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Ecological factors affecting host plant and shelter preferences of *Tetraponera rufonigra* (Hymenoptera: Formicidae) in urban ecosystem

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ABSTRACT

Host-plant preferences of *Tetraponera rufonigra* Jerdon (Hymenoptera: Formicidae) were assessed by field measurement in relation to the types of trash found in the surrounding tree perimeters. The correlations between the density of *T. rufonigra* and the plants (types of trash and levels of infestation) were determined based on the data gathered at 34 study sites in the Eastern part of the Penang Island to clarify the density differences of *T. rufonigra* among the sites. A simple linear regression analysis was also employed to assess the effects of environmental parameters i.e. UV light, temperature and humidity on the density of *T. rufonigra*. No significant difference was found between the infestation level at each site and the types of trash. Six species were identified as host-plant preferences of *T. rufonigra* i.e. *Cassia fistula* L., *Azadirachta indica* A. Juss., *Mimusops elengi* L., *Delonix regia* (Hook), *Cerberra odollam* Gaertn and *Tabebuia rosea* (Bertol.). These tree species were recorded for the first time as the most preferred host trees by *T. rufonigra* in Malaysia. The results also identified that *T. rufonigra* preferred the trees with high humidity level, suitable surrounding temperature and UV light as their habitats.

Introduction

Tetraponera rufonigra Jerdon (Hymenoptera: Formicidae) has become a medically important pest, especially in urban locations in India and Southeast Asia countries due to its painful sting that could cause severe anaphylaxis (Ratnatilaka and Dias, 2011; Fernando et al., 2015). The painful sting is due to the venom that contains several substances such as acids and alkaloids, causing toxic reactions including local and systemic reactions (anaphylaxis) (Potiwat and Sitcharungsi, 2015). In Malaysia, several cases have been reported on *T. rufonigra*. A student in Bukit Mertajam was admitted to the Intensive Care Unit (ICU) after being severely stung by *T. rufonigra* (Kasturi, 2009). In other cases, the monks and devotees were bitten by *T. rufonigra* following the infestation of this ant species at Hong Hock See temple, Penang (Priscilla, 2007). The biting had caused a swelling that lasted for two days. In Matara, India, the infestation of *T. rufonigra* occurred at places with fallen trees, resulting in the dispersal of *T. rufonigra* colonies (Malaka, 2013).

The pioneering study of Janzen (1966) with Acacia trees and *Pseudomyrmex* sp. showed that this ant species could act as biotic defense, protecting plants against herbivores and parasites. In returns, plants provide benefits such as shelter and food rewards. This relationship is known as a mutualistic interaction (Bronstein, 1998; Blatrix et al., 2009). This ant-plant interaction is based on the resources provided by plants as rewards ranging from food bodies, extra-floral nectaries (EFN) or nesting sites (domatia). The ant-plants or myrmecophytes will be continuously inhabited by ants during major parts of their life that often associated with single and specialized species (Djiéto-Lordon and Orivel, 2008; Webber et al., 2007).

T. rufonigra behavior has its own unique nesting habit, consisting of branches and dead stems of various kinds of plants. They usually live in empty spaces inside the plants (Bharti and Akbar, 2014). The host plant usually has holes in the thorns or branches, providing foods and housing to the ants (Norasmah et al., 2012). In return, the ants provide protection to the host plants through their aggressive behavior towards herbivorous insects and intruders. Workers of *T. rufonigra* are good climbers due to their arboreal nature and usually prefer to forage over trees and large shrubs. However, they can also be found foraging over the ground (Savitha et al., 2008; Mahalakshmi and Channaveerappa, 2016). This ant species usually have a large colony with a large number of workers, approximately 300–500 individuals per colony (Rakhshan, 2015). Having a large number of workers is advantageous to the colony as it helps them to establish their nest (Mahalakshmi and Channaveerappa, 2016).

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In Malaysia, the early study on foraging behavior and nutrient preferences of *T. rufonigra* were conducted by Norasmah et al. (2012). They found that this ant species was diurnal and preferred protein-based foods as their food sources. Nevertheless, the distribution and host plants preferences of *T. rufonigra* in Peninsular Malaysia has not been studied before. Therefore, the objectives of this study were to investigate the host plant preferences of *T. rufonigra* across the eastern part of Penang Island and to determine the ecological factors affecting the distribution and its shelter preferences.

Materials and methods

Study area

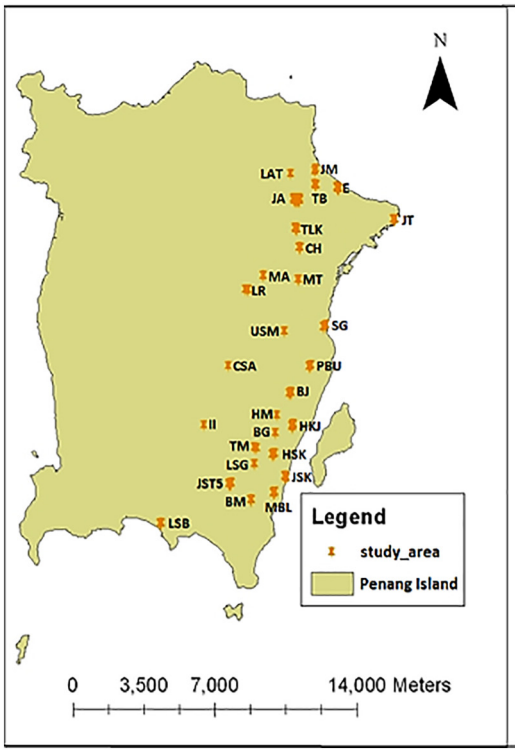
T. rufonigra workers were collected from various locations in Penang Island. A total of 58 sites in eastern part of Penang Island comprises of total 243 trees were visually surveyed. The sites were divided into 11 sub-districts as follows: Pulau Tikus, Georgetown, Jelutong, Air Itam, Gelugor, Paya Terubong, Sungai Nibong, Bayan Baru, Batu Maung, Bayan Lepas and Teluk Kumbar. Surveys were mainly targeted in urban and suburban areas since based on the earlier survey, no *T. rufonigra* was discovered in rural areas. Residential housing, industrial, park and recreation areas were included in this survey. The selected areas were randomly pointed on the map to mark the study sites by using Google Earth (2015). The GPS coordinates were taken to easily map them on GIS using ArcGIS 10.3 Software (ESRI, 2011) (Fig. 1). To minimize the bias, the distance of each point (target sites for sampling) was about the same with each other (Baker, 2010). Since the sampling was randomly conducted, only one visit was required in this survey (Zulaikha et al., 2016).

During the sampling, a jar baited with 2–3 g of tuna was placed near the infested trees, mainly in foraging areas and was collected after 30–45 min. The numbers of ants trapped in the jar were counted. For precaution, the glass jar was placed on the ground level and was labeled to avoid any human disturbance. All specimens were labeled and were kept separately according to locations. From 58 surveyed study sites, 34 sites with 243 trees were positively infested by *Tetraponera rufonigra*.

Approximately, 1–2 h per site was required to collect all parameters related to *T. rufonigra*. A preliminary study on the distribution of *T. rufonigra* populations was done to determine whether the trash types surrounding the trees could influence the preferences of host plants. The study was done by making a comparison of the similar tree species with and without the trash surrounding the perimeter. Throughout the preliminary study, it was found the *T. rufonigra* usually foraged and brought the foods back to the trees from the trashes nearby. Populations of *T. rufonigra* were subsequently studied based on three different trash types at the sites i.e. domestic (D), leaf litters (LL), domestic and leaf litters (DLL) (Fig. 2). Then, infestation levels were also determined based on the number of workers (density) collected in each surveyed tree i.e. level 1 (1–10 workers), level 2 (11–20 workers), level 3 (21–30 workers), level 4 (31–40 workers) and level 5 (> 41 workers).

Host plant and environment

Fifty-eight sites were surveyed using a Nested Circles Method (Wilson and Shmida, 1984) with the standardized radius of 200 m and an adaptation of Whittaker's plant diversity sampling method where the sampling area was circle-nested at a fixed central point (Baker, 2010). Hence, the total size of the study sites areas covered were 125,663.706 m^2. The trees were surveyed along the nested circle area. The height and the diameter of the bark of each tree were recorded. Each surveyed tree was photographed, labeled and identified to the species level. A 'Height of a Person' technique was used to estimate the height of the tree (Ontario Woodlot Association, 2003). In this technique, a pencil was vertically held by one person standing at the base of the tree. Then, that person moved away slowly from the tree until the top of the pencil was in line with the top of that person's head and the bottom of the pencil was lined up with the feet. The total lengths of the pencil to reach the top of the tree was multiplied by the height of that person to estimate the height of the tree. The technique was repeated three times for accuracy. The diameter of the bark was measured from the ground at standardized 1.35 m height.



Location code	Collection sites
PBU	Persiaran Batu Uban
LSG	Lorong Sg. Tiram
HSK	Hilir Sungai Kluang
MBL	Medan Bayan Lepas
JST5	Jalan Sungai Tiram 5
MA	Medan Angsana
TLK	Taman Lumba Kuda
LSB	Lorong Sungai Batu
USM	Universiti Sains Malaysia
CH	Cheeseman
II	Isle of Island
LR	Lebuh Rambai
BJ	Bukit Jambul
BG	Bukit Gedung
TM	Taman Mahsuri
MT	Medan Tembaga
BM	Batu Maung
CSA	Cangkat Sungai Ara
HKJ	Halaman Kampung Jawa
JA	Jesselton Avenue
E	Edgecumbe
JSK	Jalan Sungai Keluang
TB	Taman Berjaya
LAT	Lorong Air Terjun
JM	Jalan Midland
HM	Halaman Macalister

Fig. 1. Map of *Tetraponera rufonigra* distribution.