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The Impact of Human Activities to Dynamic of Insect Communities: a Case Study in Gunung Salak, West Java

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Huge areas of diverse tropical forest are lost or degraded every year with dramatic consequences for biodiversity. Human activities such as deforestation, fragmentation, over-exploitation, and monoculture practices are the main drivers of tropical forest biodiversity loss. Investigating of these threats with focusses on changes in species richness or species diversity will be able to minimize any impact of human activities at the early stage in a certain region. Therefore, to know the impact of human activities to dynamic of insect communities in Gunung Salak, West Java, we measured moth diversity and their structure within communities by comparing the index diversity, species richness and species composition across five different habitat types. The results showed that the habitat changes due to human activities had changed not only to the moth diversity but also to their structure within communities. The number of moth species decreased significantly as well as the number of lower taxa (family) in the disturbed forest (secondary forest, *Agathis* forest, and transition area) within ranges: 20-50 and 10-20%. The composition of the two main families, Geometridae and Noctuidae also showed a major change, family Geometridae decreased within ranges 10-50% in the disturbed area but Noctuidae increased up to 50% in those areas. Indeed, habitat lost due to human activities such as illegal logging, change of land use and land clearing is the main threats to decrease on macro-moth diversity and change their structures within communities.

Key words: Gunung Salak, human activities, impact, insect diversity

INTRODUCTION

Gunung Salak is one of the volcano mountains in Java which is located at 6°43' S, 106°44' E. This mountain administratively belongs to two districts, Bogor and Sukabumi. Previously, this mountain is managed by the state forest company (Perum Inhutani) but since 2003 has been included into Gunung Halimun National Park's management.

As of other national parks, this area has several functions, not only to conserve its flora and fauna but also as water resources for Bogor, Sukabumi and other surrounding areas. Moreover, more than twenty mineral water companies which are supplying water to consumers in Indonesia are depending on this area. Without any significant efforts and appropriate strategy in managing this conservation area, it is possible that no longer supply water from Gunung Salak that flow trough to Cisadane river will end up. Now, it can be seen that the water level in Cisedane river decreases from time to time during dry season and increases very fast during rainy season even though in a short period.

The changes of habitat due to human activities such as land clearing, illegal logging change of land use is one of the factors that directly influent to the hydrology system which is very easy to be detected. But, this impact is not always easy to be measured, even to determine clearly level of the degradation occurs in a certain area needs a comprehensive study based on a certain taxa that its response can representatively indicate to any environmental changes. Among them, moths is one of the best candidate as a bio-indicator which fulfill all requirements such as ease and objective in sampling, taxonomic tractability, ecological generality combined with fine-grained habitat fidelity (including low blurring of pattern through mobility and rapid response to disturbance. Moreover, they can be collected in a large number by using a light trap and also can be found in numbers in most vegetation types. So, it is possible to quantitatively calculate any statistical analysis to measure several of parameters (Sutrisno 2005, 2007).

Impact of human activities to insect diversity has been repeatedly reported by numerous authors (Holloway 1998; Beck *et al*. 2002; Fielder & Schulze 2004; Sukara 2005). However, most studies were conducted outside of Java in which the threats of human population on those areas are not as severe as in Java. Tension of human population to the most conservation area in Java is in a serious problem which needs a comprehensive solution through improving a strategy in conservation management plan which based on valid supporting data. Therefore, to provide valid information for the national park management, study on the impact of human activities to dynamic of moth communities in Gunung Salak with focused on macro-moths was conducted.

Ideally, to measure the impact of human activity to the insect diversity is by comparing data before and after human activity occurring in the conservation area. But it is very hard to be achieved within a short period and almost impossible to be conducted within a national park. Moreover, it is also not applicable to conduct research on five different habitats at the same altitude within this park. In this study, therefore, we made several assumptions by choosing five type habitats in Cidahu, Gunung Salak to represent the area without human activities (primer forest refers as is undisturbed forest), and areas with human activities (Old secondary forest, Young secondary forest, *Agathis* forest and Transition area refer as is disturbed forests). In addition, Cidahu is the best site for comparison of different habitats with less biased since among the habitat types have no significant gap on altitude. We also used the same method for collecting samples across all sites of study during three nights from 18.00 to 24.00 on each site.

MATERIALS AND METHODS

Site of Study. The study was conducted at Cidahu, Sukabumi: the Transition area (the border between the farming area and the national park, ± 900 m above sea level) and end up at Primary forest in Gunung Salak I's track (± 1500 m above sea level) (Figure 1).

Primary Forest. Sampling was conducted at ± 1500 m above sea level (E 06°60´45", S 106° 42'26"). This vegetation of this forest is characterized by a dense canopy with tree's height about 25-40 m. This site is dominated by *Schima wallichii* (Theaceae), *Castanopsis javanica*, *Lithocarpus elegans* (Fagaceae), *Altingia excels* (Hamamelidaceae), *Acer laurinum* (Aceraceae), *Polyosma ilicifolia* (Saxifagraceae), and *Prunus arboea* (Rosaceae). Light trap was set up during three nights, from 6 to 8 October 2009.

Old Secondary Forest. Sampling was conducted at ± 1400 m above sea level (E 06°43´45", S 106° 42'26"). This vegetation of this forest is characterized by a less dense canopy with several primary forest trees such as *Schima wallichii*, *Castanopsis* sp., *Lithocarpus* sp., and several species of Lauraceae. Light trap was set up from 26 to 28 June 2009.

Young Secondary Forest. Sampling was conducted at ± 1300 m above sea level (E 06°44´25", S 106° 42'50". The characteristic of this young forest is indicated by pioneer trees such as *Macropobax dispermus* (Araliaceae), *Mallotus paniculatus* (Euphorbiaceae), *Symplocos fasciculate* (Symplocaceae), and *Ficus deltoidea* (Moraceae). Light trap was set up from 29, 30 June to 1 July 2009.

***Agathis* Forest**. Sampling was conducted at ±1000 m above sea level (06°43´14", S 106° 43'13"). This forest is monoculture cultivation of *Agathis dammara*. Light trap was set up from 2 to 4 July 2009.

Transition Area. Sampling was conducted at ± 900 m above sea level (06°45´20", S 106° 43'16"). This area is border between the national park and farming area. Vegetation is mixed between secondary forest and agriculture crops: *Calliandra calothyrsus*, *Erythrina*

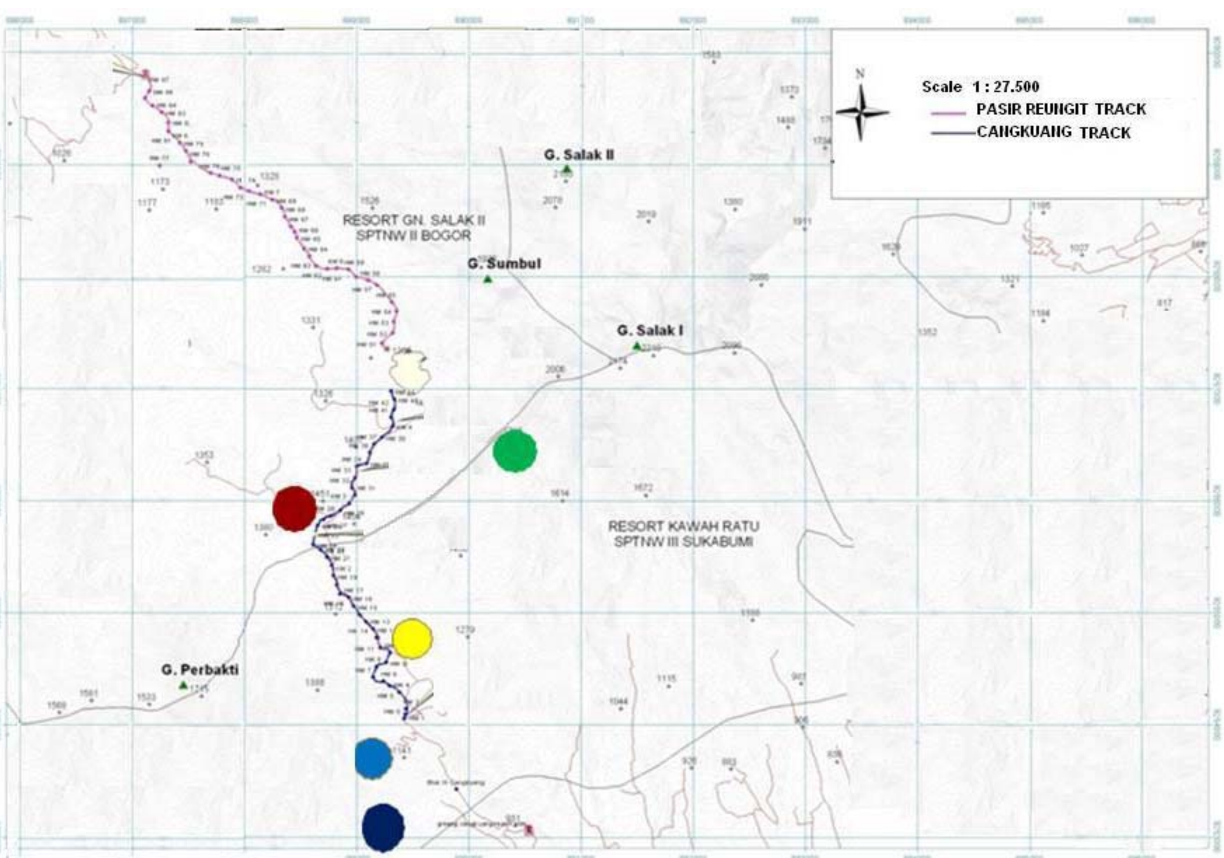

Figure 1. Sites of the study: Primary forest ( ), Old secondary forest ( ), Young secondary forest ( ), *Agathis* forest ( ), Transition area ( ).

variegata, *Maesopsis eminii*, *Paraserianthes falcataria* and agriculture crops. Sampling was conducted from 24 to 26 July 2009.

Collecting Adult Moths. Sampling has been conducted using light traps equipped with a 160 watt mercury vapor light and a 2 x 2.5 m white screen. The light trap is set up at the open area within the National Park. Moths attracted to the light trap and laid at the white screen were collected into an ethyl acetate-killing bottle. For the large moths (wing span > 5 cm) were collected by using an insect net and then injected at the thorax with a small amount of absolute ammonia. All specimens collected at the night then were pinned using insect pins No 3 and 4 at the next morning while the specimens are still in fresh condition.

Preservation. Preservation of the specimens is conducted at the laboratory of Entomology, Division of Zoology, Research Center for Biology. All moth specimens were labeled based on the field collection data. Their wings were spread and then dried up using oven at 45-50 ^{o}C for 3-5 days, depends on the condition of specimens. All the materials are deposited at Museum Zoologicum Bogorienses, the Indonesian Institute of Sciences.

Data Analysis. The diversity measure for species-richness to be used throughout this discussion is the á-statistic of Fisher *et al*. (1943). Fisher's alpha diversity index, defined implicitly by the formula: $S=a*\ln(1+n/a)$ where S is number of taxa, n is number of individuals and a is the Fisher's alpha. Justification for this on grounds of the frequent approximation of light-trap moth samples to a log-series distribution of abundance among the species is given by Taylor, Kempton and Woiwod (1976) and, within a South East Asian context, by Barlow and Woiwod (1989). Wolda (1983) demonstrated that this statistic was the most sample-size independent of a number of frequently used diversity measure. For comparison among two sites, Jaccard index of similarity is used. It is calculated as $C/N_1 + N_2$ " C, where C is the number of taxa shared between a pair of regions and N_1 and N_2 are the number of species in each of the two regions. This is a robust measure of beta diversity and widely used in biodiversity research.

In addition, we have chosen extrapolation method, which given an estimate of the total number species from empirical samples. Let N be the total number of individuals in the sample, s the total number of species, and Ni the number of individuals of species number i. The expected number of species $E(S_n)$ in a sample of size n and the variance $V(S_n)$ are then given:

$$E(S_n) = \sum_{i=1}^{s} \left[1 - \frac{\binom{N-N_i}{n}}{\binom{N}{n}} \right]$$

$$V(S_n) = \sum_{i=1}^{s} \left[\frac{\binom{N-N_i}{n}}{\binom{N}{n}} \left(1 - \frac{\binom{N-N_i}{n}}{\binom{N}{n}} \right) \right] + 2\sum_{j=2}^{s} \sum_{i=1}^{j-1} \left[\frac{\binom{N-N_i-N_j}{n}}{\binom{N}{n}} - \frac{\binom{N-N_i}{n}\binom{N-N_j}{n}}{\binom{N}{n}\binom{N}{n}} \right]$$

All this methods were implemented in "methodological Ecology" software (Krebs 1998).

RESULTS

The record of all species collected from this study is available on request and all specimens are deposited in Museum Zoologicum Bogoriense. Results showed that short collecting time spent across all sites give difference results, such as in the primary forest, species number was the highest among other sites (296 species) (Table 1). But this number was only 88.3% of the estimated species (335 species). On the other hand, the number of species in the *Agathis* forest is the lowest (156 species) or about 94% of the estimated species (165 species). The number of species with more than two individual was higher than species with only a single individual, especially on those in primary forest and old secondary forest which reached up 60%. In term of family number, the primary forest showed the largest (20 families) number while the *Agathis* forest was the lowest as well as in Transition area (16 families). Illegal logging (in secondary forest), change of land use (in monoculture *Agathis* forest) and land clearing (in transition area) cause the number of family decrease from 10 to 20% and for the number of species from 20 to 50%.

The results also showed that the three families, Geometridae, Noctuidae and Pyralidae is the most dominance in all sites. In the primary forest, the proportion of Geometridae reached 27% of the total species in this area but this proportion gradually decreased in old secondary forest, young secondary forest, *Agathis* forest and transition area, i.e: 24,6, 15.6, 16.6, and 12%, respectively (Figure 2). On the other hand, the proportion of Noctuidae in the primary forest and old secondary forest was moderately low, i.e: 19 and 16.7%, but this number was increased in young secondary forest, *Agathis* forest and transition area, i.e: 33.3, 24.35, and 38.5%. Compare to other two families mentioned above, Pyralidae did not show major difference among all sites ranging from 13.3 up to 17.9%.

Result also showed that Fisher's alpha indexes in the young secondary forest was the highest while in *Agathis* forest is the lowest (Table 2). Moreover, moth species number in the latter forest is also indicated the lowest in term of species number as well as the number of the lower taxa (family). Indeed, the value fisher alpha index is influenced by the abundance. Hence, the primary forest which has the highest number of species was not automatically showing the highest in Fisher's alpha index.

Macro-moth faunas index similarity based on Jaccard index for all pairwise comparisons were very low (Table 3). The highest value was obtained by comparison between primary forest and old secondary forest and the lowest was the comparison between primary forest and transition area.

DISCUSSION

In general, land-use change is thought to have the greatest impact on biodiversity in tropical forests. Forest clearance for agriculture or other purposes destroys the habitat and generally causes a decline in forest species abundance and diversity, particularly for species that are

Table 1. Species richness of moths collected at five different habitats in Gunung Salak, West Java: Primary forest, Old secondary forest, young secondary forest, *Agathis* forest, and transition

Taxa	Type of habitats									
	Primary		Old secondary		Young scondary		*Agathis*		Transition	
	S	%	S	%	S	%	S	%	S	%
Aganaidae	2	0.6	1	0.4	4	1.70	4	2.56	5	2.0
Arctiidae	20	6.7	16	7.4	22	8.60	18	11.50	24	9.6
Bombycidae	3	1.0	2	0.8	2	0.70	1	0.60	1	0.4
Cossidae	0	0.0	3	1.2	0	0.00	0	0.00	0	0.0
Drepanidae	5	1.6	9	4.1	1	0.30	2	1.28	2	0.8
Ethmiidae	1	0.3	0	0.0	40	15.60	0	0.00	0	0.0
Eupterotidae	2	0.6	1	0.4	0	0.00	1	0.60	1	0.4
Geometridae	80	27.0	53	24.6	40	15.60	26	16.60	30	12.0
Hesperiidae	1	0.3	0	0.0	0	0.00	0	0.00	0	0.0
Hepialidae	0	0.0	0	0	0	0.00	1	0.60	0	0.0
Lasiocampidae	5	1.6	4	1.6	7	2.74	4	2.56	1	0.4
Limacodidae	12	4.0	10	4.6	5	1.96	5	3.20	5	2.0
Lymantriidae	21	7.0	21	9.7	16	6.27	18	11.53	21	8.4
Noctuidae	57	19.2	36	16.7	85	33.30	38	24.35	96	38.5
Nolidae	10	2.9	10	4.6	17	6.60	1	0.60	8	3.2
Notodontidae	4	1.3	11	5.1	6	2.30	3	1.90	3	1.2
Oecophoridae	0	0.0	0	0.0	1	0.30	0	0.00	0	0.0
Psychidae	1	0.3	0	0.0	1	0.30	0	0.00	3	1.2
Pyralidae	53	17.9	30	13.9	34	13.30	26	16.60	36	14.4
Saturniidae	2	0.6	1	0.4	3	1.17	2	1.28	0	0.0
Sphingidae	7	2.3	4	1.6	8	3.55	2	1.28	8	3.2
Thyrididae	1	0.3	3	1.2	1	0.30	3	1.90	3	1.2
Tortricidae	1	0.3	0	0.0	0	0.00	0	0.00	0	0.0
Uraniidae	0	0.0	1	0.4	0	0.00	0	0.00	0	0.0
Total	296	100.0	211	100.0	255	100.00	156	100.00	249	100
Estimated	355		233		262		165		290	
Species with 1 indiviual	117	39.5	83	39.3	99	38.80	71	45.50	128	51.4
Species with $\geq$ 2 individual	179	60.5	127	60.7	156	61.20	85	54.50	121	48.6

S: number of species.

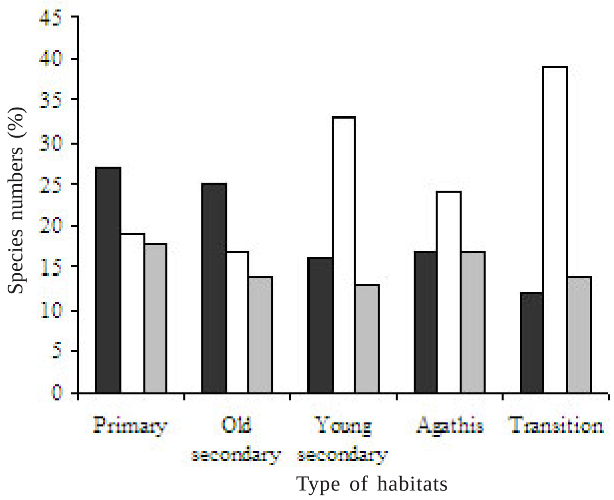

Figure 2. The proportion of the three main families of moths on five different habitats. ■:Geometriade, □ : Noctuidae, ▨ : Pyralidae.

Table 2. Index diversity and estimated species of moth collected from five different habitat in Gunung Salak

Type of forest	N	S (F)	$E(S_n)$	Fisher's Alpha
Primer	1022	296 (20)	335	139.7
Old secondary	869	211 (18)	233	96.2
Young secondary	648	255 (18)	262	154.9
Agathis forest	409	156 (16)	165	92.4
Transition	649	249 (16)	290	147.7

N: number of specimens, S: number of species, F: number of family, $E(S_n)$: Estimated species.

Table 3. Index similarity based on Jaccard coefficient from five different habitats in Gunung Salak: Primer forest, Old secondary forest, Young secondary forest, *Agathis* forest, and Transition area

	Primer	Old secondary	Young secondary	Agathis forest	Transition
Primary	-				
Old secondary	0.324	-			
Young secondary	0.118	0.096	-		
Agathis forest	0.087	0.082	0.081	-	
Transition	0.060	0.062	0.077	0.071	-

restricted in range. Diverse taxa show different and often variable responses. Following deforestation, the new habitat will determine biodiversity. For example, secondary forest regenerating after the natural forest has been cleared may never reach the same species richness and composition as primary forest. Apart from destroying habitat, forest clearance can fragment the remaining forest, leaving areas of forest that are too small for some species to persist, or too far apart for other species to move between resulting in a long process of decay in residual diversity from the remaining habitat. Edge effects on fragments also affect species richness and composition (Sala *et al*. 2000; Fahrig 2003; Ewers & Didham 2006; Barlow *et al*. 2007; Krauss *et al*. 2010).

The results of the study also showed that there is a significant change not only on the taxa diversity but also on the structure of moth communities as result of habitat changes due to human activity in this national park. Illegal logging (in secondary forest), change of land use (in monoculture practices: *Agathis* forest) and land clearing (in transition area) cause the number of family decrease from 10 up to 20% and for the number of species from 20 up to 50%. This similar impact on insect diversity due to human activity also has been documented by Holloway (1998). He compared the moth diversity at illegal logging forest and primary forests in Danum Valley, Sabah. He found a significant result, there have been decreased up to 2/3 species at illegal logging forests. Moreover, a study on butterflies in Buru Island and pyralid moths on mount Kinabalu, Sabah also gives a similar phenomenon (Hill *et al*. 1995; Fiedler & Schulze 2004). Our previous study on comparison between two types of forest management showed that moth diversity in undisturbed primary forest belong to the private company is 25% higher than those in illegally logged and land cleared forest (Giam Siak Kecil Wildlife Reserve) (Sutrisno 2009a). There is no doubt that monoculture plantation, *Agathis* forest resulted in a poor diversity as indicated by Fisher alpha index (92.4). This phenomenon also has been well documented by several authors on several groups of animals.

In general, a floral diversity will determine the composition and diversity of macro-moths because their larvae of moths indeed often show great specificity to host-plants even though their adults can use many kinds of flowers as sources of their nutrition. The larvae are mainly defoliator, but there are also leaf miners (several micro-moth families such as Nepticulidae and Gracillaridae), stem borers (for instances in Noctuidae and Pyralidae), flower feeders (Noctuidae & Geometridae), and timber borers (Cossidae & Hepialidae) (Robinson *et al*. 1994). Therefore, there is no doubt that more varies vegetations resulted more divers on moth fauna as indicated by the result of this study. Among of the five sites, the vegetation at the primary forest (1500 m above sea level) is the most varies. This site is dominated by *Litsea* sp., *Scima walichii*, *Querqus*, *Podocarpus imbricatus*, *Castanopsis argentea*, *Maglitia galauca*, and *altingia excels*. On the other hand, the vegetation at the secondary forest (1300-1400 m above sea level) are less varies and. This is a border between the protected forest and the *Agathis* forest belongs to state timber company (Inhutani) those the vegetation is dominated by *Altingia excelsa*, *Castanopsis argentea* (Walujo *et al*. 2008).

The structure of moth communities also change when the degradation occur in their habitat as usually indicated by gradually decreasing in number of lower taxa (family) from undisturbed forest to disturbed forest as shown in this study. Even though the transition area showed high number of species but those species are representing a small number of families. Some families are missing and a certain family comprising a large portion existing in the transition area (in this case Noctuidae which is comprising almost a half of the total species).

The results of the study also showed that family Geometridae gradually decreased in the disturbed area. Most larvae of Geometridae are well known as phytophagus which has no specific host plant. Thus, they tend to inhabit the green canopy of primary forest. This is opposite with the family Noctuidae in which most of their larvae have a specific host-plant. This phenomenon also has been reported in our previous study on the comparison between illegal logged forest and natural forest in Riau. Family Geometridae in natural forest reached up 28% whiles those in illegal logged/disturbed forest was only 21%. On the other hand, family Noctuidae in natural forest was about 9% whiles those in illegal logged/disturbed forest was almost double (16%) (Sutrisno 2009a). More over Beck and Khen (2007) reported that Geometrid moth ensembles from Borneo are shaped by environmental parameters such as elevation and habitat disturbance, and by temporal factors acting at small (mediated by weather) and large scales (i.e.changes over three decades). Samples are also influenced by methodological differences of sampling related to the nightly flight times of species.

The vegetation of primary forest is relatively more conserved due to its geographical position (at 1500 m s.a.l) and its access limitation. It has been reported that there is distinct altitudinal zonation in the Lepidoptera of SE Asia i.e. the low land forest has less divers on moths compared with the higher forest and the fauna low land and hill dipterocarp forest of Borneo has few species in common with that the montane forest 1000 m a.s.l. or more. The other reason for why this primary forest is the most divers because of it is far from local settlement and located at deep inside of the national park, therefore, this forest is less disturbed.

The result also showed that the similarity index between primary forest at 1500 m s.a.l. with the transition area at 900 m s.a.l. is the lowest, whiles comparison between the primary forest and the old secondary forest is the highest. This indicates that some species apparently restricted by geographical boundaries and some other may be restricted to particular forest types associated with a particular climate regime and may well reflect distribution of their host plants (Beck & Kitching 2007; Sutrisno 2008, 2009b).

Of course the methodological difference of sampling related to the nightly time of species will also influnce to the moth collecting. Therefore, to minimize this effect, the methods used in this study are similar across all sites except for the date of sampling. It has been well known that light collecting will be the best to be conduted during dark night (no moon) during rainy season, thus we can only conducted light traping effectively 9-10 nights each month during June to October 2009. During those periodes the rainfall in Gunung Salak was almost constantly high. We assume that the defferences in the date of collection will not much influent to the result of moth collecting thought that sampling was conducted at the same weather. Indeed, the best result will be attained when all the methode and samlping date are applied exactly the same accross all sites, but this is almost impossiblle to be conducted within this research due to time constraint.

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