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Butterflies as indicator taxa of ecological disturbance at Menagesha-Suba state forest, central Ethiopia

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Abstract
Menagesha-Suba State Forest, the ecological indicators role of butterflies was assessed at five and three habitat types using transect method. Thirty transects representing five different habitat types were set up at the altitudes from 2200 to 3300 masl, from the natural closed forest to the agricultural land, with a length of 100 m for each transect. Indicator values were quantified for each butterfly family, genus and species. The results showed no butterfly family and genus which could be used as ecological indicator for the natural closed forest. Nevertheless, at the species level, three butterfly species, *Charaxesphoebus*, *Vanessa abyssinica* and *Coliaselecto* can be used as ecological indicators to assess the impact of disturbance on the natural closed forest as well as the habitat inside forest. In addition, the genus *Charaxes* and *Vanessa* for the habitat inside forest and the genus *Colias* for the habitats outside forest, and for the shrub and grassland could be used as eco-indicators. As a result, conservation of their habitats at landscape level is important for conservation of butterfly fauna of the study area.

Keywords: Ecological indicator, butterflies, diversity, diversity indices, Menagesha-Suba state forest

1. Introduction
Menagesha-Suba State Forest communities have changed in composition and abundance over time due to forest succession, Agricultural intensification, weather conditions as well as habitat fragmentation and disturbance [1]. Butterfly fauna is usually associated with its corresponding vegetation types. Although many butterfly larvae feed on a variety of plants, a small number of butterfly larvae feed on only a single plant. Forest disturbance obviously causes changes in vegetation types that consequently affects butterfly fauna. Any changes in the forest can lead to changes in butterfly communities because they are highly sensitive to changes in habitat disturbance or habitat quality [2]. The response of butterfly communities to habitat changes is probably one of the most noticeable reasons. Moreover, butterflies are observed easily and the species are better known than most other groups of insects making them good subjects of study for indicator of ecological disturbance.
Insects comprise more than half of all known species of organism and represent the majority of animal taxa. Estimates also predict that 75-90% of species that remain to be discovered could be insects. With such a diverse group that lacks baseline knowledge across most of the globe, monitoring wholesale change is unfeasible. Assessing change in the status of insects relies on generalization from a few well-studied taxa and the need for reliable indicator species is paramount [3].
Evaluating the environmental impact on plants and animals is usually difficult and expensive. One rather easy and cheap way to monitor and assess environmental impacts on animals and plants is to use indicator species. Terrestrial invertebrates have received attention as bio-indicators because of their dominant biomass and diversity, sensitive to habitat structure and composition, and their significance function in the ecosystem [4-7]. Indicators have been used to assess ecosystem responses to environmental disturbance that are often associated with human land use [8-9], and are also used as to assess rapidly the environmental status under stresses of human activity.
It is suitable to use butterflies as eco-indicators of forest disturbance because they are sensitive and quickly react to changes of habitat and environment, fly during the day, are relatively diverse and in relative abundance, and have short generation times. Among insects, butterflies that are sensitive to habitat change are widely recognized as potentially valuable ecological indicators [10-11].

One method used to quantify the bioindicator value of a range of taxa is the indicator value method developed by Dufrêne and Legendre [12]. This method combines measurements of the degree of specificity of a species to a habitat type. The Indicator Value method has numerous advantages over other measures used for ecological bio indication [13]. For example, the Indicator Value is calculated independently for each species and there are no restrictions on the way in which habitats are categorized [13]. Nevertheless, the usefulness of this method is ultimately dependent on the degree to which species maintain high and significant indicator values when tested at various times and places.

Although habitat specificity is a comparatively inflexible species-specific trait, the fidelity and abundance of species in an assemblage may vary over time due to season and weather conditions [14] and disturbance-induced environmental changes [15]. The sensitivity of the Indicator Value to such changes will ultimately determine its usefulness for bio indication.

Although butterflies are widely recognized as good indicators, there is limited or no research work to define butterflies as indicators to monitor and assess the impact of human being on forest systems. Therefore, this study was undertaken to examine butterflies as ecological indicators at family, genus and species levels at Menagesha-Suba State Forest in Ethiopia.

2. Materials and Methods

2.1 Study site

The study was carried out at Menagesha-Suba State Forest, found at the coordinates of 38°33'59 E and 9°03'00 N in the Oromia National Regional State. It is one of the few remaining highland forest blocks in the Central plateau of Ethiopia, dominated by *Juniperus procera.* The structural diversity of the forest is minimum and is described as undifferentiated evergreen montane forest [16-17]. The vegetation of the area varied with altitude, from high forest on the lower slopes to sub-afro-alpine vegetation at higher altitudes [18]. It has an altitude ranging from 2200 to 3385 meter above sea level and has a bimodal rainfall pattern.

2.2 Sampling site

Thirty transects representing five different habitat types were chosen, with a length of 100 m for each transect. Transects are separated from each other by 50 m. The five habitat types in the study area were natural closed forest (Site1), Disturbed forest (Site 2), Forest edge (Site 3), Shrub and grass (Site 4) and Grass and agricultural land (Site 5).

2.3 Sampling method, collection and identification

The butterfly transect methodologies which were used, were developed in England by Pollard [19] and Pollard *et al*. [20] for monitoring changes in a butterfly population over time and studying differences in the butterfly communities of different habitat types. Transect work took place during 9:00am to 4:00pm and it took 5-7 minutes for each 100 m transect. The recorder walked at a uniform pace and recorded all butterflies seen within prescribed limits in an imaginary box about 10mx 10 m x 10m x. The study was carried out from 2012 to 2014 with the period of 4-5 days in a month.

Butterfly habitats were divided into five habitat types as indicated above. In addition, habitat types were grouped into three habitat types that are the habitat inside forests (three transects of the natural forest and three transects of the disturbed forest), the habitat along forest edge (six transects), and the habitat outside forests (three transects of shrub and grass habitat, and three transects of agricultural land.

Identification of butterflies was primarily made directly in the field. In critical condition, specimens were collected only with handheld aerial sweep nets. Each specimen was placed in plastic bottles and carried them to the laboratory for further identification with the help of field guides. Identification of butterflies was carried out according to Carcasson [21] and D'Abrera [22].

2.4 Data analysis of the indicator values of butterflies

The indicator values of butterflies were calculated for the five and three habitat types. A method used to quantify the indicator value of a range of taxa is the indicator value (IndVal) method developed by Dufrene and Legendre [12]. This method combines measurements of the degree of specificity of a species to an ecological state, for example a habitat type and its fidelity within that state [12]. High indicator values indicate a high degree of specificity and fidelity to a particular habitat [23]. High fidelity of a species across sample sites is generally associated with large abundance of individuals [24-25]. Both these characteristics facilitate sampling and monitoring, which is an important requirement for a useful indicator [26].

The individual numbers of each species recorded during the course of the study period were summed for each habitat type. The indicator value method is used to study whether an individual butterfly species would show indicator value for any of the five or three habitat types. An indicator value for each species *i* in each group *j* of sites was calculated according to Dufrene and Legendre [12]:

$IndVal_{ij} = A_{ij} x B_{ij} x\ 100$, where

IndVal - indicator value for species *i* in group *j*,

A_{ij} is specificity measure as:

A_{ij}— $N\ individuals_{ij}/NindividualS_i$ and where

N individuals— individual number of species *i* in 6 transects of habitat *j*,

N individuals — Total individual number of species *i* in 30 or 18 transects (each habitat type consists of 6 butterfly transects).

B_{ij} is fidelity measure as:

$B_{ij} = Nsites_{ij}/Nsites_j$ and where

$Nsites_{ij}$ — number of transects of habitat *j* as species *i* present,

Nsites.—total number of transects (six butterfly transects) of that habitat.

Percentage indicator value was measured for each butterfly species. Each species has a percentage indicator value with an associated measure of significance, with high and significant percentages designating good indicator species. Those species with significant indicator value of greater than 70% were regarded as characteristic indicator species for the habitat [27]. Species with indicator value from 50-70% were regarded as detector species [28]. Therefore, these species were not characteristic species, as they did not have high indicator value of ≥ 70% for any particular habitat. However, species meeting these criteria were regarded as sufficiently indicative to demonstrate an early shift in habitat. Simultaneously, these species were judged as sufficiently uncharacteristic to show potentially a marked increase in indicator value in the habitat type under disturbance conditions.

3. Results

3.1 Species richness and abundance

A total of 43 species and 671 individuals of butterflies belonging to 21 genera and 5 families were recorded to study the ecological indicator role of butterflies from Menagesha-Suba State Forest during the study period. There was a significant difference in number of species and abundance between different habitat types. Species richness and abundance was greater in the natural closed forest area and lowest in the grass and agricultural land (Table 1).

Table 1: Species number and abundance of butterflies in various habitat types at Menagesha - Suba State Forest during the year 2012 to 2014.

Habitat types	Species number	Abundance
Natural closed forest	33	290
Disturbed forest	28	108
Forest edge	21	93
Shrub and grass	22	131
Grass and agricultural land	13	49
Total	43	671

3.2 Indicator values in five habitat types

3.2.1 Indicator values of butterfly families in five habitat types

To assess the ecological indicator role of butterfly families for different habitat types, indicator values were calculated for each of the five butterfly families. As shown in Table 2, almost all butterfly families had low indicator values (less than 50%) in all the five habitat types. Only one family had indicator value greater than 50% in the natural closed forest, i.e, Nymphalidae. The family Nymphalidae had the highest indicator values in the natural closed forest and decrease with increasing forest disturbance (from the natural forest to the agricultural land).

No butterfly family that could be used as eco-indicators for habitats that are divided into small scales of disturbance (the five different habitat types). The family Nymphalidaes are characteristic for the natural closed forest since have indicator values greater than 50%, but less than 70%, so they can be only used as detector taxa for the natural forest.

Table 2: Indicator values (percentage) of butterfly family in five habitat types at Menagesha - Suba State Forest during the year 2012 to 2014.

Families	Habitat types				
	Natural closed forest	Disturbed forest	Forest edge	Shrub & grass	Grass & agricultural land
Papilionidae	38.96	14.29	6.7	6.4	2.7
Pieridae	25.36	4.48	1.92	34	4.36
Lycaenidae	26.58	6.34	14.89	18.44	0.53
Nymphalidae	50.47	11.25	9.16	14.13	3.94
Hesperiidae	25.12	3.54	13.75	0	0

3.2.2 Indicator values of butterfly genera in five habitat types

Not all the species found in a family may have the same habitat preference and thus, the indicator value of the whole family is not high enough. Indicator value of genus enables the researchers to identify indicator taxa more specific than family level.

Indicator value of butterfly genera (genera with indicator values greater than 50%) in five different habitat types is presented in Table 3. In the shrub and grassland, the genera with indicator values greater than 70% that can be used as eco-indicators for this habitat was *colias* (Family pieridae), which is the only genera that can be used as eco-indicator. The genera with indicator values from 50-70%, which could be used as detector genera for the shrub and grass habitats, were *Leptomyrina* and *Ypthima.*

In the natural forest, four genera of Nymphalidae family that could be used as detector genera of the natural forest were *Acraea, Vanessa, Charaxes and Tirumala.* No butterfly genera that could be used as ecological indicator for the natural forest.

Table 3: Indicator values (percentage) of butterfly genera in five habitat types at Menagesha – Suba State Forest during the year 2012 to 2014.

Genus	Habitat types				
	Natural closed forest	Disturbed forest	Forest edge	Shrub & grass	Grass & agricultural land
Colias	1.38	0	0	70.83	10.41
Ypthima	1.30	0	1.69	58.97	9.3
Leptomyrina	12.5	0	0	52.08	2.08
Acraea	55.43	9.78	19.02	0.5	0
Vanessa	66.4	1.36	0.68	0	0
Charaxes	62.25	8.65	1.30	0	0
Tirumala	53.35	3.64	2.42	0	0

3.2.3 Indicator values of butterfly species in five habitat types

The indicator value of species is taxa that are used most frequently in identifying indicator species [12]. The indicator value at the species level is highly accurate than genus and family level.

Indicator values of butterfly species in five different habitat types are presented in Table 4. From the 43 species of butterflies observed in five different habitats, most of the species have indicator values less than 50%. Among the 43 species recorded along the five habitat types, there are only eight species with indicator values from 50-70%. From these, three species are in the natural forest (*Tirumalaformosa*, *Acraeajohnstoni* and *Papiliodardanus*), one species is in the disturbed forest (*Bicyclus vulgaris*), two species are in the forest edge (*Uranothaumaantinorii* and *Acraealycoa*), and two species are in the shrub and grass habitat (*Ypthima simplicia* and *Leptomyrina boschi*).

There are three species with indicator values greater than 70% that can be used as ecological indicators; they are *Charaxesphoebus* and *Vanessa abyssinica* for the natural forest and *Coliaselecto* for the shrub and grass habitat. In the grass and agricultural land, all species have indicator values less than 50%.

3.3 Indicator values in three habitat types

3.3.1 Indicator values of butterfly families in three habitat types

Indicator value of butterfly families in three different habitat types is presented in Table 5. Butterfly families have the highest indicator values in the habitat inside forests and the lowest in the forest edge. As in the five habitat types, there is no butterfly family that can be used as ecological indicator for any of the habitats since they have no indicator values greater than 70% in all the habitats studied. Butterfly families that have indicator values from 50-70% are Papilionidae and Nymphalidae in the habitat inside forests and Pieridae in the habitat outside forests. Papilionidae and Nymphalidae are

butterfly families characteristic for the habitat inside forest and family Pieridae for the habitat outside forests. Therefore, these butterfly families have indicator values from 50 – 70% so they are used as detector species of these habitat types, but not as indicator species.

Table 4: Indicator values (percentage) of butterfly species in five habitat types at Menagesha – Suba State Forest during the year 2012 to 2014.

Species	Habitat types				
	Natural closed forest	Disturbed forest	Forest edge	Shrub and grass	Grass and agricultural land
Charaxesphoebus	71.93	2.27	0	0	0
Vanessa abyssinica	71.14	2.42	0	0	0
Tirumalaformosa	56.25	3.18	2.12	2.12	0
Acraeajohnstoni	51.07	5.07	7.61	0	0
Papiliodardanus	51.07	12.88	3.80	1.30	0
Bicyclus vulgaris	0	50.72	0	2.83	11.11
Uranothaumaantinorii	0	3.09	54.82	0	0
Acraealycoa	8.25	2.12	51.87	0	0
Coliaselecto	1.42	0	0	70.83	10.42
Ypthima simplicia	0	0	2.78	57.46	11.00
Leptomyrina boschi	12.50	0	0	51.88	2.12

Table 5: Indicator values (percentage) of Butterfly families in three Habitat types at Menagesha-Suba State Forest during the year 2012 to 2014.

Families	Habitat types		
	Inside forest	Forest edge	Outside forest
Papilionidae	59.4	14.59	9.4
Nymphalidae	55	16.27	21.15
Pieridae	32.69	3.0	51.51
Lycaenidae	36.52	18.76	23.24
Hesperiidae	23.68	17.36	0

3.3.2 Indicator values of butterfly genera in three habitat types

Indicator values of some butterfly genera with the values greater than 50% in three different habitat types are presented in Table 6. In the habitat inside forest, there are two butterfly genera with indicator values greater than 70%, which are *Vanessa* and *Charaxes* and both belongs to the family Nymphalidae. Two genera of Nymphalidae family have indicator values less than 70% and greater than 50%, which are *Tirumala* and *Acraea* in this habitat. The other detector genera in the habitat inside forest are *Papilio*, *Appias* and *Deudorix.*

Table 6: Indicator values (percentage) of Butterfly genera in three Habitat types at Menagesha – Suba State Forest during the year 2012 to 2014.

Genera	Habitat types		
	Inside forest	Forest edge	Outside forest
Vanessa	77.81	1.06	0
Charaxes	71.55	2.34	0
Papilio	59.67	16.20	5.32
Tirumala	55.33	2.83	2.83
Appias	53.6	3.4	0
Deudorix	53.60	3.4	0
Acraea	52.35	26.81	0.78
Colias	2.12	0	72.62
Leptomyrina	16.67	0	55.33
Ypthima	2.21	2.86	52.43

No butterfly genera that can be used as indicator as well as detector species of the habitat in the forest edge. In the habitat outside forests, two butterfly genera with indicator values less than 70% and greater than 50% are *Leptomyrina* (Lycaenidae) and *Ypthima* (Nymphalidae). In this habitat, the genus *Colias* (Pieridae) has indicator values greater than 70%, which can be used as indicator species of the habitat.

3.3.3 Indicator values of butterfly species in three habitat types

Indicator values of butterfly species with value greater than 50% in three different habitat types are presented in Table 7. The butterfly species with indicator values greater than 70% in the habitat inside forests belong to family Nymphalidae; they are *Vanessa abyssinica* and *Charaxes phoebus*. There are seven species with indicator value greater than 50% and less than 70% in the habitat inside forests, which are *Acraeanecoda*, *Acraeajohnstoni*, *Charaxes castor* and *Tirumalaformosa* (Nymphalidae), *Appiasepaphia* (peiridae), *Deudorix dinochares* (Lycaenidae) and *Papiliodardanus* (Papilionidae). There are two species with indicator value greater than 50% and less than 70% in the forest edge that are *Acraealycoa* (Nymphalidae), and *Uranothaumaantinorii* (Lycaenidae). There is only a single species (*Coliaselecto*) with indicator values greater than 70% in the habitat outside forest, belong to family Pieridae. In the habitat outside forests, two species with indicator value less than 70% and greater than 50% are *Ypthima simplicia* (Nymphalidae), and *Leptomyrina boschi* (Lycaenidae).

Table 7: Indicator values (percentage) of Butterfly species in three Habitat types at Menagesha - Suba State Forest during the year 2012 to 2014.

Species	Habitat types		
	Inside forest	Forest edge	Outside forest
Vanessa abyssinica	83.33	0	0
Charaxesphoebus	73.77	1.88	0
Acraeanecoda	67.00	0	0
Acraeajohnstoni	60.36	9.00	0
Papiliodardanus	57.06	6.18	2.12
Tirumalaformosa	55.33	2.83	2.83
Appiasepaphia	53.60	3.40	0
Deudorix dinochares	53.60	3.40	0
Charaxes castor	50.00	0	0
Acraealycoa	16.67	55.33	0
Uranothaumaantinorii	3.09	54.82	0
Coliaselecto	2.12	0	72.62
Ypthima simplicia	0	0	67.00
Leptomyrina boschi	16.67	0	55.33

4. Discussions

Butterflies have been considered as one of the best taxa as

potential ecological indicators of ecological changes in tropical regions because of the close links between butterfly diversity and health of their habitats [29]. Butterflies are providing the best rapid indicators of habitat quality and they are sensitive indicators of climatic change [30]. The result of this study shows that individual butterfly taxa can be used as indicators of disturbance.

In the use of individual indicator taxa, the Indicator Value method revealed relatively few indicator taxa for the area, particularly the natural forest and the shrub and grassland habitats. There were significant differences in richness, and community composition between habitat types and significant indicator species were found in the area. Other studies [31-34] have been demonstrated the utility of butterflies as indicators of disturbance.

Although butterflies are sensitive to forest disturbance, there is no butterfly family that can be used as ecological indicator to evaluate the impact of disturbance on the natural forest or any other habitats of the area. Nymphalidae is the most characteristic family for the natural forest but not all species of Nymphalidae live in the natural forest. Some of the species of this family live in the Shrub and grassland, disturbed forest or other habitats. These species made indicator values of Nymphalidae not high enough, but still greater than 50%. Indicator values of other butterfly families are low in the natural forest.

At the genus level, single butterfly genera *Colias* are characteristic for the Shrub and grassland habitat, with high indicator value greater than 70%, can be used as ecological indicator but, no other butterfly genera that can be used as ecological indicator for the natural habitat or other habitats. At division of three habitat types, the genus *Charaxes* and *Vanessa* for the habitat inside forest and the genus *Colias* for the habitat outside the forest are characteristic, with indicator values greater than 70%, can be used as ecological indicators for these habitats.

At the species level, only three butterfly species with indicator values greater than 70% can be used as ecological indicators; two of them for the natural forest (*Charaxes phoebus & Vanessa abyssinica*) and single species in the shrub and grass (*Coliaselecto*). These species are also ecological indicators at division of three habitat types. *Charaxes phoebus* and *Vanessa abyssinica* at the habitat inside forest and *Coliaselecto* at the habitat outside forest with indicator values greater than 70%. Therefore, these indicator genera or species can be used to assess the impact of disturbance as well as other human activities on the study area. McKenzie *et al*. [35] indicated that indicator species can be used to assess ecosystem responses to environmental disturbance that are often associated with human land use.

5. Conclusion

It has been observed that species diversity of butterflies to be quite high in the natural forest habitat. This study provides background information for identifying centers of species richness and abundance within the Menagesha – Suba State Forest and can provide a more scientific basis by which to plan and manage a system of protected areas around these centers in accordance with the Convention on Biological Diversity. Nevertheless, two habitats stood out amongst others pertaining to the cumulative abundance of butterflies, natural forest and shrub and grassland area as these two habitats were found to be the repository of butterflies.

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7. References

1. Abate Zewdie. Comparative floristic study on Menagesha – Suba State Forest on years 1980 and 2006. M.Sc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia, 2007.
2. Collinge SK, Prudic KL, Oliver JC. Effects of local habitat characteristics and landscape context on grassland butterfly diversity. Conser. Biol. 2003; 17:178-187.
3. Anon A. Sikkim state biodiversity strategy and action plan. Department of Forests, Environment and Wildlife Management, Government of Sikkim, Gangtok, India, 2003.
4. Disney RH. Assessment using invertebrates: posing the problem. In: Wildlife conservation evaluation, (Usher, M B., Ed.) Chapman and Hall, London, England, 1986, 1-293.
5. Rosenberg DM, Danks HV, Lehmkul DM. Importance of insects in environmental impact assessment. Env. mgt. 1986; 10:773-783.
6. Majer JD. Animal in primary succession: the role of fauna in reclaimed lands. Cambridge University Press, Cambridge, England, 1989, 547.
7. Samways MJ. Insects in biodiversity conservation: some perspectives and directives. Biodiversity Conser. 1993; 2:258-282.
8. Noss RF. Indicators for monitoring biodiversity: a hierarchial approach. Conser. Biol. 1990; 4:355-364.
9. McKenzie DH, Hyatt DE, McDonald VJ. Ecological indicators. Chapman and Hall, London, England, 1995, 1604.
10. Sparrow RH, Sisk DT, Ehrlich PR, Murphy DD. Techniques and Guidelines for monitoring Neotropical butterflies. Conser. Biol. 1994; 8:800-809.
11. Kerr JT, Sugar A, Packer L. Indicator taxa, rapid biodiversity assessment, and nestedness in an endangered ecosystem. Conser. Biol. 2000; 14:1726-1734.
12. Dufrene M, Legendre P. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecol. Monographs. 1997; 3:345-366.
13. McGeoch MA, Chown SL. Scaling up the value of bio indicators. Trends in Ecol. and Evol. 1998; 13:46-47.
14. Tauber MJ, Tauber CA, Nyrop JP, Villani MG. Moisture, a vital but neglected factor in the seasonal ecology of insects: hypotheses and tests of mechanisms. Env. Entoml. 1998; 27:523-530.
15. Steenkamp HE, Chown SL. Influence of dense stands of an exotic tree, *Prosopis glandulosa* Benson, on a savannah dung beetle (Coleoptera: Scarabaeinae) assemblage in southern Africa. Biol. Conser. 1996; 78:305-311.
16. Breitenbach FV, Koukal J. Menagesha State Forest: description of the forest, its management and its future development including the National Park Project. Ethio. Forest Rev. 1962; 3(4):17-34.
17. Gilbert EF. Mount Wachacha: A botanical commentary. Walia. 1970; 2:3-12.

18. Demel Teketay. Deforestation, Wood Famine and Environmental Degradation in Ethiopia's Highland Ecosystems: Urgent Need for Action. Northeast Afr. Studies, (New Series). 2001; 8(1):53-76.
19. Pollard E. A method for assessing changes in the abundance of butterflies. Biol. Conser. 1977; 12:115-134.
20. Pollard E, Elias DO, Skelton MJ, Thomas JA. A method of assessing the abundance of butterflies in Monks Wood National Nature reserve in 1973. Entomol. Gaz. 1975; 26:79-88.
21. Carcasson RH. The swallowtail butterflies of East Africa (Lepidoptera, Papilionidae). Faringdon, UK: EW Classey, 1975.
22. D'Abrera B. Butterflies of the Afrotropical Region, 2nd edition. Part I. Papilionidae, Pieridae, Acraeidae, Danaidae & Satyridae. Melbourne: Hill House, 1997.
23. Van Rensburg BJ, McGeoch MA, Chown SL, Van Jaarsveld AS. Conservation of heterogeneity among dung beetles in the Maputaland Centre of Endemism, South Africa. Biol. Conser. 1999; 88:145-153.
24. Brown JH. On the relationship between the abundance and distribution of species. Amer. Naturalist. 1984; 124:255-279.
25. Gaston KJ, Blackburn TM, Lawton JH. Interspecies abundance-range size relationships: an appraisal of mechanisms; J. of Anim. Ecol. 1997; 66:579-601.
26. Kremen C, Merenlander A, Murphy DD. Ecological monitoring: A vital need for integrated conservation and development programs in the tropics. Conser. Biol. 1994; 8:388-397.
27. McGeoch MA, Van Rensburg BJ, Botes A. The verification and application for bio indicators: A case study of dung beetles in a savanna ecosystem. J appl. Ecol. 2002; 39:661-672.
28. McGeoch MA. The selection, testing and application of terrestrial insects as bio indicators. Biological Reviews. 1998; 73:181-201.
29. Spitzer K, Jaros J, Havelka J, Leps J. Effect of small-scale disturbance on butterfly communities of an Indochinese montane rainforest. Biol. Conser. 1997; 80:9-15.
30. Venkata Ramana SP. Biodiversity and Conservation of Butterflies in the Eastern Ghats. The Ecoscan. 2010; 4(1):59-67.
31. Fuller RM, Groom GB, Mugisha P, Ipulet P, Pomeroy D, Katende A, *et al*. The integration of field survey and remote sensing for biodiversity assessment: a case study in the tropical forests and wetlands of Sango Bay, Uganda. Biol. Conser. 1998; 86:379-391.
32. Howard PC, Viskanic P, Davenport TRB, Kigenyi FW, Baltzer M, Dickinson CJ, *et al*. Complementarity and the use of indicator groups for reserve selection in Uganda. Nat. 1998; 394:472-475.
33. Parmesan C, Ryrholm N, Stefanescu C, Hill JK, Thomas CD, Descimon H, *et al*. Poleward shifts in geographical ranges of butterfly species associated with regional warming. Nat. 1999; 399:579-583.
34. Blair RB. Birds and butterflies along an urban gradient: surrogate taxa for assessing biodiversity. Ecol. 1999; 9:164-170.
35. McKenzie DH, Hyatt DE, McDonald VJ. Ecological indicators. Chapman and Hall, London, England, 1995.