

The Ant (Hymenoptera: Formicidae) Fauna of the Cedar Glades and Xeric Limestone Prairies of the Central Basin of Tennessee

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Abstract—Ants may be the most thoroughly documented group of insects inhabiting the cedar glades of the Central Basin of Tennessee with two studies conducted in the late 1930s reporting ants found in cedar glades of the region. To compare the ant fauna of modern cedar glades with the lists produced in earlier studies and to document the ant fauna of xeric limestone prairies associated with the glades, a study was conducted from June 2010–April 2011. Twenty-six total species, including the hybrid imported fire ant, were sampled from both habitat types (19 species in cedar glades and 18 in the xeric limestone prairies), which included most of the species reported in the previous studies. Two new state records for Tennessee were documented. Ordination of the species lists from cedar glade and prairie habitats indicates that the ant fauna of the two habitats are distinct.

Introduction

As the name suggests, the Central Basin physiographic region of Tennessee is a somewhat elliptical depression situated in the center of the state (Fig. 1). Elevation in the basin is typically 120–215 m below that of the surrounding Low Plateau (Fenneman, 1938). Outcroppings of the basin's Ordovician limestone bedrock and shallow soils result in conditions that favor herbaceous vegetation and limit tree growth to isolated individuals or scattered stands of eastern red cedar (*Juniperus virginiana*) and a few other woody species. These open areas, called “cedar glades,” are found on shallow Gladeville flaggy silty clay loam situated <1 to 25 cm above the Lebanon or Ridley limestone bedrock and are often saturated with precipitation from late autumn to early spring, whereas during summer they are often below wilting point (Baskin and Baskin, 1999; Quarterman 1950).

The Central Basin of Tennessee has the highest concentration of glade habitat east of the Mississippi River (Quarterman et al., 1993). These glades have long been noted for their floral distinctiveness with 4 endemic and two near endemic plant species occurring in these glades, as well as several plants that are considered

disjunct from populations in the Ozark Mountains (Gattinger, 1901; Harper, 1926; Quarterman, 1950; Baskin and Baskin, 1999). Quarterman (1950) identified seven plant communities or “zones” of the cedar glades and presented them as a successional pathway going from bare exposed bedrock to mixed hardwood forest. However, recent discussions of these habitats use the term “cedar glade” to reference only the rocky openings (Baskin and Baskin, 1999), and that is the definition used in this study. Subsequent to Quarterman's work, Baskin and Baskin (1977) described a distinct xeric limestone prairie community dominated by little bluestem (*Schizachyrium scoparium*) associated with the cedar glades in the Central Basin.

The insect fauna of the cedar glades has received less attention in general than the flora. However, among the insects inhabiting the cedar glades, the ants are probably the best documented. Meyer (1937) documented nine species of ants inhabiting a glade 21 km southeast of Nashville as part of a study documenting the Annelida, Mollusca, and Arthropoda of the site. In a list of ants from Tennessee, Dennis (1938) lists 15 species as occurring in the cedar glades. From his annotated list it appears that most of cedar glade records are from the Murfreesboro area,

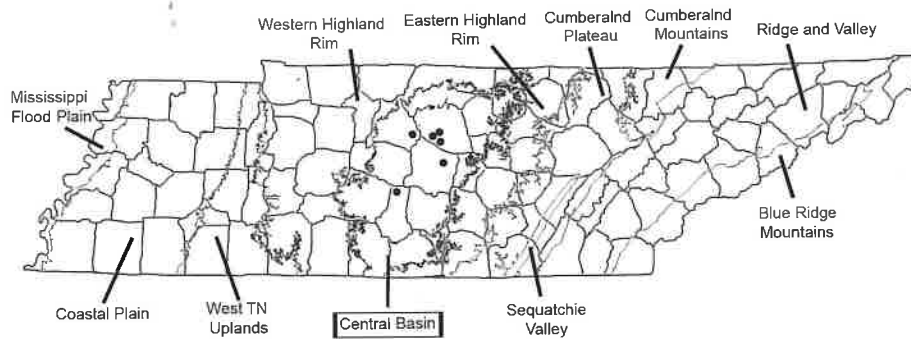


Fig. 1. Physiographic regions of Tennessee and location of study sites for this survey. (•) indicates sampling localities for this survey.

suggesting he did not include Meyer's records, for which he is cited as providing the identifications.

Among insects, ants are typically the most dominant and influential force in terrestrial ecosystems and often comprise a large amount of the animal biomass (Hölldobler and Wilson, 1990). Ants occupy a variety of ecological niches and are involved in many important aspects of ecosystem function including influencing the floral and faunal composition of communities and contributing to nutrient and soil turnover. Numerous species of ants have specific habitat requirements and respond quickly to disturbances to their environment, which make them important taxa for comparing habitat diversity and monitoring environmental changes (Ander sen, 1990; Kaspari and Majer, 2000). These factors provide a strong basis for the inclusion of ants in biological inventories and studies of ecosystem function.

The staff of the Mississippi Entomological Museum has conducted extensive surveys in the cedar glades of Tennessee to better document the insect fauna of this unique habitat. As part of this survey, the ant fauna was sampled extensively to compare our results with those of Meyer (1937) and Dennis (1938). Additionally, these cedar glades and xeric limestone prairies are natural open areas in the southeastern United States that are largely free, thus far, of imported fire ants, and documenting their current ant fauna is important as fire ants colonize these habitats.

Materials and Methods

Habitats—Cedar glades are found on shallow (0–20 cm) soil and are the most xeric habitat in

the region with the exception of bare rock (Quarterman et al., 1993). This zone is characterized by the presence of the blue green algae (*Nostoc commune*), several foliose lichens, and numerous vascular plants such as cedar glade cress (*Leavenworthia stylosa*), Missouri evening primrose (*Oenothera macrocarpa*), wild petunia (*Ruellia humilis*), Gattinger's prairie clover (*Dalea gattingeri* Barneby), Venus' pride (*Houstonia purpurea*), limestone flameflower (*Talinum calcaricum*), widow's cross (*Sedum pulchellum*), Tennessee coneflower (*Echinacea tennesseensis*); white rim scurfpea (*Pediomelum subacaule*), fluxweed (*Isanthus brachiatus*), prickly pear (*Opuntia cespitosa*), poverty dropseed (*Sporobolus vaginiflorus*), prairie fleabane (*Erigeron strigosus*), and pasture heliotrope (*Heliotropium tenellum*) (Quarterman et al., 1993; Baskin and Baskin, 1999).

The xeric limestone prairies of the Central Basin occur on slightly deeper (5–20 cm) soils than the cedar glades. These sites, also known as barrens, are often adjacent to cedar glades and in many instances grade floristically into them, as was the case at the three prairie study sites. The prairies, in contrast to the cedar glades, are dominated by the perennial grasses little bluestem (*S. scoparium*) and poverty dropseed (*S. vaginiflorus*) (Baskin and Baskin, 1977; DeSelm, 1992).

Ant Sampling—Sampling occurred at five natural areas (Couchville Cedar Glade, Flatrock Cedar Glades and Barrens, John and Hester Lane Cedar Glades, Vesta Cedar Glades, and Wilson School Road Cedar Glade and Forest) and Cedars of Lebanon State Park (Table 1 and Fig. 1). All six sites had a cedar glade component, but only three had xeric limestone prairie

Table 1. Collection locality information of study sites.

Site	County	Habitat(s)	Lat-Long
Cedars of Lebanon State Park	Wilson	Cedar Glade	36°05'31"N–86°19'55"W
Couchville Glade N. A.	Davidson	Cedar Glade and Xeric Limestone Prairie	36°06'04"N–86°31'46"W
Flat Rock Cedar Glade N. A.	Rutherford	Cedar Glade and Xeric Limestone Prairie	35°51'31"N–86°17'44"W
Lane Farm N. A.	Wilson	Cedar Glade	36°01'55"N–86°19'55"W
Vesta Cedar Glade N. A.	Wilson	Cedar Glade and Xeric Limestone Prairie	36°04'36"N–86°23'45"W
Wilson School Road N. A.	Marshall	Cedar Glade	35°39'43"N–86°47'44"W

components. Sampling took place 28 April–1 May, 2–5 June, 1–4 August, 7–10 September 2010, and 29–30 April 2011.

Ants were sampled using a multifaceted approach consisting of baiting, hand collecting, sweeping, and extraction from leaf litter and soil with a Berlese funnel. Hand collecting consisted of searching for foraging workers and colonies on the ground, under rocks, and sifting soil, grass duff and leaf litter. Sweep samples from the vegetation were taken throughout each habitat and the contents emptied into a killing jar containing ethyl acetate. Soil and litter from herbaceous vegetation and from under eastern red cedars were collected in a pillowcase and then placed on a Berlese funnel until dry for extraction of ants. To determine which species were the dominant epigeic foragers, a linear transect of 10 small piles of cookie (Keebler Sandies Pecan Shortbread®) crumbs placed 3 m apart was established twice at each site, once during June 2010 and again during September 2010. Sweeping and baiting took place at least 6 meters from the edge of an adjacent habitat.

Data Analysis—To investigate whether the fauna of these two habitats differed, community structure was ordinated using non-metric multidimensional scaling (NMS) with PC-ORD (McCune and Mefford 2011), which uses the algorithm put forth by Kruskal (1964). Ant community data consisted of presence/absence data for each site. The Sorenson (Bray-Curtis) statistic was used as the distance measure for the ordination as recommended by McCune and Grace (2002). A two-dimension representation of species composition was found to minimize the stress of the model. NMS scores for each site

were then analyzed using a one-way ANOVA to test for significant variance.

Results

A total of 26 ant species representing four subfamilies and 17 genera were collected (Table 2). All four subfamilies were found in both habitats. Eighteen species from 14 genera were found in the cedar glade habitat, whereas 18 species representing 16 genera were found in the prairies (Table 2). Twelve species were shared between the two habitat types. The number of species at glade sites ranged from a low of five (Couchville) to a high of 14 (Wilson School Rd.), and in the barrens from a low of nine (Vesta) to a high of 15 (Flat Rock). *Crematogaster lineolata*, *Forelius mccoocki*, *Tapinoma sessile*, and *Temnothorax pergandei* occurred in all glade sites. *Crematogaster lineolata*, *Crematogaster missouriensis*, *Monomorium minimum*, *Pheidole tysoni*, *Solenopsis* cf. *carolinensis*, *T. sessile*, and *T. pergandei* occurred at all three barrens sites.

Eleven species found in this survey were not reported in the lists produced by Meyer (1937) and Dennis (1938) (Table 2). Six species included in Dennis's (1938) list of ants occurring in cedar glades were not found during this survey, which included *Camponotus americanus*, *Crematogaster cerasi*, *Neivamyrmex nigrescens*, *Prenolepis imparis*, and *Solenopsis molesta*. *Camponotus americanus*, *N. nigrescens*, and *P. imparis* were seen in forested habitats adjacent to glades and barrens during this study, but never in them. Dennis may have been using the broader definition of cedar glade that included the cedar and hardwood forests adjacent to the glades. Dennis listed *C. cerasi* as *C. cerasi*

Table 2. Ants recorded in cedar glades from Meyer 1937, Dennis 1938, and this survey.

Species	Meyer 1937	Dennis 1938	Present study: Cedar Glade	Present study: Xeric Limestone Prairie
<i>Aphaenogaster treatae</i> Forel		X	X	X
<i>Crematogaster cerasi</i> (Fitch)		X		
<i>Crematogaster lineolata</i> (Say)	X	X	X	X
<i>Crematogaster missouriensis</i> Emery	X	X	X	X
<i>Crematogaster pilosa</i> Emery		X		X
<i>Dolichoderus pustulatus</i> Mayr				X
<i>Forelius mccooki</i> (McCook)	X	X	X	X
<i>Formica dolosa</i> Buren				
<i>Formica pallidefulva</i> Latreille			X	
<i>Formica integra</i> Nylander				X
<i>Hypoponera opacior</i> (Forel)		X	X	X
<i>Monomorium minimum</i> (Buckley)	X	X	X	X
<i>Neivamyrmex nigrescens</i> (Cresson)		X		
<i>Myrmica pinetorum</i> Wheeler				X
<i>Nylanderia faisonensis</i> (Forel)				X
<i>Nylanderia vividula</i> (Nylander)			X	
<i>Pheidole bicarinata</i> Mayr	X	X	X	
<i>Pheidole dentata</i> M.R.Smith	X		X	
<i>Pheidole pilifera</i> (Roger)	X		X	
<i>Pheidole tysoni</i> Forel			X	X
<i>Ponera pennsylvanica</i> Buckley			X	X
<i>Prenolepis imparis</i> (Say)		X		
<i>Solenopsis cf. carolinensis</i> Forel	X	X	X	X
<i>Solenopsis invicta</i> X <i>richteri</i>			X	
<i>Strumigenys louisianae</i> Roger		X	X	
<i>Tapinoma sessile</i> (Say)		X	X	X
<i>Temnothorax pergandei</i> (Emery)	X	X	X	X
<i>Trachymyrmex septentrionalis</i> (McCook)			X	X
Total	9	15	18	18

lineolata. During the era when Dennis did his work, *C. cerasi* was incorrectly considered a light form of *C. lineolata* (Creighton, 1950). *Crematogaster cerasi* does occur sporadically in the Southeast, so it is possible that *C. cerasi* could occur in the open habitats of the Central Basin (Johnson 1988); however, since no voucher specimens of Dennis's work are known, this record should be viewed with some skepticism. It is possible that Dennis's record of *Solenopsis molesta* and my record of *S. cf. carolinensis* are actually the same species. These species belong to the taxonomically difficult *molesta* group, but again, no voucher specimens are available for comparison.

The NMS ordination revealed two distinct ant communities based on species composition of sites from both habitat types (Fig. 2). The

ANOVA of the axis scores produced by the ordination found these communities to be significantly different along Axis 1 ($P < .009$). The results of the bait sampling also demonstrated differences in the dominant epigeic foragers between the two habitat types (Table 3). A total of twelve species were collected at baits in the glades with *F. mccooki*, *C. lineolata*, and *T. pergandei* being the most common. In the prairies, eleven species of ants were collected at baits, with *T. sessile*, *C. lineolata*, *P. tysoni*, and *M. minimum* being the most common.

Discussion

Notable ant species found during this survey included the hybrid-imported fire ant (*Solenopsis invicta* x *richteri*), *Dolichoderus pustulatus*, *Formica integra*, and *Pheidole pilifera*. A small

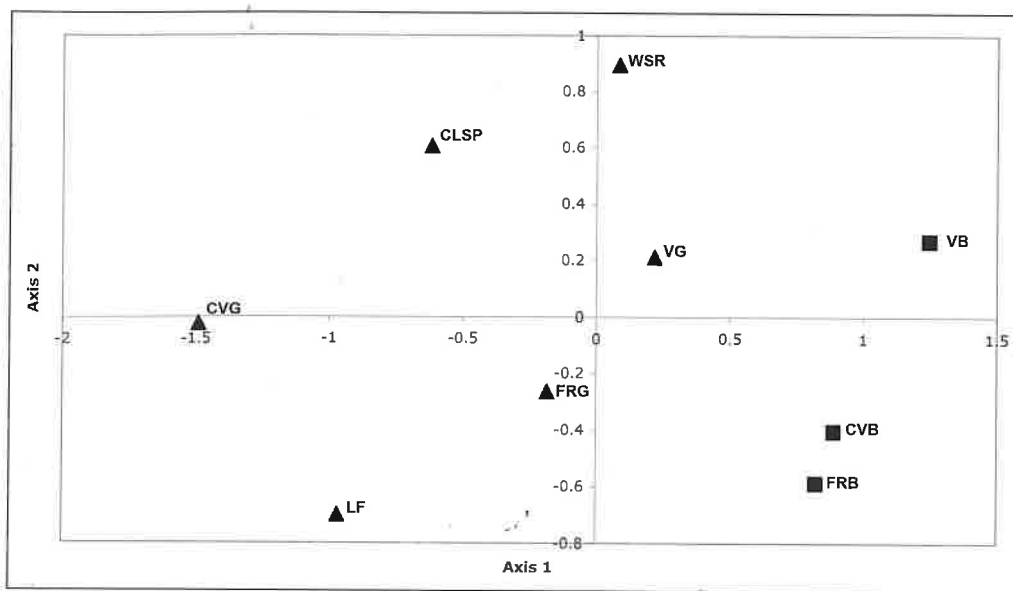


Fig. 2. Graph of NMS ordination. ■ = xeric limestone prairie, and ▲ = cedar glades.

colony of hybrid-imported fire ants, the only exotic species detected, was found nesting in a set of old tire ruts traversing part of the southernmost site (Wilson School Road) during the final sampling period. In the southeastern United States, *D. pustulatus* is restricted to high quality open habitats (Hill and Brown, 2010; MacGown et al., 2009). This collection of *D. pustulatus* represents a new record for Tennessee, according to a recent list of Tennessee ants (MacGown, 2011a). *Formica integra* was collected in sweep samples in the barren habitat at Flat Rock Natural Area. This is the first literature

report of this species from Tennessee; however, MacGown (2011b) shows a video of a large *F. integra* colony in a barren habitat in the Cedars of Lebanon State Forest filmed during a Mississippi Entomological Museum expedition to the Central Basin in 2009. Meyer (1937) reported *P. pilifera* in her list of cedar glade invertebrates, which until this study had been the only account in the literature of this species in Tennessee. Hill and Brown (2010) found *P. pilifera* to be restricted to high quality Black Belt prairie remnants, and it is likely that this species is restricted to high quality grassland sites throughout the Southeast.

Table 3. Percent species occurrence at bait stations in the two habitat types. Total sum percentage for baits do not equal 100 as baits could be occupied by more than one species or not at all.

Cedar Glade		Xeric Limestone Prairie	
Species	% Occurrence	Species	% Occurrence
<i>Forelius mccoeki</i>	35.0	<i>Tapinoma sessile</i>	21.7
<i>Crematogaster lineolata</i>	22.5	<i>Crematogaster lineolata</i>	18.3
<i>Temnothorax pergandei</i>	10.0	<i>Pheidole tysoni</i>	15.0
<i>Monomorium minimum</i>	7.5	<i>Monomorium minimum</i>	15.0
<i>Pheidole dentata</i>	7.5	<i>Temnothorax pergandei</i>	11.7
<i>Solenopsis cf. carolinensis</i>	4.2	<i>Forelius mccoeki</i>	11.7
<i>Nylanderia vividula</i>	2.5	<i>Aphaenogaster treatae</i>	6.7
<i>Aphaenogaster treatae</i>	2.5	<i>Crematogaster missouriensis</i>	5.0
<i>Pheidole tysoni</i>	1.7	<i>Formica dolosa</i>	5.0
<i>Pheidole pilifera</i>	0.8	<i>Solenopsis cf. carolinensis</i>	3.3
<i>Pheidole bicarinata</i>	0.8	<i>Myrmica pinetorum</i>	1.7
<i>Tapinoma sessile</i>	0.8	-	-

Most of the ant species found to be abundant in cedar glades by Meyer (1937) were found to be abundant at baits in glades during this study. The two exceptions included a *Pheidole* sp. listed by Meyer as the most common species sampled, and *Temnothorax pergandei* being sampled significantly more frequently in this study. The only *Pheidole* species not listed by Meyer that was found in this study was *P. tysoni*, making it the most likely possibility, but the identity of the species listed by Meyer could not be verified as no vouchers are known to exist. *Pheidole tysoni* was at only 2.7% of the baits in the cedar glade habitat in this study, but was more common in the prairies. The author has seen this species be a major component of some Black Belt Prairie remnants in Alabama and Mississippi. *Temnothorax pergandei* was present at the third (10%) most baits in the current study; whereas, Meyer (1937) lists only one sampling event of two individuals of this species. A direct comparison of the two data sets is not possible due to differences in sampling procedure and Meyer's focusing on only one site; however, it is noteworthy that most of the species commonly collected in the 1930s were still abundant in the glades during the present study. The differences mentioned above could be due to environmental differences in the sites or eras. An effort was made to examine the current fauna of Meyer's study site, as she gave precise locality information for it. Unfortunately, the site is now occupied by a gas station and concrete parking area.

The cedar glades and xeric limestone prairies of the Central Basin of Tennessee, though often adjacent to and grading floristically into one another, support significantly different ant faunas. Though the exact factors that may contribute to these differences were not investigated here, it is likely that the innate characteristics of the habitats such as vegetative structure, soil depth, and other environmental variables play an important role as has been found in Black Belt prairies in Mississippi (Hill et al., 2008). The presence of several rare species, and the heterogeneity of the ant fauna between these habitats, lends further support for the conserva-

tion and management of these habitats. Also, as the imported fire ant invasion moves northward, further monitoring of the ant fauna of these habitats is recommended.

Species Notes

The following list is annotated with collection, habitat, and site data, and is arranged by subfamily, tribe, and genus according to Bolton and Alpert (2011). Names also follow Bolton and Alpert (2011). Site abbreviations follow: CVB—Couchville Barren; CVG—Couchville Glade; CLSPG—Cedars of Lebanon State Park glade; FRB—Flat Rock Barren; FRG—Flat Rock Glade; LF—Lane Farm glade; WSR—Wilson School Rd. glade; VB—Vesta Barren; and VG—Vesta Glade.

Family Formicidae

Subfamily Dolichoderinae

Dolichoderus pustulatus: **New state record.** A single individual was found in sweep samples taken from a large barren area at Flat Rock NA. FRB

Forelius mccooki: This species is very common in the glades, particularly in the hotter parts of the day. Colonies were found nesting in the soil and under rocks. This species was one of Meyer's (1937) more frequently sampled ant species and was the most commonly sample ant at baits in this study. CVG, CLSP, FRB, FRG, LF, WSR, VG.

Tapinoma sessile: This species was found in both the gravel and barren zones. It is one of the more common ants in the wetter areas of these zones. CVB, CVG, CLSP, FRB, FRG, LF, WSR, VB, VG.

Subfamily Formicinae

Formica dolosa: This species was found only in the barren zone where it makes small mounds around clump grasses. CVB, FRB.

Formica pallidefulva: This species typically nests more commonly in forested habitats. A single individual was found in sweep samples at Wilson school road glade. WSR.

Formica integra: **New state record.** Five individuals of this species were collected in sweep samples from a large barren area at Flat Rock NA. FRB.

Nylanderia faisonensis: This species was collected from needle litter under eastern red cedars in the barren habitat. VB.

Nylanderia vividula: This species was collected at baits only. CLSP.

Subfamily Ponerinae

Hypoponera opacior: This species was found nesting in the needle litter under eastern red cedar trees and in soil around grass clumps. CVB, FRB, WSR.

Ponera pennsylvanica: Like *Hypoponera opacior*, this species was found nesting in the needle litter under eastern red cedar trees and in soil around grass. CVB, FRB, WSR.

Subfamily Myrmicinae

Aphaenogaster treatae: This species was found nesting in soil under isolated eastern red cedars in the glades and in the open in the barren zone. CVB, CVG, FRB, FRG, WSR.

Crematogaster lineolata: This was one of the most common species in both zones studied. It was found nesting in litter under isolated eastern red cedars and in grass clumps in the barren zone and under rocks and in the soil in the gravel zone. Meyer (1937) lists *C. lineolata* as the second most frequently encountered glade ant species. CVB, CVG, CLSP, FRB, FRG, LF, VB, VG, WSR.

Crematogaster missouriensis: This species was collected by sweeping, baiting and by hand. Colonies were found nesting in the soil in both habitats. Meyer (1937) lists this species as one of the more frequently encountered glade ant species in her study. It was detected at baits in the barren habitat in this study. CVB, FRB, FRG, VB, VG.

Crematogaster pilosa: This species was collected at baits and by sweeping in a large barren at Flat Rock NA. FRB.

Monomorium minimum: Meyer (1937) lists this species as one of the more commonly encountered glade ants. In this study, it was the fourth most commonly sampled species at baits in both glades and barrens. CVB, FRB, FRG, LG, VB, VG, WSR.

Myrmica pinetorum: A single individual was collected at a bait station in the barren zone, and a colony was found nesting at the base of

an isolated eastern red cedar tree in the barren zone. VB.

Pheidole bicarinata: Colonies of this species were found nesting in the soil in the gravel zone. FRG, LF.

Pheidole dentata: This species was found nesting under eastern red cedars in the glades. CLSP, FRG, WSR.

Pheidole pilifera: Workers of this species were found at a bait station in the gravel zone. Workers were followed back to their colony, which was nesting in the soil in the gravel zone. This is the first record in the literature of this species occurring in Tennessee since Meyer (1937). CVB.

Pheidole tysoni: This species was found nesting in the soil in the barren zone. It was only collected at baits in the cedar glades. See discussion section for more information on this species. CVB, FRB, FRG, VB.

Pyramica dietrichi: This species was collected in grass duff from a cedar glade VB

Solenopsis cf. carolinensis: This minute species was found nesting in the soil and under rocks in the gravel zone and in the soil in the barren zone. This is probably the same species listed by Meyer (1937) as *S. molesta*. It was one of the more commonly sampled glade ants in Meyer (1937) and the current study. CVB, CLSP, FRB, FRG, VB, VG, WSR.

Solenopsis invicta X *richteri*: A single colony of this species was found during the final sampling effort of this survey. Specimens from this colony conform morphologically to the hybrid characters in Trager (1991), and analysis of mtDNA were a common type for *Solenopsis invicta* Buren, which also suggests a hybrid status given the collection locality. WSR.

Strumigenys louisianae: This species was nesting in litter under eastern red cedars in the glades. WSR.

Temnothorax pergandei: This species was encountered commonly in both zones during this study. See the discussion section for more information on this species. CVB, CVG, CLSP, FRB, FRG, LF, VB, VG, WSR.

Trachymyrmex septentrionalis: This species was not encountered very often with one colony found in both the barren and gravel zones. CLSP, WSR.

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