Flight Activity and Flight Phenology of the Asian Subterranean Termite, *Coptotermes gestroi* (Blattodea: Rhinotermitidae)

by

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ABSTRACT

The flight activity and flight phenology of the Asian subterranean termite, *Coptotermes gestroi* (Wasmann), was investigated by the use of sticky traps over a period of 12 months in northeastern Peninsular Malaysia. Flight activity was evident throughout the year and the largest swarms occurred between January and June. Most flights were confined to the following environmental conditions: atmospheric pressure of 1,009-1,010 hPa, temperature of 27 – 28°C and 83 – 84% RH. The number of trapped alates was significantly correlated ($P < 0.05$) to atmospheric pressure and temperature. Rain was not required to trigger alate dispersal on flight days.

Key words: *Coptotermes gestroi*, flight activity, flight phenology, atmospheric pressure, temperature.

INTRODUCTION

The Asian subterranean termite, *Coptotermes gestroi* (Wasmann), is the most economically important species of subterranean termite in Southeast Asia (Kirton & Azmi 2005; Kirton & Brown 2003; Lee 2007; Lee *et al.* 2007). Termite damage was estimated to cost approximately US$400 million per year in Southeast Asia and a substantial proportion of this was caused by *C. gestroi* (Lee 2007). *C. gestroi* is believed to have originated from the Indo-Malayan region (Roonwal 1970; Tho 1992), but has spread to the Marquesas Islands (Pacific Ocean), Mauritius and Reunion (Indian Ocean), the New World tropics (Brazil & Barbados), some islands of the West Indies, southern Mexico, the Southeastern US (Scheffrahn *et al.* 1994; Su *et al.* 1997; Scheffrahn & Su 2000) and more recently to Taiwan (Tsai & Chen 2003), possibly through human activities. In Peninsular Malaysia and Thailand, ap-

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proximately 85 to 90% of termite infestation in urban areas is reportedly attributed to *C. gestroi* (Kirton & Azmi 2005; Sornnuwat *et al.* 1996; Lee 2002; Lee *et al.* 2007).

Termite flight activities are always subject to the influence of ecological factors. Temperature, air humidity, rainfall, light intensity, wind velocity, atmospheric pressure and electrical properties in the atmosphere play roles in initiating flight activity (Nutting 1969). The alate flight season of different termite species is region-specific. In the tropics, flight activity is usually confined to the rainy season, while in temperate regions, warmer summer months are favored for Sonoran desert termite dispersal (Nutting 1969).

High dispersal rate of alates (Su & Scheffrahn 1987), their ability to produce mature colonies in a few years (Costa-Leonardo & Barsotti 2001) and the high fecundity of termite queens (Pearce 1997) may in due course lead to more building and structural threats by the termites. In spite of the above, to date, termite management focuses only on managing the foraging workers. The attempts to prevent alate settlements and colony founding have been minimal, partly due to limited understanding of termite flight phenology. In addition, information on flight activity of important termite species, especially those in the tropics, has been scarce.

In the present study, we report the flight activity and phenology of *C. gestroi*. This study may serve as a tool to assess the relative impact of alate dispersal and may be used to predict future flight periods.

MATERIALS AND METHODS

The study was conducted at the Minden campus of Universiti Sains Malaysia (USM), Penang, Malaysia (2° 59'N and 102° 18'E), located in Northeastern Peninsular Malaysia. The climate of Penang is characterized by a uniform temperature (Day: 29 - 35°C; Night: 26 – 29°C) and substantial rainfall of approximately 2,670 mm per year, concentrated in the months of September to November.

The 100-ha Universiti Sains Malaysia (USM) Minden campus has a rich diversity of termite species (Wong 2006). *C. gestroi* is the most prevalent structural pest in USM which accounted for 88% of all infestations in buildings and structures (Lai 2005). Study sites which were known to have high incidence of termite infestation were selected.

Twenty-nine sticky traps (SELL Co. Ltd, Indonesia), measuring 28 x 19 cm were set out along building verandas at three different locations. The sticky traps were hung slightly below 36-watt fluorescent lamps (Phillips, Thailand) and were suspended at approximately 3 m above ground. Trapped alate numbers were assumed to be unrelated to trap height (Henderson & Delaplane 1994, *C. formosanus*). The study sites spanned between 300 and 500 m apart. The trapped alates were presumed to originate from different colonies according to flight distance record of *Coptotermes* (≈ 100 m: Higa & Tamashiro 1983). Traps were checked on a daily basis between 0900 and 1000 hours and new sticky traps were replaced for each flight event. The trapped alates in each trap were sorted out based on the descriptions in Thapa (1981), Huang *et al.* (2000), Tho (1992) and Barsotti & Costa-Leonardo (2005).

Hourly temperature (°C), relative humidity (%), atmospheric pressure (hPa) and daily rainfall (mm) data of Bayan Lepas station (5° 18'N and 100° 16'E, altitude 2.8 m), Penang Island, Malaysia were sourced from the Malaysian Meteorological Department (MMD) (Distance from study sites: 8.5 km).

The numbers of trapped alates in the three locations were pooled. The hourly meteorological data (air temperature, relative humidity, atmospheric pressure) parallel to the flight time (1900 hours to 2400 hours, personal observation) were used for analysis. We remedied the deficiencies of previous works by collecting data on a daily basis and obtaining the meteorological data that best corresponded to the flight period to allow more accurate data interpretation.

Rebello & Martius (1994) argued that flight activity cannot be accurately estimated with a mere trap catch due to bias of distribution and density-dependent factors. In order to remedy the shortcoming, relative frequency (frequency of swarming events per month) was also tested to analyze the relationship of environmental factors (Rebello & Martius 1994; Martius *et al.* 1996).

RESULTS

Flight pattern and number of trapped alates.

Flight activity of *C. gestroi* occurred most the year (Fig. 1). A total of 112 flight events were observed throughout the study period. The bulk of alates dispersed on March 29, 2008 registering ca. 2210 alates which accounts for

34.6% of the total catch. High frequencies of *C. gestroi* swarming events were recorded from January to June. The termite alates swarmed at a low rate from July to December. Traps that were closer to colonies tended to collect a higher numbers of alates. The capture of alates of the same species in each location on flight days indicated that simultaneous swarms from different colonies occurred.

Flight phenology

Atmospheric pressure (Fig. 2): *C. gestroi* swarmed under atmospheric pressure of 1006 – 1013 hPa. Most flights were confined to atmospheric pressure of 1009 - 1010 hPa, χ^2 (7, n = 112) = 83.429, $p < 0.05$, which is lower than standard atmospheric pressure (1013 hPa). The number of alates released was negatively correlated to atmospheric pressure, but the correlation was weak, $r = -0.256$, $p < 0.05$.

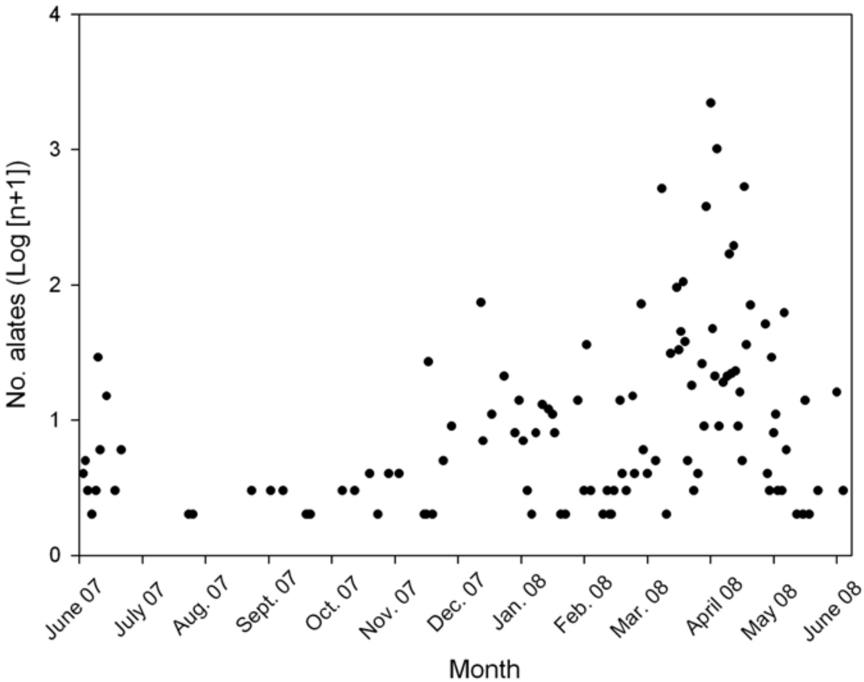

Fig. 1. Flight activity of *C. gestroi* over a period of 12 months. Data of trapped alates were transformed with log (n+1).

Rainfall (Fig. 2): Rainfall data was transformed to with or without rain recorded (1 or 0) during the flight days. By observing the incidents of rain on flight days, we found that flight occurred equally on days with or without rainfall, thus ruling out the effects of rainfall.

Temperature (Fig. 3): Temperature recorded during *Coptotermes* swarming events over the study period varied from 24 – 29°C, with most of swarming events taking place at 27 – 28°C, χ^2 (5, n = 112) = 73.571, $p < 0.05$. Weak correlation was found between the number of trapped alates and temperature, $r = 0.201$, $p < 0.05$.

Relative humidity (Fig. 3): The alates swarmed under a wide range of relative humidity, ranging from 59 – 95%. Most flights occurred under relative

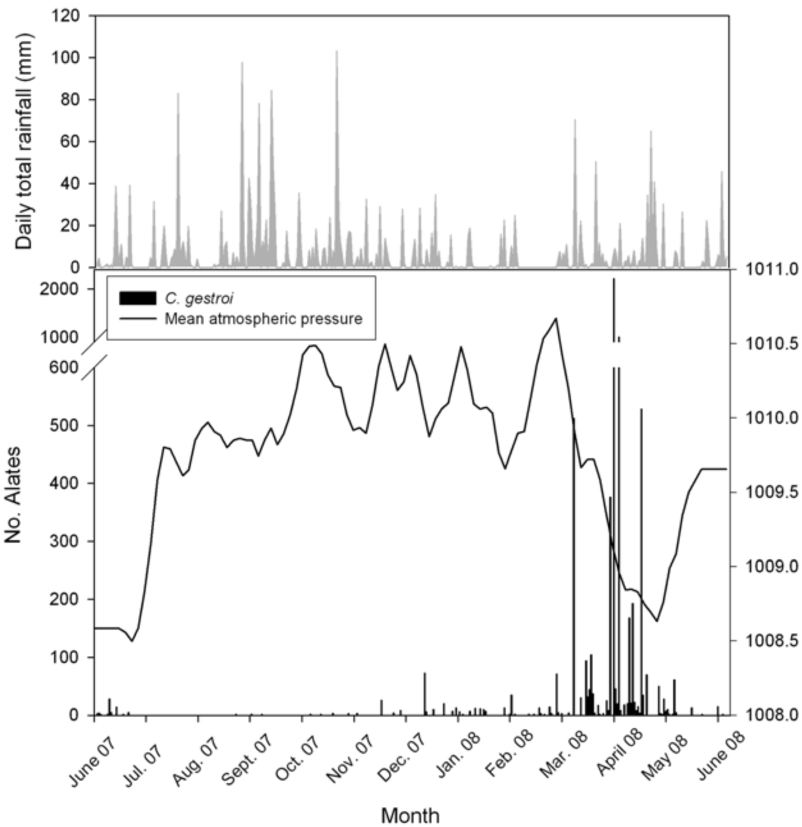

Fig. 2. Relationship between flight activity of *C. gestroi*,daily atmospheric pressure and total rainfall. The data of environmental variables were smoothed with running average of 10% of the data set.

humidity of 83 – 84%, $\chi 2$ (27, n = 112) = 75.500, $p < 0.05$. No significant correlation was observed between the number of trapped alates and relative humidity.

Relative frequency

In *C. gestroi*, swarming events were prevalent from February to April recording 14 – 21 days per month. The highest relative frequency of 18.8% was registered in April with a monthly total rainfall of 250 mm. On the other hand, a low monthly total rainfall of 51 mm was sufficient to trigger about 12.5% of flight events in February. No significant correlation was observed between relative frequency and environmental variables.

DISCUSSION

Previous works on flight activity showed mixed results (Costa-Leonardo & Barsotti 1998; Henderson 1996; Henderson & Delaplane 1994; Martius *et al.* 1996; Rebello & Martius 1994), possibly due to variations in data

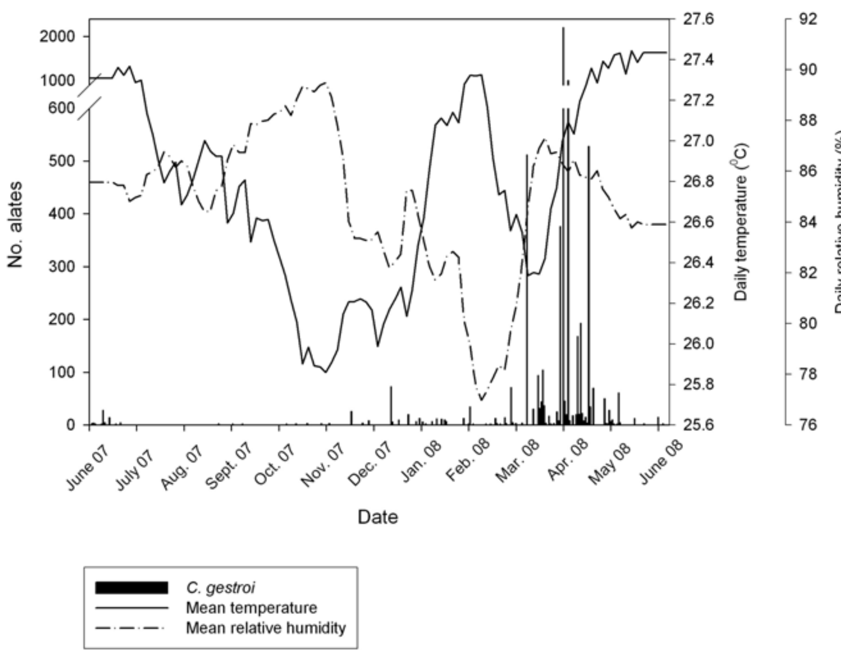

Fig. 3. Relationship between flight activity of *C. gestroi*, daily temperature and relative humidity. The data of environmental variables were smoothed with running average of 10% of the data set.

collection such as: (1) samplings that were only made on the presumable months and hours of the flight, (2) the number of traps used, and (3) the meteorological data that was adopted for data interpretation. The captured numbers of alates were probably underestimated, compared to the studies done by Su & Scheffrahn (1987) on *C. lacteus* and Henderson (1996) on *C. formosanus*. Studies may be influenced by a single bulk swarm of termites, distance of mounds between trapping sites (Henderson & Delaplane 1994; Martius *et al*. 1996; Henderson 1996) and reproductive output in one colony (Thorne 1983). There were also arguments concerning the relatedness of magnitude of trapped alates and flight activity (Nansen *et al*. 2001). Despite this, stationary traps remain a feasible tool for monitoring flight activity of termite alates due to their cryptic lifestyle.

C. gestroi swarmed throughout the year and some sporadic small flights also occurred beyond the peak season. This observation was in agreement with observations of *C. gestroi* in Brazil (Ferraz & Cancello 2001). This might represent the high plasticity of the species and long reproductive season in the tropics (Kaspari *et al.* 2001; Corbett 1999). On the other hand, Robinson (1996) noted that small swarms are valuable for alate settlement as these receive the least amount of predator attention, although we were unable to demonstrate this experimentally in the present study. Poor synchronization of alates may result in greater difficulty in finding pairs and is further complicated when alates pair selectively (Husseneder & Simms 2008). Alates of *Macrotermes michaelseni* remain in the parental colony for months if suitable environmental conditions for flight are not met (Darlington 1986). Flight period of *Coptotermes* varies across termite species and region (Costa-Leonardo & Barsotti 1998; Scheffrahn & Su 2005; Calaby & Gay 1959; Henderson 1996; Bess 1970; Coaton & Sheasby 1976).

To some extent, our results confirmed that environmental factors trigger termite flight activity, especially atmospheric pressure and temperature. However, it is in contrast to the findings by Rebello and Martius (1994), Martius *et al*. (1996) and Ferraz & Cancello (2001) and Martius (2003) who found non-relatedness between climatic factors and termite flight activity. Several authors suggested that colony intrinsic factors (Henderson & Delaplane 1994) and an endogenous biological clock (Ferraz & Cancello 2001) may affect the timing of alate flight activity.

In general, flights of *C. gestroi* occurred under a wide range of weather conditions and under warm and low humidity conditions. The results were parallel with the observations made by Ferraz & Cancello (2001). Su & Tamashiro (1987) noted that *C. formosanus* swarmed at temperatures between 20-29^{0}C and bulk swarms occurred on days with the warmest daytime temperatures. Our findings showed the flights of *C. gestroi* were affected by atmospheric pressure and temperature, and rainfall was not a factor in triggering flights.

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