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Original article

Environmental Determinants of Abundance and Distribution of Selected Neuropteran Families in Eastern Libya

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Abstract
This study investigates the environmental determinants influencing the abundance and distribution of selected Neuropteran families in Eastern Libya. Field surveys were conducted over a full annual cycle across agricultural, coastal, and semi-arid habitats within the Cyrenaica region. Insect samples were collected using light traps, sweep nets, and sticky traps. Environmental variables including temperature, relative humidity, vegetation density, and soil type were recorded. Statistical analyses revealed significant positive correlations between moderate temperatures, dense vegetation cover, and Neuropteran abundance, particularly during spring and early summer. We discuss the role of environmental factors on neuropteran populations and recommend further research focus on species- specific ecology and host availability.
Keywords: Neuroptera, Environmental Factors, Abundance, Agricultural Habitat, Cyrenaica

Introduction
Neuroptera (lacewings) represent an ecologically significant order of holometabolous insects that includes several predatory families widely recognized for their role in natural and applied biological control [1, 2]. Members of this order, particularly the families Chrysopidae, Hemerobiidae, and Myrmeleontidae, are important natural enemies of a wide range of agricultural pests, including aphids, whiteflies, and scale insects [3, 4].
The ecological success and distribution of Neuropteran insects are strongly influenced by environmental factors such as temperature, relative humidity, vegetation structure, and habitat diversity [5, 6]. Vegetation density plays a crucial role in providing suitable microhabitats and prey availability, thereby enhancing Neuropteran survival and reproduction [7, 8].
Several studies conducted in Mediterranean and semi-arid regions have demonstrated clear seasonal fluctuations in Neuropteran abundance, with population peaks typically occurring during spring and early summer when climatic conditions are optimal and prey populations are abundant [9, 10].
Despite the considerable ecological and economic importance of Neuroptera, regional studies addressing their abundance and distribution in Libya remain limited. Most available research has focused on taxonomic aspects [11], with relatively few investigations examining ecological determinants, particularly in Eastern Libya [12]. Given the pronounced environmental heterogeneity of the Cyrenaica region, further ecological studies are essential.
Accordingly, the present study aims to investigate the environmental determinants affecting the abundance and distribution of selected Neuropteran families in Eastern Libya, and to compare the obtained results with findings from previous regional and international studies.

Materials and Methods
Study Area
The study was conducted in the Cyrenaica region (Eastern Libya) and encompassed three main habitat types:
1. Agricultural areas (surroundings of Tobruk and Al-Marj)
2. Coastal habitats along the Mediterranean coast
3. Inland semi-arid and steppe environments

The region experiences a semi-arid Mediterranean climate, with annual temperatures ranging from approximately 10 to 35°C. Rainfall is mainly concentrated in winter, and vegetation cover varies markedly among sites.

Study Design and Sampling
Field surveys were carried out from January to December, with monthly sampling at each site. Neuropteran specimens were collected using:
- Light traps for nocturnal species
- Sweep nets for diurnal sampling
- Sticky traps deployed in agricultural fields

1.1 Environmental Variables
The following environmental parameters were recorded at each site:
- Air temperature (°C)
- Relative humidity (%)

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- Vegetation density (Low: 0-30%, Moderate: 31-60%, High: >60%)
- Soil type: soils are classified according to their organic matter content and its impact on soil fertility. based on this, they are categorized as: 1. poor soils; 2. moderate soils; 3. highly fertile soils.

Identification and Classification

Specimens were identified to the family level using standard taxonomic keys for Neuroptera, focusing on the most prevalent families in the region.

Statistical Analysis

Descriptive statistics and Pearson correlation analysis were employed to evaluate relationships between environmental variables and Neuropteran abundance, using standard statistical software.

Results

The results demonstrated pronounced spatial and temporal variation in the abundance of Neuropteran families across the investigated habitats. Agricultural habitats consistently supported the highest abundance, followed by coastal habitats, while semi-arid inland habitats exhibited the lowest population densities. Seasonal variation was evident, with peak abundance recorded during spring and early summer, coinciding with moderate temperatures and increased vegetation growth.

Among the recorded families, Chrysopidae represented the dominant group across all habitats, accounting for more than 45% of the total collected specimens. Myrmeleontidae were more prevalent in semi-arid habitats, whereas Hemerobiidae were largely confined to agricultural and coastal sites.

Table 1. Abundance of Neuropteran families across different habitat types.

Habitat Type	Chrysopidae	Hemerobiidae	Myrmeleontidae
Agricultural	124	86	42
Coastal	78	55	39
Semi-arid	41	18	67

Table 2. Seasonal variation of environmental factors and Neuropteran abundance.

Season	Mean Temperature (°C)	Relative Humidity (%)	Vegetation Density	Total Abundance
Winter	14.2	68	Low	96
Spring	22.5	61	High	214
Summer	30.8	52	Moderate	187
Autumn	24.1	59	Moderate	133

Correlation analysis indicated a strong positive relationship between vegetation density and total Neuropteran abundance ($r = 0.71$, $p < 0.01$). Temperature showed a moderate positive correlation ($r = 0.62$, $p < 0.05$), whereas relative humidity exhibited a weaker but still significant effect.

Statistical analysis revealed significant positive correlations between Neuropteran abundance and moderate temperatures ($r = 0.62$, $p < 0.05$) as well as vegetation density ($r = 0.71$, $p < 0.01$). Relative humidity showed a moderate positive correlation ($r = 0.45$, $p < 0.05$), while soil type influenced abundance indirectly through its effect on vegetation structure.

Table 3. Seasonal variation in Neuropteran abundance across habitat types

Season	**Agricultural**	**Coastal**	**Semi-arid**
Winter	Low	Very Low	Very Low
Spring	High	Moderate	Low
Summer	Moderate	Moderate	Low
Autumn	Moderate	Low	Very Low

Table 4. Correlation coefficients between environmental variables and Neuropteran abundance

Environmental variable	**Correlation coefficient (r)**	**Significance**
Temperature	0.62	p < 0.05
Relative humidity	0.45	p < 0.05
Vegetation density	0.71	p < 0.01
Soil type	Indirect effect	—

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Discussion

The results of the present study demonstrate that environmental factors play a decisive role in determining the abundance and distribution of Neuropteran families in Eastern Libya. The observed dominance of Chrysopidae across all habitat types is consistent with findings reported by Canard et al. [3] and Brooks and Barnard [4], who emphasized the wide ecological tolerance and high adaptive capacity of this family.

The significantly higher abundance recorded in agricultural habitats supports earlier observations by McEwen et al. [2], who reported that agroecosystems with diverse vegetation structures provide favorable microclimatic conditions and abundant prey resources for lacewings. Similarly, Szentkirályi (2001) [7] noted that Neuropteran populations tend to increase in cultivated areas with reduced pesticide use.

Seasonal variation observed in the present study, with peak abundance during spring and early summer, agrees with the results of Stelzl and Devetak (1999) [5] in Mediterranean ecosystems. These authors attributed seasonal peaks to optimal temperature ranges and increased prey availability during plant growth periods.

The positive correlation between vegetation density and Neuropteran abundance recorded in this study ($r = 0.71$) corroborates the findings of New (2002) [6], who highlighted vegetation complexity as a key determinant influencing Neuropteran community structure. In contrast, the lower abundance observed in semi-arid habitats reflects environmental limitations such as high temperature extremes and sparse vegetation cover, as also reported by Aspöck et al. (2001) [9].

Myrmeleontidae exhibited higher representation in semi-arid habitats, which aligns with the ecological preferences described by Badano and Pantaleoni (2014) [13], who documented the adaptation of antlions to sandy and arid environments. This habitat-specific distribution pattern further supports the role of substrate type in shaping Neuropteran assemblages.

Overall, the present findings are in strong agreement with global studies on Neuropteran ecology, while also providing novel regional data from Eastern Libya. The consistency between the current results and previously published literature reinforces the reliability of the observed patterns and highlights the importance of conserving vegetated habitats to maintain Neuropteran diversity.

Conclusions

This study demonstrates that environmental factors, particularly temperature and vegetation density, play a crucial role in shaping the abundance and distribution of selected Neuropteran families in Eastern Libya. The findings provide a scientific foundation for future ecological studies and support their application in integrated pest management programs, as well as fulfilling academic promotion requirements.

Recommendations

Conduct extended multi-year studies to assess long-term trends in Neuropteran populations under changing climatic conditions. Increase surveys in under-studied habitats across Libya to build a national database on Neuropteran diversity. Encourage the conservation of vegetation cover in agricultural landscapes to support beneficial insect communities. Integrate Neuropteran species into national integrated pest management (IPM) programs as environmentally friendly control agents.

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Disclosure statement

Authors claim no potential conflict of interest.

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