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Insect diversity in wet and dry seasons at hursa forest, central Ethiopia

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Abstract
Insect fauna are found almost everywhere. Yet, their abundance and diversity in some terrestrial ecosystem is still undisclosed. The diversity of insects on dry and wet seasons was conducted at Hursa Forest in Gindeberet District, Central Ethiopia during 2018. This study aimed to know the diversity of insects at Hursa Forest at different habitat and seasons. Insect diversities at Hursa forest were studied from three habitat types. The diversity of insects were investigated using transect walk method and quadrants. From a total of 572 insects collected, 14 families and five orders of insects were recorded. In both seasons, more evenness and diversity of insects were observed in the natural forest habitat (56.95%). On the other hand, the least evenness and diversity of insects were observed in artificial forest habitat (15.46%). The highest species richness (31) as well as abundant of insects (476) were recorded in wet season whereas less species richness (20) and abundance (96) were recorded in dry season. The highest Shannon wiener diversity index (H= 0.27) and Margalef's index (D= 3.08) was recorded during wet season. The highest similarity among habitats in both wet and dry season was observed in the natural forest and artificial forest habitats. Further, control action plan should be taken to stabilize disturbed habitats especially in the artificial forest study area.

Keywords: abundance, diversity, hursa forest, insect

Introduction

Insects belong to the class insecta and phylum arthropoda. The members of the phylum are characterized by a segmented body that are bearing varying members of paired, segmented appendages, bilateral symmetry, an exoskeleton that contain the nitrogenous polysaccharides, chitin that may be locally hardened and is periodically shed. They have various internal features such as an open circulatory system, malpigian tubules and the tracheal system (Gillott, 2005). Insects are highly specialized groups of invertebrates (Nayar *et al*., 1992) [14].

Insects are the earth's most abundant organisms. About half of the described species of living things are insects (Daly *et al.,* 1998) [3].They are the dominant group of all animals on the earth to day. There are millions of kinds of insects, though we do not know exactly (or even approximately) how many there are. Some estimates imply that the species richness of insects is so great that, to near approximation, all organisms can be considered to be insect (Gullan and Cranston, 2000) [9]. Insects now inhibit virtually all land surface of the globe except the extreme Polar Regions and the highest mountain peaks. Wherever they occur they tend to dominate the small fauna, being rivaled only by other group of arthropods, the mites, in some habitats. In body size most insects are one to ten mm in length. Some tiny insects are smaller than some protozoa, and some giant insects are larger than the smallest mammals (Daly *et al.,* 1998) [3].

Insect dominance applies to terrestrial and fresh water ecosystems (Gullan and Cranston, 2000) [9]. The rate of manner of insect development or growth may depend up on a number of biotic and abiotic factors (Emana Getu, 2007) [8]. These include the availability, quality and quantity of suitable food is a primary one, but other factors such as light, access to undisturbed areas and proximity to their insects of the same species are also useful. Fundamental to insect growth, however are environmental factors of temperature, relative humidity and moisture content of food materials (Emana Getu, 2007; Child, 2007) [8, 2].

Insects due to their small size, diversity and sensitivity to environmental stress have been considered as good indicators of habitat heterogeneity, ecosystem diversity and environmental stress (Stefanscu *et al*., 2003; Rothery and Roy, 2001) [24, 19].

Basic aspect of insects in the Hursa Forest such as species richness, diversity and habitat association were studied with regard to harmful or beneficial nature of insects within the forest and their conservation purpose. Insect diversity at Hursa forest is affected by natural and directly or indirectly by human activities. The other problem that rose in an insect diversity was the improper use of land management for different activities such as farming and grazing. Hence, the results of this study are expected to provide baseline data for future study and monitoring of insect diversity changes in these habitats.

Material and Methods

Description of the Study Area

The study was conducted at Hursa forest Gindeberet District, Central Ethiopia during 2018. It's located at 37°30' E longitudes, 11°30' N latitude. The mean annual minimum and maximum temperature is 16 ^{0}C and 25 ^{0}C respectively. The annual average rain fall is 1000-1400mm per year. The long rainy season starts from July and extends to September, but an expected shower may occur in all months of the year. The major plant species that grow in the forest were

Eucalyptus (*Eucalyptus globouls*), Podacarpus (*Podacarpus sp*), Yellow wood (*Podacarpus falcatus*), Juniper (*Juniper procera*), Olea tree (*Olea europea*), large cordeal (*Cordia africana*), Koa (*Acacia koa*), Winged bersama (*Bersama Abyssinia*), Red stick wood (*Pronus africana*), False-currant (*Allopyllus abessinicus*), Endod (*Pytholica dodicandra*). Hursa forest is mostly covered by *Juniper procera* (Gindeberet District Agricultural Office, 2010).

Study Design

Sampling sites from Hursa forest were systematically selected (Tayyab *et al.*, 2006) [28]. The study area was divided into different sections based on the transect line. These techniques involved dividing the study site in to different habitat (Tamrat Aydagnhum, 2007; Tayyab *et al*., 2006; Tanaka 1982) [26, 28, 27]. The study area was divided into five transects, starting at the edge of the Dilallaha River from the West of forest to the East. The distance between two successive transects and plots were 250 m and 150 m respectively. The number of quadrats were 30 (5m by 5m) which cover a total area of 0.3 hectares. The quadrats are laid on different habitats, as natural forest, artificial forest and grassland. Ten quadrats were laid on each habitat type and insect collection was done on each habitats.

Data Collection Methods and Analysis

The diversity and abundance of insect at Hursa forest were investigated on systematically selected sampling units of each habitat type in the study area. Data was collected and recorded through a series of field works. Samples of insects were collected by sweeping net. The collected insects were put in a jar which contains Chloroform in it. After the jars were packed, the collected data was transported to Ambo University for identification. The insects were identified into order and family level by using identification key. Besides journal, drawing of insects; specimens of insects in Ambo University were used as a means of identification tools.

The simplest measure of insect diversity is used to identify the number of species present (species richness).The Shannon-weaver index (H ’) is the most commonly used measure for diversity and it is defined as H’ = - (pi) (lnpi), where pi is the proportion of i^{th} species in the total sample (pi= ni/N). A species with higher value of H’ is more diverse than species with lower value of H’.

Evenness (j), can be estimated by using the formula J=H/Hmax= lnS, where S is the number of families present. Evenness from calculation would be larger for large J value. This Means insect with larger J value has more even distribution (Price, 1976; Smith, 1992).

Simpson index (D) was used to determine diversity information of species present on the sites. The Simpson’s index is a measure of diversity, which takes into account both species richness, and an evenness of abundance among the species present. In essence it measures the probability that two individuals randomly selected from an area will belong to the same species (Simpson, 1949), the index is given by the formula.

$$D=\sum\frac{ni(ni-1)}{N(N-1)}$$

Where, ni is the total number of organisms of individual species; and N is the total number of organisms of all species. $(Pi)^2$ = (Pi) (Pi), D was Simpsons’ index of diversity; Pi was proportions of families in the sample (community).

Insect order richness was calculated by Margalef’s richness index (MRI). Larger number indicates high diversity. MRI= S-1/lnS, where S was the total number of insects of a particular order and N was the total number of insects of all individual. Family abundance (the ratio between total numbers of individuals of a family in all study plots and total number of sampling units in which the family observed), Frequency (the ratio of quad-rats of occurrence and total number of quad-rats studied). Families having a high frequency value are a widely distributed family through the study area.

It is closely related to abundance, but more important in estimating of the number of families. The similarity of insects in different habitats was determined by: Jacquard’s index (Cj) = j / (a+b-j) Where, j = the number of families found in both sites a = the number of families in site A b = the number of families in site B. The Jacquard’s Index is equal to zero for two sites that are completely dissimilar. One indicates that two sites are completely similar.

Results

Comparison of Insects per Seasons and Habitats

A total of 572 insects were collected in which wet season was more populated season with mean number of 83.22% than the dry season 16.78% (Figure 1). In terms of habitat, Natural forest habitat is the most susceptible host for insects with mean number of 64.34% insects; followed by grassland and artificial forest habitats with mean of 23.78% and 11.89% insects respectively (Figure 2). So, insect population differs in all habitats. This might be due to differences in the production of leaves and shoot.

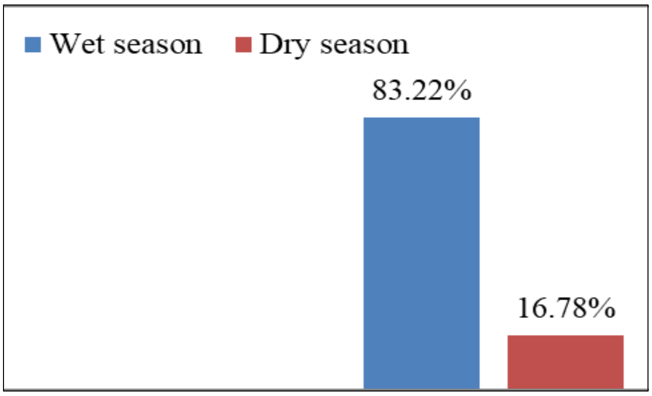

Fig 1: Number of insects per season at Hursa Forest, 2018

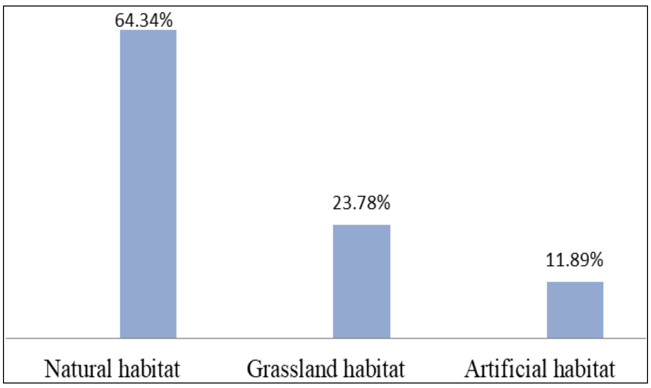

Fig 2: Number of insects per Habitats at Hursa Forest, 2018

Insect Composition at Hursa Forest

From a total of 572 insects collected, 5 orders and 14 families were identified at Hursa Forest. Insects in the Order Hymnoptera were the most dominant (32.17%)) followed by order Diptera which contain (27.97%), order Lepidoptera (22.38%), order Odonata (13.29%), and the lowest one was order Coleoptera which accounts for (4.2%) (Table1).

Table 1: Order of Insects at Hursa Forest, 2018

Order of Insects	Number of Insects	Percent (%)
Coleoptera	24	4.20
Hymnoptera	184	32.17
Diptera	160	27.97
Lepidoptera	128	22.38
Odonata	76	13.29
Total	572	100

Among the 14 insect families, family Formicidae is the most abundance frequently occurring and distributed family which accounted14.69%, followed by family Gracillariidae (12.59%), and family Oestridae (11.19%). The other abundant families were family Sesiidae (9.79%), Coenagriondae (9.79), family Bombidae (9.09%), family Muscidae (7.69%), family Tephritidae (6.23%), Cephidae (4.9%), family Aeshnidae (3.5%), Chalcidae (3.5%) family Endomychidae (2.8%), and family Sciomyzidae (2.8%). Family Scotytidae had the least value of frequency (1.4%) in the study area (Table 2).

Table 2: Frequency of Insects in terms of family level at Hursa Forest, 2018

Order of insects	Families of insects	Frequency	Percent (%)
Coleoptera	Endomychidae	16	2.8
	Scotytidae	8	1.4
Diptera	Muscidae	44	7.69
	Oestridae	64	11.19
	Sciomyzidae	16	2.8
	Tephritidae	36	6.29
Hymnoptera	Bombidae	52	9.09
	Cephidae	28	4.9
	Chalcidae	20	3.5
	Formicidae	84	14.69
Lepidoptera	Gracillariidae	72	12.59
	Sesiidae	56	9.79
Odonata	Aeshnidae	20	3.5
	Coenagriondae	56	9.79

Abundance and Diversity of Insects at Different Habitats

The highest abundance of insects in Hursa forest was observed in the natural forest in both wet and dry seasons with a value of 68.08% and 45.83% respectively. The second and the third more abundance of insects were found at grassland habitat and artificial forest habitats of the forest respectively. Artificial forest habitat holds the least diversity in both seasons of Hursa forest with an average (15.46%). From all recorded individuals in the three different habitats: the natural forest area had the highest number of individuals, which is 368 followed by grassland with 136, and artificial forest had 68. Therefore, maximum abundance within the habitats was recorded in natural forest followed by grassland and artificial forest (Table 3).

The highest homogeneity or pattern of distribution of species in relation to other species in a sampled per unit area were observed in wet season at natural forest habitat. The least homogeneity or pattern of distribution of species was found in dry season at artificial habitat. Totally, the most even distribution of insects in the two seasons was that of the natural forest habitat. Simpsons diversity index (D) showed that the presence of highest diversity of insects at natural forest habitat in wet season (0.54) and least diversity at artificial forest habitat in dry season (0.96) (Table 3).

Table 3: Insect diversity in different habitats and seasons at Hursa Forest, 2018

Season	Habitat	Number of individual	Percent (%)	H’	H’/max	D
Wet	Natural forest	324	68.08	0.27	0.39	0.54
	Artificial forest	48	10.08	0.23	2.84	0.99
	Grassland	104	21.85	0.33	3.26	0.95
Dry season	Natural forest	44	45.83	0.36	2.4	0.79
	Artificial forest	20	20.83	0.33	1.61	0.96
	Grassland	32	33.33	0.37	2.08	0.89

Diversity of Insects in Wet and Dry Seasons

The highest species richness (31) as well as abundant of insects (476) were recorded in wet season whereas less species richness (20) and abundance (96) were recorded in dry season.

The highest Shannon wiener diversity index (H= 0.27) and Margalef’s index (D= 3.08) was recorded during wet season compared to dry season (Table 4).

Table 4: Comparison of insect diversity during wet and dry seasons at Hursa Forest, 2018

Season	Species richness	Abundance	H’	MRI	Evenness	Simpson’s index
Wet season	31	476	0.27	3.08	0.34	0.06
Dry season	20	96	0.24	2.79	0.31	0.04

Insects’ Similarity between Habitats at Hursa Forest

The highest similarity among habitats in both wet and dry season was observed in the natural forest and artificial forest habitats; whereas the least similarity in both seasons was recorded between the grassland and artificial forest habitat (Table 5). When considering both dry and wet season, the highest similarity was recorded in the natural and artificial habitats. The similarity might be due to the artificial forests are closely found nearby the natural forest and have similar topography (Table 5).

Table 5: Jaccard`s Index of similarity at Hursa Forest, 2018

Habitat	Season		
	Wet season	Dry season	Both season
Natural and Grassland	0.50	0.15	0.38
Natural and Artificial	0.68	0.26	0.51
Grassland and Artificial	0.30	0.12	0.27

Discussions

Fluctuations of insect diversity, abundance and evenness were observed in all habitats of Hursa forest which can be due to the presence or absence of stability and availability of larval food, the effect of environmental factors and the quantity and quality of food. This result is in lined with different researchers. For instance, according to Emana Getu (2007) [8], the rate of manner of insect's developments or growth may depend up on a number of biotic and abiotic factors. These include, the type and amount of food, the amount of moisture, temperature, or the presence of environmental signals (Anu and Sabu, 2007; Gullan and Cranston, 2000) [1, 9]. According to Larsson and Ohmart (1988) [13], studies have shown that leaf-eating insects are restricted in their feeding to a class of leaves. The young leaves are tender and relatively nutritious, but as the leaves age, they become tougher and less nutritious. These older leaves are barriers to chewing insects, but not to sucking insects, whose styles pass directly into the phloem or xylem (Richard *et al*., 2004) [18].

Herbivorous insects that can utilize only part of their host plants are particularly vulnerable to fluctuation in the abundance of their resource (Larsson and Ohmart, 1988) [13]. According to Denliger (1980) [5], seasonality is conspicuous in the life history of many organisms. The major seasonal fluctuations occur in the insect fauna near the Equator in East Africa. Marked seasonal breeding also occurs in many species of insects in tropical Africa (Dingle and Khamala, 1970) [6]. According to Dingle and Khamala (1970) [6], the seasonal breeding and biomass of insects increase dramatically during the long rains. So, insect abundance is closely limited with rain fall and it provides a direct seasonal cue for mating and reproducing insects in Africa.

Droughts were causes for malnutrition and mortality for insect species. Distinct seasonal peaks of abundance were observed among most insect families. However, the time of peak activity differed among the various insect families, thus implying that one particular season is not universally unsatisfactory for all major insect groups. The conspicuous absence of selected insect groups at certain times of the year suggests that many tropical insects have developed strategies for escape during particular seasons (Denlinger, 1980) [5]. These are dormancy occurs in summer (aestivation) or in winter (hibernation), and may involve either quiescence or diapauses (Wickman *et al*., 1983) [31].

The seasonal changes in abundance and diversity at Hursa forest are similar to results from other studies conducted in the tropics where wet and dry seasons alternate. According to Tanaka (1982) [27], each of the major arthropod groups was most abundance during the wet season and least abundant during the dry season. Several study of tropical insect seasonality have suggested as wet-season increases in insect number are primarily caused by increased precipitation. Comparable fluctuations in abundance of tropical insect within seasons have also been found in studies where samples were regularly taken throughout the wet and dry seasons. The arthropod abundance for each collecting site was significantly correlated with rain fall patterns. There is evidence that rainfall can directly influence arthropod abundance through physiological effect on reproduction, development, or activity. For example rainfall is necessary for initiation of breeding in Diptera, such as sand flies and mosquitoes and the emergence of the adult dung beetle is initiated by rainfall. Rainfall may indirectly affect insect populations by its effect on food availability (Tanaka, 1982) [27]. Janzen (1983) [12] suggested that, the peak abundance of dung beetles were observed during the first half of rainy season.

The diversity, abundance and evenness of insects were decreased slowly in all habitats in the dry season. The reason for the decrement might be man-made activities in these habitats. The grasses under the newly planted seedlings were cleared which highly minimized the diversity of phytophagous insects. This idea was well-supported by Tamrat Aydagnhum (2007) [26]. Leaf production seems to be strongly related with rain fall. Wolda (1978) [30] showed that, major leaf flush occurs at the beginning of the rainy season and very little production during the latter part of rainy season and during the dry season. Old leaves fall mainly during the dry season. During dry season, old leaves often have toxin, are tough, and the best defense of all, have low contents of usable nutrient. So, it is not suitable to insect survival, growth and development. Tanaka and Tanaka (1982) [27] showed that, in areas with a severe dry season, insect and spider number are lowest during the dry season while peak densities occur in early to mid-wet season. An insect that live in dry environment and eat nutritionally deficient food requires longer time to maturing and the adult life of insects is devoted to mating and reproduction. Wickman *et al*., (1983) [31] stated that, insects survived annual periods of winter cold, drought, summer heat, or food shortage by entering a state of dormancy. As in other small terrestrial organisms, the surface area of insect's body is relatively large, so the risk of desiccation is always great in warm and dry seasons.

In both seasons of Hursa forest, artificial forest habitat was evident to have the least diversity of insects. Artificial forest of the study area was highly exposed to fuel wood collection which affected insect diversity. But, the local people collected fuel wood in the form of shed leaves from the ground which had minimal effect on flying insects (Tamrat Aydagnhum, 2007) [26]. Insect prefer undisturbed, stable habitats. Quality and distribution of food are also crucial factors. All the artificial forest habitats were entirely dominated by *Eucalyptus globulus* species. So, these plants might suppress the growth and development of insects.

The low similarity recorded between habitats can be due to habitat specificity for food plants. In addition, habitat fragmentation, ecosystem loss and separation account for the low species similarity and are noticed as the main causes of the current biodiversity problems (Sih *et al*., 2000) [21]. Debinski and Holt (2000) [4] also observed that habitat fragmentation reduces area, changes ecological processes and reduces connectivity.

Conclusion and Recommendations

The presence of 14 families and 5 orders in Hursa forest showed the importance of the area as good habitats for insects. Out of the total insect families, Formicidae and Gracillariidae had the highest frequency, whereas Scotytidae, Sciomyzidae and Endomychidae had the least frequency. The highest diversity and evenness of insects were found in natural forest habitat. This was due to less exposure of the natural habitats to humans and animals' activity and hence availability of food. On the other hand, less diversity and evenness of insects was observed in artificial forest habitat due to intensive interference of both human and animal, and the absence of plant diversity in the area. The artificial forest habitats are exposed to animal grazing and deforestation for fuel wood at the highest rate. In terms of season, the most diverse and abundant of insects were recorded in wet season. This is due to the availability of quality and quantity of food. There is evidence that rainfall can directly and indirectly influence insect abundance through physiological effect on reproduction, development, or activity. In the dry season of the forest, there was least diverse and abundant of insects. The availability of food also decreased and this leads to insect mortality and different resting stages.

Keeping up the diversity, habitats in the forest should be protected from human and animal interferences especially in the artificial forest and a multidisciplinary approach is needed to conserve this biota. Since this study did not include immature stage and nocturnal insects, further study should be conducted to fill the gap.

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