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An attempt of understanding butterfly monitoring methods

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Abstract

Butterflies are the important groups in Insects; they are ecologically beneficial, helps in ecosystem balance. Because of their attractiveness besides Entomologists, Researchers and Students, even the people interested in nature, wildlife, butterfly amateurs too study, observe, monitor the butterfly with the equal interest and intensity like academics. The check lists of butterflies are being prepared for various regions of world and species are being added regularly to the present check list because of interested people. If the approach is systematic and scientific the results are still accurate and can use for various conservation and ecosystem reconstruction programmes. Keeping this in view, in this paper an attempt was made to communicate microscopic information about butterfly monitoring methods, so that a beginner, lay person who is interested in butterflies, could get the butterflies monitoring methods in a single stretch.

Keywords: Butterfly, Butterfly monitoring methods, Butterfly abundance, Conservation, Pollard Walk Method

1. Introduction

Biodiversity loss has accelerated to an unprecedented level; species are becoming extinct at a rate 1,000 to 10,000 times higher than the natural rate would be. Worldwide, over 11,000 species of plants and animals face a high risk of extinction in the near future, as a result of human activity. The threat is augmented by that of climate change: a recent report predicted that climate change will threaten the extinction of a quarter of all land and animals and plants by 2050. Biodiversity loss matters. It matters for ethical, emotional, environmental and economic reasons. Ethically we have a responsibility to future generations to maintain the diversity of life on earth. Emotionally, we derive from nature pleasure, fulfillment, inspiration and solace: nature is fundamental to our culture, language, psychological and spiritual wellbeing. Environmentally, biodiversity provides a wide range of essential services including carbon-cycling and storage, clean water, climate mitigation, mitigation of natural hazards, and pollination. Economically, the financial value of the goods and services provided by ecosystems and species- by life on earth- has been estimated at Euro 26 trillion per year-nearly twice the value of what humans produce each year. The conservation and sustainable use of biodiversity is essential to poverty eradication in developing countries, and to sustainable livelihoods and sustained economic growth in Europe and worldwide. Biodiversity is part of the daily liver of every one of us and, indeed, we are part of biodiversity (Monaghan Country Council, 2010) [1]. Halting the process of biodiversity decline, or at least significant reduction of its rate, is at present one of the global challenges facing humankind (European Commission, 2001) [2]. In order to assess if the ambitious targets of these agreements are being met, comprehensive biodiversity monitoring, especially at species, community and habitat levels, is essential (Balmford *et al.*, 2005; Dobson, 2005) [3, 4].

Insects are the dominant group of organisms on earth in terms of both taxonomic diversity and ecological function (Wilson, 1992), they are the earth's most diverse organisms, accounting for half of described species of living things and three – quarters of all known animals and it is estimated that more species insects than known at present remain to be discovered (Wijesekara and Wijesinge, 2003) [5]. Due to their beauty and ecological significance, butterflies are well studied throughout the world since early 18th century (Ghauzoul, 2002) [6], they are generally regarded as one of the best taxonomically studied group of insects (Robbins and Opler, 1997) [7, 22], butterflies perform prominent roles in pollination and they increase aesthetic value and help in seed setting of plants (Kunte, 2000; Tiple *et al.*, 2006; May, 1992) [8, 9], butterflies are sensitive to the temperature, humidity, and light levels and also to the habitat disturbance (Balmer and Erhardt, 2000) [10], butterflies depend on plants for the food and completion of their life cycle, contrary to this many of the economically important plant species are pollinated by butterflies (Borges *et al.*, 2003) [11]. They serve as food for predators at various levels. The larvae which feed on foliage are primary herbivores in the ecosystem and are important in the transfer of energy fixed by plants, making them available in the ecosystem (Ghazoul J, 2002) [12], They form an important part of the food chain of birds, reptiles, amphibians, spiders and predatory insects. They also respond to disturbances and changes in the quality of habitat, and are thus a good indicator species to evaluate changes in habitat and landscape structure variations (Kremen, 1992; Kocher and Williams, 2000) [13, 30, 14]. Based on the flora of an area, one can easily predict the existing butterfly fauna of that region (Ghazoul J, 2000). They are also good indicators of environmental quality and healthy ecosystems because they are sensitive to changes in the environment and the availability of host plants for oviposition and larval development (Gunathilagaraj *et al.*, 1998) [15] and they are sensitive to biota, which get severely affected by environmental variations and changes in forest structure (Pollard, 1991) [16]. The faunistic survey of butterflies, their occurrence and characteristic provide crucial information on the ecology of a particular region (Ghazoul J, 2002) [12]. Butterflies use the landscape at a fine scale and react quickly to changes in land use, and to process such as farmland intensification or abandonment. A sustainable butterfly population relies on a network of breeding habitats scattered over the landscape. This makes butterflies especially vulnerable to habitat fragmentation. All these makes butterflies one of the best species group for monitoring changes in biodiversity (Swaay *et al.,* 2012) [17]. The population of butterflies subjected to considerable annual fluctuations when compared to vertebrates induced by both inherent population dynamics and environmental variation (Pollard, 1998; Roy *et al.,* 2001) [18, 19]. Many species are strictly seasonal, preferring only a particular set of habitats in spite of this, butterflies have been generally neglected by community ecologist and there are very few studies available on their community structure, population dynamics and the ecoclimatic factors which affect them (Chakkravarthy *et al.,* 1997) [20], they are now recognized as focal species of conservation in several areas of the world (New, 2011) [21], many of the species are sensitive to anthropic disturbance, they are the indicators of habitat feature with greater sensitivity than many other taxonomic groups, they are broadly considered as potent ecological indicators, they are the potential umbrella group for biodiversity conservation (Robbin and Opler, 1997 [7, 22]; Kunte *et al.,* 1999 [23]; Kocher and Williams, 2000 [14]; Kunte 2000 [8], Summerville and Crist, 2001 [24]; Koh, 2007 [25]; Thomas *et al.,* 2004 [26], Thomas, 2005 [27]; Erhardt, 1985 [28]; Browm, 1991 [29]; Kremen, 1992 [13, 30]; Ghazoul, 2002)· [12]. However, more precise information on which species are present at a particular site and how they might respond to management practices such as prescribed burning, weed control or grazing is typically not available to personnel responsible for such operations. Gaining detailed local knowledge about butterfly populations on public lands is therefore crucial to the development of long term conservation strategies, particularly for areas in which species may be declining or imperiled (Royer *et al.,* 1998) [31]. According to Pollard (1992) [32], the butterfly monitoring helps to access the effects of any change in climate on butterfly population, penology of a species, species range extension; the effect of temperature on species - can be studied and detected. Many methods have been explained to monitor butterflies by many Ecologist and Entomologist, in this paper we discussed only few important monitoring methods used by experts all over the world.

Butterfly Monitoring Methods

There are many methods explained by experts for scientific monitoring the butterflies for check listing the fauna or insects or particularly butterflies for to know the biodiversity of the particular region or for conservation prioritization programmes, to study the ecology of the site or to know the effect of anthropogenic disturbance on health of the specific habitat or any other determined reason a researcher need to know. As described in the introduction butterflies are one of the important taxonomic group help to know the health of the ecosystem, different butterfly monitoring methods are developed, modified thought these years to monitor precisely as much as we can. Still there is no standard specific butterfly monitoring method, different habitats and species, depending on the region where we want to monitor, which species we are focusing, need different methods. It is the responsibility of the monitoring person to choose suitable method for their study. Brereton (2011) [34] explains that however there is a great need to evaluate how well such standardized designs suit butterfly monitoring in different climatic regions. Factors such as the openness of the countryside, topography, and the time and effort necessary to walk transects in different regions differ markedly even within one single country.

Here we discussed only few important butterfly monitoring methods, they are –

Line Transect or Pollard Walk Method

According to the Wiktionary the meaning of the ‘Transect’ is, a path along which a researcher moves, counts and record his observation. (This text is extracted from http://en.wiktionary.org/wiki/transect). Method involves only a small section of large area, yet produces an accurate representative sampling of biotic and abiotic parts of that community (A Line Transect- Surveying biodiversity on your Club site). Butterfly transects are a way of monitoring the number and variety of butterflies present at a site from year to year (UK, BMS). Transects are commonly referred as “Pollard Transect” or “Pollard Walk”, it is a protocol designed to standardize the recording of butterfly observations (Wikipedia). According, to Jacqueline, “Transactions are sections with a defined length and width within the landscape tunnel”, this method applied throughout Europe for monitoring the butterfly, and it is has been used by several people in several years.

Moore, in late 1960’s, while studying the effects of toxic chemicals on wildlife, he visits his experimental area, Monks Wood, the nature reserve adjoining the Monks wood, while his study; he regularly counts the butterflies in his fixed area, along with his research work, he also intended to develop a standard butterfly monitoring method. The transect or Pollard transect as we use now is actually the modified Moore method for monitoring butterfly. In Pollard method the path or the route of monitoring are larger than used by Moore and frequency of counting or monitoring are more frequent than Moore.

After Moore, Elias and Skeleton also experimented the method and worked on improving so that the method can bring reliable results for butterfly monitoring. And then in the year 1976, butterfly monitoring scheme was started, before the inception of this scheme it has been tested for 3 years for its reliable, productive repeat value. This scheme was funded by Institute of Terrestrial Ecology and the Nature Conservation Council (NCC). The method for butterfly monitoring was described by Pollard in 1977, according to this method -

- At each site, the recorder makes a series of counts, walking a fixed route, once in a week from April to September, noting any butterflies seen within 5 meter
- Walks are carried only between 10:45 and 15:45 BST.
- Counting of butterflies at the air temperature of between 13^{o}C to 17^{0}C.
- Cloud cover more than 40%
- Avoid double counting of the individuals as much as possible
- Walk with slow, constant speed in the fixed transect
- Count all the butterflies seen within 5m in front and 2.5m each side and 5m above.
- Note the butterfly species
- Note the number of butterflies within a species
- Stop when you need time to indentify the butterfly, then resume with predefined speed

- General speed should be 3km/h

The main purpose of this butterfly monitoring scheme was-

- To provide information on change in the abundance of butterflies
- From the information, improve the conservation strategies and contributes to an understanding of the population ecology of butterflies
- Further aim to integrate the results from individual sites to gain a wider, synoptic, picture of changes in abundance
- As the scheme has developed, it has become clear that a considerable range of information has been acquired on local distributions of butterflies, colonization of sites, extinction, migration of these data may now be added to the original aims (Pollard and Yates, 1993) [42].

Pollard explains the uses of this method (1992) [32].

- This method can use to assess the effects of any change in climate on butterflies.
- Changes in the penology of a species can be detected
- Change in the species range can be studied

Yates (1992) [41] further explains the advantage of the method; the annual indices of abundance from all the sites in different regions are then collated to give regional indices. Similarly, the indices from all sites, where a species is present, are collated to give a national picture of those species fluctuations. The fluctuations of the regional or national indices are used as a baseline for comparison with specific sites, to assess the effects of local management.

After completion of all the visits of a years (Once in a week from start to end of the butterfly season, this starting and ending months differ from region to region), calculate the mean weekly count of each species, then total all the means, this number is nothing but abundance index of your selected site. The index of abundance is not a population estimate, but it has been shown to be related to population size (Pollard, 1997). This method will not provide a accurate population size, the transect counts provide only an index of population size, which can be used to measure change in abundance over time, not an estimate of the number of individuals in a population (Pollard and Yates, 1993) [42]. Swaay *et al.* (2012) [17], advised few general rules regarding selection of the transect, they are-

- Restrict the transect to one habitat and land use type
- If the study is comparison of several habitats it is better to create several short transects instead of one long transect
- Divide transect into smaller sections. This makes it easier to keep an overview, process the data and offers extra possibilities to analyze the results
- Whatever the site or habitat you choose, take care you know the exact length of each transect. This can be done by entering the transect on Google Maps and measure the length of each section
- Don't make the transect too long
- Try to stick to existing paths and use landmarks as poles, prominent trees or fences as starting points for new sections. If possible mark the start and stop of each section on a detailed map and by GPS.
- Enter transect on a Google Map by creating your own map and adding separate lines for each section. This also offers the possibility to measure the exact length of each section and the complete transect.

Royer *et al.,* (1998) [31] explains the merit and demerits of using the pollard walk as, "Pollard Walk" surveys employ fixed travel routes during counting. More rigorous statistical analysis of Pollard walk transect data is possible because counts are conducted in a much more uniform manner with respect to area covered and time spent. Fixity of location of transect allow subsequent study flora and fauna of the same transect. Definite extent and permanent location also make frequent replication possible. Some localized, sedentary species may never appear in a fixed transect, in such case the observer may lose it in data entry and analysis. Far fixed routs or path it may not be possible to account for periodic changes in larval habitat or adult nectar sources that occur off the transect. Confirmation of the presence of a particular species is limited to the transect, the surveyor is less able to generalize the status of a given species across the entire site. Dennis *et al*., (1999) missed few species in their study, hence they opined that, even in small study plots there are chance of missing butterfly species by using linear transect method, this suggest that species detectability along linear transect would further decrease with increasing area surveyed. Linear transect are perfectly appropriate for studies in which complete species lists per sites are not that important, and the main emphasis is on relative abundance of dominant species. Depending on the climate, ecosystem, need and result expectation different people used the modified Pollard walk or completely new method for their study, research or monitoring the butterfly. These methods too have limitations as in Pollard walks.

Point Counts

It is impossible to count some species in particular habitats for example mountains, wetlands by using fixed line transect; in such situation the place or site we can reach safely are marked and count is carried for either rare or single target species. (Often the maximum time is five minutes for monitoring each point)

Timed Counts

The method consist of repeated searches throughout re a study area, attempting to spot as many species/individuals as possible, paying preferential attention to such resources as nectar rich patches (Kadlec *et al.*, 2008; Spitzer *et al.*, 2009) [45, 46].

According to Swaay *et al.,* (2012) [17] timed Counts are useful method for rapid monitoring of rare species, especially those whose populations tend to 'move around' large sites.

The flight area of the species identified first, and then walks systematically and the number seen per minute of search effort recorded. This method requires considerable experience in assessing butterfly flight area and access to transect data to generate a meaningful abundance measure from the raw cont data. In this method survey path or length is not predetermined or fixed and we can alter according to the habitat and the target butterfly species count variability, and hence chance of detection, is inversely related to the abundance of particular species (Harker and Shreeve, 2008) [44].

Mark–Release-Recapture (Mr.) Method or Capture-Mark-Recapture Method

The most commonly used and most satisfactory methods of estimating population size of insects are based on Capture-Mark-Recapture techniques. Most such methods require a minimum of two sampling occasions, usually on different days. On the first occasion, insects are capture and marked in some way (usually with a small spot of paints or colored marker pen); on the second occasion recapture are made to assess the proportion of marked individuals in the population, and so to estimate is obtained for one species over one time period (Pollard and Yates, 1993) [42]. MRR provides fairly precise estimates of population size, but at the expense of considerable field work (Personnel communication of C. Schultz with Nowicki). MRR method is useful for intensive restricted small-scale and short term research projects. Few butterfly population studies with the help of MRR last for long enough to be able to monitor their trends (Nowicki *et al.,* 2008) [47], in Swaay *et al.,* (2012) [17] opinion, MRR is tried and tested technique for absolute abundance estimation of butterflies population, This method is highly labor intensive and requires capturing, handling and marking individual butterflies, for these reasons, MRR is not a practical for wide scale annual monitoring

Marking the butterflies affects their behavior and so their chance of recapture with some butterflies (Singer and Wedlake, 1981; Morton, 1984) [48]. Apart from such difficulties, Capture – Mark- Recapture considered for monitoring on a national scale (Begon, 1979) [33].

Pollard transect counts is cheap and time efficient and reliable, MRR provided fairly precise estimates of population size, but at the expense of considerable field work (Nowicki *et al.,* 2008) [47], another problem with MRR is sometimes their negative effect on the populations investigated, either direct, due to catching and handling of a large fraction of individuals, or indirect through habitat destruction by intensive trampling (Personnel communication of Nowicki with C. Schultz). According to Gall 1985 [49]; New, 1991 [50]; Warren, 1992 [51, 59]; Pollard transect counts and MRR are the two standard methods for quantifying butterfly abundance, choosing line transect method rather than CMR, the main sacrifice is of information on absolute population size, the transect counts provide only an index of population size, which can be used to estimate of the number of individuals in a population (Pollard and Yates, 1993) [42].

Checklist Surveys or Open Search Method

Checklist surveys are employed primarily to confirm the presence of species and sometimes the number of individuals of each species for the survey site. One important advantage of checklist counting is that an observer is free to search out places where butterflies typically would breed or congregate. Another is that checklist counting is procedurally simple; the recorder need merely identify and count without regard to other factor. (Royer *et al.,* 1998) [31]. Species presence may be confirmed without sophisticated research design or secondary data analysis and with a minimum of effort. This combination of procedural freedom and economy of effort is arguably the most important feature of checklist. The Royer's personnel communication with Droege noted such anecdotal data are far better than none all and can easily be produced by informed volunteer amateurs and hobbyists. In checklist surveys there is no fixed path for monitoring the butterflies, any observer can observe the selected site and note down the observed species daily or weekly once, depending on the facility and the result expected from the study. The observers are free to select sites for observing and check listing. In free site selection geographical coverage commonly becomes non-random and hence not representative of habitats and butterfly populations in general (Dover et al., 1997 [52]; Swaay and Warren, 2012 [17]; Swaay *et al.,* 2015) [53]. Free site selection is generally appreciated by recorders as they can be involved in the site selection process by influencing choice of site characteristics, accessibility and being able to relate more closely to the sites that they monitor (Swaay and Warren, 2012) [17]. Hellawell (1991) [54] has noted, however, such "open-ended" survey approaches frequently are, "inadequate to meet the rigors of statistics", he quotes further, "open ended monitoring strategy is avoidable, provided that clear objectives are set and a true monitoring yardstick is defined at the outset". If the purpose of the study is to know the presence of a species and preparing the checklist of a particular area without any focus on population size, relative abundance - then the checklist method can be used, but, if the purpose is to know the population size or relative abundance follow Pollard Walk Transect. Royer *et al.,* (1998) [31], lists the disadvantage of Pollard walk method too as - i) finite extent and precise location of a fixed transect also introduces the likelihood that some localized, sedentary species may never appear in a count, ii) because of fixed paths it may not be possible to account for periodic changes in larval habitat or adult nectar sources that occur off the transect, iii) since confirmation of the presence of a particular species is limited to the transect, the surveyor is less able to generalize the status of a given species across an entire site. These factors underscore the importance of original location and layout, especially in terms of habitats or microhabitats included and potential influences of day-to-day changes in wind, sunlight and other environmental factors.

Malaise Traps

This is another method for assessing butterfly abundance. In this method adult butterflies are trapped by using ground covering net tents. The trap is a tent like structure allows the entry of flying insects and restricted the exit. If such tents are kept in good numbers for throughout the season of adult butterflies yields the total count and diversity of adult butterflies. But these traps are most suited to small insects which occur at higher densities than butterflies, Walker in 1991 [55] used large net traps for migrating butterflies, and he got good results of migrating butterflies, all traps have the major disadvantage that the size of the catch is likely to depend greatly on behavior, particularly whether individuals are dispersing or migration (Pollard and Yates, 1993) [42]

Bait Traps

Bait traps are useful to know the relative abundance index and Nowicki *et al.,* (2008) [47] concluded that Bait and Malaise methods are labor-intensive, Malaise traps is technically difficult, bait traps simply do not work for many species.

Egg and Larval Plots or Sampling of Non Adult Life Stages

For some species the counting of eggs rather the adult within defined area provide reliable results than counting the adults on transects. Swaay, (2012) [17] gave an example of *Pgengaris alcon* and *Thecla betulae*, he further explains that for these species a plot consists of a patch of habitat which can be counts within 30-60 minutes. In few species the counting larvae are much more effectible than counting eggs or adults in selective plots or field transects respectively. Here the counts are expressed as number per unit of search time or transect length. Like with egg plots it involves systematic searches of the occupied parts of sites for larvae or larval webs, and counting the number seen along structured walks in affixed recording box. *Lycaena dispar* in Netherlands, *Euphydryas aurinia*, *Melitaea cinxia* in the United Kingdom are counted by this method (Swaay, 2012) [17]. Sampling eggs or larvae does not have the potential to become widely applicable, but is remains an effective method for assessing abundance of selected species in which eggs or larvae are relatively conspicuous. Egg count has become the standard for assessing abundance of some Lycaenids larvae surveys, in turn, can be applied with relative ease to fritillary butterflies (Elmes *et al.*, 1996 [56]; Maes *et al.*, 2004 [57]; Swaay V, personnel, communication, Thomas and Simcox, 1982) [58]. Disadvantages of this explained by Warren (1992) [51, 59], as – disadvantages of egg or larvae censuses are mostly practical ones, including little attractiveness for volunteers (exception are there) and species specific field technique. The number of eggs or larvae cannot be easily converted into the number of adults in either the preceding or the following generation due to annual variation in fecundity as well as mortality in non-adult life stages (Warren, 1992) [51, 59].

Canopy Species

There are few butterflies their habitat are forest canopy or closed to canopy, the counting, monitoring of such butterflies cannot be achieved by any of the methods described above, because they spend negligible time at lower levels, such species are monitored by focusing on canopy of the forest with good camera and suitable techniques which help them to indentify and record as much as possible accurately.

Opportinistic or Sighting Method

The North American Butterfly monitoring networks which involve in collecting data of butterflies all over the world along with North America, this network allow their volunteers to report sightings of butterflies. The volunteers report the butterfly species seen during even in a single event opportunistically. This method is helpful to prepare a raw checklist of butterflies.

Conclusion

Butterfly monitoring programmes have to apply proper survey designs as well as reliable methods of data collection and statistical analysis so that their results are scientifically sound and robust. To effectively use butterflies as indicators, it must be possible to infer trends in their occurrence and abundance in an unbiased and relatively precise way, rather than to rely on so called "expert judgment" (Nowicki *et al.*, 2008) [47]. It must not be forgotten that monitoring methods flexibly responding to spatiotemporal variation in the distribution of species. Resources are needed for some research questions, regions and habitat (Kadlec *et al.*, 2012) [61].

Our purpose of this study was not conclude or favor one method over the other, our expectation was to supplement information regarding a couple of butterfly monitoring methods along with their merits and demerits, so that the research beginners, butterfly amateur can facilitated by methods in one reach. In the present discussion we left some butterfly monitoring methods, emphasized only on repeatedly and commonly used methods by butterfly experts. There is no standardized method yet decided for butterfly monitoring, depending upon the habitat, recourse available, the expected result from the study one can follow the reliable method so that the result should less biased and more accurate driven.

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References

1. Monaghan Country Council, Tidy Towns, Biodiversity Training Initiative, Ballybay Wetlands Centre, Session 1-Biodiversity and Habitats, 2010, 24.
2. European Commission. A sustainable Europe for a better world: a European Union strategy for sustainable development. 2001.
3. Balmford A, Crane P, Dobson AP, Green RE, Mace G, The 2010 challenge : data availability information needs and extraterrestrial insights, Philosophical Transactions of the Royal Society of London Series B-Biological sciences 2005b; 360:221-228.
4. Dobson A. Monitoring global rates of biodiversity change: challenges that arise in meeting the convention on Biological Diversity (CBD) 2010 goals, Philosophical Transactions of the Royal Society B-Biological Sciences 2005; 360:229-241.
5. Wijesekara A, Wijesinge DP. History of insect collection and a review of insect diversity in Sri Lanka, Ceylon J Sci. Bicl Sci. 2003; 31:43-59.
6. Ghauzoul J. Impact of logging on the richness and diversity of forest butterflies in a tropical dry forest in Thailand, Biodivers Conserv 2002; 11:521-541.
7. Robbins RK, Opler PA. Understanding and protecting our biological resources Joseph Henry Press, Washington DC, 1997.
8. Kunte K. India –life scape, Butterflies of peninsular India, University Press, New Delhi. 2000, 254.
9. May PG. Flower selection and the dynamics of lipid reserves in two nectarivorous butterflies Eco 1992, 73(6): 2181-2191.
10. Balmer O, Erhardt A. Consequences of succession on extensively grazed grassland for central European butterfly communities: Rethinking conservation practices. Conservation Biology 2000; 14:746-757.
11. Borges RM, Gowda V, acharias M. Butterfly pollination and high contrast visual signals in a low-density distylous plant, Oecology 2003; 136:571-573.

12. Ghazoul J. Impact of logging on the richness and diversity of forest butterflies in a tropical dry forest in Thailand, Biodiversity, Conservation J 2002; 11:521-541.
13. Kremen C. Assessing the indicator properties of species assemblages for natural area monitoring Ecological Applications 1992; 2:203-217.
14. Kocher SD, Williams EH. The diversity and abundance of North American butterflies vary with habitat disturbances and geography, Journal of Biogeography, 2000.
15. Gunathilagaraj K, Permal TNA, Jayaramm K, Ganseh MK. Some South Indian butterflies. Resources communications, Pvt. Ltd, Bangalore. 1998.
16. Pollard E. Monitoring butterfly for Conservation and Ecology, Goldsmith F.B (Ed.) Chapmand and Hall London, 1991, 275.
17. Swaay V, Breton CAM, Kirkland T, Warren MS. Manual for Butterfly Monitoring, Report VS2012.010, De Vilndersstichting/Dutch Butterfly Conservation, Butterfly Conservation UK and Butterfly Conservation Europe, Wageningen, 2012.
18. Pollard E. Temperature, rainfall and butterfly numbers, Journal of Applied Ecology. 1998; 25:819-828.
19. Roy DB, Rothery P, Moss D, Pollard E, Thomas JA. Butterfly numbers and weather: Predicting historical trends in abundance and the future effects of climate change, Journal of Animal Ecology. 2001; 70:201-217.
20. Chakravarthy AK, Rajagopal D, Naganntha R. Insects as bio indicators of conservation in the tropics, Zoos' print Journal. 1997; 12:21-25.
21. New TR. Launching and Steering flagship Lepidoptera for conservation benefit, Journal of Threatened Taxa. 2011; 3(6):1805-1817.
22. Robbins RK, Opler PA. Butterfly diversity and a preliminary comparison with bird and mammal diversity, In: Biodiversity II, Understanding and protecting our Biological Resources (Red-Kudlam, Don Wilson E, Wilson EO, and EDS), Joseph Henrt Oress, Washington, DC, 1997.
23. Kunte K, Joglekar A, Utkarsh G, Padmanabhan P. Patterns of butterfly, bird and tree diversity in the Western Ghats, Current Science 1999; 77:5777-586.
24. Summerville KS, Crist TO. Diversity of Lepidoptera in Ohio forests at local and regional scales: how heterogeneous is the fauna? Annals of the Entomological Society of America 2001; 94:583-591.
25. Koh LP. Impacts of land use change on South-east Asian forest butterflies: a review, Journal of Applied Ecology. 2007; 44:703-713.
26. Thomas CD, Cameron A, Green RE *et al.*, Extinction risk from climate change, Nature 2004; 427:145-148.
27. Thomas JA. Monitoring change in the abundance and distribution of Insects using butterflies and other indicator groups. Philosophical Transactions of the Royal Society B. 2005; 360:339-357.
28. Erhardt A. Diurnal Lepidoptera: Sensitive indicators of cultivated and abandoned grassland, Journal of Applied Ecology. 1985; 22:849-861.
29. Brown KS. The conservation of insects and their habitats, In: Conservation of Neotropical Environment s: Insects as Indicators 15th Symposium of the Royal Entomological Society 1991, 350-403.
30. Kremen C. Assessing the Indicator properties of species Assemblages for natural Areas Monitoring, 1992.
31. Royer R, Jane A, Newton, Wesley. Checklist and Pollard walk Butterfly Survey Methods on public Lands, Am Mid I Nat 1998; 140:358-371.
32. Pollard E. Monitoring populations of a butterfly during a period of range expansion. In: Biological recording of changes in British Wildlife, edited by P.T. Harding London: HMSO, 1992.
33. Begon M. Investigating Animal Abundance, Edward Arnold, London, 1979.
34. Brereton TM, Cruickshank KL, Risely K, Nobel DG, Roy DB. Developing and launching a wider countryside butterfly surveys across the United Kingdom, Journal of Insect Conservation. 2011; 15:279-290.
35. Web link: http://en.wiktionary.org/wiki/transect, accessed on 3/11/2017, at 4.41PM.
36. A Line Transect-Surveying Biodiversity on your Club site, A GEN Eco- standard check Activity, Web link: gen.uga.edu/documents/biodiversity/activities/A%20 Line % 20 Transect. Pdf, Accessed on 3/11/2017, at 4.45 PM.
37. UK Butterfly Monitoring Scheme, Butterfly Conservation, G1: Monitoring Butterfly Numbers by the transect Method-summary information for recorder, Web link: www.ukbms.org, Accessed on 3/11/2017 at 5.00 PM
38. Web link: http://en.wikipedia.org/wiki/Butterfly-cont, Accessed on 15/3.2017, at 9.36 AM.
39. The butterfly transects method – Jacqueline Loos, Leuphana University Lunenburg.
40. Pollard E. A method for assessing changes in the abundance of butterflies, Biological Conservation 1977; 12:115-134.
41. Yates TG. The butterfly Monitoring Scheme, In: Harding PT., (ed.), Biological recording of changes in British Wildlife, London, HMSO, Ite Symposium 1992; 26:77-78.
42. Pollard E, Yates TJ. Monitoring butterflies for ecology and conservation, The British butterfly monitoring Scheme. Institute of Terrestrial ecology and joint nature conservation committee, Chapman and Hall, London, 1993.
43. Dennis RLH, Sparks TH, Hardy PB. Bias in butterfly distribution maps: the effects of sampling effort, J Insect Conserved. 1999; 3:33-42.
44. Harker RJ, Shreeve TG. How accurate are single site transect data for monitoring butterfly trends? Spatial and temporal issues indentified in monitoring Lasiommata megera, J Insect Coserv. 2008; 12:125-133.
45. Kadlec T, Benes J, Jarosik V, Konvicka M. Revisiting urban refuges: changes of butterfly and burnet fauna in Prague reserves over three decades, Landsc Urban Plann 2008; 85:z-11.
46. Spitzer L, Benes J. Dazech Carpathians, Ecol Indic 2009; 9:1053-1056.
47. Nowicki P, Settele J, Henry PY, Woyciechowski M. Butterfly monitoring methods: The ideal and the real world, Israel Journal of Ecology and Evolution. 2008; 54:69-88.
48. Singer MC, Wedlake. Capture does affect probability of recapture in butterfly species Ecological, 1981.

49. Gall Lf. Measuring the size of Lepidopteran population, Journal of Research on the Lepidoptera. 1985; 24:97-116.
50. New TR. Butterfly Conservation, Oxford University Press, Oxford, 1991.
51. Warren MS. Butterfly populations, In: Dennis R.L.H. Ed, The ecology of butterflies in Britain, Oxford University Press, Oxford, 1992, 73-92.
52. Dover JW, Sparks TH, Greatorex-Davies JN. The importance of shelter for butterflies in open landscape, Journal of Insect Conservation. 1997; 1:89-97. DOI: 10.1023/A:1018487127174.
53. Swaay V, Aghababyan K, Astroms, Bothan M, Brereton T, Chambers P *et al.*, The European Butterfly Indicator for Grassland species: report, 2015, VS2015.009, De Vlinderstichting, Wageningen NL, 1990-2013.
54. Hellawell JM. Development of a rationale for monitoring, 1991, In: F Goldsmith (Ed.). Monitoring for Conservation and Ecology. Chapman and Hall, London, 1991, 1-14.
55. Walker. Butterfly migration from and to peninsular Florida, Ecological Entomology 1991; 16:241-252.
56. Elmes GW, Clarkes RT, Thomas JA, Kochberg ME. Empirical tests of specific prediction dynamics from a spatial model of the population dynamics of *Maculinea rebeli*, a parasitic butterfly of red and colonies Acta Oecologica 1996; 17:61-80.
57. Maes D, Vanreusel W, Talloen W, Dyck VH. Functional conservation units for the endangered Alcon Blue butterfly *Maculinea alcon* in Belgium (Lepidoptera: Lycaenidae), Bio-logical Conservation 2004; 120:229-241.
58. Thomas JA, Simox DJ. A quick method for estimating larval populations of *Melitaea cinxia* L, during surveys, Biological Conservation 1982; 22:315-322.
59. Warren MS. Butterfly populations. In: Dennis R.L.H., Ed. The ecology of butterflies in Britain Oxford University Press, Oxford, 1992, 73-92.
60. Web link: The North American Butterfly monitoring Network, WWW.nab-net.org/monitor-tracker, Accessed on 11/3/2017 at 4:30 PM.
61. Kadlec T, Tropek R, Konvicka M. Timed surveys and transect walks as comparable methods for monitoring butterflies in small plots, J Insect Conserv. 2012; 16:275-280.