Swarming of the Formosan Subterranean Termite, *Coptotermes formosanus* Shiraki in Hawaii (Isoptera: Rhinotermitidae)[1]

STANLEY Y. HIGA[2] and MINORU TAMASHIRO[3]

ABSTRACT

Light trap collections monitored weekly over a 2-year period on Oahu indicated that major swarming of *Coptotermes formosanus* Shiraki occurred from April to July. The heaviest swarms occurred in May. Smaller flights occurred irregularly throughout the entire year. Population densities of *C. formosanus* were higher on the leeward side of the island than on the windward side. Swarming of *Cryptotermes brevis* Walker and *Incisitermes immigrans* (Snyder) generally paralleled that of *C. formosanus* except that the peaks occurred 1 to 2 months later in the year.

In termites, the size of swarms and the duration of swarming seasons have generally been correlated with the level of evolutionary development of the species (Weesner 1960). The lower termites fly under a wide range of weather conditions and stage many small flights over a prolonged season. The higher termites, on the other hand, fly under more specific sets of conditions and produce a few large flights in a short season (Castle 1934, Grasse 1949, Harris 1958, Wilkinson 1962, Nutting 1969). The Rhinotermitidae appear to fall between these 2 categories, sharing flight patterns of both higher and lower termites.

The genus *Coptotermes* contains species whose major swarms usually occur in the spring and/or summer at dusk. In India the swarming of *C. heimi* (Wasmann) occurred at dusk from March to August after heavy rains (Roonwall 1959, Sen-Sarma 1962). Sen-Sarma also reported that swarms were observed in January and February. In Western Australia, *C. acinaciformis* (Froggatt) swarmed from mid afternoon to dusk on hot humid days just prior to rain. The season lasted from October to January with the heaviest flights occurring in November (Calaby and Gay 1956).

Swarming of *C. formosanus* was observed at dusk from April to June in Hawaii (Bess 1970); late April to early June in Louisiana (King and Spink 1974); and May to early June in Taiwan and late June in Japan (Oshima 1919). In Simonstown, South Africa, swarming extended from October to February with the main flights occurring during December and January (Coaton and Sheasby 1976).

Although it is generally known that swarming of *C. formosanus* occurs on warm humid nights from April to June in Hawaii, it is not known whether swarming is limited to these months. Moreover, the distribution of the termite on Oahu, the frequency and magnitude of the swarms, and specific information on the ambient conditions in the environment during the major swarming seasons have not been recorded.

This study was undertaken to obtain information on these points. Although *C. formosanus* was the primary species concerned in this study, observations were also

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[2]Hawaii Department of Agriculture, 1428 S. King Street, Honolulu, Hawaii 96814.
[3]Department of Entomology, University of Hawaii, 3050 Maile Way, Honolulu, Hawaii 96822.

made on the swarming of the West Indian dry wood termite *Cryptotermes brevis* Walker and the lowland tree termite *Incisitermes immigrans* (Snyder).

MATERIALS AND METHODS

The alates were collected in light traps (Pratt et al. 1969) operated by the Vector Control Branch, Hawaii Department of Health. Nineteen stations, representing the wet windward, dry leeward, and the north shore areas of Oahu were selected to monitor the alates (Fig. 1). Rainfall for each station was obtained from the Hawaii Department of Land and Natural Resources. Thirteen light trap stations, in addition to the 19 used for *C. formosanus,* were used to monitor the drywood species.

These weekly collections were checked for termites for 25 consecutive months, from March 1969 to March 1971. These weekly data were tabulated by months, transformed using $\sqrt{x + .5}$, subjected to analysis of variance, and the means separated using Duncan's multiple range test.

The study of the ambient conditions during the swarming season was conducted in Wailupe Valley, Oahu, in May and June 1979. Flight was monitored with a funnel light trap equipped with a 15-watt black-light bulb, which was automatically set to turn on at 7:00 each evening. The black-light was the only source of light on the premises. Temperatures and humidities were recorded on a hygrothermograph (Bendix Model 594). Wind velocity readings were taken daily with an anemometer (Taylor Model No. 3132) at about 7:00 p.m. The rainfall for Wailupe Valley was obtained from the National Oceanic and Atmospheric Administration (NOAA).

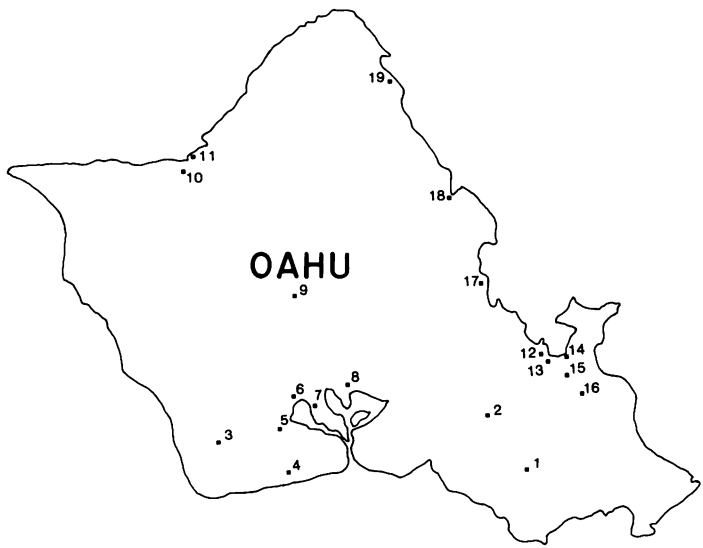

FIGURE 1. Locations of the light traps used to monitor flights of *Coptotermes formosanus* Shiraki from March 1969 to March 1971, Oahu, Hawaii.
Leeward locations: 1. Manoa, 2. Kalihi Valley, 3. Makakilo, 4. Ewa Beach, 5. Ewa Hospital, 6. Waipahu Health Center, 7. Waipio Peninsula, 8. Pearl City (Hale Mohalu), 9. Waipio (PRI).
North Shore locations: 10. Waialua, 11. Haleiwa.
Windward locations: 12. Kaneohe (Haiku), 13. Kaneohe (Gooch), 14. Kaneohe (Kokokahi), 15. Kailua (HC&D), 16. Kailua (Castle Hospital), 17. Waiahole, 18. Kahana, 19. Laie.

RESULTS AND DISCUSSION

Although the general swarming season for *C. formosanus* started in April as noted by Bess (1970), it did not end until July (Table 1). Moreover, swarming did not occur uniformly over the 4 months. May, especially the latter 2 weeks in May was the peak period for swarming in Hawaii. This was followed by June and by April and July.

Flights of *C. formosanus,* however, were not restricted to the April - July period. Small numbers of alates were caught in every month of the 2-year sampling period. There was no single light trap that caught alates every month but the Kalihi Valley trap which was the most consistent, recorded alates in 20 of the 25 months (Table 2). In addition, light traps in Waipio Peninsula (18/25), Pearl City (16/25), Kailua Quarry (16/25), Waipahu Health Center (14/25), and Ewa Hospital (14/25) all recorded flights in most of the months.

It was not known whether the alates were all produced at the same time and just flew at different times or whether alates were produced throughout the year. Alate nymphs could be found in field colonies at any time of the year although more last instar alate nymphs were found in February and March. Alates were not found from August to February in field colonies observed for 7 or more years on the University of Hawaii, Manoa Campus.

TABLE 1. Monthly alate trappings of *Coptotermes formosanus* Shiraki at 19 locations on Oahu, Hawaii.

Month	Mean (N=19)
May '70	50.5[a]
May '69	28.5[b]
Jun '70	23.6[b]
Jun '69	22.1[b]
Jul '69	10.8[c]
Apr '70	8.8[c]
Apr '69	7.5[c]
Jul '70	6.7[c]
Aug '69	2.5[d]
Oct '69	1.6[d]
Sep '70	1.2[d]
Aug '70	1.2[d]
Mar '69	1.1[d]
Jan '70	1.1[d]
Mar '70	1.0[d]
Mar '71	1.0[d]
Sep '69	0.7[d]
Feb '71	0.4[d]
Dec '69	0.4[d]
Feb '70	0.3[d]
Nov '70	0.3[d]
Jan '71	0.2[d]
Dec '70	0.2[d]
Nov '69	0.1[d]
Oct '70	0.0[d]

*Means with the same letter are not significantly different from each other at the 5% level.

Alate captures indicated that the leeward area had a larger number and/or larger colonies than the windward area (Table 2). Five of the 6 sites which recorded the most flights were located on the leeward side of Oahu.

In addition, 6 of the 8 locations where the largest numbers of alates were trapped were also located on the leeward side. The 2 non-leeward locations with large catches were on the north shore and on the windward side adjacent to a sanitary landfill. The sanitary landfills generally have high populations of *C. formosanus* since infested materials are dumped and buried there. In addition, there is a large amount of food concentrated in the area.

The leeward side of the island may be more heavily infested because the area is warmer, drier and more urbanized. More importantly, *C. formosanus* has been established on the leeward side for a longer time. *C. formosanus* was introduced into the Honolulu waterfront early in this century. Although *C. formosanus* has been established on Oahu for about 80 years, the natural spread has been very slow. It took *C. formosanus* about 50 years to reach Wahiawa, a town about 40 miles away from Honolulu harbor. It is still not recorded from the native rain forest although it has been found at the edges of the forest.

High rainfall may be detrimental to *C. formosanus.* Except for Kalihi Valley, which is an enigma, all of the areas with rainfalls over 300 cm for the observation period had low populations of alates (Table 2). Statistically, however, there were no significant correlations between total number of alates caught and the rainfall at each station. Moreover, there were no significant differences in rainfall between the swarming season (April to July) and the rest of the months. November, December, and January, had the highest rainfall for both years of the study period.

The results of the study of the ambient climatological factors during May and June to determine whether there were differences between flight and non-flight days are

TABLE 2. Number of alates of *Coptotermes formosanus* Shiraki trapped from each sampling area over a 25 month period.

Location	Total rainfall (cm) Mar. 69 to Mar. 71	Elevation m	Mean no. trapped in a mo. (N=25)	Largest no. trapped in a month	Month/yr. largest no. trapped
Haleiwa	190	6	18.6^{a}	205	May '70
Pearl City	153	5	16.2^{a}	110	Jun '70
Ewa Beach	94	12	10.8^{ab}	40	May '70
Kalihi Valley	597	73	9.5^{ab}	51	May '70
Kailua (HC&D)	234	14	9.4^{abc}	85	May '70
Waipahu	136	14	9.4^{abc}	40	Jun '70
Ewa Hospital	101	12	9.0^{abcde}	138	May '70
Waipio Peninsula	103	3	8.8^{abcde}	175	May '69
Makakilo	84	64	6.1^{bcde}	50	May '70
Kokokahi	276	9	5.8^{bcde}	28	May '69
Castle Hospital	248	12	4.8^{cdef}	85	May '70
Waialua	159	5	4.8^{cdef}	32	May '70
Waiahole	373	18	3.9^{cdef}	52	Apr '70
Kaneohe	377	107	2.7^{cdef}	35	May '70
Haiku	388	183	2.3^{def}	21	May '70
Waipio (PRI)	197	268	2.3^{def}	15	May '70
Kahana	728	3	1.8^{ef}	12	Jun '69
Laie	362	14	1.8^{ef}	14	Jun '70
Manoa	413	82	0.5^{ef}	5	Jun '69

*Means with the same letter are not significantly different from each other at the 5% level.

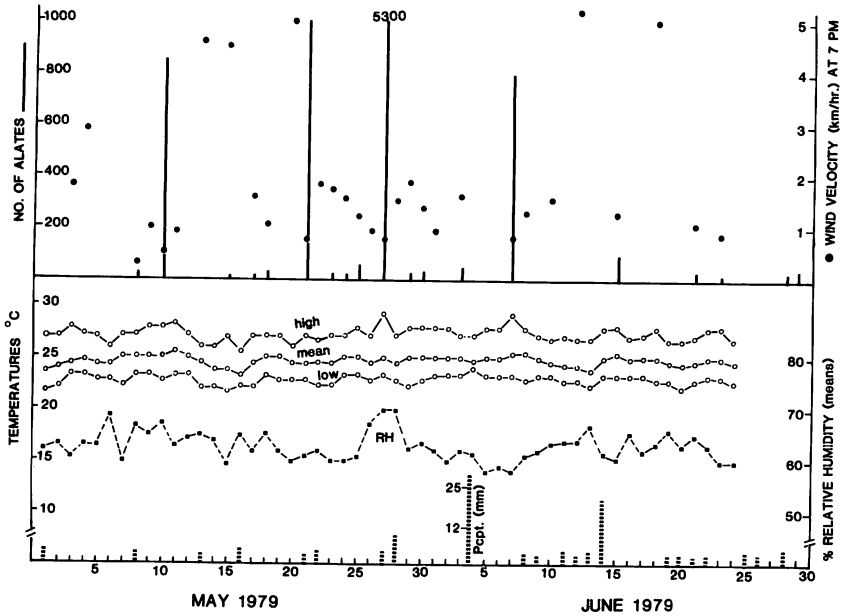

FIGURE 2. Size and frequency of flights of *Coptotermes formosanus* Shiraki and the associated ambient temperature, humidity, rainfall and wind velocity in Wailupe Valley, Oahu, Hawaii in May and June, 1979.

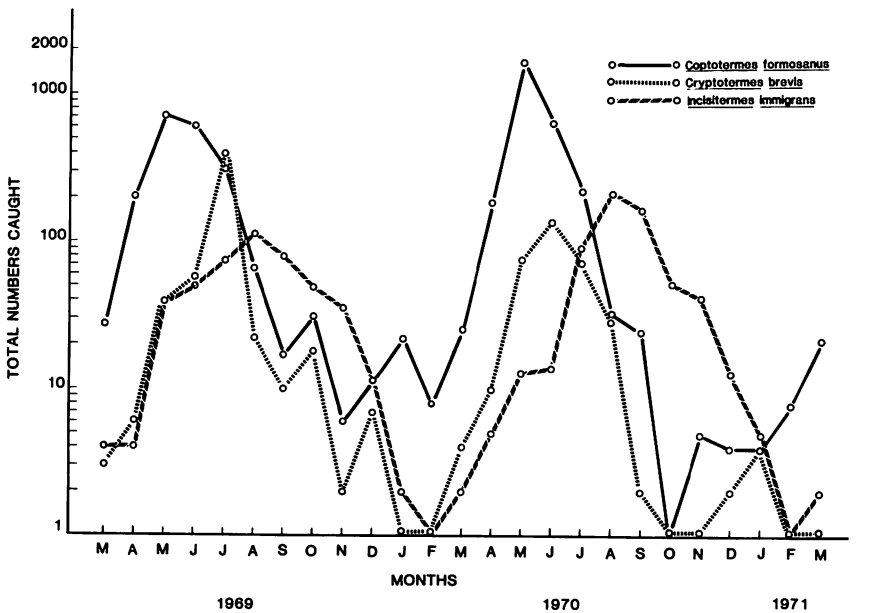

FIGURE 3. Monthly light trap catches of alates of *Coptotermes formosanus* Shiraki, *Cryptotermes brevis* Walker and *Incisitermes immigrans* (Snyder) from 32 locations on Oahu, Hawaii, from March 1969 to March 1971.

presented in Fig. 2. Flights of *C. formosanus* were recorded for 19 or about 1 out of 3 evenings during this period. Of these, 4 were major flights where 850 to 5300 alates were captured. Three of the 4 major flights occurred in May.

There were no obvious differences in climatological factors to differentiate flight and non-flight days. Two of the 4 flights occurred when the maximum daytime temperature was one or two degrees higher than usual. Rainfall was associated with 2 of the 4 days when major swarming occurred. Measurable rain fell on 22 days in May and June.

Ambient humidity was 65% or greater and the wind at 7:00 p.m. was 1 km/h or less on all nights with major flights. These two factors were consistent but there were several other days when the wind was low and the humidity high and there were no flights.

Measuring the ambient conditions at 7:00 p.m., therefore, was not sufficient to predict whether there would be a flight of *C. formosanus.* The environmental trigger(s) for swarming probably acted at the microenvironmental level.

The flights of the drywood species paralleled those of *C. formosanus* except that the peak flight activity of both drywood species occurred slightly later in the year (Fig. 3). For *C. brevis,* peaks were recorded in July in 1969 and June in 1970. For *I. immigrans,* peaks occurred in August in both years. Populations of this species started from a low in February to a peak in August and dropped back to a low in February. Approximately equal numbers of the two species of drywoods were collected in the traps but fewer drywoods were collected than *C. formosanus.* Although swarms of the drywoods are not as large or noticeable as those of *C. formosanus,* the data show that there are significant numbers of the drywoods swarming during the peak periods.

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