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WILD BEES IN SOUTHERN ITALY: IMPACT OF LANDSCAPE MANAGEMENT

RIASSUNTO

Gli impollinatori sono essenziali per il mantenimento degli ecosistemi, e i tre quarti delle principali colture alimentari del mondo necessitano dell'impollinazione animale per la produzione di frutti e semi. Negli ultimi decenni però stiamo assistendo ad un costante declino di questi importantissimi insetti in tutto il mondo, con un conseguente deficit nella produzione agricola. Se da un lato l'agricoltura è strettamente legata agli impollinatori, dall'altro è una delle cause del loro declino. Per questo motivo, in Italia, è nato il progetto "BeeNet", con lo scopo di valutare lo stato di salute degli ecosistemi agricoli italiani attraverso il monitoraggio delle api da miele e delle api selvatiche. In questo studio vengono presentati i dati del primo anno del progetto, 2021, sulle api selvatiche in due regioni meridionali (Campania e Puglia), comparando due ecosistemi agricoli diversi: uno intensivo e l'altro semi-naturale. Una volta al mese, da febbraio a ottobre, in entrambe le regioni ed entrambi gli ecosistemi, abbiamo campionato le api mediante un transetto (200 × 2 metri) percorso alla mattina e al pomeriggio. Inoltre, nelle stesse giornate abbiamo registrato tutte le specie botaniche mellifere presenti sul transetto. Le differenze riscontrate tra i due tipi di ecosistema indicano che l'agro-ecosistema intensivo ha in generale una biodiversità più bassa e una comunità di api più spostata verso specie generaliste. Questo risultato indica che l'uso di pratiche agricole più impattanti e l'omogeneità dell'ambiente influenzano fortemente, e negativamente, questi insetti e le piante spontanee di cui hanno bisogno per sopravvivere. Tuttavia, le differenze tra le ricchezze di specie e le abbondanze di specie tra i due tipi di ecosistema non sono risultate significative, e una possibile ragione di ciò potrebbe risiedere nell'irrigazione degli ecosistemi intensivi, che forse ha ridotto le differenze. È necessario

quindi, in questi ambienti, attuare misure per la tutela degli impollinatori come richiesto dalla Comunità Europea, attraverso strategie mirate come ad esempio la nuova PAC 2023-2027.

SUMMARY

In 2021, in two southern Italian regions (Campania and Puglia) we compared the biodiversity of both Apoidea and plants between intensive and semi-natural agro-ecosystems, aiming to evaluate the impacts of the agro-environment and agricultural practices on wild bees and spontaneous plant communities in southern Italy. Monthly, from February to October, we performed bee samplings (200 × 2 metres fixed transects) and botanical surveys in each site and region. We found no statistical differences between the two environments, probably because the two intensive agro-ecosystems were irrigated that year. However, the semi-natural agro-ecosystem was characterised by a higher biodiversity (bees and plants) and a higher rate of specialised bee species than the intensive agro-ecosystem, indicating that biodiversity benefits of agro-ecological practices and a more heterogeneous landscape.

INTRODUCTION

Pollinators are essential for the environment and the ecosystem conservation. About 87.5% of existing flowering plant species and over 75% of the main food crops in the world require, in part or totally, animal pollination for the production of seeds and fruits, and therefore for their own reproduction (Ollerton *et al.*, 2011). The economic value of pollination service is estimated to be hundreds of billions of dollars globally (Breeze *et al.*, 2016). However, in the last decades, we are witnessing a constant decline of these essential insects all over the world (Zattara and Aizen, 2021), a phenomenon which is also causing a deficit in agricultural production due to insufficient pollination (Reilly *et al.*, 2020). Among the main causes of this decline, we find land use changes, pathogens, climate change, pesticides, and habitat fragmentation (Goulson *et al.*, 2015). In agro-ecosystems this problem is even more serious, as they are more unstable and poorer than natural ecosystems (both in abundance and diversity of plants and pollinators) and are subject to greater inputs of pesticides and more or less impactful agricultural practices. In Italy, although the area used for agriculture has been declining in the last decades, it's still representing more than 40% of the territory.

Wild and managed bees belong to the superfamily Apoidea (Nieto *et al.*, 2014), and are the most numerous (20,000-25,000 species worldwide, about

2,000 in Europe and 1,000 in Italy, Ghisbain *et al.*, 2023) and efficient pollinators. Apoidea are also excellent environmental indicators, as they can visit very large areas around the nest (from a few tens of meters for the smallest bees, up to 7 km for *Xylocopa violacea*, one of the largest species in Europe). In addition, collecting water, pollen, nectar and other materials they carry out an extremely large number of samplings of various components of the surrounding environment (Felicioli, 2009).

In 2019 the "BeeNet - bees and biodiversity in environmental monitoring" project, funded by "the National Rural Network" of MASAF (Ministero dell'agricoltura, della sovranità alimentare e delle foreste), has started. The main goal of this project is a large integration of information deriving from landscape ecology, field monitoring, agricultural context and practices, and the implementation of RDPs (Rural Development Programs) measures. BeeNet uses two monitoring networks: one based on honey bees and the other on wild bees. The second, called the "Wild bee biodiversity network", consists of the observation and identification of wild bees and the plants they visit along a predefined route, called a transect, carried out monthly in 24 sites in 11 Italian regions. For each region, there is at least one site located in an intensive agro-ecosystem and one in a semi-natural agro-ecosystem (Giovanetti and Bortolotti, 2021). The analysis of collected data will allow the evaluation of biodiversity and quality of the Italian agro-environment.

The present study analyses data collected during the first year of wild bee monitoring in the different sites in Campania and Puglia regions, comparing the biodiversity of both plants and Apoidea in the intensive agro-ecosystems and in the semi-natural ones, to evaluate preliminarily how much the agro-environment and agricultural practices impact on Apoidea communities in southern Italy.

MATERIAL AND METHODS

Study sites

Four sites were selected on the basis of landscape analyses through the CORINE (Coordination of Information on the Environment) Land Cover (CLC) cartography (Giovanetti and Bortolotti, 2021). In particular, two sites in the intensive agro-ecosystems (IA) were selected within the CLC 2.1.1 category: non-irrigated arable land, while two sites in the semi-natural ones (SA) within the CLC 2.4 category: heterogeneous agricultural areas, in which crops and pastures are intimately mixed with natural vegetation or natural areas.

In Campania (province of Salerno), the IA (40°25′17.15″ N, 14°59′44.98″ E) was mainly composed of irrigated fields of corn, and the SA (40°11′25.2″ N, 15°33′08.3″ E) of a non-irrigated corn field and leguminous crops. In the same year, in Puglia (province of Bari), the IA (41°01′26.8″ N, 17°09′22.6″ E) was mainly composed of irrigated fields of vegetables, and the SA (41°02′05.9″ N, 16°24′15.6″ E) of a not irrigated permanent meadow.

Sampling methods

Wild bees' sampling and botanical survey at each site were performed monthly, from February to October 2021, along a fixed transect of 200 × 2 metres.

For bees, the sampling was carried out during two one-hour intervals (morning and afternoon) and all bees observed within the transect were collected by hand net. Collected bees were put into separate vials containing cork chipboard and ethyl acetate, placed in a refrigerated thermal bag, and subsequently prepared and identified at the species level. Regarding the botanical survey, carried out once each month concurrently with the monitoring of bees, all the entomophilous flowered plants within the transect were recorded, and identified at the species, or at least at genus, level. The monitoring protocols are freely available at https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/24820. The protocols are in Italian and rich of details on field procedures followed in the project.

Data analysis

We analysed differences between both regions and sites in composition of both collected bees (as individuals per family and species per family) and observed plants (as species per family) by two-way PERMANOVA. In addition, we compared both regions and sites diversity parameters for bees (number of individuals, and species and richness, Shannon indices based on number of individuals and species per family) and plants (species and family richness, Shannon index based on number of species per family) by two-way ANOVA. In all the analyses, month was used as a replicate. Statistical analyses were performed by SPSS Statistics V. 28.0.1.1.

All data are presented as mean ± SE.

RESULTS

During the transect samplings, in total, we captured and identified 690 bee individuals belonging to 137 species and 24 genera of all the six families, and we recorded and identified a total of 164 plant species belonging to 46 families.

Wild bees

During samplings, we collected 181 bees in IA and 253 in SA in Campania, and 148 in IA and 108 in SA in Puglia. Therefore, rough numbers of bee abundance are higher in Campania than in Puglia, mostly due to the period from July to

October when only a small number of bees were collected in Puglia (Fig. 1).

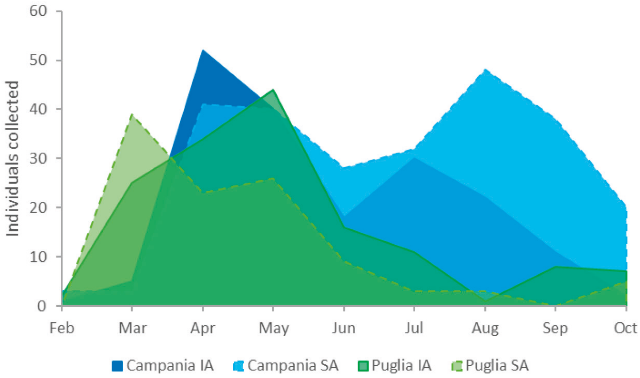

Fig. 1 - Bees collected in the transects from February to October in both regions (Campania and Puglia) and sites (intensive agro-ecosystem, IA, and semi-natural agro-ecosystem, SA).

The families most represented as number of individuals and species were Halictidae in Campania and Andrenidae in Puglia, in both type of sites (except for the number of species in SA in Campania that was most represented by Apidae) (Fig. 2).

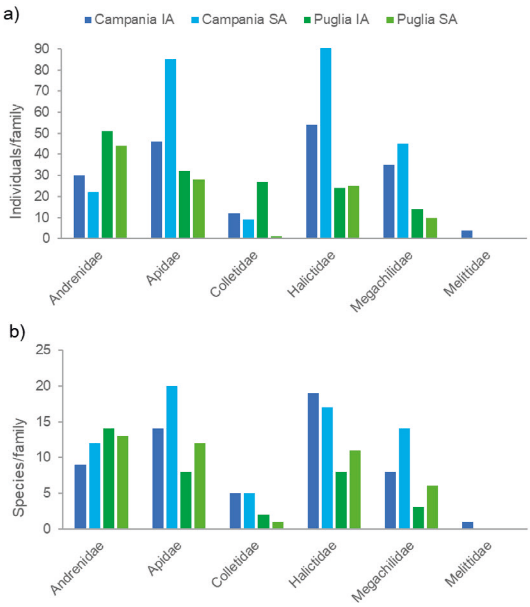

Fig. 2 - Number of a) individuals and b) species of wild bees per family collected during transect samplings in the two sites (intensive agro-ecosystem, IA, and semi-natural agro-ecosystem, SA) in the regions Campania and Puglia, respectively.

The two-way PERMANOVA analysis showed that the factor Region (Campania and Puglia) had a significant effect on both the number of individuals and the number of species per family ($F_{1,32}$ = 3.30, p = 0.011 and $F_{1,32}$ = 3.82, p = 0.013, respectively), while neither factor Site (IA and SA) nor the interaction between the two factors had effect on them (Site: $F_{1,32}$ = 0.65, p = 0.639 – Interaction: $F_{1,32}$ = 0.67, p = 0.622 and Site: $F_{1,32}$ = 1.13, p = 0.317 – Interaction: $F_{1,32}$ = 0.38, p = 0.810, respectively).

Diversity analysis on wild bee community showed that bee family and species richness were statistically higher in Campania than in Puglia, while no other differences were found between both regions and sites (Tab. 1). However, it's worth noting that all parameters, excluding individuals and family richness for Puglia, are lower in IA than in SA sites (Tab. 1).

Tab. 1 - Wild bees diversity parameters (indicated as mean ± SE) calculated for both regions (Campania and Puglia) and for both sites (intensive agro-ecosystem, IA, and semi-natural agro-ecosystem, SA), and their comparison by two-way ANOVA.

	Campania		Puglia		Region	Site	Interaction
Parameters	**IA**	**SA**	**IA**	**SA**			
Individuals	20.11 ± 5.92	28.11 ± 5.46	16.44 ± 4.97	12.00 ± 4.65	$F_{1,32}$ = 3.52 p = 0.070	$F_{1,32}$ = 0.11 p = 0.738	$F_{1,32}$ = 1.39 p = 0.246
Family richness	3.44 ± 0.56	3.67 ± 0.33	2.56 ± 0.50	2.33 ± 0.53	$F_{1,32}$ = 5.20 p = 0.030	$F_{1,32}$ = 0 p = 1	$F_{1,32}$ = 0.21 p = 0.651
Species richness	9.56 ± 2.35	12.89 ± 2.48	5.67 ± 2.06	6.00 ± 2.17	$F_{1,32}$ = 5.63 p = 0.024	$F_{1,32}$ = 0.65 p = 0.425	$F_{1,32}$ = 0.44 p = 0.514
[a]Shannon H_{indiv}	0.94 ± 0.19	1.05 ± 0.10	0.67 ± 0.17	0.79 ± 0.21	$F_{1,32}$ = 2.24 p = 0.144	$F_{1,32}$ = 0.44 p = 0.511	$F_{1,32}$ = 0.0004 p = 0.984
[b]Shannon H_{sp}	1.09 ± 0.22	1.21 ± 0.09	0.86 ± 0.20	0.87 ± 0.22	$F_{1,32}$ = 2.17 p = 0.151	$F_{1,32}$ = 0.12 p = 0.732	$F_{1,32}$ = 0.08 p = 0.780

[a] H index based on the number of individuals per family.

[b] H index based on the number of species per family.

Plants

We observed 63 plant species in IA and 75 in SA in Campania, and 31 in IA and 61 in SA in Puglia. As for bees, plant diversity was higher in Campania than in Puglia, and again most of the plant species in Puglia have been recorded within June (Fig. 3).

The families most represented by number of species were Asteraceae in both sites in Campania (20.6% and 16.0%, respectively) and in SA in Puglia (18.0%), and Fabaceae in IA in the latter (19.4%).

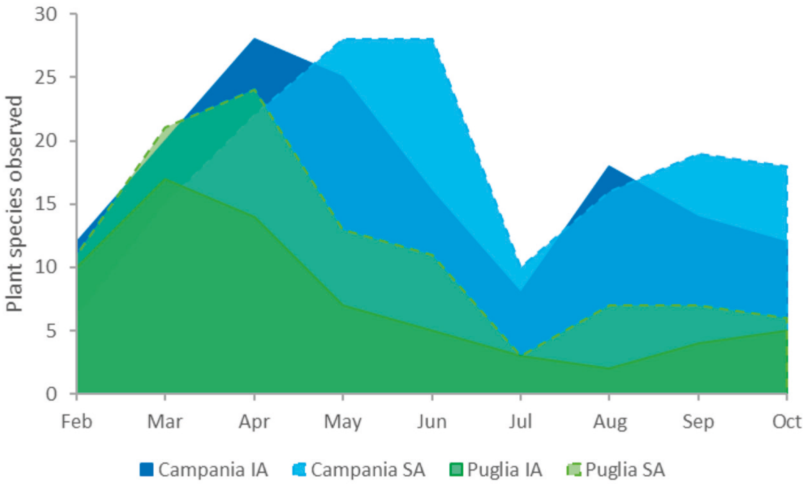

Fig. 3 - Plant species observed in the transects from February to October in both regions (Campania and Puglia) and sites (intensive agro-ecosystem, IA, and semi-natural agro-ecosystem, SA).

The two-way PERMANOVA analysis, on the number of plant species per family observed in the transects, showed a significant effect of the factor Region ($F_{1,32}$ = 3.40, p = 0.002), but not of the factor Site and their interaction ($F_{1,32}$ = 1.41, p = 0.177 and $F_{1,32}$ = 0.83, p = 0.600, respectively).

Diversity analysis showed that all the considered parameters (family and species richness, and H index) were statistically higher for the plants recorded in Campania than for those in Puglia, while no differences were found either between sites nor in the interaction between Region and Site (Tab. 2). However, again, IA values were always lower than SA, especially for Puglia (Tab. 2).

Tab. 2 - Plant diversity parameters (indicated as mean ± SE) calculated for both regions (Campania and Puglia) and for both sites (intensive agro-ecosystem, IA, and semi-natural agro-ecosystem, SA), and their comparison by two-way ANOVA.

	Campania		Puglia		Region	Site	Interaction
Parameters	**IA**	**SA**	**IA**	**SA**			
Family richness	9.89 ± 0.89	10.89 ± 1.33	5.33 ± 0.93	8.00 ± 1.36	$F_{1,32}$ = 10.51 p = 0.003	$F_{1,32}$ = 2.55 p = 0.120	$F_{1,32}$ = 0.53 p = 0.473
Species richness	17.00 ± 2.16	18.00 ± 2.47	7.44 ± 1.73	11.44 ± 2.33	$F_{1,32}$ = 13.54 p < 0.001	$F_{1,32}$ = 1.30 p = 0.262	$F_{1,32}$ = 0.47 p = 0.498
Shannon H	2.34 ± 0.08	2.43 ± 0.12	1.79 ± 0.19	2.17 ± 0.17	$F_{1,32}$ = 7.71 p = 0.009	$F_{1,32}$ = 2.68 p = 0.111	$F_{1,32}$ = 1.06 p = 0.311

DISCUSSION AND CONCLUSIONS

Anthropogenic pressure is shifting insect communities towards assemblages that are species-poor, and dominated by generalists (White and Kerr, 2007), and this is also suggested by the data of this study. In fact, in both southern Italian regions, Campania and Puglia, the intensive agro-ecosystem presents lower species richness and biodiversity than semi-natural agro-ecosystem, in both bee and plant communities. In addition, the percentages of species belonging to the families Halictidae and Andrenidae (in Campania and Puglia, respectively), families of bees with short tongues, a characteristic usually ascribed to generalist species (Danforth, 2007), are higher in the intensive agro-ecosystems than in the semi-natural ones.

The lack of statistical differences between the two environments can be due to the crop irrigation in the intensive agro-ecosystems. Climate in southern Italy, where both selected regions are located, is characterised by high temperatures and low precipitations, and it's becoming even warmer and drier in the last decades (Polemio and Casarano, 2008). Therefore, the water availability increased by crop irrigation may certainly have helped sustain bee and plant communities, mitigating the negative effects of intensive agriculture on the environment. In particular, irrigation in general can promote wild-insect abundance through higher productivity of flowering plants or by making the soil easier to excavate (Julier and Roulston, 2009; Garibaldi *et al.*, 2014). However, irrigation of cultivated fields cannot be seen as a solution in the climate change context, where, in the Mediterranean region and worldwide, there is an increase in temperatures and a decrease in the amount of precipitations, because it would lead to an unsustainable use of fresh water sources (Rocha *et al.*, 2020). Moreover, in this context, we also hypothesise that a more suitable analysis to detect differences between the two ecosystems could involve assessing the specific composition of both spontaneous plant and wild bee communities. This approach could highlight potential significant differences in ecological traits among the respective assemblages.

On the other hand, the higher diversity and abundance of both bees and plants in Campania than in Puglia can be explained by the climatic features of the two areas, in particular by annual precipitations, with a mean of about 1400 mm in Campania, and 600-800 mm in Puglia (ISPRA, 2022). Furthermore, this difference is even more evident in the warmest months of the year (July and August) and can explain why fewer bees and plants were present in Puglia in those months. Also the more abundant waterways present in the study area in Campania than in Puglia could have affected the biodiversity.

Recently European Union has expressed the importance of the role of pollinators and their protection, through several strategies as "EU Pollinators Initiative" (COM 2018/395), "EU Biodiversity Strategy for 2030" (COM

2020/380) and "Farm to Fork" (COM 2020/381). These strategies are aimed at increasing sustainable agricultural practices and diversifying agricultural systems, to counteract the negative impacts on natural resources and biodiversity of intensive agricultural systems (Rosa-Schleich *et al.*, 2019). Furthermore, the new Common Agricultural Policy (CAP) 2023-2027 has recently entered into force, which will contribute to achieving the objectives set out in the aforementioned documents. The objectives that will contribute to the protection of pollinators concern a substantial reduction in pesticide use, an increase in environmental complexity in agricultural lands, and a significant increase in agro-ecological practices and organic agriculture.

At the end of the BeeNet project, data collected in the monitoring networks (honey bees and wild bees) will help to improve our knowledge on the status of Italian agro-ecosystems, identify their critical issues and evaluate the efficacy of the agro-ecological strategies adopted. Furthermore, the wild bee monitoring network will provide an analysis of the plant-apoidea relationships and will increase the available data on wild bees in Italy, unfortunately still very scarce today.

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