Effects of Deforestation on Butterfly Diversity in and around Lambir Hills National Park, Sarawak, Malaysia

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Introduction

Tropical rainforests have been greatly disturbed by various kinds of human activities. In the lowlands of Sarawak, Malaysia, shifting cultivation based on slash-and-burn agriculture has been widely and conventionally adopted (Ichikawa 2003, 2004). The shifting cultivation accompanies deforestation of primary or secondary forests and is thus likely to influence the biodiversity of these forests. Moreover, this practice usually generates patches of remnant primary (undisturbed) forests and increasingly leads to isolation of these remnant areas (i.e., to forest fragmentation). This isolation is itself thought to reduce biodiversity in remnant forests (Laurence and Bierregaard 1997). To conserve the extremely rich biodiversity of the lowland dipterocarp forests of Sarawak, and to support the required policy development, the effects of human activities (e.g., shifting cultivation) on biodiversity must be qualitatively and quantitatively assessed.

From this perspective, various kinds of arthropods, which are considered to be the richest taxon in terms of species diversity, have been studied (e.g. Vasconcelos 1999, Willott 1999, Willott et al. 2000, Davis et al. 2001, Watt et al. 2002). Among these species, butterflies are a good indicator of biodiversity because they are mostly oligophagous herbivores. They are thus likely to reflect the status and species composition of the vegetation and the characteristics of microhabitats because they are easy to monitor by means of relatively brief, low-labor field surveys based on the observation of flying adults and because it is relatively easy to identify the different species.

In this study, we investigated the butterfly community in a lowland dipterocarp forest in Sarawak and in patchily distributed secondary forests around this primary forest. In particular, we determined the absence and presence of butterfly species in forest stands of different ages based on the elapsed time since slash-and-burn agriculture had been abandoned and in primary forest. By comparing the patterns of absence and presence among forest types, we attempted to determine the effects of the deforestation that accompanies shifting agriculture on the diversity of butterfly species.

Methods

All of our research was conducted in and around the Lambir Hills National Park (LHNP), Sarawak, Malaysia (4°2'–4°11'N, 113°50'–114°3'E; 150 to 200 m a. s. l.). The area of LHNP is ca. 70 km^2 (Yumoto

and Nakashizuka 2005), and the climate is humid-tropical, with only a weak seasonal change in rainfall (Kato et al. 1995). Most of LHNP is covered by lowland mixed dipterocarp forest. Details of the vegetational features were described by Kato et al. (1995). The park is surrounded by secondary forest of different stand ages (i.e., different elapsed times after the last slash-and-burn cultivation) and by cultivated fields, rice paddies, extensively managed rubber plantations, and intensively managed oil palm plantations.

In the secondary forest around LHNP, we chose four stand types for our survey: sapling secondary forest stands (abbreviated as SSF) that were 1 year old at the initial time of the survey, young secondary forest stands (YSF) and extensively managed rubber plantations (ERP) that were 7 to 15 years old, and old secondary forest stands (OSF) that were more than 30 years old. In ERP, rubber trees were planted and extensively cultivated, but some of the dominant tree species observed in YSF were also present and grew to a size similar to that of their conspecifics in YSF. In addition, we studied two types of remnant primary forest that were isolated from the primary forest in the national park: distant remnant forest stands (DRF) and nearby forest stands (NRF). The former were more than 1.0 km from the reserved area and the latter were located within 500 m of the border of the reserved area.

For each of the stand types except OSF, we chose three representative study stands; for OSF, we chose six study stands. In each of the 21 forest stands, we established a 100-m line transect at the approximate center of the stand. We also randomly chose two open areas (forest gaps or bordering areas) 20 m in diameter in each forest stand. In addition to the six types of forest stands, we randomly set up three line transects, separated by more than 800 m, in the reserved primary forest of LHNP; we called this type of forest "primary forest" (PF). For each of the line transects in PF, we chose two open areas similar to those in the other six types of forest stand. Nakagawa et al. (2006) provided more details on stand characteristics such as tree species composition, total basal area of trees, and physical environmental conditions. Our study plots were generally similar to those in Nakagawa's study.

We conducted surveys to determine the absence and presence of butterfly species along the line transects and in the two open areas in each study stand. To perform our census in each study stand, we walked along the line transect for ca. 10 min and stayed in each of the open areas for ca. 10 min. During this time, we attempted to capture all butterflies that we encountered. More than half of the butterflies observed were caught using nets and then all caught were identified to the species level. We were also able to visually identify most butterflies that escaped our nets to the species level. We were unable to identify fewer than about 5% of the butterflies, and we omitted these individuals from the census data. All the species were recorded and some butterflies were mounted as voucher specimens, especially for individuals of species that are difficult to identify. The census at each site, which lasted for 30 to 45 min. in total, including handling time, took place in a period under clear skies between 0930 and 1300. The absence and presence data for each species and forest type was obtained twice during this period. We obtained four data matrices (presence or absence of a given species in each type of forest): in August 2003, September 2003, January 2005, and June 2005.

Based on these four matrices, we calculated the number of species observed in each stand. We then compared this number among forest types in order to determine the effects of deforestation on the butterfly species diversity.

Results and Discussion

We identified a total of 159 butterfly species throughout the study period. The number of species observed at least once for each type of forest stand is shown in Fig. 1. The mean number of species was highest in the primary forest stands (PF) and second highest in the nearby remnant forest stands (NRF), followed by the distant remnant forest stands (DRF), the old secondary forest stands (OSF), and the young secondary forest stands (NSF). It was lowest in the sapling secondary forest stand (SSF) and second lowest in the extensively managed rubber plantations (ERP), suggesting that both stand types have substantial negative effects on the butterfly diversity. Approximately 90% of all species recorded throughout the study period were observed in PF. These results suggest that deforestation due to slash-and-burn agriculture drastically decreased the butterfly species diversity in and around the affected area and that it is likely to take a long time (at least several decades based on the results for OSF) for butterfly species diversity to recover. In addition, forest fragmentation (NRF and DRF stands) also remarkably decreased the butterfly species diversity (to roughly half the levels in PF).

The results of our study clearly demonstrate that the disappearance of or large reductions in the area of primary forest clearly threatens to seriously damage the butterfly species diversity in lowland dipterocarp forests of the Southeast Asian tropics. It is likely that similar adverse consequences will occur for other species, but further research will be required to quantify these losses.

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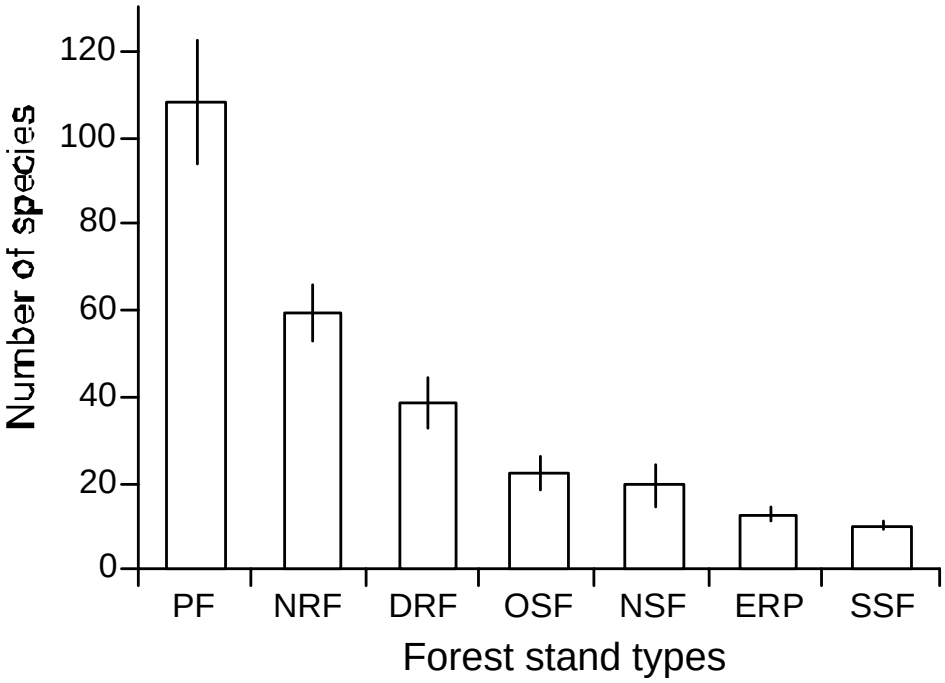

Figure 1. Number of species observed at least once for each forest stand types. Bars and vertical lines indicate the means and standard deviations, respectively. See text for abbreviations of the forest stand types.