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Biodiversity indices of noctuid moths in various conifer forests of Himachal Pradesh

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Abstract

Lepidoptera is probably one of the most suitable groups for most quantitative comparisons especially their abundance and species richness. Moths were found to be a potentially useful indicator of biodiversity. The main objective of the study was to assess biodiversity health of conifer forests by using moths as indicator species. Quantitative estimates of species diversity, evenness and richness in different locations were made. Noctuid moths were collected from different parts of Himachal Pradesh during 2012-2014. A total number of 1348 noctuid moth specimens were collected by using light traps. During the study, a total of 103 species were collected from five different conifer forest spread over 10 localities of Himachal Pradesh. Regarding different forests it was found that maximum species diversity was found in year 2014 (3.22), followed by 2013 (2.97) and finally 2012 (2.80); maximum species evenness was found in the year 2014 (2.12), followed by year 2012 (2.08) and finally 2013 (1.99); maximum species richness was found in year 2014 (16.25), followed by 2013 (15.37) and finally 2012 (13.9). Regarding different localities, it was found that year 2014 showed maximum values with Species diversity: 2.65; Species evenness: 2.11; Species richness: 10.24 followed by year 2013 with Species diversity: 2.54; Species evenness: 2.08; Species richness: 8.72 and then 2012 with Species diversity: 2.03; Species evenness: 1.69; Species richness: 8.26. The rich abundance in Chirpine forest was due to diversified fruit crop ecosystem. In this experimental finding conclude that species found in Chirpine forest predict immediate protective measures to conserve forest ecosystem.

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Introduction

Insects are predominant biota on all continents and there is hardly any place on the earth, which is not invaded by these creatures. They are believed to have appeared on this planet in the Devonian period, some 200 million years ago and since then survived the glacial periods and evolved into myriad forms. They are essentially terrestrial and are distributed through the permafrost line of the Arctic to the ice cap of the Antarctica, and through the mountain tops to the depths of caverns. They form the largest group among animals and plants in the world. It is commonly believed that 75-80 percent of the total animal species on this planet are insects (Kapoor, 1985; Ehrlich and Wilson, 1991; Varshney, 1998).

Lepidoptera are important herbivores, pollinators, and serve as food and hosts for multiple other organisms at higher trophic levels (Summerville and Crist, 2004; Summerville *et al*., 2004). Lepidoptera is probably one of the most suitable groups for most quantitative comparisons between insect faunas to be valid, for the many reasons elaborated (Holloway 1984, & 1985), especially their abundance, species richness, response to vegetation and climate, their ease of sampling using light traps and relatively advanced taxonomy.

The term biodiversity is commonly used to describe the number, variety and variability of living organisms. In general, biodiversity is defined in terms of genes, species and ecosystems, corresponding to three fundamental and hierarchically related levels of biological organization (Melchias, 2001). Biological diversity is the basis of adaptation and evolution and is basic to all ecological processes. It contributes to research and education, cultural heritage, recreation and tourism, the development of new and existing plant and animal domesticates, and the supply of harvested resources. The intrinsic importance of biological diversity lies in the uniqueness of all forms of life: each individual is different, as is each population, each species, and each association of species (Anonymous, 1988).

One characteristic attribute to multi-species populations is diversity, also probably one of the most misused and incorrectly calculated attributes. Perhaps the commonest misconception is that species richness and diversity are synonymous. Although related, they are distinct. Species richness is the total numbers of species present in a given area or sample whereas diversity takes into account how individuals are distributed amongst those species, i.e., the species frequency distribution. In fact, it turns out that nearly all quantitative measures of diversity are some combination of two components, species richness and evenness, where evenness describes how equally individuals are distributed amongst the specie. Being a megadiversity nation, the exploration of varied moth diversity is a need of the hour. The fundamental and applied importance of the Heterocera (moths) warrants all this in a systematic way. The main objective of this research study was to collect, identify and calculate diversity, species richness and evenness of noctuid moth fauna of Himachal region.

Materials and methods

Various localities in Himachal Pradesh located at different altitude were surveyed during each year for the collection of Noctuid fauna. Forest Rest Houses of all localities were chosen as an ideal site for setting up of temporary laboratory to execute the entire field work of setting light lure system, collection stretching, drying, labeling and storage of specimens.

Himachal Pradesh is a hilly and mountainous state situated between 30°22’ and 33°12’ North latitude and 75°47’ to79°04’ East longitude in the lap of the North West Himalayas. The diversity of altitude and climate has given Himachal Pradesh a rich variety of flora. Covering nearly two-third of the total area of the state, forests form an important source of income, providing raw material for industries, fodder and nutritious grasses and reservoirs to meet the need of agriculturists and other people (Balokhra, 2002).

The moths belonging to the family Noctuidae are the main objective of the present taxonomical research.

These have mainly been collected either from the fluorescent tubes or by using a portable light trap (fitted with mercury vapour lamp, 120 W) specially designed by Common, 1959. The moths were collected through attracting them to a white sheet hung vertically or a white wall illuminated by 125 W mercury vapor lamp suspended one meter from the surface. The moth's specimens were then collected individually into corked glass tubes. The moths were immediately killed after their collection with ethyl acetate vapors in insect killing bottles of various sizes, depending upon the size of moth or were given freezing treatment.

Quantitative measurements of biodiversity

Quantitative estimates of species diversity, evenness and richness in different locations were made using the data derived from the field surveys.

Measurement of diversity

The type of diversity used here is E- diversity which is the diversity of species within a community or habitat. The diversity index was calculated by using the Shannon – Wiener diversity index , 1949

$$_{*}H = \sum Pi \ln Pi$$

where Pi = S / N

S = number of individuals of one species

N = total number of all individuals in the sample

In = logarithm to base.

Measurement of species richness

Margalef's index was used as a simple measure of species richness (Margalef, 1958).This was calculated to know how the diversity of the population distributed or organized among the particular species.

$$_{*}Ma = S - 1/\ln N$$

S = total number of species

N = total number of individuals in the sample

In = natural logarithm.

Measurement of evenness

For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1966).To know the measure of how similar the abundance of different species, species evenness was calculated to estimate the equitability component of diversity

$$_{*}e = H/\ln S$$

H = Shannon – Wiener diversity index

S = total number of species in the sample.

The biodiversity (diversity index, species richness and evenness) of noctuid moth fauna in Himachal Pradesh is mainly due to the rich vegetation in this area as vegetation plays an important role for the existence of insect fauna in a community as it provides the main source of food etc. for insects.

Results and discussion

During the present study, a total of 103 species were collected from five different conifer forest spread over 10 localities of Himachal Pradesh. Regarding different forests, maximum diversity index was in Chirpine forests, for the consecutive three years. The minimum diversity index was shown for Silverfir in 2012, and Kail forests in year 2013 and 2014. Maximum species richness was in Chirpine forests for the year 2012, 2013 and 2014 and minimum species richness was shown in Silverfir forests in year 2012 and Kail forests during the year 2013 and 2014. Silver Fir forests showing maximum species evenness for the year 2012 and 2014; in 2013 maximum species evenness was shown in Deodar forests. In the year 2012 and 2013, Chilgoza forests showed minimum species evenness; in 2014, Kail forests showed minimum species evenness. By calculating mean of all the forests it was found that maximum species diversity was found in year 2014 (3.22), followed by 2013 (2.97) and finally 2012 (2.80); maximum species eveness was found in the year 2014 (2.12), followed by year 2012 (2.08) and finally 2013 (1.99); maximum species richness was found in year 2014 (16.25), followed by 2013 (15.37) and finally 2012 (13.9). Regarding different localities, maximum diversity index was in Sairightat in 2012 and 2014, Malan in 2013. The minimum diversity index was shown Shimla (Deodar) in 2012, and Theog in 2013 and Janjehli in 2014. Maximum species richness was in Sairighat region for the year 2012,

2013 and 2014 and minimum species richness was in Shimla (Deodar) region in 2012, Shimla (Kail) region in 2013 and Narkanda region in 2014. In Narkanda (Silver Fir forests) showing maximum species evenness for the year 2012 and 2013; in 2014 maximum species evenness was shown in Sairighat region (Chirpine forests). In the year 2012, Akpa (Chilgoza forests); in 2013 Theog (Kail forests) and in 2014, Janjehli (Deodar forests) showed minimum species evenness. By calculating mean of all the localities it was found that year 2014 showed maximum values with Species diversity: 2.65; Species evenness: 2.11; Species richness: 10.24 followed by year 2013 with Species diversity: 2.54; Species evenness: 2.08; Species richness: 8.72 and then 2012 with Species diversity: 2.03; Species evenness: 1.69; Species richness: 8.26.

Table 1. Quantitative estimates of different conifer forests of Himachal Pradesh.

Forests	2012			2013			2014		
Forests	Species diversity (H)	Species evenness (e)	Species richness (Ma)	Species diversity (H)	Species evenness (e)	Species richness (Ma)	Species diversity (H)	Species evenness (e)	Species richness (Ma)
Chilgoza	2.6143	2.009	12.30	2.854	1.9	15.56	3.27	2.16	16.9
Chirpine	3.525	2.07	23.22	3.48	2.07	20.8	3.69	2.15	22.7
Deodar	2.813	2.03	13	3.234	2.13	16.1	3.254	2.10	16.79
Kail	2.756	2.02	12.1	2.528	1.91	10.07	2.878	2.06	12
Silverfir	2.3	2.3	9	2.78	1.96	14.36	3.042	2.17	12.9

2012 Species diversity: 2.80; Species evenness= 2.08; Species richness: 13.9

2013 Species diversity: 2.97; Species evenness= 1.99; Species richness: 15.37

2014 Species diversity: 3.22; Species evenness= 2.12; Species richness: 16.25.

The rich abundance in Chirpine forest may be due to diversified fruit crop ecosystem (Table I and II). Humpheries *et al.*, 1996 substantiated that species richness and evenness are that most popular approach to evaluate species diversity in locality and to compare habitats on species assemblages with other locality. This relative measure of diversity is used for comparisons among different localities under same sample size to evaluate its heterogeneity (Magurran, 1988). Aslam, 2009 described diversity, species richness and evenness of Moths fauna from different parts of Peshawar. Families Noctuidae, Pyralidae, Arctiidae, Geometridae, Sphingidae and Lymantriidae were represented in collection samples. The diversity index, species richness and evenness of moth fauna in Peshawar were 3.14, 5.26 and 0.87, respectively. Emergence phenology has been shown to advance considerably in the past decades in many lepidopterans, studies have recently detected that the annual number of generations of night-active moths has changed over the last decades (Altermatt, 2010 a, Kocsis and Hufnagel, 2011). Global warming is assumed to be one of the most probable drivers of the increasing number of generations presumably by allowing more time for activity (Altermatt, 2010 b). Nocturnal moths have also been found to respond strongly to global warming by advancing spring flight periods but an immense number of species respond in a varied way to climatic changes in this taxa. European noctuid moths constitute a representative taxonomic group for studying the effects of climatic trends on insect phenology, as they represent one of the most species-rich insect families subdivided into a large number of subfamilies and tribes characterised by a high diversity of life history, possibly related to the observed variation in climatic responsiveness (Karsholt and Razowski, 1996).

Mean global temperatures have risen this century, and further warming is predicted to continue for the next 50–100 years. Some migratory species can respond rapidly to yearly climate variation by altering the timing or destination of migration, but most wildlife is sedentary and so is incapable of such a

rapid response. For these species, responses to the warming trend should be slower, reflected in poleward shifts of the range. Such changes in distribution would occur at the level of the population, stemming not from changes in the pattern of individuals' movements, but from changes in the ratios of extinctions to colonization's at the northern and southern boundaries of the range (Parmesan *et al*., 1999). The work was an attempt to describe some aspects of biodiversity of moth fauna of conifer forests of Himachal Pradesh. Ultimately it is hoped that such work may lead to the development of standard monitoring procedures assessing the value of environmental stability of areas under cultivation for different crops and the prediction and effect on the structure of moth population of conifer forest destruction.

Table 2. Quantitative estimates of different localities with conifer forests of Himachal Pradesh.

LOCALITIES	2012			2013			2014		
Localities with forests	Species diversity (H)	Species evenness (e)	Species richness (Ma)	Species diversity (H)	Species evenness (e)	Species richness (Ma)	Species diversity (H)	Species evenness (e)	Species richness (Ma)
Akpa (Chilgoza)	2.6	2	12.33	2.799	2.22	10.61	2.983	2.16	13.68
Bharmour(Chilgoza)	--------	--------	--------	2.167	1.94	8.48	2.402	2.22	7.069
Malan (Chirpine)	2.887	2.15	12.8	3.056	2.19	13.2	3.246	2.22	14.28
Sairighat (Chirpine)	3.231	2.12	16.75	3.01	2.09	13.77	3.68	2.5	15.1
Janjehli (Deodar)	2.688	2.18	9.9	2.54	2.10	9.47	1.732	1.4	8.87
Shimla (Deodar)	2.084	2.00	7.09	2.529	1.91	10.77	2.807	2.12	11.1
Theog (Kail)	2.318	2.08	7.40	2.136	1.9	6.62	2.34	2	8.04
Shimla (Kail)	2.211	2.12	7.34	2.177	2.01	6.57	2.563	2.23	8.24
Manali (Silverfir)	--------	--------	--------	2.666	2.21	10.15	2.717	2.20	9.62
Narkanda (Silverfir)	2.30	2.30	9	2.34	2.25	7.35	2.086	2.08	6.47

2012 Species diversity: 2.03; Species evenness= 1.69; Species richness: 8.26

2013 Species diversity: 2.54; Species evenness= 2.08; Species richness: 8.72

2014 Species diversity: 2.65; Species evenness= 2.11; Species richness: 10.24.

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