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A Comparison on Biodiversity between Private Conservation and Wildlife Reserve Forests in Riau by using Macro-moths as an Indicator

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ABSTRACT

A study on biodiversity of the two forest management types, private conservation forest PT. A and wildlife reserve forest of Suaka Margasatwa Giam Siak Kecil, Riau by using a rapid assessment approach with macro-moths as an indicator was conducted from 23 October to 6 November 2007. Four sample sites were established in Giam Siak Kecil Wildlife Reserve, whereas three sample sites were performed in private conservation forest PT. A. The results show that the diversity indexes based on Fisher's α of the private forest PT. A was higher than those of wildlife reserve forest Giam Siak Kecil, they were 67.98 and 47.86, respectively. The species composition of the two forests is different, pyralid moths dominate at Giam Siak Kecil. On the contrary, Geometrid moths dominate at private conservation forest PT. A. The results indicated that diversity index and species composition in Giam Siak Kecil is influenced by habitat changes and decrease on floral diversity due to illegal logging. Moreover, a low faunal similarity which is indicated by Jaccard's index that is only 0.218 showed that the samples represent significant different communities.

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Key words: biodiversity, conservation, macro-moths, Fisher's α index.

INTRODUCTION

The forest of Sumatra is increasingly being modified by men in a variety of ways. This not only happen to the protected forests but also to the wildlife or nature reserve forests and national parks such as in Giam Siak Kecil Wildlife Reserve (or Game Reserve), Tesso-Nelo National Park and other areas in Sumatra. Illegal logging, clearing for timber industry or crop plantations and agricultural encroachment threatened the biodiversity of the very survival of extensive lowland of peat swamp forest in this island. Therefore, it is not surprising if the World Bank is predicted that the lowland forests in Sumatra will no longer exist unless some efforts taken to reduce the rate of deforestation (Sukara, 2005). The impact of the deforestation themselves in Riau has been well documented together with the social and political issues behind these pressures. The most significant direct impact of the deforestation and the environmental destruction in Riau is floods that occur in several villages and cities in Riau during 2007-2008 that has never occurred before. The other impact is biodiversity lost due to forest conversion for oil plantations and pulp industries that are conducted by local governments and private companies in order to generate their own incomes. Biodiversity lost may not directly and immediately influent to our society but it will change the whole ecosystem. Thereby, monitoring of biodiversity is a very important approach for early detection of ecosystem change. Realizing the ecosystem changes in our surrounding will provide us a better future plan.

Measurements of biodiversity in a certain region can be conducted in many different ways, depend on what the level of measurements will be achieved. There are three levels of biodiversity, genes, species and ecosystems. Measurements of genetic diversity refer to the variations of genes within a species. This covers distinct population of the same species or genetic variations within population. Measurements of genetic diversity were applied mainly to domesticated species and population held in zoo or botanic garden for conservation purposes. This method requires an advanced technology such as PCR and DNA sequencing. In species diversity, measurement is based on the species diversity in simple. This species diversity refers to variety of species within region that can be measured based on morpho-species richness. The last category, ecosystem diversity, is harder to measure than species or genetic diversity because the "boundaries" of communities-association of species-and ecosystem are elusive. Therefore, it is not surprising that species diversity is more common

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in use to evaluate or measure the biodiversity of forest even to monitoring the impact of human activities to forest ecosystem in certain region such as forest fire, land clearing, illegal logging, land conversion etc.

Floristic and structural changes are often obvious to the casual observer, as are the effect of these on vertebrate groups. Very much less is known of the less apparent but possibly more serious costs to major part of biodiversity such as micro-organisms and invertebrate, particularly insects, and to the role they play in the continuing health of the forest and the survival of their component. Thus, insect is more suitable than vertebrata as indicator of the state of forest ecosystem and for monitoring the impact of changes. The importance of insect and their value as indicators is discussed by Holloway (1980), Brown (1991), and Holloway and Stork (1991).

A number of insect groups are currently championed for use as indicator in tropical rain forest ecosystem, but no single group appears paramount when assessed in relation to criteria for good indicator group, such as: (a) ease and objective in sampling; (ii) taxonomic tractability; (iii) ecological generality combined with fine-grained habitat fidelity (including low blurring of pattern through mobility); and (iv) rapid response to disturbance. Night-flying moths satisfy most of these criteria. They can be collected in a large number by using a light tarp and also can be found in numbers in most vegetation type. In addition, Lepidopterist can do rapid sorting to species level based on good taxonomic characters in wing marking and genital structure permit accurate cross-reference between samples. This is important factor to conduct a rapid assessment on biodiversity of forest. Therefore, macro-moth is chosen as indicator to evaluate and compare biodiversity between two areas of forest conservation in Riau Province, Giam Siak Kecil Wildlife reserve and private conservation forest PT. A. By knowing the status of its biodiversity, we expect that management plan on the both conservation forests can be improved.

Sites of study

The research was conducted from 23 October to 6 November 2007 on wildlife reserve forest Giam Siak Kecil and private conservation forest PT. A Bukit Batu belong to a timber forest industry, in Riau Province (see Figure 1).

Natural forest of Giam Siak Kecil Wildlife Reserve

This natural forest is located on the eastern side of Sumatra, approximately 45 km south west of Bengkalis strait. The site is located along and southwest of a 50 km section of Sungai Siak Kecil. The northern boundary is approximately 40 km from Dumai. The area consists of swamp forest, peat swamp forest and floodplain lakes. North and northeast lays a large peat dome with reportedly some of the deepest peat in Sumatra. Along the river numerous shallow floodplain lakes occur that are connected to the Siak Kecil by narrow streams. Much of the forest is secondary, having been selectively logged prior to gazettal. This natural forest covers about 100,000 ha; almost 30% of the total area is peat swamp forest.

Private conservation forest at Bukit Batu

The area consists of swamp forest, peat swamp forest and floodplain lakes and covers about 70.000 ha. The vegetation type of this forest is more or less similar to natural forest at Giam Siak Kecil, as a secondary forest, surrounded by timber industrial forests belongs to a private company.

MATERIALS AND METHODS

Collecting adult moths

Sampling was conducted using light traps equipped with a 160 watt mercury vapor light and a 2 X 2.5 m white screen. The light trap was set up at the open area within the forest. Moths attracted to the light trap and lied at the white screen were collected into an ethyl acetate-killing bottle. Large moths (wing span > 5 Cm) were collected by using an insect net, followed by injection of absolute ammonia at the thorax. All specimens collected at the night then were pined using insect pins No 3 and 4 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, Cibinong Bogor, West Java, Indonesia. All moth specimens were labeled based on the field collection data. Their wings were spread and then dried up using oven at 45-50°C for 3-5 days, depends on the condition of specimens. Shorting and identification to specific level were performed as described by Kristensen (1999), Inoue et al. (1982); Common (1990), Nassig et al. (1996), Holloway (1997), Robinson et al. (1994). Kuroko and Lewvanich (1993), Kobes (2000), and Holloway et al. (2001). All the materials are deposited at Museum Zoologicum Bogoriense, the Indonesian Institute of Sciences.

Data analysis

The diversity measure for species-richness to be used throughout this discussion is the α–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 et al. (1976) and, within a South East Asian context, by Barlow and Woiwod (1989). Wolda (1983) demonstrated that

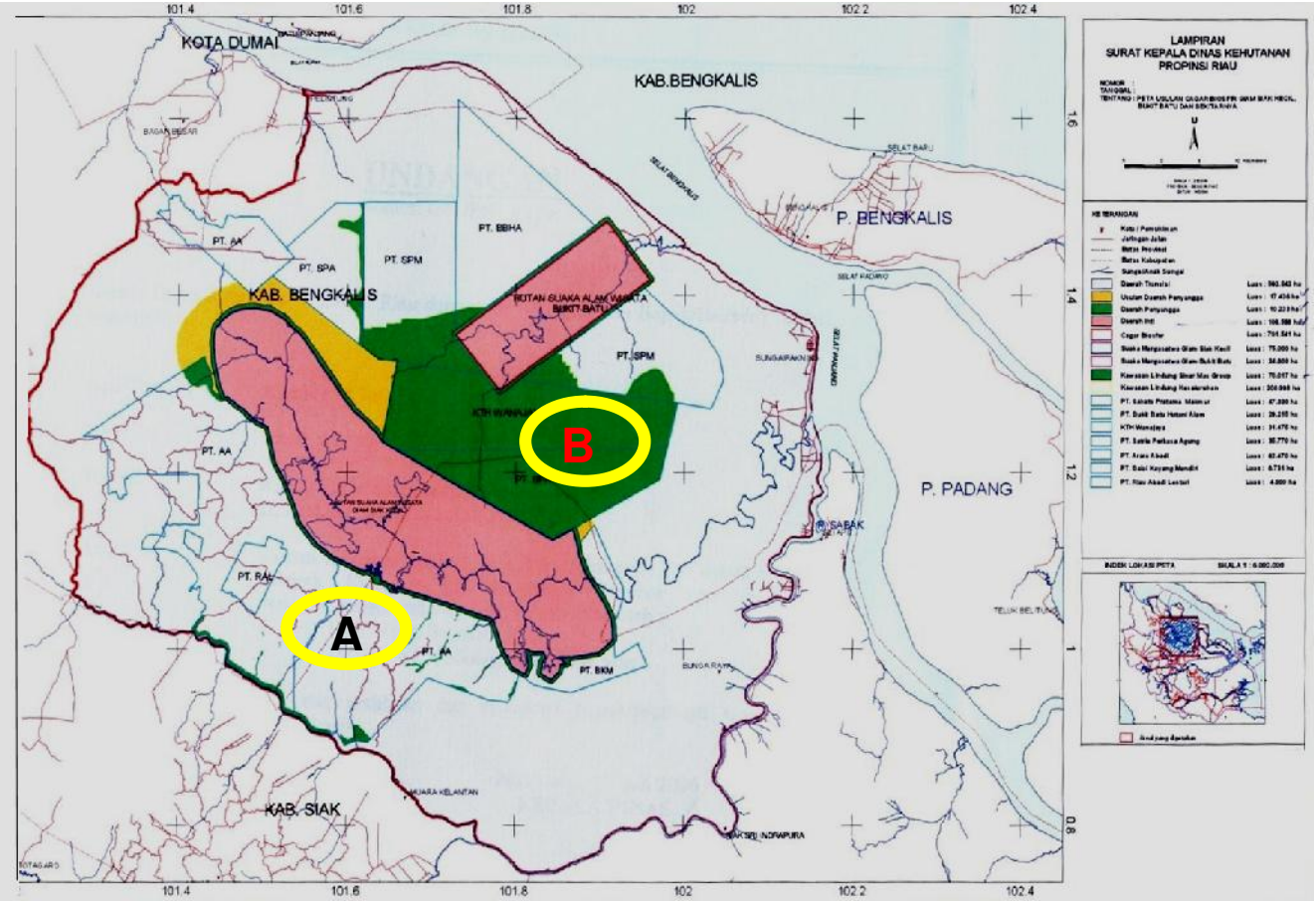

Figure 1. Site A is Nature Forest Giam Siak Kecil and site B is private conservation forest PT. A. in Riau.

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. This is a robust measure of beta diversity and widely used in biodiversity research.

In addition, we have chosen extrapolation method, which gave 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).

The value of light collecting

A correct statistical analysis first requires a certain number of replicate samples, which, secondly, have to be drawn randomly. Both conditions are not met in the present study. They are hardly achievable in these kinds of studies at all, because the use of light or light trap is a selective method and the number of replicate usually remains low. Nonetheless, the use of light in collecting Lepidoptera yields the highest proportion of the total species spectrum at a given locality. It is nearly impossible to get similar part of taxocenosis by applying other methods

RESULT AND DISCUSSION

The record of species collected from this study is available on request and all the specimens are deposited at Museum Zoologicum Bogoriense. These results in Table 1 show that the short collecting time spent across all sites in these forests makes the results only a fragment of the actual existing Lepidoptera fauna which is only 81 of 92 species (88%) at Giam Siak Kecil and 112 of 125 species

(89.6%) at private conservation forest PT. A. In addition, the number of families recorded from these two forests is quiet low, 18 families, or about 1/3 of the families of moths that exist in Indo-Malayan region (Holloway et al., 2001). Moreover, total species number of moths at the indicated areas is very low, only 162 species from 18 families (Table. 1).

Table 1. Species richness of moth collected at Giam Siak Kecil Wildlife Reserve (GSK) and private conservation forest PT. A, Bukit Batu (S= species number, ST= total species).

Locality	Taxa	S	%	ST	Species with 1 individual		Species with >2 individuals		Estimated species
GSK	Sphingidae	5	6.17		2		3		
	Geometridae	17	21.00		8		9		
	Noctuidae	14	16.47		9		5		
	Pyralidae	25	30.86		15		10		
	Arctiidae	4	4.93		0		4		
	Limacodidae	3	3.70	81	0	42	3	38	92
	Lasiocampidae	4	4.93		2		2		
	Notodontidae	1	1.23		1		0		
	Nolidae	4	4.93		2		2		
	Cossidae	2	2.47		2		0		
	Thyrididae	1	1.23		0		1		
	Agamidae	1	1.23		1		0		
PT. A	Sphingidae	7	6.25		3		4		
	Geometridae	32	28.57		18		14		
	Noctuidae	10	8.91		5		5		
	Pyralidae	22	19.64		7		15		
	Arctiidae	9	8.03		2		7		
	Limacodidae	7	6.25		3		4		
	Lasiocampidae	5	4.46		3		2		
	Notodontidae	1	0.89		1		0		
	Bombycidae	1	0.89	11	1	56	0	56	125
	Yponomeutidae	1	0.89	2	1		0		
	Nolidae	4	3.57		3		1		
	Cossidae	2	1.78		1		1		
	Thyrididae	6	5.35		0		2		
	Saturniidae	2	1.78		2		0		
	Lymantriidae	5	4.46		5		0		
	Drepanidae	1	0.89		0		1		
	Psychidae	1	0.89		1		0		

The species number at conservation forest PT. A is higher than those at Giam Siak Kecil Wildlife Reserve, they were 112 species (12 Families) and 81 species (17 families), respectively. Diversity indexes based on Fisher's α consistently revealed a greater number than that of Giam Siak Kecil; they were 67.98 and 47.86, respectively. Jaccard coefficient between two forests is very low (0.218) (Table 2).

The result shows that Families Geometridae, Pyralidae and Noctuidae is the most dominant among other families at the two sites. The most significant different between two forests is their species composition. Pyralidae were found to be dominant at Giam Siak Kecil, approximately 30.86% of the total moths; whereas family Geometridae is up to 28.57% at conservation forest PT. A.

Table 2. Index Diversity and Index similarity of moth collected at Giam Siak Kecil (GSK) and PT. A, Bukit Batu

Locality	N	S (F)	Alpha index	Jaccard's index
GSK	212	81	47.86	0.128
PT. A	285	112	67.98	

The results of the study show that the diversity of moth fauna is very low at both two forests. This is a general trend on moth diversity at the low land forests (< 100 m above sea level), especially at the peat swamp forest, as has been reported by Sutrisno (2005). He reported that the number of species in Sebangau National Park collected during 8 nights is only 100 species of 12 families with Fisher's alpha index is 50.91. More over, his study at Nusa Barong Nature Reserve, a low land forest, (<15 m), within 5 nights shows the Fishers's α index is only 34.58. The results of this study also have a similar trend with those found in Sulawesi where the low land forest (<100 m) has lower diversity than a primary high land forest at or even than secondary forest (Holloway, 1987).

In general, vegetation, latitude and altitude are the most significant factors that determine the moth diversity (Beck and Kitching, 2007). The larvae of moths indeed often show great specificity to host plants (Robinson, 1975; Holloway, 1976; Hebert, 1980; Inoue et al., 1982; Common, 1990; Robinson et al., 1994). Thus, the low diversity of the moth of the two forests is caused by availability of their host plants at these areas. Indeed, only a certain plant such as Euphorbiaceae, Dipterocarpaceae, Rubiaceae, Myristicaceae, Lauraceae, and Sapotaceae which is able to adapt to the acid environment with unfertilized soil.

Another factor that influent to the low of floral diversity in these areas is illegal loggings. Illegal loggings have caused the decrease of floral diversity and caused the change of vegetation in this area. Finally, it will influence to the moth diversity as has been reported by Holloway (1998). He compared the moth diversity at illegal logging forests 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 and Schulze, 2004).

The result of this study also shows that the moth diversity at Giam Siak Kecil is lower than private conservation forest PT. A. Giam Siak Kecil Wildlife Reserve has been illegally logged and land cleared in many areas especially on the areas that close to the local settlements. There are many evidences prove that Giam Siak Kecil has been logged for a long time such as presence of canals and changes of characteristic vegetation. There are many artificial

canals that have been used to transport logs from the deep forest to the Giam Siak Kecil river previously. This activity has caused many changes to the ecosystem such as subside of water levels and changes of vegetation. Subside of water level has caused many large trees fall down due to its root has no ability to support them anymore since the upper peat soil go down follow the decrease of water levels.

Illegal logging has caused the decrease on species tree but increase on its density since young trees and liana trees growth everywhere after illegal loggings. For example the density at Giam Siak Kecil is higher than private conservation, they are 587.7 and 566.3 and the Mischung coefficient of Giam Siak Kecil is also higher than private conservation, which are 3.9 and 2.3 (Partomihardjo, pers. comm.). Mischung coefficient, a proportion number of individual/area and the species number, indicates the complexity of a sampling site. High values indicate that the species number at the sampling site is low. Based on this parameter, private conservation forest PT. A Bukit Batu has higher floral diversity than that of Giam Siak Kecil.

The vegetation of conservation forest PT. A. is relatively more conserve due to its geographical position and its access limitation. This forest is far from local settlements and located at deep inside of the private pulp forests. Therefore, this forest is less disturbed from illegal logging. As a healthy forest at the peat swamp forest, its vegetation is dominated by very large tree Dipterocarpaceae, (*Shorea teysmanniana* and *Shorea uliginosa*). These species have been reported by Istomo (2002) and Partomihardjo (2007) as the main supporting component of the vegetation at the peat swamp forests in Sumatra. Indeed, this private forest conservation is well-protected and less disturbed. The results of the study also showed that many species of moths that usually found at the primary forest were also found at this forest such as *Attacus atlas* and *Loepa megacore* (Saturniidae).

The other difference between the two forests can be seen on its species composition. In Giam Siak Kecil, family Pyralidae is dominant while in private conservation forest family Geometridae is dominant. Pyralidae is mostly medium size moths which its larva has various behaviors such stem borers, leaf roller and leaf eaters. These larvae frequently found in open habitat areas (grasses or Poaceae). On the contrary, most Geometrids are phytophagus that inhabit the green canopy of the threes. This result is also show a similar pattern on the study of moth diversity at Meru Betiri National Park, Nusa Barong Nature Reserve, and Sebangau National Park (Sutrisno, 2005; 2007). Indeed, moth composition can tell us the natural condition of vegetation of a certain area and can be used to evaluate the changes of forest vegetations (Beck et al., 2002).

Based on the results, it is clear that Giam Siak Kecil Wildlife Reserve as well as other wildlife and nature reserves in Sumatra urgently need attention from both central and local governments to improve its management by involving local peoples to protect and stop loss of biodiversity and other disasters such as floods, forest fires and drought. But it does not means, that private companies in Riau have no responsibility. They should actively participate in stopping global warming through providing more areas to become conservation forests in order to maintain an equilibrium ecosystem.

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