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Termite resistance of *Melaleuca cajuputi* wood treated with citric acid

Manop Tarasin*, Wigunda Rattanapun

Economic Plant of Surat Thani Province Research Unit, Faculty of Science and Industrial Technology, Prince of Songkla University, Surat Thani Campus, Surat Thani 84000, Thailand

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Abstract

Many termite species are major pests of wood products. Chemical and non-chemical wood preservatives are used to enhance the termite resistance of wood structures. A laboratory study using citric acid was used to test the protection of cajuputi wood (*Melaleuca cajuputi*; Myrtaceae) against *Coptotermes gestroi* Wasmann (Isoptera: Rhinotermitidae). Treated *M. cajuputi* wood was prepared using vacuum impregnation and alternatively by dipping. Dried *M. cajuputi* wood was dipped in 50%, 25% and 15% citric acid for 15 s, while the impregnation treatments involved 6%, 3% and 1.5% citric acid under 760 mmHg (101.33 kPa) pressure for 1 hr. The controls were *M. cajuputi* wood treated with 1.5% boron and non-treated wood. All cases were exposed to *C. gestroi* in no-choice experiments, and the relative mass loss of *M. cajuputi* wood that had been vacuum impregnated with citric acid was not significantly different from that impregnated with 1.5% boron, with both remaining below 11%. In all dipping treatments, the mass loss of *M. cajuputi* wood was higher than that with the baseline boron treatment.

Introduction

Melaleuca cajuputi tree (Myrtaceae) is a medium-to-tall tree with paper-like bark, and is widespread in Australia, Southeast Asia and New Guinea, where it can grow in swamps and peat swamp forests (Nuyim, 1998). Such areas are utilized for growing agricultural crops and most wild plants cannot thrive under such conditions (Sasaki et al., 1995; Nuyim, 2000). Essential oil from *M. cajuputi* leaves is well-known as a treatment for aches and pains (Brophy and Doran, 1996). In Southeast Asia, *M.cajuputi* is used as fuel and to make charcoal (Suwansutthi, 1984). Industrially *M.cajuputi* is an economically important wood species used to make high quality particleboard and wood cement particle board (Jirayut et al., 1993).

However, wood has no inherent resistance to termites, with contemporary wood protection methods including both physical and chemical approaches (Verma et al., 2009). The physical methods include heat treatment, freezing, electricity and microwaves (Verma et al., 2009). Termiticides and some natural plant extracts are used for chemical wood treatments to improve termite resistance. The Asian subterranean termite *Coptotermes gestroi* (Isoptera: Rhinotermitidae) is a species endemic to Southeast Asia (Li et al., 2013). It is a serious pest that can severely damage wooden buildings and structures and *C. gestroi* was first found in the USA in 1996 in Miami, FL (Su et al., 1997), and within 20 years it had become a major structural pest throughout this urban region (Chouvenc et al., 2016).Chemical wood preservatives used to decrease the damage from *C. gestroi* include creosote, tanalith and chromated copper arsenate; however, the use of these agents is nowadays discouraged because they can be leached into water and cause environmental pollution (Chang et al., 2001; Iacobellis et al., 2004; Cheng et al., 2007).

* Corresponding author.
E-mail address: manop8899@gmail.com (M. Tarasin).

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Bio-pesticides such as plant essential oil (Siramon et al., 2009; Pal et al., 2011; Alavijeh et al., 2014) and eco-friendly synthetic preservatives likeboron (Williams and Bergstorm, 2005; Farid et al., 2015)are promising replacements for conventional pesticides, as the former have minimal toxicity to mammals, widespread availability, repellency or toxicity or both to pests and relatively lowcost. The present study examined the resistance of *M. cajuputi* wood treated with citric acid against *C. gestroi* infestation. Citric acid occurs naturally in citrus fruits and in the metabolism of all aerobic organisms (Penniston et al., 2008). It is used widely as an acidifier or as a flavoring and chelating agent and is safe for mammals (Berovic and Legisa, 2007). High acidity tends to be toxic to all organisms, and Toyoshima et al. (1997) reported overall decreased respiration in termites immediately after feeding them borate-treated timber (boric acid concentrations of 5 kg/m^3, 10 kg/m^3 and 20 kg/m^3).

This study focused on the possibility of using citric acid as a wood preservative against *C. gestroi*. In addition, two alternative methods of wood treatment, namely dipping and vacuum impregnation, were assessed for their efficacy in wood protection.

Materials and Methods

Sample preparation

Wood samples

Melaleuca cajuputi heartwood lumber from the Khuan Khreng peat swamp forest, Cha-uat district, Nakhon Si Thammarat province, Thailand, was collected and small samples measuring 25.4 mm × 6.4 mm were prepared. The small samples were dried in an oven at 60°C until constant weight.

Dipping method

Solutions of 1,000 mL of 50%, 25% and 15% citric acid and 1.5% boron were prepared by mixing dry powder (citric acid or boron) with reverse osmosis purified water (weight per weight). The dried wood samples were dipped in 50%, 25% and 15% citric acid solutions with pH levels of 0.94, 1.18 and 1.64, respectively, or 1.5% boron (6.73 pH level) for 15 s and then dried at 60°C until constant weight. All the dipped samples and the control (non-treated samples) were weighed before exposure to termites.

Vacuum method

Dried wood samples were treated with 6%, 3% and 1.5% citric acid with pH levels of 2.18, 2.84 and 3.21, respectively, or 1.5% boron at 760 mmHg (101.33 kPa) vacuum for 1 hr at room temperature and weighed. The control was non-treated samples that were also weighed before exposure to termites.

The percentage increase was calculated in the mass of each wood sample after treatment (weight percent gain; WPG) from using the vacuum and dipping methods as shown in Equation 1 (Hill, 2006):

$$\text{WPG (\%)} = (M_1 – M_2) / M_2 \times 100 \quad (1)$$

where $M_1$is the mass of the treated wood sample and M_2 is the mass of the wood sample before treatment with all measurements in grams.

Experiments

The no-choice experiments were carried out in the laboratory based on the ASTM D3345-17 standard (ASTM International, 2001). Each sample was put individually on sand in a cylindrical plastic box (12 cm diameter and 7.5 cm tall). One gram of worker and soldier termites, *C. gestroi*, was put in the cylindrical plastic box. The test termites were collected from damaged rubber wood logs around the laboratory building of Prince of Songkla University, Surat Thani campus, Surat Thani, Thailand. Each cylindrical plastic box was covered with a lid and left for 4 wk. Ten replications were done of each treatment and the untreated control. At the end of the 4 wk test period, all the tested wood samples were dried at 60°C until constant weight. The recorded weight was used to calculate the relative mass loss caused by *C. gestroi* (Equation 2):

$$\text{Mass loss (\%)} = (W_1 – W_2) / W_2 \times 100 \quad (2)$$

where W_1 is the weight of treated wood sample before test with termites and W_2 is the weight of treated wood sample after test with termites with all measurements in grams.

Data analysis

Statistical differences in mass loss and weight percent gain between treatments were analyzed using one-way and two-way analyses of variance and using the Tukey honestly significant difference test, using the SPSS for Windows software package (version 18.0; SPSS Inc.; Chicago, IL, USA).

Results

There was no significant difference in weight percent gain between the different concentration levels of citric acid in the percentage increase in the mass of wood samples impregnated with different concentrations of citric acid and the wood samples dipped in citric acid (two-way analysis of variance: $F_{3,72} = 0.911$; $p = 0.440$; Fig. 1). However, there was a significant difference in the weight percent gain among wood samples treated using the vacuum method and the dipping method (one-way analysis of variance: $F_{1,72} = 1247.312$; $p \leq 0.0001$). Wood samples treated using the vacuum impregnation method had higher weight percent gains than from the dipping method.

The treatments by dipping resulted insignificant differences in mass loss of *M. cajuputi* wood (one-way analysis of variance: $F_{4,45} = 17.042$; $p \leq 0.0001$). The non-treated wood (control) had the greatest mass loss, as was expected. *Melaleuca cajuputi* wood treated with 1.5% boron had the least mass loss, while no significant difference in mass loss was observed for the various concentrations of citric acid dipping. With vacuum impregnation, the mass loss of *M. cajuputi* wood treated with citric acid did not differ from that treated with1.5% boron and both were below 11%. Non-treated wood was extensively damaged by *C. gestroi* (one-way analysis of variance: $F_{4,45} = 12.530$; $p \leq 0.0001$); Figs. 2 and 3).There were no dead termites found in any of the test boxes.

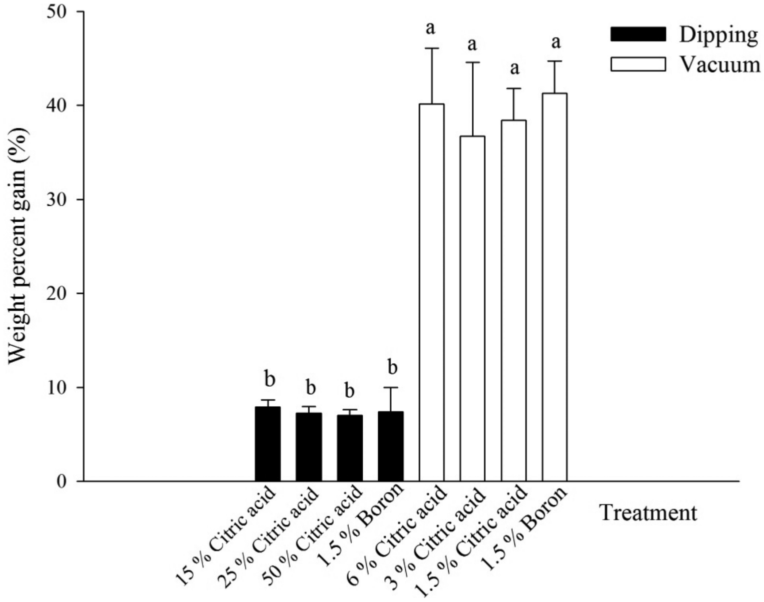

Fig.1 Weight percent gain of wood sample treated with citric acid or boron by dipping or by vacuum impregnation, where different lowercase letter above each column indicate a significant ($p < 0.05$) difference and error bars = ± SD

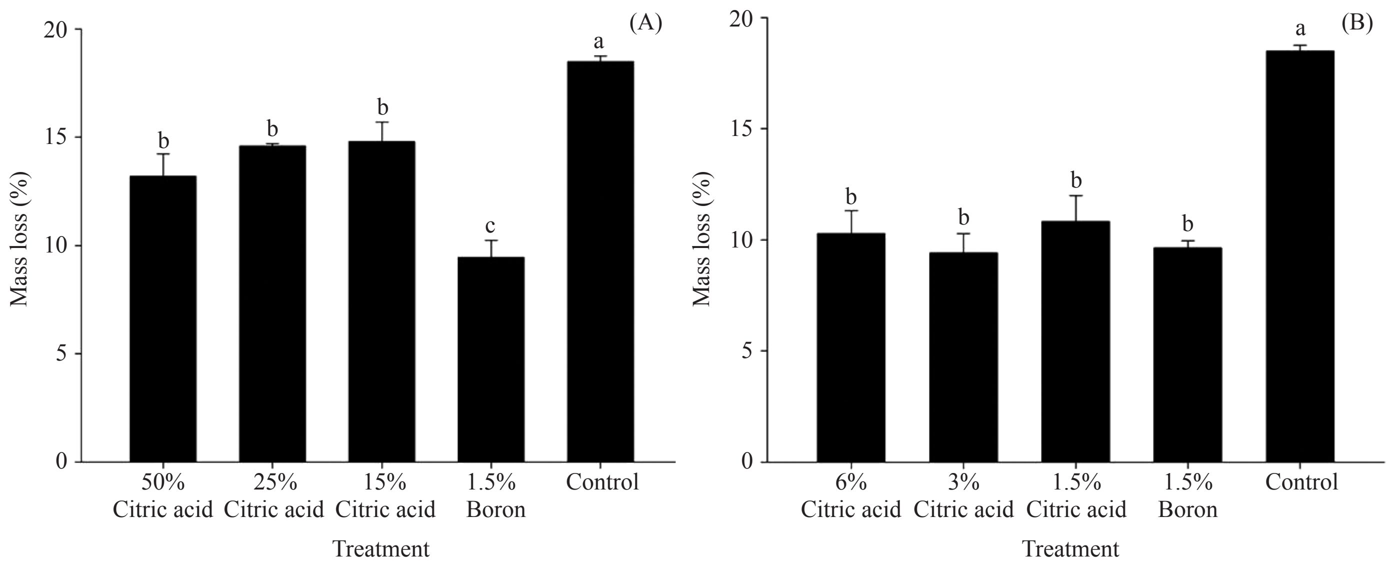

Fig. 2 Mass loss of cajuputi wood treated with citric acid or boron by dipping (A),or by vacuum impregnation (B), where the control was untreated and different lowercase letter above each column indicate a significant ($p < 0.05$) difference and error bars = ± SD

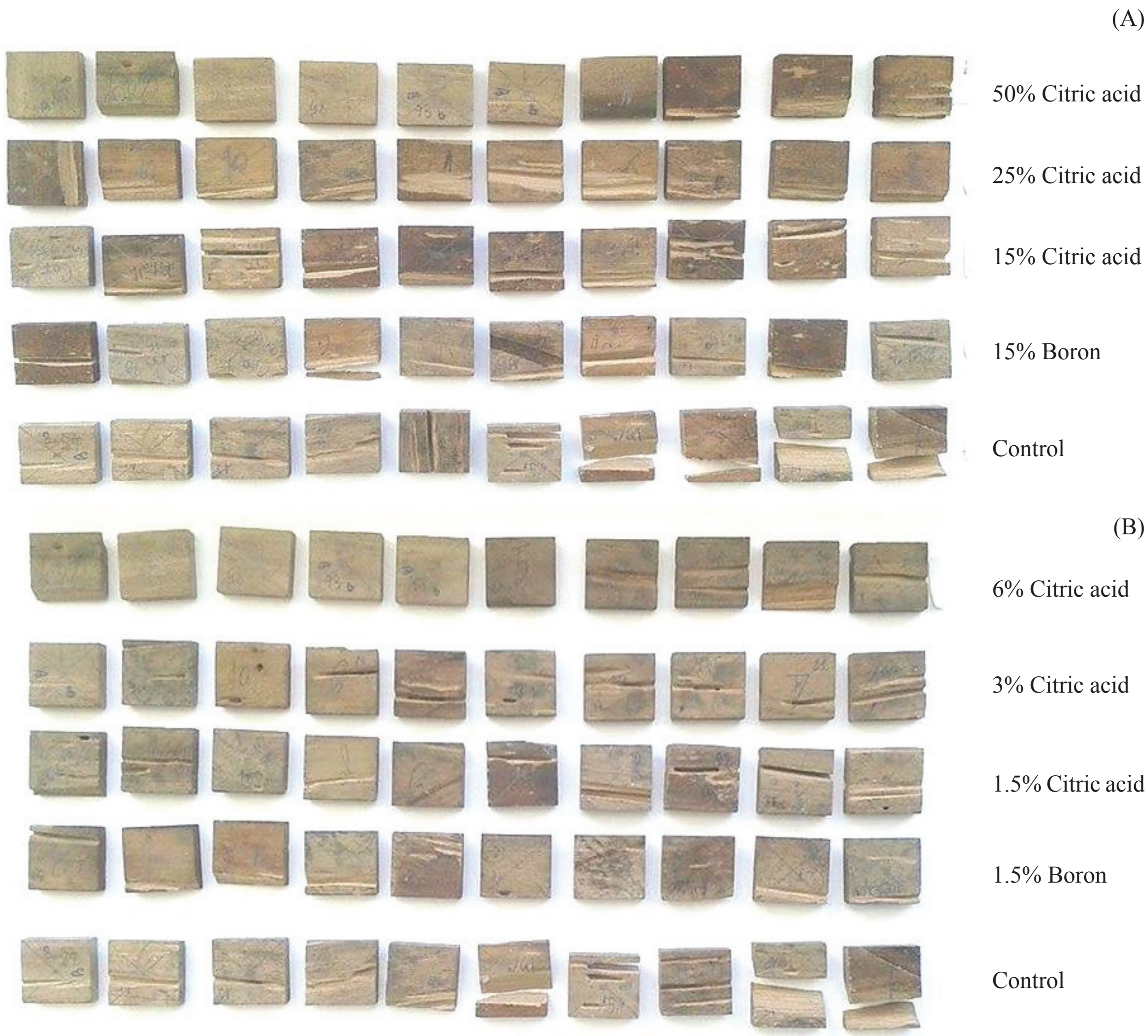

Fig. 3 Visual damage from *C. gestroi* infestation of cajuputi wood for: (A) treatment with citric acid or boron by dipping; (B) vacuum impregnation

Discussion

The results indicated that citric acid can decrease *C. gestroi* damage in *M. cajuputi* wood from that without treatment, using either dipping or vacuum impregnation treatments. This may be partly explained by the citric acid affecting the metabolism of *C. gestroi* in a similar manner to boric acid (Toyoshima et al., 1997). Indrayani et al. (2015) and Kusumah et al. (2017) supported these results, describing that the natural adhesion of citric acid is effective in prohibiting degradation by the subterranean termite *Coptotermes formosanus* Shiraki in fiberboard and particleboard bonded with citric acid by contributing to higher *C. formosanus* mortality and a lower degree of mass loss than the controls. In general, termite mortality was confirmed based on the weight loss in the specimen. However, dead termites were not found in the test boxes during the current experiment. Consequently, it is suggested that the strong odor of the high citric acid content released from the wood samples may have repelled termites or disturbed the termites while feeding.

M. cajuputi wood treated with citric acid using vacuum impregnation had better resistance against *C. gestroi* infestation than that treated with citric acid by dipping. Interestingly, when using impregnation, the mass loss at all concentrations of citric acid tested was similar to that with 1.5% boron. Generally, a liquid wood preservative can deeply permeate wood with vacuum impregnation. In contrast, when *M. cajuputi* wood was treated with high citric acid concentrations by dipping, the citric acid did not seem to penetrate deeply. This could possibly be explained by short dipping time (15 s) in the current experiment. Humar and Lesar (2009) indicated that longer dipping times resulted in higher uptakes of preservative solution into wood. DeGroot and Stroukoff (1986) reported that with water-based preservative, a dip for 3 min gave better protection for wood boxes (12.5−17.2 mm thickness) from termites and fungi damage than a dip for 1 min. Consequently, the wood samples (6.4 mm thickness) dipped in the high concentration of citric acid for 15 s in the current experiment may have provided only a surface treatment, resulting in comparatively poor protection with high mass loss.

In summary, citric acid appeared suitable for use as a wood preservative. Citric acid is a natural food preservative that adds an acidic or sour taste to foods, soft drinks or candy. It can also serve as a preservative of wooden structures, reducing termite damage. Further studies could assess the leaching of citric acid from wood.

Conflict of Interest

The authors declare that there are no conflicts of interest.

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References

Alavijeh, E.H., Habibpour, B., Moharrabipour, S., Rasekh, A. 2014. Bioactivity of *Eucalyptus camaldulensis* essential oil against *Microcerotermes diversus* (Isoptera: Termitidae). J. Crop Prot. 3: 1–11.

ASTM International. 2001. Annual Book of ASTM Standard. ASTM International, V. 04.10 (1999). West Conshohocken, PA, USA.

Berovic, M., Legisa, M. 2007. Citric acid production. Biotechnol. Annu. Rev. 13: 303–343.

Brophy, J.J., Doran, J.C. 1996. Essential oils of Tropical *Asteromyrtus, Callistemon* and *Melaleuca* Species. ACIAR Monograph No 40.

Chang, S.T., Cheng, S.S., Wang, S.Y. 2001. Antitermitic activity of essential oils and components from Taiwania (*Taiwania cryptomerioides*). J. Chem. Ecol. 27: 717–724.

Cheng, S.S., Chang, H.T., Chang, S.T., Wu, C.L. 2007. Anti-termitic activities of essential oils from coniferous trees against *Coptotermes formosanus*. Bioresour. Technol. 98: 456–459.

Chouvenc, T., Scheffrahn, R.H., Su, N.Y. 2016. Establishment and spread of two invasive subterranean termite species (*Coptotermes formosanus* and *C. gestroi*; Isoptera: Rhinotermitidae) in metropolitan southeastern Florida (1990–2015). Fla. Entomol. 99: 187–191.

DeGroot, R.C., Stroukoff, M. 1986. Efficacy of Alternative Preservatives Used in Dip Treatments for Wood Boxes. Research Paper: FPL-RP-481. Department of Agriculture, Forest Service, Forest Products Laboratory. Madison, WI, USA.

Farid, A., Bad shah, T., Khan, M., Saeed, M., Zaman, M. 2015. Evaluation of boric acid as a slow-acting toxicant against subterranean termites (*Heterotermes* and *Odontotermes*). J. Entomol. Zool. Stud. 3: 213–216.

Hill, C. 2006. Thermal modification of wood, pp. 99−127. In: Wood Modification: Chemical, Thermal and Other Processes. John Wiley & Sons Inc. New Jersey, NJ, USA.

Humar, M., Lesar, B. 2009. Influence of dipping time on uptake of preservative solution, adsorption, penetration and fixation of copper-ethanolamine base wood preservatives. Eur. J. Wood Prod. 67: 265–270.

Iacobellis, N.S., Lo Cantore, P., Capasso, F., Senatore, F. 2004. Antibacterial activity of *Cuminum cyminum* L. and *Carumcarvi* L. essential oils. J. Agric. Food Chem.53: 57–61.

Indrayani, Y., Munawar, S.S., Setyawati, D., Umemura, K., Yoshimura, T. 2015. Evaluation of termite resistance of medium density fiberboard (MDF) manufacture from agricultural fiber bonded with citric acid. Procedia Environ. Sci. 28: 778–782.

Jirayut, T., Benjachaya, S., Phupibun, U. 1993. Wood cement particleboard from *Melaleuca cajuputi* Powell. In: Annual Conference of Forestry 1993. Bangkok, Thailand, pp. 212–222.

Kusumah, S.S., Guswenrivo, I., Kanayama, K., Umemura, K., Yoshimura, T. 2017. Utilization of sweet sorghum bagasse and citric acid for manufacturing of particleboard II: Influences of pressing temperature and time on particleboard properties. J. Wood Sci. 63: 161–172.

Li, H-F., Fujisaki, I., Su, N-Y. 2013. Predicting habitat suitability of *Coptotermes gestroi* (Isoptera: Rhinotermitidae) with species distribution models. J. Econ. Entomol. 106: 311–321.

Nuyim, T. 1998. Peatswamp forest rehabilitation study in Thailand, pp. 19-25. In: Proceedings International Workshop BIO-REFOR. Brisbane, Australia.

Nuyim, T. 2000. Whole aspect on nature and management of peat swamp forest in Thailand, pp. 109–117. In: Proceedings of the International Symposium on Tropical Peatlands. Bogor, Indonesia.

Pal, M., Tewari, S.K., Verma, R.K. 2011. Anti-termite activity of essential oil and its components from *Myristica fragrans* against *Microcerotermes beesoni*. J. App. Sci. Environ. Manage. 15: 559–561.

Penniston, K.L., Assimos, D.G., Holmes, R.P., Nakada, S.Y. 2008. Quantitative assessment of citric acid in lemon juice, lime juice, and commercially-available fruit juice products. J. Endourol. 22: 567–570.

Sasaki, S., Kojima, K., Masumori, M., Niyomdham, C., Nuyim, T., Tange, T., Yagi, H., Yamanoshita, T. 1995. Reforestation trial of degraded peat swamp forest and sand dune in Narathiwat, Thailand, pp. 55–61. In: Pisoot, V. (Ed.). The International Workshop on Global Environmental Studies on Greenhouse Gas Emission and Tropical Peat Swamp in Southeast Asia. Nodai Research Institute, Tokyo University of Agriculture. Tokyo, Japan.

Siramon, P., Ichiura, H., Ohtani, Y. 2009. Biological performance of *Eucalyptus camaldulensis* leaf oils from Thailand against the subterranean termite *Coptotermes formosanus*Shiraki. J. Wood Sci. 55: 41–46.

Su, N.Y., Scheffrahn, R.H., Weissling, T. 1997. A new introduction of a subterranean termite, *Coptotermes havilandi* Holmgren (Isoptera: Rhinotermitidae) in Miami, Florida. Fla. Entomol. 80: 408–411.

Suwansutthi, K. 1984. Some of Wood and Minor Products in Thailand. Namaksornkarnpim, Bangkok. pp. 490.

Toyoshima, I., Takahashi, M.,Tsunoda, K., Yoshimura, T. 1997. Comparative toxicity, residual nature and effect on respiration of boron compounds in a lower termite, *Coptotermes formosanus* Shiraki (Isoptera: Rhinotermitidae). Material und Organismen. 31: 217–226.

Verma, M., Prasad, R., Sharma, F. 2009. Biological alternatives for termite control: A review. Int. Biodeterior. Biodegradation. 63: 959–972.

Williams, L.H., Bergstorm, T.B. 2005. Boron-treated expanded polystyrene insulation resists native subterranean termite damage after 3-year field exposure. Forest Prod. J. 55: 56–60.