

# Expansive Gallery Systems of One-piece Termites (Isoptera: Kalotermitidae)

by

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## ABSTRACT

Drywood termites (Family Kalotermitidae) have been termed “one-piece” termites to reflect the fact that they nest within their food source. We dissected a large number of hardwood shipping pallets infested by *Cryptotermes brevis* (Walker), and mapped the distribution of individual termite colonies (i.e., interconnected gallery systems) within individual boards, and within the pallet as a whole. The number of distinct colonies within a single pallet ranged from one to eight. Although some colonies occupied a single board, we also found multiple colonies within single boards, and single colonies tunneling through the junctions between boards and occupying virtually the entire shipping pallet. Although designation of drywood termites as one-piece type termites is a useful ecological distinction, these cryptic insects may have extensive gallery systems encompassing multiple adjacent food sources.

## INTRODUCTION

Drywood termites (Family Kalotermitidae) have been termed “one-piece” termites to reflect the fact that they nest within their food source (Abe 1984, 1987). From an ecological and evolutionary perspective, this distinguishes the Kalotermitidae and Termopsidae from the more advanced “intermediate” (nesting in wood but foraging outside of the nest wood for additional resources) and “separate” (nesting in and foraging through the soil) types of termites (Higashi *et al.* 2000).

The cryptic habits of drywood termites make it difficult to study their foraging patterns and social behavior in situ. Non-destructive detection methods such as acoustic emissions detectors are helpful in determining the

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presence or absence of termites in wood (Scheffrahn *et al.* 1997, Woodrow *et al.* 2006), and the extent of termite infestation in structures (Scheffrahn *et al.* 1993, Thoms 2000). The fecal pellets expelled by termites from the infested wood can be used to identify the species of termite present (Haverty *et al.* 2005) and possibly the numbers of termites present as well (Grace & Yamamoto 2009). However, these methods cannot be used to map gallery systems or determine where one colony ends and another begins.

In conjunction with evaluations of insecticides injected into naturally infested boards for control of *Cryptotermes brevis* (Walker) (Kalotermitidae), we dissected a large number of infested hardwood shipping pallets, both to measure termite mortality and to map connected galleries in order to determine the number of discrete termite colonies present in each pallet (Woodrow & Grace 2005, 2007; Woodrow *et al.* 2006). We considered the pallets to be miniature structural mesocosms, mimicking the framing within a termite-infested building. In the present report, we present information on the distribution of *C. brevis* colonies within and among the boards making up these pallets. These results indicate that many different gallery configurations are possible, and suggest greater flexibility in foraging than is suggested by their designation as one-piece type termites.

## MATERIALS AND METHODS

Based on visual evidence (i.e., fecal pellets [frass], kick-out holes used to expel fecal pellets, and open galleries), infested, unfinished, hardwood shipping pallets (frass) were selected from a collection of pallets in a warehouse at the Pearl Harbor Naval Shipyard, Honolulu, Hawaii. Typical hardwood shipping pallets consisted of two to four 5 by 10.2cm (nominal 2- by 4-inch) structural members and a number of 1.9 - 2.5cm (0.75 -1-inch) thick outer surface boards, which were between 10.2 and 20.3cm (4 and 8 inches) in width and either 101.6 or 121.9cm (40 or 48 inches) in length (Fig. 1).

In the course of the insecticide evaluations reported by Woodrow and Grace (2005, 2007) and Woodrow *et al.* (2006), we dissected approximately 60 infested shipping pallets, and found only *Cryptotermes brevis* (Walker). Since *C. brevis* is the most common drywood termite infesting seasoned wood in Hawaii (Woodrow *et al.* 1999, Grace *et al.* 2002), occurrence of this single species likely reflects a history of use of the pallets at Pearl Harbor, or

for shipping among the Hawaiian Islands or other Pacific locations where this species predominates.

The pallets were partitioned into individual boards by removing nails and wood staples. Using a band saw, boards were then cut into four equal, separate sections. All individual board sections were carefully split apart using a hammer and hand-ax to extract both living and dead termites present. Gallery interconnections within each board, and connections between boards were noted, with each discrete network of interconnected galleries considered to represent an individual *C. brevis* colony.

## RESULTS AND DISCUSSION

Termite galleries were generally oriented longitudinally (parallel to the wood grain), with occasional lateral branches and excavations of variable sizes connected by narrow ca. 1 mm diameter cylindrical passages, and were consistent in appearance with reports for other drywood termite species (Rust *et al.* 1979). Individual boards ranged from lightly infested, with a few longitudinal galleries located in the center of the board, to heavily infested with many interconnected cavities and thin, paper-like coverings on the exterior of the board.

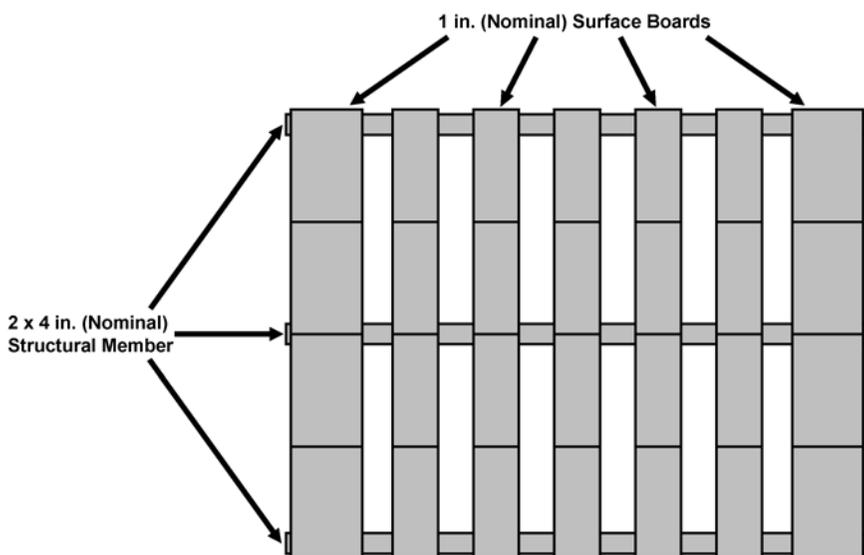


Fig. 1. Typical configuration of a hardwood shipping pallet (redrawn from Woodrow *et al.* 2006).

The extent of infestation within the pallets ranged from a single board, to all boards in the pallet; and interconnected gallery systems (each excavated by an individual *C. brevis* colony) within the pallets were highly variable in size. The number of individual *C. brevis* colonies found within a single pallet ranged from one to eight, and a heavily infested pallet might contain multiple colonies, or only a single colony with interconnected galleries extending through virtually every board (Figs. 2 and 3). Thus, galleries of this one-piece termite readily crossed the joints between individual boards.

Occurrence of several discrete termite colonies within a single board was also common. In many cases, a single colony with a large gallery system (possibly representing an older colony) occupied a large number of boards in the pallet, with one or several small colonies (possibly representing more recent infestations) occurring in boards or board sections surrounded by the larger gallery system (Fig. 3). In some pallets, all possible combinations were found: a large gallery system extending into multiple boards, single smaller colonies within single boards, and multiple unconnected colonies within the same board.

The designation of drywood termites as single-piece termites, in the sense that they nest within their food source, is certainly a useful ecological distinction. But, it is interesting to note that foraging may actually occur throughout several adjacent timbers. Drywood termites respond to unfavorable environmental conditions such as temperature extremes by moving away from the stimulus, and their gallery systems within plants (Rust *et al.* 1979), or single boards within buildings (Woodrow & Grace 1999) represent a variety of different microclimates through which they may move to escape stimuli such as heat. The observation that these gallery systems may extend even further through multiple adjacent potential or actual food sources certainly increases the variety of different microclimates available to the termites and the degree to which they may find refuge from unfavorable conditions (or predators such as ants, or insecticide treatments) in a portion of their extensive gallery system.

Drywood termites have also been found to exhibit wood feeding preferences, in the same manner as separate type subterranean termites (Indrayani *et al.*, 2007). Thus, in addition to the value of an extended gallery system for occupying food resources (in competition with other wood feeding insects)

and providing refugia, gallery extension into adjacent boards may also reflect search for more preferred and/or more nutritional foods. Grace & Yamamoto (2009) found that *C. brevis* and *Incisitermes immigrans* (Light) nymphs con-

## Pallet #8

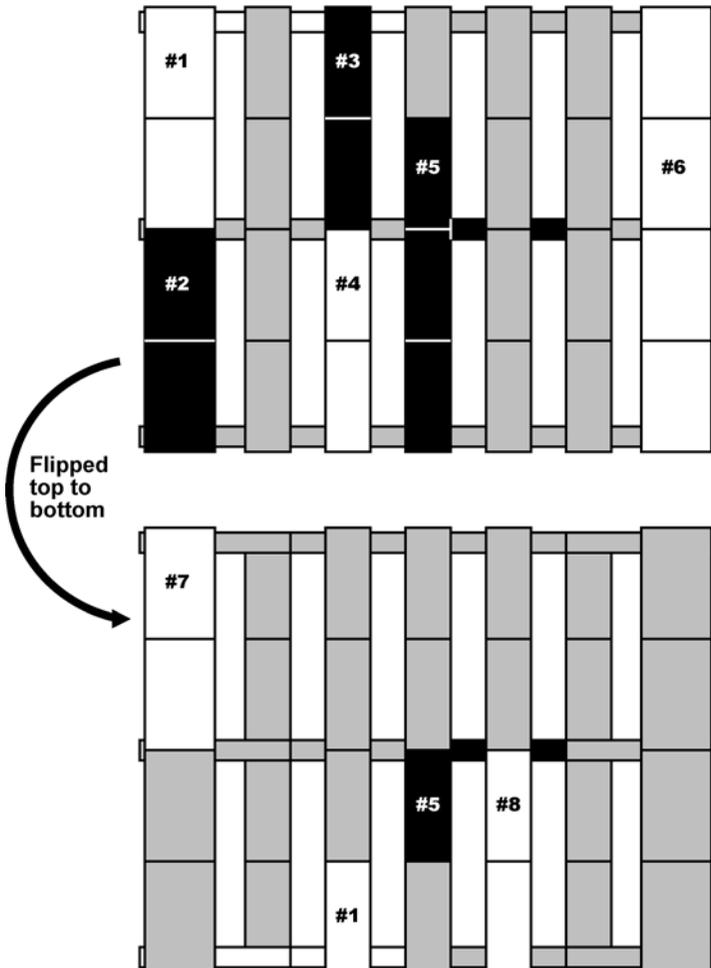


Fig. 2. Shipping pallet infested by *Cryptoterme brevis*, with individual colonies (interconnected gallery systems) designated by numbers. The pallet is flipped end-to-end to show boards on both the upper and lower sides (redrawn from Woodrow *et al.* 2006).

sumed greater quantities of food (Douglas-fir and ponderosa pine wood) with lower cellulose content than that with higher cellulose concentrations (filter paper), likely due to the more efficient utilization of high-cellulose food. It is

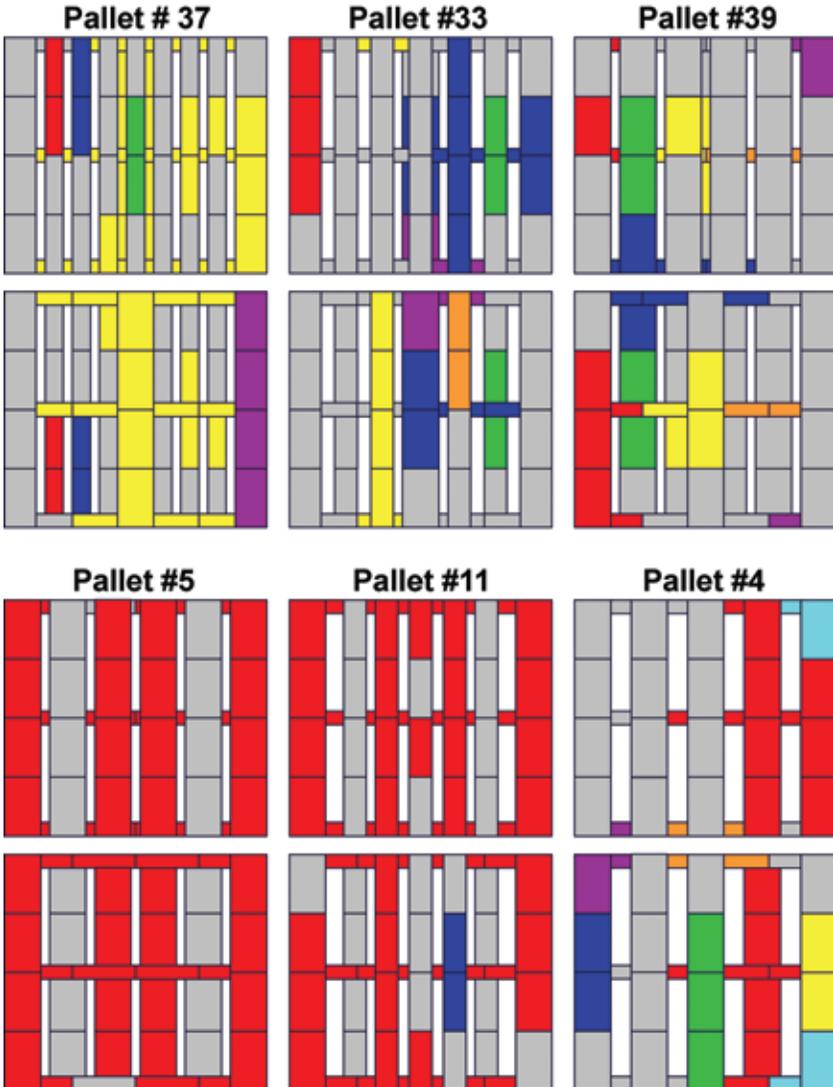


Fig. 3. Representative shipping pallets dissected to map the distribution of *Cryptotermes brevis* colonies. Individual colonies (interconnected gallery systems) within each pallet are represented by different colors.

possible that the speed of gallery construction may be negatively correlated with the nutritional value of the original nest matrix, although this may be more a consequence of physiology than a behavioral adaptation.

Is it conceivable that one-piece type Kalotermitids actually exhibit many of the same traits in foraging as their more advanced, separate type relations (e.g., Rhinotermitidae), but simply in a much different time scale? Certainly, both the small colony size of drywood termite species and the greater difficulty of excavating wood in comparison to soil would slow down growth of the gallery system significantly. However, it appears that competition, food choice and the need for refugia may affect expansion of the gallery systems of these “multiple-item” single-piece termites in a manner analogous to the more rapid and more readily observed impact of these factors on foraging by separate type subterranean termites.

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