Control of Dry-Wood Termite Infestation by Bait System

Yuliati Indrayani

Abstract

Chemical treatments with a liquid formulation have been widely used to prevent the infestation of dry-wood termites in buildings. However, such chemical treatments are problematic due to health and the environmental considerations. Therefore, it is important to develop remedial treatments that do not pose environmental hazards. This study was conducted to develop a control strategy for dry-wood termite infestation using a bait system.

Two types of experiments were designed to evaluate the performance of a bait system intended to control dry-wood termite. A gel formulation with an active ingredient (2.15% hydramethylnon) and food attractants was used for the testing (Types I and II). In the first type of experiment, Type I, the effectiveness of the bait in a small wood block specimen was evaluated. Feeding arena lumber with artificial galleries was prepared for the Type II experiment so that the response of the insects to the gel could be observed. In general, the average percentage termites that died after being exposed to the gel formulation in all two types of experiment was more than 65%, and in the gel control the average percentage of live termites was more than 75% in Type I, and more than 95% in Type II. These results suggest that the gel bait system used in this study has the potential to eliminate dry-wood termite. Further investigation will be indispensable to increase the reliability of the bait system as a control strategy for dry-wood termites.

Key words: control strategy, bait system, dry-wood termite.

Introduction

Dry-wood termites establish their colonies in non-decayed wood that contains little moisture and, unlike subterranean termites, they never need contact with the ground. The first evidence of dry-wood termite infestations is usually piles of fecal pellets below “kickout” holes in the infested wood. Infestation by dry-wood termites is difficult to detect, because the termites usually left a thin layer under the surface of the wood attacked.

Chemical treatments with a liquid formulation have been widely used to prevent the infestation of dry-wood termites in buildings. However, such chemical treatments are problematic due to health and the environmental considerations. Therefore, it is important to develop remedial treatments that do not pose environmental hazards. Whole-structure treatments such as heat treatments, and local remedial treatments such as microwaves, electrocution, screen, caulk, and paint have been developed as dry-wood termite control measures that use fewer or no chemicals (Lewis and Harverty 1996; Su and Scheffrahn 2000).

In recent years, the introduction of bait systems that use fewer chemicals to the methods of subterranean termite control may help us to develop new strategies for eliminating colonies of dry-wood termites (Su *et al*. 1982; Su and Scheffrahn 1993; Su 1994; Su *et al*. 1995; Su and Scheffrahn 1996; Su *et al*. 1997; Tsunoda *et al*. 1997; Su *et al*. 1998).This study was conducted to develop a control strategy for dry-wood termite infestation using a bait system.

Materials and Methods

Termites

As test organisms, pseudergates of *Incisitermes minor* were collected from infested timbers in Yokohama City, Kanagawa Prefecture, Japan. The termites were then extracted from the timbers and kept in plastic containers with lids containing small wood blocks of Douglas fir (*Pseudotsuga menzietti* Franco) as both a food source and harborage. The containers with the termites were kept in a termite culturing room of the Research Institute for Sustainable Humanosphere (RISH), Kyoto University, at 28±2°C, >85% RH, in the dark for at least one week before testing to ensure that only healthy termites would be used in the experiment.

Sample Preparation

Two types of experiments were carried out in the current investigation. In the first type, known as Type I, six of air-dried sapwood specimens of spruce (*Picea abies* Karst.), measuring 30 (R) x 30 (T) x 50 mm (L), were used. In our previous wood feeding preference study, spruce sapwood was the most preferred species among the ten wood species investigated (Indrayani *et al*. 2006). A hole, measuring 50 mm in depth and 10 mm in diameter, was drilled in the center of a specimen to accommodate the termites. Another hole, measuring 40 mm in depth and 10 mm in diameter, was also drilled in the center of the other specimen. These six specimens were glued together, and a hole, measuring 15 mm in depth and 10 mm in diameter, was then drilled in the center of the top surface of the combined specimen for the termites to be placed inside (Figure 1).

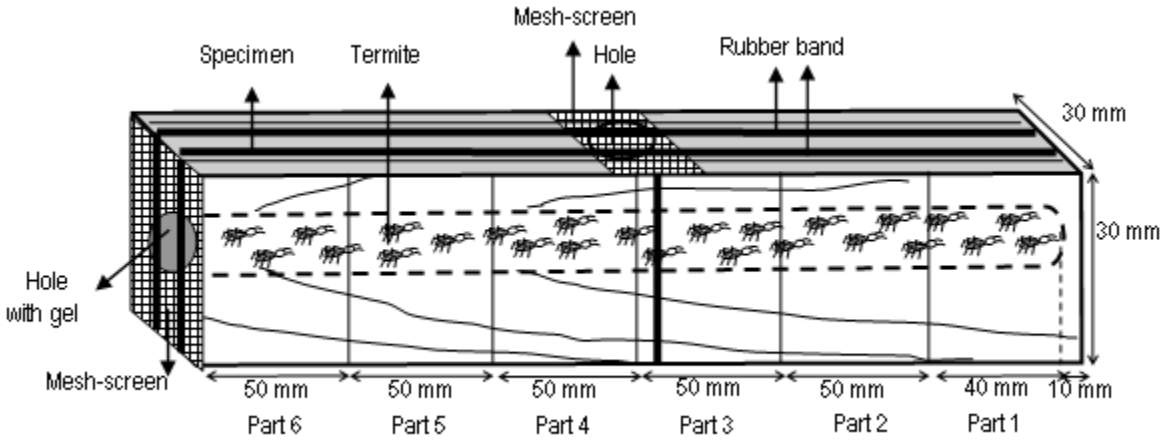

Figure 1. Test apparatus for the testing of a bait system against *I. minor* (Type I).

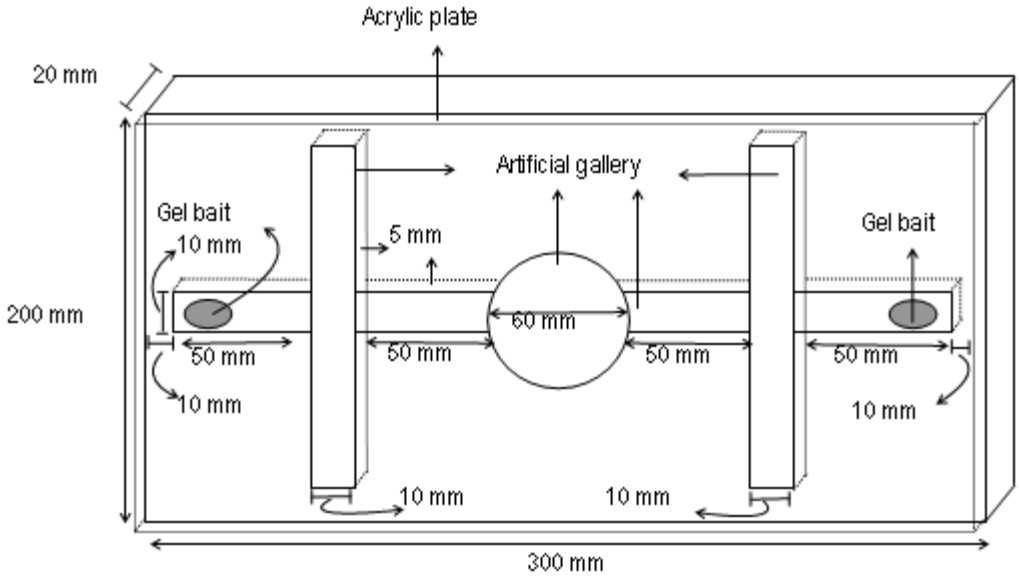

Figure 2. Test apparatus for the testing of a bait system against *I. minor* (Type II).

In the second type of experiment, known as Type II, a feeding arena was prepared by a spruce sapwood lumber (200 (R) x 20 (T) x 300 mm (L)). Artificial galleries were then drilled as shown in Figure 2. The width and depth of the galleries were 10 mm and 5 mm, respectively.

Gel Formulation

A gel formulation with an active ingredient (2.15% hydramethylnon) and food attractants was used for the testing. Gels without an active ingredient were employed as the controls. Hydramethylnon is powerful delayed-action makes it an ideal active ingredient for bait product. A slow-acting poison is desirable for controlling social insects such as termites, because they live long enough to return to the colony with the bait before they are killed. Hydramethylnon causes death by inhibiting the formation of ATP (Adenosine Triphosphate). ATP provides the energy necessary for completing most biological processes, without the formation of ATP, insects simply run out of gas.

Bioassays

A 0.4 g gel formulation was put into the hole drilled in the side of the specimen for the Type I experiments. The hole was covered with a fine mesh screen that was tightly attached using two rubber bands to prevent the termites from coming out of the hole. For the Type I experiments, ten and thirty pseudergates, respectively, of *I. minor* without external evidence of wing buds or eyes were put into the center holes of the top surfaces of the wood specimens and the holes were then covered with a fine mesh screen that was attached tightly with a rubber band (Figure 1). A similar control experimental set up was employed, except that a much greater amount of gel (two gs) was used in the Type I control.

On the other hand, 1 g of the gel formulation was placed at the center of one of the 300 mm sides of the specimen for the Type II experiment (Figure 2). For the control in Type II, the same experimental procedure as that described above was used. Forty pseudergates of *I. minor* for Type II were put in the center of the artificial gallery. The assembled arena was then covered with an acrylic plate (2 mm in thickness), which was fastened by four paperclips.

All the experiment units (Types I, and II) were kept in a termite culturing room of the Research Institute for Sustainable Humanosphere (RISH), Kyoto University, for two weeks. Three replicates were served for each type. The mortalities of the termites were evaluated for all types after two weeks. For Type I, the test set-up was disassembled and the location of the test insects was observed at the end of the experiment. On the other hand, for Type II, the location of the termites inside the test arena was observed daily.

Results and Discussion

Mortality of Termites

The percentages of live, moribund, and dead pseudergates of *I. minor* after being exposed to the gel formulation in Types I, and II for two weeks are shown in Tables 1 and 2, respectively.

As shown in Table 1, the average percentages of live, moribund and dead termites after two weeks of exposure to the gel formulation were 11.1%, 2.2%, and 86.7%, respectively, with a high variation in replicates being 0.0%, 0.0%, and 33.3% for live termites, and 100.0%, 100.0%, and 60.0% for dead termites (Table 1). The percentages of live, moribund and dead termites in the gel control of Type I were 76.7%, 0.0%, and 23.3% on average, respectively, with the variation in replicates being 73.3%, 96.7%, and 60.0% for live termites and 26.7%, 3.3%, and 40.0% for dead termites (Table 1).

For the Type II experiment, the average percentages of live, moribund and dead termites after two weeks of exposure to the gel formulation were 32.5%, 0.8%, and 66.7%, with the high variation in replicates being 0.0%. 97.5%, and 0.0% for live termites and 97.5%, 2.5%, and 100% for dead termites (Table 2). The average percentages of live, moribund and dead termites were 97.5%, 0.0%, and 2.5%, respectively, in the Type II control (Table 2).

Location of Termites

The location of the termites in the Type I and II tests are shown in Table 3 and in Figures 3 and 4, respectively.

As shown in Table 3, the termites were spread evenly in all parts of the sample when exposed to the gel formulation in all replications after two weeks. A similar result was observed in the gel control, except for the fifth and the sixth parts of the samples for replications one and two, respectively.

The termites exposed to the gel formulation were spread evenly in almost all of the galleries of the test arena in Replications 1 and 3 after one, seven, and fourteen days, while in Replication 2 the total spread of the termites in all of the galleries of the test arena was observed only after one day (Figure 3). In contrast, after seven and fourteen days, the majority of termites in Replication 2 were present on the opposite side of the gel (Figure. 3). Interestingly, the termites built a barrier using their fecal pellets and wet feces near the gel formulation in Replication 2 after seven days (Figures 3 and 5). In addition, five perforations appeared in the test arena in Replication 2 after seven and fourteen days (Figure 3), and at the end of the experiment, only nineteen termites in the test arena were observed (Figure 3).

Table 1. The response of *I. minor* pseudergates exposed to the gel formulation after two weeks (Type I).

Treatment	Replication	Condition of termites		
		Live (%)	Moribund (%)	Dead (%)
Gel formulation	1	0.0	0.0	100.0
	2	0.0	0.0	100.0
	3	33.3	6.7	60.0
	Average	11.1	2.2	86.7
Gel control	1	73.3	0.0	26.7
	2	96.7	0.0	3.3
	3	60.0	0.0	40.0
	Average	76.7	0.0	23.3

Table 2. The response of pseudergates of *I. minor* exposed to the gel formulation after two weeks (Type II).

Treatment	Replication	Condition of termites		
		Live (%)	Moribund (%)	Dead (%)
Gel formulation	1	0.0	2.5	97.5
	2	97.5	0.0	2.5
	3	0.0	0.0	100.0
	Average	32.5	0.8	66.7
Gel control	1	100.0	0.0	0.0
	2	92.5	0.0	7.5
	3	100.0	0.0	0.0
	Average	97.5	0.0	2.5

Table 3. Location of termites after two weeks in test apparatus in Type II.

Replication	Location of termites					
	Part of sample					
	1	2	3	4	5	6[1]
Gel formulation						
1	3 D	5 D	7 D	11 D	1 D	3 D
2	7 D	2 D	6 D	2 D	5 D	8 D
3	2 L, 2 M, 2 D	6 L, 1 D	2 D	6 D	2 L, 5 D	2 D
Gel control						
1	21 L, 3 D	2 D	1 L, 1 D	1 D	-	1 D
2	4 L	2 L	11 L	7 L, 1 D	5 L	-
3	2 D	4 D	2 D	6 L	2 L, 3 D	10 L, 1 D

D: dead termite; L: live termite; M: moribund termite; [1] Part in which the gel was applied.

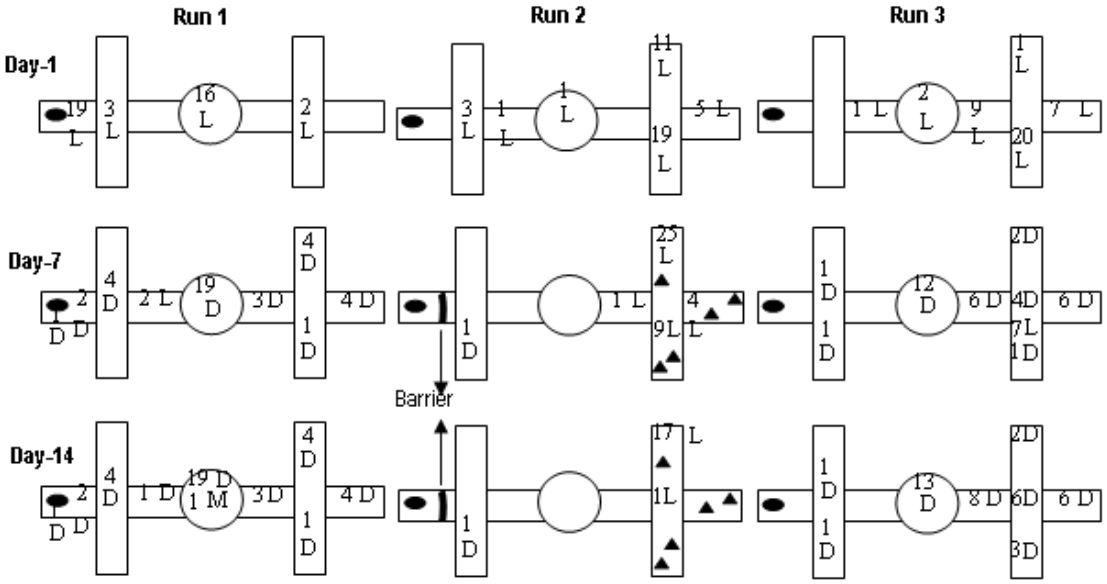

Figure 3. Locations of termites in the test arena exposed to the gel formulation in Type II after 1, 7, and 14 days. Numbers in the galleries represent numbers of termites. ⬭: gel; ▲ : perforation by termite; D: dead; L: live; M: moribund. The other live termites in run 2 after 14 days were present inside the perforations.

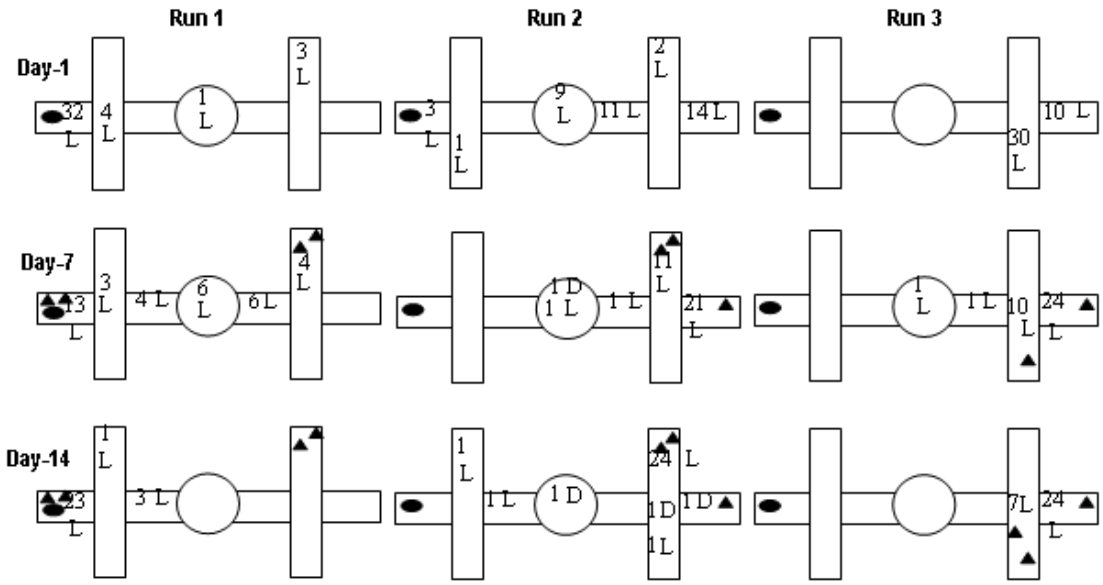

Figure 4. Locations of termites in the test arena exposed to the gel control in Type III after 1, 7, and 14 days. Numbers in the galleries represent numbers of termites. ⬭: gel; ▲: perforation by termite; D: dead; L: live. The other live termites in run 1, 2, and 3 after 7 and 14 days were present inside the perforation.

Figure 5. Termites built a barrier using their fecal pellets and wet feces.

Most termites were located near the gel control in Replication 1 throughout the experiment (Figure 4). For both Replications 2 and 3, the majority of termites were seen on the opposite side of the gel control (Figure 4). The number of termites observed was less than 40 individuals (the initial number) after seven and fourteen days in all replications in which many perforations appeared (Figure 4).

The average percentages of dead termites after two weeks of exposure to the gel formulation were more than 65% for Types II, and more than 85% for Type I. On the other hand, the average percentages of dead termites in the gel control were less than 4% for Types II, and less than 25% for Type I in the same period. These results suggest that the present test methods are suitable for evaluating the performance of the bait system against *I. minor*, and that the gel formulation used in this study has considerable potential as a control strategy for dry-wood termites.

In Type II the percentage of live termites in Replication 2 was 97.5% at the end of the experiment (Table 2), while the rest of the replications (Replications 1 and 3) did not show any sound termites after two weeks (Table 2). The fact that the termites in Replication 2 of the Type II experiment built a barrier using their fecal pellets and wet feces (Figure 5) near the gel might explain this phenomenon. The insects could not come into contact with the gel through the barrier.

Concerning the location of the termites, when exposed to the gel formulation, the insects were spread evenly in all parts of the sample at the end of the experiment in Type I (Table 1). Although the termites were not accumulated in the bait, the mortality of these test insects was 86.7% on average (Table 1). This clearly indicates that the gel formulation does not have any special attraction or repellent effect on *I. minor*, and that trophallaxis activity, one of the characteristic behaviors of termites and other social insects,

may contribute to the higher mortality (Cabrera and Rust 1999; McMahan 1969).

In the test arena, Type II, in Replication 2, the gel formulation resulted in a very low mortality among the termites (2.5%) after two weeks (Table 2). The termites avoided the bait and built a barrier using their fecal pellets and wet feces in this case (Figure 5). But in other cases, Replications 1 and 3, in which the mortalities were 97.5% and 100%, respectively (Table 2), the termites were spread evenly in all parts of the test arena (Figure 4). They were also spread evenly in the Type I experiment (Table 3). These varied results support the above-mentioned assumption well.

From the present investigation, it can be concluded that the gel bait has the potential to be used as a remedial control strategy against *I. minor*, and that consideration of its varied performance will be a key factor in constructing a reliable bait system. The search for special attractants such as trail-following substances that are spread into the entire attacked area should be the next step in this research. In Type II, some replications showed numbers of test insects that were smaller than the initial numbers (40 individuals) with many perforations. This behavior also indicates the need for attractants.

Recently, the development of control treatments for termites that use fewer chemicals than in the past or no chemicals at all has been a subject of attention. The application of the gel formulation will be one of the alternative strategies for controlling dry-wood termite infestations with fewer chemicals.

References

Cabrera, B.J.; M.K. Rust. 1999. Caste Differences in Feeding and Trophallaxis in the Western Drywood Termite, *Incisitermes minor* (Hagen) (Isoptera, Kalotermitidae). Insectes Soc 46: 244-249.

Cabrera, B.J.; M.K. Rust. 2000. Behavioral Responses to Heat in Artificial Galleries by the Western Drywood Termite (Isoptera: Kalotermitidae). J. Agric and Urban Entomol. 17: 157-171.

Indrayani, Y.; T. Yoshimura; Y. Yanase; Y. Imamura. 2006. Feeding Responses of the Western Drywood Termite *Incisitermes minor* (Hagen) (Isoptera: Kalotermitidae) Against Ten Commercial Timbers. J. Wood Science 53: 239-248.

Lewis, V.R.; M.I. Harverty. 1996. Evaluation of Six Techniques for Control of the Western Drywood Termite (Isoptera: Kalotermitidae) in Structures. J. Econ Entomol 89: 922-934.

Mc. Mahan, E.A. 1969. Feeding Relationship and Radioactive Techniques. In: Biology of Termites, ed. by Krishna, K.; Weesner, F.M., Academic Press, New York. 1: 387-406.

Su, N.Y.; M. Tamashiro; J.R. Yates. 1982. Trials on the Field Control of the Formosan Subterranean Termite with Amdro Bait. The International Research Group on Wood Preservation (IRG), IRG/WP/1163.

Su, N.Y.; R.H. Scheffrahn. 1990. Economically Important Termites in the United States and Their Control. Sociobiology 17: 77-94.

Su, N.Y.; R. H. Scheffrahn. 1993. Laboratory Evaluation of Two Chitin Synthesis Inhibitors, Hexaflumuron and Diflubenzuron, as Bait Toxicants Against the Formosan subterranean Termite and Eastern Subterranean Termite (Isoptera: Rhinotermitidae). J. Econ Entomol 86: 1453-1457.

Su, N.Y. 1994. Field Evaluation of Hexaflumuron Bait for Population Suppression of Subterranean Termites (Isoptera: Rhinotermitidae). J. Econ. Entomol. 87: 389-397.

Su, N,Y.; R.H. Scheffrahn; P.M. Ban. 1995. Effects of Sulfluramid-treated Bait Blocks on Field Colonies of the Formosan Subterranean Termite (Isoptera: Rhinotermitidae). J. Econ. Entomol. 88: 1343-1348.

Su, N.Y.; R. H. Scheffrahn. 1996. Comparative Effects of Two Chitin Synthesis Inhibitors, Hexaflumuron and Lufenuron, in a Bait Matrix Against Subterranean Termites (Isoptera: Rhinotermitidae). J. Econ. Entomol. 89: 1156-1160.

Su, N.Y.; P.M. Ban; R.H. Scheffrahn.1997. Remedial Baiting with Hexaflumuron in Above-Ground Stations to Control Structure-Infesting Populations of the Formosan Subterranean Termite (Isoptera: Rhinotermitidae). J. Econ. Entomol. 90: 809-817.

Su,N.Y.;Thomas,J.D.;R.H. Scheffrahn.1998. Elimination of Subterranean Termite Populations from the Statue of Liberty National Monument Using a Bait Matrix Containing an Insect Growth Regukator, Hexaflumuron. J. American Institute of Conservation 37: 282-292.

Su, N.Y.; R. H. Scheffrahn. 2000. Termites as Pests of Buildings. In: Termites: Evolution, Sociality, Symbioses, Ecology, ed. by Abe, T.; D.E. Bignell; M. Higash. Kluwer Academic Publishers, London. 437-453

Tsunoda, K.; H. Matsuoka; T. Yoshimura.1997. Colony Elimination of *Reticulitermes speratus* by Bait Application and the Effect on Foraging Territory. J. Econ. Entomol. 91: 1383-1386.

Yuliati Indrayani
Faculty of Forestry, Tanjungpura University
Jl. Imam Bonjol, Pontianak 78124, Indonesia
Tel./ Fax. : 0561-767673
E-mail : mandaupermai@yahoo.com