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Agus Priyono Kartono
Wild Animal Ecology Laboratory, Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University

Lin Nuriah Ginoga
Wild Animal Breeding Laboratory, Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University, IPB Darmaga Campus

Denny Rizki Herfian
Alumni of Undergraduate Program of Department of Forest Resource Conservation and Ecotourism Faculty of Forestry, Bogor Agricultural University

Rufidi Chandra
PT Indocement Tunggal Prakarsa Tbk. Palimanan Unit, Cirebon, West Java

The diversity of Papilionoidea in industrial area of PT indocement tunggal prakarsa Tbk Palimanan plant Cirebon

Agus Priyono Kartono, Lin Nuriah Ginoga, Denny Rizki Herfian and Rufidi Chandra

Abstract
A study on species diversity of Papilionoidea butterfly was carried out in industrial and quarry area of PT Indocement Tunggal Prakarsa Tbk Palimanan Plant. The habitat is divided into eight categories, namely: the conservation area of Mount Blindis (GB), tree stands area within the plant area (DP), tree stands area outside the plant area (LP), area around artificial pool/lake (KB), area of *Jatropha curcas* plant (TJ), buffer zone (BZ), shrubs area (SB), and paddy field area within industrial and quarry area (SW). Total butterfly species found are 48 species. Nymphalidae is a family that has the most number of species found. The highest abundance is in GB area, followed by LP area, and the lowest one is SW area. The highest diversity index is found in LP area. The highest community similarity is found between BZ and SB area and the lowest one is found between GB and SW area

Keywords: Papilionoidea, diversity index, evenness index, community similarity, cement plant

1. Introduction
Butterfly has a highly important functional role for most of the terrestrial ecosystem, especially in ecosystem service as the pollinator of wild crops community and by maintaining agricultural plant productivity [28; 1]. Globally, annual economic value of pollination by insects is estimated to reach US$153 billion during 2005 (9.5% of total economic value of global agricultural produces used as foodstuffs). The disappearance of pollinator overall can be converted into the decrease in consumption level by 12% for fruit crops and 6% for vegetable crops [9].

Butterfly is also one of animals that is really sensitive to environmental changes and has specific host [29], whose existence tends to be easily affected by habitat changes [28] and is related to plant diversity [16]. Butterfly population experiences a decrease due to habitat degradation, the decrease in plant species diversity, water quality, and the increase in air and soil pollution [20]. Therefore, butterfly population diversity and density in an area can be harnessed as environmental quality indicator [28; 23], best indicator for the diversity and composition of herb crop community [8], and in ecosystem health quality assessment [21]. It is because butterfly species diversity depends on vegetation type in the habitat in question [32]. Generally, the highest butterfly diversity exists in the habitat that has the highest vegetation diversity and it becomes low in an open or grass-vegetated area [7].

PT Indocement Tunggal Prakarsa Tbk (ITP) Palimanan Unit is one of companies operating in the field of cement quarry in Indonesia. Natural resources utilization, particularly limestone, for cement minerals production is expected to have an influence on butterfly habitat condition. It is because soil horizons stripping and limestone quarrying cause the disappearance of vegetation coverage, an increase in the influx of solar radiation, an increase in fire and drought risk, and loss in the form of humus disappearance. These factors eventually often lead to the growth and development of secondary vegetation such as grass, invasive climber plant species, and pioneer tree species [30] and its recovery which takes a quite long time [14].

The diversity of butterfly community in various types of habitat has been studied in various parts of the world, including Southeast Asian tropical forest [32]. However, a study on the diversity of butterfly community in various types of habitat in industrial and quarry area of cement plant has not been much conducted. This study aims to measure the level of diversity and similarity of butterfly community in various types of habitat in industrial and quarry area of PT ITP Palimanan Unit Cirebon West Java.

Correspondence
Lin Nuriah Ginoga
Wild Animal Breeding Laboratory, Department of Forest Resource Conservation and Ecotourism, Faculty of Forestry, Bogor Agricultural University, IPB Darmaga Campus

2. Material and Methods
2.1 Research Location
This research was conducted in industrial and quarry area of PT ITP Palimanan Unit Cirebon West Java from February 14 to March 9 2015. Area vastness of Mining Business License (IUP) of PT ITP Palimanan Unit was 580 ha, consisting of 234 ha processing area and 346 ha quarrying area. According to the geographical position, this area was located in 6º41'58.8'' South Latitude and 108º22'28.9'' East Longitude. The collection of Papilionoidea butterfly data was undertaken in eight types of habitat, namely: the conservation area of Mount Blindis (GB), tree stands area within the plant area (DP), tree stands area outside the plant area (LP), area around artificial pool/lake (KB), area of *Jatropha curcas* plant (TJ), buffer zone (BZ), shrubs area (SB), and paddy field area within industrial and quarry area (SW).

The range of momentary air temperature in the conservation area of Mount Blindis was between 23–27 ºC; in tree stands area within and outside the plant area, buffer zone, and shrubs zone was between 24–27 ºC, in area around artificial pool/lake and area of *Jatropha curcas* plant was between 23–26 ºC, and in paddy field area was between 22–28 ºC. Types of vegetation of seedling and understory level that dominated Mount Blindis area were *Ficus melinocarpa*, *Dalbergia latifolia*, *Lindera polyantha*, *Ficus superba*, *Ardisia humilis*, *Lantana camara*, *Stachytarpheta jamaicensis*, *Cyrtococcum accrescens*, *Streblochaete longiarista*, and *Eupatorium odoratum*. Tree stands area within the plant area was dominated by the type of *Leucaena leucocephala*, *Enterolobium cyclocarpum*, *Ficus fistulosa*, *Artocarpus elasticus*, *Calliandra calothyrsus*, *Pogonarherum paniceum*, *Ottochloa nodosa*, *Ipomoea cairica*, *Urena lobata*, and *Blumea balsamifera*. Tree stands area outside the plant area was dominated by the vegetation type of *Bischofia javanica*, *Terminalia cattapa*, *Asystasia intrusa*, *Jatropha curcas*, *Ageratum conyzoides*, *S. longiarista*, and *Pollinia ciliata*. Area around artificial pool/lake was dominated by the vegetation type of *Streblus asper*, *T. cattapa*, *Murraya paniculata*, *Leea indica*, *Acacia auriculiformis*, *Mimosa pudica*, *Wedelia trilobata*, and *Imperata cylindrica*. Vegetation types found within the buffer zone were *Anisomeles indica*, *Panicum sarmentosum*, *S. longiarista*, *Euphorbia hirta*, and *A. conyzoides*. Other than in the conservation area of Mount Blindis, most of vegetation types found were plants for ex-mining area reclamation.

2.2 Data Collection
Materials and tools utilized in this research were tape measure, insect hand net, 70% alcohol, syringe, camphor, styrofoam, specimen box, digital camera, and butterfly field guide. Sampling unit used in this research was a plot sized 20 m x 20 m located on a line transect (380–770 m), with the distance between plots of 10 m following the modified method of Auckland *et al*. [3]. The number of observation plot in each type of habitat were as follows: 28 plots in GB area, 50 plots in DP area, 52 plots in LP area, 50 plots in area around KB, 36 plots in TJ area, 26 plots in BZ area, 26 plots in SB area, and 44 plots in SW area.

Butterfly catching was carried out at the active times of butterfly, namely at 08:00–11:00 and 14:00–17:00 in a fine weather condition. The time required for observation in each transect was 40–50 minutes. The data collection of number of individual and name of species was conducted by means of direct catching using sweeping net. The number of individual butterfly caught was calculated to assess the species richness and abundance in each habitat or habitat type. The species of butterfly successfully caught were identified using book titled *The Ilustrated Encyclopedia of Butterfly World* [25] and *Butterfly of the Oriental Region* [6].

2.3 Data Analysis
Butterfly diversity was measured using Margalef's species richness index, $D_{Mg}=(S–1)/\ln(N)$ [11], Jackknife index $\hat{S}=s+[(n-1)/n].k$ [12] for for expected number of species, Shannon's diversity index $H'= –\Sigma p_i.\ln(p_i)$ [18], and Pielou's evenness index $J'=H'/\ln(S)$ [18]. Community evenness was calculated using Morisita-Horn equation $M_{Ijk}=(2\Sigma X_{ij}X_{ik})/(\Sigma X_{ij}^2 + \Sigma X_{ik}^2)$. The classification of butterfly species was analyzed using *Ward Linkage* method and described in dendrogram. The classification of butterfly species abundance refered to Vu & Vu [31], namely: classified as rare species if the number of individual found was less than 5, as uncommon species if the number of individual found was between 6 to 10, and as common species with the number of individual of more than 10.

3. Result
3.1 Species Richness
Total of Papilionoidea butterfly species found in industrial and quarry area of PT ITP Palimanan Unit was 48 species, consisting of 31 species (64.58%) members of Nymphalidae family, 7 species (14.58%) members of Papilionidae family, 5 species (10.42%) members of Lycaenidae family, and 5 species (10.42%) members of Pieridae family. Total individual butterfly of Papilionoidea caught during the observation on 312 sampling unit amounted to 1586 individuals (Table 1). However, not all of those Papilionoidea butterfly species could be found in all types of habitat observed. There were 18 butterfly species (37.5%) that were only found in certain habitat, namely: *Athyma perius*, *Cupha erymanthis*, *Junonia villida*, *Phalanta phalantha*, *Tirumala limniace*, and *Graphium antiphates* in the conservation area of Mount Blindis; *Jamides pura*, *Rapala dieneces*, and *Junonia hedonia* in tree stands area within the plant area; *Elymnias hypermnestra*, *Euthalia adonia*, *Euthalia monina*, *Eurema alitha*, and *Eurema sari* in tree stands area outside the plant area; *Elymnias nesaea* and *Junonia erigone* in shrubs area; *Tajuria mantra* in area around artificial pool/lake, and *Lethe europa* in buffer zone.

Yukawa stated that in Java Island, there are at least 583 butterfly species [36], while according to Whitten *et al*. [35], there are 626 butterfly species with 46 species of them are endemic species of Java Island [19]. Compared to the research result of Yukawa [36], the richness of Papilionoidea butterfly species in industrial and quarry area of PT ITP Palimanan Unit was 8.67%.

Papilionoidea butterfly species that were commonly found in industrial and quarry area of PT ITP Palimanan Unit were as follows: *Catopsilia pomona*, *Eurema hecabe*, *Delias hyparete*, *Neptis hylas*, *Danaus chrysippus*, *Acraea terpsicore*, and *Mycalesis mineus*. Butterfly species that were classified uncommon were *Junonia orithya*, *Euploea mulciber*, *Melanitis leda*, *Mycalesis horsfieldi*, and *Graphium doson*. All species found, other than those species, were classified rare in this area.

Tree stands area outside the plant area (LP) had the highest richness of butterfly species compared to other seven locations observed, with 30 species found or 62.50% of total butterfly species found. Meanwhile, the lowest richness of butterfly species was located in paddy field area (SW), with

10 species founded or 20.83% (Table 2). Based on one-way anova test, there was a difference in richness of butterfly species between observation locations (F=2.626, p=0.014). The highest expected number of butterfly species (Jackknife index) was found in tree stands area outside the plant area, the lowest one was found in paddy field area. Compared to the expected number of species, the finding of Papilionoidea butterfly species in area around artificial pool/lake reached 79.5%, in area of *Jatropha curcas* plant reached 72.0%, and in shrubs area reached 70.1% (Fig 1).

**Table 1:** Number of individual butterfly of Papilionoidea caught during observation

Family and species	Types of habitat								Number
	GB	DP	LP	KB	TJ	BZ	SB	SW	
Family: Lycaenidae									
Chilades pandava (Horsfield, 1829)				3	5	3			11
Jamides pura (Moore, 1886)		2							2
Lampides boeticus (Linnaeus, 1767)		2	7						9
Rapala dieneces (Hewitson, 1878)		2							2
Tajuria mantra (C. and R. Felder, 1860)				1					1
Family: Nymphalidae									
Acraea terpsicore (Linnaeus, 1758)	15	30	10	8	18				81
Ariadne ariadne (Linnaeus, 1763)		3	5	4	6	9	6		33
Athyma perius (Linnaeus, 1758)	20								20
Cupha erymanthis Drury, 1773	14								14
Danaus chrysippus (Linnaeus, 1758)	47	33		17	2	7	1	1	108
Doleschallia bisaltide (Cramer, 1777)			3	2	3				8
Elymnias hypermnestra Linnaeus, 1763			11						11
Elymnias nesaea Linnaeus, 1758							1		1
Euploea mulciber (Cramer, [1777])	35	9	5	4					53
Euthalia adonia (Cramer, [1780])			8						8
Euthalia monina (Fabricius, 1787)			7						7
Hypolimnas bolina (Linnaeus, 1758)		2	9	11	5	2	1		30
Hypolimnas misippus (Linnaeus, 1764)		4	5			1			10
Ideopsis juventa (Cramer, [1777])	1	2							3
Junonia almana (Linnaeus, 1758)		1	3	12	2	1	3	2	24
Junonia atlites (Linnaeus, 1763)		3			9	2	1	1	16
Junonia erigone (Cramer, [1775])							6		6
Junonia hedonia (Linnaeus, 1764)		7							7
Junonia iphita (Cramer, [1779])	2		8						10
Junonia orithya (Linnaeus, 1758)	5	12	6	20	12	4	10	3	72
Junonia villida (Fabricius, 1787)	8								8
Lethe europa (Fabricius, 1775)						2			2
Melanitis leda (Linnaeus, 1758)		10	1	5		7	3	13	39
Moduza procris (Cramer, [1777])			4	2		15	9		30
Mycalesis horsfieldi (Moore, [1892])			3		8	15	9	2	37
Mycalesis mineus (Linnaeus, 1758)		11	17	29	18	2	2		79
Neptis hylas (Linnaeus, 1758)	32	24	18	18	1	11	8	1	113
Phaedyma columella (Cramer, [1780])		3	7						10
Phalanta phalantha (Drury, [1773])	4								4
Tirumala limniace (Cramer, [1775])	1								1
Ypthima horsfieldii Moore, 1884			12	15					27
Family: Papilionidae									
Graphium agamemnon (Linnaeus, 1758)	2	1	8	2	4	1	2		20
Graphium antiphates (Cramer, [1775])	9								9
Graphium doson C.Felder and R.Felder, 1864	38	2	1		3				44
Graphium sarpedon (Linnaeus, 1758)	10		1						11
Pachliopta aristolochiae (Fabricius, 1775)	1		1		1				3
Papilio demoleus Linnaeus, 1758	3	1		2	1				7
Papilio memnon Linnaeus, 1758	1		2		1		2		6
Family: Pieridae									
Catopsilia pomona (Fabricius, 1775)	141	39	65	37	42	18	28	3	373
Delias hyparete (Linnaeus, 1758)	32	7	15	12	10	1		6	83
Eurema alitha (C. and R. Felder, 1862)			11						11
Eurema hecabe (Linnaeus, 1758)	41	17	29	4	11	5	1	5	113
Eurema sari (Horsfield, 1829)			9						9
Number of species (S)	22	24	30	19	20	18	18	10	48
Number of individual (N)	462	227	291	205	160	108	96	37	1586

Information: GB=the conservation area of Mount Blindis, DP=tree stands area within the plant area, LP=tree stands area outside the plant area, KB=area around artificial pool/lake, TJ=area of *Jatropha curcas* plant, BZ=buffer zone, SB=shrubs area, SW=paddy field area within industrial and quarry area.

Table 2: Number of Papilionoidea butterfly species by family

Family	Habitat								Total species
	GB	DP	LP	KB	TJ	BZ	SB	SW	
Lycaenidae	0	3	1	1	1	1	1	0	5
Nymphalidae	12	15	19	13	11	13	13	7	31
Papilionidae	7	3	5	2	5	1	2	0	7
Pieridae	3	3	5	3	3	3	2	3	5
Number of species (S)	22	24	30	19	20	18	18	10	48
Percentage (%)	45.83	50.00	62.50	39.58	41.67	37.50	37.50	20.83	100

Information: GB=the conservation area of Mount Blindis, DP=tree stands area within the plant area, LP=tree stands area outside the plant area, KB=area around artificial pool/lake, TJ=area of *Jatropha curcas* plant, BZ=buffer zone, SB=shrubs area, SW=paddy field area within industrial and quarry area.
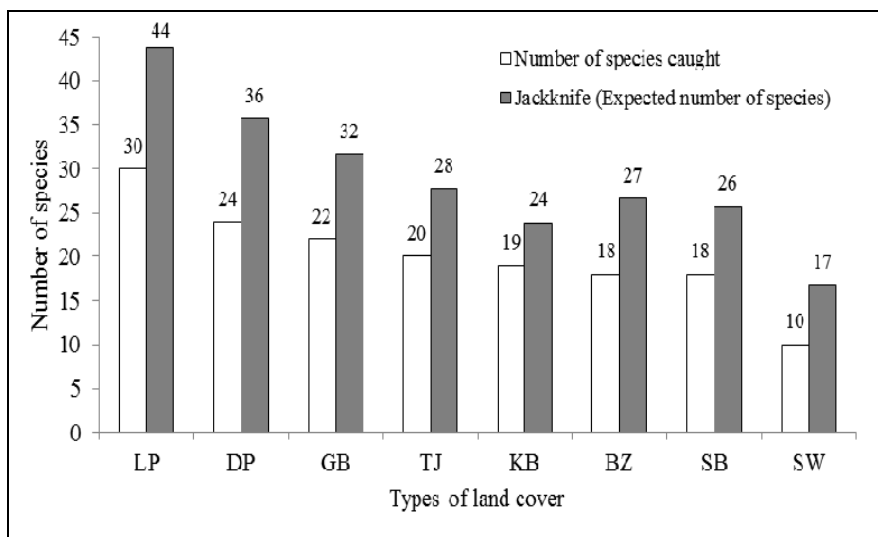
Fig 1: Comparison between number of Papilionoidea butterfly species observed and expected number of species in each type of habitat

3.2 The Diversity and Evenness of Species

The highest diversity index of Papilionoidea butterfly species was found in tree stands area outside the plant area with the value of H'=2.93±0.09 and the lowest one was in paddy field area with the value of H'=1.95±0.20 (Table 3). Based on one-way anova analysis, there was a difference in the value of species diversity index (H') between types of habitat (*p*=0.000). The difference in species diversity index happened between tree stands area outside the plant area and the conservation area of Mount Blindis (t_h=-5.447; $t_{0.05;2}$=4.303) and between tree stands area outside the plant area and paddy field area (t_h=4.431; $t_{0.05;2}$=4.303). Species diversity index between the habitat type of tree stands area outside the plant area and the conservation area of Mount Blindis as well as paddy field area was not significantly different.

Species evenness index of butterfly in all observed locations were classified high, which was more than 80%, except for the conservation area of Mount Blindis which only reached 77%. It indicated that in the conservation area of Mount Blindis, there was butterfly species which had an extremely high individual abundance compared to the other butterfly species. *Catopsilia pomona* butterfly from Pieridae family was an exceptionally dominant species in that conservation area of Mount Blindis, which had an abundance of 30.5% of total individuals caught.

Table 3: Population density, diversity index, and evenness index of Papilionoidea butterfly species

Types of habitat	Number of species (S)	Total individual (N)	Population density N/ha ($\bar{X}$±SD)	Shannon's index (H'±SD)	Pielou's index (J')
GB	22	462	412.50 ± 27.49	2.39 ± 0.05	0.77
DP	24	227	113.50 ± 5.56	2.63 ± 0.09	0.83
LP	30	291	139.90 ± 5.81	2.93 ± 0.09	0.86
KB	19	205	102.50 ± 5.00	2.57 ± 0.08	0.87
TJ	20	160	111.11 ± 6.68	2.49 ± 0.09	0.83
BZ	18	108	103.85 ± 5.28	2.52 ± 0.08	0.87
SB	18	96	92.31 ± 6.23	2.40 ± 0.10	0.83
GB	10	37	21.02 ± 2.09	1.95 ± 0.20	0.85

Information: GB=the conservation area of Mount Blindis, DP=tree stands area within the plant area, LP=tree stands area outside the plant area, KB=area around artificial pool/lake, TJ=area of *Jatropha curcas* plant, BZ=buffer zone, SB=shrubs area, SW=paddy field area within industrial and quarry area.

3.3 Community Similarity

The highest similarity of Papilionoidea butterfly community was found between the habitat type of shrubs area and buffer zone which reached 85.25%. It was followed by the similarity between the habitat type of tree sands area outside the plant area and area of *Jatropha curcas* plant which reached

84.72%. The lowest similarity of butterfly community was found between the conservation area of Mount Blindis and paddy field area, which amounted to 3.91% (Table 4).

Based on the similarity of the habitat use on the threshold of 75%, Papilionoidea butterfly in industrial and quarry area of PT ITP Palimanan Unit could be categorized into three groups. Group I was butterfly species that existed in the habitat type of conservation area of Mount Blindis (GB), tree stands area within the plant area (DP), tree stands area outside the plant area (LP), area of *Jatropha curcas* plant (TJ), and area around artificial pool/lake; group II was butterfly species that existed in the habitat type of buffering zone (BZ) and shrubs area (SB); and group III was butterfly species that existed in paddy field area (SW). Dendrogram of butterfly community grouping based on the habitat use was presented in Fig 2.

Table 4: Percentage of community similarity of Papilionoidea butterfly between types of habitat

Types of habitat	Types of habitat						
	DP	LP	KB	TJ	BZ	SB	SW
GB	34.65	40.30	27.24	35.98	24.19	30.17	3.91
DP		71.51	78.29	75.15	61.01	61.96	20.15
LP			75.01	84.72	60.79	74.30	15.65
KB				78.65	59.77	70.53	20.24
TJ					60.68	77.09	15.75
BZ						85.25	22.68
SB							17.24

Information: GB=the conservation area of Mount Blindis, DP=tree stands area within the plant area, LP=tree stands area outside the plant area, KB=area around artificial pool/lake, TJ=area of *Jatropha curcas* plant, BZ=buffer zone, SB=shrubs area, SW=paddy field area within industrial and quarry area.
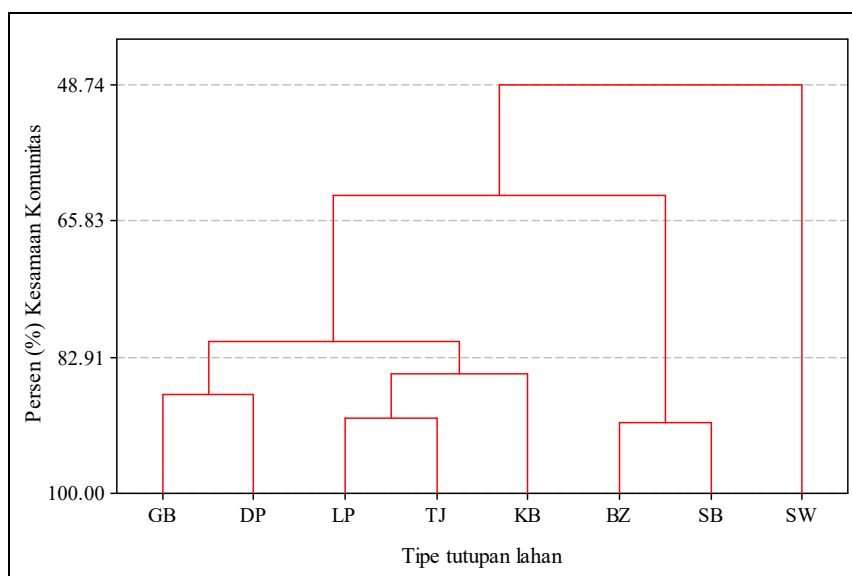
Fig 2: Dendrogram of community classification of Papilionoidea butterfly in industrial and quarry area of PT ITP Palimanan Unit

4. Discussion

Butterfly is a group of insect that holds an important role in ecosystem function and becomes the key of food chain linkage, including as the main source of feed for insectivorous animals [26]. Butterfly is also a taxon that can be used as the environmental bioindicator because it is highly sensitive to changes of habitat and climate, and is really potential to estimate the changes in the richness of other animal types, especially insects [27].

At the larva growth level, butterfly generally has a specific host plant, but at adult level, butterfly becomes a nectar generalist [24]. It is different with Bray [5] who found that there is an indication that adult butterfly is very selective in choosing source of nectar. Kuussaari *et al*. stated that the abundance and richness of insect species has a high correlation with the abundance of nectar-producing plant species [17]. The richness of butterfly species is strongly associated with the abundance of vegetation type of *Eupatorium* and *Erica* [33]. Therefore, many butterfly species are founded in grass-vegetated area [22].

Tree stands area outside the cement plant area of PT ITP Palimanan Unit had the highest richness of Papilionoidea butterfly species among other types of habitat. It was believed to be related to the density and diversity of vegetation type growing in that habitat, that could provide protection function from sunlight exposure and strong wind, provide source of feed and adequate host for butterfly larva. The optimum air temperature for butterfly to breed depends on the butterfly species, but generally ranges between 25–30 ºC [13].

A momentary air temperature in tree stands area outside the plant area ranged between 24–27 ºC. This temperature condition was expected to be suitable for the breeding of various butterfly species, although this habitat location was close to the cement plant. In global scale, cement industry contributes 20% of CO_2 emission originating from human activities and contributes 10% to the global warming potential [2]. One of important matters is that the increase in atmospheric CO_2 will increase the earth surface temperature [34]. It indicated that the air temperature around the cement plant area of PT ITP Palimanan Unit, especially in tree stands area outside the plant area, was not affected by CO_2 emission originating from the cement plant.

Boggs & Murphy stated that weather is the principal factor influencing the activity time, feed resource availability, quality and quantity of larva's host plant, and nectar source for adult butterfly [4]. Time used for flying, looking for feed, and reproduction is influenced by air and ground-level temperature, wind velocity, and sunlight intensity [15]. Karlsson & Wiklund classified butterfly species into two categories, namely species that live in an open habitat and the ones that live in shaded habitat [13]. Based on that, most of butterfly species that exist in industrial and quarry area of PT ITP Palimanan Unit were butterflies that existed in shaded habitat.

The diversity index of Papilionoidea butterfly species could have the same value between the observed types of habitat, but the species composition found as well as the population density were different. It reflected the difference in physiological needs and ecological factors between the species found. Gutiérrez & Menéndez stated that the barrier of physiological and ecological needs is associated with vegetation and elevation [10]. The habitat that got more sunlight and had a warmer microclimate was really advantageous for most of the butterfly species.

5. Conclusion
The total richness of Papilionoidea butterfly species that could be found in industrial and quarry area of PT ITP Palimanan Unit amounted to 48 species, consisting of 64.58% Nymphalidae, 14.58% Papilionidae, 10.42% Lycaenidae, and 10.42% Pieridae. The species diversity index ranged between 1.95 and 2.93. The lowest species diversity index was found in paddy field area and the highest one was in tree stands area outside the plant area. The species evenness index ranged between 77% and 87% which indicated that there was almost no dominating species in all types of habitat observed. The community similarity of Papilionoidea butterfly between types of habitat was mostly categorized low. Butterfly community that existed in paddy field area was really different with the community in other types of habitat.

Accordingly, it is recommended to conduct a continuous monitoring in order to find out the change in butterfly diversity because diversity can only be identified through monitoring and comparison of annual data. In addition, to enhance the diversity of Papilionoidea butterfly species, the use of insecticide and herbicide needs as well as land clearing by getting rid of all types of understory plant.

6. Acknowledgement

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