Spatial Distribution of Colonies of Three Carpenter Ants, *Camponotus pennsylvanicus, Camponotus floridanus, Camponotus laevigatus* (Hymenoptera: Formicidae)

by

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ABSTRACT

Spatial distribution and nest sites of *Camponotus pennsylvanicus* in Indiana, *Camponotus floridanus* in Florida, and *Camponotus laevigatus* in California were compared. For *C. floridanus*, colony size was also determined. Substantial differences exist in the adaptations of these three species to their respective environments. *C. pennsylvanicus* nests were located in standing, live trees, *C. floridanus* nests were located in rotten logs or in the ground beneath objects, and *C. laevigatus* nests were located in stumps or logs. The significance of these differences for pest control of carpenter ants is discussed.

KEYWORDS: *Camponotus pennsylvanicus, Camponotus floridanus, Camponotus laevigatus*, pest control.

INTRODUCTION

Colony size and nest distribution in carpenter ants is complicated by the presence of satellite nests, which can sometimes be numerous and often difficult to locate. For these reasons, population parameters have been seriously underestimated in the past (Akre *et al.* 1994). Early studies by Pricer (1908) with *Camponotus pennsylvanicus* (DeGeer) and *C. ferrugineus* (F.) set the size of carpenter ant colonies at well under 10,000 workers and later Fowler (1986) supported this with his estimates of mature carpenter ant colonies ranging in size from 3,000 to 6,000 workers. In comparable western species, if the entire colony is considered, including parent and satellite nests, then *C. modoc* Wheeler colonies can reach 50,000 and *C. vicinus* Mayr as many as 100,000 workers (Akre *et al.* 1994). Unlike most other North American carpenter ants which are monogynous, polygyny enables *C. vicinus* to reach such large colony sizes (Akre *et al.* 1994). Information about colony distribution and size in carpenter ants is a prerequisite for successful control of these important structural pests. Because the organization of

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carpenter ant colonies consist of parent and satellite nests, control is achieved only by elimination of the entire colony network.

The black carpenter ant, *C. pennsylvanicus*, is the principal structural ant pest of eastern North America, and in the northeast their economic significance probably exceeds that of subterranean termites (Fowler 1983, Akre and Hansen 1990). Smith (1965) states that the Florida carpenter ant, *Camponotus floridanus* (Buckley), "undoubtedly ranks as one of the most important house-infesting ants in Florida," and is also common in coastal areas of Georgia, South Carolina, North Carolina, and Alabama (Nickerson and Harris 1985). In a survey of the urban pest ants of Florida (Klotz *et al.* 1995), *C. floridanus* was the most common species of carpenter ant encountered by pest control employees. Although there has been considerable research on kin recognition in this species (Carlin and Hölldobler 1986), there is little else known about its biology. *C. laevigatus* is found in the mountains of the western states above 6,000 feet (Wheeler 1910). In Washington state, it frequently nests in fallen logs and dead trees but rarely is found in structures (Hansen and Akre 1985).

Our goal in this study was to compare colony characteristics of these three species of carpenter ants which live in different habitats: *C. pennsylvanicus* in a temperate forest, managed landscape in Indiana, *C. floridanus* in a disturbed subtropical sandhill habitat in northern Florida, and *C. laevigatus* in a montane coniferous forest, recently recovered from fire.

MATERIALS AND METHODS

The study site for *C. pennsylvanicus* was a managed hardwood forest in Tippicanoe Co., IN (Fig. 1). Within this study area, a 0.4 hectare cemetery plot bounded on all sides by a road, was studied in detail. The study was conducted in the spring and summer of 1993, when the ants were actively foraging. Carpenter ants are aggressive towards nonnestmates, so this behavior was exploited in agonistic tests of relatedness to group various nests and, thereby, estimate the territory occupied by a colony. Tests were performed in the field by collecting a foraging worker on one tree, and pairing it with another worker from a different tree. The pairs were held within a small glass jar (» 75 ml) where agonistic behavior was observed. Tests were replicated three times and because aggressive responses were so strong between nonnestmates they were scored as either 0 = no display of aggression; or 1 = intense aggression with sustained grappling and combat. Interactions between ants from different trees were then used to draw maps of the colony distributions. The territory occupied by each colony was then estimated

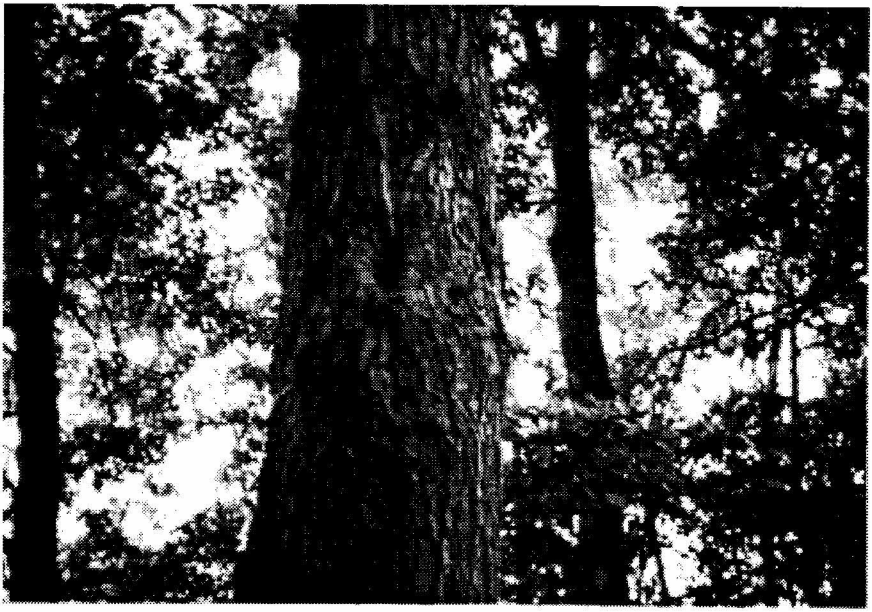

Fig. 1. Habitat of *Camponotus pennsylvanicus* showing the typical nest site of this ant in a knothole of a tree trunk

from the maps as the maximum diameter of the polygon that encompassed all the trees utilized by each single colony. The d.b.h. (diameter at breast height) of trees colonized, and the length of organized ant trails between trees were also measured.

For *C. floridanus* in Gilchrist Co., FL, we systematically searched a 0.5 hectare plot of sandhill (Fig. 2) to determine the number and location of nests. The site was being used as an illegal dump and, in addition to natural nesting sites (e.g. beneath logs or in hollow tree stumps), the ants established nests in the ready made cavities afforded by siding, floor coverings, lumber, and plastics scattered across the site. A previous study by one of the authors (LDJ) had shown that *C. floridanus* thrives in this kind of disturbed habitat (Davis and Jouvenaz 1990). We also collected each nest in order to obtain an estimate of size. Collection involved first exposing the nests which were located in or under logs, trash or leaf detritus, sometimes extending down into the soil, and then rapidly vacuuming up all the ants and brood using the methods of Akre *et al.* (1989). Collections were made during the months of September to November in 1992, during the daylight hours when the ants were inactive and in the nest. The location of each nest was recorded on a map, and the workers and brood from each nest were brought to the laboratory, and counted. These individual nests were

Fig. 2. Habitat of *C. floridanus* in a disturbed sand hill area being used as a dump site.

kept separate for tests of relatedness, maintained in the laboratory at 25°C, ambient RH, and provided with food (honey and crickets) and water.

Ants from a single nest were tested against ants from different nests to determine whether they were satellite nests of the same colony. A major worker from one nest was carefully introduced into another container with ants from a different nest. This introduced ant was observed for 10 encounters with resident ants, and interactions were recorded as either aggressive (mandibular grasping, gaster flexing) or nonaggressive (licking, trophallaxis) as described by Morel & Blum (1988). Ants that were attacked were considered to be from different colonies. If during the 10 encounters, the worker was not attacked then the ant was considered to have come from a satellite nest. The territory occupied by each colony was then estimated from the map by measuring the maximum diameter of a circle encompassing all of the satellite nests from a single colony.

The study site for *C. laevigatus* in San Bernardino Co., CA, was a 8.1 hectare plot in the Children's Forest of the San Bernardino National Forest. Children's Forest is a 1376.5 ha site located at 2208 m in the San Bernardino Mountains. In 1970 a fire destroyed most of the vegetation but a few trees survived. At the time of this study, the habitat was a mixture of bushes and trees (Fig. 3). The most common plant is

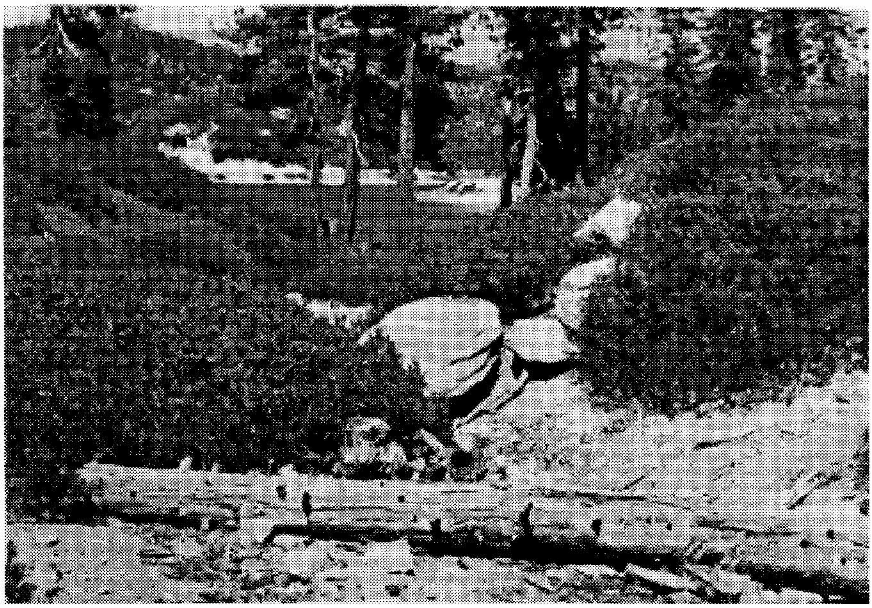

Fig. 3 Habitat of *C. laevigatus* in a mountainous region of the San Bernardino National Forest

manzanita (*Arctostaphylos* spp.). Trees were mostly Jeffrey pine (*Pinus jeffereyii*) and white fir (*Abies concolor*). A transect through a dry wash was our main study site, but nests were also located in logs scattered among the numerous rocky outcrops. The study was conducted during the spring and summer of 1997. Ant aggression tests were performed and scored as described above for *C. pennsylvanicus*. One difference in these tests, however, was that agonistic behavior was observed in 12 cm long by 1 cm diameter Tygon tubing corked at both ends (Fig. 4). The original map of the distribution of *C. laevigatus* colonies was produced with the aid of a global positioning system (Trimble Pathfinder Proexcel, Sunnyvale, CA) with sub-meter resolution. The map was further enhanced with a computer drawing program (ArcView, Environmental Systems Research Institute, Redlands, CA).

RESULTS

Fig. 5 shows the spatial distribution of colonies of *C. pennsylvanicus* at the Indiana site. Table 1 indicates that colonies were active in or on 24 of the 29 trees in the plot and these represented 7 distinct colonies. These colonies occupied from 1 to 6 trees (six different species of hardwoods), spread over an area 6 to 28 m across (average 16.3 m per territory). All of the colonies were nesting within hollows of standing

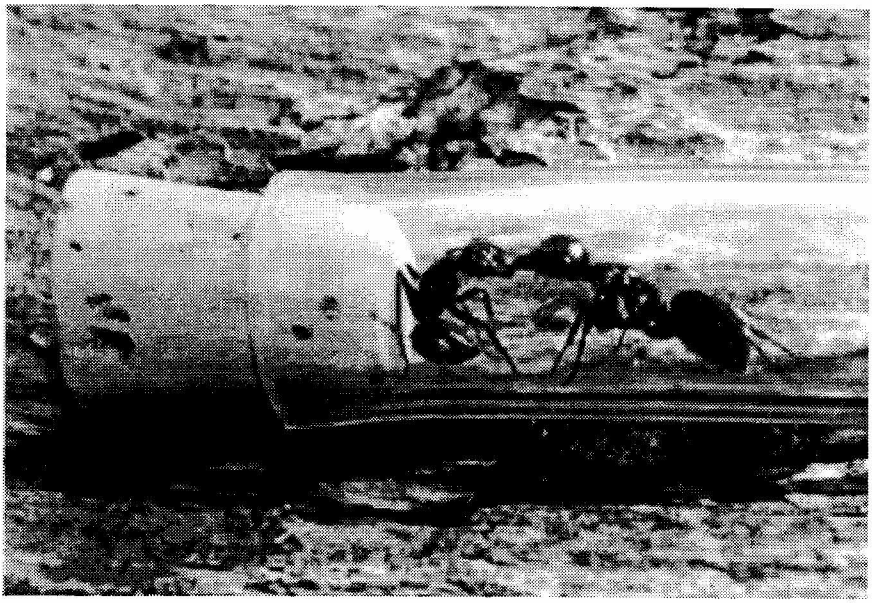

Fig. 4. Agonistic test with *Camponotus laevigatus* showing the aggressive interaction of two workers from different colonies

Table 1. Satellite nests and estimated territory of *Camponotus pennsylvanicus*, with length of organized ant trails between trees in a managed landscape in Indiana.

Colony no.[a]	Number of trees[a]	Territory diam. (m)	Length of trail (m)[a]
1	2	6	a-b 6.3
2	6	26	b-c 9.8
			d-e 10.7
3	4	16	b-d 11.5
4	5	28	a-b 7.2
			b-c 13.1
			b-e 7.6
5	3	9	a-c 9.0
6	1	-	-
7	3	13	b-c 12.3
Avg.	**3.4**	**16.3**	**9.7**

[a]Refer to Fig. 1 for location on map

trees. The tree d.b.h. ranged from 22.0 - 82.6cm. Organized ant trails between trees ranged in length from 6.3 - 13.1m.

The spatial distribution of colonies of *C. floridanus* is shown in Fig. 6. Table 2 lists the colony sizes and number of different life stages and

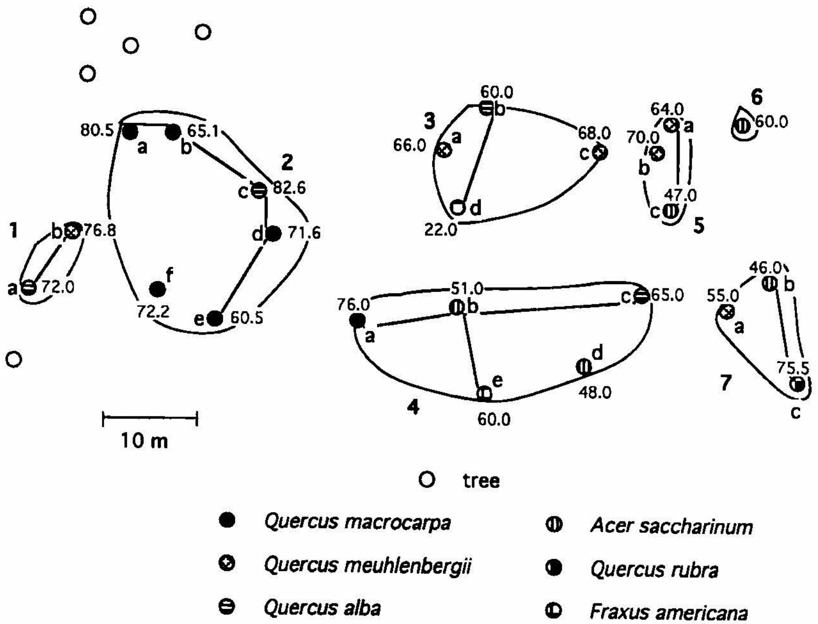

Fig. 5. Map of the managed landscape in central Indiana, the study site for *Campontus pennsylvanicus*. Enclosed areas represent territories of the different colonies which are numbered 1-7. Numbers next to tree symbols indicate the diameter (cm) of the tree at breast height. Lines connecting trees represent ant trails which were measured. Refer to table 1 for the measurement.

Table 3 describes the characteristics of the twenty nests which were located in the sandhill plot and the territorial diameter of the two colonies with satellite nests. Seven of the twenty nests were unrelated to other nests and, thus, constituted individual colonies. Worker populations in these colonies ranged from 154 to 2379, averaging 893. An eighth colony consisted of 3 nests, with a total worker population size of 2731, occupying a territory 15.8 m in diameter. The ninth colony, a "super colony" residing in 10 distinct nest sites, was populated by 8099 workers and was spread over an area measuring 43 m across. Only 7 of the 20 nests were located in natural sites, such as beneath logs or in hollow tree stumps. The remaining 13 nests were found in trash, including all 10 of the nests constituting the "super colony." The sampling methods could not collect an entire colony. For example, no queens were collected and we found eggs in only one nest (colony 7). Most nests contained many larvae and pupae.

The distribution of *C. laevigatus* nests are shown in Fig. 7. With the exception of one nest in a standing dead pine tree, all colonies were in fallen logs in early stages of decay. Only one satellite colony was found. Ants from two related nests were living in two logs that were nearly

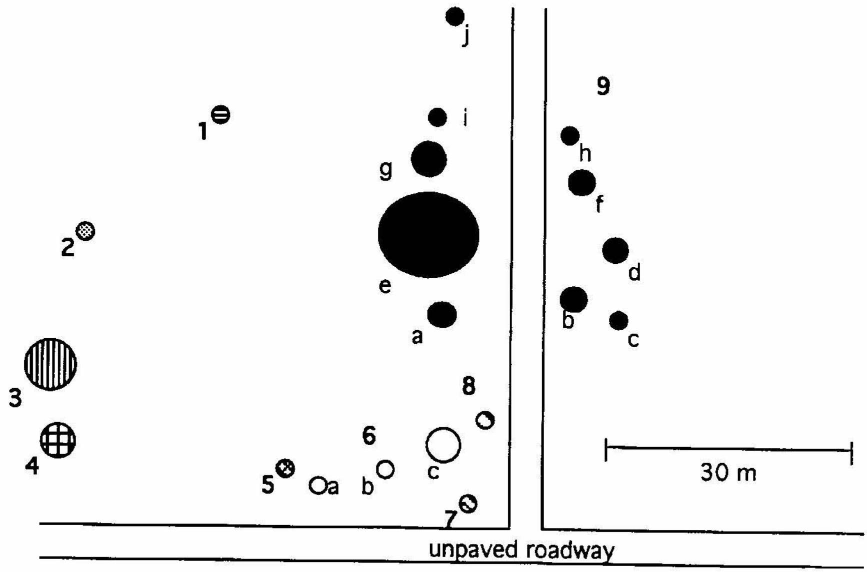

Fig. 6. Map of the disturbed sandhill habitat in northern Florida, the study site for *Camponotus floridanus*. Letters next to nests indicate satellites and numbers indicate separate colonies. The size of a circle represents the number of ants counted in that nest (see Table 2).

Table 2. Colony size and number of different life stages in nests of *C. floridanus*.

Colony (nest)a	Larvae	Pupae	Adults	Eggs
1	0	0	154	0
2	11	0	278	0
3	114	3	2379	0
4	197	614	1696	0
5	1	4	368	0
6(a)	1	2	432	0
(b)	29	35	514	0
(c)	82	84	1785	0
7	5	0	560	5
8	77	61	817	0
9(a)	21	0	624	0
(b)	17	1	679	0
(c)	4	0	254	0
(d)	0	1	608	0
(e)	59	13	3424	0
(f)	11	16	678	0
(g)	95	19	1376	0
(h)	1	41	57	0
(i)	149	3	226	0
(j)	5	1	173	0

[a]Refer to Fig. 2 for colony and nest locations

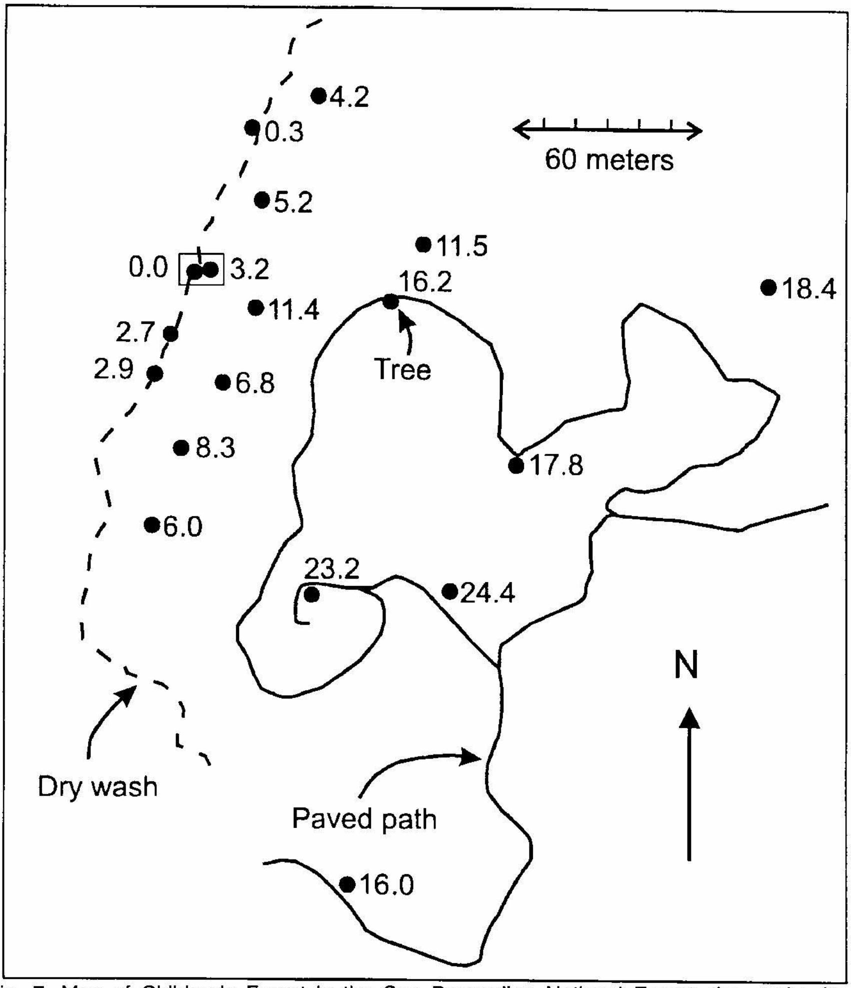

Fig. 7. Map of Children's Forest in the San Bernardino National Forest, the study site for *Camponotus laevigatus*. Each point on the map shows one colony. The numbers next to each point show the altitude in m with respect to the lowest point. The smallest box around two of the points shows the only two sites with non-aggressive worker interactions.

touching end-to-end. In all, 17 distinct colonies were found.

DISCUSSION

Carpenter ants derive their name from their nesting habits. The black carpenter ant, *C. pennsylvanicus*, makes its nest in standing, live cedar (Graham 1918). In central New Jersey, it infests 75% of urban shade trees (Fowler and Parrish 1982), and in eastern Canada, Sanders (1964) found colonies of *C. herculeanus* (L.), *C. noveboracensis* (Fitch),

Table 3. Satellite nests and estimated territory of *C. floridanus*, with location of nest sites in a sandhill habitat in Florida.

Colony[a]	Nests[a]	Territory diam.(m)	Nest site(s)[a]
1	1	-	base of live oak, in soil
2	1	-	oak log on ground
3	1	-	under plywood
4	1	-	dead long-leaf pine
5	1	-	in pine and soil
6	3	15.8	dead turkey oak stump, wood pallet, 2 x 6 pine
7	1	-	under dead turkey oak trunk
8	1	-	under rock
9	10	43.3	under trash, 2x4s, and sheath of cabbage palm

[a]Refer to Fig. 2 for location on map

and *C. pennsylvanicus* nesting in up to eight trees. Nest entrances and trails between these trees were underground. At our Indiana site all of the nests were located in standing, live trees (up to six per colony), but nest entrances were more often than not located higher in trees, such as in a hollow, lightning scar, or knothole, and the trails connecting satellite colonies or foraging areas to the parent nest were always on the surface of the ground. This geographic difference in behavior is probably due to an adaptation by carpenter ants to the extensive ground debris found on the floor of boreal forests, which is conducive to tunneling (Sanders and Pang 1992).

The Florida carpenter ant, *C. floridanus*, will establish its nests in a variety of locations, including rotten logs, under rocks, and in buildings (Nikerson and Harris 1985). The infested wood ranges from early to late stages of decay and can be moist or dry (Van Pelt 1958). At our Florida site, over 50% of the nests were located under trash. In those nests located in wood, the moisture content ranged from 9% to 40%. Van Pelt (1958) suggested that termites may supply food for these ants since they often are found coexisting in damp wood. Of the nine nests we found in wood, only three were associated with termites.

The prevalence of satellite nests in *C. pennsylvanicus*, *C. floridanus*, and many other species of carpenter ants, enables colonies to expand their territory. Akre *et al.* (1994) hypothesizes that satellite nests may be usurped by a new queen after a mating flight.

In contrast, we found only one satellite nest of *C. laevigatus*. However, their nests were spread over a much larger area. Whether this dispersion was a function of territory size or availability of nest sites was not determined.

The differences in nesting biology between carpenter ant species may have important implications for structural infestations. For example, *C. pennsylvanicus* is known to cause significant damage to structural timbers. In comparison, *C. floridanus* is more of a nuisance pest, causing only minor damage to wood (Klotz *et al.* 1995). As we have noted previously, natural preference for nest sites is very different between these two species. *C. pennsylvanicus* nests were found primarily in standing timber, whereas nest sites of *C. floridanus* and *C. laevigatus*, were found primarily on the ground in fallen timber or trash. These differences may be one reason for the controversy in the pest control industry whether carpenter ants cause damage to structures or are nuisance pests. The anecdotal reports from different parts of the country, which appear contradictory, may only reflect a difference in the nesting behavior of the various species of carpenter ant present.

Knowing the colony and territorial size of carpenter ants can help us to design management strategies which are based on sound biological principles. Carpenter ants are hard to control due to the difficulty pest control operators have in locating their nests, which is a necessary prerequisite for effective treatment. Our data stress the importance of trees in locating the nests of *C. pennsylvanicus* outside the structure. All of the colonies in our study site were nesting in standing live trees. Furthermore, the maximum diameter of the nesting territories (Table 1) were not big enough to require extensive searches over hundreds of meters. *C. floridanus*, on the other hand, was more opportunistic in their nest sites, with 45% associated with wood, but none in live trees. Therefore, inspections for these two species of carpenter ants should reflect their biology, and consequently focus on different areas.

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