ELIMINATION OF SUBTERRANEAN TERMITE POPULATIONS FROM THE STATUE OF LIBERTY NATIONAL MONUMENT USING A BAIT MATRIX CONTAINING AN INSECT GROWTH REGULATOR, HEXAFLUMURON

NAN-YAO SU, JAMEY D. THOMAS, & RUDOLF H. SCHEFFRAHN

ABSTRACT—Infestation by the eastern subterranean termite, *Reticulitermes flavipes* (Kollar), was found throughout the two ground floors of the pedestal of the Statue of Liberty National Monument. Termite activity in soil was also detected in two locations outside the monument walls. In total, four clusters of termite activity were identified. The widespread infestation suggested that termites had been in the monument for several years before they were noticed in 1994 and were probably introduced during the restoration project in the mid-1980s. Baits containing an insect growth regulator, hexaflumuron, were applied using above- and in-ground stations in mid-1996. By October 1997, all four infestations were eliminated after consuming a total of 1.8 g hexaflumuron. Monitoring stations remained in the soil to detect residual or new populations of subterranean termites on Liberty Island.

TITRE—Extermination d'une population de termites souterraines du Monument national de la statue de la Liberté à l'aide d'un appât contenant un régulateur de croissance pour insectes, l'hexaflumuron. RÉSUMÉ—On a constaté l'infestation de termites souterraines, *Reticulitermes flavipes* (Kollar) dans les deux étages inférieurs du piédestal du Monument national de la statue de la Liberté. On a aussi décelé la présence des termites à deux autres endroits dans le sol à l'extérieur des murs du monument. Au total, quatre termitières furent localisées. L'étendue de l'infestation suggérait que les termites se trouvaient dans le bâtiment depuis plusieurs années déjà avant leur découverte en 1994, et qu'elles furent probablement introduites au cours de la restauration qui eut lieu dans les années 1980. Des appâts contenant un régulateur de croissance, l'hexaflumuron, furent placés dans le sol et en surface au cours de l'année 1996. En octobre 1997, les quatre termitières étaient éliminées, après une consommation totale de 1,8 g d'hexaflumuron. Des pièges de surveillance furent laissés en place afin de détecter d'éventuelles populations résiduelles ou une nouvelle population de termites sur Liberty Island.

TITULO—Eliminación de poblaciones subterráneas de termitas del Monumento Nacional de la Estatua de la Libertad utilizando una trampa de carnada que contiene hexaflumuron, un regulador de crecimiento de insectos. RESUMEN—Se encontró una infestación de termitas subterráneas orientales, *Reticulitermes flavipes* (Kollar) en las dos plantas a nivel del suelo del pedestal del Monumento Nacional de la Estatua de la Libertad. También fue detectada actividad de termitas en el suelo en dos ubicaciones por fuera de las paredes del monumento. En total fueron identificados cuatro grupos de actividad de termitas. La extensión de la infestación sugirió que las termitas habían estado en el monumento por varios años antes de que fueran encontradas en 1994 y fueron introducidas probablemente durante el proyecto de restauración a mediados de la década de 1980. Se utilizaron trampas de carnada (cebo) conteniendo el regulador de crecimiento de insectos hexaflumuron, siendo ubicadas en estaciones fuera y dentro de la tierra hacia mediados de 1996. En octubre de 1997 las cuatro infestaciones fueron eliminadas después de consumir un total de 1.8-g de hexaflumuron. Las estaciones de monitoreo permanecen en la tierra para detectar poblaciones residuales o nuevas de termitas subterráneas en la Isla de la Libertad.

Originally Published in JAIC 37 (1998):282-92

1 INTRODUCTION

In the spring of 1994, swarmers of the eastern subterranean termite, *Reticulitermes flavipes* (Kollar), were noticed in the boiler room and the museum area in the pedestal of the Statue of Liberty National Monument, New York. Swarming was so extensive that the museum was temporarily closed to visitors.

The statue was erected in 1886 on the pedestal in the center of old Fort Wood, which was constructed between 1806 and 1811 (Hugins 1956). Since the days of Fort Wood, there has been no record of termite damage or infestation on the 14-acre Liberty Island, located 600 m east of the New Jersey shore and 2,400 m southwest of Manhattan Island (Levine 1952; Greenstein 1963). Although *R. flavipes* is an endemic species to the eastern United States and probably existed on both sides of the Hudson River before human settlement, the water apparently prevented natural termite invasion of the island. The detection of termite dispersal flights suggested the presence of mature colonies that may have been developing for several years prior to 1994. It was suspected that alate pairs or small colonies of *R. flavipes* might have hitchhiked in landscape or construction materials brought to the island during the 1984–86 restoration project. This article reports results of bait application to eliminate the subterranean termite populations from the Statue of Liberty National Monument.

2 SUBTERRANEAN TERMITES AND THEIR CONTROL

2.1 ECONOMIC IMPORTANCE OF SUBTERRANEAN TERMITES AND CONVENTIONAL CONTROL MEASURES

Subterranean termites are important structural pests in the United States, costing the public approximately $1.2 billion each year. Historic buildings and structures are particularly vulnerable to subterranean termite damage, given the traditional use of wood as a building material. Termite damage to historic buildings is both costly and irreversible and can diminish the integrity of a structure.

Conventional methods for the control of termite infestations rely heavily on the use of organic insecticides to provide a barrier for the exclusion of soil-borne termites from a structure. Typically, large quantities of liquid insecticide are applied to the soil beneath and surrounding an infested building. The insecticide barrier technique is the most common method for subterranean termite control. Creating an uninterrupted barrier of treated soil beneath an existing structure, however, is extremely difficult (Frishman and Bret 1991). A single colony of subterranean termites may contain 100,000 to 1 million workers that forage up to 100 m in search of food (Su et al. 1993). Because the soil treatment only deters termite attack, the vast majority of subterranean termites are unaffected (Su and Scheffrahn 1988). If gaps in the soil barrier occur, subterranean termites may eventually find the untreated soil and make their way back into the structure, causing more damage and necessitating further treatment.

Soil treatments often require drilling of the foundation floor before liquid insecticides are injected into subfoundation soil, an unacceptable practice for many historic structures. Another disadvantage of soil treatment is the risk of ground-water contamination in historic landscapes. This concern is especially valid in the Statue of Liberty, as the monument foundation is less than 100 m away from New York Harbor.

2.2 SENTRICON TERMITE COLONY ELIMINATION SYSTEM

In recent years, baits containing slow-acting toxicants, such as the insect growth regulator hexaflumuron, have been used as alternatives to conventional soil insecticides. Hexaflumuron inhibits the synthesis of chitin, which is essential for the formation of insect exoskeleton but is virtually harmless to vertebrates. Because of its low mammalian lethal effect (LD50:>5,000 mg/kg), it is registered in the least toxic category, "caution." Using a monitoring and baiting procedure, hexaflumuron is delivered by foraging termites to eliminate the entire colony populations of several million individuals (Su 1994). The procedure is currently marketed as the Sentricon Termite Colony Elimination System (Dow AgroSciences, Indianapolis, Indiana) to authorized pest control applicators. Studies using the in-ground Sentricon system or its commercial prototypes confirmed that termite colonies of several million individuals could be suppressed to the point of inactivity (or observed elimination) using less than 1 g of hexaflumuron (Chambers and Benson 1995; DeMark et al. 1995; Su et al. 1995; Grace et al. 1996). Moreover, elimination of colony populations created a zone of termite-free soil surrounding a building for several years (Su and Scheffrahn 1996).

The in-ground Sentricon system employs a cyclical process of monitoring and baiting for termite activity. First, Sentricon stations containing monitoring devices are installed in the soil surrounding a structure. When termite activity is discovered in a station, the monitoring device is replaced with bait containing 0.5% hexaflumuron (Recruit II, Dow AgroSciences). Hexaflumuron kills termites only when they molt, or every 1–2 months. During this period, the bait is thoroughly distributed throughout the colony population by foraging termites that feed upon the baits and by trophallaxis (food exchange among nest mates). It may take several months to achieve the colony elimination, but the result is sweeping. Once the colony is eliminated, a return to monitoring continues to detect further termite activity.

Because the in-ground baiting system is difficult to use in places without soil access, an above-ground baiting procedure was also developed to deliver hexaflumuron through stations placed directly over active termite infestations (Su et al. 1997). The above-ground baiting system provides another opportunity for bait application to control structure-infesting populations of subterranean termites. Because the objective of this project is to eliminate termite populations from Liberty Island, we used all methods possible to deliver baits containing hexaflumuron.

3 TERMITE INFESTATION IN THE STATUE OF LIBERTY NATIONAL MONUMENT

3.1 LOCATING TERMITE INFESTATIONS

An inspection conducted in spring 1995 revealed numerous signs of termite activity throughout the two ground floors of the pedestal. Old foraging tubes (no live termites) were found on the concrete walls and floors of the preparatory rooms behind the reception desk at the north end of the pedestal on the entrance level (fig. 1, p. 285). Similar signs of past termite activity were also found along the wall-floor interface of the eastern side of the museum on the second floor, on the walls of the south corner, and inside a rest room. The widespread presence of termite foraging tubes confirmed our speculation that termites had been active for several years before 1994, and subterranean populations probably originated from the soil beneath and surrounding the pedestal.

Active foraging tubes and damaged wood containing live termites were also found in numerous locations in the two ground floors of the pedestal. To identify termite activity in soil, a stake survey (Su and Scheffrahn 1986) was conducted in 1995. Spruce stakes (*Picea sp.*, 2.5 × 4.0 × 28 cm) were driven into the soil at 10 m intervals outside the exterior walls and were examined monthly to identify termite activity in soil. The survey revealed two termite activity loci: one in soil outside the boiler room and the other at the sally port (see fig. 1, T1 and T3). (The sally port was used as the visitor entrance to the statue in the late 1800s [Hugins 1956]). Based on survey results, we identified four clusters of termite activity: the boiler room (BOL), a display case in the second-floor museum area (DIS), the sally port (SAL), and the sally port exit (EXT). Termites flew in the boiler room and museum area in spring 1994, 1995, and 1996.

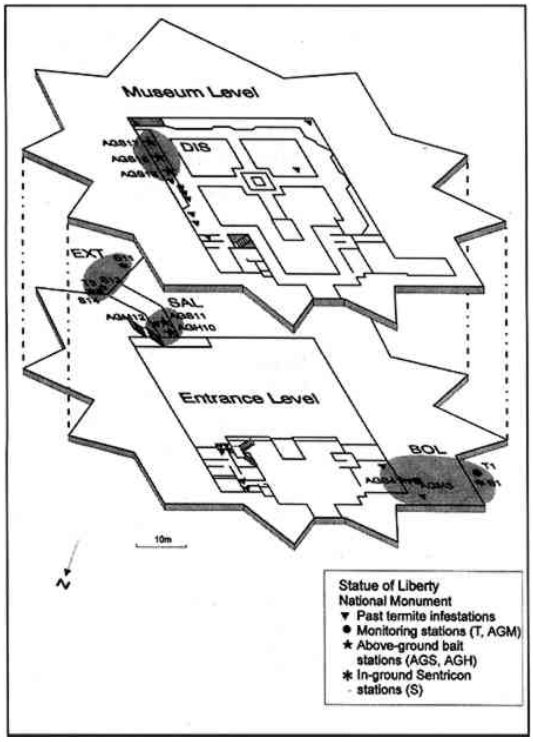

Fig. 1. Four clusters of subterranean termite activity were identified in the two ground floors of the pedestal of the Statue of Liberty National Monument: boiler room (BOL), display case in the second-floor museum (DIS), sally post (SAL), and sally port exit (EXT). Triangles: past termite infestations such as old foraging tubes. Circles: monitoring stations (T, in-ground station; AGM, above-ground station). Stars: above-ground bait stations (AGH, above-ground hard-style station; AGS, above-ground soft-style station). Asterisks: in-ground Sentricon stations (S).

3.2 MONITORING TERMITE ACTIVITY

Termite activity was monitored throughout 1995 by measuring wood consumption rate (mg wood consumed per day) from above- or in-ground monitoring stations; the number of active stations (both monitoring and bait stations with live termites); and termite feeding counts using an acoustic emission detector. Monitoring stations received untreated wood only, and baits containing hexaflumuron were applied in bait stations.

3.2.1 Above-Ground Monitoring Station (AGM)

An above-ground monitoring station (Su et al. 1996) was attached directly over foraging tubes so that termites could access the wooden block through a precut hole on the plastic container. The station consisted of a plastic box (12 × 15.5 × 4.5 cm) containing a preweighed wooden block (*Picea sp.*, 2 pieces, 9 × 3 × 2 cm and 8 × 5 × 2 cm, nailed together with a wooden handle, 8.5 × 3 × 2 cm). A thermal insulation layer made of closed-cell polyethylene foam (21.5 × 25 × 0.3 cm) was attached over the station using Velcro tape for easy detachment.

3.2.2 In-Ground Monitoring Station (T)

In-ground monitoring stations were placed in the soil surrounding the monument walls where termite activity was detected by the stake survey. The stations consisted of preweighed wooden blocks (6 pine boards, 7 × 13 × 2 cm, nailed together so that 4 were stacked atop each other and 2 were attached to the resulting 8 cm sides) surrounded by plastic collars (17 cm diameter, 15 cm high) as described by Su and Scheffrahn (1986).

Monitoring stations were checked monthly or bimonthly. Infested wooden blocks were washed to remove debris, dried at 80°C for 48 hours, and cooled in a desiccator before reweighing to determine the wood consumption rate (mg wood consumed per station per day).

3.2.3 Acoustic Emission Director

An acoustic emission detector similar to that described by Scheffrahn et al. (1993) was used to monitor termite activity in the wooden floors of the museum display area. The detector unit consisted of a main processor compartment (10 × 19 × 3 cm) connected by coaxial cables to two resonant acoustic emission sensors having integral amplifiers. The detector recorded sound waves of ultrasonic frequency (>20 kHz) that were generated when wooden fibers were broken by termite mandibles. Using the detector, termite-feeding episodes were recorded along longitudinally oriented wood grain up to 80 cm (Scheffrahn et al. 1993).

4 BAIT STATIONS

4.1 ABOVE-GROUND BAIT STATIONS

Two types of above-ground bait stations—soft-style (Recruit AG) and hard-style (Dow AgroSciences)—were used to deliver hexaflumuron to termite populations.

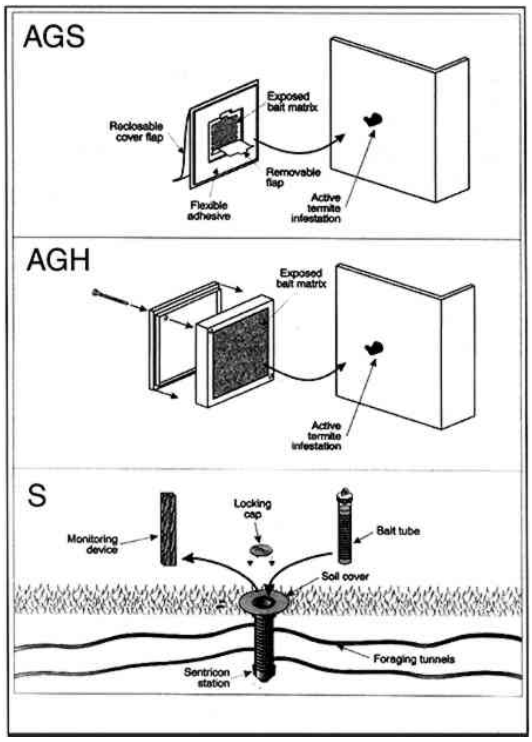

Fig. 2. Baits containing 0.5% hexaflumuron were applied using soft-style above-ground bait stations (AGS), hard-style above-ground bait stations (AGH), or in-ground Sentricon stations (S).

4.1.1 Soft-Style Above-Ground Bait Station (AGS)

The soft-style station consisted of a flexible laminated pouch (15 × 15 × 0.5 cm) containing 15 g of 0.5% hexaflumuron. On the front side of the station was a reclosable cover flap, and on the backside was a removable flap (7 × 7 cm) surrounded by a 3.5 cm-wide collar of flexible adhesive (fig. 2). In the presence of an active infestation, the removable flap was pulled to expose the bait matrix. The exposed bait matrix was moistened with 30–40 cc water and then attached over an active infestation using the flexible adhesive so that it was accessible to foraging termites. Because of its flexibility, the soft-style station was adaptable to flat, curved, or contoured surfaces (fig. 3, p. 287). The station was inspected monthly or bimonthly. When bait was substantially consumed, the reclosable outer cover flap was removed, and another soft station was stacked over the old station so that additional bait was available to termites.

4.1.2 Hard-Style Above-Ground Bait Station (AGH)

The hard-style above-ground station consisted of a plastic box (10 × 10 × 4 cm) containing 25 g of bait matrix impregnated with 0.5% hexaflumuron. One side of the box was laid open to expose the bait matrix, and the other side was protected by a removable cover (see fig. 2). The exposed bait matrix was moistened with 30–40 cc water and then attached over an active infestation using hot glue so that the exposed bait was accessible to foraging termites. Because more bait can be applied using the hard station than the soft station, AGH was used wherever it could be properly

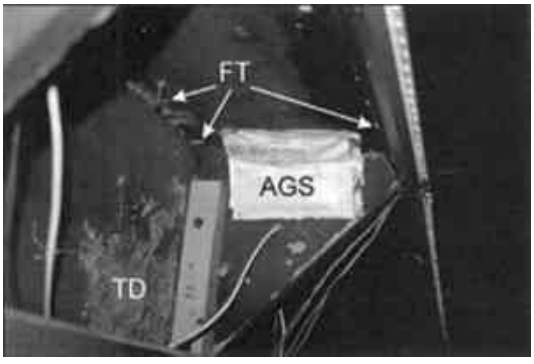

Fig. 3. The display case in the museum showed severe termite damage (TD), with many foraging tubes (FT) containing live termites. One soft-style above-ground bait station (AGS) was placed directly over the active foraging tubes.

installed, i.e., on a flat surface. The station was inspected monthly or bimonthly by removing the front cover. When needed, another bait box was stacked over the old station so that additional bait was available to termites.

4.2 IN-GROUND SENTRICON STATION (S)

The in-ground (Sentricon) station consisted of a plastic tube (4 cm inner diameter × 24 cm long) with one open end and one conical end (see fig. 2) (Su et al. 1995). Four columns of 11 rectangular holes each (3 × 1 cm) were provided along the entire surface of the tube. A soil cover made of a plastic ring (15 cm diameter with a 7.5 cm diameter inner hole and 1 cm thick) was affixed to the open end of the housing, and a locking top cap (7 cm diameter) was screwed to cover the opening. A hole (5 cm diameter × 25 cm deep) was first drilled into the soil using a gasoline-powered auger. The station was inserted into the hole with the soil cover extending on the soil surface. A monitoring device (two wooden slats, 1.4 × 2.8 × 21 cm) was placed in the station before the locking top cap was attached (see fig. 2, S). Stations were inspected monthly or bimontly to examine termite activity. When termites were found in the station, the monitoring device was replaced by a plastic tube (3.8 cm diameter by 21 cm long) containing 20 g bait matrix (0.5 % hexaflumuron). Bait tubes that were substantially consumed by termites (>50% by visual estimate) were replaced with new tubes.

At the conclusion of bait application when termite activity ceased, all bait stations were removed. The partially consumed baits were cleaned of soil debris, dried at 60°C for 48 hours, and cooled in a desiccator before reweighing to determine bait consumption by termites.

5 EFFECTS OF BAIT APPLICATION ON FOUR CLUSTERS OF TERMITE ACTIVITY

As shown in fig. 1, four clusters of subterranean termite activity were identified in the two ground floors of the pedestal of the monument: the boiler room (BOL); a display case in the second-floor museum area (DIS); the sally port (SAL); and the sally port exit (EXT). Because of the complexity of the structures where termites were found, baits containing 0.5% hexaflumuron were applied using all available delivery methods including soft-style above-ground bait stations (AGS), hard-style above-ground bait stations (AGH), and in-ground Sentricon stations (S) (see fig. 2).

5.1 BOILER ROOM (BOL)

Termites were found in foraging tubes and earthen works on the wall joints of the boiler room, indicating a soil-borne origin of this population (fig. 1). Old foraging tubes were also found on the floor-wall interface and on the interior of the pedestal walls (see triangles, fig. 1). Termites found in the boiler room were probably interconnected with those detected in soil near the boiler room exterior wall because of the numerous underground utility pipes leading to the outdoor cooling facility. Subterranean termites

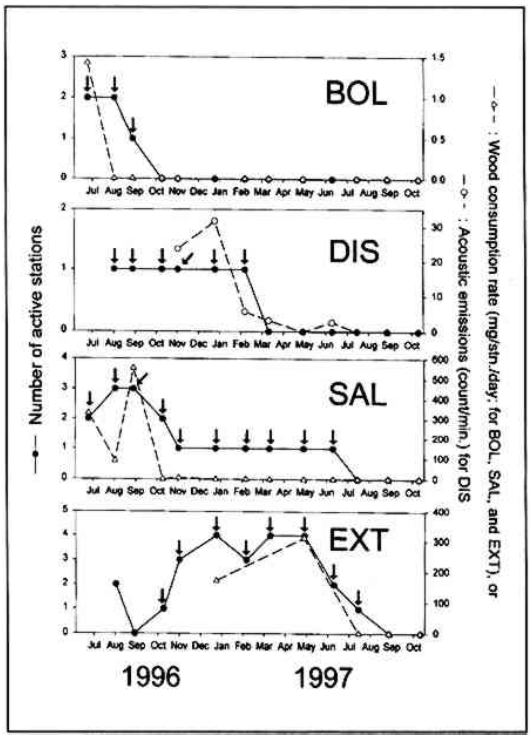

Fig. 4. Termite activity for the four populations, BOL, DIS, SAL, and EXT, found on the two ground floors at the pedestal of the Statue of Liberty National Monument. Activity is expressed by wood consumption rates (open triangles with dotted line), acoustic emission counts (open circles with dotted line), and number of monitoring and baiting stations with live termites (black circles with solid line). Arrows depict applications of baits containing 0.5% hexaflumuron.

are known to be attracted to water condensation on cooling pipes, and the warmer microclimate near the heating pipes may also harbor termites during winter. By early July 1996, termites infested one in-ground monitoring station (T1) and one Sentricon station (S1) (see fig. 1). One bait tube containing hexaflumuron was placed in S1. In mid-July, however, National Park Service personnel doing maintenance work inadvertently excavated both stations. In August, one above-ground monitoring station (AGM5) and one bait station (AGS4) were placed over the foraging tubes containing live termites (see fig. 1). The entire 15 g of bait matrix in AGS4 was consumed in September; no termite was found in any of the stations inside or outside the boiler room (fig. 4). Termites did not fly in the boiler room in spring 1997 or 1998. We concluded that population BOL was eliminated after consuming 142 mg of hexaflumuron in three months (table 1).

5.2 DISPLAY CASES (DIS)

On the northeastern end of the second floor, old foraging tubes were found on the museum floor and inside the display cases (see triangles, fig. 1). Termites had swarmed there in spring 1994, 1995, and 1996. Some wooden floors were so extensively damaged that they had to be replaced. Live termites were found in foraging tubes inside the display cases (see fig. 3).

In August 1996, one above-ground soft station was placed beneath the display cases over foraging tubes containing live termites (see fig. 3). The entire 15 g bait matrix was consumed from this station (see AGS13, fig. 1) within a month. Two double stations (two stations stacked over each other, 30 g matrix total) were added in September and October, and both were totally consumed. In November, termite feeding activity was detected using the acoustic emission device from the wooden floor of the display area (see fig. 4). Two additional bait stations (see AGS16 and 17, fig. 1) were placed on the infested wooden floor, but termites did not feed on these two stations. Termite feeding continued in AGS13 between November 1996 and February 1997, but it was less

intense than in previous months. Coincident with the sudden decrease of acoustic emission count in February, activity of population DIS came to a halt in March. Termites did not swarm in the museum area in spring 1997 or 1998. The population DIS was probably eliminated after consuming 528.5 mg hexaflumuron during the six-month baiting period (see table 1).

5.3 SALLY PORT (SAL)

In the sally port, foraging tubes and earthen works containing live termites were found in the wall joints and between the concrete floor and the stone walls of the original fortress. One hard-style (AGH10) and one soft-style (AGS11) above-ground bait station and one above-ground monitoring station (AGM12) were placed over the active foraging tubes in July 1996 (see figs. 1, 4). A considerable amount of bait was consumed from both AGH10 and AGS11 from July to September. By October, termite activity in the monitoring station AGM12 declined sharply (see fig. 4), but termites continued to feed on bait in both above-ground bait stations, AGH10 and AGS11. In November, termite feeding in AGH10 ceased. Termites continued feeding in the bait station AGS11 through winter 1996 and spring 1997, only less vigorously than in previous months. By May and June 1997, only a few termites were found in AGS11. All termites exhibited marbled coloration, which is the secondary symptom of hexaflumuron effects (Su et al. 1996). In July, only springtails (Insecta: Collembola) were found in AGS11. Collembolans feed on decaying material and fungi. The presence of such decomposers and scavengers in termite galleries usually implies the demise of the termite colony. We believe the termite population in sally port was eliminated after consuming 915 mg hexaflumuron during the 11-month baiting period (see table 1).

5.4 SALLY PORT EXIT (EXT)

In summer 1996, one wooden stake near the sally port exit detected termite activity and was replaced by an in-ground monitoring station (see T3, fig. 1). Termites were seen in T3, but feeding on the wooden block was not vigorous throughout 1996 (see fig. 4). Termites were found in one of the Sentricon stations (S13) placed near T3, and hexaflumuron bait was placed in October. Despite the cold weather, termites remained active through winter 1996 and spring 1997 (see fig. 4). By March 1997, termites were found in three Sentricon stations (S11, S13, and S14) into which hexaflumuron baits were placed (see fig. 1). Termites fed extensively on the wooden block in T3 during spring 1997. By June, termites found in T3 were lethargic and exhibited marbled coloration. Termite activity in T3 declined to zero in July (see fig. 4). Feeding on hexaflumuron baits in Sentricon stations continued in June and July, but termites found in these stations were also visibly affected by hexaflumuron, i.e., they were lethargic and had marbled coloration. By September, no termite was found in any of the Sentricon or monitoring stations. The nine-month baiting, during which 200 mg of hexaflumuron was consumed, apparently eliminated the EXT population (see table 1, p. 292).

6 CONCLUSIONS

After consuming a total of 1.8 g hexaflumuron, all four clusters of termite activity were eliminated from the Statue of Liberty National Monument (see table 1). A conventional soil treatment of trenching and rodding the monument foundation would have applied >50 kg of insecticide (active ingredient), and such a soil treatment probably would have only excluded, instead of eliminating, soil-borne termites from the structure. The baiting program required considerably less insecticide because baits were used only when and where they were needed and because termites themselves delivered hexaflumuron to nestmates. As shown in this study, however, baiting is also time- and labor-consuming. Time required for elimination ranged from three months (BOL) to 11 months (SAL), possibly due to the differences in population size of the subterranean termite colonies. Because hexaflumuron is an insect growth regulator that affects termite molting, and termites probably do not molt often when temperatures are low, termite populations that survived the baiting program before the onset of cold weather (SAL and EXT) tend to require additional bait application before elimination (see fig. 4).

After the elimination of all detectable termite populations, 77 Sentricon stations were placed in soil (see fig. 2, S) at 5 m intervals surrounding the exterior wall foundation of the monument in October 1997. The stations are monitored quarterly by volunteer pest control firms and Dow AgroSciences personnel. Because the monument is on an island, as long as precautions are taken to avoid shipment of infested materials, further immigration by termites is unlikely. It is probable that some alates that swarmed in 1994–96 may have successfully initiated small colonies on the island. Such incipient colonies may have escaped our survey. As these small populations grow, it is expected that the ongoing monitoring program with the Sentricon stations will detect termite activity and subsequently eliminate it by additional baiting before substantial damage is done.

ACKNOWLEDGEMENTS

We are grateful to Al Farrugio (Statue of Liberty National Monument, National Park Service), Paul M. Ban (University of Florida) and James R. Lofton (Dow AgroSciences) for technical assistance, and Joan Perrier (University of Florida) for figure illustrations. We also thank to Robin Giblin-Davis (University of Florida) and Mark Gilberg (National Center for Preservation Technology and Training, National Park Service) for reviewing this manuscript. Partial funding for this project was provided by NCPTT, National Park Service, Department of the Interior under the grant agreement No. MT-0424-5-NC-023. Additional funding was provided by the Statue of Liberty–Ellis Island Foundation, Inc. (This article is Florida Agricultural Experiment Station Journal Series No. R-06117).

REFERENCES

Chambers, D. M., and E. P.Benson. 1995. Evaluation of hexaflumuron for protection of structures from termites in New Orleans. *Down to Earth* 50:27–31.

DeMark, J. J., E. P.Benson, P. A.Zungoli, and B. M.Kard. 1995. Evaluation of hexaflumuron for termite control in the southeast U. S. *Down to Earth* 50:20–26.

Frishman, A., and B.Bret. 1991. Rodding is a tricky business. *Pest Control* 59:48–56.

Grace, J. K., C. H. M.Tome, T. G.Shelton, and R. J.Oshiro. 1996. Baiting studies and considerations with *Coptotermes formosanus* (Isoptera: Rhinotermitidae) in Hawaii. *Sociobiology* 28:511–20.

Greenstein, R. E.1963. Summary structural history of Fort Wood (supplement). Unpublished typescript. Liberty Island, N.Y.: Statue of Liberty National Monument Research Library Collections.

Hugins, W.1956. Short history of the Statue of Liberty. Unpublished typescript. Liberty Island, N.Y.: Statue of Liberty National Monument Research Library Collections.

Levine, B.1952. History of Bedloe's Island. Master's thesis, New York University, New York, N.Y.

Scheffrahn, R. H., W. P.Robbins, P.Busey, N.-Y.Su, and R. K.Mueller. 1993. Evaluation of a novel, hand-held, acoustic emissions detector to monitor termites (Isoptera: Kalotermitidae, Rhinotermitidae) in wood. *Journal of Economic Entomology* 86:1720–29.

Su, N.-Y.1994. Field evaluation of a hexaflumuron bait for population suppression of subterranean termites (Isoptera: Rhinotermitidae). *Journal of Economic Entomology* 87:389–97.

Su, N.-Y., and R. H.Scheffrahn. 1986. A method to access, trap, and monitor field populations of the Formosan subterranean termite (Isoptera: Rhinotermitidae) in the urban environment. *Sociobiology* 12:299–304.

Su, N.-Y., and R. H.Scheffrahn. 1988. Foraging population and territory of the Formosan subterranean termite (Isoptera: Rhinotermitidae) in an urban environment. *Sociobiology* 14:353–59.

Su, N.-Y., and R. H.Scheffrahn. 1996. Fate of subterranean termite colonies after bait applications: An update and review. *Sociobiology* 27:253–75.

Su, N.-Y., P. M.Ban, and R. H.Scheffrahn. 1993. Foraging populations and territories of the eastern subterranean termite (Isoptera: Rhinotermitidae) in southeastern Florida. *Environmental Entomology* 22:1113–117.

Su, N.-Y, P. M.Ban, and R. H.Scheffrahn. 1996. An above-ground station for monitoring structure-infesting populations of the Formosan subterranean termite (Isoptera: Rhinotermitidae). *Sociobiology* 27:39–45.

Su, N.-Y, P. M.Ban, and R. H.Scheffrahn. 1997. Remedial baiting with hexaflumuron in above-ground stations to control structure-infesting populations of the Formosan subterranean termite (Isoptera: Rhinotermitidae). *Journal of Economic Entomology* 90:809–17.

Su, N.-Y., E. M.Thoms, P. M.Ban, and R. H.Scheffrahn. 1995. A monitoring/baiting station to detect and eliminate foraging populations of

subterranean termites (Isoptera: Rhinotermitidae) near structures. *Journal of Economic Entomology* 88:932–36.

AUTHOR INFORMATION

NAN-YAO SU graduated with a Ph.D. in entomology from the University of Hawaii in 1983. After spending three years as a postdoctoral associate studying the behavioral ecology and control of subterranean termites at the Louisiana State University and the University of Hawaii, he joined the faculty of the University of Florida in 1985. He is currently professor of entomology at the Fort Lauderdale Research and Education Center, University of Florida. Address: Fort Lauderdale Research and Education Center, University of Florida, 3205 College Ave., Fort Lauderdale, Fla. 33314.

JAMEY D. THOMAS received his Ph.D. in entomology from Louisiana State University in 1994. He joined Dow AgroSciences upon graduation and is currently a senior research biologist responsible for field development of structural pest control products for the East Coast. Address: Dow AgroSciences, 5 Bel Air South Pkwy., Suite 109, Bel Air, Md. 21015.

RUDOLF H. SCHEFFRAHN obtained his undergraduate and postgraduate education at the University of California, Riverside, finishing in 1984, and joined the University of Florida faculty in 1985. He is currently professor of entomology at the Fort Lauderdale Research and Education Center, University of Florida. Address: as for Su.

TABLE 1. SUMMARY OF HEXAFLUMURON BAIT APPLICATION TO CONTROL SUBTERRANEAN TERMITE POPULATIONS IN STATUE OF LIBERTY NATIONAL MONUMENT

Population	Bait Type*	No. In-ground Bait Tubes Used	No. Above-ground Stations Used	Bait Matrix Consumed (g)	Hexaflum-uron Consumed (mg)	Months Baited
BOL	AGS, S	2	2	28.4	142.0	3
DIS	AGS	-	10	105.7	528.5	6
SAL	AGS, AGH	-	14	183.0	915.0	11
EXT	S	10	-	40.0	200.0	9

*S: in-ground Sentricon station, AGS: above-ground soft station, AGH: above-ground hard station