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# Species Diversity and Abundance of Butterfly Fauna in Surgani-Sudla, Himachal Pradesh

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**Abstract**

In this study butterflies were used in assessing as a way of biodiversity restoration at Surgani-Sundla Hydroelectric Project area. The Butterflies were used as indicator species because of their high sensitivity in ecosystems alteration. The study was done in three different areas, namely the dam site, diversion site and power house sites. Butterfly sweep nets and Butterfly traps baited were used for Butterflies capturing. Besides, monitoring will also be an indicator about the trend being followed by insects group as a whole. Biodiversity index of butterfly species has been updated from different hydroelectric project sites. The statistical data of seasonal abundance and diversity index of butterfly species have been discussed. The diversity of Butterflies was lowest at power house site during monsoon season and highest during post monsoon season at power house site. In this study butterflies were used in assessing hydroelectric project sites recommended for aesthetic, education purposes and further studies on organisms.

**Key Words:** butterfly, diversity, seasonal abundance

## Introduction

Himachal Pradesh Power Cooperation is planning to set up Surgani-Sundla Hydroelectric Project (48 MW) downstream of Baira-Siul Hydroelectric Project in Chamba District of Himachal Pradesh. The focus on conservation of biodiversity has recently received attention. Various studies and protocols have been proposed to test the apropos patterns of biodiversity (Wilson 1988; Noss 1990; Enrich and Wilson 1991). Vane Wright *et al. (*1991) classified a hierarchical composition of different level of organizations as well as groups of taxonomically related species to test the patterns of biodiversity conservation. A certain insects were used to identify the state or changes in a landscape (Harrington and Stork, 1995). The use of indicator taxa in conservation efforts from pollution control to biodiversity has been the focus of attention (Landres *et al*. 1988). Butterflies are good predictor of other species. In Portugal, Spain, France, Switzerland, Hungary, Ireland, Finland and the UK, it was observed that, after statistical evaluation with data on other components of biodiversity, Butterflies were found to be a potentially useful indicator of biodiversity, a significant predictor of the richness of birds, lichens and plants but not a good indicator of soil biodiversity (Chris, 2012).

The main objective of the study was to assess biodiversity health of Triveni Mahadev by using the Butterflies as indicator species. In India at least two species of butterflies have shown change in their distribution range, recently. The Red Pierrot, *Talicada nyseus nuseus* (Lycaenidae) a species restricted to Peninsular India has now colonized the lower West Himalayan foothills and Shiwaliks in northern India (Singh, 2005). While another species, the Brown Gorgon, *Meandrusa lachinus* (Fruhstorfer) Syn.*M. gyas* (Papilionidae), which had distribution restricted to north-east India and eastern Himalayas up to Sikkim has also now established itself in Kedarnath Musk Deer Reserve in Garhwal, the western Himalayas (Singh, 2006). There is now ample evidence of the ecological impacts of recent climate change, from polar terrestrial to tropical marine environments. The responses of both flora and fauna span an array of ecosystems and organizational hierarchies, from the species to the community levels. Despite continued uncertainty as to community and ecosystem trajectories under global change, our review exposes a coherent pattern of ecological change across systems. Although we are only at an early stage in the projected trends of global warming, ecological responses to recent climate change are already clearly visible (Walther *et al.*, 2002).

Diversity among the high-elevation-specialist butterflies is beginning to fall as temperatures become uncomfortably warm for them. As already stated Butterflies are particularly sensitive to climate and are important bio-indicators of climate change. They are good biological indicators of environmental variation as they are easily noticed as they are diurnal, flying around during sunshine, attractive, conspicuous; more easily identified group as compared to others; taxonomically track able with most species described and recognizable; have short generations and are widespread and diverse. They are also good biological indicators of environmental quality as they are sensitive and directly affected by any alteration in their habitats, atmosphere, local weather, temperature and micro-climate (Watt *et al*. 1968; Warren *et al*. 2001; Rosenberg *et al*. 1986). Butterflies are excellent indicators of the effects of climate change on the wildlife. Butterflies [Rhopalocera] are particularly sensitive to climate and are important bio-indicators of climate change (Dennis, 1993; Margaret, 2008). They are good biological indicators of environmental variation as they are easily noticed as they are diurnal, flying around during sunshine, attractive, conspicuous; more easily identified group as compared to others; taxonomically track able with most species described and recognizable; have short generations and are widespread and diverse.

Among insects, butterflies are most suitable for ecological studies, as the taxonomy, geographic distribution and status of many species is relatively well known. Those insects, which are mostly phytophagous, serve as primary herbivores in the food chain. As many butterflies are food bio-indicators of the environment, hence they can be used to identify ecologically important landscapes for conservation purposes. Butterflies show distinct pattern of habitat utilization. The nature of vegetation is an important factor, which determines the dependence and survival of a species on a particular habitat. Being highly sensitive to environmental changes, they are easily affected by even relatively minor disturbances in the habitat so much so, that they have been considered as indicators of the environment. The presence of butterflies emphasizes availability of larval food plants in great abundance. As stated earlier, most of the butterflies have specific habitat requirements, since the females usually tend to lay eggs, only on selective food plants occurring in the area (Wynter-Blyth, 1957).

## Materials and Methods

The study was carried out at Surgani-Sundla Hydroelectric Project in Chamba district. Three survey sites. (DMS: Indicating Area of Dam Site 770m; DVS: Indicating Areas of Diversion Site 890m; PWH: Indicating Areas of Powerhouse site 790m) are selected as representatives of the habitat type in the study area. Collection, preservation and storage of specimens of Butterflies have complated during the study period. Two types of Butterfly traps were used, that is the sweep nets and Butterfly traps. Identification of Butterfly fauna with the help of literature or through comparison with national reference collections being housed at Entomological Museums of I.A.R.I., New Delhi and F.R.I., Dehradun. Dissection of imagoes has done for the study of genitalia and identification and characterization of new species of Butterfly, if any.

## Methodology for analyzing biodiversity

**1.** Regular marked trails in all habitat type will be made during collection period. All butterfly species sighted are collected, identified and recorded. Identifications is confirmed from different national museum and literature. The year, in this part of the world is divided into four seasons based on general observation on the climate. The first wet season from Mid June to Mid September receives scanty rainfall through the Monsoon. The next three months from September to November are dry, relatively cooler months and receives scanty showers. The months from December to March constitute winter interrupted by rain and heavy snow. Some of high altitude areas remain separated from rest of the world due to heavy snow. Three months from April to June are hot and humid with scanty rainfall. Since sampling efforts in the four seasons will be unequal and all specimens collected over each of the month will be pooled together for analysis, only relative estimates of the abundance is possible. The mean relative abundance values of all the counts in each habitat will be calculated for the different species in the four seasons. Differences between the means across the habitats will be tested to determine any habitat preference by the moths.

**2.** Transect counts are made to monitor butterfly populations. Three transect, each with $1000x10m^2$ are selected at different habitats. Each of the transect is visited at least twice in a season and all the butterflies observed are recorded transect wise. These steps will be slow but undeviating, covering each transect in about one hour. Butterfly specimens are collected for identification. Details of habitat, plant visited, flower visited and other activity like mud puddling are recorded.

## Data analysis:

## Differentiation diversity (beta diversity)

The beta diversity is estimated using similarity coefficients as a measure of how different or similar a range of habitats or samples are in terms of variety of species found in them. Though several indices exist, Shannon-Winner index is used for the present study.

## Results and Discussions

Butterfly traps and sweep net gave the total 402 individuals from three survey sites. DMS: Indicating Area of Dam Site ; DVS: Indicating Areas of Diversion Site; PWH: Indicating Areas of Powerhouse site. Through data analysis 8 species were found during pre-monsoon season (H= -1.95, C=0.15); 11 species were found during monsoon season (H= -2.25, C=0.12); 7 species during post- monsoon season (H= -1.98, C=0.15) from dam site (Table 1-3). 9 species were found during pre-monsoon season (H= -2.05, C=0.15); 9 species were found during monsoon season (H= -1.98, C=0.15); 7 species during post-monsoon season (H= -1.86, C=0.17) from diversion site (Table 4-6). 10 species were found during pre-monsoon season (H= -2.14, C=0.13); 11 species during monsoon season (H= -2.28, C=0.11); 7 species during post-monsoon season (H= -1.83, C=0.17) from power house site (Table 7-9).

Table 1 Surgni sundla premonsoon dam site

| S.No. | Name of the Species | P | Q | Abundance | Density / sq.m. | Frequency % | (ni/n)= Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Colias erate (esper)* | 4 | 2 | 2 | 1 | 66.67 | 0.15 | -0.29 | 0.02 |
| 2 | *Eurema hecabe* | 1 | 1 | 1 | 0 | 33.33 | 0.04 | -0.13 | 0.00 |
| 3 | *Eurema laeta* | 1 | 1 | 1 | 0 | 33.33 | 0.04 | -0.13 | 0.00 |
| 4 | *Graphium colanthus* | 2 | 1 | 2 | 1 | 33.33 | 0.08 | -0.20 | 0.01 |
| 5 | *Heliophorus sena* | 4 | 3 | 1.33 | 1 | 100.00 | 0.15 | -0.29 | 0.02 |
| 6 | *Junonia lemonias* | 5 | 3 | 1.67 | 2 | 100.00 | 0.19 | -0.32 | 0.04 |
| 7 | *Neptis hylas* | 4 | 2 | 2 | 1 | 66.67 | 0.15 | -0.29 | 0.02 |
| 8 | *Papilio demoleus* | 5 | 3 | 1.67 | 2 | 100.00 | 0.19 | -0.32 | 0.04 |
| | | 26 | 16 | | | | | -1.95 | 0.15 |

Table 2 Surgni sundla monsoon dam site

| S.No. | Name of the Species | P | Q | Abundance | Density/ sq.m. | Frequency% | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Argynnis* sp. | 2 | 2 | 1 | 0.67 | 66.67 | 0.03 | -0.11 | 0.00 |
| 2 | *Candida canis* | 9 | 3 | 3 | 3 | 100.00 | 0.15 | -0.28 | 0.02 |
| 3 | *Catopsilia pyranthe* | 4 | 3 | 1.33 | 1.33 | 100.00 | 0.06 | -0.18 | 0.00 |
| 4 | *Colias erate (esper)* | 6 | 3 | 2 | 2 | 100.00 | 0.10 | -0.23 | 0.01 |
| 5 | *Eurema brigitta* | 7 | 3 | 2.33 | 2.33 | 100.00 | 0.11 | -0.25 | 0.01 |
| 6 | *Eurema hecabe* | 5 | 3 | 1.67 | 1.67 | 100.00 | 0.08 | -0.20 | 0.01 |
| 7 | *Eurema laeta* | 12 | 3 | 4 | 4 | 100.00 | 0.19 | -0.32 | 0.04 |
| 8 | *Junonia lemonias* | 2 | 1 | 2 | 0.67 | 33.33 | 0.03 | -0.11 | 0.00 |
| 9 | *Neptis hylas* | 8 | 2 | 4 | 2.67 | 66.67 | 0.13 | -0.26 | 0.02 |
| 10 | *Papilio demoleus* | 5 | 3 | 1.67 | 1.67 | 100.00 | 0.08 | -0.20 | 0.01 |
| 11 | *Parnara guttata* | 2 | 1 | 2 | 0.67 | 33.33 | 0.03 | -0.11 | 0.00 |
| 12 | | 62 | 27 | | | | | -2.25 | 0.12 |

Table 3 Surgni sundla post monsoon dam site

| S.No. | Name of the Species | P | Q | Abundance | Density/ sq.m. | Frequency% | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Ariadne ariadne* | 4 | 3 | 1.33 | 1.33 | 100.00 | 0.17 | -0.30 | 0.03 |
| 2 | *Catopsilia pyranthe* | 4 | 3 | 1.33 | 1.33 | 100.00 | 0.17 | -0.30 | 0.03 |
| 3 | *Eurema brigitta* | 1 | 1 | 1 | 0.33 | 33.33 | 0.04 | -0.14 | 0.00 |
| 4 | *Eurema hecabe* | 2 | 1 | 2 | 0.67 | 33.33 | 0.09 | -0.21 | 0.01 |
| 5 | *Graphium colanthus* | 2 | 2 | 1 | 0.67 | 66.67 | 0.09 | -0.21 | 0.01 |
| 6 | *Neptis hylas* | 2 | 2 | 1 | 0.67 | 66.67 | 0.09 | -0.21 | 0.01 |
| 7 | *Papilio demoleus* | 3 | 2 | 1.5 | 1 | 66.67 | 0.13 | -0.27 | 0.02 |
| 8 | *Parnara guttata* | 5 | 3 | 1.67 | 1.67 | 100.00 | 0.22 | -0.33 | 0.05 |
| 9 | | 23 | 17 | | | | | -1.98 | 0.15 |

Table 4 Surgni sundla pre monsoon diversion site

| S.No. | Name of the Species | P | Q | Abundance | Density / sq.m. | Frequency % | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Aulocera swaha* | 6 | 3 | 2 | 2 | 100.00 | 0.18 | -0.31 | 0.03 |
| 2 | *Candida canis* | 3 | 3 | 1 | 1 | 100.00 | 0.09 | -0.22 | 0.01 |
| 3 | *Catopsilia Pomona* | 3 | 3 | 1 | 1 | 100.00 | 0.09 | -0.22 | 0.01 |
| 4 | *Graphium colanthus* | 2 | 1 | 2 | 0.67 | 33.33 | 0.06 | -0.17 | 0.00 |
| 5 | *Graphium sarpedon luctatius* | 2 | 2 | 1 | 0.67 | 66.67 | 0.06 | -0.17 | 0.00 |
| 6 | *Heliophorus sena* | 2 | 2 | 1 | 0.67 | 66.67 | 0.06 | -0.17 | 0.00 |
| 7 | *Mycalesis francisca* | 3 | 3 | 1 | 1 | 100.00 | 0.09 | -0.22 | 0.01 |
| 8 | *Papilio polytes* | 3 | 2 | 1.5 | 1 | 66.67 | 0.09 | -0.22 | 0.01 |
| 9 | *Pieris brassicae* | 9 | 3 | 3 | 3 | 100.00 | 0.27 | -0.35 | 0.07 |
| 10 | | 33 | 22 | | | | | -2.05 | 0.15 |

Table 5 Surgni sundla monsoon diversion site

| S.No. | Name of the Species | P | Q | Abundance | Density / sq.m. | Frequency % | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Argynnis* sp. | 2 | 2 | 1 | 0.67 | 66.67 | 0.03 | -0.10 | 0.00 |
| 2 | *Ariadne ariadne* | 3 | 2 | 1.5 | 1 | 66.67 | 0.04 | -0.14 | 0.00 |
| 3 | *Aulocera swaha* | 15 | 3 | 5 | 5 | 100.00 | 0.22 | -0.34 | 0.05 |
| 4 | *Candida canis* | 9 | 3 | 3 | 3 | 100.00 | 0.13 | -0.27 | 0.02 |
| 5 | *Catopsilia pomona* | 5 | 1 | 5 | 1.67 | 33.33 | 0.07 | -0.19 | 0.01 |
| 6 | *Graphium sarpedon luctatius* | 11 | 3 | 3.67 | 3.67 | 100.00 | 0.16 | -0.30 | 0.03 |
| 7 | *Heliophorus sena* | 1 | 1 | 1 | 0.33 | 33.33 | 0.01 | -0.06 | 0.00 |
| 8 | *Papilio polytes* | 9 | 3 | 3 | 3 | 100.00 | 0.13 | -0.27 | 0.02 |
| 9 | *Pieris brassicae* | 12 | 2 | 6 | 4 | 66.67 | 0.18 | -0.31 | 0.03 |
| 10 | | 67 | 20 | | | | | -1.98 | 0.15 |

Table 6 Surgni sundla post monsoon diversion site

| S.No. | Name of the Species | P | Q | Abundance | Density / sq.m. | Frequency % | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Ariadne ariadne* | 5 | 3 | 1.67 | 1.67 | 100.00 | 0.23 | -0.34 | 0.05 |
| 2 | *Catopsilia pomona* | 3 | 3 | 1 | 1 | 100.00 | 0.14 | -0.27 | 0.02 |
| 3 | *Graphium colanthus* | 2 | 2 | 1 | 0.67 | 66.67 | 0.09 | -0.22 | 0.01 |
| 4 | *Graphium sarpedon luctatius* | 4 | 2 | 2 | 1.33 | 66.67 | 0.18 | -0.31 | 0.03 |
| 5 | *Heliophorus sena* | 4 | 2 | 2 | 1.33 | 66.67 | 0.18 | -0.31 | 0.03 |
| 6 | *Papilio polytes* | 3 | 3 | 1 | 1 | 100.00 | 0.14 | -0.27 | 0.02 |
| 7 | *Pieris brassicae* | 1 | 1 | 1 | 0.33 | 33.33 | 0.05 | -0.14 | 0.00 |
| 8 | | 22 | 16 | | | | | -1.86 | 0.17 |

Table 7 Surgni sundla pre monsoon power house site

| S.No. | Name of the Species | P | Q | Abundance | Density/ sq.m. | Frequency% | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Aulocera swaha* | 6 | 3 | 2 | 2 | 100 | 0.11 | -0.25 | 0.01 |
| 2 | *Candida canis* | 3 | 3 | 1 | 1 | 100 | 0.06 | -0.16 | 0.00 |
| 3 | *Catopsilia pomona* | 3 | 3 | 1 | 1 | 100 | 0.06 | -0.16 | 0.00 |
| 4 | *Colias erate (esper)* | 4 | 2 | 2 | 1 | 66.67 | 0.08 | -0.20 | 0.01 |
| 5 | *Eurema hecabe* | 6 | 3 | 2 | 2 | 100 | 0.11 | -0.25 | 0.01 |
| 6 | *Eurema laeta* | 1 | 1 | 1 | 0 | 33.33 | 0.02 | -0.07 | 0.00 |
| 7 | *Goneptery x rhamni* | 5 | 1 | 5 | 2 | 33.33 | 0.09 | -0.22 | 0.01 |
| 8 | *Neptis hylas* | 4 | 2 | 2 | 1 | 66.67 | 0.08 | -0.20 | 0.01 |
| 9 | *Pieris brassicae* | 9 | 3 | 3 | 3 | 100 | 0.17 | -0.30 | 0.03 |
| 10 | *Pieris candida indica* | 12 | 3 | 4 | 4 | 100 | 0.23 | -0.34 | 0.05 |
| | | 53 | 24 | | | | | -2.14 | 0.13 |

Table 8 Surgni sundla monsoon power house site

| S.No. | Name of the Species | P | Q | Abundance | Density/ sq.m. | Frequency% | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Aulocera swaha* | 15 | 3 | 5 | 5 | 100 | 0.165 | -0.30 | 0.03 |
| 2 | *Candida canis* | 9 | 3 | 3 | 3 | 100 | 0.099 | -0.23 | 0.01 |
| 3 | *Catopsilia pomona* | 5 | 1 | 5 | 1.67 | 33.33 | 0.055 | -0.16 | 0.00 |
| 4 | *Colias erate (esper)* | 6 | 3 | 2 | 2 | 100 | 0.066 | -0.18 | 0.00 |
| 5 | *Eurema laeta* | 12 | 3 | 4 | 4 | 100 | 0.132 | -0.27 | 0.02 |
| 6 | *Gonepteryx rhamni* | 4 | 3 | 1.33 | 1.33 | 100 | 0.044 | -0.14 | 0.00 |
| 7 | *Neptis hylas* | 8 | 2 | 4 | 2.67 | 66.67 | 0.088 | -0.21 | 0.01 |
| 8 | *Papilio demoleus* | 2 | 1 | 2 | 0.67 | 33.33 | 0.022 | -0.08 | 0.00 |
| 9 | *Pieris brassicae* | 12 | 3 | 4 | 4 | 100 | 0.132 | -0.27 | 0.02 |
| 10 | *Pieris candida indica* | 12 | 3 | 4 | 4 | 100 | 0.132 | -0.27 | 0.02 |
| 11 | *Pontia daplidice* | 6 | 3 | 2 | 2 | 100 | 0.066 | -0.18 | 0.00 |
| 12 | | 91 | 28 | | | | | -2.28 | 0.11 |

Table 9 Surgni sundla post monsoon power house site

| S.No. | Name of the Species | P | Q | Abundance | Density/ sq.m. | Frequency% | (ni/n) =Pi | H | C |
|---|---|---|---|---|---|---|---|---|---|
| 1 | *Catopsilia pomona* | 3 | 3 | 1 | 1 | 100 | 0.12 | -0.25 | 0.01 |
| 2 | *Eurema hecabe* | 5 | 3 | 1.67 | 1.67 | 100 | 0.2 | -0.32 | 0.04 |
| 3 | *Gonepteryx rhamni* | 6 | 3 | 2 | 2 | 100 | 0.24 | -0.34 | 0.06 |
| 4 | *Neptis hylas* | 2 | 2 | 1 | 0.67 | 66.67 | 0.08 | -0.20 | 0.01 |
| 5 | *Papilio demoleus* | 5 | 3 | 1.67 | 1.67 | 100 | 0.2 | -0.32 | 0.04 |
| 6 | *Pieris brassicae* | 1 | 1 | 1 | 0.33 | 33.33 | 0.04 | -0.13 | 0.00 |
| 7 | *Pieris candida indica* | 3 | 3 | 1 | 1 | 100 | 0.12 | -0.25 | 0.01 |
| 8 | | 25 | 18 | | | | | -1.83 | 0.17 |

The insect habitat must supply the needs throughout its life time (Samways, 1994). These needs will comprise, at the very least, food and suitable climatic conditions, and may also include shelter from disturbance and natural enemies. The effect of land-use changes on insects can be studied at three levels; on individual species, on the composition of species in a habitat or on simplified measures of the overall structure of the assemblage, such as species richness, diversity or biomass. This suggests that, the Triveni Mahadev area can be upgraded to favorable microclimate disturbance for butterflies. However some studies have showed different cases on the variation of butterfly's diversity for disturbed area (Nordqvist, 2009). For instance, the study done revealed that different disturbances did not cause difference in species diversity due to understory vegetation cover. Butterflies play a keystone species role in the ecosystems by pollination and completion of food chain (Butler, 2012).

## Conclusions

From this study, it is concluded that, Surgani-Sundla Hydroelectric Project in Chamba District had positive effects on the diversity of butterflies but not on their abundance. In this case, the programme implemented by the Himachal Pradesh Power Cooperation for restoring the biodiversity of butterfly fauna. Butterfly as indicator species have demonstrated this through this study. The focus of the study was on the Butterflies, but other fauna species were seen in the area for example other insects, various bird species, small mammals. Because of the positive indication of the programme it is recommended for restoring the Surgani-Sundla Hydroelectric Project. In addition, it is recommended to carry other studies which covers other group of fauna resources in relation to the areas be carried out. There is a need for giving conservation education to the local communities on the importance of conserving biodiversity resource. These areas can be used for study and training for students in terms of attachments, internships and research projects.

*Authors' contributions: Dr. Pawan Kumar is a Scientist and project leader, contributed in final editing of the manuscriptand also corresponding author; Shweta Thkur is Ph.D Student and conducted the survey and drafted the paper.*

## References

Butler, R., 2012. Structure and Character. Keystone Species. http://www.rainforests.mongabay.com/02keystone.htm 3rd

Chris, V.S., 2012. Potential use of butterflies as indicators of biodiversity. http://www.cordis.europa.eu/search/index.cfm?fuseaction=result.document&RS_LANG=FR&RS_RCN=6763233&q=, 12th

Dennis,R.L.H., 1993. Butterflies and climate change. Manchester University Press.Ehrlich, P.R., Breedlove, D.E., Brussard, P.F. & Sharp, M.A.(1972). Weather and the regulation of sub-alpine populations. *Ecology* 53: 243-247.

Enrlich, P. R., and Wilson, E. O., 1991. Biodiversity studies : science and policy. *Science*, 253 : 758-762.

Harrington, Richard and Stork E. Nigel., 1995. Insects in a changing environment. Academic Press Limited, 24/28 Oval Road, London NW 1 7DX : 535 pp.

Landres, P. B., Verner, J., and Thomas, J. W., 1988. Ecological uses of vertebrate indicators species: a critique. *Conservation Biology* 2 : 316-328.

Margaret,V.,2008. Butterflies as indicators of climate change. *Science Progress*

Nordqvist, E., 2009. Butterflies as indicators of forest quality in miombo woodlands, Tanzania .Degree project in biologyMaster of Science. Biology Education Centre and Department of Ecology and Evolution, Animal Ecology. Uppsala University, 2009.

Noss, R. F., 1990. Indicators for monitoring biodiversity: a hierarchial approach. *Conservation Biology*, 4: 355-364.

Rosenburg, D.M., Danks, H.V., and Lehmkuhl, D.M., 1986. Importance of insects in environmental impact assessment. *Environmental Management*10: 773-783.

Singh,A.P., 2005. Initial colonization of Red Pierrot butterfly, *Talicada nyseus nyseus* Guerin (Lycaenidae) in the lower western Himalayas: An indicator of the changing environment. *Current Science* 89(1):41-42

Singh,A.P., 2006. Range extension of Brown Gorgon Butterfly, *Meandrusa gyas gyas* into Kedarnath Musk Deer Reserve, Western Himalayas: a lesser known species from north-east India .*Indian Forester* 132(2); 187-189.

Samways, M.J., 1994. Insect Conservation Biology. Chapman & Hall. 358 pp.

Van Wrigh, R. I., Humphries C. J., and Williams P. H., 1991. What to protect ? systematics and the agony of choice. *Biological Conservation* 55 : 235-254.

Walther, G. R., Post, E., Convey P., Menzel, A., Parmesan, C. Beebee, T. J. C. Fromentin, Jean-Marc, Hoegh-Guldberg, O.and Franz Bairlein., 2002. Ecological responses to recent climate change. *Nature* 416: 389-395.

Warren M. S., Hill J. K., Thomas, J. Asher, A. J., Fox., Huntley, R.B., Royk, D. B., Telferk, M. G., Jeffcoate, S., Hardingk, P., and Jeffcoate, G., 2001. Rapid responses of British butterflies to opposing forces of climate and habitat change. letters to nature, Macmillan Magazines Ltd. 65-68

Watt W.B., Chew, F.S., Snyder, L.R.G., Watt, A.G. and Rothchild, D.E., 1968. Population structure of pierid butterflies, I. Numbers and movements of some montane *Colias* species. *Oecologia,* Berl. 27: 1-2.

.Wilson, E. O., 1988. Biodiversity. National Academy Press, Washington, D. C.

Wynter-Blyth, M.A., 1957. Butterflies of the Indian region. Today and Tomorrow's Printers and Publishers, New Delhi: 523 pp.