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).

Patterns of detection probability and detection cue

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

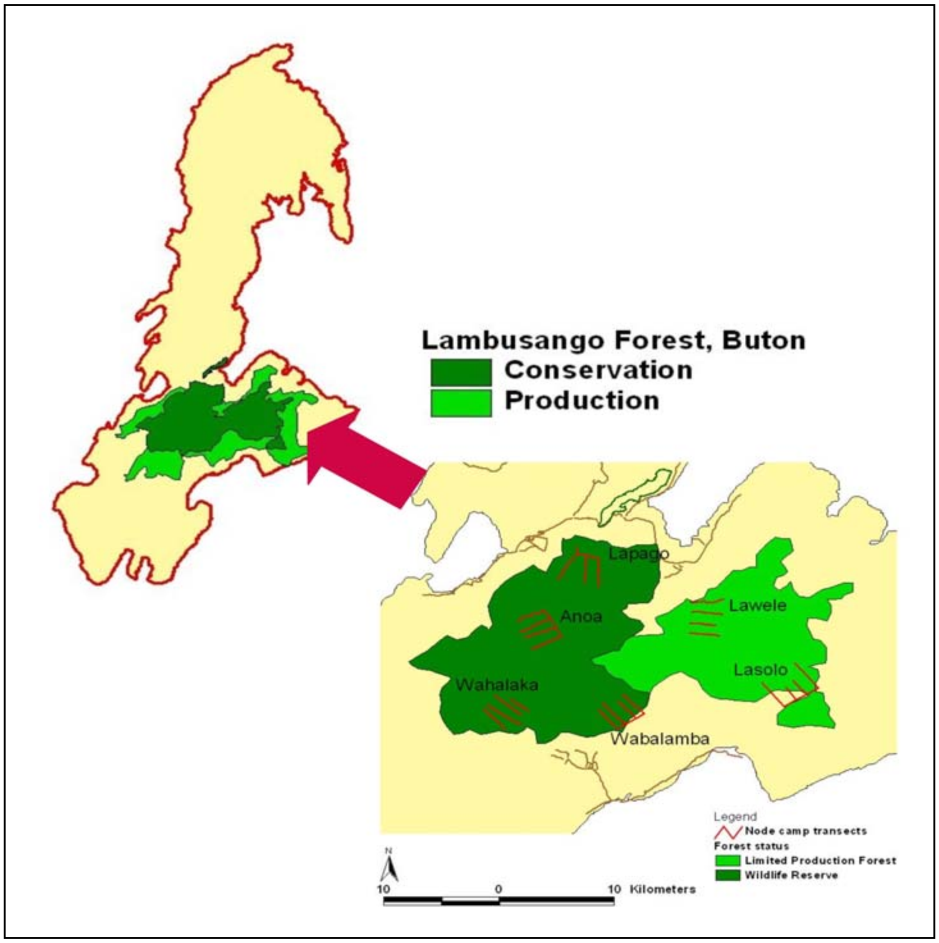

Figure 1. Lambusango Forest and location of study sites within Lambusango forest, Buton, Southeast Sulawesi

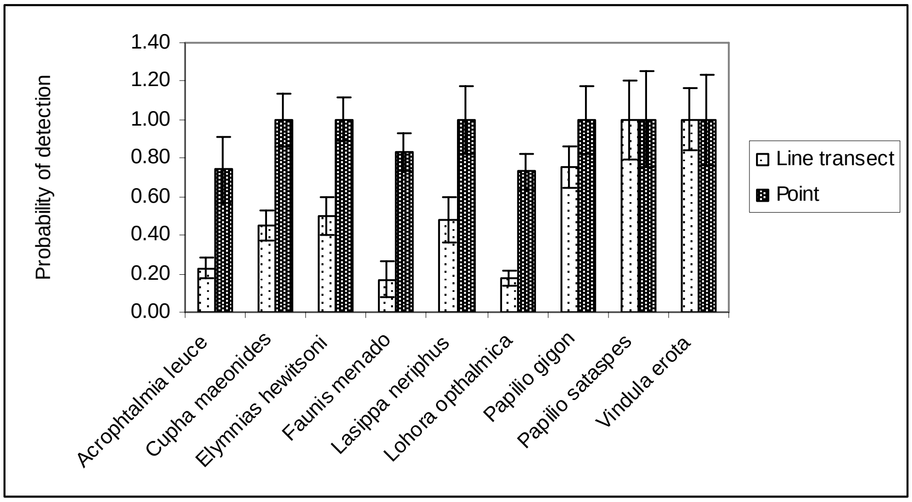

Figure 2. Detection probability of ten most common species using line transect and point count methods.