Sustainable Termite Management Using Innovative and Selective Termite Baiting Method

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Abstract. In a natural ecosystem, termites play an important role as a decomposer since termite can digest cellulose. Termites can be considered as pests once they had exerted substantial economical damages, such as Coptotermes spp known to be a major termite pests. Termites will cause a serious problem when the infestation occurred in urban areas as they give negative economic effects, reducing the value aesthetic of the buildings which lead to expensive building maintenance and repair. Chemical controls are the most common method used against pests of urban forests in Malaysia. The objectives of this studies are to evaluate the effectiveness of treatment by treating one active station out of all active termite stations (selective baiting) by using chlorfluazuron termite baits. Form the result, a termite colony population can be eliminated in selective termite baiting treatment. Elimination of termite population by selective termite baiting treatment was successful with the aid of termite behavior of trophallaxis which is the sharing of the bait toxicants among the termite nest mates. This sharing of toxicant among the nest mates circulates the active ingredients throughout the colony thus eradicate the colony along the process. Regardless of how many in ground station and above ground stations, baits placement in one out of all active stations was more than enough to kill the colony as all interceptor’s station shares the same tunnelling pathways which lead to the same colony. Chlorfluazuron baits need an average 4-8.6 weeks to eliminate termite infestation at the study sites. Furthermore, this method can cut the cost on total termiticide (bait) used. Thus, time can be save the during the baiting inspections due only single station to be monitored as reduction of termite activities in one station represent the reduction of activity in other stations only if the termite are originated from the same colony.

1. Introduction

Termites are major pests in the well develop area and categorized as social insects [1]. Termites are belonging to Blattodea order and also known as eusocial cockroaches [2]. They serve a vital role in nutrient recycling [3]. Termites also act as beneficial decomposer of organic matters [4]. Termites are regarded as pest when they infest infesting buildings, houses and crops [5]. Some termites species are able to destroy living plants in a short period of time in which, their hard and soothed jaws are capable to chop off wood despite having weak and vulnerable body [6]. They are distributed mostly in tropical and tropical forests having the highest species richness of termites [7]. Genus of Coptotermes distibuted broadly in tropical and subtropical region of the world while Globitermes sulphureus (Haviland) is abundance in Indo-Malayan region [8]. Coptotermes gestroi (Wasmann) and G. sulphureus are among the most common species of termites that can be found in Malaysia [9].
Meanwhile, Coptotermes formosanus (Shiraki) and C. gestroi are the most voracious subterranean termites that can exert a significant economic loss as up to $32 billion in the world [10]. Dusting, soil treatments and baiting have been applied oftenly to eradicate termites [11]. Southeast Asian countries including Malaysia depends heavily on the application of soil insecticides in the urban area [12]. There are two type of soil insecticides; pre-construction and post-construction [13]. Despite the effectiveness of chemical insecticides, they are not environmentally friendly [14]. Baiting is a desired method to control termite populations by manipulating the foraging behaviour and social nature of subterranean termites where food transfer among the termite workers and other nestmates through a process known as trophallaxis which provides a medium for the distribution of slow-acting toxicant throughout the whole termite colonies [15]. In October 2000, pest control operators in Malaysia had started to use hexaflumuron baits to control subterranean termites [13]. According to Su [16], only a few grams of hexaflumuron needed to eliminate a whole colony containing several hundred thousand to millions of termites. In addition, total consumption of one to three baits (<35-105g of bait matrix or <175-525mg of hexaflumuron) was lethal to eliminate colonies of subterranean termites [16]. In comparison to other active ingredient, after 12 week application of chlorfluazuron baits, colony of Coptotermes acinaformis (Frogatt) shows a declination and total colony annihilation was confirmed 5 weeks later by destructive sampling of the mound [17]. The objective of this study are to evaluate the effectiveness of treatment by treating one active station out of all active termite stations (selective baiting) by using chlorfluazuron baits in elimination of subterranean termite populations. Time taken for colony elimination and total baits consumed by the termites to achieved colony elimination were recorded.

2. Materials and methods

2.1 Study site

The research was carried out in Penang and Kedah, Malaysia. Five out of the six sites were from Penang while another one was in Kedah. Table 1 shows all of the locations involved in this experiment. Prior to establishment of colony infestation status, oven-dried wooden stakes were installed surrounding the perimeter of the infested building. All wooden stakes which have been attacked by the termites were replaced with Exterra monitoring stations (Ensystex, Malaysia Sdn. Bhd., Kuala Lumpur) and were labelled as active stations. Before the treatment, all active termite stations were inspected at every two weeks to record the consumption data and ecological data. At the end of the experiment, chlorfluazuron baits were placed in one out of all active termite monitoring station.

| State     | Sites               | Latitude    | Longitude    |
|-----------|---------------------|-------------|--------------|
| Kedah     | Bandar Baharu       | 5º 06’ 26” N | 100º 32’ 30” E |
| Penang    | Cemacs              | 5º 28’ 01” N | 100º 12’ 00” E |
|           | Taman Rupawan       | 5º 30’ 25” N | 100º 26’ 34” E |
|           | SMK Bertam Perdana  | 5º 31’ 50” N | 100º 27’ 59” E |
|           | SMK Tunku Puan Habasah | 5º 25’ 15” N | 100º 18’ 27” E |
|           | SMK Bukit Jambul     | 5º 20’ 54” N | 100º 17’ 27” E |

2.2 Bait stations preparations

There are two types of termite collection devices (station); in-ground stations (IGSs) and above-ground stations (AGSs) that were used to place the baits matrix during the treatment. An IGSs usually is a 1.3 L cylindrical plastic container (Ensystex Malaysia Sdn. Bhd.) with perforated sides and a hole at the bottom to allow termite movements ingress and egress. Termite interceptor wooden piece (Eucalyptus delegatensis) were installed in the six-inner wall of the IGSs will allowed easy termite detection and placement of bait matrix without causing much disturbance to the termite foraging activity in the station. Wooden stakes (6 by 18cm x 1.5cm x 1.5cm) of Araucaria sp were also placed
at the center of the IGSs to make the station more favorable to termite. The IGSs were installed around
the infested building perimeter at intervals of 2m and the number of IGSs installed at each infested
building varied depending on the space availability. Then, the IGSs were covered with soils to avoid
any outside disturbance. Figure 1a shows how the IGSs were setup.

The AGSs are made up of plastic box with perforations on the bottom to allow termite movement
in or out of the AGSs. Inside the AGSs, corrugated cardboard and wooden stake (1 by 9cm x 1.5cm x
1.5cm) were nicely arranged and placed to enhance termite foraging activity. The stations were
installed by using adhesive tape or nails to areas where termite activity was located. The numbers
of AGSs installed at each of the infested buildings varied depending on the number of areas of termite
activity present. The AGSs then covered by black plastic sheets to avoid any outside disturbance.
Figure 1b shows how the AGSs were setup.

2.3 Baits placement
The IGSs/AGSs were inspected at every two weeks intervals. When termite activity had established,
the stations were maintained in order to ensure that termite feeding activity were sustained.
Maintenance were done by replacing wooden stakes (6 by 18cm x 1.5cm x 1.5cm) inside the IGSs and
replacing AGSs; at every two weeks. During the treatment, only one station at each of the sites will be
chosen for bait placement. If the IGS was chosen for bait placement, wooden stakes inside IGSs were
removed and replaced with doughy bait material (Requiem), a texture obtained by mixing the baits
(100g) with 400mL of distilled water (1:4 wt:wt ratio). Similar to IGSs, corrugated cardboard and
wooden stake inside AGSs were removed and filled with the same bait ratio (when AGS was chosen
for bait placement). Inspections were continued at every two weeks. The baits were replenished at
each inspection until termite activity decreased or no termite activity found in the bait stations. The
stations were removed if the bait were still intact and the remaining baits were dried (48 hours, 80ºC)
and weighed to determine total bait consumption. Termite numbers including ratio between soldiers
and workers termite were also recorded to evaluate colony vigor status (Garcia et al., 2007). Table 2
shown total number of active stations were place and eventually baited for every study site.

Table 2. Total number of active stations at the study sites.

| Sites     | Number of active stations | Number of above ground stations (AGS) | Number of in-ground stations (IGS) | Number of stations baited |
|-----------|---------------------------|--------------------------------------|-----------------------------------|--------------------------|
| Bandar    | 4                         | 0                                    | 4                                 | 1                        |
| Baharu    | 4                         | 2                                    | 2                                 | 1                        |
| Taman     | 5                         | 2                                    | 3                                 | 1                        |
| Rupawan   | 5                         | 3                                    | 0                                 | 1                        |
| SMKBP     | 5                         | 4                                    | 1                                 | 1                        |
| SMKBJ     | 6                         | 0                                    | 6                                 | 1                        |

Figure 1. (a) Wooden stakes were placed inside the IGS (b) Corrugated cardboards and wooden stake
nicely arranged inside the AGS
2.4 Data Analysis
A t-test statistical analysis was conducted to evaluate effectiveness of chlorfluazuron baits to eliminate termite colony at each of the study sites. Total number of termites at zero day of the treatment were compared to the total termite number for the subsequent following weeks until the whole colony were eliminated. The percentage of termite number reduction were evaluated.

3. Results and discussion
For Bandar Baharu, Kedah shown that the total termite numbers had statistically significantly lower in number (15.94 ± 30.6) at the end of the treatment compared to before the treatment (62.57 ± 16.48), t (10) = 3.287, p = 0.008. For Taman Rupawan, Bertam, Penang, shown statistically significantly lower in number (7.18 ± 17.58) at the end of the treatment compared to before the treatment (82.35 ± 10.98), t (10) = 8.885, p = 0.000. Meanwhile for Sekolah Menengah Kebangsaan Bertam Perdana, Penang shown that the total termite numbers had statistically significantly lower in number (36.13 ± 29.67) at the end of the treatment compared to before the treatment (86.35 ± 2.84), t (10) = 4.127, p = 0.002. Meanwhile for Sekolah Menengah Kebangsaan Bukit Jambul, Penang shown that the total termite numbers had statistically significantly lower in number (25.57 ± 29.68) at the end of the treatment compared to before the treatment (90.34 ± 2.23), t (10) = 5.332, p = 0.000. For CEMACS, Penang shown that the total termite numbers had statistically significantly lower in number (33.78 ± 34.73) at the end of the treatment compared to before the treatment (88.67 ± 1.71), t (10) = 3.867, p = 0.003. However, for SMK Tunku Puan Habsah, Penang shown that the total termite numbers had statistically significantly lower in number (29.30 ± 36.28) at the end of the treatment compared to before the treatment (90.80 ± 1.49), t (10) = 4.149, p = 0.002. In this study, all termites’ colonies in all six study sites are eliminated by using selective termite baiting treatment. Total baits used in the treatment are less than 300 g to meet termite eradication level. The time taken for the treatment are varies ranging from one month to two months to be able to eliminate all termite colonies (Figure 2 and Table 3).

**Figure 2.** Fluctuation of total termite numbers after the baiting treatment applied. BB=Bandar Baharu; TR=Taman Rupawan; SMKBPM=SMK Bertam Perdana; SMKBJ=SMK Bukit Jambul; CEMACS; SMKTPH=SMK Tunku Puan Habsah.
Table 3. Summary of termite baiting at each of the study sites

| Sites                | Termite Number Before | Termite Number After | Bait consumed (g) | Time taken for colony elimination (weeks) |
|----------------------|-----------------------|----------------------|-------------------|-------------------------------------------|
| Bandar Baharu (BB)   | 62.57±16.48           | 15.94±30.6           | 282.2             | 4                                         |
| Taman Rupawan (TR)   | 82.35±10.98           | 7.18±17.58           | 278.6             | 4                                         |
| SMK Bertam Perdana (SMKBP) | 86.35±2.84       | 36.13±29.67          | 283.7             | 8.6                                       |
| SMK Bukit Jambul (SMKB) | 90.34±2.23          | 25.57±29.68          | 278.4             | 8.6                                       |
| Cemacs               | 88.67±1.71            | 33.78±34.73          | 296.7             | 8.6                                       |
| SMK Tunku Puan Habsah (SMKTPH) | 90.80±1.49         | 29.30±36.28          | 216.4             | 6.3                                       |

Termite populations were successfully eliminated by using alpha-cellulose powder containing chlorfluazuron as the active ingredient, which act as chitin-synthesis inhibitor (CSI). However, there was no fixed time taken needed for termite colony eradication. Bandar Baharu and Taman Rupawan take approximately 4 weeks for colony elimination, while three sites (SMK Bertam Perdana, SMK Bukit Jambul and Cemacs) take approximately 8.6 weeks and SMK Tunku Puan Habsah takes 6.3 weeks to eliminate all termite infestation. As a comparison, according to Peters et al., [18], C. acinaciformis and C. frenchi colonies in Australia were terminated within 16 weeks (112 days), C. curvignathus in Malaysia eliminated within 8 weeks (56 days) and C. vastator in Philippine needed 8 weeks (56 days). In addition, mound-building termite, C. acinaciformis takes 16 weeks to cause colony elimination [18]. The differences in time taken needed for colony elimination varies depends on many factors. According to Lee et al., [19] and Sajap et al., [20] suggests that the differences in effectiveness of these baits depends on how certain termite species response towards the baits and Coptotermes spp have a higher feeding rate under the Malaysia tropical conditions. In addition, tropical termite species tend to have a smaller population sizes and smaller foraging territories when compared to the temperate species [21]. Other factors to consider in difference time taken needed for colony elimination is that the baits are toxicant-targeted species. Coptotermes and Schedorhinotermes are the most vulnerable species towards the current baits [22]. In Malaysia, a colony of Coptotermes requires a minimum of a month for suppression of the colony while 6 months for Schedorhinotermes species [22]. In comparison with our results, termite colony baited in single active termite station in Bandar Baharu and Taman Rupawan were eliminated in the first month while the other sites took approximately 6.3-8.6 weeks for total termite elimination. Higher termite genera; Macrotermes, Globitermes, and Microtermes are not so effective against the baits [22]. Chlorfluazuron is specifically effective in colonies extinction of Coptotermes spp while Macrotermes gilvus, Odontotermes formosanus and Globitermes sulphureus consume more baits for a much longer time but eventually, were eliminated [18].

There are many advantages in choosing baiting treatment over liquid termiticides: 1) Only small amount of active ingredients (AI) used in single treatment; 2) Baits are placed inside the stations thus saved from any disturbances; 3) AI does not infiltrate into water or soil; 4) Baits have no odor; 5) no drills needed; 6) no chemicals residue after the treatment; 7) in all cases, termite colonies were eliminated and, there were also disadvantages that need to understand before opting for baiting treatment: 1) longer time taken needed to take effect; 2) successful treatment only when termite found
and eat the baits; 3) there is no residue left at the end of the treatment to protect the buildings; 4) cost more than liquid termiticides [23]. Baiting treatment are expensive due to installation fee, cost of the baits and monitoring stations, a routine service from pest management professional (PMP) to inspect termite activity during and after the baiting [23].

In this study, selected baited termite station will save the time for PMP as they only need to bait only one station out of all active termite station. Reducing number of treated stations will reduce the costs as fewer baits were used thus more economical to clients. In other words, this approach might be much better than conventional methods which PMP will treated all active termite station while in this approach, only selected termite station will be treated thus ensuring conservation in terms of time of inspection and cost of laborers. Both methods can eliminate the termite colonies within the same period of time.

As a conclusion, a termite colony population can be eliminated in selective termite baiting treatment. Elimination of termite population by selective termite baiting treatment was successful with the aid of termite behaviour of trophallaxis which is the sharing of the toxicants among the termite nest mates. This sharing of toxicant among the nest mates circulates the active ingredients throughout the colony thus eradicate the colony along the process. Therefore, regardless of how many in ground station and above ground stations, baits placement in one out of all active stations was more than enough to kill the colony as all interceptor’s station shares the same tunnelling pathways which lead to the same colony. Chlorfluazuron baits need an average 4-8.6 weeks to eliminate termite infestation at the study sites. Thus, selective baiting treatment are proven method to control termite problems and environmentally friendly which lead to sustainable green pest management.

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