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Seasonal Density and Diversity of Insect Decomposers in Three Forest Types of Sakaerat Environmental Research Station, Thailand

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Insect decomposers play many important roles in terrestrial ecosystems. Their population usually fluctuated according to seasons and associated with environmental factors. The aims of this study were to investigate seasonal density and diversity of insect decomposers in dry dipterocarp forest (DDF), ecotone area (ECO) and dry evergreen forest (DEF) in Sakaerat Environmental Research Station (SERS), Thailand. Furthermore, the correlation between density and diversity of insects and temperature, humidity and rainfall were also examined. During October 2006 to September 2009, insect decomposers were collected monthly in 20 x 20 cm plot of each study site. Climate parameters were recorded from the meteorological stations in SERS. The results revealed that a total of 4,156 individuals of insect decomposer from 9 orders 27 families were captured in SERS. The two most common families were Termitidae (termites) (26.42%) and Formicidae (ants) (24.93%). The highest average density of insect decomposers was in DEF (1.55±2.87 individuals/unit sample), followed by ECO (1.41±2.65 individuals/unit sample) and DDF (1.31±2.2 individuals/unit sample), respectively. Among the seasons, the average densities of insects were 2.01±3.49 individuals/unit sample in the summer, 1.42±2.59 individuals/unit sample in the rainy season and 0.85±1.62 individuals/unit sample in the winter. The diversity of insects were 2.34, 2.5 and 2.32 in DDF, ECO and DEF and were 2.46, 2.36 and 2.26 in the summer, the rainy season and the winter, respectively. Temperature, relative humidity and rainfall were positively correlated diversities of insect decomposers in DDF, ECO and DEF. Relative humidity also associated with insect densities in all study sites. Temperatures were correlated with insect diversities only in DDF and ECO. Correlation between rainfall and insect density was not detected in this study.

Keywords: Seasonality, density, diversity, insect decomposer, Sakaerat Environmental Research Station

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Introduction

Insect decomposers are highly abundant and diverse in most tropical ecosystems. They are classified as bioindicators of soil quality (Nakamura *et al*., 2007; Santorufo *et al*., 2012) and play various essential roles in ecosystem processes such as decompose plant materials, maintain soil structure and regulate nutrient cycling (Ashford *et al*., 2013). These activities associated with both biotic factors such as predation, competition (Ferguson and Joly, 2002) and plant species composition (Lagerlof and Wallin, 1993) and abiotic factors i.e. soil organic matter (Bengtsson *et al*., 1998), climatic factors and seasons (Wolda, 1988).

Climate factors such as rainfall, temperature and humidity have a strong influence on insect population dynamics throughout the year, especially in tropical ecosystems (Pinheiro *et al*., 2002; Vasconcellos *et al*., 2010). Moreover, some seasonal species in the tropics show seasonal peaks within a year-round. Data on insect population dynamics in the Neotropical region are well documented, but little is known about the seasonality of insect population in other tropical regions (Wolda, 1988). In addition, there is a lack of long-term study on population fluctuations of insects in the tropics (Grimbacher and Stork, 2009).

In the present study, the three years of insect study was carried out in Sakaerat Environmental Research Station, northeastern Thailand which aimed to investigate seasonal diversity and density of insect decomposers in dry dipterocarp forest, ecotone and dry evergreen forest. This study also attempted to examine the influence of climate factors on diversity and density of insects. The information from this study provides not only the composition and dynamics of insect decomposers but also a better understanding ecological processes in a tropical forest.

Materials and methods

Study area

This research was conducted in Sakaerat Environmental Research Station (SERS). The SERS is one of the four UNESCO designated biosphere reserves in Thailand. It was established in 1967 and is administered by the Thailand Institute of Scientific and Technological Research, aiming to be a natural laboratory for students and providing training and seminars in ecological and environmental research. SERS is located in Nakhon Ratchasima province, situated approximately at 14˚ 30′ N, 101˚ 55′ E at an altitude of 280 - 762 m above sea level, about 60 km south of Nakhon Ratchasima on highway

304 and 300 km northeast of Bangkok. The station ground cover an area of 78 km^2, primarily as a site for research on DEF which covers an area of about 36.67 km^2 (45.25%) and DDF covers an area of about 15.21 km^2 (18.78%). There is also an abundant grassland area which covers about 9.12 km^2 (11.26%) and reforestation areas cover about 19.41 km^2 (23.95%) (Sakaerat Environmental Research Station, 2014) (Fig 1). The average annual temperature is 26.2 ℃ and the average relative humidity is 81.9% as well as the average annual rainfall is 1,260 ml. There are three seasons i.e. the rainy season (May to October), the winter (November to February) and the summer (March to mid-May). The wettest month is September and the driest months are from December to February (Sakurai *et al*., 1998).

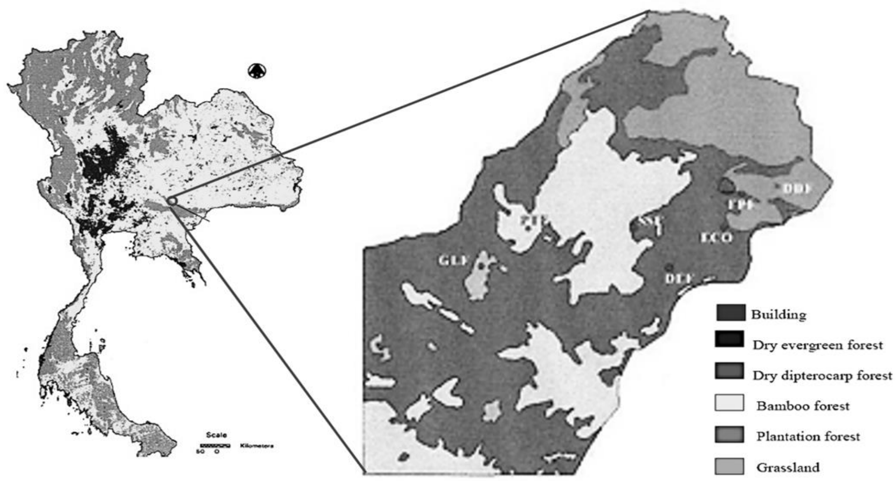

Fig. 1. Study areas in Sakaerat Environmental Research Station (SERS), northeastern Thailan

Data collection

Insect decomposer collection was performed 3 years from October 2006 to September 2009, divided into the 1st year (October 2006 - September 2007), the 2nd year (October 2007 - September 2008) and the 3rd year (October 2008 - September 2009). A permanent plot sized 100 × 100 m was established in each forest in SERS, including dry dipterocarp forest (DDF), dry evergreen forest (DEF) and ecotone between DDF and DEF (ECO) (Fig 1). Each permanent plot was divided into 25 small sample plots sized 20 × 20 m and further divided into 100 sub-plots of 2 × 2 m. Then, 10 sub-plots, each of 2 × 2 m, were chosen after the random sampling process. Then, each quadrat was divided into 5 sub-quadrats each of 20 × 20 cm, representing in each 4 corners and the centre of the sub-plot for collecting insects (modified from Suriyapong, 2003). Each permanent plot was moved to the new location within each forest after one year of data collection.

Ground dwelling insects were collected monthly using hand collection with forceps. Subsequently, the insects were preserved in 70% alcohol for later identification in the laboratory at Suranaree Universty of Technology (SUT). The collected insects were counted and identified to the family level under a stereo microscope following Morimoto (1973) and Thyssen (2009).

The climate characteristics were considered, comprising air temperature, rainfall and relative humidity. They were obtained from the meteorological station of SERS.

Data analysis

Insect density was calculated as number of individuals per unit sample (20 × 20 cm). Diversity was investigated using Shannon-Wiener index (Shannon and Weaver, 1949). Differences in insect density and diversity among forests and seasons were analysed using ANOVA. Pearson's correlation was employed to find the relationship between environmental factors and insect diversity and density. All data were statistical analysed using SPSS program version 18 for windows (IBM, USA).

Results

Climate characteristics

The climatic data from October 2006 to September 2009 displayed distinct seasons. There were highly significant differences in the temperature, rainfall and relative humidity among seasons (p < 0.01). The highest mean rainfall and humidity in the rainy season (130.25±62.98 mm, 90.08±4.64%) were higher than the summer (108.36±69.35 mm, 89.69±2.88%) and the winter (11.2±13.74 mm, 87.34±3.25%). The average temperatures were 28.41±1.25 ˚C, 27.43±1.25 ˚C and 23.17±2.31 ˚C in the summer, the rainy season and the winter, respectively (Fig 2).

Among the study sites, mean rainfall and relative humidity were highest in DDF (89.91±74.88 mm, 89.9±3.51%), whereas the highest mean temperature was in ECO (27.22±2.4 ˚C) (Fig 2). There were highly significant difference in relative humidity (p = 0.01) and significant difference in temperature among DDF, ECO and DEF (p < 0.05). However, no significant difference in rainfall among the forests (p > 0.05).

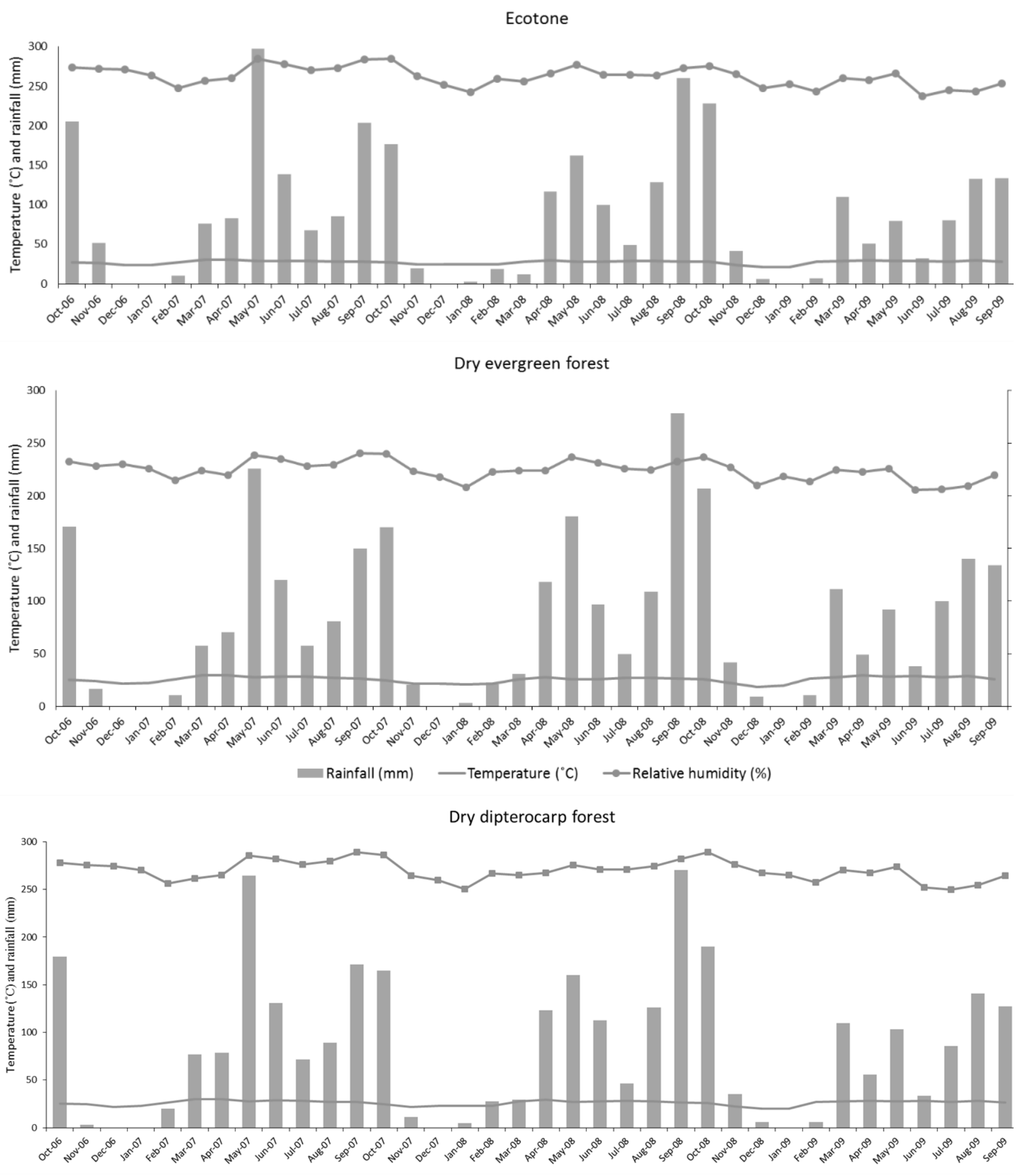

Fig. 2. The mean temperature (˚C), relative humidity (%), and rainfall (mm) in dry dipterocarp, ecotone and dry evergreen forests in SERS from October 2006 to September 2009.

Insect decomposer community

A total of 4,156 insect decomposers were collected during October 2006 to September 2009 in three different forests at SERS, which belonged to 9 orders and 27 families. The two most common families were Termitidae (termites) (26.42%) and Formicidae (ants) (24.93%).They were also highest density in each of study site. In contrast, the other remain families were rare (< 9%). The average density of insect decomposer was highest in DEF (1.55±2.87 individuals/unit sample), followed by ECO (1.41±2.65 individuals/unit sample) and DDF (1.31±2.2 individuals/unit sample), respectively (Table 1). The insect diversity in ECO (2.5) was higher than DDF (2.34) and DEF (2.32). Nevertheless, no statistical differences in density and diversity of insects among the study sites.

Table 1 Density (individuals/unit sample) of insect decomposers in dry dipterocarp forest (DDF), ecotone (ECO) and dry evergreen forest (DEF) in SERS from October 2006 to September 2009.

Order	Family	Oct 06 - Sep 07			Oct 07 - Sep 08			Oct 08 - Sep 09		
		DDF	**ECO**	**DEF**	**DDF**	**ECO**	**DEF**	**DDF**	**ECO**	**DEF**
Blattodea	Blaberidae	0.19	0.00	0.31	0.06	0.08	0.14	0.08	0.08	0.06
Coleoptera	Buprestidae	0.06	0.03	0.06	0.06	0.06	0.06	0.06	0.03	0.03
	Carabidae	0.56	0.22	0.61	0.42	0.25	0.44	0.44	0.22	0.36
	Cerambycidae	0.25	0.19	0.39	0.11	0.11	0.17	0.08	0.11	0.11
	Cicindelidae	0.31	0.25	0.17	0.19	0.22	0.08	0.11	0.08	0.06
	Curculionidae	0.06	0.00	0.14	0.06	0.06	0.08	0.06	0.00	0.08
	Elateridae	0.17	0.08	0.06	0.06	0.03	0.14	0.06	0.00	0.14
	Geotrupidae	0.17	0.08	0.03	0.14	0.06	0.11	0.11	0.06	0.06
	Hydrophilidae	0.06	0.00	0.14	0.11	0.06	0.00	0.06	0.03	0.06
	Lucanidae	0.22	0.42	0.22	0.14	0.31	0.19	0.17	0.14	0.17
	Lycidae	0.06	0.00	0.06	0.00	0.00	0.00	0.03	0.00	0.03
	Passalidae	0.08	0.06	0.03	0.08	0.11	0.06	0.08	0.03	0.03
	Scarabaeidae	0.86	0.67	0.69	0.67	0.33	0.64	0.44	0.31	0.47
	Staphylinidae	0.06	0.06	0.06	0.00	0.17	0.11	0.11	0.00	0.08

Table 1 (continued)

Collembola	Entomobryidae	0.08	0.08	0.14	0.03	0.11	0.06	0.06	0.03	0.06
Dermaptera	Anisolabididae	0.31	0.28	0.28	0.25	0.19	0.11	0.44	0.06	0.11
	Chelisochidae	0.06	0.03	0.17	0.11	0.00	0.17	0.08	0.06	0.00
	Forficulidae	0.17	0.31	0.19	0.22	0.19	0.19	0.19	0.17	0.19
	Labiduridae	0.08	0.17	0.19	0.08	0.06	0.17	0.14	0.11	0.11
Hymenoptera	Formicidae	3.75	3.78	4.14	2.58	3.39	3.25	2.92	2.47	2.50
Isoptera	Kalotermitidae	0.64	0.75	1.08	0.61	0.61	0.47	0.47	0.44	0.39
	Rhinotermitidae	0.97	0.94	1.03	0.69	0.72	0.89	0.31	0.25	0.50
	Termitidae	3.69	4.64	4.33	2.08	3.58	4.00	2.06	2.53	3.58
Orthoptera	Gryllidae	1.64	1.94	1.94	0.69	0.81	1.67	0.28	0.36	0.86
	Gryllotalpidae	0.19	0.22	0.11	0.17	0.53	0.17	0.14	0.31	0.03
Protura	Acerentomdiae	1.14	0.78	0.61	0.39	0.53	0.50	0.14	0.75	0.22
Thysanura	Lepismatidae	0.47	0.28	0.25	0.22	0.42	0.11	0.00	0.28	0.06
Total		16.28	16.25	17.42	10.22	12.97	13.97	9.11	8.89	10.33

Variations of insect decomposers

The average densities of insect decomposers were 2.01±3.49 individuals/unit sample in the summer, 1.42±2.59 individuals/unit sample in the rainy season and 0.85±1.62 individuals/unit sample in the winter (Table 2). The insect diversities were 2.46, 2.36 and 2.26 in the summer, the rainy season and the winter, respectively. Insect densities did not differ among seasons ($p > 0.05$). However, there was highly significant difference in insect diversity between the summer and the winter ($p < 0.01$) and significant difference between the summer and the rainy season ($p < 0.05$).

Among the study periods, insect diversities were highly significant difference between the 1st and the 3rd years in DEF ($p < 0.01$) but the difference in densities and diversities did not detect in DDF and ECO ($p > 0.05$). The insect diversities were also highly significant difference between the 1st and the 3rd years of the rainy seasons ($p < 0.01$) and significant difference among three years of the study in the winters ($p < 0.05$). No significant difference in densities and diversities among study years in the summers.

Table 2 Density (individuals/unit sample) of insect decomposers in summer (sum), rainy season (RAI) and winter (WIN) in SERS from October 2006 to September 2009.

Order	Family	Oct 06 - Sep 07			Oct 07 - Sep 08			Oct 08 - Sep 09		
		SUM	RAI	WIN	SUM	RAI	WIN	SUM	RAI	WIN
Blattodea	Blaberidae	0.14	0.25	0.11	0.19	0.08	0.00	0.22	0.00	0.00
Coleoptera	Buprestidae	0.06	0.06	0.03	0.11	0.06	0.00	0.11	0.00	0.00
	Carabidae	0.28	0.78	0.33	0.61	0.47	0.03	0.75	0.17	0.11
	Cerambycidae	0.28	0.39	0.17	0.28	0.11	0.00	0.28	0.03	0.00
	Cicindelidae	0.28	0.31	0.14	0.33	0.14	0.03	0.19	0.06	0.00
	Curculionidae	0.06	0.06	0.08	0.19	0.00	0.00	0.14	0.00	0.00
	Elateridae	0.06	0.14	0.11	0.17	0.06	0.00	0.17	0.00	0.03
	Geotrupidae	0.03	0.14	0.11	0.19	0.08	0.03	0.17	0.06	0.00
	Hydrophilidae	0.03	0.11	0.06	0.08	0.08	0.00	0.11	0.00	0.03
	Lucanidae	0.19	0.50	0.17	0.47	0.17	0.00	0.28	0.17	0.03
	Lycidae	0.00	0.08	0.03	0.00	0.00	0.00	0.06	0.00	0.00
	Passalidae	0.03	0.06	0.08	0.19	0.06	0.00	0.14	0.00	0.00
	Scarabaeidae	0.50	1.00	0.72	0.94	0.61	0.08	0.86	0.19	0.17
	Staphylinidae	0.03	0.08	0.06	0.22	0.06	0.00	0.14	0.03	0.03
Collembola	Entomobryidae	0.11	0.11	0.08	0.14	0.06	0.00	0.14	0.00	0.00
Dermaptera	Anisolabididae	0.17	0.39	0.31	0.36	0.19	0.00	0.47	0.06	0.08
	Chelisochidae	0.06	0.11	0.08	0.17	0.08	0.03	0.06	0.08	0.00
	Forficulidae	0.22	0.25	0.19	0.42	0.19	0.00	0.47	0.06	0.03
	Labiduridae	0.08	0.22	0.14	0.17	0.11	0.03	0.33	0.03	0.00
Hymenoptera	Formicidae	2.69	5.19	3.78	5.19	3.47	0.56	5.28	1.56	1.06
Isoptera	Kalotermitidae	0.75	1.00	0.72	0.94	0.67	0.08	0.72	0.33	0.25
	Rhinotermitidae	0.69	1.19	1.06	1.67	0.56	0.08	0.75	0.17	0.14
	Termitidae	2.14	5.50	5.03	6.33	2.67	0.67	5.58	1.64	0.94
Orthoptera	Gryllidae	0.97	2.06	2.50	2.11	0.78	0.28	0.94	0.33	0.22
	Gryllotalpidae	0.22	0.11	0.19	0.64	0.14	0.08	0.25	0.17	0.06
Protura	Acerentomdiae	0.36	1.17	1.00	1.14	0.19	0.08	0.83	0.14	0.14
Thysanura	Lepismatidae	0.28	0.39	0.33	0.56	0.17	0.03	0.22	0.06	0.06
Total		10.69	21.64	17.61	23.83	11.25	2.08	19.67	5.31	3.36

Correlation between insect decomposer community and climate factors

The results of the correlation analysis showed that temperature, relative humidity and rainfall were positively correlated diversities of insect decomposers in DDF, ECO and DEF. Relative humidity also associated with insect densities in all study sites. The temperature had correlation with insect diversities only in DDF and ECO. Correlation between rainfall and insect density was not detected in this study (Table 3).

Table 3 Correlations between density and diversity of insect decomposers and climate factors in dry dipterocarp forest, ecotone and dry evergreen forest in SERS from October 2006 to September 2009.

Climate factors	Density	Diversity
Dry dipterocarp forest		
Temperature (˚C)	0.33*	0.45**
Relative humidity (%)	0.46**	0.58**
Precipitation (mm)	0.26	0.5**
Ecotone		
Temperature (˚C)	0.35*	0.58**
Relative humidity (%)	0.41**	0.44**
Precipitation (mm)	0.2	0.4**
Dry evergreen forest		
Temperature (˚C)	0.32	0.39*
Relative humidity (%)	0.35*	0.54**
Precipitation (mm)	0.2	0.33*

** Significance at the 0.01 level; * Significance at the 0.05 level.

Discussions

Surprisingly, no differences in density and diversity of insect decomposers among DDF, ECO and DEF in this study. In contrast, many previous studies revealed that insect decomposers varied among forest types (Schowalter, 1994; Schowalter and Ganio, 1999). Furthermore, Eisenhauer *et al*. (2011) displayed that diversity of plant caused increase in soil arthropod density. The high plant diversity produced more diverse of plant litter (Lavelle 1996) and improved soil conditions (Wang *et al*., 2008), which provided resources for invertebrate decomposers. However, other factors also had influences on density and diversity of insect decomposers such as litter quality (Seeber *et al*., 2008), food chains of coexistence decomposers (Negrete-Yankelevich *et al*., 2007) and physical and chemical properties of soil (Li *et al*., 2012). These data suggested that various factors which not measured in this study had influences on insect decomposers in each study site. Further study is needed to investigate relations between these factors and insect decomposer community.

The results of seasonal patterns of insect decomposers in this study showed that there were differences in insect diversities among seasons. The other studies also showed seasonal patterns in fluctuations of insect population (Kato *et al*., 2000; Kishimoto-Yamada *et al*., 2009). Changes in insect communities among seasons probably because of difference in the life cycle of each insect group (Camara *et al*., 2012). Consideration of the whole life cycle of insects may be necessary to explain the insect seasonality patterns (Grimbacher and Stork, 2009). In this study, the highest diversity was found in the summer, whereas the lowest diversity occurred in the winter. Similarly, the data from some studies revealed that insect numbers in dry season were higher than wet season (Basu, 1997; Dibog *et al*., 1998). However, numerous studies suggested that arthropod abundance usually decreases during the dry season (Hill, 1993; Silva *et al*., 2011). These data can be concluded that seasonal patterns of insect may differ among insect taxa.

Climate has been suggested as a factor of insect seasonality (Wolda, 1988). Various studies showed that temperature, relative humidity and rainfall were the key factors which controlled the insect population. For example, Guru *et al*. (1988) showed that collembolan population was influenced by temperature, Levings (1983) demonstrated that ants appeared sensitive to litter moisture and Moura *et al.* (2006) discovered that foraging of termite *Constrictotermes cyphergaster* was correlated with rainfall. In the present study, temperature and humidity seemed effects on density and diversity of insect decomposers but no relation between rainfall and insects. These data may be concluded that temperature and humidity are two key factors which controlling fluctuations of insect decomposers. However, rainfall may also has an indirect effect on the seasonal variation of insect decomposer community in SERS.

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