Community patterns of birds and butterflies in Lambusango forest, Buton, Southeast Sulawesi in 2006

Report to GEF Lambusango Conservation Program

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Executive Summary

- This is the second year of the bird monitoring programme. The 2006 bird survey recorded 51 bird species of which 25 species are endemic to Sulawesi. Comparison between 2005-2006 data showed similar patterns with Wahalaka and Wabalamba having the most diverse and similar bird species assemblages, and Anoa, as in 2005 had the least diverse assemblage.

- Estimated densities of bird species showed variation between wet and dry seasons with many species apparently more abundant in the dry season. Estimated densities for the most abundant birds are lower in 2006 except for green imperial pigeon.

- The vegetation structure analysis suggested that all of the node camps were experiencing similar levels of disturbance although the variables measured may not be sensitive enough to differentiate the distinctiveness between sites.

- Some of the key bird species such as many Columbidae species and hornbills were more abundant in the less disturbed forest and mature forest.

- A total of 77 species of butterflies were recorded during May-August 2006 (the first year of systematic butterfly census), which included 54 Nymphalidae, 11 Papilionidae, 11 Pieridae, and 1 Riodinidae. Among these, 26 species are endemic to the region or to Sulawesi. Overall Wahalaka and Wabalamba were found to have the most diverse and most similar butterfly communities and Anoa had the lowest species richness and diversity. This means that the bird and butterfly communities show very similar patterns.

- Butterfly diversity at ground level was the lowest and dominated by *Faunis menado*. *Lohora opthalmica* and *Elymnias hewitsoni* of Nymphalidae dominated the medium and higher level.

- A paper on “the importance of detectability in butterfly monitoring: butterfly diversity of Lambusango forest, Buton, Southeast Sulawesi “ has been presented at the national insect conference held in Bogor, 27-30 January 2007.

Introduction

For the last five years, the Lambusango Forest Area of Buton Island has been the focus for biological research carried out by the Operation Wallacea programme. These long-term studies have shown that the area supports a high level of biodiversity including anoa (*Bubalus depressicornis*) and Buton macaques (*Macaca ochreata brunnescens*). Buton island is known to support at least 231 bird species including 52 Sulawesi endemics and 9 Indonesian endemics (Catterall 1996), making it an extremely important site for bird conservation. As for butterflies, 557 species are recorded for Sulawesi (Vane-Right and de Jong 2003) and although research on Buton has not been conducted thoroughly, at least 175 species have been recorded (Opwall 2000) with at least 55 species (excluding Hesperiidae and Lycaenidae) recorded around the forest of Lambusango (Wallace 2004).

The Lambusango Forest is located in the centre of Buton island, Southeast Sulawesi. The area consists of ±28,510 ha protected areas (Nature and Wildlife Reserves) and ±35,000 ha production forest (Singer and Purwanto 2006). The Lambusango Forest has been suffered from various disturbance including hunting, forest conversion to agriculture, asphalt mining, illegal logging, and uncontrolled rattan extraction (Singer and Purwanto 2006). Thus, in early 2005, a joint programme between Operation Wallacea and Global Environmental Fund (GEF) of the World Bank, established the Lambusango Forest Conservation Program. The programme aims to develop an integrating forest management system for the protection of forest and its surroundings and the development of the people living around the forest areas. One of the measures of success of the programme is a biodiversity monitoring project and this report focuses on one aspect of this, namely the monitoring of the bird and butterfly communities.

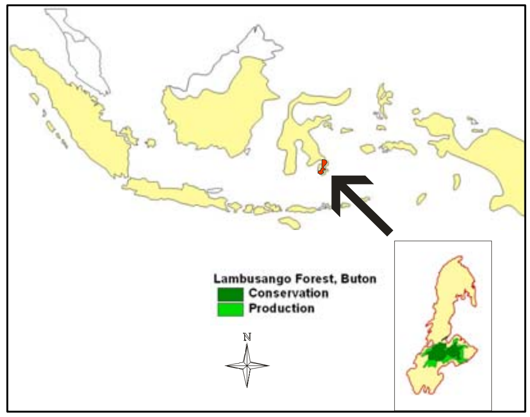
The continuous change of forests will obviously affect biological communities, and there is a necessity to conduct ecological monitoring to assess the impact on those communities (Spellerberg 2005). Spellerberg (2005) also suggests that such ecological monitoring is particularly important when the ecosystems in question have not been researched comprehensively. In addition, long-term monitoring is needed to support management schemes to combat human-induced disturbances which themselves have an impact in the longer term (Spellerberg 2005).

As part of the study to determine the community patterns of birds and butterfly in Lambusango Forest, this paper reports findings from 2006 survey including population levels of key bird species, habitat associations of key bird species, and butterfly community structure as required. Data on bird community patterns, species abundance and habitat structure are presented. At least one more visit is obviously required before we establish some of the parameters needed for the longer term monitoring programme (power analysis to estimate required sample sizes). The period of May-August 2006 constituted the second sampling for the the bird survey and first sampling for butterfly communities.

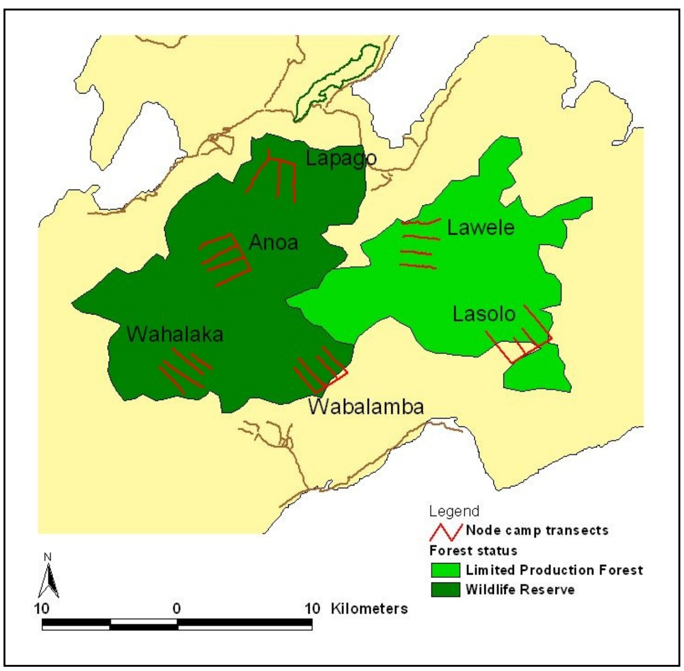
Study Area and Methods

Study Area

Studies were conducted between May-June 2006 and July-August 2006 as continuation of the 2005 surveys. Data collection was carried out at 6 'node' camps in the Lambusango Forest Area - Lawele, Lasolo, Walahaka, Anoa, Wabalamba, and Lapago. Four are situated within the Lambusango Forest Reserve, and two within the adjacent limited production forest (Lawele and Lasolo). Different nodes were experiencing different kinds of anthropogenic disturbance. The greatest levels of disturbance are reported to be in Wahalaka and Wabalamba in the south of the Lambusango Forest Reserve. Both Lapago and Anoa sampling nodes are long-abandoned gardens. Lawele sampling node in the limited production forest showed the least disturbed forest with a high frequency of large trees, though there was evidence of high levels of rattan collection in the area (Seymour 2004). Approximately one week was spent at each node camp at each season. Four transects, each 3km in length, were set up at each site and each transect was marked at 50 m intervals.



Location of Lambusango Forest, Buton, Southeast Sulawesi



Node camp locations within Lambusango forest, Buton

Methods

Different than previous year when survey only covered breeding season, the 2006 survey covered both the non-breeding season and the breeding season. The non-breeding season was conducted during May-June 2006 (wet season) and the breeding season was conducted during July-August (dry season) in correspond with Operation Wallacea.

Bird Counts

Bird species was surveyed using the Variable Circular Plot methods (point counts with distance estimates to each contact) following Bibby et al. (2000). Points were located at 150-m interval along each of the transects at each node camp and were visited between 0600 and 0800 hours. Preliminary surveys in the area suggested that bird activity started to increase at 0600 and dropped off markedly after 0800. Therefore, we decided to use a 150-m interval between adjacent points to reduce the travelling distance between each point and increase the number of points each day. Due to increased possibility of double counting the birds, we monitored the position of calling birds so that the same birds were not recorded at more than one point. Two groups consisting of 2-3 recorders led by an experienced observer stayed at each point and recorded any birds detected around the central point for 10 minutes without the use of a settling down period. Recent research has shown that settling down periods reduce the numbers of contacts recorded (M. Jones pers.comm.). Each group visited different points each day and did point counts only once at each point. When one group conducted a count at one point, then the other group would replicate the point on the following day. All birds heard and seen were recorded (those flying were noted but not used for the subsequent analysis) and an estimate of distance was made to each contact. Amongst the assumptions of this 'Distance Sampling' method are that the birds must be correctly identified and that the distance estimates are accurate (or at least the errors are small and random). All observers spent approximately one week prior to data collection, learning to recognize bird species and bird calls, as well as practicing methods. The performance of individuals on this training programme was monitored and the results will be analysed for the final report.

Bird counts during the wet season were conducted in a slightly different way where only 1 group of observer did the count. Only one replication applied to each point. The rest of the technique is the same as dry season survey.

Butterfly Counts

In 2005, we tried out different methods of surveying butterflies such as 'Pollard' walks and fruit-bait traps as well as trying to identify butterfly species in the field. We decided to use Pollard walks for the surveys as the method records many more species than using fruit-bait traps and is less time-consuming. We have also prepared a complete field guide based on "Butterflies of Southeast Sulawesi" by K. Wilmott (Willmot, 2001) supplemented with photos of live caught butterflies. All the butterfly pictures are printed and laminated into a small handy folder that will be easy to carry in the field.

Prior to data collection, observers walked along Kakenauwe road for a couple of days to familiarize themselves with the butterfly species. Butterflies were captured, photographed for identification, and then released. Butterfly species were surveyed using a modification of Pollard walk methods which is a combination of transect walk and point counts. We focused our survey on Papilionidae, Nymphalidae, and Pieridae, excluding Hesperiidae and Lycaenidae which are too small to identify directly in the field. Points are located at 150-m interval along each transect (the same as those used for bird recording. Observers walk along the 900-m transect and estimate the distance of the butterfly to observers and the angle of observer to the object as well as the angle of the path. At each point, the observer stood and recorded any butterfly detected in circular area of 5-m range (vertical and horizontal) for approximately 10 minutes. All butterflies seen were noted and distance and height of each detection was estimated. Butterflies were identified to species if possible, otherwise to genus or family. During the surveys, binoculars were used to aid identification. Only sighted but unidentified butterflies were caught by net and then released after identification. Species identification was based on Vane-Right and de Jong (2003), and the reference collection provided by Willmott (2000).

<u>Habitat Measurement</u>

To determine how bird communities related to habitat, we will examine the habitat association at two levels. At population level, we will compare population densities between forest areas which vary in their natural characteristics. At a smaller scale, we will try to identify the factors associated with the presence/absence of species at individual point counts. To address this, we quantified a number of vegetation structure and other variables within a 20-m radius circular area around the bird count points. Understory density was assessed using 1.5 m stick with fifty black bands held horizontally at approximately 100-m and counted the number of black bands seen from a distance of 10 metres. Canopy closure was estimated using sighting tube where the observer looked up the canopy through the sighting tube and recorded whether each field was occluded by the canopy or not. We recorded the undulation of the site (divided into flat, medium, and major undulation), slope (flat, medium slope 10^o-45^o, and steep slope above 45^o), and number of fallen trees, divided into freshly fallen, partially rotten, and well rotted fallen trees. We measured the DBH of the ten nearest trees with DBH $\geq$ 50 cm within 20-m radius, recorded the distance from the central point, the position of inversion (less or more than halfway of the height) as well as any indication of scars, and flowering or fruiting of the tree. Branching above the half of the tree height is usually characteristic of undisturbed forest as the tree has grown under a closed canopy (Jones et al. 2003) and presence of scars may indicate a secondary reaction to the closure of the forest canopy and may indicate regeneration following natural and human induced disturbance. Other indications of disturbances, i.e. presence of rattan, palms (Palmae), lianas, *Pandanus* were also recorded. In addition, we also recorded the number of saplings above 2m in height , number of ferns, tree ferns, and bird-nest ferns. In addition for assessing butterfly-habitat association, flowering shrubs and sapling within the plot were recorded as well.

Progress and Preliminary Results

Field work and overall progress

The first survey was conducted between July-August 2005. Surveys in 2006 were conducted in into two stages, during the wet season (May-June 2006) and during the dry season (July-August 2006). For the bird survey during the wet season, there was only one team of observers and a total of 143 counts were made overall as points were visited once. During the dry season in correspond with the Operation Wallacea season, we were able to conduct 56 counts at each node camps resulting in 366 counts in total. As in the previous year, we had students who helped with the data collection, 3 overseas students (Opwall dissertation students) for bird surveys and 1 Indonesian student (GEF dissertation student) who helped with the butterfly survey. The students usually spent approximately one week practising bird identification prior to the main survey. All students were new to the area and thus, there may be some bias within the results as two of the assumptions of Distance Sampling are correct identification and accurate distance estimation of the birds. To ensure that the assumptions are met needs experienced observers. However, we will also evaluate the observer heterogeneity for the final report.

A combination of point count and line transect was used for the butterfly survey. During 2006, survey was also divided into two seasons, the wet and dry season in correspond with the bird survey. During the wet season we have been able to conduct a total of 135 counts and approximately 39,600 m walks as we only have 1 observer. During the dry season in correspond with Operation Wallacea, 1 observer was responsible of collecting the point count data and another observer was responsible of collecting line transect data. During this season, we have been able to conduct 164 counts and approximately 43,200 m walks.

Preliminary data on butterfly survey will be presented at the national insect conference held in Bogor, 27-30 January 2007. Paper submitted to the conference "the importance of detectability in butterfly monitoring: butterfly diversity of Lambusango forest, Buton, Southeast Sulawesi" is attached. The paper discussed about the detectability differences between point count and line transect methods.

Patterns within the bird community

Diversity, abundance, and species richness – 2006 data

A total of 51 species from 23 families was observed during May-August 2006 (Appendix 1). Diversity analyses were drawn only from dry season data. During the dry season, a total of 49 bird species from 23 families was observed at point counts in the six node camps; Wahalaka with 42 had the highest number of species recorded. Twenty-five of the species are endemic to Sulawesi. Approximately 36.7% of total species recorded during 2006 are frugivores and only 8.2% are terrestrial and understory specialists such as the Sulawesi babbler, Blue-breasted pitta, Black-naped monarch, and Red junglefowl .

The five most common species recorded across all node camps were similar to 2005 – these were Green Imperial Pigeon (*Ducula aenea*), Hair-crested drongo (*Dicrurus hottentottus*), Sulawesi Babbler (*Trichastoma celebense*), Bay coucal (*Centropus celebensis*), and Black-naped oriole (*Oriolus chinensis*).

Diversity and similarity indices were calculated using program EstimateS 7.5 (Colwell 2005). Shannon's index of diversity (Magurran 1988) revealed that the diversity index ranged from 3.07-3.17 with the lowest index at Anoa and the highest index at Wahalaka (Table 1). Simpson's index of diversity (Magurran 1988) which place more emphasis on the partitioning of birds between the different species showed the same patterns (Table 1). This diversity patterns are relatively similar to the previous year with Anoa having the lowest diversity and Wahalaka the highest (Winarni and Jones 2006; Figure 1). The evenness which takes into account the distributions of individuals among species revealed that all sites have relatively similar equitability.

Wahalaka and Wabalamba, the most diverse sites, also showed the highest similarity scores and had many species in common (Table 2 & 3). The least similar communities were Anoa—Lasolo and Lasolo—Lawele (Table 2). Anoa—Lasolo also have the least number of shared species (Table 3).

Table 1. Comparison of diversity indices (Shannon-Wiener and Simpson index) and Evenness among node camps.

Node Camps	Species	Shannon's	Simpson's	Evenness
Anoa	35	3.07	16.37	0.86
Lapago	37	3.13	16.92	0.87
Lasolo	35	3.15	17.32	0.89
Lawele	36	3.16	17.44	0.88
Wabalamba	39	3.16	17.41	0.86
Wahalaka	42	3.17	17.48	0.85

Table 2. Matrix of pairwise Morisita-Horn similarity index comparing each node camp.

Node Camps	Anoa	Lapago	Lasolo	Lawele	Wabalamba
Anoa					
Lapago	0.924				
Lasolo	0.873	0.927			
Lawele	0.882	0.929	0.874		
Wabalamba	0.906	0.948	0.942	0.891	
Wahalaka	0.923	0.948	0.910	0.890	0.950

Table 3. Matrix of pairwise number of species shared between node camps.

Node Camps	Species	Anoa	Lapago	Lasolo	Lawele	Wabalamba
Anoa	35					
Lapago	37	31				
Lasolo	35	29	32			
Lawele	36	33	32	31		
Wabalamba	39	31	32	31	34	
Wahalaka	42	33	34	33	35	37

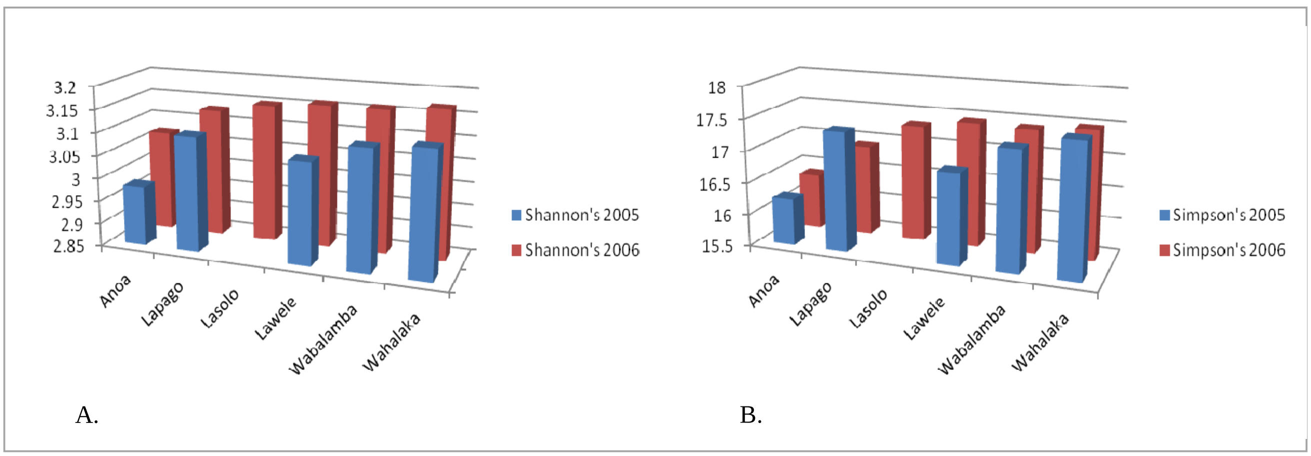


Figure 1. Comparison of bird diversity in node camps between 2005-2006. A. Comparison of Shannon's index of diversity; B. Comparison of Simpson's index

The rank abundance plots of the node camps, however, look quite similar. The proportions of rare species (those represented by only one or two individuals) composed the largest proportions of the community (Figure 2). In these areas, only a small number of abundant species are dominant.

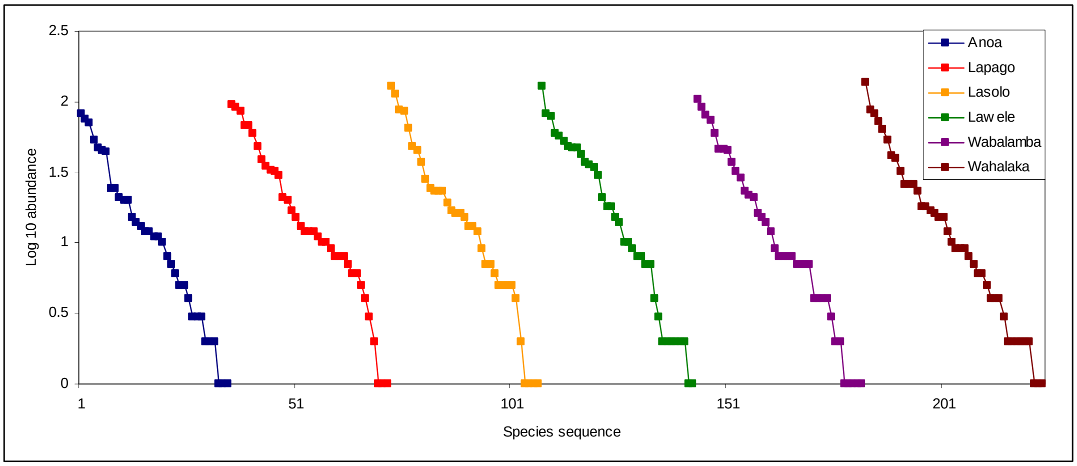


Figure 2. Abundance distribution of each node camp

As in 2005, (Winarni and Jones 2006), when areas are divided into two based on level of disturbance (least disturbed and highly disturbed), again we see that the two groups have rather different community patterns. The least disturbed areas tend to reflect a more complex community as they are less likely to be dominated by a small number of species (Figure 3). The frequency distribution of species abundance in the least disturbed areas fitted a log-normal distribution whereas the disturbed areas fitted a log-series model. The greater Simpson's index in the highly disturbed areas also indicated that the more species dominated the areas than in the least disturbed areas (Table 1).

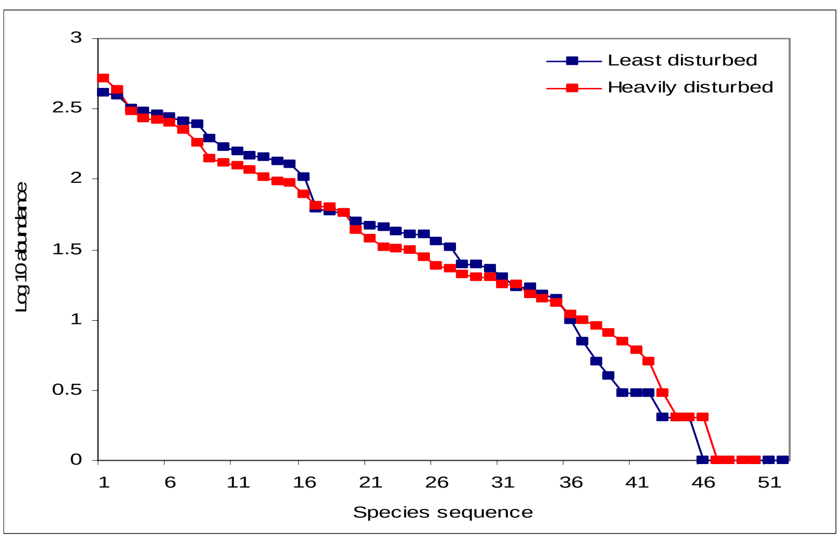


Figure 3. Abundance distribution of most disturbed and least disturbed areas based on number of individuals observed

Density estimation

The density of birds was estimated using DISTANCE 4.1 (Buckland et al. 1993, Buckland *et al*. 2001). All data from 2005-2006 were pooled and post-stratification was done during DISTANCE analysis. At this preliminary stage we only estimate the densities of the most abundant birds as sample sizes for some of the others are too small. Distances were fitted into different models of detection - half-normal, uniform, and hazard rate. The DISTANCE software then selected the best models based on the minimum AIC (Akaike's Information Criterion) values for further density estimation (Buckland et al. 2001).

There do not seem to be any consistent patterns in terms of changes in abundance between wet and dry seasons (Figure 4). Some species have higher density during dry season, although this may due to the differences in the detection rate. During the wet season, most birds are usually less active than the dry season. In most node camps, birds such as Sulawesi babbler, green imperial pigeon, and black-naped monarch are present at higher density than other species (Table 4). During wet season, some birds are detected in lower density particularly white-bellied imperial pigeon, Sulawesi black pigeon, silver-tipped imperial pigeon, and Sulawesi cicadabird. These birds are usually pronounced less call during the wet season.

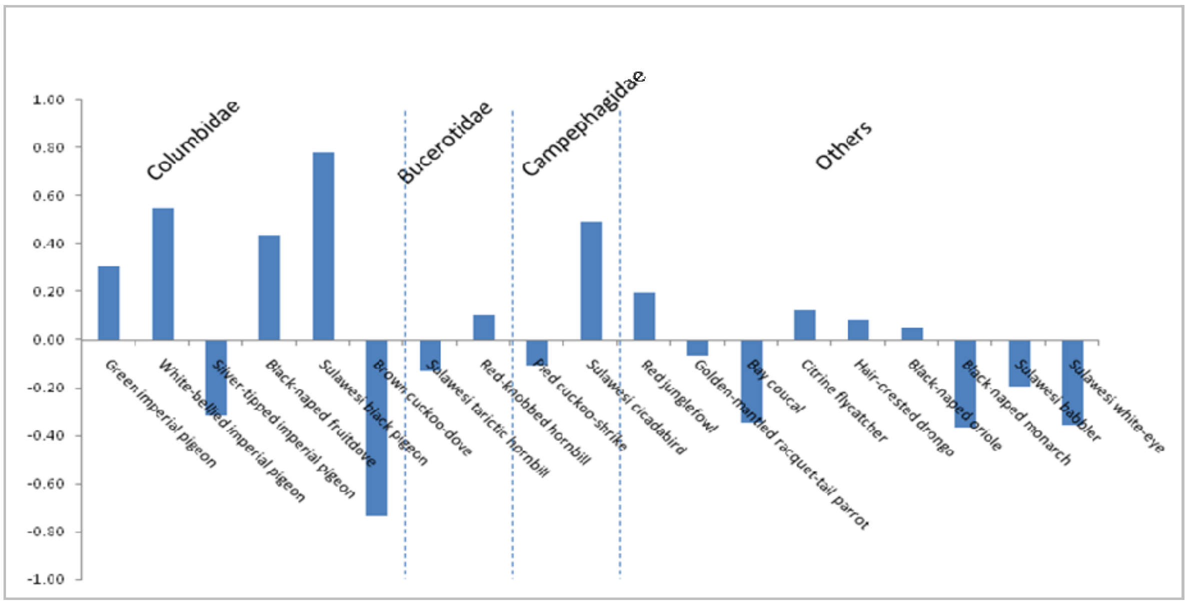


Figure 4. Changes in estimated density between wet and dry season for most abundant birds in group orders: Columbidae, Bucerotidae, Campephagidae and others (Phasianidae, Psittacidae, Cuculidae, Muscicapidae, Dicruridae, Oriolidae, Monarchidae, Timaliidae, and Zosteropidae)

When the 2006 and 2005 seasons are compared, densities for the most abundant birds are lower in 2006 except for green imperial pigeon (Figure 5). However, more data are needed to see whether the changes are significant.

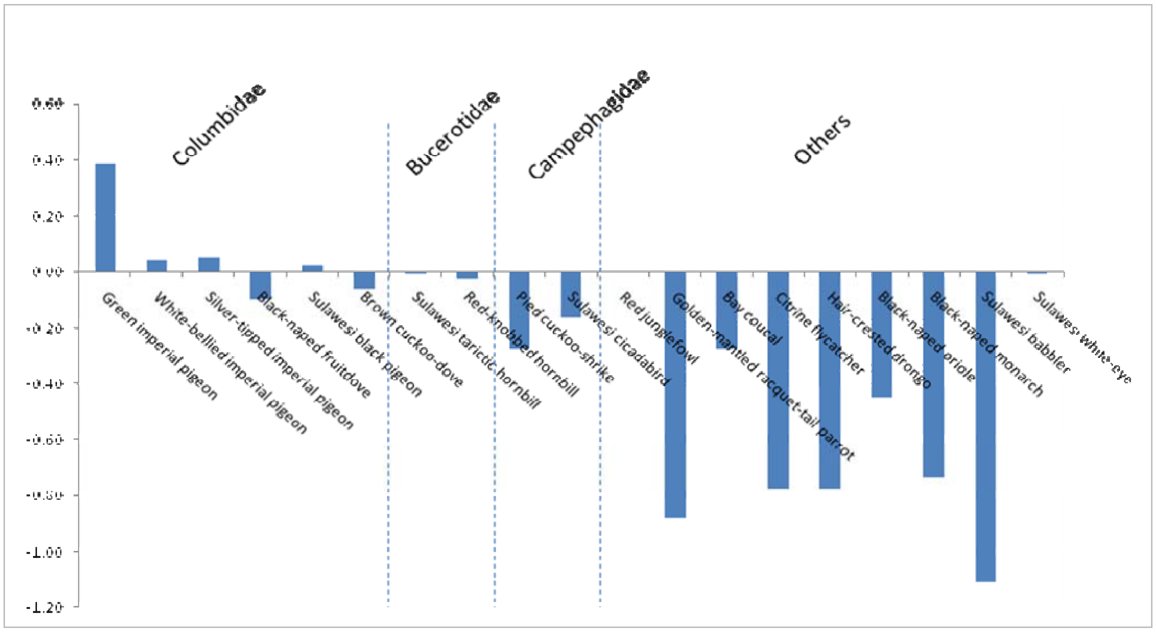


Figure 5. Changes in estimated density of most abundant birds between 2005-2006 in group orders: Columbidae, Bucerotidae, Campephagidae and others (Phasianidae, Psittacidae, Cuculidae, Muscicapidae, Dicruridae, Oriolidae, Monarchidae, Timaliidae, and Zosteropidae)

Table 4. Estimated density (per ha) of most abundant species in 6 node camps during wet and dry season

Common name	Wet season						Dry season					
	1	2	3	4	5	6	1	2	3	4	5	6
Red junglefowl	0.04	0.05	0.00	0.01	0.02	0.00	0.03	0.02	0.01	0.04	-0.01	0.05
Sulawesi babbler	0.67	0.49	0.89	0.49	0.76	0.61	0.42	0.58	0.27	0.86	0.37	0.55
White-bellied imperial pigeon	0.05	0.00	0.00	0.17	0.00	0.02	0.14	0.12	0.16	0.32	0.05	0.17
Black-naped fruitdove	0.07	0.14	0.10	0.07	0.00	0.01	0.03	0.27	0.15	0.21	0.16	0.14
Green imperial pigeon	0.48	0.76	0.92	0.90	0.33	0.38	0.91	1.23	1.95	0.79	1.31	1.12
Sulawesi black pigeon	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.02	0.08	0.07	0.19	0.06
Brown cuckoo-dove	0.82	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.04	0.02	0.05
Silver-tipped imperial pigeon	0.00	0.00	0.65	0.00	0.00	0.00	0.04	0.10	0.07	0.02	0.08	0.08
Sulawesi tarictic hornbill	0.01	0.03	0.04	0.07	0.07	0.06	0.04	0.06	0.03	0.07	0.04	0.05
Red-knobbed hornbill	0.03	0.00	0.01	0.11	0.00	0.00	0.02	0.06	0.03	0.11	0.02	0.01
Hair-crested drongo	0.19	0.27	0.41	0.32	0.40	0.18	0.39	0.44	0.19	0.38	0.35	0.30
Black-naped monarch	0.54	0.43	0.84	0.54	0.75	0.75	0.32	0.35	0.41	0.32	0.53	0.56
Citrine flycatcher	0.28	0.14	0.32	0.24	0.27	0.28	0.17	0.45	0.39	0.24	0.45	0.35
Bay coucal	0.36	0.33	0.38	0.46	0.51	0.50	0.16	0.21	0.27	0.16	0.21	0.28
Sulawesi cicadabird	0.00	0.06	0.09	0.03	0.07	0.01	0.11	0.08	0.19	0.14	0.11	0.08
Pied cuckoo-shrike	0.06	0.12	0.23	0.06	0.19	0.04	0.20	0.14	0.23	0.14	0.20	0.08
Black-naped oriole	0.16	0.50	0.78	0.12	0.52	0.78	0.20	0.58	0.86	0.53	0.51	0.46
Sulawesi white-eye	0.33	0.22	0.11	0.17	0.17	0.22	0.09	0.18	0.19	0.09	0.00	0.07
Golden-mantled raquet-tail	0.12	0.31	0.20	0.31	0.00	0.00	0.06	0.17	0.27	0.38	0.07	0.06
Ashy woodpecker	0.09	0.26	0.23	0.09	0.14	0.04	0.09	0.14	0.19	0.09	0.15	0.09
Spot-tailed goshawk	0.00	0.06	0.02	0.02	0.02	0.00	0.02	0.09	0.06	0.02	0.06	0.03

Notes: 1 = Anoa, 2 = Lapago, 3 = Lasolo, 4 = Lawele, 5 = Wabalamba, 6 = Wahalaka

Habitat structure

Analysis of the habitat structure showed that the differences between node camps were not distinct. Variables used for the analysis were: number of figs, number of saplings (0-3 scale), number of rattan (0-3 scale), number of pandanus, number of ferns, number of treeferns, number of palms, number of treevines (0-3 scale), number of birdnests ferns, undulations (1-3), fresh fallen tree, intermediate rotten tree, well-rotten tree, slope (1-3), average undergrowth, number of trees, mean girth, and mean number trees with upperhalf inversion. We started with hierarchical cluster analysis with 10 clusters down to 2 clusters. We compared the grouping results with discriminant function analysis misclasification. Then we selected the number of habitat types with the smallest misclassification. The Discriminant Function Analysis showed that 5 clusters provided 100% correctly classification. However, the fifth habitat type (which is represented by only one case) has shown to be an outlier as it persisted through all the cluster analysis. Thus, we deleted this case and divided the habitat types into 4 clusters. The clustering actually showed that all node camps are quite similar with 98.8% correct classification (Table 6). The classification results revealed that most of the point locations were clumped into the first habitat type. These results indicated that all node camps experienced similar level of disturbance or the variables measured may not be sensitive enough to differentiate the distinctiveness between sites.

Table 6. Matrix of classification results from Discriminant Function Analysis

Classification Results[a]

		Average Linkage (Between Groups)	Predicted Group Membership 1	2	3	4	Total
Original	Count	1	151	0	2	0	153
		2	0	2	0	0	2
		3	0	0	4	0	4
		4	0	0	0	1	1
		Ungrouped cases	2	0	0	0	2
	%	1	98.7	.0	1.3	.0	100.0
		2	.0	100.0	.0	.0	100.0
		3	.0	.0	100.0	.0	100.0
		4	.0	.0	.0	100.0	100.0
		Ungrouped cases	100.0	.0	.0	.0	100.0

a. 98.8% of original grouped cases correctly classified.

When number of fallen trees in 2005 and 2006 were compared, we found that anthropogenic impacts show no significant difference over the one-year period as the number of fresh fallen trees (natural or human logged trees) did not show any significant difference (df = 139; t = -1.027; P = 0.306) although in the number of fresh fallen trees were higher in most node camps (Figure 6). A complete analysis of anthropogenic impacts over three years will be done after more data are available.

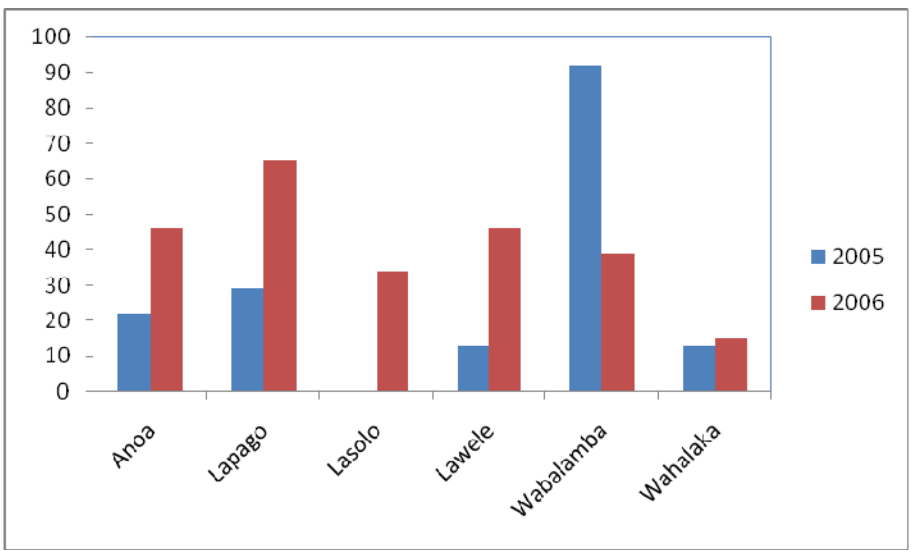


Figure 6. Comparison of fresh fallen trees at 6 node camps during 2005-2006

<u>Relationship of key-bird species with habitat structure</u>

In assessing the changes in the environment, an indicator sometime is used as quantifiable surrogates (Noss 1990) because of the difficulties of observing all taxa (Lindenmayer 1999). Landres et al. (1988) recommended several criteria to select an indicator: (1) an indicator must be sensitive to changes in the environment; (2) variability of response; (3) specialist to certain habitat; (4) large body size, (5) resident to the area; (6) have wider area requirements. Noss (1990) added the importance of the easiness and the cost-effectiveness to observe.

In the final analysis we will be examining the different approaches to selecting indicator species, but here we present the relationship between habitat structure and several of the potential indicators (in the case the more abundant species, Table 7). Analyses were conducted using binary logistic regression based on presence and absence of species at each point count as dependent variable. Logistic regression is able to use categorical variables such as saplings, rattans, and treeferns in which the lowest category (category 0) was treated as dummy variables

Results were variable. Presence of wide-ranging species such as hornbills showed no relationship with number of figs (an important food source) but were significantly correlated with less number of rattan and number of well-rotten trees indicating the need for less disturbed and old mature forest. Many Columbidae species also showed the need of less disturbed habitat as indicated by significant relationship with higher number of larger trees (number of trees and mean dbh), trees which branched above half their height, bird nest ferns, ferns, and lower incidence of rattan. Presence of Green imperial pigeons (*Ducula aenea*) was significantly correlated with areas containing larger trees and higher number of fig trees. Sulawesi black pigeon (*Turacoena menadensis*) and Brown cuckoo-dove (*Macropygia amboinensis*) were present in areas with higher number of bird nest ferns. Presence of understory and midstory birds such as Black-naped monarch (*Hypothymis azurea*) and Citrine flycatcher (*Culicicapa helianthea*) were correlated with less treevines and a high density of understory.

Table 7. Relationship between bird species and habitat structure using logistic regression (percentage of model classifications and P values of significant variables)

	Galgal	Tricel	Ducfor	Ptimel	Ducaen	Turmed	Macamb	Ducluc	Penexa	Rhycas	Dichot	Hypazu	Culhel	Cencel	Cormor	Corbic	Orichi	Zoscon	Pripla
Percentage of correct classification	76.9	66.9	70.6	75.0	93.1	68.8	80.6	78.8	70.6	80.6	91.9	85.6	76.9	94.4	65.6	76.3	88.1	73.1	78.8
Canopy openness											0.02	0.04							
Figtrees					0.008											0.02			
Saplings (0-3)																			
Rattan (0-3)				0.001					0.02										
Pandan (No)																			
Ferns (No)							0.01					0.005					0.003		
Tree ferns (No)				0.04															
Palm (No)																			
Tree vines(0-3)												0.03	0.03						
Birdnest ferns						0.03	0.009						0.01						
Fresh fallen trees														0.03					
Intermediate rotten fallen trees											0.02		0.001						
Well-rotten fallen trees	0.002		0.005		0.04					0.01									
Understory density							0.01					0.03	0.02						
Trees (No)					0.02													0.03	0.001
Meandbh					0.013														
Upperhalf inversion of trees (No)							0.01				0.02								0.04

Notes: Species code: Galgal = *Gallus gallus*; Tricel = *Trichastoma celebense*; Ducfor = *Ducula forsteni*; Ptimel = *Ptilinopus melanospila*; Ducaen = *Ducula aenea*; Turmed = *Turacoena menadensis*; Macamb = *Macropygia amboinensis*; Ducluc = *Ducula luctuosa*; Penexa = *Penelopides exarhatus*; Rhycas = *Rhyticeros cassidix*; Dichot = *Dicrurus hottentottus*; Hypazu = *Hypothymis azurea*; Culhel = *Culicicapa helianthea*; Cencel = *Centropus celebensis*; Cormor = *Coracina morio*; Corbic = *Coracina bicolor*; Orichi = *Oriolus chinensis*; Zoscon = *Zosterops consobrinorum*; Pripla = *Prionoturus platurus*

Patterns within the butterfly community

Diversity, abundance, and species richness

A total of 77 species were recorded during May-August 2006, which included 54 Nymphalidae, 11 Papilionidae, 11 Pieridae, and 1 Riodinidae (Appendix 2). Among these, 26 species are endemic to the region or to the island. In total, line transects produced 66 species while point count produced 49 species. In all node camps, line transects produced more species than point counts (Table 8). The sample-based rarefaction curves (Gotelli and Colwell 2001) of both point counts and line transects (Figure 7) showed that on daily basis line transects produced higher species richness than point counts. The rarefaction curves have not reach an asymptote indicating that more species maybe added to the list.

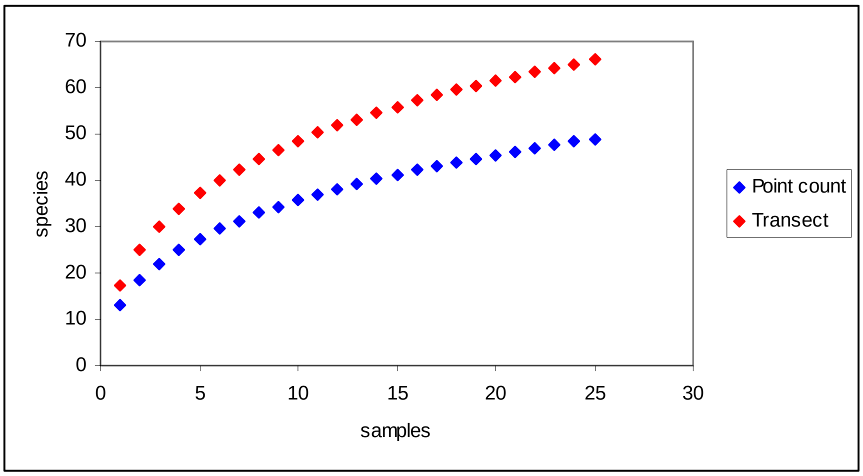


Figure 7. Sample-based rarefaction curves generated by point count and line transect methods.

Diversity and similarity indices were calculated using program EstimateS 7.5 (Colwell 2005). Data from wet and dry season are pooled together for diversity analysis Comparisons between the node camps using the two different sampling methods are presented below in Tables 8, 9 and 10. Comparison between wet and dry season will be done when more data are available after the 2007 survey.

In general, the Point Count and Line Transect methods produced similar results and the differences between the node camps are quite similar to those recorded for birds. Shannon's index of diversity (Magurran 1988) from Point Count data revealed that the diversity index ranged from 2.67—2.90 with the lowest index at Anoa and the highest index at Wahalaka (Table 8). This pattern was also shown by line transect which diversity index ranged from 2.72-2.95. Simpson's index of diversity (Magurran 1988) which places more emphasis on the partitioning of butterflies between the different species showed similar patterns when using point count (Table 8). However, with the line transect Lasolo has the lowest Simpson index.

Patterns of similarity indices provided by both methods are also comparable. Wahalaka is the most diverse community and has the greatest similarity with Wabalamba. The least similar sites are Lasolo and Lawele although the least number of of shared species is between Anoa and Lasolo (Table 9 & 10).

Table 8. Comparison of both Point Count and Line Transects in number of butterfly species, Shannon-Wiener and Simpson Indices, as well as Evenness among node camps.

Site	Species		Shannon-Wiener		Simpson		Evenness	
	Point	Transect	Point	Transect	Point	Transect	Point	Transect
Anoa	22	22	2.67	2.72	11.15	10.65	0.86	0.88
Lapago	37	46	2.78	2.86	11.27	10.88	0.77	0.75
Lasolo	23	32	2.83	2.89	11.30	10.61	0.90	0.83
Lawele	31	42	2.87	2.93	11.56	10.84	0.84	0.78
Wabalamba	31	42	2.89	2.94	11.54	10.75	0.84	0.79
Wahalaka	29	49	2.90	2.95	11.57	10.85	0.86	0.76

Table 9. Matrix of pairwise Morisita-Horn similarity index of each node camp using Point Count and Line Transects.

Site	Anoa		Lapago		Lasolo		Lawele		Wabalamba	
	Point	Transect	Point	Transect	Point	Transect	Point	Transect	Point	Transect
Lapago	0.919	0.896								
Lasolo	0.858	0.818	0.807	0.835						
Lawele	0.817	0.821	0.867	0.944	0.746	0.798				
Wabalamba	0.923	0.930	0.868	0.940	0.891	0.891	0.847	0.888		
Wahalaka	0.908	0.933	0.856	0.913	0.864	0.846	0.884	0.883	**0.946**	**0.966**

Table 10. Matrix of pairwise shared species between node camps using Point Count and Line transects.

Site	Anoa		Lapago		Lasolo		Lawele		Wabalamba	
	Point	Transect	Point	Transect	Point	Transect	Point	Transect	Point	Transect
Lapago	19	17								
Lasolo	13	11	18	18						
Lawele	18	18	25	31	16	17				
Wabalamba	16	17	21	27	14	15	20	26		
Wahalaka	15	17	20	29	18	18	20	28	19	28

Using the transect data (the method which recorded more species), the rank abundance plots of the species are shown in Figure 8. Areas such as Lapago, Wabalamba and Wahalaka appear to have more of the rare species.

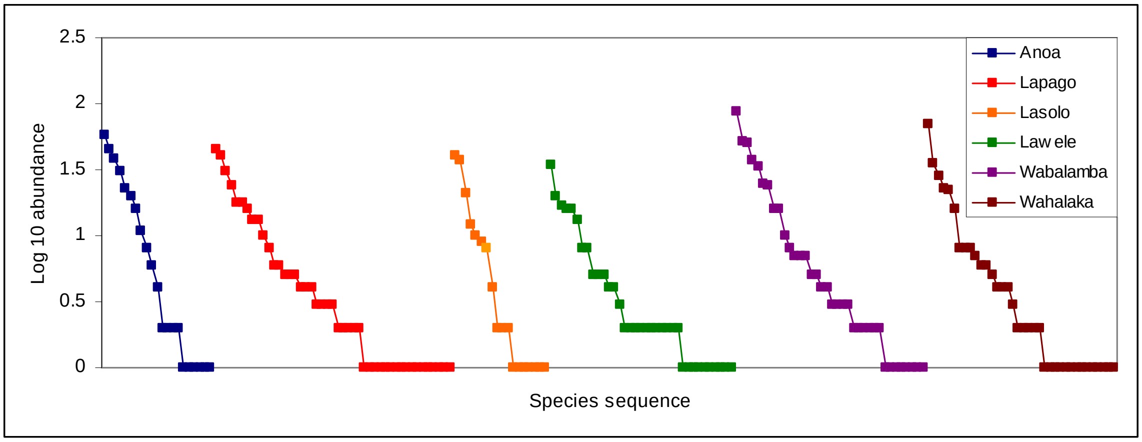


Figure 8. Abundance distribution of butterflies at each node camp during the dry season using date from transects

When areas are divided into two based on level of disturbance (least disturbed and highly disturbed), we see that the two groups have rather different community patterns. Based on Seymour (2004), Wahalaka and Wabalamba are the most disturbed areas compare to other node camps. Wahalaka experienced heavily rattan extraction and heavily logging occurs at Wabalamba (Seymour 2004), Lasolo in the other hand is an old logged area. The least disturbed areas tend to reflect a more complex community as they are less likely to be dominated by a small number of species (Figure 9). The frequency distribution of species abundance in the least disturbed areas fitted a log normal distribution whereas the disturbed areas fitted a log-series model. The greater Simpson's index in the highly disturbed areas also indicates that a small number of abundant species dominated the areas than in the least disturbed areas (Table 8).

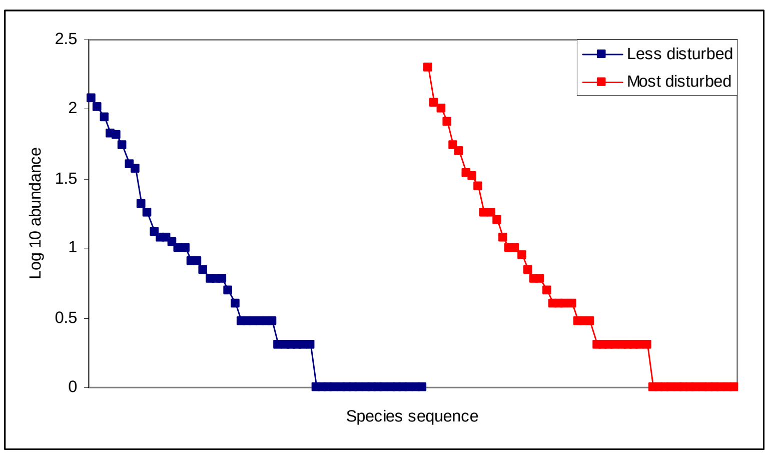


Figure 9. Abundance distribution of most disturbed and least disturbed areas during the dry season using transect method

Vertical diversity and use

Butterfly diversity at different height levels (< 1m, 1-3m, 3-5m) showed that diversity was the lowest at the ground level and quite similar diversity at the medium and highest level (Table 11). The Simpson index which accounted the dominancy of species, however, revealed that diversity at medium level was the highest. Butterflies at ground level were dominated by *Faunis menado* which was usually found on the forest floor. *Lohora opthalmica* and *Elymnias hewitsoni* dominated the medium and high level. Many species of Papilionidae were usually seen at medium and high levels and rarely near the ground.

Table 11. Diversity differences at different height level between node camps

	Anoa	Lapago	Lasolo	Lawele	Wabalamba	Wahalaka
Total species < 1m	8	11	10	11	11	10
Total species 1-3m	13	19	18	18	22	21
Total species > 3m	16	28	14	21	22	18
Shannon-Wiener						
< 1m	1.64	1.73	1.77	1.80	1.82	1.83
1-3m	2.55	2.70	2.77	2.80	2.82	2.83
> 3m	2.53	2.69	2.75	2.79	2.82	2.85
Simpson						
< 1m	4.08	3.91	3.94	3.95	3.95	3.96
1-3m	11.41	11.33	11.35	11.37	11.32	11.26
> 3m	10.72	10.21	9.68	9.53	9.51	9.51

Relationship between bird and butterfly communities

Previous research have been shown that one taxa may be able to act as surrogate across other taxonomic groups in assessing biodiversity at community level (Blair 1999, Fleishman et al. 2005). Our results showed that trends in species richness and diversity were quite similar. Wahalaka was shown to have the highest species richness and diversity while Anoa has the least richness and least diversity. Using species richness, the relationship was close to significance (R^2 = 0.54; P = 0.09; Figure 10) but there was a strong relation ship between the Shannon diversity indices of birds and butterflies (R^2 = 0.99; P < 0.001; Figure 11). There was no relationship using evenness of species assemblages (R^2 = 0.018; P = 0.79) or the Simpson's index of diversity (R^2 = 0.11; P = 0.51). The last two parameters are highly influenced by species abundance and dominance (Magurran 1988) and thus may be less suitable for making this type of comparison.

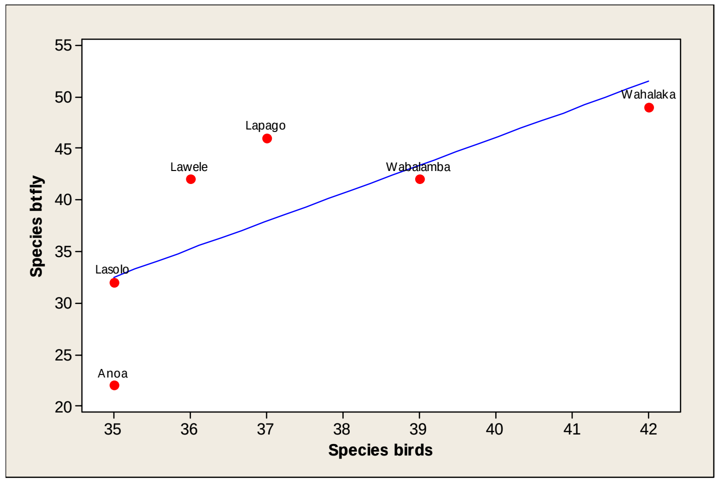


Figure 10. Line fit plot between bird species richness and butterfly species richness

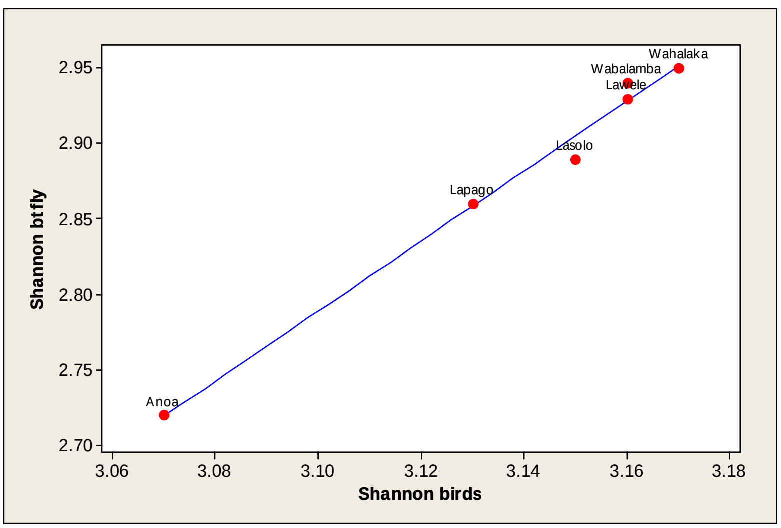


Figure 11. Line fit plot between bird's and butterflies' Shannon diversity index

Workplan for 2007-2008

The workplan for 2007 is divided into 3 phases. The first and last phases will be spent in hometown of PhD candidate (Jakarta). The first term will mainly focus in preparation for the field work which includes preparation of any permits needed for the field work. The second term will be spent in Buton which include all the field preparation and all field surveys. The third phase will be mostly concerned with the data management and analyses. The 2008 workplan is mostly dedicated to finish up data analysis and thesis. Finalizing thesis and defense will be conducted in Manchester.

Activities	2007												2008				
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5
Preparation for field work																	
Field work wet season																	
Field work dry season (Opwall)																	
Data management																	
Data analysis																	
Report GEF																	
Thesis writing																	
Final report and finishing up																	

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Appendix 1. List of bird species recorded at Lambusango forest in 2006 (wet and dry season), including their endemic status.

Familia	Species name	English name	Endemic	Anoa	Lapago	Lasolo	Lawele	Wabalamba	Wahalaka
Accipitridae	*Accipiter trinotatus*	Spot-tailed goshawk	E	x	x	x	x	x	x
	Spizaetus lanceolatus	Sulawesi hawk-eagle	E			x	x		
	Spilornis rufipectus	Sulawesi serpent-eagle	E					x	
Alcedinidae	*Alcedo meninting*	Blue-eared kingfisher				x	x	x	x
	Ceyx fallax	Sulawesi dwarf kingfisher							x
	Halcyon chloris	White-collared kingfisher			x				x
	Halcyon spp.							x	
Artamidae	*Artamus monachus*	Ivory-backed woodswallow	E	x	x	x	x	x	x
Bucerotidae	*Penelopides exarhatus*	Sulawesi dwarf hornbill	E	x	x	x	x	x	x
	Rhyticeros cassidix	Red-knobbed hornbill	E	x	x	x	x	x	x
Campephagidae	*Coracina bicolor*	Pied cuckoo-shrike			x	x			
	Coracina morio	Sulawesi cicada bird	E	x	x		x	x	x
Coraciidae	*Coracias temminckii*	Purple-winged roller	E	x	x	x	x	x	x
Columbidae	*Ducula aenea*	Green Imperial pigeon		x	x	x	x	x	x
	Ducula forsteni	White-bellied imperial pigeon	E					x	x
	Ducula luctuosa	Silver-tipped imperial pigeon	E		x				
	Macropygia amboinensis	Brown cuckoo-dove		x	x	x	x	x	x
	Ptilinopus melanospila	Black-naped fruit-dove		x	x	x	x	x	x
	Streptophelia chinensis	Spotted dove		x	x	x	x	x	x
	Treron griseicauda	Grey-cheeked green pigeon		x	x	x	x	x	x
	Turacoena manadensis	Sulawesi black pigeon	E	x			x		
Corvidae	*Corvus typicus*	Piping crow	E	x	x	x	x	x	x
Cuculidae	*Centropus celebensis*	Bay coucal	E			x	x	x	x
	Phaenicophaeus calyorhynchus	Yellow-billed malkoha	E						x
	Surniculus lugubris	Drongo cuckoo			x	x			
	Cuculus crassirostris	Sulawesi hawk-cuckoo	E	x					x
Dicaeidae	*Dicaeum spp.*			x	x	x	x	x	x
	Dicaeum aureolimbatum	Yellow-sided flowerpecker	E	x					
	Dicaeum celebicum	Grey-sided flowerpecker	E	x	x		x	x	x
Dicruridae	*Dicrurus hottentottus*	Hair-crested drongo		x	x		x	x	x
Hemiprocnidae	*Hemiprocne longipennis*	Grey-rumped tree-swift		x	x	x	x	x	x
Monarchidae	*Hypothymis azurea*	Black-naped monarch						x	x
Muscicapidae	*Culicicapa helianthea*	Citrine flycatcher		x	x	x	x	x	x
	Ficedula rufigula	Rufous-throated flycatcher		x	x	x	x	x	x
Nectarinidae	*Nectarinia aspasia*	Black sunbird		x	x	x	x	x	x
	Nectaria spp.				x	x	x	x	x
Oriolidae	*Oriolus chinensis*	Black-naped oriole			x	x		x	x
Phasianidae	*Gallus gallus*	Red junglefowl		x	x	x	x	x	x
Picidae	*Mulleripicus fulvus*	Ashy woodpecker	E	x	x	x	x	x	x
Pittidae	*Pitta erythrogaster*	Blue-breasted pitta		x	x	x	x	x	x
Psittacidae	*Cacatua sulphurea*	Yellow-crested Cockatoo		x			x	x	x
	Loriculus exilis	Small Sulawesi hanging-parrot	E	x	x	x	x	x	x
	Loriculus stigmatus	Large Sulawesi hanging-parrot	E	x	x	x	x	x	x
	Prioniturus platurus	Golden-mantled raquet-tail	E						x
	Tanygnathus sumatranus	Blue-backed parrot		x	x	x	x	x	x
	Trichoglossus ornatus	Ornate lorikeet	E	x	x	x	x	x	x
Sturnidae	*Basilornis celebensis*	Crested Myna	E	x	x	x	x	x	x
	Scissirostrum dubium	Gross-beaked starling	E	x	x	x	x	x	x
	Streprocitta albicollis	White-necked Myna	E	x		x			x
Timaliidae	*Trichastoma celebicum*	Sulawesi babbler	E	x	x	x	x	x	x
Zosteropidae	*Zosterops consobrinorum*	Sulawesi white-eye	E	x	x	x	x		x

Appendix 2. Butterfly species recorded in Lambusango forest in 2006, including their endemic status

Family	Species	Endemic	Anoa	Lapago	Lasolo	Lawele	Wabalamba	Wahalaka
Nymphalidae	*Acrophtalmia leuce*	E	x	x		x	x	x
	Amathusia sp.		x			x		
	Amathusia virgata	E	x			x	x	x
	Ariadne ariadne		x				x	
	Ariadne merionoides		x			x		
	Athyma libnites	E	x	x		x		x
	Cethosia biblis		x	x	x	x		
	Cethosia myrina	E	x	x	x	x	x	x
	Charaxes solon		x	x		x		
	Chersonesia rahria		x				x	
	Cirrochroa semiramis	E	x	x	x	x		
	Cupha maeonides	E	x	x	x	x	x	x
	Cyrestis strigata	E	x	x	x	x	x	x
	Dichorragia nesimachus		x	x	x		x	x
	Elymnias hewitsoni	E	x	x	x	x	x	x
	Euploa algea		x	x	x	x	x	x
	Euploea sp.		x					x
	Faunis menado	E	x	x	x	x	x	x
	Helycra celebensis	E	x	x				
	Hypolimnas anomala		x	x	x	x	x	x
	Hypolimnas sp		x	x		x	x	x
	Idea blanchardi	E	x	x		x		x
	Ideopsis juventa		x	x	x		x	x
	Ideopsis vitrea		x	x		x	x	x
	Junonia atlites		x				x	x
	Junonia hedonia		x	x		x	x	x
	Lasippa neriphus	E	x	x	x	x	x	x
	Lethe europa		x			x	x	
	Lohora ophtalmica		x	x	x	x	x	x
	Melanitis ieda		x		x			x
	Melanitis phedima		x	x	x			
	Melanitis velutina		x	x	x		x	x
	Mycalesis itys	E	x	x		x		
	Mycalesis janardana		x	x			x	x
	Neptis ida	E	x				x	
	NW-LB 008		x	x	x	x		x
	Nymphalidae sp.2		x			x	x	
	Nymphalidae sp1.		x			x		
	Nymphalidae sp3.		x					x
	Orsotriaena jopas	E	x				x	x
	Parantica cleona		x	x				x
	Parantica menadensis	E	x	x				x
	Phalanta alcippe		x		x			
	Pseudergolis avesta	E	x	x				
	Rhinopalpa polynice		x					x
	Symbrenthia hippoclus		x			x		x
	Tarattia lysania	E	x	x		x	x	
	Terinos taxiles		x					
	Tirumala choaspes		x				x	x
	Vagrans sinha		x	x				
	Vindula dejone		x	x	x	x	x	x
	Vindula erota		x	x		x	x	x
	Yoma sabina		x	x		x		x
	Ypthima nynias	E					x	
Papilionidae	*Graphium agamemnon*		x	x	x	x	x	x
	Graphium androcles	E	x	x				
	Graphium codrus		x	x				
	Graphium dorcus	E	x				x	
	Graphium milon		x	x		x	x	x
	Pachliopta polyphontes		x	x			x	
	Papilio ascalaphus	E	x	x	x			x

Family	Species	Endemic	Anoa	Lapago	Lasolo	Lawele	Wabalamba	Wahalaka
	Papilio gigon	E	x	x	x	x	x	x
	Papilio polytes		x	x		x		
	Papilio sataspes	E	x	x	x	x	x	x
	Troides hypolitus		x	x				
Pieridae	*Appias hombroni*		x			x	x	
	Appias spp.		x	x		x	x	x
	Appias zarinda		x	x				
	Catopsilia pomona		x				x	x
	Eurema alitha		x	x	x	x	x	x
	Eurema blanda		x			x		x
	Eurema celebensis	E	x	x	x	x	x	x
	Eurema hecabe		x	x		x	x	
	Eurema spp.		x	x	x	x	x	x
	Hebomoia glaucippe		x					x
	Pareronia tritaea	E	x	x			x	
Riodinidae	*Abisara echerius*		x	x	x	x	x	x

The importance of detectability in butterfly monitoring: Butterfly diversity of Lambusango Forest, Buton, Southeast Sulawesi

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Abstract

Rapid assessment for butterfly diversity particularly in the tropics is sometimes confounded by the lack of trained personnel in identification skill and lack of field identification guide for particular sites. In the other hand, detectability is also an important issue in biodiversity survey. A better sampling design is needed to provide a better estimates and a better snapshot of the present communities. Modification of Pollard walk using line transect and point count methods was evaluated in assessing diversity of different sites and evaluating detection probability. Patterns of butterfly community based on detection cue by the two methods were also evaluated. Studies were conducted at 6 different sites in Lambusango forest, Buton, Southeast Sulawesi. In overall, the results showed that both line transect and point count produced similar patterns of diversity. The line transect method generated higher species richness than point count method. However, detection probability of ten most common species using point count is significantly higher than line transect method. Point count method allows flexibility in detecting object than line transect. Morphological cues are more important in point count while quantified cues are more important for line transects. Refinement of survey method is important to increase the probability of detection.

Introduction

For the last five years, the Lambusango Forest Area of Buton Island has been the focus for biological research carried out by the Operation Wallacea program. These long-term studies have shown that the area supports a high level of biodiversity including anoa (*Bubalus depressicornis*), Buton macaques (*Macaca ochreata brunnescens*) and at least 231 bird species including 52 Sulawesi endemics and 9 Indonesian endemics (Catterall 1996). As for butterflies, 557 species are recorded for Sulawesi (Vane-Right and de Jong 2003) and although research on Buton has not been conducted thoroughly, at least 175 species have been recorded (Opwall 2000) with at least 55 species (excluding Hesperiidae and Lycaenidae) recorded around the forest of Lambusango (Wallace 2004).

Species richness and abundance are components of diversity (Magurran 1988). Diversity of wildlife communites reflects the health of an ecosystem and thus very important in biodiversity management of an area. However, a complete enumeration of community in an area is sometime impossible due to various reasons (Dorazio et al. 2006). Hence, a reliable sampling scheme which can provide accurate estimate of diversity is needed to produce a sound-based conclusion.

Butterflies are known as widespread, recognizable group which is conspicuous and easy to observe. This group also occurs in all parts of the world (Owen 1971). In Britain, butterfly monitoring has been longed established with standardized methodology (Pollard 1977, Pollard and Yates 1993). The group offers potential as environmental indicator due to their sensitivity on microclimate and light level (Kremen 1992) and is also useful in assessing habitat (Spitzer et al. 1993, New 1997, Spitzer et al. 1997).

Danielsen et al. (2000) argued that monitoring program in the tropics are hampered by the lack of trained person to conduct survey or identification, the scarcity of well-studied taxa to support monitoring program, and the lack of field identification guide. With these constraints, a monitoring program would give a less meaningful suggestion to management or even the wrong suggestion that would lead to incorrect management scheme. These constraints are likely occurred in butterfly surveys as identification is sometimes confounded by the lack of trained observers in identification skill. Currently, there are not many field identification guides for most of Indonesian sites and yet the number of species is very rich along with their taxonomic difficulty.

Despite all of these constraints, technical issues concerning methodology are also important in biodiversity surveys and monitoring. An oversight of methodology is a potential bias that lead to incorrect management recommendations. One of the technical concerns is the issue of detectability. Unobserved species may not necessarily indicate that the species is absent in the area (Dorazio et al. 2006). Pollard walks have been used widely in surveying butterflies (Pollard 1977, Pollard and Yates 1983). The method provides greater chance in detecting butterflies as the survey routes may traverse favorable habitats of butterflies. However, a better sampling design with systematically laid transects may provide a better estimates (Brown and Boyce 1998) and a better snapshot of the present communities.

Hill et al. (1995) used both transect and point count method to survey butterflies in Buru island, Indonesia. Brown and Boyce (1998) used line transect distance sampling to survey Karner blue butterflies in Wisconsin and found that the method provides unbiased estimate of site density. Ellingson (2003) applied distance sampling to estimate daily abundance of butterflies and argued the potential bias of Pollard walk for population estimate of particular butterfly species. In line transect distance sampling, observers traverse a line and record all objects along the line (Buckland et al. 2001). Another method of distance sampling, point count, is a method where observers stand at a point and record all of the objects observed (Buckland et al. 2001). Point count has the more flexibility in accessing the points and detecting the objects (Bibby et al. 2000). Estimation of line transect and point count data is laid on the idea that probability of detecting an animal decreases as it gets farther from transect or point (Buckland et al. 2001). The detection function *g(x)* in distance sampling provides unbiased estimates even when some objects are missed (Buckland et al, 2001, Ringvall et al. 2000). However, probability of detecting an object particularly butterfly species is sometimes related to color, size, and behavior (Gaston et al. 1995) which may bias abundance estimate (Dennis et al. 2006). This research evaluated both line transect and point count methods in assessing diversity patterns, and in generating probability of detection. Furthermore, patterns of detection cue using the two methods were also evaluated.

Study Area and Methods

Study Area

Studies were conducted between May-June 2006 and July-August 2006. Data collection were carried on in 6 node camps in the Lambusango Forest Area, Lawele, Lasolo, Walahaka, Anoa, Wabalamba, and Lapago. Four are situated within the Lambusango Forest Reserve, and two within the adjacent limited production forest (Lawele and Lasolo). Different nodes were experiencing different kinds of anthropogenic disturbance. The greatest levels of disturbance were found in Wahalaka and Wabalamba in the south of the Lambusango Forest Reserve. Both Lapago and Anoa sampling nodes are long-abandoned gardens. Lawele sampling node in the limited production forest showed the least disturbed forest with a high frequency of large trees, though there was evidence of high levels of rattan collection in the area (Seymour 2004). Approximately one week was spent at each node camp. Four transects, each 3km in length, were set up at each site and each transect was marked at 50 m intervals. Placement of transects did not favor specific butterfly habitat.

Butterfly Counts

Prior to data collection, observers walked along Kakenauwe road for couple of days to get familiar with butterfly species. Butterflies were captured, photographed for identification, and then released. Observers were also practice distance estimation prior to survey. Butterfly species was surveyed using modification of Pollard walk methods which is a combination of transect walk and point counts. We focused our survey on Papilionidae, Nymphalidae, and Pieridae, excluding Hesperiidae and Lycaenidae which are too small to identify directly in the field. Observers walk along the 900-m transect and estimate the distance of the butterfly to observers and the angle of observer to the object as well as the angle of the path. Points are located at 150-m interval at each transect. At each point, observer stood and recorded any butterfly detected in circular area of 5-m range (vertical and horizontal) for approximately 10 minutes. All butterflies seen were noted and distance of each detection was estimated. Butterflies were identified to species if possible, otherwise to genus or family. During survey, binocular was used to aid the identification. Only sighted unidentified butterflies were caught by insect net and then released after identification. Species identification was based on Vane-Right and de Jong (2003), and reference collection by Willmott (2000).

Butterfly species then were categorized by morphological cue (size, coloration, distinctiveness of wing patterns) and quantified cue (height and distance). Categorization of size (1 = small; 2 = medium, 3 = large), coloration (1 = dull, 2 = bright), and wing patterns (1= dull; 2 = distinct) is subjective based on present species. Height and distance cue were based on encounter rates of each species at different height and distance using the two methods. We use Discriminant Function Analysis (DFA) to see whether present-absence of butterflies by the two methods classified similarly. Then, we use Principal Component Analysis (PCA) to see the grouping of community produced by the two methods.

Results

Patterns within the butterfly community

A total of 70 species were recorded during May-August 2006, which included 47 Nymphalidae, 11 Papilionidae, 10 Pieridae, and 1 Riodinidae. Among these, 26 species are endemic to the region or to the island. In total, line transect produced 66 species while point count produced 49 species. In most node camps, line transect produced more species than point count (Table 1).

Diversity and similarity indices were calculated using program EstimateS 7.5 (Colwell 2005). Data from wet and dry season are pooled together for diversity analysis. Patterns of diversity of node camps are quite similar with the bird diversity patterns. Comparison of two different methods, Point Count and Line Transect in analysing diversity is presented below (Table 1, 2, 3).

In overall, both Point Count and Line Transect methods produced patterns of diversity in a similar way. Shannon's index of diversity (Magurran 1988) from Point Count data revealed that the diversity index ranged from 2.67—2.90 with the lowest index at Anoa and the highest index at Wahalaka (Table 1). This pattern was also shown by line transect which diversity index ranged from 2.72-2.95. Simpson's index of diversity (Magurran 1988) which place more emphasis on the partitioning of butterflies between the different species showed similar patterns when using point count (Table 1). However, with the line transect Lasolo has the lowest Simpson index. When the two methods are tested, only Simpson index that showed significant difference ($t = 7.3$, $df = 10$, $P < 0,001$). Both Shannon-Wiener index ($t = -1.2$, $df = 10$, $P = 0.27$) and Evenness ($t = -1.76$, $df = 10$, $P = 0.108$) showed no significant difference using both methods.

Patterns of similarity indices provided by both methods are also comparable. Being the most diverse community, butterfly community in Wahalaka has the greatest similarity with Wabalamba as it explained by the high number of shared species between the two sites. Least similarity of community is demonstrated by Lasolo and Lawele although the least number of of shared species is demonstrated by Anoa and Lasolo (Table 1 & 2).

Patterns of detection probability and detection cue

To analyze the detection probability of line transect and point count methods, program DISTANCE 5.0 (Buckland et al. 1993, Buckland et al. 2001) was used. At this stage, distances were fitted into half-normal detection curve provided by the default model. Only 9 species was used in the distance sampling analyses as they have at least 30 counts (Table 4). Detection probability generated from the distance sampling analyses showed that point count method have significantly higher detection probability than line transect method ($t = -3.412$, $df = 16$, $P = 0.004$). Probability of detection using line transect is positively correlated with number of butterfly counts ($R^2 = 0.66$, $P = 0.008$) but not in point count ($R^2 = 0.20$, $P = 0.23$).

The Discriminant Function Analysis (DFA) showed that using transect method, 71.8% of original group cases are correctly classified. Using the point count, 83.5% of original group cases are correctly classified. Principal Component Analysis (PCA) of detection cue based on line transect showed that rotated component matrix is divided into 3: 1. Groups detected by height and distance, 2. Groups detected by wing patterns and size, 3. Groups detected by coloration (Table 5). PCA of detection cue based on point count data showed that rotated component matrix is divided into 3: 1. Groups detected by wing patterns, size, and height, 2. Groups detected by coloration, 3. Groups detected by distance (Table 6).

Discussion

<u>Patterns of butterfly diversity</u>

Pollard walks have been used widely in butterfly surveys since it was proposed (Pollard 1977). This modification of pollard walks is an addition to effectively surveying butterflies in a rapid assessment project with addition of recording the distance. Distance sampling has been used widely in vertebrate population estimates but rarely used in invertebrate populations particularly insects. Many research on butterflies have used line transect methods but none search out the further use of distance sampling for population estimates (Hill et al.1995, Brown and Boyce 1998, Kitahara and Fujii 2005).

The distance sampling however, provides robust estimates of abundance as the method requires several assumptions to be met. The line transect distance sampling requires observer to traverse a line and record all objects detected. In point count, observer stands on a point and record all objects detected. Several assumptions to be met in distance sampling including: (a) objects should be detected at their initial location, (b) distance should be estimated accurately, and (c) objects are corretly identified (Buckland et al. 1993, Buckland et al. 2001). First and second assumptions are likely to obtain since 5-m range is quite narrow and butterflies are easily detected within this range. Observer may also need to practice distance estimation. Identification is one of the critical problems which may violate the assumption. Observers may need to spend some time prior to survey to capture and identify the species. Further use of distance sampling may includes estimating effective strip width (line transect) or effective distance radius (point count), probability of detection and estimating population abundance along with variances (Buckland et al. 1993, Buckland et al. 2001).

The 5-m range used in Pollard walks is similar to fixed-width transect sampling. The detection probability is probably higher in butterfly than other vertebrates as 5-m range is quite narrow for transect width. Similar to transect walks, line transect can obviously detect more species than point count and has undoubtedly provide higher species richness. Cunningham et al. (1999) who studied bird detectability in Australia revealed that line transect provide higher abundance than point count. The chance to observe more species is likely higher in line transect as the transect may crossed different variety of habitats and crossed many bird territories (Cunningham et al. 1999). In point count, on the other hand, has a limitation of detecting more species. Observer can only stand on the point and points may be located in similar habitats.

However, although not shown by all variables evaluated, both methods still produced similar patterns of species richness, diversity, and similarity of community at different sites. In general, Wahalaka has the most diverse butterfly community than other sites. This diversity patterns is similar when using Shannon-Wiener index. Wahalaka and Wabalamba are also shown to have quite similar communities. Results of line transect and point counts may not show similar properties as both methods are affected by flight behavior. Unlike immobile methods such as trapping, transect walks tend to record species with distinct flight activity (Walpole and Sheldon 1999).

<u>Patterns of detection probability and detection cue</u>

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. Despite the unfavorable taste, conspicuous butterflies are easily detected by predator (Chai 1996). Similar to predator detection, butterflies with more apparent looks (color, size, and behavior) tend to easily detected by human which may cause bias in estimating abundance of particular species (Dennis et al. 2006). Different flight patterns are known to occur in different butterfly species even within the same group (Scott 1975).

Different species may have different probability of being detected and sometimes is related to sampling design. The results shows that point count method generates higher detection probability than line transect. Probability of detection is approaching one when particular species have fewer abundance (Table 4). This is particularly true for many Papilionidae as they have larger size and usually occur in small abundance.

Comparison of different method in the detection cue provided slightly different patterns. In line transect method, both distance and height are important as detection cue.

In this method, observers traversed a line and record all butterflies seen (Buckland et al. 2001). Observers sometimes have to deal with rough terrain of the transect and thus sometimes experience fatigue and reduce detection probability. Walking and counting are two elements of concentration needed in line transect (Cunningham et al. 1999). Split concentration would likely produce bias as some butterflies may be missed during counts. Butterflies at closer distance and lower height level are obviously easier to detect as they passed close to the observers.

Using point count, butterflies with distinct wing patterns, size and height were grouped together as well as butterflies with bright coloration and butterflies with certain distance detection. This result suggested that butterflies with distinct morphology such as *Papilio gigon* or *Vindula erota* are easily detected in point count. Point count allows flexibility in detecting object than line transect as observers stayed for few minutes in a point to do the counting. In line transect method, observers have to walk in a steady pace and tend to detect the quantified cue.

The issue of detectability has been widely discussed in bird studies but rarely in butterflies. Cunningham et al. (1999) used detection cue to assign the bird groups as bird usually detected by calls which may comprise of quality, distinctiveness, and loudness. Other detection of birds may come from body size, coloration, behavioural patterns, and foraging height. Assigning butterflies to detection attributes is likely confounded by subjectiveness as field guide may not present and the more diverse butterfly community than birds. Clearly, identification skill along with good sampling design is the significant factor in obtaining the highest detection probability (Zonneveld 2003).

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 (Cook and Jacobson 1979, Nichols et al. 2000, Thomson 2002). Applying similar approach would be promising for butterfly studies.

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Table 1. Comparison of both Point Count and Line Transects in number of butterfly species, Shannon-Wiener and Simpson Indices, as well as Evenness among node camps.

Site	Species		Shannon-Wiener		Simpson		Evenness	
	Point	Transect	Point	Transect	Point	Transect	Point	Transect
Anoa	22	22	2.67	2.72	11.15	10.65	0.86	0.88
Lapago	37	46	2.78	2.86	11.27	10.88	0.77	0.75
Lasolo	23	32	2.83	2.89	11.30	10.61	0.90	0.83
Lawele	31	42	2.87	2.93	11.56	10.84	0.84	0.78
Wabalamba	31	42	2.89	2.94	11.54	10.75	0.84	0.79
Wahalaka	29	49	2.90	2.95	11.57	10.85	0.86	0.76

Table 2. Matrix of pairwise Morisita-Horn similarity index of each node camp using Point Count and Line Transects.

Site	Anoa		Lapago		Lasolo		Lawele		Wabalamba	
	Point	Transect	Point	Transect	Point	Transect	Point	Transect	Point	Transect
Lapago	0.919	0.896								
Lasolo	0.858	0.818	0.807	0.835						
Lawele	0.817	0.821	0.867	0.944	**0.746**	**0.798**				
Wabalamba	0.923	0.930	0.868	0.940	0.891	0.891	0.847	0.888		
Wahalaka	0.908	0.933	0.856	0.913	0.864	0.846	0.884	0.883	**0.946**	**0.966**

Table 3. Matrix of pairwise shared species between node camps using Point Count and Line transects.

Site	Anoa		Lapago		Lasolo		Lawele		Wabalamba	
	Point	Transect	Point	Transect	Point	Transect	Point	Transect	Point	Transect
Lapago	19	17								
Lasolo	13	11	18	18						
Lawele	18	18	25	31	16	17				
Wabalamba	16	17	21	27	14	15	20	26		
Wahalaka	15	17	20	29	18	18	20	28	19	28

Table 4. Count and detection probability of 9 most abundant butterfly species of Lambusango

Species	Counts		Detection probability (P)		Coefficient of variance	
	Line transect	Point	Line transect	Point	P CV Line	P CV Point
Acrophtalmia leuce	116	55	0.23	0.74	0.05	0.17
Cupha maeonides	153	118	0.45	1.00	0.08	0.14
Elymnias hewitsoni	187	148	0.50	1.00	0.10	0.11
Faunis menado	230	176	0.17	0.83	0.09	0.10
Lasippa neriphus	107	86	0.48	1.00	0.11	0.18
Lohora opthalmica	351	197	0.18	0.73	0.04	0.10
Papilio gigon	78	73	0.75	1.00	0.11	0.17
Papilio sataspes	30	27	1.00	1.00	0.20	0.25
Vindula erota	32	23	1.00	1.00	0.16	0.24

Table 5. Eigen values and rotated component matrix used by Principal Component Analysis of line transect data

	PC 1	PC 2	PC 3
Eigen value	1.683	1.587	1.021
% of variance	33.7	31.7	20.4
% Cumulative	33.7	65.4	85.8
Height	0.899827		
Distance	0.852148		
Wing patterns		0.911965	
Size		0.822207	
Color			0.986459

Table 6. Eigen values and rotated component matrix used by Principal Component Analysis of point count data

	PC 1	PC 2	PC 3
Eigen value	1.837	1.051	1.016
% of variance	36.7	21.0	20.3
% Cumulative	36.7	57.8	78.1
Size	0.858277		
Wing patterns	0.779919		
Height	0.682545		
Color		0.962111	
Distance			0.983362

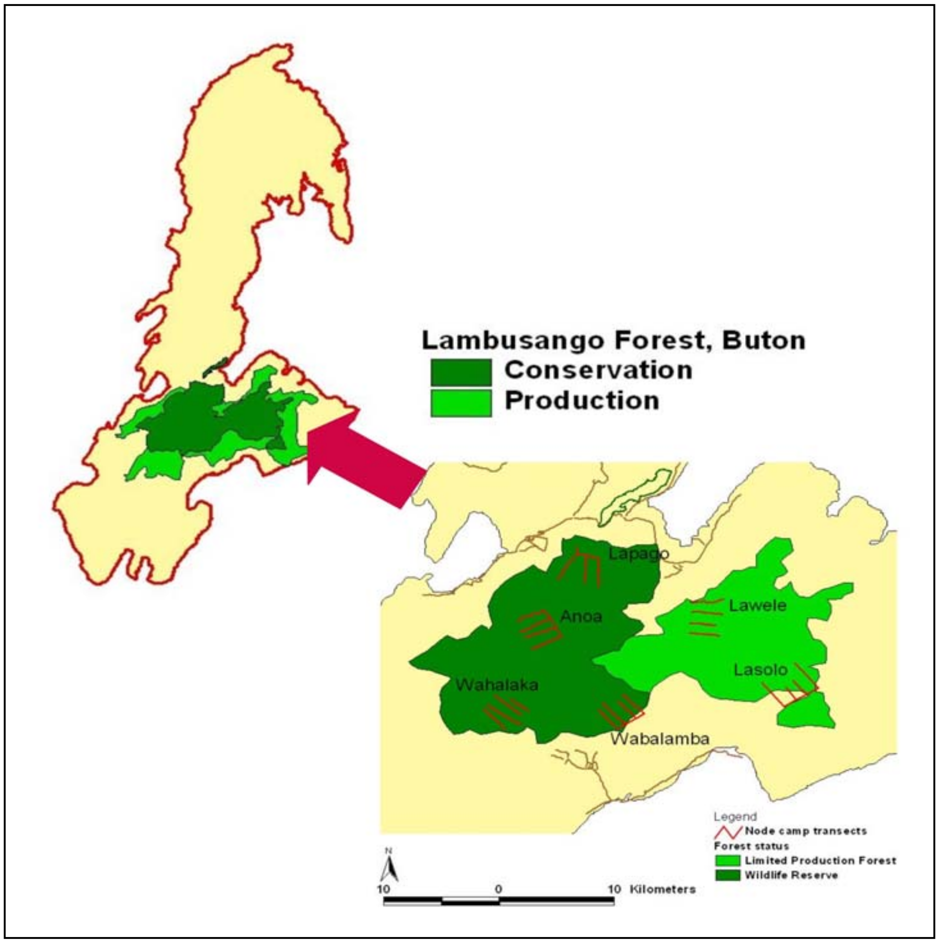

Figure 1. Lambusango Forest and location of study sites within Lambusango forest, Buton, Southeast Sulawesi

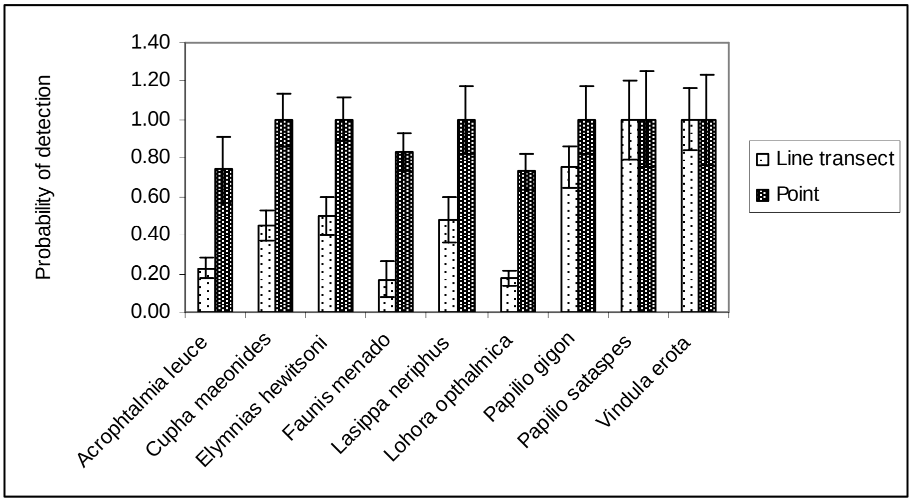

Figure 2. Detection probability of ten most common species using line transect and point count methods.