

Temporal Foraging Activity of Selected Ant Species in Northern Mississippi During Summer Months¹

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Abstract A study was conducted in northeastern Mississippi to examine temporal foraging activity of imported fire ants (*Solenopsis* spp.) and other common ant species that inhabit pasture and meadow. Baited vials were placed horizontally on the ground along straight-line transects (n = 21) every 3 h for 24 h periods during June-August. Vials remained on the ground for 30 min, then were quickly plugged with cotton and collected. Principal species captured in baited vials included *Solenopsis* spp. (black and hybrid imported fire ant) (90.6%), *Solenopsis molesta* (Say) (5.9%), *Monomorium minimum* (Buckley) (2.5%), *Tapinoma sessile* (Say) (0.7%), and *Paratrechina vividula* (Nylander) (0.3%). Imported fire ants foraged during all time periods, as did *S. molesta* and *P. vividula*. *Tapinoma sessile* and *M. minimum* slowed or ceased foraging at night. *Forelius pruinosus* (Roger) was captured on a single date while sampling at 1800 h. Implications for timing of bait applications against imported fire ants are discussed.

Key Words *Solenopsis richteri*, *Solenopsis invicta* x *richteri*, *Tapinoma sessile*, *Monomorium minimum*, *Solenopsis molesta*, *Paratrechina vividula*, imported fire ants, bait

Temporal foraging patterns of ants are relevant to studies involving coexistence and competition and are an important consideration for ant control programs involving bait products. The imported fire ants *Solenopsis invicta* Buren, *S. richteri* Forel, and their hybrid (red, black, and hybrid imported fire ant, respectively) tend to forage regardless of time of day as long as temperatures are favorable for activity (Porter and Tschinkel 1987, Vogt et al. 2003). Some native ant species [such as *Monomorium minimum* (Buckley) and *Forelius pruinosus* (Roger) (Claborn and Phillips 1986)] that coexist with imported fire ants have been shown to greatly reduce or cease foraging at night.

At least one common active ingredient (hydramethylnon) used in bait products for control of imported fire ants is also effective against other myrmicine ants (Zakharov and Thompson 1998); however, in one study in which hydramethylnon was applied to pasture, no negative effects on nontarget ants were detected (Apperson et al. 1984). Negative impacts on native ants (e.g., *M. minimum*) were documented in earlier studies involving mirex bait (Markin et al. 1974, Summerlin et al. 1977), which utilized

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the same carrier and attractant (soybean oil) as many modern formulations of hydramethylnon.

Hybrid and black imported fire ants occupy a large portion of northern Mississippi, from Sunflower and LeFlore counties in the west to the northeastern corner of the state (Streett et al. 2002). The majority of recent studies examining interactions between imported fire ants and native ants have involved *S. invicta*. Understanding temperature relations and temporal foraging patterns of native ants in the range of *S. richteri* and *S. richteri* × *invicta* would be useful for examining behavioral interactions between ant species and may allow for more judicious use of insecticidal baits. The primary objective of this study was to examine the effects of temperature and time of day on foraging of common ants in pasture and open areas in northern Mississippi.

Materials and Methods

Two sites were used for this study. The first was an open area in the Natchez Trace Parkway (National Park Service) right-of-way in Webster Co., MS (about 33°39'1"N, 89°4'29"W) (heretofore known as Natchez Trace site). The site was characterized by mixed forbs and grasses (primarily Bermudagrass, *Cynodon* sp.) and was undisturbed except for occasional mowing (1 or 2 times per year). The second site was in heavily grazed pasture in Clay Co., MS (about 33°16'39"N, 88°32'44"W) (heretofore known as pasture site). The pasture was primarily fescue (*Festuca* sp.), with some Bermudagrass and patches of bare soil.

Foraging ants were captured in 12 × 75 mm vials baited with small (about 0.5 cm³) pieces of hotdog [Bryan® Meat Wieners (9.6% protein, 15% fat, 3% sugar)]. Baited vials were placed at soil level along straight-line transects (n = 15, 9 at the Natchez Trace site and 6 at the pasture site), taking care to place them under the vegetation at ground level to avoid direct sunlight on the vial. Vial placement was altered slightly between timed runs to reduce the possibility of recruitment between sample periods. Soil temperature (2 cm deep) was recorded at 5 or 10 random points and averaged during each sampling period; ambient temperature in the shade was recorded. Transects were established and sampled in groups of three, about 10 to 30 m apart. Each mean temperature measurement corresponded to three transects. Each transect contained 10 baited vials at 5 m intervals. During each sampling period (0000, 0300, 0600, 0900, 1200, 1500, 1800, and 2100 h), vials remained in place for 30 min then rapidly collected and plugged with a small cotton ball. They were then returned to the laboratory, frozen, and ant species and numbers were recorded for each vial. Sampling was conducted during June 2002 (3 transects, Natchez Trace site), July 2002 (6 transects, Natchez Trace site), August 2002 (3 transects, pasture site), September 2002 (3 transects, pasture site), May 2003 (3 transects, pasture site) and June 2003 (3 transects, Natchez Trace site). Voucher specimens reside in the Mississippi Entomological Museum, Department of Entomology and Plant Pathology, Mississippi State University, MS.

To check for possible changes in bait dominance over time, samples taken in 2003 were examined for foraging ants every 10 min for 30 min, then plugged, collected, and returned to the laboratory for identification and counting. At each sampling interval the number of each ant species at each vial was estimated (0, 1, 10, 50, or 100), and the actual number at 30 min was determined in the laboratory.

A response surface regression model was used to model foraging activity x (mean number of ants per vial per transect) as a function of time (hour of d) and temperature

(soil or air). Foraging activity was measured as mean number of ants per vial within a transect. Fixed effect was hour with 8 levels and transect was a random block effect. All possible regressions and interactions were initially examined using r^2 values; we then used F-tests in regression analysis to reduce the model for each ant species. Error mean squares for the reduced models were compared, and the model with the best fit for each sufficiently abundant species is reported herein. Data were analyzed with Proc MIXED (Littell et al. 1996). An additional analysis of variance was performed on each ant species to compare average differences in foraging activity between hours. Transect was used as a random block effect and hour of day as a repeated measure treatment effect.

Results and Discussion

Imported fire ants were the predominant formicids in our baited vials, comprising 90.6% of a total of 80,690 ants captured. We made no attempt to separate black and hybrid fire ants for the purpose of analysis. Recent collections in Webster Co., MS, (Natchez Trace site) have been exclusively hybrid, and collections in Clay Co., MS, have been a mix of black and hybrid fire ants (Streett et al. 2002). *Solenopsis molesta* (Say) was second in abundance (5.9%), followed by *M. minimum* (2.5%), *Tapinoma sessile* (Say) (0.7%), and *Paratrechina vividula* (Nylander) (0.3%). *Paratrechina vividula* foragers were captured in very low numbers, as were *Forelius pruinosus* (Roger) foragers, which were captured on only one occasion at 1800 h.

A total of 660 vials (40%) were unoccupied at the end of our 30 min sampling period, and native ant species were only collected within some transects. Time and temperature effects for each species were modeled using only those transects in which a species was captured. For each species, the best overall model for foraging activity was chosen by eliminating non-significant terms from the full response surface model. Foraging in imported fire ants was best described using a model including the effects of hour of day, the quadratic effect of air temperature, and the interaction between hour and air temperature (Table 1). A plot of predicted values within the range of temperatures encountered during each sampling period illustrates changing response to temperature over time (Fig. 1). A model incorporating time, air temperature, and the time by temperature interaction best described foraging in *S. molesta* (Table 1). The significant interaction term in the model is due to increased response to rising temperature during afternoon hours (1300 and 1800 h) (Fig. 2). *Monomorium minimum* exhibited a simple linear response to increasing soil temperature (Table 1). Other ant species encountered during this study were captured in relatively low numbers and were only included in the second analysis of mean foraging activity within times. This analysis does not attempt to account for temperature effects, which are included as the natural variation in temperature over the 24-h sampling periods. *Tapinoma sessile* foragers were captured from 0900 to 2100 h, *P. vividula* foragers were captured during most time periods in very low numbers, and *F. pruinosus* foragers were captured on one sampling date at 1500 h. Data for all species are summarized in Table 2.

A total of 204 vials (42.5%) from 2003 samples (those examined at 10 min intervals) were unoccupied after 30 min. Data were combined across sampling times (0300 to 2400 h, 3 h intervals) to determine the percent of vials occupied by fire ants and/or native ants at 10, 20, and 30 min. Data are presented in Table 3. In general, the percentage of vials occupied by imported fire ants or *M. minimum* tended to

Table 1. Regression statistics for the effects of time (hr) and temperature (°C) on foraging for selected ant species in northern Mississippi meadow and pasture. Only significant effects are shown

Species	Effect	Estimate ± SE	P
Imported fire ants (<i>S. richteri</i> and <i>S. richteri</i> × <i>invicta</i>)	Intercept	−49.1 ± 78.9	0.5347
	hr	−10.3 ± 3.0	0.0009
	Air temp	13.1 ± 6.1	0.0327
	Air temp ²	−0.4 ± 0.1	0.0018
	hr × Air temp	0.5 ± 0.1	0.0007
<i>S. molesta</i>	Intercept	370.8 ± 77.4	0.0024
	hr	−43.1 ± 5.0	0.0001
	Air temp	−16.5 ± 3.3	0.0020
	hr × Air temp	1.8 ± 0.2	0.0001
<i>M. minimum</i>	Intercept	−74.9 ± 32.4	0.0392
	Soil temp	3.1 ± 1.1	0.0178

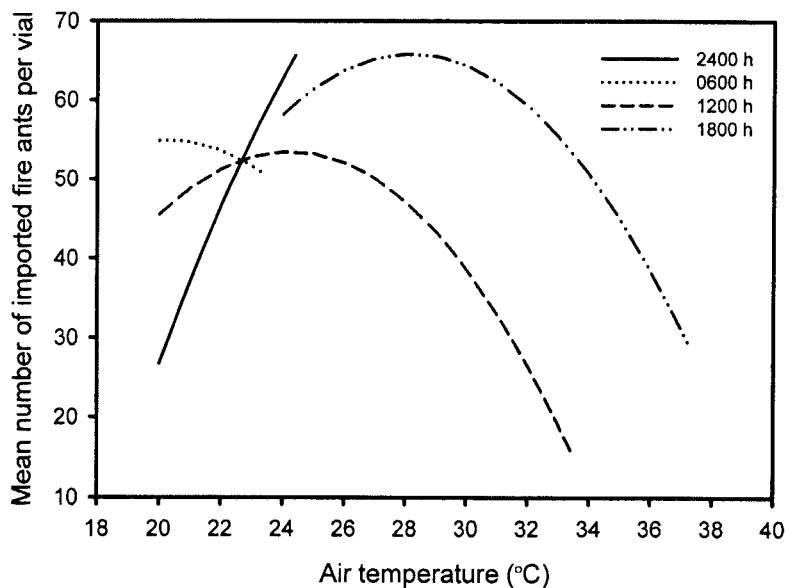


Fig. 1. Predicted effect of temperature on foraging activity of imported fire ants (*S. richteri* and *S. richteri* × *invicta*) at several times of day. Foraging activity was measured at 3 h intervals; only 4 time periods are included to prevent clutter.

increase over the 30 min sampling period. One co-occurrence of imported fire ants and *S. molesta* was noted at 10 min; imported fire ants and *M. minimum* competed within a small percentage of vials during each time interval (0.6%, 2.3%, and 2.5% at 10, 20, and 30 min, respectively). Imported fire ants displaced the native *S. molesta*

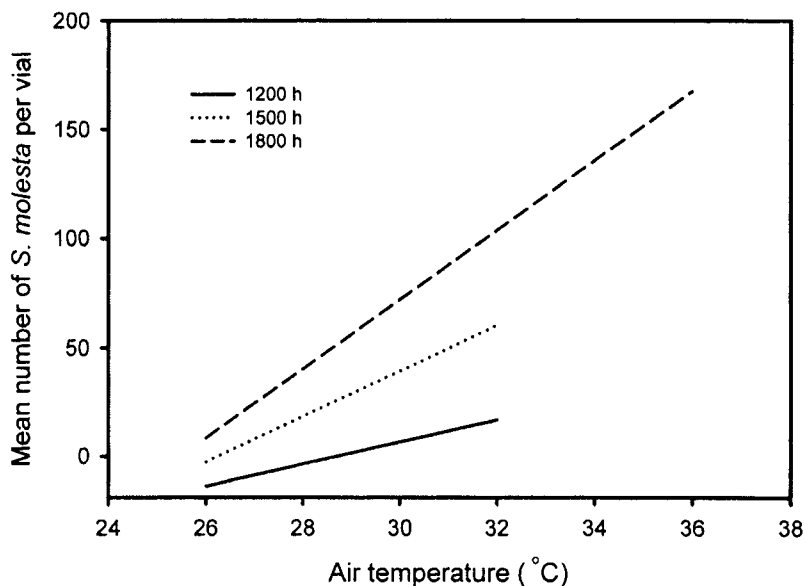


Fig. 2. Predicted effect of temperature on foraging activity of *S. molesta* at different times of day.

and *M. minimum* at baits only 5 times during the 30 min sampling periods. *Paratrechina vividula* appeared to displace *T. sessile* once. No native ants were observed displacing imported fire ants during this experiment; however, *M. minimum* foragers were able to compete directly with fire ant foragers at baits, and displacement of fire ants by *M. minimum* has been observed in similar circumstances (J. T. Reed, unpubl. data).

Our study differs from that of Claborn et al. (1988) in that we used baited vials to capture ants rather than pitfall traps. More complex baiting schemes, designed to attract different species of ants to varied food sources, have been used in previous studies of temporal foraging activity (e.g., Claborn and Phillips 1986); however, at our study sites, pitfall traps (2.5 cm I.D. vials) have yielded only low numbers of two additional species not encountered at baits [*Hypoponera* sp., *Strumigenys louisianae* (Roger)] (Vogt, unpubl. data); thus, for determining timing of foraging activity for common ants at our study sites the baiting scheme described appears to be sufficient. Additional species that either found our bait unattractive or are not easily captured in pitfall traps probably exist at our sites, but the species mentioned herein were the only ones observed actively foraging on the soil surface.

Optimal soil temperature (2 cm deep) for foraging in imported fire ants (about 28–29°C, data not shown) was very similar to optimal temperature as determined by Porter and Tschinkel (1987) for *S. invicta* in Florida, and Vogt et al. (2003) for *S. invicta* in Oklahoma. During the afternoon hours, as air temperature increased above 24°C, foraging activity of imported fire ants generally slowed (Fig. 1), while activity of the native ants *M. minimum* and *S. molesta* increased (Fig. 2, Table 1). This differ-

Table 2. Bait trap catch for selected ant species in northern Mississippi meadow and pasture

Time (hr)	Species*					
	(<i>S. richteri</i> and <i>S. richteri</i> × <i>invicta</i>)†	<i>S. molesta</i>	<i>M. minimum</i>	<i>T. sessile</i>	<i>P. vividula</i>	<i>F. pruinosa</i>
0300	45.0 ± 8.5abc	6.1 13.2a	0	0	0.02 ± 0.7a	0
0600	50.0 ± 9.2ab	0.3 13.2a	0	0	0.02 ± 0.7a	0
0900	43.1 ± 7.1abc	4.7 13.2a	1.4 ± 2.8b	3.9 ± 1.0a	1.3 ± 0.7a	0
1200	31.2 ± 5.9c	4.4 13.2a	11.1 ± 2.8a	1.3 ± 1.0ab	0.06 ± 0.7a	0
1500	38.7 ± 8.1bc	22.7 13.2a	7.2 ± 2.8ab	3.7 ± 1.0a	0	16.1 ± 1.8
1800	56.5 ± 6.1a	36.5 13.2a	1.4 ± 2.8b	0.5 ± 1.0b	1.3 ± 0.7a	0
2100	50.8 ± 11.1abc	4.2 13.2a	0	0.03 ± 1.0b	1.3 ± 0.7a	0
2400	42.6 ± 9.7abc	0	0	0	0.1 ± 0.7a	0

* Least Squares Means; means within a column followed by the same letter are not significantly different ($P > 0.05$).

† Variances for imported fire ant hour means not equal (Bartlett's test for equal variances; $\chi^2 = 15.4$, $df = 7$, $P < 0.05$); ANOVA for mean comparisons allowed for unequal variances.

Table 3. Mean percent of hotdog-baited vials occupied by different ant species at 10, 20 and 30 min. after placement in the field

Time interval (min.)	Species*				
	<i>S. richteri</i> and <i>S. richteri</i> × <i>invicta</i>	<i>M. minimum</i>	<i>T. sessile</i>	<i>S. molesta</i>	<i>P. vividula</i>
10	27.4 ± 3.6	2.1 ± 0.8	0.4 ± 0.3	0.2 ± 0.2	0
20	45.5 ± 4.4	2.8 ± 1.2	0.9 ± 0.5	0.2 ± 0.2	0
30	54.9 ± 4.1	3.0 ± 1.4	0.4 ± 0.4	0.2 ± 0.2	1.1 ± 0.6

* Mean ± SE.

ence may contribute to the coexistence of these species with imported fire ants. The slight decrease in foraging by imported fire ants during mid-day might be due to direct sunlight warming the substrate; additional temperature measurements, particularly of the soil surface, are necessary to test this hypothesis.

Buren (1983) proposed artificial faunal replacement as a possible means for biological control of imported fire ants. While this idea has not met with much interest, there may be factors that could be employed to preserve or augment species that already coexist with imported fire ants. One possibility that has received limited attention is careful timing of broadcast bait applications for periods when fire ants are most active and native ants are not (see Williams 1986). This study suggests that bait treatments would have the greatest potential effect on native ant species during mid- to late-afternoon hours, when imported fire ants slow foraging due to high temperature, and *M. minimum*, *T. sessile*, and *S. molesta* are most active (Table 2). Our study confirms earlier findings of Claborn and Phillips (1986) with regard to temporal foraging activity of *M. minimum*. *Monomorium minimum* utilizes poison gland secretions to delay competition by other ants at baits and tends to recruit at soil temperatures up to 39 to 40°C (Adams and Traniello 1981). Thus, it is likely a combination of chemical defense (competition) and niche partitioning that allows this species to coexist with imported fire ants. Potential (founder) queens of *S. invicta* are frequently preyed upon by *M. minimum*. The other ant encountered during this study that was not collected after 2100 h, *T. sessile*, is considered to be a submissive species in terms of inter-specific competition at baits (Fellers 1987, Paulson and Akre 1991). *Tapinoma sessile* has been reported to forage at night (L. Barbani, pers. comm.) but was rarely encountered in our study, and it is possible that it was active in low numbers but not collected between 2100 and 0900 h. *Solenopsis molesta* preys upon eggs and immatures of several ant species (Wheeler 1936), including red and black imported fire ants (O'Neal 1974), and is also a generalist forager. This species also recruits at relatively high soil temperature, but forages day and night as long as temperatures are suitable.

Several native ants have been shown to prey upon founding queens of the imported fire ants. These include *Dorymyrmex* sp., previously grouped with *Conomyrma insana* (Buckley) (Snelling 1995) and other ant species (Whitcomb et al. 1973, Nickerson et al. 1975), several *Pheidole* spp., native fire ants, and *M. minimum* (Nichols and Sites 1991). Because of the predatory activities of these native ants, their preservation in areas treated for imported fire ants may slow fire ant reinfestation.

At least two of the species encountered in our study appear to greatly reduce or cease foraging at night. Ongoing studies are designed to test the hypothesis that altering timing of bait treatments for imported fire ants will be effective in preserving native ants present in treated areas, and whether preservation of native ants extends the effective life of insecticidal bait treatments.

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