Spectral Sensitivity of the Compound Eyes of the Black-winged Subterranean Termite AlatesOdontotermes formosanus (Isoptera: Termitidae)alates

by

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Abstract
Spectral sensitivity of the compound eyes of Odontotermes formosanus (shiraki) alates, an economically important pest of river dikes and reservoir dams, was measured by electroretinogram (ERG) technique. 6 selected wavelength bands between 385 and 940 nm stimulated by light-emitting diodes (LEDs). The form of the ERG was found to be monophasic in nature. The relative spectral sensitivity high significantly different in descending order to violet (wave range, 385-390 nm), blue (465-470 nm), green (520-525 nm), yellow (585-590 nm), red (625-630 nm), infrared (850-940 nm) light. Peaks of electroretinogram were found in the violet and blue. Furthermore, no differences were observed between sexes.

Key words: Odontotermes formosanus, termite, spectral sensitivity, electroretinogram

Introduction
Black-winged subterranean termite Odontotermes formosanus (Shiraki) is a serious pest infests plants, river dikes and reservoir dams in the South of China, Burma, Thailand, Vietnam and other Southeast Asia countries. O. formosanus usually establishes nests in the earthwork at a depth of about 2 m. Its nests systems are subsurface defects that can cause infiltration, cavity and even collapse to the body of dikes and dams when water level is high. In the South of China, most river dikes and reservoirs dam are made of earth, over 90% of them >15 years old are damaged by O. formosanus, moreover, during annual flood season, 20% of dam leaks were caused by termite gallery systems which drill through the damed. O. formosanus responsible for many collapses of dikes and dams (Li 1991). An example in China is the disaster of the Dongkaomiao reservoir Dam in Zhejiang province, which washed away villages and fields and claimed the lives of over 180 people in June 1971. O. formosanus is the most destructive dam-termite species and the loss amounts to hundreds of million dollars annually in China (Li 2004).

Most of the attention in termite management has focused on foraging workers of mature colonies. However, every year swarming alates have the potential to establish incipient nests on river dikes and reservoir dams. In generally, workers and soldiers avoid light, they live in constant darkness, have neither functional compound eyes nor ocelli, however the alates of black-winged subterranean termites have functional compound eyes, exhibit a strong tendency to light in particularly, swarming from March to July annually in the south of China.

**Materials and Methods**

**Termite Collection and Maintenance**

During the swarming season, alates of *O. formosanus* were collected from Longdong reservoir dam (23° 11’N; 113° 23’E), Guangzhou, China. Captured and transferred them into carton box with soil immediately where maintained at 55.0% ~ 61.4% humidity and 25 ± 1°C (Liu et al. 1998, Rao et al. 1987).

**Electrophysiological recordings**

Spectral sensitivity of the compound eyes of *O. formosanus* was measured using the electroretinogram (ERG) technique, defined by Goldsmith and Bernard (1965) as the retinal action potential reflecting activities of both receptors and higher order neurons (Brown and Anderson 1996, Brown et al. 1998). Alates were embedded in a polyethylene glycol 6000 to ensure that all appendages were secured except the uppermost compound eye was unobstructed. The positive electrode end consisted of glass microelectrode which tip resistance was about 2 MΩ. The indifferent electrode end consisted of silver needle that inserted into the termite abdomen. Bioelectrical signal was fed to a Polygraph (RM-6240, Chengdu Instrument Factory, Chengdu, China) Six kinds of light-emitting diodes (LEDs) over the range 385-940 nm as optical stimulator for the alates compound eyes. We regulate the voltage and electrified time by polygraph to control the illumination intensity and duration. All illumination at the compound eyes in this experiment maintained at 100 Lux and 0.1 duration once every 5 seconds (Agee 1972, 1973; Chang et al. 2004). Mean sensitivity was calculated for males (n=5), females (n=5) and overall for both sexes (n=10). Elaborate operation with micromanipulator was under a stereoscope (Olympus, Japan) in a stainless steel box that screen environmental static. After 30 min dark adaptation the electroretinogram record began.

**Results and Discussion**

The spectral sensitivity of the compound eyes of a female alate is shown in Fig. 1. It was found to be monophasic. The value of electroretinogram-determined spectral sensitivity of the compound eyes was between 0.62 V and −0.05 V. The relative spectral sensitivity high significantly different in descending order to violet (wave range, 385-390 nm), blue (465-470 nm), green (520-525 nm), yellow (585-590 nm), infrared (850-940 nm), red (625-630 nm) light (t-test, P<0.01). Two peaks of sensitivity are clearly visible, firstly in of violet and secondly in the blue region. Alates are little sensitive in the red region, however show small sensitivity in the infrared region, they probably perceive infrared ray through compound eyes or other organs.

![Fig 1. Electroretinogram spectral sensitivity of one female alate *Odontotermes formosanus* stimulated by six kinds of LEDs, shown as the means of 10 replications. A: violet (wave range, 385-390 nm); B: blue (465-470 nm); C: green (520-525 nm); D: yellow (585-590 nm); E: red (625-630 nm); F: infrared (850-940 nm).](image-url)
Figure 2 shows no significant differences between males and females at any wavelength. Sensitivity peaks were seen distinctly in violet and blue region for both sexes.

![Electroretinogram spectral relative sensitivity of *Odontotermes formosanus* stimulated by six kinds of LEDs, shown as the results of 5 males and 5 females. A: violet (wave range, 385-390 nm); B: blue (465-470 nm); C: green (520-525 nm); D: yellow (585-590 nm); E: red (625-630 nm); F: infrared (850-940 nm).](image)

In contrast with *C. formosanus* (Chang et al. 2004), alates of *O. formosanus* possessed a broadly similar electroretinogram. The major difference is the relatively much greater sensitivity of *C. formosanus*. This may reflect the fact that it is much more vigorous, as longer flight and chasing activity than alates of *O. formosanus* which appear in the air shortly before mate.

White lights have been setting for traffic and fishing on dikes and dames and attract considerable alates to land on dikes and dames in every swarming season and pose a potential danger. It is well documented that most primary productives of *O. formosanus* on dikes and dames swarmed from hills or woods nearby, other than immigrated form dikes and dames themselves (Li and Huang 1991, Wang et al. 2002, Zhong and Liu 2002). So preventing alates swarming towards dikes and dames has great control significance. Dame-termite is a serious calamity in southern China. Especially in the Pearl River Delta Economic Zone, one of China's leading economic regions that covers an area of 41,700 km², has 12,198 km dikes and dams, has a population of 40.8 million people. By 2001 its GDP rose to just over US$100 billion accounted for 8.7 percent of China’s (State Statistical Bureau 2001). Security of dikes and dams in this zone is of vitally importance to China economy development.

In this study showed that violet and blue wave bands are of high sensitivity, otherwise, red, yellow and green are low sensitive to *O. formosanus*. The high level of relative sensitivity suggests that attraction or repellence, while low sensitivity may represent indifferent to the source of illumination. Our observation found that sodium light exhibit less termite phototaxis than fluorescent lamps. Although further behavioral experiments need to test the practical spectral lights efficiency, this experiment results probably a guide for selection of dame lighting. Our study provides a novel approach for effective dam-termite management for maintenance and protection of river dikes and reservoir dams in South China and neighboring Southeast Asia region.
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References


