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Stratification of fruit feeding butterflies at a conservation forest of oil palm plantation in West Sumatra, Indonesia

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Abstract

The research on the stratification of fruit feeding butterflies was conducted in conservation forest of oil palm plantation of Tidar Kerinci Agung (TKA) Company, Indonesia. Samples were collected on the understory and the canopy level (6 traps of each) of the forest by using cylindrical gauze with rotten pineapples. A total of 158 individuals of fruit feeding butterflies were collected which comprised 25 species belonging to three families and 16 genera. The highest number of species was found in Satyridae (11 species), followed by Nymphalidae (10 species) meanwhile Amathusidae was the lowest (four species). The diversity index for all samples collected was 2.72 with 57.14% of similarity index between understory and canopy.

Keywords: Fruit feeding butterflies, stratification, conservation forest of oil palm plantation

Introduction

Butterflies are among the most well studied of Lepidoptera group, and are typically documented to be hostplant specific ^[1]. Butterflies are also known to be sensitive to habitat changes ^[2, 3] and recognized as good bioindicator ^[1]. In tropical forests fruit feeding butterflies are a convenient indicator group because they can be easily trapped and identify ^[4].

Butterflies species composition in disturbed and undisturbed forests has been investigated such as in Southeast Asia. The primary forest contained most species meanwhile the farmland was the lowest in number of species at Sabah (Borneo), Malaysia ^[5]. Some butterflies prefer to fly more at the surface of the ground (understory) and also in the canopy which likely happened due to the distribution of host plants as well as food ^[6].

Research on the diversity of butterflies which focuses on vertical stratification in Sumatra is rarely done. About 20 species of butterflies collected from Siberut Island Mentawai, West Sumatra ^[7], 37 species in closed canopy and 28 species in gap location of butterflies was collected in Rimbo Panti Nature Reserve, Pasaman District West Sumatra ^[8], 36 species of butterflies collected from Educational and Biological Research Forest, Andalas University Padang and 22 species from Aie Sirah Forest, Pesisir Selatan District West Sumatra ^[9].

Tidar Kerinci Agung (TKA) Company is an oil palm plantation which has an area that covered about 2400 ha of conservation forest. In conservation forest of TKA Company develops a nursery with 60 kinds of plant seedling to be planted in forest area ^[10, 11]. Until now, no information about diversity of fruit feeding butterflies in the conservation forest of TKA Company. The aim of this study was to determine and compare the diversity of the vertical stratification of fruit feeding butterflies in the understory and canopy level at conservation forest of TKA Company.

2. Materials and Methods

Study Area. TKA Company is one of oil palm plantation with area 20.000 ha located in West Sumatra province (72% in Dharmasraya district, 13% in Solok Selatan district) and the province of Jambi in Bungo district (15%), located within 290 km from Padang city and 340 km from the city of Jambi. This location has a conservation forest named 'Conservation Forest of Prof. Sumitro Djojohadikusumo' which covering an area of 2400 ha that divided into 1,100 ha (Dharmasraya district) and 1,300 ha (Solok Selatan district) ^[10].

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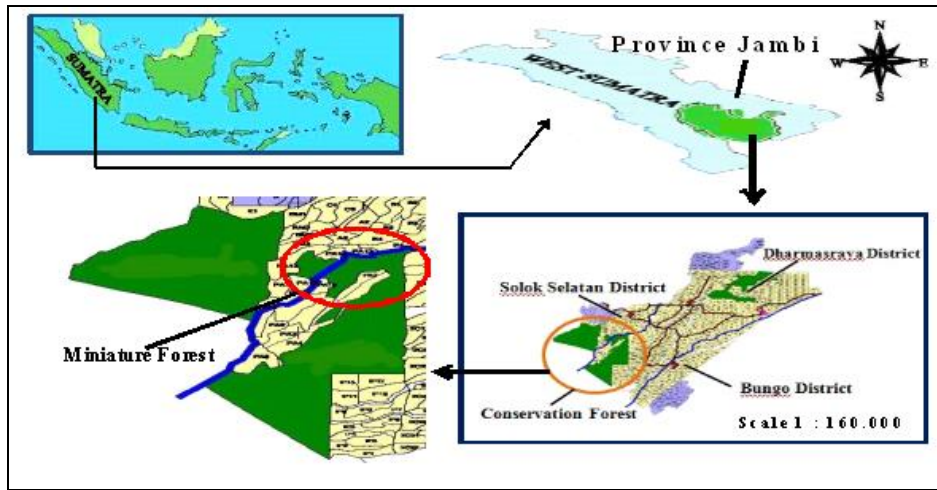


Fig 1: Map of study site at Conservation Forest of Oil Palm Plantation of TKA Company.

Sampling Procedures. Sampling of butterflies was conducted during October 2014 and March 2015 at Miniature Forest (100 ha) of Conservation Forest of TKA Company that was surrounded by oil palm plantation (Figure 1) by using cylindrical gauze trap^[12] with rotten pineapples for 48 hours. Traps were put at height of 1-1.5 m from ground level which called understory^[13] and in the canopy at height between 16-27 m^[14]. Traps were installed horizontally at about ± 100 m in distance^[1, 15]. The traps were checked every 24 hours^[16] and settled in place for 6 consecutive days without rainy days^[1]. Trapping was performed for 144 trap days (6 days x 12 traps x two periods).

Butterfly identification

Butterflies were identified with reference to the publication of Tsukada^[17-19] and all specimens were deposited in Laboratory of Animal Taxonomy of Department of Andalas University, Padang, West Sumatra.

Vegetation. Determination of vegetation at each trapping location was made in a plot (10 x10 m²) with diameter at breast height (dbh) size of 5-10 cm which was recorded as understory tree and dbh > 10 cm that was recorded as overstory tree^[7]. Furthermore, the processes of making herbarium specimens were conducted^[20].

Data Analyses. The butterfly diversity was calculated using Shannon-Wiener index^[21] by the following equation:

$$H' = -\sum_{i=1}^s pi \ln pi$$

where: H' is index of species diversity; " pi " is the proportion within the sample of the number of individuals of "ith" species and it is denoted as ni/N , where " ni " is the number of "ith" species and " N " is the total number of individuals.

Evenness is calculated^[21]: $E = \frac{H'}{\ln S}$

H' is the number derived from the diversity index and S = the number of species found.

To measure the similarity between two stratification of understory and canopy, the coefficient of Sorensen was used, calculated as follows^[21]:

$$QS = \frac{2j}{a+b} \times 100\%$$

Where Q_s = Sorensen's similarity coefficient; j = number of species in sample a and sample b (joint occurrences); a = number of species found in understory; b = number of species found in canopy.

3. Results and Discussion

A total of 158 individuals of fruit feeding butterflies were collected during the study which comprised 25 species belonging to three families (Amathusidae, Nymphalidae, Satyridae) and 16 genera (Table 1, Figure 2 and 3). The highest number of species was found in Satyridae (11 species), followed by Nymphalidae (10 species) and the lowest families found was Amathusidae with 4 species (Figure 4). Genus with the highest number of species was *Mycalesis* (4 species), *Zeuxidia* and *Elymnias* (3 species of each), *Charaxes* and *Melanitis* (2 species of each). Species with the highest number of individuals was *Mycalesis horsfieldi* (35 individuals) followed by *Mycalesis maianae* (20 individuals) and *Amathusia phidippus* with 13 individuals.

Diversity index (H') of fruit feeding butterflies during this study was 2.72, it was as medium category ($H' < 1$ = low category, $1 < H' < 3$ = medium category, $H' > 3$ = high category)^[21]. The diversity index was quite high and indicated that the presence of monoculture oil palm plantations surrounding the miniature forest of conservation forest of TKA Company did not affect negatively to the diversity of butterflies in the forest. Probably, because the TKA Company is concerned to environment as they arranged in 2400 ha forest for the conservation area to preserve the flora and fauna and their habitat.

The number of butterflies in general depends on the management of an area^[22]. The number and diversity of unique butterflies are significantly higher in natural forests^[23], beside of the friendly habitats have the highest species richness with the most unique species^[6].

A total of 120 individuals of butterflies were collected which comprised 22 species belonging to three families, 14 genera and was collected in understory level, meanwhile 38 individuals of butterflies that belonging to 12 species, three families, and 9 genera was collected in canopy level during the study. The diversity index of the species was higher in understory level (2.55) than at canopy level (2.39), because the canopy of tree was not too dense so the direct sunlight can reach the ground part. This condition has a great impact to the existence of butterflies in the forest which usually live in the canopy but fly to the area of understory for food.

Other studies of fruit feeding butterflies have shown higher

diversity at ground level, compared with the canopy [24]. About 19 % of the species were found in the canopy only, 34% were found in the understory only, and the remaining 47% of the species were found in both strata at Ecuadorian Rain Forest [6].

These may be because rotting fruit generally fall to the ground [25]. Host plant and variations in vegetation structure substantially influenced butterfly stratification in the forest [26, 27].

Table 1: List species and total number of individuals of fruit feeding butterflies at two different vertical heights that found in Conservation Forest of TKA Company.

No	Species	Cylindrical Gauze Trap		
		Understory	Canopy	Total
Amathusidae				
1	<i>Amathusia phidippus</i> (Linnaeus, 1763)	9	4	13
2	<i>Zeuxidia amethystus</i> (Butler, 1865)	3	-	3
3	<i>Zeuxidia aurelius</i> (Cramer, [1777])	2	-	2
4	<i>Zeuxidia doubledayi</i> (Westwood, [1851])	3	-	3
Nymphalidae				
5	<i>Agatasa calydonia</i> (Hewitson, 1855)	-	2	2
6	<i>Charaxes bernadus</i> (Fabricius, 1973)	1	1	2
7	<i>Charaxes solon</i> (Fabricius, 1793)	-	1	1
8	<i>Dichorragia nesimachus</i> (Doyere, 1840)	1	-	1
9	<i>Doleschallia polibete</i> (Cramer, 1885)	1	-	1
10	<i>Dophla evelina</i> (Stoll, 1790)	5	2	7
11	<i>Kallima limborgi</i> (Moore, 1878)	8	-	8
12	<i>Prothoe frank</i> (Godart, 1824)	1	-	1
13	<i>Tanaecia munda</i> (Fruhstorfer, 1899)	1	4	5
14	<i>Cynitia godartii</i> (G.R. Gray, 1846)	-	1	1
Satyridae				
15	<i>Elymnias hypermnestra</i> (Linnaeus, 1763)	2	1	3
16	<i>Elymnias nesaea</i> (Linnaeus, 1764)	1	4	5
17	<i>Elymnias panthera</i> (Fabricius, 1787)	3	6	9
18	<i>Melanitis leda</i> (Linnaeus, 1758)	5	3	8
19	<i>Melanitis phedima</i> (Cramer, [1780])	7	3	10
20	<i>Mycalesis horsfieldi</i> (Moore, [1892])	29	6	35
21	<i>Mycalesis maianeas</i> (Hewitson, [1864])	20	-	20
22	<i>Mycalesis marginata</i> (Moore, 1881)	10	-	10
23	<i>Mycalesis orseis</i> (Hewitson, [1864])	5	-	5
24	<i>Neorina lowii</i> (Doubleday, [1849])	2	-	2
25	<i>Ragadia makuta</i> (Horsfield, [1829])	1	-	1
Total number of individuals		120	38	158
Total number of species		22	13	25
Diversity index (H')		2.55	2.39	2.72
Evenness index (E)		0.82	0.93	
Similarity index (QS)		57.14%		

In addition, the high diversity index in understory level of this study is likely caused by the availability of five species of plants (*Macaranga triloba*, *Eusideroxylon zwageri*, *Bellucia pentamera*, *Aporosa bentramiana*, *Aralidium pinnatifidum*) which only found in the understory level (Table 2). The host plants of fruit feeding butterflies are from the families of Annonaceae, Malvaceae, Tiliaceae, Rutaceae, Sapindaceae,

Anacardiaceae, Leguminosae, Melastomataceae, Passifloraceae, Rubiaceae, Acanthaceae, Loranthaceae, Euphorbiaceae, Moraceae etc [28]. In this study, family Melastomataceae (*Pentamera bellucia*) was found fruitful and many of the fruits had been rotten and it only found in the understory level.

Table 2: List of vegetation in 10 x 10 m² plot (UT = understory tree dbh 5-10 cm, OT = overstory tree with dbh > 10 cm) at cylindrical gauze trap location in Conservation Forest of TKA Company.

Species		UT	OT	Condition
Burseraceae				
1.	<i>Canarium</i> sp. 1	9	4	-
2.	<i>Canarium</i> sp. 2	7	3	-
Dipterocarpaceae				
3.	<i>Neobalanocarpus heimii</i> (King) P.S Ashton	6	7	-
4.	<i>Parashorea</i> sp.	4	3	-
Euphorbiaceae				
5.	<i>Acalypha spiciflora</i> Burn. f.	7	4	-
6.	<i>Macaranga triloba</i> (Thunb.) Mull. Arg.	2	-	-
7.	<i>Mollatus subpeltatus</i> (Blume) Mull. Arg.	6	5	-
8.	<i>Trigonostemon</i> sp.	8	2	-
Lauraceae				
9.	<i>Cinnamomum cassia</i> (L.) J. Presl	5	2	-
10.	<i>Cinnamomum</i> sp.	2	7	-
11.	<i>Eusideroxylon zwageri</i> Teijsm. & Binn.	2	-	-
12.	<i>Litsea cubeba</i> (Lour.) Pers.	2	4	-

13.	<i>Litsea</i> sp.	4	7	-
Malvaceae				
14.	<i>Boschia</i> sp.	10	3	Fruitful
Melastomataceae				
15.	<i>Bellucia pentamera</i> Naudin	1	-	Fruitful
Myristicaceae				
16.	<i>Myristica</i> sp. 1	5	2	-
17.	<i>Myristica</i> sp. 2	4	4	-
Myrtaceae				
18.	<i>Eugenia</i> sp.	5	3	-
19.	<i>Syzigium cymosa</i> (Lam.) DC.	7	4	-
Phyllanthaceae				
20.	<i>Aporosa bentramiana</i> Hook. f.	3	-	-
Rhamnaceae				
21.	<i>Maesopsis eminii</i> Engl.	3	3	Fruitful
Rubiaceae				
22.	<i>Tarenna</i> sp.	7	3	Fruitful
23.	<i>Uncaria longiflora</i> (Poir.) Merr.	4	2	Fruitful
Torrilliaceae				
24.	<i>Aralidium pinnatifidum</i> (Jungth. & de Vriese)	2	-	-
Verbenaceae				
25.	<i>Vitex coriacea</i> C.B. Clarke	2	1	-
Total of species		25	20	
Total of individuals		117	73	

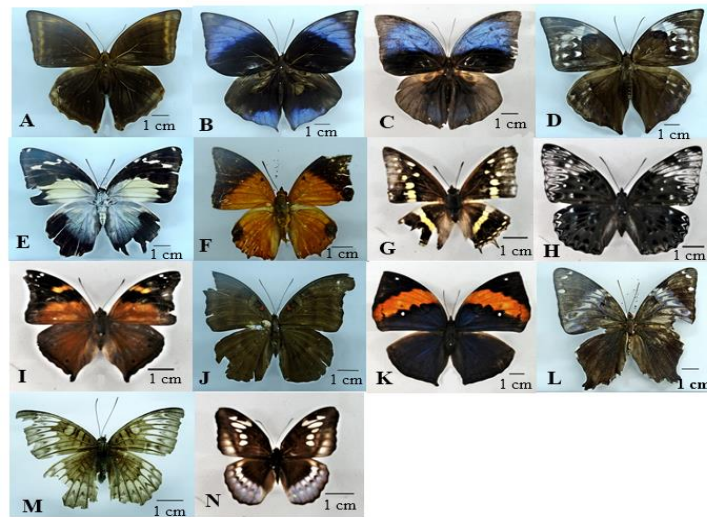


Fig 2: Amathusidae (A-D) and Nymphalidae (E-N) butterflies that were found at Conservation Forest of TKA Company (A. *Amathusia phidippus*, B. *Zeuxidia amethystus*, C. *Zeuxidia aurelius*, D. *Zeuxidia doubledayi*, E. *Agatasa calydonia*, F. *Charaxes bernadus*, G. *Charaxes solon*, H. *Dichorragia nesimachus*, I. *Doleschallia polibete*, J. *Dophla evelina*, K. *Kallima limborgi*, L. *Prothoe frank*, M. *Tanaecia munda*, N. *Cynitia godartii*).

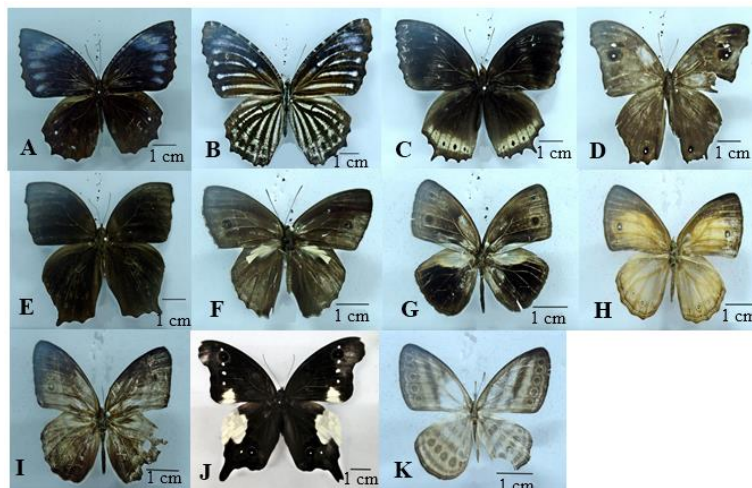


Fig 3: Satyridae butterflies that found at Conservation Forest of TKA Company (A. *Elymnias hypermnestra*, B. *Elymnias nesaea*, C. *Elymnias panthera*, D. *Melanitis leda*, E. *Melanitis phedima*, F. *Mycalesis horsfieldi*, G. *Mycalesis maianaeas*, H. *Mycalesis marginata*, I. *Mycalesis orseis*, J. *Neorina lowii*, K. *Ragadia makuta*).

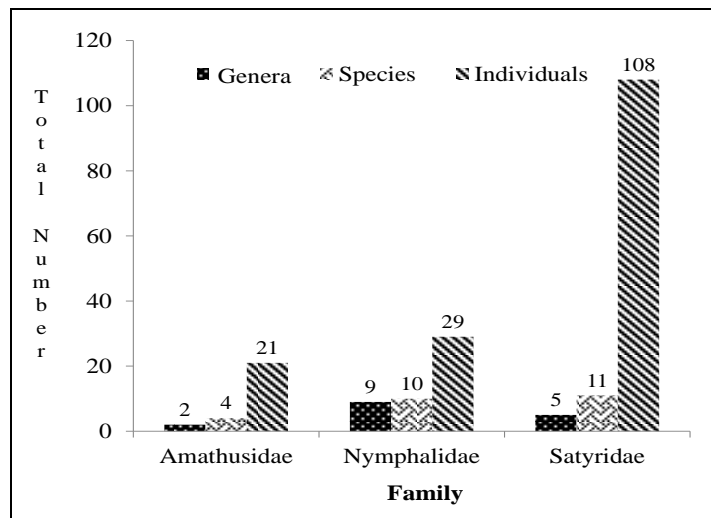


Fig 4: Distribution of family, genera, species and individuals of butterfly that collected from Conservation Forest of TKA Company.

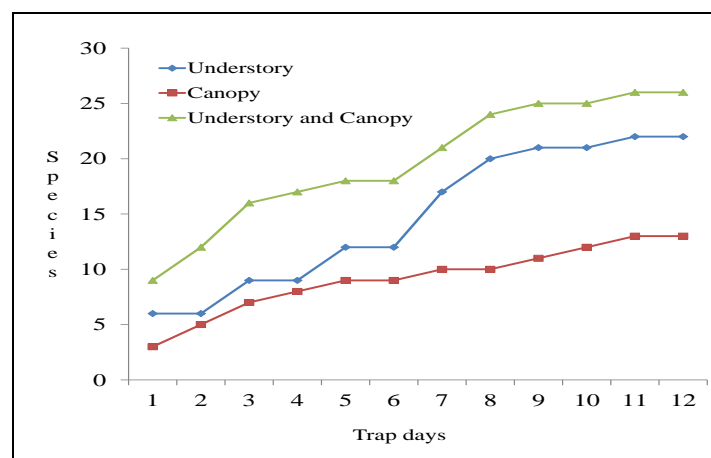


Fig 5: Cumulative number of species against trap days at the two different vertical heights along the vertical strata in Conservation Forest of TKA Company.

A fruit feeding butterfly is highly preferable to consume the rotten fruits [12, 29]. The number of species of fruit feeding butterflies will be more commonly found in the understory level compared to the canopy since more rotten fruit falling to ground [27]. The individual abundance and species of butterfly's richness are much higher in understory level than in canopy level [6].

Butterflies collection in each days showed that the total number of species was highest in understory level than at canopy level (Figure 5). Total number of species was highest in understory level compared to in canopy level. Figure 5 showed that accumulation curve already asymptote indicated that enough number of butterflies sample were collected.

Evenness index (E) in the understory level was 0.82 which was slightly lower than in the canopy level (0.93) but it's classified as a medium level [21]. So the Evenness among species was different in understory and canopy level (Table 1). The evenness index illustrates the size of individuals among species within an area.

The similarity index (QS) between understory and canopy was quite low (57.14%). Ten species that only found at both understory and canopy were *Amathusia phidippus*, *Charaxes bernardus*, *Dophla evelina*, *Tanaecia munda*, *Elymnias hypermnestra*, *Elymnias nesaea*, *Elymnias panthera*, *Melanitis leda*, *Melanitis phedima*, *Mycalesis horsfieldi*. The discovery of the resemblance species at both levels indicated that there

were some similar food plant in vegetation for both understory and canopy butterflies.

Total number of species in this study was the highest compared to the study in Siberut Island of Mentawai, West Sumatra that found 20 species (540 trap days and has a total surface area of 4030 km²) [7], but lower compared to study in Borneo that found 40 species (1008 trap days) [25], and 49 species (3360 trap days) [30]. Probably, the variation of number of species depends on duration of sampling as well as covered area variation among of the studies. However this result showed that conservation forest of oil palm plantation of TKA Company have a good condition to support the diversity of plant and animal especially of fruit feeding butterflies and their hostplants.

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