DO IMPORTED FIRE ANTS IMPACT CANOPY ARTHROPODS? EVIDENCE FROM SIMPLE ARBOREAL PITFALL TRAPS

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ABSTRACT—A new method for sampling arboreal arthropods is described. Arboreal pitfall traps were used to compare the ant faunas of a central Texas forest in the process of invasion by *Solenopsis wagneri*, the imported red fire ant. In the uninfested forest patch, 12 of 14 trees yielded ants in the tree canopy, ca. 10-m off the ground, compared to 3 of 13 trees in the infested patch. Ant diversity per trap-tree correspondingly dropped from 1.4 to 0.3 species/tree. *Solenopsis wagneri* was collected from 5 of the 27 trees studied and is likely an agent for this decrease in diversity.

RESUMEN—Describo un nuevo método para estudiar artrópodos arbóreos. Las trampas de hoyo arbóreas se usaron para comparar las faunas de hormiga de un bosque en el centro de Texas que está siendo invadido por la exótica *Solenopsis wagneri*. En una parte del bosque sin *S. wagneri*, 12 de 14 árboles tuvieron hormigas en el dosel de aproximadamente 10 m de altura, comparado con 3 de 13 árboles en una parte del bosque con *S. wagneri*. La diversidad de hormigas declinó correspondientemente desde 1.4 a 0.3 especies/árbol. *Solenopsis wagneri* se colectó de 5 de los 27 árboles estudiados y probablemente es una causa para esta disminución en la diversidad.

Ants are common and important players in terrestrial ecosystems (Hölldobler and Wilson, 1990). Although most studies focus on ground assemblages, many ant species may be found in trees, harvesting leaves and exudates and tending insects (e.g., Tilman, 1978; Davidson and McKey, 1993). At high latitudes, ant-tree associations arise when soil-nesting species climb trees (Morisita, 1941; Fritz, 1982; Warrington and Whittaker, 1985; Rosengren and Sundström, 1987; Haemig, 1994). As one moves from the poles to the equator, ants increasingly nest in the trees themselves (Jeanne, 1979; Tobin, 1995). The arboreal ant fauna of the North American subtropics may be exceptionally diverse (Wheeler and Wheeler, 1985; Deyrup and Trager, 1986; Longino and Wheeler, 1987; Hood and Tschinkel, 1990). This diversity has been poorly explored, in part for lack of methods with which to do so (Lowman and Nadkarni, 1995).

With the invasion of the imported fire ant *Solenopsis wagneri* (formerly *S. invicta* Bolton, 1995), these fauna also may be imperiled. *Solenopsis wagneri* is an invasive ant species in North America that has spread throughout the Gulf coast into Texas and Oklahoma (Lofgren, 1986). As *S. wagneri* infests an area, litter arthropod density and diversity declines (Camilo and Phillips, 1990; Porter and Savignano, 1990; Morris and Steigman, 1993), vertebrate populations suffer (Allen et al., 1995), and ecosystem processes like decomposition are disrupted (Vinson, 1991). Ant diversity is particularly impacted, with species richness dropping by up to 70% (Porter and Savignano, 1990). Although *S. wagneri* is not reported as an arboreal species, Porter and Savignano (1990) collected it on baited trunks and leaves 1 to 2 m off the ground. The impact of *S. wagneri* on arboreal ant activity has not yet been addressed.

Various methods are used to sample arboreal arthropods, include climbing, canopy fogging, and gondolas hung from construction cranes and zeppelins (Moffett and Lowman, 1995). Here I describe an inexpensive method for sampling arboreal arthropods based on a well-developed method for sampling ground fauna—the pitfall trap. I then describe its application in exploring the potential impact of *S. wagneri* in the same forests studied by Porter and Savignano (1990) in their groundbreaking work.

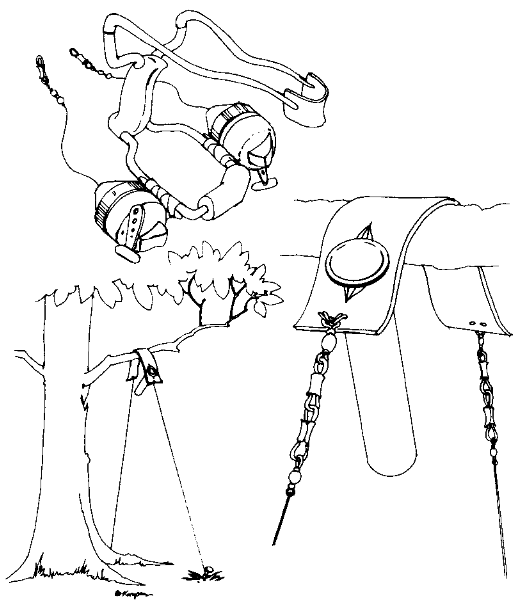

FIG. 1—The arboreal pitfall trap explained. The line is sent over a branch and controlled using a modified slingshot (top). The trap itself is a test tube inserted through a slit in a canvas strip (bottom right). The trap is hung from a branch, and monofilament lines are staked down, holding it place (bottom left).

MATERIALS AND METHODS—Pitfall traps passively sample arthropod activity—placed flush in the ground, insects crawl and fly into the trap and drown. The arboreal pitfall traps described here sample insects crawling along tree branches by providing a platform—a 10 by 30-cm strip of canvas flush with the branch. A 25 by 200-mm test tube half-filled with ethylene glycol is inserted through a slit at one end of the canvas strip. The trap is draped over a tree branch (Fig. 1), where the test tube dangles to one side.

Traps are tethered to the ground using monofilament line (20-pound test). The line needed to hang a trap is managed using a modified "wrist-rocket"-style slingshot (Fig. 1). On either side of the wrist-brace, two fishing reels are fixed using hose clamps. These fishing reels play out and take in the line attached to either end of the trap's canvas strip. Use of two lines allows careful placement and repeated retrieval of the pitfall trap. The two fishing reels allow the user to efficiently control the large quantities of line needed to send a line over a branch.

To hang the pitfall trap, a lead weight attached to the line of the first reel is fired over a low, exposed branch. The trick is to send the line just over the branch but halting the weight's upward momentum before it tangles in a thicket of higher branches. The wrist brace on the slingshot allows a careful aim, and threading the line between the slingshot's post and a finger can help control the weight's trajectory. Given the tendency of the weight to snap and ricochet, safety goggles are recommended.

Once the weight clears the branch and falls to the ground, it is removed and the line is clipped to the top of the trap (a swivel clip is sewn into either end of the trap's canvas strip). A second line, controlled by the second fishing reel, is attached to the bottom of the trap. In this way, the trap can be reeled into place on the branch. The rough texture of the canvas gives the trap a snug purchase. The second line is then cut, a swivel clip attached, and the line is staked to the ground. Finally, the first line is cut, clipped, and staked similarly.

To retrieve the trap, the first line is unclipped from the stake and attached to the line of a fishing reel. The trap is then lowered. Its contents can then be sampled, and the trap replaced. After some practice, I could hang a trap in 15 min. Checking the trap, emptying its contents, and recharging the pitfall, takes about 3 to 4 min.

Study Site and Experimental Design—This study was conducted at the Brackenridge Field Lab (BFL, 30°16'N, 97°43'W), a 32 ha combination of forest and prairie owned by the University of Texas at Austin. BFL has been the focus of ongoing studies of the invasion of the polygyne form of *S. wagneri* at a 10 by 10-m scale (Porter et al., 1988; Porter and Savignano, 1990). Over the course of the invasion, *S. wagneri* has displaced native ants and simplified the litter invertebrate community, while moving at a rate of 35 m a year over 3 years.

Four years since Porter and Savignano's (1990) study (July 1991) *S. wagneri* had continued its spread, leaving small patches of forest uninfested. I set up two transects in two forest patches. Both were parallel to E/W trails, and were separated by 300 m. Hand collecting at one of these patches, the Panther Trail, yielded a typical central Texas ground ant fauna (*Aphaenogaster texanus, Leptogenys elongata, Paratrechina terricola,* and *Pheidole dentata*). Similar hand collecting along the Quarry Trail which was infested as early as 1984 (Porter and Savignano, 1990) revealed only *S. wagneri*. The Panther and Quarry trails led through physiognomically similar forest. The forests were dominated by a 15 m canopy of plateau live oak (*Quercus fusiformis*), Ashe juniper (*Juniperus ashei*), netleaf hackberry (*Celtis reticulata*), and cedar elm (*Ulmus crassifolia*), and ground cover was a mosaic of patchy moist litter and bunch grass.

I hung one arboreal pitfall trap in each of 14 trees in both habitats on 17 July 1992. I chose trees that reached canopy height, were within 10 m of the trail, and were separated at their crown by at least 5 m (i.e., crowns of sampled trees did not directly overlap). I used a branch on each tree that was clear of surrounding vegetation, and was ca. 10 m off the ground. On 2 August (16 days later), I lowered and emptied the traps in 70% ethanol. Voucher specimens of ants are in the author's collection at the University of Oklahoma.

RESULTS—Arboreal pitfall traps captured a variety of arthropods, including Diptera, Hymenoptera other than ants, Homoptera, Hemiptera, and Araneae. Traps in the uninfested forest yielded 75 arthropods; 67 (89%) were ants. Traps in the infested forest yielded 17 arthropods; 14 (82%) were ants. One trap in the infested forest had been dislodged from its branch and emptied and is excluded from analysis.

In the infested forest, 3 of 13 (23%) trees yielded ants in the arboreal pitfall traps. In contrast, 12 of 14 (85%) of traps in the uninfested forest contained ants. The frequency of ant-active trees was higher in uninfested forests (Fishers Exact test, $P = 0.002$).

Trap yields ranged from 0 to 25 ants per trap. As most of the traps in infested forest trees were empty, the average yield per trap was over four times greater in uninfested forest (4.8 versus 1.1 ants per trap, Mann Whitney $U = 38$, $P = 0.007$). Five species (4 genera) were recorded in the uninfested forest; two species were recorded in the infested forest (Table 1). The most frequent species was *Camponotus texanus,* found in 11 of 14 (79%) traps in the uninfested forest, and one tree in the infested forest. *Solenopsis wagneri* was recorded in the canopy at both sites (5 of 27 trees sampled), but showed a trend for higher densities in the infested site. It was found in each of the three ant-active pitfalls in the infested forest. Both occurrences of *S. wagneri* in the uninfested forest were from trees next to a road and adjacent to the infested forest. Overall, average number of ant species per tree was four times higher in uninfested forest (1.4 versus 0.3 species/trap, Mann Whitney $U = 30.5$, $P = 0.002$).

DISCUSSION—Arboreal pitfall traps at BFL sampled fewer arthropods than similar soil-based pitfalls used 4 years before. The average yield from eight ground pitfall traps at BFL run for 6 days was 839 arthropods in pristine forests, and 4,666 (mainly fire ants) in infested forests (Porter and Savignano, 1990: Table 3).

TABLE 1—Species recorded in this study, listing the number of traps recorded and the mean density per trap (in parentheses) when it occurs.

Species	Infested	Uninfested
Camponotus americanus (Mayr, 1862)	0	1 (1)
Camponotus texanus (Wheeler, 1903)	1 (1)	11 (2)
Crematogaster laeviuscula (Mayr, 1870)	0	1 (3)
Pheidole hyatti (Emery, 1895)	0	4 (9.5)
Solenopsis wagneri (Santschi, 1916)	3 (4.3)	2 (1.5)

In this study, 14 arboreal traps run 16 days yielded 75 arthropods in pristine forest and 17 in infested forests.

The abundance of ants also differed. In ground pitfalls, ants made up only 20% of the arthropods in soil traps from pristine areas, and over 95% in infested areas. In this study, ants constituted over 80% of the arthropods in arboreal traps from both forests. Arboreal traps thus appear to be ant-biased, and low-yield relative to soil traps. This finding likely reflects lower activity of crawling insects on branches than in soil. Arboreal insects also may be more adept at scaling vertical surfaces—the ant *Crematogaster laeviscula* easily climbs up polished glass walls in captivity (M. Kaspari pers. obser.).

The four native arboreal species arrive in the canopy in different ways. *Camponotus texanus* and *Crematogaster laeviscula* nest in hollow tree branches and other plant cavities (Hess, 1958; Longino and Wheeler, 1987; Cokendolpher and Francke, 1990). *Camponotus americanus* nests in both soil and trees (Feener, 1978; Cokendolpher and Francke, 1990). *Pheidole hyatti* nests in soil (Hess, 1958; M. Kaspari pers. obser.) and, like *S. wagneri,* travels some distances up trees. Soil nesting thus does not preclude species from obtaining some or most of their resources from the canopy. For example, *Pheidole dentata* and *P. hyatti* are both common soil-nesting species in the litter of BFL (Feener, 1978). Both are small ants with colony sizes in the mid-hundreds (Wilson, 1986). Yet *P. dentata* is 80 times more common in soil traps than *P. hyatti,* and absent from the canopy, whereas *P. hyatti* is common in the canopy.

The south central United States and northern Mexico are home to a large endemic ant fauna (Wheeler and Wheeler, 1985). One native species common in uninfested areas of BFL is *C. texanus,* a Texas endemic (Wheeler and Wheeler, 1985; Cokendolpher and Francke, 1990). This study suggests that arboreal ant activity and species richness is lower in forests infested with large soil-nesting populations of *S. wagneri.* Given its ability to reduce ground ant diversity by 70% (Porter and Savignano, 1990) the frequent occurrence of *S. wagneri* on branches 10 m off the ground suggests it may similarly reduce canopy ant diversity and imperil this unique southwestern fauna. Long-term studies over a variety of habitats are currently underway to better test these speculations. It is hoped that the modest technology of the arboreal pitfall trap may allow naturalists an inexpensive, effective way to sample many arboreal species.

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