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Methods of Studying Butterflies

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Abstract

In the assessment of butterfly distribution, it is necessary to account for imperfect species detection at the sites of studies. This can be achieved through conducting repeated presence or absence surveys within a single season, and analyzing data with statistical models that estimate detection probability and site occupancy by a species. Transect counts, predominantly used for assessing butterfly abundance in monitoring programs, are cost-effective and easy to implement, but less reliable than mark–release–recapture sampling frequently applied for the same purpose in research studies. Deficiencies of transect counts stem from the fact that they do not account for individual detection probability and temporal fragmentation of butterfly populations, i.e., the situation in which just a small fraction of individuals belonging to a single generation is present on any day of a season. Consequently, transect counts can only yield relative abundance indices, which presumably correlate well with daily butterfly numbers, but not necessarily with their seasonal sizes of the butterfly's population.

Keywords: Abundance, Detection Probability, Population Size, Transect Counts

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Introduction:

Butterflies belongs to Lepidoptera the largest order of Class: Insecta. The term Lepidoptera is with two words: Lepido and Ptera. Both of them are the Greek terms. Lepido indicate scaly and Ptera indicate the wings. *Harper Douglas* (2011) defining the Butterfly science, the Lepidopterology as a branch of entomology concerning the scientific study of moths and the of butterflies. Someone that studies in this field is a lepidopterist or, archaically, an aurelian. 1758-1900 was the era of the gentleman scientist. Following Linnaeus' descriptions in *Systema Naturae* and with Boas Johansson in *Centuria Insectorum*, the Austrian Nikolaus Poda von Neuhaus wrote *Insecta Musei Graecensis* (1761) and Johann Christian Fabricius described very many more species in a series of major works. During this period, Ignaz Schiffermüller wrote a systematic catalogue of the butterflies of the districts around Vienna *Systematische Verzeichnis der Schmetterlinge der Wienergegend herausgegeben von einigen Lehrern am k. k. Theresianum* (1775). In Germany Eugenius Johann Christoph Esper in collaboration with Toussaint de Charpentier published *Die europäischen Schmetterlinge* and *Die ausländischen Schmetterlinge* Between 1806-1834 Jacob Hübner wrote *Sammlung exotischerSchmetterlinge*, Augsburg with Carl Geyer and Gottlieb August Wilhelm Herrich-Schäffer. During the years of 1806-1824 Hübner added *Geschichte europäischer Schmetterlinge*. Herrich-Schäffer expanded this as *Systematische Bearbeitung der Schmetterlinge von Europa, Zugleich als Text, Revision und Supplement zu Jacob Hubner's Sammlung europäischer Schmetterlinge*.

In France Jean Baptiste Boisduval, Jules Pierre Rambur and Adolphe Hercule de Graslin wrote *Collection iconographique et historique des chenilles; ou, Description et figures des chenilles (larvae) d'Europe, avec l'histoire de leurs métamorphoses, et des applications à l'agriculture*, Paris, Librairie encyclopédique de Roret, 1832 and with John Eatton Le Conte, 1829-1837 *Histoire général et iconographie des lepidoptérès et des chenilles de l'Amerique septentrionale* (General history and illustrations of the Lepidoptera and caterpillars of Northern America) which was published in Paris. Boisduval also described Lepidoptera from the expedition ship *Astrolabe* of Jean-François de Galaup, comte de La Pérouse and the *Coquille*, that of Louis Isidore Duperrey.

In Italy Giovanni Antonio Scopoli wrote *Entomologia Carniolica* published in Vienna. In the mid-century period, the expert knowledge of Lepidoptera dealers such as Otto Staudinger, Emile Deyrolle, Orazio Querci and Peter Godeffroy contributed to the field. The credit of exploration of this branch of butterfly study goes to the era of European and American voyages of scientific exploration. This era of European and American voyages of scientific exploration followed the Age of Discovery and were inspired by a new confidence in science and reason that arose in the Age of Enlightenment. Maritime expeditions in the Age of Discovery were a means of expanding colonial empires, establishing new trade routes and extending diplomatic and trade relations to new territories, but with the Enlightenment scientific curiosity became a new motive for exploration to add to the commercial and political ambitions of the past (*Herbert Sandra, 1999).*Expeditions continued to be major sources of specimens. The Baudin expedition to Australia (1800 to 1803) with two laboratory equipped ships *Géographe* and *Naturaliste* had nine zoologists and botanists on board. They brought back to France, according to Antoine François, comte de Fourcroy, the largest collection Muséum national d'Histoire naturelle had ever received including 44 crates of zoological specimens. The Österreichische Brasilien-Expedition explored the Botany, Zoology and Ethnography of Brazil. It was organized and financed for Austrian Empire and ran from 1817 to 1835. The SMS Novara, under the command of Commodore Bernhard von Wüllerstorf-Urbair, made a

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voyage of exploration in 1857–1859. Baron Cajetan von Felder and his son Rudolf Felder amassed a huge entomological collection from the Novara that is deposited in the Naturhistorisches Museum in Vienna and the Natural History Museum in London. The butterflies were described in *Reise Fregatte Novara: Zoologischer Theil., Lepidoptera, Rhopalocera* (Journey of the Frigate Novara...) in three volumes (1865–1867). Wealthy collectors played a major role: Aimée Fournier de Horrack in Paris, Walter Rothschild and James John Joicey in England and in Russia Grand Duke Nicholas Mikhailovich of Russia who funded Sergei Alphéraky and edited *Mémoires sur les Lépidoptères*. The British Empire provided opportunities to Frederic Moore author of *Lepidoptera Indica*. In the nineteenth century large collections of Lepidoptera were amongst the natural history specimens then flooding into Europe.Most of the largest and most specimens of new species are in Musée royal de l'Afrique centrale (Belgian Congo), Muséum national d'Histoire naturelle (French colonial empire), Museum für Naturkunde (German colonial empire), British Museum (Natural History) (British colonial Empire) and Rijksmuseum van Natuurlijke Historie (Dutch Empire).Museum lepidopterists include Samuel Constantinus Snellen van Vollenhoven. Francis Walker, Alois Friedrich Rogenhofer, František Antonín Nickerl, Lionel de Nicéville, Carl Heinrich Hopffer and Arthur Gardiner Butler.

Renowned World Lepidopterists

This is the list of some world renowned lepidopterists:

- Per Olof Christopher Aurivillius of Sweden: butterflies of Africa
- Henry Tibbats Stainton of England: Microlepidoptera
- Jules Léon Austaut of France: specialised in *Parnassius*
- Otto Vasilievich Bremer of Russia: Siberia and Amur
- Per Olof Christopher Aurivillius of Sweden: butterflies of Africa
- Henry Tibbats Stainton of England: Microlepidoptera
- Otto Vasilievich Bremer of Russia: butterflies of Siberia and Amur
- John Henry Leech of England: butterflies of China
- Shōnen Matsumura of Japan: butterflies of Japan
- Hans Rebel of Austria: butterflies of the Palearctic
- Ruggero Verity of Italy: butterflies of the Palearctic
- Hans Fruhstorfer of Germany: world butterflies, but especially Java
- Edward Meyrick of England: Microlepidoptera
- Herman Strecker of the U.S.A.: butterflies of the Americas

Collection and Illustrations for Butterflies

Insect collecting refers to the collection of insects and other arthropods for scientific study or as a hobby. Because most insects are small and the majority cannot be identified without the examination of minute morphological characters, entomologists often make and maintain insect collections.

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Fig.1: Wall display of butterfly specimen

Many college courses require students to form small collections. There are also amateur entomologists and collectors who keep collections.

Insect collecting refers to the collection of insects and other arthropods for scientific study or as a hobby. Because most insects are small and the majority cannot be identified without the examination of minute morphological characters, entomologists often make and maintain insect collections. Very large collections are conserved in natural history museums or universities where they are maintained and studied by specialists. Many college courses require students to form small collections. There are also amateur entomologists and collectors who keep collections.

Historically, insect collecting has been widespread and was in the Victorian age a very popular educational hobby. Insect collecting has left traces in European cultural history, literature and songs (e.g., Georges Brassens's *La chasse aux papillons* (*The Hunt for Butterflies*)). The practice is still widespread in many countries, and is particularly common among Japanese youths.

The usual method of display is in a glass-covered box, with the insects mounted on specially made non corrosive insect pins stuck into suitable foam plastic or paper covered cork at the bottom of the box. Common pins are not used. Very small insects may be pinned on "minuten" (very tiny headless pins) stuck into a block of foam plastic on a standard insect pin. Alternatively they may be glued onto a small piece of card on the pin. There are specific procedures for proper mounting that are used to show off the insects' essential characteristics. Techniques and equipment may be varied to deal with various species or requirements. For example, one or both of the wings of a beetle or grasshopper can be pulled open and fanned out to show the wing structure that otherwise would be hidden. At least the date and place of

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capture should be written or computer printed onto a piece of paper or card transfixed by the pin. This is called a data label.

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As the chief mode of study of butterflies was through pinned specimen collections, it was difficult to catalogue and communicate names and descriptions widely. Books on butterflies with plates that were either hand-painted, lithographed and printed have been a major tool in lepidopterology. These include the massive works by Adalbert Seitz.

Unusual works like the *Butterfly Fauna of Ceylon* (1942) by Lionel Gilbert Ollyett Woodhouse (1888-1965) and *Moths and Butterflies of the United States East of the Rocky Mountains* (1900) by Sherman F. Denton made use of butterfly wing-prints where the illustrations incorporated the scales of the wings (Cowan, 1968). The illustrious Russian writer, Vladimir Nabokov was a noted lepidopterist, having discovered the passion at the age of seven. He would later write about butterflies, collect, and illustrate them Nabokov volunteered at Harvard's Museum of Comparative Zoology in the Entomology Department, where he would organize specimens for as much as 14 hours a day (Batuman, 2016).

Societies for Lepidopterological Studies

Lepidopterists are served by a number of national and international scientific societies. They promote research in lepidopterology and dissemination of the findings through conferences such as the biennial European Congresses of Lepidopterology. Societas Europaea Lepidopterologica is the European society for the study of moths and butterflies and for the conservation of these insects and their natural habitats.

The society was founded in 1976 with the aims of promoting collaboration among the lepidopterists of Europe, Western Asia and North Africa, and of promoting conservation of Lepidoptera and their habitats. We now have more than 600 members. The **Societas** Europaea Lepidopterologica promotes research in lepidopterology and dissemination of the findings therefrom primarily through the arrangement of the biennial congress and through the publication of the biennial scientific journal Nota lepidopterologica. Its strong point is the collaboration between **amateurs** and **professional researchers.** A newsletter, 'SELepidoptera News' serves the communication within the society. The Societas Europaea Lepidopterologica Council is elected by the members at the General Meetings which take place during the European Congresses of Lepidopterology. Presently, Hon. Erik van Nieukerken is dealing with European Congresses of Lepidopterology as a president. The office of this society is at Naturalis Biodiversity Center, PO Box 9517, NL-2300 RA Leiden, Netherlands nieukerken@naturalis.nl or the TILS Leps Talk. Some other Societies working on the same line are listed below:

- Lepidopterists' Society
-Societas Europaea Lepidopterologica
- Lepidoptera Research Foundation
-North American Butterfly Association
-Association for Tropical Lepidoptera
-International Lepidoptera Survey
-Lepidopterological Society of Denmark

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-Lepidopterological Society of Finland
-Lepidopterological Society of Japan
-Sicilian Lepidopterological Association
-Southern Lepidopterists' Society
-Study Group of Hessian Lepidopterologists
-Lepidopterists' Society of Africa

One Example Area for the Studying Butterflies in Pune Region

The region rich in vegetation should be selected for butterfly studies. Information about the place of studies should be collected and compiled. In this paragraph the sample draft of information about place of studies of butterflies is given. The "Mayureshwar Wildlife Sanctuary"is located in Tehsil Baramati in Pune district in Maharashtra, India (Fig. 2 and 3). There are ten biogeographic zones in India, which include: Trans Himalayan zone; Himalayan zone; Desert zone; Semiarid zone; Western ghat zone; Deccan plateau zone; Gangetic plain zone; North east zone; Coastal zone and Islands present near the shore line (Chauhan, 2008). Trans Himalayan zone. The "Mayureshwar Wildlife Sanctuary" is belonging to Deccan Plateau. Beyond the Ghats is Deccan Plateau, a semi-arid region lying in the rain shadow of the Western Ghats. This is the largest unit of the Peninsular Plateau of India. The highlands of the plateau are covered with different types of forests, which provide a large variety of forest products. the Deccan plateau includes the region lying south of the Satpura range.it extends up to the southern tip of peninsular India. Anai mudi is the highest peak of this region. The Deccan plateau is surrounded by the western and the eastern ghats. These ghats meet each other at the Nilgiri hills. The western ghats includes the Sahyadri, Nilgiris, Anamalai, and cardamom hills. Many rivers such as Mahanadi, Godavari, krishna, and kaveri originates from western ghats and flow toward the east. The eastern ghats are broken into small hill ranges by river coming from the western ghats.



Fig 2: Main Gate of the Study Area: "Mayureshwar Wildlife Sanctuary".

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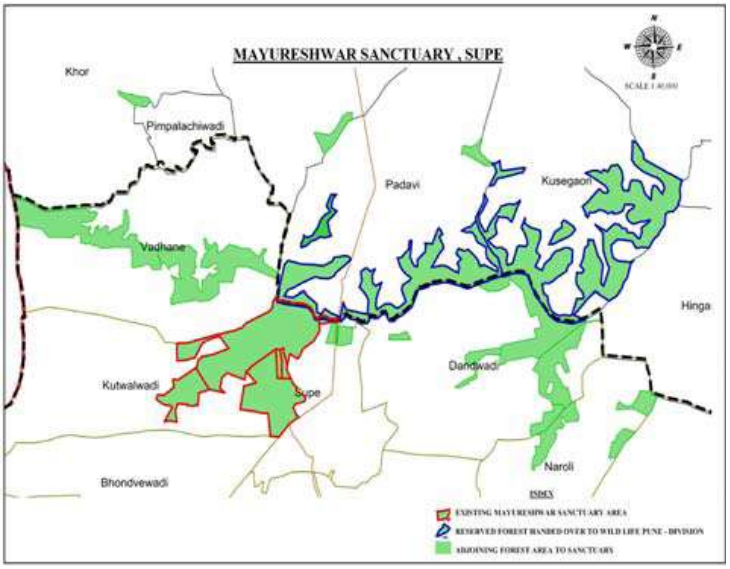

Fig. 3: Geographical Map of the Study Area: The "Mayureshwar Wildlife Sanctuary".

This "Mayureswar Wildlife Sanctuary" is 74 km away from Pune; 35 km away from Daund; 41 km away from Baramati; 220 km away from Mumbai; 88 km away from Satara; 111 km away from Ahmednagar; 198 km away from Beed; 211 km away from Solapur; 265 km away from Nashik and 205 km away from Kolhapur. The "Mayureshwar Wildlife Sanctuary" is mostly made of dry deciduous scrub forest of *Acacia catechu* (Khair), Acacia sp. (Hivar), Dalbergia latifolia (Sisoo), Ziziphus mauritiana (Ber), *Carissa opaca* (Karwand), *Alysicarpus bupleurifolius, Cyathocline purpurea, Eriocauion diane, Merremia emarginata, Cucumis melo, Cyperus kyllingia, Striga densiflora, Mareilea minuta* trees and interspersed grasslands. This sanctuary is also home to a variety of birds including, Indian roller, black-winged kite, grey hornbill, grey partridge, Eurasian collared dove, white throated kingfisher, ashy-crowned sparrow lark, shrike, laughing dove, blue-cheeked bee-eater, Indian silverbill, eagle and babbler. The wild animal species found in the refuge include: Indian Gazelle (Chinkara), Striped Hyena, Indian gray wolf, Indian Jackal, Indian fox and Indian Hare (blacknaped hare). The stunning landscapes and natural beauty is one more significant feature of the "Mayureshwar Wildlife Sanctuary". This is a good place to see the Indian gazelle. Tourists are allowed to drive their vehicles inside the sanctuary as well as on foot. The forest department has two tents within the sanctuary area. Accommodation options available in the vicinity are in Supe, outside the sanctuary. One may also stay in the Hadapsar area in Pune and drive to the sanctuary in the morning or evening. The best time to visit is from late August to February when the weather is not very harsh. Summers are hot and humid and monsoon may have heavy rainfall. Dominant plant species recorded within the sanctuary include Citrus spp., *Toddalia asiatica* L., *Murraya* spp., *Aegle marmelos* L., *Mangifera indica* L., *Polyalthia longifolia* L., *Michelia* spp., *Cinnamomum* spp., *Annona* spp., *Magnolia grandiflora* L., *Litsea* spp., *Aristolochia* spp., *Ricinus communis* L., *Derris scandens* L., *Bambusa* spp., *Cocos* spp., *Calamus* spp., *Cassia* spp., *Andropogon* spp., *Cymbopogon* sp., *Setaria glauca* L., *Terminalia* spp., *Melastoma malabathricum* L., *Dioscorea* spp., *Ageratum*

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conyzoides L., *Vallaris* spp., *Frerea* spp., *Calotropis* sp. *Ficus* sp., *Neriumsp*., *Dendrocalamus* spp., *Panicum* spp., *Sorghum* spp. This wide variety of plants supports a huge diversity of butterflies providing them an ideal breeding habitat (Vitthalrao B Khyade, Sharad G Jagtap, 2016).

Chinkara, *Gazella bennettii* (Mammalia: Cetartiodactyla: Bovidae) is the significant animal species of Mayureshwar Wildlife Sanctuary, Supe, Baramati, Pune (Gaikwad and Narawade, 2016). It is also known as the Indian gazelle. It is a gazelle species native to Iran, Afghanistan, Pakistan and India It stands at 65 cm (26 in) tall and weighs about 23 kg (51 lb). It has a reddish-buff summer coat with smooth, glossy fur. In winter, the white belly and throat fur is in greater contrast. The sides of the face have dark chestnut stripes from the corner of the eye to the muzzle, bordered by white stripes. Its horns reach over 39 cm (15 in). (Prater, 1971). Chinkaras are shy and avoid human habitation. They can go without water for long periods and can get sufficient fluids from plants and dew. Although most are seen alone, they can sometimes be spotted in groups of up to four animals. They share their habitat with several other herbivores, such as nilgai, blackbuck, chausingha, wild goat, and wild boar. Chinkaras mate once a year. Males compete for access to females. Chinkaras are preyed upon by leopards, Bengal tigers, Asiatic lions and dholes. The chinkara was a common prey of the Asiatic cheetah in India alongside blackbucks. Outside protected areas they may be attacked by pariah dogs, and both wolves and golden jackals are also known to hunt them. The chinkara occurs in over 80 protected areas in India *(Mallon, et al, 2001).* In January 2016, the Karnataka government issued a notification to establish a sanctuary especially for chinkara in the Yadahalli village in the Bagalkot district of the state. This region shelters a major population of chinkara. The chinkara is protected in nine areas of Iran and five of Pakistan.

Attempts of Butterfly Studies:

The diversity studies are important aspect of the butterfly ecology with major conservation implications. Various ecological determinants serve to control the diversity of butterfly community and are known for their value as an important ecological indicator group. The surveys should be carried out at different spots of the area selected and its vicinity by point and line transect method (Barhaum , *et al*, 1980 – 1981) for each and every month of the year. It should be repeated for three successive years for consistency in the data. The field notes, photography should be given priority for the entire growing season during the day light hours. The species should be noted along with the date, location of capture and any plant association. The other factors noted include the time of day using a twenty four hour clock and the weather conditions. At each location the same route of observations should be followed each time to reduce the number of variables presents (Pyle, 1984). Host specific plants should be recorded in each transect and identified through the preparation of herbarium.

The Taxonomic Study:

The butterflies are one of the important and most commonly seen insects of the order Lepidoptera. The order Lepidoptera is an economically important group of insects as their larvae exclusively feed on plants. This group is characterized by the high chromosome number and small size of chromosomes that make differentiation of the species difficult at the cytogenetic level (Sharma, *et al*, 2006). In India about 1,501 species of butterflies are present (Kehimkar, 2008). Some of the species are easy to identify and categorize, while many other species are still unidentified. Although many studies on morphological, ecological and molecular attributes of several species of butterflies from all over the world are available,

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very little is known about the Indian species (Klopfer and MacArthur, 1961). Morphological identification of butterflies is usually based on the wing patterns (Evans, 1932; Wynter-Blyth, 1957; Kunte, 2000). These factors make morphological criteria not a preferred way for a very accurate differentiation of these species. Various authors have identified butterfly's species by their morphology, but it's possible that some small invisible change in morphological characteristics may remain unnoticed. The molecular techniques provide an important tool that ease the assessment of genetic diversity and facilitate genotyping, classification, inventorying and phylogenetic studies (Breyne, *et al*, 1997). There are many molecular techniques available such as restriction fragment length polymorphism (RFLP), random amplified polymorphic DNA (RAPD) and arbitrary fragment length polymorphism (AFLP) etc. to characterize the butterflies at molecular level. RAPD marker is well suited for use in the large sample throughout systems required for population genetics and studies of biodiversity (Waugh and Powell, 1992). RAPD has been successfully applied to study the genetic structure of endangered populations (Zhou and Faktor, 2000) interspecific study (Tiple, et al, 2009) and gene flow between populations (Hoole, et al, 1999). Earlier RAPD was successfully applied for molecular The attempt has been made to use the latest nomenclature and common names as far as possible as per Evan (1932). The status of individual butterfly species in the locality was noted through the parameter, "Relative Abundance". This Relative Abundance or say status of individual species in locality was categorized within the forest reserve as "Very Rare" (VR) when recorded rarely; "Rare" (C) when recorded occasionally; "Uncommon" (UC) when recorded frequently; "Common" (C) when recorded regularly; "Very Common" (VC) when recorded regularly in large numbers.

Butterfly Monitoring Method:

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). 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).

Purpose of any study should not be to 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 facilitate 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.

Statistical Analysis:

Two main statistical methodologies were used in data analysis: descriptive statistics, which summarizes data from a sample using indexes such as the mean or standard deviation, and inferential statistics, which draws conclusions from data that are subject to random variation (e.g., observational errors, sampling variation). Descriptive statistics are most often concerned with two sets of properties of a *distribution* (sample or population): *central tendency* (or *location*) seeks to characterize the distribution's central or typical value, while *dispersion* (or *variability*) characterizes the extent to which members of the

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distribution depart from its center and each other. Inferences on mathematical statistics are made under the framework of probability theory, which deals with the analysis of random phenomena. A standard statistical procedure followed involves the test of the relationship between two statistical data sets, or a data set and a synthetic data drawn from idealized model. A hypothesis is proposed for the statistical relationship between the two data sets, and this is compared as an alternative to an idealized null hypothesis of no relationship between two data sets. Rejecting or disproving the null hypothesis is done using statistical tests that quantify the sense in total of which the null can be proven false, given the data that are used in the test. Working from a null hypothesis, two basic forms of error are recognized: Type I errors (null hypothesis is falsely rejected giving a "false positive") and Type II errors (null hypothesis fails to be rejected and an actual difference between populations is missed giving a "false negative"). Multiple problems have come to be associated with this framework: ranging from obtaining a sufficient sample size to specifying an adequate null hypothesis (Neyman, 1934).

Butterfly Diversity Indices:

A diversity index is a quantitative measure that reflects how many different types (such as species) there are in a dataset (a community), and simultaneously takes into account how evenly the basic entities (such as individuals) are distributed among those types. When diversity indices are used in ecology, the types of interest are usually species, but they can also be other categories, such as genera, families, functional types or haplotypes. The entities of interest are usually individual plants or animals, and the measure of abundance can be, for example, number of individuals, biomass or coverage. In demography, the entities of interest can be people, and the types of interest various demographic groups. In information science, the entities can be characters and the types the different letters of the alphabet. The most commonly used diversity indices are simple transformations of the effective number of types (also known as 'true diversity'), but each diversity index can also be interpreted in its own right as a measure corresponding to some real phenomenon (but a different one for each diversity index) (*Hill, 1973).*

Diversity Indices: Simpson's D and E

A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account. Consider two communities of 100 individuals each and composed of 10 different species. One community has 10 individuals of each species; the other has one individual of each of nine species, and 91 individuals of the tenth species. Which community is more diverse? Clearly the first one is, but both communities have the same species richness. By taking relative abundances into account, a diversity index depends not only on species richness but also on the evenness, or equitability, with which individuals are distributed among the different species.

Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. The variables used in the measurement of diversity include: D; S; Pi and E_D. The variable "D" is for Simpson's diversity index. The variable "S" is for total number of species in the community. The variable "Pi" is denoting the proportion of "S" made up of " i^{th} species". And the variable "E_D" is describing the equitability or evenness (*Hunter and Gaston, 988).*

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Methods of Calculation:

Simpson's diversity index (*D*) is a simple mathematical measure that characterizes species diversity in a community. The proportion of species *i* relative to the total number of species (p_i) is calculated and squared. The squared proportions for all the species are summed, and the reciprocal is taken:

$$D = \frac{1}{\sum_{i=1}^{s} p_i^2}$$

For a given richness (*S*), *D* increases as equitability increases, and for a given equitability *D* increases as richness increases. Equitability (E_D) can be calculated by taking Simpson's index (*D*) and expressing it as a proportion of the maximum value *D* could assume if individuals in the community were completely evenly distributed (D_{max}, which equals *S*-- as in a case where there was one individual per species). Equitability takes a value between 0 and 1, with 1 being complete evenness.

$$E_D = \frac{D}{D_{max}} = \frac{1}{\sum_{i=1}^{s} p_i^2} \times \frac{1}{S}$$

Siemann *et al*. (1997) collected the data on oak savanna arthropod communities to investigate the effects of prescribed burning on arthropods. The abundance data represent the number of individuals per family (rather than per species) collected in sweep-net sampling during a two year period (1992-1993) (from Siemann *et al*. 1997).

Although we do not have species data, we can calculate family diversity and equitability using these data. The proportions (p_i values) have been calculated by dividing the number of individuals in a given family by the total number of individuals collected in a year (8,561 in 1992 and 1,379 in 1993). To calculate Simpson's *D*, we square each proportion (p_i), sum these squared values, and take the reciprocal (divide one by the sum). For example, for the 1992 data, Simpson's *D* is calculated ($1 / [0.013^2 + 0.008^2 + 0.000^2 + 0.015^2 + ... + 0.007^2]$) = 8.732. We could then calculate the equitability (E_D) quite easily using the second equation above ($E_D = D / D_{max}$, with $D_{max} = S$). Here, one may use the number of families in place of *S*, so that E = 8.732 / 31 = 0.2817 (*Hunter and Gaston, 988).*

Interpretation of Results on Diversity Indices:

The method described above is going to help to calculate index of family diversity and evenness, rather than the standard index of species diversity and evenness. For example, if the value calculated for E_D is equal to 0.2817. It could describe the equitability, or evenness of individuals' distributions among families, in this community as relatively low (recall that E_D assumes a value between 0 and 1, and 1 is complete equitability).

Simpson's *D* is one of many diversity indices used by biologists. Others include the Shannon index (*H*), the Berger-Parker index (*d*), Hill's N_1, and Q-statistics. Each of these indices has strengths and weaknesses. An ideal index would discriminate clearly and accurately between samples, not be greatly affected by differences in sample size, and be relatively simple to calculate. Biologists often use a combination of several indices to take advantages of the strengths of each and develop a more complete understanding of community structure (*Hunter and Gaston, 988).*

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Conclusion

Butterfly monitoring methods should be designed for open habitats such as grasslands. Not all rare species occupy habitats that are easy to see across and navigate, in which cases a new approach to monitoring is necessary. It is better to use novel point transect distance sampling to monitor the Miami blue, a highly endangered butterfly that occupies dense shrub habitat. To monitor Miami blue density, the preliminary steps are the surveys consisting of butterfly counts in semi-circular plots. Then to observe the rate at which an observer detects new butterflies to determine the survey duration that meets the key assumption that butterflies are detected at their initial location. As a related secondary goal, shift for identification of the determinants of adult flight phenology to target monitoring efforts during periods of high adult abundance. The peak Miami blue densities is in in April and July/August. Peak daily density estimates ranged from 592 to 680 butterflies per hectare. Adult density was related to precipitation patterns, with high densities occurring 4–6 weeks after particularly wet 4-week intervals. For butterfly species that exist in high enough densities, it is recommend using point transect distance sampling in habitats where traditional methods are impossible to implement.

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References:

"Lepidoptera Love: Nabokov's Untold Story". library.mcz.harvard.edu. Retrieved 2017-12-18.

Singer MC, Wedlake. Capture does affect probability of recapture in butterfly species Ecological, 1981.

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.

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.

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.

Batuman, Elif (2016-03-23). "Vladimir Nabokov, Butterfly Illustrator". The New Yorker. ISSN 0028-792X. Retrieved 2017-12-18.

Batuman, Elif (2016-03-23). "Vladimir Nabokov, Butterfly Illustrator". The New Yorker. ISSN 0028-792X. Retrieved 2017-12-18.

Begon M. Investigating Animal Abundance, Edward Arnold, London, 1979.

Begon, M., J. L. Harper, and C. R. Townsend. 1996. Ecology: Individuals, Populations, and Communities, 3rd edition. Blackwell Science Ltd., Cambridge, MA.

Berger, Wolfgang H.; Parker, Frances L. (June 1970). "Diversity of Planktonic Foraminifera in Deep-Sea Sediments". Science. 168 (3937): 1345–1347. doi:10.1126/science.168.3937.1345. PMID 17731043.

Received:18 June 2018/Accepted:12 September 2018/Published:24 December 2018

Borges RM, Gowda V, acharias M. Butterfly pollination and high contrast visual signals in a low-density distylous plant, Oecology 2003; 136:571-573.

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.

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.

Chakravarthy AK, Rajagopal D, Jaganntha R. Insects as bio indicators of conservation in the tropics, Zoos' print Journal. 1997; 12:21-25.

Cowan, C.F. (1968). "Butterfly wing-prints". J. Soc. Biblphy nat. Hist. 4 (7): 368–369. doi:10.3366/jsbnh.1968.4.7.368.

Dennis RLH, Sparks TH, Hardy PB. Bias in butterfly distribution maps: the effects of sampling effort, J Insect Conserved. 1999; 3:33-42.

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.

Erhardt A. Diurnal Lepidoptera: Sensitive indicators of cultivated and abandoned grassland, Journal of Applied Ecology. 1985; 22:849-861.

European Commission. A sustainable Europe for a better world: a European Union strategy for sustainable development. 2001.

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.

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.

Gibbs, Jack P.; William T. Martin (1962). "Urbanization, technology and the division of labor". American Sociological Review. 27: 667–677. doi:10.2307/2089624. JSTOR 2089624.

Gunathilagaraj K, Permal TNA, Jayaramm K, Ganseh MK. Some South Indian butterflies. Resources communications, Pvt. Ltd, Bangalore. 1998.

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.

Harper, Douglas. "lepidoptera". The Online Etymology Dictionary. Retrieved 8 February 2011.

Herbert, Sandra (1999). "An 1830s View from Outside Switzerland: Charles Darwin on the "Beryl Blue" Glaciers of Tierra del Fuego". Eclogae Geologicae Helvetiae. pp. 92: 339–346. Retrieved 2008-12-22.

Herfindahl, O. C. (1950) Concentration in the U.S. Steel Industry. Unpublished doctoral dissertation, Columbia University.

Hill, M. O. (1973). "Diversity and evenness: a unifying notation and its consequences". Ecology. 54: 427–432. doi:10.2307/1934352.

Hirschman, A. O. (1945) National power and the structure of foreign trade. Berkeley.

http://www.tiem.utk.edu/~gross/bioed/bealsmodules/simpsonDI.html

Received:18 June 2018/Accepted:12 September 2018/Published:24 December 2018

Hunter, PR; Gaston, MA (1988). "Numerical index of the discriminatory ability of typing systems: an application of Simpson's index of diversity". J Clin Microbiol. 26 (11): 2465–2466. PMC 266921. PMID 3069867.

Hurlbert, S.H. (1971). "The nonconcept of species diversity: A critique and alternative parameters". Ecology. 52: 577–586. doi:10.2307/1934145.

Jost, L (2006). "Entropy and diversity". Oikos. 113: 363–375. doi:10.1111/j.2006.0030-1299.14714.x.

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.

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.

Kehimkar I. (2008). The Book of Indian Butterflies. Bombay Natural History Society, 2008, 497.

Kocher SD, Williams EH. The diversity and abundance of North American butterflies vary with habitat disturbances and geography, Journal of Biogeography, 2000.

Koh LP. Impacts of land use change on South-east Asian forest butterflies: a review, Journal of Applied Ecology. 2007; 44:703-713.

Kremen C. Assessing the indicator properties of species assemblages for natural area monitoring Ecological Applications 1992; 2:203-217.

Kremen C. Assessing the Indicator properties of species Assemblages for natural Areas Monitoring, 1992.

Kristensen, Niels P. (1999). "Historical Introduction". In Kristensen, Niels P. Lepidoptera, moths and butterflies: Evolution, Systematics and Biogeography. Volume 4, Part 35 of Handbuch der Zoologie:Eine Naturgeschichte der Stämme des Tierreiches. Arthropoda: Insecta. Walter de Gruyter. p. 1. ISBN 978-3-11-015704-8. Retrieved 30 November 2010.

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.

Kunte K. India –life scape, Butterflies of peninsular India, University Press, New Delhi. 2000, 254.

Magurran, A. E. 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton, NJ.

Mallon, D.P.; Kingswood, S.C.; East, R.D. (2001). Antelopes: Global Survey and Regional Action Plans. Gland, Switzerland: IUCN. p. 185. ISBN 9782831705941.

May PG. Flower selection and the dynamics of lipid reserves in two nectarivorous butterflies Eco 1992, 73(6): 2181-2191.

Monaghan Country Council, Tidy Towns, Biodiversity Training Initiative, Ballybay Wetlands Centre, Session 1- Biodiversity and Habitats, 2010, 24.

New TR. Launching and Steering flagship Lepidoptera for conservation benefit, Journal of Threatened Taxa. 2011; 3(6):1805-1817.

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.

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.

Received:18 June 2018/Accepted:12 September 2018/Published:24 December 2018

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.

Pollard E. A method for assessing changes in the abundance of butterflies, Biological Conservation 1977; 12:115-134.

Pollard E. Monitoring butterfly for Conservation and Ecology, Goldsmith F.B (Ed.) Chapmand and Hall London, 1991, 275.

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.

Pollard E. Temperature, rainfall and butterfly numbers, Journal of Applied Ecology. 1998; 25:819-828.

Prater, S. H. (1971). The Book of Indian Animals. Oxford University Press, 2005 reprint.

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.

Robbins RK, Opler PA. Understanding and protecting our biological resources Joseph Henry Press, Washington DC, 1997.

Rosenzweig, M. L. 1995. Species Diversity in Space and Time. Cambridge University Press, New York, NY.

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.

Royer R, Jane A, Newton, Wesley. Checklist and Pollard walk Butterfly Survey Methods on public Lands, Am Mid I Nat 1998; 140:358-371.

Shannon, C. E. (1948) A mathematical theory of communication. The Bell System Technical Journal, 27, 379–423 and 623–656.

Siemann, E., J. Haarstad, and D. Tilman. 1997. Short-term and long-term effects of burning on oak savanna arthropods. American Midland Naturalist 137:349-361.

Simpson, E. H. (1949). "Measurement of diversity". Nature. 163: 688. doi:10.1038/163688a0.

Spitzer L, Benes J. Dazech Carpathians, Ecol Indic 2009; 9:1053-1056.

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.

Swaay V, Breton CAM, Kirkland T, Warren MS. Manual for Butterfly Monitoring, Report VS2012.010, De Vilnderstichting/Dutch Butterfly Conservation, Butterfly Conservation UK and Butterfly Conservation Europe, Wageningen, 2012.

The butterfly transects method – Jacqueline Loos, Leuphana University Lunenburg.

Thomas CD, Cameron A, Green RE et al., Extinction risk from climate change, Nature 2004; 427:145-148.

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.

Tuomisto, H (2010). "A consistent terminology for quantifying species diversity? Yes, it does exist". Oecologia. 4: 853–860. doi:10.1007/s00442-010-1812-0.

Received:18 June 2018/Accepted:12 September 2018/Published:24 December 2018

Tuomisto, H (2010). "A diversity of beta diversities: straightening up a concept gone awry. Part 1. Defining beta diversity as a function of alpha and gamma diversity". Ecography. 33: 2–22. doi:10.1111/j.1600-0587.2009.05880.x.

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

Web link: http://en.wikipedia.org/wiki/Butterfly-cont, Accessed on 15/3.2017, at 9.36 AM.

Web link: http://en.wiktionary.org/wiki/transect, accessed on 3/11/2017, at 4.41PM.

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.

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.

Received:18 June 2018/Accepted:12 September 2018/Published:24 December 2018