

**Biology of *Calyptodesmus sanctus*
(Diplopoda: Pyrgodesmidae)
a Facultative Myrmecophile¹
Introduced into the United States**

by

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ABSTRACT

The introduced millipede *Calyptodesmus sanctus* Schubart was collected in active nests of *Pheidole crassicornis* Emery, *P. dentata* Mayr, *P. floridana* Emery, *P. lamia* Wheeler, *P. metallescens* Emery, *P. moerens* Wheeler, *Solenopsis geminata* (F.), *S. invicta* Buren, *Cyphomyrmex rimosus* (Spinola), *Cyphomyrmex* sp. and *Camponotus floridanus* (Buckley) as well as in abandoned *S. geminata* mounds, rotten logs, leaf litter, and pitfall traps in Florida and Georgia. Field and laboratory observations indicate that this millipede is a facultative myrmecophile with no preference for any specific host. Laboratory studies using ³²Phosphorus demonstrate feeding on dead ants, indicating it is a scavenger. The millipedes also ate organic materials in the laboratory. The use of a defensive secretion is described. Collection data indicate that this millipede is relatively common in Florida and Georgia, but has a patchy distribution.

Key Words: Red Imported Fire ant, *Solenopsis invicta*, Native Fire Ant, *Solenopsis geminata*, scavenger, biology and behavior, radioisotopes, distribution: United States, Florida, Georgia, introduced species

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A number of millipedes are reported to be myrmecophiles (Wilson 1971, Kistner 1982). Some have several hosts (Rettenmeyer 1962) and others are facultative myrmecophiles since they can live without their hosts for extended periods (Donisthorpe 1927). Hoffman (in press) placed several millipede names, including *Calyptodesmus schubarti*, described from Florida, in synonymy with *Calyptodesmus sanctus* (described from Argentina, Paraguay, and Brazil) and summarized the South American distribution. Millipedes, identified as the introduced *C. sanctus* were collected from the nests of several species of ants in Florida. These collections and the dearth of behavioral information, induced us to initiate the following studies to investigate the inter-relationships of the ants and this millipede. These studies were conducted, in part, as a portion of the continuing study of potential biological control agents of imported fire ants.

BIOLOGICAL OBSERVATIONS

Numerous specimens of *C. sanctus* (Fig. 1) were collected in the field from ant nests or floated from field collected fire ant mounds (Wojcik *et al.* 1977). The millipedes were held in the laboratory for testing and observation. Small numbers of millipedes were introduced into laboratory ant nests containing the original host colonies of *Pheidole lamia*, *Cyphomyrmex* sp., *Solenopsis invicta*, or *S. geminata*. No trophallactic feeding by any species of ant was observed. Millipedes were observed feeding on a piece of wax moth larva, several pieces of moldy agar-base ant diet, fresh ant diet, and honey agar. Although, millipedes were often collected in brood chambers of ant nests in the field and often observed in brood piles in laboratory nests (Fig. 2), no predation was observed.

To determine if trophallaxis occurred between the millipedes and their host ants, 2 groups of 10 specimens each of *P. lamia* and *Cyphomyrmex* sp. were fed for 3 days with red-dyed (food coloring) sugar solution. Each group of ants was transferred to a petri dish containing 4 millipedes (that had been isolated for 3 days). After 5 days, each millipede was crushed on blotter paper and no trace of red dye was found.

To better define the relationship of *Calyptodesmus sanctus* with the ants, the millipedes were tested using *S. invicta* labeled with ^{32}P (Wojcik 1975). Briefly, whole colonies of ants were fed ^{32}P

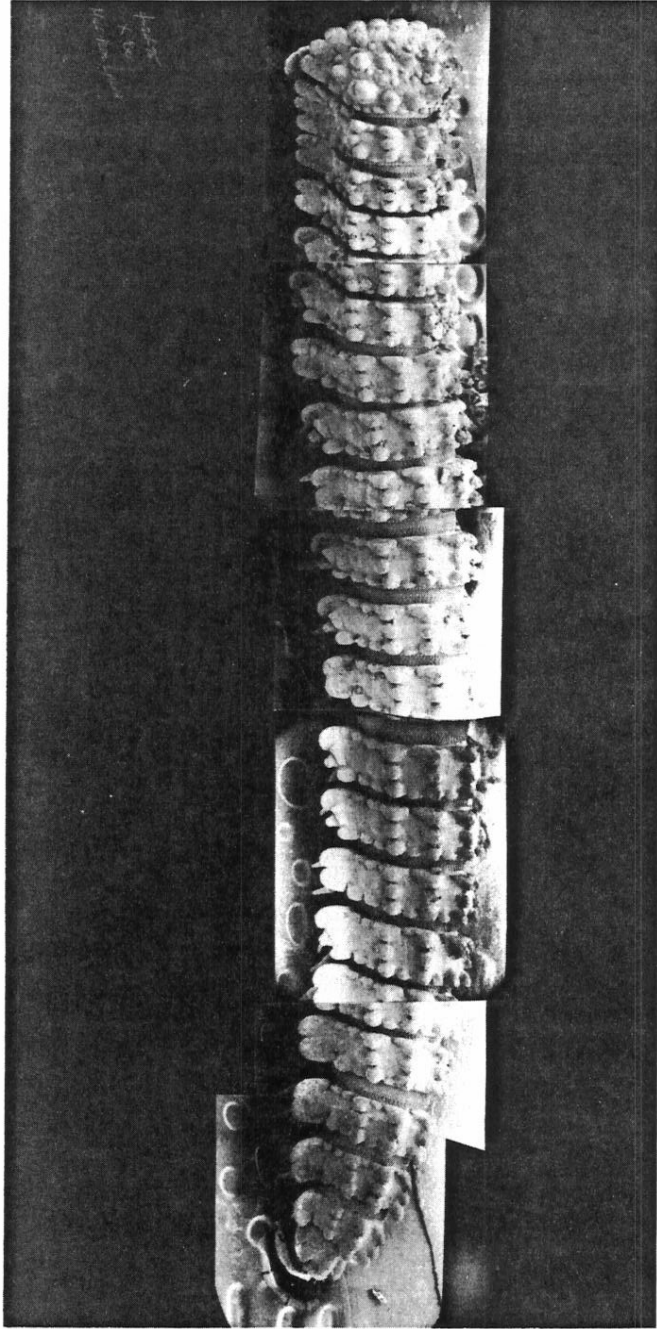


Fig. 1. SEM montage of adult *Calyptodesmus sanctus* at 80X.
SEM photos by Mrs. Pat Carlisle, USDA, ARS, Gainesville, FL.

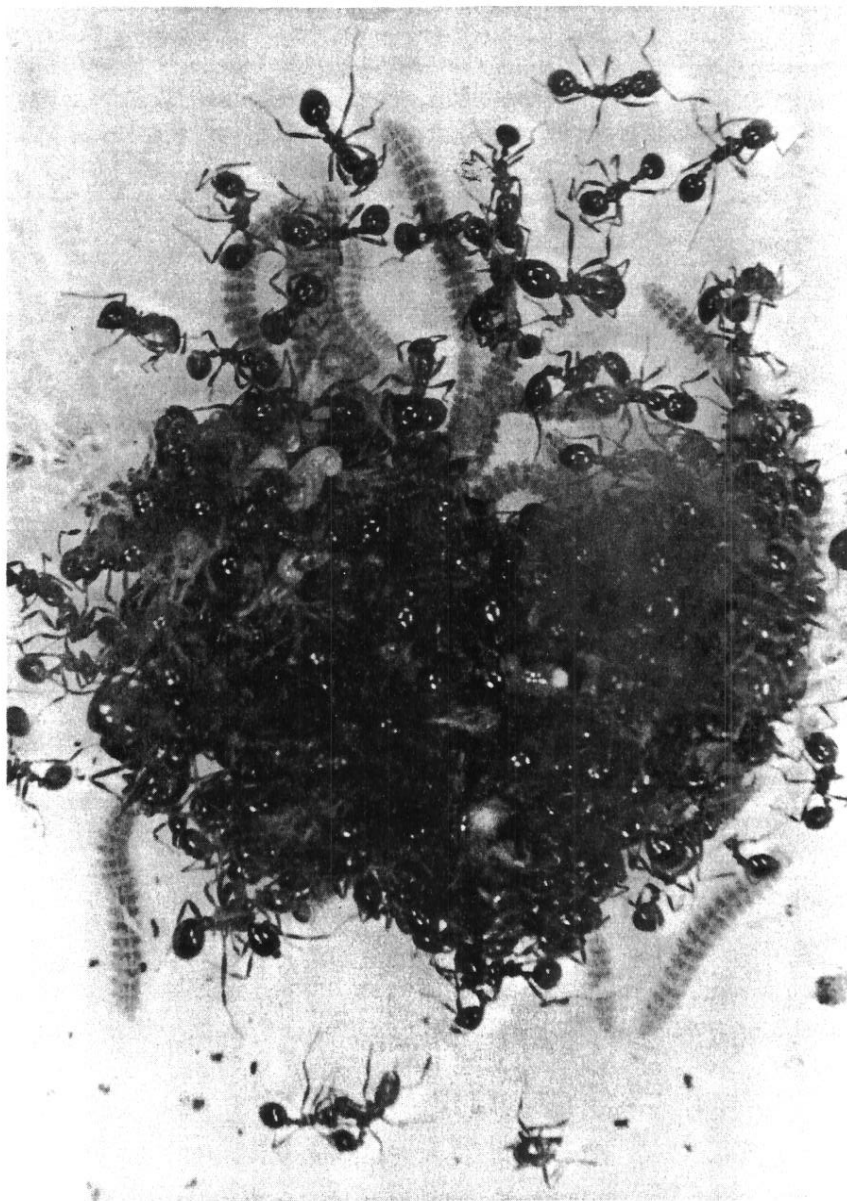


Fig. 2. Mass of *Solenopsis invicta* workers and brood in laboratory nest. Numerous *Calyptodesmus sanctus* can be seen in and around brood pile. The millipedes were not molested in any way by the ants.

in beef baby food or ant diet. House flies were fed ^{32}P in sugar water. Millipedes were isolated with the following radioactive ant castes or situations: live workers, larvae, fresh dead workers, 3-day dead workers, ant feces, and dead house flies. After 24 hr, the millipedes were removed and checked for radioactivity with a liquid scintillation counter using the methods described by Wojcik (1975). The number of millipedes used in each experiment was determined by the number on hand at the time of each experiment. The results are shown in Table 1. *C. sanctus* did not acquire radioactivity from live worker ants, larvae, or ant feces. Some millipedes did acquire radioactivity from dead ants and dead house flies indicating scavenging.

Table 1. Numbers of *Calyptodesmus sanctus* in each category of acquired radioactivity from the given radioactive sources. Millipedes exposed for 24 hr. Ant species used was *Solenopsis invicta*.

Source of Radioactivity	# of millipedes in each range (counts/min)			
	no radioactivity	up to 10 ²	up to 10 ³	up to 10 ⁴
worker ants	15	--	--	--
ant larvae	30	--	--	--
ant feces or other secretions	14	--	--	--
fresh dead ants	10	3	--	2
3-day dead ants	4	4	2	--
dead house flies	3	3	4	--

C. sanctus were maintained for several weeks in laboratory ant colonies of *Pheidole* spp., *Cyphomyrmex* sp., or *Solenopsis* spp. as well as isolated from any host ant. As long as moist organic matter was available for them to feed on and a high humidity was maintained in the containers, the millipedes survived very well. Even when held in petri dishes without organic matter, the millipedes survived up to 1 week as long as the dishes were not allowed to desiccate.

Myrmecophilous millipedes found with army ants (Rettenmeyer 1962, Akre and Rettenmeyer 1968) can follow natural trails in the field and artificial trails in the laboratory. The trail following ability of *C. sanctus* was tested, but only with *S. invicta*, one

of its more common hosts in the United States. Dufours glands were dissected from the gasters of *S. invicta* workers and crushed in n-hexane. The extract was used at a concentration of 4 glands per ml of hexane. Using a microsyringe, a trail was streaked with the extract on a paper substrate. In 10 trials, *C. sanctus* did not follow the artificial trails. Worker *S. invicta*, used as controls, followed the artificial trails as well as they followed natural trails. Since *C. sanctus* could not follow the trails of one of its common hosts, this is further evidence that *C. sanctus* is a facultative myrmecophile.

On only 1 occasion was an ant (*Cyphomyrmex* sp. worker) seen transporting a live millipede. Myrmecophiles which are well integrated into their host's societies are often transported by their hosts (Kistner 1982). Other millipedes are known to possess a variety of defensive secretions (Weatherson and Percy 1970) which they use to deter predators. *Calypodesmus sanctus* appears to have such a defensive secretion. An example of the use of this defensive secretion by *C. sanctus* was observed with *Cyphomyrmex* sp. A worker was observed trying to grasp a millipede's head with its mandibles. The ant suddenly jerked away from the millipede. Violently shaking its head and wiping its mandibles on the substrate, the ant acted as if trying to rid its mouthparts of a disagreeable substance. This behavior also was often seen in *S. invicta* colonies in the laboratory. In another instance, between a *Cyphomyrmex* sp. worker and a millipede, the ant walked up on top of the millipede and fell off immediately, knocked out. The ant had its antennae, legs and abdomen folded up (like it was dead), and took over 5 min. to recover. In cases of mild aggression, *S. invicta* medias and majors were seen to grasp the millipedes. The ant would lightly grasp the millipede on successive body segments. When the ant removed its mandibles from the millipede, it acted "strangely" and held its mandibles apart and up in the air. The ants acted as if an unpleasant substance was on them for several minutes.

Calypodesmus sanctus often feigns death when disturbed with forceps. In laboratory fire ant nests, it often feigns death when closely examined by worker ants. In 3 instances, after being starved for 10 days, *S. invicta* workers were observed killing *C. sanctus*. Non-myrmecophilous millipedes were always killed and

eaten immediately upon introduction into laboratory fire ant nests despite the presence of defensive secretions.

DISTRIBUTION

C. sanctus was collected at the following locations (Fig. 3) with 11 different species of ants (not counting the ant species from berlese samples). The following abbreviations for collectors are used in the collection data: JDA, J.D. Atwood; WAB, W.A. Banks; DMH, D.M. Hicks; DPJ, D.P. Jouvenaz; MAN, M.A. Naves; JKP, J.K. Plumley; and DPW, D.P. Wojcik. The following abbreviations are used for hosts: NFA, Native Fire Ant, *S. geminata*; and RIFA, Red Imported Fire Ant, *S. invicta*. The numbers in parenthesis indicate the numbers of specimens collected from individual ant nests or other collections. Collections listed as floated were separated from the ant nests using the method of Wojcik *et al.* (1977).

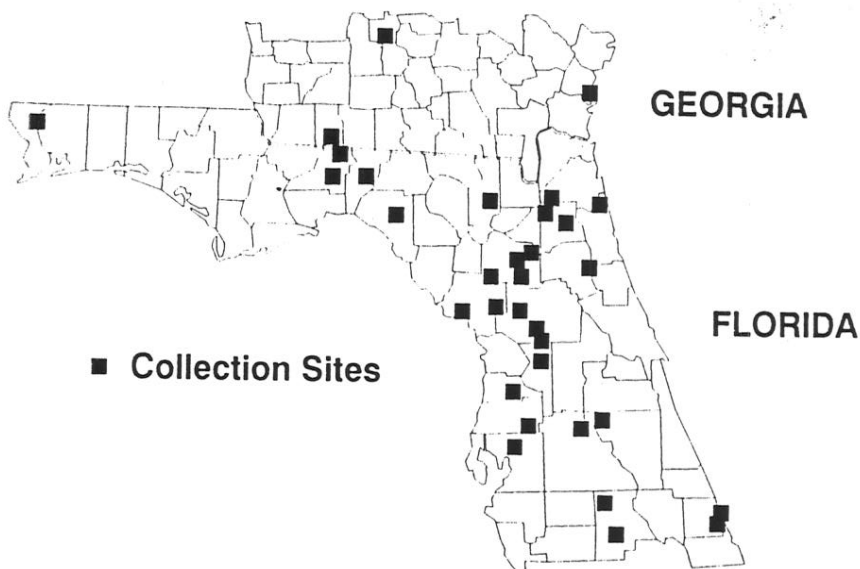


Fig. 3. The known distribution of *Calyptodesmus sanctus* in the United States.

FLORIDA: Alachua Co., 2 mi N of Archer on SR-241, 2-X-76, DPW, in rotten board, no ants seen (9); 8-X-76, DPW, floated from NFA nest (3); Gainesville, 6-VI-75, MAN, in *Pheidole*

dentata Mayr nest (4); 11-XI-75, DPW, Berlese of leaf litter containing 4 species of ants (2); Berlese of pine stump, no ants (1); 12-XI-75, DPW, floated from NFA nest (1); summer-75, MAN, in *Cyphomyrmex* sp. nest (7); 11-III-76, DPJ & DMH, floated from NFA nests (2, 5, 4); 17-XII-76, DMH & JDA, floated from NFA nests (109, 2, 22, 28, 124, 38, 18, 10, 9, 23); Paynes Prairie on shoulder of US-441, all DPW, all floated from NFA nests, 17-IV-70 (5, 10); 12-VI-73 (2, 5, 2, 2); 16-X-74 (10); [floated from abandoned NFA mounds (47, 6, 2)]; 30-X-74 (22, 7, 4, 40, 5, 1, 13, 23, 47, 3); 22-XI-74 (8, 9, 1, 2, 1, 33); 3-XII-74 (3, 45, 4, 8, 2, 8); 22-IV-75 (3, 2); 24-III-76, JDA, DMH, & DPJ, floated from NFA nests (5, 31, 18, 41); 3 mi S of Waldo on US-301, 2-II-77, JKP, floated from RIFA nest (10). Clay Co., Highlands, 20-IV-70, DPW, floated from RIFA nest (1); Middleburg, 4-II-76, DPW, Berlese of leaf litter, no ants (1); Berlese of rotten pine stick containing 3 species of ants (2); 20-II-76, DPW, Berlese of rotten oak log containing 3 species of ants (5). Duval Co., Maxville, 20-V-76, DPW, Berlese of oak leaf litter containing 3 ant species (1). Escambia Co., McDavid, 20-VI-75, MAN, in *P. moerens* Wheeler nest (2). Hernando Co., Brooksville, 17-XI-75, DPW, Berlese of rotten pine stump containing 3 colonies of ants (8). Highlands Co., Archbold Biological Station, Lake Placid, 20-VIII-75, MAN, in *Cyphomyrmex rimosus* (Spinola) nest (2); Avon Park, 18-VIII-78, DPW, Berlese of oak leaf litter (2). Hillsborough Co., Lutz, 31-VII-75, WAB & JKP, floated from RIFA nest (1). Jefferson Co., Capps, 8-IX-74, DMH & JKP, floated from RIFA nests (3, 4, 2, 7); floated from NFA nests (44, 5). Leon Co., Tall Timbers Research Station, 1-III-73, DPW, floated from RIFA nests (6, 2); 17-VII-73, MAN, in *P. lamia* nest (2); in *P. metallescens* Emery nest (2); 17-VII-74, MAN, in *P. crassicornis* Emery nest (7); 18-VIII-74, MAN, in *P. metallescens* nest (14); Southwood Plantation, 5 mi E of Tallahassee, 9-X-74, DPW, floated from RIFA nest (5). Levy Co., Otter Creek, 3-X-75, DPW, in Berlese of rotten log with *S. (Diplorhoptrum)* sp. (1); 2 mi N of Williston on CR-343, 6-XI-82, DPW, in *Cyphomyrmex* sp. nest under rotten log (1). Marion Co., Belleview, 9-IV-75, DPW & DMH, floated from NFA nest (2); Summerfield, 30-IV-80, DPW, floated from NFA nests (9, 5, 10); NW Marion Co., G. Neal's farm, 18729 NW 160 Ave, all DPW, 10-XI-90, *Cyphomyrmex* sp. nests (1, 7); RIFA nest (3); 11-XI-90,

Cyphomyrmex sp. nests (1, 1); RIFA nests (7, 1); under logs, no ants seen (1, 9); *Pheidole dentata* nest (11); *Camponotus floridanus* (Buckley) nests (12, 7, 8); 18-XI-90, RIFA nest (20); *Pheidole moerens* nest (1); 23-XI-90, RIFA nest (20); 1-XII-90, RIFA nest (2). Osceola Co., Kissimmee, 10-IV-77, DPJ, Berlese of rotten cypress log containing 4 species of ants (39). Pasco Co., Zephyrhills, 17-XI-75, DPW, in *P. floridana* Emery nest (1). Polk Co., Barnum City, 11 to 18-IV-78, pitfall trap (1). Putnam Co., Palatka, 3-VIII-75, MAN, in *P. dentata* nest (2). St. Johns Co., Dee Dot Ranch, 2 mi SW of Jacksonville Beach, 17-I-V-73, DPW, floated from RIFA nest (1). St. Lucie Co., Ft. Pierce beach, 1-XI-75, DPW, in Berlese of rotten Australian pine log with *Hypoponera opaciceps* (Mayr) (1); edge of Savannahs City Park, 9-V-76, DPW, in Berlese of rotten log with 2 species of ants (4); in Berlese of sabal palm litter with 5 species of ants (5). Sumter Co., Wildwood, Fla Turnpike right-of-way, DPW, 31-V to 6-VI-78, pitfall trap (2). Taylor Co., Perry, 2-X-75, DPW, in *Cyphomyrmex* sp. nest (4).

GEORGIA: Glynn Co., Blythe Island, SR-303, 27-I-77, DPW, floated from RIFA nests (22, 5); floated from NFA nest (10). Grady Co., Rocky Hill, Birdsong Plantation, 4-I-77, DPW, in RIFA nest (1). Turner Co., Ashburn, 26-IV-72, DPW, in RIFA nest (1).

Calyptodesmus sanctus (= *Calyptodesmus schubarti*) was previously known from the United States only from Columbia and Alachua Counties, Florida, from under boards (Causey 1960). The data given here expands the North American range considerably. Two collections (Alachua Co., Archer; Marion Co., Neal's farm) confirm the Causey (1960) collections without an ant host. These collections, coupled with the Berlese samples that did not contain any ants from rotten logs (Alachua Co.) and leaf litter (Clay Co.; Highlands Co.) are additional evidence that *C. sanctus* is a facultative myrmecophile. The presence of the millipede in abandoned NFA mounds (Alachua Co.) is additional evidence that this millipede can live without an ant host. The presence of millipedes in pitfalls (Polk Co. and Sumter Co.) show that they move over the soil surface from ant nest to ant nest. Hundreds of other ant colonies, primarily RIFA and NFA, have been sampled from other states in the Southeastern United States (Wojcik et al. 1977, Wojcik unpublished) without finding *C. sanctus*.

The patchy distribution of *C. sanctus* is demonstrated with the data from intensive collection of NFA mounds. Large numbers of NFA mounds were collected in 5 gal buckets and floated out in the laboratory (Wojcik *et al.* 1977). In each case, a large portion (at least 2½ gal) of the mound was sampled. In consecutive NFA mounds found on the road shoulder of US-441 on Paynes Prairie, Alachua Co., on 24-IX-74, this millipede was found in 0 out of 24 mounds; on 1-X-74, 0 out of 23; on 16-X-74, 4 out of 22; on 30-X-74, 10 out of 24; on 22-XI-74, 6 out of 25; and on 3-XII-74, 6 out of 19. Only 26 out of 137 colonies (19%) contained *C. sanctus*. From 1 to 47 specimens were collected from each colony for a total of 354 specimens, with an average of 13.6 specimens per colony with millipedes. *C. sanctus* may be numerous in ant nests, particularly NFA and RIFA mounds, as demonstrated by the large numbers of specimens collected by flotation from 2 NFA mounds (109 and 124 specimens, Gainesville, FL). Also in this context, the collections from Marion Co., Neal's farm, bear some discussion. This farm has not been treated with any insecticides for many years, and had a very rich ant and myrmecophile fauna. All of the collections from this farm were made by examining ant colonies which were located under rocks, logs, or other items. In this way a large number of millipedes were found, indeed, we did not collect all that we saw, just collecting those needed for new host records or laboratory studies. This species is often not noticed by the untrained collector, because of its small size and death feigning.

The facts, that *C. sanctus* can survive without any ant host for extended periods and that it can live with so many species of ants, are evidence that this species of millipede is a facultative myrmecophile.

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