MATERIALS AND METHODS

It was considered probable that any interrelations between *S. molesta* and *R. flavipes* would be initiated by the ants. Thus, in all the experiments, the termites were established first in various containers and *S. molesta* individuals were added later. In tests with other ant species, the ants were sometimes established first and sometimes the termites. Varying numbers of ants and termites were used in the different tests and these details will be included in the discussion of each particular test. Most of the activity occurred at the base of the test units, consequently, the cultures were observed by placing the unit on a wooden rack beneath which was placed a magnifying mirror and a desk lamp to enhance the illumination. When not under observation, the containers were maintained at 25°C.

RESULTS AND DISCUSSION

Two experiments were initiated, in which 200 *R. flavipes* and 50 termite eggs each were added to a clear plastic unit (4 x 7.5 x 10.5 in) containing damp earth and two small (0.5 x 3 in) pieces of wood. Twenty-four hours later the eggs in one unit (Exp. 1) had been moved and were not seen again. After 1 mo, a colony

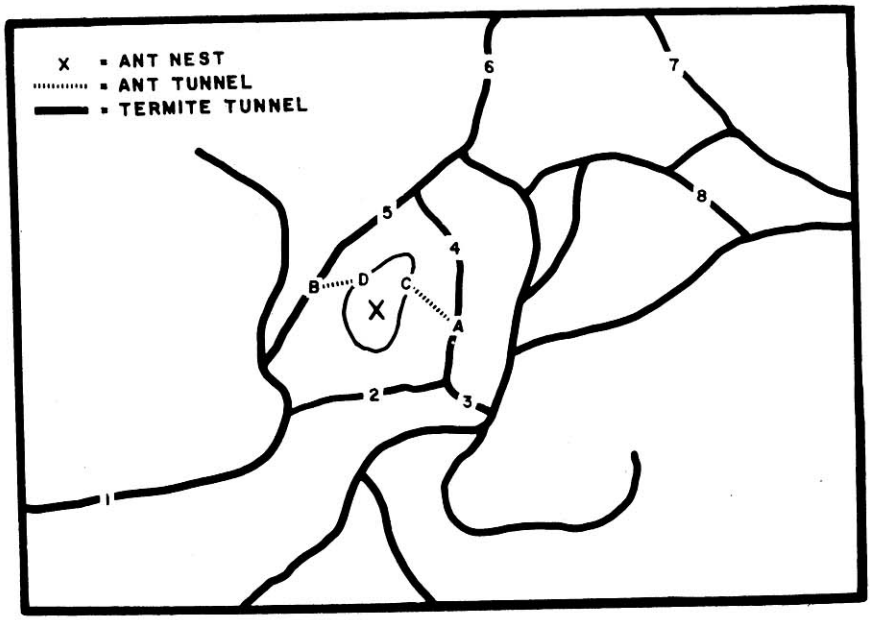

FIGURE 1. Nest cavity of *Solenopsis molesta* with ant tunnels and tunnels of *Reticulitermes flavipes*. Experiment 1.

of 50 *S. molesta* adults and 20 larvae were added. The ants quickly hollowed out an area in the dirt at the bottom of the unit and deposited their larvae in its center. The ant "nest" was surrounded on all sides by termite tunnels (Fig. 1). Within the first week the ants constructed minute passageways from the nest cavity to the termite tunnels 4 and 5 (Fig. 1, CA and DB). During the second week the ants moved through tunnels 2, 3, 4, and 5 which they blocked off for their own use. The ants erected earthen walls in the termite tunnels and created a circle of diameter about 3 in, which excluded the termites. The ant nest was approximately at the center of the circle. Toward the end of the third week, 5 dead termites were observed in tunnels 1, 6, 7, and 8. On the 25th day 7 dead termites were seen in a ring around the ants' nest. We offer no explanation for this phenomenon and it was not repeated.

The termites dug intermittently at the earthen wall blocking their entrance to tunnel 4. One soldier was always close behind the few digging workers. These workers often became excited and retreated quickly, shaking violently (vibrating their bodies on stiff legs). A termite worker finally broke through to tunnel 4 but remained in 3 with only his antennae in the ant tunnel. During this termite activity the ants rarely utilized the portion of tunnel 4 below A but moved their larvae from the center of the nest and piled them in the cavity as far as possible from the scene of activity.

The termite which had penetrated the ant tunnel remained in the same position for about 1 min at which time an ant began moving toward him. The ant slowly moved to within 1 cm of the termite, then quickly turned and retreated. The worker termite withdrew and was replaced by a soldier termite who placed his head into the confluence of the two tunnels. Within a few minutes 4 ants moved down tunnel 4 toward him. The leading ant moved to within a few mm of the termite and retreated just as it appeared the soldier would lunge. The following 2 ants immediately turned around about 15 mm from the termite and withdrew. The fourth ant moved directly to the termite's mandibles and rapidly turned around. Only after the ant had reversed himself did the soldier lunge. The ants then began to block tunnel 4 from A upward for about 15 mm. A similar wall of dirt was established in tunnel 5 upward from B and a much smaller wall was erected at D. The latter barrier was only about 2 mm thick. The termites began to penetrate and widen the ant tunnel DB, apparently having gained access to it from a tunnel in the soil not visible from below. One termite reached the thin earth barrier at D and slowly began to remove some of the dirt. The termite activity greatly activated the ants which immediately and rapidly began bolstering the

earthen wall from the other side. For about 2 hr the termites slowly broke down the wall while the ants rapidly strengthened it. The end result was a barrier about 1 cm thick. At this point the termites neglected the barrier and retreated. During the frenzied activity by the ants, some of them seized their larvae and removed them from the nest cavity and thus out of sight. Within 8 hr after the cessation of activity by both species, the ants moved most, if not all, of their larvae to their original position in the nest, and nothing unusual occurred for the next 6 months.

The ants in the second unit (Exp. 2) immediately established themselves in a cavity (X) on the floor of the container (Fig. 2). About 12 ant larvae were placed in the nest. As in the first experiment, the ants were completely surrounded by termite tunnels. For the first week no ants moved on the bottom of the container; however, as never more than 25 ants were visible in the cavity, it was assumed that they had established or usurped tunnels not visible from below. On the tenth day, some ants were observed in tunnel 1. They established a tunnel (CA) from their nest cavity to the termite tunnel and blocked off a portion of the tunnel with earthen walls. Two days later the ants tunneled (DB) to termite tunnel 2 and moved in it. They erected no visible barrier at B

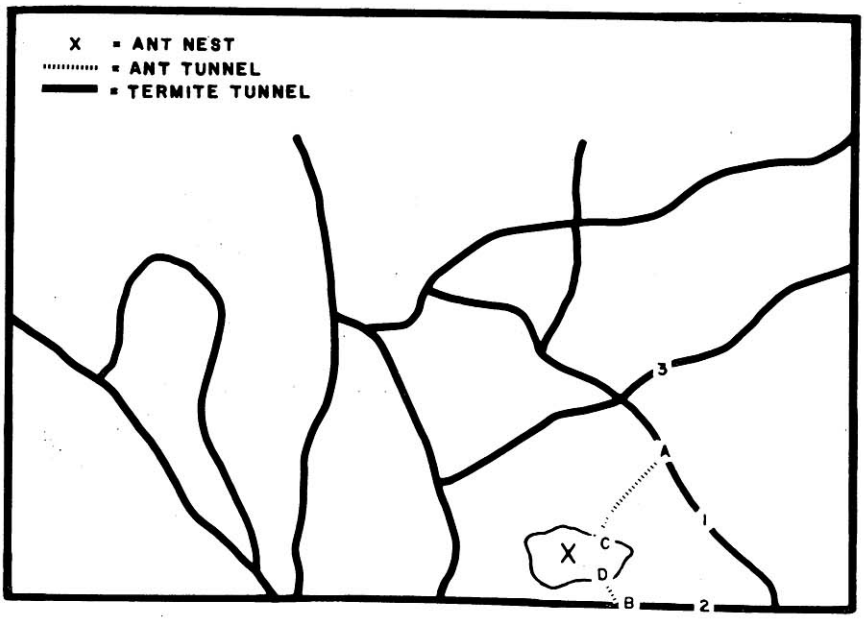

FIGURE 2. Nest cavity of *Solenopsis molesta* with ant tunnels and tunnels of *Reticulitermes flavipes*. Experiment 2.

but often seemed to move upward through the soil at this point in a tunnel not visible from below.

Termites moving along tunnel 3, after the erection of the ant wall at A, seemed to be aware of the barrier and only rarely did a termite turn off 3 and enter 1 moving toward A. On all but one of these sporadic occasions the termite did not proceed to A but turned around and re-entered 3. Once, a termite moved to the wall at A, waved his antennae slowly with their tips in contact with the barrier, then quickly backed away, reversed himself, and returned to tunnel 3. The termites never tried to break through any of the ants' earthen walls nor did the ants attempt to extend their range. After 9 weeks the experiment was discontinued.

The following tests were initiated to obtain data on the behavior of the ants toward termite eggs. In test A, an 8 dr shell vial was ⅓ filled with soil and 25 ants were added. After 48 hr, 15 termite eggs were placed in a cluster on top of the soil. Two ants almost immediately found the eggs and picked up several. Within 30 sec about a dozen ants had converged on the eggs and had placed them in a pile under a small piece of bark which extended partially into the soil. Several ants frequently handled the eggs with their mandibles. For 3 days the ants "cared for" the eggs by handling them and moving them. On the fourth day the eggs showed signs of shrinkage and the ants subsequently abandoned them.

For test B, 20 cc of moist soil were placed in a clear plastic zipper case (2 in diam. x 1.4 in high) and 25 ants were added. After 48 hr, 2 termite eggs were placed on the soil surface. For 2 days the ants showed no interest in the eggs. An additional 15 ants were introduced and after 6 hr the termite eggs had disappeared. The contents of the test unit were carefully examined but no eggs were found. Probably they were eaten by the ants.

Test C replicated B but used 15 termite eggs instead of 2. Within 3 hr the ants had located the eggs and moved them underground where they could not be seen. After 2 days, the test unit was examined. The eggs were in good condition in a little pocket near the bottom of the container. One egg appeared close to hatching. It was immediately transferred to a new container with moist earth and ants but the ants ignored it and the termite died with only its head free of the egg. It is not known whether *S. molesta* or other ant species assist young termites in emerging from their eggs.

Attempts were made to induce the ants to steal termite eggs from an established termite colony. Twenty cc of moist earth were placed in a zipper case with 15 termites and 40 termite eggs. The termites located the eggs almost immediately. A termite would pick up one or more eggs, carry them a short distance and drop

them. This was repeated many times. After 20 hr the termites had gathered about 12 eggs under a small piece of wood at the soil surface. Fifteen ants were added to the test chamber. Within 2 hr they had tunneled to the bottom along the wall of the container and hollowed out a small chamber. In the meantime, some of the ants and termites were on the soil surface. The two species moved freely among each other without evidencing any hostile behavior. Occasionally, when the antennae of the 2 species touched, the ant would hastily jerk backward, then continue as before. The termites rarely backed away. After 24 hr the ants had established several tunnels through the soil. These were not contiguous with the termite tunnels. Both species moved freely in their respective tunnels and seemed indifferent or unaware of the other's presence. Careful observation for 6 consecutive days revealed nothing unusual in the behavior of either species. Neither made any attempt to extend its domain. Occasionally 1 or 2 individuals of both species would contact each other on the soil surface with the same results as described previously. After 1 week the termites began moving more and more on the soil surface which is a preliminary indication of an unhealthy colony. An inspection of the eggs showed early signs of shrinkage. In 10 days the termites appeared unhealthy and the experiment was discontinued. Similar experiments produced no significant results. Although the termites frequently grouped clusters of their eggs, the ants were never seen to steal them.

Though *S. molesta* never was seen to steal guarded termite eggs, they readily seized unguarded eggs and at times appeared to care for or tend them. The extent of this practice or its biological significance is not known. An interesting behavioral activity of the ant was in walling off and usurping for its own use the termite tunnels adjacent to its nest. Additionally, there was the evident lack of hostility between the two species when they encountered each other on the soil surface.

INTERACTION OF *R. FLAVIPES* WITH OTHER ANT SPECIES

A cluster of approximately 5,000 termite eggs was found about 5 ft from the ground under the inner bark of a large, partially dead elm on July 30, 1963. Immediately after exposure of the eggs, many *Aphaenogaster tennessensis* (Mayr) ants moved up under the inner bark at the base of the tree from their nest in the ground and began moving large numbers of termite eggs. Occasionally the ants would seize the termites which were also attempting to remove their eggs, but primarily the ants concen-

trated on the eggs. When all the eggs were removed, the ants returned to their nest. Similar behavior records for *A. tennessensis* have not been reported in the literature. Limited laboratory studies were undertaken, but none gave any evidence of similar (egg-stealing) behavior. Laboratory studies indicated a strictly predatory relationship between the ant and termite.

Camponotus pennsylvanicus DeG., *Tapinoma sessile* (Say), and *Lasius* sp. may be considered as inquiline ants. Laboratory experiments suggested that *C. pennsylvanicus* and *R. flavipes,* given sufficient room and a preponderance of termites, will establish a relationship best described as indifferent neighbors. Field observations suggest that once this relationship is established, it will exist even under conditions of great agitation. However, crowding and a preponderance of ants destroy the inquiline relationship and the ants kill the termites.

Laboratory experiments with *T. sessile* indicated that regardless of whether the ants or termites were established first, after 1 week a condition of indifferent tolerance with no direct contact between the two species resulted. Although King (1897) reported a close association between *R. flavipes* and *T. sessile* in field observations, no such relationship was indicated in the laboratory studies. The two species were not observed together in the field.

Lasius sp. and *R. flavipes* were frequently found closely associated in the field (Smythe and Coppel, 1964). On one occasion, a weathered piece of wood lying on the ground was overturned and both species were seen moving together on the ground. Laboratry tests indicated that *Lasius* sp. occasionally would usurp portions of the termites' tunnels for its own use. After several days, however, the ants would withdraw and the termites would reinhabit their former territory. Mixed cultures of the two species invariably stabilized with the termites inhabiting tunnels in the bottom half of the test unit and the ants living in the upper half of the soil and on the soil surface. Frequently, tunnels of the two species would connect but no intermingling of the species occurred. Occasionally, the termites would erect barriers in the connecting tunnels but after several days they would remove them and thereafter reside as indifferent neighbors. Gorging the ants with honey and then introducing them to a termite inhabited unit in a small wire cage for 48 hours, so that the odors of the two species could intermingle without any physical contact, eliminated all ant aggressiveness.

SUMMARY

The eastern subterranean termite, *R. flavipes,* and the common thief ant, S. *molesta,* may coexist harmoniously in uncrowded labo-

ratory cultures. Encounters on the soil surface between the two species showed no evidence of hostility. The ants continuously walled off and usurped portions of termite tunnels close to their nests. Unguarded termite eggs were removed by the ants; however, in the studies undertaken guarded eggs were not removed. *A. tennessensis* rapidly removed exposed termite eggs in the field. In the laboratory, the ants *C. pennsylvanicus, T. sessile,* and *Lasius* sp. generally had an inquiline relationship with *R. flavipes,* which was often reflected as a neighborly indifference with or without contact. The relationship with *Lasius* sp. seemed particularly compatible. Under either crowded conditions or a preponderance of ants this was modified in favor of the ants.

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