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Diversity, Abundance and Morphological Variations of the *Xanthopimpla* (Ichneumonidae: Pimplinae) in Different Forest Habitats

(Variasi Morfologi, Kelimpahan dan Kepelbagaian *Xanthopimpla* (Ichneumonidae: Pimplinae) di Habitat Hutan Berbeza)

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ABSTRACT

The diversity and abundance of Xanthopimpla *(Ichneumonidae: Pimplinae) in the secondary and primary forest of Pasoh Forest Reserve (PFR) were studied. A total of 44 individuals of* Xanthopimpla *and 16 species were recorded. Fifteen species were recorded from the primary forest and only seven species were recorded from the secondary forest. The* X. disjunta, X. guptai maculibasis *and* X. verrucula verrucula *were new records for Malaysia. Meanwhile,* X. pleurosticta *was new record for Peninsular Malaysia. Shannon Diversity Index (H') indicated that the* Xanthopimpla *diversity at the primary forest was significantly higher (*$p<0.001$*) than the secondary forest in PFR. This suggests that logging activity would cause depletion on insect diversity. In the secondary forest a total of 20* Xanthopimpla *individuals were caught, whereas 24 individuals were caught from the primary forest. The individual of* Xanthopimpla *abundance in primary forest was not significantly (*$p>0.05$*) higher than secondary forest. The species domination in the secondary forest was more pronounced compared to the primary forest. In the secondary forests,* X. elegans elegans *(30.0%) was the highest percentage of total species representation which was higher compared with* X. melanacantha melanacantha *(16.7%) and* X. honorata honorata *(16.7%) in the primary forest. This suggests that logging activity would cause disappearance of certain species of* Xanthopimpla *and at the same time might have provided an opportunity for some species to be dominant over the other species. The evolution of the* Xanthopimpla *in term of morphological characters changes were also discussed in this paper.*

Keywords: Abundance; diversity; evolution; Xanthopimpla

ABSTRAK

Kelimpahan dan kepelbagaian Xanthopimpla *(Ichneumonidae: Pimplinae) di hutan primer dan sekunder Hutan Simpan Pasoh (PFR) telah dikaji. Sejumlah 44 individu* Xanthopimpla *dan 16 spesies telah direkod. Lima belas spesies telah berjaya direkod daripada hutan primer dan hanya tujuh spesies direkod daripada hutan sekunder. Spesies* Xanthopimpla disjunta, X. guptai maculibasis *dan* X. verrucula verrucula *adalah rekod baru untuk Malaysia. Manakala,* X. pleurosticta *adalah rekod baru untuk Semenanjung Malaysia. Indeks Kepelbagaian Shannon (H') menunjukkan kepelbagaian* Xanthopimpla *di hutan primer adalah lebih tinggi dengan bererti (*$p<0.001$*) berbanding hutan sekunder di PFR. Hasil kajian ini mencadangkan aktiviti pembalakan akan memberi kesan kepada pengurangan kepelbagaian serangga. Di hutan sekunder PFR, sejumlah 20 individu* Xanthopimpla *telah berjaya ditangkap, berbanding 24 individu di hutan primer PFR. Walau pun begitu, perbezeaan ini tidak bererti (*$p>0.05$*). Spesies dominan di hutan sekunder adalah lebih nyata berbanding hutan primer. Di hutan sekunder,* X. elegans elegans *(30.0%) meliputi peratusan kelimpahan tertinggi dan jauh lebih tinggi berbanding* X. melanacantha melanacantha *(16.7%) dan* X. honorata honorata *(16.7%) di hutan primer. Hasil kajian ini mencadangkan aktiviti pembalakan berupaya menyebabkan kehilangan spesies serangga tertentu dan pada masa yang sama menyumbang kepada spesies tertentu untuk menjadi dominan. Evolusi* Xanthopimpla *daripada segi perubahan morfologi juga dibincangkan dalam makalah ini.*

Kata kunci: Evolusi; kelimpahan; kepelbagaian; Xanthopimpla

INTRODUCTION

Both insects and plants have coevolved ever since and that they have established an extremely intimate relationship for their survival (Schnoonven et al. 1998). Plant provided the most comfortable environment for uses as isolated niche for insects to evade from their predator as well as breeding habitats. Certain plants also produce food resources (e.g. honey, pollen and stem sap which have not yet been discovered by scientists) either for the insects to generate energy or for reproduction. In return, the insects assist the plants in pollination. Some insects even play an important role in protecting the plants from mass consumption by the herbivorous insects which in a condition of check and balance (Borror & Delong 1964; Kim 1993; Miller

1993; New 1995). Generally, both insects and plants are impossible to separate; any single perturbation on a site will reflect the other.

Forest is one of the major habitats that posses the abilities to absorb million of individuals of insects and other larger animals. These living things are associated within or among other populations and at the same time formed numerous dynamic ecological processes that are necessary for the sustainable of the forest and its assemblage components (Walker 1992). The ecological processes will remain unchanged, if there are no invasions such as logging activity and serious natural disaster which will cause mass destruction on the forest structure. The alteration of the natural forest habitat to a disturbed forest creates many impediments for the insects to survive. To the resistant or high adaptive insect species, they may be able to survive by facing the many kinds of nongenetic variation such as ecological variation, including shifts in habitat and flux to temporary habitat. The genetic variation among individuals in a population contributes to a variation in the phenotypes that includes morphological, physiological and behavioral variation (Young 1982). However, the evolution of insect's genetic can only be traced after a long period of a disturbing incident occurred, probably more than a decade or more. On the other hand, a portion of insect may be too vulnerable to cope with their environmental changes. These insects will disappear or drastically decrease their population to become rare or endangered species or extinct locally. The circumstances are mainly attributing by restriction of food resources, loss of niche habitat, increased of the predatory insects in term of its population and changes of microclimate.

Study on the insect diversity and abundance in both primary and secondary growth forest (logged forest) are needed. By conducting this kind of study, not only it provides us with data of diversity and abundance of the focused insects in different forest habitat, it also provides us a more meaningful natural history record of that particular insect taxa. Taxonomic studies of insects in disturbed and undisturbed forest are important to explain its evolution. Therefore, this study aimed to investigate the diversity and abundance of *Xanthopimpla* in the secondary (selected logged area) and primary research plot of Pasoh Forest Reserve and to highlight the morphological variations of a species and its close related species of *Xanthopimpla* that were found at different forest habitat disturbances.

METHODS

STUDY SITE

Studies were conducted at the Pasoh Forest Reserve (PFR). It is a lowland dipterocarp forest in the State of Negeri Sembilan, Peninsular Malaysia (2°59' N and 102° 18E, alt. 75-190 m) situated about 140 km southwest of Kuala Lumpur. This forest covered a total of 2450 ha in area, consisting of 600 ha of primary (core area) forest and more than 1000 ha of secondary forests on adjacent sides (west, south and east) of the core. Recently, the surrounding oil palm plantation at the PFR were cleared for replanting, it make the scene of PFR boundary more conspicuous from far distance view.

Shorea and *Dipterocarpus* were the dominant tree species. A total of 329000 trees were recorded in the 50 ha plot at PFR (Kochummen et al. 1990). This included 820 species in 294 genera and 78 families, which is highly diverse compared with a forest elsewhere in the world. Mammals such as sumatran rhinoceros, guar, tigers, tapirs and bear also have been found at Pasoh but the number of these large animals have declined or disappeared since the mid 1960s (Kemper 1988).

Primary forest (50 ha dynamic research plot) at PFR The undisturbed forest covered about 50 ha located at the center of PFR. This research plot has been used as permanent 'International Research Plot' established through a collaborative research between the Forest Institute of Malaysia (FRIM) and Smithsonian Tropical Research Institute (STRI), USA.

Secondary forest (selectively logged forest) at PFR The disturbed forest is situated at the southwest portion of the PFR. This secondary forest had been subjected to logging activity between 30 and 40 years ago.

EXPERIMENTAL DETAILS

Three systematic transects were established at undisturbed and disturbed of PFR, respectively. The transects were 400 m long, each start from the west towards the east at the respective forests, parallel to each other and separated by a 150 m distance. A total of 10 Townes Malaise traps were used in this sampling. Three Malaise traps were installed along the first and third transect with 50-100 m apart, whereas for the second transect, four traps were installed. Sampling was carried out concurrently at both disturbed and undisturbed forest at PFR for a week per month for six consecutive months (April to September 2002). The collected insects were brought to laboratory, sorted and identified into order and species using Town and Chiu (1970) method.

STATISTICALLY ANALYSIS

The total number of individuals for each species of *Xanthopimpla* was recorded. Data were pooled (to reduce variance among forests) before analysis. One-way analysis of variance (ANOVA) was used to analyze the significance difference of *Xanthopimpla* abundance in the primary and secondary forest of PFR. The *Xanthopimpla* spp. diversity and richness were analyzed by using GW Basic programme (Robinson 1991).

Results and Discussion

Abundance and Composition of *Xanthopimpla*

The result presented in Table 1 shows the total number of *Xanthopimpla* species collected from the secondary and primary forests of Pasoh Forest Reserve (PFR). A total of 44 individuals of *Xanthopimpla* were collected. *Xanthopimpla elegans elegans* and *X. melanacantha melanacantha* were the most abundant species in the secondary forest, which respectively scored the highest caught number of six individuals (or 30%) and five individuals (or 25%). Meanwhile, in the primary forest, *X. honorata honorata* and *X. melanacantha melanacantha* were the most caught individual, both represented the same percentage of total caught at 16% (four individuals). Based on the percentage, it shows that species domination in the secondary forest were more obvious compared with the primary forest of PFR. This may be due to the limitation of food resources, niche to be inhabitant and lack of their parasitize insects for the other species of *Xanthopoimpla* to appear at the forest. According to Price (1997) as cited by Basset et al. (2001), the disturbed forest would be dominated by a few species which able to tolerate with the new environment. A few species (*X. elegans elegans, X. melanacantha melanacantha and X. despinosa despinosa*) were found to be more dominant in the disturbed forest and also found in both different forest habitats suggest that these parasitic wasps is a generalist parasitoid. In contrast, more singleton species of *Xanthopimpla* were found in primary forest that indicates highly endemicity and at the same time these species are vulnerable to disturbances. One species *X. pasohensis* shown to be exclusively adaptable in disturbed forest which is also a new species described by Ng et al. (2004). However, total abundance in the primary forest were found to be not significantly ($p>0.05$) higher than secondary forest. The same result was also reported by Wong (1984) in the study to compare the arthropods abundance in the secondary and virgin forest of PFR.

Diversity of *Xanthopimpla*

A total of 16 different *Xanthopimpla* species were identified, 15 species were recorded from the primary forest and only seven species were recorded from the secondary forest. *X. disjunta, X. guptai maculibasis* and *X. verrucula verrucula* were new records for Malaysia. These new record species were found at the primary forest of PFR. On the other hand, *X. pleurosticta* was new record for Peninsular Malaysia. This new record species was found in the secondary and primary forests of PFR. In addition, a proposed new species which belongs to the Elegans group was also included in this paper.

In comparison of the secondary and primary forests, the Shannon diversity index (H') indicated that *Xanthopimpla* diversity at the primary forest was significantly higher ($p<0.001$) than the secondary forest (Table 2). Low diversity has been recorded in old selective logged forest agreed with Idris et al. (2003) in a study to compare the diversity of *Xanthopimpla* between old and recently logged forest in Langat Basin. Based on the H', we predicted the trends of *Xanthopimpla* diversity changes according to the age of the forest disturbance by combining the data from Idris et al. (2003) with the results from this study (Figure 1). The *Xanthopimpla* diversity is higher in the recently logged forest which in compatible level with the virgin forest, but in the long run (30 to 40 years) the diversity of this insect will decrease to a significantly lower diversity than the virgin forest (Figure 1). This suggest that certain *Xanthopimpla* species may went through three major

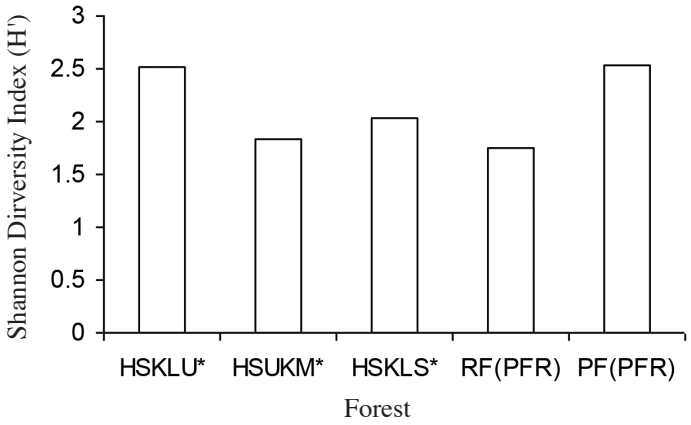
TABLE 1. List of *Xanthopimpla* (Ichneumondae: Pimplinae) species of secondary and primary forest of PFR

Species	Secondary Forest at PFR (%)	Primary Forest at PFR
X. despinosa despinosa	3 (15%)	2 (8.3)
X. ansata ansata	0	2 (8.3)
X. clivulus clivulus	0	1 (4.2)
X. tricarpus impressa	0	1 (4.2)
X. honorata honorata	0	4 (16.7)
X. elegans elegans	6 (30)	1 (4.2)
X. quitei	0	1 (4.2)
X. apendicularis	2 (10)	2 (8.3)
X. melanacantha melanacantha	5 (25)	4 (16.7)
X. decurtata detruncata	0	1 (4.2)
X. nigritarsis nigritarsis	1(5)	1(4.2)
*X. pleurosticta**	1 (5)	1(4.2)
*X. disjunta**	0	1(4.2)
*X. verrucula verrucula**	0	1(4.2)
*X. guptai maculibasis**	0	1(4.2)
X. pasohensis	2 (10)	0
Total Individual	20 (100)	24
Total no. of species	7	15

*New record

TABLE 2. The Shannon diversity index (H'), Evenness index (E') and Margalef's index (Richness index, R') of *Xanthopimpla* species in the secondary and primary forest of PFR

Forest	H'	E'	R'
RF(PFR)	1.75a	0.90	2.00
PF(PFR)	2.54b	0.93	4.40



(HSKLU*-Hutan Simpan Kuala Langat Utara, HSUKM*-Hutan Simpan Universiti Kebangsaan Malaysia, HSKLS*-Hutan Simpan Kuala Langat Selatan, RF(PFR)-Secondary Forest (PFR) and PF(PFR)-Primary Forest (PFR). (HKLU*)- 10 years logged; [(HSUKM*, HSKLS* and RF(PFR)]-30-40 years logged, [PF(PFR)]-Primary Forest (Idris et al. 2003)

FIGURE 1. Shannon diversity index (H') for different aged of logged forest and primary forest

phases of population fluctuation; growth, stabilization or realization of the carrying capacity of the environment and decline. At the realization phase, an evolutionary adjustment will occur which such a population may become vulnerable to extinction if selection pressures shift in (Young 1982). However, study on the restoration in terms of forest structure and vegetation from the newly logged to the old logged forest would add more meaningful knowledge to describe the diversity trends of *Xanthopimpla*.

MORPHOLOGICAL VARIATION OF *XANTHOPIMPLA*

The first *Xanthopimpla* species was described in 1767 by Linnaous and his work was continued by other taxonomist. Most studies of the *Xanthopimpla* was conducted from 1899 to 1914, when Krieger and Comeron described a total of 64 species of this genus. Their excellent works was not revised for more than a half century. Until in 1970, Town and Chiu made a comprehensive revision on Krieger's works by assembled all specimens in Indo-Australia region from the museum all around the world. They have classified *Xanthopimpla* to a few species group. The *Xanthopimpla pasohensis* according to Ng et al. (2004) belongs to the Elegans group. Both characters such as lower front corner of pronotum making a sharp angle of 90º to 100º (Figure 2(a)) and the areolet on the front wings are small which receiving the second recurrent vein near its outer corner (Figure 2(c)) are the most distinctive characters in recognizing the Elegans group. The identification of *Xanthopimpla* to species, the carinae on the propodeum provides more useful taxonomic characters than any other part of the body as referred in Gauld (1984) and Town and Chiu (1970). The major difference on the proposed *X. pasohensis* was the apical carina on its propodeum completely absent (Figure 2(f)), compared with the other species from the Elegans group that have a complete apical carina (Figure 2(e)). This indicates that this species may have gone through or in pathway to morphological evolution. The most interesting point is that this species was only found in the disturbed forest. This suggests that forest disturbance in term of structure alteration and ecologically factors may lead to the evolution of morphology characters of *Xanthopimpla*. According to Price (1997), morphology changes are strongly associated to the natural selection forces and this was found on *Papilio dardanus* (swallowtail butterfly) in response to the heavy predation in Africa. However, to elaborate into details of the morphological evolution on this species of *Xanthopimpla*, study by using the phylogenetic approach and their response to the environmental changes would give us more meaningful results to discuss.

CONCLUSION

The species diversity of *Xanthopimpla* is strongly influence by the history of logging activity. In this study, species diversity of *Xanthopimpla* in the selectively old logged forest was significantly lower than the primary forest.

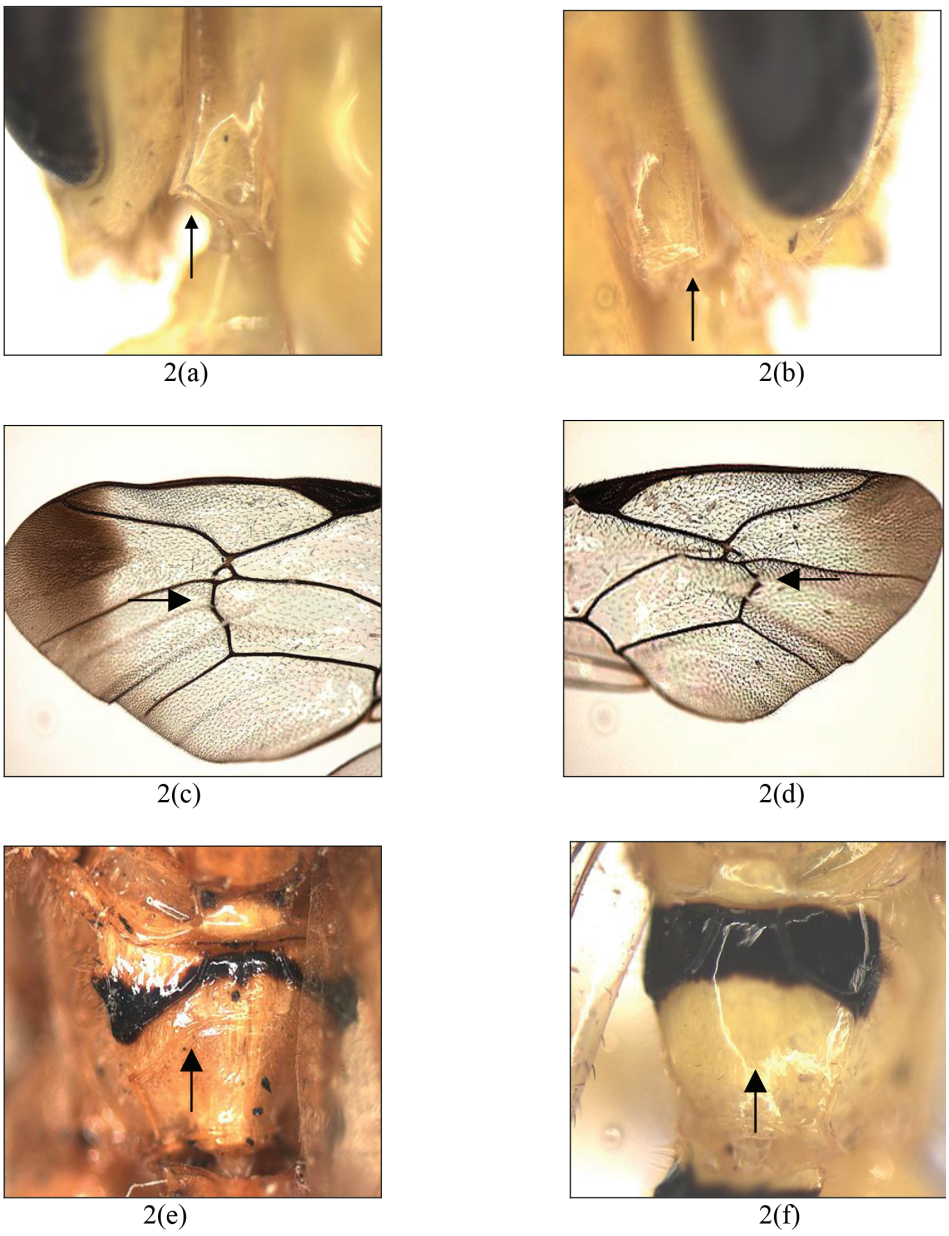


FIGURE 2. (a) Pronotum elegans group, (b) Pronoutum of *Xanthopimpla pasohensis* (Ng et al. 2004), (c) Second recurrent vein (Elegans Group), (d) Second recurrent vein (*X. pasohensis*), (e) Apical transverse Carina of propodeum complete (Elegans group) and (f) Apical transverse Carina of propodeum completely absent *(X. pasohensis)*

However, there was no significant difference in abundance between both secondary and primary forest of Pasoh Forest Reserve (PFR). Species domination in the old selectively logged forest was obvious compared to the primary forest. Forest disturbance due to logging activity may cause the *Xanthopimpla* insect to morphologically evolve.

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