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TERMITE BAITING SYSTEM: A new dimension of termite control in the Philippines

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ABSTRACT

The performance of a baiting system and efficacy of an insect growth regulator (IGR), chlorfluazuron, was evaluated against three economically important species of subterranean termites in the Philippines i.e., *Coptotermes vastator* Light, *Microcerotermes losbañosensis* Oshima and *Macrotermes gilvus* Hagen. Preliminary tests were conducted on secondary nests of *M. losbañosensis* and mounds of *M. gilvus.* In-ground Stations (IGS) baited with IGR were installed around the nests and monitored until the colonies were eliminated. Abundance of termites, mobility of colony, feeding activity and elimination period were observed.

Field tests were conducted in selected houses infested with subterranean termites. Above-ground Stations (AGS) and IGS were installed and monitored at regular intervals. The bait was prepared based on the manufacturer's recommended dosage.

Laboratory test showed that populations of *M. losbañosensis* in IGS baited with IGR were eliminated in 17 to 19 weeks. Termites in IGS baited without toxicant were still active on the 19th week, the last week of observation. On the other hand, *M. gilvus* were eliminated

in 15 to 19 weeks in stations baited with IGR. Termites were still active in Stations provided with bait without IGR.

Under field conditions, period of termite interception, period of elimination and bait consumption varied among the termite species. The behavior of termites in stations baited with IGR was similar to those observed in the laboratory. *M. losbañosensis* were eliminated in 20 to 33 weeks after consuming 1,625 g to 2,820 g of bait. An estimated 1,820 to 8,170 g of termite bait was consumed to eliminate *M. gilvus* in 8 to 18 weeks. The toxicant was found very effective against *C. vastator* which were eliminated in 6 to 13 weeks after consuming 500 to 2,370 g of the bait.

The three species of subterranean termites, *M. losbañosensis, M. gilvus* and *C. vastator,* were eliminated using 0.1% chlorfluazuron. Baiting is a potential subterranean termite control technology and its adoption by local pest control applicators will help reduce the risks brought about by using highly hazardous pest control chemicals.

Keywords: termite bait toxicant, IGR, *Coptotermes vastator, Macrotermes gilvus, Microcerotermes losbañosensis, chlorfluazuron*

1.0 INTRODUCTION

Subterranean termites which include *M. losbañosensis* Oshima (Isoptera: Termitidae), *M. gilvus* Hagen (Isoptera: Termitidae), *C. vastator* Light (Isoptera: Rhinotermitidae) and *Nasutitermes luzonicus* Oshima (Isoptera: Termitidae), are the major groups of termites that cause serious problems to home and building owners in the Philippines. The predominant method of prevention and control of subterranean termites is soil treatment, a method involving establishing a chemical barrier around the perimeter of the structure (Garcia 1972, Reyes and Garcia 2003, Garcia and Giron 2004). Conventional termite control is effective but requires a significant volume of termiticide to be applied. For a 10 m x 10 m single-story

house it would require 200 L of diluted termiticide just to treat the soil along the exterior perimeter. In cases of severe infestation, additional chemical solution is applied into drilled holes of concrete slabs in suspected point of entry of termites inside the house. Further, additional chemical solution is deemed necessary to protect wood components composed of mixed species with unknown durability.

Chemical treatment to control termites is also being used in most Asian countries (Tsunoda and Yoshimura 2004, Lee 2004, Junhong and Bingrong 2004, Tsai and Lai 2004, Vu van Tuyen 2004, Yusuf 2004, Lee et al. 2003 and Vongkaluang 2004). The first group of termiticides used as chemical barriers belong to highly persistent and toxic chlorinated hydrocarbons. However, these are now banned and prohibition in its application and distribution in Asian countries is brought about by the health hazard problem to man, environmental contamination and side effects to non target organisms (FPA 2001, Tsunoda and Yoshimura 2004, Zhong and Bingrong 2004, Tsai and Lai 2004, Garcia and Giron 2004, Lee 2004, Vongkaluang 2004).

The current major groups of chemicals being used by pest control applicators as chemical barriers include organophosphates, synthetic pyrethroids, a chlornicotinyl and a phenylpyrazole. They are relatively effective to protect the structure from termite invasion and control existing termite infestation. The bioefficacy of organophosphates and synthetic pyrethroids to protect will last only 4 to 5 years or may be shorter depending on the treatment application, dosage and prevailing conditions. Homeowners are concerned about the very low persistence of products for chemical barriers and the very short, 1 year warranty period offered by pest control operators. This often results in frequent application of chemical solution which, aside from being a financial burden, poses danger to the health of occupants, potential contamination of the environment and side effect to non-target organisms.

Recently, a termite bating system which is reported to be an effective alternative to chemical treatment was introduced in the Philippines. The system involves the application of a termite bait containing an insect growth regulator (IGR) type of toxicant. Hexaflumuron and chlorfluazuron are two novel compounds of benzolphenylurea (BPU) that are gaining importance as bait toxicants to eliminate subterranean termites (Su 1994, Su et al 1995, Robertson and Su 1995, Tsunoda et al 1998, Lee 2002, Peters and Fitzgerald 2003). Chlorfluazuron is claimed to inhibit the production of chitin thus affecting the ability of the insect or termite to complete the molting process resulting to its death. Because the bait is slow acting, the colony members will not be able to discern the danger of consuming the compound, thus they will continue feeding until their complete elimination.

With the current termite problems, the efficacy of the baiting method using chlorfluazuron therefore was evaluated against 3 economically important subterranean termite species in the Philippines. Likewise, the potential of the system as an alternative termite management tool was also assessed.

2.0 EXPERIMENTAL METHODS

2.1. Efficacy of Termite Bait Against Two Species of Subterranean Termites Under Laboratory Conditions.

The efficacy of termite bait was evaluated against two species of Philippine subterranean termites, *M. losbañosensis* and *M. gilvus.*

2.1. 1 Test against *M. losbañosensis*

The test was conducted using nests with active and vigorous populations of *M. losbañosensis* in termite chambers under controlled conditions. Five termite nests with more or less the same dimensions were collected from the orchard. Each nest was implanted into soil filled into a half-sawn 200 L plastic drum as a termite

chamber. Three nests were baited with IGR while the other two nests were baited without IGR. Two IGS were equidistantly installed 50 cm away from the base of the nest.

When the termite population was established, the termite bait with IGR was prepared by mixing 250 g of 0.1% chlorfluazuron powder with 1750 mL distilled water. Prepared bait was sufficient to fill the vacant cavity of an IGS. The same procedures were followed in baiting IGS in the control group except that only cellulose-acetate powder without IGR was used.

2. 1.2 Test against *M. gilvus*

Four nests with active populations of *M. gilvus* were selected at the Graveyard Experimental Area, FPRDI, Los Baños, Laguna, Philippines. Three nests were allocated to the termite bait with IGR and one nest to the bait without IGR. Four IGS were equidistantly installed 50 cm away from the base of each nest (Fig. 2). The preparation and application of bait with and without IGR followed the same procedures as with *M. losbañosensis*.

2.1.3 Monitoring of Efficacy

The population abundance, ratio of workers to soldiers, mobility, volume of bait consumed and elimination period of *M. losbañosensis* and *M. gilvus* were monitored weekly. During inspection, termite bait consumed was replenished. When no feeding activity was observed, the nests or mounds were destructively sampled to verify the presence of active termites.

3.0 Efficacy of Chlorfluazuron Termite Bait to Three Species of Philippine Subterranean Termites Under Field Conditions

3.1. Selection of Experimental Units

A survey of termite-infested houses and buildings in the Municipality of Los Baños was conducted. Experimental units were selected based on the presence of active infestations, species of termites and the willingness of the homeowners to cooperate in the experiment. Six, four and five experimental units were chosen to test the efficacy against *M. losbañosensis, M. gilvus,* and *C. vastator*, respectively.

3.2. Installation of Termite Baiting Stations

Each experimental unit was inspected to determine the locations where the IGS and AGS would be installed. The number of IGS and AGS varied in each experimental unit depending on the size of the area and degree of termite infestation. A pre-drawn site plan was prepared as a guide for easy monitoring of termite-baiting stations.

IGS were installed into the ground around the structure in areas where termite foraging activity was suspected, or close to the point of termite entry into the structure at a distance of 5 m between stations. Six wood interceptors made from *Eucalyptus regnans* F. Muell. were inserted through each belt loop and covered before pressing the IGS into the hole. The AGS were labeled after installation for easy monitoring. Termite bait weighing 250 g of 0.1% chlorfluazuron was mixed in 1.75 L ml of distilled water once termites were intercepted inside the IGS.

In some experimental units, AGS were mounted against a wood structural element with active termite foraging activity. Termite bait was provided immediately after installation by mixing 140 g of 0.1% chlorfluazuron in 1.0 L distilled water. Consumed baits were replenished when necessary during the succeeding monitoring schedules and baiting stopped when termites were eliminated.

3.3 Monitoring of Efficacy

Termite activity and volume of bait consumed were recorded. Likewise, termite population was observed regularly and the relative abundance of termites inside the station was classified as follows:

Population	Classification
0	None
1 to 20	Few
21 to 50	Moderately abundant
Over 50	Abundant

3.4. Determining of elimination period

The volume of bait added and bait consumed were recorded. In case no further feeding was noted, the bait remained in the station to detect residual or new termite population. If no active population occurred in 8 weeks, the IGS were retrieved, cleaned and replaced with a new batch of wood interceptors. The newly installed IGS were monitored for another 3 months to determine the termites' elimination period. Likewise, when no feeding activity in baited AGS was observed, this was monitored for another 3 months. Afterwards, the AGS was either removed or transferred to locations with active foraging activity.

4.0 RESULTS AND DISCUSSION

4.1. Efficacy of Termite Bait Against Two Species of Subterranean Termites Under Controlled Conditions

4.1. 1 Test Against *M. losbañosensis*

The IGS baited with or without IGR intercepted the population of *M. losbañosensis* as early as 1 week after installation as indicated by earthen tubes on the wood interceptors. The population was abundant and very active in baited stations with 0.1% chlorfluazuron during the first 2 weeks. There were more workers than

soldiers and they consumed only 25 to 50% of the bait. The white bait turned brownish due to the masticated mixture of wood, soil, bait and termite enzymes. Population became moderately abundant on the 3rd until the 11th week but termite movement was fast. However, the population was remarkably reduced and sluggish by the 13th and 15th weeks. *M. losbañosensis* was eliminated in 17 to 19 weeks after consuming about 570 to 910 g of bait (Table 1).

Table 1. Interception, feeding and elimination period per volume of bait consumed by *M. losbañosensis* in termite chamber.

Treatment	Interception Period (wks)	Feeding Period (wks)	Elimination Period (wks)	Volume of Bait Consumed (g)
With IGR	1 week	11 to 15 weeks	17 to 19 weeks	570 to 910 g
Without IGR	1 week	> 19 weeks	Still active	1,615 to 2,050 g

Complete destruction of the nest revealed the presence of dead termites and traces of white powdery material inside the nest. The latter indicates that workers were able transport the bait from the IGS to the nest and distribute the toxicant to the other members resulting in the elimination of the colony. The mouth to mouth trophallaxis feeding behavior and grooming habits of termites would have helped transfer of the toxicant from one member to the other members of the colony.

Termite population in stations baited without the toxicant remained active until the last observation period of 19 weeks.

4.1. 2. Test Against *M. gilvus*

The aggregation of the initial population of *M. gilvus* was noted in the IGS baited with 0.1% chlorfluazuron in 1 to 6 weeks after installation. The colony consisted of an active and abundant population with more workers than soldiers.

The elimination of the colony in 15 to 19 weeks required 3,350 to 3,450 g of bait. The foraging activity of *M. gilvus* ranged from 4 to 10 weeks (Table 2).

Table 2. Interception, feeding and elimination period per volume of termite bait consumed by *M. gilvus*.

Termite Bait	Interception Period (wks)	Feeding Period (wks)	Elimination Period (wks)	Volume of Bait Consumed (g)
With IGR	1 to 6 weeks	4 to 10 weeks	15 to 19 weeks	3,350 to 3,675 g
Without IGR	2 to 5 weeks	> 22 weeks	Still active	6,600 g

Destructive sampling of the mound revealed the presence of dead termites and head capsules inside the royal chamber and along the underground tunnels. Abundant traces of white powdery materials were found inside and along the pockets of termite galleries. The reproductives, the king and queen, were not found in the royal chamber. There was no active population inside the mound and the royal chamber, suggesting that the destructive sampling of the mound might have been too late for the post-mortem examination of the colony.

On the other hand, *M. gilvus* were still active and vigorous in IGS baited without 0.1% chlorfluazuron. Destructive sampling of the mound revealed traces of termite bait inside the royal chamber. The reproductives appeared healthy and unaffected by the bait without IGR. Likewise, traces of white powder were noted along the main termite tunnel. No dead termites or head capsules were recorded. A total of 6,600 g bait without IGR was consumed within 22 weeks.

4.1.3 Efficacy of Chlorfluazuron Termite Bait to Three Species of Philippine Subterranean Termites Under Field Conditions

The period to eliminate a termite population varied among the three species of subterranean termites. The shortest and longest elimination period was observed in *C. vastator* and *M. losbañosensis*, respectively. The former took 6 to 13 weeks to eliminate while the latter, 20 to 33 weeks.

Microcerotermes losbañosensis

Generally, termite populations of *M. losbañosensis* aggregated in the stations less than a week after installation of the IGS. These were predominantly workers and found at the bottom and middle portions of the IGS. The early interception of *M. losbañosensis* might be due to the construction of their nests located partly above the ground.

Workers start to construct shelter tubes from their nest above ground, not through the subsoil, resulting in faster tunnel construction to locate food sources. Their tunnels are often seen on the surfaces of the structure.

There were more workers than soldiers in the IGS that consumed 75% of the bait after 1 week. On the 2^{nd} to the 10^{th} week, termite population was abundant and earthen tunnels were formed inside the station. Termites became sluggish and disoriented on the 4^{th} to the 13^{th} week. No active population was observed on the 14^{th} week. Foraging activity period ranged from 12 to 29 weeks. The population was eliminated from 20 to 33 weeks after consuming 1,625 to 2,730 g of 0.1% chlorfluazuron (Table 3).

The absence of an active population inside the earthen tunnels, cessation of feeding activity in baited IGS, presence of dead termites and traces of white powdery materials in the previously infested beams and window jambs were considered signs that the colony has been eliminated. The IGS was retrieved and replaced with a clean one and baited with a freshly prepared bait.

Table 3. Estimated interception period, foraging duration and volume of termite bait needed to eliminate *M. losbañosensis* under field conditions.

Experimental House Unit No.	Qty of IGS	Termite Interception (weeks)	Foraging Activity (weeks)	Elimination Period (weeks)	Volume of Bait Consumed (g)
1	3	< 1	23	25	2,130
2	2	< 1	24	24	2,090
3	4	< 1	12	24	1,625
4	2	< 1	29	33	2,730
5	3	< 1	25	27	2,395
6	4	< 1	16	20	2,820

A secondary nest of *M. losbañosensis* located outside the infested experimental unit was destructively sampled after 2 months. Dead termites, head capsules and traces of white powder were detected inside the nest. This demonstrates that workers of the colony were able to transport the bait to their nest and transferred the toxicant to other members of the population. The distribution of the toxicant resulted in the elimination of the colony that prevented further infestation of the structure.

All wood components of the house e.g. door/window jambs, partitions, ceiling, cabinets, flooring and kitchen were termite-free 7 months after the colony was eliminated.

Macrotermes gilvus

Interception period of *M. gilvus* ranged from 2 to 15 weeks. The longer interception period may be attributed to the manner of tunnel construction and the location of the nest or mound, i.e., basically in the subsoil. Tunnel construction and galleries by the workers starts underground, resulting in the slow pace of tunnel formation

towards the food source. The occurrence of termites in the baiting stations was sporadic, suggesting intermittent feeding activities of the workers.

A moderately abundant and active population of *M. gilvus* composed mainly of workers aggregated in the baited IGS. Some stations had termite populations that remained active for 3 to 8 weeks and consumed 100% of the bait. Bait consumption was reduced to 25% in the succeeding weeks and the movement of the workers became slow. Only the soldier caste was noted in the stations during the last week of monitoring. The colony was completely eliminated 8 to 18 weeks after consuming 1,820 to 8,170 g of bait (Table 4). The wide range of elimination period might be attributed to the differences in the size of the mounds and the huge populations of *M. gilvus*. Foraging activity lasted from 8 to 13 weeks.

Table 4. Estimated interception period, foraging duration and volume of termite bait needed to eliminate *M. gilvus* under field conditions.

Experimental House Unit No.	Qty of IGS	Termite Interception (weeks)	Foraging Activity (weeks)	Elimination Period (weeks)	Volume of Bait Consumed (g)
1	4	15	12	18	5,200
2	5	8	13	17	8,170
3	2	2	8	8	1,950
4	2	2	8	8	1,820

Reproductives of *M. gilvus* were observed after destructive sampling of one of the mounds. The queen was still alive but the integument was loose, dry and dull in color. There were no eggs in the royal chamber suggesting that 0.1% chlorfluazuron had affected egg production. Likewise, there were no workers inside the royal chamber and in the fungus garden which will supposedly tend the nymphs and deposit the eggs to the fungus garden. The king and queen would have probably died soon since there were no longer workers to supply them with food.

Another mound of *M. gilvus* that was destructively sampled had a population composed of soldiers only. The reproductives were not recovered, suggesting that the timing of sampling was too late for colony examination. However, a whitish powdery residue was observed inside the destroyed royal chamber indicating the bait was carried by the workers inside the nest. Workers can transfer the toxicant by their inherent trophallaxis and grooming behavior resulting in the elimination of the colony.

No sign of feeding activity by *M. gilvus* was noted in the wood components during the final inspection. Earthen tunnels were dry, indicating the absence of termite activity.

Coptotermes vastator

Generally, the workers and soldiers of *C. vastator* were abundant to moderately abundant and active in the baited AGS after a week of installation. They consumed 50 - 75% of the bait. On the 2^{nd} to the 5^{th} week, the population consisted mainly of a few sluggish soldiers. Some dead termites and head capsules were observed on the surface of the bait on the 4^{th} and 6^{th} week.

Foraging activity in baited IGS ranged from 7 to 11 weeks. Longer foraging activity was in densely populated experimental units. The population was completely eliminated after 6 to13 weeks (Table 5). Bait consumption to completely eliminate the colonies ranged from 500 to 2,370 g. The wide variation may be due to the differences in the termite populations in the infested experimental units.

Wooden components of the building where the stations were installed showed no evidence of active feeding. The earthen tunnels were dried and no re-invasion of *C. vastator* was noted after 6 months.

Interception period varied among the experimental units. This might be attributed to variation in population abundance and the number of colonies present in each experimental house. Subsequently, not all installed IGS intercepted termites.

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Table 5. Estimated interception period, foraging duration and volume of termite bait needed to eliminate *C. vastator* under field conditions.

Experimental House Unit No.	Qty of AGS	Termite Interception (weeks)	Foraging Activity (weeks)	Elimination Period (weeks)	Volume of Bait Consumed (g)
1	4	< 1	7	7	1,620
2	3	< 1	7	7	1,410
3	2	< 1	6	6	500
4	3	< 1	11	13	1,930
5	5	< 1	10	13	2,370

The volume of bait consumed depends on termite species, population size and the number of species invading the feeding station. *M. gilvus* were more voracious feeders compared with *M. losbañosensis* and *C. vastator*

5.0 CONCLUSIONS AND RECOMMENDATIONS

- Application of 0.1% chlorfluazuron termite bait was effective in eliminating populations of *M. losbañosensis, M. gilvus* and *C. vastator,* preventing the destruction of wood components of all experimental units.
- The period to eliminate a termite population depends on the species and size of the population. Elimination period of *M. losbañosensis* ranged from 20 to 33 weeks, *M. gilvus* from 8 to 18 weeks and *C. vastator,* ranged from 6 to 13 weeks.
- The baiting method using IGR is effective in eliminating termites in hard to treat buildings and houses where the location of the target pest is difficult to locate and treat.

- The baiting method is environmentally sound, baiting stations are easy to install and safe to the applicator and residents. However, the elimination of termite population is not immediate and monitoring process is long.
- Knowledge on termite identification, nature of damage and termite behavior is necessary using the system because different termite species vary in their response to the 0.1% chlorfluazuron.

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