Alate Dispersal Distances of the Black-Winged Subterranean Termite *Odontotermes formosanus* (Isoptera: Termitidae) in Southern China

by

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ABSTRACT

Odontotermes formosanus is the most serious termite pest species of dams and dikes in Southern China. The dispersal distances of the alates are important to better understand its impact and to determine the effectiveness of control tactics. A mark-recapture study using fluorescent spray paints was conducted to characterize dispersal distances of an *O. formosanus* colony which was located in the Longdong reservoir dam, Guangzhou, China. *O. formosanus* alates were capable of flying 120 to at least 743 m in the direction of the low prevailing wind. These results could help to formulate a management strategy against *O. formosanus*. The advantages of the fluorescent spray paint / fluorescence microscopy technique is also discussed.

Keywords: *Odontotermes formosanus*, China, Mark-recapture, Dispersal distances, Fluorescent paint marker.

INTRODUCTION

The black-winged subterranean termite, *Odontotermes formosanus* (Shiraki), is an important pest of agricultural crops, plantations, and forestry in China and it endangers earthen dikes and dams (Huang *et al.* 2000). This species can build large subterranean cavities to a depth of 1 to 3 m in such structures, and its tunnel systems can cause water infiltration and even the collapse of dikes and dams (Liu *et al.* 1998). It is the most serious dam-termite in China and causes losses of hundreds of million dollars each year (Li 1989). According to an investigation in 14 provinces in southern China, over 90% of river dikes

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and reservoir dams more than 15 years old have been damaged by this species (Zhong & Chen 1997). Information on the dispersal distances of the alates of this species helps to better understand its impact and in turn to develop suitable control strategies.

In nature, colonies mature enough to produce alates will release alates initially every two or three years, and at the peak of colony life on a yearly basis for four to five years. As the colony ages, swarms may be observed again only every two or three years (Liu *et al.* 1998). However, in our studies the swarming only happened one or several times for mature colonies in the whole year, and under extreme weather conditions of thunderstorms or big rains in the early summer (Li *et al.* 2004a). The dispersal distance was known as a difficult problem to track due to this uncertainty regarding swarm times. The dispersal distances of *O. formosanus* alates have been studied by several researchers previously. Shi *et al.* (1987) estimated that alates could reach a height of 10-30 m and travel 50-400 m from the colony. Pan (1999) reported distances between 128-600 m. However, all these studies were carried out by naked eye observation, possibly limiting the reliability of the results.

A good marker is important when studying termite alate flight biology (Higa & Tamashiro 1983; Li *et al.* 2004b). Oil-soluble dyes such as Neutral red and Nile blue have been used to mark the workers in the hope that they would be transferred to mark the alates by trophallaxis between colony members. But even after feeding the colony with dyed food for a whole year, no marked *O. formosanus* alate was observed during the following swarming season (Hu *et al.* 2006). Forschler (1994) marked the workers of two species of subterranean termite, *Reticulitermes flavipes* and *R. virginicus*, with fluorescent spray paint to study the suitability of the marker, and inspected the termites with a hand-held UV-4B black light. However, if the fluorescent paint is applied too heavily, this may lead to changes in behavior (Forschler 1994).

We sprayed fluorescent paint as lightly as possible and checked for dye marks on wings under a fluorescence microscope. Our objective was to study the alate dispersal distances which might help to formulate a management strategy against *O. formosanus* and offer a novel technique for insect population research.

MATERIALS AND METHODS

A colony was selected on the landside slope of the Longdong reservoir dam (23°10'N, 113°23'E), Guangzhou, China. Alates swarmed on May 21, 2006. Weather conditions were recorded with a hand-held weather meter (AZ Co., Taipei, Taiwan): SE wind with a velocity of 0.3 m/s, temperature 25.2°C and relative humidity 92.3%. Red fluorescent spray paint (Baocili Color Co., Guangzhou, China) was chosen as the marker for the alates as they emerged from the swarming hole. The paint was sprayed downwind from a position 30 cm above the alates, so that the aerosol of the spray paint would drift down onto the wings. The spray nozzle was pressed 3 times for 1 sec each time at each swarming hole (Forschler 1994).

Shed wings were collected under lights of buildings in the vicinity of the test colony the next day. We recorded locations where the wings were collected with GPS Map 76 (Garming, Taipei, Taiwan) and used the GPS's average location function. Wings were collected within an 1×1 m square area at each GPS recording point, and were dried in an air-conditioned room for 48 hours (27°C, dehumidified). Wings were checked for fluorescent marks under a Zeiss Axioplan 2 fluorescence microscope under UV illumination (Zeiss, Jena, Germany).

RESULTS AND DISCUSSION

The paint marks on alate wings were clearly visible under the microscope with its UV illumination; even very small paint deposits (≈20 μm) could be detected. A total of 89 out of 445 collected wings were marked, and wings from 20 out of the 43 collecting points within 26.8 ha were found marked. According to the GPS records, the dispersal distances within our checked points ranged from 120 m to 743 m (Fig. 1). Most alates traveled between 401-500m, accounting for the 47% of wings we collected, while a smaller but still substantial number traveled between 301-400m, accounting for 24% of wings collected (Fig. 2).

Generally, alate flights of *O. formosanus* in Guangdong province (20°13'N-25°31'N) occurred between 18:30 and 19:30 from early April to early June. However, if the rainfall at the time was below average, swarming could be delayed beyond the following dry season to take place in the next rainy season

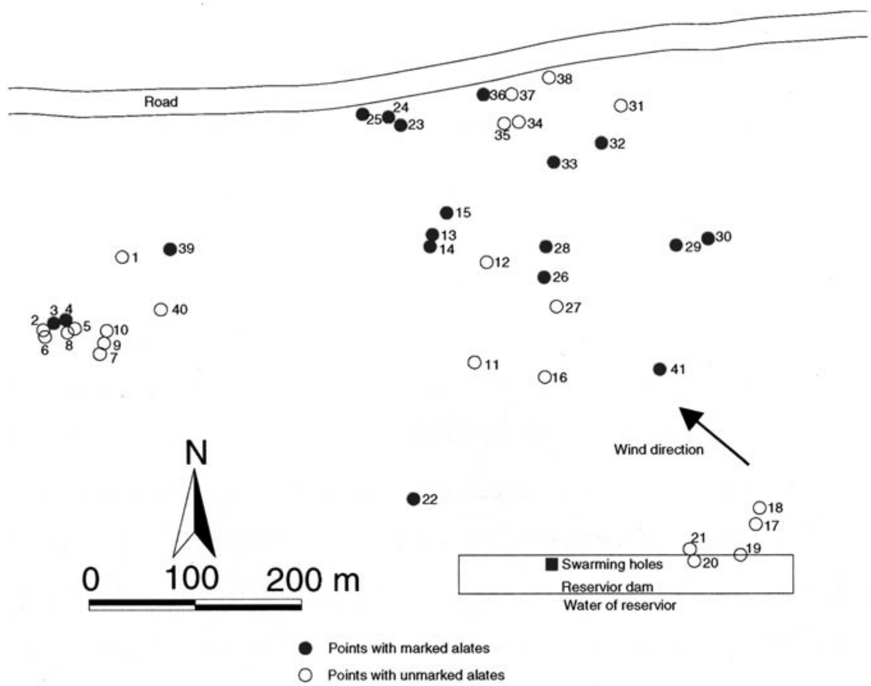

Fig. 1. Dispersal territory of *Odontotermes formosanus* alates marked by red fluorescent spray paint.

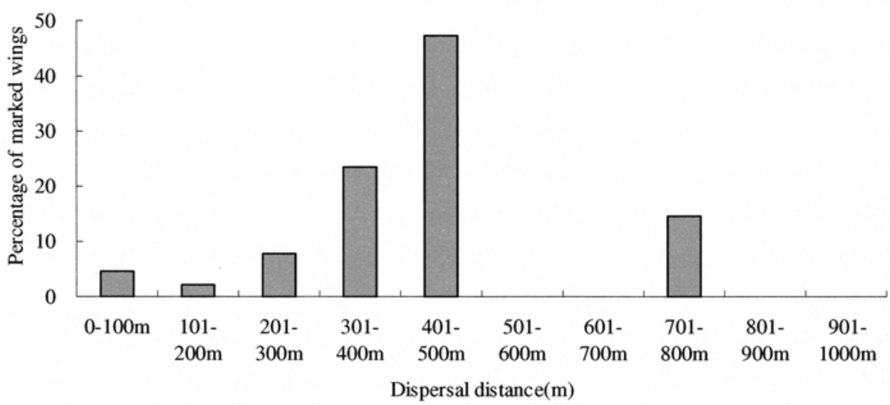

Fig. 2. The percentage of *Odontotermes formosanus* alate wings found at different dispersal distances.

in September, assuming rainfall was sufficient in the subsequent season. At times of inadequate rainfall colonies may release no alates at all (Zhong & Liu 2002).

Most swarming happened during thunderstorms or after heavy rainfall in the early evening with relative humidity no lower than 80%, temperatures of at least 25°C and with an air pressure of 0.994×105-1.004×105 Pa which is lower than a standard atmospheric pressure of 1.013×105 Pa. On the swarming day of 21 May 2006 the rainfall was 302 mm. These conditions are helpful for *O. formosanus* alates to establish new colonies. Generally, rainfall and temperature were the two most important factors that lead to the swarming.

It is well documented that most colonies of *O. formosanus* inside dikes and dams originate from alates released from colonies in nearby hills or woods (Liu *et al.* 1998; Li & Huang 1991). Estimates of the flight distances of alates are important in determining the area around dikes and dams which must have termite protection. If mature *O. formosanus* colonies in a specified area could be controlled, the number of new colonies that could establish in dikes and dams would decrease greatly. Our results from the mark-recapture program revealed that *O. formosanus* alates were capable of flying 120 to at least 743 m with the low prevailing wind at the speed of 0.3 m/s. However, 85% of alates were found to have flied less than 500 m (Fig. 2), and this is important information for the practical control strategies. We suggest that O. formosanus colonies should be treated inside an at least 500 m wide corridor on all land-facing sides of dikes and dams. Further studies may have to determine whether the treatment zone will have to extend beyond a 500 m deep corridor, taking into account potential economic tradeoffs and utilizing any additional experimental data that becomes available.

We also determined that all marked alates were flying in a southeasterly direction which was the same as the direction of the wind. From our observation, the flight direction would be the same as the prevailing (southeast) wind direction in almost all swarms every year. Southeastern wind was the monsoon direction of southern China in the spring and summer season. Flying in the direction of the wind aids the spread to more distant locations. It may be that the strategy of the termite is to fly longer distances in order to occupy more territory. The link between wind direction and flight behavior warrants further research, especially in the context of area-wide termite management.

Termite alates of *Coptotermes formosanus* were reported to have flown as far as 892 m with the aid of prevailing winds (0.83 m/s) (Messenger & Mullins 2005), and could initiate colonies at heights of up to 40 m in high-rise buildings (Su *et al.* 1989). Flying in the direction of the wind allows longer flight distances, and lighter insects will make better use of this advantage than heavier insects. As the alates of *O. formosanus* are larger and heavier-bodied than those of *C. formosanus*, we speculate that a *C. formosanus* alate should be able to fly further (and possibly higher) than one of O. formosanus.

Flight distance of alates depends on many factors, such as wind speed, wind direction, light disturbance, rain fall condition and other environmental variables during the swarming. We suggest that wind speed is an important factor in affecting the dispersal distances of alates. In our study, *O. formosanus* alates were capable of flying 120 to at least 743 m in the direction of the low prevailing wind at a speed of 0.3 m/s. This wind speed was so low that the air movement may have been of limited assistance in carrying the alates much further than they could have traveled on their own. The observed dispersal distance of 892 m for *C. formosanus* with the aid of a strong prevailing wind (0.83 m/s) (Messenger and Mullins 2005) was farther than the distance of 742 m for *O. formosanus* in our study. Higher wind speeds may provide important propulsion. A far more extensive study of several colonies under a range of weather condition is warranted.

Fluorescent spray paint in combination with fluorescence microscopy is a new application to study the population dynamics of termite alates. It has many advantages (such as consistent and observable markings, minimal behavioral effects and low cost) over traditional oil-soluble fat dyes, fluorescent powders, ordinary spray paint, radio isotopic tracers and other marking agents. Even very small fluorescent paint marks can be detected under the fluorescence microscope, and the spray paint color is unnatural and not easily mistaken for any naturally occurring termite coloration. The fluorescent spray paint / fluorescence microscopy technique may provide a feasible method to study dispersal of other termites or insects.

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