



**PROCEEDINGS
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Premise® Granules were made according to manufacturer's recommendations. Structures were inspected at 1 wk, 2 wk, and then monthly for 1 yr post-treatment. Suppression of *R. flavipes* was sustained for 8 wk in all five treated structures following application of granules.

In the open field study with active *R. flavipes*, grids measuring 8.53 m x 7.32 m were marked off, in-ground commercial termite monitors were installed, and grids were treated with Premise® Granules. Untreated pine boards were then placed in grids to determine if granules would suppress foraging and feeding on surface boards. Treatments suppressed surface feeding of *R. flavipes* for at least 9 mo post-treatment, although subterranean termites were active throughout the study at in-ground termite monitors within treated grids.

Results from these 1-yr studies demonstrated suppression of *R. flavipes* when Premise® Granules were applied as a spot treatment to structures and when broadcast over an open field.

**COMPARATIVE STUDY OF TUNNELING AND FEEDING
PREFERENCES OF *COPTOTERMES FORMOSANUS* SHIRAKI
AND *COPTOTERMES GESTROI* WASMANN (ISOPTERA:
RHINOTERMITIDAE) IN FORAGING ARENAS**

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The subterranean termite genus *Coptotermes* (Rhinotermitidae) contains a number of highly destructive species. Two of these species occur in Hawaii: *Coptotermes formosanus* Shiraki (Formosan subterranean termite) and *Coptotermes gestroi* (Wasmann) (= *C. vastator*, *C. havilandi*) (Asian subterranean termite). *C. formosanus* is the major pest species in Hawaii and is widely distributed. Annual costs of management and damage repairs have been estimated to exceed \$100 million. *C. gestroi* is a major pest in Southeast Asia, Guam, and the Philippines, but currently occurs in Hawaii only on the southwest side of the island of Oahu (Woodrow et al. 2001, Grace 2006). Comparative evaluations of the tunneling and foraging behavior of these two species in Hawaii will contribute to our understanding of their distribution and ecology and may help to improve pest management programs, particularly those based on placement of toxic baits. The present study was initiated to quantify differences in tunneling patterns that were noted qualitatively in earlier work (Grace et al. 2004). We also compared feeding rates and wood preferences, and we tested whether the presence or absence of wood influenced termite tunneling patterns.

To study tunneling behavior and spatial dispersion of tunnels, six two-dimensional acrylic laboratory foraging arenas were constructed, as described by Campora and Grace (2001, 2007). Three arenas were set up with each species. Silica sand (40-100 mesh; 150-425 μm sieve) was used as the tunneling medium. Yellow pine, *Pinus palustris*, and Douglas-fir, *Pseudotsuga menziessii*, were used as feeding substrates. *C. formosanus* was collected from a field site located on the Manoa campus of the University of Hawaii (Miller Hall). *C. gestroi* was collected from a Kalaeloa (formerly Barber's Point Naval Housing) field site on the island of Oahu (Uchima and Grace 2003a). Termites were collected and counted using techniques modified from those of Tamashiro et al. (1973) and Su and La Fage (1984). For each arena, 1500 termites (1350 workers + 150 soldiers) were added through a portal in the center, and termites were allowed to tunnel for a period of 22 d. Air temperature and humidity were recorded daily and digital photographs of tunnel galleries were taken every 12 h using a Nikon D40 digital camera with 18-55mm f/3.5-5.6 AFS-DX Nikkor lens. Tunnels were analyzed using Adobe Acrobat 8 Professional software. Visual observations were also recorded daily. Different parameters in tunnel formations were compared between the two species (following the method of Puche and Su 2001) using one-way ANOVA and Tukey HSD procedures (Minitab 15, Minitab, Inc. 2007). Mean termite biomass and wood consumption rates were also calculated for each species and each wood type using the procedure described by Su and La Fage (1984).

Our results indicate differences in tunneling and foraging behavior between these two termite species. In tunneling, *C. gestroi* constructed a large number of narrow, highly branched tunnels whereas *C. formosanus* excavated fewer, wider and less branched tunnels (Table 1).

Table 1. Summary of *C. formosanus* and *C. gestroi* tunneling comparison

Species	Total number tunnels	Total tunnel length (cm)	Total width (cm)	Area (cm ²)	Density (no. workers/cm ²)	Speed (cm / day)	Angles (1° & 2°)
<i>C. gestroi</i>	65	1043.56	0.08	87.66	15.40	47.43	52.13
<i>C. gestroi</i>	61	715.85	0.07	50.83	26.56	32.53	53.21
<i>C. gestroi</i> *	96	1294.45	0.06	81.55	16.55	58.84	54.22
<i>C. formosanus</i>	59	816.87	0.20	166.64	8.10	37.13	38.81
<i>C. formosanus</i> *	39	611.37	0.35	212.76	6.35	27.78	38.55
<i>C. formosanus</i>	31	496.00	0.50	247.01	5.47	22.55	41.10
P value ^a		0.012	0.031	0.006	0.024	0.012	

* = controls without wood.

^aTermite species comparison by ANOVA, P < 0.05.

Neither species exhibited significant differences in the number of tunnels in arenas with and without wood. Neither did we observe any differences in tunneling patterns in arenas with and without wood.

The two species exhibited different feeding rates and different wood preferences. *C. gestroi* had lower feeding rates in comparison to *C. formosanus* and fed more on yellow pine, whereas *C. formosanus* fed more on Douglas-fir. In no-choice (force feeding) experiments with Douglas-fir, Uchima and Grace (2003b) also observed a lower feeding rate with *C. gestroi*. However, this lower feeding rate, and agonism between workers of the two species, did not translate into dominance of resources by *C. formosanus* when wood was made available to both species simultaneously (Uchima and Grace 2009).

Table 2. Summary of *C. formosanus* and *C. gestroi* feeding comparison

Species	Mean termite wet biomass (g)	Feeding substrate	Wood consumption rate (mg/g per day)*	Number surviving workers	Number surviving soldiers
<i>C. gestroi</i>	1.12	Douglas-fir	0.3865	663	20
<i>C. gestroi</i>	1.24	Yellow pine	0.4675	913	29
<i>C. gestroi</i>	1.24			924	36
<i>C. formosanus</i>	1.94	Douglas-fir	3.2367	485	35
<i>C. formosanus</i>	1.72			658	66
<i>C. formosanus</i>	2.99	Yellow pine	0.8173	1040	133

*P = 0.021 (Termite species comparison of wood consumption by ANOVA)

We conclude that the two species have quantifiably different food searching/tunneling patterns. *C. formosanus* excavates fewer, wider, and less branched tunnels while *C. gestroi* makes many, narrower, highly branched tunnels. Wood consumption rates also differ, with *C. formosanus* feeding at a relatively higher rate than *C. gestroi*. Furthermore, the two species appear to show differences in their wood preferences. *C. formosanus* consumed more Douglas-fir and *C. gestroi* consumed more yellow pine. As previously found with *C. formosanus*, the presence or absence of wood in the foraging arenas did not influence the basic tunneling pattern exhibited by either termite species.

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