Termite Feeding Deterrent Derived from Brown Rot Fungus *Fibroporia radiculosa* (Peck) Parmasto 1968

褐色腐朽菌 *Fibroporia radiculosa* (Peck) Parmasto 1968 から誘導されたシロアリ摂食抑制物質

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ABSTRACT

Both wood-feeding termites and wood-decaying fungi degrade and digest wood for energy source; suggesting the existence of interaction exists between these two groups. Studies on the interactions between termites and wood-decaying fungi have mainly focused on investigating the preference of termites to different species of decayed wood. Fungi and insects use chemosensory systems to communicate and interact with the environment. Sharing of living space by these two organisms has led to the evolution of a wide range of beneficial as well as adverse interactions between them.

Both higher and lower termites interact with fungi. In particular, termites and wood-decay fungi both decompose woody substances; therefore, several forms of interactions likely formed between these two organisms. For example, non-entomopathogenic fungi can influence the palatability of wood, acting as feeding attractants, stimuli or preference inducers, or as deterrents towards termites. Thus, fungi-termite interactions are ubiquitous, although they are sometimes provisional in character and cannot be categorized as symbiosis.

Factors such as fungal strain, tree decay, or bleach status, as well as tree and termite species, should be considered in fungi-termite interactions, especially with respect to termite feeding preferences for fungus-decayed wood. Through the degradation or modification of wood components, wood-decay fungi facilitate termite consumption of lignocellulose. Wood-decay fungi trigger various responses in termite feeding behavior under field and laboratory conditions. For instance, fungal chelate accumulation during wood decay initiates lignin oxidation, cellulose

depolymerization, and lignin degradation reactions, all acting as chemosensory signals to termites that the wood is heavily degraded and therefore nutritionally inadequate. However, wood-decay fungi also appear to detoxify wood extractives, rendering soft wood more suitable for termite consumption.

Our observation in termite-infested field (RISH field, Kagoshima prefecture), termites tend to avoid feeding on the decayed parts of wood, suggesting that they are prevented from approaching or feeding on wood by decay-related chemical substances secreted by the fungi. Fungus related to this phenomenon was identified. Termite feeding of field decayed stakes, laboratory decayed wood, and its extracts were assessed again to determine the interaction. Furthermore, fungus-decayed non-wood media was assessed in order to further clarify the identity and origin of the compound.

We found that decayed stakes with no termite damage collected from a termite-infested field exhibited a deterrent effect against the termite *Reticulitermes speratus*, Kolbe, 1885 (Figure 1 and 2). The effect observed to be lost or reduced by drying (Figure 3). The fungus related with the feeding deterrent phenomenon was identified as *Fibroporia radiculosa* (Peck) Parmasto, 1968. In a no-choice feeding test, blocks decayed by this fungus under laboratory condition deterred *R. speratus* feeding and *n*-hexane extract from the blocks induced termite mortality (Figure 4).

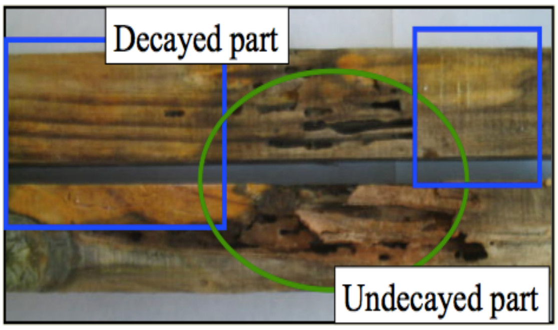

Figure 1. Termites avoided the decayed part of the field stakes (blue boxes) and fed on the undecayed part (green circle)

Figure 2. Termite aggregations on sound (upper three blocks) and decayed (lower three blocks) specimens of the same wood stake after the first 3 days of the choice feeding test. This aggregation pattern persisted until the end of the 14-day exposure period.

During an observation at the RISH field in Kagoshima Prefecture, termite damage was not detected on the fungus-decayed part of field stakes (Figure 1). In the two-choice feeding test using one of the field stakes, termite feeding was focused on wood specimens prepared from the decayed part in the first 3 days of the test. During the initial stage of the test, termites aggregated around the specimens prepared from the decayed stakes (Figure 2); however, after 3 days of exposure, most of the termites were aggregated around the specimens prepared from the sound stake. This preference persisted until the end of the 14-day exposure period.

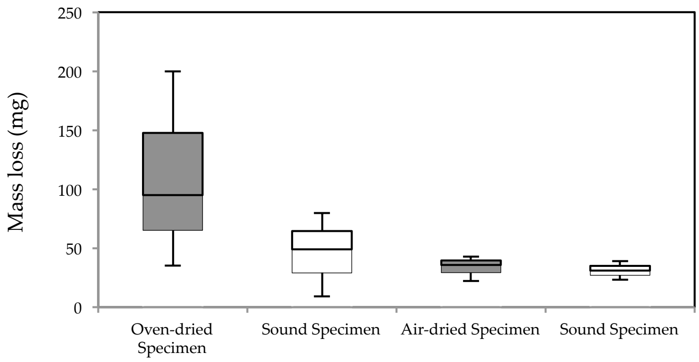

Figure 3. Box plot of mass loss from air- and oven-dried specimens prepared from decayed wooden stakes after termite feeding in the no-choice feeding test. Closed boxes indicate the mass losses of the prepared specimens originating from decayed stake No. 1, open boxes indicate the mass losses of specimens prepared from the sound stakes.

There was no significant difference between the air-dried and oven dried specimens originating from decayed stake No. 1 (Figure 3); however, neither specimen was consumed to the same extent.

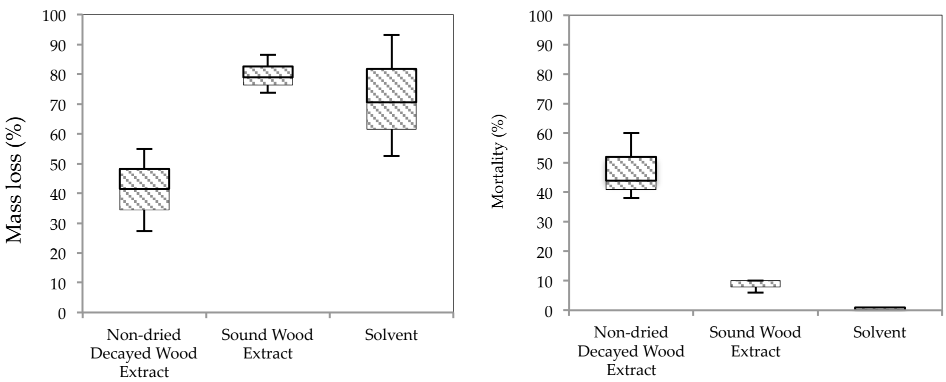

Figure 6. Box plot of mass loss (%) of wood specimens prepared from wood blocks decayed under laboratory condition in the no-choice feeding test.

The paper disks immersed with decayed wood extract showed trends similar to those of field-decayed stakes. Of note, we observed a significant difference in termite feeding between sound wood and decayed wood extracts, supporting that termite feeding deterrents are produced and released by *F. radiculosa* during the decay process.

Fibroporia radiculosa (Peck) Parmasto grown in decayed wood and non-wood material, Potato Dextrose Agar (PDA) media, deterred *Reticulitermes speratus* (Kolbe) feeding. Decayed wood and PDA media were extracted and tests were performed to assess termite-feeding behavior towards the extracts. We found that the extract from PDA media also suppressed termite feeding although it did not induce mortality.

Mass loss differences among the treated paper disks were significantly different ($X^2(4) = 16.409$, $p = 0.03$). The extract obtained from *F. radiculosa*-decayed PDA media was a significantly stronger feeding deterrent than the untreated paper disk. Although decayed wood extract did not deter termite feeding to the same extent that PDA media extract did, the mortality caused by it was higher. Based on pairwise comparison, feeding on decayed wood extract led to a similar termite mortality percentage with the feeding on sound wood extract. In contrast, feeding on decayed PDA media extract induced considerably lower mortality that than feeding on both decayed and sound wood extracts ($X^2(5) = 21.797$, $p = 0.01$). These results suggest that mortality was primarily caused by original or fungus-modified wood components.

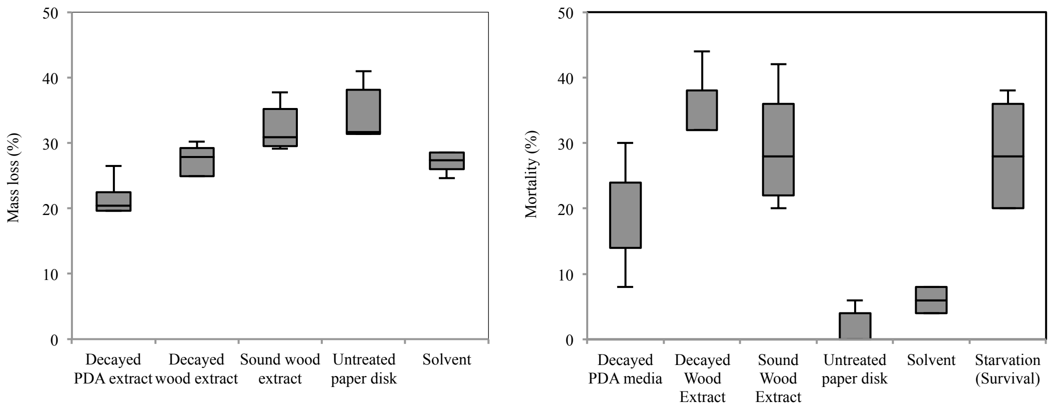

Figure 5. Box plot of mass loss (left) and mortality (right) in termites caused by feeding on paper disk treated with extracts from decayed wood and potato dextrose agar (PDA).

To compare extract bioactivity, a two-choice feeding test was performed. Differences among treatments were significant under the Kruskal-Wallis H test ($X^2(5) = 27.252$, $p < 0.01$). Lower mass loss medians were detected for paper disks treated with PDA extract, suggesting that it had a stronger deterrent effect on termite feeding. Mortality was not recorded in this test.

Table 1. Mass loss medians of two-choice feeding test between crude decayed wood and PDA media extract in test colonies.

Colony	Decayed Wood Extract (%)	PDA Extract (%)
Colony 1 (Kagoshima)	21.19	0
Colony 2 (Oarai)	34.60	19.02
Colony 3 (Oarai)	59.60	3.42

Using gas chromatography and mass spectrometry analysis, two bioactive compounds were detected from decayed wood extract, and one were detected from PDA extract. Based on NIST MS library match and compound fragmentation, all of the compounds belong to sesquiterpenes family.