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Relationship between vegetation characteristics and Lepidoptera diversity in the Hyrcanian forest, Iran (Insecta: Lepidoptera)

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Abstract

The patterns of diversity of Lepidoptera and its relationship with environmental characteristics in the Hyrcanian forests of northern Iran have not been investigated so far, while such studies are extremely effective in restoring forest biodiversity. This study aimed to assess the relationships between vegetation characteristics and the abundance and diversity of Lepidoptera in Darabkola forest, Sari district (Mazandaran province, northern Iran). Light trapping yielded a total of 474 exemplars representing 84 species and belonging to 16 families. 31 plant species belonged to 28 genera and 23 families were recorded of three distinct forests in the region. The total number of plant species and Fisher's α showed the significant difference. The regression analysis indicated that the Lepidoptera abundance was correlated with basal area, diameter at breast height and tree density, although a significant relationship was not observed between plant characteristics and Fisher's α of Lepidoptera. The lack of a significant relationship between plant diversity and the abundance and diversity of Lepidoptera represents the weak role of plant diversity in creating diversity patterns in forest ecosystems.
KEY WORDS: Insecta, Lepidoptera, conservation, richness, temperate forest, vegetation, Iran.

Relación entre las características de la vegetación y la diversidad de Lepidoptera en el bosque Hircaniano, Irán (Insecta: Lepidoptera)

Resumen

Los patrones de diversidad de los Lepidoptera y su relación con las características ambientales en los bosques Hircanianos del norte de Irán no se han investigado hasta ahora, mientras que estos estudios son sumamente eficaces para restaurar la biodiversidad forestal. Este estudio tenía como objetivo evaluar las relaciones entre las características de la vegetación y la abundancia y diversidad de Lepidoptera en el bosque Darabkola, distrito de Sari (provincia de Mazandaran, norte de Irán). Mediante trampas de luz se obtuvieron un total de 474 ejemplares que representaban 84 especies y pertenecían a 16 familias. Se registraron 31 especies de plantas pertenecientes a 28 géneros y 23 familias de tres bosques distintos de la región. El número total de especies de plantas y el α de Fisher mostraron la diferencia significativa. El análisis de regresión indicó que la abundancia de Lepidoptera estaba correlacionada con el área basal, el diámetro a la altura del pecho y la densidad de los árboles, aunque no se observó una relación significativa entre las características de las plantas y el α de Fisher de los Lepidoptera. La falta de una relación significativa entre la diversidad de plantas y la abundancia y diversidad de Lepidoptera representa el débil papel de la diversidad de plantas en la creación de patrones de diversidad en los ecosistemas forestales.
PALABRAS CLAVE: Insecta, Lepidoptera, conservación, riqueza, bosque templado, vegetación, Irán.

Introduction

Iran is categorized as a low-forest country, which covers only 8% of the total land area. During the last century, the area of Iranian forests declined by two-thirds of the original land cover, from 19.5 to 13.4 million ha. Despite extensive destruction, the country is rich in phytodiversity due to its topographic diversity, geological and climatic variation. With 8 000 plant species belonging to 150 families, Iran is one of the significant endemism countries in this zone of the world. Out of 1,727 endemic species recorded in Iran, 432 and 21 species are vulnerable and endangered, respectively. The total number of endemic species in Hyrcanian region is 115 species (12.5 per million ha) (SAGHEB-TALEBI *et al.,* 2014). The Hyrcanian forest is one of the largest and oldest temperate intact ecosystems in the world (MÜLLER *et al.,* 2018). This ecosystem has a particular ecological and conservation value, this feature is more pronounced when we know that only one percent of the broadleaf forests of the northern hemisphere remains intact (SILANDER, 2001).

Lepidoptera with 158,000 described species is the second most diverse order among insect groups and this number will probably continue to 300,000-400,000 species (KRISTENSEN *et al.,* 2007). The number of moth species is at least ten to one compared to butterflies (AARVIK *et al.,* 2017). Lepidoptera play crucial ecological roles, such as pollinators, herbivores, detritivores, and prey for migratory birds, rodents, and bats in diverse terrestrial landscapes (CHOI, 2011). Some of these functions directly affect plant diversity patterns by influencing the food chain (SCHERBER *et al.,* 2010).

The richness of plant species affects the abundance and diversity of arthropods (EBELING *et al.,* 2018; TYLER, 2020). Increasing plant diversity leads to improved net primary productivity, food resources for herbivorous and increasing the total biomass in ecosystems (HOOPER *et al.,* 2005; BORER *et al.,* 2012). Although there is a positive correlation between plant diversity and the abundance and diversity of arthropod (SCHERBER *et al.,* 2010; BORER *et al.,* 2012) in ecological studies in low-diversity grassland (PEARSON & DYER, 2006) and in agriculture fields (COOK-PATTON *et al.,* 2011), negative relationships between vegetation characteristics and the diversity of arthropod taxa are common in the mentioned ecosystems (AXMACHER *et al.,* 2011). Note that the analysis of the relationship between moth diversity and environmental characteristics has been more focused on the tropical and Mediterranean regions (UHL *et al.,* 2016; MERCKX *et al.,* 2019; DELABYE *et al.,* 2020; RABL *et al.,* 2020), but few studies have been conducted in temperate or boreal ecosystems (HORVATH *et al.,* 2016; ZOU *et al.,* 2016; TYLER, 2020).

Nutritional exchanges between plants and insects play an important role in diversity patterns and herbivores distribution. In some complex forest ecosystems, a positive correlation has been reported between plant diversity and insects (ROOT *et al.,* 2017; DELABYE *et al.,* 2020). Plant diversity is correlated with species richness or community structure of insect herbivores because specific environmental parameters affect simultaneously the distribution of vegetation and insects that feed on plants along environmental gradients (AXMACHER *et al.,* 2009). On the other hand, most studies reported a weak (HAWKINS & PORTER, 2003; AXMACHER *et al.,* 2009) or even negative (CUEVAS-REYES *et al.,* 2003; AXMACHER *et al.,* 2004) correlations between the abundance and diversity of Lepidoptera with plant diversity in forest types. This lack of significant correlation may indicate that some moth families can have similar response to some environmental variables compared to other factors (BREHM *et al.,* 2003).

The patterns of diversity of Lepidoptera and its relationship with environmental factors in the Hyrcanian forests of northern Iran have not been investigated so far, while such studies are extremely effective in restoring forest biodiversity. Therefore, the main aim of the present study was to investigate the relationship between vegetation characteristics and the abundance and diversity of moths within different forest types in a temperate deciduous forest of northern Iran.

Material and Methods

STUDY AREA AND FOREST TYPES

The study area is located within the Darabkola forest of Sari (Mazandaran, northern Iran) (lat. 36º 28’ - 36º 33’ N, long. 53º 16’ - 53º 20’ W), along an altitudinal gradient ranging from 100 to 900 m a.s.l. The average slope of region is about 40%. The mean annual precipitation is 938.8 mm, which occurs as mostly snow at high altitudes and mostly rain at lower latitudes. The mean annual temperature of site study is 31ºC. The region's climate is cold and humid based on the Emberger climograph. The main soil texture of the study area is loam silty and clay. The Darabkola forest, located within Hyrcanian forest, consists of natural temperate and uneven aged stands. The main tree species are chestnut-leaved oak (*Quercus castaneifolia* C. A. Mey.), hornbeam (*Carpinus betulus* L.), velvet maple (*Acer velutinum* Bioss), Caucasian alder (*Alnus subcordata* C. A. Mey.), lime-tree (*Tilia begonifolia* Stev.), Persian ironwood (*Parrotia persica* C. A. Mey.), elm (*Ulmus glabra* Huds), Norway maple (*Acer platanoides* L.), Caucasian persimmon (*Diospyros lotus* L.), Siberian elm (*Zelkova carpinifolia* Pall.), oriental beech (*Fagus orientalis* Lipsky), coliseum maple (*Acer cappadocicum* Gled.) and planted Brutia pine (*Pinus brutia* Ten.). Mixed coniferous and broad-leaved forest (MCBF) (less than 400 m), Persian ironwood-common hornbeam forest (PCF) (between 400 and 650 m) and beech forest (BF) (between 650 and 900 m) were selected for sampling the moth assemblages. Note that, forest types of the studied area are mainly including pure and mixed broad-leaved forests.

Vegetation survey

Three plots with a size of 20x20 m^2 were set within each of the three forests. Each plot divided into four sub-plots with equal sizes to survey the vegetation characteristics. All woody (trees and shrubs) species were recorded in each of the sub-plots. Herbaceous species were surveyed in four smaller plots with a size of 1x1 m^2 that were randomly selected inside each of the sub-plots. The vegetation characteristics included tree height (TH), tree canopy (TC), tree density (TD), diameter at breast height (DBH), basal area (BA), herbaceous richness (HR), tree richness (TR), Shannon diversity for herbaceous species (HH) and Shannon diversity for tree species (HT).

Lepidoptera sampling

Three light traps were installed inside each forest type (OXBROUGH *et al.,* 2012). Traps were made of the white sheet (2 m high x 1.5 m wide) and UV (20 W tube, Blacklight). The traps were set at 1.5 m above the ground, and the distances among them were at least 200 m (FERRO & ROMANOWSKI, 2012). To reduce the effects of spatial margins, the traps were at least 100 m away from the roads and forest edges. The traps were not installed in a straight line of sight to prevent light interference. Sampling nights were selected under pre-defined weather forecast parameters (minimum temperature 10ºC and maximum wind speed 20 km/h). Sampling was not performed on nights when it was likely to rain (MERCKX *et al.,* 2009). Furthermore, sampling was not approximately performed one week after rainy days. Sampling was carried out during the autumn of 2015 (October, November, and December), the spring of 2016 (April, May and June) and the summer of 2016 (July, August and September). The traps were installed on average once every one or two weeks (from sunset to midnight). Moths were collected same time in all three forests and ethyl acetate was used to kill moths.

Statistical analysis

The abundance of moth species collected during the sampling period was combined to enlarge the sample adequately for statistical analysis and prevent the effect of annual variations on the results. The correlation between overall plant species and Fisher's α index (α -diversity) was examined. This index is completely independent of sample size changes and has been widely used in the study of patterns of insect diversity (BREHM *et al.,* 2003; AXMACHER *et al.,* 2004, 2009; ZOU *et al.,* 2014). Multiple linear regression was used to evaluate the relationships between vegetation characteristics with moth abundance and richness. The abundance of moths and Fisher's α were considered as response variables. Modelling included vegetation parameters as independent variables. To understand the changes in vegetation with elevation, principal component analysis (PCA) was used based on the presence-absence of plant species. Diversity indices were computed using PAST software, version 15.2. All other data analysis was applied to the data using IBM SPSS Statistics 19.0.

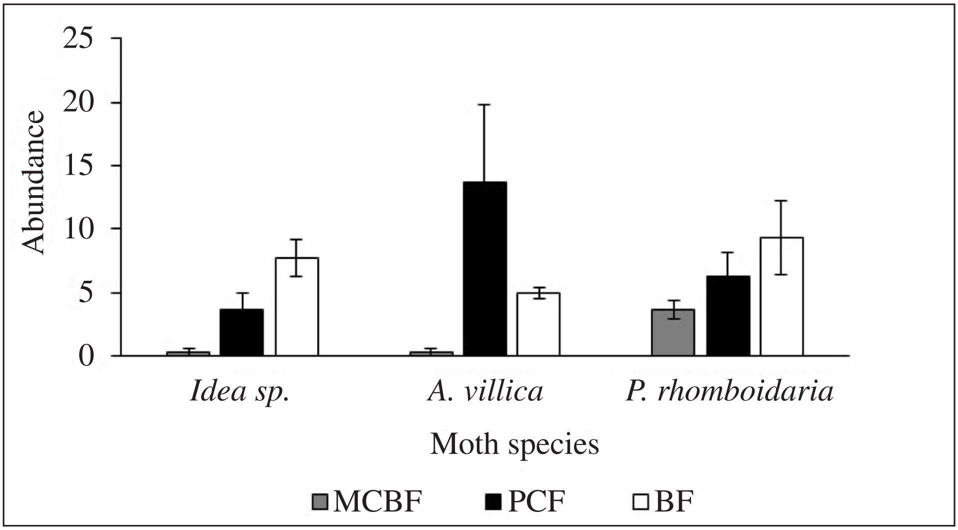

Fig. 1.– Mean abundance of the three most dominant species in three distinct forest types in Darabkola forest of Sari (Mazandaran, northern Iran). Note; Error bars indicate standard error of the mean; Abbreviations: *A. villica = Arctia villica*, *P. rhomboidaria = Peribatodes rhomboidaria*).

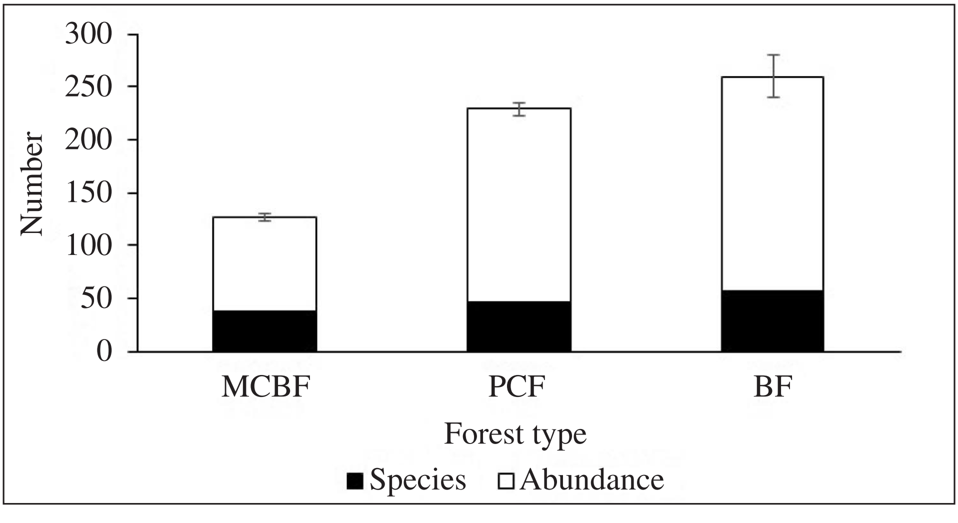

Fig. 2.– Total abundance and species diversity of species collected in three forests in the study area.

Results

LEPIDOPTERA RICHNESS AND ABUNDANCE

474 specimens belonging to 84 species and 16 families were collected in light traps (Table 1).

Idaea sp. (20.22%), *Arctia villica* (L.) (13.73%), and *P. rhomboidaria* (12.8%) were dominant in MCBF, PCF and BF, respectively (Fig. 1). MCBF and BF had the lowest (37) and highest (57) species diversity, respectively (Fig. 2). Furthermore, the lowest (18.77%) and highest (42.82%) abundance were in MCBF and BF, respectively (Fig. 2). Geometridae family with 225 specimens (47.46 % of total) and 29 species (34.11 % of total) had the highest abundance and diversity of species. Moreover, the families of Arctiidae and Crambidae were in next ranks with 72 and 41 specimen, respectively. In contrast, only one species belongs to Heterogynidae, Nolidae and Tineidae families.

VEGETATION COMPOSITION

We recorded a total of 31 plant species belonging to 28 genera and 23 families in three forests (Tables 2-3). In fact, the woody (tree and shrub) layer was included of 16 species belonging to 15 genera and 12 families and the herb layer covered 15 species of 13 genera and 11 families (Fig. 3).

Table 2.– Average woody covering percent of different forest types in the Darabkola forest of Sari.

Woody species	**MCBF**	**PCF**	**BF**
Zelkova carpinifolia (Pallas)	3.19	-	-
Mespilus germanica L.	4.78	0.06	-
Ficus carica L.	0.06	-	-
Parrotia persica (Mey)	3.06	0.06	-
Quercus castaneifolia C. A. Mey	4	-	-
Acer velutinum Boiss	0.25	7.56	2.25
Alnus subcordata C. A. Mey	-	-	0.25
Diospyros lotus L.	-	2.29	7.56
Fagus orientalis L.	-	24.19	78.61
Acer cappadocicum Gled.	0.56	-	-
Pinus brutia Ten.	0.06	-	-
Juglans regia L.	0.06	-	-
Carpinus betulus L.	-	0.56	0.15
Crataegus rhipidophylla Gand.	7.25	4	0.06
Fraxinus excelsior L.	0.25	-	0.06
Epigaea repens L.	1.56	0.06	-

Table 3.– Average herbal covering percent of different types in Darabkola forest of Sari.

Herbal species	**MCBF**	**PCF**	**BF**
Galium odoratum (L.) Scop.	-	4	16.28
Viola alba Besser.	1	15.76	-
Primula hecterochroma Stapf	-	-	0.12
Ruscus hyrcanus Woron.	-	0.06	-
Mercurialis perennis L.	-	-	0.41
Pteris cretica L.	-	2.5	-
Cyclamen persicum Mill.	-	0.41	1.56
Euphorbia helioscopia L.	-	0.91	33.53
Carex sylvatica Huds.	1	11.79	4
Carex remota L.	0.06	2.78	0.25
Ruscus hyrcanus Woronow	-	25.62	-
Urtica dioica L.	-	0.25	1.66
Lamium album L.	-	3.06	-
Hypericum androsaemum L.	-	-	0.78
Oplismenus undulatifolius P. Beauv.	-	10.5	27.56

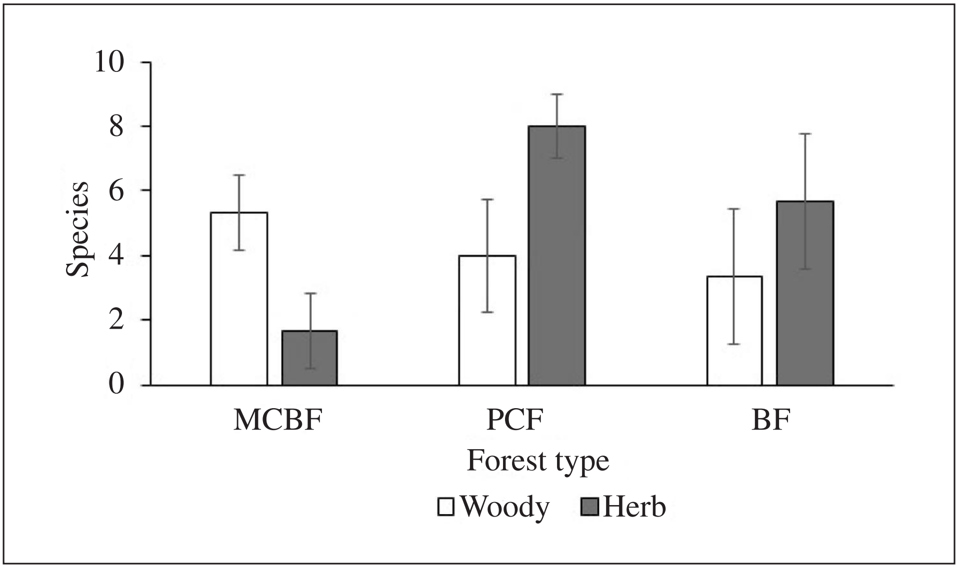

Fig. 3.– Average plant species diversity recorded on the three forest types (bars show standard deviation).

LEPIDOPTERA-PLANT RELATIONSHIPS

The total number of plant species with Fisher's α index had a significant correlation (Spearman's r = 0.87, P<0.01) (Fig. 4). Analysis of linear regression relationships showed a significant difference between the abundance of moths and some of the vegetation parameters (DBH, BA and TD) (Table 4). None of the vegetation parameters was significantly linked with Fisher's α (Table 5). Classification of plots based on PCA analysis in two main axes based on vegetation composition indicated three distinct clusters along elevation gradients (Fig. 5). The first cluster includes MCBF that covers an elevation range of less than 400 m. The second cluster consists of PCF deployed at an altitude of 400 to 650 m. Finally, the third one indicates the distribution of BF between 650-900m.

Table 4.– Results of stepwise linear regressions using species abundance (dependent variable) and vegetation parameters (independent variables).

Model	**TH**	**TC**	**TD**	**DBH**	**BA**	**HR**	**TR**	**HH**	**HT**
Adjusted R^2	-0.123	-0.132	0.432	0.565	0.573	0.036	-0.143	0.114	-0.049
F	0.122	0.067	7.088	11.405	11.723	1.298	0.001	2.034	0.629
Model p-value	0.288	0.085	0.000	0.373	0.022	0.068	0.071	0.07	0.014
ß	0.557	-0.351	-0.94	1.292	0.028	3.249	-0.142	16.469	-15.546
Std. Error of ß	1.594	1.356	0.353	0.383	0.008	2.852	5.536	11.547	19.598
t	0.35	-0.259	-2.662	3.377	3.424	1.139	-0.026	1.426	-0.793
p-value	0.737	0.803	**0.032***	**0.012***	**0.011***	0.292	0.98	0.197	0.454

$*$ = significant at $p < 0.05$

Table 5.– Results of stepwise linear regressions using Fisher's α (dependent variable) and vegetation parameters (independent variables).

Model	**TH**	**TC**	**TD**	**DBH**	**BA**	**HR**	**TR**	**HH**	**HT**
Adjusted R2	-0.028	0.174	-0.143	-0.057	-0.057	-0.122	-0.083	-0.141	-0.109
F	0.758	2.689	0.000	0.568	0.571	0.133	0.387	0.012	0.212
Model p-value	0.004	0.029	0.000	0.001	0.000	0.000	0.006	0.000	0.002
ß	-0.262	0.369	0.001	-0.087	-0.002	-0.218	0.651	-0.28	1.802
Std. Error of ß	0.296	0.225	0.097	0.116	0.002	0.597	1.046	2.545	3.913
t	-0.886	1.64	0.008	-0.753	-0.756	-0.365	0.622	-0.11	0.461
p-value	0.405	0.145	0.994	0.476	0.475	0.726	0.553	0.916	0.659

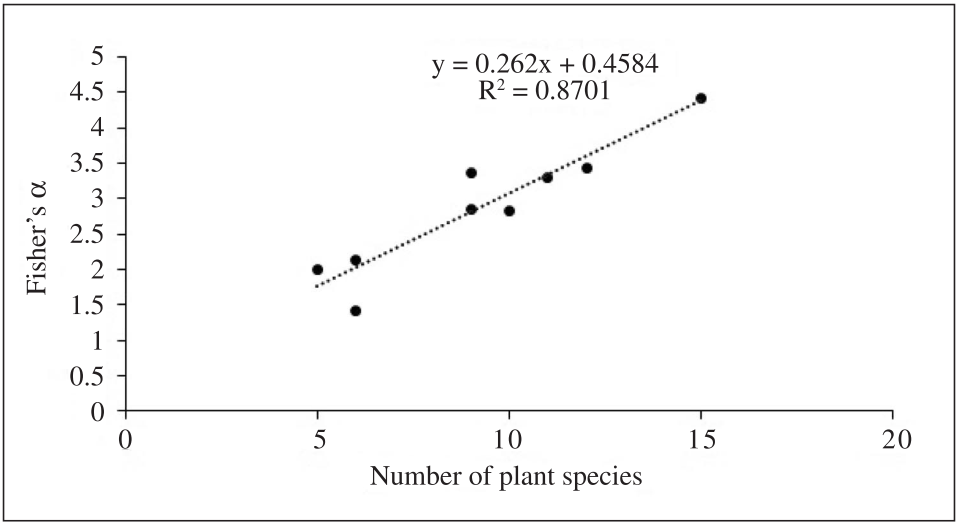

Fig. 4.– Relationship between the number of plant species and Fisher's α index.

Discussion

LEPIDOPTERA ABUNDANCE, RICHNESS AND COMMUNITY COMPOSITION IN DIFFERENT FOREST TYPES

We recorded 84 moth species belonging to 16 families within different forest types of the study area for the first time and it is necessary to be sampled in all other northern mountainous forests of Iran. Literature reviews indicate that not much information is available on moth fauna of this natural ecosystem, with the most important reason being lack of moth specialists of different families in Iranian educational departments.

However, our work is the first record of changes in the patterns of moth diversity with environmental gradients (e. g. vegetation characteristics) in the forests of Iran. Obviously, we declare that our finding cannot be generalized to all Hyrcanian forests, as this area with 130 woody (tree and shrub) species, elevation range up to 2800 m and 800 km length (SAGHEB-TALEBI *et al.,* 2014) had no similar species composition, where the distribution patterns from east to west will be affected by biotic and abiotic factors.

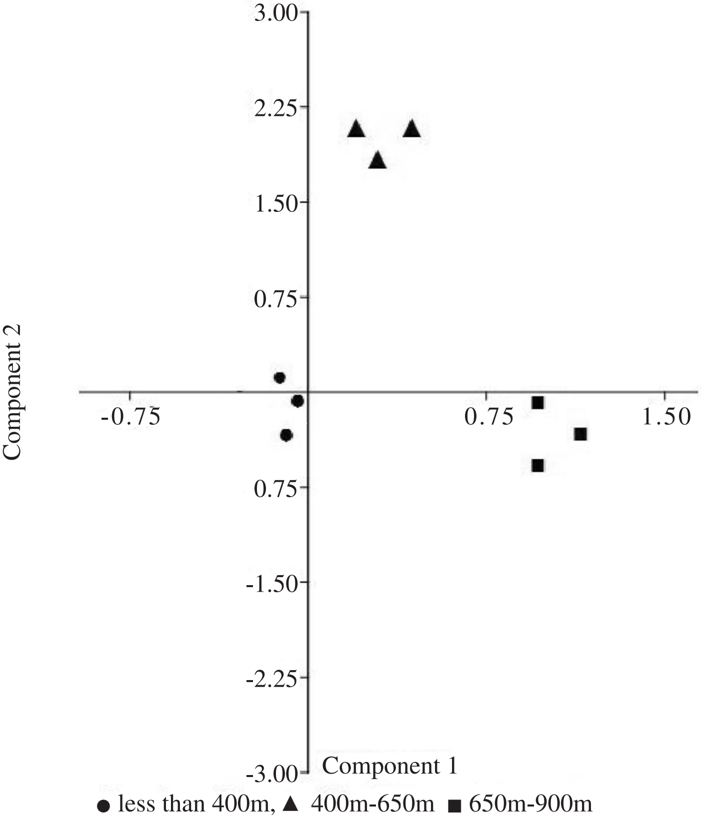

Fig. 5.– PCA ordination plot according to vegetation composition showing three distinct clusters of forest types. (Proportion variance explained for PC1 = 56.49% and for PC2 = 15.77%; eigenvalues for PC1 = 180.65 and PC2 = 50.44).

Note that since so far, no checklist of fauna of Darabkola forest and other areas of Hyrcanian forests has been reported, it is not possible to compare the fauna and percentage of species observed with other records. As discussed, most studies on moths in Iran have focused on describing new species or in some cases, providing checklists of some families. In a study, 38 species of Noctuidae belonging to 8 subfamilies of agroecosystems in Mashhad (Eastern Iran) were reported with their Shannon and dominance diversity indices calculated to be 3.11 and 0.85, respectively (RABIEH, 2018). *P. rhomboidaria* (11.8%) had the largest abundance in our study. ÖZDEMIR (2019) reported 26 species of Geometridae from humid coniferous forests that had the highest diversity compared to other habitats in the western part of the black sea region of Turkey with *P. rhomboidaria* (13.1%) being the dominant species in the area. There is a similarity of the dominant species presented by ÖZDEMIR (2019) with our results, which can be related to vegetation types and microclimate of the studied areas. The fauna structure of moths varied across the entire study area. Of these, a total of 45 species were observed exclusively in one of the types (MCBF, 15; PCF, 9 and BF, 21) while 39 common species were active in all three forests. However, the majority of species that were exclusively observed in one forest had a low abundance (rare species) and may have not been collected in the sampling from other areas. For example, *Trichiura sp.* with 8 individuals has been presented exclusively in MCBF, which can be a good index for its limited presence only in the planted forests. In the current study, the highest moth diversity was observed in BF. The reasons for this difference may be related to changes in environmental conditions, forest management method, plant diversity and the preference for hosting moth species.

RELATIONSHIP BETWEEN MOTH-PLANT DIVERSITY

As discussed, the change of moth communities with structure and diversity of vegetation has been monitored in the grasslands and agriculture landscapes more than complex forest ecosystems. The dominant form of relationships between vegetation characteristics and the moth abundance and diversity is a negative correlation and, in some cases, a significant relationship has been reported (UNSICKER *et al.,* 2006; AXMACHER *et al.,* 2011). In complex forest ecosystems, most studies have been limited to tropical and Mediterranean regions and few studies conducted on the relationship between moth diversity and vegetation parameters in the temperate and boreal areas (TYLER, 2020). In the current study, DBH, BA and TD had a significant relationship with the abundance of moths. On the other hand, we observed a negative correlation between α-diversity of moths and vegetation characteristics which is in line with AXMACHER *et al.* (2004, 2009) and CUEVAS-REYES *et al.* (2003). Plots with more tree density probably have higher productivity level. In fact, the high density of woody plants not only improves soil moisture available and consequently a favorable microclimate for the taxon and their larvae, but also more litter is formed on the floor of the plots, ultimately leading to soil fertility, and increasing the available food for herbivores (MAGURA *et al.,* 2005). The occurrence of negative correlation between α-fisher and plant diversity refers to changes in the composition of tree species in different forest types (UNSICKER *et al.,* 2006) which is consistent with the differences in species composition of natural (PCF and BF) and plantation (MCBF) forests. In Cameroon tropical ecosystems, butterfly communities had a significant relationship with forest canopy and followed with plant diversity and canopy for moths. Also, a positive correlation has been observed between the richness of Lepidoptera and plants in forest ecosystems in some studies (NYAFWONO, 2015). Note that, all relationships between plant diversity and moth richness in tropical ecosystems had a significant correlation (DELABYE *et al.,* 2020) except for a study conducted by AXMACHER *et al.* (2004) in Kilimanjaro Mt., whose reasons attributed by authors to the young age of forest stands and geographical isolation of the study area.

The lack of a significant relationship between plant diversity and the abundance and diversity of moths represents the weak role of plant diversity in creating diversity patterns in forest ecosystems. These findings emphasize that other factors (e. g. elevation) is a more critical factor in changing the abundance and alpha diversity of moths. The variation in elevation is mainly related to changes in temperature and precipitation indicating the effect of these factors on the diversity of moths, which is consistent with other studies that are closely related to insect diversity patterns and non-living environmental factors compared to vegetation in a wide range of geographic scales (AXMACHER *et al.,* 2009). Finally, it is suggested that more research is needed to understand better insect diversity patterns in Iran's forest ecosystems and how they respond to environmental changes (such as elevational gradients and vegetation characteristics). The results of these studies can improve conservation of biodiversity of these ecosystems by identifying areas in need of more attention as some moth families can be good bioindicators for understanding environmental changes.

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Table 1.– Number of individuals for each moth species collected in three distinct forest types in Darabkola forest of Sari (Mazandaran, northern Iran).

Species	**Family**	**MCBF**	**PCF**	**BF**	**Total**
Abraxas sylvata (Scopoli, 1763)	Geometridae	0	0	2	2
Acronicta aceris (Linnaeus, 1758)	Noctuidae	1	0	0	1
Agrotera nemoralis (Scopoli, 1763)	Crambidae	0	0	1	1
Agrotis segetum ([Denis & Schiffermüller], 1775)	Noctuidae	1	0	0	1
Archipini	Tortricidae	1	0	0	1
Arctia villica (Linnaeus, 1758)	Arctiidae	1	25	24	50
Boarmiini	Geometridae	0	2	1	3
Cabera exanthemata (Scopoli, 1763)	Geometridae	0	1	0	1
Catocala sp.	Erebidae	1	0	0	1
Chloroclystis v-ata (Haworth, 1809)	Geometridae	0	0	1	1
Conistra vaccinii (Linnaeus, 1761)	Noctuidae	0	0	2	2
Cosmia trapezina (Linnaeus, 1758)	Noctuidae	2	11	2	15
Cosmorhoe ocellata (Linnaeus, 1758)	Geometridae	0	0	2	2
Cossus cossus (Linnaeus, 1758)	Cossidae	2	0	0	2
Crambinae	Crambidae	0	1	0	1
Craniophora ligustri ([Denis & Schiffermüller], 1775)	Noctuidae	1	0	0	1
Cyclophora linearia (Hübner, [1799])	Geometridae	1	1	1	3
Deltote pygarga (Hufnagel, 1766)	Noctuidae	0	4	3	7
Drymonia sp.	Notodontidae	4	1	0	5
Ectropis crepuscularia ([Denis & Schiffermüller], 1775)	Geometridae	0	1	1	2
Eilema sororcula (Hufnagel, 1766)	Arctiidae	0	0	2	2
Eilema sp.	Arctiidae	0	0	2	2
Endotricha flammealis ([Denis & Schiffermüller],1775)	Pyralidae	0	2	3	5
Ennomos quercinaria (Hufnagel, 1767)	Geometridae	1	4	8	13
Epirrhoe alternata (Müller, 1764)	Geometridae	0	0	1	1
Erannis defoliaria (Clerck, 1759)	Geometridae	0	3	9	12
Erannis sp.	Geometridae	0	0	1	1
Eudonia sp.	Crambidae	0	0	1	1
Euproctis sp.	Erebidae	0	1	3	4
Furcula sp.	Notodontidae	0	0	1	1
Geometridae 1	Geometridae	0	1	0	1
Geometridae 2	Geometridae	0	0	1	1
Geometrinae 1	Geometridae	0	1	3	4
Geometrinae 2	Geometridae	0	1	1	2
Habrosyne pyritoides (Hufnagl, 1766)	Drepanidae	0	2	3	5
Helicoverpa armigera (Hübner, [1808])	Noctuidae	0	0	1	1
Hemithea aestivaria (Hübner, [1789])	Geometridae	1	3	1	5
Heterogenea asella ([Denis & Schiffermüller], 1775)	Limacodidae	0	0	1	1
Heterogynis anella (Hübner, [1819])	Heterogynidae	0	1	0	1
Heterogynis asella ([Denis & Schiffermüller, 1775)	Limacodidae	0	0	1	1
Hyles livornica (Esper, 1804)	Sphingidae	1	0	0	1
Hypenodes sp.	Erebidae	1	0	0	1
Idaea aversata (Linnaeus, 1758)	Geometridae	0	1	1	2
Idaea degeneraria (Hübner, [1799])	Geometridae	2	7	1	10
Idaea sp.	Geometridae	18	0	3	21
Lamoria anella ([Denis & Schiffermüller], 1775)	Pyralidae	0	2	2	4

Larentiinae	Geometridae	0	0	1	1
Lasiocampidae	Lasiocampidae	0	0	1	1
Lithosia quadra (Linnaeus, 1758)	Arctiidae	2	6	10	18
Lymantira dispar (Linnaeus, 1758)	Erebidae	3	5	3	11
Macaria notate (Linnaeus, 1758)	Geometridae	3	10	5	18
Malacosoma neustria (Linnaeus, 1758)	Lasiocampidae	0	1	1	2
Meganola sp.	Nolidae	1	0	0	1
Mimas tiliae (Linnaeus 1758)	Sphingidae	1	0	0	1
Morophaga sp.	Tineidae	0	1	0	1
Nomophila noctuella ([Denis & Schiffermüller], 1775)	Crambidae	0	0	1	1
Notodontidae	Notodontidae	3	1	2	6
Notodontidae phoesia (Fabricius, 1777)	Notodontidae	1	0	0	1
Olethreutini	Tortricidae	0	1	0	1
Operophtera brumata (Linnaeus, 1758)	Geometridae	0	5	8	13
Opisthograptis luteolata (Linnaeus, 1758)	Geometridae	0	0	3	3
Pandemis heparana ([Denis & Schiffermüller], 1775)	Tortricidae	2	1	0	3
Paracolax tristalis (Fabricius, 1794)	Erebidae	0	1	3	4
Peribatodes rhomboidaria ([Denis & Schiffermüller], 1775)	Geometridae	9	21	26	56
Phycitinae	Pyralidae	1	1	1	3
Phyllodesma tremulifolia (Hübner, [1810])	Lasiocampidae	1	0	0	1
Plusia festucae (Linnaeus, 1758)	Noctuidae	1	0	0	1
Polymixis latesco Fibiger, 2001	Noctuidae	0	0	2	2
Proteuchloris neriaria (Herrich-Schäffer, 1852)	Geometridae	0	2	0	2
Ptilodon capucina (Linnaeus, 1758)	Notodontidae	2	0	0	2
Pyraustinae	Crambidae	1	11	23	35
Rivula sericealis (Scopoli, 1763)	Noctuidae	0	1	0	1
Schrankia costaestrigalis (Stephens, 1834)	Erebidae	1	2	1	4
Scoparia sp.	Erebidae	1	1	0	2
Scopula nigropunctata (Hufnagel, 1767)	Geometridae	1	15	3	19
Scopula sp.	Geometridae	0	1	0	1
Selenia tetralunaria (Hufnagel, 1767)	Geometridae	6	5	5	16
Spilomenini	Crambidae	0	1	1	2
Stauropus fagi (Linnaeus, 1758)	Notodontidae	0	1	2	3
Tephronia sp.	Geometridae	1	5	3	9
Thyatira hedemanni (Hedemann, 1894)	Drepanidae	1	6	5	12
Tortricidae sp.	Tortricidae	0	1	2	3
Trichiura sp.	Lasiocampidae	8	0	0	8
Zeuzera pyrina (Linnaeus, 1761)	Cossidae	0	0	1	1