

Off With Their Heads – Phorid Decapitating Flies to the Rescue

By Jason Oliver, Karla Adesso, and Nadeer Youssef (Tennessee State University); Karen Vail and Bill Klingeman (University of Tennessee); and Steve Powell (Tennessee Department of Agriculture). (May want to consider involving Sanford Porter in authorship if he is willing, just to confirm that everything below is accurate. Alternatively, I will need to spend a little time with the literature fact checking everything I typed below).

“Off with their heads” was a favorite snap of the ill tempered Queen of Hearts in Lewis Carroll’s Alice’s Adventures in Wonderland story. But in real life, the equally infamous imported fire ant (*Solenopsis* spp.) has the same head-disposing enemy. The U.S. Department of Agriculture has been involved over multiple decades in the search for natural enemies of imported fire ants in South America (the native range of the ants). One such enemy is the phorid-decapitating flies in the genus *Pseudacteon*. These small gnat-sized flies (Fig. 1) belong to a fly family called the “hump-backed” flies, so named for the enlarged thorax that gives a hump back appearance. Some species in this family parasitize ants.

The phorid species that attack fire ants do so by injecting an egg in the thorax of a worker fire ant. After hatching, the fly larva relocates to the head capsule of the fire ant and begins to feed and grow. The larva eventually kills the ant and causes the head to fall off of the body (Fig. 2), which gives the flies their common name of “decapitating”. The fly larva pupates inside the ant’s head capsule and after completing its development, the adult fly exits the head by pushing through the mandibles (Fig. 3). The flies developing inside the ants have the ability to modify the worker ant’s behavior, causing them to exit the mound and seek out sheltered locations (such as under leaves) to die. The process of manipulating the ant has been referred to as “creating zombie ants”.

There are at least 18 phorid species in South America that are known to attack fire ants in the genus *Solenopsis*. To date, the USDA has approved 6 species for release in the United States after extensive testing to ensure the flies would not pose a threat to other insects, humans, or animals. In cooperation with USDA-ARS and USDA-APHIS, 4 of these fly species have been released in Tennessee by our TSU, UT, and TDA groups from 1999 to 2017. Release locations of the 4 species are depicted in Fig. 2. The USDA release program ended in 2017. We are presently involved in efforts to determine establishment success of these fly species in the state. One species, *Pseudacteon curvatus* is now established statewide. Each of these fly species offer different potential benefits. For example, *P. cultellatus* and *P. curvatus* attack small and medium sized worker ants and *P. tricuspis* and *P. obutus* attack medium and large sized worker ants. Some of these species prefer to attack red or black imported fire ant species (the two species that infest Tennessee) or their hybrid. Finally, some of these species attack the ants along foraging trails and some attack near the mound when the colony is disturbed (e.g., during mating flights). Because each phorid species potentially brings a different “service” to the management table, it is important to establish as many species as possible in a given area to maximize the benefits against fire ants.

There are a number of potential benefits offered by these flies. One obvious direct benefit is they kill fire ants. However, it is estimated that only about 3% of the worker ants in a fire ant colony are parasitized by phorid flies at any given time. Consequently, these flies are not going to eliminate fire ants, nor could they, since any biological control agent cannot be 100% effective or they would eliminate all of the hosts necessary for the species to survive. A potential

greater benefit of these flies is their ability to harass fire ant workers when they are foraging, which reduces colony success at procuring food resources. Just like nursery plants need water, sunshine, and soil nutrients to grow and thrive, a fire ant colony needs to collect food resources to sustain the colony members and to grow. Because fire ants are social insects, colony members include the queen, larvae, worker ants, and reproductives. The reproductives are a special caste of ants that serve to propagate and spread the species by periodically leaving the colony during mating flights. Only large mature colonies have sufficient resources to produce reproductives. By harassing foraging workers, phorid flies may reduce or limit colony growth and reproductive outputs. Because fire ant workers can detect phorid fly attacks and often exhibit an instinctual defensive curl to prevent oviposition, another benefit offered by phorid flies is a reduction in the time colonies remain agitated after mound disturbance. If you have ever had the unfortunate experience of being stung by multiple fire ants after disturbing a mound, you will appreciate phorid flies for their help in chasing the ants back into the mound. Finally, although it has not been proven conclusively, it has been speculated that phorid flies may facilitate the transmission of some fire ant pathogens. It is possible the ovipositor phorid flies use to inject eggs into fire ants may spread some pathogens among ants via the “dirty” hypodermic needle effect.

Fire ants are still spreading northward in Tennessee and now partially or completely infest 66 counties in an infestation area of about ## million acres (Fig. ##), including all of the primary middle Tennessee nursery growing counties. The ants have achieved all of this range expansion in just the 32 years since their first confirmed natural entry into Hardin County in 1987. Unfortunately, fire ant presence in the nursery-growing areas adds cost and hassle to growers, who must apply required regulatory treatments to certify nursery stock for shipment out of the Federal Quarantined area. It is hoped these phorid flies may be one component of a larger management plan for reducing the fire ant problem in Tennessee. One big benefit of the flies is they are “free” and “self-maintaining” once they are established, so maybe the Queen of Hearts was right after all ---“off with their heads”.

Comment [Reviewer1]: I have a spreadsheet of county acreages and estimates for partial counties, but might need to update it to get the latest “million acre” estimate.

2018 Imported Fire Ant Quarantine Area (Image courtesy of the Tennessee Department of Agriculture)



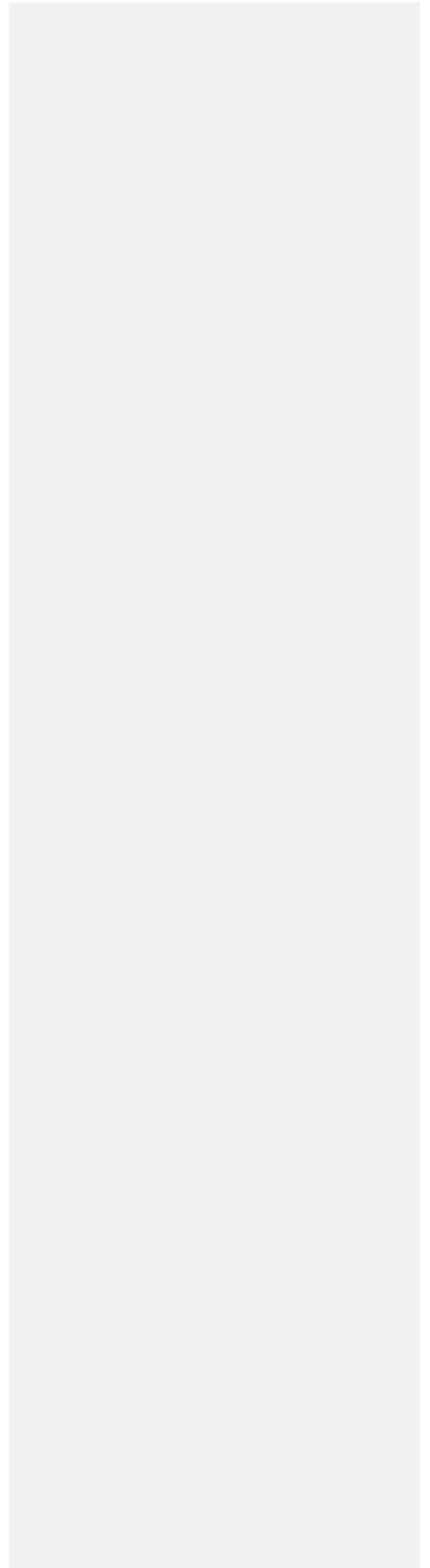
These 2 somewhat blurry photos were part of a movie we made of flies attacking ants. I captured a couple of brief seconds of action in images below, but probably not good enough quality for publication.



I think these two adult fly pictures were taken by our group and would not require permission, but it may be better to re-photograph some adult flies to be sure we are not violating someone's source. We should be able to collect fresh flies this time of the year to get good ovipositor pictures. We can also probably simulate a decapitated ant head by just plucking the head and putting next to body in a photo. Other photos are available on bugwood that may be useful, including fly emerging from head and worker ant being attacked.



Some additional potential images below with permissions from sources.



U.S. Release	Species	Native Range	
		Distribution	Abundance
Yes	<i>P. curvatus</i>	South America	Common
	<i>P. obtusus</i>	South America	Common
	<i>P. tricuspis</i>	South America	Very Common
	<i>P. cultellatus</i>	South America	Rare
	<i>P. nocens</i>	South America	Uncommon
No	<i>P. litoralis</i>	South America	Very Common
	<i>P. affinis</i>	Brazil	Rare
	<i>P. borgmeieri</i>	South America	Uncommon
	<i>P. comatus</i>	Brazil	Rare
	<i>P. convexicauda</i>	Brazil	Rare
	<i>P. dentiger</i>	Brazil	Rare
	<i>P. lenkoi</i>	Brazil	Rare
	<i>P. nudicornis</i>	South America	Uncommon
	<i>P. pradei</i>	Brazil	Common
	<i>P. solenopsis</i>	Brazil	Localized
	<i>P. wasmanni</i>	Brazil	Very Common
	Unidentified A	Brazil	Rare
	Unidentified B	Brazil	Rare

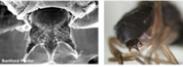
Phorid Flies in Tennessee (1999 to 2017)



Pseudacteon curvatus
47,656 flies



Pseudacteon tricuspis
13,202 flies



Pseudacteon obtusus
53,449 flies



Pseudacteon cultellatus
64,713 flies

