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FACTORS DRIVING *PAEDERUS* OUTBREAKS IN HUMAN SETTINGS: CLIMATIC FACTOR OR HUMAN INTERVENTION?

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Abstract Dermatitis linearis is skin irritation resulting from contact with the hemolymph of rove beetles from the genus *Paederus*. *Paederus* neither bite nor sting, but accidental crushing on human skin causing the release of the toxin paederin. Massive outbreaks are frequently reported in tropical regions of Asia and sporadic cases are documented elsewhere in temperate countries. It was hypothesized that climate factors have been the major determinant causing the massive dispersal to human settings as most outbreaks coincided with warmer summer months. In the present study, a year-long weekly sampling was conducted at infestation-prone human settings in Malaysia. The correlation between the numbers of rove beetle capture and climatic factors as well as the crop cycle activity was tested using Principal Component Analysis. The dispersal activity of *P. fuscipes* showed two peaks, which was from February to March and August to October. However, the result rejected the null hypothesis. Habitat disturbance and site unsuitability due to human intervention have been the main factors. In particular, massive dispersal of rove beetle was frequently observed during rice harvesting, including straw burning, and cultivation. The activity may disrupt the habitat, normal activities and reduce its prey. This activity could have rendered the rice fields unfavorable refuges and driven the rove beetles away to human settings. In addition, the management challenges such as the development of insecticide resistance owing to widespread use of insecticide in agricultural field is also discussed in this paper.

Key words Dermatitis linearis, rove beetle, insecticide resistance, habitat disturbance.

INTRODUCTION

Of 50,000 staphylinids species distributed worldwide, only the genus *Paederus* of the Paederine Staphylinid subtribe Paederina (Coleoptera: Staphylinidae) is notoriously known to cause dermatitis linearis on human skin. *Paederus* is well adapted to habitats associated with moist environments like freshwater lakes, marshes, riverine floodplains, riverbanks, and crop fields (Frank and Kanamitsu, 1987). Similar to other staphylinids, this genus is beneficial to agricultural systems as they are polyphagous predator to agricultural pests (Frank and Kanamitsu, 1987). However, contact with these species causes serious health impact in humans, resulting in dermatitis linearis (Frank and Kanamitsu, 1987).

Beetle infestations in human settlements are of increasing concern among the public. Adult *Paederus* are attracted to incandescent and fluorescent lights. Thus, adult flights are restricted to night and congregated around the fluorescent lights in human dominated areas. Inadvertently, human comes into contact with this beetle. This beetle neither bite nor sting. However, accidental brushing against or crushing the beetle provokes the release of its toxic haemolymph called paederin, the potent vesicant that causes dermatitis linearis on human skin (Frank and Kanamitsu, 1987).

Clinically, dermatitis linearis is a necrotic blister that is characterized by linear vesiculobullous lesions on erythematous bases and pruritus (Frank and Kanamitsu, 1987; Nicholls et al., 1990; Zargari et al., 2003). This clinical appearance is sometimes confused with liquid burns, herpes simplex, herpes

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The medical importance of *Paederus* had been an annual feature throughout the world. However, the insect in human setting system have received little attention from biologists. Considering that future climate changes and landscape disturbance may place further outbreak pressure to human setting landscape, adequate attention to the predicted outbreak crisis is required. To date, publications on *Paederus* have focused mainly its medical important. In contrast, knowledge about ecology and biology of *Paederus* is very limited. In the present study, a year-long weekly sampling was conducted at infestation-prone human settings in Malaysia. In the study, we hypothesize that climate factors may be the major determinant causing the massive dispersal to human settings as most outbreaks coincided with warmer summer months that reported elsewhere.

MATERIALS AND METHODS

Study site

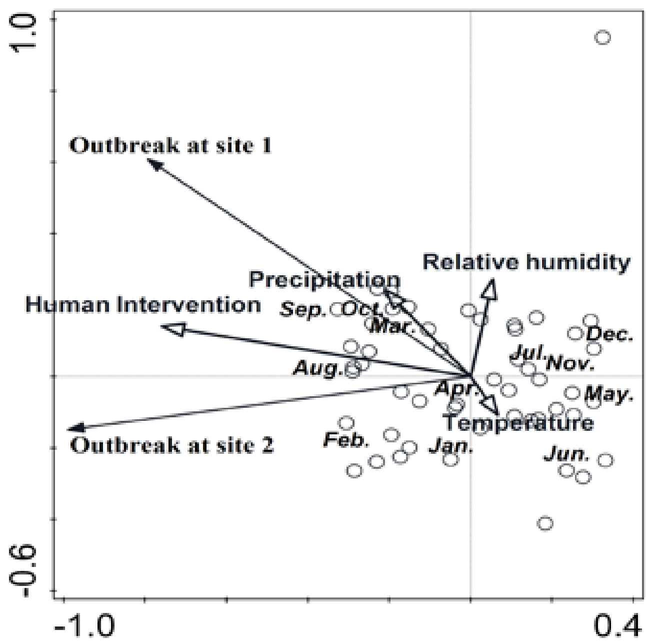

Figure. 1. Principal Component Analysis (PCA) ordination diagram showing the abundance of *Paederus* species sampled (close arrows) in Site 1 and Site 2 and environmental variables (open arrows) throughout a year. The result indicates that outbreaks are peak in the months of February and March, and August to October. First axis is horizontal, second axis is vertical. The eigenvalues for the first two axes of the ordinations were 0.90 and 0.10, respectively.

The study was carried out on Mainland Penang that experience a uniformly warm and humid climate throughout the year and receives mean annual rainfall of 2,670 mm. The temperature falls between 29 and 35°C during the day and 26 and 29°C at night. The sampling sites were selected in two high-rise residential buildings where cases of *P. fuscipes* infestation were numerous (hence, site 1 and site 2) that set approximately 10km apart. Site 1 is located 1.89 km away from 1,016 ha of rice fields, whereas Site 2 is located 500 m away from 1,036 ha of rice fields

Data collection and statistical analysis

At the two locations, samples were collected using six sticky traps that measuring 28 by 19 cm. The sticky traps were deployed below a 36-W fluorescent lamp. Insects were collected at weekly intervals and the traps were replaced with new traps. Sampling was carried out for a 1-yr period. The number of trapped insect were correlated with meteorological data, such as hourly air temperature and relative humidity and daily precipitation readings obtained from meteorological stations as well as annual crop activity nearby the rice field. Principal Component analysis (PCA) was employed to examine the association between the *Paederus* outbreak and environmental variables as well as crop cycle activity close to the sampling sites (human intervention).

RESULTS AND DISCUSSION

A total of 628,513 *P. fuscipes* were caught throughout the sampling period. In general, the outbreak period was peak from February and March and from August to October (Figure 1). The association of *Paederus* outbreak with environmental variables was not significant but marginal association was detected between the outbreak and precipitation. The insignificant association between the outbreak and environment variables reflected that minor climatic variation in the tropical region contributed subtle impact on flight activity. Similarly, a study conducted in northeastern Brazil reported that only annual moisture and drought cycles are responsible for *Paederus* flight activity (Silva et al., 2015). In addition, PCA revealed that the *Paederus* outbreak were most closely associated to human intervention in the rice fields. This is particularly true as most flights occurred in the months during harvesting, cultivation, and transplanting of seedlings (Figure 1). The activity may disrupt the habitat, normal activities and reduce its prey. This activity could have rendered the rice fields unfavorable refuges and driven the rove beetles away to human settings.

MANAGEMENT CHALLENGE

Direct management effort by reducing *Paederus* population in rice fields is impossible because *Paederus* is beneficial arthropod predator, which needs to be conserved in this agricultural setting. Insecticide applications using thermal fogging and direct chemical spraying are usually the only resort to control *Paederus* infestation in human settings using (Bong et al. 2013); yet the success is not guaranteed due to insecticide resistance. Bong et al. (2013) documented that the LT_{50} and LT_{95} values were significantly different between strains collected from different localities. Combined with their short mean generation time (Bong et al. 2012), the discrepancy of lethal time likely hinted at *Paederus* might have developed certain level of tolerances towards several conventional insecticides, which are widely used for crop pest management such as pyrethroids, organophosphates (chlorpyrifos and phenthoate), carbamates (e.g., isoprocarb, fenobucarb, and propoxur), and neonicotinoids (imidacloprid and thiamethoxam). Meta-analysis by combining the bioassay data from different biogeographical regions are required to ascertain the possibility of insecticide tolerance development in *Paederus*. This information is of crucial to formulate sustainable pest management in human dominating areas.

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