A survey of the prevalence of endoparasitism by *Vertica fasciventris* Malloch (Diptera: Calliphoridae) in colonies of *Macrotermes carbonarius* (Hagen) (Blattodea: Termitidae) in Penang Island, Malaysia

by

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Abstract

A survey of the infestation rate of *Macrotermes carbonarius* (Hagen) (Termitidae: Macrotermitinae) colonies by the endoparasitoid *Vertica fasciventris* Malloch (Diptera: Calliphorida) was conducted in Penang Island, Malaysia from April to December 2015. Of the 313 *M. carbonarius* colonies surveyed, 105 (33.5%) were parasitized by *V. fastrivencis.* A high frequency was recorded in Balik Pulau (62.0%) and Youth Park-Botanical Garden (61.8%). Parasitized mounds were not found in Air Itam (28 surveyed mounds) and Jelutong (22 surveyed mounds). In all of the surveyed sites, the parasitized colonies were recorded as healthy. The height and diameter of parasitized mounds (n=105) was significant higher ($t = -3.3$; $df = 311$, $P < 0.01$) and larger ($t = -3.2$; $df = 311$; $P < 0.01$) than those of the not-parasitized ones.

Key words: endoparasitoid, *Macrotermes carbonarius*, mound size, infestation rate

Introduction

The fungus-growing termite *Macrotermes carbonarius* (Hagen) is widely distributed in Malaysia, Thailand, and Cambodia (Roonwal 1970). It is an open-air foraging species commonly found in forested and undisturbed areas (Lee et al. 2014). Parasitization by dipteran flies was first recorded by Kemner (1925), in which, a large larva parasitoid was found in the head of the soldiers *Macroteremes malaccensis* (Haviland). Recently, *Macrotermes barneyi* (Hagen) (Sze 2008) and *M. carbonarius* (Neoh & Lee 2011) were found to be parasitized by *Verticia fasciventris* Malloch in Hong Kong and Malaysia, respectively. *V. fasciventris* is an Oriental bengaline blow fly, which common in some Southeast Asian countries (Kurahashi et al. 1997). Neoh and Lee (2011) described the development of the larva parasitoid *V. fasciventris* in the head of *M. carbonarius.* The larva consume the entire content of the head of termite soldiers and eventually, fully fill the head capsule. The effect of the parasitoid *V. fasciventris* on the morphology of the host, *M. carbonarius*, was also described. Parasitized soldiers possess a square-like head with a pair of short mandibles.

Little is known about the infestation rate of *M. carbonarius* colonies by these larval parasitoids. Therefore, the goal of this study was to determine the prevalence and describe distribution of *M. carbonarius* parasitized by *V. fasciventris.*

Materials and Methods

Termite collection

The study was conducted on Penang Island, located on the northeastern coast of Peninsular Malaysia. A total of 313 *M. carbonarius* mounds were surveyed from April 2015 to December 2015. The coordinates of each termite mound was recorded by GPS (Garmin eTrex HCx Vista, USA). The details of the surveyed sites are presented in the Table 1.

M. carbonarius mounds were opened to determine whether the mounds were infested with *V. fasciventris*. The colony was considered infested with *V. fasiventris* if parasitized major or minor soldiers were sighted. Parasitized soldiers were characterized by a square-like head capsule and short mandibles and are commonly found in isolated, concealed chambers within infested termite mounds (Neoh & Lee 2011). Diameter and height of mounds were measured before excavation.

Status of colony health

Colony healthy was evaluated based on the ability of termites to repair damaged sections of the mound within 1-3 days. The mounds were classified as healthy if termites were able to repair the mound, and classified as unhealthy if the damaged part was not repaired.

Statistical analysis

A Student T-test was used to compare mound size (diameter and height) between parasitized and unparasitized mounds. Analyses were performed using SPSS version 20.1 for Windows (SPSS Inc. Chicago, IL, USA).

Results and Discussion

Parasitism frequency, colony healthy of *M. carbonarius* mounds

The number of surveyed *M. carbonarius* mounds and parasitism frequencies at each surveyed site are presented in Table 1. Of the 313 *M. carbonarius* mounds examined, 105 (33.5%) were infested with *V. fastrivencis*. The highest frequency of parasitism was recorded in Balik Pulau (62.0%) and Youth Park-Botanical Garden (61.8%), followed by USM Minden Campus (39.6%), Teluk Bahang (37.5%), Gelugor

(27.0%) and Bayan Lepas (19.5%). Parasitized mounds were not found in Air Itam (28 surveyed mounds) and Jelutong (22 surveyed mounds). Parasitized colonies were classified as healthy at all surveyed sites.

The mean height of parasitized (n = 105) and unparasitized (n = 208) mounds was 40.9 cm (range = 81 cm) and 34.8 cm (range = 85cm), respectively. The mean diameter of parasitized and not-parasitized was 107.1 cm (range=209 cm) and 92.0 cm (range=208 cm), respectively. The mound size (height and diameter) of parasitized colonies (n = 105) was higher ($t = -3.3$; $df = 311$, $P < 0.01$) and broader ($t = -3.2$; $df = 311$; $P < 0.01$) in comparison to not-parasitized colonies.

Table 1. Frequencies of parasitism at each surveillance site in Penang Island

Location	Longtitude	Latitude	No. mound surveyed	N. mound infested	Parasitism frequency %
Bayan Lepas	100 17.042	5 18 935	41	8	19.5
Gelugor	100 18 727	5 22 354	37	10	27.0
Balik Pulau	100 18.013	5 21.080	29	18	62.0
USM	100 18.380	5 21.634	106	42	39.6
Youth park-bontany garden	100 18.399	5 26.198	34	21	61.8
Air Itam	100 16.804	5 23.366	28	0	0
Jelutong	100 18.712	5 23.004	22	0	0
Teluk Bahang	100 13.255	5 27.720	16	6	37.5
Total			**313**	**105**	**33.5**

Discussion

The current study showed high parasitism frequencies in Balik Pulau and Youth Park-Botanical Garden, which are shaded areas with dense vegetation. Additionally, parasitized colonies were not found in areas with limited vegetation and in urban settings (Air Itam and Jelutong). Similar to our study, two blow flies *Chrysomyia albiceps* (Widemann) and *Chrysomyia marginalis* (Widemann) are usually in forested areas compared to open shrub lands (Braack & Retief 1960). Habitats with dense vegetation such as forests and undisturbed areas probably provide richer food resources than urban areas. Therefore, we suggest that the adult parasitoids prefer shaded, dense vegetation areas.

In colonies of Macrotermitinae, it is documented that mound size and termite numbers have a positive correlation (Josens & Soki 2010). Large and healthy populations are probably more preferred due to its rich resources for parasitoids exploiting. This premise was supported by the results of Smith and

Schwarz (2009), in which, the allodapine social parasites, *Inquilina schwarzi* Michener prefered to attack larger colonies of its host, *Exoneura robusta* Cokerell. Additionally, Cervo and Turillazzi (1996) also found that cuckoo paper wasps, *Plistes sulcider* Zimmermann, actively selected the larger and more developed colonies. In this study, we found that the size of parasitized colonies was significant larger than that of not-parasitized ones. In addition, the parasitized colonies were classified as healthy in all surveyed sites. It suggests that the parasitioid fly *V. fasciventris* might prefer to parasitize larger mounds and healthy colonies.

Conclusion

This study examined the distribution and parasitism frequency of *M. carbonarius* colonies parasitized by *V. fasciventris*. The adult parasitoid flies showed a preference for shaded areas with dense vegetation. The size of parasitized mounds was significant larger compared to the not-parasitized mounds. It suggests that the parasitoid *V. fasciventris* prefers to parasitize larger *M. carbonarius* colonies. In addition, the parasitoid flies tend to select healthy colonies to deposit their eggs.

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