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Kleptoparasitic flies and jumping spiders (Araneae: Salticidae)

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Abstract. Kleptoparasitic flies that associate with predatory insects and spiders are also vulnerable to the attacks of salticid spiders.

Keywords. Cecidomyiidae, *Didactylomyia longimana*, *Harpegnathos saltator*, *Hyllus semicupreus*, Indian Jumping Ant, Karnataka, Milichiidae, *Myrmarachne*, myrmecophily, Sepsidae, *Telamonia dimidiata*

Many flies are *kleptoparasites*, feeding on prey captured by predatory insects or spiders (Table 1, Figures 1-5).

Table 1. Flies (Diptera) that are known to be spider kleptoparasites. Sepsidae is included here as some species may feed on the remains of insects captured by spiders.

family	genera	common names	references
Cecidomyiidae	*Didactylomyia*	gall midges or gall gnats	Gagné 1994; Sivinski & Stowe 1981; Sivinski et al. 1999; Fedotova & Perkovsky 2012; Gillung & Borkent 2017
Ceratopogonidae	*Atrichopogon, Culicoides*	biting midges	Sivinski et al. 1999; Gillung & Borkent 2017
Chloropidae	*Anomoeoceros, Guarax, Olcella, Trachysiophonella*	frit flies or grass flies	Sivinski et al. 1999; Brake & von Tschirnhaus 2010; Gillung & Borkent 2017
Dolichopodidae	*Microphor*	long-legged flies	Sivinski et al. 1999; Gillung & Borkent 2017
Lonchaeidae	*Lonchaea, Setisquamalonchaea*	lance flies	Sivinski et al. 1999; Gillung & Borkent 2017
Milichiidae	*Desmometopa, Leptometopa, Milichiella, Neophyllomyza, Olcella, Paramyia, Phyllomyza, Stomosis*	jackal flies or freeloader flies	Frost 1913; Robinson & Robinson 1977; Landau 1987; Sivinski & Stowe 1981; Eisner et al. 1991; Sivinski et al. 1999; Brake 2000; Brake & von Tschirnhaus 2010; Swann 2016; Gillung & Borkent 2017
Phoridae	*Megaselia*	scuttle flies	Sivinski et al. 1999; Gillung & Borkent 2017
Sepsidae	*Australosepsis, Dicranosepsis, Meroplius, Perochaeta, Sepsis*	black scavenger flies or ensign flies	Iwasa & Tewari 1994; Pont & Meier 2002

Figure 1. Phoretic milichiid fly riding on a Jerdon's or Indian Jumping Ant, *Harpegnathos saltator* (T. C. Jerdin 1851) in Karnataka. These female ant workers (*gamergates*) can mate and lay eggs (Liebig & Poethke 2004).

Figure 2. Kleptoparasitic flies and spiders in Karnataka. **1,** Milichiid flies feeding on bee (*Apis* sp.) captured by a thomisid spider. **2,** Sepsid fly approaching the prey of a feeding thomisid. **3,** Milichiid flies feeding on bee captured by a thomisid spider. **4,** Pholcid spider with captured Green Tree or Weaver Ants, *Oecophylla smaragdina* Fabricius 1775. **5,** Small flies feeding on the head of a Weaver Ant captured by this pholcid (4). **6,** Small fly (arrow) on a captured Weaver Ant. At lower left the male of a small kleptoparasitic theridiid can be seen. **7-9,** Milichiid flies feeding on the prey of a *Parawixia* sp. (Araneidae).

Figure 3. Kleptoparasitic flies and spiders in Karnataka (1-7) and South Carolina (8-9). **1,** Gall gnats (Cecidomyiidae: *Didactylomyia* sp.) in a web shared by two theridiid spider species, one a molting female (bottom), and the other (male and female, above) smaller. **2-3,** Fly on abdomen of Weaver Ant, *Oecophylla smaragdina*, captured by a thomisid spider, *Amyciaea forticeps* (O. Pickard-Cambridge 1873). *A. forticeps* is a specialised mimic of the ants that it preys upon (Mathew 1954; Sunil Jose st al. 2003). **4,** Gall gnats (arrows) with a sparassid, *Heteropoda* sp. **5,** Gall gnats feeding on the prey of a ctenid. **6-7,** Flies feeding on the wrapped prey of a hersiliid spider. **8-9,** Milichiid flies feeding on wasps (*Vespula* sp.) held by female oxyopids, *Peucetia viridans* (Hentz 1832). Note the attending male in (9). Photos 8-9 by David E. Hill.

Figure 4. *Hyllus semicupreus* (Simon 1885) with kleptoparasitic flies in Karnataka. **1-3,** Female *H. semicupreus* feeding on a captured gall gnat (Cecidomyiidae: *Didactylomyia* sp.). Within two minutes this salticid captured three of these gall gnats in succession. Note the aggregation of gall gnats in a nearby spider web. **4-8,** Milichiid flies with a male *H. semicupreus* feeding on a captured female of the same species. Feeding on conspecific females by male salticids is unusual. The feeding male spider intermittently attempted to bat away these milichiids.

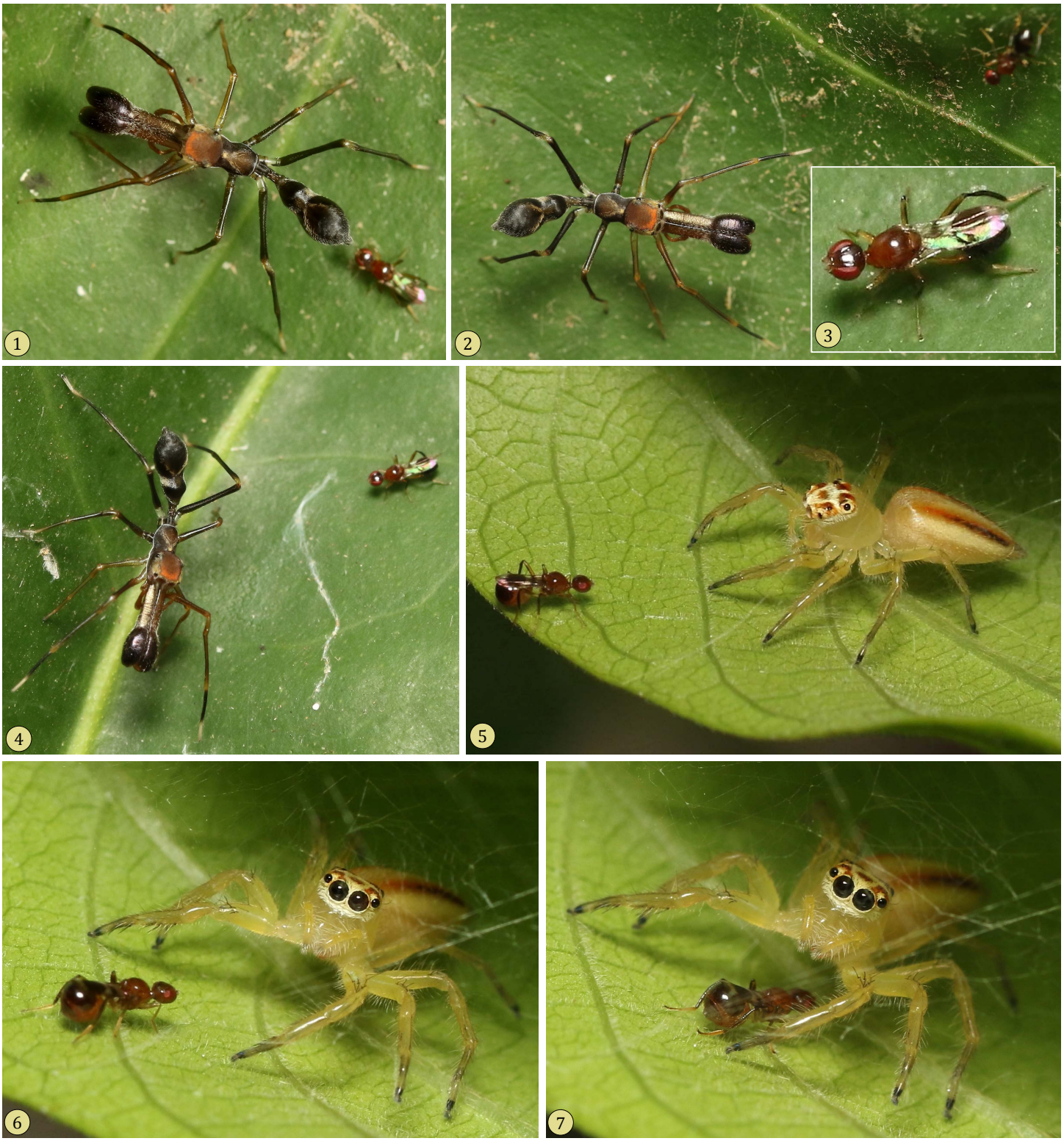

Figure 5. Sepsid flies following salticids in Karnataka. **1-2, 4-5,** Sepsid fly following an adult male *Myrmarachne* sp. **3,** Detail of sepsid fly shown in (4). Note the rounded head. **5-7**, Sequence showing approach and entry into the shelter of an adult female *Telamonia dimidiata* (Simon 1899) by a sepsid fly. Perhaps because of either their ant-like appearance or their chemical defense, sepsids may not be taken as prey by these salticids.

Diptera: Nematocera: Cecidomyiidae. The gall gnat *Didactylomyia longimana* (Felt) is a cosmopolitan kleptoparasite often found with spiders (Gagné 1994; Fedotova & Perkovsky 2012). Sivinski & Stowe (1981) reported that this fragile species was the dominant dipteran parasite on spiders in north central Florida, although some araneid spiders would bat at them with their forelegs. In Karnataka *Didactylomia* were observed either in aggregations on spider webs (Figures 3:1, 4:1-3) or in association with feeding spiders (Figure 3:4-5).

Diptera: Brachycera: Milichiidae. Small, compact jackal flies can be found as kleptoparasites in association with spiders, ants and other predatory insects on all continents except Antarctica (Robinson & Robinson 1977; Brake 2000; Brake & von Tschirnhaus 2010; Schwann 2016). Their larvae tend to live in and feed upon decaying plants (Brake 2000). Myrmecophilous species may be phoretic and they may take food directly from the mouth of ants (Figure 1; Wild & Brake 2009; Yusah & Fayle 2014). Some species that associate with spiders (e.g., *Milichiella*, *Neophyllomyza* and *Olcella*) appear to be attracted to the volatile chemical defenses of captured Hemiptera (Frost 1913; Landau 1987; Eisner et al 1991). Other spider kleptoparasites (e.g., *Desmometopa*) are often found on captured bees and wasps (Figures 2:1-3, 3:8-9; Landau 1987; Brake 2000).

Diptera: Brachycera: Sepsidae. Many of the small (2-6 mm) scavenger flies, identified by their unusually spherical heads and ant-like shape, feed on insect carrion (Pont & Meier 2002). They may associate with spiders in their search for this carrion (Figures 2:2, 5; Hill et al. 2019). Some sepsids may have defensive glands associated with the rectum that produce chemicals that make them unpalatable to spiders (Bristowe 1979; Pont 1987; Dettner 2015).

Kleptoparasitic flies have seldom been observed in association with salticid spiders. Frost (1913) reported the milichiid *Desmometopa latipes* Meig. with a *Phidippus clarus* (*multiformis*) Keyserling 1885 feeding on the plant bug *Lygus pratensis* L. Landau (1987) documented the milichiid *Desmometopa m-nigrum* (Zetterstedt 1848) feeding on bees (*Apis mellifera* L. 1758) captured by both the salticid *Phidippus audax* Hentz 1845) and the oxyopid *Peucetia viridans* (Hentz 1832). Welch (2013) has posted a series of photographs that may depict a sepsid fly approaching from below and feeding directly from the mouthparts of a female salticid, cf. *Artabrus* sp., in West Java. Here we document milichiids feeding on the salticid prey of a *Hyllus semicupreus* (Figure 4:4-8), and sepsids approaching a *Myrmarachne* (Figure 5:1-4) and a female *Telamonia dimidiata* (Figure 5:6-8), both in Karnataka.

But where larger spiders may neglect or simply bat away these kleptoparasitic flies, they may also represent a food source for salticid spiders. As shown here (Figure 4:6-8), *Hyllus semicupreus* (Simon 1885) may be attracted to aggregations of gall gnats (*Didactylomyia*) where they can be easily captured. A North American *Phidippus princeps* (Peckham & Peckham 1883) was once observed as it macerated a mass of small flies, most likely milichiids, captured one by one as they approached the partly liquified feeding mass of this salticid (Hill 2018). Dipteran kleptoparasites that lack a chemical defense may be quite vulnerable to salticids.

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