Food Preferences of Workers of *Coptotermes formosanus* (Isoptera: Rhinotermitidae)

by

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ABSTRACT

Coptotermes formosanus Shiraki is an amphibious termite which severely damages wood components of housing construction, stored cellulose materials, living trees, and communication facilities. The food preference of this termite was investigated in laboratory conditions. Our research results indicated that among 8 kinds of woods (teak *Tectona grandis*, Chinese fir *Cunninghamia lanceolata*, oak *Quercus mongolica*, taxis *Melia azedarach*, birch *Betula allegansis*, beech *Fagus syliatica*, pine *Pinus massoniana*, and poplar *Populus tremula*), the consumption rate of pine wood by *C. formosanus* (30.46%) is higher than that of seven other species of wood. After pine was treated by eight different methods, the pine wood treated repeatedly (three times) by the method of dipping 24 hours in water and drying in the sun (SD method) was significantly preferred by *C. formosanus*. When adding 30% sugar into water for treatment of pine wood blocks in the SD method, the pine wood blocks attracted more termites to feed compared to other concentrations of sugar in water. Moreover, Adding 10% Formosan subterranean termite nest material into 30% sugar solution increased the preference to the treated pine wood blocks by *C. formosanus*. This information shows that *C. formosanus* likes to feed on pine wood blocks treated repeatedly by the method of dipping in mixed solutions of Formosan subterranean termite nest material and 30% sugar for 24 hours and drying in the sun.

Keywords: *Copototermes formosanus*, pine wood block, consumption rate, efficacy, attraction.

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INTRODUCTION

Although the efficacy of traditional chemicals chlordane and mirex to control termites is good, these two chemicals have been banned because of their high toxicity, long persistent period and harm to environment and human health. Use of bait to control termites has also been one of the most important and effective measures in China because of its simplicity, feasibility, minimal pollution, and high efficacy. However, many factors affect the feeding of termites on bait. Some researchers (Becker 1969; Behr *et al.* 1972; Carter *et al.* 1983; Waller & LaFage 1987; Delaplane & LaFage 1989; Sornnuwat *et al.* 1995) have summarized some factors that affect the feeding preference in termites. Of these, food components is one of the most important factors.

In China, *Coptotermes formosanus* Shiraki is found in areas north of latitude 33.5° and is a amphibious termite which severely damages wood components of housing construction, stored cellulose materials, living trees, and communication facilities. It causes tremendous economic losses every year in China. Therefore, people hope to improve the bait to better control the damage of *C. formosanus* and to reduce the economic losses. In this paper, we determined the feeding preference of *C. formosanus* to different wood materials in laboratory conditions.

MATERIALS AND METHODS

Source of termites

A *Coptotermes formosanus* nest was collected from the field and was maintained in laboratory conditions for two years.

Woods for experiment

Eight species of wood were used in this study. They were teak *Tectona grandis* (A), Chinese fir *Cunninghamia lanceolata* (B), oak *Quercus mongolica* (C), taxis *Melia azedarach* (D), birch *Betula allegansis* (E), beech *Fagus syliatica* (F), pine *Pinus massoniana*(G), and poplar *Populus tremula* (H). They were purchased from the Sanhe Timber Factory (Deqing County, Zhejiang Province) and processed into wood blocks (5 cm×5 cm×2.5 cm) before experiments.

Experimental procedures

Experiments were divided into four steps. The first step was to determine the feeding preference of *C. formosanus* to different wood species. Before experiments, the 8 kinds of wood blocks were put into an oven for 24 hours at 70°C, and then immediately weighed**.** When experiments started, one wood block of each wood species was randomly placed on the surface of the *C. formosanus* nest. Two weeks later, the rest of the wood blocks were taken out and the mud on the wood was removed with water. Finally, the blocks were put in a room to air dry. After that, they were baked for 24 hours at 70°C and weighed again. According to the weight variation of wood blocks, the wood species mostly preferred by *C. formosanus* was determined.

The second step was to determine the feeding preference of *C. formosanus* to the pine wood blocks treated with different methods. Before experiments, the pine wood blocks were treated according to the methods shown in Table 1. When the experiment was done, the pine woods were tested as the method described on the first step.

Table 1. Methods for pine wood treatment.

Treatment methods of treating pine wood blocks for experiments.			
Drying in the sun (SA)	Dipping in water for 24 hours and then drying in the sun (SB)	Repeating SB method 2 times (SC)	Repeating SB method 3 times (SD)
Drying in oven at 70°C (OA)	Dipping in water for 24 hours and drying in oven at 70°C (OB)	Repeating OB method 2 times (OC)	Repeating OB method 3 times (OD)

The third step was to determine the feeding preferences of *C. formosanus* to wood blocks treated with different concentrations of sugar solution. Before experiments, the pine wood blocks were treated by the best method screened out from the second experiment (that is, the pine wood blocks treated by this method were the ones most preferred by *C. formosanus*) but water solutions were replaced with 10%, 20%, 30%, 40%, 50% or sugar solution when wood blocks were treated. When the experiment was done, the consumption of the wood blocks was evaluated by the method described on the first step.

The fourth step was to determine the feeding preference of *C. formosanus* to the pine wood blocks treated with 30% sugar solution and different concentrations of Formosan subterranean termite nest material extract solutions.

Before experiments, the pine wood blocks were treated by the best method screened out from the third step experiment (that is, the pine wood blocks treated by this method were the ones most preferred by *C. formosanus*) but the sugar solution contained 1%, 2%, 5%, 10%, and 20% of Formosan subterranean termite nest material when pine wood blocks were treated. When the experiment was done, the consumption of the wood blocks was evaluated by the method described in the first step.

Statistical analysis

DPS data processing system was used to analyze the experimental data. One way ANOVA was used to analyze difference of all data through Duncan's new multiple range method for multiple comparisons (Tang & Feng 2010).

RESULTS

Feeding preference of *C. formosanus* to eight species of wood

Among eight species of woods tested, *C. formosanus* most preferred the pine wood (Fig.1). The consumption rate of pine wood (30.46%) was significantly higher than that of other seven species of wood ($p < 0.05$). Consumption rate of poplar wood (18.44%) and beech wood (14.63%) ranked second and

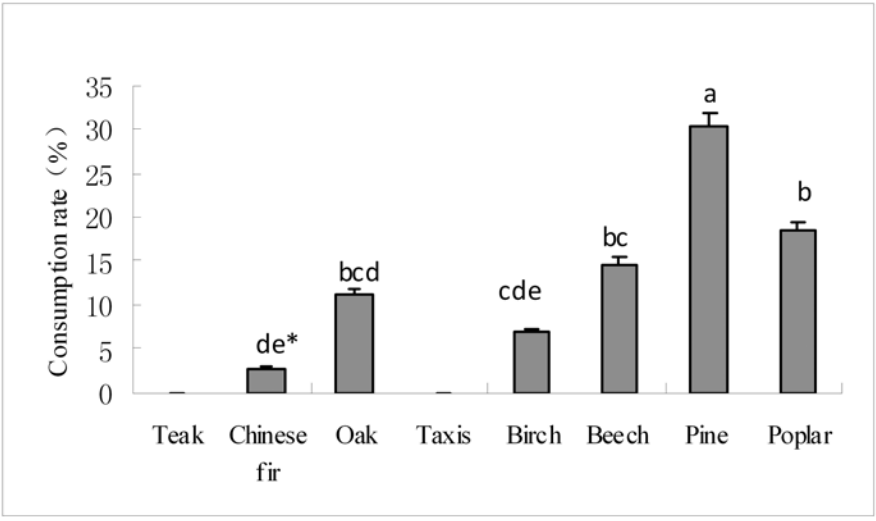

Fig.1. The consumption rate of different wood blocks by *C. formosanus.* The same letter means the difference between groups was not significant ($p>0.05$); each test was repeated eight times.

third, respectively. There were no significant differences in the consumption rate among oak, birch or Chinese fir, ($p > 0.05$). In addition, *C. formosanus* did not like teak wood or taxis wood.

Feeding preference of *C. formosanus* to pine woods treated with different methods

Among the eight treatment methods, the SD method most significantly enhanced the feeding of *C. formosanus* on pine wood blocks (Fig.2). The consumption rate of pine wood blocks treated with SD method by *C. formosanus* (46.09%) was significantly higher than that treated with other seven methods ($p < 0.05$). Moreover, there were no significant difference among other seven methods ($p > 0.05$), the consumption rate of pine wood blocks treated with other seven methods ranged from 22.54% to 29.42%.

Feeding preference of *C. formosanus* to pine woods treated with different concentrations of sugar solution

Among five concentrations of sugar solutions tested, 30% sugar solution most significantly enhanced the feeding of *C. formosanus* on pine wood blocks treated (Fig.3). The consumption rate of pine wood blocks treated with 30% sugar solution by *C. formosanus* (46.77%) was significantly higher than that

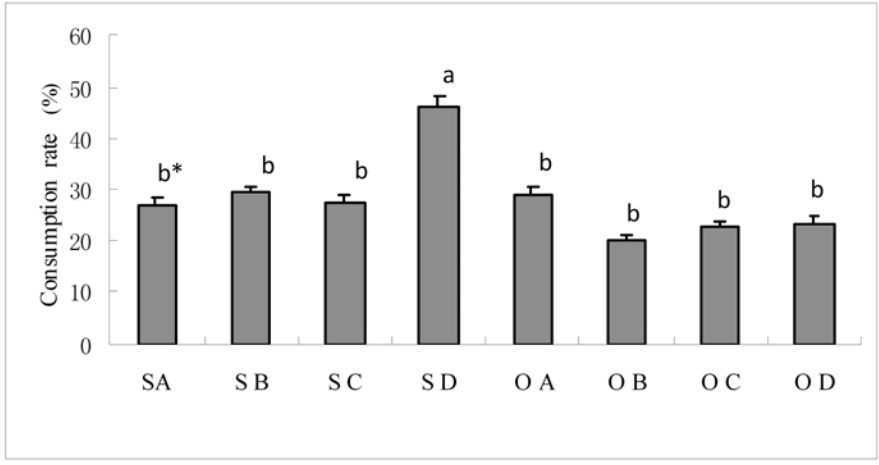

Fig.2. The consumption rate of treated pine wood blocks treated with different methods by *C. formosanus*. The same letter means the difference between groups was not significant ($p > 0.05$); each test was repeated eight times.

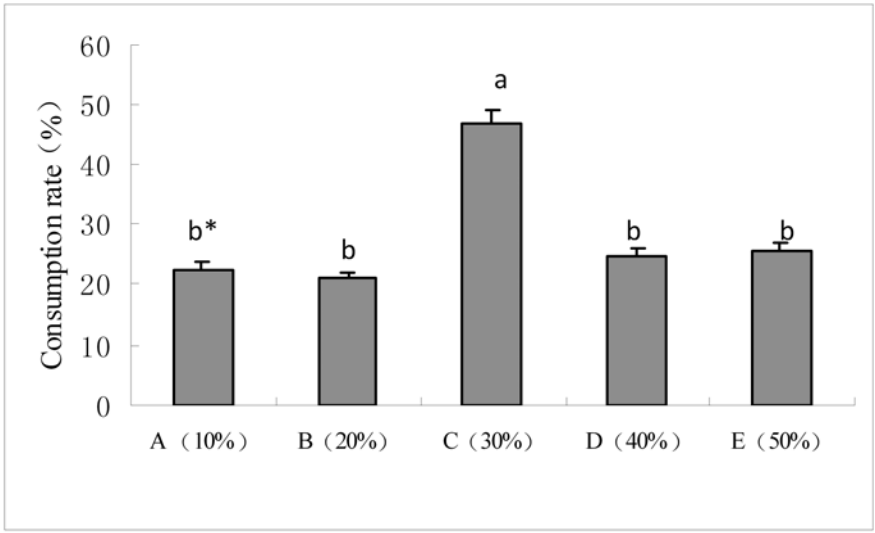

Fig.3. The consumption rate of pine wood blocks treated with different concentrations of sugar solution by *C. formosanus.* The same letter means the difference between groups was not significant (p> 0.05); each test was repeated eight times.

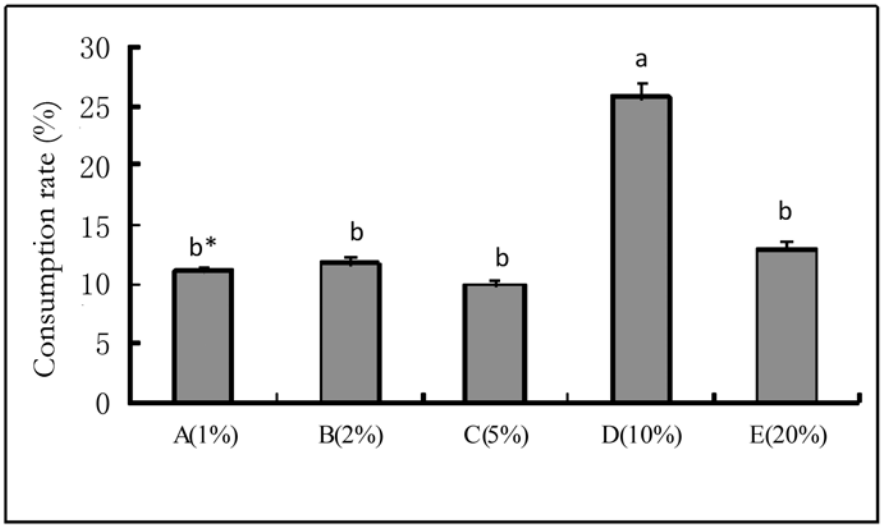

Fig.4. The consumption rate of pine wood blocks treated with different concentrations of Formosan subterranean termite nest material by *C. formosanus*. The same letter means the difference between groups was not significant (p> 0.05); each test was repeated eight times.

treated with other four sugar solutions ($p<0.05$). There were no significant differences among the other four glucose concentration ($p> 0.05$).

Feeding preference of *C. formosanus* to pine woods treated with different concentrations of Formosan subterranean termite nest material

Among five concentrations of Formosan subterranean termite nest material tested, 10% nest material solution most significantly enhanced the feeding of *C. formosanus* on pine wood blocks treated (Fig.4). The consumption rate of pine wood blocks treated with 10% nest material solution (25.74%) was significantly higher than that treated with the other four concentrations of nest material solution ($p<0.05$).

DISCUSSION

Among the 8 kinds of wood species studied, *C. formosanus* preferred to feed on the pine wood. Our results were consistent with results of other researchers. Song (1993) reported that pine wood mainly contains cellulose, lignin, little volatile oil (turpentine) and rosin (resin), etc. Volatile oil includes α-pinene, β-pinene and less t-camphene. Rosin contains rosin anhydride, hydrocarbon resins. Preference of *C. formosanus* to pine wood may be due to the strongest temptation of turpentine or rosin. Morales-Ramos & Rojas (2003) found Formosan subterranean termites significantly preferred the bait matrix over southern yellow pine wood *(Pinus taeda* L.) in laboratory and field evaluations. At the same time, the consumption rate of teak wood, taxis wood and other woods is low, which is probably related with large density and hardness of these woods. Wood density is a physical property of wood, which is positively correlated with the hardness of wood. Considering research on wood species attracting termites, many researchers found that termites have preference for low-density tissue wood types. Peng-Soon *et al.* (2004) indicated that rubber, jelutong and terentang were the most preferred species among the 29 wood species tested in the laboratory on four Malaysian termite species (*Coptotermes gestroi* Wasmann, *Coptoterme curvignathus* Holmgren, *Globitermes sulphureus* Haviland and *Microcerotermes crassus* Snyder). Delaplane & LaFage (1989) indicated that *C. formosanus* preferred low density and moist wood or wood damaged by conspecifics. Arango *et al.* (2006) found that wood density was

inversely correlated with wood consumption rate by *Reticulitermes flavipes* Kollar in tropical regions of the hard wood species in North America.On the contrary, the wood density was positively correlated with wood consumption rate by *R. flavipes* among the soft wood species.

Among the 8 treatment methods in our study, the consumption rate of the pine wood blocks treated with the SD method by *C. formosanus* was the largest. Timber contents include fat, fatty acids, fatty alcohols, phenols, steroids, resin acid, resin, wax, and many other trace organic chemicals. Most plants, especially the ones in tropical environments, use these substances as defensive components. Therefore, the allelochemicals of wood such as terpenoids, quinones, phenols and flavonoids are generally considered as repellent and/or toxic for termites. Yatagai *et al.* (2002) reported three kinds of wood acetic acid which were extracted from *Pseudotsgu menziesii,* oak and pine could effectively kill *Reticulitermes speratus* Kollbe. These compounds increased the mechanical strength of woods and had anti-feeding repellent and toxic effects on termites. In addition, pine contains some poisonous compounds that are toxic to termites. In this study, use of repeated dipping-drying treatment methods can effectively remove these poisonous compounds, and therefore improve preference of *C. formosanus* to pine wood.

Many researchers have found high concentrations of carbohydrates could highly appeal to termites (Waller & Curtis 1996; Reinhard & Kaib 2001). The study of Saran & Rust (2008) found that adding carbohydrates can significantly increase intake of hexaflumuron baits by *Reticulitermes hesperus*. Choice tests by Swoboda *et al.* (2004) determined that several types of sugars and uric acid would stimulate preferential feeding in the presence of a competing food resource. Haifig *et al.* (2008) found *Heterotermes tenuis* fed preferentially on filter paper treated with 0.03 g/ml trehalose and 0.015 g/ml urea solutions. In addition, Zhang *et al.* (2004) also found that certain concentrations of sucrose can improve the attractive ability of woods to *C. formosanus* and *Reticulitermes flaviceps*. Lin *et al.* (2011) via bioassay showed that pine wood blocks with 20% glucose had the strongest attraction to *C. formosanus*. Our study showed use of 30% sugar solution to treat the SD method-treated pine wood blocks could significantly enhance the feeding of *C. formosanus* on the wood. This means a high concentration of sugar solution is indeed a feeding stimulus for *C. formosanus*.

Adding 10% Formosan subterranean termite nest material in to 30% sugar solution also increased feeding of *C. formosanus* on the SD method-treated pine wood blocks. This means the nest material also contains stimulant compounds to *C. formosanus*. Li *et al.* (2001) found that adding homemade additive into pine sawdust significantly increased its attractiveness to *C. formosanus,* and the additive improved feeding addiction of termites on bait as well as food consumption. Cornelius (2003) reported that ergosterol acted as a feeding stimulant at a concentration of 1 mg/g of filter paper for Formosan subterranean termites.

Our study indicated that if pine wood blocks were treated repeatedly three times by the method of dipping in water solution with 30% sugar and 10% Formosan subterranean termite nest material for 24 hours and drying in the sun, it would be preferred strongly by *C. formosanus*. Therefore, pine wood blocks treated by this method treatment may be used in baiting systems for the monitoring of *C. formosanus* in the field.

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