Fragmenta entomologica, 50 (2): 161-169 (2018)

eISSN: 2284-4880 (online version)
pISSN: 0429-288X (print version)

Research article
Submitted: October 2nd, 2018 - *Accepted*: December 5th, 2018 - *Published*: December 31st, 2018

The importance of beech forests as reservoirs of moth diversity in Mediterranean Basin (Lepidoptera)

Marco INFUSINO [1,*], Stefano SCALERCIO [1]

[1] *Council for Agricultural Research and Economics, Research Centre for Forestry and Wood (CREA-FL) - Contrada Li Rocchi, 87036 Rende (CS), Italy* - marco.infusino@crea.gov.it; stefano.scalercio@crea.gov.it
* Corresponding author

Abstract
Study analyzes the macrolepidoptera assemblages in beech woodlands of the Orsomarso Mountains (Pollino National Park, Southern Italy) to assess the role of beech forests in preserving diversity in Mediterranean Basin. Research was run between 2015 and 2016 in 15 stands representative of the main successional stages of forest maturation, placed between 990 and 1,475 meters of elevation. Monthly-based sampling was performed using UV-LED light traps. A total of 33,957 individuals belonging to 410 species was collected. The community is rich and the most abundant and characteristic species (*Eilema lurideola, Operophtera fagata, Campaea margaritata*) are almost all trophically linked to broadleaves or lichens. The community structure appears fairly constant and recognizable in all stands over the two years of sampling. Young beech forests hosted the greatest number of species compared to other forest maturation stages, though the difference is small. The greatest differences in the community structure are found in the clearings, where generalist and/or related to the herbaceous layer species are mostly represented. Biogeographically widely distributed species prevail, 87% of them having European or Asian-European distribution. There are a number of species of faunistic interest, among which *Perizoma juracolaria, Chelis maculosa, Tiliacea citrago, Poecilocampa populi, Triphosa dubitata, Sideridis reticulata, Nebula senectaria*, including 13 Italian endemics such as *Coenotephria antonii.* Populations of many species show significant genetic diversities compared to other European populations. The Orsomarso Mountains beech forests represent an important biodiversity reservoir, even at the genetic level, and show a good degree of naturalness.

Key words: community, Italy, Natura 2000, fauna, DNA barcoding, *Fagus sylvatica*.

Introduction

In Europe, beech forests have a key role in the conservation of biodiversity (Annex 1, Habitats Directive, 92/43/EEC) and their conservation value is even greater in the South, where beech forests are ecologically ecologically and biogeographically older than those in Central and Northern Europe (Walentowski et al. 2014). For the Mediterranean Basin there are few studies on the relationships between biodiversity and beech forest attributes (Negro et al. 2013; Redolfi De Zan et al. 2014), although they harbour unique species assemblages including endemics and relict species (Walentowski et al. 2014).

The Pollino Massif is the highest mountainous area of the southern Apennines, reaching 2,267 m elevation (Serra Dolcedorme). It marks the administrative border between Basilicata and Calabria, the two southernmost regions of the Italian peninsula. This mountain range is included in the Pollino National Park, the largest protected area in Italy, with its 192,000 ha. The Pollino Massif is structurally contiguous with the Apennines, but it also marks a biogeographical boundary: further to the South, in fact, the mountain reliefs are of different origin and geological nature (Calabria-Peloritani Terrane) (Amodio-Morelli et al. 1976), and are geographically separated from a wide plain of alluvial origin.

Woodland surface of the Park extends for 86,326 ha, 39.6% of which is occupied by the dominant tree species *Fagus sylvatica*. In Calabria, beech forests cover 77,237 ha, 6.6% of the total forest surface (INFC 2015). Pollino beech forests extend between 900 and 1,900 m a.s.l., with exceptional presence above 2,000 m of elevation too.

Due to its characteristics, the Pollino Park is of great interest in wildlife studies (Brandmayr et al. 2002; Belmonte et al. 2006; Todaro et al. 2007; Di Gristina et al. 2015). In particular, moths offer many possibilities for analysis in these environments, considering the numerous ecological roles they play (Usher & Keiller 1998; Summerville & Crist 2004).

Knowledge about the Lepidoptera of Pollino mainly concerns the Basilicata side and was often drawn from occasional research (Parenzan 1977, 1979, 1988, 1994; Marini & Russo 1980; Maffei, 1984; Parenzan & Scalercio 1996; Parenzan et al. 1999; Parenzan & Porcelli 2006;

Scalercio 2014), while regular monitoring has only been dedicated to the highest peaks of the massif (Scalercio 2009; Scalercio et al. 2014). These studies demonstrated the biogeographic interest of this area as several species with relict and disjunct populations were discovered but, in most cases, studies refer to open grasslands.

In studies concerning the assessment of the conservation status of forest environments, Lepidoptera are considered good indicators (Summerville et al. 2003), although often saproxylic beetles, better known and easily sampled, are used (Badano et al. 2016; Mazzei et al. 2017). The latter, however, provide only partial information on the environment, being essentially associated to the mass of dead wood, while the Lepidoptera show a greater number of links with the entire ecological network (Summerville et al. 2001). Knowledge on the Lepidoptera of beech forest is fragmented and it has never been a specific subject under study. In addition to the articles mentioned above, the report by Parenzan et al. (2005) and the faunistic contributions by Teobaldelli (1994) and Dapporto et al. (2004), covering a variety of environments among which beech forest in Central Italy, should be considered. The only community study that involved the beech forests is that of Scalercio et al. (2008) which, however, was made near a wide wet pasture on the edge of a beech forest in the Sila Massif (Calabria, Italy).

This research aims to provide new data on the macro moth fauna of beech forests in the Mediterranean Basin and, more in detail, to analyze the composition of the macro moth assemblages, underlying the importance of this habitat for the conservation of biodiversity at a continental scale.

Material and Methods

Study area

The study area, Orsomarso Mountains, is almost entirely comprised in the south-western part of the Pollino National Park. These mountains are separated from the Pollino Chain from the Campotenese Plain and represent the wildest part of the Park (Fig. 1). According to Barbati et al. (2014), the beech forest studied can be classified as Apennine-Corsican mountainous beech forest (EFTs - Type level 7.3), and it appears after the typical thermophilic plant association Aquifolium-fagetum (Piovesan et al. 2005) (Fig. 2).

The geological substrate is mainly calcareous. The morphology of the landscape, shaped by frequent karst phenomena, is characterized by a succession of mountains, plains, dolines, caves and gorges, offering a great variety of microclimates depending on the exposure of the slopes. Generally the climate is wetter on west-facing slopes. Up to 500 meters the Mediterranean climate dominates, higher up, a cool temperate climate prevails, while above 1,000 meters the climate is typically montane: winter is stiff and snowy, while summer is cool and windy, with some afternoon thunderstorms. Precipitation exceeds 2,000 mm per year.

Sampling methods

Moths were sampled by UV-LED traps (emission peak 398 nm, light angle per LED 120°, ~ 15 W) positioned at approximately 1.30 meters above the ground and powered by a 12V battery (Infusino et al. 2017a).

We identified 15 sampling stands grouped in triplets

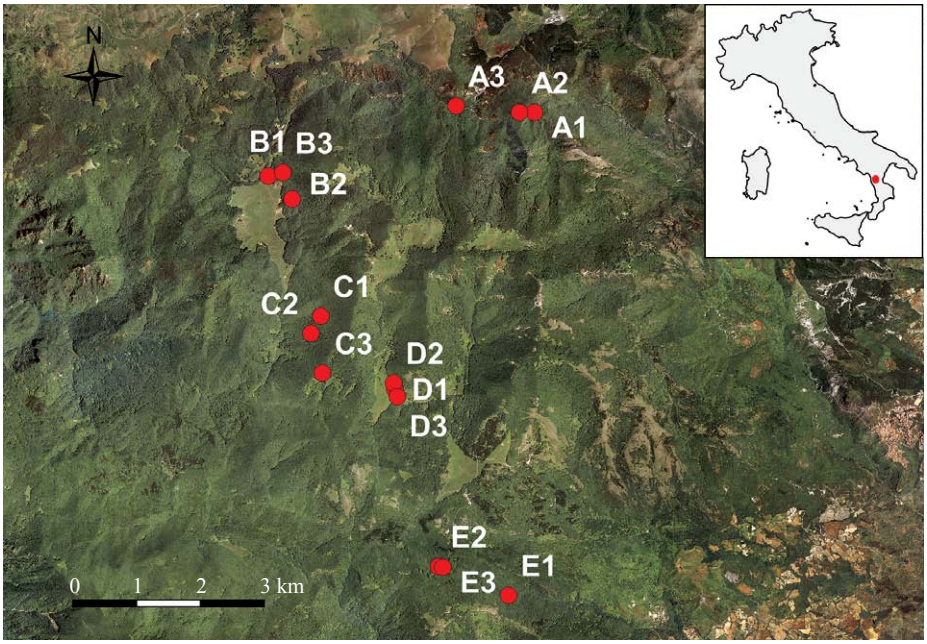

Fig. 1 – Study area. Location of sampling sites.

Fig. 2 – Study area. Typical aspect of the Orsomarso Mountains beech forests.

between 990 and 1,475 meters of elevation (Fig. 1; Table 1). Any triplet included a gradient of woodland maturity, that is: (1) mature and uneven aged beech stands; (2) young beech forests/mature coppices converted to high forests; (3) clearings and pastures surrounded by a forest matrix. Sampling was performed one night per month from May to November 2015 and from April to October 2016, during nights favorable to moth activity (no wind, temperatures not too low). The experimental design was planned to investigate three sites during the first year ($A_{1.2.3}$, $B_{1.2.3}$, $C_{1.2.3}$), and two new sites during the second year ($D_{1.2.3}$, $E_{1.2.3}$), replicating $C_{1.2.3}$ (Table 1). Nine traps worked contemporaneously.

Chorology has been drawn from Hellmann & Parenzan (2010), Bertaccini et al. (1995; 1997) and Scalercio & Infusino (2006).

Evenness index was calculated using Excel 2007.

In the list of species (see supplementary material), the families follow the taxonomic order by Parenzan & Porcelli (2006) modified and updated according to subsequent changes in the higher classification of Noctuoidea, while species within the single families are listed in alphabetical order. Nomenclature and family assignments follow the most updated European Checklist (Karsholt & Nieukerken 2013). For any species we recorded the number of individuals collected in each stand, the total abundance and the phenology indicated as the month of sampling.

The specimens were determined on the basis of the wing pattern or, in doubtful cases, by examination of genitalia. Moreover, some specimens, belonging to 29 species of faunistic importance or randomly selected among others (Table 2), have been processed for barcoding analysis, according to the procedures indicated by the Canadian Centre for DNA Barcoding (CCDB) for sequencing the mitochondrial 5' cytochrome oxidase subunit 1 gene (COI), fragment length 658 bp (Hajibabaei et al. 2006). These data were utilised to confirm morphological identifications and to explore genetic diversification of local population. Specimens were deposited in the Lepidoptera collection of the Research Centre for Forestry and Wood (CREA-FL), Office of Rende.

Results

During the samplings, 33,957 individuals belonging to the 410 species listed below were collected (see supplementary material). The "head" of the community is well characterized: the 15 most abundant species represent about the 70% of the total, almost all of them trophically linked to broadleaved trees (especially beech) or lichens. The relative abundances of the species are distributed rather evenly, with the exception of the first three species (*Eilema lurideola, Operophtera fagata, Campaea margaritata*), which alone constitute 44% of the whole assemblage (Fig. 3). However, this data is strongly influenced by the exceptional massive capture of *E. lurideola* in July 2015 in stands $A_{1,2,3}$, mainly due to the peak of adult emergence of this species, and the synergic effect of high nocturnal temperatures and topography of the sites (for more information see Greco et al. 2017). Excluding this unusual event, for example by aligning the figures for *E. lurideola*

Table 1 – Detailed data about the location of sampled stands.

Stand	Locality	Longitude Est (EPSG:4265)	Latitude North (EPSG:4265)	Elevation (m)	Year of sampling
A1	Serrapaolo	16.090377	39.820183	990	2015
A2	Serrapaolo	16.087639	39.820174	1010	2015
A3	Serra Ambruna	16.076070	39.821070	1035	2015
B1	Bocca di Novacco	16.041719	39.811224	1315	2015
B2	Bruscata	16.046084	39.807978	1370	2015
B3	Bocca di Novacco	16.044414	39.811704	1339	2015
C1	Timpone della Magara	16.051344	39.791553	1465	2015, 2016
C2	Timpone della Magara	16.049549	39.789142	1460	2015, 2016
C3	Timpone della Magara	16.051644	39.783554	1475	2015, 2016
D1	Piano del Minatore	16.064845	39.781264	1433	2016
D2	Piano del Minatore	16.064646	39.782148	1440	2016
D3	Piano del Minatore	16.065325	39.780223	1419	2016
E1	Carraci	16.085653	39.752315	1270	2016
E2	Piano del Faggio	16.072849	39.756353	1357	2016
E3	Piano del Faggio	16.073649	39.756253	1366	2016

in those stands to the average of the other sites, the overall value of the Eveness Index is rather high (E_{SH} = 0.70).

Regarding the chorology, widespread species are prevalent, representing about 87% of the assemblage (60% with Holarctic or Asian-European distribution, 27% with European distribution), while Mediterranean species sum up to only 7% of the total. In quantitative terms, the prevalence of individuals of widely distributed species is even more pronounced, exceeding 95% of the total (Fig. 4).

The monthly frequency of the sampling does not allow an accurate evaluation of the phenology, however some considerations can be made. Most species fly between June and August (65%), peaking in July. Autumn species, present between September and November, represent about 14%, while only 10% of the species is active at the beginning of spring, between April and May, many of which overwintering as larva or adult. For the remaining species it is not possible to define a clear phenology. Bivoltine species are few (10%).

Some specimens were subjected to barcoding analysis. Therefore, the genetic data of 29 species are available (Table 2). Of these, 7 show a divergence between 1% and 3% compared to other European populations: *Coenotephria ablutaria, Drymonia dodonaea, Hyloicus pinastri, Nycteola revayana, Perizoma juracolaria, Trichiura crataegi*, and *Triphosa dubitata*.

Discussion and conclusions

The assemblage of macro-Heterocera hosted by the beech forest of Orsomarso Mountains is very rich in species. Its structure appears fairly constant and recognizable in all stands and in the two years of sampling, with the important exception of *Operophtera fagata* (see supplementary material). This species, trophically linked to beech, is on the whole one of the species most characterizing the assemblage, but it is definitely less present in the sites $A_{1,2,3}$ and in all the sites sampled in 2016. The sites $A_{1,2,3}$ are positioned at lower altitudes, where the beech tree, although still predominant, cohabits with other broadleaved trees, on which *O. fagata* does not feed. The difference in abundance between the two years is essentially due to a meteorological event: a late frost in April 2016 which caused the complete loss of beech foliage in a range between 1,400 and 1,600 altitude meters (Greco et al. 2018a). As a result, the primary food source for *O. fagata* larvae disappeared, causing the collapse of the population.

Young beech forests are the ones that have shown the greatest number of species, even if the differences with the other stages of woodland maturity are small. The greater differences in the community structure are found in the clearings (see supplementary material). Even if surrounded by forest, they show their own characteristics: first of all, the generalist species (e.g. *Alcis repandata, Gymnoscelis rufifasciata,*) and those related to herbaceous vegetation (e.g. *Agrotis cinerea, Mythimna conigera, Dasypolia templi, Athetis pallustris*) are more represented.

Remarkable is the presence of 13 Italian sub-endemic species: *Hydriomena sanfilensis, Coenotephria antonii* (South-Apennine)*, Hemistola siciliana, Idaea mutilata, Hylaea mediterranea* (South-Apennine-Sicilian)*, Xanthorhoe vidanoi* (Apennine-Sicilian)*, Itame sparsaria, Megalycinia serraria, Lycia florentina* (Apennine)*, Clematha-*

Table 1 – List of species subjected to DNA Barcoding analisys. For each species are reported: the Barcode Index Number (BIN) generated by BOLD, minimum and maximum genetic distance (in percentage) and relative geographical origin of the specimen to which it is referred, number of the samples subjected to Barcoding analisys (N), information related to biogeographically consistent clustering.
* Species to which the BOLD System assigns more BIN.
** Species that show clusters with a potential taxonomic interest, but related to geographical areas different than those treated in this research.

Species	BIN	Min. distance Country	Max. distance Country	N	Clustering
Charissa variegata	BOLD:AAC1039	0.76% - Sicily (IT)	2.61% - Greece	1	NO
Coenotephria ablutaria	BOLD:ACF5573*	0.46% - France	3.77% - Greece	3	YES
Coenotephria antonii	BOLD:ADB7125	3.98% - Abruzzi (IT)	3.98% - Abruzzi (IT)	1	YES
Drymonia dodonaea	BOLD:ADH0342*	1.68% - Czech Rep.	2.14% - Austria	2	YES
Epirrhoe alternata	BOLD:ACE4142	0.15% - Sardinia (IT)	1.07% - Germany	1	NO
Eupithecia dodoneata	BOLD:AAC1636	0.17% - Germany	1.16% - Germany	1	NO
Eupithecia innotata	BOLD:AAB8929	0.15% - Germany	0.61% - Germany	1	NO
Gymnoscelis rufifasciata	BOLD:AAA7404*	0.16% - United Kingdom	4.53% - Spain	1	YES**
Hoplodrina superstes	BOLD:AAK5525	0.15% - Macedonia	0.76% - France	2	NO
Hyloicus pinastri	BOLD:AAA8863	1.38% - Cen.-North Europe	1.68% - Turkey	1	YES
Lithophane socia	BOLD:AAE6607	0.15% - Switzerland	0.78% - Germany	1	NO
Nebula senectaria	BOLD:AAC6527	0.15% - Abbruzzi (IT)	1.01% - Turkey	1	NO
Nothocasis rosariae	BOLD:AAM2755	0.31% - Basilicata (IT)	1.77% - Greece	6	YES
Nycteola columbana	BOLD:AAB8994	0.15% - Spain	0.46% - Spain	1	NO
Nycteola revayana	BOLD:AAB8993	0.15% - Abbruzzi (IT)	1.53% - Austria	2	YES
Perizoma juracolaria	BOLD:AAD4226	0.31% - Abbruzzi (IT)	0.61% - Lazio (IT)	1	YES
Phlogophora meticulosa	BOLD:AAB7358	No difference between the European populations		1	NO
Ptilophora variabilis	BOLD:AAL6676	Endemic: Genetic data available only for Calabria		4	-
Puengeleria capreolaria	BOLD:AAD9519	0.15% - Germany	1.99% - Germany	1	NO
Scotopteryx angularia	BOLD:AAC9097	0.15% - France	0.31% - France	1	NO
Scotopteryx moeniata	BOLD:AAE1660*	0.52% - Germany	2.29% - Sudtirol (IT)	1	YES**
Selidosema brunnearia	BOLD:ACE5955	0.31% - Sicily	0.76% - Denmark	1	NO
Shargacucullia lychnitis	BOLD:ABY4109	0.15% - Denmark	0.46% - Austria	1	NO
Shargacucullia thapsiphaga	BOLD:ABY4819	0 % - Greece	0.15% - Austria	1	NO
Sideridis reticulata	BOLD:AAD4204*	0.15% - Cen.-North Europe	1.99% - Georgia	1	YES**
Tephronia sepiaria	BOLD:AAD2603	0.15% - Spain	0.31% - Austria	2	NO
Tiliacea cypreago	BOLD:ADJ6365*	2.60% - Bulgaria	2.60% Bulgaria	2	NO
Trichiura crataegi	BOLD:AAB4489	0.65% - France	1.53% - Finland	2	NO
Triphosa dubitata	BOLD:AAD3995*	0.51% - Germany	2.78% - Georgia	1	YES

da calberlai (Alpine-Apennine-Sicilian)*, Perizoma juracolaria* and *Stilbia faillae* (Alpine-Apennine), to which we must add *Ptilophora variabilis*, from recent research considered as *bona species* replacing *P. plumigera* along the Apennines (Infusino et al. 2018).

There are many species of faunistic interest only recently reported in Calabria (*Perizoma juracolaria, Chelis maculosa, Tiliacea citrago* and *Poecilocampa populi*) (Infusino et al. 2016; Greco et al. 2018b) that had been previously reported for the Pollino Massif but only for the Basilicata side; in addition, also *Coenotephria antonii, Triphosa dubitata* and *Sideridis reticulata* were found for the first time in Calabria, while for *Nebula senectaria*, the Orsomarso Mountains are the only known locality for central-southern Italy (Infusino et al. 2017b). In particular, the specimen of *C. antonii* we found is the only known male of this species (Infusino et al. 2017b).

The finding in many stations of *Euplagia quadripunctaria*, species included in Annexes II and IV of the Habitats Directive, should be noted.

The species composition of Macrolepidoptera Heterocera of the Orsomarso Mountains is quite rich and well

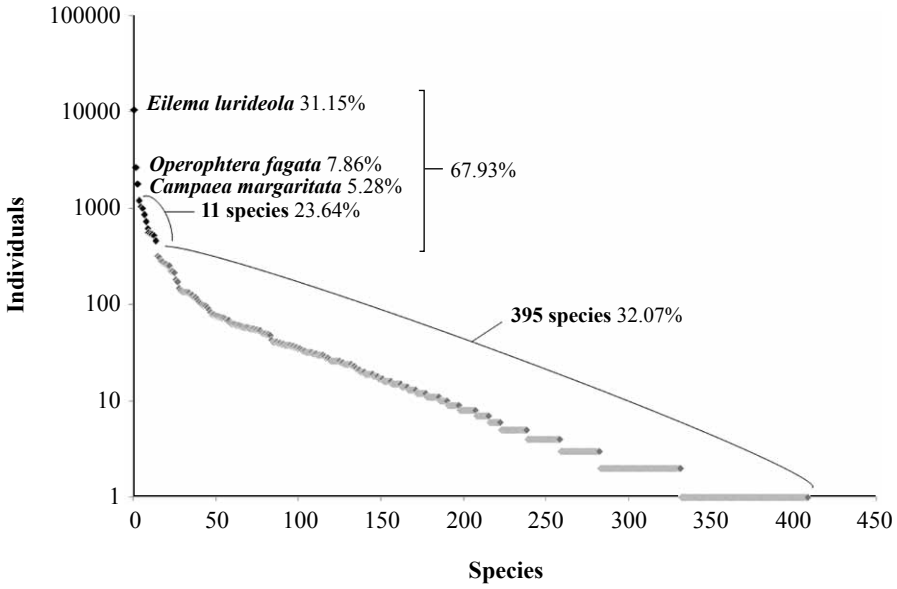

Fig. 3 – Community structure. Relative abundances are expressed in a logarithmic scale.

characterized. The clearings show their own composition and showed a biodiversity comparable to those of forested stands. Actually, where pasture is less intense (as in C3 site), the number of species is similar or slightly greater than in the corresponding wooded sites: this is because these clearings, some of which are of considerable extension, are mostly of natural origin, due to the action of the karst phenomena that characterize the geomorphology of this mountainous area.

The sites of the A triplet are of particular ecological and conservation importance. The particular topographic conformation of this area, a valley, makes it a perfect corridor that connects the beech forest with the mixed thermophilous woods, typical of lower elevation. The result is a great species richness that benefits too from species such as *Tiliacea cypreago, P. populi, C. antonii* and *Triphosa dubitata.*

The lack of bibliographic documentation does not allow a direct comparison of fauna with other similar environments. In Scalercio et al. (2008), the community of Lepidoptera of Monte Curcio (Sila Massif) was performed with a different methodology and was focused in an area at the edge of beech forest. In fact, in the community of Monte Curcio species related to herbaceous environ-

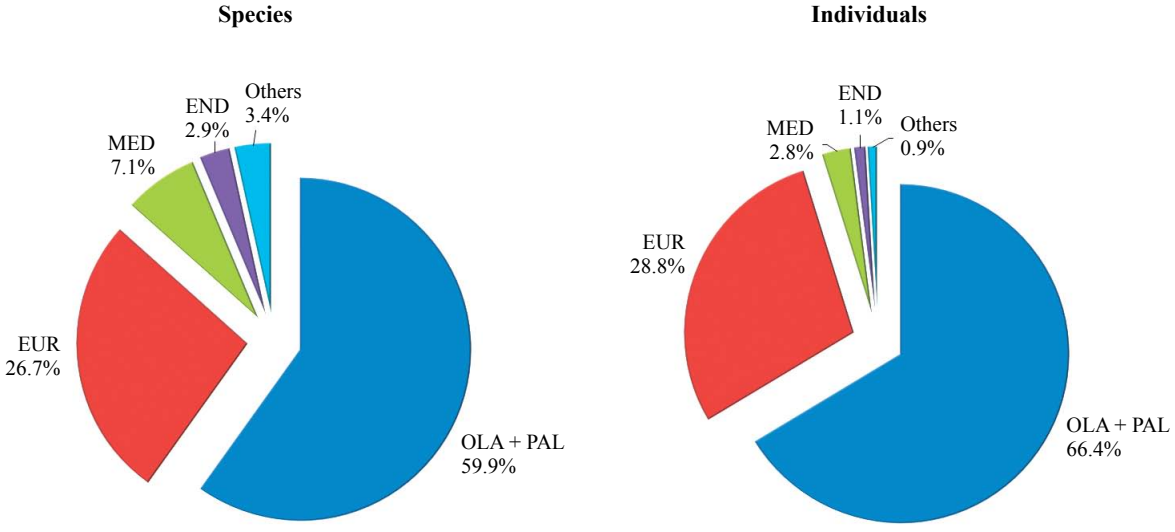

Fig. 4 – Chorological analysis of the community. Percentage breakdown of the number of species (on the left) and individuals (on the right) based on the main chorological categories. OLA+PAL: species with a wide Holarctic distribution (Holarctic, Palearctic, Asian-European); EUR: species with European distribution; MED: species with Mediterranean gravitation; END: Italian endemic species.

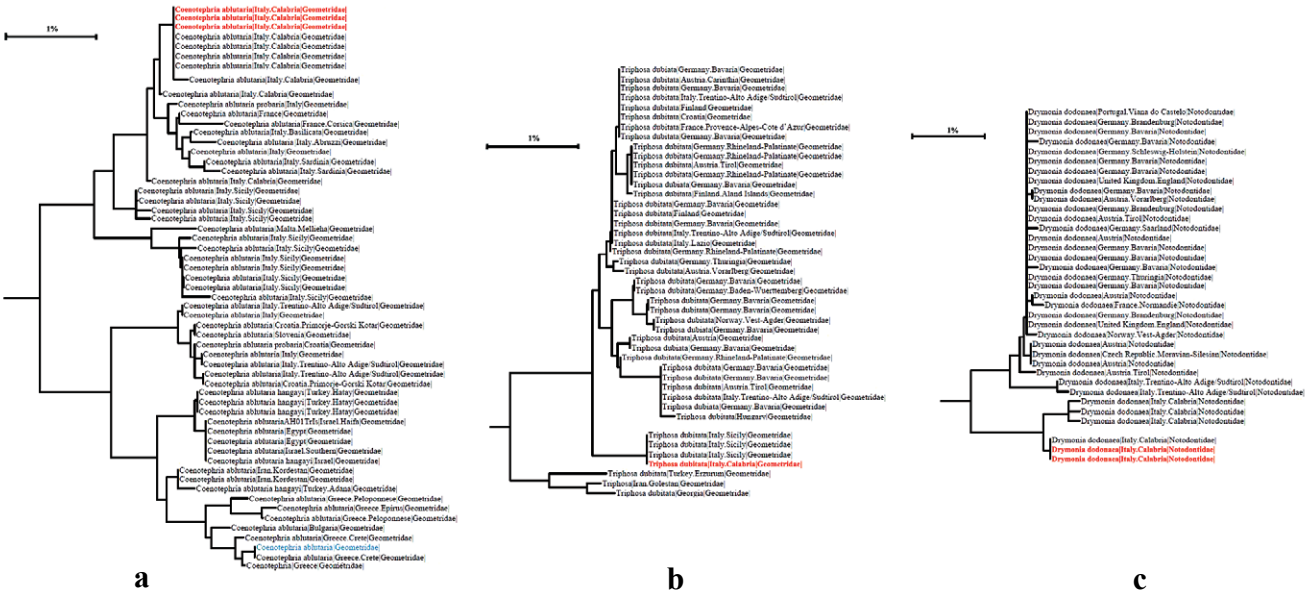

Fig. 5 – Neighbor joining trees (Kimura 2-parameter distance model for COI-5P marker) of species covered in this paper built using sequences deposited in BOLD. **a**, *Coenotephria ablutaria*, **b**, *Thiphosa dubitata*, **c**, *Drymonia dodonaea*. In red the specimens subjected to barcoding analysis in this study, in blue the species of unknown country.

ments, such as *Agrotis cinerea, A. segetum*, *A. clavis, Peridroma saucia* and *Tholera decimalis* are more represented, while among the strictly forest species characterizing the community, only *O. fagata, Watsonalla cultraria*, and *Colocasia coryli* show relative abundance comparable in both woods. The distribution of the chorotypes is similar in both sites, with the difference that in the community of Monte Curcio the species with a wide Paleartic distribution are mostly represented, thus weakening the European component.

Barcoding analysis has shown some peculiar genetic lineages that can also have taxonomic relevance, as shown by recent papers about *Nothocasis rosariae* and the *Ptilophora* species group (Scalercio et al. 2016; Infusino et al. 2018). This is the case, for example, of *C. ablutaria, T. dubitata* and *D. dodonaea*, for which the biomolecular data show a relatively high genetic distance from northern populations. In addition, the specimens from the Pollino/Orsomarso area form a cluster separate with respect to other populations, suggesting the need of taxonomic studies for these populations (Fig. 5). Also for other species, *G. rufifasciata, Scotopteryx moeniata* and *S. reticulata*, genetic information suggests taxonomic insights but, in these cases, the interpretation appears more complex and involves biogeographical areas different than those treated in this research. The barcoding analysis of the other species, although not bearing on taxonomic relevance, highlights a certain degree of genetic distance of these populations. Of the 29 species subjected to molecular investigations, 7 showed evident genetic divergence. Extending the data at the whole species sample, potentially, 20-30% of the species could present a distinct genetic footprint, demonstrating the high biodiversity value of this forest type in the Mediterranean Basin. The barcoding analysis is used almost exclusively to deepen taxonomic studies, but they can provide new biogeographic keys to interpretation, or valuable information on the isolation degree of the populations (Dapporto et al. 2017). This information can be important for the conservation of biodiversity and the development of wildlife management plans (Vodă et al. 2016).

The Orsomarso Mountains show a good degree of naturalness. Grazing, which is the main disturbance factor, is generally limited to the largest grassland areas and is not particularly intense. This area of the Pollino National Park represents, therefore, an important reservoir of biodiversity, even at the genetic level, not yet exhaustively investigated.

Acknowledgements – We are deeply indebted with Silvia Greco, Carlo Di Marco, Francesco Leonetti and Franco Calabrese for their technical support. We also thank the Pollino National Park for released us the permits for collecting. The work was financially supported by the Project "ALForLab" (PON03PE_00024_1) co-funded by the National Operational Programme for Research and Competitiveness (PON R&C) 2007-2013, through the European Regional Development Fund (ERDF) and national resource (Revolving Fund - Cohesion Action Plan (CAP) MIUR).

References

Amodio-Morelli L., Bonardi G., Colonna V., Dietrich D., Giunta G., Ippolito F., Liguori V., Lorenzoni S., Paglionico A., Perrone V., Piccarreta G., Russo M., Scandone P., Zanettin-Lorenzoni E., Zuppetta A. 1976. L'arco calabro-peloritano nell'orogene appenninico-maghrebide. Memorie della Società Geologica Italiana, 17: 1–60.

Badano D., Balestrieri R., Basile M., Birtele D., Cistrone L., Corezzola S., Costa M., de Groot M., Jurc M., Mason F., Meterc G., Posillico M., Romano A., Zapponi L. 2016. Assessing indicators of animal diversity. In: D'Andrea E., Ferretti F., Zapponi L. (eds), Indicators of sustainable forest management: application and assessment. Annals of Silvicultural Research, 40: 88–97.

Barbati A., Marchetti M., Chirici G., Corona P. 2014. European forest types and forest Europe SFM indicators: tools for monitoring progress of forest biodiversity conservation. Forest Ecology and Management, 321: 145–157.

Belmonte G., Alfonso G., Moscatello S. 2006. Copepod fauna (Calanoida and Cyclopoida) in small ponds of the Pollino National Park (South Italy), with notes on seasonality and biometry of species. Journal of Limnology, 65: 107-113.

Bertaccini E., Fiumi G., Provera P. 1995. Bombici e Sfingi d'Italia (Lepidoptera Heterocera). Volume I. Natura, Giuliano Russo Ed., Monterenzio (BO), 248 pp.

Bertaccini E., Fiumi G., Provera P. 1997. Bombici e Sfingi d'Italia (Lepidoptera Heterocera). Volume II. Natura, Giuliano Russo Ed., Monterenzio (BO), 256 pp.

Brandmayr P., Mingozzi T., Scalercio S., Passalacqua N., Rotondaro F., Pizzolotto R. 2002. *Stipa austroitalica* garigues and mountain pastureland in the Pollino National Park (Calabria, Southern Italy), pp 53–66. In: Redecker B., Härdtle W., Finck P., Riecken U., Schröder E. (eds) Pasture landscapes and nature conservation. Springer, Berlin, Heidelberg.

Dapporto L., Fiorini G., Fiumi G., Flamigni C. 2004. I Macrolepidotteri del Parco Nazionale delle Foreste Casentinesi, del Monte Falterona e di Campigna (Lepidoptera). Memorie della Società entomologica italiana, 83: 211–280.

Dapporto L., Cini A., Menchetti M., Vodă R., Bonelli S., Casacci L.P., DincăV., Scalercio S., Hinojsa J.C., Biermann H., Forbicioni L., Mazzantini U., Venturi L.,Zanichelli F., Balletto E., Shreeve T.G., Dennis R.L.H., Villa Roger. 2017. Rise and fall of island butterfly diversity: Understanding genetic differentiation and extinction in a highly diverse archipelago. Biodiversity research, 23: 1169–1181, Doi: https://doi.org/10.1111/ddi.12610

Di Gristina E., Scafidi F., Domina G. 2015. A new species of *Isatis* (Brassicaceae) from the Pollino National Park (Basilicata, S Italy). Flora Mediterranea, 25: 297–303.

Greco S., Infusino M., Scalercio S. 2017. Massive capture of *Eilema lurideola* (Lepidoptera: Erebidae) in a beech forest: outbreak vs. dispersal. Entomologia Generalis, 36: 193-206, DOI: 10.1127/entomologia/2017/0337

Greco S., Infusino M., De Donato C., Coluzzi R., Imbrenda V., Lanfredi M., Simoniello T., Scalercio S. 2018a. Late spring frost in Mediterranean beech forests: extended crown dieback and short-term effects on moth communities. Forests, 9: 388, DOI: 10.3390/f9070388

Greco S., Ienco A., Infusino M., Leonetti F., Scalercio S. 2018b. New records of moths elucidate the importance of forests as biodiversity hot-spots in Central Mediterranean landscapes (Lepidoptera). Redia [in press].

Hajibabaei M., Janzen D.H., Burns J.M., Hallwachs W., Hebert P.D.N. 2006. DNA barcodes distinguish species of tropical Lepidoptera. Proceedings of the National Academy of Sciences, 103: 968–971.

Hellmann F., Parenzan P. 2010. I macrolepidotteri del Piemonte. Museo regionale di scienze naturali, Torino, 1062 pp.

INFC. 2015. Inventario Nazionale delle Foreste e dei Serbatoi forestali di Carbonio, 2015. Secondo inventario forestale nazionale. Available on-line at: http://www.infc.it [Accessed on 28 May 2018].

Infusino M., Greco S., Turco R., Bernardini V., Scalercio S. 2016. Managed mountain forests as diversity reservoirs in Mediterranean landscapes: new data on endemic species and faunistic novelties of moths. Bulletin of Insectology, 69: 249–258.

Infusino M., Brehm G., Di Marco C., Scalerico S. 2017a. Assessing the efficiency of UV LEDs as light sources for sampling the diversity of macro-moths (Lepidoptera). European Journal of Entomolology, 114: 25–33, DOI: 10.14411/eje.2017.004

Infusino M., Luzzi G., Scalercio S. 2017b. New insights on Lepidoptera of Southern Italy with description of the male of *Coenotephria antonii* Hausmann 2011 (Lepidoptera). Journal of Entomological and Acarological Research, 49: 6783, DOI:10.4081/jear.2017.6783

Infusino M., Hausmann A., Scalercio S. 2018. *Ptilophora variabilis* Hartig, 1968, bona species, and description of *Ptilophora nebrodensis* sp. n. from Sicily (Lepidoptera, Notodontidae). Zootaxa, 4369: 237–252, DOI: 10.11646/zootaxa.4369.2.5

Karsholt O., Nieukerken E.J. van. 2013. Lepidoptera, Moths. Fauna Europaea, version 2017.06. Available on-line at: http://www.fauna–eu.org [Accessed on 28 May 2018].

Mazzei A., Bonacci T., Horák J., Brandmayr P. 2017. The role of topography, stand and habitat features for management and biodiversity of a prominent forest hotspot of the Mediterranean Basin: Saproxylic beetles as possible indicators. Forest Ecology and Management, 410: 66-75, DOI: 10.1016/j.foreco.2017.12.039

Negro M., Vacchiano G, Berretti R, Chamberlain D.E., Palestrini C., Motta R., Rolando A. 2013. Effects of forest management on ground beetle diversity in alpine beech (*Fagus sylvatica* L.) stands. Forest Ecology and Management, 328: 300–309.

Parenzan P. 1977. Contributi alla conoscenza della Lepidotterofauna dell'Italia Meridionale. IV. Heterocera (Bombyces et Sphinges) di Puglia e Lucania. Entomologica, 13: 183–245.

Parenzan P. 1979. Contributi alla conoscenza della Lepidotterofauna dell'Italia Meridionale. V. Heterocera: Noctuidae. Entomologica, 15: 159–278.

Parenzan P. 1994. Contributi alla conoscenza della Lepidotterofauna dell'Italia meridionale. XVII. Heterocera: Geometridae. Entomologica, 28: 99–246.

Parenzan P. 1988. Nuove segnalazioni di Geometridae (Lepidoptera) per l'Italia Meridionale. Entomologica, 23: 139–160.

Parenzan P., Scalercio S. 1996. Nuove segnalazioni di Nottuidi (Lepidoptera) per l'Italia meridionale. (Contributi alla conoscenza della Lepidotterofauna dell'Italia meridionale. XIX). Entomologica, 30: 105–133.

Parenzan P., Hausmann A., Scalercio S. 1999. Addenda e corrigenda ai Geometridi dell'Italia meridionale (Contributi alla conoscenza della Lepidotterofauna dell'Italia meridionale. XX). Entomologica, 32: 51–79.

Parenzan P., Sannino L., Scalercio S., Sciarretta A. 2005. Nuovi dati sulla Macrolepidotterofauna dell'Italia meridionale (Lepidoptera). Entomologica, 39: 183–209.

Parenzan P., Porcelli F. 2006. I macrolepidotteri italiani. Fauna Lepidopterorum Italiae (Macrolepidoptera). Phytophaga, 15: 5–391.

Piovesan G., Biondi F., Bernabe M., Di Filippo A., Schirone B. 2005. Spatial and altitudinal bioclimatic zones of the Italian peninsula identified from a beech (*Fagus sylvatica* L.) tree-ring network. Acta Oecologica, 27: 197–210, DOI:10.1016/j.actao.2005.01.001

Redolfi De Zan L., Bellotti F., D'amato D., Carpaneto G.M. 2014. Saproxylic beetles in three relict beech forests of central Italy: analysis of environmental parameters and implications for forest management. Forest Ecology and Management, 328: 229–244.

Scalercio S. 2009. On top of Mediterranean Massif: Climate change and conservation of orophilus moths at the southern

boundary of their range (Lepidoptera: Macroheterocera). European Journal of Entomology, 106: 231-239.
Scalercio S. 2014. Nuovi dati di distribuzione dei macrolepidotteri eteroceri della fauna calabrese. Memorie della Società Entomologica Italiana, 91: 3–59.
Scalercio S., Infusino M. 2006. I Macrolepidotteri notturni del Basso corso della Fiumara Trionto (Calabria, Italia meridionale) (Lepidoptera). Quaderni della Stazione di Ecologia, Civico Museo di Storia naturale di Ferrara, 16: 181–204.
Scalercio S., Infusino M., Tuscano J. 2008. I macrolepidotteri notturni della faggeta di Monte Curcio, Sila Grande (Calabria, Italia meridionale) - (Lepidoptera). Quaderni della Stazione di Ecologia, Civico Museo di Storia naturale di Ferrara, 18: 5–19.
Scalercio S., Bonacci T., Mazzei, A., Pizzolotto R., Brandmayr P. 2014. Better up, worse down: Bidirectional consequences of three decades of climate change on a relict population of *Erebia cassioides*. Journal of Insect Conservation, 18: 643-650, DOI: 10.1007/s10841-014-9669-x
Scalercio S., Infusino M., Hausmann A. 2016. *Nothocasis rosariae* sp. n., a new sylvicolous, montane species from southern Europe (Lepidoptera: Geometridae, Larentiinae). Zootaxa, 4161: 177–192, DOI: 10.11646/zootaxa.4161.2.2
Summerville K.S., Metzler E.H., Crist T.O. 2001. Diversity of Lepidoptera in Ohio forests at local and regional scales: how heterogeneous is the fauna? Annals of the Entomological Society of America, 94: 583–591, DOI: 10.1603/0013-8746(2001)094[0583:doliof]2.0.co;2
Summerville K.S., Boulware M.J., Veech J.A., Crist T.O. 2003. Spatial variation in species diversity and composition of forest Lepidoptera in eastern deciduous forests of North America. Conservation Biology, 17: 1045–1057, DOI: 10.1046/j.1523-1739.2003.02059.x
Summerville K.S., Crist T.O. 2004. Contrasting effects of habitat quantity and quality on moth communities in fragmented landscapes. Ecography, 27: 3–12, DOI: 10.1111/j.09 06-7590.2004.03664.x
Teobaldelli A. 1994. Macrolepidotteri rinvenuti nel territorio di Valleremita e zone circostanti (Appennino Marchigiano) (Lepidoptera). Biogeogrphia, 17: 243–260.
Todaro L., Andreu L., D'Alessandro C.M., Gutiérrez E., Cherubini P., Saracino A. 2007. Response of *Pinus leucodermis* to climate and anthropogenic activity in the National Park of Pollino (Basilicata, Southern Italy). Biological conservation, 137: 507–519.
Usher M.B., Keiller S.W. 1998. The macrolepidoptera of farm woodlands: determinants of diversity and community structure. Biodiversity Conservation, 7: 725–748, DOI: 10.1023/A:1008836302193
Vodă R., Dapporto L., Dincă V., Shreeve T.G., Khaldi M., Barech G., Rebbas K., Sammut P., Scalercio S., Hebert P.D.N., Vila R. 2016. Historical and contemporary factors generate unique butterfly communities on islands. Scientific Reports, 6: 28828, DOI: 10.1038/srep28828
Walentowski H., Müller-Kroehling S., Bergmeier E., Bernhardt-Römermann M., Gossner M.M., Reif A., Schulze E.D, Bussler H., Strätz C., Adelmann W. 2014. Faunal diversity of *Fagus sylvatica* forests: a regional and European perspective based on three indicator groups. Annals of Forest Research, 57: 215–231.