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Background and Purpose of the Pacific Rim Termite Research Group

Several institutions in the Pacific Rim region have been conducting some international collaborative projects on termites and their management. Examples of such successful collaboration are the CSIRO Termite Group (Forestry & Forest Products and Entomology) and Wood Research Institute of Kyoto University with scientific institutions in Thailand, Indonesia, Malaysia and China.

It now appears timely to create a forum that would allow for wider collaboration through linking all relevant universities and institutions to accelerate the pace of mutual basic and applied research.

Termites are serious pests in the Pacific Rim region. Furthermore, many countries within the region have high market potential for termite management technology. Therefore, it is essential that we gain a far better and more detailed understanding of the diversity of termite related problems within the region. We propose that one way forward is to organize a Pacific Rim Termite Research Group to initiate purposeful collaborative research projects among scientists of neighboring countries.
Issues of termite management should be first on the agenda for collaboration. Concurrently, areas of fundamental research can be identified, and taken up at a later stage provided funding is available.

Current Termite Management in Japan

by

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Abstract

Of 21 termite species recorded in Japan, two subterranean termites, *Reticulitermes speratus* (Kolbe) and *Coptotermes formosanus* Shiraki are major pests to wood houses and other structures, accounting for >99% annual economic loss (0.8-1.0 billion US dollars) in Japan. Chemical treatment is widely applied to prevent and control termite infestations using imidacloprid, befenthrin, permethrin, fenobucarb, chlorfenapyr and others. According to building code and homebuilder's specifications, pressure-treated wood sills and superficially treated framing timbers have been increasingly used these years. In addition, on-ground concrete slab and damp-proofing plastic sheet with or without termiticides in it have been common to Japanese houses to reduce the potential of termite invasion into Japanese houses. Baiting program was already accepted to control *C. formosanus* infestations in southern parts of Japan. Physical barrier such as stainless steel mesh was introduced and partly commercialized as well. Improvements of crawlspace environments have been common to newly built houses. These recent developments should be highly appreciated to establish environmentally sound termite management in the near future.

Key words: *Reticulitermes speratus*, *Coptotermes formosanus*, chemical soil and wood treatment, baiting program, physical barrier, construction design

1 Introduction

Termites are serious pests to wooden houses and other structures in urban environment in Japan. Japanese houses are characterized by a crawlspace that has been considered to provide subterranean termites with an access to cellulosic building materials, although the recent constructional development somewhat improved the crawl space environment to prevent an invasion of termites into houses (IBEC* 1998, 1999a, 1999b).

Soil and wood treatment with chemicals has been conventionally applied to protect Japanese houses. Since chlorinated hydrocarbons such as γ-BHC, DDT, aldrin, dieldrin and chlordane were introduced into Japanese market in the late 1940's, these had been widely used until the use of chlordane was finally banned in 1986 because of their high persistence in the environment and toxicity to living things including human beings. Organophosphates primarily took over their market place after the late 1980'. However, they have disappeared from the market since they were thought to be toxic volatile compounds. Other chemical replacements have become available in turn

* Institute for Building Environment and Energy Conservation

and chemical treatment is still a major termite management measure in Japan.

The concept of integrated termite management (ITM) has been considered over the last two decades to develop environmentally sound strategy for termite management by scientists and termite management experts. Unfortunately, the concept is not yet commercially accepted in Japan.

2 Termite species recorded and their distribution

As already reviewed elsewhere (Takematsu 2001, Tsunoda 2003), 21 species of termites are recognized in Japan. Among the Japanese termites, both *Reticulitermes speratus* (Kolbe) and *Coptotermes formosanus* Shiraki are considered to cause damage to wooden construction. The former species is distributed nationwide and the latter is limited in warmer southern parts (Fig. 1).

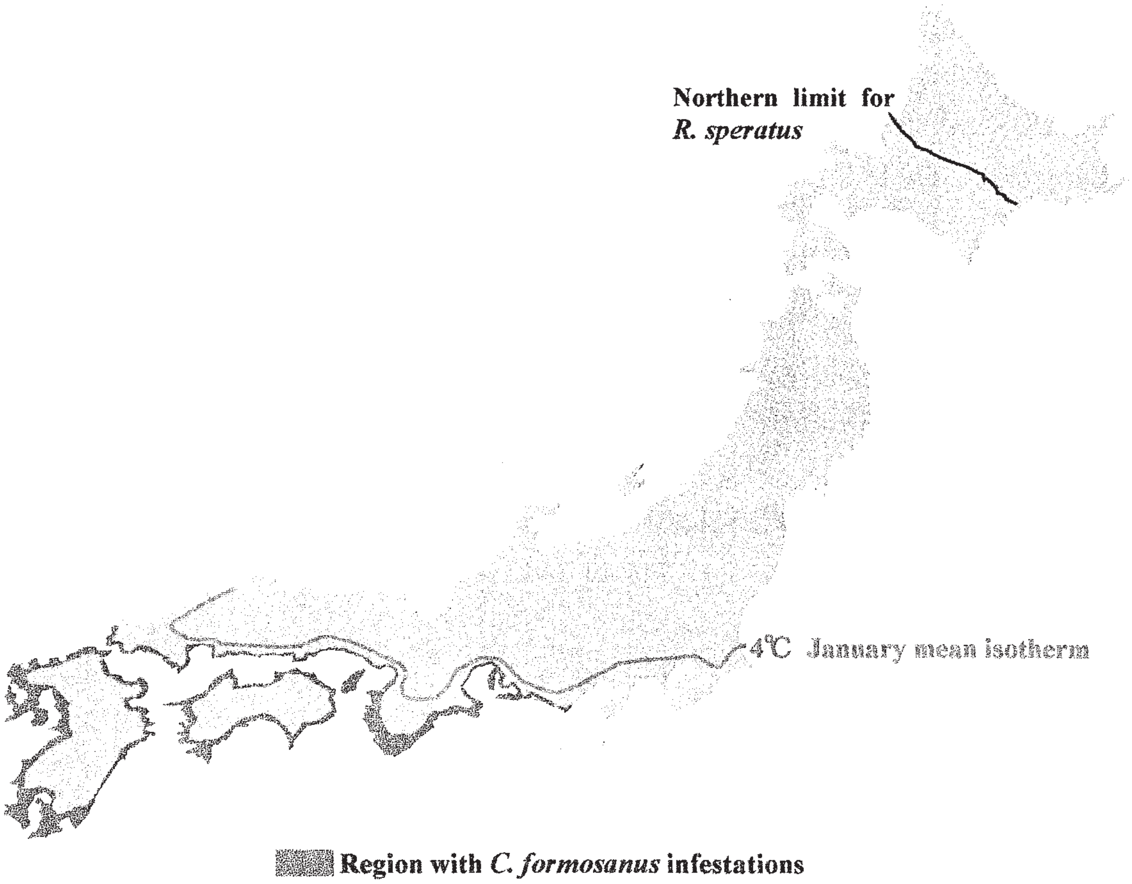

Fig. 1 Current distribution of two major termite species in Japan.

The two species used to be distributed only in narrow coastal bands with high populations, and started spreading northerly and further from the coast as evidenced by previous investigations (e.g.

3 Economic importance of termites

3.1 Economically important termite species

Termites are serious urban pests to wooden homes and constructions in Japan, whereas they are not causing any conspicuous damage to forests and agro-crops. *R. speratus* is economically the most important because of its wide distribution and followed by *C. formosanus*. Others are not economically important in the urban area.

3.2 Estimate of economic loss

Although there is no reliable data available to estimate the annual costs of preventing and controlling termite infestations and of repairing the resulting damage, the costs roughly amount up to one US billion dollars per year based on sales figures for termiticidal formulations in 1996 (Fushiki 1998). It is estimated that R. speratus accounts for 70% of the total cost and C. formosanus is related to the remaining 30%.

4 Currently used chemicals for termite management

4.1 Soil treatment chemicals

Since organophosphates are not widely used any more, neonecotinoid compound (*e.g.* imidacloprid), synthetic-pyrethroid compound (*e.g.* bifenthrin and permethrin) carbamate compound (*e.g.* fenobucarb) are currently used as replacements. Non-repellent termiticides such as chlorfenapyr (pyrrol compound) and fipronil (phenyl pyrazole compound) were recently introduced into Japan for commercialization.

4.2 Wood treatment chemicals

The same chemicals used for soil treatment are applied superficially (brushing, spraying and momentary dipping) to wood treatment. In addition, some structural timber components of houses are pressure treated mainly with ACQ (ammonial copper quat), and copper azole.

5 Termite management measures other than the use of chemicals

5.1 Baiting program

Baiting system was introduced approximately 10 years ago, and has been discussed its feasibility for Japanese termites (Tsunoda *et al.* 1998, 2000). The system definitely contributes to the reduction of chemical use, and is proved to be high effective to the control of *C. formosanus* infestations. (Yamauchi *et al.* 1997; Tsunoda *et al.* 2000).

5.2 Physical barrier

Barrier system using stainless steel mesh was introduced From Japan a few years ago, although some modifications are needed for Japanese houses. Metal collar for floor post and metal floor post are also commercialized.

5.3 Biological control

Biological control measure using entomogenous fungi has been introduced. Since some fungal species perform well in the laboratory, the measure has potential for wide commercialization.

However, reliability of efficacy and persistence in the filed still remains questionable. That is why biological control is not accepted for ITM in Japan.

5.4 Constructional design

On-ground 15 cm thick concrete slab has been common to Japanese houses supplied by big homebuilders. A damp-proofing plastic with or without termiticide in it is also applied underneath the concrete slab to control relative humidity inside the crawlspace. Heat insulation materials are often used inside the wall, under the floor, and inside and/or outside concrete foundation for energy conservation, which results in the reduction of carbon dioxide emission. Unfortunately, these heat insulation materials sometimes lead termites into houses because the materials are not resistant to termites.

6 Specifications for termite management

Treatments are conducted according to JTCA (Japan Termite Control Association) specifications.

6.1 Soil treatment

Soil treatment is generally done by the application of liquid termiticidal formulations at a rate of 3 l/m^2. The rate of 1 l/m, 20 cm wide along the interior perimeter of concrete foundation and 20 cm deep is applied. This rate should be applied to the soil around floor post bases and service pipes, because these parts are thought to be most critical for termites to gain access to timber components of houses.

6.2 Wood treatment

Liquid termiticidal formulations are applied to the wood surface by spraying or brushing at a rate of 300 ml/m^2. Requirements for penetration and retention are varied with chemicals and use conditions, when pressure treatment is applied.

Conclusion

With an increased public concern about environment soundness and safety, POP's (persistent organic pesticides) were practically banned in 1986, and termiticides shifted to rather biodegradable compounds since then. New termite management technologies, that use less amount of chemicals or no chemicals have been commercialized partly in Japan. However, the predominant termite management is still heavily dependent on chemical use.

There are two options for the future generations. One is total protection system to protect houses from termite attack and decay by treating all timber components with inorganic preservatives for ceasing from treating soil with termiticides. Because inorganic compounds would not change chemically and would not emit any volatile substance, either and this property serves for a longer service life of houses. The other is to replace all timber materials with substances such as metals, plastics and minerals immune to biological attacks.

References

Fushiki, S. 1998 Report of the inquiry on termite prevention and control. *Shiroari* (Termite) **112**, 32-38. (in Japanese).

IBEC 1998 Report on the project to spread foundation insulation method in the fiscal year 1997. 128 pp. IBEC (Tokyo) (in Japanese).

IBEC 1999a Standards and guidance of energy conservation of the houses for the next generation. 340 pp. IBEC (Tokyo) (in Japanese).

IBEC 1999b Report on the project to spread foundation insulation method in the fiscal year 1999. 187 pp. IBEC (Tokyo) (in Japanese).

Takematsu, Y. 2000 Termites in the world and Japan. [In] Housing and termites. (Y. Imamura et al. eds.). 57-66, Kaiseisha (Ohtsu, Shiga, Japan) (in Japanese).

Tsunoda, K. 2003 Economic importance of Formosan termite and control practices in Japan. *Sociobiology* **41**(1), 27-36.

Tsunoda, K., H. Matsuoka and T. Yoshimura 1998 Colony elimination of *Reticulitermes speratus* (Isoptera: Rhinotermitidae) by bait application and the effect on foraging activity. *J. Econ. Entomol.* **91**, 1383-1386.

Tsunoda, K., Y. Hikawa and T. Yoshimura 2000 Efficacy of hexaflumuron as a bait-toxicant in the field using a transferred nest of *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae). *The Int. Res. Group on Wood Preserv. Doc.* No. IRG/WP 00-10379.

Yamauchi, K., H. Ishikura, J. Otake, I. Maeda, A. Kashihara and K. Uechi 1997 Field evaluation of the Sentricon system – confirmation of colony elimination. *Shiroari* (Termite) **112**, 11-15. (in Japanese).

Current Termite Management in Korea

by

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1. History of termite damage

1.1. Termite damage in Korea

The termite damage became an economical problem in Korea since 1990's even though termites had been present before then. According to a book called "Forest Economics(林園經濟誌)" published in 1834, the use of potassium alum, charcoal and salt recommended to build cornerstone of wooden construction for the prevention of termite attack. This clearly supported that the termite attack occurred that time. A survey of termite distribution and railway maintenance was conducted in 1920's according to the construction record of the railroad from Pusan to Seoul. The limited survey just around the railroad construction claimed that termites were spread via crossties imported from Japan for the railroad construction. However, the crossties were not imported from Japan, but supplied by domestic manufacturers.

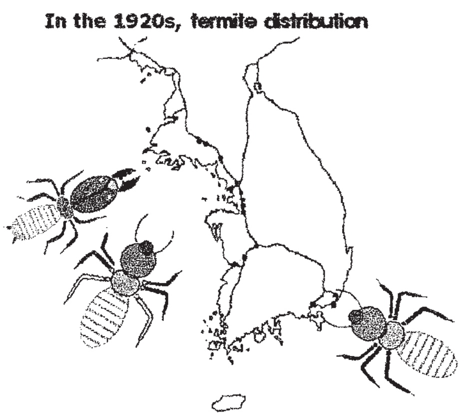

Fig 1. Termite distribution in the 1920's. (Shin, D.S *et al.* 1996).

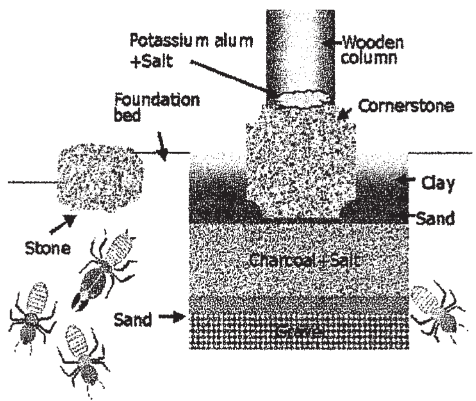

Fig 2. An example of traditional termite prevention measures.

In recent years, the survey of termite conducted by the Korea Forest Research Institute (KFRI) showed that *Reticulitermes* spp. are distribute all over the country, and they cause damage to houses and other wooden constructions. Particularly, termite damage is naturally severe in southern areas around Pusan than in other areas.

1.2. Traditional termite prevention measures

Wood, clay, and stone have been traditionally used as building materials. Wood is also used for the construction of palaces, temples, government buildings, and high-class houses, while houses for ordinary people are built with clay and some wood used as rafters. In constructing a house, the foundation is mounted above the ground to allow air to pass through and to regulate air humidity in the space between floor and ground. And charcoal is also mixed with soil, and charcoal and salt are placed underneath the foundation stones. In addition, potassium alum is used between studs and foundation stones in the case of temples.

Ondol, a traditional heating system has been widely used in ordinary houses, and closely related to the life style of Korean people. This system uses fire to heat stones placed underneath the floor, which can warm up the air over the floor via radiation and conventional heating. This traditional heating system plays a great role to prevent the access of termite to the house. Since the *Ondol* system uses woods as fuel, wood tar emitted from wood is thought to block termite access due to fumigant effect while combustion of wood. However, the increased use of petrochemical fuels resulted in the decrease in number of the *Ondol* systems, and most of heating systems employ boilers, which use warm water to heat the floor. This system causes lots of water condensation without the occurrence of smoke, which allow termites to cause damage to buildings.

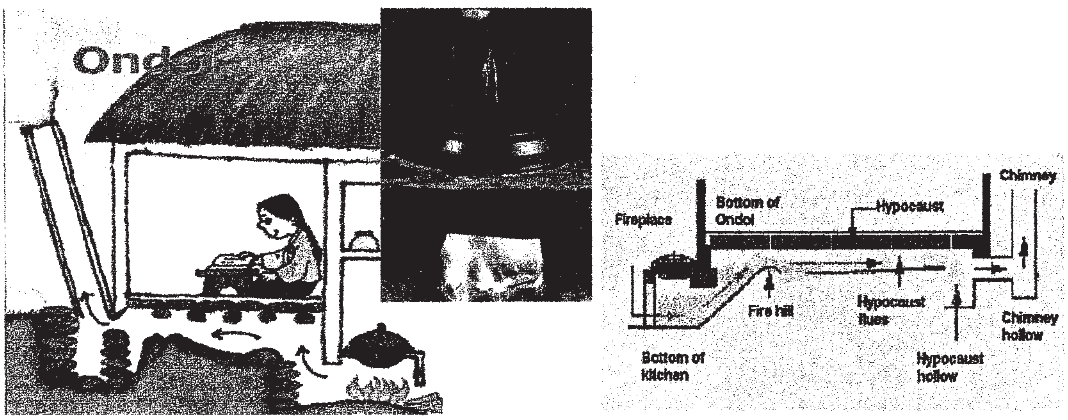

Fig 3. A schematic diagram of the *Ondol* structure of the Korean floor heating system

1.3. Distribution of termites

A termite of genus *Reticulitermes* is distribute all over the Korean peninsula, but its specific name was not identified yet. Termites present in southern parts build wide galleries and have bigger bodies than those in the central area. These termites hive off in a big aggregate from early May to June. In southern area, particularly in Pusan, termite attacks inside the wall, which is in a very dry state and causes a serious economic damage. Average temperature of January in Pusan rose up to 4°C six times for the last forty years. Since its frequency is increasing in recent years, the temperature is approaching to the limit temperature of north region of genus *Coptotermes*.

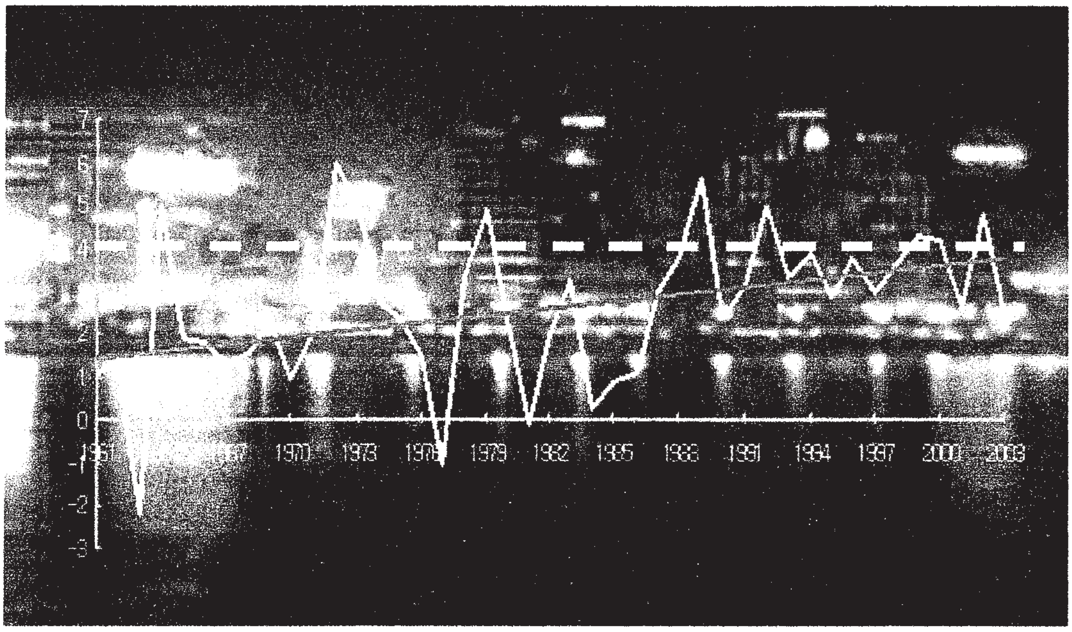

Fig 4. Change of average temperature of January in Pusan for last forty years.

In addition, Ra et al. (2003) reported that odorant-binding proteins (OBPs) of *Reticulitermes speratus* as signaling means differ from those of a dampwood termite *Zootermopsis nevadensis* (Ishida et al., 2002).

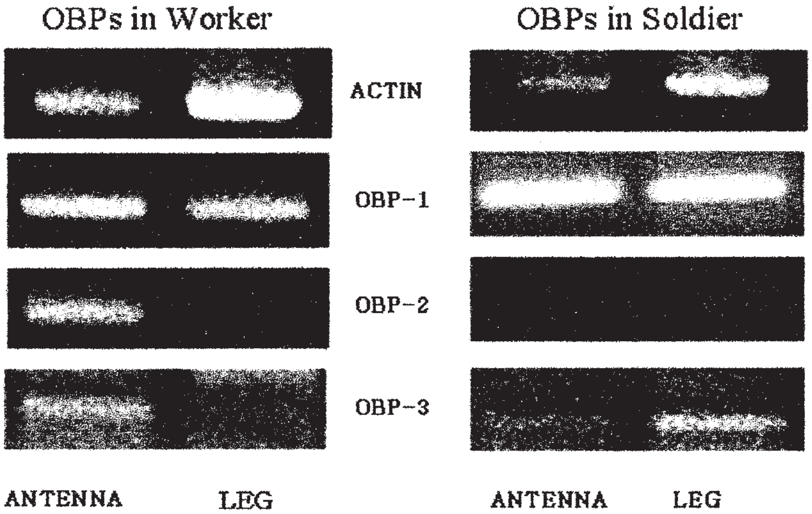

Fig 5. Expression patterns of OBPs of *Reticulitermes speratus*.

2. Damage caused by termite

2.1. Appearance of termite damaged wood

Termites cause a severe damage to wooden constructions and buildings. For example, wood studs, rows and head penetrating ties are often seriously attacked. Rafters are also attacked in some wooden buildings. The locations observed termite damages includes constructions with boiler system replaced by the *Ondol*, floor covered with plastic mats, place without drains, and place with leaking rain falls. Traditional Korean houses use small wood sticks put on the top of the mud plaster to give a slope to the roof. These small wood sticks are infested with termites, resulting in the damage by termite attack easily because of the fissure of the roof or leaking of rainfalls.

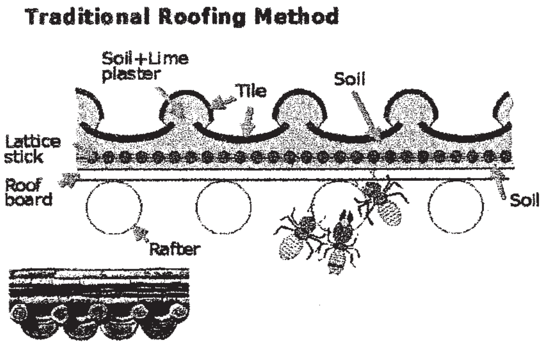

Fig 6. Traditional roofing method.


Fig 7. Termite attacked rafter.

2.2 Perception of termite prevention

The main materials of constructions and buildings were replaced by concrete after 1960, following the government policy. Since then the amount of wood used was rapidly decreased as well as the number of carpenters. As a result, wood-processing technology had not been developed for forty years, and termite prevention was not considered properly.

Due to the lack of termite perception, there are many risks by termites, including the stumps left after felling trees around houses, building demolition without removing termite nests, and new wooden parts treated with fumigation agent without termiticide treatment. Reduced durability of cultural wooden properties is attributed to the above-mentioned inattention.

Fig 8. Examples of termite attacks, including the stumps left after tree cutting around houses, building demolition without removing termite nests.

3. Current termite management

Although termite management was not regarded as an important issue over the last few decades in Korea, termites have been recently becoming serious pests to wooden cultural properties in southern areas. Number of detached (single-family) houses has been growing, and public concern about termite management has been increasing. However, the number of house constructed in 2002 is about 5000, which indicates relatively small market size.

In recent years, various preventive agents such as baiting systems are being introduced into Korea from Hawaii, USA by an epidemic company, including hexaflumunon, hydamethylnon, sulfluramin, and imidacloprid. Soil modifying agents are being imported, but its uses are very limited. The Korea Forest Service will announce the standards of preservation and degradation of wood to promote the use of wood. Most of exterior woods are pressure-treated with preservatives. In 2002, the amount of exterior wood in Korea increased to 1.2 million m^3, which was 250% compared to that of 1999.

References

1. Seo, Euo-ku. 1834. Imwonkyungjaeji (Forest Economics, 林園經濟誌).

2. Shin, Dong So, Se-Hea An. 1996. Mokjebojonhak. Seoul National University Press Co. 249pp.

3. Ra, Jong-Bum, Gyu-Hyeok Kim, Jea-Kyung Kim. 2003. The signal transduction of Oderant-binding protains from *Reticulitermes* speratus. 2003 Proceedings of the Korean Society of Wood Science and Technology Annual Meeting. 133-136.

Current Termite management in China

by

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Abstract

There are 476, scientifically recognized, different species of termites that are represented by 4 families with 44 genera (Huang *et al.*, 2000) and have been found to occur in more than 40% of the total land area in China (Li *et al.*, 1989). So far, 26 provinces are found to be affected by termite infestations. Termites damage structures, dams, communication facilities, forestry , crops and cause over US$ 0.3 billion worth damage annually. Current control of termites in developed cities relies on preconstruction chemical barrier. After chlordane was restricted by our country in 2001, chlorpyrifos, bifenthrin, cypermethrin, permethrin, and other synthetic pyrethroids as alternative insecticides for use in chemical barrier were approved by most of provinces in China at the beginning of 2001. Dusting with arsenic trioxide (or mirex) is a traditional method and is sufficient to eradicate termite colony in 7—30 days. Baiting is a simple, economical and effective method to destroy colony of subterranean termites and become more widely adopted by termite control firms in cities in recent years. Direct destruction of the colony of *C. formosanus* is sometimes operated under circumstances where the termite nest can be located.

Keywords: *Coptotermes formosanus, Reticulitermes,flaviceps,* soil treatment, wood treatment, remedial control

1 Distribution and damage of termite

Termites are considered major economic insect pests in China. There are 4 families represented in China by a total of 476 species assigned to 44 genera (Table 1.). The important genera include *Cryptotermes* (Kalotermitidae), *Reticulitermes, Coptotermes*, (Rhinotermitidae), *Macrotermes* and *Odontotermes* (Termitidae) Their northern limits and representative species in China are shown in Table 2.

Cryptotermes, with 8 described species, is the most important economic pests in this family and restricted to South China. There are two important termite species of *Cryptotermes*, *C. domesticus* and *C. declivis.* , which are wood-dwelling and attack hardwood timbers in service, such as timbers in buildings, wooden furniture.

Reticulitermes and *Coptotermes* contain the most economically important termites occurring in China. The *Reticulitermes* comprises 111 species and is by far the largest Chinese genus with a wide distribution in China. The limits of its distribution extend from Hainan Island (at 18.5°N latitude) to Beijing and Dangdong, Liaonin Province (at 40° N latitude), through to Shanxi (Jiexiu, about 37°N). *Coptotermes*, which includes 24 species, is widespread in the warmer regions in China. The north limits of its distribution lie at 33.5°N latitude and the south limits at the Xisha Island . *Coptotermes formosanus* and three species of *Reticulitermes*, *R. flaviceps, R. speratus, R. chinensis*, are the most important economic group of termites in China and cause damage to timbers in buildings, to synthetic materials, to underground cables, to living trees and to crops. In Guangdong Province and Hainan Island, the percentage of termite-infested hours is over 90%, in other areas such as Guangxi, Hunan, Fujian, Jiangxi, Zhejiang, jiangsu, Hubei, Anhui about 60%--80% (Li *et al.*,1989).

Odontotermes (with 27 species) and *Macrotermes* (with 25 species) are responsible for greater economic looses, in the aggregate, than all the other genera in this family. The species of *Odontotermes* extend from Loyang (at 35°N latitude in Henan Province) across the Changjiang (Yangtze) River valley to Hainan Island. This is due not only to that they attack forests, nursery stocks, crops, underground cables and buildings, but also to that they construct nests and tunnels inside the dams of rivers and reservoirs and result in dams leaking and collapsing. Over 90% of river and reservoir dams of more than 15 years old in southern China are damaged by *Odontotermes or Macrotermes* (Li *et al.*,1989).

2 Economic loss

Lin (1986) estimated the cost of termite damage to structures is $ 100 million annually and Li (1989) estimated the total cost of termite damage is $ 0.2 billion annually. Recently the estimated cost of termite damage to structures, including repair and control, is exceed $ 0.3 billion per year in China.

3 Current Termite management in China

3.1 Soil treatment of structures

For many years, the traditional method of controlling subterranean termites was to apply remedial treatment. The Chinese Government has supported coordinated termite control strategies since 1980s. In 1993, the rule for the protection of new buildings were issued by the National Construction Committee and Chlordane was recommended as only the legal insecticide for soil treatment. At present, termite prevention sector includes more than 800 firms with over 10000 operators. Since 1 Jan. of 2001, the use of Chlordane for termite control has been banned in China due to the persistence of it in the environment associated with its high mammalian toxicity. In 1997, the Agricultural Ministry of P. R. China approved registration of a Chlorpyrifos product for use as the chemical of termite prevention. More than 20 products from chlorpyrifos, permethrin, bifenthrin, cypermethrin, esfenvalerate, imidacloprid, silafluofen, fenvalate and fipronil are also registered for termite prevention in the past few years.

3.2 Wood treatment

Treating wood is one of the alternatives to soil treatment. Copper chrome arsenic preservative (CCA) was one treatment option which has been used for railway sleeper treatment, sometimes used for building timber treatment by pressure method to protect timber or buildings from termite attack since the 1970s. Ammoniacal copper quaternary (ACQ) is an environmentally advanced formulation that is arsenic and chromium free, in recent years, has been used for structural timbers of houses or landscape gardens to provide long-term protection for timbers from rot, decay and termite attack in China. In addition, a formulation, Meganium 2000, containing Chlorfenapyr, has been used as a glueline treatment for container plywood manufactured from hardwood substrates, Keruing (*Diptocarpus* spp.) and European beech (*Fagus sylvaticus*).

3.3 Remedial control

3.3.1 Straight Dusting

In China, the formula of arsenic had been kept secretly by private firms before the 1940s. Si Tuyao and Si Tuqiao (1954) made known the formula to the public. Li Shimei (1957 to 1958) gave lectures on how to control termites and also opened the formula of arsenic in Guangzhou, Hangzhou and Shanghai. Since those days, arsenic trioxide has been popularly used for Formosan subterranean termite control by termite control professionals. Results made by Si (1957), Chang (1956) and Li (1982) showed arsenic formula dust was sprayed in the main route of the termite or around the nest, and after 7 to 30 days all of the termites were killed. Now dusting with arsenic trioxide is one of the treatments for an active termite infestation in China.

3.3.2 Dusting in Traps

China has adopted trap means to control the Formosan subterranean termite since 1980s. Some of the methods such as bait-box and bait-pit established by researchers in Guangdong Entomological Institute have been successfully used to suppress active colonies of *C. formosanus* Shiraki in Guangdong Province. The bait-box is made of pine wood and its dimensions are 30X40X40cm. Fill the box with pine planks and bury it into the soil outside the buildings or near the base of a tree which are infested with termites. Termites usually come up after a month. Dust with arsenic trioxide or Mirex if termites are present in the box. Bait-pit is to dig pits outside the buildings or near the base of trees which are infested with termites. Fill the pit with pine planks and cover the pit with plastic films. If termites present in bait-pits, blow toxicant into pine planks in the pits.

Moreover, in order to reduces the dosage of toxicant, the aggregated termites may also be removed, transferred to a jar and dusted with arsenic trioxide or Mirex, and then released back into the trap-box or Trap-pit and the termites carry the toxin back to the colony and destroy the rest.

3.3.3 Bait technique

The technique was developed by Yao et al(1984). The bait is a slice of eucalyptus bark treated with 0.5% mirex-acetone-solution. Press the baits into the gallery systems or swarming holes of *Odontotermes* or *Macrotermes* and all termites are killed after eating bait materials within 2 or 3 weeks. Bait technique with eucalyptus bark is widely used in southern China for dam-termite control owing to its simple operation and excellent efficacy. By reason of that mirex is one of the POPs and is NOT a registered insecticide in our country, searching for alternative to mirex in baiting system is a pressing affair in China.

From 2000 to 2002, field evaluation of Sentricon baiting system containing 0.5% hexaflumuron was made for their effectiveness against colonies of *Coptotermes formosanus* in Guangzhou, P. R. China. Fourteen colonies of *Coptotermes formosanus* with actively foraging termites in different buildings were selected. The result shows that termite activity of *Coptotermes formosanus* ceased in the blank bait stations within 32 to 163 days with consumption of 36.92 to 279.73 g baits or 184.60 to 1398.65 mg hexaflumuron(Zhong *et al.*, 2002). The system was registered and is one of the most effective measures for termite control to structures in China.

3.3.4 Destruction of the colony

This is usually undertaken when an infestation has been identified. If the nest can be found it may be possible to destroy it directly. The nest can be destroyed by complete removal or by the use of a short lived insecticide such as permethrin.

3.4 Biological control

An insect pathogenic fungus (*Metarhizium*), insect pathogenic nematode (*Heterorhabditis*) and antibiotics (Jingangmycin) were used for control of termites and are not commercially available in China now. We are currently looking at options for commercialising their use

3.5 Prevention for cables

Copper naphthenate and some synthetic pyrethroid chemicals are used as active ingredient to provide protection for plastic cables from termite attack.

3.6 Fumigation

Fumigation is a treatment used for packages of timber or pieces of furniture attacked by drywood termites or other wood destroying pests. The fumigants often used are: phosphide, methyle bromide and sulphuryl fluoride.

3.7 Other Preventive Measures

Prior to constructing a home or other structure, removing all stumps, roots, or other construction materials such as all form boards or grade stakes used in construction, which covered by some provincial standard such as " Termite prevention rule for new house in Guangdong province".

Conclusion

Although the withdrawal from use of Chlordane was issued by China Government in 2000, the official continues to require that the period of efficacy of termite prevention of new structures must be at least 15 years and producers of chlordane are still available in China. It is estimated that there are about several hundred tons of chlordane in China annually used as chemical for soil treatment. Hence the current legislative rules needs to be adjusted to promote the use of alternatives in termite prevention.

Termite baiting technique distinctly reduces the dosage of insecticides and the remains of termite consumption can be retrieve-treated or recycled. Consequently the baiting technique for termite control is the likely direction for the future in China.

Mirex is one of the POPs and is not a registered insecticide, but commonly used for dam termite control in south China, so searching for an alternative to mirex is also a pressing affair.

References

Chang Cheng Shien.1956.A preliminary study on the behavior and control of subterranean termite,*Coptotermes formosanus* Shiraki. Acta Etomologica Sinica. 6(4):513--527.

Huang Fusheng, Zhu Shimo, Ping Zhengming, He Xiusong, Li Guixiang and Gao Daorong. 2000. Isoptera. Fauna Sinica--Insect Vol. 17.. Science Press. Beijing, China.

Li Guixiang, Dai Zirong and Li Dong. 1989. China termites and their cotrol methods. Science Press.

Lin Shuqing and Gao Daorong. 1986. Isoptera of China and management and control of important economic termites. Tianjin science and technology press.

Si Tuyao & Si Tuqiao 1957. Termite control. Kunchong Zhishi. Vol.4.P.164--168.

Yao Dachang, 1985. The selection of perfect programme for dam-termite control. Science and technology of water and electricity in Guangdong. (3) : 29--35

Zhong Junhong , Li Liying, Dai Zirong & Liu Liling. 1991. Experiments on the toxicities of antibiotics towards *Coptotermes formosanus* Shiraki. Natural Enemies of Insects. 13(1):43--50.

Zhong Dengqing, Huang Shunming and Yao Dachang. 1998. A comparative study on methods of preventing and controlling termites in dam. Journal of South China Agricultural University.Vol. 19(4):41--44.

Zhong Junhong and Liu Liling.2002. Termite fauna in China and their economic importance. Sociobiology Vol.40.No.1:25--32

Zhong Junhong, Liu Liling, Huang Zhenyou and Liu Bingrong, 2002. Assessment of forager population size and foraging distance of the colonies, *Coptotermes formosanus* Shiraki, and field evaluation of Sentricon baiting system. Proceedings of annual symposium of Guangdong termite society. Guangzhou, China, Nov. 2002. p.1—10.

Table 1. Brief list of Chinese termite classification

Family	Genus	No. of species	Genus	No. of species
Hodotermitidae	*Hodotermopsis*	1		
Kalotermitidae	*Cryptotermes* *Incisitermes* *Neotermes*	8 1 18	*Kalotermes* *Glyptotermes*	1 36
Rhinotermitidae	*Prorhinotermes* *Schedorhinotermes* *Reticulitermes* *Stylotermes*	4 5 111 34	*Parrhinotermes* *Coptotermes* *Tsaitermes*	2 24 6
Termitidae	*Microcerotermes* *Hypotermes* *Macrotermes* *Speculitermes* *Sinotermes* *Microtermes* *Termes* *Malaysiocapriterm* *Sinocapritermes* *Pseudocapritermes* *Arcotermes* *Havilanditermes* *Peribulbitermes* *Xiaitermes* *Sinonasutitermes* *Ahmaditermes*	5 5 25 1 3 3 1 2 14 7 1 2 3 2 11 16	*Odontotermes* *Parahypotermes* *Euhamitermes* *Indotermes* *Globitermes* *Ancistrotermes* *Microcapriterme* *Disuspiditermes* *Pericapritermes* *Hospitalitermes* *Cucurbitermes* *Periaciculiterme* *Pilotermes* *Nasutitermes* *Mironasutiterme*	27 4 13 2 5 6 2 1 11 4 2 1 1 45 10

Table. 2. The distribution of the most economic important termites in China

Genus	Northern limits	Representative species	Distribution in China (province)																					
			Guizhou	Liaoning	Hebei	Gansu	Shanxi	Shaanxi	Shandong	Henan	Anhui	Jiangsu	Hubei	Hunan	Zhejiang	Sichuan	Yunnan	Jiangxi	Fujian	Taiwan	Guangdong	Guangxi	Hainan	Hongkong
Reticuliterm	40 °N	*R.. speratus*		*	*																			
es		*R.. chinensis*			*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*		
		R. .flaviceps										*		*	*			*	*	*	*		*	
	35°N	*O.*	*			*		*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Odontoterm		*formosanus*															*		*		*	*	*	
es		*O.*																						
	33.5°N	*hainanensis*									*	*	*	*	*	*		*	*	*	*	*	*	*
Coptotermes	28.4°N	*C.*	*												*	*	*		*		*	*	*	
		formosanus													*					*	*	*	*	
Cryptoterme																								
s	22.8°N	*C. declivis*								*	*	*	*	*	*	*	*	*	*		*	*	*	*
		C.domesticu																						
		s																						
Macroterme																								
s		*M. barneyi*																						

Current Termite Management in Taiwan

by

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Abstract

Termites are widespread in Taiwan. Among the 17 termite species found in Taiwan, *Coptotermes formasanus* Shiraki is by far the most destructive to wooden and other structures in urban areas. *Reticulitermes* spp. are mostly distributed in northern Taiwan and cause damages at a lesser extent. *Odontotermes formosanus* is common in the field; however, it is not considered as pest of forest and agricultural crops. Chemical treatment to soil and wood has been conventionally applied for termite control in Taiwan. Bait system is only affective in controlling *C. formosanus* and *Reticulitermes* spp. in Taiwan. This system is not known to be effective against *O. formosanus*. Both chemical treatment and bait system are used by some pest control companies for termite control in Taiwan. Some biological control approaches have been tested but not commercialized. The concept of integrated pest management (IPM) has been gradually accepted in the market.

Key words: *Coptotermes formosanus*, *Reticulitermes*, *Odontotermes formosanus*, chemical treatment, bait system

Introduction

Termites are widely distributed from the temperate to tropical regions, but are predominant in the tropics. Termites are common pests to wooden structures in urban environment in Taiwan, causing considerate damage to buildings, trees and other structures. They can also be found in the forests, but the role that they play in that ecosystem is a decomposer not a pest.

Soil and wood treatments with chemicals have been conventionally employed in termite control in Taiwan. Chlorinated hydrocarbons, such as DDT, aldrin and chlordane, had been widely used. After chlordane was banned in 1986, organophosphates became popular in the market. However, they are being replaced by other chemicals such as synthetic pyrethroids because of their toxic volatile property. The concept using bait system to control termite was introduced into Taiwan around 1996. It costs much more than other chemical treatments. But because of its lower risk in contaminating the environment, more cases using bait system for termite control are being made by the pest control industry in Taiwan. However, chemical treatment with chlropyrifos and synthetic pyrethroid is still the major termite control method in Taiwan.

Some researchers and pest control companies (PCO) have popularized the concept of integrated pest management (IPM) for many years. The concept is gradually accepted in the market.

Termite species recorded and their distribution

The fauna of Taiwanese termites was investigated actively before 1914 (Oshima, 1909, 1911, 1912, 1914). Chung and Chen (1994) summarized and revised the list of Taiwanese termites with 16 species recorded. Tsai and Chen (2003) added a new record species, *Coptotermes gestroi,* with a total of 17 species of termites identifiable in Taiwan. Among the Taiwanese termites, *Reticulitermes* spp. and *Coptotermes formosanus* are considered most destructive to wooden structures. The former species are mostly distributed in northern Taiwan and the latter can be found all around Taiwan. *Odontotermes formosanus* is the most common species in the field in Taiwan and also can be found in those areas under the altitude of 1,000 m around Taiwan. In southern Taiwan, drywood termites, *Cryptotermes domesticus* and other species of Kalotermitidae can easily be found in the field but they do not cause serious damages on buildings and wooden structures.

Economic important of termites

In urban environments, termites can cause serious damage to wooden structures in Taiwan, but they are not considered as a pest of forests and agricultural crops. *O. formosanus* used to be the major sugarcane pest before the extensive uses of agricultural chemicals. Its damage to sugarcane becomes less important with the decrease in sugarcane planting in Taiwan. Some species of termites may have been attributable to unexpected power supply problems. They, especially *C. formosanus*, have been found in and around polyvinyl chloride (PVC) cables buried underground in Taiwan (Huang *et al.*, 2000). Lead sheathings of electric and telephone cables have been reported being penetrated by *C. formosanus* in the Far East, Central America and Hawaii (Lai, 1977), causing water to leak into the system and leading to short circuits and interruptions in service (Tsai *et al.*, 2004). Economically, *C. formosanus* is considered the most important species because it is widely distributed in the urban settings in Taiwan.

There are no official reports on the estimation of the costs for termite management, including prevention and control treatments and repair of the damage in Taiwan. In the recent years, the governments paid more attention to the conservation of cultural heritage. It is commonly recognized that termite is one of the main causes of the damage to wooden elements of those historical buildings and other cultural properties. Recently efforts are being made by the government and private organizations in repairing and maintaining the cultural properties. A preliminary survey of some culture foundations, city governments and PCO companies, it is roughly estimated that the costs of the treatments of the actual termite damage alone amounted to US$3 millions per year, excluding the use of pretreated building materials. More than 70 % of the total damage was due to the damage caused by *C. formosanus* and the remaining was by *O. formosanus*, *Reticulitermes* spp. and species of Kalotermitidae.

Current principles of termite control

Most of the termite damage in urban areas occurs in houses or trees around the house. The modern buildings are often constructed by concrete, rarely with wooden materials. Termites enter houses from the garden of the house by underground gallery constructed by workers. Soil treatments were made to create chemical barriers to protect buildings. For those buildings without gardens, swarming alates enter into the buildings from openings or through air conduits. There are no specific constructional codes requiring designs for preventing termite damage except for screening doors, windows or other openings, including air conduits. Some major termite control methods are discussed as follows:

1. Chemical treatments

Organophospates, particularly chlorpyrifos, are widely used as the major termiticide in the world. Due to the voluntary cancellation taken by the manufacturer in 2001, chlorpyrifos is being phased out from the market. Its use in spot and local treatments is being deleted from the label effective December 31, 2002 and all of other uses will be deleted from the label effective December 31, 2004. The use of the existing stock of chlorpyrifos as termiticide will be permitted until December 31, 2005 (U.S. EPA, 2001). This means that none of the uses of chlorpyrifos will be permitted after 2005. The action to voluntarily cancel the use of chlorpyrifos products is a result of the concern over its potential contamination with groundwater resulting from its extensive use as a termiticide. Other chemicals such as synthetic pyrethroid compounds (*e.g.* cypermethrin, permethrin, bifenthrin, deltamethrin,), and others including neonecotinoid compound (*e.g.* imidacloprid), fipronil, propoxur and boric acid are used, to an extent, to replace chlorpyrifos. These chemicals are used for both soil and wood treatments. As soil treatment, chemicals in liquid formulation are applied in soil as barriers around buildings or trees. As wood treatment, they are brushed or sprayed on wood surface or injected into woods with high pressure. In addition, lumbers treated with chromated copper arsenate (CCA) are commonly used as building materials to prevent termite infestation in Taiwan.

2. Bait system

The bait system for termite control was introduced into Taiwan around 1996. Since the cost of the bait system is higher than the chemical treatment, promotion of its use in Taiwan has been limited. However, due to the recent concerns on the potential impact of termite control on our environment, the concept to reduce the use of chemicals to control termite damage has become better accepted. As a result, the market share of the use of the bait system in termite control has become larger. However, this system is known to be only effective against *C. formosanus* and *Reticulitermes* spp., but not against *O. formosanus*, which is one of the most common species in Taiwan. Some PCO companies will use a combination of both chemical treatment and bait system to control termites. For serious damaged structures, termiticides were directly applied as spot treatments to provide an immediate control of the termite damage and then followed by the use of the bait system for long-term protection or monitoring of termite activities.

3. Biological control

Biological control using entomogenous fungi, *Beauveria bassiana* and *Metarhizium anisopliae* (Lai *et al.*, 1982) and nematodes (Fujii, 1975; Wu *et al.*, 1991) against termites has been studied. Entomogenous fungi and nematodes caused high mortality on termites in laboratory. Although they seem to be effective against termites in the laboratory, their value for termite control in the field still remains unknown. There is no further study being reported on biological control of termites using other biocontrol agents in Taiwan.

4. Physical barrier

There was a project conducted in Taiwan to test the feeding preference of *C. formosanus* on different wooden materials (Chang *et al., 2002).* No other studies have been made in Taiwan.

Conclusion

As people paid more attention to the environmental problems resulting from the use of chemicals, some longer lasting pesticides have been banned or their uses have been restricted the last two decades. As an alternative, the concept of integrated pest management incorporating the use of chemicals, bait system and other control measures has gained a considerable ground in termite control. Researchers and PCO companies around the world are promoting pest control methods with reduced reliance on chemicals. With this effort, fewer and less chemicals were applied to control termite problems in Taiwan. However, until chemicals can be completely replaced by other control methods, they are still considered as the major tool for managing termite problems in the foreseeable future in Taiwan.

References

Chang, L., W. J. Wu, and E. L. Hsu. 2002. The food preference of the Formosan subterranean termite, *Coptotermes formosanus* (Isoptera: Rhinotermitidae). Plant Prot. Bull. 44: 135-139.

Chung, C. H. and C. S. Chen. 1994. A review of Taiwanese termite species (Insecta, Isoptera) with keys to adults and soldiers. Yushania 11: 193-203 (in Chinese).

Fujii, J. K. 1975. Effects of an entomogenous nematode, *Neoaplectans carpocapsae* Weiser, on the Formosan subterranean termite, *Coptotermes formosanus* Shiraki, with ecological and biological studies on *C. formosanus.* Ph. D. Dissertation, University of Hawaii.

Huang, F., S. Zhu, Z. Ping, X. He, G. Li, and D. Gao. 2000. Fauna Sinica Insecta 17, Isoptera. Science Press, China. 961 pp. (in Chinese).

Lai, P. Y. 1977. Biology and ecology of the Formosan subterranean termite, *Coptotermes formosanus,* and its susceptibility to the entomogenous fungi, *Beauveria bassiana* and *Metarhizium anisopliae.* Ph.D. Dissertation, University of Hawaii

Lai, P. Y., M. Tamashiro and J. K. Fujii. 1982. Pathogenicity of six strains of entomogenous fungi to *Coptotermes formosanus*. J. Invertebr. Pathol. 39:1-5.

Oshima, M. 1909. The first official report on termites. Taiwan Tsutokofu, Taihoku. pp. 37-40 (In Japanese).

Oshima, M. 1911. The second official report on termites. Taiwan Tsutokofu, Taihoku. 152 pp. (In Japanese).

Oshima, M. 1912. The third official report on termites. Taiwan Tsutokofu, Taihoku. 186 pp. (In Japanese).

Oshima, M. 1914. The fourth official report on termites. Taiwan Tsutokofu, Taihoku. 173 pp. (In Japanese).

Tsai, C. C. and C. S. Chen. 2003. First record of *Coptotermes gestroi* (Wasmann, 1896) (Isoptera, Rhinotermitidae) from Taiwan. Formosan Entomologist 23: 157-161.

Tsai, C. C. and C. S. Chen. 2004. Identifying *Coptotermes formosanus* and *C. gestroi* (Isoptera: Rhinotermitidae) by cuticular hydrocarbon composition. Formosan Entomologist (in press).

Tsai, C. C., C. S. Chen and J. R. Cheng. 2004. Subterranean termite control in the Hsinchu Science-based Industrial Park Land. Monthly Journal of Taipower's Engineering 665: 92-106 (in Chinese).

Wu, H. J., Z. N. Wang, C. F. Ou, R. S. Tsai and Y. S. Chow. 1991. Susceptibility of two formosan termites to the entomogenous nematode, *Steinernema feltiae* Filipjev. Bull. Inst. Zool. Academia Sinica 30(1):31-39.

Present Status of Termite Management in the Philippines

by

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Abstract

There are 54 known species of Philippine termites, represented in 17 genera and distributed throughout the archipelago. Forty species are earth-dwelling in habit while 14 species are wood-dwellers. Only 6 species are economically important, 4 of which are earth dwellers (*Coptotermes vastator* Light, *Macrotermes gilvus* Hagen, *Microcerotermes los-bañosensis* Oshima and *Nasutitermes luzonicus* Oshima) and 2 are wood-dwellers (*Cryptotermes cyanocephalus* Light and *C. dudleyi* Banks).

Termite control is mainly dependent on chemical method using conventional treatment applications like brushing, spraying, rodding and dusting. Soil poisoning is commonly used as preventive and remedial treatment. Chlorinated insecticides were banned in the early 1990's and replaced by the new groups of insecticides, which include organophosphates, pyrethroids, chloronicotinyl, phynyl pyrazole and benzol urea. The use of environment-friendly alternative methods has to be evaluated as far as their efficacy on Philippine termite is concerned.

Key words: *Coptotermes vastator, Macrotermes gilvus, Microcerotermes los-bañosensis, Nasutitermes luzonicus, Cryptotermes cyanocephalus, C. dudleyi,* chemical treatment

1. Introduction

Termites are considered as major structural pests that cause extensive damage to wooden components of furniture, houses and buildings in the Philippines. According to their habit, termites are classified into two groups: (1) the earth-dwelling termites and (2) the wood-dwelling termites. The earth-dwelling termites live and build their nest primarily in the soil but, frequently, extend their activities to wood above-ground to feed. They are further classified into subterranean termites and scavengers group. On the other hand, wood dwelling termites confine their activities strictly in wood and grouped into drywood termite and dampwood termite. The subterranean termites and drywood termites are considered as the group of Philippine termites with economic importance. The moist tropical conditions in the Philippines makes it very favorable for these species to thrive well, proliferate and continue to cause damage, if appropriate preventive and control measures are not undertaken.

The prevention and control of termites depend mainly on the application of chemicals by soil or wood treatment. The soil is poisoned with toxicant through conventional spraying, sprinkling, baiting, dusting, foaming or rodding method.

In the 1950 to early 1990's, chlorinated chemicals were the first generation products used and provided excellent protection against termites. However, the environmental and health hazards posed by chlorinated compounds prompted the Fertilizer and Pesticide Authority (FPA) of the Philippines, the regulatory agency on the registration and use of pesticides, to ban their use. Subsequently, other new groups of compounds which includes organophosphates, pyrethroids, phynyl pyrazole, chloronicotinyl and benzol urea were introduced in the market. The advent of various termiticides in the market did not change the strategy of termite control and the availability of several products to choose from makes the only difference. Chemical control remains as the most effective measures against termites.

Although there are other available technologies for termite control like baiting technique, physical barrier and biological control, there are some drawbacks on its application. Unknown efficacy or performance, no knockdown effects specificity against certain species and not applicable to pre-construction treatment are some of the reasons why other alternative methods are not frequently used in termite control.

2. Termite species recorded and distribution

The Philippine geographical location in the tropics with climate of wet and dry seasons combined with relatively high moisture and adequate food source make it a favorable niche for termites to proliferate throughout the archipelago. There are 54 known species of termites, represented in 17 genera and distributed in 3 families namely, Kalotermitidae, Rhinotermitidae and Termitidae. Of the 54 known species, 40 are soil-dwelling in habit while 14 species are wood-dwellers'. Only 6 species (4 soil-dwellers of subterranean termites group and 2 wood-dwellers of drywood termites group) are considered economically important urban pests of furniture and wooden components of houses and buildings. On the other hand, the damage of termites in agriculture are not well defined, and if any, their occurrence was not reported or documented maybe because the effect is not substantial as compared to the economic importance of termites in houses and buildings.

It appears that the majority of the members of Philippine termites are scavengers, which are responsible for the nutrient recycling of dead trees, stumps, debris, shrubs and other non-wood waste materials into the soil. However, with the development of housing projects and conversion of their habitats in the forest and orchard, it is speculated that the niches of termites are destroyed and may affect their feeding habits. As a result of this development, some drywood or scavenger species may have shifted their status to become urban pests. For example, species of *Nasutitermes* were occasionally found to climb building but have never been observed to cause severe damage in the country as reported in 1960. But today, they are frequently observed infesting wooden components of houses. The genus consists of 20 species and only *N. luzonicus* was identified as economically important. It is possible that other *Nasutitermes* or subterranean termite species are already attacking structure.

3. Economic Importance of Termites

3.1. Economically important termite species

According to the habit-type and families, the 6 economically important termite species are as follows: four species of soil-dwelling termites (*Coptotermes. vastator* Light (Rhinotermitidae), *Macrotermes gilvus* Hagen (Termitidae), *Microcerotemes los-bañosensis* Oshima (Termitidae) and *Nasutitermes luzonicus* Oshima (Termitidae); and two species of wood-dwelling termites (*Cryptotermes cyanocephalus* Light and *C.dudleyi* Banks, both under Family Kalotermitidae).

Among the earth-dwelling termites, *C. vastator* is by far the most destructive. This species is known locally as the Philippine milk termite owing to the characteristic milky secretion from the soldier when disturbed or provoked. Of the drywood termites, *C. cyanocephalus* and *C. dudleyi* are serious pests of furniture and cabinets, dry lumber and wooden components of houses and buildings.

Most members of the soil-dwelling termites are not economically important but are important components of the food chain in the nutrient recycling of wood and other cellulosic materials. Without them, the Philippine forest maybe filled up with dead trees, logs, stumps, dead trees and other forest non-wood materials.

3.2. Estimate of economic loss

There is no data on the annual economic losses due to termite infestation in the Philippines.

4. Currently used chemicals for termite management

4.1. Soil treatment chemicals

The first generation chemicals used by pest control operators for soil or wood treatment are the chlorinated compounds, which include chlordane, aldrex, aldrien, dieldren, endrin, pentachlorophenol and arsenical compounds. However, the FPA banned the use of chlorinated chemicals in the early 90's due to health hazards and environmental problems. New groups of chemicals were introduced into the local market namely the synthetic pyrethroids (permethrins, cypermethrin, alphacypermethrin, biphentrin, fenvalerate, and deltamethrin) chloronicotinyl (imidachloprid), benzoylurea (hexaflumuron), phenyl pyrazole (fipronil) and organophosphates (chlorpyrifos).

4.2. Wood treatment chemicals

For wood treatment, synthetic pyrethroids containing an active ingredient like deltamethrin, permethrins, cypermethrin, alphacypermethrin, biphentrin or fenvalerate are commercially available as wood preservatives. These are commonly applied by brushing or spraying as superficial treatment.

5. Termite management measures other than the use of chemicals.

Sanitation and new construction systems (like construction of concrete posts, window jambs, doorjambs and steel trusses) are some of the common termite management practices other than the use of chemicals.

6. Specification for termite management

Soil or wood treatment procedures are based on specifications according in a pamphlet on "How to Control Termites in Houses", an FPRDI Publication.

6.1 Soil treatment

The application of chemical treatment in the soil is done by drenching, spraying or sprinkling 50% of the total termiticidal solution requirement at the rate of 4 l/m into the trench. The trench is dug 14 to 30 cm from the edge of the exterior wall about 30 cm wide and 30 cm deep. Soil is backfilled into the treated foundation and the 50% remaining chemical solution is drenched, sprayed or sprinkled on the backfilled soil.

6.2. Wood treatment

Although wood remained to be the preferred construction materials by homeowners, the commercial lumber and plywood today is incomparable with the premium quality of the Philippine traditional timber before. The current supply of less durable wood construction materials has brought about the need to apply chemical treatment prior to installation or during construction. This is applied by conventional spraying or brushing of chemical solution to lumber or plywood, interior walls, panels and ceiling wood components. It is important that all surfaces are well covered with chemical solutions.

Conclusions

The moist tropical climate of the Philippines provides a very favorable niche for the proliferation of destructive termites. The economic impact of termite destruction in the country is still undetermined and there is a need therefore to address the situation.

Termite control in the Philippines is still dependent on chemical application since the 19th century to the present. The application of chemical treatment to soil and wood is proven to be the most effective method in preventing and controlling termite infestation. The complete dependence on chemical control will consequently result to hazards and environmental problems in soil and water resources of the country in the near future. There is a need to change this termite management approach to avoid the drawbacks in the use of chemicals.

The environment-friendly alternatives to prevent and control termite infestation have to be evaluated as far as their efficacy on Philippine termite is concerned.

Finally, the utilization of lesser-known non-durable timber in housing/building construction and the destruction of niches of termites in the countryside may influence the classification status of termites from forest pests or scavengers to become urban pests. Identification of termite species in infested houses is necessary to verify this speculation.

References

Calora, D.G. 1969. Some observations on the habits and behavior of Drywood termites. *Wood Preservation Report* **III**(1):15-16.

Fertilizer and Pesticide Authority. 2000. Pesticide Regulatory Policies and Implementing Guidelines. 2nd Edition. Philippines. 337 pp

Francia, F.C and M.K. Monroy. 1967. The Los Baños termite, *Microcerotermes los-bañosensis.* Wood Preservation Report. Forest Products Research and Industries Development Commission, College, Laguna. WP Report **II**(5) :19-20

Garcia, M.L. 1962. The termite control industry in the Philippines. FORPRIDECOM Library. College, Laguna. 10 pp.

Garcia, M. L. 1967. How they gain access to buildings. Forest Products Research and Industries Development Commission, College, Laguna. *WP Report* **II**(1):5-7

Garcia, M.L. 1969. Philippine wood-destroying insects. Termites. Terminal Report. FPRDI Library, Laguna, Philippines.

Garcia, M.L. 1969. Some observations on the ecology and behavior of *Coptotermes vastator* Light (Rhinotermitidae: Isoptera). Forest Products Research and Industries Development Commission, College, Laguna. *WP Report* **IV**(4):24-27.

Garcia, M.L. 1972. Economic aspects of soil poisoning for subterranean termite control. Forest Products Research and Industries Development Commission, College, Laguna. *WP Report* **VII**(1).

Garcia, M.L., A.V. Reyes and S.M. Bato. 1979. Life history and behavior of the common drywood termites, *Cryptotermes cyanocephalus* Light and *C. dudleyi* Banks. FORPRIDECM. Technical Note. FPRDI Library, Laguna, Philippines.18p.

Monroy, M.K. 1969. A study of some aspects of the Life history and habits of *Microcerotermes los bañosensis.* Forest Products Research and Industries Development Commission, College, Laguna. *WP Report* **IV**(2):21-23.

Reyes, A.V. and C.M. Garcia. 2003. How to control termites in buildings. Terminal Report Forest Products Research and Development Institute Library. Laguna, Philippines. 12p.

Snyder, T. and F. C. Francia. 1960. A summary of Philippine termites with supplementary biological notes. The Phil. Jour. of Science. *National Institute of Science and Technology. Manila, Philippines*. **89**(1):63-77.

Valino, A.J. 1968. Random notes on Philippine termites. Forest Products Research and Industries Development Commission, College, Laguna. *WP Report* **III**(1):11-12.

Valino , .A.J. 1967. Know your termites. Forest Products Research and Industries Development Commission, College, Laguna. *WP Report* **II**(1):8-10.

Valino, A.J. 1966. Soil treatment for subterranean termite control in building construction. Forest Products Research and Industries Development Commission, College, Laguna. *WP Report* **I**(4):43-45.

Current Termite Management in Vietnam

by

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Abstract

Of 115 species of termites recorded in Vietnam, 7 species of *Coptotermes*, *Globitermes sulphureus*, *Cryptotermes domesticus* are major pests to wood house and other structures; 13 species of *Macrotermes*, 23 species of *Odontotermes* and 2 species of *Hypotermes* are major pests to dike and dam because their nest systems are subsurface defects which can cause infiltration and collapse to the body of dike and dam. The economic importance of termites to dike and dam, as well as to construction is high, however, the annual loss of damage has not been evaluated yet. Chemical treatment is widely applied to prevent and control termites by using permethrin, deltamethrin, chlorpyrifos and fippronil. Baiting program is not commercialized while physical such as stainless mesh is not introduced in Vietnam.

Key words - *Coptotermes, Globitermes,Cryptotermes domesticus, Macrotermes, Odontotermes Hypotermes,* dike ,dam, chemical soil and wood treatment

1 Introduction

Vietnam is a hot and humid country extending from the 8th to the 23rd North parallel, where termites are abundant. Up to the date, 115 species of termites have been identified preliminarily, but the general investigation is only at the first step.

One of the peculiarities of termite problem in Vietnam is the existence of termites in dikes and dams. Dike and dam bodies of Vietnam are made mostly of earth, and are preferable medium for termites to locate. Termite nest is a system of holes which causes infiltration of water from the reservoir and then - dike and dam collapse resulting in terrible inundations.

The termite control in Vietnam is composed of three parts: termite control for constructions, termite control for dikes and dams, termite control for living trees.

In the control of termites for constructions, arsenic trioxide is still used to deal with *Coptotermes*. In all parts of termite control, chemical treatment is still a major management measure in Vietnam (permethrin, deltamethrin, chlorpyrifos and fippronil)

2 Termite species recorded

Summing up data collected by different authors (P.Durand, 1972; Nguyen duc Kham, 1976; Vu van Tuyen, 1985, 1991, 1993, 1994, 1996) showed that 115 species of termites have been recorded in Vietnam. However, the identification has been made preliminarily only and necessary to be reviewed.

On the other hand, the termite investigation has not covered all the territory yet, it means that the list of termites may be longer.

3 Economic importance of termites-

3.1 Economically important termite species

As pests to constructions, *Coptotermes formosanus* ,*C .ceylonnicus* ,*C .havilandi, C. .travians* , *C. emersoni, C. dimorphus, C. curvignathus* are the most harmfull, then come *Cryptotermes domesticus, Globitermes sulphereus.*

As pests to dikes and dams made of earth ,the most dangerous species are: *Macrotermes gilvu ,M.carbonarius, M.maesodensis, M.malaccensis, M. barney, M. estherae, M. menglongensis, M. chaiglomi, M.tuyeni, M.songanensis, M.latignathus, M. serrulatus, M. langsonensis, Odontotermes graveli, O.ynnanensis, O. horni, O. hainanensis, O.angustignathus, O. feae, O.formosanus, O. djampeensis, O.proformosanus, O.pahamensis, O. maesodensis, O.latignathus, O. malaccensis, O.ceylonicus ,O.cornignathus, O.javanicus, O.adampurensis, O. profeae, O. giriensis, O. foveafrons, O. annulicornis, O. obscuriceps, O. sumatrensis, Hypotremes makhamensis, H.xenotermitis.*

In regard to pests to living trees, very few investigations have been done; it results in missing global reliable data related to each species of living trees. Some separated researches showed that *C. emersoni, M.malaccensis,O.hainanensis* ... are pests to coffee trees in South Vietnam; Eucalyptus are heavily attacked by *Macrotermes barney, Odontotermes formosanus* and *O.hainanensis*; Pelonix regia attacked by *Coptotermes travians, O. hainanensis, O.angustignathus*

3.2 Economic loss

There is no data to estimate the annual loss of preventing, controlling termite infestations and repairing the resulting damage.

4 Currently used chemicals for termite management

Since organophosphates are not widely used any more, permethrin, deltamethrin, chlorpyrifos, and fipronil are used for soil treatment as well as for wood superficial treatment. Arsenic trioxide is still used for curative treatment to deal with species of *Coptotermes.*

5 Termite management measures other than the use of chemicals

5.1 Baiting program -

The *Sentricon Colony Elimination System* was tested in Vietnam 5 years ago and has been effective to control species of *Coptotermes* which are pests to constructions (Vu van Tuyen , 2001), while not effective to *Odontotermes* and *Macrotermes* which are pests to dikes and dams. However, this method has not been commercialized in Vietnam yet.

5.2 Physical barrier

Metal collar for floor post was used longtime ago for store- houses constructed in the forest but not widely used now.

Barrier system using stainless mesh is not introduced in Vietnam yet.

5.3 Biological control

There have been some scientific researches and dissertations on using entomogenous fungi to control termites .But the reliability of efficacy and persistence in the field is not affirmed.

5.4 Constructional design

There is no regulation on the use of constructional design for termite prevention.

6 Specifications for termite management

6.1 Termite control for dike and dam conducted according to the Ministry of Water Resources Standard 14-TCN - 88-93 and composed of three steps:

- investigation and location of termite nests without excavation
- eradication of termite colony by pumping termiticide solution into the nest
- filling up all holes and galleries of the nest by pumping clay mortar into the nest

6.2 *Soil treatment for construction* *is* conducted according to the Ministry of Construction Standard TCXD – 204.

6.3Wood treatment

Liquid termicidal formulations are applied to the wood by spraying or brushing or by pressure treatment.

Conclusion

As mentioned above , Vietnam is a country where termites are abundant , but there is much to be done in the investigation , identification , and control of termites.

The existence of termites in dike and dam made of earth is a big problem of Vietnam. To deal with termite nests in dike and dam (termite elimination , filling up all holes caused by termites) the detection of termite nests must be proceeded before the treatment .In the termite control for dike and dam, one of the most important items is the protection of dike and dam from termite infestation, however, the measure of protection requests new technology.

In general, the termite management is heavily dependent on chemical use.

References

Patrick Y. Durand 1971 *.Les termites du Vietnam .Institut des recherches agronomiques .Saigon*

Nguyen duc Kham 1976 . *Termites in Northern Vietnam .Agric. Publ. House , Hanoi ,Vietnam*

Nguyen duc Kham - Vu van Tuyen 1985 *.Termites and technique for their control .Agric. Publ. House , Hanoi ,Vietnam*

Vu van Tuyen ,1985 .*Bioecological characteristics of termites in dam- reservoir of Vietnam . Scientific report on the national research subject code 06-04-03-05*

Vu van Tuyen , 1990 . *First study on the method of termite prevention for dams- reservoirs .Scientific report on the national independent research subject*

Vu van Tuyen ,1991 .*First study on the termite control for coffee tree . Scientific report at the National Scientific Research Center of Vietnam*

Vu van Tuyen ,Hoang khac Ba , Hoang xuan Hong ,1994 . *Component ,quantity of the investigation and the treatment of termites in dams made of earth .Ministry of Water resources Standard ,code 14-TCN- 88-93*

Vu van Tuyen - P.K. Sen Sarma ,1994 .*Termites damaging dikes and dams and their management. Surya Publications ,Dehra Dun ,India*

Vu van Tuyen ,1996 .*The study on termites of economic importance in the region from Quang tri to Quangnam -Danang and method for their control.Scientific report on the national independent research subject*

Vu van Tuyen , 2001 -*Performance of the SentriconTermite Colony Elimination to control Coptotermes formosanus and C. travians in Northern Vietnam . Proceedings of the 4thAsia Pacific Conference of Entomology (4th APCE) 14-17 August , 2001 , Kuala Lumpur , Malaysia*

Current Termite Management in Indonesia

by

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Abstract

Forest industries are very important to the Indonesian economy, since exports of forest-products amounts to nearly USD 8 billion in 1995 and is ranked second as a foreign exchange earner, after oil and gas.

Among more than 2,200 species of termites in the world, about 150 species are known to damage wooden structures. Although it has been estimated that over 200 species of termites are distributed in Indonesia, only 179 species were already listed. Of these recorded so far, 52 species are from Java Island. *Coptotermes sp.*, *Macrotermes gilvus* Hagen, *Schedorhinotermes javanicus* Kemner, and *Cryptotermes cynocephalus* Light are the most important urban (building) pests in Indonesia. In 2000, the economic loss caused by termite attack on the building was estimated at 200-300 million USD. Chemical treatment is widely applied to prevent and control termite infestations using chlorpyrifos, phoxim, imidacloprid, permethrin, cypermethrin, deltamethrin, alphamethrin, bifenthrin, chlorfenapyr, fenvalerate and others. Since the slab on-ground type have been common in Indonesian houses to reduce construction cost, superficially treated framing timber have been increasingly used these years in addition to the soil treatment (pre- and post-construction treatments). The recent public concern should be highly appreciated to establish environmentally sound termite management in the near future such as physical barrier and biological control. Baiting system was recently introduced into Indonesia commercially, however it is not accepted yet by the Indonesian.

Key words: Indonesian termites, *Coptotermes sp*, *Macrotermes gilvus*, termite management, pre- and post-construction soil treatments, wood treatment

1 Introduction

Since wood is one of the oldest, most important and most versatile building materials and still widely utilized, particularly in developing countries, it might continue to be only one renewable and sustainable material in the future. Termites have long been a serious pest to wooden constructions, timber products and any other lignocellulosic materials, and they are still causing a serious problem in most tropical regions. This is quite true for Indonesia.

Indonesia has an enormous tropical rain forest, the second biggest in the world after Brazil. According to the official statistics, about 64 million ha of 144 million ha forestland are production forests, 49 million ha are protected areas and nature reserves, and the remaining 31 million ha are scheduled for converting into agricultural production.

Forestry is very important industry for the Indonesian economy, since the export of forest-products earned the second biggest amount of approximately USD 8 billion in 1995 after oil and gas as a foreign exchange earner. Having banned the export of logs in 1980, Indonesia initiated to establish industry with rapidly growing forest-products, which has been squeezing out other suppliers of plywood internationally. Meanwhile as most wood species get deteriorated readily in the tropical region including Indonesia, durable wood products have been preferred. These wood species, however, are becoming more and more scarce. Therefore, secondary species are gaining increasingly interest, although those are more susceptible to biological deterioration.

2 Termite species recorded in Indonesia

In spite of the economical importance, economic damage by termites in urban areas has not been fully investigated in Indonesia. About 200 species of termites are distributed in Indonesia, and about 52 species are from Java Island (Tarumingkeng, 1971). However, up to now, research activity on termite control has not been much promoted yet. Although Tho (1992) mentioned that athe number of termites species in Indonesia (Java, Sumatra and Kalimantan) amounted to 233, only 179 species are known today. All area of Indonesia is distributed by termite species as shown in Fig.1.

Fig. 1. Termite distribution in all of Indonesia

3 Economic importance of termites

3.1 Economically important termite species

Among the Indonesian termites, three subterranean [*Coptotermes curvignathus* Holmgren (others *Coptotermes sp* were also found in West Java, Sulawesi Island and Kalimantan Island), *Macrotermes gilvus* Hagen, *Schedorhinotermes javanicus* Kemner] and one dry wood termite species [*Cryptotermes cynocephalus* Light] are considered as the most important building pests in Indonesia.

3.2 Estimate of economic loss

Termites are known to be the most important pests causing damage to wooden constructions and other wood products in most of the tropical regions of the word. Slab ground type and wooden houses are still common in Indonesia, that is similar to other tropical countries. Even modern houses in urban areas also use relatively much timber, and wooden furniture is very common in every house throughout the country. Termite infestations in the building, particularly in the urban areas, have been causing a serious economic problem. In 2000, the financial loss caused by termite attack on building was estimated at 200-300 million USD.

4 Currently used chemicals for termite management in Indonesia

4.1 Soil treatment chemicals

Organophosphates (*e.g.* chlorpyrifos, phoxim), neonecotinoid compounds (*e.g.* imidacloprid), synthetic pyrethroids (*e.g.* permethrin, cypermethrin, deltamethrin, alphamethrin, bifenthrin, fenvalerate), boric acid, chlorpenapyr (non-repellent termiticide) are currently used in Indonesia.

4.2 Wood treatment chemicals

The same chemicals used for soil treatment are applied superficially (brushing, spraying, momentary dipping) to wood treatment. Recently, non-repellent termiticides such as chlorfenapyr has been used for glued-line treatment of plywood in Indonesia. Inorganic compound *e.g.* CCB (copper-chrome-boron), CCF (copper-chrome-fluorine) are used for some structural timber components of houses by pressure treatment.

5 Termite management measures other than the use of chemicals

5.1 Baiting program

Baiting system was recently introduced into Indonesia commercially. However, it has not been widely accepted yet in Indonesia. Physical barrier and biological control using entomogenous fungi have not been commercialized yet, still in research in the laboratory but these seem to have some potential in the next future.

5.2 Constructional design

There are three types of model houses in Indonesia: slab on-ground type, crawlspace type and high pole type. Recently, the slab on-ground type houses are commonest. Crawlspace and high pole types are often seen in the rural area of Java Island and out of Java Island (Sumatra, Kalimantan, Sulawesi and Irian Jaya Island), respectively. High pole type houses are usually build by concrete poles or wooden poles (high quality of wood) with about 2 meter in high, and crawlspace type ones are by 0.5 meter thick stones. Figure 2 shows the foundation design of a typical slab on-ground type house.

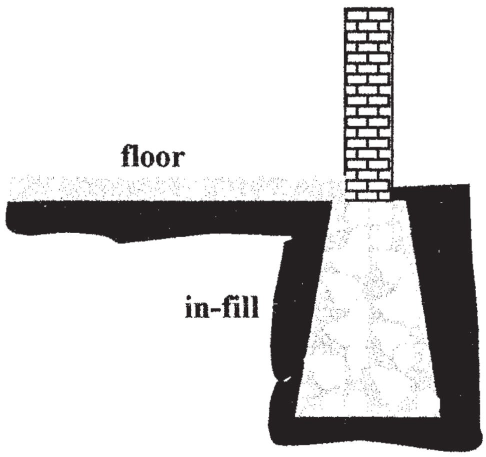

Fig. 2. The slab on-ground type foundation of Indonesian houses

6 Specification for termite management

All treatments should be conducted according to specifications of SNI (National Industrial Standard) issued by Ministry of Industrial and Trade and National Standard Agency (BSN)

6.1 Soil treatment

Current termite control in buildings is considered to be carried out in two distinct time phases.

6.1.1 Pre-construction termite control

Treatment of the building site before construction is the easiest, cheapest and most effective method for preventing termite invasion into the house after construction. The areas to be treated are shown in Figure 2. First **trenches** are treated with liquid termiticidal formulation at a rate 5 liters/m^2 and then **footings, in-fill** and **back-fill** along the inside of all internal and external walls should be treated at the rate 5 liters/m.

6.1.2 Post-construction termite control

Post-construction treatment is usually conducted by drilling holes in the floor, wall or other structural parts Floor slab along all external walls and along both sides of those internal (partition) walls, which pass through the slab gets first holes drilled for the later operation. The drilled holes should be located both inside and outside of the wall and should be 8-10 cm from the face of the wall and 40 cm apart from each other and 40-60 cm deep. Each hole should be injected with 5 liters of termiticidal fluid, using a sub-slab injector.

For outdoors application, trenches should be dug around the building until the foundation wall is exposed (but not below the toe of the footing). Trenches are about 20-30 cm wide and 40-60 cm deep. Flood the trench with fluid at the rate 5 liters/m to allow the fluid to run down the wall into the trench.

6.2 Wood treatment

Liquid termiticidal formulations are applied to the wood surface by brushing or spraying at a rate of 250 g/m^2. Requirements for penetration and retentions are varied with chemicals and application condition, when pressure treatment is applied.

Conclusion

In Indonesia, organochlorine insecticides have been proved sufficiently effective for soil treatment. Due to the long-term persistence of these insecticides, however, the public has become aware of environmental and human health risks. The use of organophosphates has resultantly been banned since 1993. Chlorinated hydrocarbons are banned in many developed countries and must be totally banned in other developing countries in the near future. All countries are now seeking for the safer chemicals or the more effective methods for termite management. Organophosphates and synthetic pyrethroids insecticides are the promising alternative compounds as termite control agents, because most of them have exceptionally high insecticidal activity, low mammalian toxicity and low environmental impact. More attention should be paid for the establishment of environmentally sound termite management in the near future, such as physical barrier and biological control.

References

Tarumingkeng, R.C. 1971. Biologi dan Pengendalian Rayap Perusak Kayu Indonesia. Lap. LPPK No 138. Bogor.

Dodi Nandika. 1999. Status bahaya serangan rayap pada bangunan gedung. Seminar Nasional. Pemantapan sistem pengendalian rayap pada bangunan gedung. Dep. PU dan IPPHAMI, Jakarta.

Tho, Y.P. 1992. Termites of Peninsular Malaysia. Edited by Laurence G. Kirton. Malayan Forest Records No. 36. Forest Research Institute Malaysia, Kuala Lumpur.

Edwards R. and A. E. Mill. 1986. Termites in Building. Their Biology and Control. Rentokil Limited.

Current Termite Management in Peninsular Malaysia

by

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Abstract

Subterranean termites are an important group of insect pests in the urban environment in Malaysia. Despite about 175 species of termites have been recorded in Peninsular Malaysia, only a handful of them are important insect pests to the urban environment. Control of this pest group accounted about 50% of total business turnover of the Malaysian pest control industry which chalked between US$10 – 12 million, and it is generally believed that the cost to repair the damage due to termite infestation could be 3 – 4 times higher than that of the control. About 70% of termite treatments were done on residential premises, 20% on industrial buildings, and another 10% on commercial complexes. The two most important structural termite species are *Coptotermes gestroi* and *Coptotermes curvignathus*. *C. curvignathus* usually attack houses built in areas where rubber trees (*Hevea brasilliensis*) were previously planted, while *C. gestroi* is mainly found in urban buildings. Other subterrenean and mound-building species that are found around living premises, urban gardens and parkland, but usually do not attack structures include *Schedorhinotermes* spp., *Macrotermes gilvus*, *Macrotermes carbonarius*, *Globitermes sulphureus*, *Microtermes pakistanicus*, *Microcerotermes spp.* and *Odontotermes* spp. Current control of subterranean termites in Malaysia rely heavily on pre- and post-construction soil treatments. Baiting is gaining popular, especially in middle to upper scale housing estates. Dusting is also commonly done in buildings. The ban of chlordane usage in 1999 as a soil termiticide has caused pest control operators to opt for organophosphate and pyrethroid insecticides.

Key words: subterranean termites, Malaysia, control strategies, baiting, pre- and post-construction treatment.

1. Introduction

Termites are an important group of insects. In Malaysia, they are pests in the urban, agricultural and forest environment (Dhanarajan 1969; Tho 1992). The study of termites in Malaysia was pioneered by Haviland (1898), followed by Bugnion (1913) who compiled a list of Indo-Malayan termites, and John (1925) on termites of Ceylon, Peninsular Malaysia, Sumatra and Java. Most of the early studies concentrated on basic information on termite taxonomy and biology. The introduction of rubber trees (*Hevea brasilliensis*) by the British, followed by mass planting of this crop, indirectly initiated the study of termites as a pest in Malaysia. It was in the early 1900s when termites became a serious pest of the rubber tree, that had led to a number of studies and observation on these pests (Bailey 1901, Corey 1902, Ridley 1909, Togwood 1909, Baker 1910, Beeley 1934). Many subsequent studies had dealt with termite taxonomy, and control of termites in agriculture and forestry. However, limited studies have been reported on termites attacking residential structures and buildings.

There has been a steady increase in the termite control business in Malaysia over the last 10 years. The cost of termite control and related services, which was estimated at US$5 million in 1995 (Yap & Lee 1996), increased to US$8 - 10 million in 2000 (Lee 2002). With the popularity of baiting in the last three years, it was estimated that current termite control business rakes between US$10 – 12 million per year (Su & Lee 2003). In terms of proportion, termite control and related services contributed to 50% of the total business turnover of the pest control industry in 1995 (Yap & Lee 1996), and increased to 50% in 2000.

2. Termite species recorded and economically important species

About 175 species of termites has been recorded in Peninsular Malaysia, covering a total of 42 genera (Tho 1992). In the urban and suburban environment, four species of *Coptotermes* were previously identified as important pests to the pest control industry, namely *C. travians*, *C. curvignathus*, *C. havilandi* and *C. kalshoveni* (Sajap & Wahab 1997; Lee 2002a). The first two are the most notorious species, readily attacking urban structures and buildings. Another species, *C. sepangensis* is usually found infesting suburban and rural structures. A preliminary study conducted in 1998 on the various premises (n = 32) serviced by pest control companies, indicated that 53% of the infestation in structures and buildings in central Peninsular Malaysia are due to *C. travians*, 28% by *C. curvignathus* and the remaining by the other three *Coptotermes* spp. and other species (Lee 2002a). *C. curvignathus* is also a serious pest in rubber and oil palm plantations. However, the recent revision by Kirton & Brown (2003) on the taxonomic status of pest species of *Coptotermes* in Southeast Asia reported that *C. gestroi* is the primary pest species of *Coptotermes* in Southeast Asia; *C. gestroi* has been misidentified in many literatures as *C. travians* while *C. travians* has been misidentified as *C. havilandi*. Thus, there is a serious need to conduct a new authoritative survey on the structural termite pest species in Peninsular Malaysia. A recent brief examination of 42 samples of *Coptotermes* species which were collected from Northern Peninsular Malaysia from my laboratory to Dr Laurence Kirton (Forest Research Institute Malaysia) found *Coptotermes gestroi* to be the predominant one, along with *Coptotermes curvignathus* (C.Y. Lee, unpublished).

In addition to the *Coptotermes* species, several other termite pests are also readily found along perimeters of buildings and structures, urban gardens and parklands. These include *Schedorhinotermes* spp., *M. gilvus*, *M. carbonarius*, *G. sulphureus*, *M. pakistanicus*, *Odontotermes* sp. and *Microcerotermes crassus*. Among these species, *M. gilvus*, *M. carbonarius* and *G. sulphureus* are mound-builders. Most of them attacked small wooden structures (eg. ladders, park benches, etc) and trees around the houses. There have been a few isolated cases of *M. gilvus* and *G. sulphureus* attacking residential wooden structures. *M. gilvus*, *G. sulphureus* and *M. pakistanicus* are also pests of rubber and oil palm plantations.

Termite infestation is a major problem to residential premises in Malaysia. This is clearly reflected in the fact that 65% of the pest control services provided for termite control were carried out in residential premises, compared to 20% in the industrial sectors (*e.g.* manufacturing plants, factories, warehouses, etc), 10% in commercial buildings (office complexes, shopping malls, etc) and 5% for other locations. One of the major reasons could be due to the use of ex-rubber and oil palm plantations for residential housing projects. Many of these plantations were cleared during the period when commodity prices for rubber and oil-palm were not satisfactory. Most of the time, the trunk of the trees were cut down, but the roots were left in the soil. This will sustain the food source to the *Coptotermes* sp. until the houses were completely built.

Table 1 showed the common locations of infestation of subterranean termites within buildings/structures in Malaysia. The data was based on information provided by 10 major pest control companies through their services over the period of two years (July 1998 – June 2000). A total of 124 structures/buildings were inspected. Door and window frames and parquet floors were found to be most prone to termite attack within the structures. These are also the locations where most householders would first detect the presence of termite infestation in their house. Another location, which is common to termite attack is the wood frame around the bathroom door where moisture is abundant.

Table 1 Common locations of infestation of structural subterranean termite pests (after Lee 2002a)

Location	% total infestation found
door/window frame	35
parquet/wooden floor	30
baseboard/skirting area	5
built-in wall cabinet	5
roof/ceiling	10
bathroom area	10
others	5

3. Termite management in Malaysia

Like most Southeast Asian countries, control strategies against subterranean termites in the urban environment in Malaysia rely heavily on the use of soil insecticides (Lee & Chung 2003). Basically, the usage of soil insecticides can be divided into pre- and post-construction treatments. A total of 48% of the total pest control business was done at pre-construction of the buildings, while the remaining was at the post-construction. Most of the post-construction treatment utilized dusting, trenching and corrective soil treatment.

A survey on 10 major pest control companies in the country indicated that 50% of the total post-construction treatment jobs comprise dusting and corrective soil treatment, followed by 30% using dusting only, and 20% using dusting and trenching (Lee 2002a). Arsenic trioxide is still heavily used for dusting, despite being an unregistered item in Malaysia. Since the banning of chlordane usage in 1999, chlorpyrifos-based products have dominated the termiticide market due to its lower cost. For chlorpyrifos usage, the generic compound produced by manufacturers in China is very popular among the pest control operators due to its low cost. Other termiticides that are gaining popularity include imidacloprid and fipronil.

Baiting by pest control operators against subterranean termites using hexaflumuron baits started in October 2000 in Malaysia. It is gaining popularity among the middle to upper class residential house owners. So far, good results have been registered against *Coptotermes* spp. Colony suppression or even elimination is usually achieved between 30 - 90 days upon baiting. Several papers had been published on the efficacy of hexaflumuron baits against *Coptotermes* spp. in Malaysia (Sajap et al. 2000; Lee 2002b).

Termiticide usage in Malaysia is governed by Pesticide Control Division, Ministry of Agriculture, Malaysia. Before a termiticide can be allowed for sale, it need to undergo registration with the governmental body.

At present, there are no physical barrier and biological control agent in use for control of termites in Malaysia.

4. Challenges to termite management

There are several major challenges to termite control in Malaysia. First, although current building legislation encourages building or housing developers to do pre-construction treatment, it is not compulsory. It is also not mandatory for them to engage professional services from pest control operators to conduct the treatment. Thus in order to save cost, many housing developers resorted to untrained workers to do the treatment.

Secondly, there is also a serious need to have more trained pest control operators. At present, pest control operators are not required to be licensed to perform their services. This means that none of the operators are required to undergo any examination or test to check their competency to conduct pest control operations. Several cases of mistreatment due to lack of knowledge of pest control operators had happened in the past. These included conducting corrective soil treatment for wood borer infestation, residual spraying on baseboard for termite control, and pouring cement slab onto the freshly treated soil without protective or plastic cover. However, it is anticipated that the upcoming amended Pesticide Control Act (Pesticide Control [amended] Act 2004) will require all pest control personnel to be licensed before they are allowed to practice.

Lastly, the incidence of peridomestic subterranean termite species infesting residential premises which had been previously treated for *Coptotermes* spp. using hexaflumuron baits had been regularly observed lately. Upon the suppression or elimination of the *Coptotermes* spp., species such as *Schedorhinotermes* spp. and *M. gilvus* were found in the house as early as two months later. This observation concurs with that reported earlier by Su et al. (1995) who found *Reticulitermes flavipes* invaded homes which had previously been baited for *C. formosanus*. They suggested that with the elimination of *C. formosanus*, *R. flavipes* was able to reclaim its former territory. However, compared to *R. flavipes* which can be successfully baited, it is very challenging to bait some of these species such as *M. gilvus* due to its poor response to paper-based bait matrix, and sensitive nature to disturbance from bait inspection. There is an urgent need to further understand the biology and behaviour of these least-known peridomestic species, so that proper pest management strategy can be designed and executed.

References

Bailey W.W. 1901. Report on the attack of white ants or termites – '*Termes gestroi*' on para rubber trees. Agricul. Bull. Straits Fed. Malay. States **1**: 27 – 29.

Baker C.A. 1910. Instruction to managers and assistants on rubber estates. Tree sanitation. White ants, '*Termes gestroi*'. Their detection and remedy. Agricul. Bull. Straits Fed. Malay. States **9**: 371 - 373.

Beeley F. 1934. Experiments in control of the termite pest of young rubber trees. J. Rubber Res. Inst. Malay. **5**: 160 – 175.

Bugnion E. 1913. Liste des termites indo-malais avec l'indication du nombre des articles des antennes dans les trois castes. Bull. Soc. Vaud. Sci. Natur. **49**: 165 – 172.

Corey E.V. 1902. White ants and rubber. Agricul. Bull. Straits Fed. Malay. States 1: 223 – 226.

Dhanarajan G. 1969. The termite fauna of Malaya and its economic significance. Malay. Forest. **32**: 274 – 278.

Haviland G.D. 1898. Observation on termites, with descriptions of new species. J. Linn. Soc. Zool. **26**: 358 – 442.

John O. 1925. Termiten von Ceylon, der Malayischen, Halbinsel, Sumatra, Java und der Aru Inseln. Treubia **6**: 360 – 419.

Kirton, L.G. & V.K. Brown. 2003. The taxonomic status of pest species of *Coptotermes* in Southeast Asia: Resolving the paradox in the pest status of the termites, *Coptotermes gestroi*, *C. havilandi* and *C. travians* (Isoptera: Rhinotermitidae). Sociobiology **42**: 43 – 63.

Lee C.Y.. 2002a. Subterranean termite pests and their control in the urban environment in Malaysia. Sociobiology **40**: 3 – 9.

Lee C.Y. 2002b. Control of foraging colonies of subterranean termites, Coptotermes travians (Isoptera: Rhinotermitidae) in Malaysia using hexaflumuron baits. Sociobiology 39: 411 – 416.

Lee C.Y. & K.M. Chung. 2003. Termites. *In* C.Y. Lee, J. Zairi, H.H. Yap & N.L. Chong, eds. Urban Pest Control – A Malaysian Perspective. Universiti Sains Malaysia Press, Penang, Malaysia. pp. 99 – 111.

Ridley H.N. 1909. Trees attacked by *Termes gestroi*. Agricul. Bull. Straits Fed. Malay. States **8**: 563 – 564.

Sajap A.S. & Y.A. Wahab. 1997. Termites from selected building premises in Selangor, Peninsular Malaysia. Malay. Forest. **60**: 203 – 215.

Sajap A.S., S. Amit & J. Welker. 2000. Evaluation of hexaflumuron for controlling the subterranean termite *Coptotermes curvignathus* (Isoptera: Rhinotermitidae) in Malaysia. J. Econ. Entomol. **93**: 429 – 433.

Su N.Y., E.M. Thoms, P.M. Ban & R.H. Scheffrahn. 1995. Monitoring/baiting station to detect and eliminate foraging populations of subterranean termites (Isoptera: Rhinotermitidae) near structures. J. Econ. Entomol. **88**: 932 – 936.

Su N.Y. & C.Y. Lee. 2003. A system approach for managing populations of subterranean termites near structures. *CropLife International*: In press.

Tho Y.P. 1992. Termites of Peninsular Malaysia. Malayan Forest Records No. 36: 1 – 224.

Togwood W. 1909. *Termes gestroi*. Agricul. Bull. Straits Fed. Malay. States **8**: 97 – 104.

Yap H.H. & C.Y. Lee. 1996. Current status of pest control industry in Malaysia. Malaysian Pest Control Seminar: Urban Pest Control for a healthier environment. Pest Control Association of Malaysia. Genting Highlands, Pahang, Malaysia. 22 – 23 March 1996.

Current Termite Management in Thailand

by

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Introduction

Termites are most significant social insects, which have an important place in the world economic. Apart from their famous role as the decomposer who provides the most efficient nutrient recycling within the forest ecosystem, termites are considered as the most detrimental pest to human properties especially items derived from cellulose materials.

In Thailand, termites particularly subterranean termites, are the most destructive pest of wooden houses and other structures as well as household utensils made of wood or wooden derivatives. Estimated economic loss caused by termites within the country each year during the past 5 years were around US$ 500 million inclusive of reconstruction and replacement of destructive wooden parts.

Soil treatment with chemicals has been applied conventionally to prevent invasion of subterranean termites into houses and buildings in Thailand since late 1950's. Wood treatment to protect wooden houses was not so common since construction timbers normally used in those days were mostly teak or other hardwood which are naturally highly durable to termite attack. Chlorinated hydrocarbons were the first group of termiticides used for soil treatment followed by organophosphates as represented by chlorpyrifos in most cases. Synthetic pyrethroids were introduced into the country for soil treatment around early 1990's and have been very common to date together with some new group of termiticide such as fipronil.

Termite management other than soil treatment such as baiting, physical barrier and biological control were experimental into some extent in Thailand in the late 1990's. Baiting is most successful as compared to other methods and is gaining much interest from many homeowners.

Distribution of termites and their role in the ecosystem

Survey and study on the distribution of termites within Thailand was reported for the first time in 1913 by Holmgren. In 1965 Ahmad published listed of 74 species and Morimoto in 1973 listed 90 species of termite distributed in Thailand. Results from accumulative surveys of Royal Forest Department, Thailand revealed the diversity of 153 species within the country (Vongkaluang *et al.*, 2004). *Coptotermes gestroi* Wasmann is the most economically important species accounting for approximately 95% of annual damage to houses and cellulose materials. Other species of *Coptotermes* such as *C. havilandi* and *C. kalshoveni* are detected sometimes as pests to wooden materials and construction as well (Sornnuwat, 1996). In local area *Microcerotermes crassus* and *Globitermes sulphureus* are found building their nests within or adjacent to thatches in villages in humid areas.

Most of the termites found in the forest except for *Coptotermes, Microcerotermes* and *Globitermes* are beneficial in terms of their activities that help recycling nutrients and enhancing organic matters of forest soil. Moreover, *Macrotermes*, *Microtermes*, *Hypotermes*, *Odontotermes* and *Ancistrotermes* are mushroom growers, cultivating and tending fungus combs in their nests and producing delicious and nutritious mushrooms that grow nowhere else on the earth in certain atmospheric conditions.

Economic importance of termites

Coptotermes gestroi Wasmann is the most destructive species to housing and building in urban area. Other species of *Coptotermes* such as *C. havilandi*, *C. kalshoveni* and *C. premrasmii* are sometimes found within the foraging territory of *C. gestroi* but much to the lesser extent. *Microcerotermes crassus* Snyder is the destructive species in the rural area attacking living complexes of villagers in almost every part of the country but of minor importance in southern part.

Economic loss caused mainly by termite *C. gestroi* accounted for over 90% of total loss by subterranean termites (Sornnuwat, 1996). Annual economic loss caused by termite was estimated at about US$ 2,200,000 in 1990 (Vongkaluang, 1990). To date the annual costs of preventing and controlling termite together with repairing of damage is calculated roughly at about US$ 0.5 billion.

Prevention and control of termite in Thailand

<u>Pre-construction treatment</u>: Pre-construction treatments by soil injection became common since late 1970's. Main chemicals used in the treatment at that time belonged to the chlorinated hydrocarbon group. Chlordane, dieldrin, aldrin and heptachlor were the termiticides used widely. The uses of these termiticides were totally banned in the year 2000. Organophosphates came as alternatives to the chlorinated hydrocarbons, that was, chlorpyrifos as the leading name in the termiticide lists. Synthetic pyrethroids have been recognized as more environmental safer since late 1990's and are widely used at present . Fipronil is now emerging as major competitor.

<u>Post-construction treatment</u>: Chemicals used for post-construction treatment for buildings have the same story as the pre-construction. The methods normally include soil injection and dusting of the termiticides as mentioned earlier.

Termite management other than using termiticides

Alternatives to the chemical control introduced into practices include baiting, physical barrier, biological control and use of treated or highly durable timber.

Bait system was introduced into Thailand in early 2000's and gained much popularity to premium market. The system works well to eradicate termite in building but reinfestation usually occurs after times, which suggests the continuous inspection of monitoring stations in the building for necessary re-baiting.

Physical barrier was experimented only within government premises using gravels of suitable sizes which stopped the invasion of *Coptotermes gestroi* (Vongkaluang *et al.*, 1999). The use of stainless steel mesh is now under investigation. No commercial products for physical barrier have appeared yet in PCO market in Thailand.

Biological control is not very well known to termite control measure in Thailand. Attempts had been made using insect pathogens such as fungi, bacteria and nematodes which are known to be effective in controlling agricultural pests, but the results in depth for reliable application are still inadequate.

Use of treated or highly durable timbers can protect the construction parts being eaten out by termite but cannot stop the invasion of termite into the building. Chemicals used for wood treatment are the same chemicals used for soil treatment. However, for structural timber and railroad ties, impregnation of wooden components with CCA has been used to enhance the durability of non-durable species after World War II.

Specification for termite management

Thailand Pest Control Association provides Code of Practice for termite control that is widely accepted by the public Food and Drugs Authority, Ministry of Public Welfare takes responsibility for controlling the use and registration of termiticides. However, there is no organization within the country governing the standardization on the method of application for termite management and control.

References

Somnuwat, Y. 1996. Studies on damage of construction caused by subterranean and its control in Thailand. Ph.D. Thesis, Kyoto University, Kyoto.

Vongkaluang, C. 1990. Review of insecticides used for the prevention of subterranean termite in Thailand. *Sociobiology* **17**:85-102.

Vongkaluang, C., Y. Sornnuwat and K. Chareonkrung. 1999. Comparative study on the Efficacy of Some Natural Rocks Bed as Termite Ground Tunneling Barrier for Research Development in Thailand (Bangkok)(in Thai).

Vongkaluang C., Y. Sornnuwat, K. Charoenkrung, K. Chaikuad, S. Chutibhapakorn, Y. Takematsu, T. Inoue and T. Kudo. 2004. Survey and Study on Termite Diversity in some National Parks of Thailand. Proceeding International Symposium Bio-recycle Research, Japan.

Current Termite Management in Australia
1. Hazard, detection, standards/regulatory bodies and preservation of wood and wood products

by

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1 Hazard and estimate of economic loss

Australia has a diverse termite fauna of approximately 370 species. It has representatives from five families in 41 genera: two in Termopsidae, eight in Kalotermitidae, five in Rhinotermitidae, 25 in Termitidae and a single species in the endemic Mastotermitidae (*Mastotermes darwiniensis*). At least three exotic "drywood" termites (*Cryptotermes*) are established in Australia. Only about 25 or so species of termites are considered economically-important as pests of trees and crops, timber-in-service, timber products and building and construction materials. Most of these species belong to the genera *Mastotermes, Coptotermes, Heterotermes, Schedorhinotermes, Nasutitermes* and *Cryptotermes*. Apart from *Cryptotermes*, all key pest species are subterranean termites. Species of *Coptotermes* are by far the most economically-important whereas *Mastotermes* is considered the most voracious. The cost of prevention and remedial treatment for timber-in-service in Australia has been estimated to be in excess of AUD$780 million per annum.

2 Termite hazard map

A recent Australia-wide survey of 5122 buildings looked at the influence of geographical location and building construction type on subsequent infestation by subterranean termites. The major finding of the survey was that termite infestation was directly related to age of construction and not construction type, thereby confirming some earlier results obtained in the 1970's for the City of Sydney. The survey also revealed that chemical treatment of soil and treatment of timbers were the most successful practices for the protection of buildings from termite infestation. Damage caused by termites inside buildings was more frequent in walls, flooring, house stumps, architraves, skirting boards, joists, bearers and window frames and less often in roofing timbers. One can estimate from the survey results that the rate of termite ingress into houses in Australia is approximately 1.5% per year. The survey data was used to create a tentative termite hazard map. This hazard map should not be seen as definitive, rather as a base for further surveys and research.

3 Detection

Nowadays in Australia, a variety of conventional and novel devices are used for detecting subterranean termite infestations in buildings. The more basic devices include probes (e.g. screwdrivers) or sharp instruments, drills, hammers, torches, stethoscopes and good eyesight. In addition, a more sophisticated device, the 'Donger Pest Probe' has been developed for tapping and sounding of suspect infested timbers. More recently, the use of moisture meters, borescopes, 'sniffer dogs', microwave detectors and thermal imaging cameras have enabled the location of concealed termite activity with little or no damage to the surrounding building structure and furnishings which is often associated with inspection. The moisture meter remains a popular tool for detecting areas of high timber moisture content that may indicate termite activity within. Borescopes assist in viewing often dark and inaccessible areas of concern, without the need to destroy or remove skirting boards, lining materials etc. There is also an increasing usage of borescopes in detecting and/or confirming the presence of termites and nests of termites in dead and live trees. Many of these detection devices are used in combination with each other to substantiate a termite infestation. For example, 'sniffer dogs' have a high rate of success in detecting termite infestation but they are not perfect. Hence, a borescope or other device may be used to confirm the actual presence of live termites. Two novel devices for the non-destructive evaluation of termite activity are now widely used in and outside of Australia, the Australian-designed microwave detector Termatrac® and a thermal imaging camera - TermiCam®. Termatrac® can detect movement of termites through timber, plasterboard, tiles, concrete and brick. The distributor of TermiCam® claims their thermal imaging device is quick and accurate in locating termite infestations and nests. Extensive trialing of this device is well underway. In 1998, Standards Australia published AS 4349.3-Inspection of Buildings (Timber pest inspections); in which the standard states the minimum acceptable requirements for visual inspection and reporting of the activity of timber pests (specifically subterranean and dampwood termites, borers of seasoned timber and wood decay fungi).

4 Standards/regulatory bodies

Late in 2000, Standards Australia published the long awaited set of three standards on Termite Management for whole-of-house protection (AS 3660.1, AS 3660.2 and AS 3660.3). Both AS 3660.1 and AS 3660.2 are revisions of previous standards. AS 3660.3 is a newly-written standard. These standards are intended for builders, building designers, regulatory authorities, termite management system manufacturers and installers, and indeed the consumer. AS 3660.1-2000 (New building work) is a performance-based standard that sets out requirements for site management, building practices and the design and installation of subterranean termite management systems for new buildings and ground level extensions. It includes provisions for both physical and chemical termite barriers, and other deemed-to-satisfy solutions, throughout mainland Australia. AS 3660.1 emphasises that the installation of a termite management system does not negate the need for regular competent inspections. AS 3660.2-2000

(Existing buildings and structures) provides guidelines on procedures for the detection, treatment and minimisation of subterranean termite activity in and around existing buildings and structures. The standard also includes steps to be followed to determine the extent of termite infestation in existing buildings, the type of treatment to control or eradicate termites, the use of termite-resistant materials, and methods for managing the risk of reinfestation by termites. AS 3660.3-2000 (Assessment criteria for termite management systems) specifies the criteria and procedures for assessing the effectiveness of termite management systems (i.e. whether or not a system meets the manufacturer's claims) intended for use in buildings and structures as required by AS 3660.1 or AS 3660.2. If satisfactory results are obtained, data on the performance of a termite management system (assessed in accordance with AS 3660.3) can then be used to seek national or state accreditation, i.e. approval to use. CSIRO Building Products and Systems Appraisals (CSIRO Appraisals) can assist manufacturers and distributors of new termite management systems gain acceptance by regulators and specifiers.

Buildings in Australia are constructed in accordance with the provisions of the Building Code of Australia (BCA). These provisions specify that all susceptible structural members of buildings be protected from damage by subterranean termites. If the materials and method of construction comply with Australian Standard AS 3660.1, the requirements of the BCA are satisfied. The use of other management systems (not specified in AS 3660.1) that will prevent damage to buildings by termites is also permitted in the BCA. The decision to accept these management systems that are not covered in AS 3660.1 is at the discretion of each local government council. Compliance with the BCA can be achieved by simply using termite-resistant materials for all structural components of a building, well short of the requirements of AS 3660.1. Termite-resistant materials, including a list of termite-resistant timbers and, reference to the use of preservative-treated timbers are given in AS 3660.1. If the structural components of a building are of termite susceptible materials, then a termite management system as specified in AS 3600.1 will be deemed-to-comply. However, the BCA only sets a minimum level of performance required to ensure safety and integrity of the building structure. Hence, individual states and local government authorities can invoke variations that are additional to the BCA requirements. Such is the case for the Northern Territory and, for the state of Queensland.

5 Preservation of wood and wood products

Another important standard that has implications for the management of termites is AS 1604.1-2000: Specification for preservative treatment - Sawn and round timber. The standard specifies requirements for the preservative treatment of sawn and round timbers that are to be protected from fungal decay, insect or marine borer attack for all exposure conditions throughout Australia. Four other standards on preservative treatments – AS 1604.2-2002: Reconstituted wood-based products, AS 1604.3-2002: Plywood, AS 1604.4-2002: Laminated veneer lumber (LVL), and AS 1604.5-2002: Glue laminated timber products – have now been published.

Copper-chromium-arsenate (CCA) salts are the most widely used wood preservatives in Australia. Light Organic Solvent Preservatives (LOSP's) are widely used for the treatment of finished wooden joinery, such as window joinery. LOSP's are based mainly on a white spirit solvent carrier in which a fungicide (tributyltin napthenate or a combination of azoles) and a synthetic pyrethroid insecticide (permethrin) are dissolved. High Temperature Creosote (HTC) and Pigmented Emulsifiable Creosote (PEC) are still used in certain niche industrial applications (vineyard posts, transmission poles etc). More recent developments include the approval of an envelope treatment system for softwood house framing and the use of a synthetic pyrethroid for the protection of engineered wood products from attack by termites. The envelope treatment system (Tanalith™ T) is only approved for use south of the Tropic of Capricorn in regions not inhabited by *Mastotermes darwiniensis*. Tanalith™ T treatment of softwood framing utilises a novel solvent that carries an insecticide to a depth of 5 mm, thereby creating a protective 'envelope' that is able to resist attack by termites. Bifenthrin is approved as an active in highly alkaline phenolic adhesives of LVL and plywood, commodities that are subsequently used for the construction of some engineered wood products such as I-joists.

CCA preservatives are now under review by the Australian Pesticides and Veterinary Medicines Authority (APVMA), particularly their use in certain domestic applications (decking, children's playground equipment etc). The trend to replace heavy metal preservatives containing chromium and arsenic with more environmentally-acceptable formulations is demonstrated in AS 1604.1 by the inclusion of the alternatives such as ammoniacal copper quaternary formulations (ACQ's) and copper azoles. Other chromium- and arsenic-free preservatives are sure to follow. Research on natural preservatives, such as essential oils extracted from termite-resistant timbers and plants, is progressing towards commercialisation. However, before approval and subsequent listing in AS 1604.1 each candidate preservative formulation (and indeed any candidate insecticide) must be registered by the APVMA. The registration process is based on satisfactory efficacy data and health and environmental considerations. The APVMA will consider favourably biocidal efficacy data on candidate formulations that have been obtained from both laboratory and field evaluations using the minimum procedures as specified in 'Protocols for Assessment of Wood Preservatives'- a publication of the Australasian Wood Preservation Committee (1997). In Queensland and New South Wales, State legislation regulates the quality assurance of preservative-treated timbers - the Timber Utilisation Marketing Act (TUMA) and the Timber Marketing Act (TMA), respectively.

References

Australasian Wood Preservation Committee, AWPC. (1997). *Protocols for the assessment of wood preservatives.* Australasian Wood Preservation Committee. Corporate Initiatives (Melbourne).

Australian Standard AS 4349.3-1998. " *Inspection of buildings: Part 3: Timber pest inspections.*" Standards Australia, Sydney, NSW, 1998.

Australian Standard AS 1604.1-2000. *"Specification for preservative treatment: Part 1: Sawn and round timber."* Standards Australia, Sydney, NSW, 2000.

Australian Standard AS 3660.1-2000. " *Termite management: Part 1: New building work.*" Standards Australia, Sydney, NSW, 2000.

Australian Standard AS 3660.2-2000. " *Termite management: Part 2: In and around existing buildings and structures – Guidelines.*" Standards Australia, Sydney, NSW, 2000.

Australian Standard AS 3660.3-2000. " *Termite management: Part 3: Assessment criteria for termite management systems.*" Standards Australia, Sydney, NSW, 2000.

Australian Standard AS 1604.2-2002. *"Specification for preservative treatment: Part 2: Reconstituted wood-based products."* Standards Australia, Sydney, NSW, 2002.

Australian Standard AS 1604.3-2002. *"Specification for preservative treatment: Part 3: Plywood."* Standards Australia, Sydney, NSW, 2002.

Australian Standard AS 1604.4-2002. *"Specification for preservative treatment: Part 4: Laminated veneer lumber (LVL)."* Standards Australia, Sydney, NSW, 2002.

Australian Standard AS 1604.5-2002. *"Specification for preservative treatment: Part 5: Glued laminated timber products."* Standards Australia, Sydney, NSW, 2002.

Cookson, L.J. and Trajstman, A. (2002). *Termite survey and hazard mapping.* CSIRO FFP Report No. 137. http:/www.ffp.csiro.au/wft/wpc/termmap/index.htm.

Current Termite Management in Australia
2. Physical, chemical and biological options

by

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Chemical soil barriers employing persistent organochlorine insecticides such as aldrin, dieldrin, chlordane and heptachlor, have been used for decades worldwide (including Australia) to deter subterranean termites from gaining concealed access to buildings and other structures. The same compounds, together with mirex, were also key termiticides for managing active termite infestations. These insecticides were withdrawn from the Australian market in 1995 when a number of alternative termite management options demonstrated their reliability and accessibility to consumers. Only mirex can still be used under special circumstances in geographically restricted areas of tropical Australia.

In 2004, a diverse range of alternative technologies for termite management is available in Australia. Several of the global termite management systems (TMS) are being used in Australia. Many other TMS are Australian-made and their manufacturers have either already achieved acceptance, or are seeking acceptance of their system in other parts of the world.

The main focus for Australian termite management is on: non-chemical preventive measures ('physical barriers'); methods permitting safer application of chemical barriers with more environmentally acceptable termiticides; and control of infestations in existing buildings through 'trap-and-treat', dusting and bait systems. The latter also includes the use of insect pathogens. The concept of 'building-out' termites also forms an integral part of the strategy to reduce the incidence of termite damage. This comprises measures such as: ensuring that the building site is less attractive to termites; appropriate design of buildings and adequate inspection of their structural elements whilst keeping termite biology in mind; and on-going site maintenance.

In detail, the TMS currently available to the consumer (or under development) include:

1 Physical barriers

(1) The oldest form of such a barrier, ***a combination of raising the floor of a house*** to a height where termites cannot reach the superstructure from the soil through free-standing galleries, ***and the use of metal sheeting*** ('ant caps', 'ant shields') between posts, piers or lower parts of walls and the superstructure.

(2) ***Perforated or solid sheet material barriers***: To date, the major TMS include stainless steel mesh ('termimesh' of smartbuild), flexible stainless steel sheets (Termite Tite) and marine grade aluminium (Alterm).

(3) ***Graded particle barriers***: To date, crushed stone ('graded granite termite barrier', Granitgard), and other materials currently under investigation.

(4) A ***concrete slab***, designed and formed to certain specifications ("engineered slab") that minimises cracking. Specific physical barriers are available to impede termite entry at joints and service penetrations in such a slab. For example, metal or graded stone 'pipe collars' either as part of the major TMS listed above, or as stand-alone protection systems (made from plastic or metal) for service penetrations. The latter are usually installed by plumbers, while only trained and accredited installers can place any component of the more comprehensive physical barrier systems.

The Australian Standard AS3660 – 1995 on termite management has given for the first time recognition that the concrete slab, if constructed according to certain standards, may form part of the barrier system allowed in new on-ground constructions. This has enabled the installation of most of the physical TMS as partial rather than complete barriers.

2 Chemical barriers

The major products among the liquid termiticides are:

(1) ***Chemical presence detected by termites*** (more or less repellent): Organophosphates: Chlorpyrifos ('Dursban') and generics (number of sources); synthetic pyrethroids: Bifenthrin ('Biflex'); α-cypermethrin.

(2) ***Chemical not detected by termites*** (non-repellent barriers): Imidacloprid ('Premise'), and Fipronil ('Termidor').

These formulations can be applied either directly to the soil or via a reticulation system (several Australian companies, such as Altis, Termguard, SlabSet, with specific systems).

(3) The chemical Deltamethrin, a synthetic pyrethroid, is applied in a carrier other than soil, a fibrous blanket, laminated between two sheets of plastic ('Kordon TMB'). The effectiveness of the product relies on the repellency of the Deltamethrin. Kordon TMB has a dual role: it also serves as the moisture membrane below the slab. Similar products are under development.

3 Management of active infestations, including biological options

A number of options are available:

(1) ***Restoration or establishment of physical or chemical soil barriers.*** This has been combined by one company with the application of ***insectpathogenic nematodes*** (*Steinernema carpocapsae*) to the termites 'trapped' inside the building.

(2) Direct ***treatment of nests***.

(3) ***Dusting***, stand-alone or with 'trap-and 'treat' systems: arsenic trioxide, triflumuron ('Intrigue'), and experimental spore formulations of the ***insectpathogenic fungus*** *Metarhizium anisopliae* (CSIRO Entomology; different companies).

(4) ***Bait systems*** with chitin synthesis inhibitors: Sentricon® and 'Exterra'; ***biological agents***: formulations of the fungus *Metarhizium anisopliae* under development, potential for nematodes.

(5) Various ***devices for termite aggregation and monitoring*** with or without an active bait toxicant.

In this context, it is worthwhile mentioning the continued use of the organochlorine mirex in baits against *Mastotermes darwiniensis* for protecting horticultural crop trees such as mango, and *Citrus*, in Australia's tropics: the Northern Territory; and parts of NW Western Australia. Mirex is targeted by the United Nations Environment Program (UNEP) in an international treaty for global reduction/elimination of persistent organic pollutants (POPs). While Australia has eliminated the use of other organochlorines in termite management, alternative actives to the use of mirex for the management of *Mastotermes* in baiting and aggregation devices are still under investigation.

4 Methods for assessing the efficacy of Termite Barrier Systems

Laboratory and field methods for determining the efficacy of termite management systems vary widely between countries and between laboratories within countries. The two CSIRO Termite Research laboratories in Canberra and Melbourne have developed a more uniform approach in their assessments, applying high volume termite pressure on the TMS. Due to the fact that several Australian pest species of termite build above-ground mounds in which the nest is located, the impact of dusts and bait systems on the entire colony can be successfully evaluated.

Reference

Australian Standard AS 3660.1-1995. *"Protection of buildings from subterranean termites: Part 1: New buildings."* Standards Australia, Sydney, NSW, 1995.

Appendices I
Questionnaire Survey

Summarized results of the questionnaire survey

	Australia	China	Indonesia	Japan	Korea	Malaysia	Philippines	Taiwan	Thailand	Vietnam
(1) Number of termite species recorded	*ca.* 370	476	179	21	1	164	54	17	153	115
(2a) Economic importance as urban pests	High	High	High	High	High	High	High	High	High	High
(2b) Economic importance as agricultural pests	Low	High	Low	Low	Low	High	Low	Low	Low	
(2c) Economic importance as forest pests	Low	Low	High	Low	Low	High	Low	Low	Low	Medium
(3) Most economically important termite species	*Coptotermes acinaciformis*, *C. frenchi*, *Mastotermes darwiniensis*	*Cryptotermes declivis*, *C. domesticus*, *Coptotermes formosanus*, *Reticulitermes flaviceps*, *R. chinensis*, *R. speratus*, *Odontotermes formosanus*, *O. hainanensis*, *Macrotermes barneyi*	*Coptotermes curvignathus*;, *Macrotermes gilvus*, *Schedorhinotermes javanicus*, *Crptotermes cynocephalus*	*Reticulitermes speratus*, *Coptotermes formosanus*	*Reticulitermes speratus*	*Coptotermes gestroi*	*Coptotermes vastator*; *Macrotermes gilvus*; *Microcerotermes los-banosensis*; *Nasutitermes luzonicus*; *Cryptotermes cyanocephalus*; *C. dudleyi*	*Coptotermes formosanus*, *Reticulitermes* spp.	*Coptotermes gestroi*	*Cryptotermes domesticus*; *Globitermes sulphureus*; 7 *Coptotermes* species; 14 *Macrotermes* species; 23 *Odontotermes* species; 2 *Hypotermes* species
(4) Annual economic loss estimate	AU$780 million	US$0.3 billion	US$200-300 million	US$0.8-1.0 billion	US$200 million	US$10-12 million	No data	No data	US$500 million	No data
(5) POP's use allowed	mirex	chlordane, mirex	No	No	No		No	mirex	No	No
(6a) Widely-used termiticides for soil treatment	bifenthrin imidacloprid fipronil chlorpyrifos	chlorfenapyr, bifenthrin, permethrin, fenobucarb, chlordane	phoxim chlorpyrifos pyrethroids imidacloprid fipronil chlorfenapyr	Imidaclopridb ifenthrin permethrin fenobucarb silafluofen chlorfenapyr	imidacloprid	chlorpyrifos imidacloprid fipronil	organo-phosphates	chlorpyrifos imidacloprid fipronil	fipronil pyrethoids fenobcarb chlorfenapyr	permethrin, arsenic trioxide fipronil deltamethrin chlorpyrifos
(6b) Termiticides for wood treatment by pressure impregnation	CCA; ACQ; Copper-azole; LOSP	CCA, ACQ	CCA; CCF	ACQ copper-azole	CCA; CCFZ; ACQ; copper-azole; CB-HDO; AAC	CCA			CCA	
(6c) Termiticides for the superficial treatment of wood	TanlithTM (a.i.: permethrin)	chlorfenapyr for glueline treatment	Same as those in (6a) + boric acid	Same as those in (6a)	chlorpyrifos phoxim		organo-phosphates pyrethroids	chlorpyrifos	cypermethrin alpha-cypermethrin	

	Australia	China	Indonesia	Japan	Korea	Malaysia	Philippines	Taiwan	Thailand	Vietnam
(7) Commercialization of physical barriers	Yes	No	No	Yes	No	No	No	No	No	No
(8) Commercialization of biological control	Yes	No	No	Yes	No	No	No	No	No	No
(9) Any government agency in charge of termite control	Yes Australian Pesticide and Veterinary Medicines Authority; Building Codes Board, Housing Department	Yes Ministry of Construction	Yes Pesticide Commission, Ministry of Agriculture of Indonesia; Ministry of Public Health	Yes Ministry of Land, Infra-structure and Transport of Japan	No	Yes Pesticide Control Division, Ministry of Agriculture	Yes Fertilizer and Pesticide Authority	Yes Environmental Protection Agency	Yes Ministry of Public Health	No
(10) Any industrial association of termite control operators	Yes Australian Environmental Pest Managers Association; Australian Pest Controllers Association	Yes Chinese Estate Management Association, Chinese Forestry Association	Yes Indonesia Pest Control Industry Association	Yes Ministry of Land, Infra-structure and Transport of Japan	No	No	Yes Pest Control Association of the Philippines; Phil. Extermination Association of the Philippines	Yes Chinese Pest Control Association	Yes Thailand Pest Control Association	No

Questionnaire

Name of country: Australia Respondent's name: Michael Lenz & Jim Creffield

(1) How many termite species recognized in your country? **Recorded species listed on a separate sheet of paper.**	As dry wood (furniture) termites: 5 As damp wood (forest) termite: 2 As subterranean (house) termites: *ca.* 20 Only species of economic importance given here and in list. Total termite fauna approx. 370 species
(2) How import are termites as pests in your country? Tick the appropriate box.	As urban pests ☑ high ☐ low As agricultural pests ☐ high ☑ low [higher in horticulture in parts of tropics] As forest pests ☐ high ☑ low
(3) List the most economically important termite species in you country?	*Coptotermes acinaciformis; C. frenchi* *Mastotermes darwiniensis*
(4) Estimate of economic loss caused by termites in your country?	Aus$ 780 million
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: Mirex only against *Mastotermes darwiniensis* in the Northern Territory and Western Australia (in the latter State only in agricultural situations) If no, when was the use of the chemicals banned (year): 1995 for all other organochlorines
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e.g.* superficial, pressure treatment, *etc.*).	As soil treatment termiticide(s): bifenthrin, imidacloprid, fipronil, chlorpyrifos (being phased out) As wood treatment termiticide(s): By pressure impregnation: copper-chromium-arsenate salts (CCA), copper azoles, ammoniacal copper quats (ACQ), Light Organic Solvent Preservatives (LOSP's) containing tributyltin napthenate or an azole plus permethrin. By dipping: Tanalith™ T (novel solvent plus permethrin); for softwoods only, in areas not inhabited by *M. darwiniensis*. By glueline addition: bifenthrin, deltamethrin (for panel and engineered wood products).
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	☑ Yes ☐ No If yes, please describe products. Termimesh (stainless steel mesh); Alterm (sheet of marine grade aluminium alloy); Termitet Tite (stainless steel sheet); Grantigard (2 types of size ranges of crushed granite: one type South, the other North of the Tropic of Capricorn); so-called "engineered" concrete slabs are recognized as part

	of a termite barrier system
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	☑Yes ☐No If yes, please describe products. To date only several small scale attempts to use nematodes or the fungus *Metharizium anisopliae*
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	☑Yes ☐No If yes, please give its name. Regulators: Australian Pesticides and Veterinary Medicines Authority (AVPMA) for chemical products; Australian Building Codes Board for non-chemical products; Housing Departments& local shires in each State for implementation
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	☑Yes ☐No If yes, please give its name. Australian Environmental Pest Managers Association (AEPMA) and Australian Pest Controllers Association (APCA).
(11) Give brief comments on the termite problems in your country	Termites are major pests in the built environment with key species in the genera *Coptotermes, Schedorhinotermes and Mastotermes*. The latter is also a major pest in tropical horticulture. A wide range of termite management systems is available and detailed in the national Australian Standard AS 3660 (2000) "Termite management". Parts 1, 2 and 3.

Questionnaire

Name of country: China　　　　　　　　　　　　　　　Respondent's name: Zhong Junhong

(1) How many termite species recorded in your country? **Recorded species listed on separate sheets of paper**	As dry wood (furniture) termites: 9 As damp wood (forest) termite: 56 As subterranean (house) termites: 411　Total: 476
(2) How important termites as pests in your country?	As urban pests ☑high ☐low As agricultural pests ☑high ☐low As forest pests ☐high ☑low
(3) List the most economically important termite species in you country?	*Cryptotermes declivis, C. domesticus* *Coptotermes formosanus,* *Reticulitermes flaviceps, R.. chinensis, R. . speratus* *Odontotermes formosanus, O. hainanensis* *Macrotermes barneyi*
(4) Estimate of economic loss caused by termites in your country?	US$0.3 billion/year
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: Chlordane, Mirex If no, when was the use of the chemicals banned (year): 2001 (chlordane)
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e.g.* superficial, pressure treatment, *etc.*).	As soil treatment termiticide(s): chlorfenapyr, bifenthrin, permethrin, fenobucarb and chlordane, As wood treatment termiticide(s): CCA and ACQ for pressure treatment, Chlorfenapyr used as a glueline treatment
(7) Are physical barrier such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	☐Yes ☑ No If yes, please describe products.
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	☐Yes ☑ No If yes, please describe products.
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	☑ Yes ☐No If yes, please give its name. Ministry of Construction
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	☑ Yes ☐No If yes, please give its name. Chinese Estate Management Association and Chinese Forestry Association

(11) Brief comments on the termite problems in your country	*Coptotermes formosanus* and three species of *Reticulitermes*, *R. flavicep*, *R. speratus*, *R. chinensis*, are the most important economic group of termites in China and cause damage to timbers in buildings, to synthetic materials, to underground cables, to living trees and to crops. In Guangdong Province and Hainan Island, the percentage of termite-infested hours is over 90%.Over 90% of river and reservoir dams of more than 15 years old in southern China are damaged by *Odontotermes or Macrotermes*. Mirex is one of the POPs and is not a registered insecticide, but commonly used for dam termite control in south China, so searching for an alternative to mirex is a pressing affair.

Questionnaire

Name of country: Indonesia Respondent's name: Sulaeman Yusuf

(1) How many termite species recognized in your country? **Recorded species listed on separate sheets of paper.**	As dry wood (furniture) termites: 4 As damp wood (forest) termite: 166 As subterranean (house) termites: 9
(2) How important termites as pests in your country? Tick the appropriate box.	As urban pests [√] high [ ] low As agricultural pests [ ] high [√] low As forest pests [√] high [ ] low
(3) List the most economically important termite species in you country?	*Coptotermes curvignathus* Holmgren (new *Coptotermes* sp. were also found in West Java, Sulawesi and Kalimantan) *Macrotermes gilvus* Hagen *Schedorhinotermes javanicus* Kemner *Cryptotermes cynocephalus* Light
(4) Estimate of economic loss caused by termites in your country?	USD 200-300 million/year
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: If no, when was the use of the chemicals banned (year): dieldrin, endrin, aldrin and heptachlor (1980); chlordane (1993)
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e.g.* superficial, pressure treatment, *etc.*).	As soil treatment termiticide(s): phoxim, chlorpyrifos, permethrin, cypermethrin, deltamethrin, alphamethrin, bifenthrin, fenvalerate, imidachloprid, fipronil, chlorfenapyr As wood treatment termiticide(s): the same as those listed above + boric acid for superficial treatment; copper-chrome-boron , copper-chrome- fluorine for pressure treatment Bait system: hexaflumuron
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	[ ] Yes [√] No If yes, please describe products.
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	[ ] Yes [√] No If yes, please describe products.
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	[√] Yes [ ] No If yes, please give its name. Pesticide Commission, Ministry of Agriculture of Indonesia for chemical approval; Ministry of Public Health for PCOs registration
(10) Is there an industry association of termite control operators in your country?	[√] Yes [ ] No If yes, please give its name. Indonesia Pest Control Industry Association (IPPHAMI)

Tick the appropriate box.	
(11) Give brief comments on the termite problems in your country.	*Coptotermes* sp., *Macrotermes gilvus* and other termite sp. (including drywood termites) account for approximately 60%, 30% and 10% of the total economic loss, respectively. The chemical treatment is still a primary mean of termite prevention and control.

Questionnaire

Name of country: Japan Respondent's name: Kunio Tsunoda

(1) How many termite species recorded in your country? Recorded species listed on a separate sheet of paper.	As dry wood (furniture) termites: 3 As damp wood (forest) termite: 15 As subterranean (house) termites: 3
(2) How important termites as pests in your country? Tick the appropriate box.	As urban pests ☑ high ☐ low As agricultural pests ☐ high ☑ low As forest pests ☐ high ☑ low
(3) List the most economically important termite species in you country?	*Reticulitermes speratus* (Kolbe) *Coptotermes formosanus* Shiraki
(4) Estimate of economic loss caused by termites in your country?	US$0.8~1.0 billion/year
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: If no, when was the use of the chemicals banned (year): chlordane (1986)
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e.g.* superficial, pressure treatment, *etc.*).	As soil treatment termiticide(s): imidacloprid, bifenthrin, permethrin, fenobucarb, silafluofen, chlorfenapyr As wood treatment termiticide(s): the same as those listed above for superficial treatment; ACQ and Copper Azole for pressure treatment
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	☑ Yes ☐ No If yes, please describe products. Termimesh (stainless steel mesh)
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	☑ Yes ☐ No If yes, please describe products. Bio-Blast (*Metarhizium anisopliae*, an entomogenous fungus)
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	☑ Yes ☐ No If yes, please give its name. Ministry of Land, Infrastructure and Transport of Japan
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	☑ Yes ☐ No If yes, please give its name. Japan Termite Control Association
(11) Brief comments on the termite problems in your country	*R.eticulitermes speratus* accounts for approximately 70 % of the total economic loss, and *Coptotermes formosanus* occupies the remaining part. A few scattered incidences of dry and damp wood termites have been reported. Less chemical or non-chemical termite management has been taking some market place, although chemical treatment is still a primary mean of termite prevention and control.

Questionnaire

Name of country: Korea — Respondent's name: Dong-heub Lee

(1) How many termite species recognized in your country?	As dry wood (furniture) termites: 0 As damp wood (forest) termite: 0 As subterranean (house) termites: 1 *Reticulitermes*, species not identified yet
(2) How important termites as pests in your country? Tick the appropriate box.	As urban pests [√] high low As agricultural pests high [√] low As forest pests high [√] low
(3) List the most economically important termite species in you country?	*Reticulitermes speratus*
(4) Estimate of economic loss caused by termites in your country?	US$200 million/year
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: If no, when was the use of the chemicals banned (year): chlordane (1990)
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e.g.* superficial, pressure treatment, *etc.*).	As soil treatment termiticide(s): imidacloprid As wood treatment termiticide(s): CCA, CCFZ, ACQ, CuAz, CB-HDO and ACC for pressure treatment; chlorpyrifos and phoxim for superficial treatment
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	Yes [√] No If yes, please describe products.
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	Yes [√] No If yes, please describe products.
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	Yes [√] No If yes, please give its name.
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	Yes [√] No If yes, please give its name.
(11) Give brief comments on the termite problems in your country	Termites have been causing serious damage to wooden cultural properties especially in southern parts of Korea, and public concern about termite management has been increasing to protect houses in recent years.

Questionnaire

Name of country: Malaysia　　　　Respondent's name: Chow-Yang Lee

(1) How many termite species recognized in your country? **Recorded species listed on separate sheets of paper.**	As dry wood (furniture) termites: As damp wood (forest) termite: As subterranean (house) termites:
(2) How important termites as pests in your country? Tick the appropriate box.	As urban pests ☑ high ☐ low As agricultural pests ☑ high ☐ low As forest pests ☑ high ☐ low
(3) List the most economically important termite species in you country?	*Coptotermes gestroi*
(4) Estimate of economic loss caused by termites in your country?	US$ 10 – 12 million
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: If no, when was the use of the chemicals banned (year):
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e.g.* superficial, pressure treatment, *etc.*).	As soil treatment termiticide(s): chlorpyrifos, imidacloprid, fipronil As wood treatment termiticide(s): CCA
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	☐ Yes ☑ No　If yes, please describe products.
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	☐ Yes ☑ No　If yes, please describe products.
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	☑ Yes ☐ No　If yes, please give its name. Pesticide Control Division, Ministry of Agriculture
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	☐ Yes ☑ No　If yes, please give its name. However, we do have a general pest control association – Pest Control Association of Malaysia
(11) Give brief comments on the termite problems in your country	Termite control is the most important service offered by pest control operators in Malaysia. It accounted about 50% of the total business turnover of the industry.

Questionnaire

Name of Country: Philippines   Respondents' names: Carlos Garcia & Magdalena Giron

(1) How many termite species recognized in your country? **Recorded species listed on separate sheets of paper**	As dry wood (furniture) termites: 2 As damp wood (forest) termites: 12 As subterranean (house) termites: 4 Unspecified : 36
(2) How important termites as pests in your country? Tick the appropriate box.	As urban pests [√] high [ ] low As agricultural pests [ ] high [√] low As forest pests [ ] high [√] low
(3) List the most economically important termite species in your country?	(1)Subterranean termites (*Coptotermes vastator* Light, *Macrotermes gilvus* Hagen, *Microcerotermes los-bañosensis* Oshima and *Nasutitermes luzonicus* Oshima (2)Drywood termites (*Cryptotermes cyanocephalus* Light and *C. dudleyi* Banks
(4) Estimate of economic loss caused by termites in your country?	No benchmark information on the economic loss due to termite's infestation.
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: None If no, when was the use of the chemicals banned (year): 1991
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (e.g. superficial, pressure treatment, etc.)	As soil treatment termiticide(s): organophosphates As wood termiticides(s): pyrethroids and organophosphates commonly applied by brushing and spraying as superficial treatment
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	[ ]Yes [√]No If yes, please describe products
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	[ ]Yes [√]No If yes, please describe products.
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	[√]Yes [ ] No If yes, please give its name. Fertilizer and Pesticide Authority (FPA) – not directly involved in termite control, regulatory body only on pesticides use and registration.
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	[√]Yes [ ]No If yes, please give its name PCAP – Pest Control Association of the Philippines PEAP – Phil. Extermination Association of the Philippines
(11) Give brief comments on the termite problems in your country.	Termite infestation is still a serious problem. No benchmark information to estimate economic losses due to termites. Method of control is mainly by chemical application. The pest status of dampwood termites as forest pests becoming an urban pest is speculated.

Questionnaire

Name of country: Taiwan Respondent's name: Tsai, Chun-Chun

(1) How many termite species recognized in your country? **Recorded species listed on a separate sheet of paper.**	As dry wood (furniture) termites: 5 As damp wood (forest) termite: 8 As subterranean (house) termites:3 One species not specified
(2) How important termites as pests in your country? Tick the appropriate box.	As urban pests [√] high [ ] low As agricultural pests [ ] high [√] low As forest pests [ ] high [√] low
(3) List the most economically important termite species in you country?	*Coptotermes formosanus* *Reticulitermes* spp.
(4) Estimate of economic loss caused by termites in your country?	No official report so far
(5) Is the use of aldrin, endrin, chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country?	If yes, which chemical(s) is still used: mirex If no, when was the use of the chemicals banned (year): Aldrin (2 May 1989); Endrin (2 May 1989); Chlordane (24 June 1988); Dieldrin (2 May 1989); Heptachlor (2 May 1989)
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e.g.* superficial, pressure treatment, *etc.*).	As soil treatment termiticide(s): Chlorpyrifos, imidacloprid, fipronil, As wood treatment termiticide(s): Chlorpyrifos
(7) Are physical barrier such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	[ ] Yes [√] No If yes, please describe products.
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	[ ] Yes [√] No If yes, please describe products.
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	[√] Yes [ ] No If yes, please give its name. Environmental Protection Administration
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	[√] Yes [ ] No If yes, please give its name. Chinese Pest Control Association (CPCA)
(11) Give brief comments on the termite problems in your country	More serious in urban area than in forest. Need to develop more advanced techniques or low polluted methods to control termites.

Questionnaire

Name of country: Thailand　　　　Respondent's name: Charunee Vongkaluang

(1) How many termite species recognized in your country? Recorded species listed on separate sheets of paper. 153 species	As dry wood (furniture) termites. As damp wood (forest) termite: As subterranean (house) termites:
(2) How important termite as pest in your country? Tick the appropriate box.	As urban pests ☑ high ☐ low As agriculture pests ☐ high ☑ low As forest pests ☐ high ☑ low
(3) List the most economically important termite species in your country?	*Coptotermes gestroi* Wasmann
(4) Estimate of economic loss caused by termites in your country?	US$ 0.5 billion/year
(5) Is the use of aldrin, endrin, Chlordane, dieldrin, heptachlor or mirex allowed for termite control in your country? No.	If yes, which chemical(s) is still used: If no, when was the use of the chemicals banned (year): 2000
(6) Which chemical(s) is widely used for termite control in your country? If it is common practice to use chemicals to protect wood from termite attack, give treatment method (*e g.* superficial, pressure treatment, *etc.*) superficial, pressure treatment	As soil treatment termiticide(s): Fipronil, Chlorpyrifos, Alphacypermethrin, Cypermethrin, Fenobucarb, Chlorfenapur As wood treatment termiticide(s): Cypermethrin and Alphacypermethrin for superficial. CCA for pressure treatment.
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country? Tick the appropriate box.	☐ Yes ☑ No　If yes, please describe products.
(8) Is biological control commercialized for termite control in your country? Tick the appropriate box.	☐ Yes ☑ No　If yes, please describe products.
(9) Is there a government agency in charge of termite control in your country? Tick the appropriate box.	☑ Yes ☐ No　If yes, please give its name. Ministry of Public Health.
(10) Is there an industry association of termite control operators in your country? Tick the appropriate box.	☑ Yes ☐ No　If yes, please describe products. Thailand Pest Control Association
(11) Give brief comments on the termite problems in your country.	*Coptotermes gestroi* is the most economically important termite species in Thailand. Estimate economic loss caused by this termite species account for 95% of total loss caused by termite every year. *Microcerotermes* and *Globitermes sulphureus* sometimes attacking wooden house in local area, usually in the farmland. Many species of the family Termitidae which thrive in the forest are beneficial because of their involvement in the production of termite mushroom which are delicious and expensive.

Questionnaire

Name of country: Vietnam Respondent's name: Vu van Tuyen

(1) How many species of termite recorded in your country **Recorded termite species listed on separate sheets of paper**	Investigation has not been accomplished yet; up to the date 115 species recorded
(2) How important termites as pests in your country?	As dike and dam pest : high As construction pest :high As living trees pest: medium
(3) List of the most important termite species in your country?	*Cryptotermes domesticus, Globitermes sulphureus* ;all 7 species of *Coptotermes* ;all 14 species of *Macrotermes* ; all 23 species of *Odontotermes* and 2 species of *Hypotermes*
(4) Estimate of economic loss	Economic loss not estimated yet
(5) Is the use of aldrin, chlordane, eldrin, dieldrin, heptachlor or mirex allowed for termites control in your country?	No. The use of these chemicals banned around 1990
(6) Which chemicals are widely used for termite control in your country?	Permethrin, arsenic trioxyde, fippronil, deltamethrin, chlorpyrifos
(7) Are physical barriers such as gravels and stainless steel mesh commercialized for termite control in your country?	No
(8) Is biological control commercialized for termite control in your country?	The study on using entomogenous fungi has been carried out but not developed widely
(9) Is there a government agency in charge of termite control in your country?	No .There is no governmental agency that manages the termite control work of different termite control organizations.
(10) Is there an industry association of termite control operators in your country?	No
(11) Brief comments on the termite problems in your country	The general investigations on termites in Vietnam are not accomplished due to long time of war. Very little of research on termites in living trees has been carried out. Chemical treatment is still a primary mean of termite prevention and control .New technology of termite control is requested.

Appendices II

List of termites in each country

Australian main pest species of termite

Family	Species	Remarks
Mastotermitidae (1)*	*Mastotermes darwiniensis* Froggatt	Subterranean termite, buildings, horticulture, agriculture
Termopsidae (5)	*Porotermes adamsoni* (Froggatt)	Damp wood termite, forests
Kalotermitidae (34)	*Cryptotermes brevis* (Walker)	Dry wood termite, buildings
	Cryptotermes cynocephalus Light	Dry wood termite, buildings
	Cryptotermes domesticus (Haviland)	Dry wood termite, buildings
	Cryptotermes dudleyi Banks	Dry wood termite, buildings
	Cryptotermes primus (Hill)	Dry wood termite, buildings
	Glyptotermes brevicornis Froggatt	Dampwood termite, forests
	Glyptotermes tuberculatus Froggatt	Dampwood termite, forests
	Neotermes insularis (Walker)	Damp wood termite, forests
Rhinotermitidae (25)	*Coptotermes a. acinaciformis* (Froggatt)	Subterranean termite, buildings, forests
	Coptotermes acinaciformis raffrayi Wasmann	Subterranean termite, buildings
	Coptotermes frenchi Hill	Subterranean termite, buildings, forests
	Coptotermes michaelseni Silvestri	Subterranean termite, buildings
	Heterotermes ferox (Froggatt)	Subterranean termite, buildings
	Heterotermes vagus (Hill)	Subterranean termite, buildings
	Heterotermes validus Hill	Subterranean termite, buildings
	Heterotermes venustus (Hill)	Subterranean termite, buildings
	Schedorhinotermes actuosus (Hill)	Subterranean termite, buildings
	Schedorhinotermes breinli (Hill)	Subterranean termite, buildings
	Schedorhinotermes intermedius (Brauer)	Subterranean termite, buildings
	Schedorhinotermes seclusus (Hill)	Subterranean termite, buildings
Termitidae (197)	*Nasutitermes exitiosus* (Hill)	Subterranean termite, buildings
	Nasutitermes graveolus (Hill)	Subterranean termite, buildings
	Nasutitermes walkeri (Hill)	Subterranean termite, buildings
	Microcerotermes sp.	Subterranean termite, buildings

*** In brackets: Number of species listed and with distribution map in:** J.A.L. WATSON & H.M. ABBEY (1993): ***Atlas of Australian Termites.*** Melbourne & Canberra: Commonwealth Scientific and Industrial Research Organisation, 158 pp. Total Australian termite fauna: ca. 370 species.

Termite species recorded in China

Family	Species	Remarks
Hodotermitidae	*Hodotermopsis sjostedti*	Forest pests, damp wood termite
Kalotermitidae	*Cryptotermes angustinotus*	Dry wood termite
	Cryptotermes declivis	Urban pests, dry wood termite
	Cryptotermes domesticus	Urban pests, dry wood termite
	Cryptotermes dudleyi	Dry wood termite
	Cryptotermes hainanensis	Dry wood termite
	Cryptotermes havilandi	Dry wood termite
	Cryptotermes luodianis	Dry wood termite
	Cryptotermes pingyangensis	Dry wood termite
	Kalotermes inamurae	Forest pests, damp wood termite
	Incisitermes minor	Dry wood termite
	Glyptotermes angustithorax	Forest pests, damp wood termite
	Glyptotermes baliochilus	Forest pests, damp wood termite
	Glyptotermes bimaculifrons	Forest pests, damp wood termite
	Glyptotermes brachythorax	Forest pests, damp wood termite
	Glyptotermes chinpingensis	Forest pests, damp wood termite
	Glyptotermes curticeps	Forest pests, damp wood termite
	Glyptotermes daiyunensis	Forest pests, damp wood termite
	Glyptotermes daweishanensis	Forest pests, damp wood termite
	Glyptotermes emei	Forest pests, damp wood termite
	Glyptotermes euryceps	Forest pests, damp wood termite
	Glyptotermes ficus	Forest pests, damp wood termite
	Glyptotermes fuscus	Forest pests, damp wood termite
	Glyptotermes fujianensis	Forest pests, damp wood termite
	Glyptotermes guizhouensis	Forest pests, damp wood termite
	Glyptotermes hejiangensis	Forest pests, damp wood termite
	Glyptotermes Hesperus	Forest pests, damp wood termite
	Glyptotermes ingyunensis	Forest pests, damp wood termite
	Glyptotermes latithorax	Forest pests, damp wood termite
	Glyptotermes liangshanensis	Forest pests, damp wood termite
	Glyptotermes limulingensis	Forest pests, damp wood termite
	Glyptotermes longnanensis	Forest pests, damp wood termite
	Glyptotermes maculifrons	Forest pests, damp wood termite
	Glyptotermes magnioculus	Forest pests, damp wood termite
	Glyptotermes mandibulicinus	Forest pests, damp wood termite
	Glyptotermes nadaensis	Forest pests, damp wood termite
	Glyptotermes orthognathus	Forest pests, damp wood termite
	Glyptotermes parvus	Forest pests, damp wood termite
	Glyptotermes satsumensis	Forest pests, damp wood termite
	Glyptotermes shanxiensis	Forest pests, damp wood termite

Kalotermitidae	*Glyptotermes simaoensis*	Forest pests, damp wood termite
	Glyptotermes succineus	Forest pests, damp wood termite
	Glyptotermes tsaii	Forest pests, damp wood termite
	Glyptotermes xiamenensis	Forest pests, damp wood termite
	Glyptotermes yingdeensis	Forest pests, damp wood termite
	Glyptotermes yui	Forest pests, damp wood termite
	Glyptotermes zhaoi	Forest pests, damp wood termite
	Neotermes amplilabralis	Forest pests, damp wood termite
	Neotermes angustigulus	Forest pests, damp wood termite
	Neotermes binovatus	Forest pests, damp wood termite
	Neotermes brachynotus	Forest pests, damp wood termite
	Neotermes dolichognathus	Forest pests, damp wood termite
	Neotermes dubiocalcaratus	Forest pests, damp wood termite
	Neotermes fujianensis	Forest pests, damp wood termite
	Neotermes fovefrons	Forest pests, damp wood termite
	Neotermes humilis	Forest pests, damp wood termite
	Neotermes koshunensis	Forest pests, damp wood termite
	Neotermes longiceps	Forest pests, damp wood termite
	Neotermes miracapitalis	Forest pests, damp wood termite
	Neotermes sinensis	Forest pests, damp wood termite
	Neotermes sphenocephalus	Forest pests, damp wood termite
	Neotermes taishanensis	Forest pests, damp wood termite
	Neotermes tuberogulus	Forest pests, damp wood termite
	Neotermes undulatus	Forest pests, damp wood termite
	Neotermes yunnanensis	Forest pests, damp wood termite
Rhinotermitidae	*Prorhinotermes hainanensis*	Subterranean termite
	Prorhinotermes japonicus	Subterranean termite
	Prorhinotermes spectabilis	Subterranean termite
	Prorhinotermes xishaensis	Subterranean termite
	Parrhinotermes khasii	Subterranean termite
	Parrhinotermes ruiliensis	Subterranean termite
	Schedorhinotermes fortignathus	Subterranean termite
	Schedorhinotermes ganlanbaensis	Subterranean termite
	Schedorhinotermes insolitus	Subterranean termite
	Schedorhinotermes magnus	Subterranean termite
	Schedorhinotermes pyricephalus	Subterranean termite
	Coptotermes bannaensis	Subterranean termite
	Coptotermes changtaiensis	Subterranean termite
	Coptotermes chaoxianensis	Subterranean termite
	Coptotermes cochlearus	Subterranean termite
	Coptotermes cyclocoryphus	Subterranean termite
	Coptotermes dimorphus	Subterranean termite
	Coptotermes formosanus	Urban pests, subterranean termite

Rhinotermitidae	*Coptotermes gestroi*	Subterranean termite
	Coptotermes grandis	Subterranean termite
	Coptotermes guangdongensis	Urban pests, subterranean termite
	Coptotermes guizhouensis	Subterranean termite
	Coptotermes gulangyuensis	Subterranean termite
	Coptotermes hainanensis	Subterranean termite
	Coptotermes hekouensis	Subterranean termite
	Coptotermes longignathus	Subterranean termite
	Coptotermes longistrialus	Subterranean termite
	Coptotermes melanoistriatus	Subterranean termite
	Coptotermes monosetosus	Subterranean termite
	Coptotermes obliquus	Subterranean termite
	Coptotermes ochraceus	Subterranean termite
	Coptotermes shanghaiensis	Urban pests, subterranean termite
	Coptotermes suzhouensis	Urban pests, subterranean termite
	Coptotermes varicapitatus	Subterranean termite
	Coptotermes yaxianensis	Subterranean termite
	Reticulitermes aculabialis	Subterranean termite
	Reticulitermes ampliceps	Subterranean termite
	Reticulitermes angustatus	Subterranean termite
	Reticulitermes bicristaus	Subterranean termite
	Reticulitermes brachygnathus	Subterranean termite
	Reticulitermes chinensis	Urban pests, subterranean termite
	Reticulitermes choui	Subterranean termite
	Reticulitermes chrysens	Subterranean termite
	Reticulitermes citrinus	Subterranean termite
	Reticulitermes coelceps	Subterranean termite
	Reticulitermes conus	Subterranean termite
	Reticulitermes curticeps	Subterranean termite
	Reticulitermes dabieshanensis	Subterranean termite
	Reticulitermes davongensis	Subterranean termite
	Reticulitermes emei	Subterranean termite
	Reticulitermes fengduensis	Subterranean termite
	Reticulitermes gaoshi	Subterranean termite
	Reticulitermes gaoyaoensis	Subterranean termite
	Reticulitermes guiyangensis	Subterranean termite
	Reticulitermes hainanensis	Subterranean termite
	Reticulitermes hubeiensis	Subterranean termite
	Reticulitermes hunanensis	Subterranean termite
	Reticulitermes labralis	Subterranean termite
	Reticulitermes largus	Subterranean termite
	Reticulitermes latilabrum	Subterranean termite
	Reticulitermes leiboensis	Subterranean termite

Rhinotermitidae	*Reticulitermes leigongshanensis*	Subterranean termite
	Reticulitermes leptogulus	Subterranean termite
	Reticulitermes leptomandibularis	Subterranean termite
	Reticulitermes levatoriceps	Subterranean termite
	Reticulitermes luofunicus	Subterranean termite
	Reticulitermes majiangensis	Subterranean termite
	Reticulitermes maopingensis	Subterranean termite
	Reticulitermes mirogulus	Subterranean termite
	Reticulitermes nanjiangensis	Subterranean termite
	Reticulitermes neochinensis	Subterranean termite
	Reticulitermes paralucifugus	Subterranean termite
	Reticulitermes parvus	Subterranean termite
	Reticulitermes perangustus	Subterranean termite
	Reticulitermes perilabralis	Subterranean termite
	Reticulitermes perilucifugus	Subterranean termite
	Reticulitermes planifrons	Subterranean termite
	Reticulitermes planimentus	Subterranean termite
	Reticulitermes pseudaculabialis	Subterranean termite
	Reticulitermes qingjiangensis	Subterranean termite
	Reticulitermes rectis	Subterranean termite
	Reticulitermes setosus	Subterranean termite
	Reticulitermes solidimandibulas	Subterranean termite
	Reticulitermes subhgulosus	Subterranean termite
	Reticulitermes tianpingshanensis	Subterranean termite
	Reticulitermes tibetenus	Subterranean termite
	Reticulitermes tricholabralis	Subterranean termite
	Reticulitermes xingshanensis	Subterranean termite
	Reticulitermes yinae	Subterranean termite
	Reticulitermes yunsiensis	Subterranean termite
	Reticulitermes affinis	Urban pests, subterranean termite
	Reticulitermes altus	Subterranean termite
	Reticulitermes angusticephalus	Subterranean termite
	Reticulitermes assamensis	Subterranean termite
	Reticulitermes aurantius	Subterranean termite
	Reticulitermes bitumulus	Subterranean termite
	Reticulitermes cancrifemuris	Subterranean termite
	Reticulitermes castanus	Subterranean termite
	Reticulitermes cymbidii	Subterranean termite
	Reticulitermes dantuensis	Subterranean termite
	Reticulitermes dichrous	Subterranean termite
	Reticulitermes flaviceps	Urban pests, subterranean termite
	Reticulitermes fukienensis	Urban pests, subterranean termite
	Reticulitermes fulvimarginalis	Subterranean termite

Rhinotermitidae	*Reticulitermes grandis*	Subterranean termite
	Reticulitermes guangzhouensis	Urban pests, subterranean termite
	Reticulitermes guilinensis	Subterranean termite
	Reticulitermes guizhouensis	Subterranean termite
	Reticulitermes gulinensis	Subterranean termite
	Reticulitermes huapingensis	Subterranean termite
	Reticulitermes hypsofrons	Subterranean termite
	Reticulitermes jiangchengensis	Subterranean termite
	Reticulitermes lii	Subterranean termite
	Reticulitermes lingulatus	Subterranean termite
	Reticulitermes longigulus	Subterranean termite
	Reticulitermes longipennis	Subterranean termite
	Reticulitermes microcephalus	Subterranean termite
	Reticulitermes minutus	Subterranean termite
	Reticulitermes mirus	Subterranean termite
	Reticulitermes ovatilabrum	Subterranean termite
	Reticulitermes periflaviceps	Subterranean termite
	Reticulitermes pingjiangensis	Subterranean termite
	Reticulitermes speratus	Urban pests, subterranean termite
	Reticulitermes sylvestris	Subterranean termite
	Reticulitermes trichocephalus	Subterranean termite
	Reticulitermes trichothorax	Subterranean termite
	Reticulitermes tricolorus	Subterranean termite
	Reticulitermes wuganensis	Subterranean termite
	Reticulitermes wugongensis	Subterranean termite
	Reticulitermes wuyishanensis	Subterranean termite
	Reticulitermes xingyiensis	Subterranean termite
	Reticulitermes yizhangensis	Subterranean termite
	Reticulitermes yongdingensis	Subterranean termite
	Reticulitermes zhaoi	Subterranean termite
	Reticulitermes ancyleus	Subterranean termite
	Reticulitermes brevicurvatus	Subterranean termite
	Reticulitermes chayuensis	Subterranean termite
	Reticulitermes croceus	Subterranean termite
	Reticulitermes curatus	Subterranean termite
	Reticulitermes dinghuensis	Subterranean termite
	Reticulitermes lianchengensis	Subterranean termite
	Reticulitermes longicephalus	Subterranean termite
	Reticulitermes qingdaoensis	Subterranean termite
	Reticulitermes sublongicapitatus	Subterranean termite
	Reticulitermes testudineus	Subterranean termite
	Reticulitermes translucens	Subterranean termite
	Tsaitermes ampliceps	Subterranean termite

Rhinotermitidae	*Tsaitermes hunanensis*	Subterranean termite
	Tsaitermes mangshanensis	Subterranean termite
	Tsaitermes oocephalus	Subterranean termite
	Tsaitermes oreophilus	Subterranean termite
	Tsaitermes yindeensis	Subterranean termite
	Styloterme acrofrons	Subterranean termite
	Styloterme alpinus	Subterranean termite
	Styloterme angustignathus	Subterranean termite
	Stylotermes changtingensis	Subterranean termite
	Stylotermes chengduensis	Subterranean termite
	Stylotermes chongqingensis	Subterranean termite
	Stylotermes choui	Subterranean termite
	Stylotermes crinis	Subterranean termite
	Stylotermes curvatus	Subterranean termite
	Stylotermes fontanellus	Subterranean termite
	Stylotermes guiyangensis	Subterranean termite
	Stylotermes hanyuanicus	Subterranean termite
	Stylotermes inclinatus	Subterranean termite
	Stylotermes jinyunicus	Subterranean termite
	Stylotermes labralis	Subterranean termite
	Stylotermes laticrus	Subterranean termite
	Stylotermeslatilabrum	Subterranean termite
	Stylotermes latipedunculus	Subterranean termite
	Stylotermes lianpingenesis	Subterranean termite
	Stylotermes longignathus	Subterranean termite
	Stylotermes mecocephalus	Subterranean termite
	Stylotermes mirabilis	Subterranean termite
	Stylotermes orthognathus	Subterranean termite
	Stylotermes planifrons	Subterranean termite
	Stylotermes robustus	Subterranean termite
	Stylotermes setosus	Subterranean termite
	Stylotermes sinensis	Subterranean termite
	Stylotermes sui	Subterranean termite
	Stylotermes triplanus	Subterranean termite
	Stylotermes tsaii	Subterranean termite
	Stylotermes undulatus	Subterranean termite
	Stylotermes valvules	Subterranean termite
	Stylotermes wuyinicus	Subterranean termite
	Stylotermes xichangensis	Subterranean termite
Termitidae	*Microcerotermes crassus*	Subterranean termite
	Microcerotermes marilimbus	Subterranean termite
	Microcerotermes periminutus	Subterranean termite
	Microcerotermes remotus	Subterranean termite

Termitidae	*Microcerotermes rhombilidus*	Subterranean termite
	Odontotermes angustignathus	Subterranean termite
	Odontotermes annulicornis	Subterranean termite
	Odontotermes assamensis	Subterranean termite
	Odontotermes conignathus	Subterranean termite
	Odontotermes dimorphus	Subterranean termite
	Odontotermes fontanellus	Subterranean termite
	Odontotermes formosanus	Dam pests, subterranean termite
	Odontotermes foveafrons	Subterranean termite
	Odontotermes fuyangensis	Subterranean termite
	Odontotermes giriensis	Subterranean termite
	Odontotermes gravelyi	Subterranean termite
	Odontotermes guizhouensis	Subterranean termite
	Odontotermes hainanensis	Dam pests, subterranean termite
	Odontotermes luoyangensis	Subterranean termite
	Odontotermes parallelus	Subterranean termite
	Odontotermes pujiangensis	Subterranean termite
	Odontotermes pyriceps	Subterranean termite
	Odontotermes quinquedentatus	Subterranean termite
	Odontotermes sellathorax	Subterranean termite
	Odontotermes shanglinensis	Subterranean termite
	Odontotermes shixingensis	Subterranean termite
	Odontotermes wuzhishanensis	Subterranean termite
	Odontotermes yaoi	Subterranean termite
	Odontotermes yarangensis	Subterranean termite
	Odontotermes yunnanensis	Subterranean termite
	Odontotermes ziyangensis	Subterranean termite
	Odontotermes zunyiensis	Subterranean termite
	Hypotermes bawanensis	Subterranean termite
	Hypotermes meiziensis	Subterranean termite
	Hypotermes mengdingensis	Subterranean termite
	Hypotermes wandingensis	Subterranean termite
	Hypotermes wayaoensis	Subterranean termite
	Parahypotermes manyunensis	Subterranean termite
	Parahypotermes ruiliensis	Subterranean termite
	Parahypotermes sumatrensi	Subterranean termite
	Parahypotermes yingjiangensis	Subterranean termite
	Macrotermes acrocephalus	Subterranean termite
	Macrotermes annandalei	Subterranean termite
	Macrotermes barneyi	Dam pests, subterranean termite
	Macrotermes chebalingensis	Subterranean termite
	Macrotermes choui	Subterranean termite
	Macrotermes constrictus	Subterranean termite

Termitidae	*Macrotermes denticulatus*	Subterranean termite
	Macrotermes guangxiensis	Subterranean termite
	Macrotermes hainanensis	Subterranean termite
	Macrotermes incisus	Subterranean termite
	Macrotermes jinghongensis	Subterranean termite
	Macrotermes latinotus	Subterranean termite
	Macrotermes longiceps	Subterranean termite
	Macrotermes longimentis	Subterranean termite
	Macrotermes luokengensis	Subterranean termite
	Macrotermes meidoensis	Subterranean termite
	Macrotermes menglongensis	Subterranean termite
	Macrotermes orthognathus	Subterranean termite
	Macrotermes pertrimorphus	Subterranean termite
	Macrotermes planicapitatus	Subterranean termite
	Macrotermes trapezoids	Subterranean termite
	Macrotermes trimorphus	Subterranean termite
	Macrotermes yunnanensis	Subterranean termite
	Macrotermes zhejiangensis	Subterranean termite
	Euhamitermes bidentatus	Subterranean termite
	Euhamitermes concavigulus	Subterranean termite
	Euhamitermes daweishanensis	Subterranean termite
	Euhamitermes guizhouensis	Subterranean termite
	Euhamitermes melanocephalus	Subterranean termite
	Euhamitermes mengdingensis	Subterranean termite
	Euhamitermes microcephalus	Subterranean termite
	Euhamitermes quadratceps	Subterranean termite
	Euhamitermes retusus	Subterranean termite
	Euhamitermes yui	Subterranean termite
	Euhamitermes yunanensis	Subterranean termite
	Euhamitermes yuntaishanensis	Subterranean termite
	Euhamitermes zhejiangensis	Subterranean termite
	Speculitermes angustigulus	Subterranean termite
	Indotermes isodentatus	Subterranean termite
	Indotermes menggarensis	Subterranean termite
	Sinotermes hainanensis	Subterranean termite
	Sinotermes luxiensis	Subterranean termite
	Sinotermes yunnanensis	Subterranean termite
	Globitermes brachycerastes	Subterranean termite
	Globitermes menglaensis	Subterranean termite
	Globitermes mengpengensis	Subterranean termite
	Globitermes minor	Subterranean termite
	Globitermes sulphureus	Subterranean termite
		Subterranean termite

Termitidae	*Microtermes manzhuangensis*	Subterranean termite
	Microtermes menglunensis	Subterranean termite
	Microtermes mengpingensis	Subterranean termite
	Ancistrotermes crassiceps	Subterranean termite
	Ancistrotermes dimorphus	Subterranean termite
	Ancistrotermes ganlanbaensis	Subterranean termite
	Ancistrotermes hekouensis	Subterranean termite
	Ancistrotermes menglianensis	Subterranean termite
	Ancistrotermes xiai	Subterranean termite
	Termes marjoriae	Subterranean termite
	Mirocapritermes hsuchiafui	Subterranean termite
	Mirocapritermes jiangchengensis	Subterranean termite
	Malaysiocapritermes huananensis	Subterranean termite
	Malaysiocapritermes zhangfengensis	Subterranean termite
	Dicuspiditermes garthwaitei	Subterranean termite
	Sinocapritermes albipennis	Subterranean termite
	Sinocapritermes fujianensis	Subterranean termite
	Sinocapritermes guangxiensis	Subterranean termite
	Sinocapritermes magnus	Subterranean termite
	Sinocapritermes mushae	Subterranean termite
	Sinocapritermes parvulus	Subterranean termite
	Sinocapritermes planiforns	Subterranean termite
	Sinocapritermes sinensis	Subterranean termite
	Sinocapritermes sinicus	Subterranean termite
	Sinocapritermes songtaoensis	Subterranean termite
	Sinocapritermes tianmuensis	Subterranean termite
	Sinocapritermes vicinus	Subterranean termite
	Sinocapritermes xiushanensis	Subterranean termite
	Sinocapritermes yunnanensis	Subterranean termite
	Pericapritermes beibengensis	Subterranean termite
	Pericapritermes fuscotibialis	Subterranean termite
	Pericapritermes gutianensis	Subterranean termite
	Pericapritermes hepuensis	Subterranean termite
	Pericapritermes jiangtsekiangensis	Subterranean termite
	Pericapritermes latignathus	Subterranean termite
	Pericapritermes nitobei	Subterranean termite
	Pericapritermes planiusculus	Subterranean termite
	Pericapritermes semarangi	Subterranean termite
	Pericapritermes tetraphilus	Subterranean termite
	Pericapritermes wuzhishanensis	Subterranean termite
	Pseudocapritermes jiangchengsnsis	Subterranean termite
	Pseudocapritermes largus	Subterranean termite
	Pseudocapritermes minutus	Subterranean termite

Termitidae	*Pseudocapritermes planimentus*	Subterranean termite
	Pseudocapritermes pseudolaetus	Subterranean termite
	Pseudocapritermes sinensis	Subterranean termite
	Pseudocapritermes sowerbyi	Subterranean termite
	Hospitalitermes damenglongensis	Subterranean termite
	Hospitalitermes jinghongensis	Subterranean termite
	Hospitalitermes majusculus	Subterranean termite
	Hospitalitermes luzonensis	Subterranean termite
	Arcotermes tubus	Subterranean termite
	Cucurbitermes sinensis	Subterranean termite
	Cucurbitermes yingdeensis	Subterranean termite
	Havilanditermes communis	Subterranean termite
	Havilanditermes orthonasus	Subterranean termite
	Periaciculitermes menglunensis	Subterranean termite
	Peribulbitermes dinghuensis	Subterranean termite
	Peribulbitermes jinghongensis	Subterranean termite
	Peribulbitermes parafulvus	Subterranean termite
	Pilotermes jiangxiensis	Subterranean termite
	Xiaitermes tiantaiensis	Subterranean termite
	Xiaitermes yinxianensis	Subterranean termite
	Nasutitermes bannaensis	Subterranean termite
	Nasutitermes bulbus	Subterranean termite
	Nasutitermes choui	Subterranean termite
	Nasutitermes communis	Subterranean termite
	Nasutitermes curtinasus	Subterranean termite
	Nasutitermes dolichorhinos	Subterranean termite
	Nasutitermes dudgeoni	Subterranean termite
	Nasutitermes falciformis	Subterranean termite
	Nasutitermes fengkaiensis	Subterranean termite
	Nasutitermes fulvus	Subterranean termite
	Nasutitermes gardneri	Subterranean termite
	Nasutitermes gardneriformis	Subterranean termite
	Nasutitermes garoensis	Subterranean termite
	Nasutitermes grandinasus	Subterranean termite
	Nasutitermes guizhouensis	Subterranean termite
	Nasutitermes hejiangensis	Subterranean termite
	Nasutitermes inclinasus	Subterranean termite
	Nasutitermes kinoshitae	Subterranean termite
	Nasutitermes mangshanensis	Subterranean termite
	Nasutitermes medoensis	Subterranean termite
	Nasutitermes mirabilis	Subterranean termite
	Nasutitermes moratus	Subterranean termite
	Nasutitermes obtusimandibulus	Subterranean termite

Termitidae	*Nasutitermes ovatus*	Subterranean termite
	Nasutitermes parvonasutus	Subterranean termite
	Nasutitermes planiusculus	Subterranean termite
	Nasutitermes qingjiensis	Subterranean termite
	Nasutitermes sinensis	Subterranean termite
	Nasutitermes subtibetanus	Subterranean termite
	Nasutitermes subtibialis	Subterranean termite
	Nasutitermes takasagoensis	Subterranean termite
	Nasutitermes tiantongensis	Subterranean termite
	Nasutitermes tibetanus	Subterranean termite
	Nasutitermes tsaii	Subterranean termite
	Nasutitermes vallis	Subterranean termite
	Sinonasutitermes admirabilis	Subterranean termite
	Sinonasutitermes dimorphus	Subterranean termite
	Sinonasutitermes erectinasus	Subterranean termite
	Sinonasutitermes guangxiensis	Subterranean termite
	Sinonasutitermes hainanensis	Subterranean termite
	Sinonasutitermes mediocris	Subterranean termite
	Sinonasutitermes planinasus	Subterranean termite
	Sinonasutitermes platycephalus	Subterranean termite
	Sinonasutitermes trimorphus	Subterranean termite
	Sinonasutitermes xiai	Subterranean termite
	Sinonasutitermes yui	Subterranean termite
	Mironasutitermes bashanensis	Subterranean termite
	Mironasutitermes changningensis	Subterranean termite
	Mironasutitermes heterodon	Subterranean termite
	Mironasutitermes huangshanensis	Subterranean termite
	Mironasutitermes longwangshanensis	Subterranean termite
	Mironasutitermes machengensis	Subterranean termite
	Mironasutitermes qimenensis	Subterranean termite
	Mironasutitermes shangchengensis	Subterranean termite
	Mironasutitermes tianmuensis	Subterranean termite
	Mironasutitermes xingshanensis	Subterranean termite
	Ahmaditermes choui	Subterranean termite
	Ahmaditermes crassinasus	Subterranean termite
	Ahmaditermes deltocephalus	Subterranean termite
	Ahmaditermes dukouensis	Subterranean termite
	Ahmaditermes foveafrons	Subterranean termite
	Ahmaditermes guizhouensis	Subterranean termite
	Ahmaditermes lipingensis	Subterranean termite
	Ahmaditermes perisinuosus	Subterranean termite
	Ahmaditermes pingnanensis	Subterranean termite
	Ahmaditermes pyricephalus	Subterranean termite

Termitidae	*Ahmaditermes shichuanensis*	Subterranean termite
	Ahmaditermes sinensis	Subterranean termite
	Ahmaditermes sinuosus	Subterranean termite
	Ahmaditermes tianmuensis	Subterranean termite
	Ahmaditermes tiantongensis	Subterranean termite
	Ahmaditermes xiangyunensis	Subterranean termite

Termite species recorded in Indonesia

Family	Species	Distribution*	Remarks
Kalotermitidaee	*Neotermes artocarpi* (Haviland)	SU, Kal	Forest pests, damp wood termite
	N. dalbergiae (Kalshoven)	JV	Forest pests, damp wood termite
	N. longipennis Kemner	SU	Forest pests, damp wood termite
	N. medius (Oshima)	SU	Forest pests, damp wood termite
	N. sonneratiae Kemner	JV	Forest pests, damp wood termite
	N. tectonae (Dammerman)	SU, JV	Forest pests, damp wood termite
	Cryptotermes cynocephalus Light	JV, Kal	Dry wood termite
	C. domesticus (Haviland)	SU, Kal	Dry wood termite
	C. dudleyi Banks	SU, JV	Dry wood termite
	C. sumatrensis Kemner	SU	Dry wood termite
	Glyptotermes borneensis (Haviland)	Kal	Forest pests, damp wood termite
	G. brevicaudatus (Haviland)	SU, Kal	Forest pests, damp wood termite
	G. caudominatus Kemner	JV	Forest pests, damp wood termite
	G. concavifrons Krisnha	JV	Forest pests, damp wood termite
	G. dentatus (Haviland)	Kal	Forest pests, damp wood termite
	G. kirkbyi Snyder	SU	Forest pests, damp wood termite
	G. montanus Kemner	JV	Forest pests, damp wood termite
	G. niger Kemner	JV	Forest pests, damp wood termite
	G. pinangae (Haviland)	Kal	Forest pests, damp wood termite
Rhinotermitidae	*Heterotermes tenuior* (Haviland)	Kal	Forest pests, damp wood termite
	Coptotermes borneensis Oshima	Kal	Urban pests, subterranean termite
	C. curvignathus Holmgren	SU, JV, Kal	Urban pests, subterranean termite
	C. gestroi Wasmann	Kal	Urban pests, subterranean termite
	C. haviland Holmgreni	JV	Urban pests, subterranean termite
	C. kalshovenii Kemner	JV	Urban pests, subterranean termite
	C. sinabangensis Oshima	SU	Urban pests, subterranean termite
	C. travians (Haviland)	SU, JV, Kal	Urban pests, subterranean termite
	Termitogeton planus (Haviland)	Kal	Forest pests, damp wood termite
	Prorhinotermes krakatani (Holmgren)	JV	Forest pests, damp wood termite
	P. ravani Roonwal & Maiti	JV	Forest pests, damp wood termite
	Parrhinotermes aequalis (Haviland)	Kal	Forest pests, damp wood termite
	P. buttle-reepeni Holmgren	SU	Forest pests, damp wood termite
	P. inaequalis (Haviland)	Kal	Forest pests, damp wood termite
	P. pygmaeus John	SU	Forest pests, damp wood termite
	Schedorhinotermes brevialatus (Haviland)	JV. Kal	Forest pests, damp wood termite
	S. celebensis (Holmgren)	SU	Forest pests, damp wood termite

Family	Species	Distribution*	Remarks
Rhinotermitidae	*Schedorhinotermes holmgren* Emersoni	SU	Forest pests, damp wood termite
	S. Javanicus Kemner	JV	Urban pests, subterranean termite
	S. karakensis (Oshima)	JV, Kal	Forest pests, damp wood termite
	S. leopoldi Kemner	SU	Forest pests, damp wood termite
	S. longirostris Ahmad	JV	Forest pests, damp wood termite
	S. maximus (Holmgren)	Kal	Forest pests, damp wood termite
	S. sarawakensis (Holmgren)	SU, Kal	Forest pests, damp wood termite
	S. translucens (Haviland)	SU, JV,	Forest pests, damp wood termite
Termitidae	*Protohamitermes globiceps* Holmgren	Kal	Forest pests, damp wood termite
	Prohamitermes hosei (Desneux)	Kal	Forest pests, damp wood termite
	P. mirabilis (Haviland)	SU, Kal	Forest pests, damp wood termite
	Labritermes buttle-reepeni Holmgren	SU	Forest pests, damp wood termite
	Amitermes dentatus (Haviland)	SU, Kal	Forest pests, damp wood termite
	A. minor Holmgren	SU	Forest pests, damp wood termite
	Globitermes globulus (Haviland)	Kal	Forest pests, damp wood termite
	G. vadaensis Kemner	JV	Forest pests, damp wood termite
	Microceratermes dammermani Roonwal & Maiti	SU	Forest pests, damp wood termite
	M. depokensis Kemner	SU, JV	Forest pests, damp wood termite
	M. distans (Haviland)	Kal	Forest pests, damp wood termite
	M. havilandi Holmgren	SU, Kal	Forest pests, damp wood termite
	M. madurae Kemner	JV	Forest pests, damp wood termite
	M. serrula (Desneux)	Kal	Forest pests, damp wood termite
	Termes brevicornis Haviland	Kal	Forest pests, damp wood termite
	T. comis Haviland	Kal	Forest pests, damp wood termite
	T. laticornis Haviland	SU, Kal	Forest pests, damp wood termite
	T. propinquus (Holmgren)	SU	Forest pests, damp wood termite
	T. rostratus Haviland	Kal	Forest pests, damp wood termite
	Miricapritermes connectens Holmgren	SU	Forest pests, damp wood termite
	Procapritermes atypus Holmgren	SU	Forest pests, damp wood termite
	P. minutus (Haviland)	Kal	Forest pests, damp wood termite
	P. setiger (Haviland)	SU, Kal	Forest pests, damp wood termite
	Hamallotermes eleanorae Krisnha	Kal	Forest pests, damp wood termite
	H. exiguus Krisnha	Kal	Forest pests, damp wood termite
	H. foraminifer Holmgren	SU, Kal	Forest pests, damp wood termite
	Pericapritermes brachygenathus (John)	SU	Forest pests, damp wood termite
	P. buitenzorgi (Holmgren)	JV	Forest pests, damp wood termite

Family	Species	Distribution*	Remarks
Termitidae	*P. dolichocephalus* (John)	SU	Forest pests, damp wood termite
	P. latignathus (Holmgren)	JV	Forest pests, damp wood termite
	P. modiglianii (Silvestri)	SU	Forest pests, damp wood termite
	P. mohri (Kemner)	JV	Forest pests, damp wood termite
	P. semarangi Holmgren	SU, JV	Forest pests, damp wood termite
	P. speciosa (Haviland)	SU, Kal	Forest pests, damp wood termite
	Dicuspiditermes nemorosus (Haviland)	SU, Kal	Forest pests, damp wood termite
	D. santchii (Silvestri)	SU	Forest pests, damp wood termite
	Macrotermes carbonarius (Hagen)	SU, Kal	Forest pests, damp wood termite
	M. gilvus (Hagen)	SU, JV, Kal	Urban pests, subterranean termite
	M. malaccensis (Haviland)	SU, Kal	Forest pests, damp wood termite
	Odontotermes billitoni (Holmgren)	SU	Forest pests, damp wood termite
	O. bogoriensis (Kemner)	JV	Forest pests, damp wood termite
	O. butteli Holmgren	SU	Forest pests, damp wood termite
	O. denticulatus Holmgren	SU, Kal	Forest pests, damp wood termite
	O. dives (Hagen)	SU, JV	Forest pests, damp wood termite
	O. grandiceps Holmgren	SU, JV	Forest pests, damp wood termite
	O. hageni (Holmgren)	Kal	Forest pests, damp wood termite
	O. incisus Holmgren	SU	Forest pests, damp wood termite
	O. indrapurensis Holmgren	SU	Forest pests, damp wood termite
	O. javanicus Holmgren	SU, JV	Forest pests, damp wood termite
	O. karawajeri John	JV	Forest pests, damp wood termite
	O. karnyi Kemner	JV	Forest pests, damp wood termite
	O. lattisimus (Kemner)	SU	Forest pests, damp wood termite
	O. makassarensis Kemner	JV	Forest pests, damp wood termite
	O. maximus (Kemner)	SU	Forest pests, damp wood termite
	O. sarawakensis Holmgren	Kal	Forest pests, damp wood termite
	O. sinabangensis Kemner	SU	Forest pests, damp wood termite
	O. sundaicus Kemner	JV	Forest pests, damp wood termite
	O. taprobanes (Walker)	SU, Kal	Forest pests, damp wood termite
	Hypotermes sumatrensis Holmgren	SU	Forest pests, damp wood termite
	Microtermes insperatus Kemner	JV	Forest pests, damp wood termite
	M. jacobsoni Holmgren	SU, JV	Forest pests, damp wood termite
	M. pakistanicus Ahmad	JV	Forest pests, damp wood termite
	M. tenuis Oshima	SU	Forest pests, damp wood termite
	Hirtitermes hirtiventris Holmgren	Kal	Forest pests, damp wood termite
	H. spinocephalus (Oshima)	Kal	Forest pests, damp wood termite

Family	Species	Distribution*	Remarks
Termitidae	*Havilanditermes atripennis* (Haviland)	SU, Kal	Forest pests, damp wood termite
	Nasutitermes acutus (Holmgren)	SU, JV	Forest pests, damp wood termite
	N. corporaali (Wasmann)	JV	Forest pests, damp wood termite
	N. fuscipennis (Haviland)	Kal	Forest pests, damp wood termite
	N. havilandi (Desneux)	SU, Kal	Forest pests, damp wood termite
	N. jacobsoni Oshima	SU	Forest pests, damp wood termite
	N. longinasus (Holmgren)	Kal	Forest pests, damp wood termite
	N. longilostris (Holmgren)	Kal	Forest pests, damp wood termite
	N. luzonicus (Oshima)	Kal	Forest pests, damp wood termite
	N. matangensiformis (Holmgren)	SU, JV, Kal	Forest pests, damp wood termite
	N. matangensis (Haviland)	SU, JV, Kal	Forest pests, damp wood termite
	N. ovipennis (Haviland)	Kal	Forest pests, damp wood termite
	*N. regularis (*Haviland)	Kal	Forest pests, damp wood termite
	N. sandakanensis (Oshima)	Kal	Forest pests, damp wood termite
	N. simaluris Ishima	SU	Forest pests, damp wood termite
	N. timoriensis (Holmgren)	Kal	Forest pests, damp wood termite
	Bulbitermes borneensis (Haviland)	Kal	Forest pests, damp wood termite
	B. constrictiformis (Holmgren)	SU	Forest pests, damp wood termite
	B. constrictoides (Holmgren)	SU, JV	Forest pests, damp wood termite
	B. constrictus (Haviland)	Kal	Forest pests, damp wood termite
	B. durianensis Roonwal & Maiti	SU	Forest pests, damp wood termite
	B. flavicans (Holmgren)	Kal	Forest pests, damp wood termite
	B. gedeensis (Kemner)	SU	Forest pests, damp wood termite
	B. kraepelini (Holmgren)	SU	Forest pests, damp wood termite
	B. lakshmani Roonwal & Maiti	JV	Forest pests, damp wood termite
	B. nasutus (Holmgren)	SU	Forest pests, damp wood termite
	B. neopusillus Snyder & Emerson	SU, JV	Forest pests, damp wood termite
	B. rosae (Kemner)	JV	Forest pests, damp wood termite
	B. salakensis (Kemner)	JV	Forest pests, damp wood termite
	B. sarawakensis (Haviland)	SU, Kal	Forest pests, damp wood termite
	B. singaporensis (Haviland)	SU, Kal	Forest pests, damp wood termite
	B. subulatus (Holmgren)	SU	Forest pests, damp wood termite
	B. vicinus (Kemner)	JV	Forest pests, damp wood termite
	Lacessititermes albipes (Haviland)	Kal	Forest pests, damp wood termite
	L. atrior (Holmgren)	Kal	Forest pests, damp wood termite
	L. batavus Kemner	JV	Forest pests, damp wood termite
	L. breviarticulatus (Holmgren)	Kal	Forest pests, damp wood termite

Family	Species	Distribution*	Remarks
Termitidae	*L. filicornis* (Haviland)	Kal	Forest pests, damp wood termite
	L. jacobsoni Kemner	SU	Forest pests, damp wood termite
	Lacessititermes laborator (Haviland)	SU	Forest pests, damp wood termite
	L. lacessitiformis (Holmgren)	Kal	Forest pests, damp wood termite
	L. piliferus (Holmgren)	Kal	Forest pests, damp wood termite
	L. sordidus (Haviland)	Kal	Forest pests, damp wood termite
	Longipeditermes longipes (Haviland)	Kal	Forest pests, damp wood termite
	Hospitalitermes bicolor (Haviland)	SU	Forest pests, damp wood termite
	H. birmanicus (Snyder)	SU	Forest pests, damp wood termite
	H. butteli (Holmgren)	SU	Forest pests, damp wood termite
	H. diurnus Kemner	JV	Forest pests, damp wood termite
	H. ferrugineus (John)	JV	Forest pests, damp wood termite
	H. flavinentris (Wasmann)	SU	Forest pests, damp wood termite
	H. flavoantennaris Oahima	SU	Forest pests, damp wood termite
	H. grasii Ghidini	SU	Forest pests, damp wood termite
	H. hospitalis (Haviland)	SU, JV, Kal	Forest pests, damp wood termite
	H. lividiceps (Holmgren)	JV	Forest pests, damp wood termite
	H. nemorosus Ghidini	SU	Forest pests, damp wood termite
	H. rufus (Haviland)	Kal	Forest pests, damp wood termite
	H. umbrinus (Haviland)	SU, JV, Kal	Forest pests, damp wood termite
	*Aciculitermes aciculatus (*Haviland)	SU, Kal	Forest pests, damp wood termite
	Subulioiditermes emersoni Ahmad	Kal	Forest pests, damp wood termite
	S. subulioides Ahmad	Kal	Forest pests, damp wood termite
	Eleanoritermes borneensis Ahmad	Kal	Forest pests, damp wood termite
	Proaciculitermes malayanus Ahmad	Kal	Forest pests, damp wood termite
	P. sabahensis Ahmad	Kal	Forest pests, damp wood termite
	Aciculioiditermes denticulatus Ahmad	Kal	Forest pests, damp wood termite
	A. holmgreni Ahmad	Kal	Forest pests, damp wood termite
	A. sarawakensis Ahmad	Kal	Forest pests, damp wood termite
	Leucopitermes leucops (Holmgren)	SU, Kal	Forest pests, damp wood termite
	Oriensubulitermes borneensis Ahmad	Kal	Forest pests, damp wood termite
	O. inanis (Haviland)	SU, Kal	Forest pests, damp wood termite
	O. kemneri Ahmad	Kal	Forest pests, damp wood termite

*Distribution-SU: Sumatra Island, JV: Java Island, Kal: Kalimantan Island

Termite species recorded in Japan

Family	Species	Remarks
Kalotermitidae	*Cryptotermes domesticus* (Haviland)	Dry wood termite
	Glyptotermes focus (Oshima)	Forest pests, damp wood termite
	Glyptotermes satsumaensis (Matsumura)	Forest pests, damp wood termite
	Glyptotermes nakajimai Morimoto	Forest pests, damp wood termite
	Incisitermes immigrans (Snyder)	Dry wood termite
	Incistermes minor (Hagen)	Dry wood termite
	Neotermes koshunensis (Shiraki)	Forest pests, damp wood termite
Termopsidae	*Hodotermopsis sjoestedti* Holmgren	Forest pests, damp wood termite
	Coptotermes guanzhouensis Ping	Urban pests, subterranean termite
	Coptotermes formosanus Shiraki	Urban pests, subterranean termite
	Reticulitermes amamianus Morimoto	Forest pests, damp wood termite
	Reticulitermes flaviceps (Oshima)	Forest pests, damp wood termite
	Reticulitermes kanmonensis Takematsu	Urban pests, subterranean termite
	Reticulitermes miyatakei Morimoto	Forest pests, damp wood termite
	Reticulitermes okinawanus Morimoto	Forest pests, damp wood termite
	Reticulitermes speratus (Kolbe)	Urban pests, subterranean termite
	Reticulitermes yaeyamanus Morimoto	Forest pests, damp wood termite
Termitidae	*Nasutitermes takasagoensis* (Shiraki)	Forest pests, damp wood termite
	Odontotermes formosanus (Shiraki)	Forest pests, damp wood termite
	Pericapritermes nitobei (Shiraki)	Forest pests, damp wood termite
	Sinocapritermes mushae (Oshima)	Forest pests, damp wood termite

List of recorded termite species in Peninsular Malaysia (based on Tho 1992[1])

Family KALOTERMITIDAE

Subfamily Kalotermitinae

Neotermes tectonae Dammerman
Neotermes sp. A [sp. nov]
Cryptotermes cynocephalus Light
Cryptotermes domesticus Haviland
Cryptotermes dudleyi Banks
Cryptotermes thailandis Ahmad
Cryptotermes sp. A [sp. nov]
Glyptotermes pinangae (Haviland)
Glypototermes borneensis (Haviland)
Glyptotermes buttel-reepeni (Holmgren)
Glyptotermes sp. A [? sp. nov]
Glyptotermes sp. B
Glyptotermes sp. C [? sp. nov]
Glyptotermes sp. D
Glyptotermes sp. E [? sp. nov]
Glyptotermes sp. F [? sp. nov]

Family RHINOTERMITIDAE

Subfamily Heterotermitinae

Heterotermes tenuior (Haviland)

Subfamily Coptotermitinae

Coptotermes gestroi Wasmann
Coptotermes curvignathus Holmgren
Coptotermes kalshoveni Kemner
Coptotermes sepangensis Krishna
Coptotermes travians (Haviland)
Coptotermes havilandi Holmgren
Coptotermes bentongensis Krishna
Coptotermes sinabangensis Oshima

Subfamily Termitogetoninae

Termitogeton planus (Haviland)

Subfamily Rhinotermitinae

Prorhinotermes flavus Bugnion & Popoff
Parrhinotermes buttel-reepeni Holmgren
Parrhinotermes aequalis (Haviland)
Parrhinotermes inaequalis (Haviland)
Parrhinotermes pygmaeus John

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[1] Tho YP. 1992. *Termites of Peninsular Malaysia*. Kirton LG (ed.). Malayan Forest Records No. 36. Forest Research Institute Malaysia. 224 pp.

Parrhinotermes sp. A [sp. nov.]
Parrhinotermes sp. B [sp. nov.]
Parrhinotermes sp. C [sp. nov.]
Schedorhinotermes sarawakensis (Holmgren)
Schedorhinotermes malaccensis (Holmgren)
Schedorhinotermes medioobscurus (Holmgren)
Schedorhinotermes translucens (Haviland)
Schedorhinotermes longirostris (Brauer)
Schedorhinotermes butteli (Holmgren)
Schedorhinotermes sp. A [? sp. nov.]

Family TERMITIDAE

Subfamily Apicotermitinae

Speculitermes sp. A
Euhamitermes hamatus (Holmgren)

Subfamily Termitinae

Protohamitermes globiceps Holmgren
Prohamitermes mirabilis (Haviland)
Labritermes sp. A
Amitermes dentatus (Haviland)
Globitermes sulphureus (Haviland)
Globitermes globosus (Haviland)
Microcerotermes dubius (Haviland)
Microcerotermes haviland Holmgren
Microcerotermes serrula (Densneux)
Microcerotermes crassus Snyder
Microcerotermes distans (Haviland)
Microcerotermes annandalei Silvestri
Microcerotermes paracelebensis Ahmad
Termes comis Haviland
Termes laticornis Haviland
Termes rostratus Haviland
Termes propinquus Holmgren
Mirocapritermes connectens Holmgren
Procapritermes augustignathus (Holmgren)
Procapritermes greeni John
Procapritermes setiger (Haviland)
Procapritermes minutus (Haviland)
Hamallotermes foraminifer (Haviland)
Homallotermes eleanorae Krishna
Pericapritermes speciosus (Haviland)
Pericapritermes dolichocephalus (John)
Pericapritermes semarangi (Holmgren)
Pericapritermes mohri (Kemner)
Pericapritermes brachygnathus John

Pericapritermes sp. A [?sp. nov.]
Pericapritermes sp. B [?sp. nov.]
Pericapritermes sp. C [?sp. nov.]
Pericapritermes sp. D [?sp. nov.]
Dicuspiditermes nemorosus (Haviland) [possibly two sympatric species]
Dicuspiditermes laetus (Silvestri)

Subfamily Macrotermitinae

Macrotermes carbonarius Hagen
Macrotermes ahmadi Tho
Macrotermes gilvus Hagen
Macrotermes malaccensis (Haviland)
Macrotermes singaporensis (Oshima)
Macrotermes sp. A [sp. nov.]
Macrotermes sp. B [sp. nov.]
Odontotermes bullitoni Holmgren
Odontotermes butteli Holmgren
Odontotermes denticulatus Holmgren
Odontotermes grandiceps Holmgren
Odontotermes javanicus Holmgren
Odontotermes longignathus Holmgren
Odontotermes dives (Hagen)
Odontotermes malaccensis Holmgren
Odontotermes oblongatus Holmgren
Odontotermes praevalens (John)
Odontotermes sarawakensis Holmgren
Odontotermes taprobanes (Walker)
Odontotermes proximus Holmgren
Odontotermes assmuthi Holmgren
Odontotermes sp. D
Odontotermes sp. F
Odontotermes sp. H [? formosanus (Shiraki)]
Odontotermes sp. I [? paraoblongatus Ahmad]
Hypotermes xenotermitis (Wasmann)
Hypotermes sp. A [?sp. nov.]
Microtermes obesi Holmgren
Microtermes pakistanicus Ahmad
Microtermes insperatus Kemner
Microtermes jacobsoni Holmgren

Subfamily Nasutitermitinae

Hirtitermes hirtiventris (Holmgren)
Hirtitermes spinocephalus (Oshima)
Hirtitermes sp. A [sp. nov.]
Havilanditermes atripennis (Haviland)
Havilanditermes proatripennis Ahmad

Nasutitermes acutus (Holmgren)
Nasutitermes alticola (Holmgren)
Nasutitermes bulbiceps (Holmgren)
Nasutitermes havilandi (Desneux)
Nasutitermes dimorphus Ahmad
Nasutitermes johoricus (John)
Nasutitermes longinasus (Holmgren)
Nasutitermes matangensis (Haviland)
Nasutitermes ovipennis (Haviland)
Nasutitermes tungsalangensis Ahmad
Nasutitermes regularis (Haviland)
Nasutitermes sp. A
Nasutitermes sp. B
Bulbitermes constrictiformis (Holmgren)
Bulbitermes constrictoides (Holmgren)
Bulbitermes germanus (Haviland)
Bulbitermes singaporiensis (Haviland)
Bulbitermes flavicans (Holmgren)
Bulbitermes perpusillus (John)
Bulbitermes sarawakensis (Haviland)
Bulbitermes kraepelini (Holmgren)
Lacessititermes laborator (Haviland)
Lacessititermes atrior Holmgren
Lacessititermes lacessitus (Haviland)
Lacessititermes sp. A [? ransoneti Holmgren]
Lacessititermes sp. B [? sp. nov.]
Lacessititermes sp. C [sp. nov.]
Lacessititermes sp. D [sp. nov.]
Longipeditermes longipes Holmgren
Hospitalitermes bicolor (Haviland)
Hospitalitermes hospitalis (Haviland)
Hospitalitermes medioflavus (Holmgren)
Hospitalitermes umbrinus (Haviland)
Hospitalitermes flaviventris (Wasmann)
Hospitalitermes sp. A [? rufus (Haviland)]
Aciculitermes aciculatus (Haviland)
Subulioiditermes subulioides Ahmad
Subulioiditermes emersoni Ahmad
Malaysiotermes spinocephalus Ahmad
Proaciculitermes lowii Ahmad
Proaciculitermes malayanus Ahmad
Proaciculitermes orientalis Ahmad
Proaciculitermes sabahensis Ahmad
Aciculioiditermes holmgreni Ahmad
Aciculioiditermes denticulatus Ahmad
Leucopitermes leucops (Holmgren)

Leucopitermes paraleucops Morimoto
Oriensubulitermes borneensis Ahmad
Oriensubulitermes inanis (Haviland)
Oriensubulitermes sp. A [? sp. nov.]

Termite species recorded in the Philippines

Family	Species	Remarks
Kalotermitidae (12 species)	1. *Kalotermes mcgregori* Light	Wood-dwelling termites, Dampwood
	2. *K. taylori* Light	Wood-dwelling termites, Dampwood
	3. *Neotermes grandis* Light	Wood-dwelling termites, Dampwood
	4. *N. lagunensis* (Oshima)	Wood-dwelling termites, Dampwood
	5. *N. malatensis* (Oshima)	Wood-dwelling termites, Dampwood
	6. *N. microphthalmus* Light	Wood-dwelling termites, Dampwood
	7. *N. parvisculatus* Light	Wood-dwelling termites, Dampwood
	8. *Cryptotermes cyanocephalus* Light	Wood-dwelling termites **Drywood termites, Urban pests**
	9. *C. dudleyi* Banks	Wood-dwelling termites **Drywood termites, Urban pests**
	10. *Glyptotermes chapmani* Light	Wood-dwelling termites, Dampwood
	11. *G. franciae* Snyder	Wood-dwelling termites, Dampwood
	12. *G. magsaysayi* Snyder	Wood-dwelling termites, Dampwood
Rhinotermitidae (8 species)	13. *Heterotermes philippinensis* (Light)	Soil-dwelling termites
	14. *Coptotermes flavicephalus* Oshima	Soil-dwelling termites
	15. *C. vastator* Light	Soil-dwelling termites, **Subterranean, Urban pests**
	16. *Prorhinotermes gracilis* Light	Wood-dwelling termites, Dampwood
	17. *P. tibiaonensis* (Oshima)	Wood-dwelling termites, Dampwood
	18. *Schedorhinotermes bidentatus* (Oshima)	Soil-dwelling termites
	19. *S. longirostris (Brauer)*	Soil-dwelling termites
	20. *S. tarakanensis* (Oshima)	Soil-dwelling termites
Termitidae (34 species)	21. *Microcerotermes distans* (Haviland	Soil-dwelling termites
	22. *M. los-banosensis* (Oshima)	Soil-dwelling termites **Subterranean termites, Urban pests**
	23. *M. philippinensis* Ahmad	Soil-dwelling termites
	24. *Capritermes paetensis* (Oshima)	Soil-dwelling termites
	25. *Macrotermes gilvus* (Hagen)	Soil-dwelling termites **Subterranean termites, Urban pests**
	26. *Odontotermes (Odontetermes) dives* (Hagen)	Soil-dwelling termites
	27. *Odontotermes (Odontetermes) paradenticulatus* Ahmad	Soil-dwelling termites
	28. *Nasutitermes balintauacensis* (Oshima)	Soil-dwelling termites
	29. *N. brevicornis* Light and Wilson	Soil-dwelling termites
	30. *N. busuangae* Light	Soil-dwelling termites
	31. *N. castanaeus* (Oshima)	Soil-dwelling termites
	32. *N. chapmani* Light and Wilson	Soil-dwelling termites
	33. *N. constricticeps* Light and Wilson	Soil-dwelling termites
	34. *N. culasiensis* (Oshima)	Soil-dwelling termites
	35. *N. latus* Light and Wilson	Soil-dwelling termites
	36. *N. luzonicus* (Oshima)	**Soil-dwelling termites Subterranean termites, Urban pests**
	37. *N. mariveles* (Light and Wilson)	Soil-dwelling termites
	38. *N. mcgregori* (Oshima)	Soil-dwelling termites
	39. *N. meridianus* Light and Wilson	Soil-dwelling termites
	40. *N. mindanensis* (Light and Wilson)	Soil-dwelling termites
	41. *N. mollis* Light and Wilson	Soil-dwelling termites
	42. *N. oshimae* Light and Wilson	Soil-dwelling termites
	43. *N. panayensis* (Oshima)	Soil-dwelling termites
	44. *N. parvus* Light and Wilson	Soil-dwelling termites
	45. *N. rotundus* Light and Wilson	Soil-dwelling termites
	46. *N. simulans* Light and Wilson	Soil-dwelling termites

	47. N. taylori Light and Wilson	Soil-dwelling termites
	48. Havilanditermes atripennis (Haviland)	Soil-dwelling termites
	49. Grallatotermes admirabilus Light	Soil-dwelling termites
	50. G. splendidus Light and Wilson	Soil-dwelling termites
	51. Lacessititermes holmgreni Light&Wilson	Soil-dwelling termites
	52. L. palawanensis Light	Soil-dwelling termites
	53. Hospitalitermes hospitalis (Haviland)	Soil-dwelling termites
	54. H. luzonensis (Oshima)	Soil-dwelling termites
Termite species in bold letters are the most economically important termite species attacking fruntiure and wooden components of houses and buildings.		

Termite species recorded in Taiwan

Family	Genus	Species	Reamrks
Termopsidae	*Hodotermopsis*	*sjoestedi*	damp wood termite
Kalotermitidae	*Cryptotermes*	*domestic*	dry wood termite
	Glyptotermes	*fuscus*	dry wood termite
	Glyptotermes	*satsumensis*	dry wood termite
	Kalotermes	*inamurae*	dry wood termite
	Neotermes	*koshunesis*	dry wood termite
Rhinotermitidae	*Coptotermes*	*formosanus*	subterranean termite
	Coptotermes	*gestroi*	damp wood termite
	Reticulitermes	*flaviceps*	subterranean termite
	Reticulitermes	*chinese leptomandibularis*	subterranean termite
	Prorhinotermes	*japonicus*	
Termitidae	*Odontotermes*	*formosanus*	damp wood termite
	Nasutitermes	*parvonasutus*	damp wood termite
	Nasutitermes	*takasagoensis*	damp wood termite
	Nasutitermes	*kinoshitae*	damp wood termite
	Pericapritermes	*nitobei*	damp wood termite
	Sinocapritermes	*mushae*	damp wood termite

Termite genera and species in Thailand

Family and species	Nest habitat*				Food Habitat**				Distribution***					
	IW	A	E	S	W	W&L	S/H	L	N	NE	C	S	W	E
1. F Kalotermitidae														
1.1 SF. Kalotermitinae														
1. *Cryptotermes thailandis*	x				x							x		x
2. *Cryptotermes domesticus*	x				x									
3. *Cryptotermes bengalensis*	x				x									
4. *Glyptotermes brevicaudatus*	x				x									x
5. *Glyptotermes pinangae*	x				x									
6. *Glyptotermes kachongensis*	x				x									
7. *Glyptotermes* sp.	x				x									
8. *Glyptotermes* sp.1	x				x									x
9. *Glyptotermes* sp.2	x				x									x
10. *Glyptotermes* sp.3	x				x									x
11. *Neotermes* sp.1	x				x									x
12. *Neotermes* sp.2	x				x									x
13. *Neotermes* sp.3	x				x							x		x
14. *Neotermes* sp.4	x				x							x		x
15.*Bifiditermes indicus*	x				x							x		
16. *Incisitermes* sp.	x				x					x				
17. *Postelectrotermes tongyaii*	x				x									
2. F Termopsidae														
2.1 SF Termopsinae														
18. *Archotermopsis* sp.														
3. F. Rhinotermitidae														
3.1 SF. Rhinotermitinae														
19. *Schedorhinotermes medioobscurus*				x	x				x	x		x		x
20. *Schedorhinotermes rectangularis*				x	x									x
21. *Schedorhinotermes sarawakensis*				x	x				x			x		
22. *Schedorhinotermes* sp.				x	x									
23. *Parrhinotermes* sp.1				x	x							x		
24. *Parrhinotermes* sp.2				x	x							x		
3.2 SF. Prorhinotermitinae					x									
25. *Prorhinotermes tibiaoensiformis*					x				x			x		x
26. *Prorhinotermes* sp	x				x							x		
3.3 SF. Heterotermitinae														
27. *Reticulitermes khaoyaiensis*					x				x	x				
28. *Reticulitermes* sp.					x				x	x				
3.4 SF. Coptotermitinae														
29. *Coptotermes gestroi*				x	x				x		x			x
30. *Coptotermes havilandi*				x	x						x	x	x	x
31. *Coptotermes premrasmii*				x	x									x
32. *Coptotermes curvignathus*				x	x				x			x		x
33. *Coptotermes kalshoveni*														
34. *Coptotermes* sp.1				x	x				x		x	x		x
4. F. Termitidae														
4.1 SF. Macrotermes														
35. *Macrotermes carbonarius*			x			x						x		x
36. *Macrotermes chaiglomi*				x	x		x							
37. *Macrotermes annandalei*			x	x	x	x	x	x	x			x	x	x
38. *Macrotermes maesodensis*			x		x	x	x		x			x	x	x
39. *Macrotermes gilvus*			x		x				x			x	x	x
40. *Macrotermes malaccensis*					x							x		
41. *Macrotermes* sp.					x		x		x				x	
42. *Microtermes obesi*				x	x	x	x		x	x	x	x	x	x
43. *Ancistrotermes pakistanicus*				x	x	x	x		x		x	x	x	x
44. *Hypotermes makhamensis*				x	x	x	x	x	x		x	x	x	x

45. *Hypotermes xenotermitis*														
46. *Hypotermes obculiceps*														
47. *Odontotermes hainanensis*				x		x								
48. *Odontotermes paraoblongatus*														
49. *Odontotermes javanicus*														
50. *Odontotermes sarawakensis*					x									
51. *Odontotermes proformosanus* (L)					x		x		x			x		x
52. *Odontotermes proformosanus* (M)					x		x		x	x	x			x
53. *Odontotermes proformosanus* (S)					x				x				x	x
54. *Odontotermes longignathus*					x						x	x		
55. *Odontotermes feae*				x	x	x			x	x	x		x	x
56. *Odontotermes prodives*				x	x	x						X		X
57. *Odontotermes maesodensis*					x				x		x	x		
58. *Odontotermes oblongathus*				x		x					x			x
59. *Odontotermes takensis*			x		x		x		x		x			
60. *Odontotermes formosanus*				x	x	x			x		x		x	
61. *Odontotermes* sp.1				x	x	x	x	x	x		x	x		x
62. *Odontotermes* sp.2					x		x		x					x
63. *Odontotermes* sp.3					x				x					x
64. *Odontotermes* sp.4										x				
65. *Odontotermes* sp.5				x		x			x					
66. *Odontotermes* sp.6				x		x			x					
67. *Odontotermes* sp.7					x				x					
68. *Odontotermes* sp.8									x					
69. *Odontotermes* sp.9							x		x					
70. *Odontotermes* sp.10														
71. *Odontotermes* sp.11					x		x				x			
72. *Odontotermes* sp.12					x		x				x			
73. *Odontotermes* sp.13					x		x				x			
74. *Odontotermes* sp. 14			x		x	x					x		x	
75. *Odontotermes* sp. 15					x		x				x		x	
76. *Odontotermes* sp. 16							x		x					
77. *Odontotermes* sp.17														
4.2 SF. Termitinae														
78. *Amitermes dentatus*		x									x		x	
79. *Amitermes longignathus*				x			x							x
80. *Microcerotermes crassus*		x	x		x		x		x	x	x	x	x	x
81. *Microcerotermes distans*			x		x									
82. *Microcerotermes annandalei*			x		x								x	x
83. *Microcerotermes minutus*			x		x		x		x		x	x	x	x
84. *Microcerotermes paracelebensis*			x	x	x	x			x			x		
85. *Microcerotermes* sp.							x		x					
86. *Globitermes sulphureus*			x		x				x	x	x	x	x	x
87. *Synhamitermes* sp.														
88. *Prohamitermes* sp.														
89. *Termes cosmis*			x	x										
90. *Termes propinquus*			x	x			x		x					x
91. *Termes huayangensis*			x		x		x		x			x	x	x
92. *Termes major*			x						x					
93. *Dicuspiditermes garthwaitei*														
94. *Dicuspiditermes makhamensis*			x				x		x					
95. *Dicuspiditermes* sp.1				x			x					x		x
96. *Pericapritermes semarangi*				x			x					x		
97. *Pericapritermes latignathus*				x	x		x		x					x
98. *Pericapritermes* sp.B				x	x		x							x
99. *Pericapritermes* sp.C				x			x						x	
100. *Pericapritermes* sp.D														
101. *Pericapritermes* sp.E			x	x			x		x			x		
102. *Procapritermes parasilvaticus*			x		x								x	x
103. *Procapritermes prosetiger*					x		x		x			x		

104. *Procapritermes longignathus*										x				
105. *Mirocapritermes concaveus*				x			x							x
106. *Mirocapritermes latignathus*							x		x					
107. *Mirocapritermes prewensis*														
108. *Homallotermes* sp.1														
109. *Angulitermes* sp.				x			x							x
110. *Angulitermes* sp.3				x			x							x
4.3 SF. Apicotermitinae														
111. *Indotermes thailandis*														
112. *Euhamitermes hamatus*							x		x					
113. *Euhamitermes* sp.				x			x							x
114. *Speculitermes macrodentatus*														
115. *Spculitermes* sp.				x	x		x		x		x			x
4.4 SF. Nasutitermitinae														
116. *Nasutitermes johoricus*		x				x						x		x
117. *Nasutitermes matangensiformis*		x			x	x		x	x		x	x	x	x
118. *Nasutitermes fuscipennis*					x				x					x
119. *Nasutitermes dimorphus*		x			x		x				x		x	
120. *Nasutitermes matangensis*														
121. *Nasutitermes tungsalangensis*														
122. *Nasutitermes brachynasutus*														
123. *Nasutitermes profuscipennis*														
124. *Nasutitermes* sp.1		x				x								x
125. *Nasutitermes* sp.2		x				x						x		x
126. *Nasutitermes* sp.3		x				x								x
127. *Nasutitermes* sp.4		x				x								x
128. *Nasutitermes* sp.5		x				x								x
129. *Nasutitermes* sp.6		x				x						x		
130. *Nasutitermes* sp.		x			x					x		x		x
131. *Nasutitermes preparvus*		x			x		x				x			
132. *Bulbitermes parapusillus*		x			x	x			x					x
133. *Bulbitermes laticephalus*		x			x	x				x				x
134. *Bulbitermes prabhae*		x	x		x	x	x		x			x		x
135. *Bulbitermes makhamensis*														
136. *Bulbitermes deltocephalus*														
137. *Bulbitermes germanus*														
138. *Bulbitermes* sp.1		x			x	x			x					x
139. *Bulbitermes* sp.2		x				x								x
140. *Bulbitermes* sp.3		x				x								x
141. *Hospitalitermes birmanicus*			x					x				x		
142. *Hospitalitermes ataramensis*			x		x		x	x	x			x	x	x
143. *Hospitalitermes jepsoni*			x	x				x	x					x
144. *Hospitalitermes medioflavus*														
145. *Hospitalitermes* sp.1								x				x		
146. *Hospitalitermes* sp.2							x	x	x					
147. *Hospitalitermes* sp.3			x					x						x
148. *Hospitalitermes* sp.4								x						x
149. *Aciculitermes maymyoensis*												x		
150. *Havilanditermes proatripennis*												x		
151. *Longipeditermes longipes*												x		
152. *Lacessititermes* sp.1		x				x								x
153. *Lacessititermes* sp.2		x				x								x

***Nest habitat**
IW = In wood nest
A = Arboreal nest
E = Epigeal nest
S = Subterranean nest

****Food habitat**
W = Wood feeder
W&L = Wood and leave feeder
S/H = Soil or humus feeder
L = Lichen feeder

*****Distribution**
N = Northern
NE = North eastern
C = Central
S = Southern
W = Western
E = Eastern

Termite species recorded in Vietnam

Family	Species	Remark
Kalotermitidae	*Neotermes termillesemus* (Nguyen)	
	N. koshunensis (Shiraki)	
	Cryptotermes domesticus (Havilandi)	
	C. declivis (Tsai et Chen)	
	Glyptotermes satsumensis (Matsumura)	
	G.fuscus (Oshima)	
Termopsidae	*Hodotermopsis sjostedt* (Holmgren)	
	H. japonicus (Holmgren)	
Rhinotermitidae	*Reticulitermes chinensis* (Snyder)	
	R.magdalenae (Silvestri)	
	R.flavicep (Oshima)	
	R. speratus (Kolbe)	
	R. dangi (Nguyen)	
	R.microcephalus (Nguyen)	
	Schedorhinotermes magnus (Ts et Chen)	
	S. malaccensis (Holmgren)	
	S.medioobscurus (Holmgren)	
	S. sarawakensis (Holmgren)	
	S . javanicus	
	Coptotermes formosanus (Shiraki)	
	C.ceylonicus (Holmgren)	
	C. travians (Havilandi)	
	C. emersoni (Ahmad)	
	C. curvignathus (Holmgren)	
	C. dimorphus (Nguyen)	
	C.havilandi (Holmgren)	
Termititdae	*Speculitermes donhannensis* (Nguyen)	
	Globitermes sulphureus (Havilandi)	
	G. audax (Silvestri)	
	Euhamitermes hamatus (Holmgren)	
	Microcerotermes bugnioni (Holmgren)	
	M.crassus (Snyder)	
	M. burmanicus (Ahmad)	
	M. dammermani	
	Termes comis (Havilandi)	
	T. laticornis (Havilandi)	
	T. majoriae	
	Macrotermes annandalei (Silvestri)	
	M. gilvus (Hagen)	
	M. carbonarius (Hagen)	
	M. maesodensis (Ahmad)	
	M. malaccensis (Havilandi)	
	M. barneyi (Light)	
	M. estherae (Holmgren)	

Termititdae	*M. menglongensis* (Han)	
	M. chaiglomi (Ahmad)	
	M. tuyeni (Vuong)	
	M. songanensis (Vuong)	
	M. latignathus (Thapa)	
	M. serrulatus (Snyder)	
	M. langsonensis (Vu et Chu)	
	Microtermes obesi (Holmgren)	
	M. dimorphus (Tsai et Chen)	
	M. insertoides (Holmgren)	
	M. comis (Havilandi)	
	M. laticornis (Havilandi)	
	M. pakistanicus (Ahmad)	
	Odontotermes graveli (Silvestri)	
	O.ynnanensis (Tsai et chen)	
	O. horni (Wasmann)	
	O. hainannensis (Light)	
	O. angustignathus (Tsai et Chen)	
	O. feae (Wasmann)	
	O.formosanus (Shiraki)	
	O. djampeesis (Kemner)	
	O. proformosanus (Ahmad)	
	O. pahamensis (Nguyen)	
	O. maesodensis	
	O. latignathus	
	O. malaccensis (Holmgren)	
	O. ceylonicus (Wasmann)	
	O. cornignathus	
	O. javanicus (Holmgren)	
	O. adampurensis	
	O.profeae	
	O. giriensis (Roonwall)	
	O. foveafrons	
	O. annulicornis	
	O. obscuriceps Wasmann)	
	O. sumatrensis (Holmgren)	
	Hypotermes makhamensis (Ahmad)	
	H. xenotermitis (Wasmann)	
	Pericapritermes semarangi (Holmgren)	
	P. tetraphilus (Silvestri)	
	P. frontalus (Nguyen)	
	P. nitobei (Shiraki)	
	P. latignathus (Holmgren)	
	Procapritermes sowerbyi (Light)	
	P. albipenis (Tsai et Chen)	
	P. nitobei (Shiraki)	
	Discuspiditermes orientalis (Harris)	
	Nasutitermes paranacutus (Shiraki)	

Termitidae	*N. deltocephalus* (Tsai et Chen)	
	N. moratus (Silvestri)	
	N. gardneri (Snyder)	
	N. bulbiceps (Holmgren)	
	N. matangengiformis (Havilandi)	
	N. parpavus (Ahmad)	
	N. communis (Tsai et Chen)	
	Bulbitermes laticephalus (Ahmad)	
	B. prabhae (Krisna)	
	Trinervitermes orthonasus (Tsai. et Chen)	
	T. senae (Nguyen)	
	T. disparatus (Silvestri)	
	Lacessititermes homgreni (Light - . Wilson)	
	L. cuphus (Silvestri)	
	Hospitalitermes luzonensis (Oshima)	
	H. ataramensis (Prasad et Sen Sarma)	
	H. jepsoni (Snyder)	
	Prorhinotermes flavus (Bugnion)	
	Pseudhamitermes sp.	
	Pseudocapritermes parasilvaticus	
	Microcapritermes sp.	

Appendices III

Statues and membership application forms (draft)

Draft

Pacific Rim Termite Research Group
Statues
Effective 8 March 2004

Article 1 Name

The name of the organization is **Pacific Rim Termite Research Group** (hereinafter referred to as "TRG").

Article 2 Organization

TRG will have a President, Secretary General and Executive Council (hereinafter referred to "EC"). The EC shall consist of the President, Secretariat General and two other ordinary and/or sponsor members. The day-to-day conduct of the affairs of TRG shall be transacted by the EC.

Article 3 Secretariat

TRG's Secretariat will be located initially at the **Wood Research Institute*** of Kyoto University, Uji, Kyoto 611-0011, Japan. * WRI will be called Research Institute for Sustainable Humanosphere from 1 April 2004

Article 4 Aim and functions of TRG

The aim of TRG is to promote research in the Pacific Rim regions on the subject of termites.

The function of TRG shall be to pursue its aim in particular to

+ facilitate collaborative research projects among termite researchers
+ provide a forum for exchanging scientific and technical information
+ promote relationships among termite researchers for further research
+ undertake any other action likely to facilitate the aim of TRG

Article 5 Membership

4.1 Ordinary member: TRG shall be open to those who are active in termite research in universities and other scientific research institutions.

4.2 Sponsor member: Companies with a global interest in termite management as well as relevant academic societies and industrial associations can support the activities of TRG.

Article 6 Application for membership

Application for membership shall be submitted to the President of TRG. New members may be admitted only with the approval of all members of the Executive Council.

Article 7 Termination of membership

Any member may resign from TRG by giving notice in writing to the President.

Article 8 Membership and conference fees

8.1 Membership fee: Nil for ordinary. members and US$200.00 *per annum* for sponsor members.

8.2 Conference fee: Conference fee shall be decided by the Executive Council.

8.3 Members are expected to be self-funded, especially with regard to conferences and project participation.

Draft

Ordinary Membership Application Form for the Pacific Rim Termite Research Group

Please fill out the form and e-mail, fax or mail it to Dr. Kunio Tsunoda not later than 31 December, 2003

Dr. Kunio Tsunoda
Wood Research Institute, Kyoto University, Uji, Kyoto 611-0011, Japan
Fax: 81-774-38-3664 Tel: 81-774038-3661
e-mail: **tsunoda@termite.kuwri.kyoto-u.ac.jp**

Application form for the ordinary membership

Name	
Title Tick the appropriate box.	☐ Mr. ☐ Mrs. ☐ Miss ☐ Dr.
Position	
Affiliation	
Address	
Telephone number (country code + area code + number)	
Fax number (country code+ area code +number)	
e-mail address	

Please list best 5 papers related to termite research [author(s), article title, journal name, volume (number), page, year].

1)

2)

3)

4)

5)

Draft

Sponsor Membership Application Form for the Pacific Rim Termite Research Group

Please fill out the form and e-mail, fax or mail it to Dr. Kunio Tsunoda not later than 31 December, 2003

Dr. Kunio Tsunoda
Wood Research Institute, Kyoto University, Uji, Kyoto 611-0011, Japan
Fax: 81-774-38-3664 Tel: 81-774038-3661
e-mail: **tsunoda@termite.kuwri.kyoto-u.ac.jp**

Application form for the sponsor membership

Name of company	
Contact person	
Title Tick the appropriate box.	☐ Mr. ☐ Mrs. ☐ Miss ☐ Dr.
Position	
Address	
Telephone number (country code + area code + number)	
Fax number (country code + area code + number)	
e-mail address	