

1 *For: American Entomologist*

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3 **Sharing the most updated knowledge on subterranean termites in Hawai‘i: What the Late**
4 **Professor Minoru Tamashiro taught**

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6 Jia-Wei Tay^{1,*}, Sang-Bin Lee^{2,3,*}, Reina Tong¹, Faith Oi⁴ and Nan-Yao Su²

7 ¹Department of Plant and Environmental Protection Sciences, University of Hawai‘i at Mānoa,
8 HI, USA

9 ²Ft. Lauderdale Research and Education Center, Entomology and Nematology, University of
10 Florida, FL, USA

11 ³Division of Agriculture and Natural Resources, University of California, Fairfield, CA, USA

12 ⁴Entomology and Nematology, University of Florida, Gainesville, FL, USA

13 *Corresponding authors: Jia-Wei Tay (jwtay@hawaii.edu) and Sang-Bin Lee (sablee@ucanr.edu)

14 The field of termite research is diverse as termites are an interesting model to study
15 various biological topics such as eusociality, carbon recycling, symbiosis, gut protists and
16 microbes, and behaviors. Although termites play a vital role in the ecosystem, some termites are
17 economically important structural pests in urbanized areas around the world (Rust and Su 2012).
18 Only a small portion of termite species are considered pests, but there are numerous studies on
19 termite control. Among the termite pest species, the Formosan subterranean termite (FST),
20 *Coptotermes formosanus* Shiraki, was extensively researched because this termite causes
21 substantial economic damage in subtropical and temperate regions including Hawai‘i (HI),
22 California (CA), Florida (FL), Texas (TX), Louisiana (LA), and Georgia (GA) in the United
23 States of America (US) (Su and Lee 2023).

24 The devastating impact of the FST in Hawai‘i spurred Drs. Minoru Tamashiro and Nan-
25 Yao Su to organize the first international conference on FST in 1985 to share research and
26 management strategies. A second international conference on FST was held in New Orleans in
27 2001. Recently, the third international conference of the subterranean termite was held in
28 Honolulu, HI to discuss termite research and to honor the late Professor Emeritus Minoru
29 Tamashiro, a long-serving entomologist/termitologist who pioneered termite control research in
30 the US.

31

32 **What Dr. Tamashiro taught**

33 Dr. Minoru Tamashiro (1924-2021), a pioneering entomologist from the University of
34 Hawai‘i (UH), significantly advanced the field of termite research through his innovative work
35 and groundbreaking discoveries. After returning from World War II as a highly decorated
36 veteran, Dr. Tamashiro earned his B.S. (1952) and M.S. (1954) degrees from UH. He then

37 attended the University of California, Berkeley, and earned his Ph.D. in 1959 under Dr. E. A.
38 Steinhaus, the Father of Insect Pathology.

39 One of his most notable contributions was the development of the Basaltic Termite
40 Barrier (BTB), a non-chemical method designed to protect buildings from termite infestations
41 (Tamashiro et al. 1991). Basaltic Termite Barrier is made from volcanic rock ground to a precise
42 size, creating a physical barrier that termites cannot penetrate and that the weight of concrete
43 slabs will not crush. The material is raked and graded to a 4-inch thickness before a slab is
44 poured over it. Additionally, the BTB is applied around the foundation, ensuring a
45 comprehensive defense against termite intrusion. This innovative method has become a standard
46 in the construction of new schools, government buildings, and military facilities in Hawai'i,
47 highlighting Dr. Tamashiro's enduring impact on termite management practices.

48 Dr. Tamashiro's research extended beyond just physical barriers. He developed a highly
49 cited sampling protocol for studying the Formosan subterranean termite. This protocol, detailed
50 in the 1973 paper authored by Tamashiro, Fujii and Lai, "*A simple method to observe, trap, and*
51 *prepare large numbers of subterranean termites for laboratory and field experiments,*" has
52 become a fundamental reference for termite researchers worldwide. He also developed a widely
53 used bioassay that quantified termite mortality and penetration into treated soil, also known as
54 the "tube test" or "glass tube tunneling assay" (Tamashiro and Su 1987, Tamashiro et al. 1989,
55 1990, Su and Scheffrahn 1990, Grace et al. 1993, Su et al. 1993, Osbrink and Lax 2002, Keefer
56 et al. 2012). His meticulous approach to studying termite behavior and ecology has provided a
57 robust foundation for subsequent research in the field (Figs. 1 and 2).

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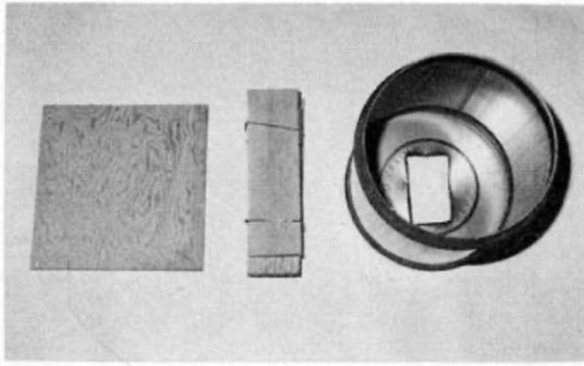


FIG. 1.—Basic components of the trap used for *C. formosanus*. Note the previously attacked wood included in the bundle.

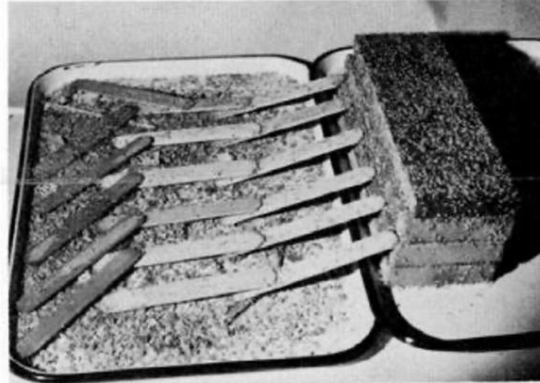


FIG. 2.—Formosan subterranean termites moving from the tray, across tongue depressors, to the collecting pieces.

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60 Figure 1. From Tamashiro et al. 1973: “Basic components of the trap used for *C. formosanus*.

61 Note the previously attacked wood included in the bundle.”

62 Figure 2. From Tamashiro et al. 1973: “Formosan subterranean termites moving from the tray,
63 across tongue depressors, to the collecting pieces.”

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65 Another significant area of Dr. Tamashiro's work involved exploring biological control
66 methods for termites. He supervised numerous projects that investigated the use of
67 entomopathogenic nematodes and fungi to manage termite populations. These studies pave the
68 way for exploring more environmentally friendly termite control methods. Dr. Tamashiro's
69 commitment to least-toxic termite management strategies has influenced many researchers and
70 stakeholders who continue to seek sustainable solutions for termite control.

71 Dr. Tamashiro was most proud of “picking good people”. His legacy in termite research
72 is marked by his mentorship and collaboration with other prominent scientists. At the “Honoring
73 Professor Minoru Tamashiro's Contributions to Entomology: His Legacy and Academic Genes”
74 symposium, held in 2016 during the Pacific Branch Meeting of the Entomological Society of
75 America (ESA), respected colleagues such as Drs. J. Kenneth Grace and Nan-Yao Su highlighted
76 his profound influence on their careers and the field of urban entomology. Dr. Tamashiro's other

77 graduate students included “Dr. Jack Fujii, UH Hilo Dean Emeritus; former U.S. Navy
78 entomologist Dr. Stan Higa; Dr. Po-Yung Lai, who has had distinguished careers with the
79 Hawai‘i Dept. of Agriculture (Director), University of Hawai‘i, College of Tropical Agriculture
80 and Human Resources (Associate Dean for Extension, and T-STAR Director), Taiwan’s National
81 Pingtung University of Science and Technology (Director of the Institute of Tropical
82 Agriculture), and the City and County of Honolulu; and Dr. Nan-Yao Su, Distinguished
83 Professor at the University of Florida and inventor of the Sentricon termite-baiting system”
84 (University of Hawai‘i 2022). Through his innovative research, dedication to sustainable
85 practices, and mentoring of future generations, Dr. Tamashiro has left an indelible mark on the
86 study and management of termites, ensuring his contributions will continue to benefit the field
87 for years to come, and, more importantly, on the people who he touched who carry his spirit of
88 “aloha”.

89

90 **Termite symposia in the past**

91 The 1st International Symposium on the Formosan Subterranean Termite was the “first
92 gathering of scientists especially to zero in on the termite” (Altonn 1985). The symposium was
93 held in conjunction with the Pacific Branch Meeting of the ESA in Honolulu, Hawai‘i in 1985,
94 organized by Drs. Minoru Tamashiro and Nan-Yao Su (Tamashiro and Su 1987). As the FST was
95 a serious threat of growing concern, there were over 120 attendees at the symposium. The
96 symposium aimed to have entomologists who worked on the FST from China and Japan, where
97 the FST has long been a serious pest, discuss the status of the problem with minimal language
98 barriers. In Altonn (1985), Dr. Tamashiro stated, “We had all these experts come in to discuss the
99 problems and what they are doing to control the termite in their areas and (to) bounce ideas”. Ten

100 papers were presented by speakers from China, Japan and the USA, and topics that were
101 discussed during the symposium included the history of the FST, current control practices, and
102 current and future research trends (Tamashiro and Su 1987).

103 The 2nd International Formosan Subterranean Termite Symposium in New Orleans, LA
104 was organized by the United States Department of Agriculture Agricultural Research Service
105 (USDA-ARS) as part of the Operation Full-Stop project, in 2001. About 45 termite experts from
106 Japan, Taiwan, USA, Australia and elsewhere presented research on termite biology, ecology,
107 reproduction, chemical ecology and control, and the symposium was very successful. These two
108 previous symposia were held to share knowledge on the biology and control of *C. formosanus*.

109

110 **A demand for an international conference on termites**

111 In the past, both conferences were focused on the Formosan subterranean termite.
112 However, other invasive termites have been introduced into new locations and are causing
113 problems, and the FST has expanded its range. Recently, *C. formosanus* was found in Israel
114 (Scheffrahn et al. 2020) and in the state of California, USA (Tseng et al. 2021), and the Asian
115 subterranean termite, *Coptotermes gestroi* (Wasmann) has established in Egypt (Barakat et al.
116 2024). *Coptotermes* and *Incisitermes minor* (Hagen) have fully established in Korea (Lee et al.
117 2024).

118 In addition to the Formosan subterranean termite, *C. gestroi* was introduced into HI and
119 FL, USA. The distribution of these two termite species overlaps in only three places in the world,
120 including Hawai‘i, Florida, and Taiwan. Recent studies showed that those two termites can
121 hybridize and survive in the field (Chen et al. 2024). Therefore, we decided to expand the
122 meeting scope to include other invasive and economically important termite species. The purpose

123 of the 3rd International Conference of the Subterranean Termite was to gather termite researchers
124 from around the world and share recent progress on termite biology, ecology and control.

125

126 **The 3rd International Conference of the Subterranean Termite**

127 The 3rd International Conference of the Subterranean Termite: Dr. Minoru Tamashiro
128 Memorial Symposium was held at the University of Hawai‘i (UH) in Honolulu, HI, on
129 September 18-19, 2023, hosted by the UH Urban and Medical Entomology Laboratory. The
130 conference was organized by Drs. Jia-Wei Tay, Reina Tong (UH) and Sang-Bin Lee (University
131 of Florida) to share current research and discuss future directions in the study of termites.

132 During the two day symposium, 17 presentations were delivered on various topics
133 including biology, ecology, microbiomes, invasive species, hybridization, etc. (Table 1).
134 Speakers from various universities and research institutes from Japan, Taiwan, and USA
135 participated (Figure 3). In the symposium, studies on *Reticulitermes* were also presented and
136 attendants shared the most updated research progress and discussed future research projects
137 during the meeting.

138 As the conference progressed, many participants reflected on its significance and the
139 legacy of termite research. These reflections brought into focus the broader importance of such
140 gatherings for knowledge-sharing and collaboration. The conference organizers and/or article co-
141 authors shared their thoughts on the experience:

142

143 Jia-Wei Tay stated: “*It was a great honor and privilege for the Hawaii Urban Entomology*
144 *Program to host this conference. The event provided a unique platform for termite researchers to*
145 *exchange knowledge, build professional networks, and foster new collaborations. Personally, we*

146 *saw this as a valuable opportunity to guide and inspire the next generation of scientists who may*
147 *wish to pursue a career in this field. Although termite research is relatively niche within*
148 *entomology, its significance cannot be overstated, even if it often goes unnoticed by*
149 *undergraduates, large funding bodies, and university administrations. I am hopeful that with*
150 *continued efforts and increased awareness, this field will receive the recognition and support it*
151 *deserves.”*

152

153 Sang-Bin Lee stated *“The future of urban entomologists, including termitologists, will be*
154 *challenging after the golden years of termite research. However, we are seeing a new batch of*
155 *young urban entomologists gradually established in new locations. This conference was a great*
156 *opportunity to meet all termitologists and discuss future research questions. After the conference,*
157 *I have no doubt to have another termite symposium in the near future with more participants as*
158 *some invasive termites continue to spread and the economic importance of termites keeps*
159 *growing.”*

160

161 Reina Tong stated *“It was a pleasure to hear stories of Dr. Tamashiro’s kindness, generosity, and*
162 *dedication. His impact continues to be felt in the laboratory and through the many wonderful*
163 *people he has mentored and taught. The presentations were amazing, and I feel lucky to have*
164 *been able to spend time with everyone.”*

165

166 Faith Oi stated *“It has been a long time since I have seen such camaraderie and open dialog at a*
167 *scientific meeting. I was encouraged to see that the impacts of education and training were also*

168 included. I look forward toward the next symposium and seeing more termitologists engage!
 169 Thank you for the opportunity to contribute to this program.”
 170
 171 Nan-Yao Su stated “Thank you all for hosting this symposium. I’ve heard many comments that
 172 this is the best meeting they’ve had, and it is not only because of the weather and food. There
 173 was such a strong “aloha” among participants that it reminded me of the old days when we used
 174 to have a handful of friendly termite researchers. This is a good start to rekindle that old
 175 togetherness.”

176

177 Table 1: Speakers and presentation titles from the 3rd International Conference of the
 178 Subterranean Termite

Speaker	Presentation Title
Kenneth Grace	Pursuing least-toxic termite management in Hawai‘i
Nan-Yao Su	M. Tamashiro Lab: An incubator of subterranean termite research
Vernard Lewis	Dr. Minoru Tamashiro’s impact on subterranean termite foraging behavior research in California
Joel Melia	A comparison of morphology among <i>Coptotermes formosanus</i> on O‘ahu
Jia-Wei Tay	Necrophobic behavior in <i>Coptotermes gestroi</i> and the chemical profiles of subterranean termite soldiers in Hawai‘i
Mark Janowiecki	Alate monitoring after area-wide control of the Formosan subterranean termite, <i>Coptotermes formosanus</i> in the French Quarter and Jackson Barracks
Carrie Cottone	The New Orleans French Quarter after Operation Full Stop: Where are we today?
Edward Vargo	Deciphering the invasion history of the Formosan subterranean termite in the U.S.
Chow-Yang Lee	Formosan subterranean termite infestations in California – are they here to stay?
Thomas Chouvinc	From a bucket trap to decades of colony field demographic observations on Formosan subterranean termites
Hou-Feng Li	Hybridization between Formosan and Asian subterranean termites in Taiwan
Faith Oi	The impact of extension programs in the management and control of subterranean termites

Nobuaki Mizumoto	Evolution of termite tandem runs: How Formosan termite differs and is similar to other lineages
Yuki Mitaka	Identification of an attractant aggregation pheromone used by workers of the termite <i>Reticulitermes virginicus</i>
Joerg Graf	Insights into the composition and function of the <i>Reticulitermes flavipes</i> microbiome
Reina Tong	Distribution of termites on O‘ahu
Sang-Bin Lee	History and future of termite research in the United States

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180

181 Figure 3. Group photo from the 3rd International Conference of the Subterranean Termite.

182 Photo credit: University of Hawai‘i CTAHR Office of Communication Services.

183 Bottom (from left to right): David Oi, Nan-Yao Su, Kenneth Grace, Shripat Kamble, Julian Yates
 184 III, Vernard Lewis, Motoyuki Sasaki , Jia-Wei Tay

185 Top (from left to right): Sarah Kim, Joey Chang, Hou-Feng Li, Carrie Cottone, Faith Oi, Chow-
 186 Yang Lee, Edward Vargo, Yuki Mitaka, Thomas Chouvenc, Hiroaki Shindo, Mark Janowiecki,
 187 Makena Mason, Nobuaki Mizumoto, Sang-Bin Lee, Reina Tong, Adam Lawrence, Joel Melia

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