Are butterfly species useful indicators of ecosystem health in Bali Barat National Park?

N L Winarni¹, Z Afifah², and Nuruliawati²

¹Research Center for Climate Change Universitas Indonesia (RCCC UI), Multidisciplinary Building 7th floor, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
²Wildlife Conservation Society-Indonesia Program, Jl. Malabar 1 No. 11, Babakan, Kecamatan Bogor Tengah, Kota Bogor, Jawa Barat 16128, Indonesia

Corresponding author’s email: n.winarni@sci.ui.ac.id

Abstract. In 2015, Bali Barat National Park was chosen for a Rainforest Standard (RFS) demonstration project. As part of the requirement for the Protected Area Credit of the RFS, species or a group of species that can act as indicators of ecosystem health in Bali Barat National Park (BBNP) have to be identified. Butterflies was one of the taxa assessed for this purpose. A biological survey was conducted in Bali Barat National Park during August-September 2015. Butterfly species were surveyed using a modification of Pollard walk methods by recording species while walking along transects. A total of 82 butterfly species were recorded representing the families Papilionidae, Nymphalidae, Pieridae, Lycaenidae and Riodinidae. Forty-one species, 50%, were from the family Nymphalidae and 21, 25% from Pieridae. Nymphalidae and Pieridae was found to be correlated to vegetation structures. The selection process for indicator species was based on Indicator Value (IV) developed by Dufrene and Legendre (1997). Indicator Value uses both abundance and frequency to identify species that may be effective as indicators of ecosystem health. Most of the species with high IV values were associated with savanna vegetation, which is more open and often disturbed. The only Lycaenidae found with a high IV was Tarucus waterstradti, which may be considered as a potential indicator species. However, caution is needed in assessing the potential for butterflies to be used as indicator species because they are small and may be difficult to identify and there is a lack of trained observers in many parts of the tropics.

Keywords: Butterfly, ecosystem health indicator, Bali Barat National Park

1. Introduction
Butterfly communities are well known as good indicators [1, 2] because butterflies are widespread, recognizable, conspicuous and generally easy to observe [1, 3]. The group offers potential as environmental indicator due to their sensitivity on microclimate and light level [1] and is also useful in assessing habitat [4-6]. Butterfly communities have been used as indicator of habitat quality and habitat change [7, 8] but species or multi-species per se are rarely used as indicator, although several species are usually associated [9].

The use of butterflies as indicator species in the tropics faces constraints because of difficulties in identification compounded by the lack of trained observers in identification skills – a situation
particularly likely to occur in monitoring program in the tropics [10]. Currently, there are not many field identification guides for most areas of Indonesia and yet the number of species is very rich and taxonomic differentiation sometimes difficult. Bias in recording butterfly species is one of the crucial issues when seeking the use of butterfly as indicator. Morphological and behavioral characteristics of butterflies are developed to contend with their protective adaptations [11]. Different flight patterns are known to occur in different butterfly species even within the same group [12].

The Bali Barat National Park (BBNP) which was formally gazetted by the Indonesian Government in 1995 to protect the endemic Bali starling (Leucopsar rothschildi), was selected for a demonstration project for the Protected Area Credit (PAC) initiative developed by the University of Indonesia and Columbia University using the Rainforest Standard™ (RFS) developed by Warfield et al. [13] during 2015. Part of the scheme is to identify a group of species or a single species, which may serve as a predictor of habitat change through a complete biodiversity benchmark survey covering several different taxa, mammals, birds, butterflies, herpetofauna, and plants [13]. In this study we examined the use of butterflies as indicator groups/species.

2. Study area and method

2.1. Study area

This research was carried out in Bali Barat National Park (8°05’S – 18°15’S and 114°25’E –114°34’E). The protected area covers around 19,366 ha areas, comprising different habitat types such as savanna, mangroves, montane, and mixed monsoon forest [14]. The park was originally gazetted by the Dutch in 1941 during the Dutch colonization to protect the Endangered Bali Starling (Leucopsar rothschildi) and the remaining wild banteng (Bos spp.) and then formally established in 1995 by the Indonesian Government (figure 1).

Bali Barat National Park is known as the last stronghold of the Critically Endangered and endemic Bali starling (Leucopsar rothschildi) (Birdlife International 2016) and the other approximately 160 species of birds and various protected mammal species such as pangolin (Manis javanica), porcupine (Hystrix branchyura), deer (Cervus timorensis), and mouse deer (Tragulus javanicus). The design of sampling plots followed the Rainforest Standard [13] and the survey was conducted from the 22nd of August to the 2nd of September 2015. Three study sites were selected, Lebak Buah which is composed of monsoon and secondary forest, including former commercial teak plantations left abandoned since 1979, Megatransects which is composed of montane rainforest, and Brumbun which is composed of mixed shrubs, monsoon forest, mango, and savannah. We set up 4 transects of 2 km each in Lebak Buah and Brumbun. Distance between transects was at least 1 km. In Megatransect, due to difficult access, only one transect of 3 km was set up. At each transect, points were laid every 200 m (figure 1).

2.2. Method

Butterfly survey data was taken using a modified Pollard walk method [15, 16]. This method combines the line-transect method and the point-count method, but in this study we used only point counts. Point counts are taken at sampling locations set along a line transect of predetermined length and direction, at 200 m intervals between points.

Data on butterflies was taken from 09:30 to 11:30. Observers walked along the transect and stopped at each sampling location for 10 minutes to record and identify butterflies detected visually within a 5 m radius (vertical and horizontal). The distance between each butterfly encountered and the central point of observation, as well as the height of the butterfly above the ground, were also recorded.

Butterflies were be identified using two methods. First, the easily-observed butterflies can be identified visually using binoculars. Then, in order to verify identification results—especially of small-size, lively butterflies—we captured butterflies using insect nets, for later identification in the lab.
Butterflies were identified to species if possible, otherwise to genus or family. Species identification was based on Corbet and Pendlebury [17].

2.3. Analysis

We conducted the Spearman Correlation to see the correlation of vegetation structure to number of species found in each family. The data related to species recorded was then analysed for performance as an indicator species based on Indicator Value developed by Dufrene dan Legendre [18]. The method combines relative abundance and relative frequency of the species present in plots.

\[
IV_{ij} = A_{ij} \times B_{ij} \times 100
\]

\[
IV_{ij} = \text{Indicator Value of species } i \text{ in habitat } j
\]

\[
A_{ij} = \text{Relative abundance of species } i \text{ in habitat } j
\]

\[
B_{ij} = \text{Relative frequency } i \text{ in habitat } j
\]

3. Results and discussion

3.1. Butterfly community of Bali Barat National Park

During 2015, we carried out butterfly surveys at 97 observation points: 39 points in Lebak Buah, 14 points in Megatransect, and 44 points in Brumbun.

A total of 82 butterfly species from Papilionidae, Nymphalidae, Pieridae, Riodinidae, and Lycaenidae were recorded during this survey. The highest number of species recorded in the study sites belonged to Nymphalidae (41 species, 50 %), followed by Pieridae (21 species, 25.6 %) (figure 2).
Figure 2. Butterfly community in Bali Barat based on families recorded.

In Lebak Buah, Ypthima hosfieldii was the most common; in Brumbun, Tarucus waterstradti and Leptosia nina were the most common species; while Euploea spp. was the cost common in Megatransect. Six families of butterflies were recorded in Lebak Buah and Megatransek, while 4 families of butterflies recorded in Brumbun.

Nymphalidae and Pieridae are the most abundant families in these sites. Lebak Buah has the highest number of Nymphalidae species (29), followed by Megatransect (16) and Brumbun (13). Brumbun, which has mixed mangrove, savanna, and secondary shrubs, has the highest number of Pieridae species (19). This finding was reflected as well findings of significant differences in the numbers of Nymphalidae species and Pieridae species present between the three sites (Nymphalidae $\chi^2 = 16.063$, $P < 0.001$, Pieridae $\chi^2 = 11.162$, $P = 0.004$).

The presence of Nymphalidae and Pieridae may be correlated to vegetation structure (figure 3). Based on Spearman’s correlation analysis, the number of Nymphalidae species was correlated to the tall trees (tree height Spearman $\rho = 0.376$, $P = 0.000$). This was probably associated to the presence of primary forest in Lebak Buah and Megatransect. The Pieridae, on the other hand, was much more attracted to secondary shrubs [19] in Brumbun where the area has more open canopy (canopy openness Spearman $\rho = 0.321$, $P = 0.001$). Both the numbers of Nymphalidae species and Pieridae species presence were significantly different among the three sites (Nymphalidae $\lambda^2 = 16.063$, $P < 0.001$, Pieridae $\lambda^2 = 11.162$, $P = 0.004$). This finding was reflected in the species with the highest IV (table 1). In Brumbun where the area is mostly savanna, species with the highest IV were from Pieridae. Leptosia nina, for example, is usually associated with more open and disturbed areas [20]. Most Pieridae are usually white and yellow [17]. The only Lycaenidae found with high IV was Tarucus waterstradi, which may be considered as a potential indicator species, or may require further study as they are quite small to see in the field, which makes monitoring difficult [21]. Brumbun is also composed of the highest IV species, Appias spp., Papilio demoleon, Tarucus waterstradti, and Leptosia nina. Lebak buah is the area with the second high IV and Megatransect is the lowest. Ypthima horsfieldi which is also the most common, was the species with the highest IV in both in Lebak Buah and Megatransect (table 1).

Bias in recording butterfly species is an important issues when using butterfly species as indicator groups/species since their morphological and behavioural characteristics are developed to habituate with protective adaptations. Despite the unfavorable taste, conspicuous butterflies are easily detected by predator [11]. Similar to predator detection, butterflies with more apparent looks (color, size, and behavior) tend to easily detected by human, suggesting that field observation and identification is possible [22]. For example, Pieridae is the butterflies easily identified because of the white and yellow color and Papilionidae is identified because of large size with mostly black color [17]. Different flight patterns are known to occur in different butterfly species even within the same group [12].
Figure 3. Numbers of Nymphalidae and Pieridae in three sites relative to vegetation structure: tree height and canopy openness.

Table 1. Highest indicator value of butterfly species for Bali Barat National Park (only shows > 0.4 Indicator Value)

| Species              | Lebak Buah | Megatransek | Brumbun |
|----------------------|------------|-------------|---------|
| Appias sp.           | 13.33      |             |         |
| Papilio demoleon     | 13.33      |             |         |
| Tarucus waterstradi  | 13.33      |             |         |
| Leptosia nina        | 0.65       | 13.33       |         |
| Catopsilia scylla    | 1.00       |             |         |
| Cepora temena        | 1.00       |             |         |
| Pareronia sp.        | 0.46       | 8.75        |         |
| Ypthima horsfieldii  | 11.11      | 1.56        |         |
| Euthalia sp.         | 7.47       |             |         |
| Lasippa tiga tiga    | 7.47       |             |         |

Detection probability in butterfly survey is critical when providing sound-based information for biodiversity management. Refinement of methods and sampling design is needed. Currently, double observer approach in distance sampling has been developed for many bird studies [23, 24]. Applying similar approach would be promising for butterfly studies although it needs to be exercised.

The use of Indicator Value to select indicator species for butterfly was simple as it counts both abundance and frequency [18] and thus, avoiding the selection of rare species. Common species ensures that monitoring of indicator species is cost-effective [2]. Butterflies have been suggested to use as indicator species because they can be identified easily for many species and their correlations to plant may indicate plant diversity index [1]. However, Kremen [1] found out that butterflies are more related to vegetation heterogeneity than plant species richness. The correlations of butterflies to vegetation structure correspond to the species selected with the Indicator Value, suggesting that this method is also
applicable for butterflies. However, survey efforts should be put into concerns when surveying areas with low abundance butterflies such as Megatransect, a primary forest of Bali Barat National Park.

4. Conclusion
We conclude that butterflies are potential to use as indicator species. Pieridae and Nymphalidae were mostly selected as indicator species. In Bali Barat National Park, butterflies are more correlated to vegetation structure. The Indicator Value method can be applied to butterflies with regards to detection and identification.

References
[1] Kremen C, 1992 *Ecol. Appl.* **2** 203-17
[2] Carignan V and Villard M A, 2002 *Environ. Monit. Assess.* **78** 45-61
[3] Owen D F, 1971 *Tropical butterflies: The Ecology and Behaviour of Butterflies in the Tropics with Special Reference to African Species* (London: Clarendon Press)
[4] Spitzer K, Novotny V, Tonner M and Leps J, 1993 *J. Biogeogr.* **20** 109-21
[5] New T R, *Butterfly Conservation* 2nd edition (Melbourne: Oxford University Press)
[6] Spitzer K, Jaros J, Havelka J and Lepg J, 1997 *Biol. Conserv.* **80** 9-15
[7] Lomov B, Keith D A, Britton D R and Hochuli D F 2006 *Ecol. Manag. Restor.* **7** 204-10
[8] Nelson S M 2007 *Ecol. Indic.* **7** 469-80
[9] Erhardt A 1985 *J. Appl. Ecol.* **22** 849-61
[10] Danielsen F, Balete D S, Poulsen M K, Enghoff M, Nozawa C M and Jensen A E 2000 *Biodivers. Conserv.* **9** 1671-705
[11] Chai P 1996 *Journal of Linnaeus Society* **59** 37-67
[12] Scott J A 1975 *Ecology* **56** 1367-77
[13] Warfield J J, Arango N, Cabrera H and Melnick D J 2015 *The Rainforest Standard: Integrating Social, Environmental and Economic Well-being Vers. 2.0* (New York: The Trustees of Columbia University)
[14] van Balen S, Dirgayusa I W A, Putra I M W and Prins H H T 2000 *Oryx* **34** 188-97
[15] Pollard E 1977 *Biol. Conserv.* **12** 115-34
[16] Winarni N L 2007 *The Importance of Detectability in Butterfly Monitoring: Butterfly Diversity of Lambusango Forest, Buton, Southeast Sulawesi* available at https://noonathome.files.wordpress.com/2008/01/detect_2methods_symposium2007.pdf
[17] Corbet A S and Pendlebury H M 1992 *The Butterflies of the Malay Peninsula* (Kuala Lumpur: Malayan Nature Society)
[18] Dufrene M and Legendre P 1997 *Ecol. Monogr.* **67** 345-66
[19] Vu L V, Bonebrake T C, Vu M Q and N. Nguyen T 2015 *Pan-Pacific Entomologist* **91** 29-38
[20] Ghazoul J 2002 *Biodivers. Conserv.* **11** 521-41
[21] Caro T M and O’Doherty G 1999 *Conserv. Biol.* **13** 805-14
[22] Dennis R L H, Shreeve T G, Isaac N J B, Roy D B, Fox R and Asher J 2000 *Biol. Conserv.* **128** 486-92
[23] Nichols J D, Hines J E, Sauer J R, Fallon F W, Fallon J E and Heglund P J 2000 *The Auk* **117** 393-408
[24] Thomson W L 2002 *The Auk* **119** 18-25