CHAPTER VIII

Chapter VIII

Butterfly community and habitat association

8.1. Introduction

Biotic inventories provide critical data for conservation planning, but frequently conservation decisions are made without surveys due to lack of time, funds, expertise or appropriate methodology. To set aside representative area around the globe, that will protect the fullest range of biological diversity requires far more complete knowledge of the distribution and abundance of organisms than currently available (Soule & Kohm 1989). Biodiversity surveys are becoming popular in protected areas (Debinski & Brussard 1992, 1994). A method for target taxon analysis is therefore proposed for streaming regional biotic inventories. Species rich taxon with adequate knowledge about natural history has been recommended to surrogate biological diversity (Kremen 1992, Blair 1999). Many researchers (Gilbert 1980, 1984, Pyle 1980, Brown 1982, Murphy *et al.* 1990, Kremen 1992) have suggested that butterflies are well suited as indirect measures of environmental variations because they are sensitive to local climate and light levels (Ehrlich *et al.* 1972, Weiss *et al.* 1987, 1988). Moreover, butterfly diversity surrogates measures of plant diversity as there are strong interactions between larvae and adult host plants (Kremen 1992). The use of butterfly in assessment of biological diversity has gained much ground in the recent years.

A variety of biotic and abiotic factors, such as distribution of food, shelter, microclimate or intra- and interspecific interactions influence the distribution of animals in a habitat. In butterflies, the distribution of food and microclimate are thought to be especially important (Douwes 1975, Murphy *et al.* 1984, Boggs 1987). Therefore, butterflies are widely used as indicator species by many researchers and conservationists (Cheverton & Thomas 1982, Kremen 1992, Pearson & Cassola 1992).

Himalaya is rich in all components of biodiversity. In the Himalaya, 80 per cent of the butterflies have been reported as forest species, of which about 60 per cent of them occur within the forests below 3,000 m. Inspite of high butterfly richness, no serious attempt has been made in Sikkim except a few general documentation (Haribal 1992, see also Chapter II). The present study is an attempt to survey the habitat use pattern of butterflies along the Yuksam-Dzongri trail. In the study, species composition, diversity indices and relationship with the habitat types were examined at the designated areas as described before. The results were then tested to answer the usefulness of bird and butterfly taxa as indicator species for biodiversity assessment.

8.2. Methods

Butterflies were monitored both by visual and baited trap methods at 19 transects each measuring 100 m crossing each of the permanent plots [4 each at closed canopy stand (CC) of lower forest (LF) and upper forest (UF), 5 at open canopy stand (OC) of LF, 4 at CC of UF and 6 at OC of UF] during summer (May-August) and in winter (October-February) for one year. Identification of specimens were made using the photoplates provided by Haribal (1992). The total number of sampling made was 114. At each permanent plot (see Chapter V), a station for butterfly observation was set and diversity indices and density were extrapolated from the collected data. Butterfly species were recorded by transect walk (modified from Pollard *et al.* 1975, Pollard 1977) with visual observations for two hours (morning 1100-12-00 and afternoon 1200 - 1300) in good weather days. Species that were not easily recognisable were identified with the help of fermented banana baiting (De Vries 1988). Each day trapped butterflies were collected for identification or marked and released after identification (Kremen 1992). The canopy foragers were observed with the help of a binocular.

8.2.1. Data analysis

The recorded data on identified species were considered for the analysis. Simple regressions were applied to examine diversity trends with elevation. Analysis of variance (ANOVA) was performed for interactions between forest types, habitat conditions and seasons for the species composition. Comparison of diversity indices for effect of forest types and habitat conditions were tested with Mann-Whitney U test following Hill *et al.* (1995) with some modifications. Pearson correlation and linear regression were used to evaluate the relationship between butterfly and habitat as well as with bird. All tests were made using SYSTAT (1996).

8.3. Results

8.3.1. Butterfly species composition

A total number of 391 butterfly individuals were recorded in 114 samplings during 1997-1998. These individuals represented 49 species under five families (Appendix B). The list of the species furnished in the Nymphalidae was the most dominant group (47%) followed by Papilionidae (24%), and Pieridae (18%) (Fig. 8.1). Mean number of species and densities at different forests are presented in Table 8.1. The highest number of species was recorded at open canopy condition of lower forest followed by closed canopy condition at LF and the least was at the closed canopy condition of upper forest (UF). Similarly, butterfly richness and density were also higher at the open canopy forests of LF and UF (Table 8.1). Seven species are exclusively found in the lower open forest, followed by six in lower closed canopy forest, three at open forest at the upper forest and only one in closed canopy forest at upper forest (Appendix B).

Butterfly species diversity, its richness and the evenness significantly differed between the forest types (Mann Whitney test values were U=2489.5, P<0.000, U=2070.5, P<0.009, U=2175.5, P<0.001) respectively (Table 8.2). On the other hand, the difference in butterfly species between the open and closed canopy conditions was significant (U=1799.5, P<0.21).

8.3.2. Seasonal change in butterfly species

Mean number of species of butterflies differed significantly between the forest types and habitat condition (ANOVA: $F_{1,106}$= 7.4, P<0.007 and $F_{1,106}$= 5.9, P<0.01) respectively (Fig. 8.2). Significant interaction between the forest types and seasons ($F_{1,106}$= 9.2, P<0.003) indicates that the forest types and seasons influenced the variation in number of species among the forest types with the change of the season. But, other interactions were not significant.

8.3.3. *Butterfly habitat relationship*

As predicted (Chapter I) both butterfly species diversity ($Y=9.58-1.2lnX$, $R^2=0.59$, $P<0.001$) and its richness ($Y=9.08-1.1lnX$, $R^2=0.30$, $P<0.01$) were significantly and negatively correlated with the rise in elevation (Fig. 8.3) showing decreasing trend with the rise of elevation. The regression drawn (Fig 8.3) on the diversity indices of 19 transects showed significant positive relationship between the tree species diversity and butterfly species diversity ($Y=-0.42+0.46X$, $R^2=0.53$, $P<0.001$) but the relationship among the species richness of these two groups were not significant ($Y=0.64+0.12X$, $R^2=0.12$, $P<0.15$). Pearson product moment correlation on 3PCs (see Chapter VII) extracted from the vegetation data showed significant positive correlation of butterfly diversity only with PC3. The correlation with the other components was not significant (Table 8.3).

8.3.4. *Indicator properties*

There were distinct variation of the habitat between the lower and upper forests and open and closed canopy conditions (Chapter V). Moreover, the relationships between the tree diversity indices and bird diversity indices were also significantly positive (Fig. 7.1). The overall trend in diversity indices in butterflies, birds and the trees were remarkably similar across the elevation and habitat types (Figs. 6.4, 8.4 and Tables 5.2, 6.3 and 8.1). Though the number of butterfly species was consistently lower, all the three groups (trees, birds and butterflies) were generally higher at the open canopy forest and showed a strong correlation among the groups (Table 8.4). Tree species diversity, bird species diversity and the butterfly species diversity had significantly positive correlation (Table 8.4) suggesting that they are directly related to each other.

8.4. Discussion

Butterfly diversity in the Yuksam-Dzongri trekking corridor is not rich as the bird. The record of only 49 species in the whole corridor suggests that the area is poor in butterfly habitat. Species are sparsely distributed along the corridor. Majority of species explored the lower forest as their habitat. A linear decrease in the diversity along the altitude suggests similar to cases of tree and bird species diversity. One of the reasons for such decrease could be due to remarkable decrease in temperature along the trail, which is an important factor for the survival of butterfly (Brakefield 1992). Higher number of butterfly species and their diversity at the lower forest suggest that the lower forest is much better habitat compared to the upper forest. Higher relative humidity due to shade trees and dense canopy cover limits the number of butterfly species and their mean density in the closed canopy forest. Because, at higher relative humidity the larvae are susecptible to viral and bacterial diseases leading to their death. Furthermore, lack of plant species diversity in the closed canopy condition limits the food resources of both larvae and adult. This finding is contrary to report of Hill *et al.* (1995). In their study, Hill and his coworkers stated that there was greater species richness in unlogged forest due to greater vegetation cover with more shade but they have overlooked the physical feature of the habitat such as temperature and humidity which creates the microclimate in the habitat. Moreover, in contrary to the present study, the vegetation structure such as tree height and basal area are similar in their field stations. Therefore, it was assumed that such variation in habitat conditions might have brought about the differences.

Butterfly species richness, its diversity and evenness were all significantly higher at the open canopy compared to closed canopy forest at LF. Increase in diversity at the open canopy forest suggests that the butterflies use the open canopy forest where the diversity of tree species is higher. As discussed in chapter V, VI and the VII, open canopy forests are diverse in their vegetation composition and stratification. Butterfly also used these habitat conditions more extensively than the closed canopy forest. Some previous studies have also demonstrated such reduction in diversity following more extreme form of forest disturbance

(Holloway *et al.* 1992). Raguso and Llorente-Bousquets (1990) found an apparent increase in butterfly diversity following fragmentation in habitats due to selective logging. The significant relationship between butterfly diversity indices and tree diversity indices suggested that there is a strong interaction between the two groups (Hill *et al.* 1995). This relationship is expected because butterfly species diversity is a function of plant species diversity as their food plants and these are the product of coevolution (Ehrlich & Raven 1964, Loertscer 1995).

Though birds and butterflies use the environment in very different ways, significant relationship between these two groups and the strong association with the habitat types in them have suggested that they are directly related to the habitat quality. Moreover, significant correlation among trees, birds and butterflies suggest that the bird or butterfly study surrogates to each other. Therefore, if the conservation planners are interested in species richness, diversity and habitat quality evaluation, either group would serve as an adequate measure for the other at regional level. But, one would not intuitively guess that the bird and butterfly communities, on the whole, would respond to habitat in all areas in the same pattern as these were recorded in the present study. The differences may come due to variation on geographical feature, weather and the vegetation types (Blair 1999). For example, Pearson and Cassola (1992) studied on bird and butterfly species in the North America and found a strong correlation. Later Flather *et al.* (1997) reported that the pattern of bird and butterfly association was much weaker when the study was conducted across the different latitudes.

It is important to assess the human impact as it influences either by changing the habitat or by the maintenance thereof (Jones *et al.* 1987, Hannah *et al.* 1995). Usefulness of target taxa in monitoring such natural areas for biodiversity assessments are well documented (Kremen 1992, Pearson & Cassola 1992, Debinski & Brussard 1994, Blair 1999). As far as the suitability of bird and butterfly in biodiversity assessment is concerned, many of the researchers have supported the view of their usefulness (Kremen 1992, Pearson & Cassola 1992, Debinski & Brussard 1994). In the present work, butterfly community structure could show a distinct variation even between the open and closed canopy conditions which was not much convincing in the case of bird community. This finding has suggested that butterflies are more sensitive to the habitat disturbance compared to the birds (Debinski & Brussard 1994). Therefore, both bird and butterfly can be used as an important tool in the natural area management where there are time and funds constrains. Simple records of butterfly or birds can be used to predict the quality of habitat as they showed strong correlation and also can surrogate other taxa until there is no drastic change in vegetation types or the microclimate due to major geographical difference.

8.5. Conclusion

The accelerating human pressure in Yuksam-Dzongri trail has changed the vegetation structure (Chapter V). Most of the closed canopy forests have already opened creating degraded patches. Still the degradation has not reached at the critical level as higher diversity is maintained in the open canopy condition along the trail. But the increasing demand of forest resources by community and the use of firewood for tourism related activities have threatened the future of this biologically rich area. Although, the area is not rich in butterfly species, the discussion so forth has cleared that the disturbance in the natural areas brings about changes in the biological diversity. Higher diversity in the open forest condition has reflected that the disturbance is within the intermediate level. Information on organisms of the area and their response to habitat change due to human disturbance provides the planning efficacy in the protected areas for maintenance of biological diversity.

Structural diversity in the forests and differences in elevation are important factors to explain distribution and community organisation. Moreover, use of ordination technique with firsthand conceptual models on the aim and objectives of the study are equally important to come to a proper conclusion. In the present study, the assessment of habitat and the relationship of bird/butterfly provided a valuable concept on usefulness of bird and butterfly in biodiversity assessment. The easy method, less effort and higher sensitivity of butterfly on habitat change have advantage over the bird which is an important message to all conservationists and forest managers to use it as indicator animal community.

Table: 8.1. Sample size, composition and species diversity indices of butterfly in different habitat conditions and forest types at Yuksam-Dzongri trekking corridor.

Parameters	Lower forest		Upper forest	
	CC	OC	CC	OC
Sampling size (100 m transect)	23	22	3	10
Species recorded	26	34	12	17
Species per transect (mean±SE)	2.0±0.3	2.8±0.2	1.6±0.2	1.9±0.2
Individuals per transect (mean±SE)	3.3±0.5	4.2±0.3	2.8±0.4	3.1±0.3
Shannon Weiner's diversity (H')	0.39	0.77	0.32	0.28
Margalef's species richness index	0.91	1.29	0.58	0.87
Pielou's evenness index	0.29	0.67	0.22	0.58

CC= closed canopy condition, OC= open canopy condition.

Table: 8.2. Comparative assessment of butterfly community structure between forest conditions (open and closed canopy) and forest types (lower forest and upper forest) of Yuksam-Dzongri trekking corridor.

Variable	Forest condition effect			Forest type effect		
	Mann-Whitney* U- value	$X^{2\#}$	P	Mann-Whitney! U- value	$X^{2\#}$	P
BTSD	1799.5	1.54	0.21	2489.5	24.4	0.000
BTSR	1961.5	4.8	0.02	2070.5	6.8	0.009
BTEV	1917.5	3.8	0.05	2175.0	10.3	0.001

(BTSR = butterfly species richness, BTSD = butterfly species diversity and BTEV = butterfly evenness).
*Count number $U_{0.05(2),54,60}$; !Count number $U_{0.05(2),66,48}$; # chi-square approximation with df 1

Table 8.3. Correlation coefficient between butterfly community attributes and principal components (PC) along Yuksam-Dzongri trekking corridor.

Community attributes	PC1	PC2	PC3
Butterfly species richness	0.015	-0.225	**0.524**
Butterfly species diversity	-0.264	-0.270	0.372
Pielou's evenness index	-0.123	-0.286	0.419

Bold value is significant at P<0.05

Table 8.4. Pearson correlation coefficient for overall tree, bird and butterfly diversity indices along the Yuksam-Dzongri trekking corridor (*n*=19, d.f.=17).

Diversity indices	TSR	TSD	BSR	BSD	BTSD	BTSR
Tree species richness (TSR)	-	0.926	0.842	0.834	0.767	0.343
Tree species diversity (TSD)	0.01	-	0.963	0.794	0.732	0.318
Bird species richness (BSR)	0.01	0.01	-	0.963	0.635	0.594
Bird species diversity (BSD)	0.01	0.01	0.01	-	0.615	0.611
Butterfly species diversity (BTSD)	0.01	0.01	0.01	0.01	-	0.377
Butterfly species richness (BTSR)	NS	0.01	0.01	0.01	NS	-

NS= not significant; Lower matrix = probability values; Upper matrix = correlation coefficients

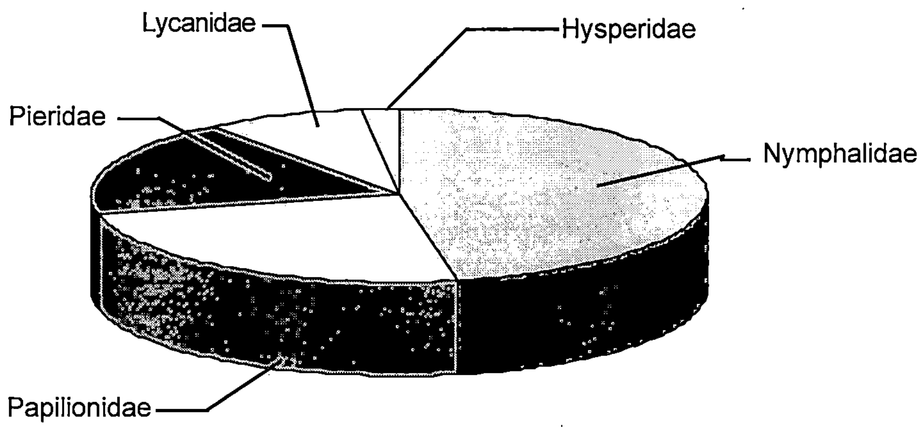

Fig. 8.1. Composition of butterflies of different families recorded from the Yuksam-Dzongri trekking corridor.

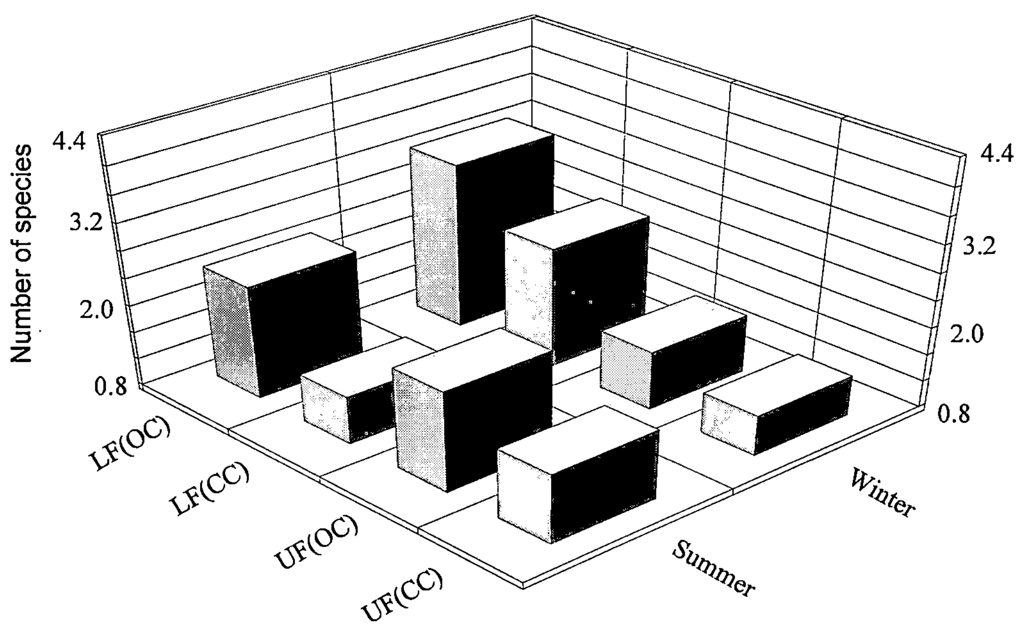

Fig. 8.2. Mean number of butterfly species in the summer and winter seasons during 1997-1998 in the open and closed canopy conditions of lower and upper forests in Yuksam-Dzongri trekking corridor. ANOVA: Forest types $F_{1,106}$=7.5, P<0.007, Forest condition $F_{1,106}$=5.9, P<0.01, Forest types x Seasons $F_{1,106}$=9.2, P<0.003; other interactions not significant, LSD $_{(0.05)}$=1.66.

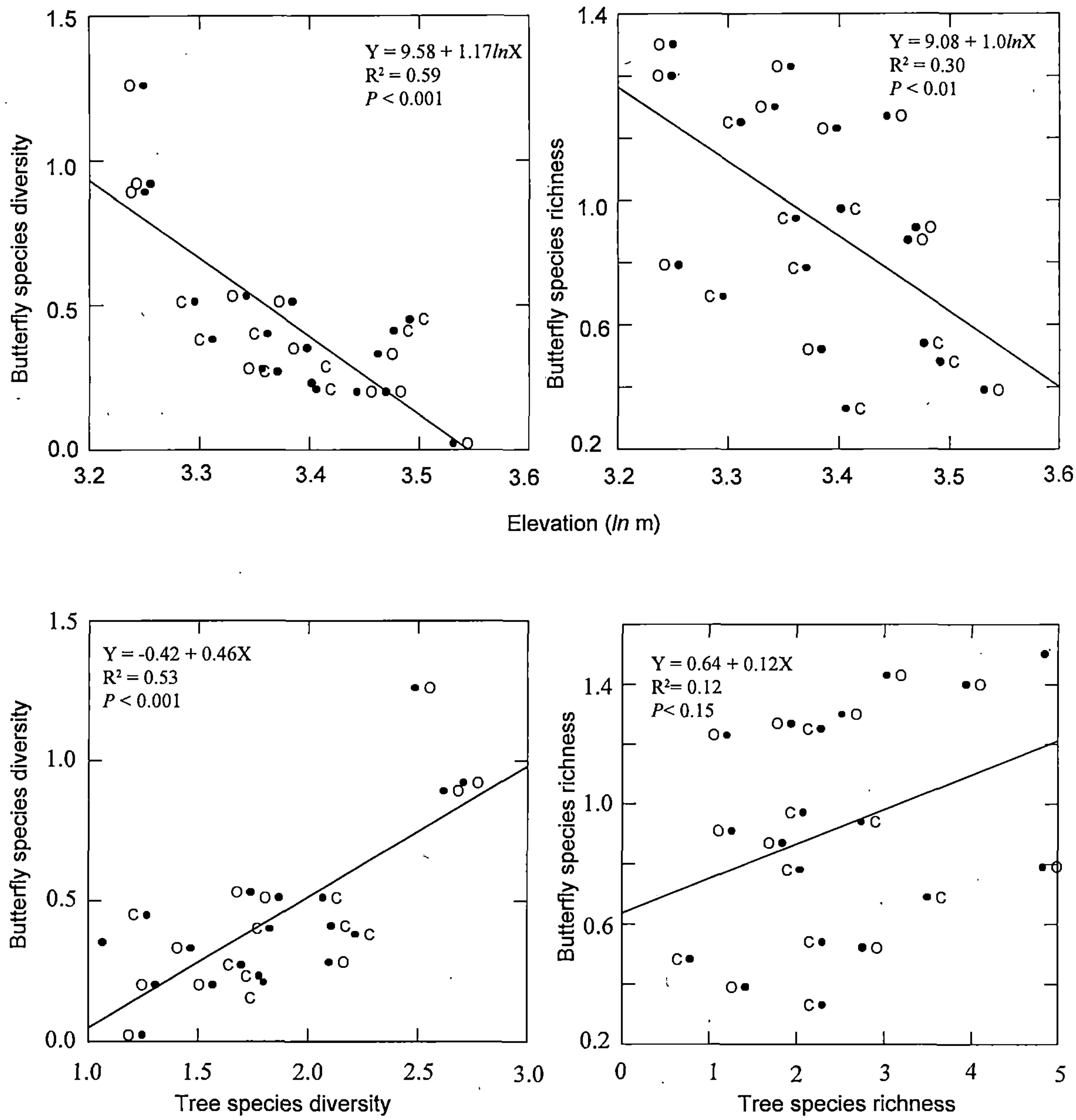

Fig 8.3. Relationship between butterfly diversity indices, tree diversity indices and elevation (O = open canopy condition, C = closed canopy condition) of Yuksam-Dzongri trekking corridor.

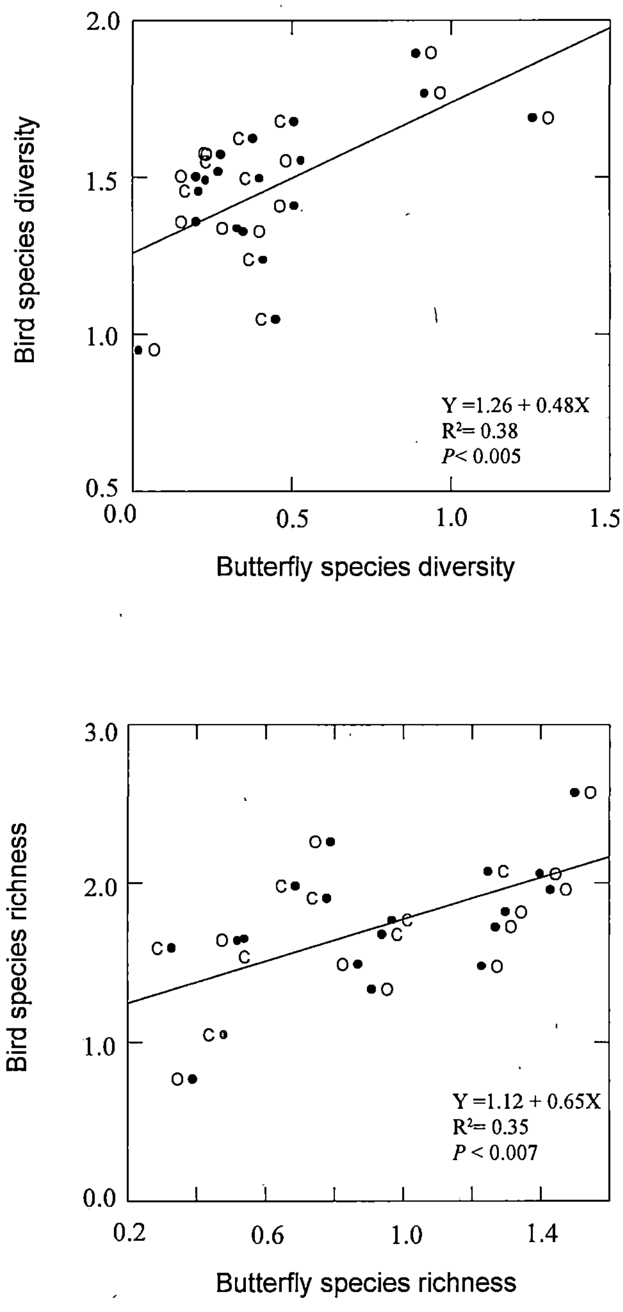

Fig. 8.4. Relationships between the bird abd butterfly diversity indices along the Yuksam-Dzongri trekking corridor (O = open canopy condition, C = closed canopy condition).