URBAN PEST MANAGEMENT OF CARPENTER ANTS

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Abstract—In North America 20 species of *Camponotus* have been recorded as pest species causing either structural damage or occurring as nuisance species. Structurally damaging species are found in the subgenera: *Camponotus, Tanaemyrmex*, and *Myrmothrix*. Carpenter ants causing the most serious damage in eastern United States include *C. pennsylvanicus, C. herculeanus*, and *C. noveboracensis* while *C. modoc* and *C. vicinus* are the chief damaging species in western United States. *C. abdominalis* causes damage in Florida. Other species of these subgenera are nuisance pests as well as seven species of the subgenus *Myrmentoma*.

Urban pest management is especially applicable in control of carpenter ants where a knowledge of biology and behavior is essential. Colonies of many of these species are much larger than previously documented. Collections of colonies with over 100,000 workers have been made of *C. vicinus* and of over 50,000 ants for *C. modoc*. These numbers include both the main colony and all satellite colonies. Location of the main colony as well as satellite colonies is essential for effective control. Main colonies are most often located outside the structure in living trees, dead trees, stumps, wood piles, buried wood, or wood in contact with soil. Satellite colonies are most often encountered within the structure under insulation, in wall voids, or in other hollow areas. For an established nest outside the structure, it is not uncommon to find four to eight satellite colonies in nearby structures. In natural settings, satellite colonies are usually located in wood that has less moisture than the parent colony.

The most effective chemical controls for carpenter ants with the least hazards to the homeowner, environment, technician, and the structure include the application of a dust formulation in wall voids and the use of wettable powder synthetic pyrethroids as perimeter sprays. Efficacy studies of treated surfaces show synthetic pyrethroids provide over a year of protection while organophosphates have fewer than two months of residual activity.

INTRODUCTION

Integrated pest management encompasses all available techniques utilized to manage a pest population so that economic damage is avoided, and the adverse side effects on the environment are minimized. The modern concept of integrated urban pest management includes the consideration of ecological parameters of the pest that can be modified to reduce its numbers to tolerable levels, and the application of procedures for pest management suited to current technology that is compatible with economic and environmental quality.

In urban environments, management of pests such as carpenter ants requires the eradication or control of the infesting organisms. Pest control and pest management in urban entomology have similar objectives. By definition pest control is the elimination of the pest problem; whereas, pest management involves decisions in applying ecological approaches to coordinate strategies for effective pest control (Stone, 1992). Where carpenter ants are structural pests, the application of pest management has been important in successfully reducing infestations. Included in this paper are management approaches that rely on the knowledge base of the identification of carpenter ant species and the life history of the pest species involved in infestations. Behavioural strategies in nesting and foraging are also included in the ecological parameters of this knowledge base.

SCOPE OF THE CARPENTER ANT PROBLEM

Carpenter ants cause damage because of their habit of burrowing into wood to create and expand nesting sites. Although carpenter ants have long been recognized as pest species, only recently have data indicated that carpenter ants cause vast structural and other damage. The role of carpenter ants as structural pests in the world other than in North America is poorly documented. Two European papers detail structural damage caused by *Camponotus herculeanus L., C. ligniperda*

Proceedings of the First International Conference on Urban Pests.
K.B. Wildey and Wm H.Robinson (editors). 1993

Latreille (Butovitsch, 1976), and *C. vagus* Scopoli (Benois, 1972). In the last 15 years carpenter ants have been recognized as important North American structural pests (Hansen and Akre, 1985; Fowler, 1986). In the Pacific Northwest of the United States damage caused by carpenter ants is considered equal to or more serious than that caused by termites (Furniss and Carolin, 1977). Information from university extension personnel in the states of Washington, Ohio, Minnesota, and New York indicate that carpenter ants are usually the number one insect problem for which extension receives requests for information (Akre and Hansen, 1988). In the state of Washington in 1981, a conservative estimate of 23,000 structures were treated by licensed pest control operators (Hansen and Akre, 1985). We suggest that in 1993 this number approximates 50,000. Estimating that at least an equal number of homeowners treat the problem themselves, several millions of dollars are expended annually for the control of carpenter ants. Fowler (1986) presented data that showed these ants also cause millions of dollars of damage each year in the northeastern part of the United States.

Nonstructural damage by carpenter ants is also important. Sanders (1964) in New Brunswick, Canada found that 10% of the merchantable crop of spruce and balsam fir was lost to carpenter ants, and earlier reports by Graham (1918) in Minnesota showed that infestations in white cedar ranged from 15 to 70%, depending on locality. In 1988 cedar mills in Minnesota also reported that the problem is severe with the loss of much timber (Akre and Hansen, 1990). Infestation and loss of merchantable timber due to carpenter ants remains an undocumented problem across the northern United States and southern Canada.

IDENTIFICATION OF PEST SPECIES

Camponotus, the largest genus in the Family Formicidae, is comprised of about one thousand species worldwide (Brown, 1973), with 36 species in the Nearctic fauna (Creighton, 1950; Snelling, 1970; Snelling, 1988). Pest species are limited to four of the seven subgenera, and 20 species have been identified as pests in the urban environment (Table 1). In North America the structural pests are limited to *C. modoc* Wheeler and *C. vicinus* Mayr in the West, *C. pennslyvanicus* (DeGeer), *C. noveboracensis* (Fitch), and *C. herculeanus* in the East, and *C. abdominalis* (Buckley) in the Southeast. Species of the Subgenera *Myrmentoma* with major workers less than 8 mm long rarely cause structural damage but can be serious nuisance pests when the colonies overwinter within a structure. Other species are found in landscaping timbers or occasionally invade structures during swarming or foraging activities. These species are also categorized as nuisance species.

Table 1. Species of *Camponotus* infesting structures in North America.

Subgenus	Species	Pest Status	Citation
Camponotus	*modoc*	structural	Hansen and Akre 1985
	pennsylvanicus	structural	Smith 1965
	americanus	nuisance	Hansen unpub.
	laevigatus	nuisance	Hansen and Akre 1985
	noveboracensis	structural	Hansen and Akre 1985
	herculeanus	structural	Smith 1965
	ferrugineus	nuisance	Smith 1965
Tanaemyrmex	*vicinus*	structural	Hansen and Akre 1985
	tortuganus	nuisance	Smith 1965
	semitestaceus	nuisance	Akre and Hansen unpub.
	castaneus	nuisance	Smith 1965
	variegatus	nuisance	Yates 1988
Myrmothrix	*abdominalis*	structural	Smith 1965
Myrmentoma	*essigi*	nuisance	Hansen and Akre 1985
	nearcticus	nuisance	Hansen and Akre 1985
	clarithorax	nuisance	Snelling 1988
	hyatti	nuisance	Snelling 1988
	caryae	nuisance	Smith 1965
	discolor	nuisance	Smith 1965
	decipiens	nuisance	Smith 1965

BIOLOGY OF CARPENTER ANTS

Life History

In mature colonies alates are produced in late summer and overwinter in the nest. Major swarms occur between mid-April to mid-June for *C. modoc, C. vicinus* (Hansen and Akre, 1985), *C. pennsylvanicus* (Pricer, 1908) and *C. herculeanus L.* (Sanders, 1964, 1970; Hölldobler and Maschwitz, 1965). The flight of both sexes is synchronized by a pheromone secreted from the mandibular glands of the males (Hölldobler and Maschwitz, 1965).

After mating *Camponotus* queens found colonies singly and claustrally (Pricer, 1908; Benois, 1972; Hansen and Akre, 1985). Each queen seeks a sheltered nesting site, and over a period of several days produces eggs which hatch after two to three weeks (Mintzer, 1979; Hansen and Akre, 1985). Nourishment for the queen and her first larvae is derived by the dissolution and metabolism of her fat bodies and flight muscles. The larval stage lasts two to three weeks as does the prepupal-pupal period. Emerging workers are assisted by the queen in freeing themselves from the cocoon. In older colonies, workers assist newly emerged workers from their cocoons as the emerging adults cannot free themselves. In the first brood the workers are minor and show little size variation (Mintzer, 1979; Hansen and Akre, 1985). Oviposition of the second brood commences when the initial brood develops to the prepupal stage in late July and August (Hansen and Akre, 1985; Gibson and Scott, 1990). Minor workers produced in the initial brood assist the queen in brood care, maintain and enlarge the nesting site, and forage for food. Colony growth with a founding queen is slow with an average population of 4 to 25 workers in the first summer (Pricer, 1908; Mintzer, 1979; Hansen and Akre, 1985).

In late summer, colony activities decrease and the queen, workers, and larvae enter a dormant phase to overwinter (Fig. 1) (Hansen and Akre, 1990). The only North American species that do not experience a winter dormancy are *C. abdominalis* (Carlin et al., 1987) and *C. variegatus* (Yates, 1988). The dormant queens resume egg production in late winter or early spring after larvae have broken diapause and mature to the prepupal stage (Hansen and Akre, 1985). Colonies in their second year and older have two periods of oviposition and larval development (Fig. 2). The spring brood averages 55 to 70 days to develop from egg to worker; however, the second larval or summer brood enters diapause in the late summer and resumes development the following spring (Pricer, 1908; Hölldobler, 1961; Benois, 1972; Mintzer, 1979; Hansen and Akre, 1985).

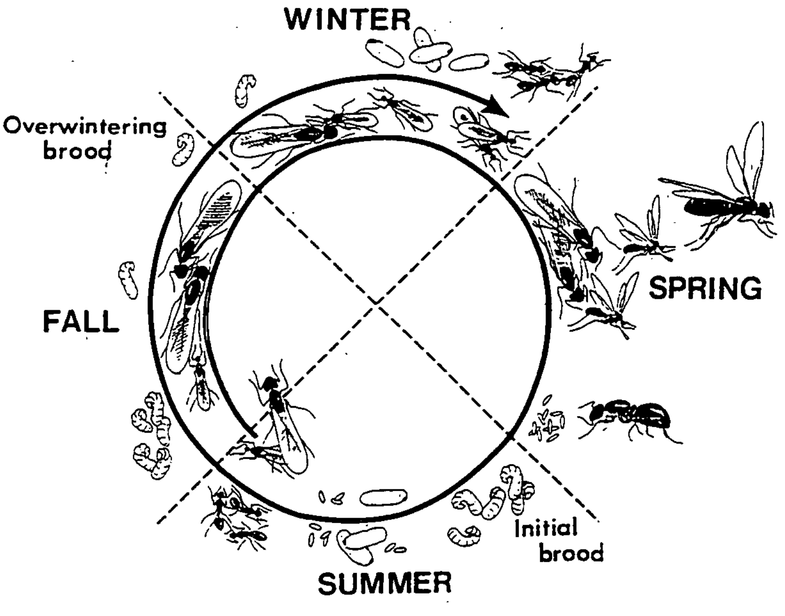

Figure 1. Founding of a colony of *Camponotus*. After a spring flight, a queen produces eggs which develop into workers. Eggs produced in late summer, hatch and overwinter before completing development.

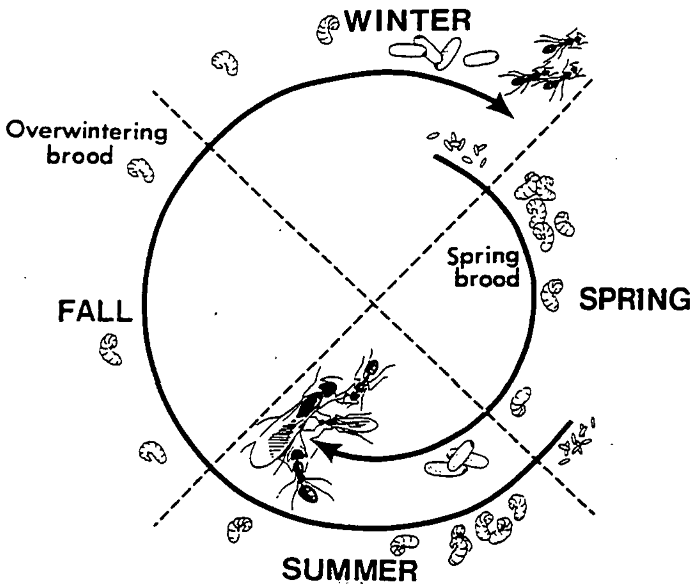

Figure 2. In an established *Camponotus* colony, a queen has two egg producing periods. A summer brood develops in one season while the overwintering brood, which are produced in late summer, overwinter and complete development in early spring.

Production of alates in the colony occurs at six to ten years (Hansen and Akre, 1990). These mature colonies exist in partitioned populations with a parent or main colony and a number of satellite colonies (Sanders, 1964; Kloft et al., 1965; Hansen and Akre, 1985). Contact among these colonies is maintained by movement of workers and brood on trails built on and through the forest floor (Sanders, 1964; Hansen and Akre, 1985). The queen, workers, eggs, and early larval instars are located in the parent colony which is established in an area of high humidity. Satellite colonies are located in drier, warmer areas and are composed of workers, mature larvae, pupae, and winged reproductives (Hansen and Akre, 1990).

The number of satellite colonies per parent colony varies. Sanders (1964) found up to eight satellites encompassing areas up to 830 m^2 for *C. herculeanus* and C. noveboracensis. Kloft et al. (1965) found a *C. herculeanus* colony living in 13 sites in an area of 130 m^2. *C. modoc* and *C. vicinus* often inhabit up to five sites (Hansen and Akre, 1985), and *C. modoc* in southwestern Canada has been reported to have 20 to 25 satellite colonies (Hansen, data from pest control operators). In a survey by Hansen and Akre (1985) satellite colonies were collected and analyzed. Numbers of ants in *C. modoc* satellite colonies ranged from 200 to over 12,000 workers, with larval and pupal populations up to 1,500. Empty pupal cases (60,000+) recovered at one location indicated that nesting sites of satellite colonies are perennial.

Size of Colonies

Limited reports on the size of *Camponotus* colonies are available in the literature. Sanders (1970) reported a colony with 12,000 workers and Hölldobler and Maschwitz (1965) stated that the average number of alates that emerged from a single nest of *C. herculeanus* in Europe was 4,500 males and 1,800 queens. Counts of 3,000 to 6,000 are given as the average size of colonies for most species of carpenter ants (Fowler, 1986). Estimates of colony size are difficult because the colony may be partitioned into several locations at the time of collection, and reports are restricted to only one site. Akre et al. (unpublished) have collected and analyzed a number of complete colonies of *C. modoc* and *C. vicinus* in the Pacific Northwest. Colonies of *C. modoc* contain up to 50,000 workers while colonies of *C. vicinus* can number over 100,000. Colonies of *C. vicinus* have also been collected with multiple functional queens.

Nesting Sites

Carpenter ants excavate decayed and sound wood to create nesting sites. Workers cut galleries into sound wood to accommodate the increasing brood in both parent and satellite colonies. They also cut runways through wood or between adjacent timbers to exit the structure for foraging activities. Galleries are irregular in shape and generally are excavated with the grain and follow softer portions of the wood (Akre and Hansen, 1990). Some of the harder layers remain as walls separating the galleries. The nest walls are smooth with a sand-papered appearance.

In a natural environment carpenter ants nest in live or dead trees and in decaying logs and stumps. They enter live trees through cracks, scars, knot holes, and decayed areas (Fig. 3) (Akre and Hansen, 1990). Inside the tree, ants remove decayed wood and extend galleries into adjacent sound wood. Reports that carpenter ants nest in soil and beneath rocks (Creighton, 1950) are misleading in that these locations serve only as incubation sites used for thermal regulation of developing brood. The actual nest is located in decaying roots, buried timbers, or wood debris beneath these rocks.

Trails and Foraging

Carpenter ants follow chemical and physical trails on the ground surface (Fig. 4) (Akre and Hansen, 1990), and in forested areas may construct extensive tunnel systems through soil litter (Sanders, 1964; Hansen and Akre, 1985). Tunnels are 1.5 to 3 cm diam and 1 cm to over a meter deep. These underground trails are lined with firmly packed wood chips and soil particles. Length of trails is demonstrated in two studies where Sanders (1970) measured a trail of 185 m for a *C. herculeanus* colony and David and Wood (1980) measured a *C. modoc* colony trail of 200 m long.

Observations made on carpenter ant daily foraging patterns indicate the highest period of activity occurs at night. A dramatic increase in numbers of foragers leaving *C. modoc* nests occurs at sunset, with peaks in foraging occurring between 8 p.m. and 4 a.m. (Hansen and Akre, 1985). In California, *C. modoc* foragers were observed on the trail during daylight hours from May to October, but in July and August were almost entirely nocturnal (David and Wood, 1980).

Distribution of food by means of trophallaxis among workers and from workers to larvae and to the queen forms a fundamental bond in the social life of ants. The number of foragers, however, represents only a small percentage of the total colony population. In two colonies of *C. herculeanus*, the number of workers found outside the nest was two to three percent of the total population (Ayre, 1962). Similarly, in colonies of *C. nylanderi* Emery, the average daily number of foragers was less than one percent of the total population (Baroni Urbani, 1965).

MANAGEMENT

Parent and Satellite Colonies

With a knowledge base of the biology and behavior of carpenter ants, management approaches can be investigated. Locations of the parent and satellite colonies are of primary importance (Table 2). The exterior of the structure as well as the yard and landscaping should be carefully examined for the location of the parent colony which is usually located outside the structure. An important prerequisite for the nest of a parent colony includes constant high humidity which is necessary for the development of the eggs and young larvae. Ideal locations are wood used in landscaping such as railroad ties (Fig. 5), timbers, driftwood, buried stumps or lumber. Living trees also make ideal sites for main colonies if access is available to the heartwood through injury, knotholes, or an area of decay that is exposed (Fig. 3). When structural timbers are in contact with soil, moisture will be absorbed. Other structural problems where wood is exposed to high levels of humidity also are conducive to infestations by carpenter ants. Satellite colonies are found in drier and warmer areas such as wall voids, hollow doors, attic spaces, under subfloor insulation (Fig. 6), and in stacks of wood (Table 2). Inspections of buildings should include: (1) attics, crawl spaces, and under insulation with has been added to these areas; (2) plumbing accesses, electrical outlets, lighting fixtures, and central vacuum connections; (3) unfinished basement areas; (4) casings around

Table 2. Nest locations of *Camponotus modoc* and *C. vicinus* in structural infestations, 1981–1984. Multiple sites occurred inside and outside the structure. Total infestations are in parentheses. Modified from Hansen and Akre, 1985.

NEST LOCATIONS	*C. modoc* (96)		*C. vicinus* (14)	
	No.	%	No.	%
Inside the structure				
Floor or subfloor	18	18.8	4	28.6
Attic	20	20.8	0	0
Interior wall void	9	9.4	3	21.4
Outside wall void	34	35.4	3	21.4
Ceiling	18	18.8	2	14.3
Roof	3	3.1	0	0
Sill plate/supports	3	3.1	1	7.1
Stacked lumber	3	2.1	0	0
Unknown	3	3.1	0	0
None	14	14.6	4	28.6
Outside the structure				
Forest (within 50m)	26	27.1	1	7.1
Infested tree in yard	16	16.7	5	35.7
Wood in landscaping	7	7.3	3	21.4
Buried Wood	8	8.3	1	7.1
Firewood	3	3.1	0	0
Stacked lumber	3	3.1	0	0
Stump or dead tree	15	15.6	1	7.1
Unknown	21	21.9	3	21.4
None	3	3.1	1	7.1

skylights, windows, and entrances. Indications of a carpenter ant infestation include the presence of ants, extruded sawdust from nesting sites, rustling noises in the walls, and foraging trails. Ants establish trails among the parent and satellite colonies as well as to foraging sites (Fig. 4). If trail activity cannot be located during daylight hours, observations should be made after sunset when peak foraging occurs.

Figure 3. Site of a parent *Camponotus modoc* colony at the base of a Douglas-fir.

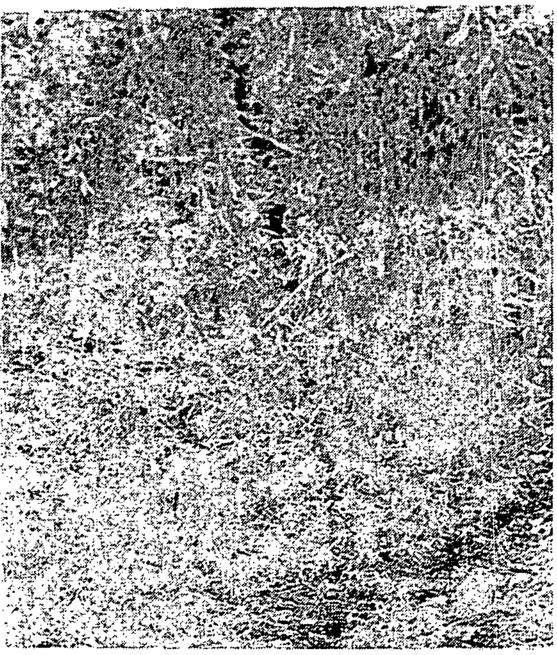

Figure 4. Trail between a *Camponotus modoc* parent colony and a satellite colony.

Figure 5. *Camponotus modoc* colony in railroad ties used in landscaping.

Figure 6. Satellite colony of *Camponotus modoc* under subfloor insulation.

Conducive Conditions for Infestation

Conditions conducive to carpenter ant infestations need to be corrected in the control of an existing infestation or for the protection of a structure in an area where infestations are common (Table 3). Moisture levels should be controlled throughout the structure to eliminate habitats. Areas to check include: (1) grades, patios, and walkways which should drain water away from the structure; (2) crawl spaces for vapour barriers and proper ventilation; (3) supports for porches, decks, and fencing resting on concrete rather than soil; (4) the roof and areas around plumbing, air conditioning units, drains, and gutters for moisture leaks; (5) vegetation, particularly trees, to determine that no vegetation is in contact with the structure. Removal of trees and shrubs in contact with buildings not only reduces moisture, but eliminates entry by these routes into the structure.

Table 3. Conditions present in structural infestations of *Camponotus modoc* and *C. vicinus* that may have contributed to the infestation. Many structures have several conditions. Total infestations are in parentheses. Modified from Hansen and Akre, 1985.

CONDITIONS:	*C. modoc* (96)		*C. vicinus* (14)	
	No.	%	No	%
Wood in contact with soil	34	35.4	9	64.3
Vegetation/structure	31	32.3	5	35.7
Wood in landscaping	9	9.4	3	21.4
Wood buried near structure	8	8.3	1	7.1
Within 50m of forest	56	58.8	6	42.9
Poor vent/crawl space	8	8.3	1	7.1
Poor vent in attic	3	3.1	0	0
Leaks in plumbing	5	5.2	0	0
Roof or drain leaks	15	15.6	1	7.1
Infested tree in yard	12	12.5	3	21.4
Drainage/poor grade	1	1.0	0	0
Stacked firewood/lumber	4	4.2	0	0
Stumps or dead trees	7	7.3	0	0
Unknown	1	1.0	0	0

Wood should be stacked off the ground away from buildings. Any moisture leaks should be repaired, and decayed wood replaced.

New Construction

In the construction of new housing, certain precautions against carpenter ant infestations can be made. Before houses are constructed in forested areas, an inspection should be made to determine whether colonies of carpenter ants are located on the property. Trees with large parent colonies should be removed or the colonies should be controlled chemically before construction begins. All wood and stumps should be removed or burned rather than buried at the construction site. When carpenter ants are common, a dust application may be made to the wall voids of a new structure after the electrical wiring, plumbing, and insulation are installed but before the drywall is added. Dust can also be applied to either side of sheet insulation in open beam or cathedral ceilings to prevent the establishment of satellite colonies. Dust formulations will kill ants as they enter the void to establish nests and many chemicals will remain effective, if kept dry, for many years.

Chemical Control

To achieve effective control, the parent and satellite colonies should be located, and a pesticide applied directly to the nesting sites. When colonies cannot be located and treated directly, wall voids should be treated with a dust application through access openings around plumbing or electrical outlets and fixtures. Dust formulations are the most effective formulation for Hymenoptera because of the pubescence on body surfaces. A number of dust formulations containing borates, bendiocarb, chlorpyrifos, diazinon, or synthetic pyrethroids are available. A perimeter application with a wettable powder formulation of a synthetic pyrethroid or an organophosphate on the exterior of the structure under the lower edge of sidings and around window and door frames will prevent entry by ants. In structures with a crawl space, the interior side of sill plates, the foundation, and all structural supports should be treated. Most spray applications made early in the season to areas that do not receive direct sunlight and rainfall will remain effective throughout the year, and the most residual synthetic pyrethroids will remain effective through a second season (Hansen unpublished).

Baits

The use of a poison bait for carpenter ant control is an approach totally compatible with the maintenance of environmental quality. Although a number of ant baits are available, none of the current materials is useful against carpenter ants. However, a bait soon to be licensed by Washington State University has been effective in controlling more than 60 colonies of *C. modoc* and *C. vicinus* over the past five years.

CONCLUSION

Current technologies useful for carpenter ant control combine both chemical application and environmental modifications. Chemical control should use the least amount of chemical placed into areas where they will be most effective for the longest period of time. This application must be coupled with a knowledge of the biology and life strategies of carpenter ants.

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