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Insect floral visitors of thermo-mediterranean shrubland maquis (Ajaccio, Corsica, France)

Maestracci Pierre-Yves^{1,2,3}, Plume Laurent¹, and Gibernau Marc¹

¹ CNRS – University of Corsica - Laboratory Sciences for the Environment (UMR 6134 SPE), Natural Resources Project - Vignola – Route des Sanguinaires, 20000 Ajaccio, France

² ENGIE Lab CRIGEN, 93240 Stains, France

³ University Paris-Panthéon-Assas, Laboratory Management Research (Largepa) - Maison des Sciences de gestion - 1 rue Guy de la Brosse, 75005 Paris, France

Corresponding author: Marc Gibernau (gibernau_m@univ-corse.fr) and Pierre-Yves Maestracci (maestracci_p@univ-corse.fr)

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ABSTRACT

The Mediterranean region represents a biodiversity hotspot with a high rate of endemism. In its western part, Corsica Island is notable in terms of biodiversity due to its large surface and its large range of habitats from seaside to alpine biotopes. Among diverse groups, insects, notably the main orders of pollinators composed of Coleoptera, Hymenoptera, Diptera and Lepidoptera, represent a good part of the insular richness.

Our sampling effort focused on the insects from these four orders visiting flowers in a characteristic thermo-mediterranean vegetation. Our database is an insight on the Corsican floral visitor biodiversity from three sites separated by a few kilometres in the region of Ajaccio during 13 months over two successive years. In total, 4012 specimens were sampled and 270 species or morpho-species identified from 134 genera and more than 28 families. Beetles were by far the most abundant order representing about 54% of the sampled specimens. The most diverse order was the Hymenoptera representing 39% of the species. Our continuous survey

showed that these orders are temporally dynamics both between years and between seasons in terms of abundance and diversity.

KEYWORDS

Insects ; Pollinators; Coleoptera ; Hymenoptera ; Diptera ; Lepidoptera

INTRODUCTION

Most of the 400,000 flowering plants are pollinated by animals and a recent global estimate suggests that 87.5% of angiosperms utilize invertebrates or vertebrates in this way (Ollerton 2017). Actually, there are approximately 350,000 known species of pollinators, and 98.4% of them are insects from the four orders Lepidoptera, Coleoptera, Hymenoptera and Diptera (Ollerton 2017). In a context of global change and preservation of the biodiversity, listing species diversity is important but understanding of how an ecosystem function is a key component to conserve ecosystems (Weisser and Siemann 2008). Plant–pollinator interactions represent a major ecosystem function not only for conservation biology but also for the evolution of many terrestrial ecosystems as species diversity of pollinators is crucial to how most plants reproduce (Layek et al. 2022). Pollinator diversity is not evenly distributed in space, pollinator diversity follows the expected pattern of increasing species richness with latitude, the tropics having more pollinators and richer floras. However, it has long been known that the diversity of bees, one of the major groups of pollinators, peaks not in the tropics but rather in dry, subtropical, Mediterranean-type communities (Michener 2007, Ollerton 2017).

In Europe, the species richness is explained by the diversity of landscapes, their structure and the weather seasonality. In mainland France, a country with a large diversity of landscapes it is estimated that more than 20,000 insect species feed in flowers (IPBES 2016) with a highest richness in the south, the Mediterranean region, a biodiversity hotspot (Mittermeier et al. 2004). In Corsica, significant works on insect diversity has been carried out in recent years, including the MNHN “Planète revisitée” expeditions (Ichter et al. 2021, Ichter et al. 2022) and works of the Territory with its reference organization: the OCIC (Jiroux et al. 2019). But none have focused on the pollination function, apart from bees (Menegus 2018). Our study didn’t aim to provide an exhaustive inventory of the entomofauna but rather an ecosystemic approach. We chose to characterize plant–pollinator interactions by capturing regularly insects visiting wildflowers along transects and static observations, as pan traps do not reflect these interactions (O’Connor et al. 2019).

This paper aims to (1) make public the data of insect flower visitors sampled in a thermo-Mediterranean scrubland maquis over 13 months spread over 2 years, (2) show the differences of floral visitor communities in spring between two consecutive years, and (3) study the dynamic of floral insect corteges throughout a year.

GENERAL DESCRIPTION

Purpose: The aim of this publication is to make public the records of insect visiting flowers collected during a 13-months study on plant-pollinator interactions in Corsica.

PROJECT DESCRIPTION

Title: Insect floral visitors of thermo-mediterranean shrubland maquis (Ajaccio, Corsica, France).

Description: The study was carried out within the framework of the mitigation hierarchy (ERCA: Avoid-Reduce-Compensate-Support in French) regulatory sequence of an industrial project, called Loregaz of the Engie company, located in Ajaccio, Corsica, France.

Personnel: Pierre-Yves Maestracci; Laurent Plume ; Marc Gibernau and students

Funding sources: UMR SPE 6134, CPER project N°40137 “BiodivCorse – Explorer la biodiversité de la Corse” (Collectivité de Corse – Ministère de la Cohésion du territoire et des Relations avec les Collectivités territoriales), Lab. CRIGEN-ENGIE and CIFRE doctoral program (ENGIE/Lab. CRIGEN-Univ. Corsica-Univ. Panthéon-Assas).

Study area description: Sampling was conducted on three sites near Ajaccio namely Loretto, Suartello and Vignola (Table 1) representing the ecological compensation zones for the Loregaz project, and managed on its behalf by an association, the Conservatoire d'Espaces Naturels de Corse. On each site, the main vegetation is the Mediterranean maquis and the sampling design took into account the environmental differences within and among sites in order to have a good vegetation representativeness.

Design Description: The data published in this paper are part of a larger research project including plant-pollinator insect interaction networks (Nicolson 2017) and their dynamics over time (Burkle and Alarcón 2011).

SAMPLING METHOD

On each of the three sites every two weeks from March to May 2021, and every two weeks from mid-February to mid-November 2022 all insects visiting flowers were collected during the different time slots of the day (9am-5pm). Two pollinating insect sampling methods were carried consecutively out at the three study sites (Loretto, Suartello and Vignola). The first method was dynamic and all the insects visiting flowers were collected along 2 transects (30 m long and 2 m wide) for 30 min/transect. The transects crossed the different types of vegetation in the studied area. The second method was static and consisted in capturing all the insects visiting the flowers for a period of 5 minutes on two different plants of the same species. For

each field session, six different characteristic flowering species were selected depending on their abundance in the environment, resulting in a total of 12 flowers observed during a total period of 1 hour. The selected six species changed along the year according to their flowering seasons.

In total, over the three sites in 2021 (Table 1), 27 transects (equivalent to 13,5 hours) were sampled with the dynamic method and 24 flowers observations were achieved during the static method (equivalent to 24 hours). In 2022, 172 transects (equivalent to 86 hours) were sampled with the dynamic method and 154 flowers observations were achieved during the static method (equivalent to 77 hours) (Table 1).

Table 1.

Number of transects and flower observations and their hour equivalents per studied sites.

Site	2021		2022	
	Dynamic sessions	Static sessions	Dynamic sessions	Static sessions
Loretto	9	8	28	26
Suartello	9	8	28	26
Vignola	9	8	30	25
Total (h)	13,5	24	86	77

These two methods were chosen because of the complementary information of the dynamic and static sampling in order to obtain a better representation of the floral visitor insect communities (Table 2).

Table 2.

Abundance and diversity of insect pollinators according to sampling method

Year	Dynamic method		Static method		Total
	2021	2022	2021	2022	
Abundance	683	1747	419	1163	4012
Diversity	86	205	51	173	270

GEOGRAPHIC COVERAGE

South-West Corsica, Ajaccio region (Fig. 1): The Loretto site, located a few hundred meters from the city centre of Ajaccio adjoining the industrial Loregaz site, is made up of a plant mosaic, alternating open areas and groves (Table 3). The Suartello site, located on the edge of

a wooded area, is made up of an open environment (*e.g.* grassland) and a plant mosaic environment (Table 3). The Vignola site facing the sea (ca. 200 m inland) was partly degraded by heavy rotary grinding in 2018, 4 years before the study. The proximity of the sites to each other makes it possible to consider their average temperatures and precipitation as being similar. Thus, they have a warm temperate climate with an average annual temperature of 16.3°C. However, some differences exist, Vignola been more exposed to sea spray and Suartello slightly shadier due to the presence of trees on one side (Table 3).

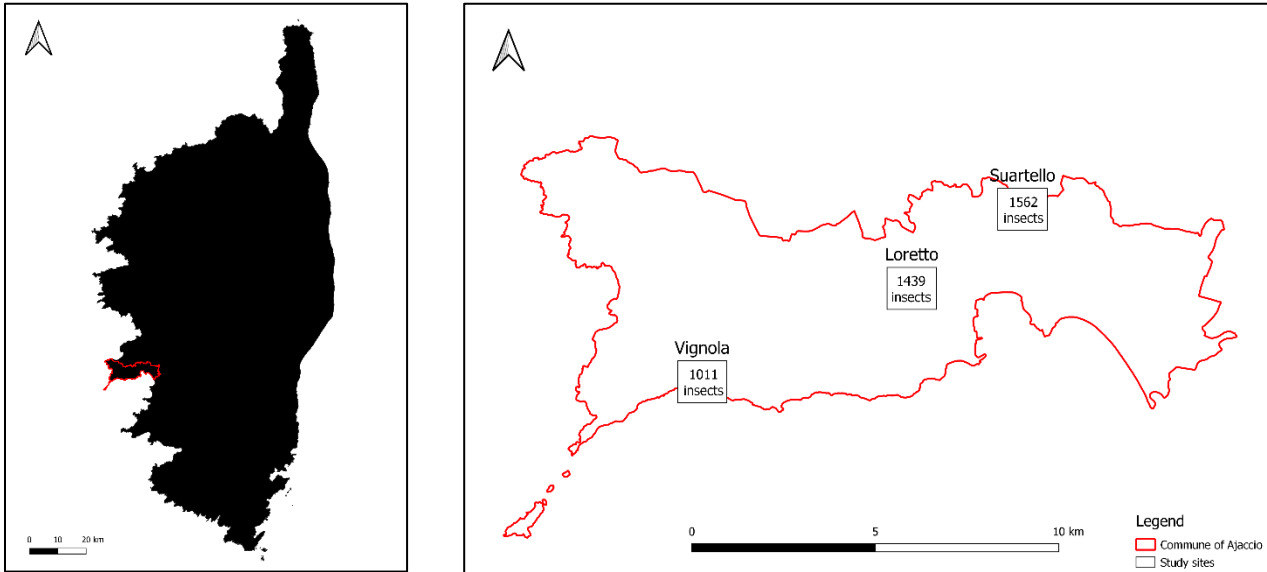


Figure 1. Geographical localisation of the three studied sites and total specimen abundances sampled per site.

Table 3. Studied sites and detailed main characteristics (geographical and vegetation)

Locality	Geographical coordinates		Orientation	Main Vegetation	Area (ha)
	Latitude, longitude	Altitude (m)			
Loretto	41°93'35''N 8°71'82'' E	85	S	Wasteland [CORINE-Biotope: 87.1) Matorral with olive trees and mastic trees [CORINE-Biotope: 32.12)	1,9
Suartello	41°95'31''N 8°75'58'' E	90	SSE	Grassland [CORINE-Biotope: 34.4] High maquis of the western Mediterranean [CORINE-Biotope: 32.311]	2,5
Vignola	41°91'19''N 8°65'00'' E	30	SW	Medium maquis with <i>Cytisus laniger</i> and <i>Pistacia lentiscus</i> in mosaic with <i>Olea europea</i> – Fruity calicotome [CORINE-Biotope: 32.215] Maquis with <i>Cistus monspeliensis</i> [CORINE-Biotope: 32.341]	18

TAXONOMIC COVERAGE

Description: 4012 specimens were sampled. 270 species or morpho-species are identified in the collection. The specimens belong to the orders Hymenoptera [1347 specimens], Coleoptera [2177 specimens], Diptera [262 specimens] and Lepidoptera [151 specimens]. Among these orders we distinguish particularly the following families (Table 4):

- Order Hymenoptera: Apidae [724], Colletidae [153], Megachilidae [141], Halictidae [113], Andrenidae [106], Vespidae [39], Crabronidae [16], Sphecidae [16], Scoliidae [10].
- Order Coleoptera: Melyridae [449], Scarabaeidae [419], Mordellidae [373], Oedemeridae [301], Chrysomelidae [300], Buprestidae [104], Dermestidae [42], Cerambycidae [41], Meloidae [28].
- Order Diptera: Syrphidae [140], Bombyliidae [75], Muscidae [22], Rhiniidae [10], Tachinidae [6].
- Order Lepidoptera: Lycaenidae [94], Pieridae [16], Nymphalidae [10], Papilionidae [6], Sesiidae [5].

Families with less than 5 specimens are grouped in Other Hymenoptera [49], Other Coleoptera [130], Other Diptera [36], Other Lepidoptera [21] and Other Families [17].

Insects identified in other orders [70] incidentally sampled are also included in the database.

Table 4.

List of taxa included in the database

Rank	Scientific name
Order	Hymenoptera
family	Andrenidae
family	Apidae
family	Colletidae
family	Halictidae
family	Megachilidae
family	Chrysididae
family	Crabronidae
family	Ichneumonidae
family	Scoliidae
family	Sphecidae
family	Vespidae
Order	Coleoptera
family	Brentidae
family	Buprestidae
family	Cerambycidae
family	Chrysomelidae
family	Curculionidae
family	Dermestidae
family	Meloidae
family	Melyridae
family	Mordellidae
family	Oedemeridae
family	Scarabaeidae
Order	Diptera
family	Bombyliidae
family	Conopidae
family	Muscidae
family	Stratiomyidae
family	Syrphidae
family	Rhagionidae
family	Rhiniidae
family	Tachinidae
Order	Lepidoptera
family	Hesperidae
family	Lycaenidae
family	Nymphalidae
family	Papilionidae

family	Pieridae
family	Sesiidae
family	Sphingidae

In total, 134 genera have been identified but only six were represented by more than 200 specimens, namely: genera *Apis*, *Bombus*, *Psilothrix*, *Mordellistena*, *Oedemera* and *Tropinota* (Table 5).

Table 5.

Genera with more than 200 specimens and the corresponding numbers of species per genus.

Genus	Number of specimens	Number of species
<i>Apis</i>	318	1
<i>Bombus</i>	244	6
<i>Psilothrix</i>	403	1
<i>Mordellistena</i>	384	10
<i>Oedemera</i>	300	8
<i>Tropinota</i>	282	1

TEMPORAL COVERAGE

Data range: 2021-03-02 – 2022-11-15

Specimens were collected over several months in 2021 (from March to May) and 2022 (from February to November).

DATASET DESCRIPTION

Data package title: Insect floral visitors of thermo-mediterranean shrubland maquis (Ajaccio, Corsica, France)

Resource link: <https://doi.org/10.5281/zenodo.10360901>

Number of data sets: 1

Data set name: Insect_floral_visitors_data_Corsica_France.csv

Download URL: <https://doi.org/10.5281/zenodo.10360901>

Data format: CSV (tab delimited values)

Data format version: Darwin core.

Description: The whole dataset includes 4012 specimens from Ajaccio region, South-West Corsica

This dataset includes own identifications of the authors with geo-localisation within Corsica, France.

Column label	Column description
occurrenceID	Individual identification: combination of Museum name, collection identification, box number and specimen number within each box.
basisOfRecord	The specific nature of the data record (i.e. PreservedSpecimen).
eventDate	Event date in the format YYYY-MM-DD if the date is known to the day, or YYYYMM if only the month and the year are known, or YYYY if only the year is known.
Year	Year of capture if known.
Month	Month of capture if known.
Day	Day of capture if known.
verbatimEventDate	Date of capture, if known, in format DD/MM/YYYY.
scientificName	Lowest taxonomic rank possible, usually the species name. If the species is unknown, the genus or family names are given.
Kingdom	Kingdom (i.e. Animalia).
Phylum	Phylum (i.e. Arthropoda).
Class	Class (i.e. Insecta).
Order	Order (i.e. Hymenoptera).
family	Family name.
genus	Genus name.
specificEpithet	Species epithet of the scientificName.
sex	Male (M) or Female (F).
taxonRank	Taxonomic rank of the most specific name in the scientificName.
IdentifiedBy	Name of the entomologist who identified the specimen, if indicated by the label.
dateIdentified	Year of identification, if known.
identificationVerificationStatus	Whether (coded 1) or not (coded 0) the identification was recently (since 2009) checked.
decimalLatitude	Geographic latitude (in decimal degrees) of the location.
decimalLongitude	Geographic longitude (in decimal degrees) of the location.
geodeticDatum	Coordinate system and set of reference points upon which the geographic coordinates are based (i.e. WGS 84).
coordinateUncertaintyInMeters	Uncertainty in coordinates (a few hundred meters at most).
Country	Country of capture (France)
countryCode	Two letter country code of the specimen origin (FR).
stateProvince	French departmental administrative division (Corse-Du-Sud).
locality	Location of capture, usually the locality (3 locality : Loretto, Suartello and Vignola).
verbatimLocality	Any geographical indication on the label (commune of ajaccio).
InstitutionCode	Place where the specimen is held (University of Corsica - CRIGEN-ENGIE).
CatalogNumber	Box identifier within each Museum.

occurrenceRemarks	Any ecological data or comment on the label.
RecordedBy	Name of collector.
OrganismQuantity	Number of individuals bearing the same label (usually 1).
OrganismQuantityType	Individuals.
previousIdentifications	Species name originally given by the original collector, if different from scientificName.
georeferencedBy	Identity of the person who added the Latitude and longitude data, usually Maestracci, Pierre-Yves.
georeferenceProtocol	How the georeference was computed, i.e. from label data (Locality).
georeferenceSources	Georeference code was inferred from geoportail.fr.
georeferencedDate	Georeference work was performed in 2023.
language	The data set is mainly written in French, apart from column headings, which are in English
CollectionCode	
locationRemarks	

ADDITIONAL INFORMATION

Specimen identification

Morphological identifications (Hymenoptera and Lepidoptera: P-Y Maestracci and A. Cornuel-Willermoz, Diptera and Coleoptera: L Plume, Syrphidae: V. Sarthou and T. Lebard) and CO1 barcoding (unpub. data).

Morphological identifications were possible thanks to reference works (Michez et al. 2019, Rasmont et al. 2021, Cooper et al. 2022, Albouy and Richard 2017, Jiroux et al. 2019, Sapoll 2018, Sarthou and Sarthou 2021) and checklists (Ghisbain et al. 2023, Wiemers et al. 2018).

Specimen preservation methods

Dried and pinned specimens, and specimens in 70° alcohol.

Contacts

University of Corsica: gibernau_m@univ-corse.fr and maestracci_p@univ-corse.fr

Dataset management

UnivCorse: maestracci_p@univ-corse.fr

GENERAL DISCUSSION

Global abundance & Diversity

Over the 13 months of the study spread over 2 years, a total of 4012 specimens were sampled, high numbers of specimens were obtained in spring (March-June) and in September-October (Figure 2).

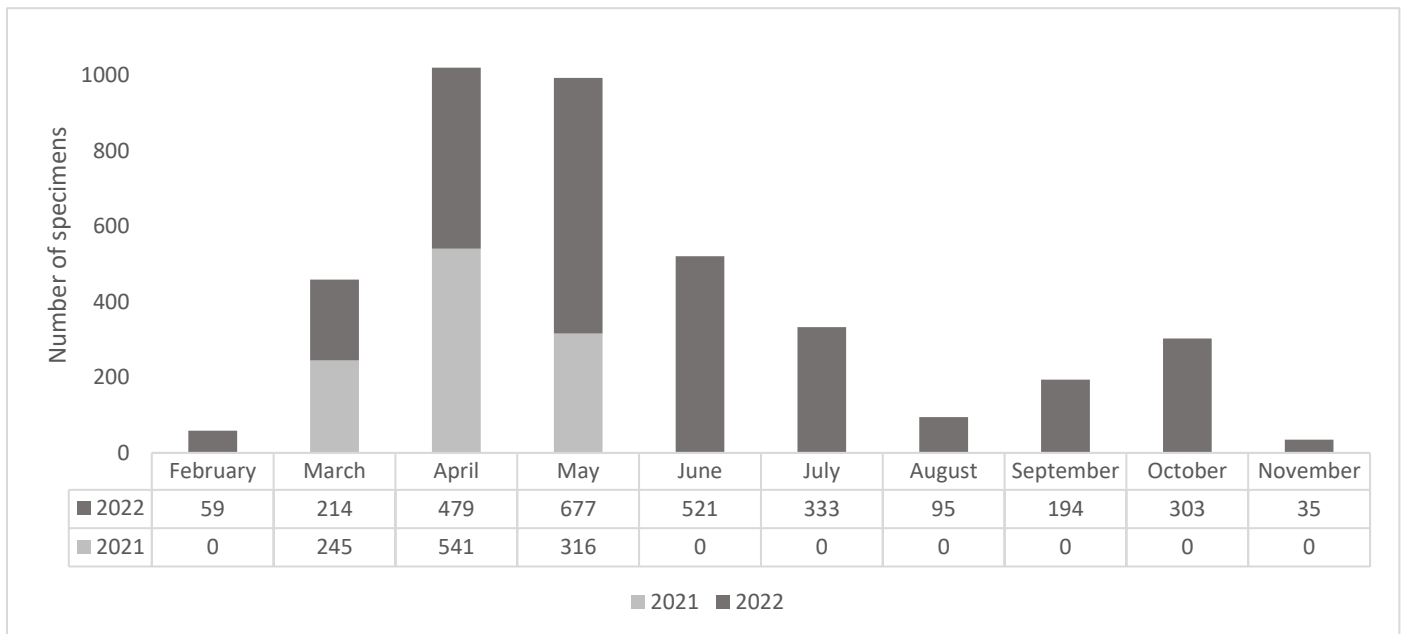


Figure 2.

Monthly variation of sampled specimens in 2021 and 2022.

Our database represents a total of 270 insect species and morpho-species. The richest insect order was the Hymenoptera with 38,9% of the morpho-species, followed by the Coleoptera (27,4 %), the Diptera (24,4 %) and finally the Lepidoptera (7,8 %). On the other hand, the Coleoptera was the most abundant insect order representing 54,3% of the sampled individuals, with notably two species *Psilothrix viridicoerulea* (403 insects) and *Tropinota squalida* (282 insects). The Hymenoptera was the second most abundant insect order representing 33,6% of the specimens, and the two most represented species were *Apis mellifera* (318 insects) and *Bombus xanthopus* (214 insects). Lastly, the Diptera (6,5%) and the Lepidoptera (3,8%) were the less abundant orders in our sampling.

Site specificities

When calculating the sampling completeness of the three sites, the diversity of Suartello (0.73) and Loretto (0.80) appeared to have been better sampled than from Vignola with a completeness

of only 0.61. Consequently, the estimate of total species richness (Table 6) was higher in Vignola (249.2 by Chao1 or 244.3 by ACE) than in Loretto (214.3 by Chao1 or 213.1 by ACE) or Suartello (241.9 by Chao1 or 233.7 by ACE). Such result is partly due to relative a higher percentage of singletons (species sampled only once) in Vignola (41,8% of the 153 species) than in Loretto (29.8% of the 171 species) or Suartello (33.3% of the 177 species).

Table 6.

Diversity indices (number of species and specimens, Shannon index and the estimate number of species with the improved Chao1 estimator or the Abundance-base Coverage Estimator) for the 3 sites obtained with Past 4.14 statistical software (Hammer et al. 2001).

	Loretto	Suartello	Vignola
Taxa_S	171	177	153
N	1439	1562	1011
Shannon	4.125	4.095	4.073
iChao1	214.3	241.9	249.2
ACE	213.1	233.7	244.3

When looking at the site differences in terms of species composition (Table 7), the site of Vignola appeared to be slightly more different from the other two sites (Loretto and Suartello). Such diversity difference could be due to the geographical distance, the coastal location (Figure 1) and/or the specificity of the site in terms of habitat and vegetation (Table 1).

Table 7.

Beta diversity (Whittaker) comparisons among the studied 3 sites (Past 4.14 statistical software, Hammer et al. 2001)

	Loretto	Suartello	Vignola
Loretto	0	0,33908	0,37654
Suartello	0,33908	0	0,41212
Vignola	0,37654	0,41212	0

Globally, our sampling of the floral visitors on the 3 studied sites in 2021 coincided with 3 months (March, April and May) of our survey of 2022 (Figure 2). The abundances of monthly sampled insects varied significantly among the two years ($\text{Chi}^2=109.3$, $\text{df}=2$, $p<10^{-5}$). In March no inter-annual differences were found but in April proportionally more insects ($n=541$) were captured in 2021 than in 2022 ($n=479$, $p<10^{-5}$) and on the opposite in May proportionally more insects ($n=677$) were sampled in 2022 than in 2021 ($n=316$, $p<10^{-5}$, Fig.2 and Fig. 3 left).

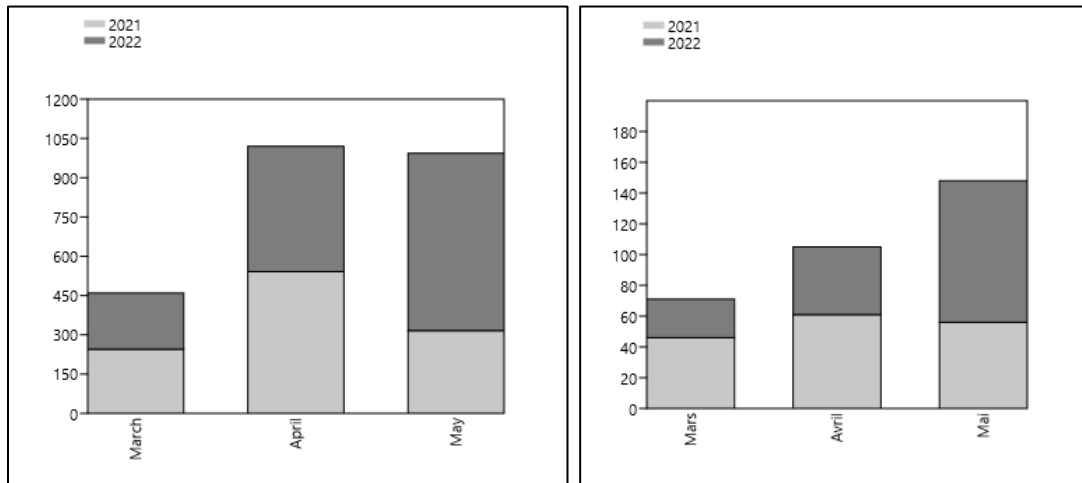


Figure 3.

Inter-annual variation of insect abundance (left graph) and insect species diversity (right graph) variation over 3 months

The total species richness of monthly sampled insects varied significantly among the two years ($\text{Chi}^2=17.7$, $\text{df}=2$, $p<1.4\times 10^{-4}$). Contrary to the abundances, no difference in species diversity was detected between April 2021 and 2022. On the other hand, March 2021 was proportionally richer (46 species) than March 2022 (25 species, $p=0.035$) whereas it was the contrary in May with 2021 been significantly poorer (56 species) than May 2022 (92 species, $p=2.3\times 10^{-4}$; Fig. 3 right).

The monthly species diversity per order also significantly varied between the two years ($\text{Chi}^2=38.21$, $\text{df}=15$, $p<8.3\times 10^{-4}$). No species diversity was detected for Lepidoptera, represented by a low number of species (≤ 4). For Hymenoptera, a significant inter-annual species diversity was found only in May with 6 more species in 2021 than in 2022 ($p=0.041$). For Coleoptera, the poorest month was March both in 2021 and 2022 (6-8 species), but a different species diversity in May, 2021 been proportionally less diverse (18 species) than 2022 (48 species, $p=0.00015$). Finally, for the Diptera, at least twice the number of species were sampled in March and April 2021 (14-15) in comparison to 2022 (4-7) ($p\leq 0.035$).

Monthly annual variation in 2022

In 2022, insect visiting flowers were sampled during 10 successive months (Fig. 2). Interestingly the annual distribution of specimens was not homogenous and varied among insect orders (Fig. 4). Coleoptera are mainly present in spring (April, May and June) representing 82.4% of the sampled beetles (1257 insects). Hymenoptera appeared to be present evenly all year round. Diptera are mainly active on flowers at the end of summer (September and October) with 56.4% of captured flies (123 insects). Finally, Lepidoptera were rare in our sampling (maximum of 26 specimens during a given month) but their number appeared to linearly increase between spring and autumn (Fig. 4).

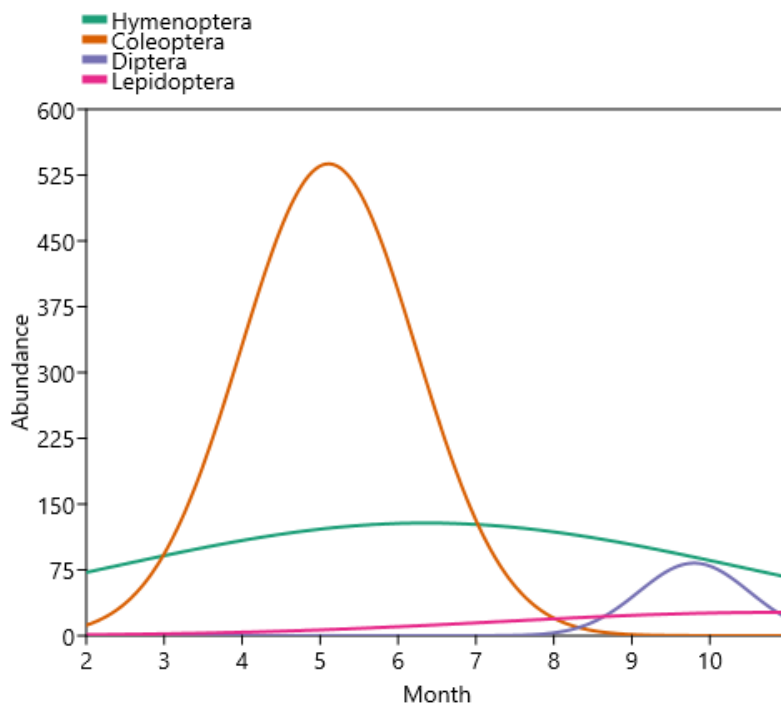


Figure 4.

Insects' abundance sampled according to orders and months (module Species packing Gaussian, Past 4.14 statistical software)

In terms of species diversity per insect order, slightly different results were obtained (Fig. 5). For Coleoptera, as for the abundance, the species diversity occurred mainly during the late spring (May and June) with 89% of the Coleoptera diversity sampled during these two months

which represent 27.1% of total species diversity. On the other hand, the species diversity of Hymenoptera is higher in summer (June and July and August) with 78% of Hymenoptera diversity sampled during these three months, representing 30.9% of total species diversity. The species diversity of Diptera presented a different pattern been low at the beginning of the year (February) and regularly increasing during the year until reaching a maximum in October relatively low during all the year until autumn. In fact, 67.3% of the species diversity of Diptera were captured in September and October, representing 14.8% of the total species diversity. Finally, the species diversity of Lepidoptera is relatively low (maximum 4 species) and quite regular through the year (Fig. 5).

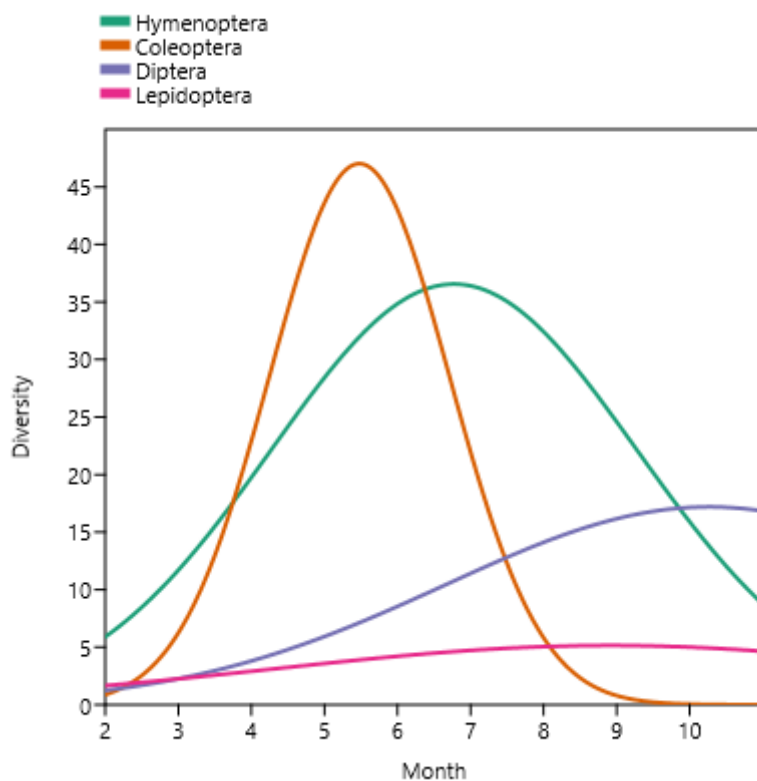


Figure 5.

Insects' diversity sampled according to orders and months (module Species packing Gaussian, Past 4.14 statistical software)

CONCLUSION

In our data the diversity of orders of flower-visiting insects and their relative abundance are not linked. Beetles are by far the most abundant with more than 1 in 2 individuals belonging to this order. The latter is not the most diverse since one species in three is a Hymenoptera.

By considering the entire year rather than a limited period as is generally the case in other studies, we consider to have obtained a better representation of the Mediterranean insect

community visiting flowers with an almost exclusive presence of Coleoptera in spring and early summer, and Hymenoptera, Diptera and Lepidoptera until late in the year. Indeed, the climate of Corsica, and more specifically the coastal climate, allows late flowering of plant species, and therefore a late period of activity for the associated insects. In addition, the observed inter-annual variations of these flower-visiting insects, both for the abundances and the species diversities, suggest that these insect communities are highly dynamic.

The insects visiting flowers represent an important proportion of the insect diversity and focusing on these communities is interesting for understanding their complex insect-plant interactions at the ecosystem level. Our next work will focus on establishing the pollination efficiency of these different flower-visitor insects and further studying these plant-insect interaction networks.

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