A benchmark assessment of ecosystem health indicator species groups at Bali Barat National Park

N L Winarni1, A A Dwiyahreni1, D Hartiningtias1, Sunaryo1 and J Supriatna1, 2

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
2Department of Biology, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia

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

Abstract. Bali Barat National Park was assessed for its suitability to receive RFS Protected Area Credits™. Part of the requirement is to select indicator groups from among 5 terrestrial taxa, within the eligible forest in the park boundaries, (1) insects - butterflies, (2) amphibian, (3) reptiles, (4) birds, and (5) mammals that can serve as indicators for the overall ecosystem health of the TNBB. To select indicator groups, a biodiversity survey was conducted for during August-September 2015 in 3 study sites within Bali Barat National Park, Lebak Buah, Megatransect, and Brumbun. Different taxa were surveyed using peer-reviewed methods. The best indicator species within each taxon group (plants, butterflies, herpetofauna, birds and mammals) were defined based on their abundance and distribution in the eligible forest of the project area using Indicator Value method. Potential animal and plant indicator species were then assessed empirically for their cost-effectiveness based on survey effort and cost during the initial survey. Then they were evaluated for generality, functional importance, available scientific knowledge, and cross-taxon representation. Our results suggested that birds would be the best indicator species group, followed by butterflies, and plants. Such indicator is important surrogate for ecosystem health which can be used for conservation management priorities within protected area.

Keywords: Health indicator, biodiversity, Indicator Value method, Bali Barat National Park

1. Introduction

In a monitoring program, the use of indicator groups or taxa is a practical way to assess environmental changes, since observing all taxa in an area is logistically difficult and therefore is important to management of protected areas [1, 2]. Indicator taxa can provide an early warning of ecosystem alteration, an understanding of the cause of the alteration, and continuous assessment over wide range of pressures [3, 4]. Single species or multi-taxon groups may serve as indicator. However, studies on indicator species are relatively rare in in Indonesia. Groups of animals have been used to predict species richness of other taxa [5]. For example, Schulze et al. [5] used plants, birds, butterflies, fruit-feeding butterflies, and dung beetles.

Landres et al. [6] recommended several criteria to select an indicator: (1) sensitivity to changes in the environment; (2) variability of response; (3) specialist to certain habitats; (4) large body size,
(5) resident to the area and (6) wider area requirements. The most important initial step in selecting indicator species is identifying the state of the ecosystem as reflected by indicator species, and then by confirming the performance of potential species as indicators, using baseline information criteria [7]. Selecting from multiple ecological indicator groups will encompass a wide range of responses to disturbance and other management impacts [2]. To ensure the selection of high-performance indicators, the framework for selecting ecological disturbance indicators should integrates the sensitivity and reliability to disturbance response, as well as cost-efficiency [2].

The Bali Barat National Park (BBNP) which was formally gazetted in 1995, 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. [8] during 2015. The first funding mechanism applied to protected area in Indonesia, is a funding mechanism to support protected area management to maintain and conserve the biological values of protected areas while generating social, economic, and other environmental benefits, including the storage of carbon (http://cees.columbia.edu/rainforest-standard). Biological indicators in practice, can be used to evaluate compliance against required management scheme [2]. In order to detect the impacts of habitat changes for duration of the project, the current RFS demonstration project in Bali Barat National Park examined plants and 5 terrestrial animal taxa as potential ecological indicator groups: (1) insects – butterflies, (2) amphibians, (3) reptiles, (4) birds, and (5) mammals. In this study, we performed the selection of indicator species for Bali Barat National Park based their abundance and proportions in the area as well as cost-effective indicators. Such study will favor protected area management of Bali Barat National Park.

2. Study area and method

2.1. Study area
Research was conducted in Bali Barat National Park. The Bali Barat National Park (BBNP) covers around 19,366 Ha areas (8°05’S – 18°15’S and 114°25’E –114°34’E), comprising different habitat types such as savanna, mangroves, montane, and mixed monsoon forest. 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 [9] (figure 1).

Bali Barat National Park is the last stronghold of the endangered and endemic Bali starling (Leucopsar rothschildi) and the other approximately 160 species of birds and various protected mammal species such as pangolin (Manis javanica), black giant squirrel (Ratufa bicolor), porcupine (Hystrix branchyura), deer (Cervus timorensis), and mouse deer (Trangulus javanicus). Sampling plots were designed to traverse each possible combination of climate and geological types. The design followed the Rainforest Standard (RFS) and the survey was conducted from the 22nd of August to the 2nd of September 2015. We selected three study sites, 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, mangrove, 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, we only set up one transect of 3 km. At each transect, points were set up every 200 m (figure 1).

2.2. Method
Sampling techniques varied by taxonomic groups. We selected herpetofauna, butterflies, birds, and mammals. We chose the sampling techniques most applicable for each taxa associated with tropical forest conditions. Butterfly species were surveyed using a modification of Pollard’s walk method [10] by taking observations at points along the transect. Herpetofauna was surveyed using a belt transect and
pit-fall trap [11]. Birds were surveyed using the Point Count method, or Variable Circular Plots (VCP) [12]. Mammals were surveyed using the line transect method [13] and camera traps [14]. Location of all sampling sites and geographic coordinates were marked.

2.3. Analysis
The general framework for selecting high-performance ecological indicators within eligible forest in Bali Barat National Park was adapted from Gardner [2] (figure 2). The first filters for selection is assessment of standardised survey costs and Indicator Value. To assess the standardised survey costs, we conducted empirical assessment of sets of candidate taxa, herpetofauna, butterflies, birds, and mammals on the cost-effectiveness of the indicator, based on, number of labor, number of days, as well as hours of effort spent to calculate man-hour of effort and cost/man-hour [2]. Because the whole survey work took 12 days, number of days for surveying most taxa was mostly 12 days except for mammals where both line transect and camera trap method was used. Therefore, total survey days for mammals was 14 days which included 12 days of transect surveys and 2 days setting up and setting of camera trap (10 camera traps were deployed for 30 days but not included for calculation of man-hour).

While calculating the cost-effectiveness of the candidate, we also carried out the selection filter using Indicator Value method [15]. This method combines relative abundance and relative frequency of the species present in plots.

$$ IV_{ij} = A_{ij} \times B_{ij} \times 100 $$

$ IV_{ij} $ = Indicator Value of species $ i $ in habitat $ j $

$ A_{ij} $ = Relative abundance of species $ i $ in habitat $ j $

$ B_{ij} $ = Relative frequency $ i $ in habitat $ j $
The calculation of Indicator Value only applies to birds, butterflies, and vegetation since there were not enough data for herpetofauna and mammals. Then, to confirm the utility of the high performance indicator species we selected, we applied simple secondary selection filters including prior ecological knowledge, functional importance, generality, and cross-taxon representation [2].

3. Results and discussion

3.1. Standardize survey costs and indicator value

Our first filter of selection suggested that mammal survey was a high-cost activity. The mammal survey used both a line transect and camera traps, which required more equipment and persons for labor. Herpetofauna was found to be the second highest-cost taxa to survey. Because of their low cost-effectiveness, mammals and herpetofauna were rejected as indicator groups. Among the three remaining taxa selected as representative Ecological Indicator Group Species, the most cost-effective indicator group species are birds, followed by butterflies, and plants (table 1, figure 3). Birds are selected as the most cost-effective indicator because birds can be identified directly in the field without cost of identification processing. Relevant experts and identification guide books are available to many parts of Indonesia [16].

Within ecological indicator groups, we selected a representative set of 10 Ecological Indicator Group Species within the group. These representative species were selected based on the highest IV within each group. Only birds, butterflies, and plants have sufficient IV in eligible forest. Amongst these, plants have the highest IV and butterflies were the lowest (table 2). However, birds were more likely to be found at more than one site.

Indicator Value [15] is probably the first step and the most popular method to select indicator species. In this report, both IVs and site representation are the most important criteria to validate the Indicator Species. These criteria represent relative abundance and representation on sites. Some taxa were disqualified as indicators despite having characteristics that are generally predictive of IV. For example,
Table 1. Summary of efforts for each taxa surveys.

| Taxon   | Method          | Labour | Day work | Hour work | Hour work/day | Man-hour | Labour price (Average in Rupiah) | Cost Man-hour |
|---------|-----------------|--------|----------|-----------|---------------|----------|----------------------------------|---------------|
| Mammals | Line transect   | 4      | 14       | 4         | 0.33          | 1.33     | 450,000                          | 598,500       |
|         | Camera trap     | 2      | 2        | 3         | 1.50          | 3.00     | 450,000                          | 1,350,000     |
|         | Total mammals   |        |          |           |               | 1.83     | 4.33                             | 1,948,500     |
| Herpetofauna | Belt transect | 4      | 12       | 8         | 0.67          | 2.67     | 450,000                          | 1,200,000     |
| Plants  | Sampling plot   | 5      | 12       | 6         | 0.50          | 2.50     | 450,000                          | 1,125,000     |
| Butterflies | Point count | 4      | 12       | 5         | 0.42          | 1.67     | 450,000                          | 750,000       |
| Birds   | Point count     | 4      | 12       | 3         | 0.25          | 1.00     | 450,000                          | 450,000       |

Figure 3. Comparison of labor, hour-work/day, man-hour, and cost/man-hour for each taxa survey costs

body size, which can correlate to turnover rates and size of area requirement [6], did not seem important. Mammal species *Trachypithecus auratus*, although considered an important seed disperser, is present around Prapat Agung Peninsula [17] including within the Lebak Buah area, at only low density. Because of this low density within eligible forest this species is not applicable for IV calculation. Large-bodied birds with a large homorange—such as the Wreathed hornbill (*Aceros undulatus*) or large terrestrial birds such as *Gallus gallus* and *Gallus varius*—were also present at only low abundance. Although terrestrial birds are usually more sensitive to disturbance [18], they may not be as efficient to monitor, and need more survey effort than common birds because of the low population abundance [19, 20].

3.2. Prior ecological knowledge, functional importance, generality, and cross-taxon representation

The secondary selection filters including prior ecological knowledge, functional importance, generality, and cross-taxon representation were general descriptions of each taxa represented [2]. Only birds, butterflies, and plants were described (table 3).

Generality is defined as the degree of representation of the species across study sites [2]. During the survey, we found 4 bird species which were detected in all 3 study sites (Lebak Buah, Megatranssect and Brumbun). However, each species has a different IV at each site, which indicate sensitivity (i.e. species which rely on relatively narrow or specific conditions for survival, the opposite of “generality”) (Appendix 1). Sensitivity was more apparent in plants. None of the plant species in eligible forest were found in more than one site, except for *Shoultenia ovata* (Appendix 1). A taxon that performs well as an indicator in a wider forest ecosystem is likely possesses functional importance. They are good
indicators because they perform a critical function within the ecosystem. Such functions include seed dispersal, pollination, and biotic interactions, which may be affected as a result of biodiversity loss [2] and so loss of species with functional important can signal negative consequences for ecosystem health.

Prior knowledge specific to surveyed species, in Bali, was usually very limited. We found some information on taxa such as birds and butterflies based on previous research in other areas [21-23]. Cross-taxon representation denotes the extent to which taxa can act as functional surrogates or substitutes for other taxon [2]. Birds and butterflies are commonly used as cross-taxon representatives for one another [24]. In this report, cross-taxon representation of birds and butterflies is considered solely at the taxon -not species- level (not species specific) (table 3).

**Table 2.** Ecological indicator group species among plants, birds, and butterflies with Indicator Value for each species.

| Taxa         | Species            | Lebak Buah | Megatransek | Brumbun |
|--------------|--------------------|------------|-------------|---------|
| Birds        | Aegithina tîphia   | 1.45       | 59.46       |         |
|              | Dicaeum sp.        | 25.60      | 0.71        | 0.26    |
|              | Dicrurus paradiseus| 22.40      | 0.71        | 0.26    |
|              | Macropygia sp.     | 16.00      |             |         |
|              | Nectarinia jagularis| 3.27      | 34.66       |         |
|              | Oriolus chínensis  | 0.57       | 16.33       | 1.47    |
|              | Orthotomus sepium  | 28.57      | 7.77        | 44.32   |
|              | Pitta guajana      | 5.82       | 18.18       |         |
|              | Pycnonotus goaviuer| 8.67       |             | 27.85   |
|              | Pycnonotus melanicterus | 24.89 | 1.59      |         |
| Butterflies  | Appias sp.         |            |             | 13.33   |
|              | Papilio demolion   |            |             | 13.33   |
|              | Tarucus waterstradhi|          |             | 13.33   |
|              | Leptosia nina      | 0.65       |             | 13.99   |
|              | 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       |             |         |
| Plants       | Averrhoa sp.       | 1.46       | 0.65        |         |
|              | Cyathocalyx sumatranus|        | 11.11       |         |
|              | Grewia koordersiana|          | 11.11       |         |
|              | Ficus glomerate    | 5.56       |             |         |
|              | Tectona grandis    | 5.56       |             |         |
|              | Croton argyrratus  |            |             | 5.56    |
|              | Shoultenia ovata   | 1.85       |             | 5.56    |
|              | Symplocos javanica |            |             | 5.56    |
|              | Beilschmiedia lucidula |      | 11.11       |         |
|              | Pterospermum javanicum |       | 11.11       |         |
Table 3. Secondary selection filter of the cost-effective Ecological Indicator Group Species

| Taxa       | Generality          | Functional importance | Prior knowledge                      | Cross-taxon representation                             |
|------------|---------------------|-----------------------|--------------------------------------|-------------------------------------------------------|
| Birds      | Some are present in more than 1 site | Seed dispersers        | Specialist to habitat type           | Bird community indicator of butterfly richness         |
|            |                     | Insectivores - pest control | Commonly used as indicator species   | Nectarivores are associated with flowering plants      |
|            |                     | Pollinators            |                                      |                                                       |
| Butterflies| Present in open areas or forest gaps | Pollinators            | Pieridae tend to be in open areas    | Butterflies indicator for bird richness                |
|            | May be present in more than 1 site | Pest to some vegetation | Commonly used as indicator species   |                                                       |
| Plants     | More likely to be site-specific | Provide habitat for wildlife |                                      | Mangroves may be associated with particular bird species |
|            |                     | Fruting plants (figs) a food source for wildlife (birds, primates) |                                      | Some plants associated with Nectarivore birds          |

4. Conclusion
Bali Barat National Park is a small confined protected area in Bali, and yet wildlife populations are low in number and density, contrary to Island biogeography theory which assumes that species density is greater on small islands [25]. Because of this anomaly, selection of indicator species should be treated more cautiously at TNBB. The Brumbun area is clearly the flagship habitat for Bali Barat National Park. Its flagship species, the Bali mynah (*Leucopsar rothschildi*), only occurs there. In Brumbun, almost all bird species are small, except *Gallus varius*. The Common iora is usually associated with mangroves [26], which habitat type occur in Brumbun. Birds are found to be cost-effective indicator species for Bali Barat National Park. Common abundant species can be effective indicator as they are usually well represented across different habitat types [27]. *Bruguiera gymnorrhiza* is an example of a mangrove plant that support the habitat for indicator species (Appendix 1). Common abundant species with high IV may be efficient indicator species because of the ease of detection and observation in the field. However, presence or absence of these species should be monitored to confirm their performance as indicator species.

References
[1] Lindenmayer D B 1999 *Ecology and Management* 115 277-87
[2] Gardner T 2010 *Monitoring Forest Biodiversity* (London and New York: Earthscan)
[3] Noss R F 1990 *Conserv. Biol.* 4 355-64
[4] Carignan V and Villard M-A 2002 *Environ. Monit. Assess.* 78 45-61
[5] Schulze C H 2004 *Ecol. Appl.* 14 1321-33
[6] Landres P B, Verner J and Thomas J W 1988 *Conserv. Biol.* 2 316-29
[7] Hilty J and Merenlender A 2000 *Biol. Conserv.* 92 185-97
[8] Warfield J J, Arango N, Cabrera H and Melnick D J 2012 *The Rainforest Standard: Integrating Social, Environmental, and Economic Well-being. Vers. 2.0.* (New York: The Trustees of Columbia University in the City of New York and Its Center for Environment, Economy, and Society)
[9] Van Balen S, Dirgayusa I W A, Putra I M W A and Prins H H T 2000 *Oryx* 34 188-97
[10] Pollard E 1977 *Biol. Conserv.* **12** 115-34
[11] James C D 1991 *Herpetologica* **47** 194-210
[12] Bibby C J, Burgess N D, Hill D A and Mustoe S 2000 *Bird Census Technique* 2nd edition (London: Academic Press)
[13] Buckland S T, Anderson D R, Burnham K P, Laake J L, Borchers D L and Thomas L 2001 *Introduction to Distance Sampling: Estimating Abundance of Biological Populations* (Oxford: Oxford University Press)
[14] O’Brien T G 2011 *Abundance, density and relative abundance: A conceptual framework Camera Traps in Animal Ecology* ed O’Connell A F et al. (London: Springer) pp. 71-96
[15] Dufrene M and Legendre P 1997 *Ecol. Monogr.* **67** 345-66
[16] Gardner T A 2008 *Ecol. Lett.* **11** 139-50
[17] Leca J-B, Gunst N, Rompis A, Soma G, Putra I G A A and Wandia I N 2013 *Primate Conserv.* **26** 133-44
[18] Winarni N L, O’Brien T G, Caroll J P and Kinnaird M F 2009 *The Auk* **126** 341-50
[19] Verner J 1984 *Environmental Management* **8** 1-13
[20] Purcell K L, Mori S R and Chase M K 2005 *The Condor* **107** 305-20
[21] Cleary D F R, Boyle T J B, Setyawati T and Menken S B J 2005 *J. Appl. Entomol.* **129** 52-9
[22] Cleary D F R, Genner M J, Boyle T J B, Angraesti C D and Menken S B J 2005 *Landsc. Ecol.* **20** 989-1001
[23] Cleary D F R and Genner M J 2006 *Biods. Conserv.* **15** 517-38
[24] Blair R B *Ecol. Appl.* **9** 164-70
[25] Connor E F, Courtney A C and Yoder J M 2000 *Ecology* **81** 734-48
[26] Sodhi N S, Choo J P S, Benjamin P, Lee Y-H, Quek K C and Kara A U 1997 *Raffles B. Zool.* **45** 1-14
[27] Chase M K, Kistam W B, Lynam A J, Price M V and Rotenberry J T 2000 *Conserv. Biol.* **14** 474-87

Appendix 1.
List of birds, butterflies, and plants with Indicator Values as selected indicator in eligible forest area of Bali Barat National Park.

| Species                  | Lebak Buah | Megatransect | Brumbun  |
|--------------------------|------------|--------------|----------|
| Accipiter soloensis      | 5.13       |              |          |
| Aceros undulatus         | 3.20       | 12.86        |          |
| Aegithina tipha          | 1.45       |              | 59.46    |
| Alectro sp               | 4.00       |              |          |
| Alophoexus sp            | 4.00       |              |          |
| Anthracoceros albirostris| 4.00       |              |          |
| Arachnothera sp          | 8.00       |              |          |
| Artamus leucorhynanus    | 6.67       | 7.14         | 1.28     |
| Chalcoptus indica        |            |              | 5.13     |
| Chloropapis coccinchenis | 8.00       |              |          |
| Chloropapis sonnerati    | 8.00       |              |          |
| Chloropapis sp           | 12.00      |              |          |
| Coraciina javensis       |            |              | 7.69     |
| Cypsinina temia          |            |              | 5.13     |
| Dicrurus sp              | 25.60      | 0.71         | 0.26     |
| Dicrurus trigonostigma   | 20.00      |              |          |
| Dicrurus trochileum      | 1.33       |              | 3.42     |
| Dicrurus paradiaseus     | 22.40      | 0.71         | 0.26     |
| Dicrurus sp              |            |              | 7.69     |
| Dinopium javanense      |            |              | 5.13     |
| Gallus gallus            | 1.33       |              | 7.14     |
| Gallus varius            |            |              | 1.71     |
| Geopela strata           | 10.26      |              |          |
| Gerygone sulphurea       |            |              | 10.26    |
| Species                          | Lebak Buah | Megatransect | Brumbun |
|---------------------------------|------------|--------------|---------|
| Graculidae religiosa            | 2.00       | 3.57         |         |
| Haliaeetidae leucogaster        |            |              | 2.56    |
| Hemiprocne longipennis          |            |              | 7.69    |
| Hemipus hirundinaceus           |            |              | 7.69    |
| Hypothymis azurea               | 6.00       |              | 2.56    |
| Icterinaeus malayensis          | 8.00       |              |         |
| Lalage nigra                    |            |              | 5.13    |
| Lonchura sp.                    | 5.33       |              | 0.85    |
| Macropygia sp.                  | 16.00      |              |         |
| Malacopteron sp.                | 8.00       |              |         |
| Megalaima armillaris            | 4.00       |              |         |
| Megalaima australis             | 2.00       |              | 1.28    |
| Megalaima haemacephala haemacephala | 0.33 |              | 14.10   |
| Megalaima sp.                   |            | 7.14         |         |
| Merops leschenaulti             |            |              | 5.13    |
| Nectarinia jugularis            | 3.27       | 34.07        |         |
| Nectarinidae                     | 7.14       |              |         |
| Oriolus chinensis               | 0.57       | 16.33        | 1.47    |
| Oriolus sp.                     | 5.33       | 0.00         | 0.85    |
| Orthotomus sepium               | 28.57      | 7.77         | 44.32   |
| Parus major                     |            |              | 12.82   |
| Pellarine capistratum            | 4.00       |              |         |
| Pericrocotus cinnamomea          |            |              | 5.13    |
| Picoides moluccensis             |            |              | 23.08   |
| Picus vittatus                  | 4.00       |              |         |
| Pita guajana                    | 5.82       | 18.18        |         |
| Prinia familiaris               | 4.00       |              |         |
| Prinia sp.                      |            |              | 2.56    |
| Ptilinopus cinctus              |            |              | 2.56    |
| Pycnonotus goiavier             | 8.67       | 27.85        |         |
| Pycnonotus melanicterus         | 24.89      | 15.38        |         |
| Rhodinura javanica              |            |              |         |
| sp.4                           | 7.14       | 20.5         |         |
| Spilornis cheela                |            |              |         |
| Stachyris melanotyrax           | 4.00       |              | 7.69    |
| Streptopelia bitoquata          |            |              |         |
| Timaliidae                      | 3.57       | 1.28         |         |
| Todiramphus chloris             |            |              | 10.26   |
| Treron vernans                  | 4.00       |              |         |
| Zosterops palpebrosus           | 16.00      |              |         |
| Zosterops sp.                   | 1.00       |              | 5.77    |
| **Butterflies**                 |            |              |         |
| Alloitus sp.                    | 3.70       |              |         |
| Appias lynca                    | 1.01       | 7.27         |         |
| Appias olfere                   |            |              | 3.33    |
| Appias sp.                      |            |              | 13.33   |
| Arrhopala sp.                   | 3.70       |              |         |
| Artophaneura sp.                |            | 6.25         |         |
| Bassaroma danya mahara           | 3.70       |              |         |
| Catopsis pomona                 |            | 6.67         |         |
| Catopsis pyrunthe               | 2.78       | 2.08         |         |
| Catopsis scylla                 |            | 10.00        |         |
| Catopsis sp.                    |            | 3.33         |         |
| Cepora juddith                  |            | 6.67         |         |
| Cepora nerissa                  |            | 3.33         |         |
| Cepora sp.                      |            | 6.67         |         |
| Cepora temena                   |            | 10.00        |         |
| Cherioniesta peraka             |            |              |         |
| Cepha erymanthis                | 6.67       | 2.67         |         |
| Danaus cresius                  |            | 3.33         |         |
| Danaus sp.                      |            | 3.33         |         |
| Delias sp.                      |            | 6.67         |         |
| Dolechallia bisaltidæ           | 1.85       |              | 1.67    |
| Drupadina ravinthera            | 1.23       | 4.17         |         |
| Euploea caramolchæman           | 1.85       | 3.13         |         |
| Euploea gamelia                 |            | 6.25         |         |
| Euploea phaenoreita             |            | 6.25         |         |
| Euploea sp.                     | 1.54       | 3.65         | 1.39    |
| Euereina alitha                 |            | 6.25         |         |
| Species                | Lebak Ruah | Megatransect | Brumbun |
|------------------------|------------|--------------|---------|
| Eurema hecabe          | 0.62       | 1.92         | 3.08    |
| Eurema sp.             | 1.71       | 6.25         |         |
| Euthalia monina        | 3.70       |              |         |
| Euthalia sp.           | 7.41       |              |         |
| Faunis canens          |            |              | 6.25    |
| Hebomoea glaucipes     |            |              | 6.67    |
| Ideopsis sp.           | 1.85       |              | 3.33    |
| Isias pyrene           |            |              | 3.33    |
| Isias reinwardtii baliensis |      |              | 3.33    |
| Jamides bochus         |            |              | 3.33    |
| Jamides sp.            |            |              | 3.33    |
| Junonia iphita         | 1.85       |              | 1.67    |
| Junonia sp.            | 1.23       |              | 4.44    |
| Lasippa tiga tiga      | 7.41       |              |         |
| Leptosa nina           | 0.06       |              | 13.10   |
| Megisiba mutila        | 3.70       |              |         |
| Melanitis teda         |            |              | 6.25    |
| Mycalesis horfieldii   | 3.70       |              | 6.25    |
| Mycalesis sp.          | 3.70       |              |         |
| Neocadora subperusia   | 3.70       |              |         |
| Neocera dominia        |            |              | 6.25    |
| Nepis niah             | 3.70       |              |         |
| Nepis sp.              | 4.12       | 0.69         | 2.22    |
| Papilio demolon        |            |              | 13.33   |
| Papilio menmon         | 3.70       |              |         |
| Papilio nephelium      | 3.70       |              |         |
| Papilio partis         |            |              | 6.67    |
| Papilio peranthus      | 1.85       |              | 1.67    |
| Papilio polytes        | 3.70       |              |         |
| Papilio sp.            | 3.70       |              |         |
| Paramenica aglooides   | 3.70       |              |         |
| Pareronia sp.          | 0.46       |              | 8.75    |
| Phaedyma collumela     | 2.47       | 2.08         | 2.22    |
| Phaedyma sp.           | 0.00       | 6.25         |         |
| Pieris sp.             | 3.70       |              |         |
| Prothoe franck pranck  |            |              | 6.25    |
| Tanaecia japit         | 3.70       |              |         |
| Tanaecia palguna       | 6.25       |              |         |
| Tanaecia pelea         | 6.25       |              |         |
| Tanaecia sp.           | 6.25       |              |         |
| Tarucus waterstradii   |            |              | 13.33   |
| Thaumantis odana       | 3.70       |              |         |
| Yoma subina            | 1.85       |              | 1.67    |
| Ypthima horfieldii     | 11.11      | 1.56         |         |
| Zemerus flegyas         | 3.70       |              |         |

### Plants

| Species              | Percentage |
|----------------------|------------|
| Aglaea rubiginosa    | 28.93      |
| Alstonia macrophylla | 21.37      |
| Averrhoa sp.         | 58.22      |
| Beilschmiedia lucidula | 49.59     |
| Bruguiera gymnorryza | 32.39      |
| Caecaria sp.         | 70.08      |
| Cordia dichotoma     | 16.48      |
| Cryptocarya vorea    | 41.41      |
| Croton argyryatus    | 19.37      |
| Cyathocalyx sumatr anus | 25.84    |
| Dendrognidae sp.     | 37.80      |
| Diospyros buculofila | 55.12      |
| Eugenia jambulolides | 23.65      |
| Eugenia javanica     | 64.08      |
| Eugenia sp.          | 87.77      |
| Excoecaria angallocha| 59.28      |
| Ficus                | 50.86      |
| Ficus glomerate      | 32.21      |
| Grewia koordersiana  | 42.90      |
| Gulam-gulam          | 65.07      |
| Hymenodictyum excelsum | 34.74    |
| Species                      | Lebak Buah | Megtransect | Brumbun |
|------------------------------|------------|-------------|---------|
| Litocarpus sp.               |            | 37.30       |         |
| Pemphis acidula              |            |             | 50.27   |
| Pterospermum diversifolium   | 18.81      |             |         |
| Pterospermum javanicum       | 17.60      |             |         |
| Schleichera oleosa           | 38.36      |             |         |
| Sclerodendron sp.            | 44.87      | 77.04       |         |
| Shoultenia ovata             |            | 44.28       | 42.39   |
| Sterculia sp                 |            |             |         |
| Symplocos javanica           |            |             | 34.70   |
| Toona sureni                 |            |             | 26.46   |
| Vitex pubescens              |            |             | 30.37   |