).

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