N O T E

New Flight Distances Record for Alates of *Odontotermes formosanus* (Isoptera: Termitidae)[1]

Jian Hu, Jun-Hong Zhong[2] and Wei-Liang Xiao

Guangdong Entomological Institute, Guangzhou 510260, China

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In the south of China, the black-winged subterranean termite, *Odontotermes formosanus* (Shiraki), is the most serious pest species in levees, dams, and floodwalls (Huang et al. 2000, Pg. 317 *In* Fauna Sinica, Insecta, Vol. 17, Isoptera, Science Press, Beijing; Hu et al. 2006, Sociobiology 48: 661 - 672). This species can build large subterranean cavities at a depth of 1 – 3 m inside soil levees and dams, and the tunnel can be as large as 0.06 m in diameter (Li et al. 2004, Acta Entomol. Sin. 47: 645 - 651). Its complex tunnel systems can cause leakage, seepage, and erosion, which can eventually lead to the breakage and collapse of levees (Yang et al. 2009, Environ. Entomol. 38: 1241 - 1249).

Previous investigation indicated that termite colonies are initiated mainly through the act of swarming and dispersal (Li and Huang 1991, Sci. Technol. Termites 8: 18 - 23; Thorne 1996, Sociobiology 28: 253 - 261). Information on how far alates are capable of flying from a dispersal point (i.e., its 'flight distance') is important to better understand its impact and to determine the effectiveness of control tactics. This is especially true in area-wide management within the maximum flight distances that may prevent new colony foundation in a soil levee area.

In contrast to well-known, long distance and high altitude flying insects, adult termite alates are known as weak dispersal insects (Pan 1999, Termite Research 146 - 150). It has been estimated that alates of *O. formosanus* can travel several hundreds of meters at heights of tens of meters (Li 2002, Pg. 428 *In* Termites and Their Control in China, Science Press, Beijing). However, many flight estimates were conducted and recorded by visual observation of active swarms (Shi et al. 1987, Entomol. Knowl. 24: 337 - 343; Liu et al. 1998, Pg. 94 *In* Biology and Control of Termites in China, Publishing House of Chengdu Science and Technology University, Chengdu; Pan 1999, Termite Research 146 - 150), possibly limiting the reliability of the results. This paper reports on the flight distances of alates of *O. formosanus* using the mark-recapture method. The objectives of the study were to (1) estimate how far alates of

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[2]Address inquiries (email: zhong@gdei.gd.cn).

O. formosanus are capable of flying, and (2) measure how high alates of *O. formosanus* can reach.

Field colonies marked as A, B and C were selected (23°11'N, 113°23'E, Guangzhou, China) for the current estimates. Mark-recapture studies by Forschler (1994, Sociobiology 24: 27 - 38) and Hu et al. (2007, Sociobiology 50: 513 - 520) presented a feasible method of using fluorescent spray paint-fluorescence microscopy techniques to mark subterranean termites. Their method was used to measure alate flight distances for 3 colonies of *O. formosanus*. The spray paint can was held 0.6 m away from and 0.3 m above the alates. The spray nozzle was depressed when they emerged from the exit holes of the colony, thus, allowing the paint to flow downwind and passively drift down onto the wings. The spray nozzle was pressed 3 times for 1 sec each time at each exit holes from which alates were swarming. Shed wings were collected with lights traps in the vicinity of 2000 m around colonies on the day after swarming. We recorded locations where the wings were collected with GPS Map 76 (Garming, Taipei, Taiwan). Wings were collected within a 1 × 1 m square area at each GPS recording point, and were dried in an air-conditioned room for 48 h (27°C, dehumidified). Fluorescent spray paint markers were checked for fluorescent marks under a Zeiss Axioplan 2 fluorescence microscope under UV illumination (Zeiss, Jena, Germany).

Colony A swarmed on 04 May 2007. Red fluorescent spray paint (Baocili Color Co., Guangzhou, China) was chosen as the marker for the alates of colony A. The wind direction was from southeast at an average speed of 0.2 m/sec (Meteorological Meter, AZ Co., Taipei, Taiwan). Twenty-one of 56 trap points trap points were observed with paint-marked wings. The maximum horizontal flight distance of colony A was 319 m, and the maximum vertical flight distance was 21 m (Table 1).

Colony B swarmed on 26 May 2007. Green fluorescent spray paint was chosen as the marker. The wind direction was from southeast with a velocity of 0.7 m/sec. The maximum horizontal flight distance for alates of colony B was 1070 m, and the maximum vertical flight distance was 64 m (Table 1).

Colony C also swarmed on 26 May 2007. Red fluorescent spray paint was chosen as the marker for this colony. The maximum horizontal flight distance for alates of colony C was 888 m, and the maximum vertical flight distance was 14 m (Table 1).

Table 1. ANOVA result of alate horizontal dispersal distances and vertical dispersal distances for different colonies.

		Horizontal distance (m)			Vertical distance (m)		
Colony	n	Means	Min.	Max.	Means	Min.	Max.
A	121	46.2 ± 6.0a	7	319	14.3 ± 0.8y	−11	21
B	74	281.8 ± 31.2b	18	1070	16.9 ± 1.3y	−21	64
C	55	183.5 ± 18.7c	96	888	−29.4 ± 1.4z	−45	14
Total	250	146.1 ± 12.3	7	1070	6.58 ± 1.3	−45	64

*Different letters following means are significantly different at the $\alpha = 0.05$ level by Tukey test. Comparisons are made between colonies means (a, b and c) for horizontal dispersal distances and vertical dispersal distances (y and z).

Analysis of variance among colonies was performed using SPSS 16.0 for Windows, GmbH. Termite colony origin appeared to affect flight distances. The average horizontal and vertical flight distances of colony B were significantly farther and higher than either Colony A or C (Table 1). This was not directly related to differences in the physical size of the alates, because individuals in Colony B were equivalent in size to those from other colonies. It is possible that intercolony differences in colony origin, wind speed, and/or wind direction may have caused these observed differences.

The results of the 3-colony investigation indicated that alates of *O. formosanus* are capable of flying horizontal distances of 1070 m and vertical distances of 64 m. In southern China, many levees and dams failed caused by termite infestation. This knowledge was a point of discussion about the size of the area that should be considered appropriate for extermination of all *O. formosanus* colonies around the levees and dams. The determination of that area could be based on the maximum flight distance of alates (Li et al. 2004, Acta Entomol. Sin. 47: 645 - 651). We suggest that *O. formosanus* mature colonies should be treated inside a corridor of at least 1070 m on all land-facing sides of levees and dams.

Flight distance appears to vary among species. Formosan subterranean termites, *Coptotermes formosanus* Shiraki, were capable of flying a horizontal flight distance of 100 m (Higa and Tamashiro 1983, Proc. Hawaii. Entomol. Soc. 24: 233 - 238), 460 m (Ikehara 1966, Bull. Arts Sci. Div. Univ. Ryukyu, 9: 49 - 178), 892 m (Messenger and Mullins 2005, Florida Entomol. 88: 99 - 100) and as far as 1000 m (Husseneder et al. 2006, Insect. Soc. 53: 212 - 219), and a vertical flight distance of 40 m (Su et al. 1989, J. Econ. Entomol. 82: 1643 - 1645). Tethered flight tested by Shelton et al. (2006, J. Insect Behav. 19: 115 - 128) indicated that the maximum distance flown by alates of the Eastern subterranean termite, *Reticulitermes flavipes* (Kollar), was 458.3 m. Liu (1998, 94) estimated that *R. flaviceps* (Oshima) disperse as far as 50 - 80 m and as high as 20 - 30 m. He and Wang (1986, Sci. Technol. Termites 3: 28 - 30, 32) observed that alates of *Macrotermes barneyi* Light could travel 150 m and reach a height of 25 m. Alates *O. hainanensis* were reported to fly 50 - 400 m and reach a height of 10 - 30 m (Shi et al. 1987, Entomol. Knowl. 24: 337 - 343). Our results show that alates *O. formosanus* were able to fly a horizontal flight distance of 1070 m and vertical flight distance of 64 m. This indicates that alates of *O. formosanus* fly further and higher than alates of all termite species that have been thus far reported. One possible mechanism that could promote long-range dispersal of alates is outbreeding and reducing the likelihood that nestmates encounter each other during tandem pair formation (Vargo and Husseneder 2009, Annu. Rev. Entomol. 54: 379 - 403).

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