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Study on the diversity of insects at Bihere Tsige public park, central Ethiopia

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Abstract
Studies on diversity of insects at different habitats (grassland, flowers and grass mixed and mixed vegetation) of Bihere Tsige Public Park were investigated using quadrate and transect walk methods. Insect collections were carried out using sweep net, and identified at the order and family levels. The data were analyzed using diversity indices. Nineteen families of insects belonging to seven orders were recorded. Flowers and grass mixed vegetation of the park has the highest insect diversity and mixed vegetation of the park had the highest evenness. Orthoptera and Lepidoptera were the most abundant orders. Based on Jaccard's similarity index, Flower and grass mixed vegetation and grassland vegetation showed the highest similarity. Grassland showed the highest Margalef's Richness Index. Abundance of food, species of vegetation, stability of the habitats and human activities determined insect diversity at the Public Park. The administration and local people have to give due attention to the purposeful use of the park through protection of the different vegetation types which are habitats and food sources of the various insects in the study area.

Keywords: Bihere Tsige public park, insect abundance and diversity, species richness

1. Introduction
Insects are the earth's most diverse organisms, accounting for about half of the described species of living things and about three-quarters of all known animals, and it is estimated that more species of insects than known at present remain to be discovered (Wijesekara and Wijesinghe, 2003) [20]. Approximately 100,000 species of insects have been described from sub-Saharan Africa, but there are very few overviews of the fauna as a whole (Miller & Rogo, 2001) [12]. It has been estimated that the African insects make up about 10-20% of the global insect species richness, (Gaston and Hudson, 1994) and about 15% of new species descriptions come from Afrotropical region (Gaston, 1991). Thus, insects lie in the zone of maximum species richness. Borror *et al*. (1992) [4] reported insects as the dominant group of animals on the earth to date.

The biological diversity encompasses species diversity, richness and genetic resources in a mutually interacting community of a given habitat. Insects are the major components of animal diversity in terms of number of species in most of the habitats and ecosystems. Their removal or loss can cause negative effects in the ecosystem as they play a crucial role in the maintenance of ecosystem stability and diversity (Ananthakrishnan 1988) [2]. Along with plants, they constitute the major food of higher animal species. Among insects, butterflies are treated as indicators of the status of the ecosystem and have been considered as important mega-species. Living organisms are not uniformly distributed all over the habitats, but are limited to those areas, where the species-specific ecological requirements are available. This is one of the major factors governing distribution of animals in various habitat types (Balakrishnan and Easa, 1986) [3].

Ethiopia has diverse biological resources. This is reflected by altitudinal range and the diversity of climate, vegetation, and landscape. Ethiopia is one of the few countries in the world that possesses unique and characteristic fauna with a high level of endemism (Shibru Tedla, 1995; Jacobs and Schloender, 2001) [17, 9]. Over the years, the natural ecosystem in Ethiopia has been altered because of human and natural factors. Much of the highland and some parts of the lowlands have been converted into agricultural and pastoral land and the vegetation has been used for fuel wood, construction and other purposes (Hillman, 1993) [8]. Accelerating rates of biodiversity loss lead to the signing of international agreements, such as the convection on biological diversity and agenda 21, have called for the world biodiversity to be inventoried and monitored (Stork and Samways, 1995) [19].

Insects are the most important components of an ecosystem. Their contribution in terms of pollination, bio-control agents, and provision of useful products to humans can be categorized as useful aspect. On the other hand, few insect species are pests of plants, stored products, clothes, and causes of fatal diseases. Basic aspects of insects in the ecosystem such as species richness, diversity, and habitat similarity should be studied regardless of the harmful or beneficial nature of insects for conservation purpose. Hence, the current study was initiated with the objective to know the diversity, abundance, and similarity of insects in various habitats at *Bihere Tsige* Public Park.

2. Materials and Methods

2.1. Description of the study area

The study was carried out at *Bihere Tsige* Public Park, which is located in southeastern part of Addis Ababa, Ethiopia. It covers an area of 400-square-kilometer and a preserve where several hundreds of bird species and Ethiopian flora. Geographically it is located 38°45'12 E latitude and 8°57'14 N longitude. The public park is relatively flat with an altitude of 2202 meter above sea level. There is only one major river, highly polluted, that crosses the park. The climate is categorized as warm temperate climate that has a distinct dry month in winter. The mean temperature of the coldest month is below 19 °C. The hottest month was May with an annual temperature of 19 °C; while the coldest month is December with an annual average temperature of 14.2 °C.

It composed of various types of vegetation, large trees, grasses and herbaceous plants. The most commonly occurring plants were *Ficus ovata, Podocarpus falcatus, Grevillea robusta, Mimosa pigra, Phoenix reclinata, Spathodea nilotica, Rosa sinensis, Jacaranda mimosifolia, Ficus vasta, Cactus* spp., *Sedum* spp., *Rosa abyssinica, Allophylus abyssinicus, Iri germanica, Juniperus procera, Acacia abyssinica, Eucalyptus globulus, Olea africana, Prunus africana, Cordia africana* and *Hagenia abyssinica* (Ensermu Kelbessa, 2005) [7].

2.2 Selection of sampling site

The species diversity, composition, distribution, and abundance of Public Park were investigated on systematically selected sampling sites of each habitat types in the study area. The study area were divided into different sections based on the transect line. The study area was categorized into three habitat types as: Grassland, flowers and grass mixed vegetation, and mixed vegetation. The public park was divided in to four transects with six quadrants in each of the three habitats and insect collection were done in each habitat types. Each quadrate in the park, having a size of 10m x 10m in four transects line were sampled.

2.3 Sampling methods, insect collection and identifications

Studies on diversity of insects at different habitats of *Bihere Tsige* Public Park, Ethiopia were conducted during 2015. Insect collections were carried out using sweep net. All sampling were done once in a month for about four days. After each series of sweeps, the contents of the net were emptied in to killing bottle (jar) with chloroform soaked sponge in it. In the case of Lepidoptera, the specimens were killed by pinching their thorax by taking proper care or by killing the small specimen, using ethyl acetate and finally placed in paper envelop.

The collected insects were identified using binocular microscope and identification key at the family level with the help of available literatures. Besides books, drawings of insects and datasheets were used as a means of identifications tools. When identifying and describing insect taxon, morphological characteristics were used.

2.4 Data analysis

2.4.1 Measurement of diversity

The diversity index was calculated by using the Shannon-Wiener diversity index (Shannon, 1949). The Shannon-weaver index (H') is the most commonly used measure for diversity and it is defined as:

$$\text{Diversity index} = H = -\sum Pi \ln Pi$$

Where $Pi = S/N$
S = number of individuals of one species.
N = total number of all individuals in the sample.
In = logarithm to base e.

2.4.2 Simpson's Index (D)

It measures the probability that two individuals randomly selected from a sample will belong to the same species or some category other than species. Simpson Index (Simpson, 1949) was computed for each of the sites.

Simpson's Index is expressed as:

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

Where,
n = The total number of organisms of a particular family
N = The total number of organisms of all family.

The value of D ranges between zero and one. In this index, zero represents infinite diversity, while, one represents no diversity. That is, the bigger the value of D, the lower the diversity.

This is neither intuitive nor logical, so to get over this problem, D is subtracted from 1 to give: Simpson's Index of Diversity 1-D. The value of this index also ranges between zero and one, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample were belonging to different species.

2.4.3 Measurement of species richness

In the ecological literature the number of species at a site, in a region or in a collection is called species richness, which is the simplest and most useful measure of species diversity. Insect family richness was calculated by Margalef's richness index (MRI) (Magurran, 1988) [11]. Large numbers indicate high diversity.

Margalef's Richness Index (MRI) = S-1/ln N,

Where,
S= Total number of families observed.
N= Total number of individuals observed in all quadrates.
In= Natural logarithm.

2.4.4 Measurement of evenness
For calculating the evenness of species, the Pielou's Evenness Index (e) was used (Pielou, 1969) [14].
e= H/In S
H= Shannon-Wiener diversity index.
S= Total number of species in the sample (S = family number examined).

Insect with larger evenness value has more even distribution (Price, 1976; Smith, 1992).

2.4.5 Jaccard's similarity index
The similarity of insects in different habitats was determined by:

Jaccard's index (C j) = 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 Jaccard's Index is equal to zero for two sites that are completely different, and is equal to one for two sites that are completely similar.
Microsoft excel were used to calculate the number of abundance of insects in each habitat types and to draw figures.

3. Results
3.1 Diversity of insects
Insect diversity at *Bihere Tsige* Public Park is shown in Table 1. Flowers and grass mixed vegetation had the most diverse insect family followed by mixed vegetation, and their H' value was 2.40 and 2.10, respectively. In terms of evenness, mixed vegetation habitat had been the first followed by flower and grass mixed vegetation, and their evenness index was 0.88 and 0.85, respectively. The grassland habitat was the least in insect diversity (H'= 1.80) as well as evenness (e= 0.72). Simpson's diversity index supported Shannon weaver index in indicating diversity of insects. Simpson's diversity index indicated higher diversity in the flower and grass mixed habitat and least diversity in the grassland habitat.

Table 1: Insect diversity in different habitats at *Bihere Tsige* Public Park during 2015

Habitat Types	Number of individuals	Shannon Wiener Index H'	Evenness	Simpson's diversity index 1-D
Grassland	197	1.80	0.72	0.81
Flowers and Grass mixed	222	2.40	0.85	0.89
Mixed vegetation	88	2.10	0.88	0.87

3.2 Insect similarities between habitats
The similarity indices for the different habitats are shown in Table 2. The similarity index demonstrated the differences and similarities between insects composition recorded in the three habitat types. The level of similarity between each pair in terms of their insect composition was generally below 48%. The highest similarity was recorded between flower and grass mixed vegetation habitat and the grassland habitat, which is 47.8 followed by mixed vegetation habitat with Flowers and grass mixed habitat with similarity index of 37. Grassland and mixed vegetation shared the lowest similarity index, 34. This indicated that 47.8% of the insect species at flower and grass mixed vegetation habitat and the grassland habitat were similar and 34% of the insect species at grassland and mixed vegetation were similar.

Table 2: Similarity in insect communities (Jaccard's coefficient index) in different habitats at *Bihere Tsige* Public Park during 2015

	Grassland	Flowers and grass mixed	Mixed vegetation
Grassland	*	47.8	34
Flowers and grass mixed	47.8	*	37
Mixed vegetation	34	37	*

3.3 Species richness of insects
The Margalef´s richness index (MRI) values of the insect orders recorded at *Bihere Tsige* Public Park are shown in Table 3. The order Orthoptera was seen only in grassland habitats. Flowers and grass mixed vegetation and mixed vegetation were devoid of Orthopterans. The order Hymenoptera was observed in all the habitats with MRI values of 0.76 in the grassland, 0.74 in the mixed vegetation and 1.04 in Flowers and grass mixed vegetation habitats. Flowers and grass mixed vegetation was the only preferable habitat for the order Coleoptera with richness index of 0.84. Flowers and grass mixed vegetation was highly dominated by the order Lepidoptera, which had MRI value of 2.06. The richness index of Lepidoptera in grassland and mixed vegetation is 0.86. The MRI values of Diptera ranges from 0.88 to 1.70. The highest MRI value of Diptera was recorded in the mixed vegetation habitat while, the lowest MRI value in the grassland habitat.

Table 3: Margalef´s richness index of insect orders in various habitats at *Bihere Tsige* Public Park during 2015

Insect orders	Habitat Types		
	Grassland	Flowers & grass mixed	Mixed vegetation
Orthoptera	0.84	0.00	0.00
Hemiptera	0.24	0.00	0.10
Hymenoptera	0.76	1.04	0.74
Coleoptera	0.00	1.08	0.00
Lepidoptera	0.86	2.06	0.86
Diptera	0.88	1.14	1.70
Odonata	0.12	0.00	0.00

3.4 Abundance of insects
The Abundance of insect per families is shown in Figure 1. Nineteen families belonging to seven orders were recorded in *Bihere Tsige* Public Park. Acrididae was highly abundant family in the public park followed by Cixiidae, Aptoide and Pieridae, Respectively. Tettigoniidae, Paccnnodae, Anthophoridae, Braconidae, Scarabaeidae, Syrphidae and Pyralidae were the least abundant families in the study area.
The Abundance of insect per families is shown in Figure 2. In terms of order, Orthoptera, even though represented by only two families Acrididae and Tettigoniidae, was the order with the highest abundant of insects followed by Lepidoptera and Hemiptera while, Odonata was the least encountered order in the study area. Lepidoptera comprised five families Pieridae, Lycaenidae, Hesperiidae, Pyralidae and Danaidae while, Hemiptera contained a single family Cixiidae.

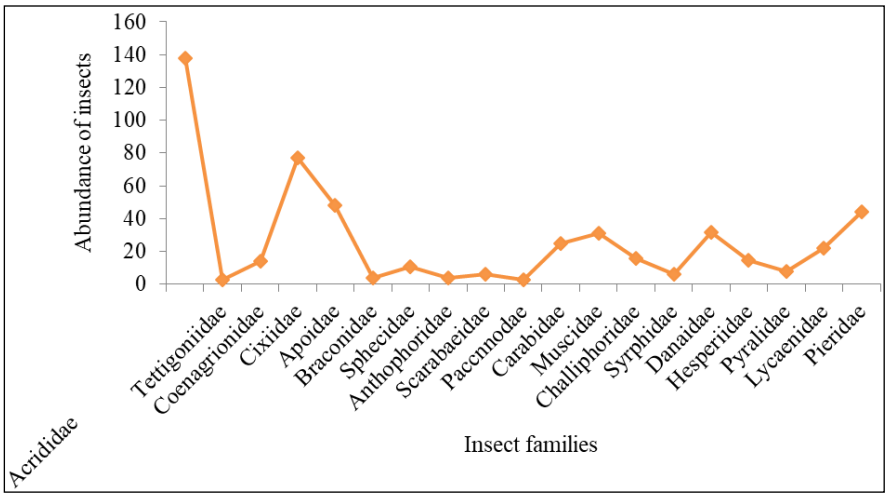

Fig 1: Abundance of insect families at *Bihere Tsige* Public Park during 2015

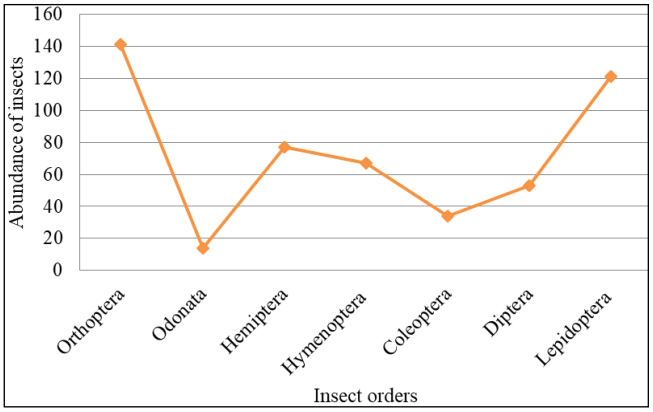

Fig 2: Abundance of insect orders at *Bihere Tsige* Public Park during 2015

4. Discussions

4.1 Insect diversity

Different species of herbivorous insect's peak in abundance depending upon the time that the resource they exploit is most abundant (Pinheiro *et al*., 2002) [15]. Flower and grass mixed vegetation had the opportunity to attract both nectar-loving and phytophagous insects. Moreover, the flower and grass mixed vegetation had wide access of protection, which helped it to become stable. Hence, flower and grass mixed vegetation was the most diverse habitat in the study area. The mixed vegetation had also surplus amount of nutrition quality particularly during the wet season, due to high precipitation (Abaynew Jemal and Emana Getu, 2018) [1].

4.2 Insect similarities between habitats

The most similar habitats at *Bihere Tsige* Public Park were grassland and flowers mixed with grass. The reason might be the overlapping of the flowering seasons of plants in both habitats. Therefore, the grassland vegetation and flowers mixed with grass shared the same vegetation (grass) and thus shared phytophagous insects like butterflies. This can be the reason for the high similarity of insects between grassland and flowers mixed with grass habitats. In general, the low similarity recorded between habitats can be due to habitat specificity of insects for food plants. Perrins *et al.* (1991) [13] asserted that the distribution of any species is restricted by the distribution of its habitat and within that habitat the availability of food and other resources.

4.3 Abundance and species richness of insects

Fluctuation of insect abundance and species richness was evident in *Bihere Tsige* Public Park. The causes of fluctuations in insect abundance and the differences among species are still not completely understood. There are probably both biotic and abiotic factors responsible for the phenomenon (Pinheiro *et al*., 2002) [15]. However, Wolda (1980) [21] gave some reasons for insect fluctuation. The reasons include microclimatic changes and variation in the availability of food resources. Restricted periods of abundance may be dictated by periodic food supply as well as advantages in predator avoidance and enhancement of mating success. Denlinger (1980) [6] evidenced the most important factor for insect fluctuation is rainfall. Rainfall may directly affect insect populations (Janzen, 1973) [10]. It has also an indirect effect (Chaniotis *et al*., 1971) [5]. Even minor variations of rainfall can cause important crucial variation in leaf variations (Wolda, 1978) [22]. Though rainfall contribute for insect abundance and fluctuations significantly, it cannot be responsible for all of the observed fluctuations (Tanaka & Tanaka, 1982). Each taxon could respond differently relative to the seasons, so that the effects of the wet or the dry season could be reflected in numeric responses in arthropod populations (Pinheiro *et al*., 2002) [15]. These could be the reasons for the abundance of order Orthoptera in the grassland habitat and Lipedoptera in the flower and mixed grass habitat. In general, human activities and food played great roles in the diversity, abundance and habitat similarity or variation of insects at *Bihere Tsige* Public Park.

5. Conclusions

The presence of 19 families of insects at *Bihere Tsige* Public Park revealed the importance of the area as good habitats of insects. High diversity of insects at *Bihere Tsige* Public Park was observed in flowers and grass mixed vegetation and mixed vegetation. This was due to high and surplus amount of food in these habitats. Moreover, these habitats were relatively the stable part of the park. Flowers mixed with grass vegetation showed similarity with grassland vegetation. This might be due to the overlapping of floral seasons and commonality of food for adults and larvae. The study revealed the preferred habitats and food for the major insects.

The Park area has an appreciable diversity of insects. However, it would have very big diversity of insects, had it been kept properly. The administration and local people have to give due attention to the purposeful use of the park through protection of the different vegetation types which are habitats and food sources of the various insects in the study area.

6. Competing interest

The authors declare that there are no conflicts of interest regarding the publication of this paper. The article has not been published in another publication and is not being submitted simultaneously to another journal.

7. Data availability

Data are available from the corresponding author upon request.

8. Acknowledgement

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