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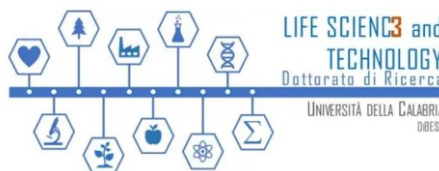


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Biodiversity and sustainable agriculture production in Calabria, southern Italy

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Aim of research

Biodiversity is indispensable for the functioning of ecosystems and includes plants, animals and micro-organisms that coexist and interact with each other. Currently, factors such as human activity, introduction of alien species, use of pollutants, fragmentation and consequently reduction of habitats, limited trophic availability and climate change are causing a drastic decline in biological, genetic and habitat diversity (Colazza *et al.*, 2018; PNR 2021-2027) and, for these reasons, it is essential to take actions to protect and safeguard it at all levels. Pollinators are extremely sensitive and vulnerable to human disturbance and, for examples, prolonged exposure to chemical pesticides can impair their learning capacity, short-term memory and orientation, leading a reduction in pollination rates of both cultivated and wild plants (Ispra, 2020). In addition, climate change causes a no overlapping between the flowering period and the phenological rhythms of oligolectic species, closely related to particular plant essences. This phenomenon, often overlooked, is particularly alarming because it can cause the extinction of many animal and plant species. Furthermore, the placement of hives in natural environments due to the increase in the beekeeping industry leads to interspecific trophic competition between domestic and wild bees (Mouillard-Lample *et al.*, 2023). The majority of flowering plant species require pollination to produce fruit and seeds and it is also known that entomological biodiversity contributes to improving the quality of plantations and, consequently, agricultural products, especially if sustainable cultivation practices are adopted. In agroecosystems, the preservation of uncultivated ecotonal areas is important as they are reservoirs of biodiversity, providing feeding and shelter sites for numerous pollinator species (Colazza *et al.*, 2018; Bortomeus *et al.*, 2014). Despite their importance, in Italy (and especially in the South) there is no available data about the faunal community and the conservation status of Italian bees. It is crucial to study wild bees to assess species presence, their abundance and their distribution in natural settings and in agroecosystems, with particular reference to oligolectic species, which are more sensitive to environmental variations (Danforth *et al.*, 2019).

In forest habitats, saproxylic beetles are used as bioindicators of the health and conservation status of these peculiar ecosystems and they are crucial to maintain ecosystem balance. In fact, saproxylic insects depend on decaying wood during at least one stage of their life cycle and they are important because, by feeding on the dead wood, they recycle essential nutrients. However, wrong silvicultural practices, as the removal of fallen logs and perishing trees, can interrupt the nutrient recycling and eliminate entire populations of saproxylics. Some species of saproxylic are protected by law and many beetles are included in the IUCN Red List of Italian Saproxylic Beetles (Audisio *et al.*, 2014).

The agroecosystems of the Sila Plateau are immersed in distinctive landscapes contexts dominated by natural and semi-natural vegetation ecotones. Ecotones create unique environmental conditions that must be enhanced and protected. The main objective of the research project is the study and safeguard of entomological diversity in both mountain and agricultural contexts located within Sila Plateau, to assess possible differences based on vegetation and land use. Specifically, agroecosystems dedicated to the cultivation of Sila IGP potatoes were selected for the project activities and investigated for the first time in

order to identify species of agronomic interest, phytophagous and insect antagonists. Another aim of the project is to assess the health status of pollinator populations linked to natural areas and agroecosystems by verifying the potential impact of agricultural practices adopted by the chosen farms.

Carabidae, the main soil bioindicators for assessing environmental quality, were also analysed. A bioindicator is an organism that responds predictably and rapidly to disturbance factors. The presence (or absence) of some species indicates environmental quality and the impact of human activities on ecosystems. From a naturalistic perspective, the main biological characteristics of Carabidae include dispersal power (the presence or absence of membranous wings suitable for flight), geographic distribution (from wide distribution to endemism), diet and degree of specialization and species diversity (Brandmayr *et al.*, 2005). Soil fauna also play a key role in environmental quality. In particular, underground biological forms can indicate the degree of soil alteration by the QBS-ar method. This method is based on the organism's morpho-physiological adaptation to soil life. In fact, edaphic fauna have a higher EMI value than less adapted forms. The value is assigned based on certain morphological features, such as the presence or absence of eyes, number of legs and body coloration (<https://www.arpa.veneto.it>).

Current growth in food demand as a result of the increasing human population requires immediate alternatives to the use of synthetic fertilizers. Green agricultural innovation involves experimenting with new and organic techniques (Bogusz *et al.*, 2021; Klamsteiner *et al.*, 2020; Houben *et al.*, 2020). For example, some insects, are bred to produce animal feed, for aquaculture and for human diet; their mass farming generates large amounts of waste, known as frass (excrements and exuviae) that could be used as a biofertilizer in order to contribute to the development of resilient and sustainable agriculture (Zim *et al.*, 2022). In light of this, another objective of the research is to analyse the use of frass of some insect species through both laboratory and field tests. Firstly, the laboratory tests evaluated the vegetative response and growth of *Solanum lycopersicum* cv. Micro-Tom plants, while the field test at the open area Laboratory of Forensic Science and General and Applied Entomology of DIBEST, UNICAL, evaluated the influence of frass on soil biological quality.

1. Introduction

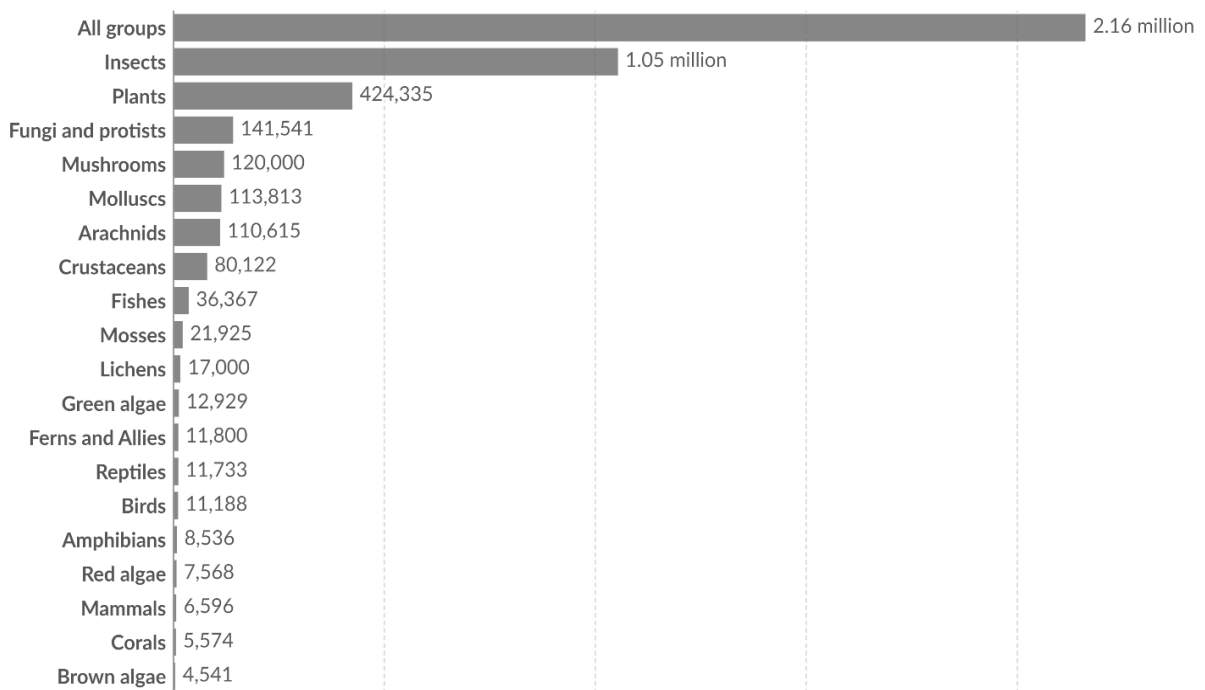
1.1 Biodiversity

Biodiversity is the variability among living organisms in all existing ecosystems. Current biodiversity is originated from millions of years of evolution and now it is influenced by natural processes and human activity (Gaston & Spicer, 2004; Rawat & Agarwal, 2015). Among Eukaryotes, more than 2 million species have been described and, of these, more than a million are insects (Graph 1.1) (<https://ourworldindata.org>).

Number of described species



The number of identified and named species in each taxonomic group¹, as of 2022. Since many species have not yet been described, this is a large underestimate of the total number of species in the world.



Data source: International Union for Conservation of Nature (IUCN) Red List (2022)

OurWorldInData.org/biodiversity | CC BY

1. **Taxonomic group:** A taxonomic group is a category in the scientific classification of living things, based on shared characteristics and genetic similarity. It is arranged in a hierarchical system, with each group being more specific than the one above it, and all groups forming the entire classification of living things.

Graph 1.1 Number of Eukaryotes currently described (ourworldindata.org)

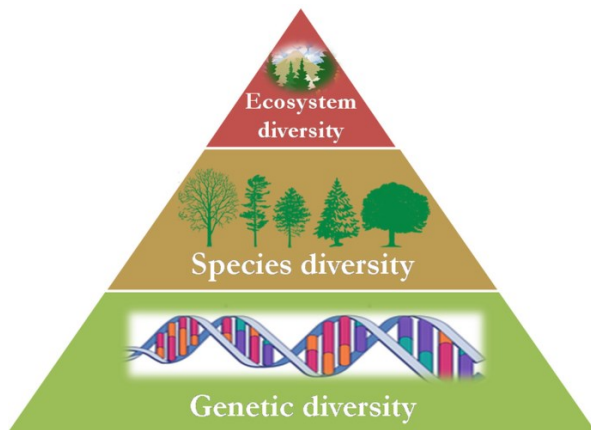


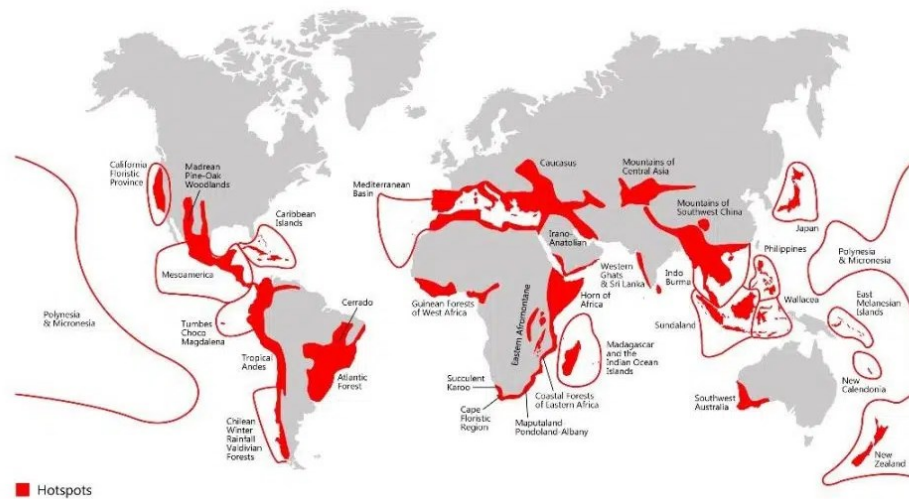
Figure 1.1 Biodiversity pyramid (Nonić & Šijačić-Nikolić, 2021)

Biodiversity is studied at the genetic, species and community levels (Fig. 1.1) and all these levels are essential for the persistence of ecosystems balance (Levin, 2001; Primack, 2007; Verma, 2016). Biodiversity corresponds to intraspecific genetic variability between geographically separated populations and between individuals of the same population (Primack, 2007). Genetic variation, in individuals with sexual reproduction, occurs through genetic recombination (Levin, 2001). Undoubtedly, small populations with low dispersal power are more

vulnerable to inbreeding depression due to consanguinity which can reduce the survival and reproduction fitness of organisms. In fact, populations with less genetic diversity may not respond positively to environmental stresses and bottlenecks (Mukhopadhyay & Bhattacharjee, 2016; Nonić & Sijacic-Nikolic, 2021). Nevertheless, high biodiversity value means that communities are more likely to respond positively to environmental pressure (Ryan, 2022). Species richness is the number of species present in a certain habitat (Levin, 2001) and, in healthy ecosystems, community is composed of numerous and equally distributed species. In addition, species depend on each other because all organisms have a key role in maintaining the ecosystem equilibrium (Ebeling, 2014). Biodiversity also includes the differences between the biological communities and the intra- and interspecific relationships (Primack, 2007). Furthermore, biodiversity consist in the variety of ecosystems, such as deserts, forests, wetlands, mountains, lakes, rivers and agricultural landscapes, which are composed of a community interrelating with abiotic factors like air, water and soil around them (Rawat & Agarwal, 2015).

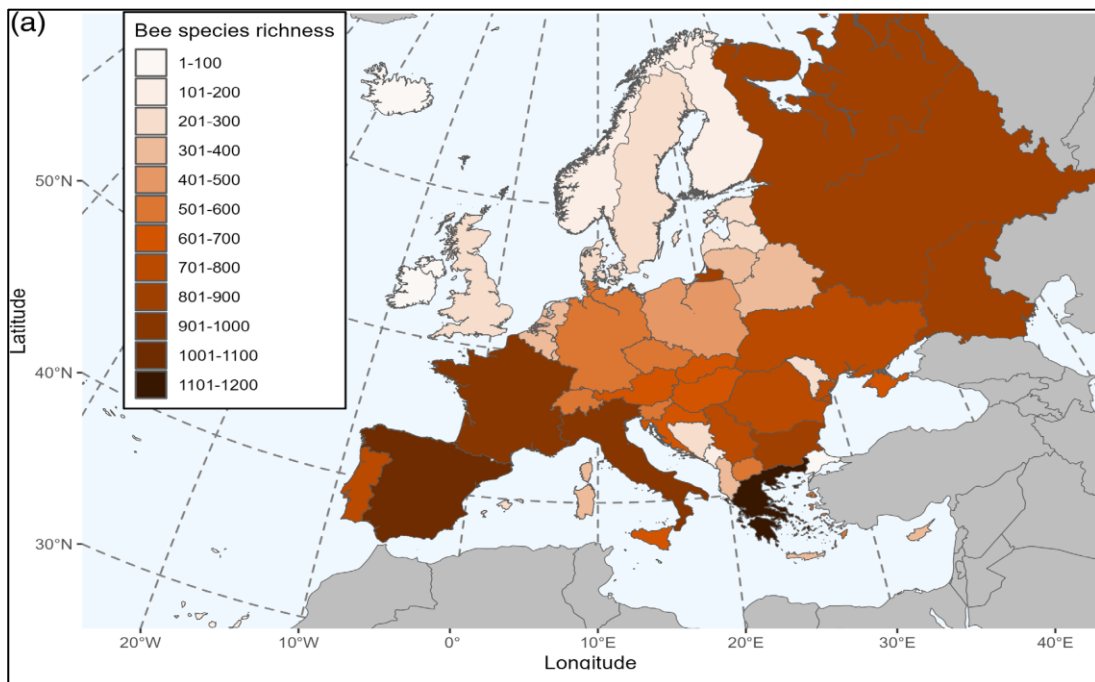
Biodiversity is not equally distributed on Earth. In general, there is a latitudinal gradient where diversity increases from the polar zones to tropics and the equator. In fact, it is higher near the equator thanks to the warm climate and high primary production (Primack, 2007; Rawat & Agarwal, 2015). In terrestrial habitats, species richness is influenced by topography, hydrography, climate and habitats, as well as its paleogeography. Additionally, species diversity decreases at high altitudes and increases with sunlight irradiation and precipitation. Furthermore, complex topography generates a wide variety of habitats, making genetic isolation and eventual speciation possible (Primack, 2007).

Endemism usually refers to species with a restricted or even punctiform distribution. The existence of endemic species is linked to geographical isolation and the geological history of the area. In fact, areas that remained isolated during glaciations and many islands in the Mediterranean Basin are characterised by a high degree of endemism. Endemism is crucial in relation to extinction: if the populations of an endemic species contract to the point of extinction, that species disappears from the planet (Primack, 2007; Isik, 2011).



Map 1.1. Biodiversity hotspots (Mariotti, 2015)

Endemic species are mainly concentrated in areas defined as biodiversity hotspots, where there are 44% of all plant species in only 1,4% of the Earth's surface area (Map 1.1). Initially the biodiversity hotspots identified were 25 (Myers *et al.*, 2000; Rawat & Agarwal, 2015) while now they are 34 and are still being updated (Mariotti, 2015). Hotspots have to satisfy some criteria such as contain a minimum of 0,5% or 1.500 species of endemic vascular species and have lost at least 70% of their primary vegetation (Myers *et al.* 2000). The Mediterranean Basin is one of these biodiversity hotspots and it is divided into ten sub-hotspots based on endemism and floristic richness (Médail & Quezel, 1999). Thanks to its central location in the Mediterranean Sea, Italy has a remarkable biodiversity in terms of species, communities, ecosystems and landscapes, compared to other temperate countries. Furthermore, the Alps, Continental and Mediterranean biogeographical regions are co-present with possible interpenetrations between them despite their differences. Moreover, the Alps and the Apennines create geographical barriers which can influence the mesoclimate and species distribution (Primack, 2007; Mariotti, 2015; Revertè *et al.*, 2023). As we can see from the map (Map 1.2), Italy is one of the richest European countries in wild bees species and this because it was a refuge during glaciation and also because geographically it is extremely close to Africa (Revertè *et al.*, 2023).



Map 1.2. Different bee species richness in Europe (Reverté *et al.*, 2023)

Any strategy for the conservation of biological diversity requires a solid understanding of how many and which species exist and how they are distributed. According to current knowledge, insects are undoubtedly the most diverse group with the greatest number of described species. Moreover, it is estimated that about half of the species that actually exist have been described (Primack, 2007). Knowledge of the world's existing species is far from complete for several reasons, especially for species that are inconspicuous and difficult to sample. Moreover, a general problem that limits the knowledges of biodiversity, and consequently its protection, is the lack of a sufficient number of specialist taxonomists capable of classifying samples to the species level (Raven & Wilson, 1992).

1.2 Threats to biodiversity

Biological communities are strongly threatened by human activities (Naeem *et al.*, 1994) and the genetic diversity can also decrease, even among species whose populations are in good condition (Primack, 2007). Threats to biodiversity can cause extinction of several species in a short time (Primack, 2007; Proenca & Pereira, 2013) especially if they act synergistically: for example, acid rain and deforestation combinations can cause intensely negative effects on trees' health, making them more vulnerable to parasitic attacks (such as fungi, insects and other pathogens) (Myers, 1987; Primack, 2007; Brat & Pathak, 2020). In earlier geological eras, extinction was compensated by the evolution of new species. Instead, now the rate of species extinction is higher than the rate of speciation due to human activity (Leakey & Lewin, 1996; Primack, 2007).

The main pressures on biodiversity can be summarized in (Fig. 1.2):

- Fire, destruction and fragmentation of habitats;
- Pollution;
- Intensive agriculture;
- Climate change and global warming;
- Introduction of alien species and pathogens (Primack, 2007; Rawat & Agarwal, 2015; Colazza *et al.*, 2018).

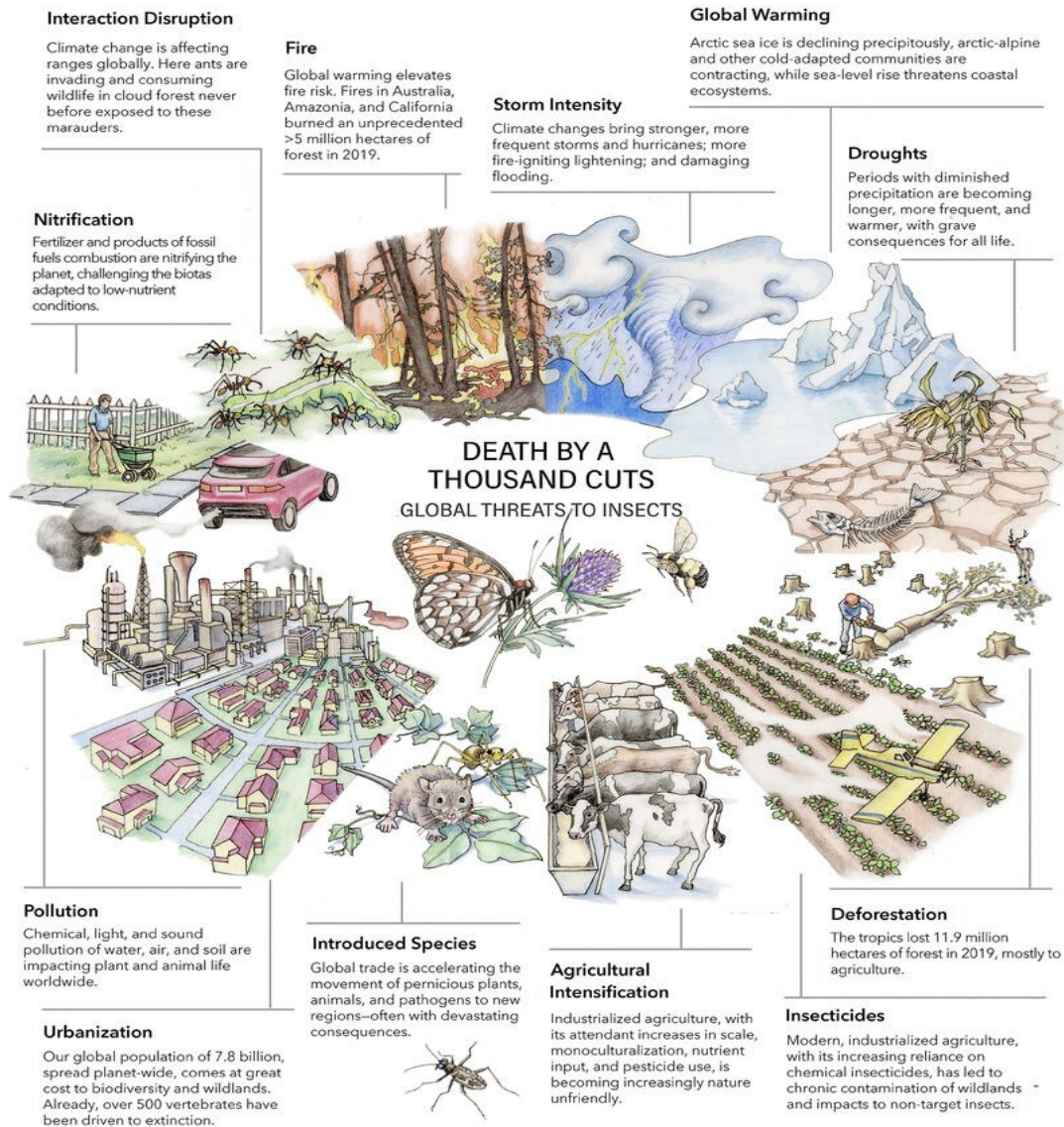


Figure 1.2. Causes of Biodiversity Decline (Wagner *et al.*, 2021)

Due to the increase of human population, many natural environments have been turned into agricultural land. In addition, habitat destruction is also caused by mining and deforestation for logging and urban expansion (Primack, 2007; Wagner *et al.*, 2021). As a result of centuries of human activity, only 10% of the Mediterranean basin's native forests are currently intact (Primack, 2007; Barbera *et al.*, 2023).

Therefore, it is vital to protect and conserve natural habitats, especially those where species, communities or ecosystems of special interest are found (Primack, 2007).

Soil is a highly altered abiotic component in habitats; unsustainable agricultural practices and mechanical tillage erode it, reducing its capacity to absorb and process water. Additionally, intensive grazing and incorrect silvicultural practices have changed the natural vegetation cover and consequently the soil composition. Moreover, it is susceptible to desertification in Mediterranean areas (Allan & Warren, 1993; Primack, 2007).

In addition to the destruction of natural environments, habitat fragmentation (Fig. 1.3) is another cause to the biodiversity decline.

This phenomenon, caused by human activity such as the building of infrastructures, divides a continuous habitat into several sub-areas,

restricting the migration of species, especially those with a low dispersal power. Moreover, fragmentation makes both trophic resources and reproductive partner more difficult to find; additionally, it has an impact on abiotic parameters that are essential for the survival of species like light, temperature, humidity and wind (Allan & Warren, 1993; Primack, 2007; Barbera *et al.*, 2023).

Another risk factor for the environment is the pollution caused by pesticides and synthetic substances used in intensive agriculture, but also from livestock farming and toxic gases emitted by industries and vehicles (Primack, 2007; Ispra, 2020); it has strong effects on climate, biodiversity, agricultural products and human health (Primack, 2007). In addition, deforestation, fire and the over-exploitation of wood for domestic heating have further released more CO₂ into the atmosphere (Primack, 2007). As is well known, biodiversity is strongly influenced by climate change (Bellard *et al.*, 2012). In fact, changing of seasonal temperature alters the phenology, physiology and distribution of species as well as encouraging the settlement of alien species (Primack, 2007). Organisms that are outside their natural range of distribution due to human intervention are known as non-native species (or alien species). In contrast, species that have evolved and spread spontaneously in a certain area are defined as native species (Pellizzari & Dalla Montà, 1997; Primack, 2007). Invasive alien species are a threat to local biodiversity because they can disturb native species through competitions or disease transmission (Pellizzari & Dalla Montà, 1997; Kenis *et al.*, 2009).

Effective conservation plans are necessary to protect biodiversity and to apply them, only a medium-long term monitoring can assess the state of a population over time, which may be stable, fluctuating, declining or growing. In addition, the study of the natural history of rare or threatened species is a pillar in successful conservation programmes (Primack, 2007; Montgomery *et al.*, 2021).

The International Union for the Conservation of Nature (IUCN) has defined different categories of risk and, thanks to their classification, a species can be considered Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT) or Least Concern (LC).

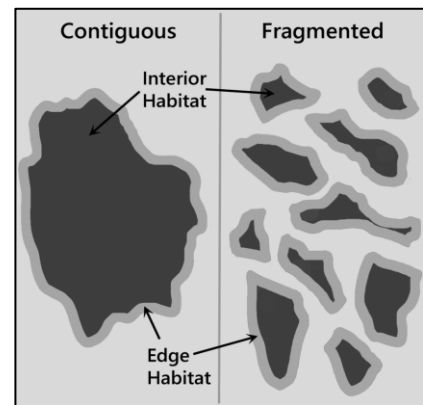


Figure 1.3 Graphic example of habitat fragmentation (www.naturetrust.bc.ca)

However, for many species it is impossible to precisely assess their risk of extinction because there are not sufficient data about their population health (Primack, 2007). The IUCN also collected information about rare species and what measures could be taken to prevent extinction (Begon *et al.*, 2000).

1.3 Entomological diversity and its importance

Arthropods are the largest phylum of living organisms (Levin, 2001; <https://ourworldindata.org>) and among these, insects are the dominant animal group on earth in terms of taxonomic diversity and ecological function (Schowalter, 2006). Currently, the 60% of all described species are insects and the number of undescribed species is quite difficult to estimate (Price, 1997); species are distributed unequally among orders and those with the greatest number of taxa are: *i*) Coleoptera (~ 350.000 species); *ii*) Hymenoptera (~ 250.000 species); *iii*) Lepidoptera (~ 158.000 species); *iv*) Diptera (~ 150.000 species); *v*) Hemiptera (~ 95.000 species) (Fig. 1.4) (Gullan & Craston, 2010).

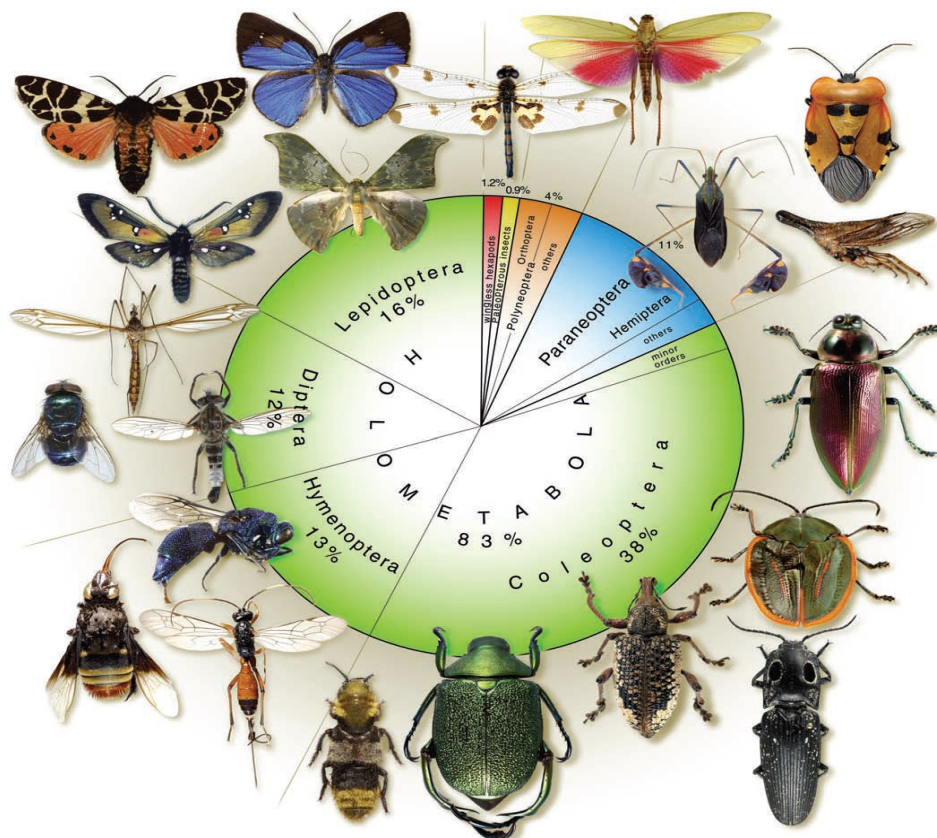


Figure 1.4 Entomological Diversity (Grimaldi & Engel, 2005)

The high species richness depends on several factors:

- Small size;
- Quick life cycle;
- Evolutionary relations with plants;
- Metamorphosis;
- Flying ability.

The small size of insects is a morphological characteristic that allows them to distribute in numerous ecological niches unlike large animals: for example, a single tree can offer trophic resources for a large herbivorous vertebrate while it can support the entire life cycle of several small-sized species with different ecological roles. In addition, small size can reduce intra and inter-specific competition. Importantly, rapid life cycle makes insects better adapt to environmental changes through genetic recombination between generations (Gullan & Craston, 2010; Prince, 2011). Furthermore, their life cycle, which consists of several dissimilar stages, influence speciation because they can use different resources and colonize distinct habitats according to their life stage (Gullan & Craston, 2010; Prince, 2011). Finally, insects are the first organisms to develop flight and therefore they have a high dispersal power (Grimaldi & Engel, 2005).

Insect orders have different morphologies and habits. For example, beetles are characterized by the presence of wings modified in sclerified structures called elytra and below them there are a pair of membranous wings. Although elytra are structures for the protection from dehydration and fungi, generally they make these insects inefficient flyers (Grimaldi & Engel, 2005; Gullan & Craston, 2010). Beetles are all holometabolic and their diet is extremely varied: they could be saprophytes, necrophagous, saproxylic and phytophagous. The European beetles are divided into two suborders, Adephaga and Polyphaga (Fig. 1.4); the second group is the most numerous and it diverges from the first one by the absence of notopleura sutures (Chinery, 2010).

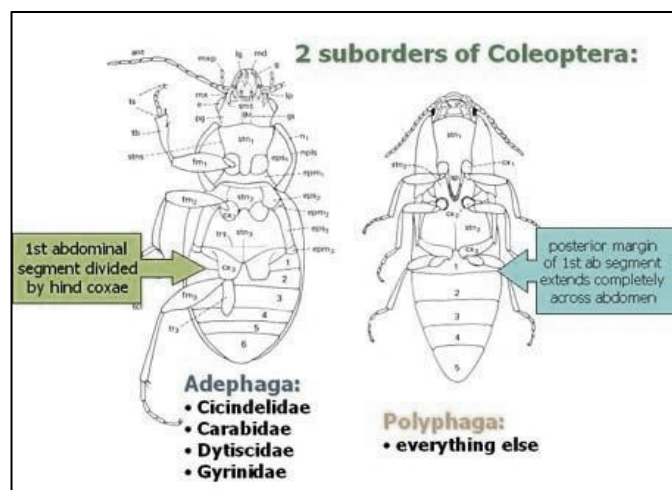


Figure 1.4 Adephaga vs Polyphaga morphology (<https://archivo.infojardin.com>)

Hymenoptera is the most diversified order because it includes ants, wasps and bees. Hymenoptera are divided in Symphyta (Sawflies), which have a conventional trisegmented thorax, and Apocrita (ants, bees and wasps) which present a constriction between thorax and abdomen (Fig. 1.5). Apocrita are an extremely varied group of insects which includes species with different ecological functions, such as ectoparasites, cleptoparasites, predators and pollinators (Branstetter *et al.*, 2017). In this group there are 3 superfamilies: Chrysoidea, Apoidea and Vespoidea (Chinery, 2010).

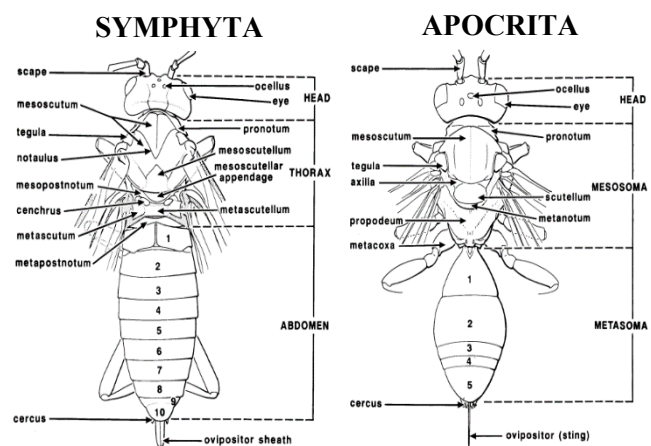


Figure 1.5 Symphyta vs Apocrita morphology (Goulet & Huber, 1993)

Chrysoidea is a very large cosmopolitan group and they are called cuckoo wasps because they are all cleptoparasites of other insects. Instead, Apoidea

have their bodies covered with hairs and special structures for collecting the pollen from flowers. In addition to pollinators, this taxon also includes cuckoo bees that parasitize other species of wild bees. In contrast, Vespidae have a glabrous body and a bright aposematic coloration (Chinery, 2010).

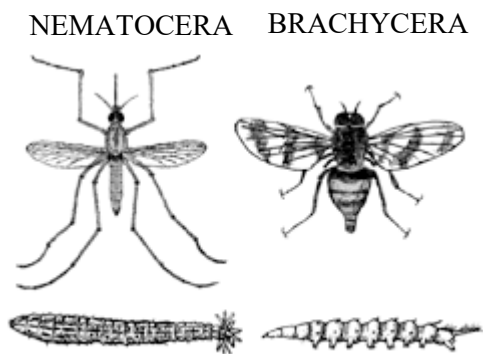


Figure 1.6 Nematocera vs Brachycera morphology (Beracko et al., 2017)

Diptera are divided into two suborders: Nematocera, which includes mosquitoes, and Brachycera, commonly called flies (Fig. 1.6). The peculiarity of this order is the presence of a pair of membranous wings and a second pair modified in two halteres, one on each side and club-shaped, which perform the function to adjust balance during their efficient flight. The differences between the two groups are notably evident: Brachycera have a more robust body with a developed chaetotaxy while Nematocera are slender; in addition, Brachycera have antennae with short arista, whereas in the Nematocera they are long and filiform.

Brachycera also play different ecological roles from the decomposition of organic matter to pollination; they are also holometabolic insects (Chinery, 2010).

Lepidoptera include butterflies and moths (Fig. 1.7). In Italy there are more than 4000 species and, between them, there are important pollinators. These insects are characterized by two very developed pairs of wings, covered by bright and showy scales. In butterflies, antennae are long and clavate while filiform or combed in moths. Lepidoptera are all holometabolic. Adult Lepidoptera feed on sugary substances like nectar, while caterpillars often eat leaves (Chinery, 2010).

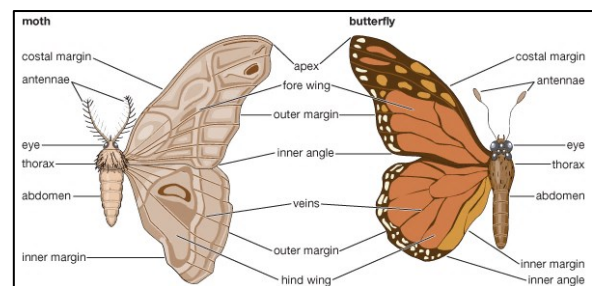


Figure 1.7 Morphology differences between Butterfly and Moth (<https://www.majordifferences.com>)

The order of the Hemiptera is subdivided into two sub-orders: Homoptera and Heteroptera. They are two very divergent groups of insects and the only similar morphological character is a mouthpart modified into a rostrum useful for piercing and extracting liquids from animals and plants. Heteroptera are particularly colourful insects that are distinguished by the presence of a pair of wings modified to form the hemelytra: unlike beetles, in this case wings are membranous in the distal portion and subsequently sclerified near the body. On the other hand, Homoptera (cicadas and aphids) are small insects with two pairs of membranous wings closed as roof in a resting condition (Chinery, 2010).

Finally, Orthoptera includes crickets and grasshoppers. They are divided into Ensifera, with antennae longer than body, and Celifera, with shorter ones. They are elongated insects with particularly developed hind legs for powerful jumping. Characteristic is the species-specific stridulation they emit in the reproductive period. In addition, they have also developed a mimetic coloration that makes them extremely cryptic in the environment (Chinery, 2010).

Insects are extremely significant for the ecosystems balance (Prince, 1997). They play a key role in several ecological functions, such as:

- Transformation of plant biomass into animal biomass through phytophagous species;
- Preys for zoophagous species (both vertebrates and invertebrates);
- Decomposition of woody and plant biomass and recycling of nutrients by herbivorous, detritivores and saproxylic insects;
- Decomposition of animal biomass biomass and recycling of nutrients through necrophagous and saprophagous species;
- Control of animal community by transmission of diseases, predation and parasitism;
- Maintenance of the composition and structure of the plant community through phytophagous and spermophagous species;
- Plant propagation, including pollination and seed dispersal (Gullan & Craston, 2010; Prince, 2011).

1.4 Insects for environmental quality and forest management assessment

The conservation of biodiversity requires the maintenance of healthy and functional ecosystems. Given the inherent complexity of ecosystems, the use of indicator species is crucial to accurately assess the quality of ecosystems. Indeed, bioindicators are widely used for detecting and monitoring environmental changes and, to be considered as effective, they must possess the following characteristics: *i*) a well-defined taxonomy and clearly understood ecology; *ii*) a wide distribution over a large geographic area; *iii*) a specialisation for specific habitat requirements; *iv*) provide early signals of environmental change; *v*) simple and inexpensive sampling; *vi*) a stress response that is representative of other species in the ecosystem (Kremen *et al.*, 1993; Han *et al.*, 2015; Chowdhury *et al.*, 2023).

According to their context, bioindicators are divided in biological, ecological and environmental indicators. The first category is represent by functional groups with considerable diversity in terms of characteristics, species richness or level of endemism used to assess and to identify areas of high conservation value (McGeoch, 1998; Stewart *et al.*, 2007; Chowdhury *et al.*, 2023); the ecological indicators reflect the impact of long-term stress on a biotic system, such as habitat fragmentation or climate change, providing information on ecosystem dynamics, while environmental indicators are used to gather data on local environmental changes, such as soil or water pollution (Gullan & Craston, 2010). Anyway, there are different bioindicator insects that can be used in distinct habitats (Fig 1.8). For example, ground beetles (Coleoptera, Carabidae) communities are useful to assess environmental quality, while the abundance of dung beetles (Coleoptera, Scarabidae) can give information about the seriousness of habitat fragmentation

(Lagiz, 2008; Chowdhury *et al.*, 2023). In contrast, Lepidoptera and Apoidea can be used to assess the degree of pollution in agroecosystems because pollinators are sensitive to heavy metals and pesticides (Sharma & Sharma, 2017; De Groot *et al.*, 2022; Chowdhury *et al.*, 2023). In particular, the wild bees consume and accumulate pollutants from flower nectar, which they then transfer to their nests. In fact, dead bees and their nests are chemically analysed precisely to assess pollutant levels (Porrini *et al.*, 2003; Chowdhury *et al.*, 2023). Moreover, the presence of these pollutants in soil can also be measured through the presence of Formicidae (Andersen *et al.*, 2002; Chowdhury *et al.*, 2023). Dipterans are considered good bioindicators as well: for example, the family Chironomidae show the presence of pollutants in mountain ecosystems through the formation of morphological aberrations on antennae (Chowdhury *et al.*, 2023), while hoverflies are effective bioindicators of the management of forest habitat (Sommaggio, 1999).

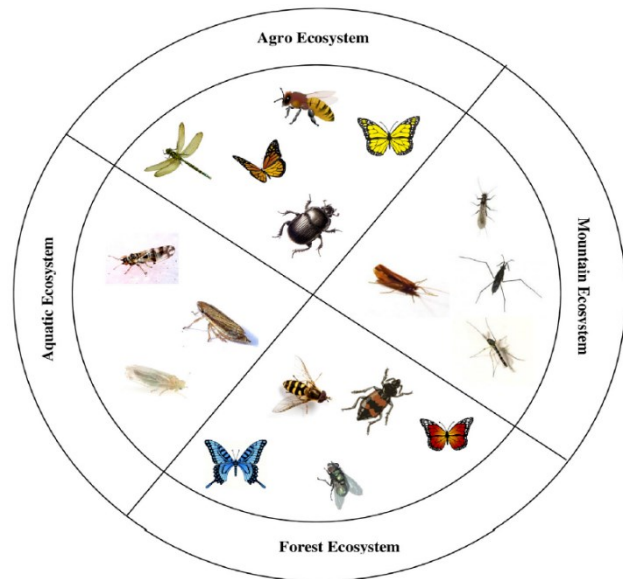


Figure 1.8 Principal insects bioindicators (Chowdhury *et al.*, 2023).

The most widely used and studied bioindicators are ground beetles because they are able to adapt to different environmental conditions. The carabidofauna change in abundance and specific composition according to environmental quality and vegetation cover. Infact, the over 1300 Italian species are distributed in diverse habitat even if the highest number of species is in alpine grasslands, beech forests and mixed oak forests because of altitude, soil type and local climatic conditions (Brandmayr *et al.*, 2005).

In addition to species richness, the distribution range, trophic specialization and dispersal power of carabids should also be considered to assess environmental quality. For example, endemic species, which have a restrict distribution range, are sentinels of good quality while widely distributed species, which are able to adapt to changing conditions, may indicate less environmental stability. Infact, endemic species of ground beetles are more common in beech and oak forests, than in sclerophyll forests or arid Mediterranean landscapes (Baroni *et al.*, 1978; Brandmayr *et al.*, 2005). Brachypterous and zoophagous species colonized generally climax ecosystems, unlike the zoospermophagous and macropterous species which prefer grazing area, grasslands, steppes or other less stable environments and this because a generalist flying species can adapt better to environmental changes than a more specialist ones (Brandmayer, 2005; Mazzei *et al.*, 2015; Mazzei *et al.*, 2017).

For example, several species prefer cool forests, while others, such as *Abax parallelepipedus* (Piller & Mitterpacher, 1783) (Fig. 1.9), are more generalist because they are adapted to various types of woodland.

The presence of some target species, such as *Carabus italicus* Dejean, 1826, can be an indicator of good soil conservation in forests. In contrast, practical genera, such as *Harpalus* Latreille, 1802 and *Amara* Bonelli, 1810, which are generally characterized by metallic coloured liveries, show a close association with herbaceous habitat linked to dietary specialisation. Some examples of opportunistic species which live in cropland soil are *Harpalus distinguendus* (Duftschmid,



Figure 1.9. Individual of *A. parallelepipedus* (F. Carlomagno)

1812) and *Pseudoophonus rufipes* (DeGeer, 1774) (Thiele, 1977; Brandmayr *et al.*, 2005; Pizzolotto *et al.*, 2005; Gobbi & Fontaneto, 2008; Pizzolotto *et al.*, 2008; Pizzolotto, 2022; Pezzi *et al.*, 2024).

To preserve biodiversity, it is essential to pay attention to the forest management practices. In the past, forests were overexploited and rotten wood was often removed because it was considered attractive to pathogens and harmful insects. Fortunately, in recent years, decaying wood has finally been recognised as a pool of biodiversity, as it provides shelter and nutrition, and hosts many different ecological categories (Fig. 1.10) (Motta, 2020). In addition, necromass is important for forest regeneration and the carbon cycle. In fact, dead trees gradually return carbon to soil through their decomposition (Motta, 2020).

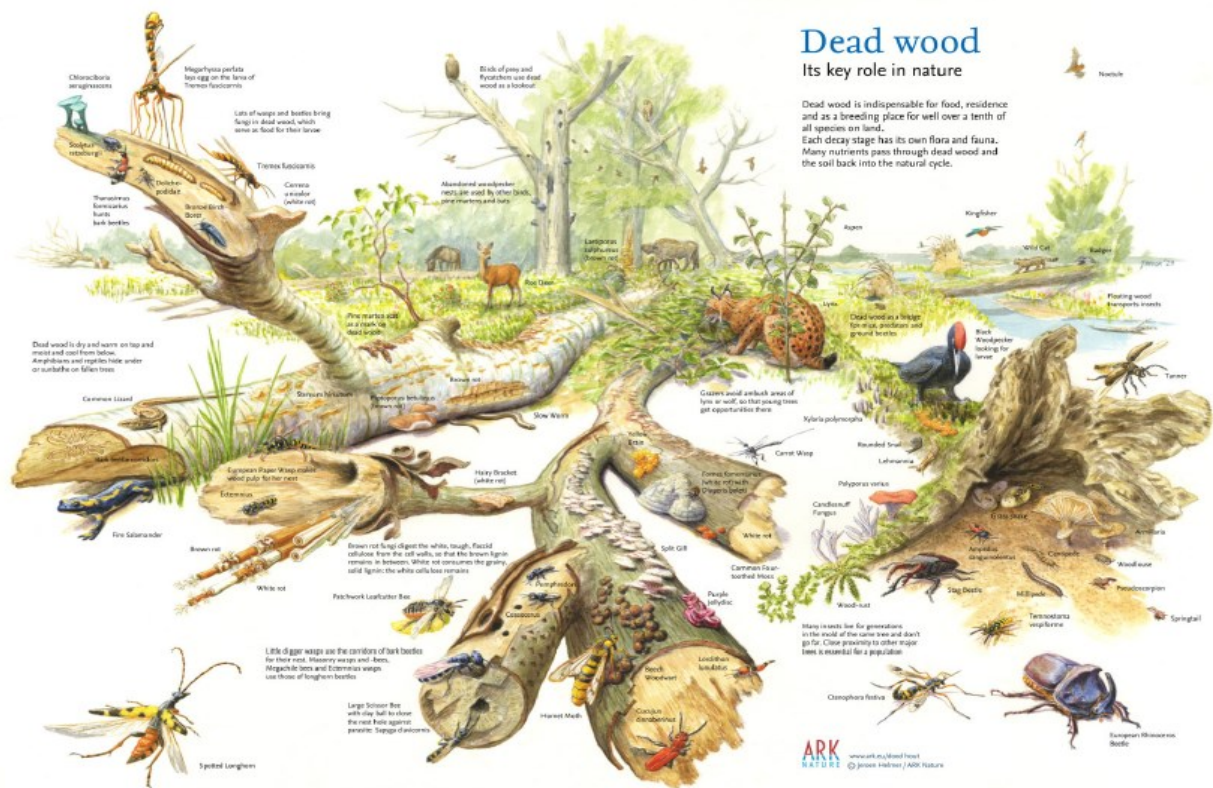


Figure 1.10 Importance of dead wood (www.ark.eu).

Woody necromass is divided in Standing Dead Trees (SDT) and Lying Deadwood. SDT includes dead plants that are still in an upright position while the second category includes trees and branches no longer anchored to the ground. Lying Deadwood are categorized in coarse woody debris (CWD) and fine woody debris (FWD). CDW includes wood with a diameter more than 10 cm while FWD include wood with smaller diameter (Morelli *et al.* 2007; Audisio *et al.*, 2014).

Saproxyllic beetles are insects that are linked to dead and decaying wood for at least a stage of their life cycle. These insects are extremely important in European forest habitat because, together with fungi, they provide the wood decomposition and nutrient recycling in natural ecosystems. Saproxyllic beetles are also an important trophic source for vertebrates and some species participate in the pollination process (Calix *et al.*, 2018). In Italy, research on saproxyllic beetles has increased significantly over the last decade, with a red list of 2049 species of beetles belonging to 66 families (Amori *et al.*, 2022).

Soil is an important and often underestimated store of biodiversity and the soil fauna plays a central role in the functionality of the soil by improving its chemical and physical properties, such as porosity, air circulation and natural matter dissemination. Pedofauna feeds on litter, which is composed by decomposing plant particles and animal debris (Bal, 1970; Gullan & Craston, 2010), recirculating important nutrients. Moreover, interactions between microarthropods and fungi inside the rhizosphere and other soil layers make nitrogen and phosphate more accessible for plants (Gullan & Craston, 2010). In summary, pedofauna diversity increases soil fertility (Jeffery *et al.*, 2010; Maharning *et al.*, 2008).

However, fertilizers, herbicides and synthetic pesticides decrease the abundance and variety of soil communities (Altieri, 1999; Tabaglio *et al.*, 2009). Edaphic fauna has some common morphological and anatomical characters like the reduction of body size, anophthalmia or microphtalmia, apterism or microapterism, reduction of cuticle thickness and depigmentation (Bal, 1970; Gullan & Craston, 2010).

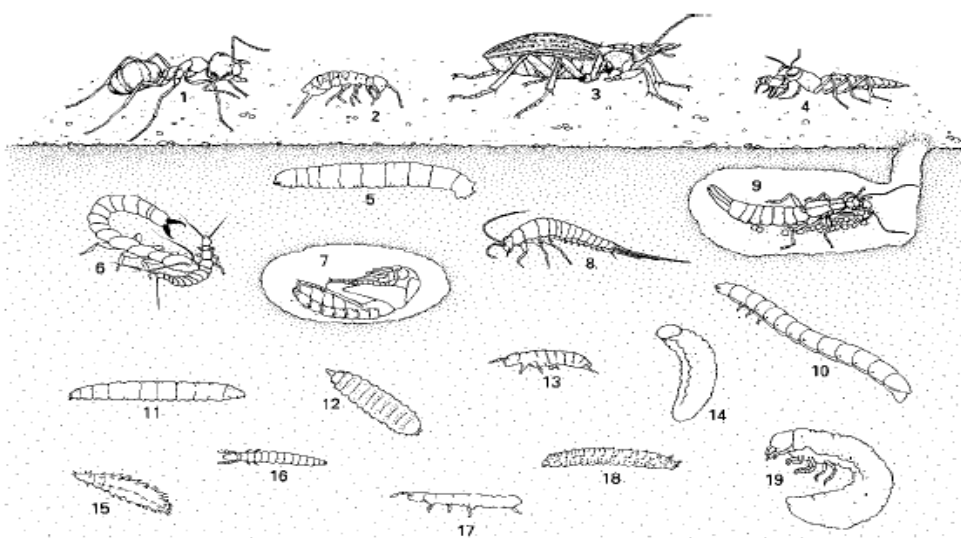


Figure 1.11 Diagram of view of soil profile. The organism deceptive are: Formicidae (1); Collembola (2;13;17); Coleoptera adults (3;4); Dipteran larvae (5;11;12;15;18); Diplura (6); pupa of Coleoptera (7); Archeognata (8); Dermpatera (9); Coleoptera larvae (10;14;19); Protura (16) (Gullan & Craston, 2010).

In the soil profile (Fig. 1.11) there is a gradual transition from the upper layer, composed of naturally fallen material, to the lower one, consisting of well-decomposed litter and humus-rich soil. Generally, arthropods may be restricted to a specific profile layer but their distribution changes seasonally. In particular, the warm deep soil is especially attractive during winter because it is a good way to escape from the low temperatures of surface layers (Gullan & Craston, 2010). Moreover, light penetrates only the first few millimetres of soil, and the temperature, which changes according to every day and seasonal cycles, gradually stabilizes in the lower layers (Condurri, 2005).

The QBS-ar method (Soil Biological Quality) is a biomonitoring technique that evaluates soil quality based on the presence of edaphic arthropods. These organisms are sensitive to soil conditions and their presence/absence is an indicator of soil health. The method is based on the concept of "Biological Form" and uses ecomorphological indices (EMI) to characterize the pedofauna community (Parisi *et al.*, 2005). As a qualitative assessment, it is useful for distinguishing the disturbances and alterations in soil quality more quickly than traditional indicators (Masarin *et al.*, 2006). A QBS-ar index value over 150 means undisturbed rich of organic matter soil, such as forests, and this value indicates good soil biological quality. In contrast, in agrarian and regularly worked soil the index takes values below 100. Values below 50 show poor quality situations while values around 100 indicate adequate soil quality (<https://www.arpa.veneto.it>).

1.5 Pollination

Pollinator populations ensure the reproductive success of plants and they are extremely important for the protection of biodiversity and ecosystems (Ispra, 2020). In fact, plants need pollination for sexual reproduction (Fig. 1.12), which consists of the transfer of pollen grains (containing the male germ nucleus) from the anthers of a flower to the stigma of the same flower (self-pollination) or another co-specific flower (cross-pollination) (Tandon *et al.*, 2016). Subsequently, the pollen tube develops from the stigma and, once the pollen tube reaches the ovule in the female ovary, reproduction occurs (Walker, 2021).

Cross-pollination

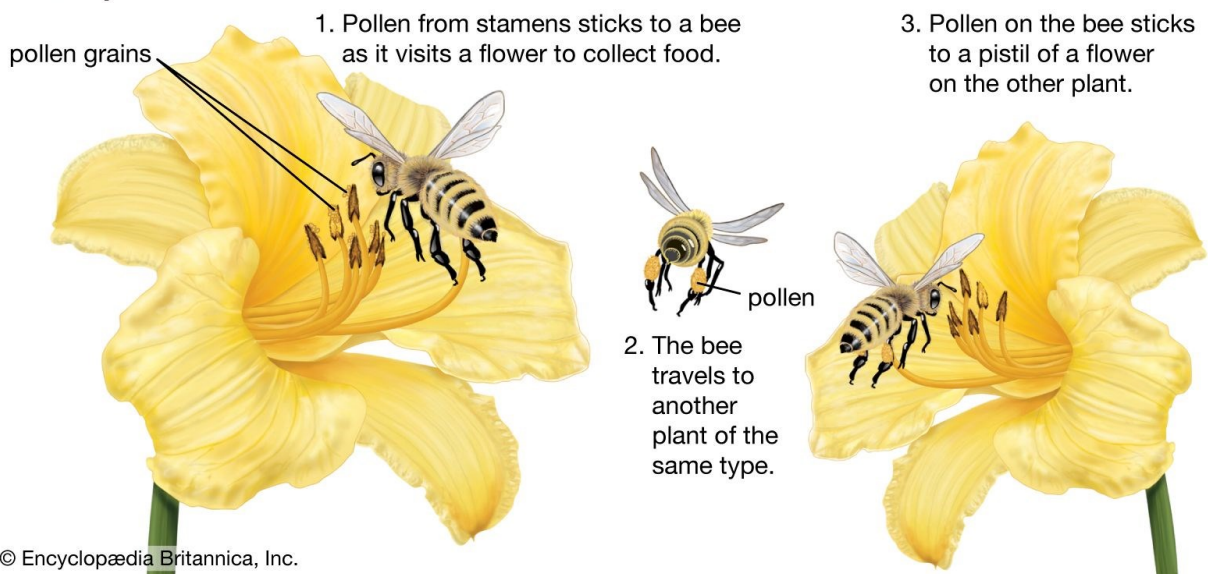


Figure 1.12. Scheme about pollination process (<https://www.britannica.com>).

Pollen can be transferred by wind (anemophily pollination) but entomophilous pollination is more efficient for flowering plants (Walker, 2021) for several reasons:

- Reduction of wasted pollen;
- Pollination under environmental conditions not conducive;
- Increased genetic recombination (Gullan & Craston, 2010).

Cross pollination is an insect-plant mutualistic relationship because, thanks to insects, plants can be pollinated by another conspecific individual to guarantee genetic recombination, while pollinators can feed on pollen and nectar of flowers. To attract pollinators, plants use diverse strategies, such as the movement of the flowers (for bumblebees), visual and olfactory signals and the production of trophic rewards (Faheem *et al.*, 2004; Khalifa *et al.*, 2021). Nectar is a solution of glucose, fructose and sucrose while pollen is a high protein substance composed of starch, lipids, vitamins and inorganic salts (Kevan & Baker, 1983; Ollerton, 2017). Generally, it is more advantageous for plants that pollinators are specialised organisms, faithfully visiting only the flowers of one or a few plant species, as they are much more effective than generalists (Gullan & Craston, 2010; Ollerton, 2017).

Pollinators share common morphological characteristics such as a body covered with bristles (Fig. 1.13) and a mouthpart suitable for nectar harvesting. The bristles hold pollen, which is transferred from a flower to another (Ispra, 2020).

The main pollinators are Coleoptera, Diptera, Hymenoptera and Lepidoptera (Fig.1.14). Normally, these insects visit the flowers mainly to obtain trophic resources but some species, especially beetles, can use flower as a shelter or as a predation site, thus becoming accidental pollinators (Gullan & Craston, 2010; Ollerton, 2017).

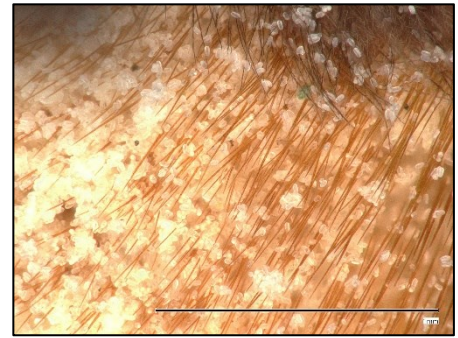


Figure 1.13 Pollinia on Scopa of a wild bee (F. Mendicino).



Figure 1.14 Pollinators. In **A**: individuals of Lycaenidae; in **B**: individual of *Bombylius* sp.; in **C** individual of *Oxythyrea funesta*; in **D** individual of *Habropoda tarsata* (F. Carlomagno).

Cantharophily is the pollination made by beetles. Among Coleoptera, the families of main flower visitors are: Buprestidae, Cantharidae, Cerambycidae, Cleridae, Dermestidae, Lycidae, Melyridae, Mordellidae, Nitidulidae and Scarabaeidae (Gullan & Craston, 2010). In particular, Coleoptera are considered the most primitive pollinators as they were already well differentiated during the Angiosperms evolution (Kevan & Baker, 1983) but, despite this, beetles are identified as “secondary pollinators” both because they have not specialized structures for pollination and they often can damage the flowers’ corolla (Potts *et al.*, 2021; Muinde & Katumo, 2024).

Myophily, on the other hand, is pollination by flies that visit flowers in search of nectar, although Syrphidae feed mainly on pollen (Gullan & Craston, 2010). Many dipterans are able to use different food sources, so their pollination activity is quite unpredictable. However, their abundance makes them important pollinators for many plants, especially to compensate the wild bees decline (Gullan & Craston, 2010). Hoverflies play a significant role in the pollination of several plants (Potts *et al.*, 2021), especially those with hidden nectar such as *Ranunculus* sp. (L., 1753), *Gallium* sp. L., 1753, *Matricaria* sp. L., 1753, *Chrysanthemum* sp. L., 1753, *Taraxacum* sp. F. H. Wigg, 1780 and *Mentha* sp. L., 1753 (Drabble & Drabble, 1917). As well as hoverflies, Bombyliidae are important too in pollination process because they have a long sucking mouthpart which is suitable for flowers with deep corolla (Kevan & Baker, 1983). Pollination by Hymenoptera is called sphecophily. Insects belonging to the superfamilies Ichneumonoidea, Vespidea and Chalcidoidea are strongly specialized in pollinating *Ficus* spp. Tourn, 1753. Ants are rather poor pollinators, although for some species of plants the myrmecophily is known (Levin, 2001). Bees are generally considered the most important pollinating insect group (Kevan & Baker, 1983) and they collect nectar and pollen for their offspring, as well as for their own diet (Gullan & Craston, 2010). Another pollinator group is Lepidoptera, which feed on flowers using a long proboscis. Phalaenophily (pollination by moths) is typically associated with light-coloured hanging flowers with crepuscular or nocturnal anthesis while psychophily (pollination by butterflies) is related with diurnal anthesis (Gullan & Craston, 2010; Kevan & Baker, 1983).

1.5.1 Importance of Apoidea

As previously discussed, the most specialized pollinators are Apoidea (Fig. 1.15). Bees do not refer only to the honey bee, but to a multitaxon of wild bees (Danforth *et al.*, 2019). Unlike honey bees, wild bees are mostly solitary. The female of solitary bees are all capable of producing progenies, building and maintaining their own nest and looking for the floral resources (pollen and nectar). However, some solitary bees form community nests where several active breeding females share a common area. In these communities, each female behaves as a solitary bee and there is no cooperation



Figure 1.15 Individual of *Andrena* sp. (F. Carlomagno).

between them. In contrast, social bees have a reproductive division of work, which means that the queen bee is only interested in generating progeny while the other females both build and defend the nest and collect pollen and nectar for the developing offspring (Danforth *et al.*, 2019; Richards, 2019).

There are deep differences between solitary and social bees. The time life in solitary bees is shorter than eusocial and social bees. Generally, socially bees are multivoltine, unlike solitary bees. In addition, the foraging distance from the nest in solitary bees is much smaller (sometimes on the order of 300-500 m from its nest) than those of social bees. In fact, social bees, thanks to communication between colony mates, can

fly farther (in some species in the order of a kilometre). Moreover, the species richness of solitary bees is highest in arid regions with a Mediterranean climate because these regions have an extraordinarily high plant diversity and highly seasonal rainfall rates. In contrast, the biodiversity of social bees is highest in the humid tropics. The aim of these differences in distribution are several. Firstly, solitary bees generally nest on land and, for this reason, prosper in humid soil is not advantageous for them because fungi could invade the broad. Secondly, blooming period in arid and desert environments are short and solitary bees can schedule their emergence to coincide with blooming, while social bees need flower resources for much longer time therefore they need longer blooms (Danforth et al., 2019; Ispra, 2020).

Solitary bees build nests in various substrate. In particular, the majority (64%) build it in the ground (Fig. 1.16) while others in wood, in cut stems or using already existing cavities which are closed with their glandular secretions, floral oils or a combination of sand and plant products, like pieces of leaves (Danforth et al., 2019).



Figure 1.16 Nest of *Colletes hederæ* (F. Carlomagno).

Bees have a several adaptations which make them specialized in feeding pollen and nectar. They have, in fact, a ligula in their mouthpiece useful to collect the nectar. The morphology of ligula divides Apoidea into short-tongued (ST) and long-tongues (LT) bees (Fig. 1.17). The ST are Colletidae, Halictidae, Andrenidae and Melittidae while Apidae and Megachilidae are LT bees (Danforth et al., 2019).



Figure 1.17 Different morphologies tongue. In **A** the short-tongued *Andrena tibialis* (Kirby, 1802) (Fam: Andrenidae); in **B** the Long-tongued *Eucera nigrescens* Pérez, 1879 (Fam: Apidae) (F. Mendicino)

Moreover, wild bees have evolved diverse structures to collect pollen which could be taken with their head, legs and different part of meso- and metasoma. A structure suitable for collecting pollen is the pollen brush present on the last pair of legs of all females, except in Megachilidae, where it is below the abdomen (Fig. 1.18); in addition, cuckoo bees have not brush. The most widely used method for collecting pollen is called "scrabbling" (Thorp, 2000; Michez et al., 2019) and it is a movement that bees perform on the anthers of flowers while collecting pollen on the head, legs and mesosoma. Other pollen collection strategy is called

"drumming" (Cane, 2017), in which they give abdominal blows: this movement is realized by the Megachilidae which have evolved a developed brush on the abdominal sternites (Danforth *et al.*, 2019).



Figure 1.18 Different scopa. In **A** *Osmia nivetata* (Fabricius, 1804) (Fam: Megachilidae) with pollen brush under abdomen; in **B** *Andrena nigroaenea* (Kirby, 1802) (Fam: Andrenidae) with pollen brush on hind legs (F. Mendicino).

Furthermore, not all species of bees feed at the same time of day. Most species fly from 9:00 to 16:00, with a single mode distribution of activity that generally reaches its maximum during the hottest part of the day. However, many bees show a different time of flight. For example, some wild bees forage in the early hours of the day and in late afternoon, with a marked break at mid-foraging activity, while others do not start foraging until sunset (Griswold & Parker, 1988). Temperature is a clear element of the foraging behaviour of wild bees. However, unlike many insects, bees are also optional endotherms and can regulate body temperature through a variety of mechanisms (Danforth *et al.*, 2019). The minimum thorax temperature required for bee flight is between 20°C and 30°C (Willmer & Stone 2004). Therefore, bees which live in cool and temperate habitats must increase their thorax temperature. Similarly, bees living in warm environments must cool their thorax muscles to avoid exceeding the critical upper temperature. Body size is another determining factor in the temperature control capacity of bees. Larger bees are better able to warm up in cool conditions, but overheat with high temperatures. Conversely, smaller bees need more time to warm up but are able to tolerate higher temperatures. Several studies have demonstrated that in warm and temperate habitats, larger bees limit foraging early morning and in late afternoon, while small and medium-sized bees can feed at midday (Danforth *et al.*, 2019). The evening and sundown bees, on the other hand, show both behavioural and morphological adaptations to forage in the dark. Generally, they have a large body to permit them to warm up rapidly during the night. Nocturnal and twilight bees have a lighter colour, probably because they are not exposed to the strongly UV radiation present in bright sunlight (Danforth 1989; Faheem *et al.*, 2004).

Bees can be oligotrophic, polytrophic and monotropic. The oligotrophic species feed on nectar of species of the same genus whereas the polytrophic species feed on pollen of plants of different taxa. In contrast, monotropic species feed on the pollen of a single species. Oligotrophic species frequently have to compete with generalist and specialist trophic resources. Specialist species, however, are much more resourceful in collecting pollen than generalists. Furthermore, oligolectic bees gain an advantage over polytrophic bees

by maintaining a close synchronization with their target plant, especially in arid or rigid habitats (Danforth *et al.*, 2019; ISPRA, 2020).



Figure 1.19 Image to raise awareness of the decline of wild bees (<https://davidsuzuki.org>).

Wild bees are in strong population decline and therefore it is essential to implement monitoring plans (Fig. 1.19); in Europe 45% of the species of bumblebees are considered in decline due to habitat loss, climate alteration, exposure to pesticides and pathogen spread (Nieto *et al.*, 2014). *Apis mellifera* Linnaeus, 1758 is the most widespread non-native bee. Colonies are composed of thousands of polytrophic bees and they consume huge quantities of pollen and nectar.

It has been estimated that a single colony of honeybees can eat pollen like about 111.000 offspring of solitary bees in 3 months. Nevertheless, there does not seem to be a trophic competition between honey bee and wild bees, probably because honey bees, communicating in the colony, can quickly move too far and more rewarding floral resources (O' Neal & Waller, 1984; Cane & Tepedino, 2017).

Global warming and consequent increase of temperatures can drastically modify the areal of bee species and can also affect the floral resources such as the number and size of flowers, quality and quantity of nectar and pollen and floral perfume. Moreover, climatic change can alter spatial and temporal synchrony between plants and their pollinators and it could have huge repercussions on the reproductive success of bees and plants and their long-term variability (Memmott *et al.*, 2007; Brown & Paxton, 2009; Danforth *et al.*, 2019; Decourtye *et al.*, 2019; ISPRA, 2020). Finally, the intensive grazing of large mammals is impactful on wild bees because vertebrates alter the arrangement of floral resources and the nesting environment (Danforth *et al.*, 2019).

1.6 Phytophagous insects

Plants provide food for a wide range of phytophagous, which can be classified in according to the diversity of plant species they feed on. In particular, phytophagous insects can be divided into monophagous, oligophagous or polyphagous species. Monophagous insects are highly specialized to feed on a single plant species while oligophagous feed on a limited number of related species. Finally, polyphagous insects are generalists and they are able to exploit a wide variety of plants (Gullan & Craston, 2010; Cates, 1981; Prince, 2011).

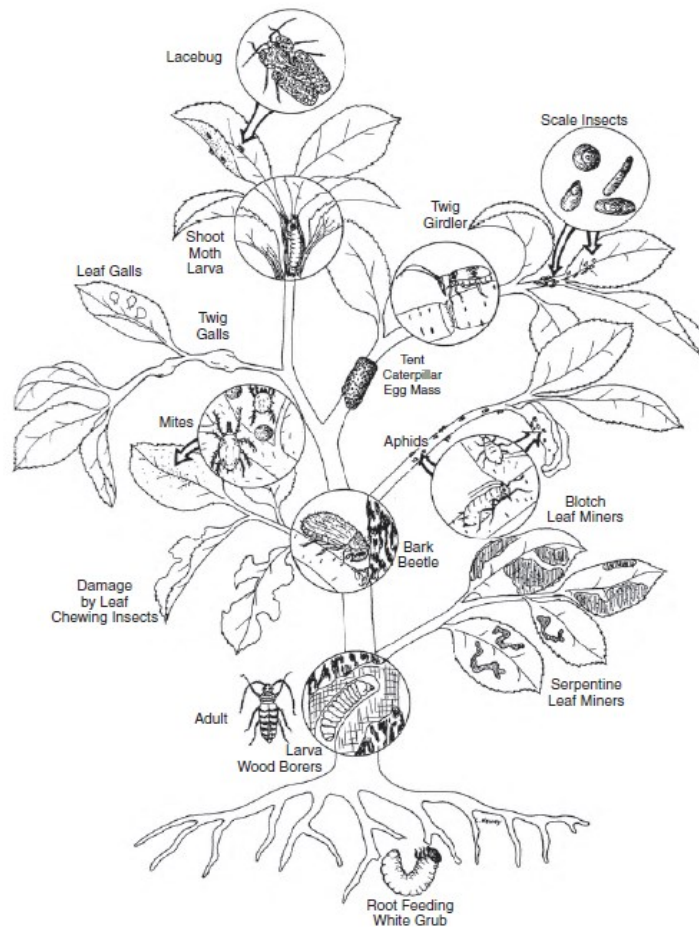


Figure 1.20 Distribution of different phytophagous species on a plant (Prince *et al.*, 2011).

Phytophagous insects can also be classified into chewers, sap suckers and endophages and, according to this, they can be placed in different areas of the plants (Fig. 1.20). For example, the chewers are Lepidoptera and Coleoptera, which feed on leaves, flowers, pollen, inflorescences and fallen seeds (Prince, 2011). Beetle larvae belonging to families Elateridae, Tenebrionidae, Curculionidae, Scarabaeidae and Chrysomelidae (Alticinae and Galerucinae) often are root-feeding and detecting their presence is quite complicated and, for this reason, they can cause the collapse of plants (Gullan & Craston, 2010).

Visible damage to plants is caused by defoliating insects which are generally easier to identify than small gallogenic insects. Large populations of defoliators cause serious economic losses, especially in forestry

and agriculture, and for this reason reliable and reproducible methods are often needed to limit the damage. Moreover, plants are not all same attractive and vulnerable to pest attacks and this difference may depend on the nutritional value and the degree of sclerification of the leaves (Gullan & Craston, 2010; Prince *et al.*, 2011).

The trophic activity of phytophagous significantly affects the reproductive fitness of plants, as they feed on vital plant tissues, fruits and seeds. The most damaging fruit-feeding insects belong to the orders Diptera, Lepidoptera, Hemiptera and Coleoptera (Gullan & Craston, 2010; Prince *et al.*, 2011). Having higher nutrient concentrations than other plant tissues, seeds are a target trophic resource and the main spermophagous insects are beetles, ants (*Messor* Forel, 1890 and *Pheidole* Westwood, 1839) and some bedbugs (Fam: Lygaeidae, Pentatomidae and Scutelleridae) (Gullan & Craston, 2010). Unlike the other groups, the action of ants is not entirely harmful as they transport the seeds inside the anthill, where germination of the seedlings is often helped (Gullan & Craston, 2010; Kergoat *et al.*, 2015; Burt *et al.*, 2022). Many plants develop broad-spectrum defences against phytophagous and pathogenic species. Mechanical defences include spines or pubescence on stems and leaves and the accumulation of silica or sclerenchyma in tissues. In addition, many plants can produce defensive secondary metabolites or allelochemicals, which include phenols, terpenoids, alkaloids, cyanogenic glycosides and sulfur-containing glucosinolates. These compounds can act as repellents, inhibiting insect grazing or egg laying and also reducing the nutritional value of plant parts (Gullan & Craston, 2010; Latif *et al.*, 2017; Santamaria *et al.*, 2018).

1.6.1 Invasive alien species

In recent decades, several alien species have been recorded in Italy (Pellizzari & Dalla Montà, 1997; Pellizzari *et al.*, 2005) due to the human activities, climatic conditions and the strategic position in the Mediterranean Sea. Alien species are considered as one of the threats to biodiversity loss (Kenis *et al.*, 2009) because they could compete with native species for trophic resources and territory (Jucker & Lupi, 2011). Short-range expansion is mostly attributed to the dispersal power of adult insects, while long-range expansion is often the result of unintentional movements induced by human carriage. In addition, the rates of spread of invasive species are strongly influenced by habitat fragmentation (Perrings *et al.*, 2010). Fortunately, only some alien arthropods become harmful and once the species has established itself, damage can only be severe when the population is sufficiently large (Sakai *et al.*, 2001). In addition, an alien species could arrive in a potential new habitat during a season that is not favourable for the insect, imposing challenges to its survival and establishment. For example, the larvae of *Leucinodes orbonalis* Guennée, 1854 (Lepidoptera, Pyralidae) were recorded in Milan Airport during a phytosanitary control of imported eggplant fruits in winter and, luckily, the temperature was unsuitable for the development of the insect



Figure 1.21 Individual of *Harminia axyridis* (<https://www.inaturalist.org>)

(Jucker *et al.*, 2007). However, if it arrived in the spring or summer, a potential colonisation can not be excluded. In addition, a tropical or subtropical species could survive the winter in greenhouses or houses in a temperate climate. The white fly *Trialeurodes vaporariorum* (Westwood, 1856) (Hemiptera, Aleyrodidae) and *Harmonia axyridis* Pallas, 1773 (Coleoptera, Coccinellidae) (Fig. 1.21) represent two examples of the application of this strategy in Italy (Jucker & Lupi, 2011).

Moreover, climate change may alter biodiversity and provide new opportunities for alien species introduction in areas where previously they were unable to survive (Sutherst, 2000). For example, the Mediterranean fruit fly, *Ceratitis capitata* Wiedemann, 1824 (Diptera, Tephritidae) (Fig. 1.22), is native to sub-Saharan Africa and it is a highly polyphagous phytophagous currently distributed in areas below 41° parallel. In Northern Italy, this species cannot overwinter in outdoor during their pre-imaginary stages while adults can survive indoors for long periods (Rigamonti, 2004). Although, climate change, with the progressive increase in global temperatures, could promote a colonization of *C. capitata* at higher latitudes (Jucker & Lupi, 2011). Initial colonization is favoured if there is the ability to establish a self-sustaining population with asexually reproduction or switch between r- and k-selected strategies (Sakai *et al.*, 2001). Invasive alien species can act as vectors of pathogens (nematodes, fungi, viruses, bacteria) for plants and animals. For example, in 1983 the American *Frankliniella occidentalis* (Pergande, 1895) (Thysanoptera, Thripidae) was recorded for the first time in Europe and it is the primary vector of the tomato spotted wilt virus, a thoughtful illness of numerous crops of worldwide economic importance (Pellizzari & Dalla Montà, 1997; Jucker & Lupi, 2011).



Figure 1.22 Individual of *C. capitata* (<https://www.wikipedia.org>)

Among Hemiptera, more than 50% of alien species attack woody plants, while 34% are phytophagous on various herbaceous plants (Jucker & Lupi, 2011). In 2002, the Asian Psyllidae *Acizzia jamatonica* (Kuwayama, 1908) was recorded for the first time in Italy (and in Europe), where it was introduced with its ornamental host plant, *Albizia julibrissin* Durazz., 1772 (Alma *et al.*, 2002; Jucker & Lupi, 2011). Western conifer seed bug *Leptoglossus occidentalis* Heidemann, 1910 (Hemiptera, Coreidae) is a dangerous American pest of conifer seeds and since its introduction in Italy, the production of pine nuts has rapidly declined in quantity and quality (Roversi *et al.*, 2011). In addition, the Homoptera *Corythucha ciliata* (Say, 1832) and *Corythucha arcuata* (Say, 1832) are introduced in Italy from North America and respectively they feed on *Platanus* spp. (L., 1753) and *Quercus* spp. L., 1753 (Bernardinelli & Zandigiacomo, 2000). Among the fruit plants, the species *Vitis vinifera* L., 1753 was seriously attacked by the American *Scaphoideus titanus* Ball, 1932 (Hemiptera, Cicadellidae), an alien species introduced in

Europe and nowadays common in vineyards; it is the vector of the golden flavescence, a vine disease caused by the bacterium *Candidatus Phytoplasma vitis* (Angelini *et al.*, 2001). Another vine parasite is the American *Erythroneura vulnerata* Fitch, 1851 (Fam: Cicadellidae) (Duso *et al.*, 2005). Several citrus pests are located in Italy and among them there are *Aonidiella citrina* (Coquillett, 1891) (Hemiptera, Diaspididae), *Aphis spiraecola* Patch, 1914 (Hemiptera, Aphidae), *Aleurothrixus floccosus* (Maskell, 1896) and *Aleurocanthus spiniferus* (Quaintance, 1903) (Hemiptera, Aleyrodidae) (Jucker & Lupi, 2011).

Some alien beetles have easily acclimatized in our country. For example, one of the most widespread pests in our territory is *Leptinotarsa decemlineata* Say, 1824 (Fig. 1.23). This American species is considered a harmful defoliator of potatoes (*Solanum tuberosum*); feed damage can cause a significant loss of yield. Tomatoes and eggplants may be attacked too in the field, but they can also feed on wild Solanaceae species (EFSA *et al.*, 2020). Additionally, *Diabrotica virgifera* Le Conte, 1898 (Fam: Chrysomelidae) is considered the main corn pest in North America; this insect colonized Italy in 1998 and now it occupies all the corn area in northern and central Italy (Miller *et al.*, 2005). Moreover, the red palm weevil *Rhynchophorus ferrugineus* (A.G. Olivier, 1791) (Fam. Dryophthoridae) is native of southern Asia and its first Italian record is dated in 2004 in Sicily. Today, this pest is found in the majority regions of peninsula (Longo *et al.*, 2005). Among the most harmful species to woody plants there are the Cerambycidae *Anoplophora chinensis* (Forster, 1771) and *Anoplophora glabripennis* (Motschulsky, 1854) (Colombo & Limonta, 2001; Maspero *et al.*, 2007). Both are dangerous xylophagous species to many broad-leaved plants. In Italy, more than 18.000 plants have been removed in an eradication programme of *A. chinensis* and the cost of this process was around 12 million euros (Jucker & Lupi, 2011).



Figure 1.23 Larvae of *Leptinotarsa decemlineata* (F. Mendicino)

Among the alien Lepidoptera, there are some species that cause serious economic and ecological damages, such as *Paysandisia archon* (Burmeister, 1880) (Fig. 1.24). It is a South America palm pest and it has easily established itself in our country, especially on the Mediterranean shores (Espinosa *et al.*, 2003). Originally, it fed on the palm *Trithrinax campestris* (Burmeist.) Drude & Griseb., but in Europe this species changed hosts and now it is adapted to the only native European palm, *Chamaerops humilis* Linnaeus, 1753 (Montagud, 2004). In 2008, the tomato moth *Tuta absoluta* (Meyrick, 1917) was recorded for the first time in Italy and it represents a pest of several Solanaceae plants, especially tomatoes ones (Viggiani *et al.*, 2009), while alien defoliation that attack



Figure 1.24 Individual of *Paysandisia archon* (<https://verdepubblico.it>)

woody plants are *Cameraria ohridella* Deschka & Dimic, 1986, *Parectopa robiniella* Clemens, 1863 and *Phyllocnistis citrella* Stainton, 1856 (Fam: Gracillariidae) (Butin & Fuhrer, 1994; Jucker & Lupi, 2011).

The Asian wasp *Vespa velutina* Lepeletier, 1836 (Hymenoptera, Vespidae) is a predator of Apoidea and, thus poses a risk the local beekeeping as well as autochthonous wild bees' biodiversity (Cerri *et al.*, 2022), while the Cinipidae *Dryocosmus kuriphilus* Yasumatzu, 1951 is one of parasite of chestnut which cause serious economic losses. This species was documented for the first time in Italy in 2002 and now it is present in many regions of the country (Melika *et al.*, 2002; Jucker & Lupi, 2011).

Among the fruit parasites that cause economic losses, in Italy we find the oriental fruit fly *Bactrocera dorsalis* (Hendel, 1919) (Diptera, Tephritidae) (Nugnes *et al.*, 2018) and *Rhagoletis completa* Cresson, 1929 (Duso, 1991). In addition, the Americans *Liriomyza trifolii* (Burgess, 1880) and *Liriomyza*



Figure 1.25 Individual of *Drosophila suzukii*
(<https://agronotizie.imagelinenetwork.com>)

huidobrensis (Blanchard, 1926) (Diptera, Agromyzidae) cause substantial damage to the green component of plants, especially those in greenhouse (Arzone, 1979; Süß, 1992).

The Asian *Drosophila suzukii* Matsumura, 1931 (Fig. 1.25) (Diptera, Drosophilidae) is a pest of red fruits, plums and other fruits. In Italy the species was recorded for the first time in Trentino Alto Adige in 2009 (Grassi *et al.*, 2011; Jucker & Lupi, 2011) and now it also arrived in Calabria (Bonelli *et al.*, 2022). Today, it represents a serious risk both for many fruit crops and for the underwood in natural habitats.

1.7 Agroecosystem

The agroecosystem is a semi-natural habitat where the production compartment, ecotones and human settlement interact with each other (Fig. 1.26) (Altieri, 1995; Moonen & Barberi, 2008; Norris, 2008; Lele *et al.*, 2013; Liu *et al.*, 2022).

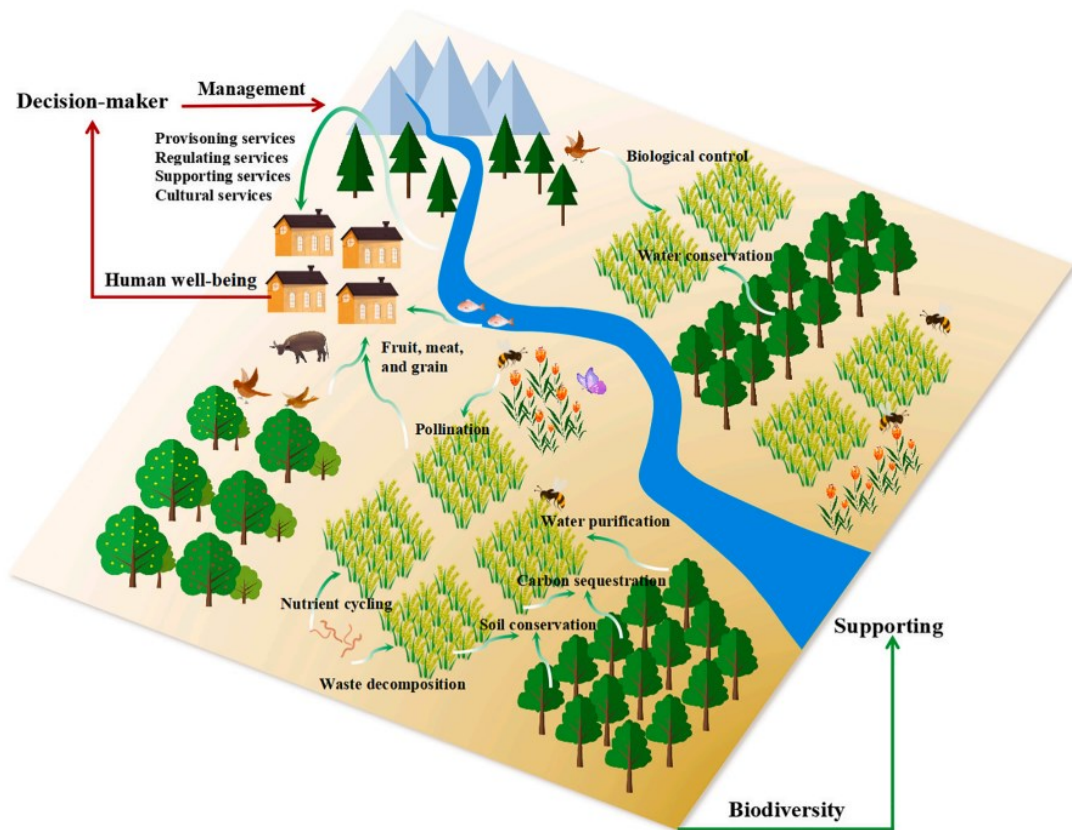


Figure 1.26 Scheme about agroecosystem services (Liu *et al.*, 2022).

Ecotonal areas are crucial because they positively affect soil fertility, pollination, pest control, gas regulation and water purification (Poschlod & Bonn, 1998; Liu *et al.*, 2022) and for this reason several agricultural lands are located in natural environments (Wiggering *et al.*, 2016; Liu *et al.*, 2022). The rates of dispersion between natural and agricultural areas affect the community within the fields (Lens *et al.* 2002), although it will never be the same as the ecotonal habitat (Poschlod & Bonn, 1998; Donald 2004). In addition, some natural components, like shrubs, must be maintained as they play an important role in maintaining the productivity and stability of agroecosystems (Power, 2010). As previously discussed, the soil is also of high importance in maintaining the ecosystem balance (Lavelle *et al.*, 1997) and the conservation of land management practices, such as no-tillage and crop rotation, can promote: *i*) high soil biodiversity; *ii*) mitigation of climate change through carbon sequestration; *iii*) nutrient cycle. Moreover, integrated farming and livestock can provide positive conditions for the development of soil fauna (Kassam, 2020).

1.7.1 Sustainable agricultural production

In the enlarged European Union (EU 27) are present about 103 million hectares of agricultural land (Poschlod & Bonn, 1998). In addition, global food demand is estimated to double by 2050 (Tilman *et al.*, 2002) and, in order to satisfy demand, the agricultural land needs to increase, especially in tropical and subtropical areas of high biodiversity. Furthermore, land conversion for industrial raw materials, such as bioenergy, is increasing (Field *et al.* 2008). For this reason, farmers have intensified their production methods, moving towards agricultural mechanisation and advanced irrigation. In addition, high-yielding crops, that are resistant to disease, and increased use of pesticides and chemical fertilizers are also selected (ISPRA, 2020). This has led to the reduction of traditional European agricultural landscapes, significantly damaging biodiversity and species (Poschlod & Bonn, 1998). In addition, greenhouse gas emissions, soil compaction and degradation, and pollution and eutrophication of water resources, due to nitrogen runoff, are becoming increasingly severe, thus also posing a threat to food safety (Tillman, 1999; ISPRA, 2020; Ollerton, 2017). It is therefore important to regulate the intensity of agricultural management.

As discussed previously, the worrying decline of pollinators is due to the widespread use of insecticides, fungicides and herbicides (ISPRA, 2020; Ollerton, 2017). For example, exposure to sub-lethal pesticides alter the bees' vital functions such as learning, memory and orientation. In particular, the disorientation of bees prevents them from returning to the hives, leading to significant losses in the colonies and compromising pollination of both cultivated and wild plants (Leonard *et al.*, 2018). For this reason, promoting at least integrated management of agricultural land is crucial to balance the economic interests of farmers with the protection of biodiversity. In fact, farmers should be actively involved in the planning and implementation of agrienvironmental policies, to ensure that proposed legislation is feasible and above all socially acceptable (Henle *et al.*, 2008). The European Union (EU) has established severe laws and regulations on both the use and sale of chemical pesticides; in particular, some substances extremely harmful to pollinating insects were recently it banned. To achieve the Green Deal objectives, the European agriculture policy promotes more environmentally friendly farming practices by reducing the use of pollutants and encouraging some possible alternatives to pesticides such as crop rotation, biological control, the conservation of natural areas and the use of organic fertilizers (Colazza *et al.*, 2018; ISPRA, 2020; Porrini *et al.*, 2003).

In addition, agroecosystems optimization must also be directed to maintain non-floral resources essential to pollinators, including Apoidea nesting sites and habitats that will support the larvae of both lepidopteran and dipteran species. Moreover, ecotones and biocorridors can also contribute considerably to pollinators biodiversity, providing habitats and food resources and species migration (Norris, 2008). In addition, mass flowering crops such as rape (*Brassica napus* L., 1753), broad beans (*Vicia faba* L., 1753), sunflower (*Helianthus annuus* L., 1753) and citrus fruits (*Citrus* spp. L., 1753) may have a significant effect. For example, it has been shown that rapeseed not only increases the number of bumblebee colonies but also the abundance and the species richness of wild bees and other pollinating insects that nest in wood cavities or soil (Scheper *et al.*, 2013; Diekötter *et al.*, 2014). Pollination is known to increase the yield and quality of

fruits, nuts, oils and other plant products (Giannini *et al.*, 2015) and it has been estimated that their population generated around 153 billion euros, 9.5% of the total economic value of agricultural production for direct human consumption (Gallai *et al.*, 2009). However, increased production also leads to an increase in demand for pollination services (Montoya *et al.*, 2020). Europe has a number of funding programmes to compensate for any economic losses and promote sustainable agriculture. European agrienvironment programmes (AES) require at least two-year monitoring to assess changes in pollinator populations (Goulson, 2015; Pywell *et al.*, 2011). The Common Agricultural Policy (PAC) is an agreement between Europe and farmers which promotes the creation of habitats and resources for insects, the reduction of pesticides, crop rotation and maintenance of ecotones (fig. 1.27) (ISPRA, 2020).



Figure 1.27 The nine objectives of the PAC post-2020 (ISPRA, 2020)

Like the other EU Member States, Italy has adopted a National Action Plan (PAN) to promote an agriculture that introduces specific measures for the defence of pollinators in protected areas, in the Natura 2000 network and throughout the country. In the period 2015-2019, ISPRA conducted a monitoring project to assess the effectiveness of PAN measures in protecting biodiversity where it has been shown that there are more pollinators in organic crops than in those treated with pesticides (ISPRA, 2020). In conclusion, conservation agriculture includes minimal disturbance of the soil, plant diversity, crop rotation and the preservation of natural grassland areas to obtain better infiltration and retention of water, an increase in soil organic matter, a more efficient nutrient cycle and an increasing of biodiversity, especially of pollinators and antagonists (Brown *et al.*, 2018).

1.7.2 Biological control

The main aim of sustainable agriculture is limiting the phytophagous species in cultivated land without chemical substances (Porhajsova & Babosova, 2022). In fact, the overuse of insecticides can kill antagonistic insects and at the same time select phytophagous-resistant (Georghiou, 1972). Therefore, the use of natural antagonists against pests represent an environmental-friendly strategy (Ozgen & Mamay, 2022), although it often fails to compensate the financial losses. The classical biological control involves the introduction of natural antagonists of harmful alien insects but often it could pose a risk to other native species (Gullan & Craston, 2010; Colazza et al., 2018; Ozgen & Mamay, 2022).

For this reason, the conservation methods remain the most effective strategy because ecotonal habitats (forests, hedges and meadows) contribute to increase the complexity of the agricultural landscape and, consequently, act as biodiversity reserves for many species (Benton *et al.* 2003; Bianchi *et al.*, 2005), such as antagonists (Landis *et al.*, 2000). However, further research is needed to fully understand the dynamics between landscape composition and natural enemies of pest (Bianchi *et al.*, 2006).

The orders with the largest number of parasitoids are Diptera and Hymenoptera (Gullan & Craston, 2010). For example, *Sitophilus zeamais* Motschulsky & V.de, 1855 (Coleoptera, Curculionidae) is a widespread stored rice parasite of the Mediterranean basin and it has been shown to be able to be eradicated by the parasitoid *Anisopteromalus calandrae* (Hymenoptera, Pteromalidae) (Riudavets *et al.*, 2021). *Exorista larvarum* (Linnaeus, 1758) and *Exorista japonica* (Townsend, 1909) (Diptera, Tachinidae) are two parasitoids that effectively reduce the populations of the moth *Lymantria dispar* Linnaeus, 1758 (Dindo & Nakamura, 2018). The superfamily Aleocharinae (Coleoptera, Staphylinidae) have been tested on *Musca domestica* Linnaeus, 1758 (Diptera, Muscidae) and *Delia* sp. Robineau-Desvoidy, 1830 (Diptera, Anthomyiidae) and it was shown that these may have positive effects on their control (Ozgen & Mamay, 2022).

General predator efficacy studies suggest that spiders, ants, ground beetles, Staphylinidae and Coccinellidae can significantly reduce pest density (Symondson *et al.*, 2002). Zoophagous ground beetles show a wide range of food specializations, including consumption of invertebrates such as collembola, snails, slugs, aphids and insect larvae (Kulkarni *et al.*, 2015), as demonstrated by stomach remains analysed in some Carabidae collected in soybean fields, corn and cotton (Matta *et al.*, 2017; Cividanes, 2021). In addition, it has been shown that the combined action between Carabidae and Coccinellidae reduces populations of aphids in the fields of alfalfa (Grez *et al.*, 2011). It has also been shown that *Lebia* sp. Latreille, 1802 (Coleoptera, Carabidae) is an effective predator of the *Leptinotarsa decemlineata* (Say, 1824) (Coleoptera: Chrysomelidae) (Cañas et al., 2002), while the genus *Calosoma* is recognized as efficient predator of the larvae of Lepidoptera (Allen, 1977). In addition, other research highlights that species of genera *Harpalus* and *Pterostichus* are active predators of *Ceratitis capitata* (Nourmohammadpour-Amiri *et al.*, 2022). Moreover, spermophagous species are fundamental too to weed control, such as the genera *Harpalus* and *Amara* (Kromp, 1999)

1.7.3 Alternatives to synthetic fertilisers

Modern agriculture must satisfy the growing world population with efficient food production. As previously discussed, intensive crops have serious environmental effects, such as soil degradation, loss of biodiversity and impurity of air, soil and water (Lindgren *et al.*, 2018). For this reason, sustainable agriculture can restore soil quality through the use of non-chemical fertilizers and pesticides (Farooq *et al.* 2019).

In recent times, the use of insects as food and feed has been attracting increasing interest (van Huis, 2020) and as a result, the number of insect farms is growing fast. One of the waste products from insect livestock is frass (excrements and exuviae) which can be considered as a valid organic fertilizer (Ortiz *et al.*, 2016); it can also be important in the nutrient cycle (Yildirim-Aksoy *et al.*, 2020) as an essential source of nitrogen, carbon, phosphorus and potassium that can be easily assimilated by the roots of plants (fig. 1.28) (Poveda *et al.*, 2019).

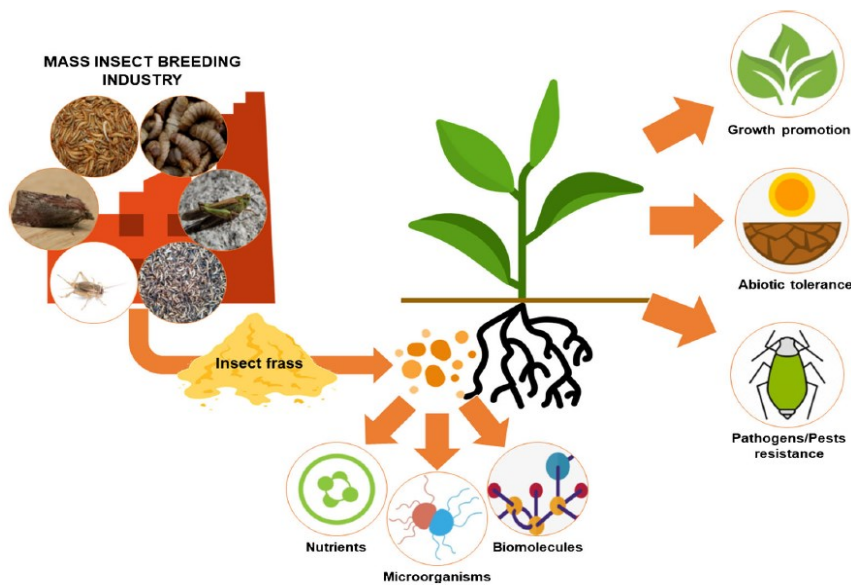


Figure 1.28 Summary diagram of the importance of frass as an organic amendment (Poveda, 2021).

In addition, another important aspect to consider is the intestinal microbiota of insects: it depends on the environmental habitat, insect diet and stage of development (Yun *et al.*, 2014) and it represents a plant growth promoter (PGPM), making plants more tolerant to abiotic stress factors (Poveda, 2021). Moreover, insect chitin is a sugar-amino polysaccharide which has been shown to positively affect plant growth (Barragan-Fonseca *et al.*, 2022). This being so, it is interesting to consider the proposal of a potential circular economy using as fertilisers the frass of different insects bred for both food purposes and waste conversion.

Several insect species are bred for different reasons. For example, *Tenebrio molitor* Linnaeus, 1758 (Coleoptera, Tenebrionidae) represents a more sustainable edible protein source for humans than milk, chicken, pork or beef (Oonincx & De Boer, 2012). Recent trials also indicate that mealworms are a suitable alternative source for broilers and fish (Bovera *et al.*, 2015). Instead, the *T. molitor* frass is recently tested

as a fertilizer and, for example, in bean plants increases the tolerance of seedlings to drought, flooding and salinity (Poveda *et al.*, 2019).

Another species which is widely bred is *Hermetia illucens* (Linnaeus, 1758) (Diptera, Stratiomyidae) because the larvae effectively transform organic matter into high quality fats and proteins (Klammsteiner *et al.*, 2020). In addition, extracting fat from *H. illucens* maggots allows for the production of biodiesel (Li *et al.*, 2011). Existing research have also shown that the frass of the black soldier fly has a positive effect on the growth of basil and lettuce plants (Borkent & Hodge, 2021), ryegrass (Menino *et al.*, 2021) and turnip (Agustiyani *et al.*, 2020).

Moreover *T. molitor* and the migratory locust, *Acheta domesticus* (Linnaeus, 1758) (Orthoptera, Gryllidae) was declared a novel food under Regulation (EU) 2015/2283 of the European Parliament and of the Council in 2022 (Siddiqui *et al.*, 2022) and recently the frass of migratory locust had also been tested, proving to be effective in the development of Brassicaceae (van de Zanden *et al.*, 2024).

1.8 Medical and veterinary entomology

Within the agrosystems there are also areas where sheep and cattle graze; for this reason, it is interesting to focus on species that can cause damage to them. Myiasis is defined as the infestation of Diptera larvae in living tissues or settle on open wounds or lesions on live vertebrates (Zumpt, 1965). It caused mainly by maggots of Calliphoridae and Sarcophagidae and if it left untreated, can be fatal (Gullan & Craston, 2010). A warmer climate leads to an increase in generations of flies and, due to global warming, the increase in the number of cases is expected (Bernhardt *et al.*, 2018).

These infestations can cause discomfort to the animals and alter their normal habits, including feeding and resting. In addition, it could cause milk and weight loss, sterility, poor skin quality and a weakening of the animals (Otranto *et al.*, 2004). The most common host for myiasis are cattle (46.4%) followed by dogs (15.3%), humans (14.7%), pigs (6%), horses (4%) and sheep (1%) (Rahman *et al.*, 2009). Wounds, ulcers, sores, broken horns, wounded eyes and attract flies that cause myiasis. The myiasis, however, can also be urogenital due to poor hygiene of the animal: flies, in fact, can be attracted by tangled hair contaminated with excrement and urine (Juyena *et al.*, 2013).

Several species of Calliphoridae in Calabria have been reported as myiasis agents for wild and domestic animals. For example, *Calliphora vicina* Robineau-Desvoidy, 1830, caused a myiasis on *Hystrix cristata* Linnaeus, 1758 (Scaravelli *et al.*, 2017) while *Lucilia sericata* (Meigen, 1826) on *Anser domesticus* (Linnaeus, 1758) (Pezzi *et al.*, 2022) and *Lucilia caesar* on wild boar (Pezzi *et al.*, 2021). Among Sarcophagidae, the most reported species in Calabria is *Wohlfahrtia magnifica* (Schiner, 1862), that caused myiasis in dogs (Bonacci *et al.*, 2020), goats (Bonacci *et al.*, 2013) and sheep (Bonacci *et al.*, 2017) (Fig. 1.29).

On the other hand, insects can be vectors of pathogens by mechanical or biological transfer too (Gullan & Craston, 2010). For example, the fly *Musca domestica* Linnaeus, 1758 (Diptera, Muscidae) is contributing to the spread of various infectious diseases such as cholera, shigellosis and salmonellosis (Olsen *et al.*, 2001; De Jesus *et al.*, 2004). Also, the monitoring of hematophagous insects, such as Hippoboscidae, Fleas, Lice, Ticks, Tabanidae and Muscidae, should not be neglected (Prudhomme *et al.*, 2023).

Among others, *Stomoxys calcitrans* Linnaeus, 1758 (Diptera, Muscidae) (Fig. 1.30), commonly known as "stable fly", it is considered a dangerous hematophagous of livestock, especially for cattle, horses and pigs, because it can cause reduction of the animal's weight and subsequently stop the production of meat and milk (Campbell *et al.*, 2001; Patra *et al.*, 2018). In addition, this species represent a potential vector of several pathogens such as *Besnoitia besnoiti* (Franco and Borges, 1916), which is responsible for Besnoitiose, a disease currently spreading in Europe. Finally, it is also responsible for the transmission of Surra, bovine viral diarrhoea, lumpy skin dermatitis, Rift Valley fever and bovine leukosis (Alvarez-Garcia *et al.*, 2013; Prudhomme *et al.*, 2023).



Figure 1.30 individual of *Stomoxys calcitrans* (<https://en.m.wikipedia.org>)



Figure 1.29 Infestation by *Wohlfahrtia magnifica*. A, B and C: myiasis in sheep; D: myiasis in goat; E and F: myiasis in a sheepdog (Bonacci *et al.*, 2017).

the production of meat and milk (Campbell *et al.*, 2001; Patra *et al.*, 2018). In addition, this species represent a potential vector of several pathogens such as *Besnoitia besnoiti* (Franco and Borges, 1916), which is responsible for Besnoitiose, a disease currently spreading in Europe. Finally, it is also responsible for the transmission of Surra, bovine viral diarrhoea, lumpy skin dermatitis, Rift Valley fever and bovine leukosis (Alvarez-Garcia *et al.*, 2013; Prudhomme *et al.*, 2023).

2. Materials and Methods

2.1 Sampling areas

Entomological sampling was conducted in the Sila Plateau in the province of Cosenza (Calabria, Italy) (Map. 2.1). Calabria is the most southerly region in peninsular Italy. This region is predominantly hilly and mountainous with a mediterranean weather on the coasts and temperate climate in mountainous regions (Rivas-Martinez, 1996).



Map 2.1 Maps of Sampling areas (Software Qgis)

Six sampling areas were selected for the research to verify possible differences in fauna, both in terms of vegetation cover and agricultural techniques used. The sites investigated fall into a transect in which there

are a biologic field of potatoes Sila IGP (Fbio), an ecotonal grassland grazing area (Gecot), a Pine forest ecotonal area (Pecot) and an integrated field for the cultivation of Sila IGP potatoes (Fint). As control, a natural grazing area (Gnat) and a natural pine forest (Pnat) in Sila National Park were selected too.

2.1.1 Fbio (Field_Biological)

Coordinates: 39°21'54,8"N, 16°31'11,3"E

Altitude: 1178 m a.s.l.

Municipality: Spezzano della Sila (CS)



Figure 2.1 Satellite photo of Fbio (Google Earth)

Fbio is a biological potatoes field in the project partner farm “Scrivano Terre D’Altopiano”. The biological management encourage the traditional natural farming techniques, excluding the use of OGMs and reducing pollutants and mechanisation (Ispra, 2004). The investigation area is about 9.83 hectares and it is located near an arm of Cecita Lake (Fig. 2.1). All around, there are cereals crops and greenhouses used for strawberries cultivation. In addition, dairy cows are raised in the farm and they graze in a small adjacent area to Fbio. The ecotonal areas here are rather absent (Fig. 2.2).

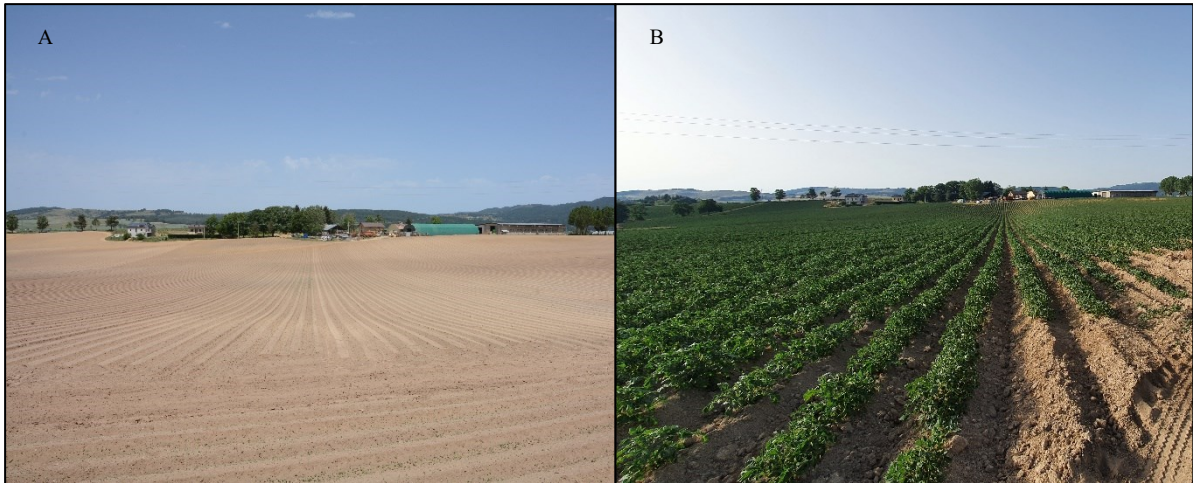


Figure 2.2. Fbio before (A) and after (B) of Sila IGP potatoes sowing (F. Mendicino)

2.1.2 Fint (Field_Integrated Management)

Coordinates: 39°21'35.1" N, 16°31'25.0" E

Altitude: 1204 m a.s.l.

Municipality: Spezzano della Sila (CS)



Figure 2.3. Satellite photo of Fint (Google Earth)

The Fint area is an integrated management field of Sila IGP potatoes in the farm “Fattoria Pupo”. Integrated farming is an intermediate method between conventional and organic agriculture, where the use of chemical

substances is not excluded, but priority strategies are planned to reduce the use of synthetic substances (Ispra, 2004). This area is about 2.5 hectares and, unlike Fbio, it is immersed in a natural context (Fig. 2.3; Fig. 2.4). This field is characterized by ecotones, specifically the areas Gecot and Pecot, as well as a small wheat field. There are also other cultivations land for the production of red fruits, such as blueberries, blackberries and raspberries.



Figure 2.4. Fint before (A) and after (B) of Sila IGP potatoes sowing (F. Mendicino)

2.1.3 Gecot (Grassland Grazing Ecotonal)

Coordinates: 39°21'27.8"N, 16°31'13,4" E

Altitude: 1240 m a.s.l.

Municipality: Spezzano della Sila (CS)

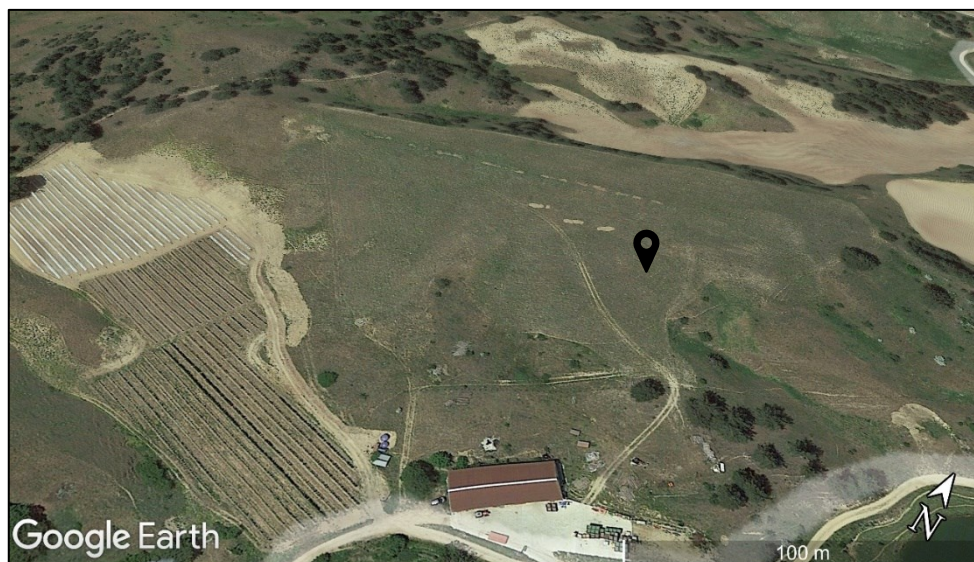


Figure 2.5 Satellite photo of Gecot (Google Earth)

Gecot is an ecotonal area of about 2.3 hectares (Fig. 2.5). It used in the spring and summer as a grazing area for about 30 cattle. The area, which leads to Popini Mount, is near Fint and a biological berry

cultivation area. This grassland is characterized by several herbaceous species such as *Dacus carota* L., 1753, *Carduus* sp. L., 1753, *Cirsium* sp. Miller, 1754, *Leucanthemum vulgare* Lam., 1778, *Allium* L., 1753, *Malva sylvestris* L., 1753, *Anacamptis morio* (L.) R. M. Bateman, Pridgeon & M. W. Chase, 1997, *Papaver* sp. (L., 1753) and sporadic trees of *Sambucus* L., 1753 and *Pinus* sp., 1753 (Fig. 2.6).

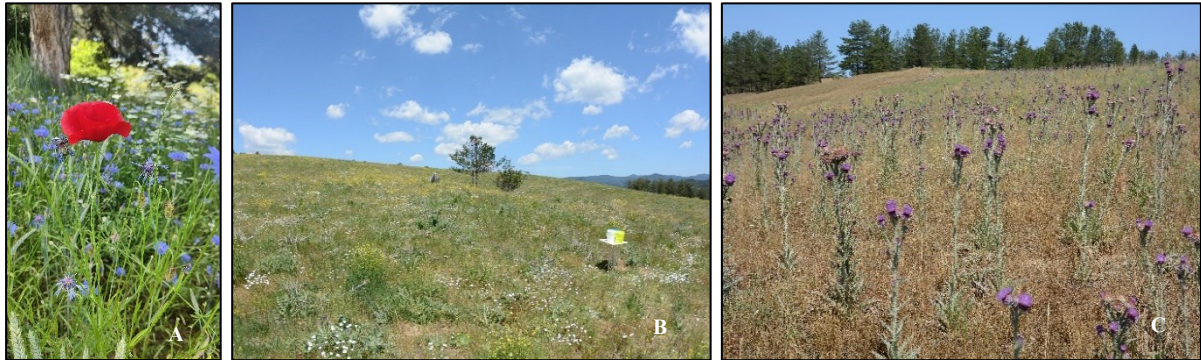


Figure 2.6 Photos of Gecot in June (A), July (B) and August (C) (F. Carlomagno)

2.1.4 Pecot (Pine Forest_Ecotonal)

Coordinates: 39°21'41,0"N, 16°31'21,0" E

Altitude: 1192 m a.s.l.

Municipality: Spezzano della Sila (CS)



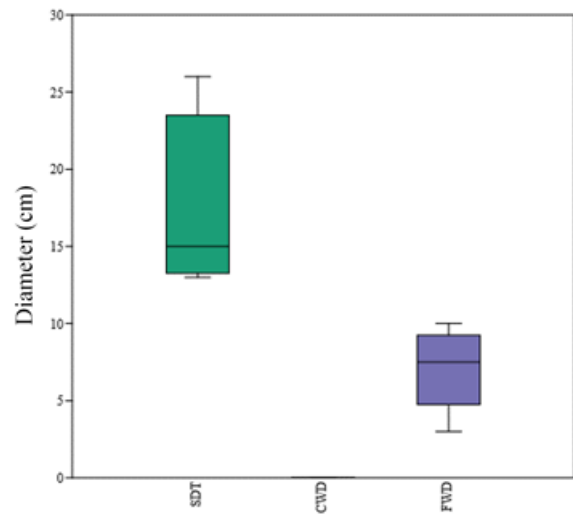
Figure 2.7 Satellite photo of Pecot (Google Earth)

The pine forest ecotone is located in Fattoria Pupo and it is about 2,2 hectares (Fig. 2.7). This sampling area is characterized mainly by *Pinus nigra* J. F. Arnold, 1785 trees and grass cover. From mid-August until autumn, the cattle, that are usually present in Gecot, move to Pecot (Fig. 2.8).



Figure 2.8 On the Left a picture of Pecot; on the right a cow in the sampling area (F. Mendicino)

In this sampling area there are few rotting woods on soil: this boxplot (Graph 2.1) summarizes the distribution of diameters (cm) of SDT (standing dead trees), CWD (coarse woody debris) and FWD (fine woody debris) (Audisio *et al.*, 2014). There are no trees smashed to the ground and the only necromass present are some dead trees standing with diameter between 15 and 24 cm and branches on the ground with diameters less than 10 cm.



Graph 2.1 Boxplot of wood necromass (Software Past)

2.1.5 Gnat (Grassland Grazing_Natural)

Coordinates: 39°22'29,6"N, 16°32'17,0" E

Altitude: 1181 m a.s.l.

Municipality: Spezzano della Sila (CS)



Figure 2.9 Satellite photo of Gnat (Google Earth)

A grazing control area was selected within the Sila National Park (zone C). This area is about 9 hectares and it is located between Cecita Lake and a pine forest of *Pinus nigra*. Gnat is characterized by intensive cattle grazing. From a vegetative point of view, there are several herbaceous species such as *Daucus carota* Linnaeus, 1753, *Carduus* L., 1753, *Malva moschata* L., 1753, *Anacamptis morio* (L.) R. M. Bateman, Pridgeon & M. W. Chase, 1997 and *Verbascum* sp. L., 1753, but also shrub species such as *Spartium junceum* L., 1753.



Figure 2.10 Pictures of plants in Gnat (F. Mendicino)

2.1.6 Pnat (Pine Forest_natural)

Coordinates: 39°23'16,3"N, 16°34'16,5"E

Altitude: 1275 m a.s.l.

Municipality: Longobucco (CS)



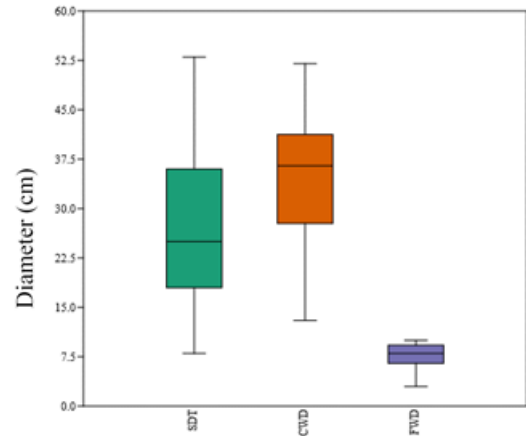
Figure 2.11 Satellite photo of Pnat (Google Earth)

To verify the faunistic differences from Pecot, a natural pine forest near Biogenetic Natural Reserve Golia-Corvo was identified (Fig. 2.11). This area it characterizes by *Pinus nigra* J. F. Arnold, 1785 trees and an undergrowth composed of *Pteridium aquilinum* (L.) Kuhn, *Epipactis* sp. Zinn, 1757 and *Fragaria vesca* L., 1753 (Fig. 2.12).



Figure 2.12 Picture of habitat and plants of Pnat (F. Mendicino)

In addition, it is in a good state of conservation thanks to the lack of grazing and a good amount of necromass in the area (Graph 2.2), that means that there is a good forest management. The trees that are fallen to the ground have a diameter of 20-30 cm, while standing trees have diameters greater than 40 cm. There are also branches below 10 cm in diameter on the ground.



Graph 2.2 Boxplot of wood necromass (Software Past)

2.2 Sampling methods

The insects collection was carried out during two sampling seasons (May to November 2022 and May to November 2023) in relation to the sowing and harvesting of potatoes. In each sampling area, different traps were placed inside an appropriately chosen transect of about 200 m (Montgomery *et al.*, 2021). In particular, the placed traps were (Fig. 2.13):

- 5 *pitfall traps*, spaced 15 m apart from each other and activated with salt, vinegar and a drop of soap to break the surface tension. These were put inside the soil to collect walking insects, such as Carabidae and Staphylinidae (Honek, 1988; Brandmayr *et al.*, 2005);
- 3 *pan traps*, activated with water, salt and a drop of soap. These traps use different fluorescent colours (yellow, white and blue) to specially attract different pollinators and they are placed about 50 cm above the ground (Vrdoljak & Samways, 2012);
- 1 Malaise trap, a particular white/black tent-shaped trap, useful for attracting different groups of flying insects (Uhler *et al.*, 2022).



Figure 2.13 Pictures of traps. In A a pitfall trap, in B the pan traps and in C Malaise trap (F. Mendicino)

In addition, in all sampling areas, hand entomological nest was used to collect flying insects which are not attracted by traps. Moreover, in the pine forests, the inspection of rotting wood was also carried out to assess the presence or absence of saproxylics species (Fig. 2.14).



Figure 2.14 Pictures of direct sampling. On the left the hand net, on the right the debarking of decay wood (F. Carlomagno)

2.3 Insect morphological identifications

The entomological material was collected almost every 15 days and subsequently sorted and partially dry prepared. Once dried, the prepared specimens were placed in entomological boxes within the DiBEST Entomological Collection (supervised by Prof. Teresa Bonacci). The remaining material was preserved in 70% ethanol and stored in the Laboratory of General and Applied Entomology of DiBEST, Unical (Head Prof. Teresa Bonacci). The insects were morphologically determined in the laboratory of General and Applied Entomology using a stereomicroscope Euromex 55x and specialized dichotomous keys (Allegro, 2021; Allegro *et al.*, 2022; Amiet *et al.*, 2001, 2004, 2007, 2010, 2014; Cerretti, 2010; Chinery, 2010; Dathe *et al.*, 2016; Dijkstra & Schroter, 2021; Dvorak & Roberts, 2006; Falk *et al.*, 2016; Friese, 1896; Gregor *et al.*, 2016; Intoppa *et al.*, 2009; Latella & Gobbi, 2008; Lebas *et al.*, 2016; Leraut, 2019 (a, b); Massa *et al.*, 2012; McAlpine *et al.*, 1981 (a,b,c); Michez *et al.*, 2019; Negrisolo & Pagliano, 2005; Oesterbroek, 2006; Porta, 1923, 1926, 1929; Richet *et al.*, 2011; Rognes, 2002; Rozkosny *et al.*, 1997; Schmid-Egger & Scheuchl, 1997; Tamanini, 1988; Tschorsnig & Herting, 1994; Tolman & Lewington, 2014; van Veen, 2010).

The determination of Carabidae species was confirmed thanks to the comparison with the DiBEST Entomological Collection under the supervision of Prof. Pizzolotto R. and Dr. Mazzei A. (Unical).

Regarding wild bees, due to the lack of complete specialist dichotomous keys, during my period abroad in Switzerland at the Institute of Biology - University of Neuchatel, Switzerland (Supervisor: Dr. Christoph J. Praz), the Apoidea were firstly identified by comparing our samples with the entomological collections of UniNE (Fig. 2.15) and subsequently confirmed by the principal European experts (Megachilidae: Dr. Christophe J. Praz, University of Neuchatel (Switzerland); Andrenidae: Dr. Thomas J. Wood, Naturalis Biodiversity Centre (Netherlands); Eucerinae: Dr. Achik Dorkin, University of Mons (Belgium); Halictidae: Dr. Simone Flaminio, University of Mons (Belgium) and University of Bologna (Italy); *Hylaeus* spp.: Dr. Romain Le Divelec, University of Mons, (Belgium)).

The photos of the specimens were taken at the University of Calabria, using the stereomicroscope Kern OZP 558C825 with Kern Optix ODC 825 camera and at the University of Mons, with a Digital Microscope VHX - Keyence VHX-970F.

2.4 Determination of insects by barcoding

Due to difficulties in morphological determination of some Apoidea, 38 specimens were identified by Barcoding at the Laboratory of Genetic in University of Neuchâtel. The molecular analysis were performed to confirm uncertain species and to load missing species sequences to the Bold system.

The DNA extraction was carried out using the NucleoSpin Tissue Kit (Macherey-Nagel) (Fig 2.16). For pre-lysis, a midleg was placed in an Eppendorf tube with 180 μ L of Lysis Buffer T1 and 25 μ L of proteinase K and incubate at 56°C overnight. After this procedure, 200 μ L of Lysis Buffer B3 were added to the solution and the samples were placed in dry bath at the temperature of 70°C for 10 minutes. Subsequently, 210 μ L of ethanol 99% were added. At this point, the sample was washed first with 500 μ L and then with 600 μ L of Wash Buffer. The last step was to add the Evolution Buffer BE (25-50 μ L, depending on the size of the insect). The 658 bp mitochondrial DNA fragment was amplified using LepF1 (ATT CAA CCA ATC ATA AAG ATA TTG G; Hebert *et al.*, 2004) and LepR1 (TAA ACT TCT GGA TGT CCA AAA TA; Hebert *et al.*, 2004) primers; it is also used a forward primer UAE3 (TAT AGC ATT CCC ACG AAT AAA TAA; Lunt *et al.*, 1996) together with LepR1 to amplify a 409 bp fragment of the same gene. In summary, each sample was amplified twice time.



Figure 2.15 Determination of sample with the reference collection in University of Neuchatel

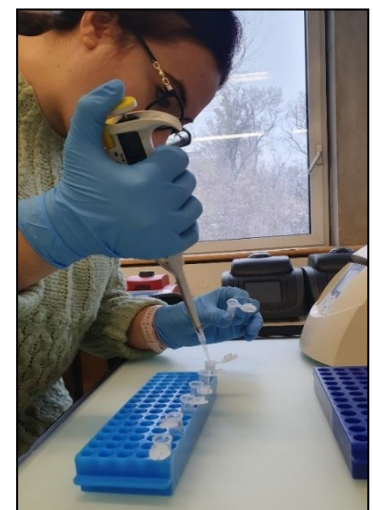


Figure 2.16 Extraction of DNA in genetic laboratory of Unine

In the pre-pcr phase, a solution composed by 7,125 μL of water H_2O , 3,0 μL of 5x Buffer concentration, 1,5 μL of MgCl_2 25mN, 1,5 μL of dNTPs 2 mM, 1,0 μL of DNA, 0,6 μL of LepF1/UAE3, 0,6 μL of LepR1 and 0,075 μL of Taq polymerase was done.

Samples were, then, placed in a Biometra TProfessional Basic 96 thermal cycle. The polymerase chain reaction (PCR) is a cyclic reaction consisting of 36 cycles each with 3 successive steps: denaturation of DNA, pairing of oligonucleotides and polymerizations. During denaturing, the DNA solution is heated to 94°C, so that the double helix of DNA is completely split into two strands. Subsequently the temperature is lowered to 45-51°C to allow the primers to bind to complementary regions of the denatured DNA strands (pairing or annealing phase). Finally, the temperature is rised to 72°C to maximise the DNA polymerase activity. After this procedure, electrophoretic running was done (Fig. 2.17). The gel consists of 1.5 g agarose and 100 ml of running buffer 1x TAE. For the electrophoretic run, the sample is prepared by taking 4.0 μL of PCR and adding 1.5 μL of fluorescent GelRed Nucleic Acid Gel Stain (Biotium). The electrophoretic run lasted 20 minutes at 100V 76 mA. Once the run is over, the gel was placed in the UVP GelStudio Plus - Analytick Jena and observed under UV light.

At this point, the samples should be prepared for sequencing. In the Post-PCR phase, 3,6 μL of H_2O , 1,0 μL 5x of PCR buffer, 0,2 μL of Exonuclease 20 u/ μL and 0,2 μL of Thermosensitive Alkaline Phosphatase 1 u/ μL were added to the solution.

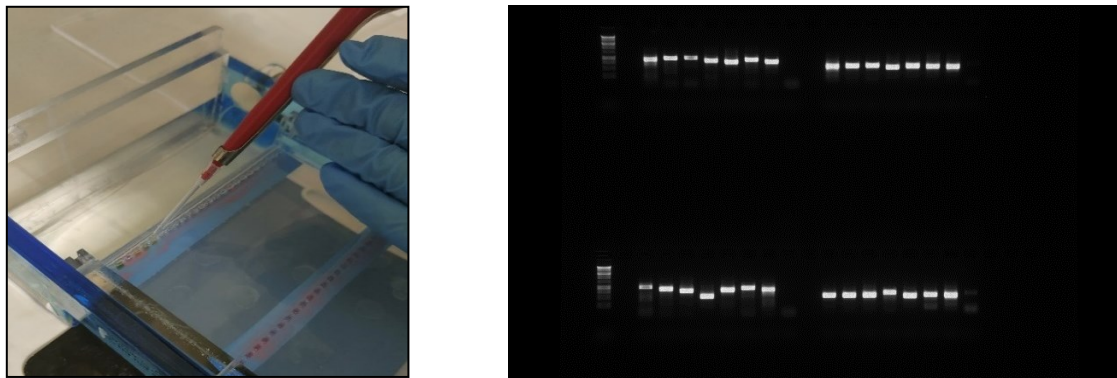


Figure 2.17 On the left preparation of electrophoretic run, on the right the result of electrophoretic run

The centrifuged samples were placed again in Biometra TProfessional Basic 96 thermocycle in a programme divided into two parts: 20 minutes at 37°C and 20 minutes at 80°C. After this step, in a PCR plate was inserted 12 μL of solution composed by: 3 μL of Primer (LepR1/UAE3) and 3-9 μL of DNA solution (depending on the quality of the band obtained from the electrophoretic run) and the remaining (0-6 μL) of H_2O .

For sequencing, samples were sent to Microsynth AG Sequencing Service (Balgach, Switzerland) and, once received, the analysis of sequences and the phylogenetic trees (Genetic Distance Model: Tamura-Nei; Tree Build Method: Neighbour-Joining) were done using Geneious prime 2024 0.7 software (GraphPad Software LLC) (Fig. 2.18). The sequences will be recorded in the Bold system and the National Centre for Biotechnology Information (NCBI).

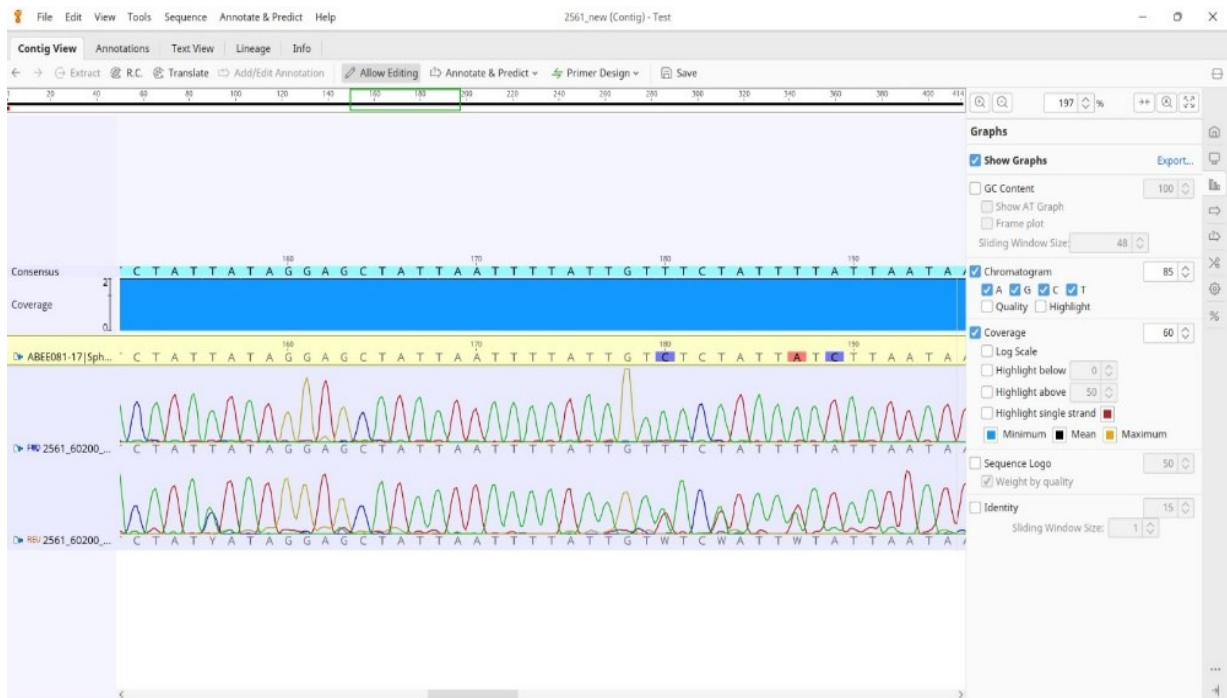
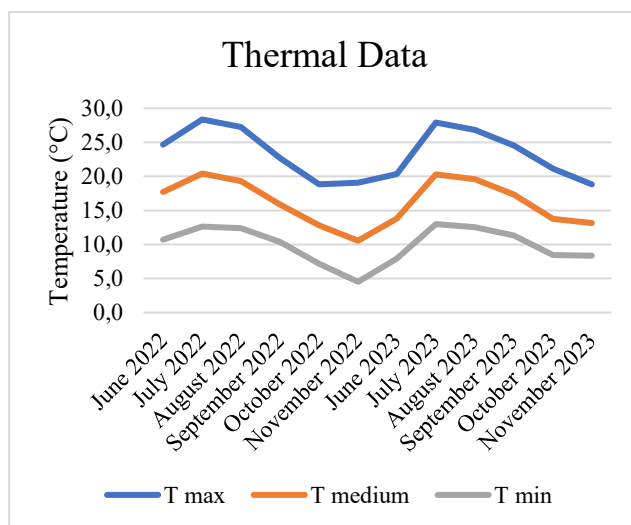


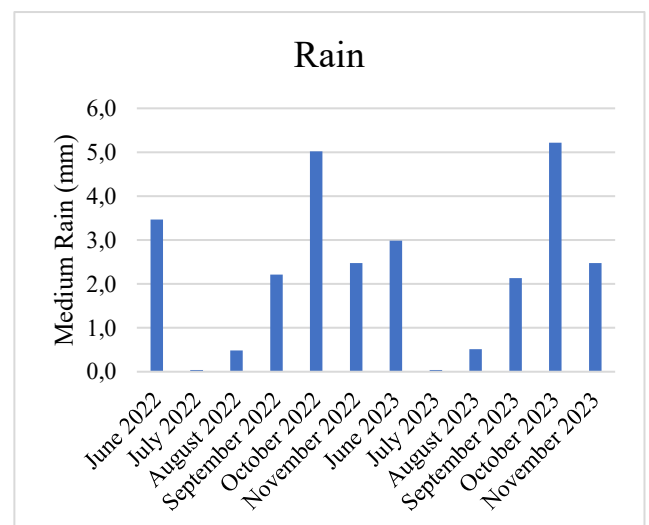
Figure 2.18 Software Geneious prime with a DNA sequence

2.5 Sila plateau climate data

The thermo-pluviometry data (Graph 2.3; Graph 2.4) of the investigated areas were obtained from the online service of the Multirisk Functional Centre-ARPACAL (Regional Agency for Environmental Protection of Calabria) (Catanzaro, Italy), Station of Cecita (cod. 1100).



Graph 2.3 Temperature during the sampling (ARPACAL)



Graph 2.4 Rainfall during the sampling (ARPACAL)

About temperature (Graph. 2.3) there is an increasing in July and August with medium temperature around 20°C while the lowest temperature is recorded in November. As regarding rainfall, the abundance of rain is recorded from September to November even if in the first year there is an abundance of rainfall also in June.

2.6 Analysis of soil quality with QBS-ar

To study soil fauna and therefore soil biological quality (QBS-ar), in spring and late summer 4 replicates of soil were taken in each sampling area. Soil clods, about 10 cm x 10 cm and 10 cm deep, were placed inside Berlese selectors at the Laboratory of General and Applied Entomology, DiBEST (UNICAL) for 15 days (Masarin *et al.*, 2006).

A Berlese selector (Fig. 2.19) consist in a funnel of 25 cm with a 2 mm mesh steel sieve, where a single soil clod was placed. Above the soil pad is placed a 60 W light bulb while a container with 70% alcohol is put under the funnel. The light and heat produced by the bulbs cause the movement of arthropods downward and they fall into the collector box (Masarin *et al.*, 2006). The entomological material was preserved in 70% alcohol and then analysed for QBS-ar.



Figure 2.19 Berlese selectors (F. Mendicino)

The QBS-ar index evaluates the entire edaphic microarthropod community, which is classified using biological form (FB). Each FB is associated to an Ecomorphological Index (EMI) value, between 1 and 20. In some cases, the score is unique, emphasizing the characteristics of the affinity group to the soil compartment while, in other cases, the score may vary and assume different values according to morphological adaptations to the hypogeal environment. At least 3 replicates per site are required and the final QBS-ar value is the maximum recorded value. The table below (Fig. 2.20), show the scheme for compiling EMI values (Parisi, 2001).

SCHEDA QBS-ar

Sigla	Località	Date		
		Prelievo	Fine Estr.	Smistamento

GRUPPO	FORMA BIOLOGICA	EMI	S-A	S-B	S-C	EMI _{max}	Note
Pseudoscorpioni		20					
Scorpioni	Forme giovanili	10					
Palpigradi		20					
Opilioni		10					
Aranei	Forme superiori a 5mm	1					
	Forme piccole e poco pigmentate	5					
Acari		20					
Isopodi		10					
Diplopodi	Forme superiori a 5mm	10					
	Forme inferiori a 5mm	20					
Pauropodi		20					
Sinfili		20					
Chilopodi	Forme superiori ai 5 mm, ma con zampe ben sviluppate	10					
	Altre forme (Gaofilomorfi)	20					
Proturi		20					
Dipluri		20					
Collemboli	Forme epigee: appendici allungate, ben sviluppate. Apparato visivo (macchia oculare e occhi) ben sviluppato. Dimensioni medie/grandi, presenza di livrea complessa	1					
	Forme epigee non legate alla vegetazione arborea con buon sviluppo delle appendici con forte sviluppo di setole o squame. Apparato visivo ben sviluppato.	2					
	Forme di piccola dimensione con medio sviluppo delle appendici, apparato visivo ben sviluppato, livrea modesta, forme limitate alla lettera	4					
	Forme emiedafiche con apparato visivo ben sviluppato, appendici non allungate, livrea con colore	6					
	Forme emiedafiche con riduzione del numero di occhi, appendici poco sviluppate, con furca ridotta o assente. Presenza di pigmentazione.	8					
	Forme euedafiche con pigmentazione assente, riduzione o assenza di occhi. Furca presente, ma ridotta	10					
	Forme euedafiche depigmentate, prive di furca, appendici tozze, presenza di pseudoculi, organo postantennale sviluppato (ma non necessariamente presente), strutture sensoriali apomorfiche	20					
Microcorifi		10					
Zigentomi		10					
Dermatteri		1					
Ortotteri	In generale	1					
	Famiglie Grillidae	20					
Embiotteri		10					
Fasmodei		1					
Mantodei		1					
Mecotteri		1					
Isotteri		10					
Blattari		5					
Psocotteri		1					
Emitteri	Forme epigee	1					
	Larve cicala	10					
Rafidiotteri		1					
Tisanotteri		1					
Coleotteri (*)	Forme epigee	1					
	Dimensioni < 2mm	+ 4					
	Tegumenti sottili, con colori testacei	+ 5					
	Microatterismo o atterismo	+ 5					
	Microftalmia o anoftalmia	+ 5					
	Nel caso di forme edafobie	20					
Imenotteri	In generale	1					
	Formicidi	5					
Ditteri	Adulti	1					
Rafidiotteri		10					
Planipenni		1					
Mecotteri (Irv)		10					
Coleotteri (Irv)		10					
Ditteri (larve)		10					
Imenotteri		10					
Lepidotteri		10					
Altri olometaboli	Adulti	1					
		QBS-ar per ogni repicla (R)					
		QBS-ar massimo					

(*) per le forme chiaramente **NON** epigee, si assegnano 5 punti per la presenza di ciascuno dei caratteri elencati con il + (max = 20)

Figure 2.20 Table with EMI values for QBS-ar (Parisi *et al.*, 2001)

2.7 Organic and sustainable fertilizer trials

On behalf of the partner company “Scrivano Terre d'Altopiano” and in collaboration with the Laboratory of Plant Biology (BioVeLab; Head Prof. Leonardo Bruno, Unical) and the “Italian cricket farm”, frass (excrements and remains of insects) of some insect species were tested as biofertilizer on *Solanum lycopersicum* cv. Micro-Tom to verify their growth and yield. The experiment was conducted at the Laboratory of General and Applied Entomology under controlled conditions inside a climatic chamber.

2.7.1 Breeding of insects for the frass production

The frass of *Tenebrio molitor* and *Acheta domesticus* were provided by Italian Cricket Farm, with which our research group collaborates. The frass of *H. illucens* was produced by a bred in the Laboratory of General and Applied Entomology. The larvae of the black soldier fly were purchased from Italian Cricket Farm and subsequently bred in our laboratory in a climate chamber at 27°C and 70% humidity. The photoperiod was set to 16:8= light:dark (cold light 6000 K) while the food substrate consisted of bran and rotting fruit (Georgescu *et al.*, 2020; Caruso *et al.*, 2013) (Fig. 2.21).



Figure 2.21 Breeding of *Hermetia illucens* in Applied and General Entomology Laboratory (F. Mendicino)

2.7.2 Nutrient contents of fertilisers

The nutritional contents of *T. molitor* and *A. domesticus* frass were obtained from analyses by Caim Grop - A Tentamus company on behalf of Italian Cricket farm while the frass of *H. illucens* was analysed by Idro Consult – Laboratori Uniti s.r.l.

Frass of *H. illucens* has the highest value of Mg, K, Ca, Mn, Cu, Zn while the highest value of P₂O₅ is in *T. molitor* frass. The highest nutrient value in *A. domesticus* are Na and Fe (Tab. 2.1).

Table 2.1 Nutritional content of the frass

Determination	<i>A. domesticus</i>	<i>T. molitor</i>	<i>H. illucens</i>	U. M.
	Results	Results	Results	
pH	6,02	6,27	6,9	%
Ammoniacal nitrogen	0,14	0,11	0,01	%
Total organic carbon (TOC)	39,02	46,47	37,8	% s.s.
Total nitrogen	5,41	4,23	4,7	% s.s.
C/N ratio	7,21	10,99	8	
Nitrates (N)	<0,25	<0,25	<0,25	mg/kg s.s.
Total phosphorus (P ₂ O ₅)	22100	25900	15169	mg/kg s.s.
Sodium (Na)	2990	2100	1531	mg/kg s.s.
Magnesium (Mg)	3380	4112	5789	mg/kg s.s.
Potassium (K)	12610	15320	16737	mg/kg s.s.
Calcium (Ca)	10230	12200	29591	mg/kg s.s.
Manganese (Mn)	63,8	96,4	236	mg/kg s.s.
Iron (Fe)	323	297	275	mg/kg s.s.
Copper (Cu)	21,6	23,9	31	mg/kg s.s.
Zinc (Zn)	98	93,4	154	mg/kg s.s.

2.7.3 Frass test on plants under controlled conditions

Insects frass was tested on a culture of tomato plants (*Solanum lycopersicum* cv. Micro-Tom) grown in pot under controlled conditions, at the Laboratory of General and Applied entomology, University of Calabria. Specifically, 5 treatments, with 7 replicates each, were carried out with different soil improvers: *i*) Control, without fertilisers; *ii*) Biocompost (organic waste dried Terra Sana Bio); *iii*) *Hermetia illucens* frass; *iv*) *Tenebrio molitor* frass; *v*) *Acheta domesticus* frass.



Figure 2.22 Seedbeds inside the climatic chamber (F. Mendicino)

The seeds of *S. lycopersicum* were germinated in paper towel and subsequently planted in seedlings with autoclaved soil (Fig. 2.22) composed by coconut granules, Irish peat, volcanic pumice and superfine peat. Once the leaves were produced, the plants were transplanted in pots with frass and soil mix at 1:20 volume ratio, according to the protocol of Zim *et al.* (2022). Plants were kept in a climatic chamber at 21°C, with 60% humidity and L/D:16/8 h photoperiod for 168 days. They were watered twice a week with about 200 ml of distilled water (Fig. 2.23).

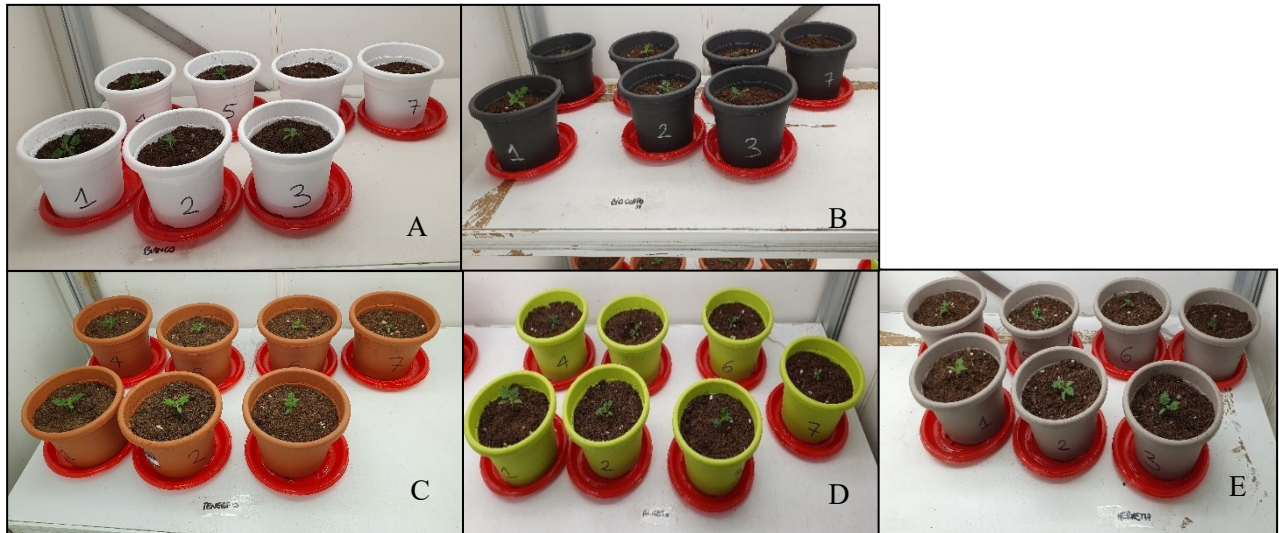


Figure 2.23. Culture of *Solanum lycopersicum* cv. Micro-Tom inside the climatic chamber. A: control; B: Biocompost; C: *Tenebrio* frass; D: *Acheta* frass; E: *Hermetia* frass (F. Mendicino)

In order to verify the effect of different fertilizers on the growth of tomato plants, every week the height of the plant, the number of leaves, flowers and fruits were evaluated. In addition, at the end of the trial, the development time of plants, fruit size and root size and dry weight were also estimated. In particular, 30 fruits were collected for each treatment and measured using the ImageJ software (National Institutes of Health, USA) while the dry weight of the roots is obtained after drying the roots in a stove at 60°C for about 10 hours and they were assessed using a precision scale. The roots (3 per treatment) once placed inside the stove, were measured periodically after about 3 hours: when the weight of the root no longer decreased, they could be considered dry.

2.7.4 Field test of the frass on the pedofauna

From January to July 2024, the frass of *Tenebrio molitor* was tested to assess the soil quality after treatment in an experimental area of the Laboratory of Forensic Sciences and General and Applied Entomology of DiBEST, Unical (Head: Prof. Teresa Bonacci). In particular, two plots of 1x2 m were selected: one was untreated as a control, while the second one was treated with frass (Fig. 2.24) (Zim *et al.*, 2022). These plots were located at a distance of 15 meters from each other with the same sun exposure. The soil was taken after 1, 12 and 24 weeks since the start of the study. The soil clods (size 10x10x10 cm) were taken

from each treatment with four replicates and placed into Berlese selectors to subsequently perform the QBS-ar analysis.

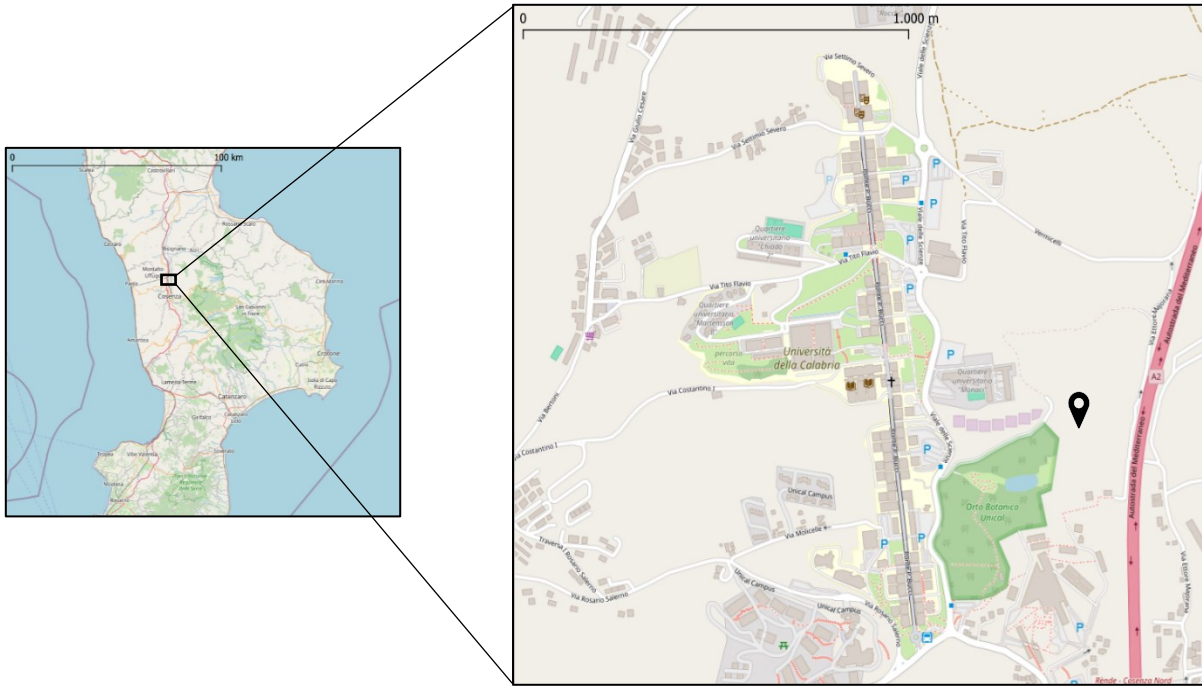


Figure 2.24 In **A** fertilization of plot; in **B** control after 24 weeks; in **C** plot treated with *T. molitor* on the right

The open air laboratory (39°21'35.70" N, 16°13'53.39" E; 318 m a.s.l.) is a 0,46-hectare grassland with sparse deciduous trees of *Quercus pubescens* Wild. (Fagales: Fagaceae) and *Olea europaea* L. (Lamiales: Oleacea) (Fig. 2.25). The granulometry of the experimental area's soil was examined by the Laboratory of Geodynamics and Earth Surface Processes, DiBEST (Unical) and it is identified as sandy clay loam because it is composed mainly of sand (54%) and also of silt (23%), clay (14%) and gravel (9%) (Pezzi *et al.*, 2024).

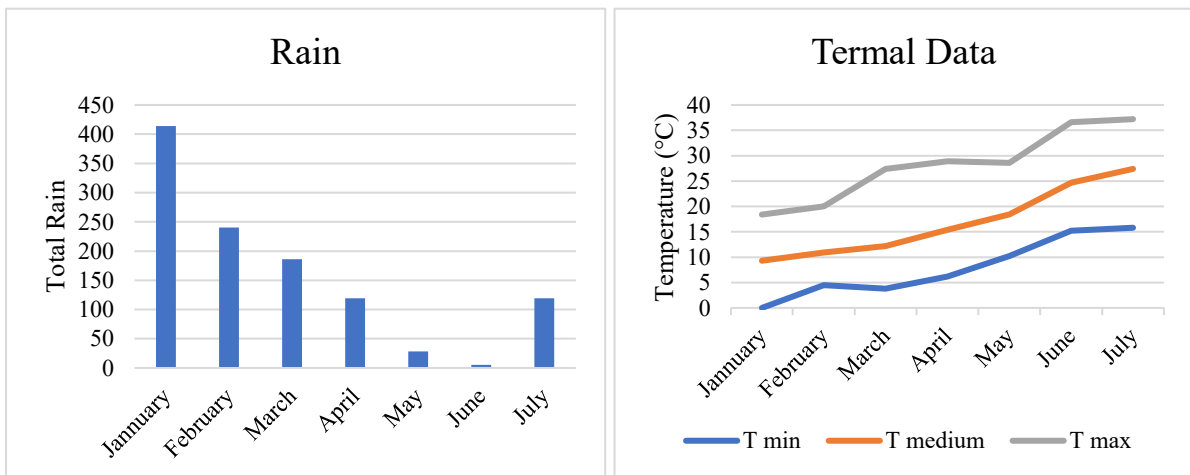


Figure 2.25. Sperimental area (F. Carlomagno)



Map . Map of sperimental area (Software Qgis)

The thermo-pluviometry data were obtained from the Multirisk ARPACAL (Regional Agency for Environmental Protection of Calabria) (Catanzaro, Italy), in relation to the meteorological record station 1060 - Montalto Uffugo (CS).



Graf. Rainfall and temperature during the research (ARPACAL)

2.8 Statistical data analysis

Biodiversity indices of the groups investigated (pollinators, predators, phytophagous, ground beetles and saproxylics) were calculated using Past v.4.11 software (Hammer *et al.*, 2001). In particular, were considered:

- Dominance (D), which indicate if there is dominant species. When the index is higher it means that there is low biodiversity (Magurran, 2004);
- Shannon Diversity Index (H'), which estimates how many diversities of species are in habitat (Magurran, 2004);
- Margalef index, which compensates for differences due to the size of sampling effort and it considers both species richness and total number of individuals present in a sample (Margalef, 1972);
- Evenness Index, which provides information about the community. Its value range is from 0 to 1, where 1 indicates a fair distribution of species where 0 means an imbalance distribution (Pielou, 1984);

In order to verify possible differences between the various sampling areas on the abundance of phytophagous, ground beetles, pollinators and saproxylic, we applied permanova analysis using the software Past v.4.11 (Anderson, 2001). The species rarefaction curve, calculated with the software Past v4.11, was performed on total species and in wild bees communities to identify the number of taxa expected for any areas (Krebs, 1989). In addition, cluster analysis (algorithm: paired groups; similarity index: Bray-Curtis; 1000 bootstraps) is performed using the software Past 4.11 to analyse the similarity between areas and the community of ecological categories considered (Matthiesen, 2010). Instead, with the IBM SPSS software (IBM Corp, 2022), the Correspondence analysis (CA or CoA) was conducted both to assess whether there is a relationship between areas and species and to sort the species within considered groups (Podani, 2007). Finally, the Canonical Correspondence Analysis (CCA), carried out using the Past 4.11 software, was conducted to correlate species with different environmental variables (Podani, 2007).

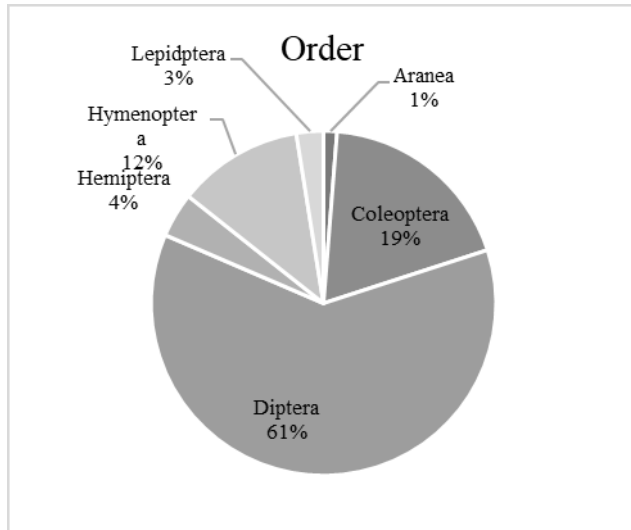
As regards the graphs, the Boxplots were done using the software Past 4.11 while the others using Excel software.

Finally, to analyse the results obtained from the frass test, the non-parametric Friedman test was carried out on Several-sample repeated (Bortz *et al.*, 2000) and the Wilcoxon pairwise - Bonferroni test corrected p values for non-parametric data that had repeated measurements over time (for example, n leaves, height, n fruits, n flowers) were conducted. Instead, parametric data of non-repeated measurements over time (roots and tomato size) were examined by the Kruskal-Wallis test and the post hoc Dunn's-Bonferroni corrected p values.

3. Results

3.1 Orders

During the sampling period, a total of 76.844 individuals were collected (Tab.3.1), in particular N=14.224 Coleoptera (19%), N=46.672 Diptera (61%) and N=8956 Hymenoptera (12%) (Graph 3.1).

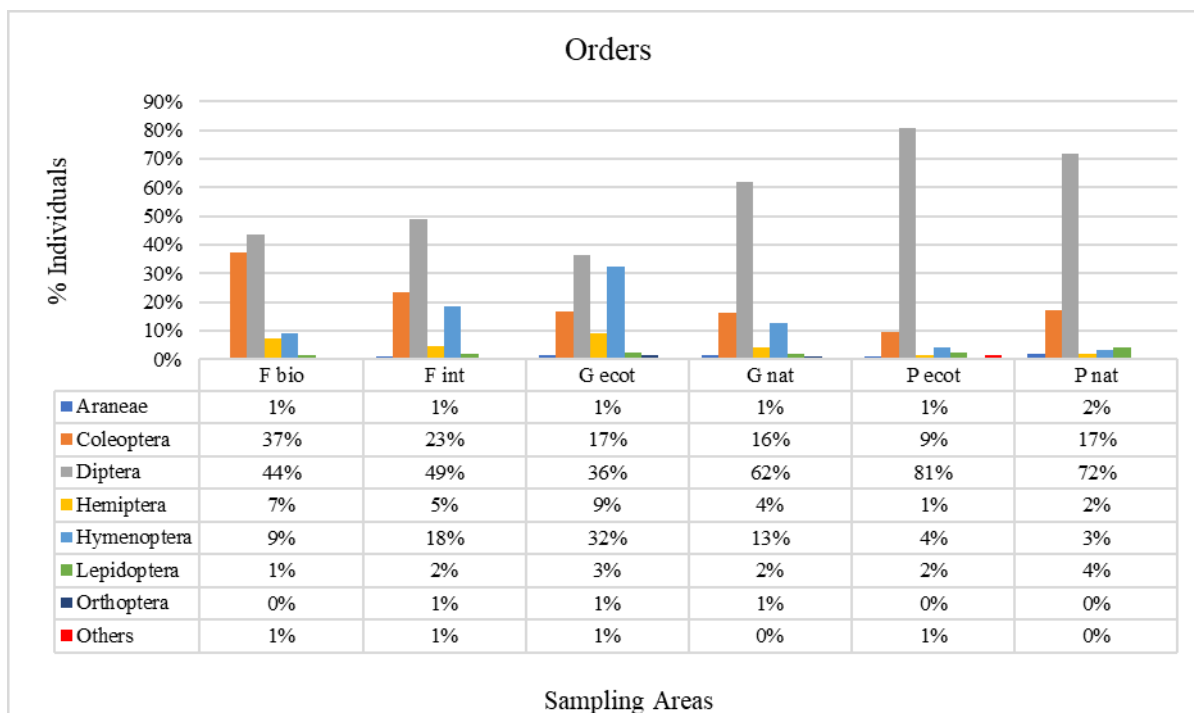


Graph 3.1 Abundance of Order

Table. 3.1 Abundance of Order

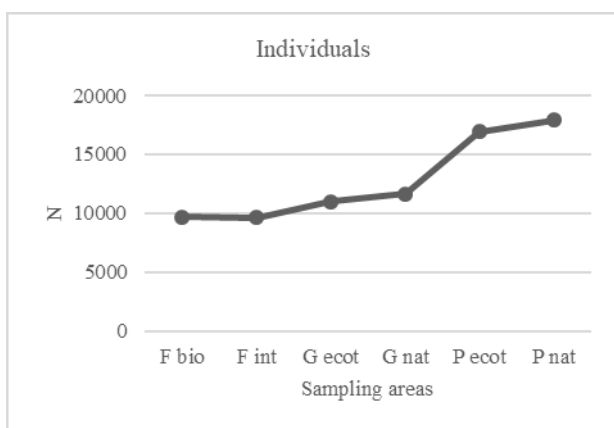
Order	TOT	%
Araneae	952	1,24%
Others	28	0,04%
Coleoptera	14224	18,51%
Dermaptera	175	0,23%
Diptera	46660	60,73%
Dictyoptera	288	0,37%
Hemiptera	3173	4,13%
Hymenoptera	8956	11,66%
Lepidoptera	1929	2,51%
Mantodea	1	0,00%
Mecoptera	4	0,01%
Neuroptera	21	0,03%
Odonata	4	0,01%
Opiliones	22	0,03%
Orthoptera	394	0,51%
Raphidioptera	13	0,02%
TOT	76844	

From graph 3.2, a clear predominance of Diptera over all other groups is evident. In the area Fbio (Field_Biological) the most abundant orders are mainly Coleoptera (37%) and Dipterans (44%); in Fint (Field_integrated) the number of Coleoptera is reduced (23%) while Diptera increase (49%); however, the Hymenoptera are abundant too (18%). As regards the grazing areas, in Gecot (Grassland Grazing_Ecotonal area) Diptera and Hymenoptera have similar abundances (respectively 36% and 32%) while the Coleoptera have an abundance of 17%. In Gnat (Grassland Grazing area_Natural) Diptera dominates over the other orders (62%); the second most abundant group is Coleoptera (16%). In the pine forests there is a dominance of Diptera (Pecot 82%; Pnat 72%) (Graph 3.2).

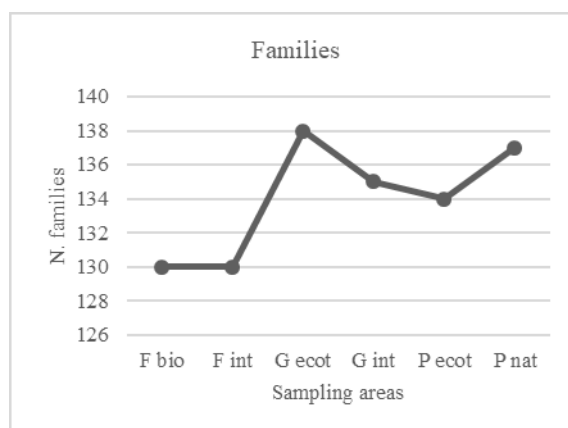


Graph 3.2. Abundance of Order for each sampling area

The number of individuals recorded in agricultural fields is lower than that in pine forests (Graph 3.3). In terms of the number of families, they are more abundant in open grassland than in agrosystems, probably due to the presence of monocultures (Graph 3.4).



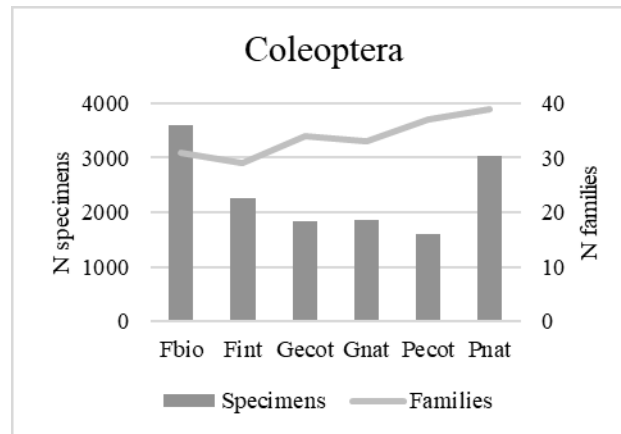
Graph 3.3 Abundance of individual for sampling area



Graph 3.4 Abundance of family for sampling area

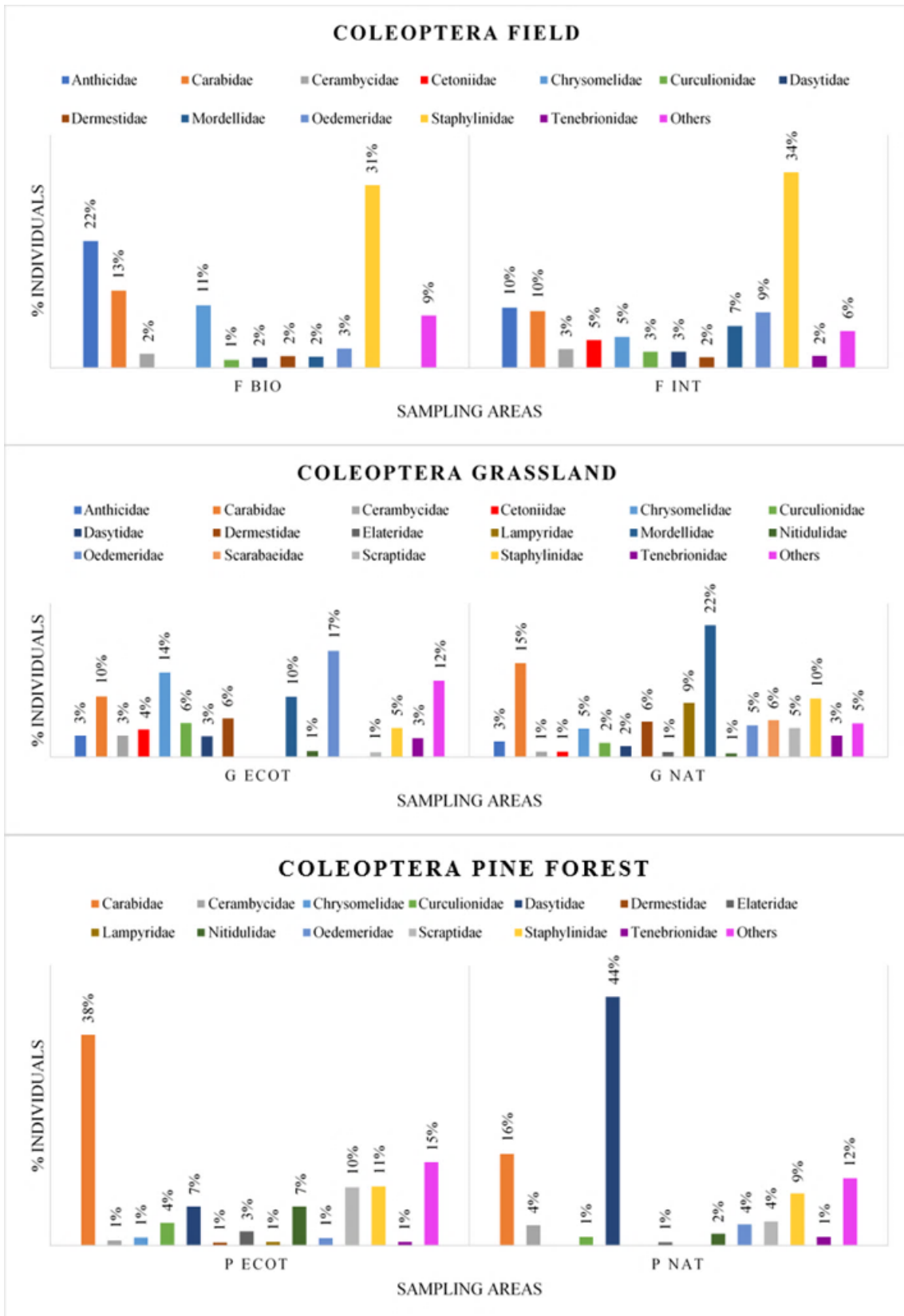
3.2 Analysis of family

The graph 3.5 shows the relative abundance of individual and families of beetles collected. The higher abundance of Coleoptera specimens was recorded in Fbio (N=3.593) and Pnat (N=3.033), while the largest number of families was present in pine forests (Pnat N=39 and Pecot N=37).



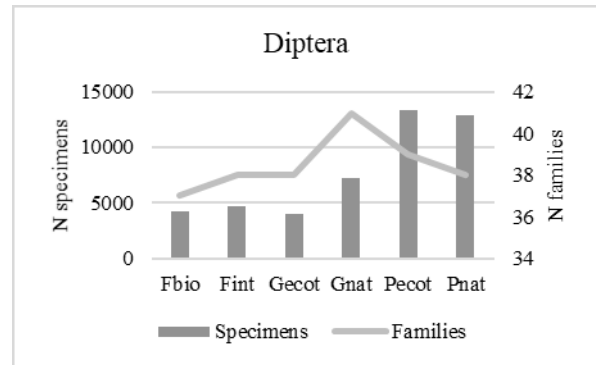
Graph 3.5 Abundance of Coleoptera Families for sampling area

In the biological field (Fbio) the most abundant families are Staphylinidae (31%), Anthicidae (22%), Carabidae (13%) and Chrysomelidae (11%), while in the integrated field (Fint) besides Staphylinidae (34%), the Anthicidae (10%), Carabidae (10%) and Oedemeridae (9%) are abundant too. In the grassland grazing ecotonal area (Gecot) we find mainly Oedemeridae (17%), Chrysomelidae (14%), Mordellidae (10%) and Carabidae (10%). In contrast, in the natural area of pasture (Gnat) (N families: 33; N specimens: 1869) there is an abundance of Mordellidae (22%), Carabidae (15%), Staphylinidae (10%) and Lampyridae (9%). Finally, in the ecotonal pine forest (Pecot), the families Carabidae (38%), Staphylinidae (11%) and Scaptidae (10%) dominate, while in the natural pine forest (Pnat) we find the dominance of Dasytidae (44%) followed by Carabidae (16%) and Staphylinidae (9%) (Graph 3.6).

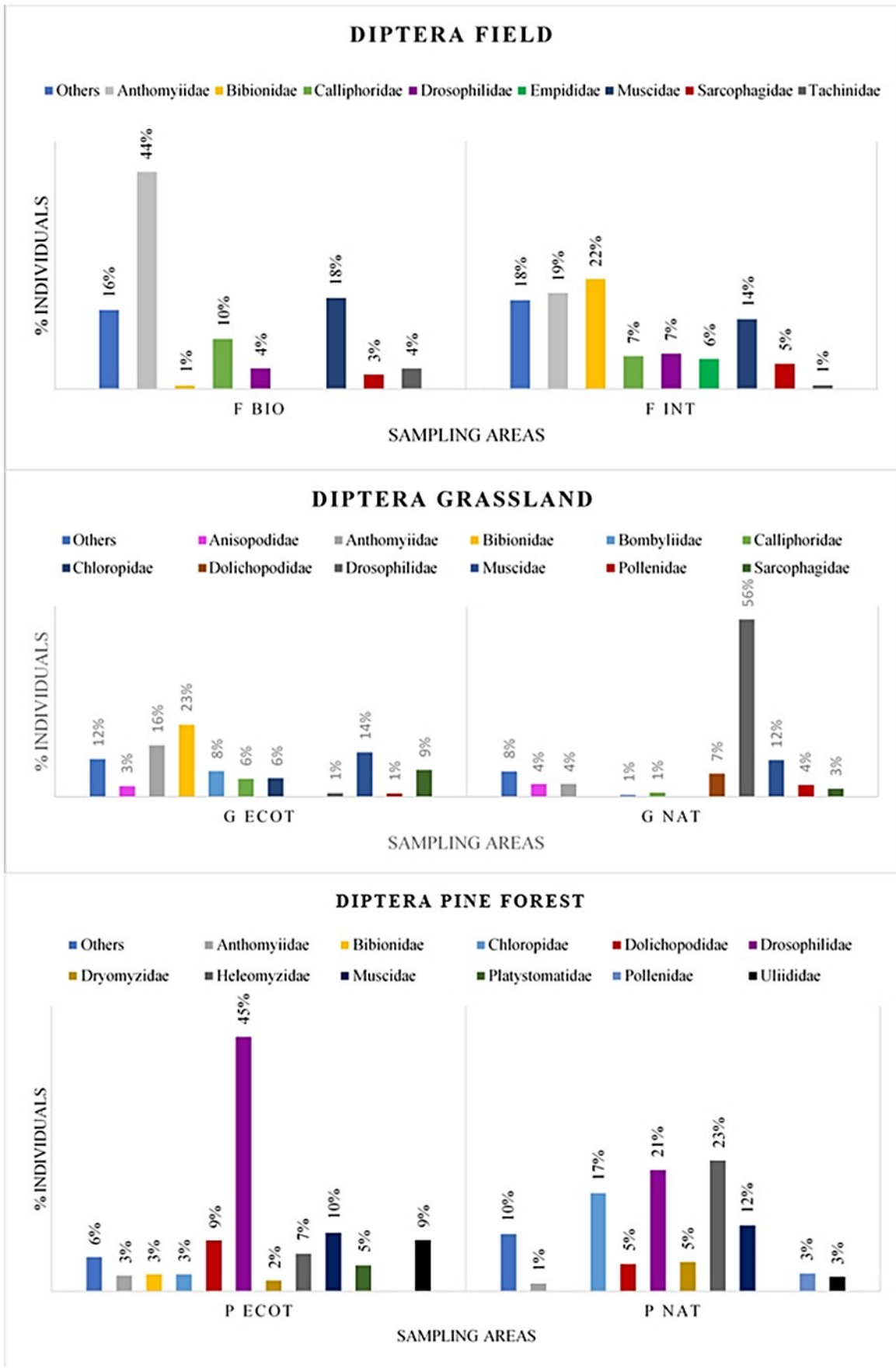


Graph 3.6 Abundance of family of Coleoptera in sampling areas

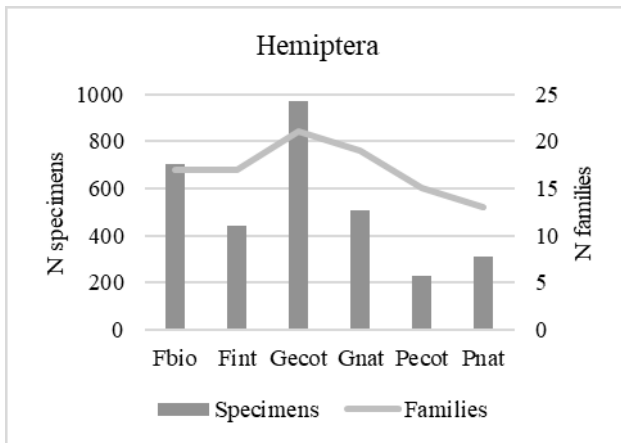
About Diptera (Graph 3.7), the highest number of families was found in Gnat (N=41), while the lowest in Fbio (N=37); however, inside the pine forests, the largest number of specimens were collected (Pecot N=13366 and Pnat N=12868). Specifically, the graph 3.8 shows the percentages of families in the survey areas. In Fbio the most abundant are Anthomyiidae (44%), Muscidae (18%) and Calliphoridae (10%) while in Fint abundant are Bibionidae (22%), Anthomyiidae (19%) and Muscidae (14%). In Gecot we find quite similar abundances (Bibionidae 23%, Anthomyiidae 16% and Muscidae 14%) while in Gnat abundant are Drosophilidae (56%) and Muscidae (12%). In Pecot, Drosophilidae (45%) with Muscidae (10%) and Uliididae (9%) predominate while in Pnat the most abundant are Heleomyzidae (23%), Drosophilidae (21%), Chloropidae (17%) and Muscidae (12%).



Graph 3.7 Abundance of Dipteran Families for sampling area

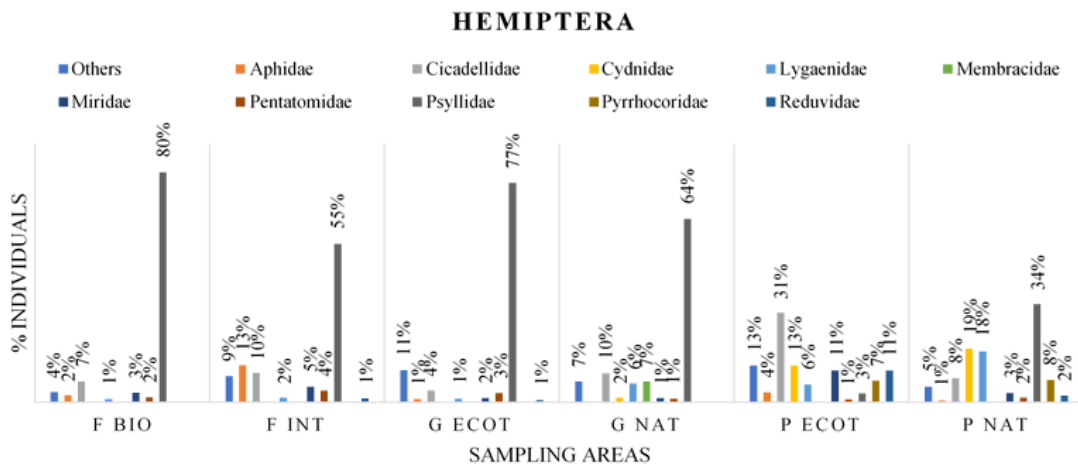


Graph 3.8 Abundance of family of Diptera in sampling areas

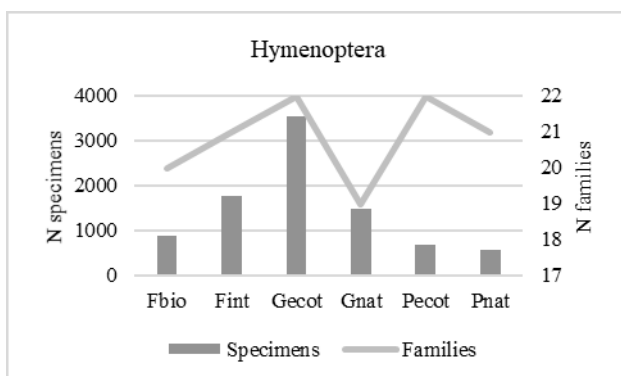


Graph 3.9 Abundance of Hemiptera families for sampling area

Among Hemiptera (Graph 3.9) the largest number of families and specimens was collected in Gecot (N families= 21; N specimens= 968); the smallest number of specimens was collected in Pecot (N= 227) while the smallest abundance of families was estimated for Pnat (N= 13). In the graph 3.10 we have the abundances as a percentage of the different families collected in each area. In all areas, abundant are the families Psyllidae and Cicadellidae, but in the pine forests there are also Cydnidae and Pyrrhocoridae.

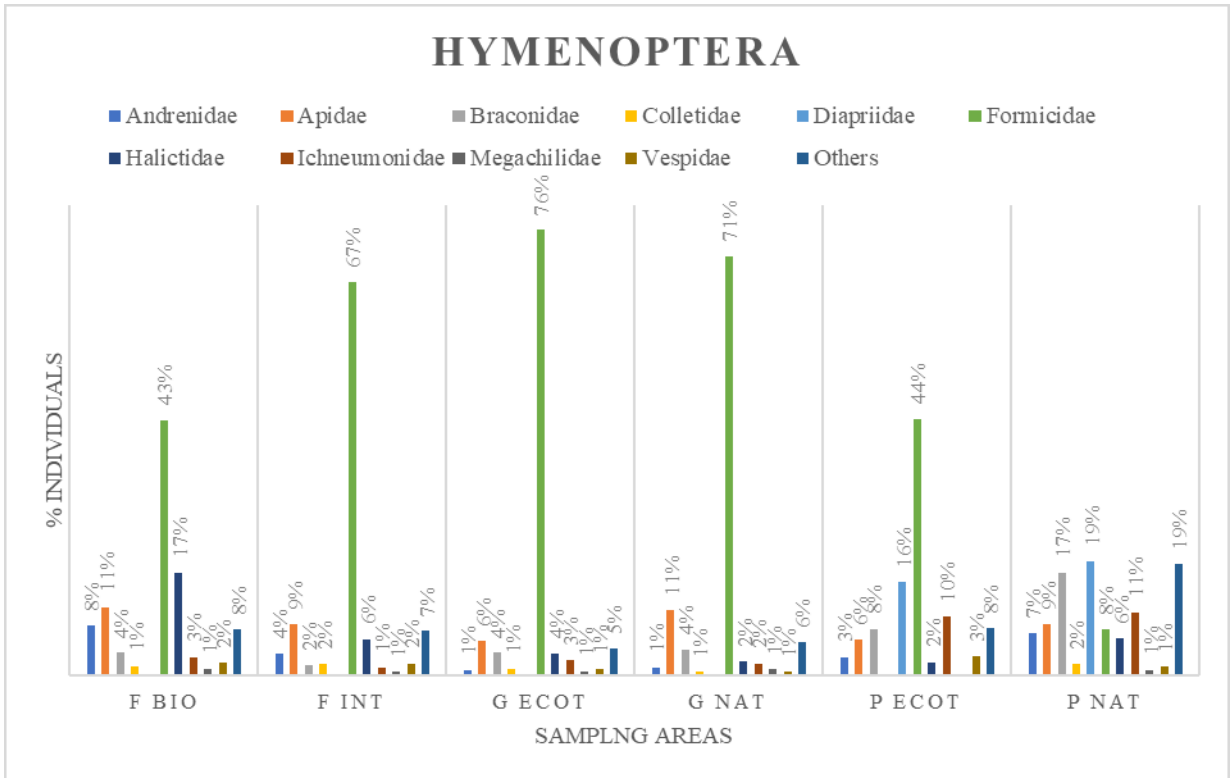


Graph 3.10 Abundance of family of Hemiptera in sampling areas



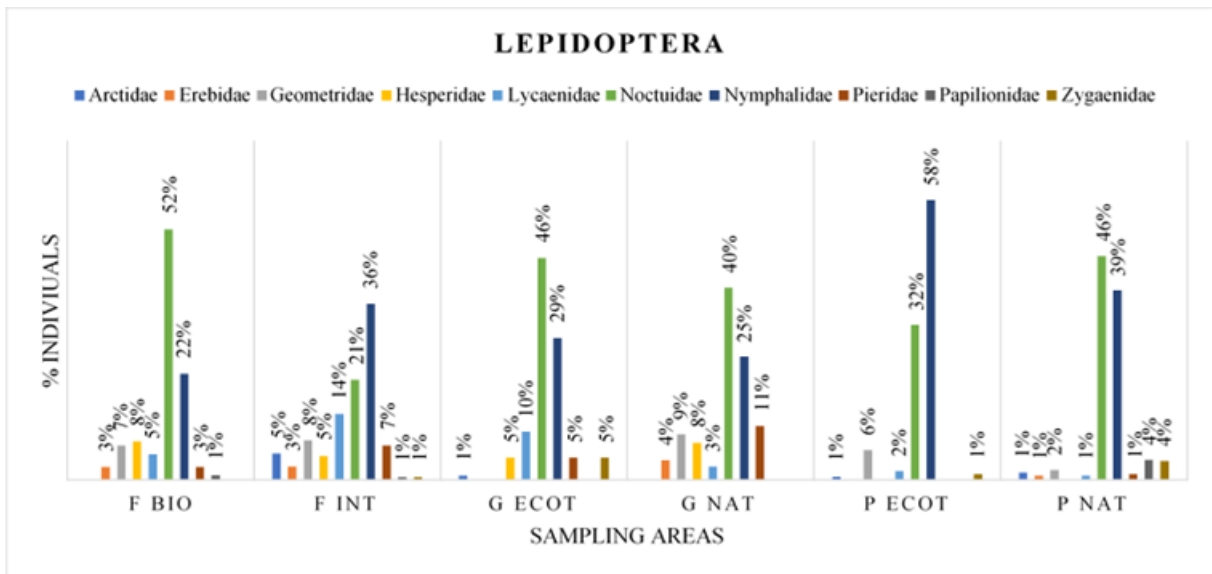
Graph 3.11 Abundance of Hymenoptera Families for sampling area

As regards the order of the Hymenoptera, the largest number of families was collected in Gecot and Pecot, while the smallest in Fbio; the highest abundance was recorded in Gecot and the lowest in Gnat (Graph 3.11). About families, the Formicidae predominate in all areas except Pnat, where the abundance of other families is almost distributed. Other abundant families are Apidae and Halictidae; in the pine forests, then, there are Diapriidae (Graph 3.12).



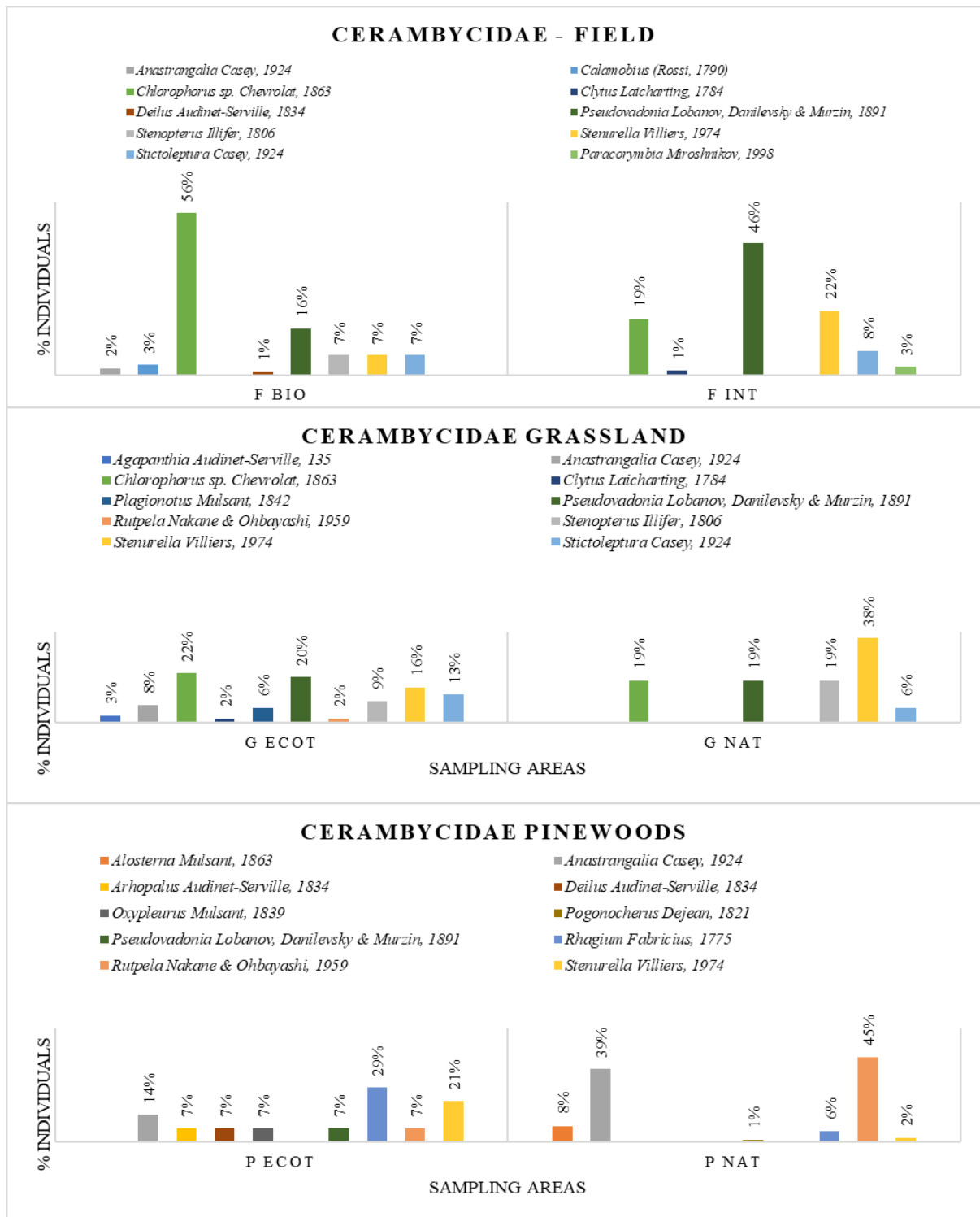
Graph 3.12 Abundance of family of Hymenoptera in sampling areas

Finally, among Lepidoptera, Noctuidae are abundant in all sampling areas but in pine forests Nymphalidae are abundant too (Graph 3.13).



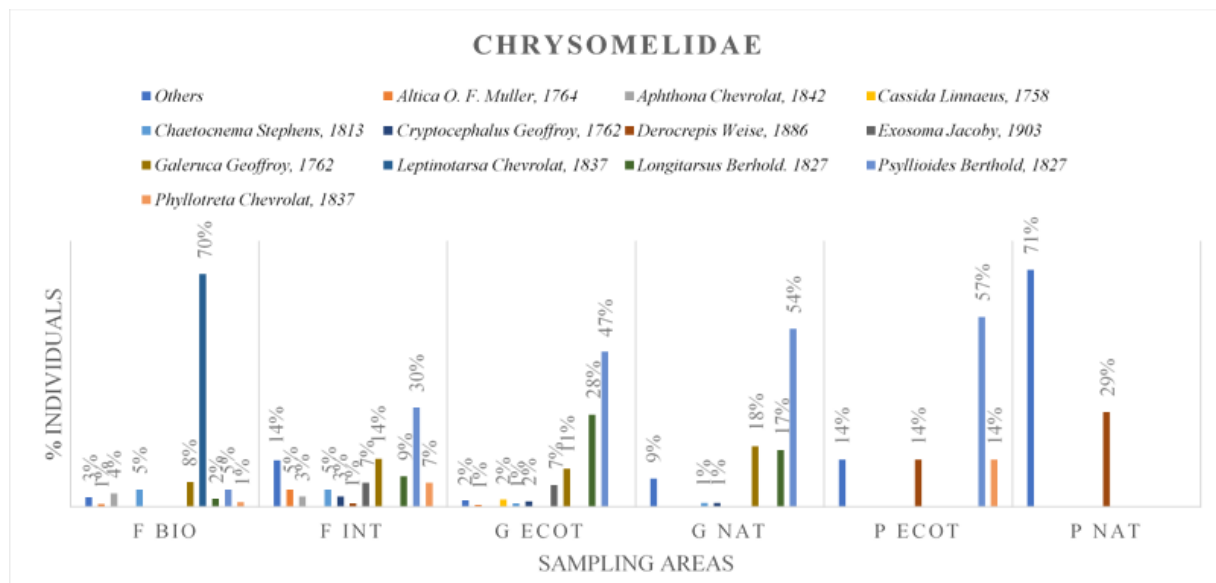
Graph 3.13 Abundance of family of Lepidoptera in sampling areas

3.3 Genera



Graph 3.14 Abundance of genus of Cerambycidae in sampling areas

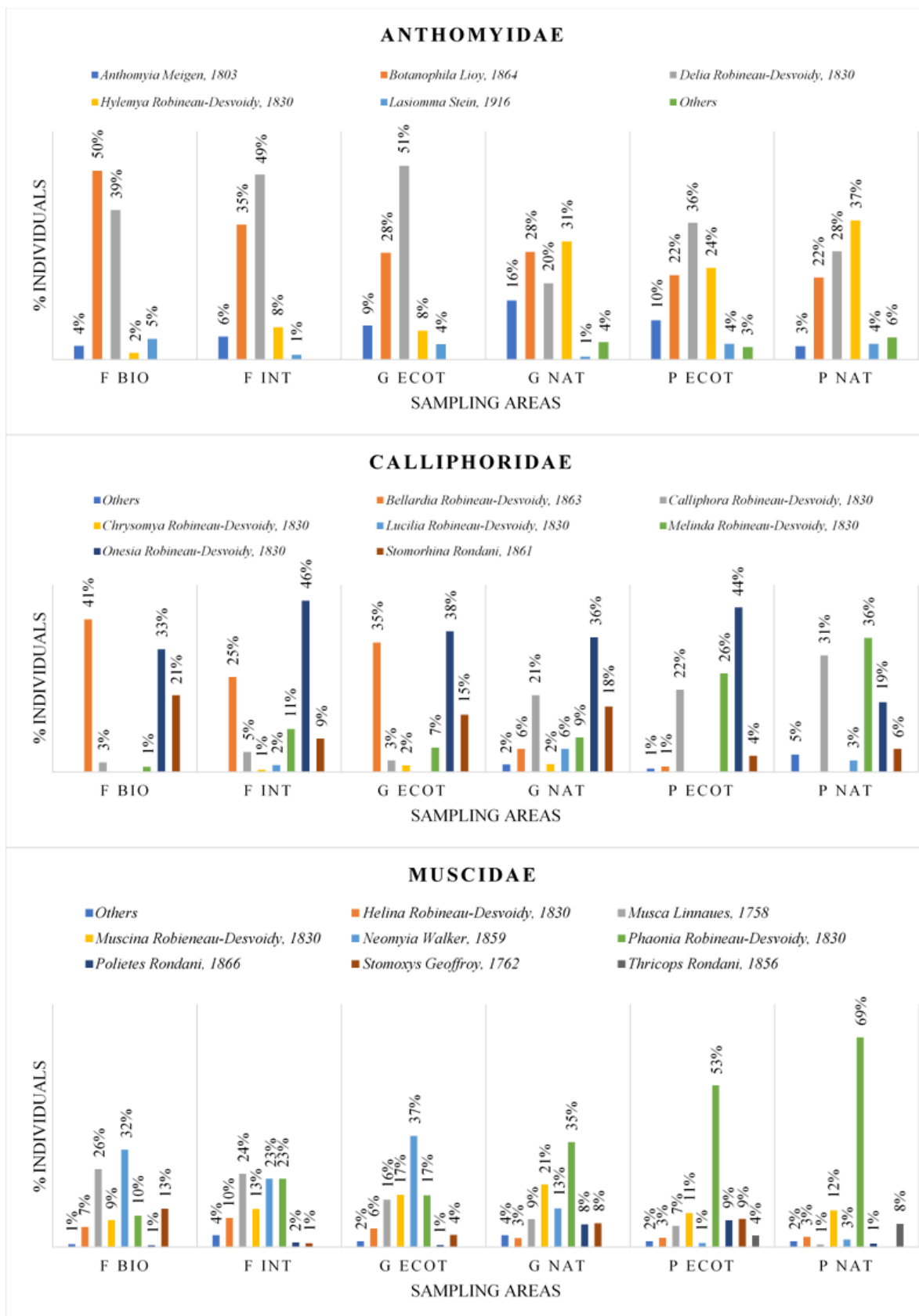
As regards the Coleoptera Cerambycidae (Graph 3.14), in the potatoes fields and in the open areas abundant genera are *Chlrophorus* Chevrolat, 1863 and *Pseudovadonia* Lobanov, Danilevsky & Murzin, 1981, both xylophagous insects. In addition, in the open areas are also abundant *Stictoleptura* Casey, 1924 and *Stenurella* Villiers, 1974. In the pine forests is also present the genus *Rhagium* Fabricius, 1775.



Graph 3.15 Abundance of genus of Chrysomelidae in sampling areas

About Chrysomelidae (Graph 3.15) there are a significant presence of the phytophagous *Chaetocnema* Stephens, 1831 and *Galeruca* Geoffroy, 1762. In addition, in the biological field (Fbio) abundant is the pest of the Solanaceae *Leptinotarsa decemlineata* Say, 1824.

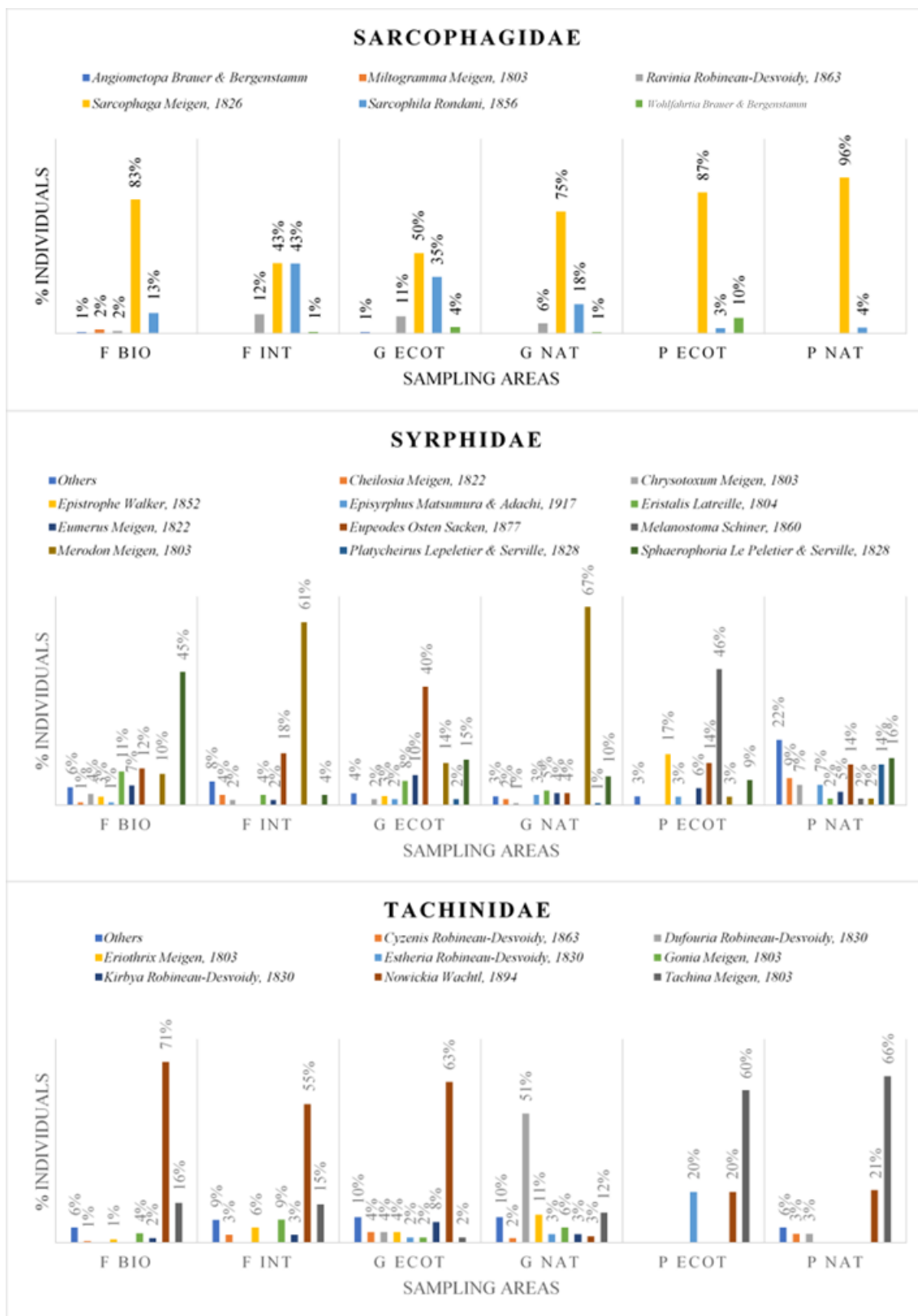
Among Diptera (Graph 3.16), within the family Anthomyiidae we find *Botanophila* Lioy, 1864 and *Delia* Robineau-Desvoidy, 1830 while between Calliphoridae the most abundant is the genus *Onesia* Robineau-Desvoidy, 1830. In the agroecosystems (Fbio and Fint) and in the ecotonal area (Gecot) genera *Bellardia* Robineau-Desvoidy, 1863 and *Stomorhina* Rondani, 1861 are present, while in the pine forest there is the genus *Melinda* Robineau-Desvoidy, 1830. Regarding the genera of Muscidae, in the crops (Fbio and Fint) are abundant *Neomyia* spp. Walker, 1956, *Musca* spp. Linnaeus, 1758 and *Thricops* spp. Rondani, 1856; in addition, in Fbio is also abundant *Stomoxys* Geoffroy, 1762, which is a genus composed by hematophagous species of cattle and probably it is present in that area because of the proximity of the farm's stable. Finally, in the pine forests and in the pasture area we have an abundance of the genus *Phaonia* Robineau-Desvoidy, 1830. The genus *Muscina* is abundant especially in grazing areas.



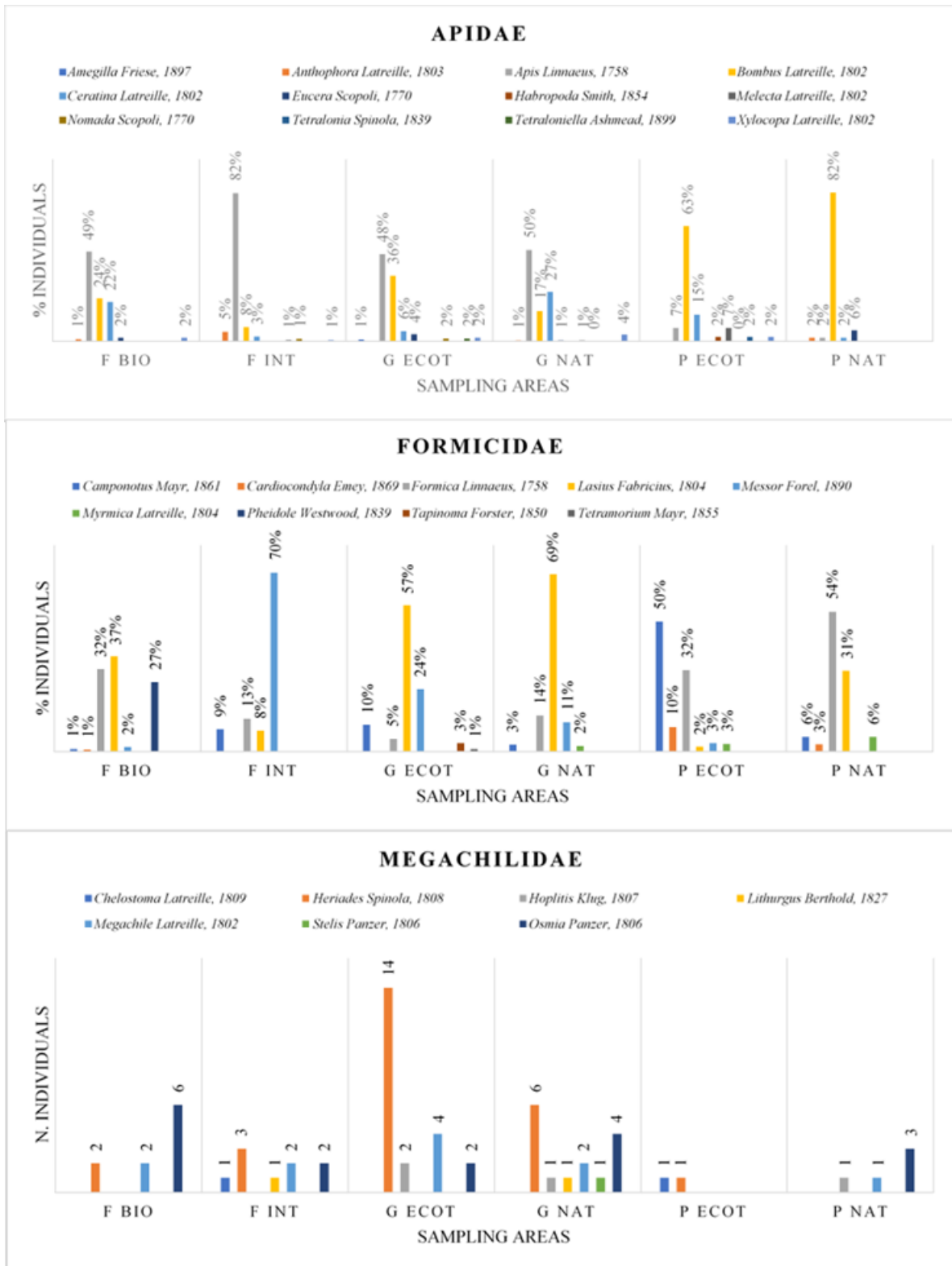
Graph 3.16 Abundance of genus of Diptera family in sampling areas

In all areas, the family Sarcophagidae (Graph 3.17) is abundant with genus *Sarcophaga* Meigen, 1826. In crops and Gnat *Angiometopa* Brauer & Bergenstamm, 1889 is abundant too, while in Pecot there is the genus *Wohlfahrtia* Brauer & Bergenstamm, 1889; in Fint and in Gecot is present also the genus *Ravinia* Robineau-Desvoidy, 1863. As regards the family Syrphidae, in the biological field is abundant the genus *Sphaerophoria* Le Peletier & Serville, 1828 followed by the genera *Eupeodes* Osten Sacken, 1877, *Eristalis* Latreille, 1804 and *Merodon* Meigen, 1803, while in the integrated field there are *Merodon* and *Eupeodes*. About grazing area, if in the ecotone the most abundant genus is *Eupeodes*, in the natural ones is *Merodon*. Finally, in Pecot are abundant *Melanostoma* Schiner, 1860 and *Epistrophe* Walker, 1852 while in Pnat *Sphaerophoria*. At the end, for the Tachinidae, in crops and in Gecot is abundant the genus *Nowickia* Wachtl, 1894 while in Gnat *Dufouria* Robineau-Desvoidy, 1830. In pine forests (Pecot and Pnat) we have the presence of genus *Tachina* Meigen, 1803.

About Hymenoptera (Graph 3.18), the family Apidae is one of the best represented. For example, *Apis mellifera* Linnaeus, 1758 is abundant in agroecosystems while the genus *Bombus* Latreille, 1802, although it is present in all areas, is more abundant in pine forests. *Ceratina* Latreille, 1802 is abundant in Fbio, in Gnat and in Pecot while in Pnat it is interesting the presence of the genus *Eucera* Scopoli, 1770. Among the family Megachilidae, abundant are the genera *Heriades* Spinola, 1808 and *Osmia* Panzer, 1806. On the other hand, the most abundant genera of Formicidae in Fbio are *Formica* Linnaeus, 1758, *Lasius* Fabricius, 1804 and *Pheidole* Westwood, 1839 while in Fint are *Messor* Forel, 1890 and *Formica*; in Gecot abundant are *Lasius*, *Messor* and *Camponotus* Mayr, 1861 while in Gnat *Lasius* with *Messor* and *Formica*. At the end, in Pecot are present *Camponotus* and *Formica*, while in Pnat *Formica* and *Lasius*.



Graph 3.17 Abundance of genus of Diptera family in sampling areas



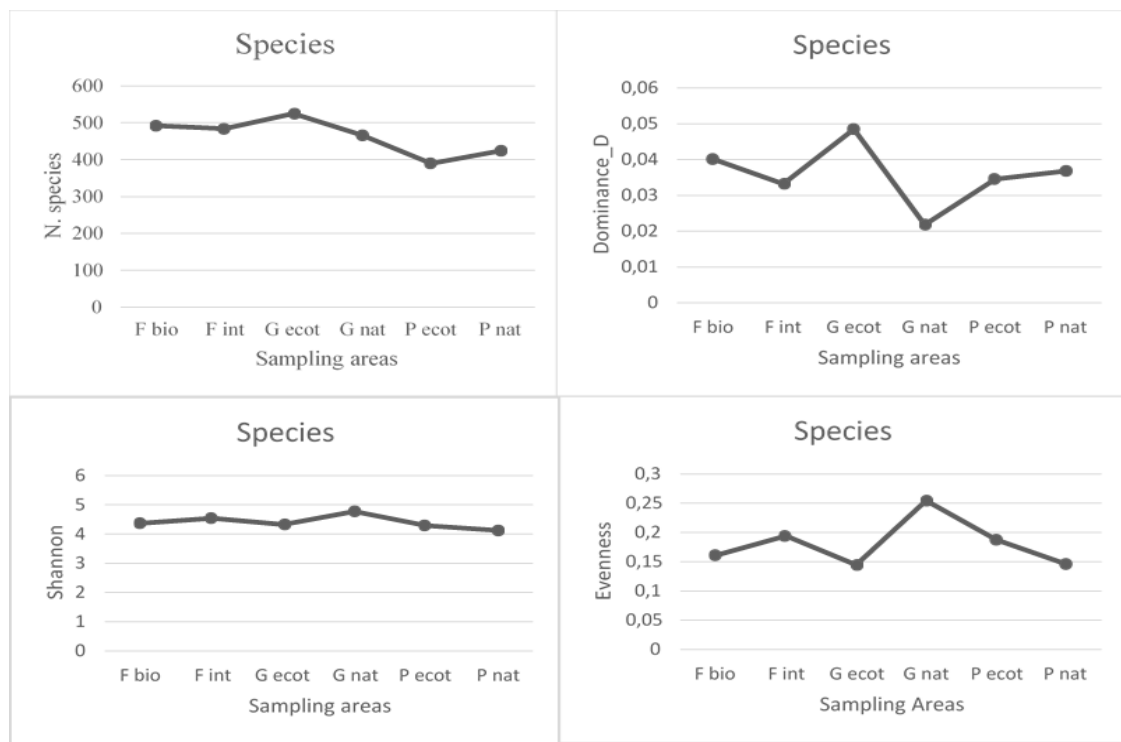
Graph 3.18 Abundance of genus of Hymenoptera family in sampling areas

3.4 Descriptive analysis of species

The number of species and morphotypes determined is different between the investigated areas (Graph 3.19; Tab. 3.2), with higher richness for Gecot (525 species) and Fbio (491 species) and fewer species in Pecot (390 species) and Pnat (424 species).

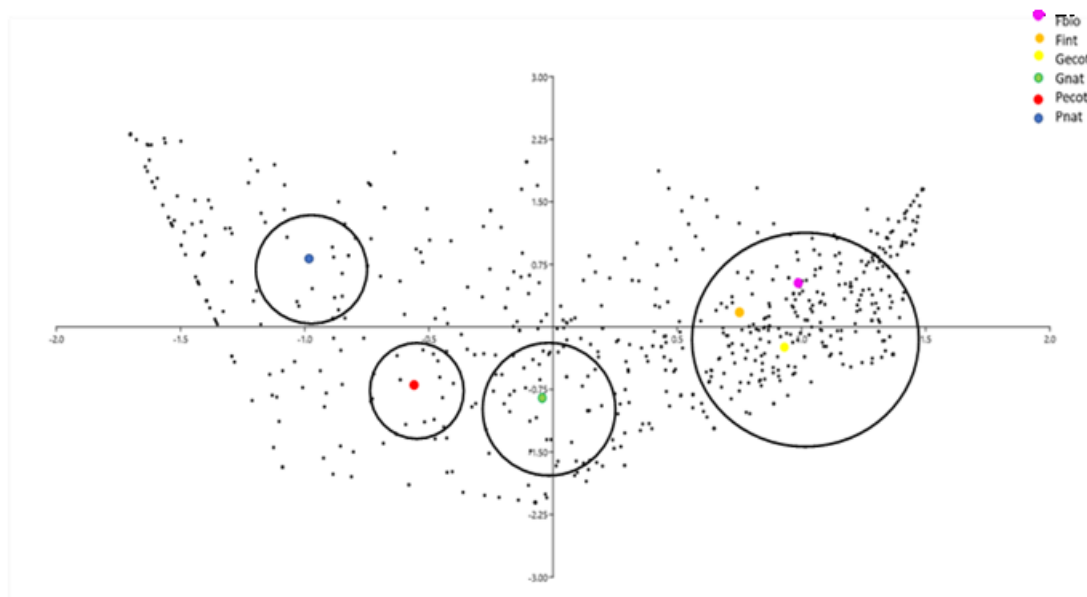
Table 3.2 Biodiversity index

	F bio	F int	G ecot	G nat	P ecot	P nat
Taxa_S	491	483	525	466	390	424
Individuals	7459	7562	9101	6518	8714	11048
Dominance_D	0,04018	0,03323	0,0485	0,02183	0,03455	0,03682
Simpson_1-D	0,9598	0,9668	0,9515	0,9782	0,9655	0,9632
Shannon_H	4,373	4,543	4,329	4,776	4,293	4,126
Evenness_e^H/S	0,1611	0,1942	0,1446	0,2545	0,1876	0,146
Brillouin	4,237	4,407	4,208	4,623	4,197	4,044
Menhinick	5,969	5,566	5,503	5,772	4,178	4,034
Margalef	55,06	54,08	57,48	52,95	42,88	45,43
Equitability_J	0,7055	0,7349	0,6912	0,7773	0,7195	0,682
Fisher_alpha	118,3	115,3	121,2	114,9	83,8	87,49
Berger-Parker	0,1235	0,109	0,1657	0,0942	0,1367	0,1189
Chao-1	748	700,8	862,3	722,5	653,5	648,8
SD	45,65134	41,98981	61,28208	29,1572	49,34947	64,61904



Graph 3.19 Biodiversity index

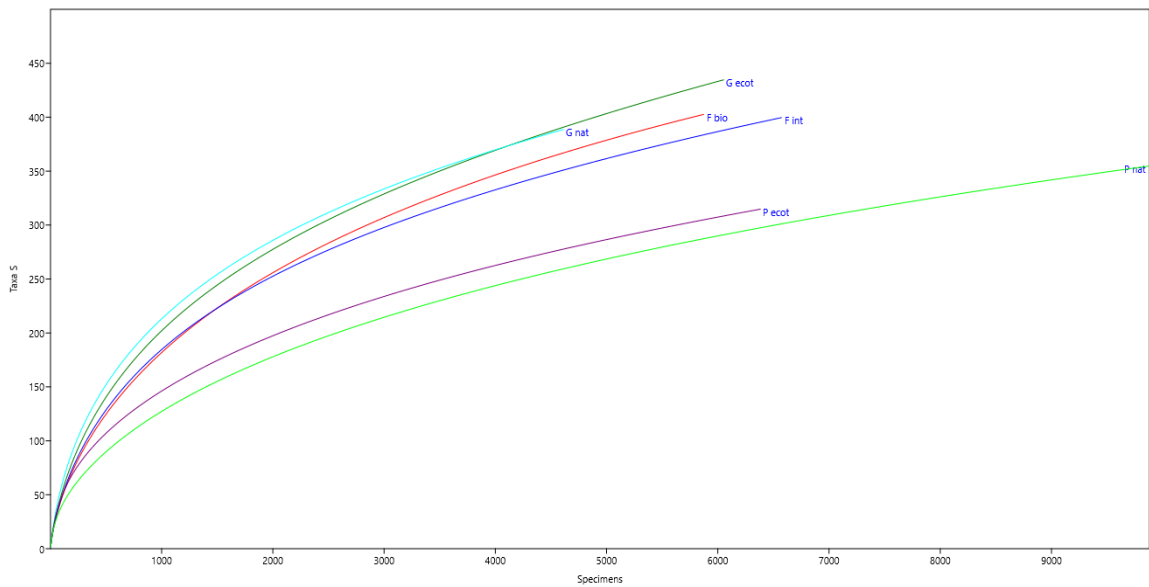
About Biodiversity index, dominance values are rather low, indicating that there are not particular dominant species in sampling areas. Specifically, Gecot shows the highest dominance value while Fint and Gnat show lower values. In addition, the Shannon index shows a low variability between areas, with values ranging around 4. In particular, Gnat has slightly higher diversity value while in Pnat and Pecot it is lower. Moreover, Gnat has a high value of Evenness index (0.25), indicating that the species present in that area are more similarly distributed than others even if the value is rather low. In contrast, the species in Fbio and Pnat are less equally distributed.



Graph 3.20 Correspondence analysis of all species (Software Past)

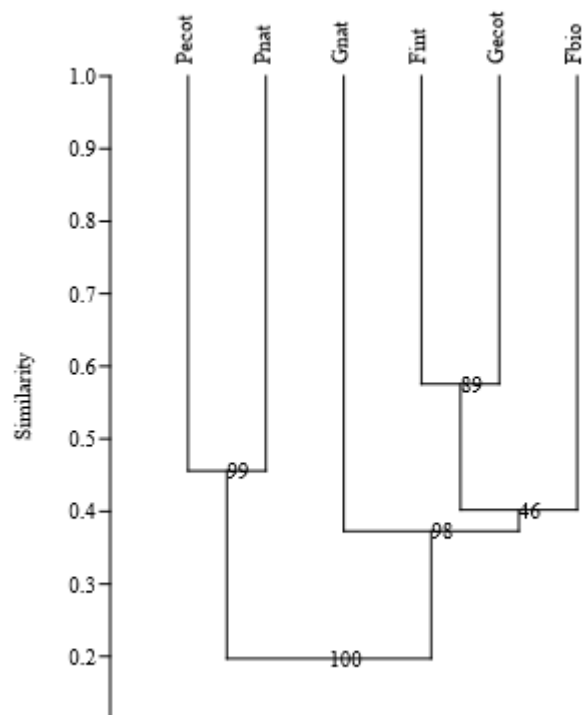
The correspondence analysis (Graph 3.20) shows the distribution of species in the different sampling areas. We can distinguish four distinct groups. In detail, Pnat (in blue), Pecot (in red) e Gnat (in green) show a distinct species community compared to that present in crops and in Gecot. Within the macro group of Fbio, Fint and Gecot, a higher concentration of species is observed, especially near Gecot and Fint, indicating that the ecotone area is a reservoir of biodiversity for the integrated management field.

The individual rarefaction graph (Graph 3.21) relates the number of individuals (x axis) and taxonomic richness (y axis). Pine forests show slower growth in taxonomic richness than open grassland. The agricultural fields show intermediate curves, with the integrated field slightly higher than the biological field. The curve pattern reflects habitat complexity, availability of trophic resources or selective pressure.



Graph 3.21 Species rarefaction (Software Past)

The cluster analysis (Graph 3.22) (algorithm: paired groups; similarity index: Bray–Curtis; 1000 bootstraps, cophenetic correlation coefficient: 0.9191) shows the similarity between sampling areas based on species composition. Pecot and Pnat are quite similar, indicating that these two habitats share many species, which are probably specialized to live in forest environments, although there is a different degree of naturalness between the two areas. Gecot and Fint form a subgroup with a relatively high degree of similarity because, despite the ecological differences between a grazing and a managed agricultural field, there is overlap and exchange of species. Fbio is linked to this group at a lower level of similarity probably due to the different management of the agricultural field (biological) and the absence of natural or semi-natural ecotones. Gnat, despite being related to this group, is still distinct from the agroecosystem, suggesting a different species composition compared to other habitats.



Graph 3.22 Cluster analysis of all species (Software past)

3.5 Analysis of the phytophagous community

About phytophagous species, there is a significant difference between the sampling areas (Permanova; $f:2,251$; $p: 0,0001$). In the table (Tab.3.3) the Bonferroni test is also performed. In particular there is a significant difference between the phytophagous species, except between Fint vs. Gecot, because the ecotonal area and crop share species, and between Pecot vs. Pnat and Gnat vs Pecot.

Table 3.3 Bonferroni-corrected p values.

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Fbio		0,003	0.0015	0.0015	0.0015	0.0015
Fint	0.003		1	0.0195	0.0015	0.0015
Gecot	0.0015	1		0.0075	0.0015	0.0015
Gnat	0.0015	0.0195	0.0075		0.09	0.0015
Pecot	0.0015	0.0015	0.0015	0.09		1
Pnat	0.0015	0.0015	0.0015	0.0015	1	

The largest number of phytophagous species was recorded in the ecotonal area (Gecot), while the greatest abundance of specimens is found in the biological field, although the species abundances are not uniform (as indicated by the Evenness value) due to the predominance of leaf miner *Leptinotarsa decemlineata*. In the open natural area (Gnat) we have a greater value of biodiversity (Tab. 3.4).

Table 3.4 Phytophagous biodiversity index

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
N° taxa	67	80	92	65	48	47
N° specimens	2361	2291	2171	688	1195	850
Shannon_H	1,885	2,306	2,509	3,179	2,216	2,421
Evenness	0,09827	0,1254	0,1336	0,3695	0,1911	0,2395
Margalef	8,498	10,21	11,84	9,795	6,633	6,82

Table 3.5 CA and CCA code

COLEOPTERA		HEMIPTERA	
C1	<i>Agrilus</i> sp. Curtis, 1825	H1	<i>Cercopis arcuata</i> Fieber, 1775
C2	<i>Agapanthia</i> sp. Serville, 1835	H2	<i>Cercopis sanguinolenta</i> (Scopoli, 1763)
C3	<i>Calamobius filum</i> (Rossi, 1790)	H3	<i>Haematoloma dorsatum</i> (Ahrens, 1812)
C4	<i>Agapanthia cynarae</i> (Gyllenhal, 1817)	H4	<i>Aphrodes</i> sp. Curtis, 1833
C5	<i>Alosterna tabacicolor</i> (De Geer, 1775)	H5	<i>Eupelix cuspidata</i> (Fabricius, 1775)
C6	<i>Tropinota (Tropinota) squalida squalida</i> (Scopoli, 1783)	H6	<i>Ledra aurita</i> (Linnaeus, 1758)
C7	<i>Tropinota (Epicometis) hirta</i> (Poda, 1761)	H7	<i>Cicadella viridis</i> (Linnaeus, 1758)
C8	<i>Althica</i> sp. Geoffroy, 1762	H8	<i>Coriomeris</i> sp. Westwood, 1842
C9	<i>Cassida (Cassida) prasina</i> Illiger, 1798	H9	<i>Coriomeris scabricornis</i> (Panzer, 1809)
C10	<i>Cassida (Cassida) rubiginosa</i> O.F. Muller, 1776	H10	<i>Spathocera lobata</i> (Herrich-Schäffer, 1840)
C11	<i>Cassida sanguinolenta</i> Muller, 1776	H11	<i>Syromastus rhombeus</i> (Linnaeus, 1767)
C12	<i>Cassida</i> sp. Linnaeus, 1758	H12	<i>Centrocoris variegatus</i> Kolenati, 1845
C13	<i>Chrysolina (Chalcoidea) interstincta</i> (Suffrian, 1851)	H13	<i>Coriomeris hirticornis</i> (Fabricius, 1794)
C14	<i>Chrysolina rossia</i> (Illiger, 1802)	H14	<i>Canthophorus</i> sp. Mulsant & Rey, 1866
C15	<i>Chrysolina (Synerga) herbacea</i> (Duftschmid, 1825)	H15	<i>Ochetostethus</i> sp. Fieber, 1860
C16	<i>Crepidodera aurea</i> (Geoffroy, 1785)	H16	<i>Issus</i> sp. Fabricius, 1803
C17	<i>Cryptocephalus</i> sp. O. F. Müller, 1764	H17	<i>Lygaeus equestris</i> (Linnaeus, 1758)
C18	<i>Derocrepis sodalis</i> (Kutschera, 1860)	H18	<i>Rhyparochromus vulgaris</i> (Schilling, 1829)
C19	<i>Exosoma lusitanicum</i> (Linnaeus, 1767)	H19	<i>Eremocoris plebejus</i> (Fallen, 1807)
C20	<i>Galeruca (Galeruca) littoralis</i> (Fabricius, 1787)	H20	<i>Gastrodes grossipes</i> (De Geer, 1773)
C21	<i>Galeruca (Galeruca) pomonae</i> subsp. <i>pomonae</i> (Scopoli, 1763)	H21	<i>Melanocoryphus albomaculatus</i> (Goeze, 1778)
C22	<i>Galeruca (Galeruca) tanacetii</i> (Linnaeus, 1758)	H22	<i>Rhyparochromus vulgaris</i> (Schilling, 1829)
C23	<i>Galerucella lineola</i> (Fabricius, 1781)	H23	<i>Xanthochilus saturnius</i> (Rossi, 1790)
C24	Halticinae	H24	<i>Eremocoris</i> sp. Fieber, 1861
C25	<i>Hispa atra</i> Linnaeus, 1767	H25	<i>Emblethis verbasci</i> (Fabricius 1803)
C26	<i>Leptinotarsa decemlineata</i> (Say, 1824)	H27	<i>Raglius confusus</i> (Reuter, 1886)
C27	<i>Lupeus</i> sp. Geoffroy, 1762	H28	<i>Gargara genistae</i> (Fabricius, 1775)
C28	<i>Mantura (Mantura) obtusata</i> (Gyllenhal, 1813)	H29	<i>Adelphocoris lineolatus</i> (Goeze, 1778)
C29	<i>Neocrepidodera ferruginea</i> (Scopoli, 1763)	H30	<i>Calocoris nemoralis</i> (Fabricius, 1787)
C30	<i>Neocrepidodera impressa</i> (Fabricius, 1801)	H31	<i>Calocoris</i> sp. Fieber, 1858
C31	<i>Pachybrachis</i> sp. Dejean, 1836	H32	<i>Deraeocoris (Deraeocoris) ruber</i> (Linnaeus, 1758)
C32	<i>Phyllotreta cruciferae</i> (Goeze, 1777)	H33	<i>Deraeocoris punctum</i> (Rambur, 1839)
C33	<i>Phyllotreta</i> sp. Chevrolat, 1837	H34	<i>Deraeocoris</i> sp. Kirschbaum, 1856
C34	<i>Phyllotreta undulata</i> Kutschera, 1860	H35	<i>Grypocoris (Lophyromiris) sexguttatus</i> (Fabricius, 1777)
C35	<i>Psylliodes (Psylliodes) chrysocephala</i> (Linnaeus, 1758)	H36	<i>Lygus pratensis</i> (Linnaeus, 1758)
C36	<i>Bothynoderes affinis</i> (Schrank, 1781)	H37	<i>Metopoplax</i> sp. Fieber, 1860
C37	<i>Coniocleonus (Plagiographus) pseudobliquus</i> (G. Muller, 1921)	H38	<i>Aelia acuminata</i> (Linnaeus, 1758)
C38	<i>Lixus</i> sp. J.C.Fabricius, 1802	H39	<i>Aelia rostrata</i> Boheman, 1852
C39	<i>Phyllobius (Subphyllobius) virideaeris</i> (Laicharting, 1781)	H40	<i>Carpocoris mediterraneus mediterraneus</i> (Tamanini, 1958)
C40	<i>Pityogenes</i> sp. Bedel, 1888	H41	<i>Dolycoris baccarum</i> (Linnaeus, 1758)
C41	<i>Pentodon bidens</i> (Pallas, 1771)	H42	<i>Dyroderes umbraculatus</i> (Fabricius, 1775)
C42	<i>Agriotes</i> sp. Eschscholtz, 1829	H43	<i>Eurydema (Eurydema) oleracea</i> (Linnaeus, 1758)
C43	<i>Agrypnus murinus</i> (Linnaeus, 1758)	H44	<i>Eurydema (Eurydema) ornata</i> (Linnaeus, 1758)
C44	<i>Athous (Athous) ineptus</i> Candèze, 1860	H45	<i>Eurydema fieberi</i> Schummel, 1837
C45	<i>Athous</i> sp. Eschscholtz, 1829	H46	<i>Eurydema ventralis</i> (Kolenati, 1846)
C46	<i>Cidnopus pseudopilosus</i> Platia & Gudenzi, 1985	H47	<i>Graphosoma lineatum</i> (Linnaeus, 1758)
C47	<i>Ctenicera cuprea</i> (Fabricius, 1775)	H48	<i>Palomena prasina</i> (Linnaeus, 1761)
C48	<i>Ctenicera pectinicornis</i> (Linnaeus, 1758)	H49	<i>Sciocoris</i> sp. Fallen, 1829
C49	<i>Cerocoma (Cerocoma) schaefferi</i> (Linnaeus, 1758)	H50	<i>Pyrrhocoris apterus</i> (Linnaeus, 1758)
C50	<i>Amadotrogus quercanus</i> (Burmeister, 1855)	H51	<i>Pyrrhocoris marginatus</i> (Kolenati, 1845)
C51	<i>Firminus baudii</i> (Brenske, 1886)	H52	<i>Chorosoma schillingii</i> (Schilling, 1829)
C52	<i>Firminus ciliatus vexillis</i> (Reitter, 1902)	H53	<i>Corizus hyoscyami</i> (Linnaeus, 1758)
C53	<i>Rhizotrogus marginipes</i> Mulsant, 1842	H54	<i>Xanthochilus saturnius</i> (Rossi, 1790)
C54	<i>Rhizotrogus aestivus</i> (Olivier, 1789)	H55	<i>Odontoscelis (Odontoscelis) fuliginosa</i> (Linnaeus, 1761)
C55	<i>Mycterus (Eutryptes) tibialis</i> Kuster, 1850	H56	<i>Tettigomedia</i> sp. Latreille, 1804
C56	<i>Mycterus (Mycterus) curculioides</i> (Fabricius, 1781)	H57	<i>Dictyla humuli</i> (Fabricius, 1794)
C57	<i>Urophorus humeralis</i> (Fabricius, 1798)	H58	<i>Tingis</i> sp. Fabricius, 1803
C58	<i>Amphimallon ochraceum</i> (Knoch, 1801)		
C59	<i>Amphimallon pseudomajale</i> Sabatinelli, 1976		
C60	<i>Omophilus lepturoides</i> (Fabricius, 1787)		
C61	<i>Omophilus picipes</i> (Fabricius, 1792)		
C62	<i>Opatrum</i> sp. Fabricius, 1775		
C63	<i>Omophilus</i> sp. Solier, 1835		
C64	<i>Apteropeda orbiculata</i> (Marshall, 1802)		
C65	<i>Chaetocnema</i> spp.		
C66	<i>Psyllioides</i> spp. Stephens, 1831		
C67	<i>Orthotomicus</i> sp. Ferrari, 1867		
C68	<i>Oryzaephilus surinamensis</i> (Linnaeus, 1758)		
ORTHOPTERA		DIPTERA	
O1	<i>Ailopus</i> sp. Fieber, 1853	D1	<i>Eustalomyia</i> sp. Kowarz, 1873
O2	<i>Calliptamus italicus</i> (Linnaeus, 1758)	D2	<i>Aulacigaster leucopeza</i> (Meigen, 1830)
O3	<i>Calliptamus siciliae</i> Ramme, 1927	D3	<i>Bibio hortulanus</i> (Linnaeus, 1758)
O4	<i>Eyprepocnemis plorans</i> (Charpentier, 1825)	D4	<i>Bibio marci</i> (Linnaeus, 1758)
O5	<i>Oedipoda caerulescens</i> (Linnaeus, 1758)	D5	<i>Dilophus femoratus</i> Meigen, 1804
O6	<i>Omocestus (Omocestus) rufipes</i> (Zetterstedt, 1821)	D6	<i>Carpomya schineri</i> (Loew, 1856)
O7	<i>Stenobothrus lineatus lineatus</i> (Panzer, 1796)	D7	<i>Drosophila sukuzii</i> Matsumura, 1931
O8	<i>Gryllus campestris</i> Linnaeus, 1758	D8	<i>Loxocera aristata</i> (Panzer, 1801)
O9	<i>Tetrix</i> sp. Latreille, 1802	D9	<i>Chaetorellia</i> Hendel, 1927
O10	<i>Chorthippus</i> sp. Fieber, 1852	D10	<i>Tephros</i> sp. Ragonot, 1891
O11	<i>Decticus</i> sp. Serville, 1831	D11	<i>Nephrotoma</i> sp. Meigen, 1803
		D12	<i>Pegomyia</i> sp. Robineau-Desvoidy, 1830
		D13	<i>Anthomyia</i> sp. Meigen, 1803
		D14	<i>Botanophila</i> sp. Lioy, 1864
		D15	<i>Delia</i> sp. Robineau-Desvoidy, 1830
		D16	<i>Hylemya</i> sp. Robineau-Desvoidy, 1830
		D17	<i>Lasionomma</i> sp. Stein, 1916
		D18	<i>Chlorops</i> sp. Meigen, 1803

Tab.3.6 CA and CCA code

HYMENOPTERA		LEPIDOPTERA	
Hy1	<i>Arge</i> sp. Schrank, 1802	L1	<i>Amata phegea</i> Linnaeus, 1758
Hy2	<i>Athalia bicolor</i> Serville, 1823	L2	<i>Amata</i> sp. Fabricius, 1807
Hy3	<i>Athalia circularis</i> (Klug, 1815)	L3	<i>Epilecta linogrisea</i> (Denis & Schiffermuller, 1775)
Hy4	<i>Dolerus</i> sp. Panzer, 1801	L4	<i>Noctua pronuba</i> (Linnaeus, 1758)
Hy5	<i>Macrophya (Macrophya) montana</i> (Scopoli, 1763)	L5	<i>Trigonophora (Trigonophora) flammea</i> (Esper, 1785)
Hy6	<i>Nematus (Pteronidea) myosotidis</i> (Fabricius, 1804)	L6	<i>Adscita manni</i> (Lederer, 1853)
Hy7	<i>Nematus</i> sp. Panzer, 1801	L7	<i>Zygaena</i> sp. Fabricius, 1775
Hy8	<i>Tiphia</i> sp. Fabricius, 1775	L8	<i>Noctua orbona</i> (Hufnagel, 1766)
Hy9	<i>Athalia</i> sp. Leach, 1817		

The correspondence analysis (chi square= 11812,777; $p < 0,01$) (Graph 3.6; legend codes are explained in Tab. 3.5; Tab. 3.6) is useful to explore the relationships between phytophagous species (red dots) and sampling areas (yellow rhombuses). For example, there are four groups of species: one related to Pnat, one to Pecot, one to Fbio and a numerous group associated with Gnat, Gecot and Fint. What emerges from the correspondence analysis is that the greater number of species are linked to agrosystems.

Several species correspond to Fbio (Field_biological) such as the Pentatomidae (Hemiptera) *Eurydema (Eurydema) oleracea* (Linnaeus, 1758) (H43), which is a well-known pest of cruciferous vegetables (Pollini, 2013), the Chrysomelidae (Coleoptera) *Chaetocnema* sp. Stephens, 1831 (C65), the potatoes pest *Leptinotarsa decemlineata* (Say, 1824) (C26) (Boniotti, 2020), the first record for Calabria *Galeruca (Galeruca) littoralis* (Fabricius, 1787) (C20), *Chrysolina (Synergia) herbacea* (Duftschmid, 1825) (C15), *Mantura (Mantura) obtusata* (Gyllenhal, 1813) (C28) and *Pachybrachis* sp. Dejean, 1831 (C31); among the Curculionidae (Coleoptera), important is the presence of the beet pest *Bothynoderes affinis* (Schrank, 1781) (C36) (Fig. 3.1)



Figure 3.1 Photo by stereomicroscope of *Bothynoderes affinis* (F. Mendicino)

(Toshova *et al.*, 2019), which is a first report for Calabria; in addition, there are *Calamobius filum* (Rossi, 1790) (C3) (Coleoptera, Cerambycidae) and *Urophonus humeralis* (Fabricius, 1798) (C57) (Coleoptera, Nitidulidae), which is a pest of orchards (Vincent & Lindgren, 1972). Between Diptera, there is the genera *Eustalomyia* sp. Kowarz, 1873 (D1) and *Lasiomma* sp. Stein, 1916 (D17) (Fam: Anthomyiidae), whose larvae can feed of the roots of many plants (Pollini, 2013). Instead, closely associated to the natural pine forest (Pnat), among Hemiptera there is the family Cydnidae with genera *Ochetostethus* sp. Fieber, 1860 (H15) and *Canthophorus* sp. Mulstant & Rey, 1866 (H14), while between Diptera there is the Drosophilidae *Drosophila suzukii* Matsumura, 1931 (D7), which is an Asian alien pest of red fruits typical of the underwood of forests (Cini *et al.*, 2012). In addition, there the Elateridae (Coleoptera) *Cidnopus pseudopilosus* Plantia & Gudenzi, 1985 (C46) and the Chrysomelidae (Coleoptera) *Derocrepis solidalis* (Kutschera, 1860) (C18): the last one species is a first record for Sila National Park.

In contrast, the ecotonal pine forest (Pecot), among Coleoptera, is associated with the Elateridae *Athous inepust* Candèze, 1860 (C44) and the Chrysomelidae *Phyllotreta undulata* Kutschera, 1860 (C34), which is a phytophagous of Euphorbiacea and Crucifere (Boniotti, 2020). About Diptera, there is *Tephritis* sp. Ragonot, 1891 (D10) (Fam: Tephritidae).

In the macrogroup Fint, Gecot and Gnat there is the majority of species; in particular, in Fint and Gecot there are the beetles of Cerambycidae family *Agapanthia* sp. Serville, 1835 (C2), the Silvanidae *Oryzaephilus surinamensis* (Linnaeus, 1758) (C68), which is a cereal pest (Hashem et al., 2021) and the Mycteridae *Mycterus (Mycterus) curculioides* (Fabricius, 1781) (C56). Moreover, among Diptera there is the Tipulidae *Nephrotoma* sp. Meigen, 1803 (D11), which is a cereal pest too (Hofsvang, 2010). Between Hemiptera there are the wheat pest, such as the Cercopidae *Cercopis sanguinolenta* (Scopoli, 1763) (H2) and the Pentatomidae *Aelia acuminata* (Linnaeus, 1758) (H638) (Biedermann, 2002; Pollini, 2013), *Dolycoris baccarum* (Linnaeus, 1758) (H41), that feeds on fruits (Pollini, 2013) and *Eurydema (Eurydema) ornata* (Linnaeus, 1758) (H44) which is a pest of cereals and potatoes (Pollini, 2013).

In Gnat (natural grazing area) there are the Hemiptera of Lygaeidae family *Rhyparochromus vulgaris* (Schilling, 1829) (H19) and the Cercopidae *Haematoloma dorsatum* (Ahrens, 1812) (H3); among Coleoptera there are the Melolonthidae *Firminus baudii* (Reitter, 1902) (C51) and the first record for Sila National Park *Rhizotrogus marginipes* Mulsant, 1842 (C53).

The CCA analysis (Graph. 3.24), instead, correlates the phytophagous species to the variables tree cover vegetation, land use, average temperature, rainfall and the presence of grazing. The Eigenvalue for the first (0,42773) and the second axis (0,2268) indicate that the canonical axes represent strong gradients and that a large percentage of variance is concentrated between them (Axis1=43,82%; Axis2=23,24%). A simulation with 9999 permutation indicates that the distributions along the axes are not casual (p: 0,0002).

In this analysis emerges that a strong influence on the distribution of species is given mainly by the vegetation cover and, therefore, the amount of light and by the average temperature, the number of days of rain and land use. For example, species positively affected by vegetation cover and grazing and negatively by land use are the Hemiptera *Spathocera lobate* (Herrich-Schäffer, 1840) (H10) (Fam: Coreidae) and *Ochetostethus* sp. Fieber, 1860 (H15) (Fam: Cydnidae). Among Hymenoptera there is the Tenthreniidae *Nematus (Pteronidea) myosotidis* (Fabricius, 1804) (Hy6), while between Diptera the genera *Eustalomyia* sp. Kowarz, 1873 (D1), *Pegomyia* sp. Robineau-Desvoidy, 1830 (D12) and *Hylemya* sp. Robineau-Desvoidy (D16) (Fam: Anthomyiidae). About Coleoptera there is the Elateridae *Cidnopus pseudopilosus* (Leske, 1785) (C46) while between Orthoptera the Acrididae *Calliptamus siciliae* Ramme, 1927 (O3).

In contrast, the average temperature positively affects several species of beetles including the Elateridae *Agripnus murinus* (Linnaeus, 1758) (C43) and the Melolonthidae *Rhizotrogus aestuvus* (Olivier, 1792) (C54). Among Hemiptera there are the Miridae *Dereacoris punctum* (Rambur, 1839) (H33), the Pentatomidae *Dolycoris baccarum* (Linnaeus, 1758) (H41) and the Scutelleridae *Odontoscelis (Odontoscelis) fuliginosa* (Linnaeus, 1761) (H55). About Lepidoptera there is *Amatha* sp. Fabricius, 1807 (L2) while between Hymenoptera *Tiphia* sp. Fabricius, 1775 (Hy8). Finally, about Orthoptera there is *Stenobothrus lineatus* (Panzer, 1796) (O7). The beetle Curculionidae *Bothinoderes affinis* (Schrank, 1781) (C36) and the dipterans *Delia* sp. Robineau-Desvoidy (D15) and *Lasiomma* sp. Stein, 1916 (D17) (Fam: Anthomyiidae) are positively correlated to the land use. In addition, there are the Hemiptera Coreidae *Coriomeris scabricornis* (Panzer, 1809) (H9) and the Miridae *Calocoris nemoralis* (Fabricius, 1787) (H30). To conclude, to the rains there are some species such as the Coleoptera Chrysomelidae *Chrysolina rossia* (Illiger, 1802) (C14) and *Galeruca (Galeruca) tanaceti* (Linnaeus, 1758) (C22). Among the Hemiptera there is the Lygaeidae *Rhyparochromus vulgaris* (Schilling, 1829) (H18) while between Diptera the Bibionidae *Dilophus femoratus* Meigen, 1804 (D5).

Not all phytophagous species are damaging for plants and the species reported in the literature as potentially harmful are distributed differently in the areas. Specifically (Tab. 3.7), the species reported as potentiality pest are 21 in Fbio, 16 in Fint, 22 in Gecot, 23 in Gnat, 11 in Pecot and 9 in Pnat.

Table 3.7 Number of pest species and number of specimens (Pollini, 2013)

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
N° species	21	16	22	23	11	9
N° specimens	1097	1593	1436	232	815	448

In detail, in the farm Scrivano Terre d'Altopiano (Tab. 3.8) were collected 7 pests for the cereal plantation, 2 for the cherry and 2 for the field of alfalfa. For other vegetables present in this farm, 9 pests were collected, in particular 8 for the organic strawberry plantation and 5 for the potato Sila IGP BIO crop. However,

obvious damage were only recorded during the first season of sampling on the leaves of potatoes plants by *L. decemlineata*. In the following year, the number of individuals of that insects were decidedly reduced.

Table 3.8 Pest in Fbio – Scrivano terre D’altopiano

Species/genera	Fbio	Cereal	Cerry	Alfalfa	Vegetables	Strawberries	Patatoes
<i>Agrilus</i> sp. Curtis, 1825	3					X	
<i>Calamobius filum</i> (Rossi, 1790)	3	X					
<i>Tropinota (Epicometis) hirta hirta</i> (Poda, 1761)	4	X				X	
<i>Tropinota (Tropinota) squalida squalida</i> (Scopoli, 1783)	12	X				X	
<i>Chaetocnema</i> sp. Stephens, 1831	19				X		
<i>Galeruca (Galeruca) pomonae</i> subsp. <i>pomonae</i> (Scopoli, 1763)	2			X			
<i>Galeruca (Galeruca) tanaceti</i> (Linnaeus, 1758)	3	X			X		X
<i>Leptinotarsa decemlineata</i> (Say, 1824)	260						X
<i>Psylliodes (Psylliodes) chrysocephala</i> (Linnaeus, 1758)	1				X		
<i>Phyllotreta cruciferae</i> (Doeze, 1777)	2				X		
<i>Bothynoderes affinis</i> (schrank, 1781)	3				X		
<i>Agrypnus murinus</i> (Linnaeus, 1758)	3						X
<i>Urophorus humeralis</i> (Fabricius, 1798)	1					X	
<i>Delia</i> sp. Robineau-desvoidy, 1830	730	X			X		X
<i>Dilophus femoratus</i> Meigen, 1804	28	X				X	
<i>Drosophila suzukii</i> Matsumura, 1931	6					X	
<i>Haematoloma dorsatum</i> (Ahrens, 1812)	7		X			x	
<i>Lygus pratensis</i> (Linnaeus, 1758)	5			X	X		X
<i>Dolycoris baccarum</i> (Linnaeus, 1758)	1				X	X	
<i>Chorthippus</i> sp. Fieber, 1852	1	X					
<i>Gryllus campestris</i> Linnaeus, 1758	3		X		X		

On the farm Fattoria Pupo, different pests are collected (Tab. 3.9; Tab.3.10; Tab.3.11). Cereal-harmful species are in total 14, respectively 9 species in the potatoes field, 12 in the ecotonal area (Gecot) and 6 in the ecotonal pine forest (Pecot); the pest of alfalfa collected are 5, two in the field and pine forest and in the open area; pest of vegetables are 10, of which 8 in the potato field and open area and 4 in the pine forest. As regards pest of berries, 9 species are recorded, of which 6 in the field, 9 in the ecotone and 4 in the pine forest; potatoes pests species are 10, of which 4 in the field, 7 in the open area and 3 in the pine forest. The damage were mainly recorded in the BIO berry plantation due to the alien pest *D. suzukii* but also from *D. baccarum*. In the integrated management potatoes crop, on the other hand, damage to potatoes were observed due to the larvae of *Agrypnus murinus* and *Agriotes* spp.

Table 3.9 Pests in Fint- Fattoria Pupo

Species/genera	Fint	Cereal	Alfalfa	Vegetables	Redfruits	Patatoes
<i>Tropinota (Epicometis) hirta hirta</i> (Poda, 1761)	29	X			X	
<i>Tropinota (Tropinota) squalida squalida</i> (Scopoli, 1783)	62	X			X	
<i>Chaetocnema</i> sp. Stephens, 1831	5			X		
<i>Galeruca (Galeruca) pomonae</i> subsp. <i>pomonae</i> (Scopoli, 1763)	9		X			
<i>Galeruca (Galeruca) tanacetii</i> (Linnaeus, 1758)	1	X		X		X
<i>Neocrepidodera ferruginea</i> (Scopoli, 1763)	2	X				X
<i>Psylliodes (Psylliodes) chrysocephala</i> (Linnaeus, 1758)	2			X		
<i>Delia</i> sp. Robineau-Desvoidy, 1830	446	X		X		X
<i>Bibio hortulanus</i> (Linnaeus, 1758)	241	X		X	X	
<i>Dilophus femoratus</i> Meigen, 1804	758	X			X	
<i>Drosophila suzukii</i> Matsumura, 1931	17				X	
<i>Nephrotoma</i> sp. Meigen, 1803	1		X			
<i>Dolycoris baccarum</i> (Linnaeus, 1758)	6			X	X	
<i>Eurydema (Eurydema) ornata</i> (Linnaeus, 1758)	2	X		X		X
<i>Chorthippus</i> sp. Fieber, 1852	5	X				
<i>Gryllus campestris</i> Linnaeus, 1758	7			X		

Table 3.10 Pests in Gecot- Fattoria Pupo

Species/Genera	Gecot	Cereal	Alfalfa	Vegetables	Red fruit	Patatoes	Carduus
<i>Agrilus</i> sp. Curtis, 1825	22				X		
<i>Tropinota (Epicometis) hirta hirta</i> (Poda, 1761)	43	X			X		
<i>Tropinota (Tropinota) squalida squalida</i> (Scopoli, 1783)	21	X			X		
<i>Chaetocnema</i> sp. Stephens, 1831	2			X			
<i>Galeruca (Galeruca) pomonae</i> subsp. <i>pomonae</i> (Scopoli, 1763)	13		X				
<i>Galeruca (Galeruca) tanacetii</i> (Linnaeus, 1758)	1	X		X		X	
<i>Galerucella lineola</i> (Fabricius, 1781)	1				X		
<i>Lixus</i> sp. J.C.Fabricius, 1802	1						X
<i>Rhizotrogus aestivus</i> (Olivier, 1789)	1		X				
<i>Oryzaephilus surinamensis</i> (Linnaeus, 1758)	1	X					
<i>Opatrum</i> sp. Fabricius, 1775	1					X	
<i>Delia</i> sp. Robineau-Desvoidy, 1830	332	X		X		X	
<i>Bibio hortulanus</i> (Linnaeus, 1758)	33	X		X	X		
<i>Dilophus femoratus</i> Meigen, 1804	860	X			X		
<i>Drosophila suzukii</i> Matsumura, 1931	14				X		
<i>Aelia rostrata</i> Boheman, 1852	3	X				X	
<i>Dolycoris baccarum</i> (Linnaeus, 1758)	7			X	X		
<i>Eurydema (Eurydema) ornata</i> (Linnaeus, 1758)	6	X		X		X	
<i>Eurydema ventralis</i> (Kolenati, 1846)	1	X		X		X	
<i>Calliptamus italicus</i> (Linnaeus, 1758)	2	X	X		X	X	
<i>Chorthippus</i> sp. Fieber, 1852	67	X					
<i>Gryllus campestris</i> Linnaeus, 1758	4			X			

Table 3.11 Pests in Pecot – Fattoria Pupo

Genere/Specie	Pecot	Cereals	Alfalfa	Vegetables	Red Fruit	Patatoes	Pine
<i>Galerucella lineola</i> (Fabricius, 1781)	1				X		
<i>Agriotes</i> sp. Eschscholtz, 1829	1	X	X	X		X	
<i>Agrypnus murinus</i> (Linnaeus, 1758)	1					X	
<i>Oryzaephilus surinamensis</i> (Linnaeus, 1758)	1	X					
<i>Delia</i> sp. Robineau-Desvoidy, 1830	133	X		X		X	
<i>Bibio hortulanus</i> (Linnaeus, 1758)	1	X		X	X		
<i>Dilophus femoratus</i> Meigen, 1804	234	X			X		
<i>Drosophila suzukii</i> Matsumura, 1931	425				X		
<i>Nephrotoma</i> sp. Meigen, 1803	1		X				
<i>Haematoloma dorsatum</i> (Ahrens, 1812)	16						X
<i>Eurydema (Eurydema) ornata</i> (Linnaeus, 1758)	1	X		X		X	

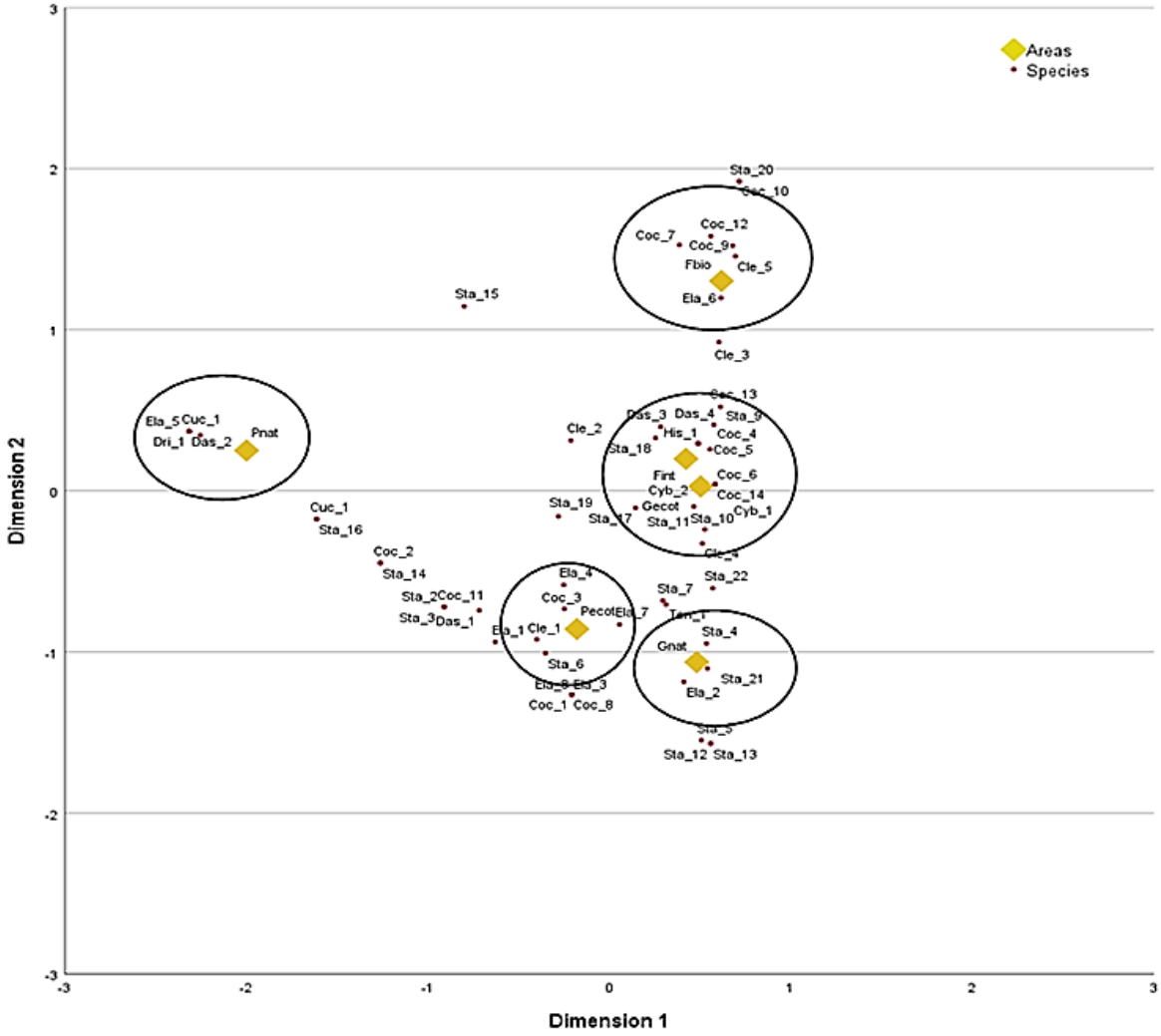
3.6 Analysis of predator insect communities

Assessing the presence of predator species and how their distribution change in the investigates areas is interesting, especially in sites where the presence of pests has been highlighted.

The CA analysis (chi square = 1780,031; $p < 0,001$) (Graph 3.25; legend code Tab. 3.12), show the distribution of zoophagous species in the sampling areas. In particular, there is the formation of 5 groups where each area has a distinct community, except for Fint and Gecot which share species. For example, the natural pine forest (Pnat) is correlated to the species *Cucujus cinnaberinus* (Scopoli, 1763) (Cuc_1) (Coleoptera, Cucujidae). This species is considered a predator of saproxylics and it is included in the red list of Italian saproxylic with risk category “Vulnerable” (VU) and it is strongly linked to rotting woos. Other generalist zoophagous species, like the Staphylinidae *Ocypus (Matidus) italicus* (Aragona, 1830) (Sta_8), the Dasytidae *Divales bipustulatus* (Fabricius, 1781) (Das_1), the Drillidae *Drilus flavescens* Olivier, 1790 (Dri_1) and the Elateridae *Cidnopus pilosus* (Leske, 1785) (Ela_5) are founded. In contrast, the ecotonal pine forest (Pecot) corresponds to species like *Calvia quatuordecimguttata* Linnaeus, 1758 (Coc_3; Fam: Coccinellidae), *Opilo mollis* (Linnaeus, 1758) (Cle_1; Fam: Cleridae), *Ampedus (Ampedus) sinuatus* Germar, 1844 (Ela_1; Fam: Elateridae) and *Lordithon lunulatus* (Linnaeus, 1760) (Sta_6; Fam: Staphylinidae). In the grazing natural area (Gnat) the predators connected to this zone are the Staphylinidae *Gyrophypnus punctulatus* (Paykull, 1789) (Sta_4) and *Xantholinus (Typhlonus) appennincola* Steel, 1946 (Sta_21). In addition, in Fbio for example, there are the Cleridae *Trichodes alvearius* (Fabricius, 1792) (Cle_3) and *Trichodes leucospideus* (Olivier, 1795) (Cle_5), the Coccinellidae *Coccinula quatuordecimpustulata* (Linnaeus, 1758) (Coc_7) and *Hippodamia (Hippodamia) variegata* Goeze, 1777 (Coc_9) and the Elateridae *Drasterius bimaculatus* (Rossi, 1790) (Ela_6).

Finally, in Gecot and in Fint, there are mainly Coccinellidae, such as *Ceratomegilla (Ceratomegilla) undecimnotata* Schneider D. H., 1792 (Coc_4), *Coccinella (Coccinella) septempunctata* Linnaeus, 1758

(Coc_5) and *Coccinella (Spilota) undecimpunctata* Linnaeus, 1758 (Coc_6), but also the Cybocephalidae *Cybocephalus politus* Gyllenhal, 1813 and the Dasytidae *Enicopus (Enicopus) pilosus* (Scopoli, 1763) (Das_4). Coccinellidae are insects well known in the literature as predator of phytophagous, such as aphids, and they are often used in biological control. For this reason, these species are more closely related to agrosystems (Franzmann, 2002; Cabral *et al.*, 2009).



Graph 3.25 Correspondence analysis of predator species

Table 3.12 Code CA predator species

Species	Code	Species	Code
Cleridae		Cucujidae	
<i>Opilo mollis</i> (Linnaeus, 1758)	Cle_1	<i>Cucujus cinnaberinus</i> (Scopoli, 1763)	Cuc_1
<i>Thanasimus formicarius</i> (Linnaeus, 1758)	Cle_2	<i>Pediacus dermestoides</i> (Fabricius, 1792)	Cuc_2
<i>Trichodes alvearius</i> (Fabricius, 1792)	Cle_3	Cybocephalidae	
<i>Trichodes apiarius</i> (Linnaeus, 1758)	Cle_4	<i>Cybocephalus politus</i> Gyllenhal, 1813?	Cyb_1
<i>Trichodes leucospideus</i> (Olivier, 1795)	Cle_5	<i>Cybocephalus</i> sp. Erichson, 1844	Cyb_2
Coccinellidae		Histeridae	
<i>Adalia (Adalia) bipunctata</i> (Linnaeus, 1758)	Coc_1	<i>Saprinus (Saprinus) semistriatus</i> (Scriba, 1790)	His_1
<i>Adalia (Adalia) decempunctata</i> (Linnaeus, 1758)	Coc_2	Staphylinidae	
<i>Calvia quatuordecimguttata</i> Linnaeus, 1758	Coc_3	<i>Bolitobius castaneus</i> (Stephens, 1832)	Sta_1
<i>Ceratomegilla (Ceratomegilla) undecimnotata</i> Schneider D. H., 1792	Coc_4	<i>Boreaphilus velox</i> (Heer, 1839)	Sta_2
<i>Coccinella (Coccinella) septempunctata</i> Linnaeus, 1758	Coc_5	<i>Carphacis striatus</i> (Olivier, 1795)	Sta_3
<i>Coccinella (Spilota) undecimpunctata</i> Linnaeus, 1758	Coc_6	<i>Gyrohypnus angustatus</i> Stephens, 1833	Sta_4
<i>Coccinula quatuordecimpustulata</i> (Linnaeus, 1758)	Coc_7	<i>Gyrohypnus punctulatus</i> (Paykull, 1789)	Sta_5
<i>Exochomus (Exochomus) quadripustulatus</i> Linnaeus, 1758	Coc_8	<i>Lordithon lunulatus</i> (Linnaeus, 1760)	Sta_6
<i>Hippodamia (Hippodamia) variegata</i> Goeze, 1777	Coc_9	<i>Ocyopus (Pseudocyopus) fulvipennis</i> Erichson, 1840	Sta_7
<i>Hyperaspis</i> sp. Chevrolat, 1836	Coc_10	<i>Ocyopus (Matidus) italicus</i> (Aragona, 1830)	Sta_8
<i>Myrrha octodecimguttata</i> (Linnaeus, 1758)	Coc_11	<i>Ocyopus (Ocyopus) olens</i> (O. Muller, 1764)	Sta_9
<i>Propylea quatuordecimpunctata</i> (Linnaeus, 1758)	Coc_12	<i>Ocyopus (Pseudocyopus) sericeicollis</i> (Menetries, 1832)	Sta_10
<i>Psyllobora vigintiduopunctata</i> (Linnaeus, 1758)	Coc_13	<i>Othius laeviusculus</i> Stephens, 1833	Sta_11
<i>Scymnus (Scymnus) frontalis</i> (Fabricius, 1787)	Coc_14	<i>Ontholestes murinus</i> (Linnaeus, 1758)	Sta_12
Dasytidae		<i>Oxytelus (Oxytelus) piceus</i> (Linnaeus, 1767)	Sta_13
<i>Aplocnemus</i> sp. Stephens, 1830	Das_2	<i>Phyllodrepa salicis</i> (Gyllenhal, 1810)	Sta_14
<i>Divales bipustulatus</i> (Fabricius, 1781)	Das_3	<i>Platydracus stercorarius</i> (Olivier, 1795)	Sta_15
<i>Enicopus (Enicopus) pilosus</i> (Scopoli, 1763)	Das_4	<i>Quedius (Microsaurus) latinus</i> Gridelli, 1938	Sta_16
Elateridae		<i>Quedius (Raphirus) semiobscurus</i> (Marsham, 1802)	Sta_17
<i>Ampedus (Ampedus) sinuatus</i> Germar, 1844	Ela_1	<i>Tachinus humeralis</i> Gravenhorst, 1802	Sta_18
<i>Cardiophorus (Cardiophorus) collaris/italicus</i>	Ela_2	<i>Tasgius (Rayachiela) morsitans</i> (Rossi, 1790)	Sta_19
<i>Cardiophorus (Cardiophorus) italicus</i> Platia & Bartolozzi, 1988	Ela_3	<i>Tasgius pedator</i> (Gravenhorst, 1802)	Sta_20
<i>Cardiophorus</i> sp. Eschscholtz, 1829	Ela_4	<i>Xantholinus (Typholinus) appennincola</i> Steel, 1946	Sta_21
<i>Cidnopus pilosus</i> (Leske, 1785)	Ela_5	<i>Xantholinus (Polydonthophallus) elegans</i> (Olivier, 1795)	Sta_22
<i>Drasterius bimaculatus</i> (Rossi, 1790)	Ela_6	<i>Xantholinus</i> sp. Dejean, 1821	Sta_23
<i>Hemicrepidius hirtus</i> (Herbst, 1784)	Ela_7	Tenebrionidae	
<i>Melanotus (Melanotus) castanipes</i> (Paykull, 1800)	Ela_8	<i>Gonocephalum granulatum</i> (Fabricius, 1791)	Ten_1
<i>Melanotus crassicornis</i> (Erichson, 1841)	Ela_9	<i>Grynocaris oblonga</i> (Linnaeus, 1757)	Ten_2
Drillidae			
<i>Drilus flavescens</i> Olivier, 1790	Dri_1		

3.7 Carabidofauna analysis

Analysis of the carabidofauna in the sampling areas revealed significant differences in species composition and abundance. The aim of these analyses is to evaluate the data collected, highlighting the ecological linkage to diverse habitats. The Permanova analysis with the Bray-Curtis index, confirm a significant difference in the specific composition in study areas (F:7,739; p:0,0001). This indicates that the structure of communities differs significantly between the groups considered and these differences are real and not causal. The Bonferroni test also confirmed these differences, especially between pine forests and agricultural and grazing areas (Tab. 3.13).

Table 3.13 Permanova – Test Bonferroni (Software Past)

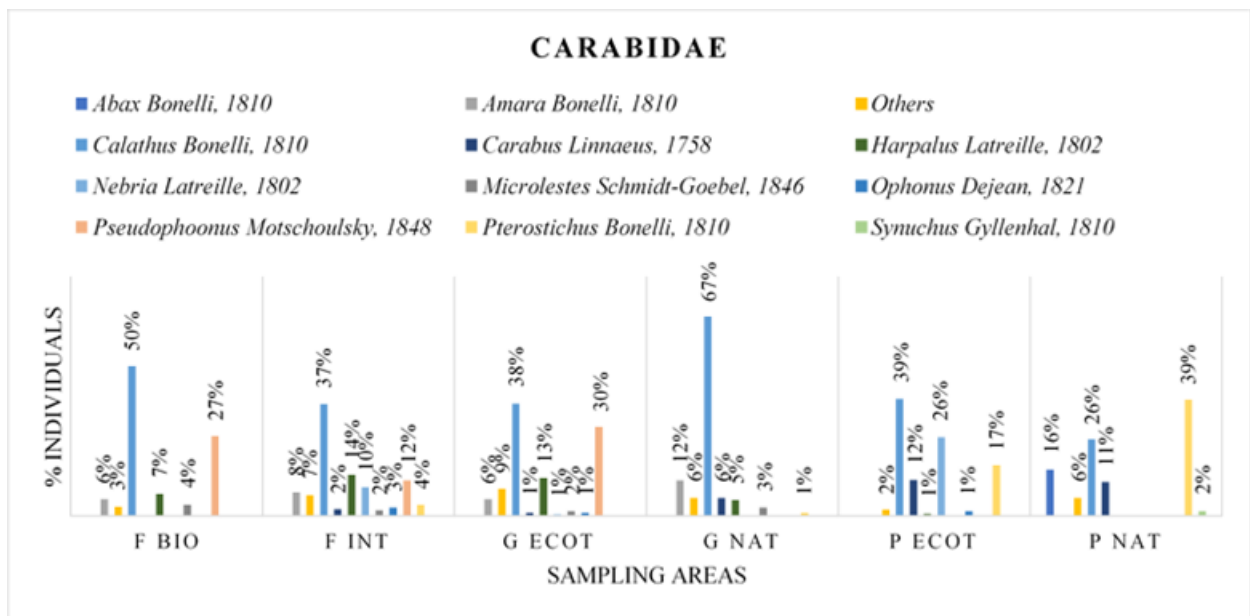
	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Fbio		0,0015	0,5745	0,0015	0,0015	0,0015
Fint	0,0015		1	0,351	0,0015	0,0015
Gecot	0,5745	1		0,198	0,0015	0,0015
Gnat	0,0015	0,351	0,198		0,0015	0,0015
Pecot	0,0015	0,0015	0,0015	0,0015		0,0015
Pnat	0,0015	0,0015	0,00150	0,0015	0,0015	

Table 3.14 Diversity index (Software Past)

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
N° taxa	33	30	20	20	23	13
N° specimens	482	219	178	286	601	496
SD	3,781163	3,981818	3,178571	5,107143	10,73214	8,857143
Shannon	2,114	2,563	2,06	1,437	1,821	1,71
Evenness	0,2511	0,4326	0,3922	0,2105	0,2686	0,4253
Margalef	5,18	5,381	3,667	3,359	3,438	1,933

The areas with the greatest diversity are agricultural fields and their ecotonal grazing area. The pine forests, both ecotonal and natural, have a lower biodiversity, but the most abundance. However, as indicated by Evenness index, in these areas specimens are not evenly distributed among the species, suggesting the presence of dominant species (Tab. 3.14).

There is a clear ecological preference by some genera for specific habitats. The most abundant genus is certainly *Calathus* Bonelli, 1810, especially in agroecosystems; later there are *Pseudophoonus* Motschoulsky, 1848 in the field of biological management (27%) and *Harpalus* Latreille, 1802 in the integrated management (14%). In the pine forests there are the presence of *Pterostichus* Bonelli, 1810, especially in the natural pine forest (39%) and *Carabus* Bonelli, 1810, (Pecot 12%; Pnat 11%). In addition, in the natural pine forest (Pnat) there are also the presence of *Abax* Bonelli, 1810 (16%) (Graph 3.26).



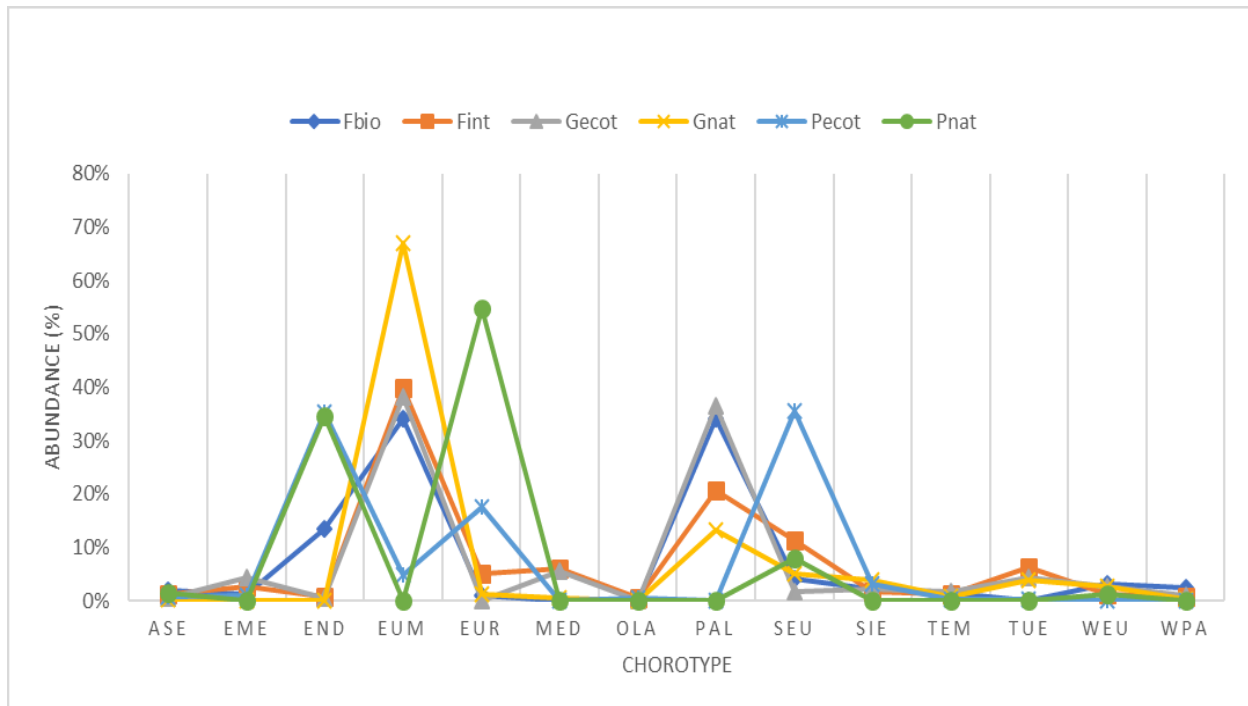
Graph 3.26 Abundance Genus of Carabidae in Sampling Areas

In the following table (Tab. 3.15) are indicated the abundances in percentage of the individuals by species collected for each area, together with their choriotype, diet, presence or absence of wings and size.

Table 3.15 Abundance of species and distribution, wings, diet and size. Abbreviations of chorotypes as reported in Vigna Taglianti et al., 1999 e Brandmayer et al., 2005: **EUR**: European, **OLA**: Oleartic, **PAL**: Palearctic, **ASE**: Asiatic-European, **WPA**: W-Palearctic, **EUM**: European-Mediterranean, **WEU**: W-European, **END**: endemic, **SEU (APPE)**: S-European Apennine, **SEU (APDI)**: S-European Apennine-Dinarie, **SIE**: Siberico-European, **MED**: Mediterranean, **TUE**: Turanic-European, **TEM**: Turanic-European-Mediterranean. Wing: **B**: Brachypterous, **M**: Macropterous, **D**: dimorphic. Diet **Z**: Zoophagous, **ZS**: Zoospermophagous, **S**: spermophagous.

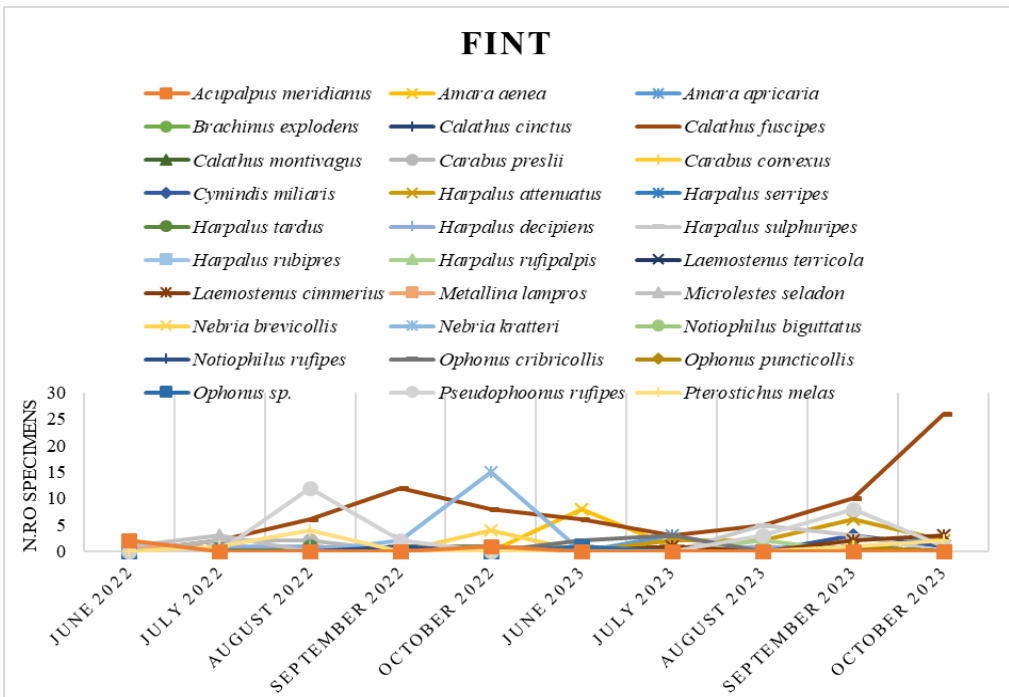
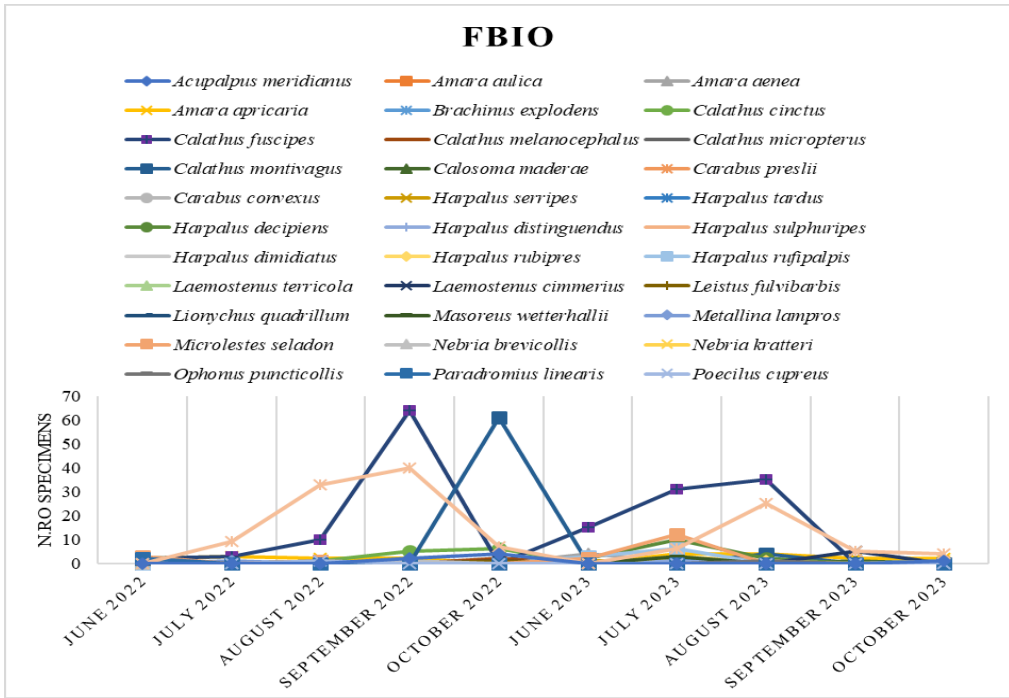
Species	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	Chorotype	Diet	Wing	Size
<i>Abax (Abax) parallelepipedus subsp. curtulus</i> (Fairmaire, 1856)	0,0%	0,0%	0,0%	0,0%	0,0%	15,5%	EUR	ZS	B	4
<i>Acupalpus (Acupalpus) meridianus</i> (Linnaeus, 1761)	0,0%	0,5%	0,0%	0,0%	0,0%	0,0%	EUR	ZS	M	1
<i>Amara aulica</i> (Panzer, 1796)	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	OLA	ZS	M	2
<i>Amara (Amara) aenea</i> (De Geer, 1774)	1,0%	4,6%	1,7%	11,9%	0,0%	0,0%	PAL (OLA)	ZS	M	2
<i>Amara (Bradytus) apricaria</i> (Paykull, 1790)	4,4%	3,2%	4,5%	0,0%	0,0%	0,0%	PAL (OLA)	ZS	M	2
<i>Brachinus (Brachinus) explodens</i> Duftschmid, 1812	0,2%	0,5%	0,0%	0,0%	0,0%	0,0%	ASE	Z	M	1
<i>Calathus cinctus</i> Motschulsky, 1850	2,5%	0,9%	1,1%	0,3%	0,0%	0,0%	WPA	Z	M	2
<i>Calathus fuscipes</i> (Goeze, 1777)	33,4%	35,8%	36,0%	66,4%	4,7%	0,0%	EUM	Z	D	3
<i>Calathus melanocephalus</i> (Linnaeus, 1758)	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	EUR	Z	D	2
<i>Calathus micropterus</i> (Duftschmid, 1812)	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	PAL	Z	D	2
<i>Calathus (Amphyginus) rotundicollis</i> Dejean, 1828	0,0%	0,0%	0,6%	0,0%	0,0%	1,0%	WEU	Z	B	2
<i>Calathus (Calathus) montivagus</i> Dejean, 1831	13,5%	0,9%	0,6%	0,0%	34,4%	24,6%	END	Z	B	3
<i>Calosoma (Campalita) maderae</i> (Fabricius, 1775)	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	MED	Z	D	5
<i>Carabus (Chaetocarabus) lefebvrei subsp. bayardi</i> Solier, 1835	0,0%	0,0%	0,0%	0,0%	0,7%	7,5%	END	Z	B	5
<i>Carabus (Oreocarabus) preslii subsp. neumeyeri</i> Schaum, 1856	0,2%	1,8%	0,0%	2,4%	9,7%	3,8%	SEU (APDI)	Z	B	5
<i>Carabus (Tomocarabus) convexus subsp. convexus</i> Fabricius, 1775	0,2%	0,5%	1,1%	3,5%	1,7%	0,0%	SIE	Z	B	5
<i>Clinidium (Arctoclinidium) canaliculatum</i> (O.G. Costa, 1839)	0,0%	0,0%	0,0%	0,0%	0,0%	3,8%	SEU (APPE)	Z	B	2
<i>Cychrus italicus</i> Bonelli, 1810	0,0%	0,0%	0,0%	0,0%	0,3%	2,4%	END	Z	B	5
<i>Cymindis (Menas) miliaris</i> (Fabricius, 1801)	0,0%	2,3%	3,4%	2,8%	0,0%	0,0%	TUE	Z	D	2
<i>Dromius (Dromius) agilis</i> (Fabricius, 1787)	0,0%	0,0%	0,0%	0,0%	0,2%	0,0%	EUR	Z	M	2
<i>Dromius fenestratus</i> (Fabricius, 1794)	0,0%	0,0%	0,0%	0,0%	0,2%	0,0%	EUR	Z	M	2
<i>Harpalus (Harpalus) attenuatus</i> Stephens, 1824	0,0%	6,0%	5,6%	0,3%	0,0%	0,0%	MED	ZS	M	2
<i>Harpalus (Harpalus) serripes</i> (Quensel in Schonherr, 1806)	0,4%	0,5%	0,0%	0,0%	0,0%	0,0%	PAL	ZS	M	2
<i>Harpalus (Harpalus) tardus</i> (Panzer, 1797)	0,4%	0,5%	0,0%	0,0%	0,5%	0,0%	ASE	ZS	M	2
<i>Harpalus (Harpalus) decipiens</i> Dejean, 1829	3,1%	1,4%	2,2%	2,8%	0,0%	0,2%	WEU	ZS	M	2
<i>Harpalus (Harpalus) distinguendus</i> (Duftschmid, 1812)	0,2%	0,0%	1,1%	0,0%	0,0%	0,0%	PAL	ZS	M	2
<i>Harpalus (Harpalus) sulphuripes</i> Gemmar, 1824	0,2%	4,1%	2,2%	1,0%	0,0%	0,0%	EUM	ZS	D	2
<i>Harpalus (Harpalus) dimidiatus</i> (P. Rossi, 1790)	0,0%	0,0%	0,0%	0,3%	0,0%	0,0%	EUR	ZS	M	2
<i>Harpalus (Harpalus) rubripes</i> (Duftschmid, 1812)	1,0%	0,5%	0,6%	0,3%	0,0%	0,0%	ASE	ZS	M	2
<i>Harpalus (Harpalus) rufipalpis</i> Sturm, 1818	1,9%	0,9%	1,1%	0,3%	0,2%	0,0%	SIE	ZS	M	2
<i>Laemostenus (Pristonychus) terricola</i> (Herbst, 1783)	0,2%	0,5%	0,0%	0,0%	0,0%	0,0%	EUR (OLA)	Z	M	4
<i>Laemostenus (Pristonychus) cimmerius subsp. cimmerius</i> (Fischer von Waldheim, 1823)	1,2%	2,8%	4,5%	0,0%	1,0%	0,0%	EME (APDI)	Z	B	4
<i>Lebia trimaculata</i> (Villers, 1789)	0,0%	0,0%	1,7%	0,7%	0,0%	0,0%	TEM	Z	M	2
<i>Leistus (Pogonophorus) spinibarbis subsp. florii</i> Lutshnik, 1913	0,0%	0,0%	0,0%	0,0%	0,2%	0,0%	EUR	ZS	M	1
<i>Leistus fulvibarbis</i> Dejean, 1826	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	EUM	ZS	M	2
<i>Lionychus (Lionychus) quadrillum</i> (Duftschmid, 1812)	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	EUR	Z	M	1
<i>Masoreus wetherhallii</i> (Gyllenhal, 1813)	0,6%	0,0%	0,0%	1,0%	0,0%	0,0%	PAL	Z	D	1
<i>Metallina (Metallina) lampros</i> (Herbst, 1784)	0,2%	0,5%	0,0%	0,0%	0,0%	0,0%	PAL (OLA)	Z	M	1
<i>Microderes scaritides</i> (Sturm, 1818)	0,0%	0,0%	0,0%	0,7%	0,0%	0,0%	TUE	S	M	1
<i>Microlestes seladon</i> Holdhaus, 1912	3,7%	1,8%	1,7%	2,8%	0,0%	0,0%	SEU	Z	D	1
<i>Nebria (Nebria) brevicollis</i> (Fabricius, 1792)	0,2%	1,8%	0,6%	0,0%	0,3%	0,0%	TUE	Z	M	3
<i>Nebria (Nebria) kratteri</i> Dejean & Boisduval, 1830	0,2%	7,8%	0,0%	0,0%	26,0%	0,2%	SEU (APDI)	Z	M	3
<i>Notiophilus biguttatus</i> (Fabricius, 1779)	0,0%	0,5%	0,0%	0,0%	0,5%	0,0%	OLA	Z	D	2
<i>Notiophilus rufipes</i> Curtis, 1829	0,0%	0,5%	0,0%	0,0%	0,0%	0,2%	EUR	Z	D	1
<i>Notiophilus substriatus</i> G. R. Waterhouse, 1833	0,0%	0,0%	0,0%	0,0%	0,2%	0,0%	EUR	Z	M	1
<i>Ophonus cribricollis</i> (Dejean, 1829)	0,0%	2,3%	0,6%	0,3%	0,0%	0,0%	TUE	Z	M	2
<i>Ophonus puncticollis</i> (Paykull, 1798)	0,2%	0,5%	0,0%	0,0%	1,5%	0,0%	SIE	S	D	2
<i>Paradromius (Manodromius) linearis</i> (Olivier, 1795)	0,4%	0,0%	0,0%	0,0%	0,0%	0,0%	EUM	Z	D	1
<i>Philorhizus crucifer</i> (Lucas, 1846)	0,0%	0,0%	0,0%	0,3%	0,2%	0,0%	MED	Z	D	1
<i>Poecilus cupreus</i> (Linnaeus, 1758)	0,2%	0,0%	0,0%	0,0%	0,0%	0,0%	ASE	Z	M	3
<i>Pseudophoonus (Pseudophoonus) rufipes</i> (De Geer, 1774)	26,8%	11,9%	29,2%	0,3%	0,2%	0,0%	PAL	S	M	4
<i>Pterostichus (Feronidius) melas subsp. italicus</i> (Dejean, 1828)	0,0%	3,7%	0,0%	1,0%	17,0%	38,9%	EUR	Z	B	4
<i>Syntomus impressus</i> Dejean, 1825	0,0%	0,0%	0,0%	0,0%	0,2%	0,2%	MED	Z	D	1
<i>Synuchus vivalis</i> (Illiger, 1798)	0,0%	0,0%	0,0%	0,0%	0,2%	1,6%	ASE	Z	M	2
<i>Trechus (Trechus) obtusus</i> Erichson, 1837	0,0%	0,0%	0,0%	0,0%	0,2%	0,0%	EUM (OLA)	Z	M	1
<i>Trechus (Trechus) quadristriatus</i> (Schrank, 1781)	1,5%	1,4%	0,0%	0,0%	0,3%	0,0%	TEM	Z	M	1

As regards the choriotype (Graph 3.27), in Fbio are abundant the euromediterranean species and the palearctic species. In Fint and Gecot, the euromediterranean and palearctic species are particularly important. In Gnat we have a dominance of 70% of euromediterranean species while in Pecot species of the Apennines. Finally, in Pnat we have an abundance of endemic and euromediterranean species.

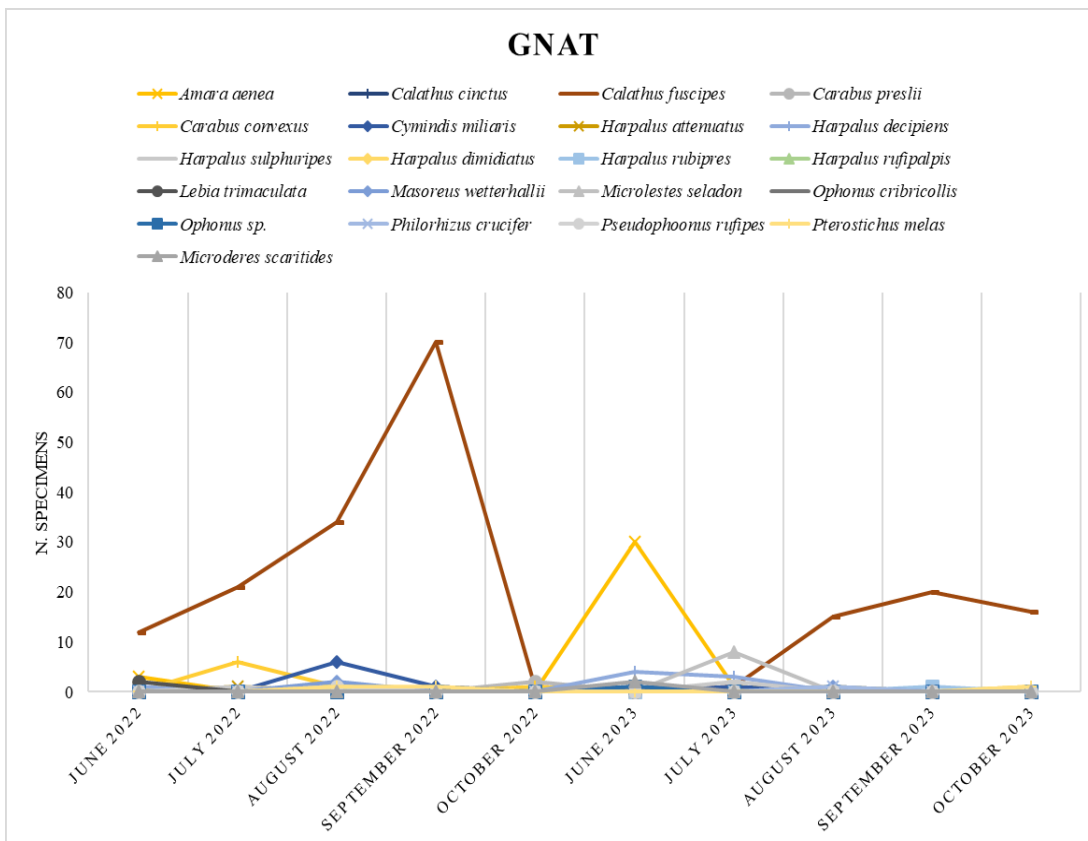
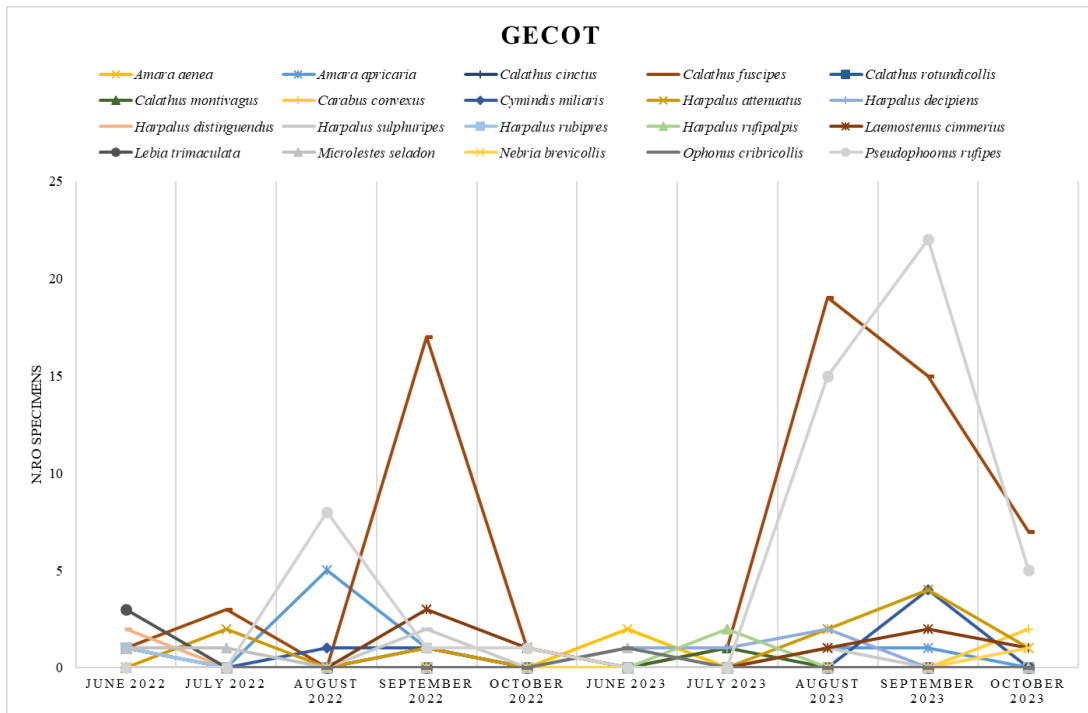


Graph 3.27 Abundance of chorotypes. **EUR**: European, **OLA**: Oleartic, **PAL**: Palearctic, **ASE**: Asiatic-European, **WPA**: W-Palearctic, **EUM**: European-Mediterranean, **WEU**: W-European, **END**: endemic, **SEU (APPE)**: S-European Apennine, **SEU (APDI)**: S-European Apennine-Dinarie, **SIE**: Siberico-European, **MED**: Mediterranean, **TUE**: Turanic-European, **TEM**: Turanic-European-Mediterranean.

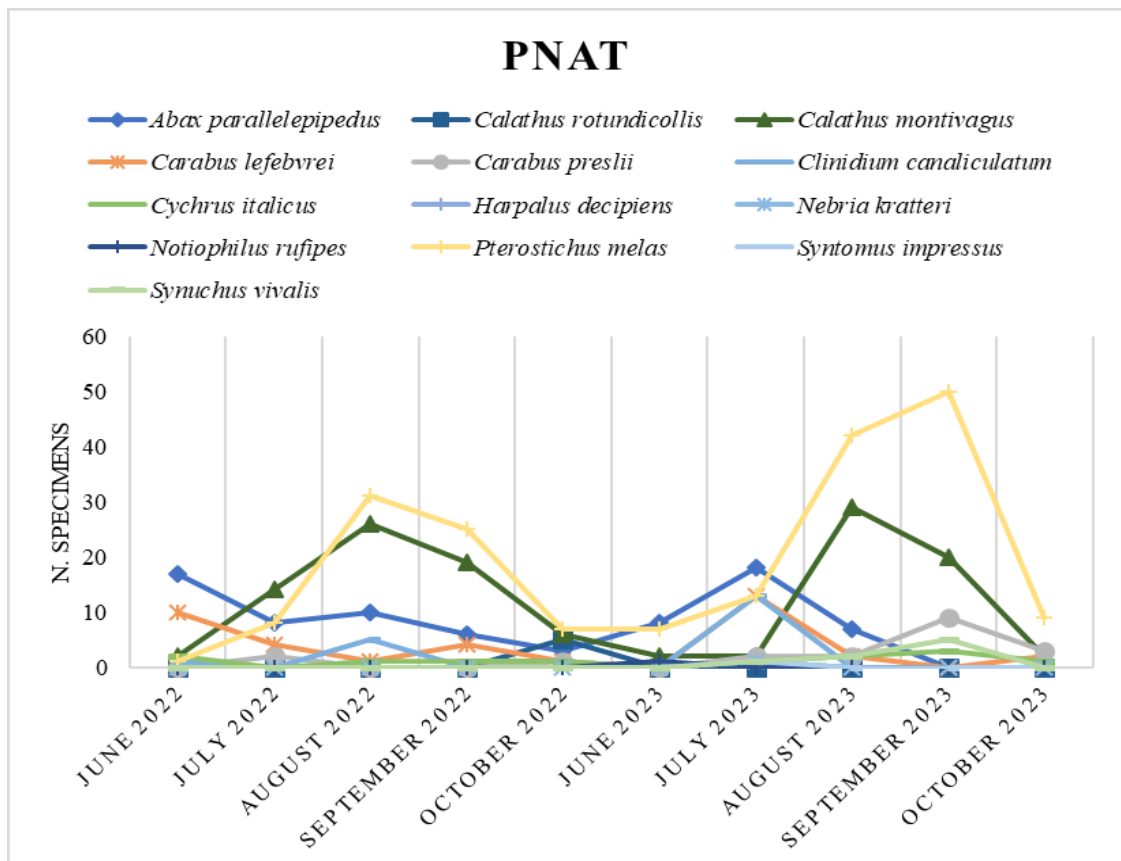
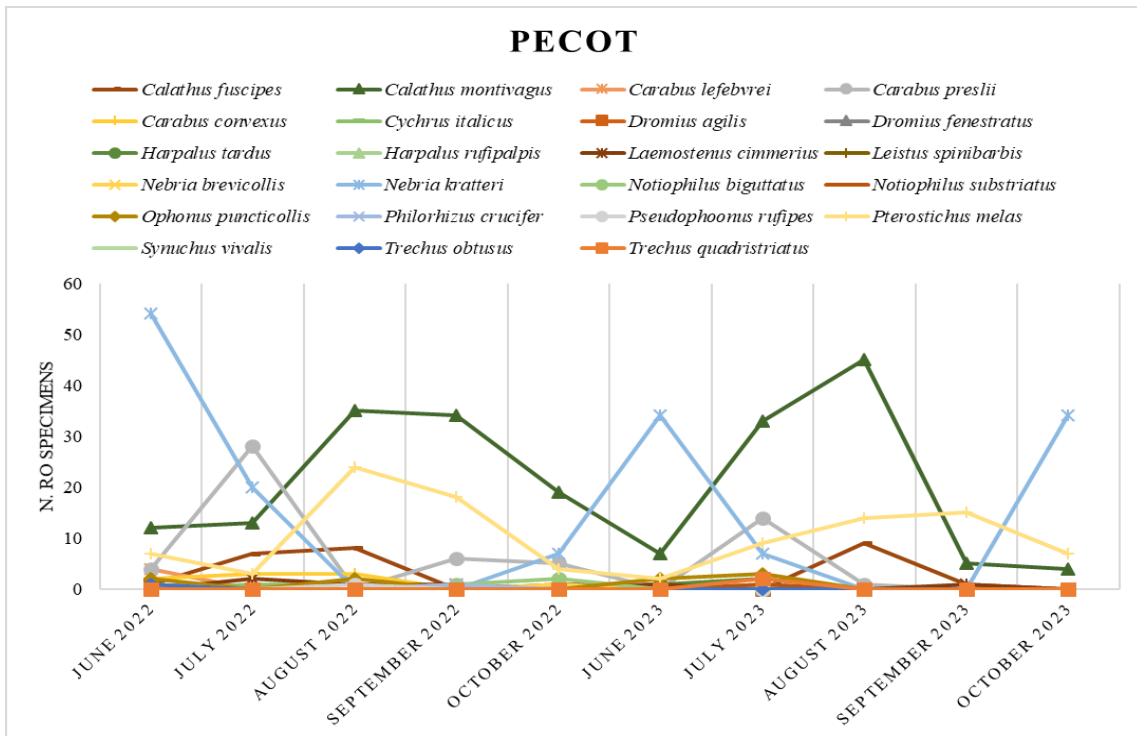
The species show different abundance according to the use of soil. In fact, as shown by phenological graphs (Graph 3.28; Graph 3.29; Graph 3.30), in the agricultural fields the species are abundant especially from August. Specifically, in Fbio between August and September are abundant the species *C. fuscipes* and *C. presli* while in October *C. montivagus*. On the other hand, in Fint there is the presence of *A. apricaria* in June 2023; in addition, between August and September there is mainly present *C. presli* while in October *N. kratteri*. In Gecot the peaks of presence are also between August and October, with *C. fuscipes*, *P. rufipes* and *A. apricaria*. In contrast, in Gnat there are peaks of presence in June of *C. convexus* and *A. aenea*, while in September *C. fuscipes*. In Pecot have peaks of *N. kratteri* in June, *P. rufipes* in July and *C. montivagus* from August to September. Finally, in Pnat there are peaks of *A. parallelepipedus* in June, *C. montivagus* in July and *P. melas* in August.



Graph 3.28 Relative abundance of species in Fbio and Fint

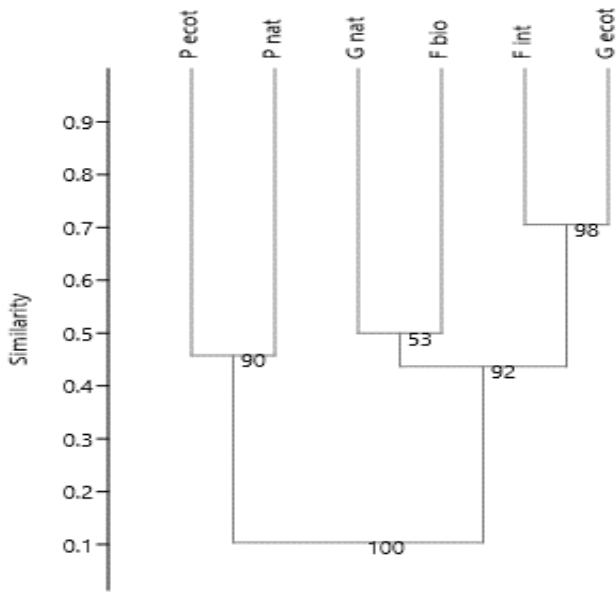


Graph 3.29 Relative abundance of species in Fbio and Fint

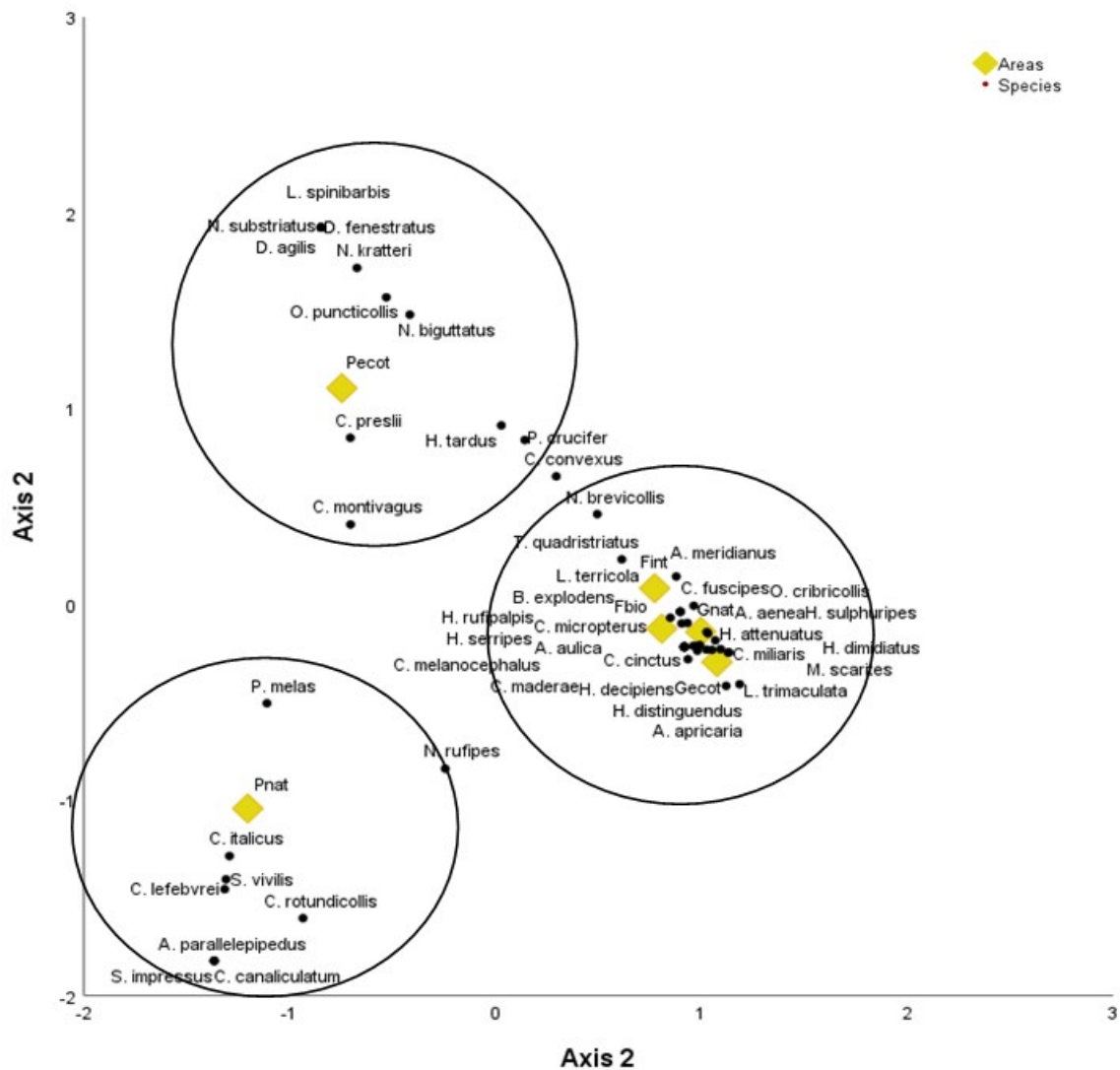


Graph 3.30 Relative abundance of species in Pecot and Pnat

The cluster analysis (Graph 3.31) (algorithm: paired groups; similarity index: Bray–Curtis; 1000 bootstraps, cophenetic correlation coefficient: 0.9703) show a clear separation, in terms of similarity, between the pine forests and other areas because the wood communities is very different from those in the agriculture fields and grazing areas. In addition, the cluster consisting of biological field (Fbio) and the natural grazing area (Gnat) differs from Fint and Gecot. The last two areas constitute a third cluster have a high similarity (0,7) because there is a species interpenetration between the agricultural field and its inbuilt ecotonal area. Fbio and Gnat are much more similar to each other and differ from the Fint-Gecot group due to the strategies used by the integrated management farm.

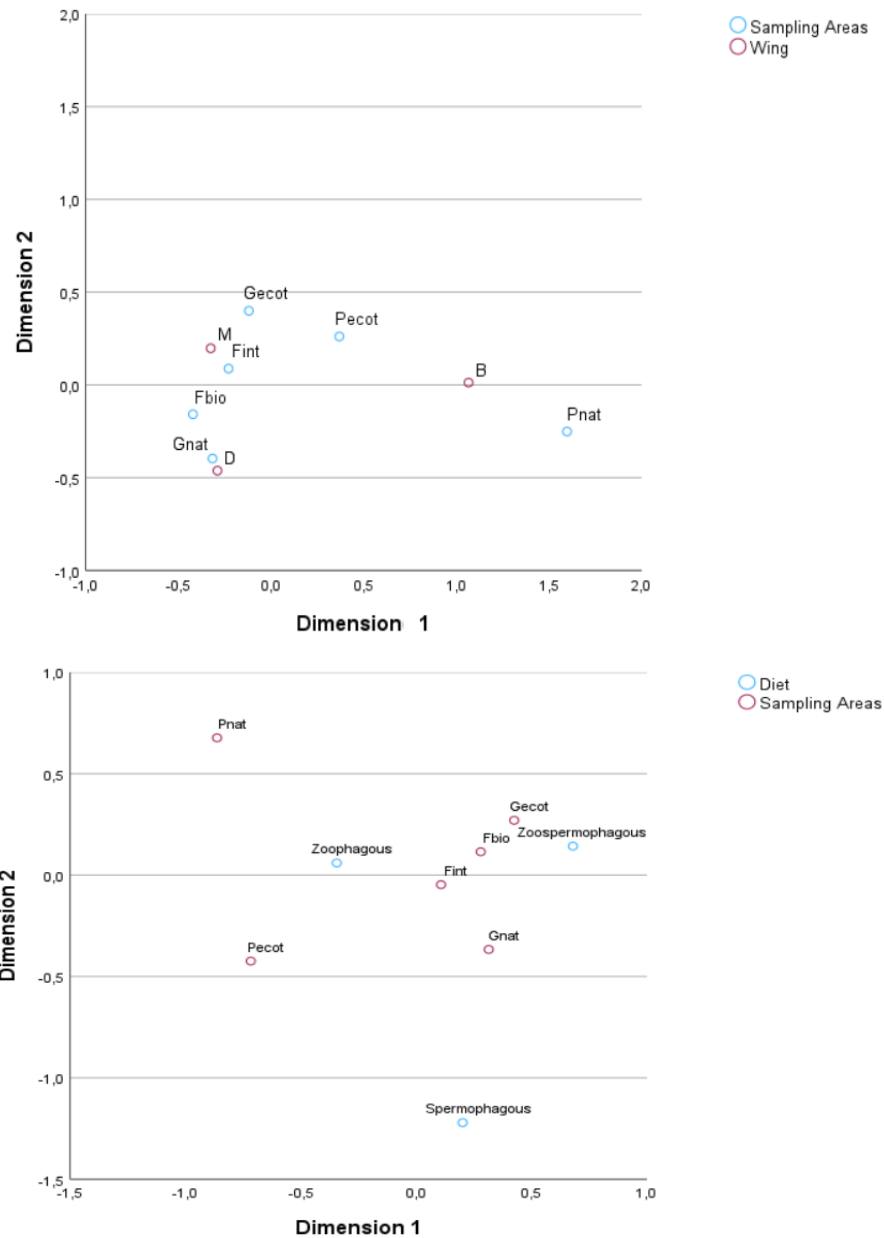


Graph 3.31 Cluster Analysis of Carabidae in Sampling Areas (Software Past)



Graph 3.32 Correspondence of species of Carabidae in Sampling Areas (Software SPSS)

From the analysis of correspondences (Graph 3.32) ($\chi^2 = 3282,528$; $p < 0,01$) species vs. sampling areas we can observe the presence of 3 macrogrups. The species associated with the ecotonal pine forest (Pecot) are several, including *N. kratteri*, *N. substriatus*, *O. puncticollis* and *C. presli*. The second group of species, associated with the natural pine forest (Pnat), includes the species *P. melas*, *N. rufipes*, *C. italicus*, *C. lefebvrei*, *C. canaliculatum* and *A. parallelepipedus*. In addition, all these species are zoophagous and there are almost all brachypterous species. The wingless species non associated to the natural pine forest, are linked to the ecotonal pine forest (Pecot). All other species are related to open grazing areas and crops, thus showing an environmental preference and because they are also predators and could be useful in biological control vs. phytophagous species. In addition, these species are macropterous or dimorphic and that means that crops and grazing areas are fewer stable environments than pine forests.

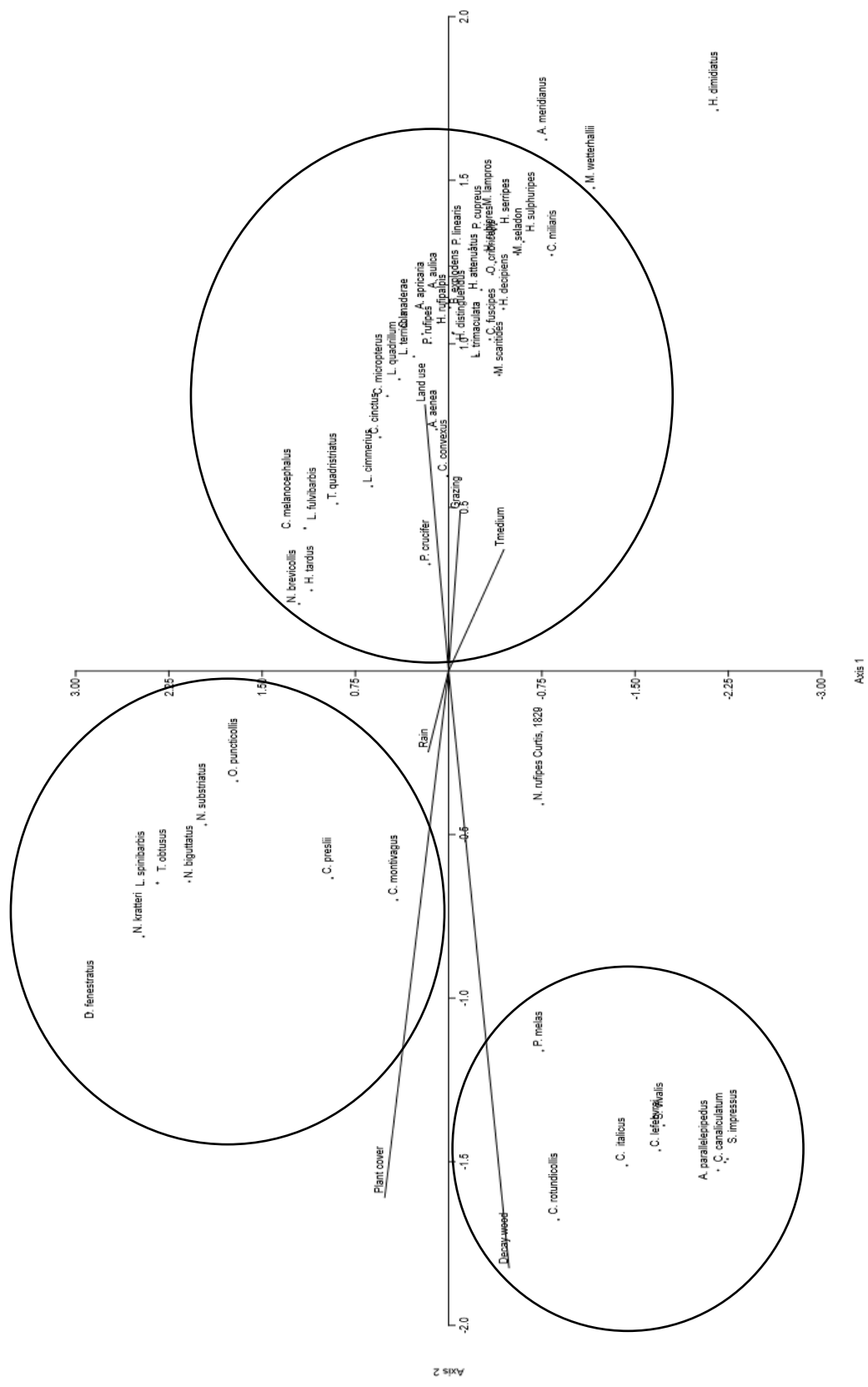


Graph 3.33 Distribution of macropterous, brachypterous and dimorphic species and categories related to trophic preference among the sampling areas (Software SPSS).

In the correspondence analysis (Graph 3.33) between the wing conformation of the species vs. the sampling areas, we can observe how the brachypterous species are associated to the Pine forest, thus confirming a stable environmental condition. In contrast, macropterous and dimorphic species are more common in disturbed environments such as agricultural and grazing. Regarding, instead, the trophic regime, the generalists are related especially to agrosystems, especially Fbio and Gecot, demonstrating how these environments are disturbed and not stable, while the zoophagous are positioned between the pine forests, indicating how stable these environments are, and the crops, which are area with a rich presence of phytophagous individuals.

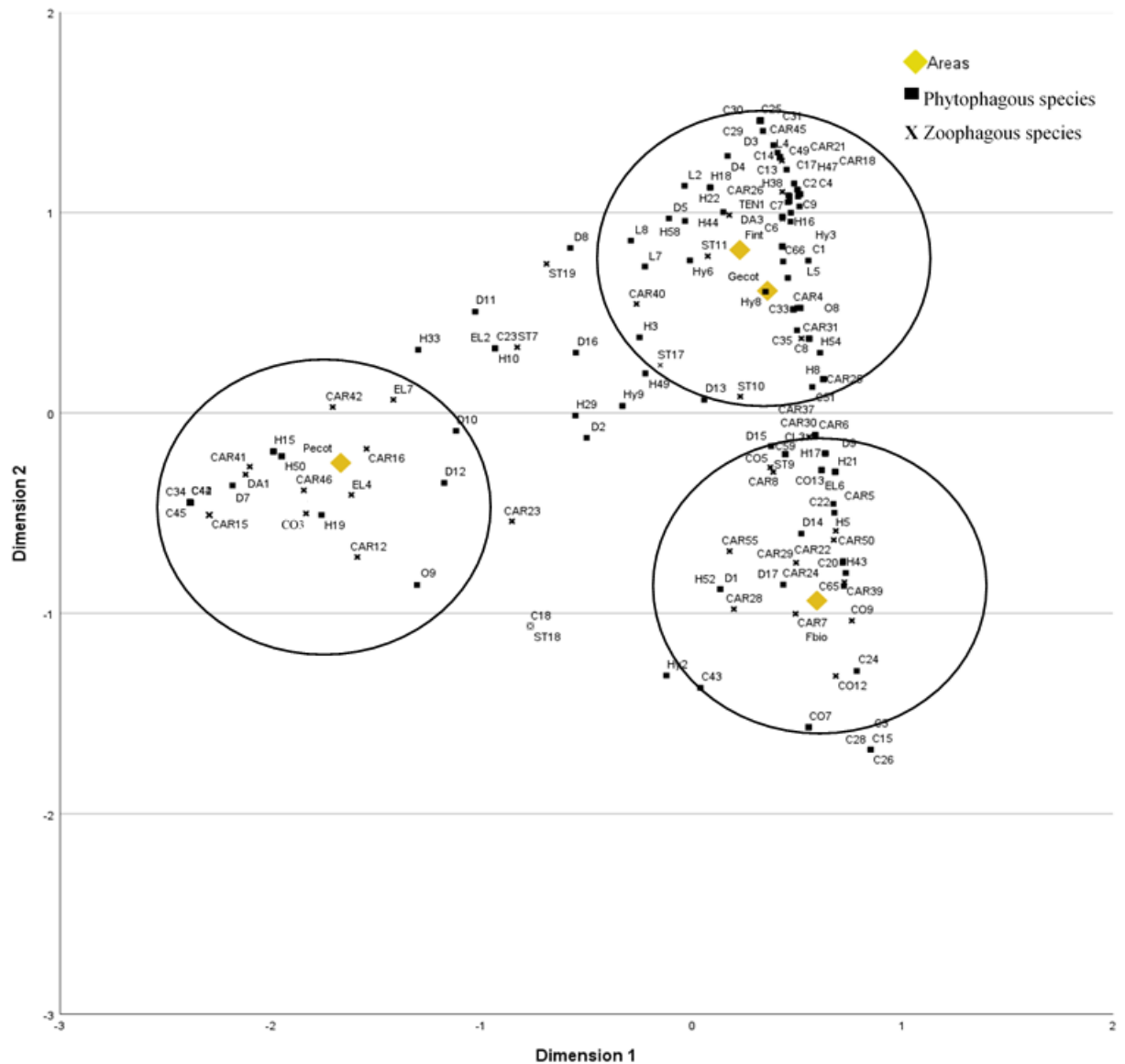
In addition, a CCA (Graph 3.34) was carried out correlating the collected species with 6 variables: use of soil, presence of grazing, average of temperature and rainfall, tree cover and presence of decay woods. The large eigenvalue for the first (0,73194) and the second axis (0,36909) indicate that the canonical axes represent strong gradients and that a large percentage of variance is concentrated between them (Axis1=51,89%; Axis2=26,17%). A simulation with 9999 permutations indicates that the distribution of species along the axes is not random (p: 0,0001).

This analysis show that the distribution of species is influenced mainly by land use, tree vegetation cover and dead wood. In particular, we can distinguish 3 macrogroups. In the first group there are the species that are positively related mainly to the degree of arboreal vegetation cover, such as *D. agilis*, *N. kratteri*, *N. biguttatus* and *N. substriatus*, mostly zoophagous and macropterous species. The presence of dead wood, on the other hand, affects 8 species such as *P. melas*, *C. rotundicollis*, *C. italicus*, *C. lefebvrei* and *S. vivalis*, which are species associated to pine forest and stable environments. The other species (39 species), mostly macropterous and generalist, are mainly associated with land use and the presence of grazing.



Graph 3.34 CCA of Carabidofauna (Software Past)

3.8 Phytophagous vs predators in agroecosystems



Graph 3.35 Distribution phytophagous vs. zoophagous species among the sampling areas (Software SPSS).

From the analysis of the correspondences (chi square= 9840,513; $p < 0,01$) phytophagous vs. predators present exclusively within the agrosystem (Fbio, Fint, Gecot and Pecot) we can observe 3 macrogroups (Graph 3.35; legend Code Tab. 3.16). The largest macrogroup of species is linked to the integrated management crop (Fint) and its ecotonal area (Gecot). Zoophagous linked to Fint are the Staphylinidae *Othius laeviusculus* Stephens, 1833, the Dasytidae *Enicopus (Enicopus) pilosus* (Scopoli, 1763) (DA3) and the Tenebrionidae *Gonocephalum granulatum* (Fabricius, 1791) (TE1) while in Gecot are mainly Carabidae such as *Amara (Amara) aenea* (De Geer, 1774) (CAR4), *Laemostenus (Pristonychus) terricola* (Herbst,

1783) (CAR31) and *Leistus fulvibarbis* Dejean, 1826 (CAR35). Among the phytophagous in Fint there are the Hemiptera *Aphrodes* sp. Curtis, 1833 (H4) (Fam: Cicadellidae) and *Eurydema (Eurydema) ornata* (Linnaeus, 1758) (H44) (Fam: Pentatomidae) and the beetle *Tropinota (Tropinota) squalida squalida* (Scopoli, 1783) (C6) (Fam: Scarabaeidae) while in Gecot the Hymenoptera *Tiphia* sp. Fabricius, 1775 (Hy8) (Fam: Tiphidae). In the group of species corresponding to Pecot there is the Hemiptera phytophagous *Ochetostethus* sp. Fieber, 1860 (H15) and *Pyrrhocoris apterus* (Linnaeus, 1758) (H50) (Fam: Pyrrhocoridae) while among the zoophagous beetles there are the Elateridae *Cardiophorus* sp. Eschscholtz, 1829 (EL4) and the Carabidae *Carabus (Tomocarabus) convexus* subsp. *convexus* Fabricius, 1775 (CAR16), *Nebria (Nebria) brevicollis* (Fabricius, 1792) (CAR41), *Nebria (Nebria) kratteri* Dejean & Boisduval, 1830 (CAR42) and *Ophonus cribricollis* (Dejean, 1829) (CAR46).

Finally, in the biological field (Fbio) the phytophagous are, for examples, the beetles *Galeruca (Galeruca) littoralis* (Fabricius, 1787) (C20) and *Chaetocnema* spp. Stephens, 1831 (C65) and the Diptera *Lasiomma* sp. Stein, 1916 (D17). Among predators there are the Coccinellidae *Hippodamia (Hippodamia) variegata* Goeze, 1777 (CO9) and the Carabidae *Calathus cinctus* Motschulsky, 1850 (CAR7), *Calathus melanocephalus* (Linnaeus, 1758) (CAR9), *Harpalus (Harpalus) attenuatus* Stephens, 1824 (CAR22), *Harpalus (Harpalus) tardus* (Panzer, 1797) (CAR24) and *Microderes scaritides* (Sturm, 1818) (CAR39). All these predators could be potential antagonists of the phytophagous present in the agroecosystem.

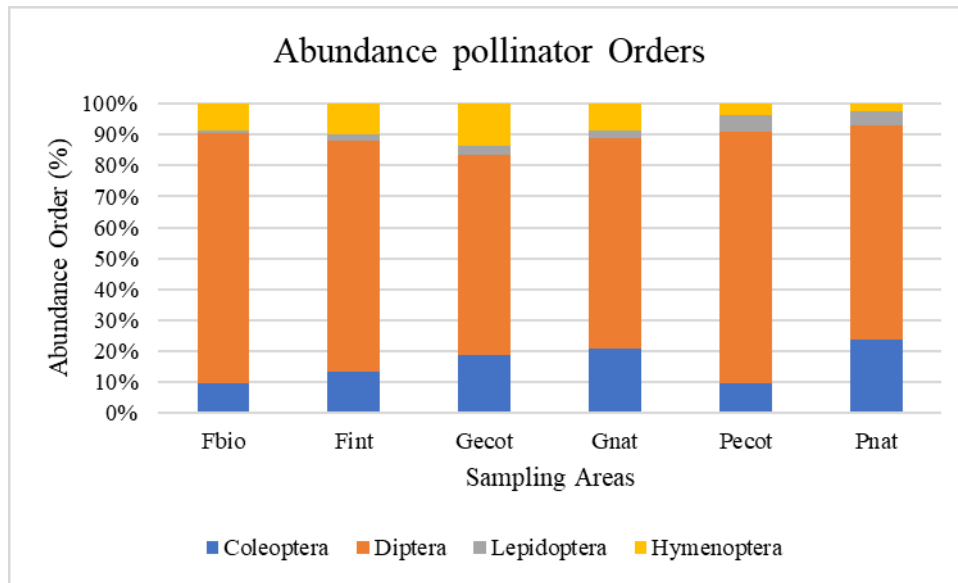
Table 3.16 CA code – Phytophagous species

COLEOPTERA	DIPTERA
C1 <i>Agrilus</i> sp. Curtis, 1825	D1 <i>Eustalomyia</i> sp. Kowarz, 1873
C2 <i>Agapanthia</i> sp. Serville, 1835	D2 <i>Asiaticgaster leucopæa</i> (Meigen, 1830)
C3 <i>Calamobius flum</i> (Rossi, 1790)	D3 <i>Bibio hortulanus</i> (Linnaeus, 1758)
C4 <i>Agapanthia cynaræ</i> (Gyllenhal, 1817)	D4 <i>Bibio marci</i> (Linnaeus, 1758)
C6 <i>Tropinota (Tropinota) squalida squalida</i> (Scopoli, 1783)	D5 <i>Dilophus femoratus</i> Meigen, 1804
C7 <i>Tropinota (Epicometis) hirta</i> (Poda, 1761)	D6 <i>Carpomya schinari</i> (Loew, 1856)
C8 <i>Athica</i> sp. Geoffroy, 1762	D7 <i>Drosophila suzukii</i> Matsumura, 1931
C9 <i>Cassida (Cassida) prasina</i> Illiger, 1798	D8 <i>Loxocera aristata</i> (Panzer, 1801)
C10 <i>Cassida (Cassida) rubiginosa</i> O.F. Muller, 1776	D9 <i>Chaetorellia</i> Hendel, 1927
C11 <i>Cassida sanguinolenta</i> Muller, 1776	D10 <i>Taphris</i> sp. Ragonot, 1891
C12 <i>Cassida</i> sp. Linnaeus, 1758	D11 <i>Nephrotoma</i> sp. Meigen, 1803
C13 <i>Chrysolina (Chalcoidæ) interstincta</i> (Suffrian, 1851)	D12 <i>Pegomyia</i> sp. Robineau-Desvoidy, 1830
C14 <i>Chrysolina rossia</i> (Illiger, 1802)	D13 <i>Anthomyia</i> sp. Meigen, 1803
C15 <i>Chrysolina (Synorga) herbacea</i> (Dufschmid, 1825)	D14 <i>Botanophila</i> sp. Liow, 1864
C16 <i>Crepidodera aurea</i> (Geoffroy, 1785)	D15 <i>Dalia</i> sp. Robineau-Desvoidy, 1830
C17 <i>Cryptocephalus</i> sp. O.F. Muller, 1764	D16 <i>Hylemya</i> sp. Robineau-Desvoidy, 1830
C18 <i>Derocephalus sodalis</i> (Kutschera, 1860)	D17 <i>Lasiomma</i> sp. Stein, 1916
C19 <i>Erosoma lusitanicum</i> (Linnaeus, 1767)	D18 <i>Chlorops</i> sp. Meigen, 1803
C20 <i>Galeruca (Galeruca) littoralis</i> (Fabricius, 1787)	HEMPTERA
C21 <i>Galeruca (Galeruca) pomonæ</i> subsp. <i>pomonæ</i> (Scopoli, 1763)	H2 <i>Cercopis sanguinolenta</i> (Scopoli, 1763)
C22 <i>Galeruca (Galeruca) tanacetii</i> (Linnaeus, 1758)	H3 <i>Haematoloma dorsatum</i> (Ahrens, 1812)
C23 <i>Galerucella lineola</i> (Fabricius, 1781)	H4 <i>Aphrodis</i> sp. Curtis, 1833
C24 <i>Alicinæ</i>	H5 <i>Eupelix cuspidata</i> (Fabricius, 1775)
C25 <i>Hispa atra</i> Linnaeus, 1767	H6 <i>Ladra aurita</i> (Linnaeus, 1758)
C26 <i>Leptinotarsa decemlineata</i> (Say, 1824)	H7 <i>Cicadella viridis</i> (Linnaeus, 1758)
C27 <i>Lapsus</i> sp. Geoffroy, 1762	H8 <i>Coriomaris</i> sp. Westwood, 1842
C28 <i>Mantura (Mantura) obtusata</i> (Gyllenhal, 1813)	H9 <i>Coriomaris scabricornis</i> (Panzer, 1809)
C29 <i>Neocrepidodera ferruginea</i> (Scopoli, 1763)	H10 <i>Spathocera lobata</i> (Hemich-Schäffer, 1840)
C30 <i>Neocrepidodera impressa</i> (Fabricius, 1801)	H11 <i>Syromastus rhombus</i> (Linnaeus, 1767)
C31 <i>Pachybrachis</i> sp. Dejean, 1836	H12 <i>Centrocoris variogatus</i> Kolenati, 1845
C32 <i>Phyllotreta crucifera</i> (Goeze, 1777)	H13 <i>Coriomaris hirticornis</i> (Fabricius, 1794)
C33 <i>Phyllotreta</i> sp. Chevrolat, 1837	H15 <i>Ochatostethus</i> sp. Fieber, 1860
C34 <i>Phyllotreta undulata</i> Kutschera, 1860	H16 <i>Issus</i> sp. Fabricius, 1805
C35 <i>Psylliodes (Psylliodes) chrysocephala</i> (Linnaeus, 1758)	H17 <i>Lygaeus aquastris</i> (Linnaeus, 1758)
C36 <i>Bothynoderus affinis</i> (Schrank, 1781)	H18 <i>Rhyparochromus vulgaris</i> (Schilling, 1829)
C37 <i>Coniocleonus (Plagiographus) pseudobliquus</i> (G. Muller, 1921)	H19 <i>Bramocoris plabejus</i> (Fallen, 1807)
C38 <i>Lacus</i> sp. J.C. Fabricius, 1802	H20 <i>Gastrodes grossipis</i> (De Geer, 1773)
C39 <i>Phyllobius (Subphyllobius) viridæaris</i> (Laicharting, 1781)	H21 <i>Malanocoryphus albomaculatus</i> (Goeze, 1778)
C40 <i>Pitygonus</i> sp. Bedel, 1888	H22 <i>Rhyparochromus vulgaris</i> (Schilling, 1829)
C41 <i>Pentodon bidens</i> (Pallas, 1771)	H23 <i>Xanthochilus saturnius</i> (Rossi, 1790)
C42 <i>Agrion sp.</i> Eschscholtz, 1829	H24 <i>Bramocoris</i> sp. Fieber, 1861
C43 <i>Agrypnus murinus</i> (Linnaeus, 1758)	H25 <i>Emblethis vrbasci</i> (Fabricius 1803)
C44 <i>Athous (Athous) ineptus</i> Candèze, 1860	H27 <i>Raglius confusus</i> (Reuter, 1886)
C45 <i>Athous</i> sp. Eschscholtz, 1829	H28 <i>Gargara genistæ</i> (Fabricius, 1775)
C46 <i>Cidnopus pseudopilosus</i> Platia & Cadenzi, 1985	H29 <i>Adelphocoris lineolatus</i> (Goeze, 1778)
C48 <i>Ctenicera pectinicornis</i> (Linnaeus, 1758)	H30 <i>Calocoris nemoralis</i> (Fabricius, 1787)
C49 <i>Carocoma (Carocoma) schaffneri</i> (Linnaeus, 1758)	H31 <i>Calocoris</i> sp. Fieber, 1858
C50 <i>Amadotrogus quercanus</i> (Burmeister, 1855)	H32 <i>Deraocoris (Deraocoris) ruber</i> (Linnaeus, 1758)
C51 <i>Firminus baudii</i> (Brenske, 1896)	H33 <i>Deraocoris punctum</i> (Rambur, 1839)
C54 <i>Rhizotrogus aestivus</i> (Olivier, 1789)	H34 <i>Deraocoris</i> sp. Kuschbaum, 1856
C55 <i>Mycterus (Eutryptus) tibialis</i> Kuster, 1850	H35 <i>Grypocoris (Lophymiris) sagittatus</i> (Fabricius, 1777)
C56 <i>Mycterus (Mycterus) curculionidis</i> (Fabricius, 1781)	H36 <i>Lygus pratensis</i> (Linnaeus, 1758)
C57 <i>Urophorus humeralis</i> (Fabricius, 1798)	H37 <i>Metopoplax</i> sp. Fieber, 1860
C58 <i>Amphimallon ochraceum</i> (Knoch, 1801)	H38 <i>Aslia acuminata</i> (Linnaeus, 1758)
C59 <i>Amphimallon pseudomajale</i> Sabatinelli, 1976	H39 <i>Aslia rostrata</i> Boheman, 1852
C60 <i>Omophilus lepturoides</i> (Fabricius, 1787)	H40 <i>Carpocoris mediterraneus mediterraneus</i> (Tamanini, 1958)
C61 <i>Omophilus picipes</i> (Fabricius, 1792)	H41 <i>Dolycoris baccarum</i> (Linnaeus, 1758)
C62 <i>Opatrum</i> sp. Fabricius, 1775	H43 <i>Eurydema (Eurydema) olivacea</i> (Linnaeus, 1758)
C63 <i>Omophilus</i> sp. Solier, 1835	H44 <i>Eurydema (Eurydema) ornata</i> (Linnaeus, 1758)
C64 <i>Aptaropoda orbiculata</i> (Marsham, 1802)	H45 <i>Eurydema faberi</i> Schummel, 1837
C65 <i>Chaetocnema</i> spp.	H46 <i>Eurydema ventralis</i> (Kolenati, 1846)
C66 <i>Psylliodes</i> spp. Stephens, 1831	H47 <i>Graphosoma lineatum</i> (Linnaeus, 1758)
C67 <i>Orthotomicus</i> sp. Ferrari, 1867	H49 <i>Sciocoris</i> sp. Fallen, 1829
C68 <i>Oryzaephilus surinamensis</i> (Linnaeus, 1758)	H50 <i>Pyrrhocoris apterus</i> (Linnaeus, 1758)
HYMENOPTERA	H52 <i>Chorosoma schillingii</i> (Schilling, 1829)
Hy1 <i>Argo</i> sp. Schrank, 1802	H53 <i>Corizus hyoscyami</i> (Linnaeus, 1758)
Hy2 <i>Athalia bicolor</i> Serville, 1823	H54 <i>Xanthochilus saturnius</i> (Rossi, 1790)
Hy3 <i>Athalia circularis</i> (Klug, 1815)	H55 <i>Odontoscelis (Odontoscelis) fuliginosa</i> (Linnaeus, 1761)
Hy4 <i>Dolarus</i> sp. Panzer, 1801	H56 <i>Tetrigomadra</i> sp. Latreille, 1804
Hy5 <i>Macrophya (Macrophya) montana</i> (Scopoli, 1763)	H57 <i>Dictyla humuli</i> (Fabricius, 1794)
Hy6 <i>Nematus (Pteronidea) myosotidis</i> (Fabricius, 1804)	H58 <i>Tingis</i> sp. Fabricius, 1805
Hy7 <i>Nematus (Pteronidea) oligospilus</i> Forster, 1854	ORTHOPTERA
Hy8 <i>Tiphia</i> sp. Fabricius, 1775	O1 <i>Ailopus</i> sp. Fieber, 1853
Hy9 <i>Athalia</i> sp. Leach, 1817	O2 <i>Calliptamus italicus</i> (Linnaeus, 1758)
LEPIDOPTERA	O3 <i>Calliptamus siciliae</i> Ramme, 1927
L2 <i>Amata</i> sp. Fabricius, 1807	O4 <i>Epyrapocnemis plorans</i> (Charpentier, 1825)
L4 <i>Noctua pronuba</i> (Linnaeus, 1758)	O5 <i>Oedipoda caeruleascens</i> (Linnaeus, 1758)
L5 <i>Trigonophora (Trigonophora) flamma</i> (Esper, 1785)	O6 <i>Omocastus (Omocastus) rufipis</i> (Zetterstedt, 1821)
L7 <i>Zygæna</i> sp. Fabricius, 1775	O7 <i>Stenobothrus lineatus lineatus</i> (Panzer, 1796)
L8 <i>Noctua orbona</i> (Hufnagel, 1766)	O8 <i>Gryllus campestris</i> Linnaeus, 1758
	O9 <i>Tetrix</i> sp. Latreille, 1802
	O10 <i>Chorthippus</i> sp. Fieber, 1852

Table 3.17 CA code – Zoophagous species

Cleridae		Tenebrionidae	
<i>Thanasinus formicarius</i> (Linnaeus, 1758)	CL2	<i>Gonocephalum granulatum</i> (Fabricius, 1791)	TE1
<i>Trichodes alvearius</i> (Fabricius, 1792)	CL3	Carabidae	
<i>Trichodes aptarius</i> (Linnaeus, 1758)	CL4	<i>Acupalpus (Acupalpus) meridianus</i> (Linnaeus, 1761)	CAR 2
<i>Trichodes leucospideus</i> (Olivier, 1795)	CL5	<i>Amara aulica</i> (Panzer, 1796)	CAR 3
Coccinellidae		<i>Amara (Amara) aenea</i> (De Geer, 1774)	CAR 4
<i>Adalia (Adalia) bipunctata</i> (Linnaeus, 1758)	CO1	<i>Amara (Bradytus) apricaria</i> (Paykull, 1790)	CAR 5
<i>Adalia (Adalia) decempunctata</i> (Linnaeus, 1758)	CO2	<i>Brachinus (Brachinus) explodens</i> Duftschmid, 1812	CAR 6
<i>Calvia quatuordecimguttata</i> Linnaeus, 1758	CO3	<i>Calathus cinctus</i> Motschulsky, 1850	CAR 7
<i>Ceratomegilla (Ceratomegilla) undecimnotata</i> Schneider D. H., 1792	CO4	<i>Calathus fuscipes</i> (Goeze, 1777)	CAR 8
<i>Coccinella (Coccinella) septempunctata</i> Linnaeus, 1758	CO5	<i>Calathus melanocephalus</i> (Linnaeus, 1758)	CAR 9
<i>Coccinella (Spilota) undecimpunctata</i> Linnaeus, 1758	CO6	<i>Calathus micropterus</i> (Duftschmid, 1812)	CAR 10
<i>Coccinula quatuordecimpustulata</i> (Linnaeus, 1758)	CO7	<i>Calathus (Amphyginus) rotundicollis</i> Dejean, 1828	CAR 11
<i>Exochomus (Exochomus) quadripustulatus</i> Linnaeus, 1758	CO8	<i>Calathus (Calathus) montivagus</i> Dejean, 1831	CAR 12
<i>Hippodamia (Hippodamia) variegata</i> Goeze, 1777	CO9	<i>Calosoma (Campalita) maderae</i> (Fabricius, 1775)	CAR 13
<i>Hyperaspis</i> sp. Chevrolat, 1836	CO10	<i>Carabus (Chaetocarabus) lefebvrei</i> subsp. <i>bayardi</i> Solier, 1835	CAR 14
<i>Myrrha octodecimguttata</i> (Linnaeus, 1758)	CO11	<i>Carabus (Oreocarabus) preslii</i> subsp. <i>neumeyeri</i> Schaum, 1856	CAR 15
<i>Propylea quatuordecimpunctata</i> (Linnaeus, 1758)	CO12	<i>Carabus (Tomocarabus) convexus</i> subsp. <i>convexus</i> Fabricius, 1775	CAR 16
<i>Psyllobora vigintiduopunctata</i> (Linnaeus, 1758)	CO13	<i>Clinidium (Arctoclinidium) canaliculatum</i> (O.G. Costa, 1839)	CAR 17
<i>Scymnus (Scymnus) frontalis</i> (Fabricius, 1787)	CO14	<i>Cychnus italicus</i> Bonelli, 1810	CAR 18
Dasytidae		<i>Cymindis (Menas) miliaris</i> (Fabricius, 1801)	CAR 19
<i>Aplocnemus</i> sp. Stephens, 1830	DA1	<i>Dromius (Dromius) agilis</i> (Fabricius, 1787)	CAR 20
<i>Divales bipustulatus</i> (Fabricius, 1781)	DA2	<i>Dromius fenestratus</i> (Fabricius, 1794)	CAR 21
<i>Enicopus (Enicopus) pilosus</i> (Scopoli, 1763)	DA3	<i>Harpalus (Harpalus) attenuatus</i> Stephens, 1824	CAR 22
Elatereidae		<i>Harpalus (Harpalus) serripes</i> (Quensel in Schonherr, 1806)	CAR 23
<i>Ampedus (Ampedus) sinuatus</i> Germar, 1844	EL1	<i>Harpalus (Harpalus) tardus</i> (Panzer, 1797)	CAR 24
<i>Cardiophorus (Cardiophorus) collaris/italicus</i>	EL2	<i>Harpalus (Harpalus) decipiens</i> Dejean, 1829	CAR 25
<i>Cardiophorus (Cardiophorus) italicus</i> Platia & Bartolozzi, 1988	EL3	<i>Harpalus (Harpalus) distinguendus</i> (Duftschmid, 1812)	CAR 26
<i>Cardiophorus</i> sp. Eschscholtz, 1829	EL4	<i>Harpalus (Harpalus) dimidiatus</i> (P. Rossi, 1790)	CAR 28
<i>Drasterius bimaculatus</i> (Rossi, 1790)	EL6	<i>Harpalus (Harpalus) rubripes</i> (Duftschmid, 1812)	CAR 29
<i>Hemicrepidius hirtus</i> (Herbst, 1784)	EL7	<i>Harpalus (Harpalus) rufipalpis</i> Sturm, 1818	CAR 30
<i>Melanotus (Melanotus) castanipes</i> (Paykull, 1800)	EL8	<i>Laemostenus (Pristonychus) terricola</i> (Herbst, 1783)	CAR 31
<i>Melanotus crassicornis</i> (Erichson, 1841)	EL9	<i>Laemostenus (Pristonychus) cimmerius</i> (Fischer von Waldheim, 1823)	CAR 32
Staphylinidae		<i>Lebia trimaculata</i> (Villers, 1789)	CAR 33
<i>Boreaphilus velox</i> (Heer, 1839)	ST2	<i>Leistus (Pogonophorus) spinibarbis</i> subsp. <i>florii</i> Lutshnik, 1913	CAR 34
<i>Carphacis striatus</i> (Olivier, 1795)	ST3	<i>Leistus fulvibarbis</i> Dejean, 1826	CAR 35
<i>Gyrophypnus angustatus</i> Stephens, 1833	ST4	<i>Lionychnus (Lionychnus) quadrillum</i> (Duftschmid, 1812)	CAR 36
<i>Gyrophypnus punctulatus</i> (Paykull, 1789)	ST5	<i>Masoreus wetherhallii</i> (Gyllenhal, 1813)	CAR 37
<i>Lordithon lunulatus</i> (Linnaeus, 1760)	ST6	<i>Microderes scaritides</i> (Sturm, 1818)	CAR 39
<i>Ocypus (Pseudocypus) fulvipennis</i> Erichson, 1840	ST7	<i>Microlestes seladon</i> Holdhaus, 1912	CAR 40
<i>Ocypus (Matidus) italicus</i> (Aragona, 1830)	ST8	<i>Nebria (Nebria) brevicollis</i> (Fabricius, 1792)	CAR 41
<i>Ocypus (Ocypus) olens</i> (O. Muller, 1764)	ST9	<i>Nebria (Nebria) kratteri</i> Dejean & Boisduval, 1830	CAR 42
<i>Ocypus (Pseudocypus) sericeicollis</i> (Menetries, 1832)	ST10	<i>Notiophilus biguttatus</i> (Fabricius, 1779)	CAR 43
<i>Othius laeviusculus</i> Stephens, 1833	ST11	<i>Notiophilus rufipes</i> Curtis, 1829	CAR 44
<i>Phyllodrepa salicis</i> (Gyllenhal, 1810)	ST14	<i>Notiophilus substriatus</i> G. R. Waterhouse, 1833	CAR 45
<i>Platydracus stercorarius</i> (Olivier, 1795)	ST15	<i>Ophonus cribricollis</i> (Dejean, 1829)	CAR 46
<i>Quedius (Microsaurus) latinus</i> Gridelli, 1938	ST16	<i>Ophonus puncticollis</i> (Paykull, 1798)	CAR 47
<i>Quedius (Raphirus) semiobscurus</i> (Marsham, 1802)	ST17	<i>Paradromius (Manodromius) linearis</i> (Olivier, 1795)	CAR 48
<i>Tachinus humeralis</i> Gravenhorst, 1802	ST18	<i>Philorhizus crucifer</i> (Lucas, 1846)	CAR 49
<i>Tasgius (Rayachiela) morsitans</i> (Rossi, 1790)	ST19	<i>Poecilus cupreus</i> (Linnaeus, 1758)	CAR 50
<i>Tasgius pedator</i> (Gravenhorst, 1802)	ST20	<i>Syntomus impressus</i> Dejean, 1825	CAR 53
<i>Xantholinus (Typhlolinus) appennincola</i> Steel, 1946	ST21	<i>Synuchus vivalis</i> (Illiger, 1798)	CAR 54
<i>Xantholinus (Polydonthallus) elegans</i> (Olivier, 1795)	ST22	<i>Trechus (Trechus) obtusus</i> Erichson, 1837	CAR 55
<i>Xantholinus</i> sp. Dejean, 1821	ST23	Cybocephalidae	
Histeridae		<i>Cybocephalus</i> sp. Erichson, 1844	CY2
<i>Saprinus (Saprinus) semistriatus</i> (Scriba, 1790)	H11		

3.9 Analysis of the pollinator community



Graph 3.36 Abundance of pollinator orders

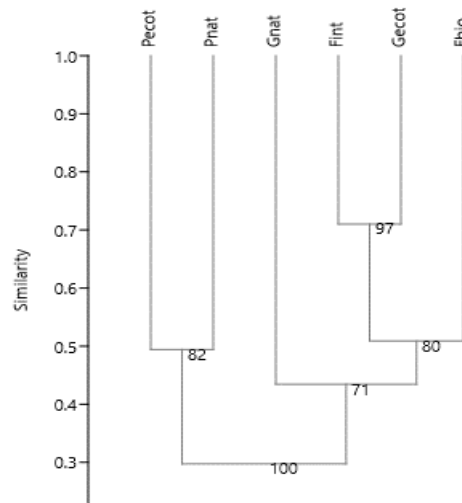
Although with different abundances, in all the areas we have a clear presence of the Diptera, and following the Coleoptera, Hymenoptera and Lepidoptera (Graph 3.36).

Data analysed by permanova show a significant difference between the areas in terms of specific composition ($F:3,256$; $p:0,0001$), as confirmed by Bonferroni-corrected p values. There are substantial differences between the areas, except for Fbio vs. Fint, Fint vs. Gecot, and between the two pine forests (Tab. 3.18).

Table 3.18. Bonferroni-corrected p values (Software Past)

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Fbio		0,0555	0,009	0,0015	0,0015	0,0015
Fint	0,0555		1	0,0255	0,0015	0,0015
Gecot	0,009	1		0,0165	0,0015	0,0015
Gnat	0,0015	0,0255	0,0165		0,0015	0,0015
Pecot	0,0015	0,0015	0,0015	0,0015		1
Pnat	0,0015	0,0015	0,0015	0,0015	1	

The cluster analysis (similarity index: Bray-Curtis; Boot N: 1000; cophen. Corr: 0,8816) (Graph 3.37), highlights two mainly clusters, one composed by pine forests, which are medially similar to each other (similarity about 0.5) and open areas. Fint and Gecot are the most similar areas, precisely for the exchange of species between field and ecotone. Fbio differs from this group probably not only because the different use of soil, but also for the lack of margins of grass; from this last group, it differs even more Gnat in that it presents different floral essences.



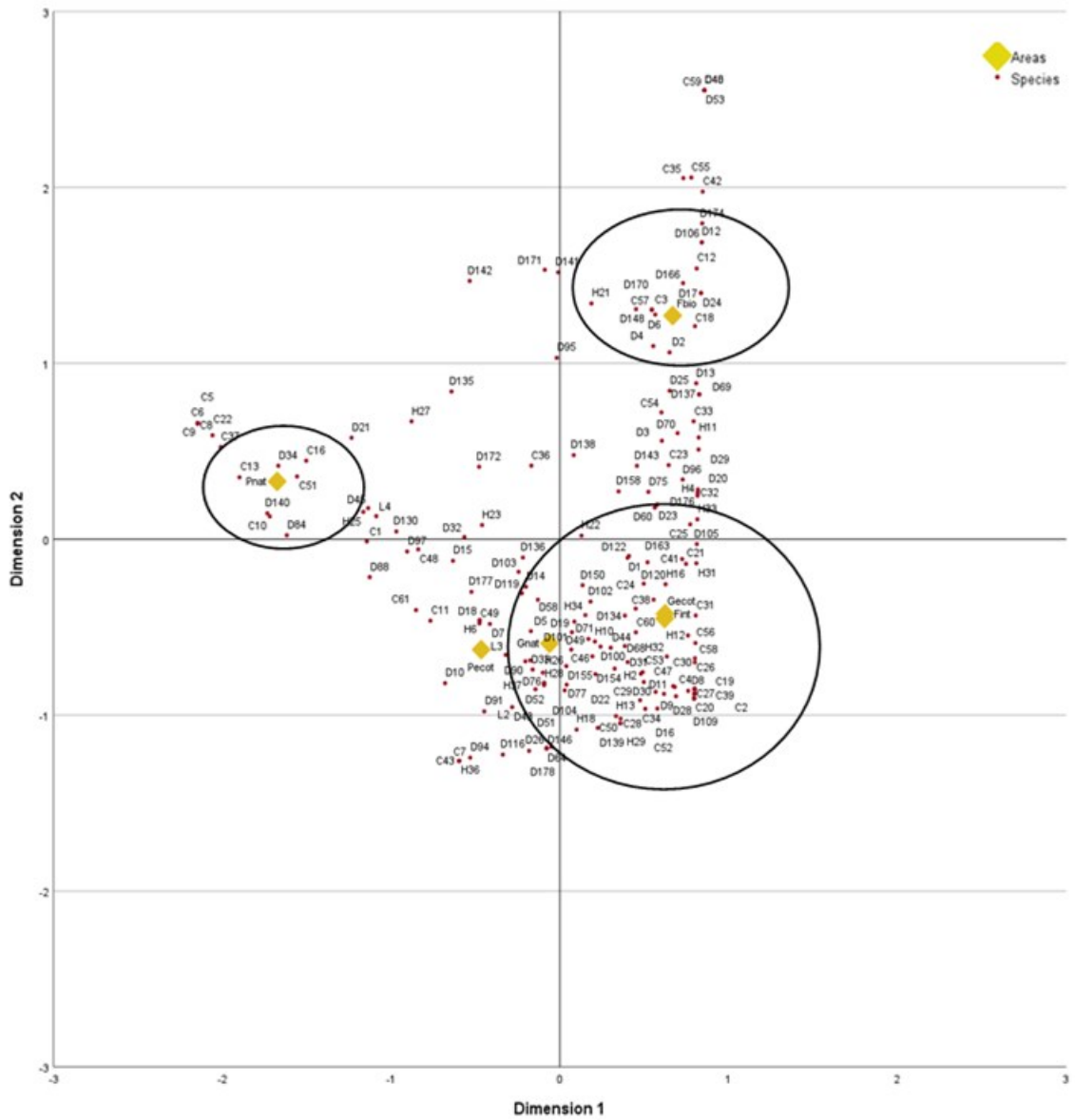
Graph 3.37 Cluster analysis of pollinators (Software Past)



Graph 3.38 Biodiversity index

It was chosen to divide the main pollinators (Apoidea, Syrphidae, Bombyliidae and diurnal Lepidoptera) from all other flowers visitor and nectariferous mentioned in literature as according to Proposal for an EU Pollinator monitoring scheme (Potts *et al.*, 2021) because beetles and other families of Diptera are less specialized pollinators, although they could help to compensate the reduced pollination rate because of the wild bees decline.

The different parameters describing biological diversity in the six sampling areas are shown in the graphs 3.38. Gecot has the greatest number of taxa while Pecot has the least number; the largest number of specimens in total and flower visitors is in the Fint area, while the most pollinators are present in Gecot, representing, therefore, a remarkable hotspot of biodiversity; Pecot shows the lowest number of specimens. Gnat has the highest value of Shannon and Evenness indexes both in total pollinators and in Flower visitors, while among the main pollinators the area Fbio has a higher biodiversity value. Pnat has the lowest value of diversity and equity in total and among flower visitors, while Pecot for specialised pollinators. In conclusion, in Fbio there is a lower diversity of flowers visitors compared to the integrated field and ecotonal area while the diversity of main pollinators is greater in Fbio than Fint and Gecot, probably due to the use of pesticides and the presence of grazing to which pollinators are particularly sensitive. Furthermore, the species of specialised pollinators in Fbio are equally distributed unlike Gecot and Fint.



Graph 3.39 Correspondence analysis Flower Visitors (Software SPSS)

Table 3.18 Code CA Flower visitors

COLEOPTERA		HYMENOPTERA	
<i>Anthaxia (Melanthis) helvetica</i> Stierlin, 1868	C1	<i>Chrysis bicolor</i> Lepeletier, 1806	H1
<i>Anthaxia mendazabali</i> Cobos, 1965	C2	<i>Chrysis</i> sp. Linnaeus, 1761	H2
<i>Anthaxia (Haplarthaxia) millefolii</i> (Fabricius, 1801)	C3	<i>Elampus</i> sp. Spinola, 1806	H3
<i>Anthaxia (Anthaxia) nitidula</i> (Linnaeus, 1758)	C4	<i>Argogorytes</i> sp. Ashmead, 1899	H4
<i>Anthaxia (Anthaxia) semicuprea</i> Kuster, 1851	C5	<i>Astata</i> sp. Latreille, 1796	H5
<i>Anthaxia</i> sp. Eschscholtz, 1829	C6	<i>Cerceris</i> sp. Latreille, 1802	H6
<i>Cantharis decipiens</i> Baudi, 1871	C7	<i>Ectemnius massiliensis</i> (Kohl, 1883)	H7
<i>Cantharis</i> sp. Linnaeus, 1758	C8	<i>Ectemnius</i> sp. Dahlbom, 1845	H8
<i>Dichelotarsus procerulus</i> (Kiesenwetter, 1860)	C9	<i>Gorytes</i> sp. Latreille, 1804	H9
<i>Malthinus</i> sp. Latreille, 1806	C10	<i>Lindernius</i> sp. Lepeletier & Brullé, 1835	H10
<i>Metacantharis clypeata</i> (Illiger, 1798)	C11	<i>Oxybelus</i> sp. Latreille, 1796	H11
<i>Rhagonycha (Rhagonycha) fulva</i> (Scopoli, 1763)	C12	<i>Oxybelus subspinosus</i> Klug, 1835	H12
<i>Rhagonycha (Rhagonycha) lignosa</i> (Muller, 1764)	C13	<i>Colpa (Heterelis) quinquecincta</i> (Fabricius, 1793)	H13
<i>Rhagonycha (Rhagonycha) hutea</i> (Muller, 1764)	C14	<i>Colpa sexmaculata</i> (Fabricius, 1781)	H14
<i>Alosterna tabacicolor</i> (De Geer, 1775)	C15	<i>Megascolia flavifrons</i> (Fabricius, 1775)	H15
<i>Anastrangalia dubia</i> (Scopoli, 1763)	C16	<i>Scolia (Discolia) hirta</i> (Schrank, 1781)	H16
<i>Anastrangalia sanguinolenta</i> (Linnaeus, 1761)	C17	<i>Ammophila</i> sp. W. Kirby, 1798	H17
<i>Chlorophorus sartor</i> (Müller, 1766)	C18	<i>Ammophila pubescens</i> Curtis, 1836	H18
<i>Clytus lama</i> Mulsant, 1847	C19	<i>Sphex</i> sp. Linnaeus, 1758	H19
<i>Clytus rhamni</i> Germar, 1817	C20	<i>Arge</i> sp. Schrank, 1802	H20
<i>Pseudovadonia livida</i> (Fabricius, 1776)	C21	<i>Athalia bicolor</i> Serville, 1823	H21
<i>Rutpela maculata</i> (Poda, 1761)	C22	<i>Athalia circularis</i> (Klug, 1815)	H22
<i>Stenopterus rufus</i> Linnaeus, 1767	C23	<i>Athalia</i> sp. Leach, 1817	H23
<i>Stenurella bifasciata</i> (O. F. Muller, 1776)	C24	<i>Dolerus</i> sp. Panzer, 1801	H24
<i>Stictoleptura cordigera</i> (Fuessly, 1775)	C25	<i>Macrophya (Macrophya) montana</i> (Scopoli, 1763)	H25
<i>Paracorymbia fulva</i> (De Geer, 1775)	C26	<i>Nematus (Pteronidea) myosotidis</i> (Fabricius, 1804)	H26
<i>Cetonia aurata</i> subsp. <i>pisana</i> Heer, 1841	C27	<i>Nematus</i> sp. Panzer,	H27
<i>Protaetia (Netocia) cuprea</i> subsp. <i>cuprea</i> (Fabricius, 1775)	C28	<i>Ancistrocerus</i> sp. Wesmæl, 1836	H28
<i>Protaetia (Netocia) morio morio</i> (Fabricius, 1781)	C29	<i>Dolichovespula media</i> (Retzius, 1783)	H29
<i>Tropinota (Epicometis) hirta hirta</i> (Poda, 1761)	C30	<i>Eumenes mediterraneus</i> Kriechbaumer, 1879	H30
<i>Tropinota (Tropinota) squalida squalida</i> (Scopoli, 1783)	C31	<i>Polistes atrimandibularis</i> Zimmermann, 1930	H31
<i>Valgus hemipterus</i> Linnaeus, 1758	C32	<i>Polistes dominula</i> (Christ, 1791)	H32
<i>Trichodes alvearius</i> (Fabricius, 1792)	C33	<i>Polistes gallicus</i> (Linnaeus, 1767)	H33
<i>Trichodes apicatus</i> (Linnaeus, 1758)	C34	<i>Polistes nimphus</i> (Christ, 1791)	H34
<i>Trichodes leucospideus</i> (Olivier, 1795)	C35	<i>Polistes sulcifer</i> Zimmermann, 1930	H35
<i>Danacea</i> sp. Laporte de Castelnau, 1836	C36	<i>Vespa crabro</i> Linnaeus, 1761	H36
<i>Dasytes</i> sp. Paykull, 1799	C37	<i>Vespula germanica</i> (Fabricius, 1793)	H37
<i>Divales bipustulatus</i> (Fabricius, 1781)	C38		
<i>Enicopus (Enicopus) pilosus</i> (Scopoli, 1763)	C39	LEPIDOPTERA	
<i>Psyllothrix</i> sp. Kuster, 1858	C40	<i>Epilecta linogrisea</i> (Denis & Schiffmuller, 1775)	L1
<i>Psyllothrix viridicoerulea</i> (Geoffroy, 1785)	C41	<i>Noctua orbona</i> (Hufnagel, 1766)	L2
<i>Anthrenus (Florilinus) signatus</i> Erichson, 1846	C42	<i>Noctua pronuba</i> (Linnaeus, 1758)	L3
<i>Anthrenus</i> sp. Geoffroy, 1762	C43	<i>Trigonophora (Trigonophora) flammea</i> (Esper, 1785)	L4
<i>Mylabris (Eumylabris) fabricii</i> Soumacov, 1924	C44		
<i>Mylabris (Mylabris) variabilis</i> (Pallas, 1781)	C45		
<i>Mordella</i> sp. Linnaeus, 1758	C46		
<i>Mordellistena</i> sp. Costa, 1854	C47		
<i>Chrysanthia viridissima</i> (Linnaeus, 1758)	C48		
<i>Nacerdes (Xanthochroa) carniolica</i> (Gistel, 1834)	C49		
<i>Oedemera (Oedemera) atrata</i> W. Schmidt, 1846	C50		
<i>Oedemera femorata</i> (Scopoli, 1763)	C51		
<i>Oedemera (Oedemera) flavipennis</i> W. Schmidt, 1846	C52		
<i>Oedemera flavipes</i> (Fabricius, 1792)	C53		
<i>Oedemera lurida/crassipes</i>	C54		
<i>Oedemera (Oedemera) nobilis</i> (Scopoli, 1763)	C55		
<i>Oedemera podagrariae</i> (Linnaeus, 1767)	C56		
<i>Oedemera (Oedemera) pthysica</i> (Scopoli, 1763)	C57		
<i>Oedemera (Oedemera) simplex</i> (Linnaeus, 1767)	C58		
<i>Oedemera</i> sp. Olivier, 1789	C59		
<i>Olibrus</i> sp. Erichson, 1845	C60		
<i>Anaspis</i> sp. Geoffroy, 1762	C61		
<i>Trotomma (Trotomma) pubescens</i> Kiesenwetter, 1851	C62		

Table 3.19 Code CA Flower visitors

DIPTERA			
<i>Anthomyia</i> sp. Meigen, 1803	D1	<i>Loxocera aristata</i> (Panzer, 1801)	D99
<i>Botanophila</i> sp. Lioy, 1864	D2	<i>Rhagio</i> sp. Fabricius, 1775	D100
<i>Delia</i> sp. Robineau-Desvoidy, 1830	D3	<i>Paykullia</i> sp. Robineau-Desvoidy, 1830	D101
<i>Eustalomyia</i> sp. Kowarz, 1873	D4	<i>Phyto</i> sp. Robineau-Desvoidy, 1830	D102
<i>Hylemyia</i> sp. Robineau-Desvoidy, 1830	D5	<i>Rhinophora lepida</i> (Meigen, 1824)	D103
<i>Lasionomma</i> sp. Stein, 1916	D6	<i>Stevenia</i> sp. Robineau-Desvoidy, 1830	D104
<i>Pegomyia</i> sp. Robineau-Desvoidy, 1830	D7	<i>Angiometopa falleni</i> Pape, 1986	D105
<i>Bibio hortulanus</i> (Linnaeus, 1758)	D8	<i>Miltogramma</i> sp. Meigen, 1803	D106
<i>Bibio marci</i> (Linnaeus, 1758)	D9	<i>Pterella grisea</i> Meigen, 1824	D107
<i>Bibio</i> sp. Geoffroy, 1762	D10	<i>Ravinia pemix</i> (Harris, 1780)	D109
<i>Dilophus femoratus</i> Meigen, 1804	D11	<i>Sarcophaga (Helicophagella) crassimargo</i> Pandelle, 1896	D116
<i>Bellardia viarum</i> (Robineau-Desvoidy, 1830)	D12	<i>Sarcophaga (Heteronychia) haemorrhoea</i> Meigen, 1826	D119
<i>Bellardia vulgaris</i> (Robineau-Desvoidy, 1830)	D13	<i>Sarcophaga (Thyrsocnema) incisilobata</i> Pandelle, 1896	D120
<i>Calliphora vicina</i> Robineau-Desvoidy, 1830	D14	<i>Sarcophaga (Helicophagella) melanura</i> Meigen, 1826	D122
<i>Calliphora vomitoria</i> (Linnaeus, 1758)	D15	<i>Sarcophaga (Myorhina) nigriventris</i> (Meigen, 1826)	D124
<i>Chrysomya albiceps</i> Wiedemann, 1819	D16	<i>Sarcophaga (Sarcophaga) subvicina</i> Rohdendorf, 1937	D130
<i>Cynomyia mortuorum</i> (Linnaeus, 1761)	D17	<i>Chloromyia formosa</i> (Scopoli, 1763)	D134
<i>Lucilia ampullacea</i> Villeneuve, 1922	D18	<i>Microchrysa polita</i> (Linnaeus, 1758)	D135
<i>Lucilia caesar</i> (Linnaeus, 1758)	D19	<i>Chrysops (Chrysops) caecutiens</i> (Linnaeus, 1758)	D136
<i>Lucilia sericata</i> (Meigen, 1826)	D20	<i>Chrysops viduatus</i> (Fabricius, 1794)	D137
<i>Melinda geritils</i> Robineau-Desvoidy, 1830	D21	<i>Haematopoda italica</i> Meigen, 1804	D138
<i>Melinda viridicyanea</i> (Robineau-Desvoidy, 1830)	D22	<i>Haematopoda</i> sp. Meigen, 1803	D139
<i>Onesia floralis</i> Robineau-Desvoidy, 1830	D23	<i>Hybomitra montana</i> (Meigen, 1820)	D140
<i>Protocalliphora azurea</i> (Fallen, 1817)	D24	<i>Tabanus rectus</i> Low, 1858	D141
<i>Stomoxia lunata</i> (Fabricius, 1805)	D25	<i>Tabanus</i> sp. Linnaeus, 1758	D142
<i>Leopoldius</i> sp. Rondani, 1843	D26	<i>Tabanus tergestinus</i> Egger, 1859	D143
<i>Sicus</i> sp. Scopoli, 1763	D27	<i>Bithia modesta</i> (Meigen, 1824)	D144
<i>Tireocophora</i> sp. Rondani, 1845	D28	<i>Bithia</i> sp. Robineau-Desvoidy	D145
<i>Zodion</i> sp. Latreille, 1796	D29	<i>Cistogaster globosa</i> (Fabricius, 1775)	D146
<i>Empis (Empis) pennipes</i> Linnaeus, 1758	D30	<i>Chasmodon</i> sp. Rondani, 1856	D147
<i>Empis</i> sp. Linnaeus, 1758	D31	<i>Cylindromyia intermedia</i> (Meigen, 1824)	D148
<i>Fannia canicularis</i> (Linnaeus, 1761)	D32	<i>Cylindromyia</i> sp. Meigen, 1803	D149
<i>Fannia lineata</i> (Stein, 1895)	D33	<i>Cyzenis albicans</i> (Fallen, 1810)	D150
<i>Fannia</i> sp. Robineau-Desvoidy, 1830	D34	<i>Dexisoma caninum</i> (Fabricius, 1781)	D151
<i>Lyciella</i> sp. Collin, 1948	D43	<i>Dufouria chalybeata</i> (Meigen, 1824)	D152
<i>Minettia fasciata</i> (Fallen, 1820)	D44	<i>Dufouria nigrita</i> (Fallen, 1810)	D153
<i>Minettia</i> sp. Robineau-Desvoidy, 1830	D45	<i>Eriothrix monticola</i> (Egger, 1856)	D154
<i>Sapromyia quadri-punctata</i> (Gimmerthal, 1842)	D46	<i>Eriothrix rufomaculata</i> (DeGeer, 1776)	D155
<i>Coenosia tigrina</i> (Fabricius, 1775)	D49	<i>Estheria microcera</i> (Robineau-Desvoidy, 1830)	D156
<i>Eudasyphora cyanella</i> (Meigen, 1826)	D51	<i>Estheria petiolata</i> (Bonsdorff, 1866)	D157
<i>Eudasyphora cyanicolor</i> (Zettenstedt, 1845)	D52	<i>Gonia bimaculata</i> Wiedemann, 1819	D158
<i>Graphomyia maculata</i> (Scopoli, 1763)	D53	<i>Gonia picea</i> (Robineau-Desvoidy, 1830)	D159
<i>Helina impunctata</i> (Fallen 1825)	D58	<i>Gonia vacua</i> Meigen, 1826	D160
<i>Helina reversio</i> (Harris, 1780)	D60	<i>Gynasoma nitens</i> Meigen, 1824	D161
<i>Hydrotaea albipuncta</i> (Zettenstedt, 1845)	D64	<i>Gynasoma</i> sp. Meigen, 1803	D162
<i>Mesembrina meridiana</i> (Linnaeus, 1758)	D68	<i>Kirbya moerens</i> (Meigen, 1830)	D163
<i>Morellia simplex</i> (Loew, 1857)	D69	<i>Microphthalma europea</i> Egger, 1860	D164
<i>Musca autumnalis</i> De Geer, 1776	D70	<i>Nowickia</i> sp. Wachtl, 1894	D165
<i>Musca domestica</i> Linnaeus, 1758	D71	<i>Nowickia strobili</i> (Rondani, 1865)	D166
<i>Neomyia cornicina</i> (Fabricius, 1781)	D75	<i>Peleteria</i> sp. Robineau-Desvoidy, 1830	D167
<i>Neomyia viridescens</i> (Robineau-Desvoidy, 1830)	D76	<i>Peleteria rubescens</i> (Robineau-Desvoidy, 1830)	D168
<i>Phaonia angelicae</i> (Scopoli, 1763)	D77	<i>Smidtia</i> sp. Robineau-Desvoidy, 1830	D169
<i>Phaonia pallida</i> (Fabricius, 1787)	D84	<i>Tachina casta</i> (Rondani, 1859)	D170
<i>Phaonia subventa</i> (Harris, 1780)	D88	<i>Tachina fera</i> (Linnaeus, 1761)	D171
<i>Phaonia tuguriorum</i> (Scopoli, 1763)	D90	<i>Tachina magnicornis</i> (Zettenstedt, 1844)	D172
<i>Poliates meridionalis</i> Peris & Llorente, 1963	D91	<i>Tachina</i> sp. Meigen, 1803	D173
<i>Thricops semicinereus</i> (Wiedemann, 1817)	D94	<i>Wegneria</i> sp. Diakonoff, 1951	D174
<i>Pipunculus</i> sp. Latreille, 1802	D95	<i>Carpomya schineri</i> (Loew, 1856)	D175
<i>Pollenia grisotomentosa</i> (Jacentkovsky, 1944)	D96	<i>Chaetorellia</i> Hendel, 1827	D176
<i>Pollenia rudis</i> (Fabricius, 1794)	D97	<i>Tephritis</i> sp. Ragonot, 1891	D177
<i>Pollenia</i> sp. Robineau-Desvoidy, 1830	D98	<i>Thereva</i> sp. Latreille, 1797	D178
		<i>Thereva valida</i> Loew, 1847	D179

In the correspondences analysis of less specialized pollinators (chi square= 25894,666; $p < 0,01$) a different distribution of species in the areas is observed (Graph 3.39; legend code Tab. 3.18; 3.19) and the majority of species are related to Fint, Gecot and Gnat and less to Fbio, Pecot and Pnat.

In the biological field (Fbio), associated species are the dipterans of the genera *Eustalomyia* sp. Lowarz, 1873 (D4), *Botanophila* sp. Lioy, 1864 (D2) and *Lasiomma* sp. Stein, 1916 (D6) (Fam: Anthomyidae), the Calliphoridae *Cynomya mortorum* (Linnaeus, 1761) (D17) and *Protocalliphora azurea* (Fallen, 1817) (D24) and the Tachinidae *Cylindromyia intermedia* (Meigen, 1824) (D148), *Nowickia strobili* (Rondani, 1865) (D166) and *Tachina casta* (Rondani, 1859) (D170); among beetles there are the Cerambycidae *Chlorophorus sartor* (Muller, 1766) (C18) and the Buprestidae *Anthaxia (Haplantaxia) millefolii* (Fabricius, 1801) (C3).

The integrated field (Fint) and its ecotonal area (Gecot) have common species, such as the Hymenoptera *Oxybelus subspinosus* Klug, 1835 (H12) (Fam: Crabronidae) and the beetles *Tropinota (Tropinota) squalida squalida* (Scopoli, 1783) (C31) (Fam: Cetoniidae), *Divaes bipustulatus* (Fabricius, 1781) (C38) (Fam: Dasytidae) and *Olibrus* sp. Erichson, 1845 (C60) (Fam: Phalacridae).

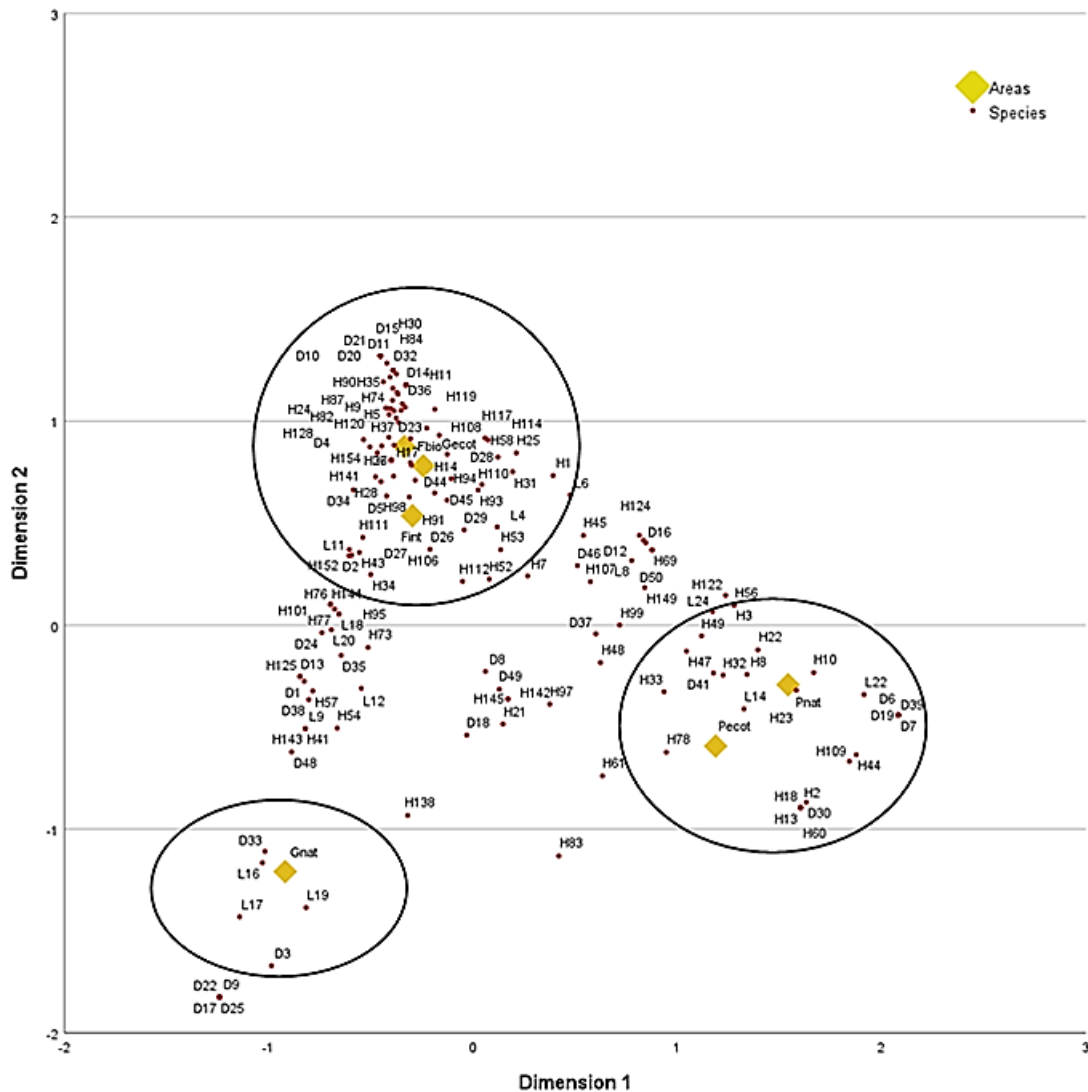
In contrast, in Gnat there are the Hymenoptera *Nematus (Pteronidea) myosotidis* (Fabricius, 1804) (H26) (Fam: Tenthrenidae) and *Ancistrocerus* sp. Wesmael, 1836 (H28) (Fam: Vespidae) and the Diptera *Hylemya* sp. Robineau-Desvoidy, 1830 (D5) (Fam: Anthomyidae) and *Lucilia caesar* (Linnaeus, 1758) (D19) (Fam: Calliphoridae).

Associated with Pecot there are several species such as the Coleoptera *Metacantharis clypeata* (Illiger, 1798) (C11) (Fam. Cantharidae) and *Anaspis* sp. Geoffroy, 1762 (C61) (Fam: Scaptidae) and the dipteras Antomyiidae *Pegomyia* sp. Robineau-Desvoidy, 1830 (D7), the Bibionidae *Bibio* sp. Geoffroy, 1762 (D10) and the Muscidae *Phaonia tuguriorum* (Scopoli, 1763) (D90);

Finally, in Pnat among the beetles there are the Cantharidae *Malthinus* sp. Latreille, 1806 (C10) and *Rhagonycha (Rhagonycha) lignosa* (Muller, 1764) (C13), the Cerambycidae *Anastrangalia dubia* (Scopoli, 1763) (C16) and the Oedemeridae *Oedemera femorata* (Scopoli, 1763) (C51); among Diptera there are the Fanniidae *Fannia* sp. Robineau-Desvoidy, 1830 (D34) and the Tabinidae *Hybomitra* sp. Enderlein, 1922 (D140).

Table 3.20 Code CA of pollinators

DIPTERA		HYMENOPTERA	
<i>Amictus</i> sp. Wiedemann, 1817	D1	<i>Andrena afzelskii</i> (Kirby, 1802)	H1
<i>Bombylius minor</i> (Linnaeus, 1758)	D2	<i>Andrena agassiana</i> (Scopoli, 1770)	H2
<i>Lomatia</i> sp. Meigen, 1822	D3	<i>Andrena barbarus</i> Panzer, 1805	H3
<i>Usia</i> sp. Latreille, 1802	D4	<i>Andrena bicolor</i> Fabricius, 1775	H4
<i>Villa</i> sp. Liny, 1864	D5	<i>Andrena cinerea</i> Brullé, 1832	H5
<i>Arctophila superbiens</i> (Müller, 1776)	D6	<i>Andrena combinata</i> (Christ, 1791)	H6
<i>Brachypalpoides lentus</i> Meigen, 1822	D7	<i>Andrena curvicauda</i> Thomson, 1870	H7
<i>Cheilosia</i> sp. Meigen, 1822	D8	<i>Andrena dorsata</i> (Kirby, 1802)	H8
<i>Cheilosia vulpina</i> (Meigen, 1822)	D9	<i>Andrena flavipes</i> Panzer, 1799	H9
<i>Chrysotoxum fastivum</i> (Linnaeus, 1758)	D10	<i>Andrena fucata</i> Smith, 1847	H10
<i>Chrysotoxum elegans</i> Loew, 1841	D11	<i>Andrena fulva</i> (Müller, 1766)	H11
<i>Chrysotoxum intermedium</i> (Meigen, 1822)	D12	<i>Andrena fulvata</i> (Christ, 1791)	H12
<i>Chrysotoxum octomaculatum</i> Curtis, 1837	D13	<i>Andrena fulvata</i> E. Stöckert, 1930	H13
<i>Chrysotoxum</i> sp. Meigen, 1803	D14	<i>Andrena fulvitaris</i> Brullé, 1832	H14
<i>Dasyrphus</i> sp. Enderlein, 1938	D15	<i>Andrena fumida</i> Perez, 1895	H15
<i>Episyrphus</i> sp. Walker, 1852	D16	<i>Andrena gabrius</i> van der Vecht, 1927	H16
<i>Episyrphus (Meliscasus) auricollis</i> (Meigen, 1822)	D17	<i>Andrena griseiventris</i> Imhoff, 1832	H17
<i>Episyrphus balteatus</i> (De Geer, 1776)	D18	<i>Andrena halvola</i> (Linnaeus, 1758)	H18
<i>Episyrphus</i> sp. Matsumura & Adachi, 1917	D19	<i>Andrena humilis</i> Imhoff, 1832	H19
<i>Eristalis arbutorum</i> (Linnaeus, 1758)	D20	<i>Andrena kanarti</i> Schmiedeknecht, 1900	H20
<i>Eristalis jugorum</i> Egger, 1925	D21	<i>Andrena labiata</i> Fabricius, 1781	H21
<i>Eristalis partinax</i> (Scopoli, 1763)	D22	<i>Andrena minutuloides</i> Perkins, 1914	H22
<i>Eristalis</i> sp. Latreille, 1804	D23	<i>Andrena minutula</i> (Kirby, 1802)	H23
<i>Eristalis tenax</i> (Linnaeus, 1758)	D24	<i>Andrena (Melanandra) morio</i> Brullé, 1832	H24
<i>Eumerus flaviventris</i> Zetterstedt, 1843	D25	<i>Andrena nigroaenea</i> (Kirby, 1802)	H25
<i>Eumerus</i> sp. Meigen, 1822	D26	<i>Andrena ovata</i> Schenck, 1853	H26
<i>Eupodis corollae</i> (Fabricius, 1794)	D27	<i>Andrena pilipes</i> Fabricius, 1781	H27
<i>Eupodis latifasciatus</i> (Macquart, 1829)	D28	<i>Andrena polita</i> Smith, 1847	H28
<i>Eupodis luniger</i> (Meigen, 1822)	D29	<i>Andrena thoracica</i> (Fabricius, 1775)	H29
<i>Melanostoma melanum</i> (Linnaeus, 1758)	D30	<i>Andrena tomora</i> Wanckle, 1975	H30
<i>Mallota fuciformis</i> (Fabricius, 1794)	D31	<i>Andrena trimmerana</i> (Kirby, 1802)	H31
<i>Merodon aberrans</i> Shannon, 1927	D32	<i>Andrena wilkella</i> (Kirby, 1802)	H32
<i>Merodon aeneus</i> Meigen, 1822	D33	<i>Panurgus calcaratus</i> (Scopoli, 1763)	H33
<i>Merodon albifrons</i> Meigen, 1822	D34	<i>Amegilla quadrifasciata</i> (Villers, 1789)	H34
<i>Merodon avidus</i> (Russi, 1790)	D35	<i>Anthophora balnearum</i> Lepeletier, 1841	H35
<i>Merodon equestris</i> (Fabricius, 1794)	D36	<i>Anthophora bimaculata</i> (Panzer, 1801)	H36
<i>Merodon rufus</i> Meigen, 1838	D37	<i>Anthophora plumpas</i> Pallas, 1772	H37
<i>Merodon</i> sp. Meigen, 1803	D38	<i>Anthophora rufus</i> (Linnaeus, 1758)	H38
<i>Myathropa florea</i> (Linnaeus, 1758)	D39	<i>Anthophora</i> sp. Latreille, 1803	H39
<i>Palaeocera</i> sp. Meigen, 1822	D40	<i>Apis mellifera</i> Linnaeus, 1758	H40
<i>Platychirus angustatus</i> (Zetterstedt, 1842)	D41	<i>Bombus hortorum</i> (Linnaeus, 1758)	H41
<i>Sphaerophoria ruspalli</i> (Wiedmann, 1830)	D42	<i>Bombus lapidarius</i> Linnaeus, 1758	H42
<i>Saricomyia silvatica</i> (Harris, 1776)	D43	<i>Bombus</i> sp. Latreille, 1802	H43
<i>Sphaerophoria scripta</i> (Linnaeus, 1758)	D44	<i>Bombus pascuorum</i> (Scopoli, 1763)	H44
<i>Sphaerophoria</i> sp. Le Peletier & Serville, 1828	D45	<i>Bombus pratensis</i> (Linnaeus, 1761)	H45
<i>Syrphus</i> sp. Fabricius, 1775	D46	<i>Bombus ruderatus</i> (Fabricius, 1775)	H46
<i>Syrphus vitripennis</i> Meigen, 1822	D47	<i>Bombus ruderatus</i> (Fabricius, 1775)	H47
<i>Tropidia fasciata</i> Meigen, 1822	D48	<i>Bombus sylvarum</i> Linnaeus, 1761	H48
<i>Tropidia</i> sp. Meigen, 1822	D49	<i>Bombus terrestris</i> (Linnaeus, 1758)	H49
<i>Xylota</i> sp. Meigen, 1822	D50	<i>Bombus vastalis</i> (Geoffroy, 1785)	H50
LEPIDOPTERA		<i>Carantina cucurbitina</i> (Russi, 1792)	H51
<i>Anata phaea</i> (Linnaeus, 1758)	L1	<i>Eucera cineraria</i> Eversmann, 1852	H52
<i>Pyrgus armericanus</i> (Oberthur, 1910)	L2	<i>Eucera longicornis</i> (Linnaeus, 1758)	H53
<i>Thymelicus lineola</i> (Ochsenheimer, 1808)	L3	<i>Eucera nigricornis</i> Lepeletier, 1841	H54
<i>Cupido (Cupido) minimus</i> (Fuessly, 1775)	L4	<i>Eucera pannonica</i> Mocsáry, 1878	H55
<i>Platbejus (Platbejus) argus</i> (Linnaeus, 1758)	L5	<i>Eucera albifasciata</i> Friese, 1895	H56
<i>Argynnis (Argynnis) paphia</i> (Linnaeus, 1758)	L6	<i>Habropoda tarsata</i> (Spinola, 1838)	H57
<i>Cosmonympha pamphilus</i> (Linnaeus, 1758)	L7	<i>Meloe</i> sp. Latreille, 1802	H58
<i>Hipparchia (Hipparchia) fagi</i> (Scopoli, 1763)	L8	<i>Nomada armata</i> Herrich-Schäffer, 1839	H59
<i>Hipparchia statilinus</i> (Hübner, 1766)	L9	<i>Nomada fucata</i> Panzer, 1796	H60
<i>Issoria lathonia</i> (Linnaeus, 1758)	L10	<i>Nomada mutabilis</i> Murawitz, 1870	H61
<i>Manniola jurtina</i> (Linnaeus, 1758)	L11	<i>Nomada panzeri</i> gr.	H62
<i>Melanargia galathea f. prociada</i>	L12	<i>Nomada pleurosticta</i> Herrich-Schäffer, 1839	H63
<i>Melitaea cinxia</i> (Linnaeus, 1758)	L13	<i>Nomada signata</i> Junie, 187	H64
<i>Pararge aegeria</i> (Linnaeus, 1758)	L14	<i>Nomada</i> sp. Scopoli, 1770	H65
<i>Polygona c-album</i> (Linnaeus, 1758)	L15	<i>Tatralonia malvas</i> (Russi, 1790)	H66
<i>Vanessa cardui</i> (Linnaeus, 1758)	L16	<i>Tatraloniella dentata</i> (Germar, 1839)	H67
<i>Aporia crataegi</i> (Linnaeus, 1758)	L17	<i>Xylocopa iris</i> (Christ, 1791)	H68
<i>Colias croceus</i> (Furroury, 1785)	L18	<i>Xylocopa valga</i> (Gerstaecker, 1872)	H69
<i>Euchloe (Euchloe) osonia</i> (Hübner, 1804)	L19	<i>Xylocopa cyliacea</i> (Linnaeus, 1758)	H70
<i>Pieris rapae</i> (Linnaeus, 1758)	L20	<i>Colletes mikolossowiczii</i> Radoszkowski, 1891	H71
<i>Pontia edusa</i> (Fabricius, 1777)	L21	<i>Colletes similis</i> Schenck, 1853	H72
<i>Parnassius mnemosyne</i> (Linnaeus, 1758)	L22	<i>Hylaeus bravicornis</i> Nylander, 1852	H73
<i>Abscissa manni</i> (Lederer, 1853)	L23	<i>Hylaeus hyalinatus</i> (Schenck, 1853)	H74
<i>Zygasmia</i> sp. Fabricius, 1775	L24	<i>Hylaeus communis</i> Nylander, 1852	H75
		<i>Hylaeus dilatatus</i> (Kirby, 1802)	H76
		<i>Hylaeus hyalinatus monteborensis</i> (Pittioni, 1950)	H77
		<i>Hoplitis papaveri</i> (Latreille, 1799)	H78
		<i>Hylaeus kahri</i> Förster, 1871	H79
		<i>Hylaeus imparilis</i> Förster, 1871	H80
		<i>Hylaeus incongruus</i> Förster, 1871	H81
		<i>Hylaeus sinuatus</i> (Schenck, 1853)	H82
		<i>Hylaeus tasmiolatus</i> Förster, 1871	H83
		<i>Halictus albifrons</i> Stand, 1909	H84
		<i>Halictus aurygnatus</i> Blüthgen, 1930	H85
		<i>Halictus brunnescens</i> (Eversmann, 1852)	H86
		<i>Halictus fulvipes</i> (Klug, 1817)	H87
		<i>Halictus maculatus</i> Smith, 1848	H88
		<i>Halictus scabiosus</i> (Rossi, 1790)	H89
		<i>Halictus saxicinctus</i> (Fabricius, 1775)	H90
		<i>Halictus simplex</i> gr.	H91
		<i>Halictus subauratus</i> (Rossi, 1792)	H92
		<i>Halictus quadricinctus</i> (Fabricius, 1776)	H93
		<i>Lasioglossum aequatum</i> (Kirby, 1802)	H94
		<i>Lasioglossum albocinctum</i> (Lucas, 1849)	H95
		<i>Lasioglossum bimaculatum</i> (Dours, 1872)	H96
		<i>Lasioglossum brevicornis</i> (Schenck, 1870)	H97
		<i>Lasioglossum calceatum</i> (Scopoli, 1763)	H98
		<i>Lasioglossum crassipunctatum</i> (Blüthgen, 1923)	H99
		<i>Lasioglossum convexusculum</i> (Schenck, 1853)	H100
		<i>Lasioglossum fulvicornis</i> (Kirby, 1802)	H101
		<i>Lasioglossum glabriusculum</i> (Murawitz, 1872)	H102
		<i>Lasioglossum griseolum</i> (Murawitz, 1872)	H103
		<i>Lasioglossum (Evylaeus) immutatum</i> (Vachal, 1895)	H104
		<i>Lasioglossum interruptum</i> (Panzer, 1798)	H105
		<i>Lasioglossum laevis</i> Kirby, 1802	H106
		<i>Lasioglossum laevigatum</i> (Kirby, 1802)	H107
		<i>Lasioglossum laticaps</i> (Schenck, 1869)	H108
		<i>Lasioglossum lativentris</i> (Schenck, 1853)	H109
		<i>Lasioglossum leucopum</i> (Kirby, 1802)	H110
		<i>Lasioglossum leucozonium</i> (Schränk, 1781)	H111
		<i>Lasioglossum lineare</i> (Schenck, 1870)	H112
		<i>Lasioglossum majus</i> (Nylander, 1852)	H113
		<i>Lasioglossum morio</i> (Fabricius, 1793)	H114
		<i>Lasioglossum nitidiusculum</i> (Kirby, 1802)	H115
		<i>Lasioglossum pauperatum</i> (Brullé, 1832)	H116
		<i>Lasioglossum paucillum</i> (Schenck, 1853)	H117
		<i>Lasioglossum punctatissimum</i> (Schenck, 1853)	H118
		<i>Lasioglossum pygmaeum</i> (Schenck, 1853)	H119
		<i>Lasioglossum rufitarsis</i> (Zetterstedt, 1838)	H120
		<i>Lasioglossum sambrucens</i> (Alfken, 1914)	H121
		<i>Lasioglossum transitivum</i> (Schenck, 1868)	H122
		<i>Lasioglossum tricinatum</i> (Schenck, 1874)	H123
		<i>Lasioglossum villusulum</i> (Kirby, 1802)	H124
		<i>Lasioglossum xanthopus</i> (Kirby, 1802)	H125
		<i>Saladonia saladonia</i> sp. Robertson, 1918	H126
		<i>Saladonia smaragdula complex</i>	H127
		<i>Sphacodas aphippius</i> (Linnaeus, 1758)	H128
		<i>Sphacodas minutus</i> von Hagens, 1882	H129
		<i>Sphacodas reticulatus</i> Thomson, 1870	H130
		<i>Sphacodas</i> sp. Latreille, 1804	H131
		<i>Sphacodas pseudofasciatus</i> Blüthgen, 1925	H132
		<i>Chalostoma cf. florissoma</i> (Linnaeus, 1758)	H133
		<i>Chalostoma grande</i> (Nylander, 1852)	H134
		<i>Hariadas</i> sp. Spinola, 1808	H135
		<i>Hariadas crenulatus</i> (Nylander, 1856)	H136
		<i>Hoplitis tridentata</i> (Dufour & Perris, 1840)	H137
		<i>Hariadas (Hariadas) truncorum</i> (Linnaeus, 1758)	H138
		<i>Hoplitis scutellaris</i> Murawitz, 1868	H139
		<i>Lithurgus chrysurus</i> (Fonscolombe, 1834)	H140
		<i>Megachile centuncularis</i> (Linnaeus, 1758)	H141
		<i>Megachile melanopyga</i> Costa, 1863	H142
		<i>Megachile argentata</i> (Fabricius, 1793)	H143
		<i>Stelis</i> sp. Panzer, 1806	H144
		<i>Osmia cephalotes</i> Murawitz, 1870	H145
		<i>Osmia cerinthidis</i> Murawitz, 1876	H146
		<i>Osmia dimidiata</i> Murawitz, 1870	H147
		<i>Osmia laziana</i> (Kirby, 1802)	H148
		<i>Osmia (Hoplasmia) ligurica</i> Murawitz, 1868	H149
		<i>Osmia niveata</i> (Fabricius, 1804)	H150
		<i>Dasygaster hirtipes</i> (Fabricius, 1793)	H151
		<i>Osmia targastensis</i> (Dunke, 1897)	H152
		<i>Nomada castellana</i> Dusmet, 1913	H153
		<i>Meloe</i> sp. Latreille, 1802	H154
		<i>Meloe fastiva</i> Lieftinck, 1980	H155
		<i>Hoplitis papaveri</i> (Latreille, 1799)	H156
			H157
			H158



Graph 3.40 Correspondence analysis of pollinators (Software Past). Code in Tab. 3.20

As regards the correspondences analysis of specialized pollinators (chi square= 5069,432; $p < 0,01$) there are three groups in the distribution of species: Gnat, pine forests and the groups composed by agricultural fields (Fbio and Fint) and the ecotonal area (Gecot) with the greatest number of species (Graph 3.40).

The agrosystem is the richest area in pollinators: there are several species related to Fbio, Fint and Gecot, such as, among Diptera, the Bombylidae *Usia* sp. Latreille, 1802 (D4) and the Syrphidae *Eristalis* sp. Latreille, 1804 (D23) and *Sphaerophoria scripta* (Linnaeus, 1758) (D44); about Hymenoptera there are the Andrenidae *Andrena cinerea* (Brullè, 1832), *Andrena pilipes* Fabricius, 1781 (H27), *Andrena gravaida* Imhoff, 1832 (H17) and *Andrena curvungula* Thomson, 1870 (H7) and these last two first records for the southern Italy. There are also the Colletidae *Colletes mkojossexiczi* Radoszkowski, 1891 (H74), *Hylaeus imparilis* Forster, 1871 (H82) and *Hylaeus sinuatus* (Schenck, 1853) (H84) and the Halictidae *Halictus scabiosae* (Rossi, 1790) (H91), *Lasioglossum albocinctum* (Lucas, 1849) (H98), *Lasioglossum griseolum* (Morawitz, 1872) (H106), *Lasioglossum interruptum* (Panzer, 1798) (H108), *Lasioglossum laticeps*

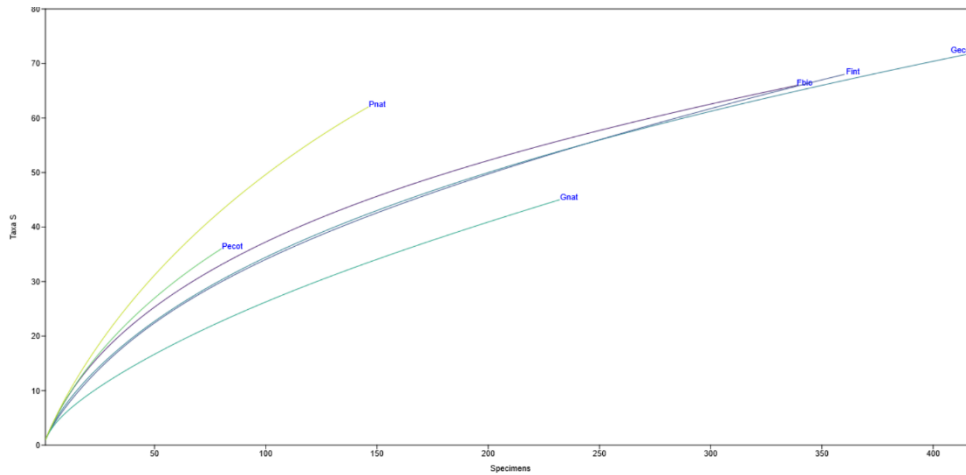
(Schenk, 1869) (H111), *Lasioglossum laevigatum* (Kirby, 1802) (H110), *Lasioglossum leucozonium* (Schrank, 1781) (H114) and *Lasioglossum xanthopus* (Kirby, 1802) (H128); the last two species are included in the red list of European wild bees as NT. Finally, there are also the Apidae *Anthophora balneorum* Lepeletier, 1841 (H36).

In the natural grazing area (Gnat) there are mainly Lepidoptera, including the Nymphalidae *Vanessa cardui* (Linnaeus, 1758) (L16), the Pieridae *Aporia crataegi* (Linnaeus, 1758) (L17) and *Euchloe (Euchloe) ausonia* (Hübner, 1804) (L19), but also the Diptera *Merodon aeneus* Meigen, 1822 (D33) (Fam: Syrphidae). Finally, in the pine forests (Pecot and Pnat), the correlated species are the Lepidoptera Nymphalidae *Pararge aegeria* (Linnaeus, 1758) (L14) and the Hymenoptera Andrenidae *Andrena dorsata* (Kirby, 1802) (H8), *Andrena fucata* Smith, 1847 (H10) and *Andrena minutuloides* Perkins, 1914 (H22), both new record for the southern Italy, but also *Andrena minutula* (Kirby, 1802) (H23) and *Andrena trimmerana* (Kirby, 1802) (H32). In addition there are the Colletidae *Hylaeus communis* Nylander, 1852 (H78) and the Halictidae *Halictus alfenellus* Stand, 1909 (H86) and *Lasioglossum laeve* Kirby, 1802 (H109): while the last one is rare in Europe and it is included in the European red list of wild bees as endangered species, *H. alfenellus* is a new record for Italy mainland.

About the analysis of species and morphotypes, the areas with the greatest biodiversity of wild bees are Pnat and Fbio due to the absence of pesticides (Tab. 3.21) while Gnat is the area with the lowest bee biodiversity because of the presence of intensive and massive grazing that altered the vegetation composition and the diversity of the floral essences.

Table 3.21 Biodiversity index of bees (Software Past)

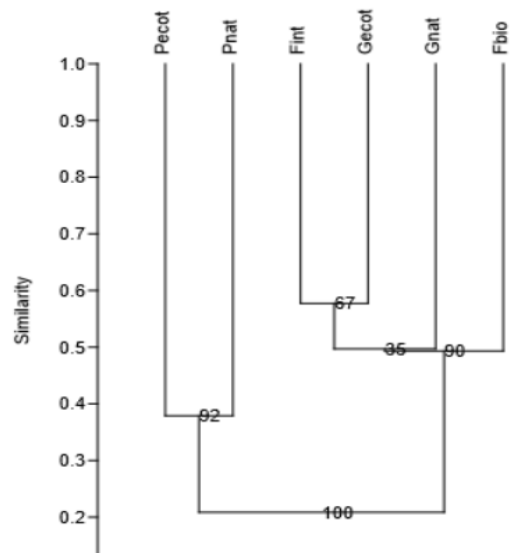
	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
N° taxa	65	71	74	47	36	60
N° specimens	338	364	419	235	81	146
SD	5,8448	10,38	9,7568	7,568531	7,686516	1,547245
Shannon	3,548	3,167	3,293	2,63	3,404	3,846
Evenness	0,5344	0,3342	0,364	0,2952	0,8356	0,78
Margalef	10,99	11,87	12,09	8,426	7,965	11,84



Graph 3.41 Rarefaction of bees species (Software Past)

As regards the rarefaction of wild bee species (Graph 3.41), Pnat has a rapidly growing curve about species richness than other areas because it is a habitat more favourable for wild bees due to its high degree of naturalness. Gnat, Fbio, Fint and Gecot have very similar rarefaction curves, indicating a comparable richness of species due to the less variety of flowering plants, increased use of pesticides and anthropogenic disturbance. The results therefore underline the importance of preserving and improving habitat quality to counter pollinator decline.

In the cluster analysis (similarity index: Bray-Curtis; Boot N:1000; Cophen corr. 0.9811) (Figure 3.42) we can observe the similarity between the sampling areas. In particular, pine forests (Pecot and Pnat) form a cluster with a high degree of community similarity, as they share similar ecological characteristics such as vegetation. Another cluster with a high degree of similarity is that composed by Fint and Gecot, which also in the case of bees confirm that ecotonal areas are reservoirs of biodiversity. Although there is a presence of a smaller quantity of pollutants in Fint, Gecot manages to repopulate it with pollinators. To this cluster join Gnat and Fbio, who have a low degree of dissidence. These two areas have environmental and ecological characteristics (such as the absence of pesticides) that affect the composition of wild bee species slightly different from other agricultural areas.

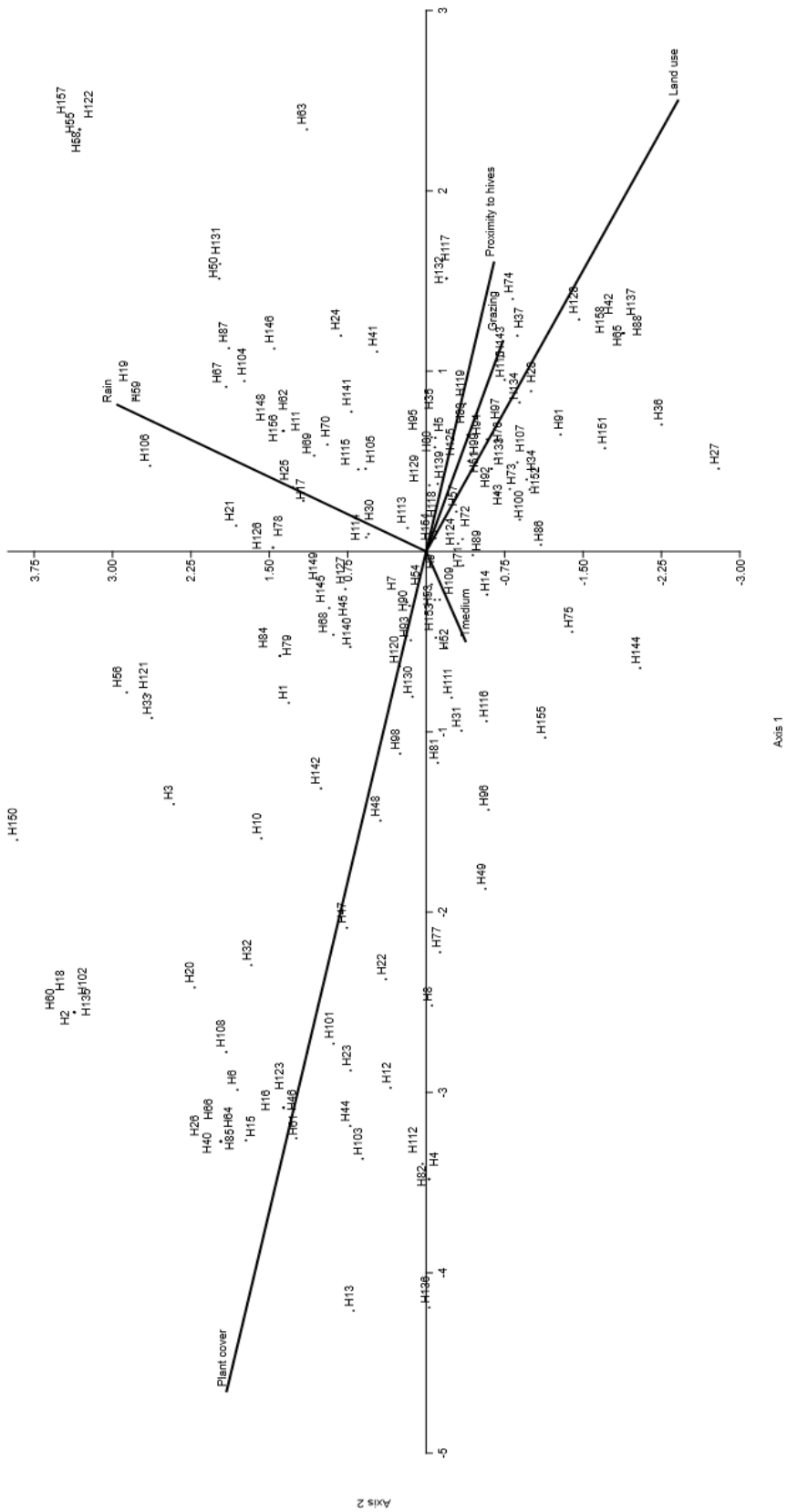


Graph 3.42 Cluster analysis of bees (Software Past)

The permanova analysis (Similarity index: Bray-Curtis; Permutation N: 9999) shows a significant difference between areas (F:3,259; p: 0,0001), which is confirmed by the Bonferroni test. There is a significant difference in the specific composition between the areas except for Fbio vs. Gnat, Fint vs. Gecot, Gecot vs. Gnat, Pecot vs. Gnat and between the pine forests (Tab. 3.21).

Table 3.21 Bonferroni-corrected p values

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Fbio		0,0017	0,0051	0,0238	0,0001	0,0001
Fint	0,0017		0,234	0,0055	0,0001	0,0001
Gecot	0,0051	0,234		0,0143	0,0001	0,0001
Gnat	0,0238	0,0055	0,0143		0,0351	0,0017
Pecot	0,0001	0,0001	0,0001	0,0351		0,436
Pnat	0,0001	0,0001	0,0001	0,0017	0,436	



Graph 3.43 CCA of Bees (Software: Past) Code in Tab 3.19

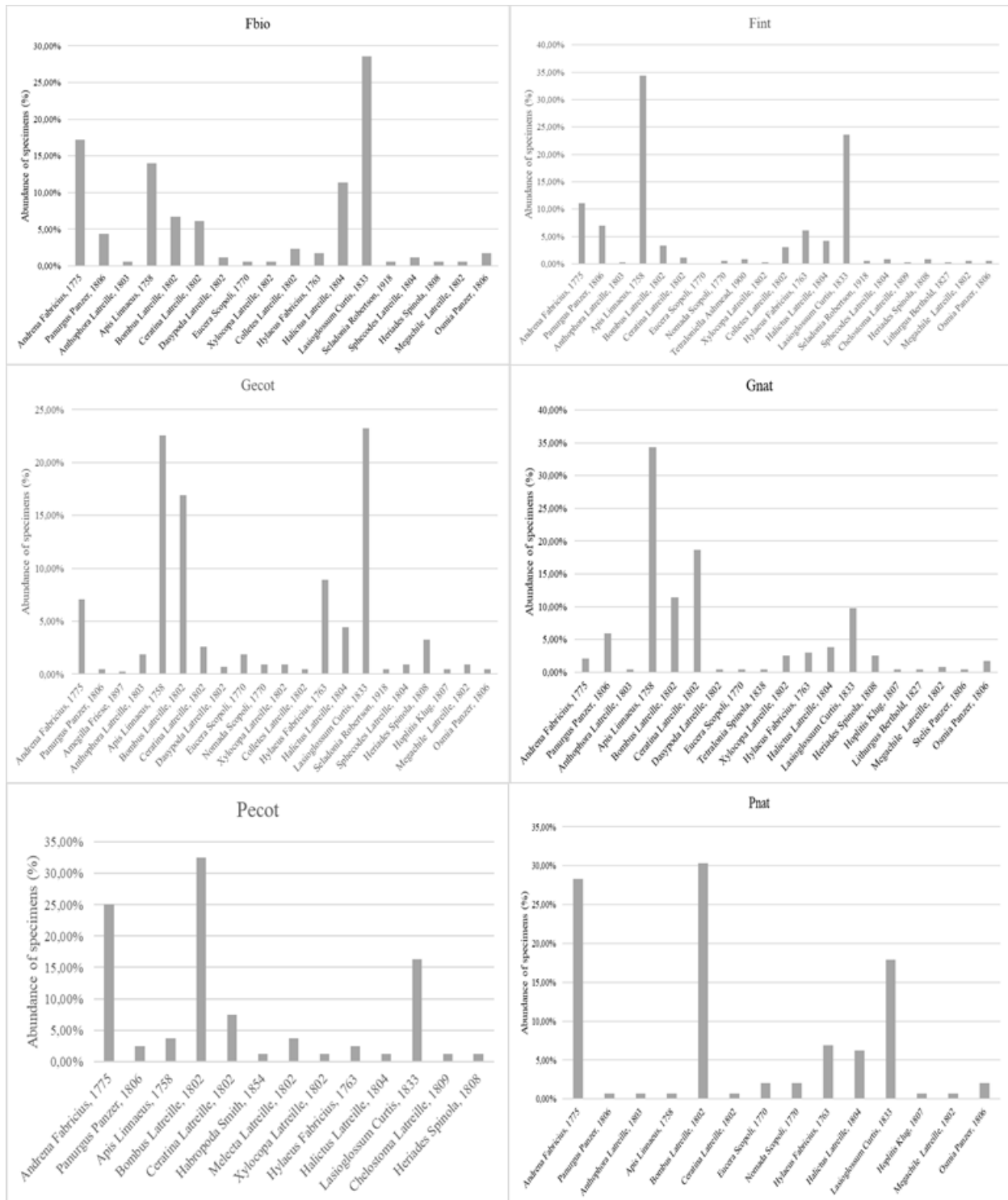
The CCA analysis was performed by correlating species to tree cover, rainy days, presence and abundance of grazing, temperature, land use and proximity of hives (Graph 3.43). The eigenvalues for the first (0.4313) and second axis (0.35202) compared to the other axes indicate that the canonical graph represent strong gradients and that a large percentage of variance is concentrated between them (Axis1=31.66%; Axis2=25.84%). A simulation with 9999 permutations indicates that the distribution of species along the axes is not random (p: 0.0001; trace: 1.362). Bees are affected by the degree of shading, land use and humidity. Species at the centre of the axes, such as *Dasyglossa hirtipes* (Fabricius, 1793) (H154) (Fam: Melittidae) and *Lasioglossum semilucens* (Alfken, 1914) (H124), indicate that they are not affected by any of the environmental variables.

Species that are not negatively affected by the proximity to hives, grazing and land use are: the Andrenidae *Andrena ovata* Schenck, 1853 (H26), the Apidae *Apis mellifera* Linnaeus, 1758 (H43) and *Anthophora bimaculata* (Panzer, 1801) (H37), the Colletidae *Colletes mlokosiewiczii* Radoszkowski, 1891 (H74), the Halictidae *Halictus scabiosae* (Rossi, 1790) (H91), *Halictus subauratus* (Rossi, 1792), *Lasioglossum albipes* (Fabricius, 1781) (H97), *Lasioglossum binaculatum* (Dours, 1872) (H99), *Lasioglossum brevicorne* (Schenck, 1870) (H100) and *Lasioglossum xanthopus* (Kirby, 1802) (H128) and the Megachilidae *Chelostoma grande* (Nylander, 1852) (H137). These species do not appear to be disadvantaged by land use (integrated management agriculture) and competition with honey bees. On the contrary, species that seem to be negatively affected by the proximity of the hives are the Andrenidae *Andrena curvungula* Thomson, 1870 (H7), the Apidae *Bombus lapidarius* Linnaeus, 1758 (H45) and the Megachilidae *Hoplitis tridentata* (Dufour & Perris, 1840) (H140).

The variable “tree cover” influence species such as the Apidae *Bombus pratorum* (Linnaeus, 1761) (H48), the Halictidae *Lasioglossum albocinctum* (Lucas, 1849) (H98), *Lasioglossum calceatum* (Scopoli, 1763) (H101) and *Lasioglossum paucillum* (Schenck, 1853) (H120), the Andrenidae *Andrena minutula* (Kirby, 1802) (H23) and the Megachilidae *Hoplitis scutellaris* Morawitz, 1868 (H142). These species are therefore positively influenced by rather stable and shady environments, while species in the opposite direction show a preference for more sunny environments. In contrast, species such as *Eucera albofasciata* Friese, 1895 (H59) (Fam: Apidae), which is a first record for Italy mainland, *Andrena gravida* Imhoff, 1832 (H17), *Andrena nigroaenea* (Kirby, 1802) (H25), *Andrena thoracica* (Fabricius, 1775) (H30) (Fam: Andrenidae), *Lasioglossum griseolum* (Morawitz, 1872) (H106) and *Lasioglossum leucozonium* (Schrank, 1781) (H114) (Fam: Halictidae) are strongly associated with the rain conditions. This is because the rain influence on flower availability and soil moisture, which can affect nesting. The increase of the temperature slightly affects community distribution of wild bees.

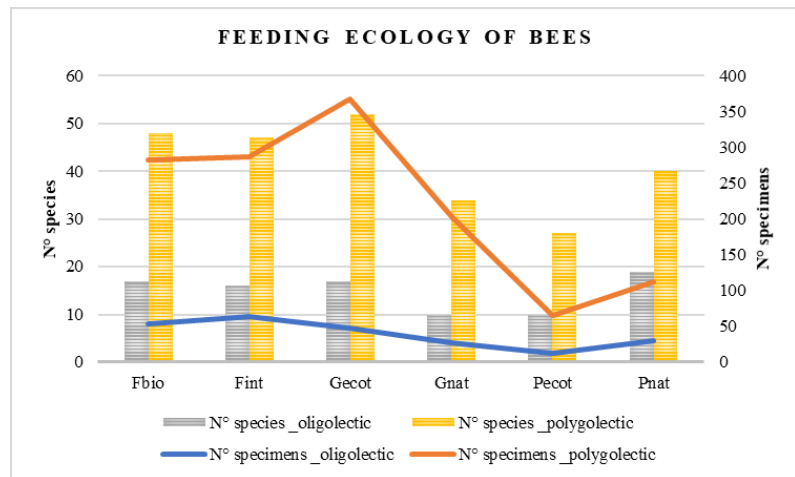
Graphs 3.44 show the genera's abundances in sampling areas. In Fbio the most abundant genera, in terms of number of specimens, are *Lasioglossum* Curtis, 1833, *Andrena* Fabricius, 1775 and *Halictus* Latreille, 1804. In Fint abundant is *Apis mellifera*, probably because of the proximity of beehives (about 700 meters), but also *Lasioglossum* spp.; in Gecot there are *Hylaeus* Fabricius, 1763 and *Bombus* Latreille, 1802 while

in Gnat also *Ceratina* Latreille, 1802. In pine forests the most abundance genera are *Andrena*, *Bombus* and *Lasioglossum*.



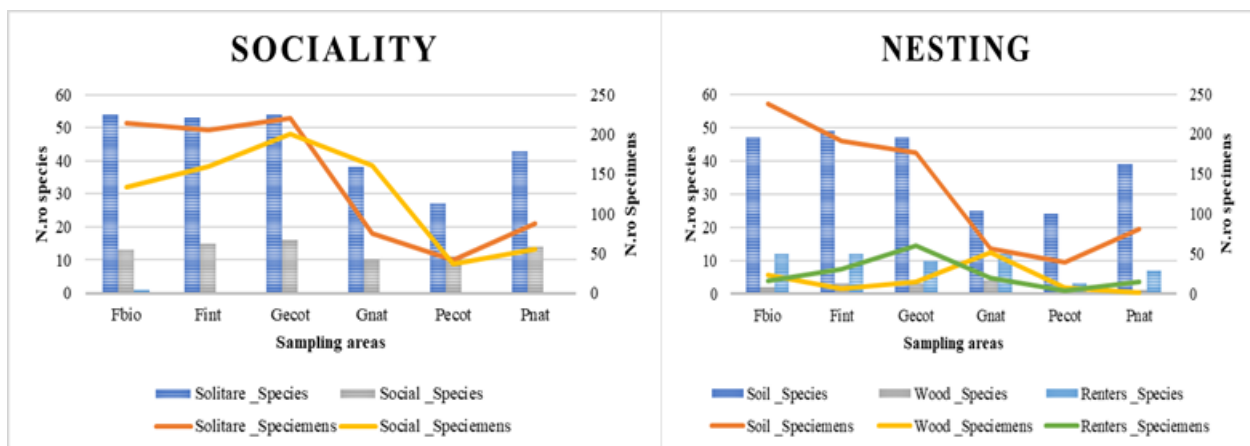
Graph 3.44 Abundance of genera of wild bees

The abundance of oligolectic and polygolectic species is also interesting (Graph 3.45). Oligolectic are fewer in both abundance and specific composition. In agricultural fields, however, the polygolectic species are about twice as many as the oligolectic ones due to the non-differentiation of the floral essences. The same is in the ecotonal pine forest and in natural grazing area. In natural pine forest, there is less difference in terms of specific composition between oligolectic and polygolectic.



Graph 3.45 Oligolectic vs polygolectic species (Comba, 2019)

Moreover, evaluate the sociality of bees and where they make their nest (Graph 3.46) is important to assess their state of conservation. As for the sociality of bees, most of them are solitary, so they are probably bees that have a nest nearby from the sampling area. In addition, the most collected wild bees in agroecosystems make their nest in the ground. There are also the renters that built their nest in already existing cavities.



Graph 3.46 Sociality and Nesting of wild bees (Danforth, 2019)

Finally, the species included in the European Red List of Wild Bees are several (Nieto *et al.*, 2014).

Tab. 3.22 Bees in European Red List of Wild Bees (Nieto *et al.*, 2014)

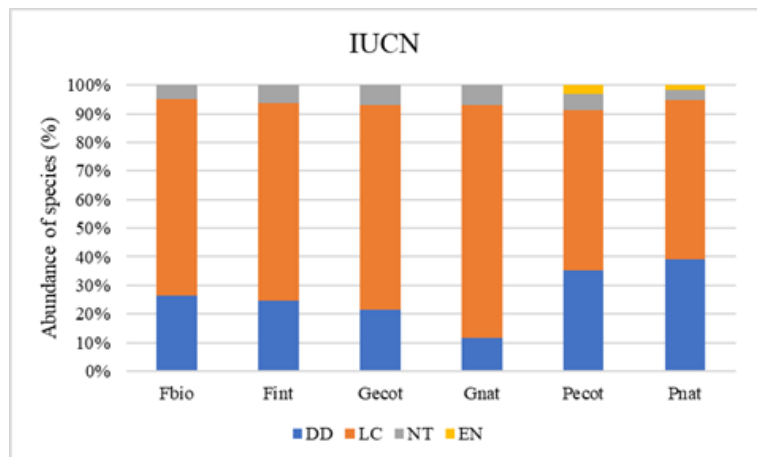
	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Andrenidae							
<i>Andrena afzeliella</i> (Kirby, 1802)		X					X
<i>Andrena agilissima</i> (Scopoli, 1770)	DD					X	
<i>Andrena barbareae</i> Panzer, 1805)	DD			X			X
<i>Andrena bicolor</i> Fabricius, 1775	LC						X
<i>Andrena cinerea</i> Brulle, 1832	DD	X	X	X			
<i>Andrena combinata</i> (Christ, 1791)	DD						X
<i>Andrena curvungula</i> Thomson, 1870	DD		X			X	
<i>Andrena dorsata</i> (Kirby, 1802)	DD		X			X	X
<i>Andrena flavipes</i> Panzer, 1799	LC	X	X	X	X	X	X
<i>Andrena fucata</i> Smith, 1847			X				X
<i>Andrena fulva</i> (Muller, 1766)	DD			X			
<i>Andrena fulvago</i> (Christ, 1791)	DD						X
<i>Andrena fulvata</i> E. Stockhert, 1930	DD					X	
<i>Andrena fulvitarsis</i> Brullè, 1832	LC	X	X	X		X	
<i>Andrena fumida</i> Perez, 1895	DD						X
<i>Andrena gelriae</i> van der Vecht, 1927	DD						X
<i>Andrena gravida</i> Imhoff, 1832	DD	X	X	X	X	X	
<i>Andrena helvola</i> (Linnaeus, 1758)	DD					X	
<i>Andrena humilis</i> Imhoff, 1832	DD	X					
<i>Andrena (Chlorandrena) kamarti</i> Schmiedeknecht, 1900	DD						X
<i>Andrena labiata</i> Fabricius, 1781	DD		X		X		X
<i>Andrena minutuloides</i> Perkins, 1914	DD	X	X			X	X
<i>Andrena minutula</i> (Kirby, 1802)	DD	X				X	X
<i>Andrena (Melandrena) morio</i> Brullè, 1832	DD	X	X	X			
<i>Andrena nigroaenea</i> (Kirby, 1802)	LC	X		X			X
<i>Andrena ovata</i> Schenck, 1853							X
<i>Andrena pilipes</i> Fabricius, 1781	LC		X				
<i>Andrena polita</i> Smith, 1847	LC		X	X	X		
<i>Andrena thoracica</i> (Fabricius, 1775)	DD	X		X			
<i>Andrena tomora</i> Warncke, 1975	DD	X	X				X
<i>Andrena trimmerana</i> (Kirby, 1802)	DD	X		X		X	X
<i>Andrena wilkella</i> (Kirby, 1802)	DD		X			X	
<i>Panurgus calcaratus</i> (Scopoli, 1763)	LC	X	X	X	X	X	X

	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Apidae							
<i>Amegilla quadrifasciata</i> (Villers, 1789)	LC			X			
<i>Anthophora balneorum</i> Lepeletier, 1841	LC		X				
<i>Anthophora bimaculata</i> (Panzer, 1801)	LC		X	X			
<i>Anthophora plumipes</i> Pallas, 1772	LC						X
<i>Anthophora retusa</i> (Linnaeus, 1758)	LC		X		X		
<i>Apis mellifera</i> Linnaeus, 1758	DD	X	X	X	X	X	X
<i>Bombus hortorum</i> (Linnaeus, 1758)	LC					X	X
<i>Bombus lapidarius</i> Linnaeus, 1758	LC			X		X	X
<i>Bombus</i> sp. Latreille, 1802	LC						X
<i>Bombus pascuorum melleofacies</i> Vogt, 1909	LC	X	X		X	X	X
<i>Bombus pratorum</i> (Linnaeus, 1761)	LC	X		X	X	X	X
<i>Bombus ruderatus</i> (Fabricius, 1775)	LC			X		X	X
<i>Bombus rupestris</i> (Fabricius, 1793)	LC			X			
<i>Bombus sylavurum</i> Linnaeus, 1761	LC			X			
<i>Bombus terrestris</i> (Linnaeus, 1758)	LC	X	X	X	X	X	X
<i>Bombus vestalis</i> (Fourcroy, 1785)	LC	X	X	X	X		X
<i>Ceratina cucurbitina</i> (Rossi, 1792)	LC	X	X	X	X	X	X
<i>Eucera albofasciata</i> Friese, 1895	DD	X					
<i>Eucera cineraria</i> Eversmann, 1852	LC			X			
<i>Eucera longicornis</i> (Linnaeus, 1758)	LC			X			X
<i>Eucera nigrifacies</i> Lepeletier, 1841	LC			X	X		
<i>Eucera pannonica</i> Mocsàry, 1878	DD			X			X
<i>Habropoda tarsata</i> (Spinola, 1838)	LC					X	
<i>Melecta festiva</i> Lieftinck, 1980	DD						
1839	NT						X
<i>Nomada castellana</i> Dusmet, 1913	LC						
<i>Nomada fucata</i> Panzer, 1798	LC			X			
<i>Nomada mutabilis</i> Morawitz, 1870	LC		X				
<i>Nomada panzeri</i> gr.	LC						X
<i>Nomada pleurosticta</i> Herrich-Schaffer, 1839	NT		X				
<i>Nomada signata</i> Jurine, 187	LC						X
<i>Tetralonia malvae</i> (Rossi, 1790)	LC			X		X	
<i>Tetraloniella dentata</i> (Germar, 1839)	LC			X			
<i>Xylocopa iris</i> (Christ, 1791)	LC			X			
<i>Xylocopa valga</i> (Gerstaecker, 1872)	LC				X		
<i>Xylocopa violacea</i> (Linnaeus, 1758)	LC	X	X	X	X	X	

Genera/Species	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Halictidae							
<i>Halictus alfenellus</i> Stand, 1909	DD						X
<i>Halictus brunnescens</i> (Eversmann, 1852)	DD	X		X			
<i>Halictus eurygnatus</i> Bluthgen, 1931	DD	X	X	X			
<i>Halictus fulvipes</i> (Klug, 1817)	LC		X				
<i>Halictus maculatus</i> Smith, 1848	LC	X	X				
<i>Halictus scabiosae</i> (Rossi, 1790)	LC	X	X	X	X	X	X
<i>Halictus sexcinctus</i> (Fabricius, 1775)	LC				X		
<i>Halictus subauratus</i> (Rossi, 1792)	LC	X	X	X	X		X
<i>Halictus quadricinctus</i> (Fabricius, 1776)	NT		X	X	X		
<i>Lasioglossum aeratum</i> (Kirby, 1802)	LC	X	X	X			
<i>Lasioglossum albipes</i> (Fabricius, 1781)	LC	X	X		X	X	X
<i>Lasioglossum albocinctum</i> (Lucas, 1849)	LC	X	X	X	X	X	
<i>Lasioglossum binaculatum</i> (Dours, 1872)	LC	X	X	X	X	X	X
<i>Lasioglossum brevicorne</i> (Schenck, 1870)	NT	X	X	X	X		
<i>Lasioglossum calceatum</i> (Scopoli, 1763)	LC	X	X		X		
<i>Lasioglossum crassepunctatum</i> (Bluthgen, 1923)	DD						X
<i>Lasioglossum convexiusculum</i> (Schenck, 1853)	NT					X	
<i>Lasioglossum fulvicorne</i> (Kirby, 1802)	LC						X
<i>Lasioglossum glabriusculum</i> (Morawitz, 1872)	LC			X			
<i>Lasioglossum griseolum</i> (Morawitz, 1872)	LC	X	X	X	X		X
<i>Lasioglossum (Evylaeus) immunitum</i> (Vachal, 1895)	DD	X				X	
<i>Lasioglossum interruptum</i> (Panzer, 1798)	LC	X	X	X			X
<i>Lasioglossum laeve</i> Kirby, 1802	EN					X	X
<i>Lasioglossum laevigatum</i> (Kirby, 1802)	NT		X	X		X	
<i>Lasioglossum laticeps</i> (Schenck, 1869)	LC		X	X	X		
<i>Lasioglossum lativentre</i> (Schenck, 1853)	LC	X		X	X		X
<i>Lasioglossum leucopus</i> (Kirby, 1802)	LC						X
<i>Lasioglossum leucozonium</i> (Schränk, 1781)	LC	X	X	X	X		
<i>Lasioglossum lineare</i> (Schenck, 1870)	DD	X		X			
<i>Lasioglossum majus</i> (Nylander, 1852)	NT			X			
<i>Lasioglossum morio</i> (Fabricius, 1793)	LC	X	X				X
<i>Lasioglossum nitidiusculum</i> (Kirby, 1802)	LC		X				
<i>Lasioglossum pauperatum</i> (Brullé, 1832)	LC	X	X	X			X
<i>Lasioglossum pauxillum</i> (Schenck, 1853)	LC	X	X	X			
<i>Lasioglossum punctatissimum</i> (Schenck, 1853)	LC	X					
<i>Lasioglossum pygmaeum</i> (Schenck, 1853)	NT	X					X
<i>Lasioglossum rufitarse</i> (Zetterstedt, 1838)	LC			X			
<i>Lasioglossum semilucens</i> (Alfken, 1914)	LC	X					X
<i>Lasioglossum transitorium</i> (Schenck, 1868)	LC	X			X		
<i>Lasioglossum tricinctum</i> (Schenck, 1874)	DD	X	X	X			
<i>Lasioglossum villosulum</i> (Kirby, 1802)	LC	X					
<i>Lasioglossum xanthopus</i> (Kirby, 1802)	NT	X		X	X		
<i>Seladonia smaragdula complex</i>	LC	X	X	X			
<i>Sphecodes ephippius</i> (Linnaeus, 1758)	LC	X					
<i>Sphecodes miniatus</i> von Hagens, 1882	LC	X	X				
<i>Sphecodes reticulatus</i> Thomson, 1870	LC			X			
<i>Sphecodes pseudofasciatus</i> Bluthgen, 1925	DD						X

Genera/Species	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Colletidae							
<i>Colletes mlokoszewiczi</i> Radoszkowski, 1891	LC	X	X	X			
<i>Colletes similis</i> Schenck, 1853	LC		X				
<i>Hylaeus brevicornis</i> Nylander, 1852	LC	X	X		X		
<i>Hylaeus clypearis</i> (Schenck, 1853)	LC	X	X	X	X		
<i>Hylaeus communis</i> Nylander, 1852	LC	X	X		X	X	X
<i>Hylaeus dilatatus</i> (Kirby, 1802)	LC	X					
<i>Hylaeus hyalinatus montebovensis</i> (Pittioni, 1950)	LC	X					
<i>Hylaeus kahri</i> Forster, 1871	DD						X
<i>Hylaeus imparilis</i> Forster, 1871	LC		X	X			
<i>Hylaeus incongruus</i> Forster, 1871	DD				X		X
<i>Hylaeus sinuatus</i> (Schenck, 1853)	LC			X			
<i>Hylaeus taeniolatus</i> Forster, 1871	LC	X					
Genera/Species	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Megachilidae							
<i>Chelostoma cf. florisomme</i> (Linnaeus, 1758)	LC					X	
<i>Chelostoma grande</i> (Nylander, 1852)	DD		X				
<i>Heriades crenulatus</i> (Nylander, 1856)	LC				X		
<i>Heriades (Heriades) truncorum</i> (Linnaeus, 1758)	LC	X	X	X	X		
<i>Hoplitis tridentata</i> (Dufour & Perris, 1840)	LC			X			
<i>Hoplitis scutellaris</i> Morawitz, 1868	DD			X	X		X
<i>Lithurgus chrysurus</i> (Fonscolombe, 1834)	LC		X		X		
<i>Megachile argentata</i> (Fabricius, 1793)	LC		X	X			
<i>Megachile centuncularis</i> (Linnaeus, 1758)	LC	X	X		X		
<i>Megachile melanopyga</i> Costa, 1863	LC			X	X		X
<i>Osmia cephalotes</i> Morawitz, 1870	LC			X			
<i>Osmia cerinthidis</i> Morawitz, 1876	LC		X				X
<i>Osmia dimidiata</i> Morawitz, 1870	LC						X
<i>Osmia leaiana</i> (Kirby, 1802)	LC				X		
<i>Osmia (Hoplosmia) ligurica</i> Morawitz, 1868	LC	X	X	X	X		
<i>Osmia niveata</i> (Fabricius, 1804)	LC	X					
Genera/Species	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Melittidae							
<i>Dasydoda hirtipes</i> (Fabricius, 1793)	LC	X		X	X		

Although the biological field showed a slightly higher biodiversity value of wild bees (Tab. 3.21), it is important to highlight that in the integrated agricultural field (Fint) there are several wild bee species (~7%) considered rare and included in the European red list of wild bees as near threatened (NT) (Nieto *et al.*, 2014); in fact, these species have a high ecological value and their presence is ensured precisely by the presence of the ecotonal area (Gecot) that guarantees trophic resources and ideal nesting sites, as well as mitigating the effects of agricultural practices (Graph 3. 47). Graph 3.47 also shows the high percentage of Data Deficient (DD) species, especially the genera *Andrena*, which underscores how extremely important it still is to continue studying and monitoring wild bees.



Graph 3.47 Abundance of IUCN category of risk of wild bees

3.10 Analysis by barcoding

The barcoding analysis was conducted on 35 Apoidea specimens to identify the species. Further genetic and morphological analyses are currently underway in collaboration with University of Neuchatel, University of Mons and Naturalis Biodiversity Center of Netherlands to further explore some aspects.

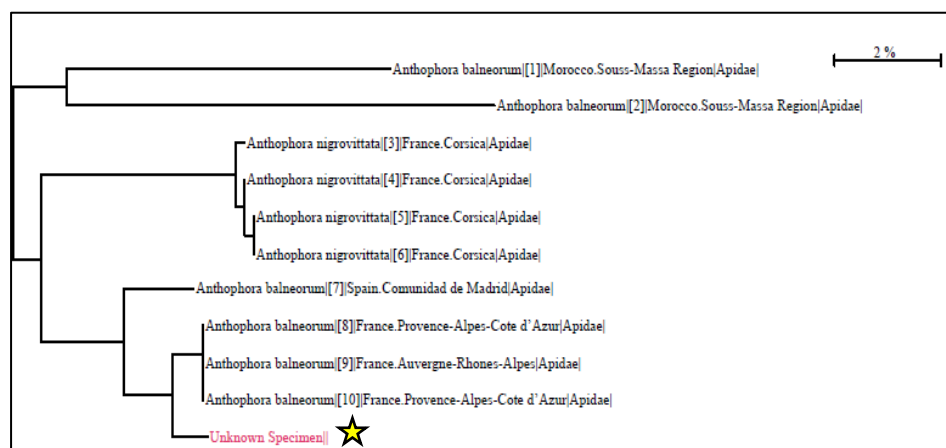


Figure 3.1 Phylogenetic tree of *Anthophora balneorum* (Bold systems)

For example, the population of *Anthophora balneorum* Lepeletier, 1841 (Fig. 3.1), which is the first record for Calabria, is much more similar to the French populations than to those of Spain or Morocco.

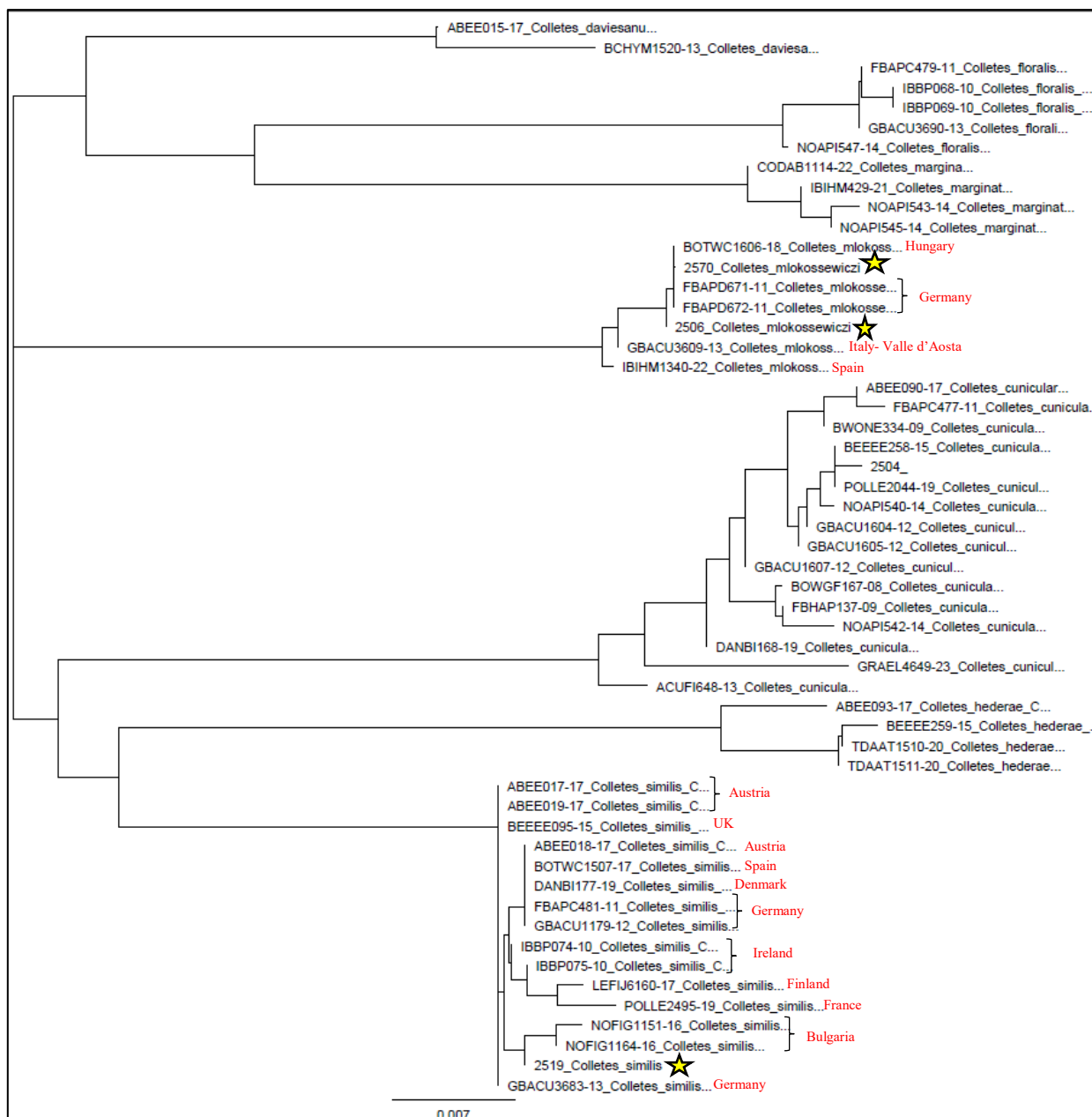


Figure 3.2 NJ tree of *Colletes* spp. Latreille, 1802 (Geneious Prime Software)

The genetic analysis is also conducted on the Colletidae *Colletes mlokoszewiczi* Radoszkowski, 1891 and *Colletes similis* Schenck, 1853, and this last one is a first report for Calabria (Fig. 3.2). It was found that *C. mlokoszewiczi* is much closer to the population of Germany and Hungary, while it differs from the Italian population (Valle da Aosta) and even more from Spanish populations. As far as *C. similis* is concerned, our population is more similar to the population of Bulgaria.

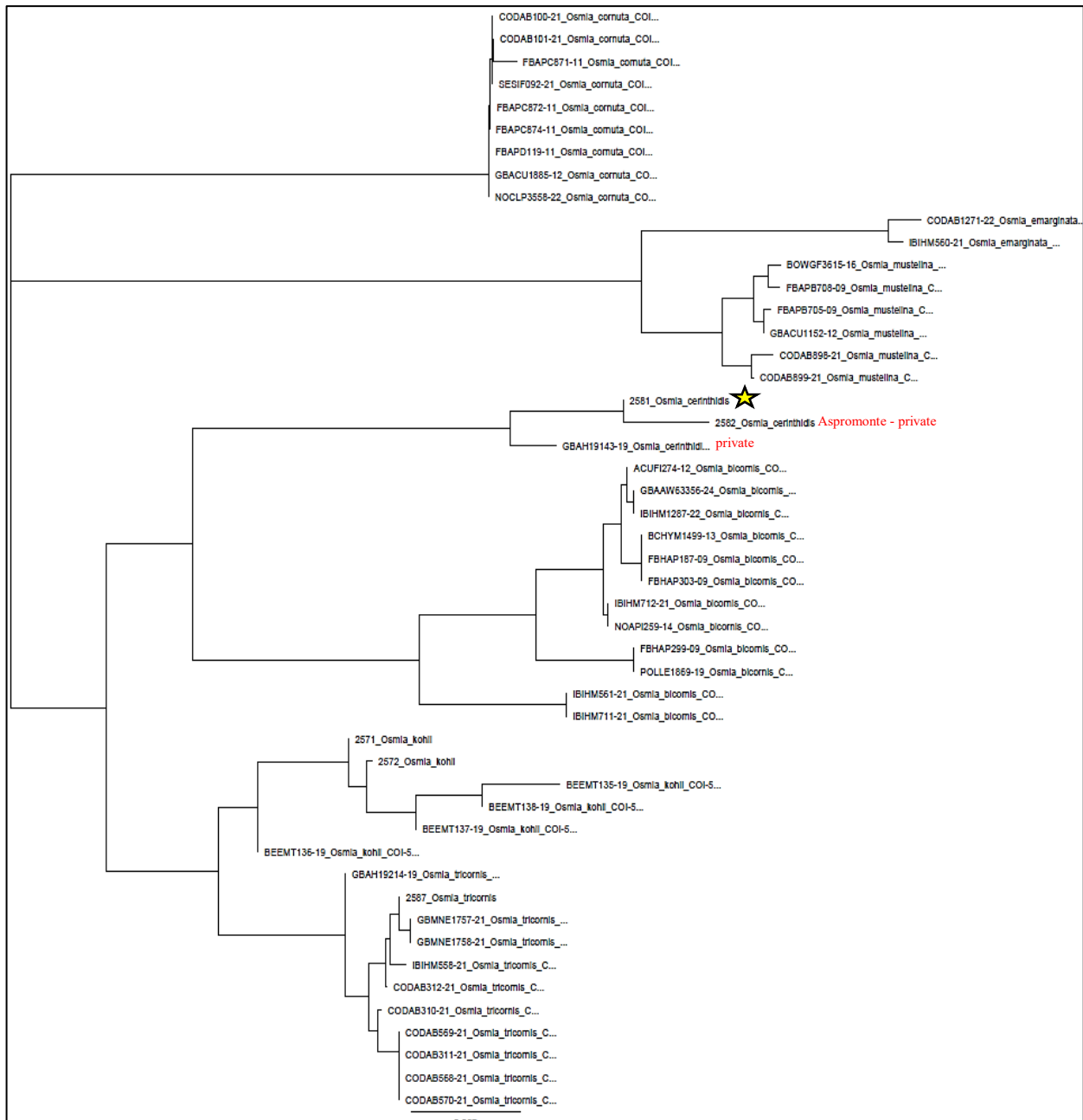


Figure 3.3 NJ tree of *Osmia cerinthidis* Morawitz, 1876 (Geneious Prime Software)

Osmia cerinthidis Morawitz, 1876 is a first report for the Southern Italy. As shown in the phylogenetic tree (Fig. 3.3), the sample collected in Pnat and Fint differs from the sequence previously loaded on the Bold system. The interesting fact is that it is quite different also from a specimen collected by our research group in the Aspromonte National Park, indicating that they could be two isolated populations, although the two areas are within the same region and therefore not particularly far apart.

Instead, the species *Osmia tergestensis* (Ducke, 1897) is rather isolated from the Spanish population and the French population (Fig. 3.4).

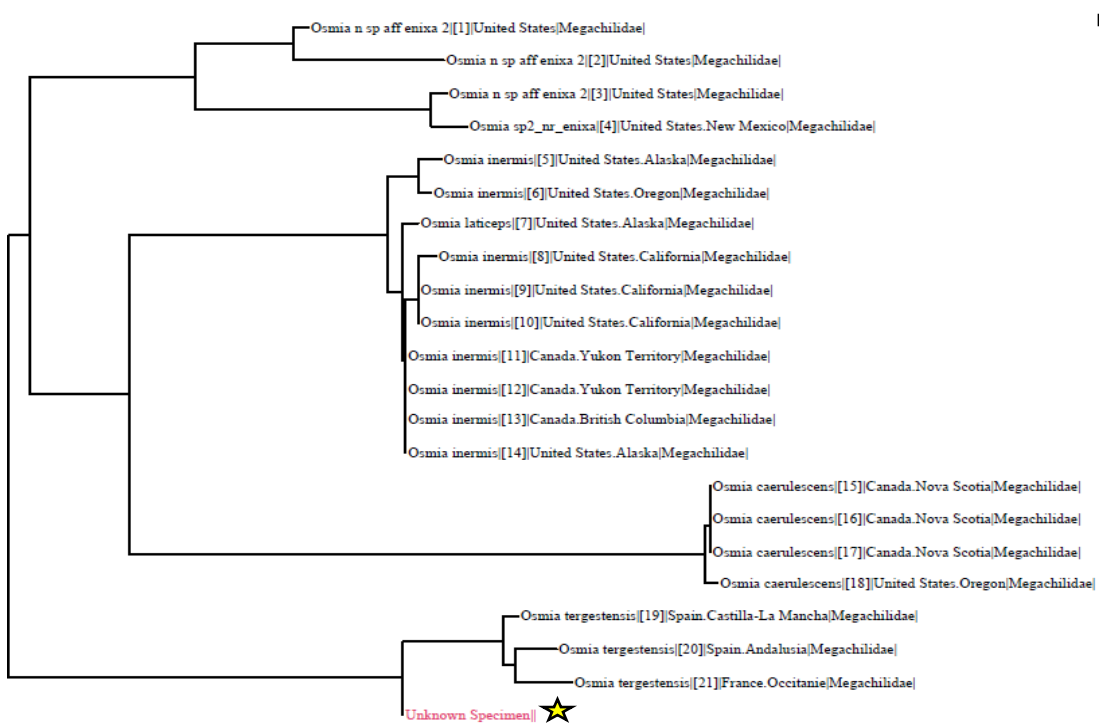


Figure 3.4 Phylogenetic tree of *Osmia tergestensis* (Ducke, 1897) (Bold System)

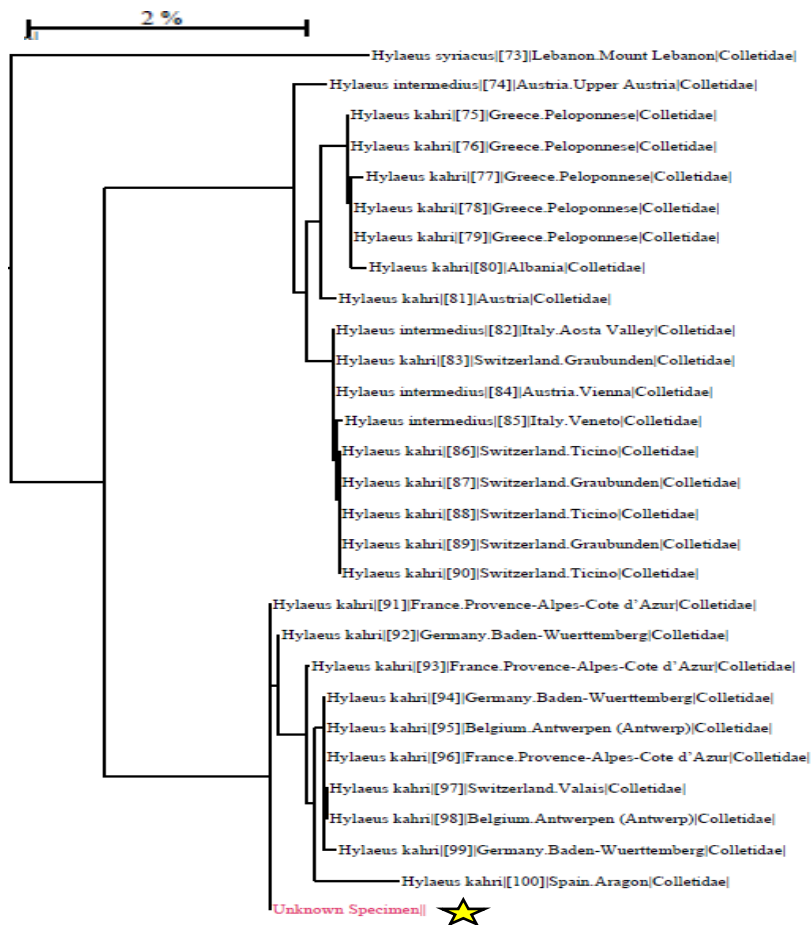


Figure 3.5 Phylogenetic tree of *Hylaeus kahri* Forster, 1871 (Bold System)

Impressive is the result obtained from the genetic analysis of *Hylaeus kahri* Forster, 1871 (Fig. 3.5). That actually know in literature is that this species is represents by two BINs group (Praz *et al.*, 2023), and actually several researches are carrying on. These groups are distributed one in northern Europe and the other one in Mediterranean basin. Our individuals are genetically much more similar to the French, Swiss and German populations than to the Italian, Greek and Albanian ones. This extremely important data could confirm that both groups are present in the Italian region and also this population could represent a biogeographical relic, but additional studies are crucial. For this reason, several studies about this subject are carrying on.

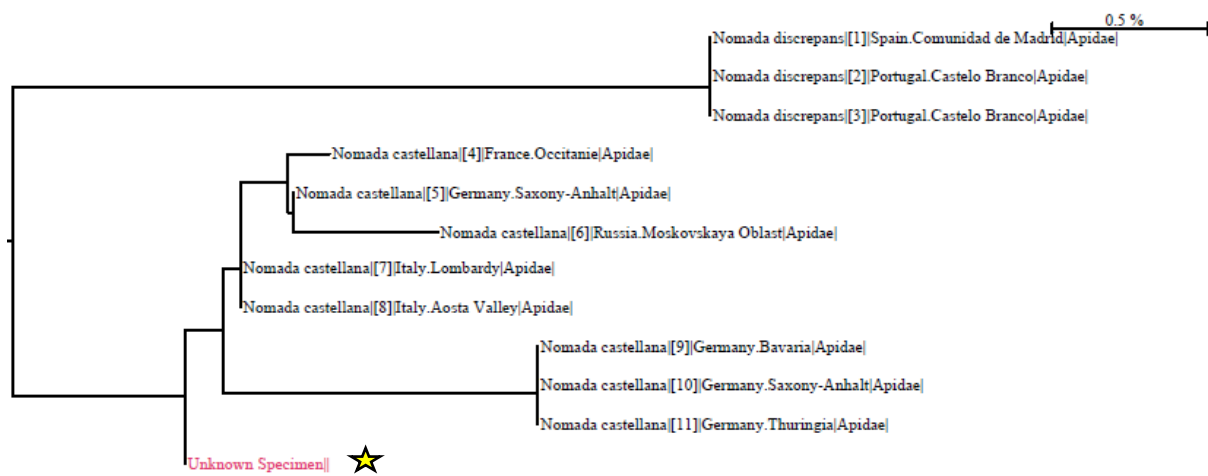
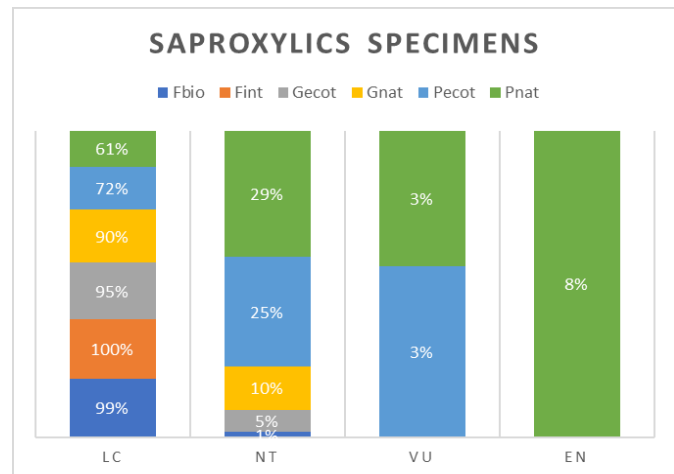


Figure 3.6 Phylogenetic tree of *Nomada castellana* Dusmet, 1913 (Bold System)

Interesting is also the case of *Nomada castellana* Dusmet, 1913, which is a first report for the South and cleptoparasite of *Andrena* spp. Our sample is placed in a different clade compared to the German, French and northern Italian populations, indicating that it could be therefore an isolated population (Fig. 3.6).

3.11 Saproxylic beetles

Several species of saproxylics are listed by the IUCN with different category of endangered risk. In particular, the red list of Italian saproxylic beetles is considered (Audisio *et al.*, 2014). The LC species were collected in every sampling area and they are species whose adults have a high dispersive power while the NT species were collected in pine forests and in Gnat and Gecot because of their proximity to neighbouring pine forests. Finally, while the vulnerable species were collected only in the two pine forests, endangered species were found only in the natural pine forest (Graph 3.48).



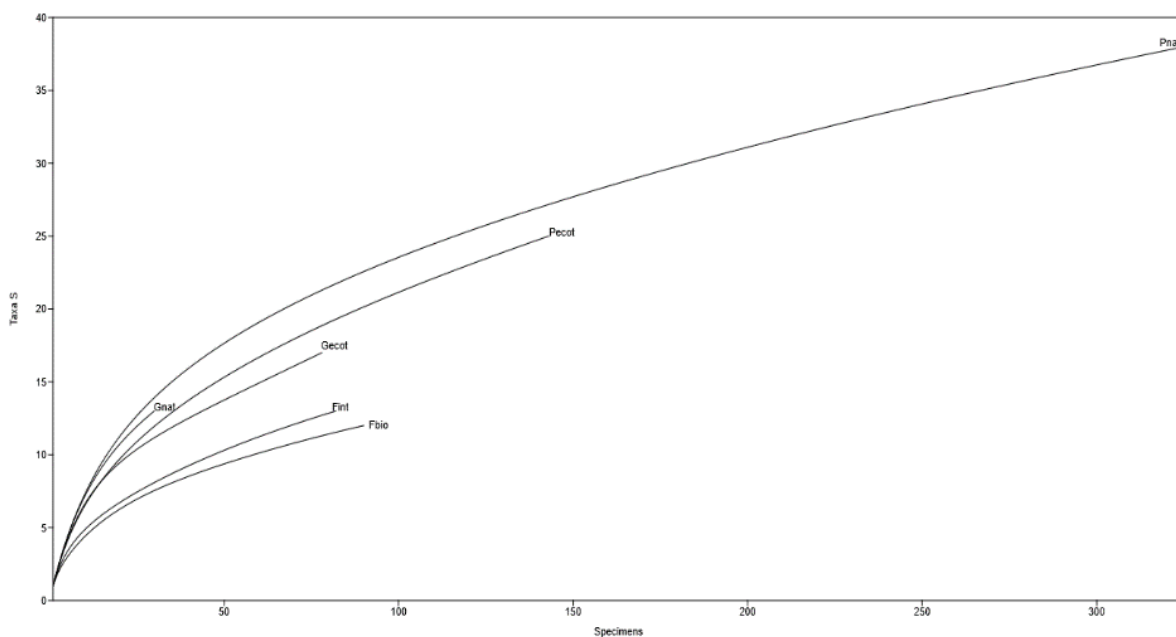
Graph 3.48 Abundance of IUCN category of risk of Italian saproxylics (Audisio *et al.*, 2014)

The majority of saproxylics species were collected in Pnat (N= 40) and then in Pecot (N= 26), while the smallest number was collected in Fbio (N= 12). Higher values for Fint and Gecot suggest greater variation in specimens distribution. Pnat has the highest value of Shannon and Margalef index, confirming its high biodiversity, while Fbio has the lowest value, being the area furthest from forests. In Gnat there is a higher uniformity index, suggesting a more balanced distribution, while Fbio has the lowest value, indicating that few species numerically dominate the group (Tab. 3.23).

Table 3.23 Biodiversity index of saproxylics (Software Past)

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
N° taxa	12	13	17	13	26	40
N° specimens	90	82	78	30	147	331
SD	6,51273	4,944857	3,130681	1,197565	6,011557	10,83398
Shannon	1,642	1,876	2,484	2,553	2,63	2,954
Evenness	0,4306	0,5021	0,7053	0,9877	0,5335	0,4796
Margalef	2,445	2,723	3,672	3,528	5,01	6,722

From the species rarefaction graph (Graph 3.49), all curves show an increase in specific richness as the number of specimens sampled increases. Curves like Fint and Fbio tend to reach the plateau at lower specimen values, indicating a lesser specific diversity, whereas the pine forests curve flattens more slowly, indicating a degree of structural complexity and a greater availability of microhabitats.

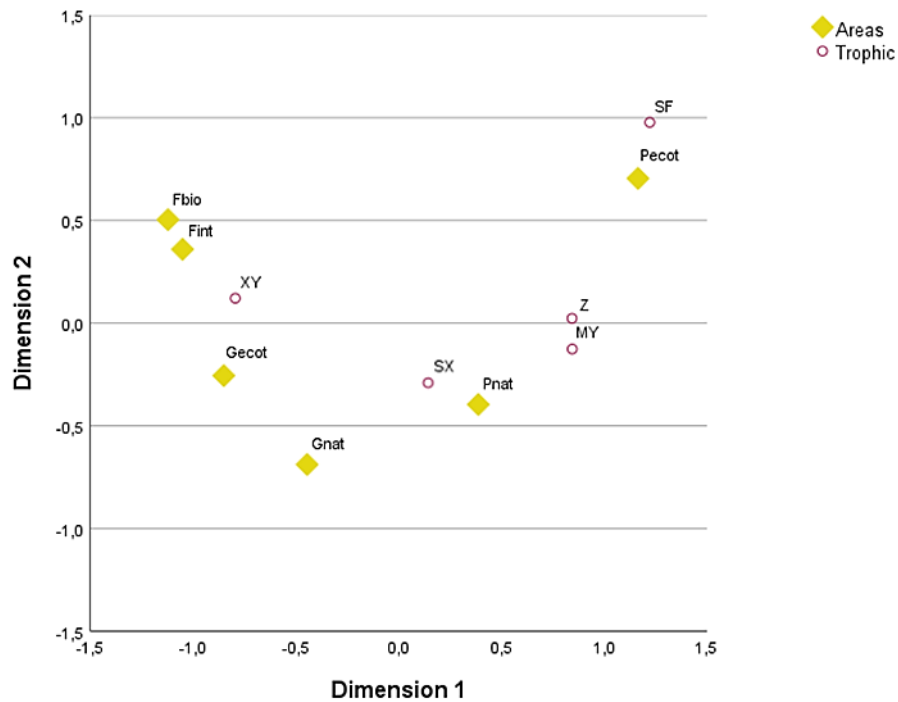


Graph 3.49 Rarefaction of saproxylic species (Software Past)

From the permanova analysis, there are significant differences between the sampling areas in terms of communities ($F:2,895$; $p:0,0001$). In particular, as confirmed by the Bonferroni-corrected p values, there are differences between pine forests and open areas, but not between distinct pine forests (Tab. 3.24). The few species that differentiate Pnat from Pecot, however, have a high naturalistic value.

Table 3.24 Bonferroni corrected p values (Software Past)

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Fbio		1	1	1	0,0015	0,0015
Fint	1		1	1	0,0015	0,0075
Gecot	1	1		1	0,0045	0,0135
Gnat	1	1	1		0,0015	0,0075
Pecot	0,0015	0,0015	0,0045	0,0015		0,858
Pnat	0,0015	0,0075	0,0135	0,0075	0,858	



Graph 3.50 Correspondence analysis between sampling area and Trophic categories. **SX:** saproxylic; **XY:** xylophagous; **MY:** mycetophagous; **SF:** sap-feeder; **Z:** zoophagous of saproxylics (Software SPSS)

The correspondence analysis (Graph 3.50) ($\chi^2 = 367,333$; $p < 0.01$) show how trophic categories are distributed in different areas. The xylophagous are related to agricultural fields and to Gecot both for the presence of shrubs and fruit trees and for the vagility of the insects. In the natural pine forest, on the other hand, the associated species are saproxylics, saproxylic predators and mycetophagous, as they are extremely linked to dead wood in decomposition. In Pecot, species that feed on fermented sap produced by previous xylophagous attacks are related.

Table 3.25 List of saproxylic beetles (Audisio et al., 2014) **SX**: saproxylic; **XY**: xylophagous; **MY**: mycophagous; **SF**: sap-feeder; **Z**: zoophagous

	IUCN	IUCN Eu	Trophic Categories	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Buprestidae									
<i>Acmaeoderella flavofasciata</i> (Piller & Mitterpacher, 1763)	LC		XY	1	1		1		1
<i>Anthaxia (Melanthaxia) helvetica</i> Stierlin, 1868	LC		XY		1		1		3
<i>Anthaxia mendizabali</i> Cobos, 1965	LC		XY			1			
<i>Anthaxia (Haplantaxia) millefolii</i> (Fabricius, 1801)	LC		XY	2					
<i>Anthaxia (Anthaxia) nitidula</i> (Linnaeus, 1758)	LC		XY		1	1			
<i>Anthaxia (Anthaxia) semicuprea</i> Kuster, 1851	LC		XY						1
<i>Chalcophora mariana</i> (Linnaeus, 1758)	LC		XY			1			
Carabidae									
<i>Clinidium (Arctoclinidium) canaliculatum</i> (O.G. Costa, 1839)	NT		Z						19
Cerambycidae									
<i>Anastrangalia dubia</i> (Scopoli, 1763)	LC		XY	2		5		2	28
<i>Anastrangalia sanguinolenta</i> (Linnaeus, 1761)	LC		XY						14
<i>Arhopalus rusticus</i> (Linnaeus, 1758)	LC		XY					1	
<i>Chlorophorus sartor</i> (Muller, 1766)	LC	LC	XY	49	14	14	3		
<i>Clytus lama</i> Mulsant, 1847	LC	LC	XY		1				
<i>Clytus rhamni</i> Germar, 1817	LC	LC	XY			1			
<i>Deilus fugax</i> (Olivier, 1790)	LC	LC	XY	1				1	
<i>Oxypleurus nodieri</i> (Mulsant, 1839)	NT		XY					1	
<i>Pogonocherus decoratus</i> Fairmaire, 1855	NT		XY						1
<i>Pseudovadonia livida</i> (Fabricius, 1776)	LC		XY	14	33	13	3	1	
<i>Rhagium (Hagrium) bifasciatum</i> Fabricius, 1775	LC		SX						2
<i>Rhagium (Rhagium) inquisitor</i> Linnaeus, 1758	LC		SX					4	4
<i>Rutpela maculata</i> (Poda, 1761)	LC		XY			1		1	49
<i>Stenopterus rufus</i> Linnaeus, 1767	LC	LC	XY	6		6	3		
<i>Stenurella bifasciata</i> ssp. <i>bifasciata</i> (O. F. Muller, 1776)	LC		XY	6	16	10	6	3	2
<i>Stictoleptura cordigera</i> (Fuessly, 1775)	LC		XY	6	6	8	1		
<i>Paracorymbia fulva</i> (De Geer, 1775)	LC		XY		2				
Cetoniidae									
<i>Cetonia aurata</i> subsp. <i>pisana</i> Heer, 1841	LC		XY		1	1			
<i>Protaetia (Netocia) cuprea</i> subsp. <i>cuprea</i> (Fabricius, 1775)	LC		XY			1	1		
<i>Valgus hemipterus</i> Linnaeus, 1758	LC	LC	XY	1	1	1			
Cleridae									
<i>Opilo mollis</i> (Linnaeus, 1758)	LC		Z				2		1
<i>Thanasimus formicarius</i> (Linnaeus, 1758)	LC		Z		3				1
Cryptophagidae									
<i>Pteryngium crenulatum</i> (Erichson, 1846)	LC		MY					16	
<i>Sternodea baudii</i> Reitter, 1875	LC		MY					1	1
Cucujidae									
<i>Cucujus cinnaberinus</i> (Scopoli, 1763)	VU	NT	Z						7
<i>Pediacus dermestoides</i> (Fabricius, 1792)	NT	DD	Z					1	2

	IUCN	IUCN Eu	Trophic Categories	Fbio	Fint	Gecot	Gnat	Pecot	Pnat
Curculionidae									
<i>Hylastes ater</i> (Paykull, 1800)	LC		XY					5	4
<i>Hylastes attenuatus</i> Erichson, 1836	LC		XY					12	11
<i>Tomicus minor</i> (Hartig, 1834)	LC		XY						1
Dasytidae									
<i>Aplocnemus (Aplocnemus) nigricornis</i> (Fabricius, 1792)	LC		Z			1		10	4
Elateridae									
<i>Ampedus (Ampedus) sinuatus</i> Germar, 1844	VU	LC	Z					4	1
<i>Melanotus (Melanotus) castanipes</i> (Paykull, 1800)	LC	LC	Z					4	
Endomychidae									
<i>Lycoperdina bovistae</i> (Fabricius, 1792)	LC		MY				1		1
Erotilidae									
<i>Dacne rufifrons</i> (Fabricius, 1775)	NT	DD	MY						1
<i>Triplax lacordairii</i> Crotch, 1870	NT	EN	MY					1	6
<i>Triplax marseuli</i> Bedel, 1864	NT	DD	MY					30	53
<i>Triplax rufipes</i> (Fabricius, 1787)	LC	LC	MY					2	
Lycidae									
<i>Lygistorus anorachilus</i> Ragusa, 1838	NT		MY					1	2
Melandridae									
<i>Rushia parreyssi</i> (Mulsant, 1856)	NT		MY						7
Nitidulidae									
<i>Glischrochilus quadrisignatus</i> (Say, 1835)	NT		MY	1		4	2	1	1
<i>Ipidia binotata</i> Reitter, 1875	VU		MY						1
<i>Pityophagus ferrugineus</i> (Linnaeus, 1758)	LC		Z					9	11
<i>Soronia grisea</i> (Linnaeus, 1758)	LC		SF					31	24
Staphilinidae									
<i>Anisotoma castanea</i> (Herbst, 1792)	LC		MY						1
<i>Phyllodrepa salicis</i> (Gyllenhal, 1810)	VU		Z					1	1
<i>Scaphium immaculatum</i> (Olivier, 1790)	NT		MY				1		
Tenebrionidae									
<i>Diaperis boleti</i> (Linnaeus, 1758)	LC		MY						23
<i>Enoplopus dentipes</i> (Rossi, 1790)	LC		SX		2	9	5		8
<i>Helops caeruleus</i> (Linnaeus, 1758)	LC		SX						1
<i>Nalassus dryadophilus</i> (Mulsant, 1854)	LC		SX					3	3
Trogroscidae									
<i>Grynocaris oblonga</i> (Linnaeus, 1757)	NT		Z						2
Zoopheridae									
<i>Corticus celtis</i> Germar, 1824	LC		SX						1
<i>Endophloeus marcovichianus</i> (Piller&Mitterpacher, 1783)	NT		SX					1	
<i>Pycnomerus italicus</i> (Ganglbauer, 1899)	EN		SX						27

As shown in table (Tab. 3.25) numerous and important species are collected only in the natural pine forest, such as the endangered and endemic species *Pycnomerus italicus* (Ganglbauer, 1899), the NT species *Clinidium* (*Arctoclinidium*) *canaliculatum* (O.G. Costa, 1839), *Pogonocherus decoratus* Fairmaire, 1855 and *Grynocaris oblonga* (Linnaeus, 1757) and the vulnerable species *Cucujus cinnaberinus* (Scopoli, 1763) (Fig. 3.7).



Figure 3.7 Photo of some saproxylic beetles. **A:** *Pycnomerus italicus*; **B:** *Clinidium canaliculatum*; **C:** adult of *Cucujus cinnaberinus*; **D:** larvae of *Cucujus cinnaberinus* (F. Mendicino)

3.12 Species of medical and veterinary interest

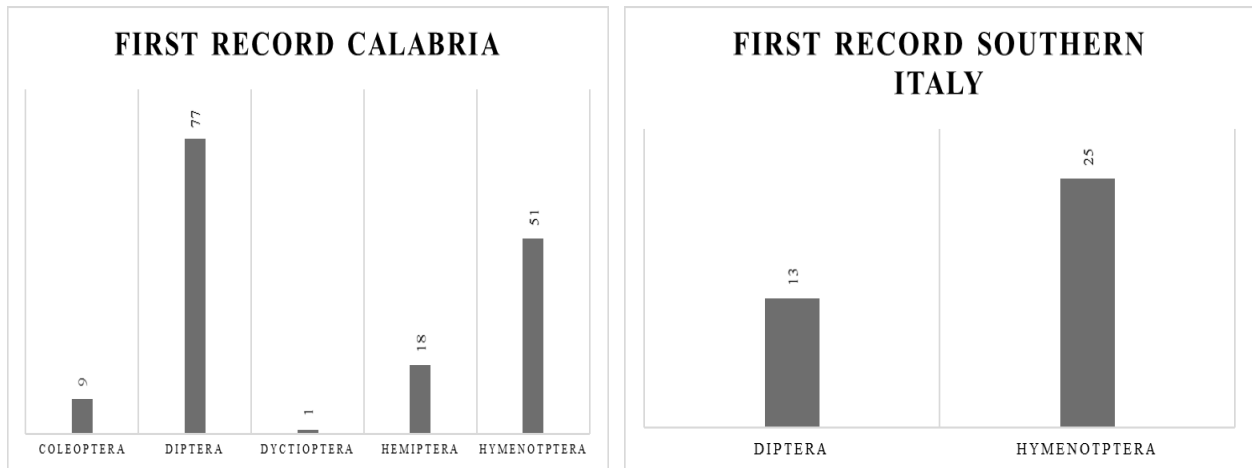
Several species of veterinary interest are collected in the sampling areas (Tab. 3.26). As regards the myiasigen agents reported in the literature, several Calliphoridae have been collected, including *Calliphora* spp., *Chrysomya albiceps* and *Lucilia* spp., the Muscidae *Muscina stabulans*, the Sarcophagidae *Wohlfhartia magnifica* (Schiner, 1862) and the Syrphidae *Eristalis tenax* (Linnaeus, 1758). There are also different vectors of pathogens such as *Musca domestica* Linnaeus, 1758 and *Musca autumnalis* De Geer, 1776. Among the hematophagous species, the dangerous *Stomoxys calcitrans* (Linnaeus, 1758) (Fam: Muscidae) was also collected. As listed in the table 3.23, this species has been found in or near grazing areas. No serious damage has been documented from farmers at present, but monitoring and control of this species is necessary.

Table 3. 26. List of medical-veterinary interest species

	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	VECTOR	MYIASIS	BLOND	Bibliography
Calliphoridae										
<i>Calliphora vicina</i> Robineau-Desvoidy, 1830	X	X	X	X	X	X		X		Pezzi et al., 2017
<i>Calliphora vomitoria</i> (Linnaeus, 1758)	X	X	X	X	X	X		X		Amendt et al., 2004
<i>Chrysomya albiceps</i> Wiedemann, 1819		X	X	X				X		Sotiraki & Hall, 2012
<i>Lucilia ampullacea</i> Villeneuve, 1922			X	X		X		X		Principato & Cioffi, 1996
<i>Lucilia caesar</i> (Linnaeus, 1758)	X	X		X		X		X		Pezzi et al., 2021
<i>Lucilia sericata</i> (Meigen, 1826)	X	X						X		Sotiraki & Hall, 2012
Muscidae										
<i>Haematobosca stimulans</i> (Meigen, 1824)					X	X			X	Gregor et al., 2016
<i>Musca autumnalis</i> De Geer, 1776	X	X	X	X		X	X			Steve & Lilly, 1965
<i>Musca domestica</i> Linnaeus, 1758	X	X	X	X	X	X	X			Bertelloni et al., 2023
<i>Muscina stabulans</i> (Fallen, 1817)		X	X	X	X	X	X	X		Wang et al., 2019; Pezzi et al., 2022
<i>Stomoxys calcitrans</i> (Linnaeus, 1758)	X	X	X	X	X				X	Patra et al., 2018
Sarcophagidae										
<i>Ravinia pernix</i> (Harris, 1780)	X	X	X	X			X			da Silva Xaviet & Carvalho Queiroz, 2016
<i>Sarcophaga (Bercaea) africa</i> (Wiedemann, 1824)			X	X				X		Snyman et al., 2022
<i>Sarcophaga crassipalpis</i> Macquart, 1839		X						X		Giangaspero et al., 2017
<i>Sarcophaga (Helicophagella) melanura</i> Meigen, 1826	X	X	X	X		X		X		Chigusa et al., 1997
<i>Sarcophaga (Liosarcophaga) portschinskyi</i> (Rohdendorf, 1937)	X	X	X	X				X		Pezzi et al., 2022
<i>Wohlfartia magnifica</i> (Schiner, 1862)		X	X	X	X			X		Bonacci et al., 2017
Syrphidae										
<i>Eristalis tenax</i> (Linnaeus, 1758)	X		X	X				X		Tolba, 2020
Tabanidae										
<i>Chrysops (Chrysops) caecutiens</i> (Linnaeus, 1758)	X	X	X		X	X			X	Southwick, 2019
<i>Chrysops viduatus</i> (Fabricius, 1794)	X		X						X	Southwick, 2020
<i>Haematopoda italica</i> Meigen, 1804	X	X			X				X	Kremar & Maric, 2006
<i>Hybomitra montana</i> (Meigen, 1820)					X	X			X	Kremar & Maric, 2006
<i>Tabanus rectus</i> Low, 1858	X		X			X			X	Kremar & Maric, 2007
<i>Tabanus tergustinus</i> Egger, 1859	X		X	X					X	Kremar & Maric, 2008

3.13 New records

There are several new reports. Specifically, for Calabria, there are 197 first records including 9 species of Coleoptera and a species of Dictyoptera for Calabria. Among the Hemiptera, the new records for Calabria are 18 while the Diptera new reports are 90, specifically 77 for Calabria and 13 for the South. Regarding the Hymenoptera, there are 79 new reports, including 25 new reports for the South and 3 new reports for the Italian mainland (Graph. 3.51).



Graph 3.51 New records for Calabria and Southern Italy

In the following tables we have the list of species.

Table 3. 27. List of new records of Coleoptera

Coleoptera		
Family	Genera/Species	New Calabria New Southern Italy New Italy
Carabidae	<i>Laemostenus (Pristonychus) terricola</i> (Herbst, 1783)	X
Cerambycidae	<i>Oxypleurus nodieri</i> (Mulsant, 1839)	X
Chrysomelidae	<i>Galeruca (Galeruca) littoralis</i> (Fabricius, 1787)	X
Curculionidae	<i>Bothynoderes affinis</i> (Schrank, 1781)	x
Cybocephalidae	<i>Cybocephalus politus</i> Gyllenhal, 1813	X
Erotylidae	<i>Dacne rufifrons</i> (Fabricius, 1775)	X
	<i>Triplax rufipes</i> (Fabricius, 1787)	X
Melolonthidae	<i>Rhizotrogus marginipes</i> Mulsant, 1842	X
Nitidulidae	<i>Glischrochilus quadrisignatus</i> (Say, 1835)	X

Table 3. 28 List of Dictyoptera and Hemiptera new records

Dictyoptera				
Family	Genera/Species	New Calabria	New Southern Italy	New Italy
Ectobidae	<i>Ectobius (Ectobius) pallidus</i> (Olivier, 1789)	X		
Hemiptera				
Family	Genera/Species	New Calabria	New Southern Italy	New Italy
Alydidae	<i>Alydus calcaratus</i> (Linnaeus, 1758)	X		
Cercopidae	<i>Cercopis arcuata</i> Fieber, 1775	X		
	<i>Haematoloma dorsatum</i> (Ahrens, 1812)	X		
Coreidae	<i>Centrocoris variegatus</i> Kolenati, 1845	X		
	<i>Coriomeris hirticornis</i> (Fabricius, 1794)	x		
	<i>Coriomeris scabricornis</i> (Panzer, 1809)	x		
Lygaeidae	<i>Spathocera lobata</i> (Herrich-Schäffer, 1840)	x		
	<i>Eremocoris plebejus</i> (Fallen, 1807)	x		
	<i>Emblethis verbasci</i> (Fabricius 1803)	x		
Membracidae	<i>Xanthochilus saturnius</i> (Rossi, 1790)	x		
	<i>Gargara genistae</i> (Fabricius, 1775)	x		
Miridae	<i>Grypocoris (Lophyromiris) sexguttatus</i> (Fabricius, 1777)	x		
Pentatomidae	<i>Dyrodere umbraculatus</i> (Fabricius, 1775)	x		
	<i>Eurydema fieberi</i> Schummel, 1837	x		
Pyrrochoridae	<i>Pyrrochoris marginatus</i> (Kolenati, 1845)	x		
Reduviidae	<i>Rhynocoris (Rhynocoris) annulatus</i> (Linnaeus, 1758)	x		
Rhopalidae	<i>Chorosoma schillingii</i> (Schilling, 1829)	x		
Rhyparochromidae	<i>Xanthochilus saturnius</i> (Rossi, 1790)	x		
Scutelleridae	<i>Odontoscelis (Odontoscelis) fuliginosa</i> (Linnaeus, 1761)	x		
Tingidae	<i>Dictyla humuli</i> (Fabricius, 1794)	x		

Table 3. 29 List of new records of Diptera

Diptera				
Family	Genera/Species	New Calabria	New Southern Italy	New Italy
Asilidae	<i>Machimus cyanopus</i> (Loew, 1849)	X		
Aulacigastridae	<i>Aulacigaster leucopeza</i> (Meigen, 1830)	X		
Bibionidae	<i>Dilophus femoratus</i> Meigen, 1804	X		
Calliphoridae	<i>Angioneura cyrtoneurina</i> (Zetterstedt, 1859)	X	X	
	<i>Bellardia viarum</i> (Robineau-Desvoidy, 1830)	X		
	<i>Cynomya mortuorum</i> (Linnaeus, 1761)	X	X	
	<i>Eurychaeta muscaria</i> (Meigen, 1826)	X		
	<i>Melinda gentilis</i> Robineau-Desvoidy, 1830	X		
	<i>Melinda viridicyanea</i> (Robineau-Desvoidy, 1830)	X		
	<i>Onesia floralis</i> Robineau-Desvoidy, 1830	X		
	<i>Stomorphina lunata</i> (Fabricius, 1805)	X		
Dolichopodidae	<i>Neurigona suturalis</i> Fallem, 1823	X		
Drosophilidae	<i>Leucophenga (Leucophenga) maculata</i> (Dufour, 1839)	X		
Dryomyzidae	<i>Dryomyza flaveola</i> (Fabricius, 1794)	X		
Heleomyzidae	<i>Suillia flava</i> (Meigen, 1830)	X		
	<i>Suillia flavifrons</i> (Zetterstedt, 1838)	X	X	
Lauxanidae	<i>Minettia fasciata</i> (Fallen, 1820)	X		
	<i>Sapromyza quadripunctata</i> (Gimmerthal, 1842)	X		

		Diptera		
Family	Genera/Species	New Calabria	New Southern Italy	New Italy
Muscidae	<i>Coenosia intermedia</i> (Fallén, 1825)	X	X	
	<i>Coenosia tigrina</i> (Fabricius, 1775)	X		
	<i>Helina celsa</i> (Harris, 1780)	X		
	<i>Helina confinis</i> (Fallén, 1825)	X		
	<i>Helina cothurnata</i> (Rondani, 1866)	X		
	<i>Helina impuncta</i> (Fallén, 1825)	X		
	<i>Helina quadrinotata</i> (Meigen, 1826)	X	X	
	<i>Helina reversio</i> (Harris, 1780)	X		
	<i>Helina setigera</i> (Pokorný, 1887)	X	X	
	<i>Hydrotaea albipuncta</i> (Zetterstedt, 1845)	X	X	
	<i>Hydrotaea meridionalis</i> Porchinskiy, 1882	X		
	<i>Neomyia cornicina</i> (Fabricius, 1781)	X		
	<i>Neomyia viridescens</i> (Robineau-Desvoidy, 1830)	X	X	
	<i>Phaonia incana</i> (Wiedemann, 1817)	X	X	
	<i>Phaonia mediterranea</i> Hannig, 1963	X		
	<i>Phaonia pallida</i> (Fabricius, 1787)	X		
	<i>Phaonia rufipalpis</i> (Macquart, 1835)	X	X	
	<i>Phaonia trimaculata</i> (Bouché, 1834)	X		
	<i>Phaonia tuguriorum</i> (Scopoli, 1763)	X		
<i>Thricops semicinereus</i> (Wiedemann, 1817)	X			
Pallopteridae	<i>Palloptera muliebris</i> (Harris, 1780)	X		
Pollenidae	<i>Pollenia griseotomentosa</i> (Jacentkovsky, 1944)	X		
Psillidae	<i>Loxocera aristata</i> (Panzer, 1801)	X	x	
Rhinophoridae	<i>Rhinophora lepida</i> (Meigen, 1824)	X	X	
Sarcophagidae	<i>Angiometopa falleni</i> Pape, 1986	X		
	<i>Pterella grisea</i> Meigen, 1824	X		
	<i>Oebalia cylindrica</i> (Fallén, 1810)	X		
	<i>Sarcophaga (Helicophagella) agnata</i> Rondani, 1860	X		
	<i>Sarcophaga (Discachaeta) amita</i> Rondani, 1860	X		
	<i>Sarcophaga (Helicophagella) crassimargo</i> Pandelle, 1896	X		
	<i>Sarcophaga (Heteronychia) filia</i> Rondani, 1860	X		
	<i>Sarcophaga (Thyrsoenema) incisilobata</i> Pandelle, 1896	X		
	<i>Sarcophaga (Thyrsoenema) kentejana</i> (Rohdendorf, 1937)	X	X	
	<i>Sarcophaga (Helicophagella) novercoides</i> Bottcher, 1913	X		
	<i>Sarcophaga (Pandelleana) protuberans</i> Pandelle, 1896	X		
	<i>Sarcophaga (Sarcotachinella) sinuata</i> Meigen, 1826	X		
	<i>Sarcophaga (Heteronychia) vicina</i> Macquart, 1835	X		
	<i>Sarcophila latifrons</i> (Fallén, 1817)	X		
Sepsidae	<i>Sepsis thoracica</i> (Robineau-Desvoidy, 1830)	X		
Stratiomyidae	<i>Microchrysa polita</i> (Linnaeus, 1758)	X		
Syrphidae	<i>Arctophila superbiens</i> (Muller, 1776)	X		
	<i>Brachypalpoides lentus</i> Meigen, 1822	X		
	<i>Cheilosia vulpina</i> (Meigen, 1822)	X		
	<i>Episyrphus (Meliscaeva) auricollis</i> (Meigen, 1822)	X		
	<i>Eristalis jugorum</i> Egger, 1925	X		
	<i>Eumerus flavitarsis</i> Zetterstedt, 1843	X		
	<i>Merodon equestris</i> (Fabricius, 1794)	X		
	<i>Merodon rufus</i> Meigen, 1838	X		
	<i>Syrphus vitripennis</i> Meigen, 1822	X		
	<i>Tropidia fasciata</i> Meigen, 1822	X		
Tabanidae	<i>Chrysops (Chrysops) caecutiens</i> (Linnaeus, 1758)	X		
	<i>Chrysops viduatus</i> (Fabricius, 1794)	X		
	<i>Haematopoda italica</i> Meigen, 1804	X		
	<i>Tabanus rectus</i> Low, 1858	X		
Tachinidae	<i>Tabanus tergestinus</i> Egger, 1859	X		
	<i>Bithia modesta</i> (Meigen, 1824)	X		
	<i>Cylindromyia intermedia</i> (Meigen, 1824)	X		
	<i>Dufouria chalybeata</i> (Meigen, 1824)	X		
	<i>Dufouria nigrita</i> (Fallén, 1810)	X		
	<i>Eriothrix monitica</i> (Egger, 1856)	X		
	<i>Eriothrix rufomaculata</i> (DeGeer, 1776)	X		
	<i>Estheria microcera</i> (Robineau-Desvoidy, 1830)	X		
	<i>Estheria petiolata</i> (Bonsdorff, 1866)	X		
	<i>Gonia picea</i> (Robineau-Desvoidy, 1830)	X		
	<i>Gonia vacua</i> Meigen, 1826	X		
	<i>Gymnosoma nitens</i> Meigen, 1824	X		
	<i>Kirbya moerens</i> (Meigen, 1830)	X		
	<i>Microphthalma europea</i> Egger, 1860	X		
	<i>Nowickia strobili</i> (Rondani, 1865)	X		
	<i>Tachina magnicornis</i> (Zetterstedt, 1844)	X		
Tephritidae	<i>Carpomya schineri</i> (Loew, 1856)	X		
Therevidae	<i>Thereva valida</i> Loew, 1847	X		

Table 3. 30 List of Hymenoptera New records

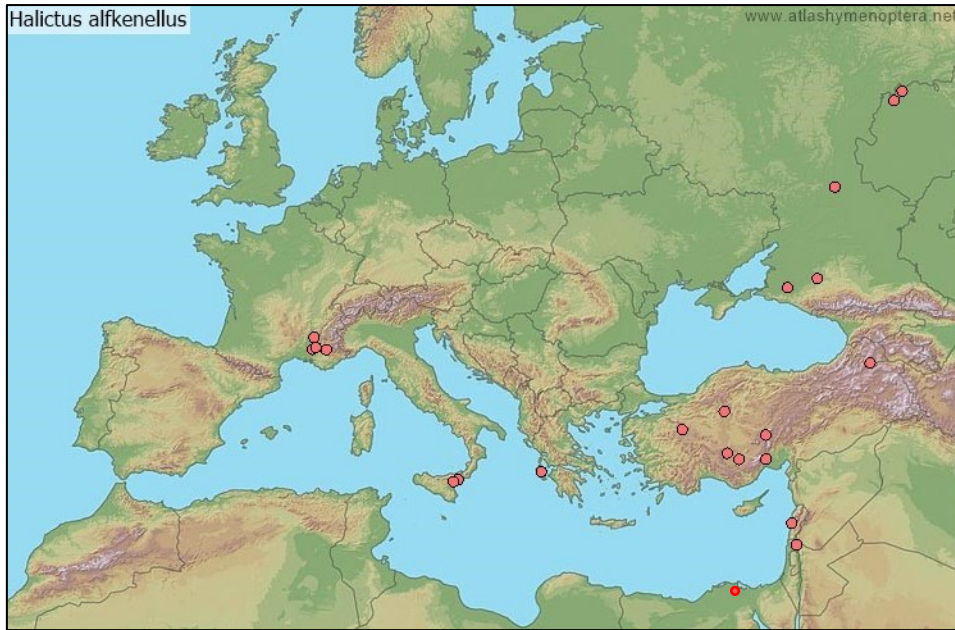
Hymenoptera				
Family	Genera/Species	New Calabria	Southern	New Italy
Andrenidae	<i>Andrena afzeliella</i> (Kirby, 1802)	X		
	<i>Andrena barbarae</i> Panzer, 1805)	X	X	
	<i>Andrena curvungula</i> Thomson, 1870	X	X	
	<i>Andrena fucata</i> Smith, 1847	X	X	
	<i>Andrena fulva</i> (Muller, 1766)	X		
	<i>Andrena fulvata</i> E. Stockhert, 1930	X	X	
	<i>Andrena fumida</i> Perez, 1895	X		
	<i>Andrena gelriae</i> van der Vecht, 1927	X		
	<i>Andrena gravida</i> Imhoff, 1832	X	X	
	<i>Andrena (Chlorandrena) kamarti</i> Schmiedeknecht, 1900	X	X	X(P)
	<i>Andrena minutuloides</i> Perkins, 1914	X		
	<i>Andrena ovata</i> Schenck, 1853	X		
	<i>Andrena pilipes</i> Fabricius, 1781	X		
	<i>Andrena trimmerana</i> (Kirby, 1802)	X		
<i>Andrena wilkella</i> (Kirby, 1802)	X			
Apidae	<i>Anthophora balneorum</i> Lepeletier, 1841	X	X	
	<i>Anthophora retusa</i> (Linnaeus, 1758)	X		
	<i>Eucera albofasciata</i> Friese, 1895	X	X	X(P)
	<i>Eucera nigri-facies</i> Lepeletier, 1841	X		
	<i>Eucera pannonica</i> Mocsàry, 1878	X	X	
	<i>Melecta festiva</i> (Fabricius, 1804)	X	X	
	<i>Nomada armata</i> Herrich-Schäffer, 1839	X		
	<i>Nomada castellana</i> Dusmet, 1913	X	X	
	<i>Nomada mutabilis</i> Morawitz, 1870	X	X	
	<i>Nomada panzeri</i> Lepeletier, 1841	X		
	<i>Nomada pleurosticta</i> Herrich-Scaffer, 1839	X	X	
<i>Nomada signata</i> Jurine, 187	X			
<i>Tetralonia malvae</i> (Rossi, 1790)	X			
Crabronidae	<i>Ectemnius massiliensis</i> (Kohl, 1883)	X		
	<i>Oxybelus subspinosus</i> Klug, 1835	X		
Colletidae	<i>Colletes similis</i> Schenck, 1853	X		
	<i>Hylaeus dilatatus</i> (Kirby, 1802)	X	X	
	<i>Hylaeus hyalinatus montebovens</i> (Pittioni, 1950)	X		
	<i>Hylaeus kahri</i> Forster, 1871	X	X	
	<i>Hylaeus incongruus</i> Forster, 1871	X	X	
Cynipoidea	<i>Brachymeria femorata</i> (Panzer, 1801)	X	X	
Formicidae	<i>Camponotus (Myrmentoma) gestroi</i> Emery, 1878	X		

Hymenoptera

Family	Genera/Species	New Calabria	Southern	New Italy
Halictidae	<i>Halictus alfenellus</i> Stand, 1909	X	X	X(P)
	<i>Halictus fulvipes</i> (Klug, 1817)	X		
	<i>Halictus simplex</i> gr.	X		
	<i>Lasioglossum aeratum</i> (Kirby, 1802)	X		
	<i>Lasioglossum albipes</i> (Fabricius, 1781)	X		
	<i>Lasioglossum calceatum</i> (Scopoli, 1763)	X		
	<i>Lasioglossum convexiusculum</i> (Schenck, 1853)	X	X	
	<i>Lasioglossum fulvicorne</i> (Kirby, 1802)	X	X	
	<i>Lasioglossum griseolum</i> (Morawitz, 1872)	X		
	<i>Lasioglossum laeve</i> Kirby, 1802	X		
	<i>Lasioglossum laevigatum</i> (Kirby, 1802)	X		
	<i>Lasioglossum lativentre</i> (Schenck, 1853)	X		
	<i>Lasioglossum leucopus</i> (Kirby, 1802)	X	X	
	<i>Lasioglossum lineare</i> (Schenck, 1870)	X	X	
	<i>Lasioglossum morio</i> (Fabricius, 1793)	X		
	<i>Lasioglossum pygmaeum</i> (Schenck, 1853)	X		
	<i>Lasioglossum rufitarse</i> (Zetterstedt, 1838)	X		
	<i>Lasioglossum semilucens</i> (Alfken, 1914)	X	X	
	<i>Lasioglossum transitorium</i> (Schenck, 1868)	X		
	<i>Lasioglossum tricinctum</i> (Schenck, 1874)	X		
	<i>Lasioglossum xanthopus</i> (Kirby, 1802)	X		
	<i>Seladonia smaragdula</i> complex	X		
	<i>Sphecodes miniatus</i> von Hagens, 1882	X	X	
<i>Sphecodes reticulatus</i> Thomson, 1870	X			
<i>Sphecodes pseudofasciatus</i> Bluthgen, 1925	X	X		
Megachilidae	<i>Chelostoma grande</i> (Nylander, 1852)	X	X	
	<i>Heriades crenulatus</i> (Nylander, 1856)	X		
	<i>Hoplitis scutellaris</i> Morawitz, 1868	X		
	<i>Hoplitis papaveris</i> (Latreille, 1799)	X	X	
	<i>Megachile centuncularis</i> (Linnaeus, 1758)	X		
	<i>Osmia cephalotes</i> Morawitz, 1870	X		
	<i>Osmia cerinthidis</i> Morawitz, 1876	X	X	
	<i>Osmia (Hoplosmia) ligurica</i> Morawitz, 1868	X		
Mutillidae	<i>Cystomutilla ruficeps</i> (Smith, 1855)	X		
	<i>Myrmilla (Myrmilla) calva</i> (Villers, 1789)	X		
Pompilidae	<i>Anoplius viaticus</i> (Linnaeus, 1758)	X		
Scolidae	<i>Colpa (Heterelis) quinquecincta</i> (Fabricius, 1793)	X		
	<i>Athalia bicolor</i> Serville, 1823	X		
	<i>Athalia circularis</i> (Klug, 1815)	X		
Tenthrenidae	<i>Nematus (Pteronidea) myosotidis</i> (Fabricius, 1804)	X		
	<i>Dolichovespula media</i> (Retzius, 1783)	X		
Vespidae	<i>Polistes atrimandibularis</i> Zimmermann, 1930	X		

Some new reports are quite interesting.

3.13.1 *Halictus alfkenellus* Strand, 1909



Map 3.1 Distribution of *Halictus alfkenellus* (<http://www.atlashymenoptera.net>)

H. alfkenellus is a rather rare Halictidae from central Asia and south-eastern Europe (Map. 3.1). In Italy it is reported only in Sicily (Pagliano, 1988; Revertè *et al.*, 2023). A female (Fig. 3.9) was collected on 05/05/2023 in Pnat by yellow chromotactic trap and it was identified both on a morphological basis by Federica Mendicino (Unical) and Thomas Brau (UniMons). The genetic data also confirms the morphological identification (Fig. 3.8).

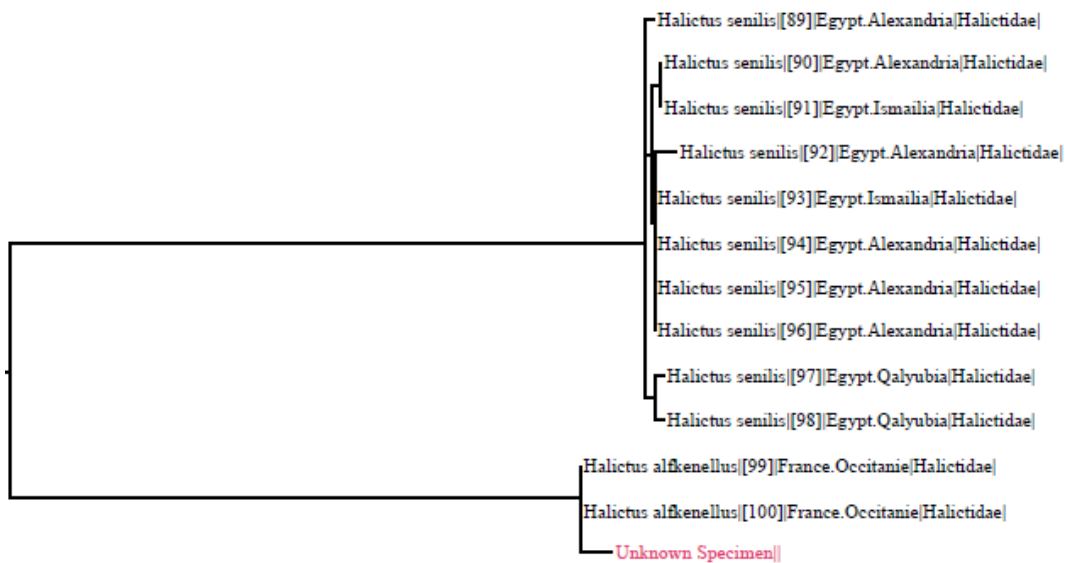


Fig. 3.8 Phylogenetic tree of *Halictus alfkenellus* (Bold systems)



Figure 3.9 Photo of a female of *Halictus alfenellus*. **A:** dorsal view; **B:** lateral view; **C:** head; **D:** abdomen (F. Mendicino)

3.13.2 *Eucera albofasciata* Friese, 1895

E. albofasciata is a European species and it is present in Bulgaria, Greece, Russia and Ukraine (Revertè *et al.*, 2023). In Italy it has been reported only in Sicily and, therefore, is a new report for the peninsular Italy. In addition, the last record in Sicily was in 1860 (Comba, 2019). Two females (Fig. 3.10) of this species were collected by pitfall traps on 08/06/2022 in Fbio. The samples were determined on both morphological basis by Federica Mendicino, Unical and Achik Dorchin, UniMons.

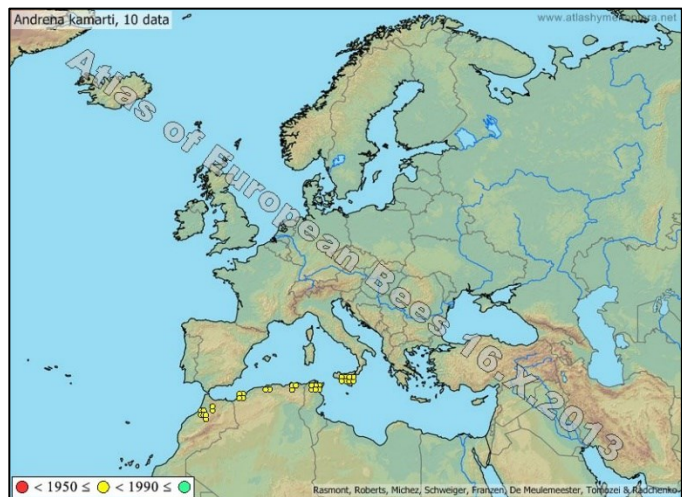


Figure 3.10 Photo of *Eucera albofasciata* female. **A:** dorsal view; **B:** lateral view; **C:** head; **D:** abdomen
(F. Mendicino)

3.13.3 *Andrena (Chlorandrena) kamarti* Schmiedeknecht, 1900

This species is part of the family Andrenidae and it is a first report for the Italian Mainland. The species has been collected only in Sicily and in North Africa (Wood, 2023). A male was collected by pitfall trap in Pnat on 08/07/2022 while the female on 05/07/2023 by yellow chromotactic trap.

The species was identified on morphological basis by Thomas Wood (Naturality Biodiversity Centre – Netherland) and genetically confirmed.



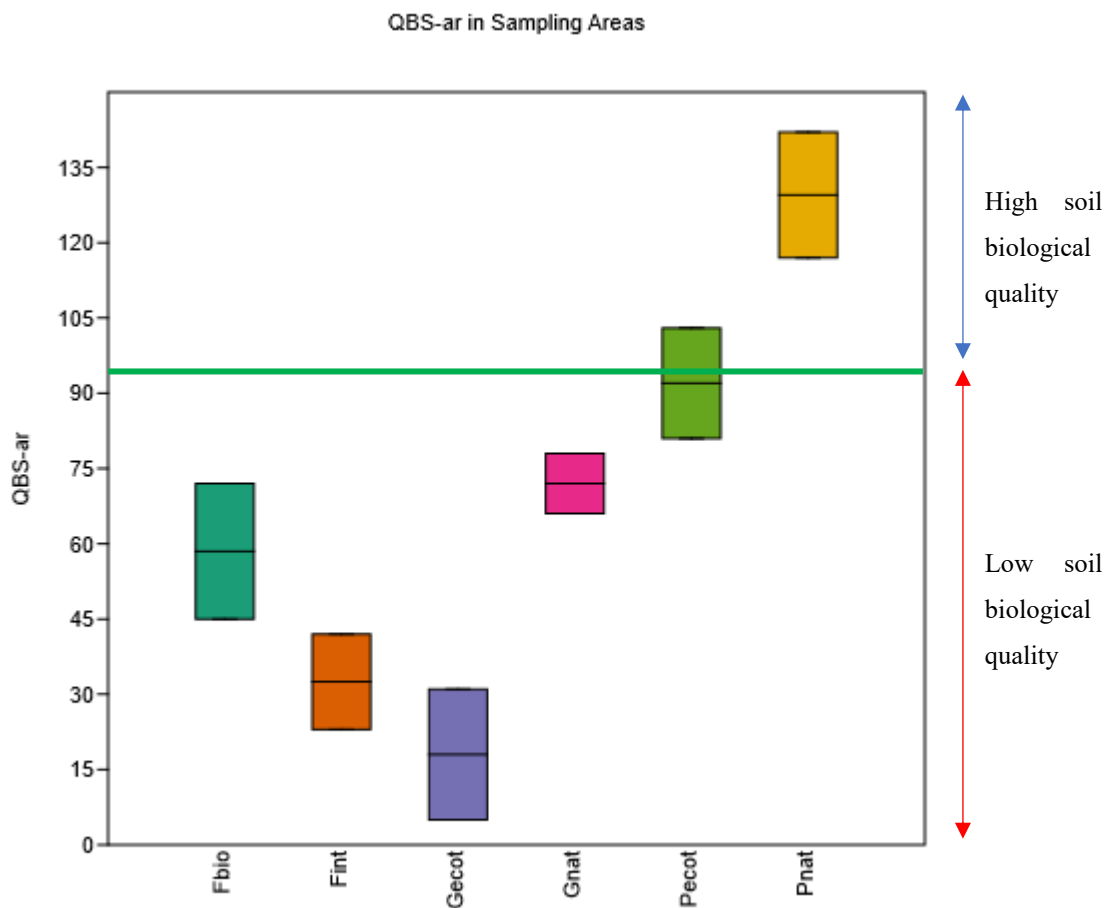
Map 3.3 Distribution of *Andrena kamarti*
(<http://www.atlashymenoptera.net>)



Fig. 3.11 Photo *Andrena kamarti* male. **A:** dorsal view; **B:** lateral view ; **C:** head; **D:** genitalia.
(F. Mendicino)

3.14 QBS-ar of Sampling areas

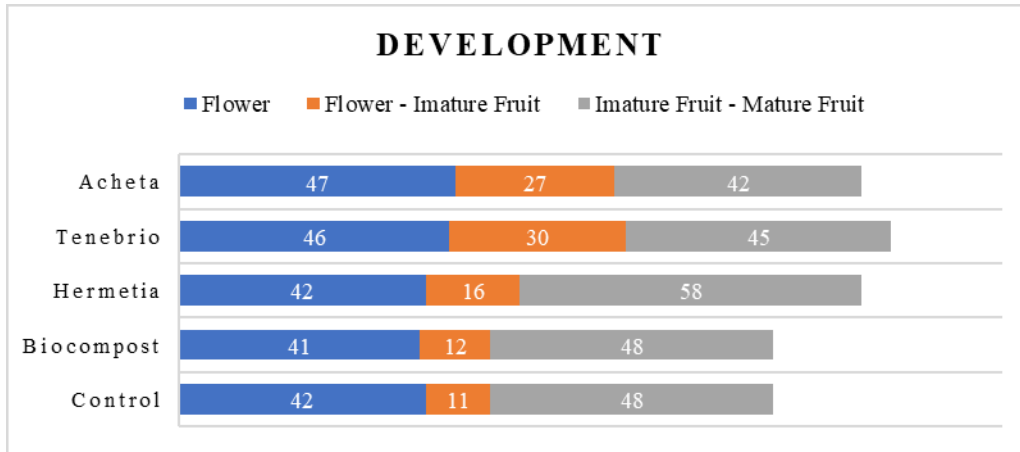
QBS-ar was also analysed in the sampling areas to assess soil quality. In the boxplot created with the software Past, the green line highlights the margin of good soil quality at 93,7, according to Menta *et al.*, 2018. In the graph 3.52 both pine forests show a good soil quality, typical of forest environments, even if Pnat shows a higher biological quality of the soil than the Pecot due to the absence of anthropogenic disturbance and grazing. All other areas have low soil biological quality. Gnat, following the parameters of Menta *et al.* (2018) presents typical values of "Soils in natural degraded conditions" while Fbio the typical values of "agriculture lands". Extremely low values were recorded in Fint and Gecot, indicating a strong anthropogenic disturbance and poor soil quality.



Graph 3.52 Box-plot of QBS-ar in sampling areas (Software Past; Menta *et al.*, 2018)

3.15 Frass

About the testing of organic fertilisers, there are several results. As regards the time of development (graph 3.53), from the day of repotting until the first ripe fruit, the plants that developed more quickly were those of control and those treated with the organic control (Biocompost). The slowest plants were those treated with *Tenebrio molitor* frass.



Graph 3.53 Development of plant tested

Regarding the number of leaves of the various plants treated, the results show significant differences thanks to the Friedman test on several-sample repeated (chi square= 82,28; p: 3,5893 E⁻¹⁷); these differences are also confirmed by the Wilcoxon pairwise - Bonferroni corrected p values test (Tab 3.31).

Table 3.31 Wilcoxon pairwise – Bonferroni corrected p value of leaves (Software Past)

	Control	Biocompost	Hermetia	Tenebrio	Acheta
Control		0,0001773	0,02947	0,0001229	0,0002001
Biocompost	0,0001773		0,0001229	0,0006766	0,01561
Hermetia	0,02947	0,0001229		0,0001229	0,0001229
Tenebrio	0,0001229	0,0006766	0,0001229		0,0005612
Acheta	0,0002001	0,01561	0,0001229	0,0005612	

As regards the height of the plant, the Friedman test (chi square= 67.355, p:7,7904E⁻¹⁴) shows a significant difference between the different treatments during development, as confirmed by Wilcoxon pairwise - Bonferroni corrected p values. Specifically, there are significant differences between all treatments except between Control vs. *Hermetia* and *Hermetia* vs. *Acheta* (Tab. 3.32).

Table 3.32 Wilcoxon pairwise – Bonferroni corrected p value of height of plants (Software Past)

	Control	Biocompost	Hermetia	Tenebrio	Acheta
Control		0,0004613	1	0,0004613	0,002947
Biocompost	0,0004613		0,000401	0,02155	0,000401
Hermetia	1	0,000401		0,000401	0,7157
Tenebrio	0,0004613	0,02155	0,000401		0,000401
Acheta	0,002947	0,000401	0,7157	0,000401	

Also, regarding to the number of flowers, the Friedman test (chi square= 27,611; p:1,2816E⁻⁰⁵) shows that there are significant differences in the development between the diverse treatments, especially as indicated by the Wilcoxon pairwise - Bonferroni corrected p values, between Control vs. *Hermetia*, Control vs. *Tenebrio* and *Hermetia* vs. *Tenebrio* (Tab. 3.33).

Table 3.33 Wilcoxon pairwise – Bonferroni corrected p value of number of flower (Software Past)

	Control	Biocompost	Hermetia	Tenebrio	Acheta
Control		0,0004613	5,722E ⁻⁰⁵	0,000114	0,05375
Biocompost	0,4867		1	0,8743	1
Hermetia	5,722E ⁻⁰⁵	1		0,04749	1
Tenebrio	0,000114	0,8743	0,04749		0,9551
Acheta	0,05375	1	1	0,9551	

About the number of fruits, the Friedman test show significant differences (chi square= 35.4; p: 3.9973 E⁻⁰⁷) in the development trend and, as shown by the Wilcoxon pairwise - Bonferroni corrected p values, there are significant differences between all groups except between Biocompost vs. *Hermetia*, *Hermetia* vs. *Acheta* and *Acheta* vs. *Tenebrio* (Tab. 3.34).

Table 3.34 Wilcoxon pairwise – Bonferroni corrected p value of number of fruits (Software Past)

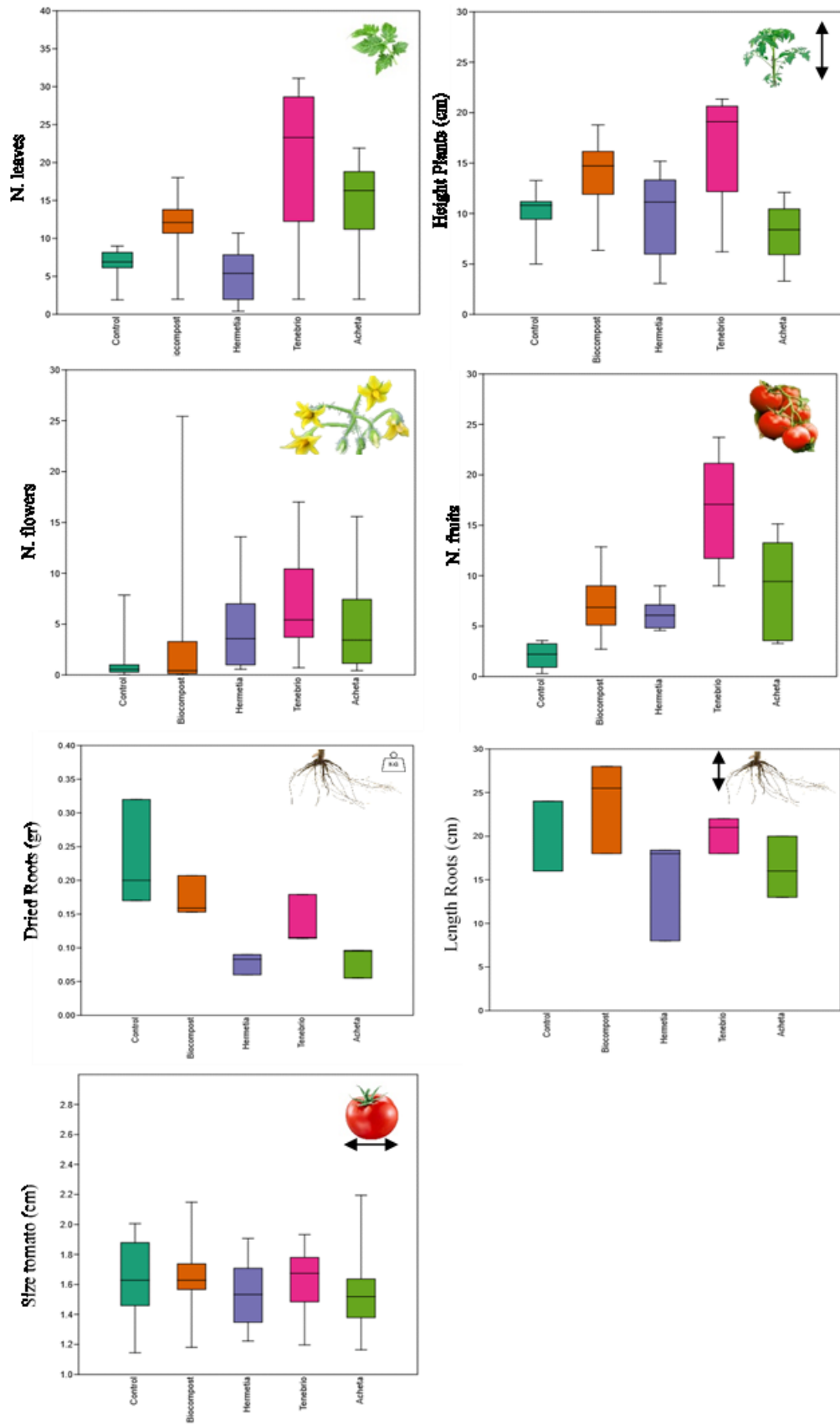
	Control	Biocompost	Hermetia	Tenebrio	Acheta
Control		0,007322	0,007322	0,007322	0,05375
Biocompost	0,007322		0,6712	0,007322	1
Hermetia	0,007322	0,6712		0,007322	1
Tenebrio	0,007322	0,0007322	0,007322		0,1635
Acheta	0,007322	1	1	0,1635	

As regards fruit size, the Kruskal-Wallis test shows a significant difference between the medians (chi square= 10.74; p: 0.01321), although the Dunn's post hoc-Bonferroni corrected p values show no significant differences between individual groups. Finally, the dry weight shows a significant difference between the medians (Anova Kruskal-Wallis test, chi square= 11,4; p: 0,02242) although the Dunn's post hoc - Bonferroni corrected p values show no significant differences between the various groups while, about the size, the Kruskal-Wallis test (chi square: 5,358; p: 0,2472) does not show significant differences between the different treatments.

The graph 3.54 show the value of the various parameters measured weekly. Plants treated with the *Tenebrio* and *Acheta* frass produced on average many more leaves, while those that produced less are plant treated with the *Hermetia* frass. In general, plants treated with frass show a wider range, as they have a greater variability in the number of leaves, while Biocompost and control show a rather stable distribution, although with lower values than the plants treated with *Tenebrio* and *Acheta*.

Also, as regards the measured height of the plant, the ones treated with *Tenebrio* frass were the highest, followed by those treated with Biocompost. The lowest average height is observed in plants treated with *Acheta's* frass. In this case, plants treated with the *Tenebrio* and *Hermetia* frass show a greater variability in plant height, while the other treatments are more stable. In addition, plants treated with frass, especially of *Tenebrio*, produced more flowers, while the control produced fewer flowes. The Biocompost, on the other hand, has an upper outlier, showing that there was plant with a greater number of flowers than average. Finally, as regards the number of fruits, plants treated with frass have the greatest number of fruits, while the Control has the least number of fruits.

The size of the fruits in the control has a relatively higher median than other groups while the smallest are those of plants treated with the *Acheta* frass. The other three treatments are quite similar, although *Hermetia* has a longer range than Biocompost which seems stable, even if it has outliers. At the end, as far as the roots are concerned, the plants of Control have a higher dry weight, while those of *Hermetia* have the lowest dry weight. Finally, the plants with Biocompost have a longer root system, while those of *Hermetia* are the smallest.



Graph 3.54 Boxplot of weekly plant response (Software PAST)

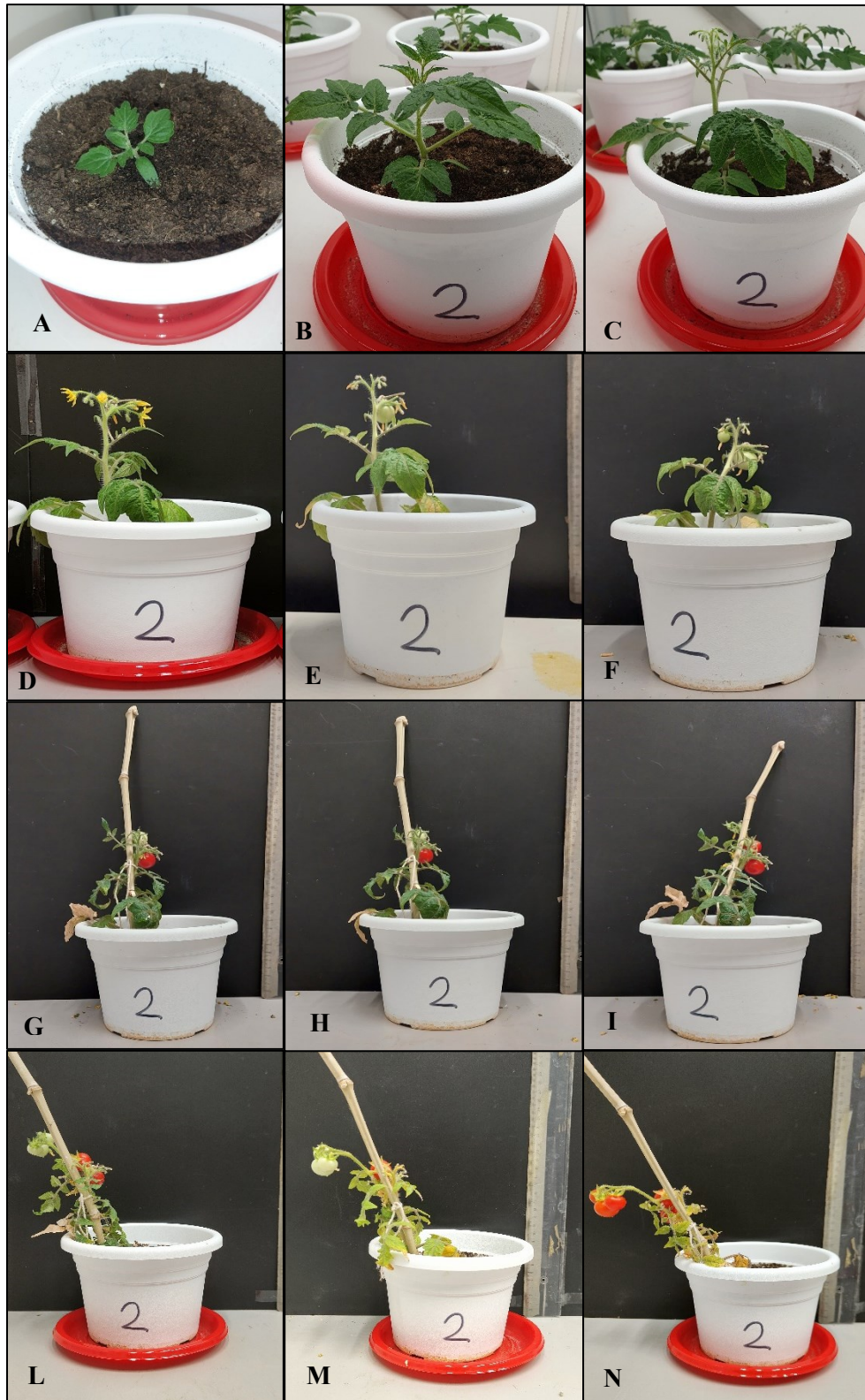


Figure 3.12 Control Plant. **A:** 0-day, **B:** 21 days, **C:** 35 days, **D:** 49 days; **E:** 63 days, **F:** 77 days, **G:** 98 days, **H:** 105 days, **I:** 119, **L:** 140 days, **M:** 154 days, **N:** 168 days (F. Mendicino)

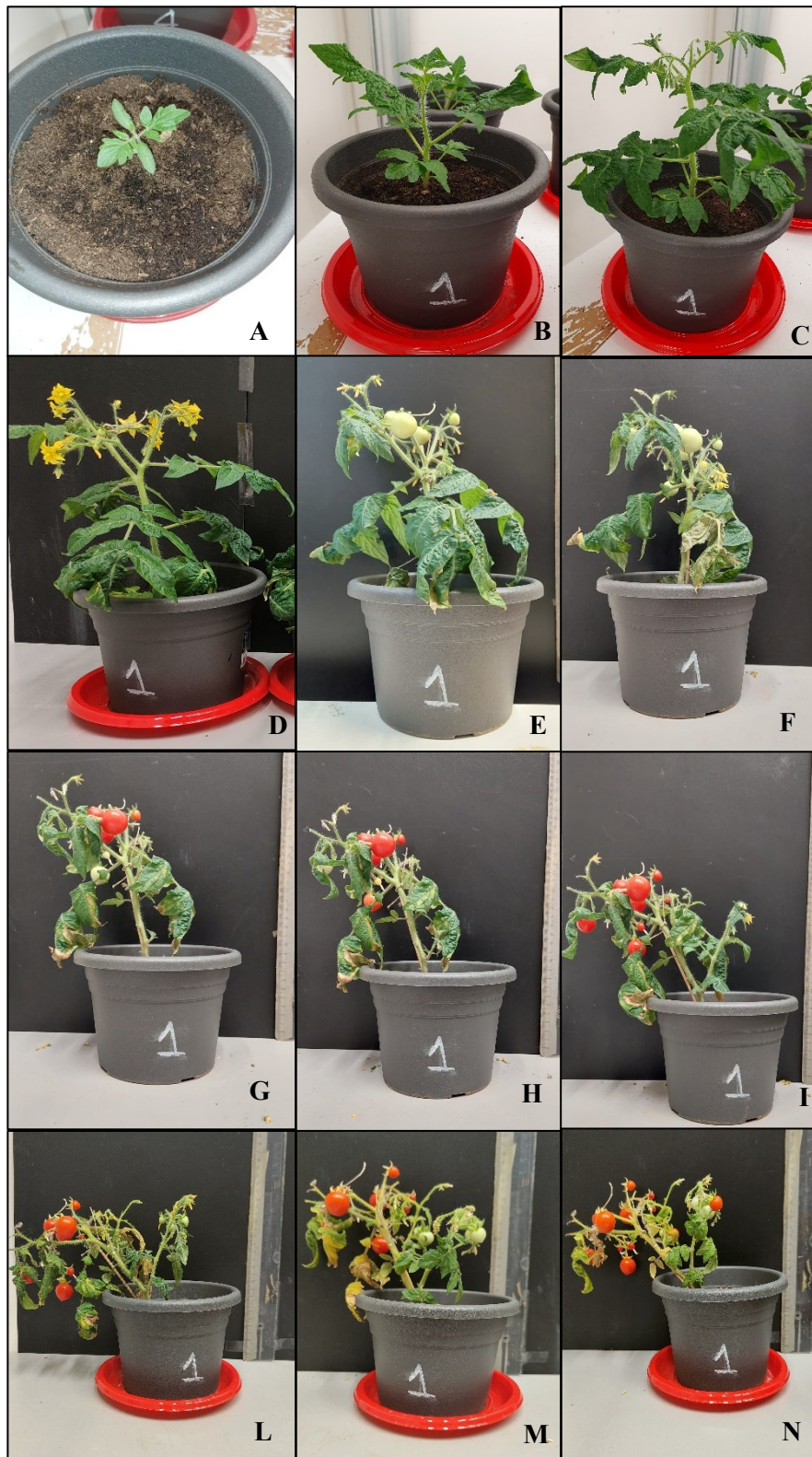


Figure 3.13 Biocompost. **A:** 0-day, **B:** 21 days, **C:** 35 days, **D:** 49 days; **E:** 63 days, **F:** 77 days, **G:** 98 days, **H:** 105 days, **I:** 119, **L:** 140 days, **M:** 154 days, **N:** 168 days (F. Mendicino)

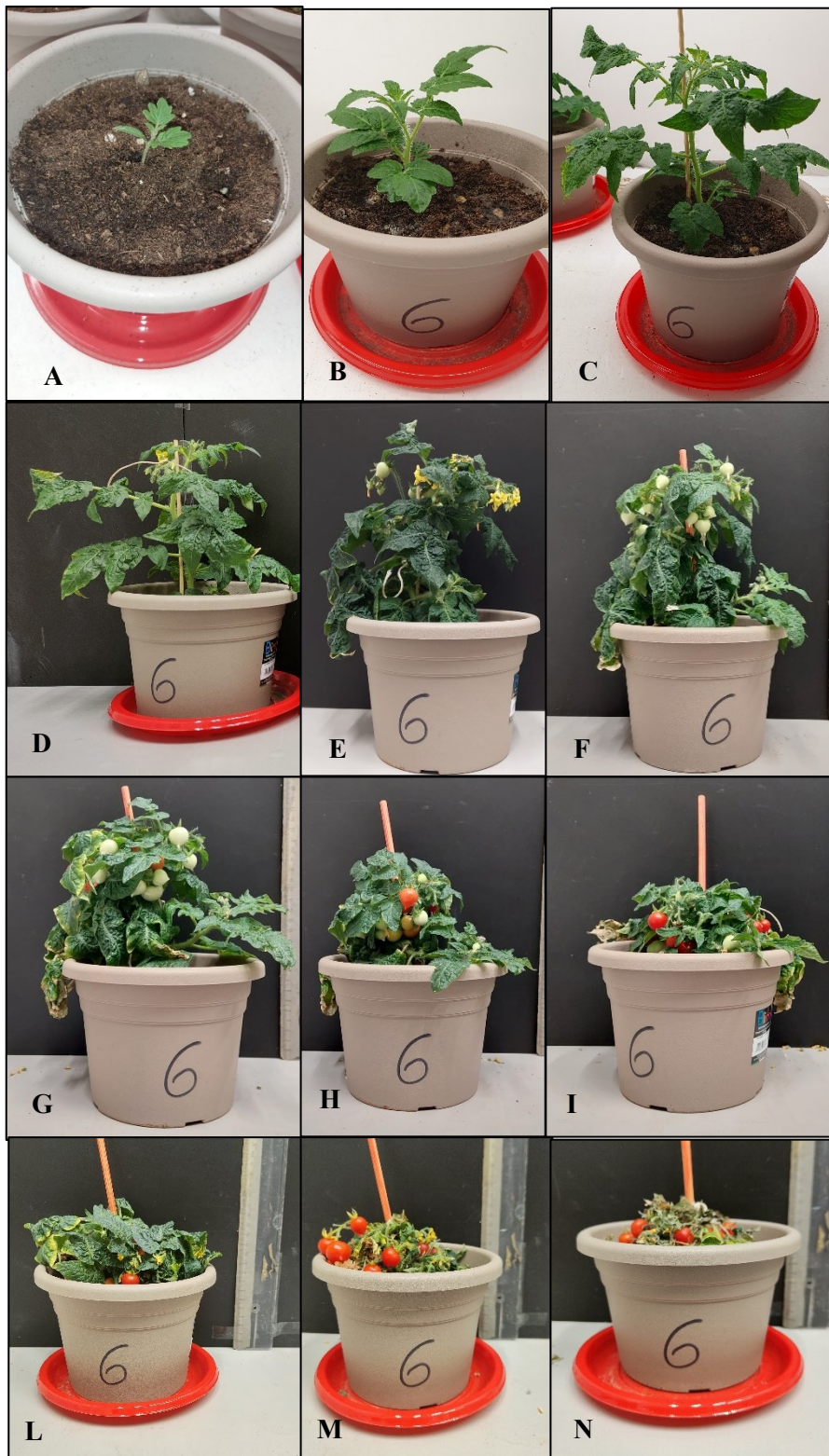


Figure 3.14 *Hermetia illucens*. A: 0-day, B: 21 days, C: 35 days, D: 49 days; E: 63 days, F: 77 days, G: 98 days, H: 105 days, I: 119, L: 140 days, M: 154 days, N: 168 days (F. Mendicino)

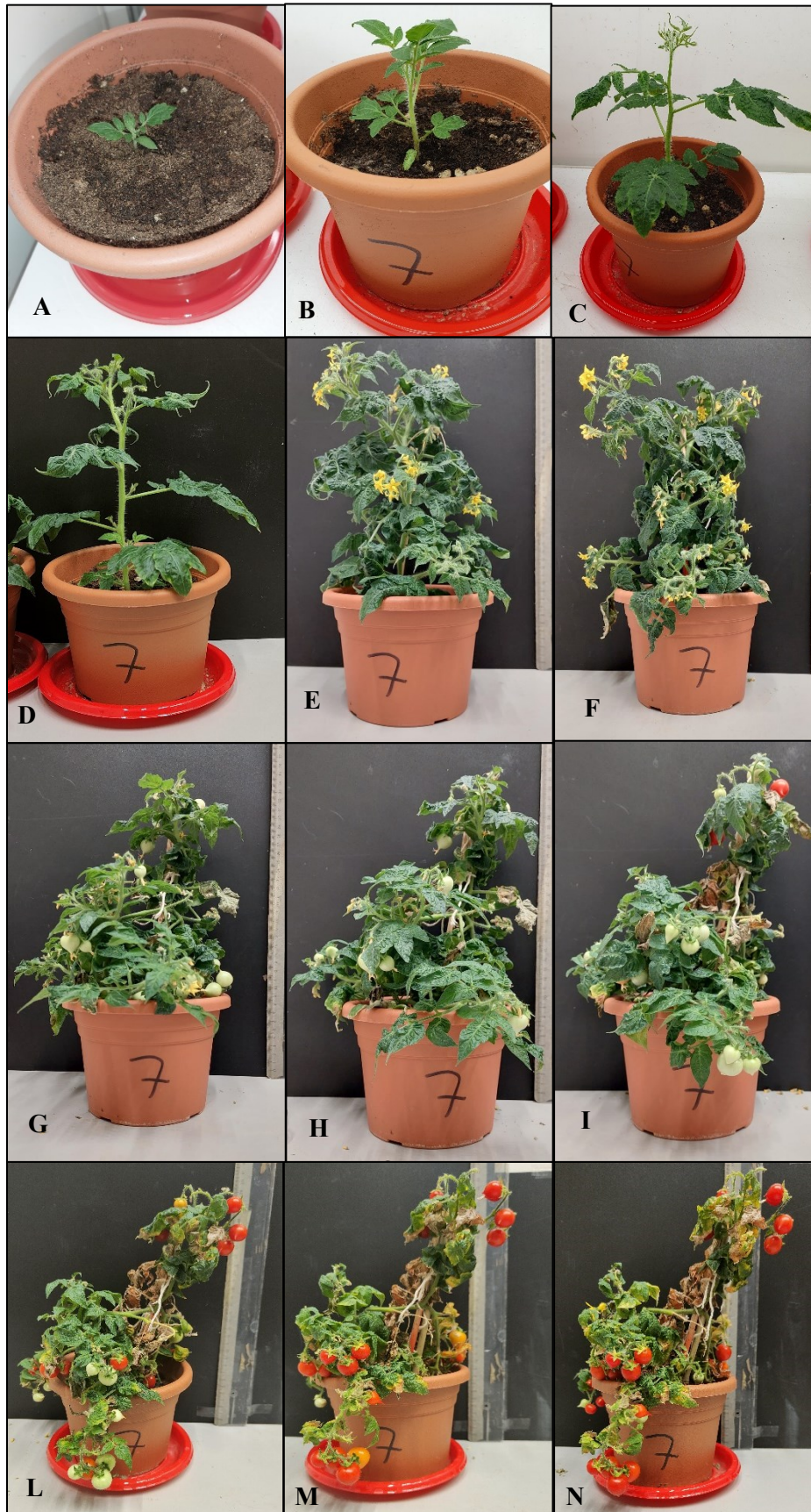


Figure 3.15 *Tenebrio molitor*. **A:** 0-day, **B:** 21 days, **C:** 35 days, **D:** 49 days; **E:** 63 days, **F:** 77 days, **G:** 98 days, **H:** 105 days, **I:** 119, **L:** 140 days, **M:** 154 days, **N:** 168 days (F. Mendicino)

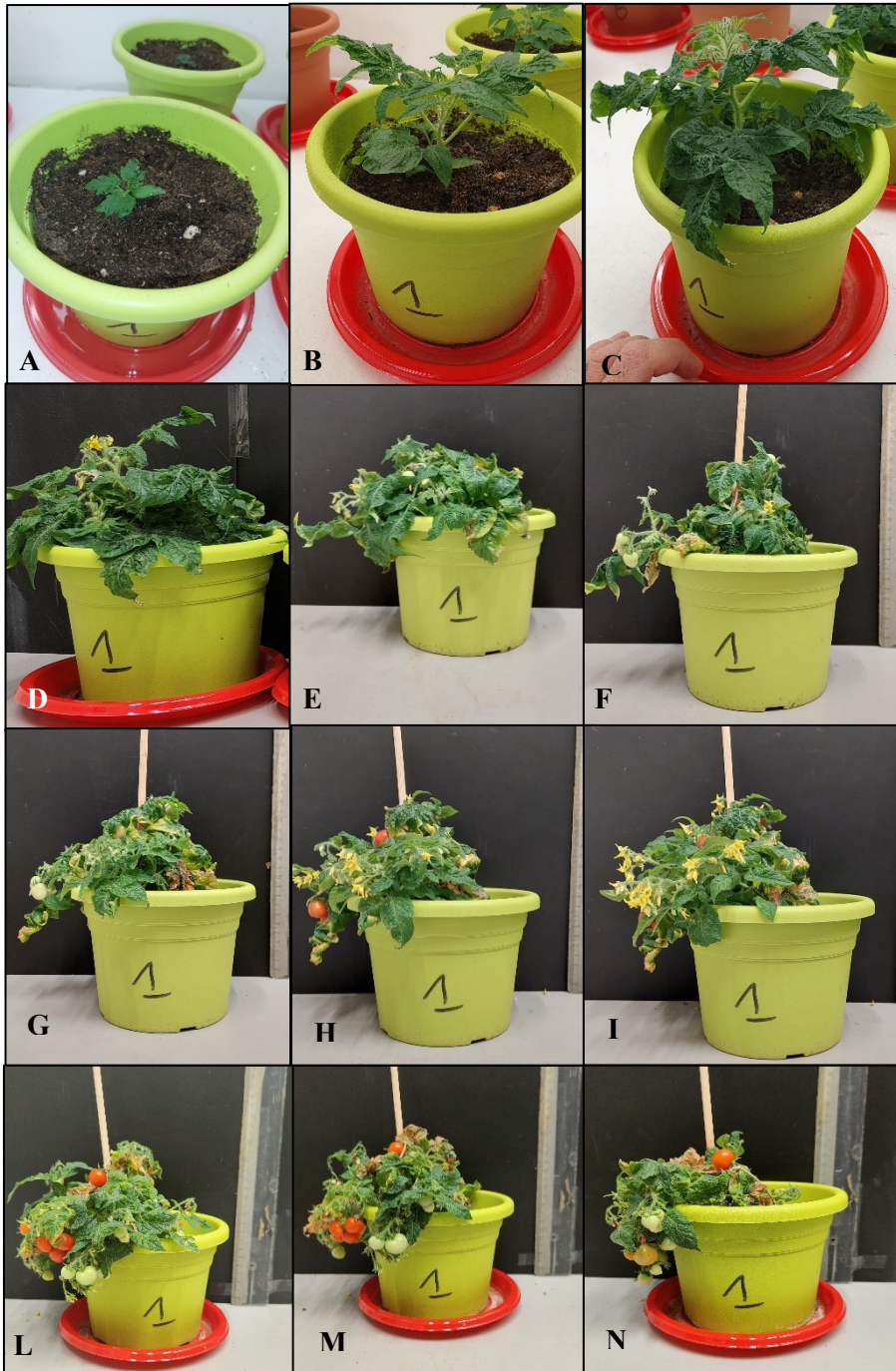


Figure 3.16 *Acheta domesticus*. **A:** 0-day, **B:** 21 days, **C:** 35 days, **D:** 49 days; **E:** 63 days, **F:** 77 days, **G:** 98 days, **H:** 105 days, **I:** 119, **L:** 140 days, **M:** 154 days, **N:** 168 days (F. Mendicino)

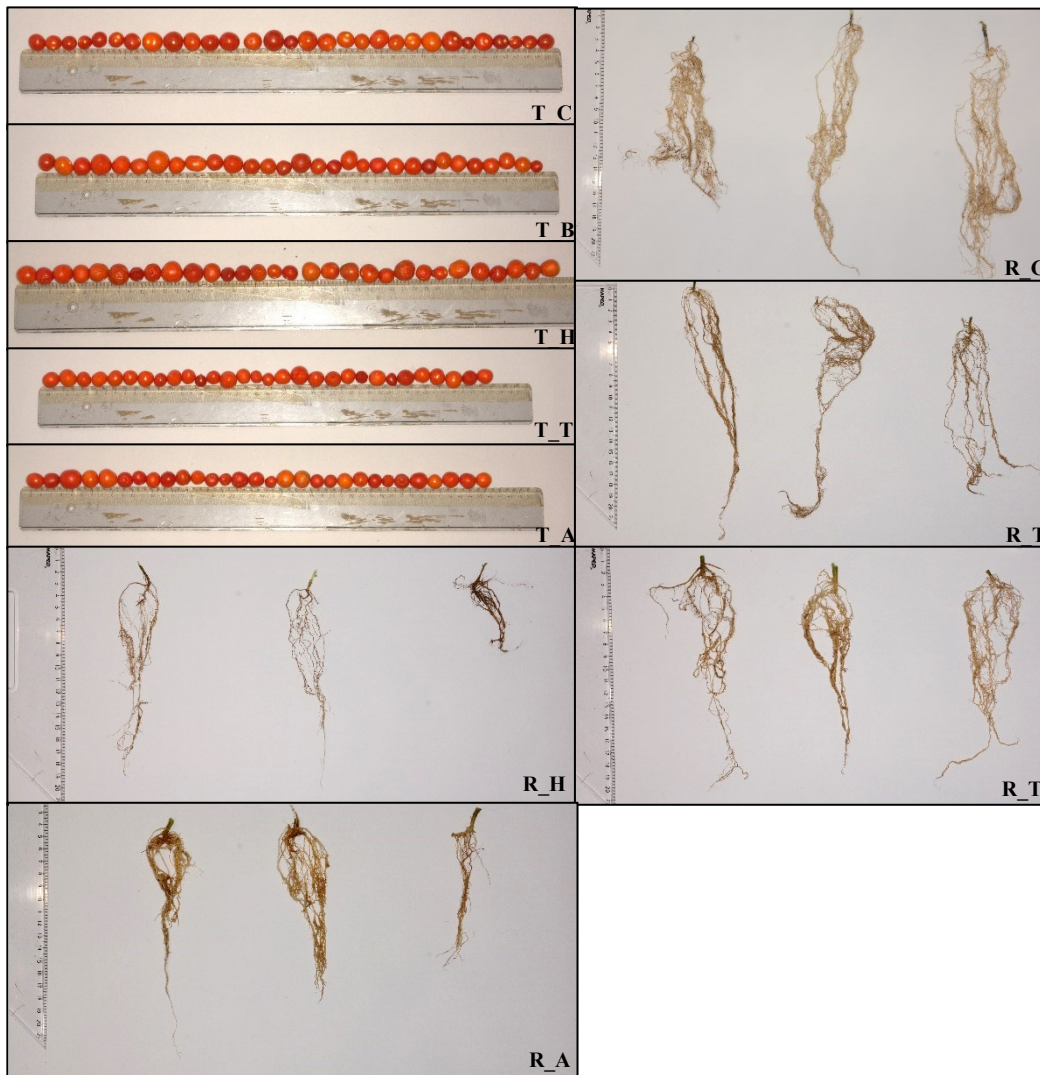
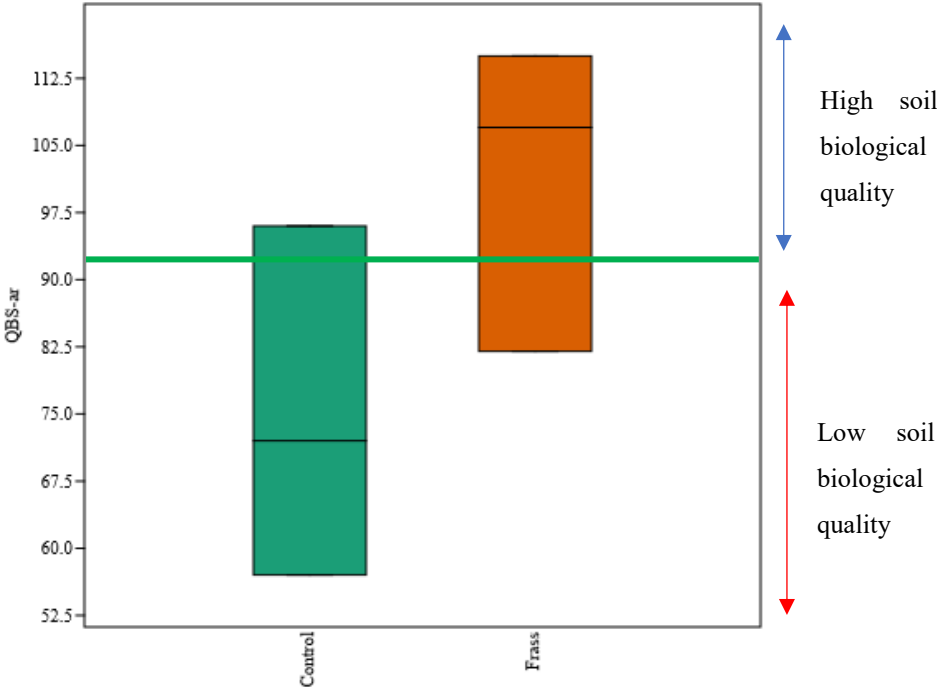


Figure 3.14 Tomatoes and roots measured **T_C**: Tomato control, **T_B**: Tomato Biocompost, **T_H**: Tomato Hermetia, **T_T**: Tomato Tenebrio, **T_A**: Tomato Acheta, **R_C**: Roots Control, **R_B**: Roots Biocompost, **R_H**: Roots Hermetia, **R_T**: Root Tenebrio, **R_A**: Roots Acheta (Foto: F. Mendicino)

3.16 Field trials of *Tenebrio molitor* frass

From the field experiments with the *T. molitor* frass, the box plot (Graph 3.55) shows how the soil treated with this biofertilizer have a much higher quality than the control. The median of the QBS-ar values of the control plot is in a low biological quality of the soil, while that of the plot treated with frass is in a high biological quality of the soil. In addition, the plot with frass, according to Menta *et al.*, 2018, has a typical value of Soils in natural degraded conditions while the plot control of the transition values between this and Agriculture land.



Graph 3.55 QBS-ar of sperimental plot with *Tenebrio* frass (Software PAST)

4. Discussion

The agroecosystems of the Sila Plateau are located in a peculiar landscape context, characterized by natural and semi-natural ecotones, which create unique environmental traits to be enhanced and protected. This pioneering project has allowed a better knowledge of insects present to assess their conservation status and their role in the ecosystems. This research also provides a better understanding about the ecosystems health through the analysis of bioindicators, which can contribute to the comprehension of ecological dynamics and species distribution. Biological and genetic biodiversity, as well as habitat, is threatened by human activities such as the use of chemical pesticides, fungicides and herbicides, but also habitat fragmentation and climate change (Colazza *et al.*, 2018; PNR 2021-2027).

The natural grassland ecosystem (Gnat) shows the highest diversity than other areas investigated because the presence of a wider vegetation diversification while the agricultural fields and the ecotone grazing area (Gecot) have similar levels of diversity; on the other hand, despite being characterized by a biological management of the soil, Fbio has lower biodiversity values than Fint and Gecot precisely because of the limited interconnections with adjacent natural areas. More specifically, despite being integrated management field, Fint has ecotonal areas that bring useful faunistic elements to the agricultural system. In fact, Gecot is a reservoir of biodiversity which represent a transition area between natural environments and agricultural fields that allows the overlap between several communities (Wielgolaski *et al.*, 2017) and ensure shelter/reproduction sites not subject to mechanical soil treatment. As for the pine forests, they have a rather low biodiversity values, with the ecotonal pine forest (Pecot) better structured than the natural pinewood. Nevertheless, in the natural pine forests (Pnat) saproxylic insects at risk of extinction and of high natural value have been observed.

An aspect that deserves particular attention is the correlation of species with areas. In the agrosystems we have a greater number of species, compared to the natural grazing area and the two pine forests; each of them presents exclusive species, unlike Fbio, Fint and Gecot which instead show communities of similar species. In addition, because of the overlap of species, the entomological communities of Fint and Gecot have a high degree of similarity. This confirms that, despite the ecological differences between a grazing area and a managed agricultural field, there is overlap and exchange of species between adjacent areas. Fbio differs slightly from Fint and Gecot, indicating that the community in this habitat shows significant differences compared to Fint and Gecot, due to different management and natural context. Gnat differs from the fields and the ecotonal area, as well as being totally different are the communities of the pine forests.

As far as the phytophagous insects, Fint have a greater diversity of phytophagous than Fbio even if this last one shows a greater richness of harmful insects. Several species related to the biological field (Fbio) are reported in literature (Pollini, 2013) as potential pest, such as the pest of cruciferous vegetables (*Eurydema oleracea*, Hemiptera: Pentatomidae), the potatoes alien pest (*Leptinotarsa decemlineata*, Coleoptera: Chrysomelidae), the beet pest (*Bothynoderes affinis*, Coleoptera: Curculionidae) and the pest of fruit trees (*Urophorus humeralis*, Coleoptera: Nitidulidae); these species can attack different agricultural crops

present on the farms, where they can feed both on the fruits and the leaves of the plants. Closely associated to the natural pine forest we have the Drosophilidae *Drosophila suzukii* (Diptera: Drosophilidae) which is an Asian alien species and pest of red fruits typical of the pinewood undergrowth. In addition, in the ecotonal pine forest we find the presence of *Phyllotreta undulata* (Coleoptera, Chrysomelidae), a phytophagous of Euphorbiaceae and Cruciferae. Fint and Gecot are correlated with the cereal pests (*Oryzaephilus surinamensis*, Coleoptera: Silvanidae and *Nephrotoma* sp., Diptera: Tipulidae), the red fruits pest (*Dolycoris baccarum* Hemiptera: Pentatomidae) and the cereal and potatoes pest (*Eurydema ornata* Hemiptera: Pentatomidae). These species could be harmful to fruit orchards and cereals crops present in the farm. Although there are not many pests and therefore there are a good condition of balance, the damage recorded in Fbio is due to the presence of *Leptinotarsa decemlineata* while in the farm Fattoria Pupo, damage was reported to red fruits by *Drosophila suzukii* (Diptera: Drosophilidae) and to potatoes tubers by larvae of *Agripnus murinus* and *Agriotes* sp. (Coleoptera: Elateridae). The population of *D. suzukii* was reduced by using a bait traps composed by apple cider vinegar, red wine and cane sugar, while entomopathogenic nematodes of the species *Steinernema carpocapsae* of Koppert company were used to reduce the population of Elateridae larvae. Both methodologies had positive responses, excluding the use of synthetic substances.

Predators are greater in Fint and Gecot. In the agrosystems we have abundance of Coccinellidae, known for their active predation especially of aphids; in the ecotonal pine forest we have the Staphylinidae and Elateridae, while in the natural pine forest we found others Elateridae and saproxylic predators, like *Cucujus cinnaberinus*. The predator community, therefore, differs between different ecosystems.

As for the carabidofauna, in the agrosystem (Fint, Gecot and Fbio) we have a greater diversity than the pine forests and the natural grazing area, just because among them are so many potential antagonists of pest. In the pine forests, especially in the natural one, however, we found not only endemic species, such as *Calathus montivagus*, *Carabus lefebvrei* and *Cychrus italicus*, but also NT species like *Clinidium canaliculatum*. As for the similarity of the community, we have the formation of three distinct groups: Fint and Gecot, Gnat and Fbio and the two pine forests. This means that there is a difference in the distribution of species not only by habitat but also by land use. While the integrated field has a similar biogenesis to its ecotone as a result of species interpenetration, the carabidofauna of the biological field is similar to the natural grazing area (Gnat). Thus, indicating that there is a better environmental quality, more similar to a natural area than another agrosystem. The correlation between the species of ground beetles and the sampling areas showed clear differences. Species correlated to Pecot are *Nebria kratteri*, *Notiophilus substriatus*, *Ophonus puncticollis* and *Carabus presli*, while the others correlated to Pnat are *Pterosticus melas*, *Notiophilus rufipes*, *Cychrus italicus*, *Carabus lefebvrei*, *Clinidium canaliculatum* and *Abax parallelepipedus*: these are all zoophagous and almost brachypterous species and this confirms that the pine forests, especially the natural ones, are stable environments rich of natural interest species. All other species collected are related to grazing areas and agricultural fields, showing an environmental preference based on their trophic strategies. In addition, in these areas, the species identified are all macropterous or

dimorphic, capable of moving rapidly following sudden changes in agricultural or grazing environments. As regards, however, the trophic regime, while generalists are mainly related to agrosystems (demonstrating how these environments are disturbed and not stable), zoophagous species are linked to both Pine Forests, which are more stable environments, and in Fint, which is an area with a rich presence of phytophagous individuals that may represent potential prey. The distribution of ground beetles depends on land use, but also on tree cover: *N. biguttatus*, *N. substriatus* and *C. montivagus* prefer forest environments while other species such as *C. canaliculatum*, *C. lefevbrei*, *A. parallelepipedus* and *Syntomus impressus* are linked to climax forest with decay wood. Moreover, in Fbio, Fint and Gecot, due to agricultural practices and the mechanical working of the soil associated with sowing, the peaks of abundance of ground beetles are concentrated in the months of August, September and October, while in the pine forest and in natural areas there are peaks of presence also in June and July. Finally, the species distribution is also indicative of the environmental quality. In Pnat there is an abundance of mainly endemic and eumediterranean species, with a restrict distribution, which indicates a rather stable environmental condition. In Pecot the species found have a wider distribution, up to the southern Apennines, indicating also a stable environment although lesser than Pnat. In Gnat the species have a Euro-Mediterranean distribution while in Fbio, Fint and Gecot are both Euro-Mediterranean and Palearctic, therefore with a wider distribution. Species with a wide distribution have less restricted ecological preferences and their presence may indicate fewer stable soils. To conclude, data collected shows that land management has a significant impact on the composition and diversity of carabidofauna.

Saproxylic insects, for the majority Coleoptera, are linked at least in one phase of their life cycle to rotting wood (Calix *et al.*, 2018). They are fundamental because, feeding on dead wood, they put back in circulation important nutrients and due to wrong silvicultural practices are protected and included in the red list of the Italian saproxylic beetles of the IUCN. *Pycnomerus italicus* Fam: Zoopheridae (EN) was collected exclusively in Pnat. This shows optimal forest management compared to Pecot. Vulnerable species were found only in pine forests (*Ipedia binotata* and *Phyllodrepa salicis* Fam: Nitidulidae; *Ampedus sinuatus* Fam: Elateridae; *Cucujus cinnaberinus* Fam: Cucujidae), while species NT are collected in pine forests and less in other areas, such as *Clinidium canaliculatum*, *Oxypleurus nodieri* and *Pogonocherus decoratus* (Fam: Cerambycidae), *Pediacus dermostoides* (Fam: Cucujidae), *Dacne rufifrons*, *Triplax lacordarii* and *Triplax marseuli* (Fam: Erotilidae), *Lygistopterus anorachilus* (Fam: Lycidae), *Rushia parreyssi* (Fam: Melandridae) and *Glischrochilus quadrisignatus* (Fam: Nitidulidae). In addition, the xylophagous species are related to the agricultural fields and to Gecot both for the presence of shrubs and fruit trees and for the agility of the adults. In the natural pine forest, on the other hand, the species fall into the group of saproxylics, zoophagous of saproxylics and mycetophagous, as they are extremely related to dead wood in decomposition. In Pecot we find the species that feed on fermented sap produced by previous xylophagous attacks.

The pollinators collected during this research project include Coleoptera, Diptera, Lepidoptera and Hymenoptera. Among these, the Syrphidae, Diurnal Lepidoptera and Apoidea are considered of primary

importance, while the other taxa are considered secondary pollinators as they do not present morphological adaptations that make them specialists. Beetles and other families of Diptera are less specialized pollinators, although they may help to compensate the reduced pollination rate due to the bees decline (Potts *et al.*, 2021; Muinde & Katumo, 2024), particularly in agroecosystems. The area with the greatest biodiversity of pollinators in general is the area of natural grazing; however, if we consider only the specialized pollinators, the most biodiverse area is Fbio which has a good equipartition of species too. The difference compared to other sampling areas may be associated with the not use of pesticides to which specialized pollinators are particularly sensitive, and also for the lack of grazing that reduces the amount of floral essences.

In the biological field the flower visitors are mainly dipterans of the families Anthomyiidae (*Eustalomyia* sp.; *Botanophila* sp. and *Lasiomma* sp.), Calliphoridae (*Cynomya mortorum* and *Protocalliphora azurea*) and Tachinidae (*Cylindomya intermedia*, *Nowickia strobili* and *Tachina casta*); among Coleoptera there is Cerambycidae (es. *Chlorophorus sartor*) and Buprestidae (es. *Anthaxia millefolii*). The integrated field (Fint) and the ecotonal area (Gecot) share species, specifically Crabronidae (es. *Oxybelus subspinosus*) and beetles Cetoniidae (es. *Tropinota squalida*), Dasytidae (es. *Divaes bipustulatus*) and Phalacridae (es. *Olibrus* sp.). In Gnat there are Tenthreniidae (es. *Nematus myosotidis*) and Vespidae (es. *Ancistrocerus* sp.), the Diptera Anthomyiidae (es. *Hylemyia* sp.) and Calliphoridae (es. *Lucilia caesar*). Linked to Pecot there are the Coleoptera Cantharidae (es. *Metacantharis clypeata*) and the dipterans Anthomyiidae (es. *Pegomyia* sp.), Bibionidae (es. *Bibio* sp.) and Muscidae (es. *Phaonia tuguriorum*). In Pnat among beetles there are Cantharidae (*Malthinus* sp. and *Rhagonycha lignosa*), Cerambycidae (es. *Anastrangalia dubia*) and Oedemeridae (es. *Oedemera femorata*) while about dipterans there are Fanniidae and Tabinidae (es. *Hybomitra* sp.). There is, therefore, a different distribution of species according to the different habitats.

As regards the specialized pollinators, the agricultural fields are the richest species to which are associated Diptera Bombyliidae (es. *Usia* sp.) and Syrphidae (*Eristalis* sp. and *Shaerophoria scripta*). Among the Hymenoptera there are above all the Andrenidae (*Andrena cinerea*, *Andrena pilipes*, *Andrena gravida* and *Andrena curvungula*), the Colletidae (*Colletes mlokosiewiczzi*, *Hylaeus imparilis* and *Hylaeus sinuatus*), the Halictidae (*Halictus scabiosae*, *Lasioglossum albocinctum*, *Lasioglossum griseolum*, *Lasioglossum interruptum*, *Lasioglossum laticeps*, *Lasioglossum laevigatum*, *Lasioglossum leucozonium* and *Lasioglossum xanthopus*) and finally, the Apidae *Anthophora balneorum*. In the natural grazing area there are mainly the Lepidoptera Nymphalidae (es. *Vanessa cardui*), the Pieridae (*Aptoria crataegi* and *Euchloe ausonia*) and the Diptera Syrphidae (es. *Merodon aeneus*). About pine forests, the groups associated are the Lepidoptera Nymphalidae (*Pararge aegeria*) and the Hymenoptera of family Andrenidae (*Andrena dorsata*, *Andrena fucata*, *Andrena minutuloides*, *Andrena minutula* and *Andrena trimmerana*), Colletidae (es. *Hylaeus communis*) and Halictidae (*Halictus alfkenellus* and *Lasioglossum laeve*).

For wild bees, the areas with the greatest biodiversity are Pnat and Fbio, due to the absence of human activity, in the former environment, and pesticides and grazing in the latter. Gnat is the area with the lowest bee biodiversity due to the presence of intensive and massive grazing that alters the vegetation composition and the diverse presence of floral essences. The results underline the importance of preserving and

improving habitats in areas with high diversity such as Pnat and Pecot, and investigating and mitigating limiting factors in other areas. In addition, although we have a lower level of biodiversity in Fint, we find several NT species with high ecological value in this area precisely because of the transition areas. The distribution of wild bees is influenced by several factors, such as land use, rainfall and vegetation cover. Interesting is how the species are distributed according to trophism: the polygolectic species, in fact, are much more abundant in the transept Fbio, Fint and Gecot than in other areas. The majority of the oligolectic species are present in Pnat and in the agricultural fields, while few species are in Gnat and Pecot: if in Pecot the flowers in the undergrowth are rather absent, in Gnat massive grazing in the area influences the bee communities. As regards sociality, the social species are present mainly in crops and in Gecot; solitary bees are abundant in the agricultural transept because of the possibility of nesting in the surrounding areas. In those areas, in fact, there are many species that nest in the soil, while in Gnat the species that nest on the ground are equally abundant as those that nest inside the wood.

Several wild bees are in the European red list of species (the Italian red list is currently incomplete). The endangered species were collected in pine forests, while the near threatened species were found in pine forest and in grazing areas. In particular, one of the EN species is *Lasioglossum laeve*, which is a rare species in Europe and it was collected only in Pine forest, while the NT species are the Halictidae *Halictus quadricinctus*, *Lasioglossum brevicorne*, *Lasioglossum convexiusculum*, *Lasioglossum laevigatum*, *Lasioglossum majus*, *Lasioglossum pygmaeum* and *Lasioglossum xanthopus* and the Apidae *Nomada pleurosticta* and *Nomada armata*. Unfortunately, many species, especially those with a southern distribution, are data deficient: for this reason, it is extremely important to know which species are present in order to apply monitoring plans.

The genetic analysis of the wild bees has revealed interesting results. Many species are genetically distinct from other European and northern Italy populations; for example, *Anthophora balneorum* (Apidae) is distinct from the French and Spanish population while the Colletidae, *Colletes mlokoszewiczi* is much more similar to the central European populations (Germany and Hungary) than to the population of the Valle d'Aosta. Instead, *Colletes similis* is related to the populations of Bulgaria compared to that of the North-Central Europe. Interesting, then, is the result obtained from the genetic analysis of *H. kahri*. This species has two subgroups, one distributed in northern Europe, while the other in southern Europe and our individuals are genetically much more similar to the central/northern European populations (France, Switzerland and Germany) as to the southern regions (northern Italy, Greece and Albania). This extremely important data confirms not only that both groups are present in the Italian territory, but that this population could represent a biogeographic relict confined to our mountain. The results obtained from the analysis of the Megachilidae are also noteworthy. For example, *Osmia cerinthidis* was collected both in the sampling areas of this research and in other projects conducted in Aspromonte National Park: genetically these population are quite different, indicating that could be isolated populations. In addition, *Osmia tergestinis* is also totally different from other European populations (Spain and France). Among the Apidae, the result obtained with the genetic analysis of *Nomada castellana* appear to be particular interesting: our population

differs not only from other European populations (Spain, Portugal, France, Germany, Russia), but also from the populations of Valle d'Aosta and Lombardy.

In addition, in the Sila plateau there are both species with extensive distribution and species typical of the Mediterranean and Alpine environments; for example, *Lasioglossum immunitum* (Fam: Halictidae) is a species typical of the Mediterranean environments, while species such as *Hylaeus dilatatus* and *Hylaeus incongrus* (Fam: Colletidae) (Straka & Bogusch, 2011), *Sphecodes pseudofasciatus* (Fam: Halictidae) and *Chelostoma grande* (Fam: Megachilidae) are typical of the Northern Italy. Moreover, *Eucera pannonica* (Fam: Apidae) is present only in central Italy, Portugal and Southern France. The species with a wide distribution are, for examples, the Holarctic species *Anthophora plumipes*, *Ceratina cucurbitina* (Fam: Apidae), *Hylaeus kahri* (Fam: Colletidae), *Halictus subauratus* and *Lasioglossum leucozonium* (Fam: Halictidae) but also the palearctic species *Amegilla quadrifasciata* (Fam: Apidae) and *Colletes similis* (Fam: Colletidae).

Finally, *Eucera cineraria*, *Melecta festiva*, *Nomada mutabilis*, *Tetralonia malve* (Fam: Apidae), *Halictus fulvipes*, *Lasioglossum immunitum*, *Lasioglossum pauperatum*, *Lasioglossum semilucens*, *Sphecodes pseudofasciatus* (Fam: Halictidae), *Heriades crenulatus* and *Osmia ligurica* (Fam: Megachilidae) are collected for the first time above 800 m a.s.l. However, there are many new records for the South of the wild bees and this shows the need to continue studying this group. Among these, interesting are the finding of *Eucera albofasciata* which is a new record for the peninsula.

Important is the new record for Calabria of *Oxypleurus nodieri* (Fam: Cerambycidae), *Dacne rufifrons* (Fam: Erotylidae) and *Glischrochilus quadrisignatus* (Fam: Nitidulidae): while the first is a xylophagous species, the other two are mycetophagous and all are included in the red list of Italian saproxylic species with category of risk NT; also interesting is the first record in Calabria of the pest of vegetables and sugar beet *Bothynoderes affinis*.

Among the dipterans, there are several first reports for Calabria, but the most interesting is definitely the forensic indicators *Cynomya mortorum* (Fam: Calliphoridae) (Breat *et al.*, 2015). For the Calliphoridae, remarkable is the further finding of the species *Calliphora rohdendorfi*: this species, collected by our research group for the first time in Italy in 2018, is distributed in central/northern Europe and whose ecological role is not known (Pezzi *et al.*, 2024) and are being further studied.

Several species of medical and veterinary interest were collected during the sampling, which could have disastrous effects on milk and meat production and on animals' health, such as the myiasis agents *Calliphora vicina*, *Calliphora vomitoria*, *Chrysomya albiceps*, *Lucilia ampullacea*, *Lucilia caesar*, *Lucilia sericata*, *Sarcophaga* spp. and *Eristalis tenax*, but also the hematophagous *Stomoxys calcitrans*. There are currently no serious cases reported by farmers, but monitoring of these species is necessary because the climate change could increase their activity; it is also essential to monitor and maintain optimum hygiene conditions of cattle.

Soil arthropods are crucial for nutrient recycling and they contribute to the fertility of the soil. The QBS-ar analyses showed that both pine forests environments, although Pnat shows a higher biological soil quality

than the more ecotonal pine forest. All other areas have low soil biological quality. Gnat, following the parameters of Menta *et al.*, 2018 presents typical values of soils in natural degraded conditions because of intensive grazing, while Fbio shows typical values of agriculture lands. Lower values than standard were recorded in Fint and Gecot, indicating a strong overuse of soil.

The ever-increasing demand for food as a result of the increase in human population requires immediate alternatives to the use of synthetic fertilizers and the mass-produced insect feed is a sustainable and environmentally friendly alternative to natural soil improvers. Plants treated with insect frass fo insects generally have longer development times. As regards the number of leaves, flowers and fruits, plants treated with *Tenebrio molitor* frass are significantly larger value than the other treatments; the size of the fruit, on the other hand, is very similar to that of the other experimental plots, but these showed no significant differences. The root size of plants treated with *T. molitor* frass was also smaller, especially compared to those treated with Biocompost. But even here the difference is not significant. The size of the roots is important because generally larger roots could absorb more water and nutrients (Tajima, 2021), but since there is no significant difference between treatments it does not appear to be a disadvantage. Also, the plants treated with the frass of *Acheta domesticus* and *Hermetia illucens* responded well, especially for the number of flowers and fruits, but they were less efficient. Therefore, the frass obtained from mass breeding of insects (in particular *Tenebrio molitor*), therefore, is not only a sustainable and ecological alternative to the production of synthetic fertilizers but also positively affects the development of the plant compared to organic agents.

The *Tenebrio molitor* frass, moreover, at the same environmental conditions of soil and solar irradiation, has produced a superior biological quality of the soil, assessed by QBS-ar, going from low average values to good quality values. It is known that more arthropods lead to more nutrient recycling and more fertile soil (Gullan & Craston, 2010).

To conclude, this PhD work provides pioneering key aspects of species conservation and understanding of ecological dynamics, providing a basis for future conservation and sustainable management strategies, as well as evaluating possible new biofertilizers that, in addition to lowering costs, could promote a sustainable circular economy. In addition, several important data emerged from this research and numerous faunal elements of economic and ecological importance and the identification of crop-related pests were identified. The agroecosystems of the Sila plateau show a close correlation between soil management and species distribution, also in reference to the presence of ecotonal areas that serve as reservoirs of biodiversity. Agricultural practices that avoid the use of synthetic pesticides, such as organic farming, have been found to be beneficial for the biodiversity of pollinators and natural predators, although the land use negatively affects soil quality and the presence of epigeal species. However, the presence of ecotonal areas has been found to be a predominant factor in risk mitigation, as well as having an important ecological role in the conservation of endangered species and, for this reason, it is extremely important to encourage the maintenance of grassed areas as well as to apply organic farming practices. The presence of saproxylic and predatory species in pine forests underlines the importance of forest management that preserves dead wood

and reduces anthropogenic disturbance. Well managed natural areas bring positive influences towards agrosystems by increasing the diversity of pollinating and antagonist species. Finally, the study of wild bees communities has highlighted the need for further research to monitor the health of wild bee populations, especially in relation to climate change and habitat fragmentation.

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Appendix 1 – Checklist

Below is the checklist of the species collected with their respective qualitative data, trophic categories, IUCN categories (Audisio *et al.*, 2014; Nieto *et al.*, 2014; Balletto *et al.*, 2015; Calix *et al.*, 2018; Quaranta *et al.*, 2018; Vujic *et al.*, 2022) and distribution.

Trophic category: **CLEP**: Cleptoparasite; **CP**: Coprophagous; **D**: Detritivores; **EMA**: Hematophagous; **FV**: flower visitor; **MY**: mycetophagous; **N**: Necrophagous; **P**: Phytophagous; **Par**: Parasite; **POL**: Pollinator; **S**: saprophagous; **SS**: Sarcosaprophagous; **SX**: Saproxilic; **XY**: Xylophagous; **Z**: zoophagous; **ZS**: Zoospermophagous; **?**: unknown

New: **C**: first record for Calabria; **S**: first record for Southern Italy; **P**: first record for Italy Mainland.

Coleoptera

Anobiidae													
Genera/Species	Trophic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Ptinus</i> sp. Linnaeus, 1767	D	Dutto, 2018			X			X	X	X			Angelini, 2020
Anthicidae													
Genera/Species	Trophic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Anthicus niger</i> (Oliver, 1811)	S	Telnov <i>et al.</i> , 2010					X						Angelini, 2020
<i>Anthicus</i> sp. Paykull, 1798	S	Telnov <i>et al.</i> , 2010			X	X	X	X			X		Angelini, 2020
<i>Anthicus tristis</i> W. L. E. Schmidt, 1842	S	Telnov <i>et al.</i> , 2010					X						Angelini, 2020
<i>Hirticomus hispidus</i> (Rossi, 1792)	S	Telnov <i>et al.</i> , 2010			X	X	X	X					Angelini, 2020
<i>Hirticomus quadriguttatus</i> (Rossi, 1792)	S	Telnov <i>et al.</i> , 2010			X		X	X					Angelini, 2020
Apionidae													
Genera/Species	Trophic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	P	Pollini, 2013			X	X	X	X	X				Angelini, 2020
Apionidae													
Genera/Species	Trophic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Acmaeoderella flavofasciata</i> (Piller & Mitterpacher, 1763)	XY/SX	Ceccolini <i>et al.</i> , 2020	LC		X	X		X			X		Angelini, 2020
<i>Acmaeodera</i> sp. Eschscholtz, 1829	XY/SX	Audisio <i>et al.</i> , 2014			X	X		X					Angelini, 2020
<i>Agrilus</i> sp. Curtis, 1825	P	Pollini, 2013			X		X	X					Angelini, 2020
<i>Anthaxia (Melanthaxia) helvetica</i> Stierlin, 1868	XY/SX/FV	Rastelli & Curletti, 2007	LC			X		X			X		Angelini, 2020
<i>Anthaxia mendizabali</i> Cobos, 1965	XY/SX/FV	Audisio <i>et al.</i> , 2014	LC				X						Angelini, 2020
<i>Anthaxia (Haplantaxia) millefolii</i> (Fabricius, 1801)	XY/SX/FV	Audisio <i>et al.</i> , 2014	LC		X								Angelini, 2020
<i>Anthaxia (Anthaxia) nitidula</i> (Linnaeus, 1758)	XY/SX/FV	Audisio <i>et al.</i> , 2014	LC			X	X						Angelini, 2020
<i>Anthaxia (Anthaxia) semicuprea</i> Kuster, 1851	XY/SX/FV	Audisio <i>et al.</i> , 2014	LC								X		Angelini, 2020
<i>Anthaxia</i> sp. Eschscholtz, 1829	XY/SX/FV	Audisio <i>et al.</i> , 2014									X		Angelini, 2020
<i>Chalcophora mariana</i> (Linnaeus, 1758)	XY/SX	Audisio <i>et al.</i> , 2014	LC				X						Angelini, 2020
<i>Meliboeus amethystinus</i> (Olivier, 1790)	XY	Sparacio, 1982			X	X	X						Angelini, 2020
<i>Meliboeus (Meliboeoides) parvulus</i> (Kuster, 1852)	XY	Niehuis & Waitzbauer, 2023					X	X					Angelini, 2020
<i>Meliboeus</i> sp. Deyrolle, 1864	XY	Niehuis & Waitzbauer, 2023			X		X						Angelini, 2020
<i>Sphenoptera (Sphenoptera) barbarica</i> (Gmelin, 1790)	XY	Audisio <i>et al.</i> , 2014						X					Angelini, 2020
Cantharidae													
Genera/Species	Trophic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Cantharis decipiens</i> Baudi, 1871	FV	Audisio <i>et al.</i> , 2014							X				Angelini, 2020
<i>Cantharis</i> sp. Linnaeus, 1758	FV	Duff, 2020									X		Angelini, 2020
<i>Dichelotarsus procerulus</i> (Kiesenwetter, 1860)	FV	Duff, 2020									X		Angelini, 2020
<i>Malthinus</i> sp. Latreille, 1806	FV	Duff, 2020							X	X			Angelini, 2020
<i>Metacantharis clypeata</i> (Illiger, 1798)	FV	Duff, 2020			X		X		X	X			Angelini, 2020
<i>Rhagonycha (Rhagonycha) fulva</i> (Scopoli, 1763)	FV	Duff, 2020			X		X	X					Angelini, 2020
<i>Rhagonycha (Rhagonycha) lignosa</i> (Muller, 1764)	FV	Duff, 2020							X	X			Angelini, 2020
<i>Rhagonycha (Rhagonycha) lutea</i> (Muller, 1764)	FV	Duff, 2020									X		Angelini, 2020

Carabidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Abax (Abax) parallelepipedus</i> subsp. <i>curtulus</i> (Fairmaire, 1856)	ZS	Brandmayr et al., 2005								X		Angelini, 2020	
<i>Acupalpus (Acupalpus) meridianus</i> (Linnaeus, 1761)	ZS	Corazza et al., 2022				X						Angelini, 2020	
<i>Amara (Amara) aenea</i> (De Geer, 1774)	ZS	Pizzolotto et al., 2009			X	X	X	X				Angelini, 2020	
<i>Amara (Bradytus) apricaria</i> (Paykull, 1790)	ZS	Gobbi et al., 2013			X	X	X					Angelini, 2020	
<i>Amara (Curtonotus) aulica</i> (Panzer, 1796)	ZS	Gobbi et al., 2013			X							Angelini, 2020	
<i>Brachinus (Brachynidius) explodens</i> Duftschmid, 1812	Z	Pizzolotto et al., 2009			X	X						Angelini, 2020	
<i>Calathus cinctus</i> Motschulsky, 1850	Z	Pizzolotto et al., 2009			X	X	X	X				Angelini, 2020	
<i>Calathus fuscipes</i> (Goeze, 1777)	Z	Pizzolotto et al., 2009			X	X	X	X	X			Angelini, 2020	
<i>Calathus melanocephalus</i> Linnaeus, 1758)	Z	Gobbi et al., 2013			X							Angelini, 2020	
<i>Calathus micropterus</i> (Duftschmid, 1812)	Z	Gobbi et al., 2013			X							Angelini, 2020	
<i>Calathus (Calathus) montivagus</i> Dejean, 1831	Z	Pizzolotto et al., 2009			X	X	X		X	X		Angelini, 2020	
<i>Calathus (Amphyginus) rotundicollis</i> Dejean, 1828	Z	Pizzolotto et al., 2009					X			X		Angelini, 2020	
<i>Calosoma (Campalita) maderae</i> (Fabricius, 1775)	Z	Brandmayr et al., 2005			X							Angelini, 2020	
<i>Carabus (Tomocarabus) convexus</i> subsp. <i>convexus</i> Fabricius, 1775	Z	Brandmayr et al., 2005			X	X	X	X	X			Angelini, 2020	
<i>Carabus (Chaetocarabus) lefebvrei</i> subsp. <i>bayardi</i> Solier, 1835	Z	Pezzi et al., 2024							X	X		Angelini, 2020	
<i>Carabus (Oreocarabus) preslii</i> subsp. <i>Neumeyeri</i> Schaum, 1856	Z	Pezzi et al., 2024			X	X		X	X	X		Angelini, 2020	
<i>Cychrus italicus</i> Bonelli, 1810	Z	Gobbi et al., 2013							X	X		Angelini, 2020	
<i>Clinidium (Arctoclinidium) canaliculatum</i> (O.G. Costa, 1839)	Z/SX	Audisio et al., 2014	NT							X		Angelini, 2020	
<i>Cymindis (Menas) miliaris</i> (Fabricius, 1801)	Z	Brandmayr et al., 2005				X	X	X				Angelini, 2020	
<i>Dromius (Dromius) agilis</i> (Fabricius, 1787)	Z	Gobbi et al., 2013							X			Angelini, 2020	
<i>Dromius fenestratus</i> (Fabricius, 1794)	Z	Brandmayr et al., 2005							X			Angelini, 2020	
<i>Harpalus (Harpalus) attenuatus</i> Stephens, 1824	ZS	Pizzolotto et al., 2009				X	X	X				Angelini, 2020	
<i>Harpalus (Harpalus) decipiens</i> Dejean, 1829	ZS	Pezzi et al., 2024			X	X	X	X		X		Angelini, 2020	
<i>Harpalus (Harpalus) dimidiatus</i> (P. Rossi, 1790)	ZS	Pizzolotto et al., 2009						X				Angelini, 2020	
<i>Harpalus (Harpalus) distinguendus</i> (Duftschmid, 1812)	ZS	Pizzolotto et al., 2009			X		X					Angelini, 2020	
<i>Harpalus (Harpalus) rubripes</i> (Duftschmid, 1812)	ZS	Brandmayr et al., 2005			X	X	X	X				Angelini, 2020	
<i>Harpalus (Harpalus) rufipalpis</i> Sturm, 1818	ZS	Pezzi et al., 2024			X	X	X	X	X			Angelini, 2020	
<i>Harpalus (Harpalus) serripes</i> (Quensel in Schonherr, 1806)	ZS	Pizzolotto et al., 2009			X	X						Angelini, 2020	
<i>Harpalus (Harpalus) sulphuripes</i> Germar, 1824	ZS	Pizzolotto et al., 2009			X	X	X	X				Angelini, 2020	
<i>Harpalus (Harpalus) tardus</i> (Panzer, 1797)	ZS	Pizzolotto et al., 2009			X	X			X			Angelini, 2020	
<i>Laemostenus (Pristonychus) cimmerius</i> subsp. <i>cimmerius</i> (Fischer von Waldheim, 1823)	ZS	Pizzolotto et al., 2009			X	X	X		X			Angelini, 2020	
<i>Laemostenus (Pristonychus) terricola</i> (Herbst, 1783)	ZS	Brandmayr et al., 2005			X	X					C		
<i>Lebia trimaculata</i> (Villers, 1789)	ZS	Brandmayr et al., 2005					X	X				Angelini, 2020	
<i>Leistus fulvibarbis</i> Dejeans, 1826	ZS	Pizzolotto et al., 2009			X							Angelini, 2020	
<i>Leistus (Pogonophorus) spinibarbis</i> subsp. <i>fiorii</i> Lutshnik, 1913	ZS	Pizzolotto et al., 2009							X			Angelini, 2020	
<i>Lionychus (Lionychus) quadrillum</i> (Duftschmid, 1812)	Z	Brandmayr et al., 2005			X							Angelini, 2020	
<i>Nebria (Nebria) brevicollis</i> (Fabricius, 1792)	Z	Pizzolotto et al., 2009			X	X	X		X			Angelini, 2020	
<i>Nebria (Nebria) kratteri</i> Dejean & Boisduval, 1830	Z	Pizzolotto et al., 2009			X	X			X	X		Angelini, 2020	
<i>Masoreus wetherhallii</i> (Gyllenhal, 1813)	Z	Pizzolotto et al., 2009			X			X				Angelini, 2020	
<i>Metallina (Metallina) lampros</i> (Herbst, 1784)	Z	Pizzolotto et al., 2009			X	X						Angelini, 2020	
<i>Microderes scaritides</i> (Sturm, 1818)	SP	Brandmayr et al., 2005						X				Angelini, 2020	
<i>Microlestes seladon</i> Holdhaus, 1912	Z	Brandmayr et al., 2005			X	X	X	X				Angelini, 2020	
<i>Notiophilus biguttatus</i> (Fabricius, 1779)	Z	Brandmayr et al., 2005				X			X			Angelini, 2020	
<i>Notiophilus geminatus</i> Dejean & Boisduval, 1830	Z	Pizzolotto et al., 2009										Angelini, 2020	
<i>Notiophilus rufipes</i> Curtis, 1829	Z	Pezzi et al., 2024				X				X		Angelini, 2020	
<i>Notiophilus substriatus</i> G. R. Waterhouse, 1833	Z	Pezzi et al., 2024							X			Angelini, 2020	
<i>Ophonus cribicollis</i> (Dejean, 1829)	Z	Pizzolotto et al., 2009				X	X	X				Angelini, 2020	
<i>Ophonus puncticollis</i> (Paykull, 1798)	SP	Pizzolotto et al., 2009			X	X	X		X			Angelini, 2020	
<i>Poecilus cupreus</i> (Linnaeus, 1758)	Z	Pizzolotto et al., 2009			X							Angelini, 2020	
<i>Paradromius (Manodromius) linearis</i> (Olivier, 1795)	Z	Brandmayr et al., 2005			X							Angelini, 2020	
<i>Pseudophoonus (Pseudophoonus) rufipes</i> (De Geer, 1774)	SP	Pizzolotto et al., 2009			X	X	X	X	X			Angelini, 2020	
<i>Philorhizus crucifer</i> (Licas, 1846)	Z	Brandmayr et al., 2005						X	X			Angelini, 2020	
<i>Pterostichus (Feronidius) melas</i> subsp. <i>italicus</i> (Dejean, 1828)	Z	Pizzolotto et al., 2009				X		X	X	X		Angelini, 2020	
<i>Syntomus impressus</i> Dejean, 1825	Z	Brandmayr et al., 2005								X		Angelini, 2020	
<i>Synuchus vivalis</i> (Illiger, 1798)	Z	Pezzi et al., 2024							X	X		Angelini, 2020	
<i>Trechus (Trechus) obtusus</i> Erichson, 1837	Z	Pizzolotto et al., 2009							X			Angelini, 2020	
<i>Trechus (Trechus) quadristriatus</i> (Schrank, 1781)	Z	Pizzolotto et al., 2009			X	X			X			Angelini, 2020	

Cerambycidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Agapanthia cynarae</i> (Gyllenhal, 1817)	P	Poloni & Morelli, 2021					X					Angelini, 2020
<i>Agapantia</i> sp. Serville, 1835	P	Poloni & Morelli, 2021					X					Angelini, 2020
<i>Alosterna tabacicolor</i> (De Geer, 1775)	P/FV	Poloni & Morelli, 2021								X		Angelini, 2020
<i>Anastrangalia dubia</i> (Scopoli, 1763)	XY/SX/FV	Audisio et al., 2014	LC		X		X		X	X		Angelini, 2020
<i>Anastrangalia sanguinolenta</i> (Linnaeus, 1761)	XY/SX/FV	Audisio et al., 2014	LC							X		Angelini, 2020
<i>Arhopalus rusticus</i> (Linnaeus, 1758)	XY/SX	Audisio et al., 2014	LC						X			Angelini, 2020
<i>Calamobius filum</i> (Rossi, 1790)	P	Sláma, 1998			X							Angelini, 2020
<i>Chlorophorus sartor</i> (Muller, 1766)	XY/SX/FV	Audisio et al., 2014	LC	LC	X	X	X	X				Angelini, 2020
<i>Clytus lama</i> Mulsant, 1847	XY/SX/FV	Audisio et al., 2014	LC	LC		X						Angelini, 2020
<i>Clytus rhamni</i> Germar, 1817	XY/SX/FV	Audisio et al., 2014	LC	LC			X					Angelini, 2020
<i>Deilus fugax</i> (Olivier, 1790)	XY/SX	Audisio et al., 2014	LC	LC	X					X		Angelini, 2020
<i>Oxypleurus nodieri</i> (Mulsant, 1839)	XY/SX	Audisio et al., 2014	NT						X		C	
<i>Pogonocherus decoratus</i> Fairmaire, 1855	XY/SX	Audisio et al., 2014	NT							X		Angelini, 2020
<i>Plagionotus scalaris</i> (Brullé, 1832)	XY/SX	Hernandez & de la Rosa, 2001					X					Angelini, 2020
<i>Pseudovadonia livida</i> (Fabricius, 1776)	XY/SX/FV	Audisio et al., 2014	LC		X	X	X	X	X			Angelini, 2020
<i>Rhagium (Hagrium) bifasciatum</i> Fabricius, 1775	SX	Audisio et al., 2014	LC							X		Angelini, 2020
<i>Rhagium (Hagrium) inquisitor</i> Linnaeus, 1758	SX	Audisio et al., 2014	LC						X	X		Angelini, 2020
<i>Rutpela maculata</i> (Poda, 1761)	XY/SX	Audisio et al., 2014	LC				X		X	X		Angelini, 2020
<i>Stenopterus rufus</i> Linnaeus, 1767	XY/SX	Audisio et al., 2014	LC	LC	X		X	X				Angelini, 2020
<i>Stenurella bifasciata</i> (O. F. Muller, 1776)	XY/SX/FV	Audisio et al., 2014	LC		X	X	X	X	X	X		Angelini, 2020
<i>Stictoleptura cordigera</i> (Fuessly, 1775)	XY/SX/FV	Audisio et al., 2014	LC		X	X	X	X				Angelini, 2020
<i>Paracorymbia fulva</i> (De Geer, 1775)	XY/SX/FV	Audisio et al., 2014	LC			X						Angelini, 2020
Cetoniidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Cetonia aurata</i> subsp. <i>pisana</i> Heer, 1841	XY/SX/FV	Audisio et al., 2014	LC			X	X					Angelini, 2020
<i>Protaetia (Netocia) cuprea</i> subsp. <i>cuprea</i> (Fabricius, 1775)	XY/SX/FV	Audisio et al., 2014	LC				X	X				Angelini, 2020
<i>Protaetia (Netocia) morio morio</i> (Fabricius, 1781)	SX/FV	Audisio et al., 2014			X	X	X	X	X			Angelini, 2020
<i>Tropinota (Epicometis) hirta hirta</i> (Poda, 1761)	SX/FV	Keplan, 2020			X	X	X					Angelini, 2020
<i>Tropinota (Tropinota) squalida squalida</i> (Scopoli, 1783)	SX/FV	Pollini, 2013			X	X	X					Angelini, 2020
<i>Valgus hemipterus</i> Linnaeus, 1758	XY/SX/FV	Mahar & Oemke, 1981	LC	LC	X	X	X					Angelini, 2020
Cholevidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	P	Duff, 2016							X			Angelini, 2020

Chrysomelidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
Alticinae	P	Duff, 2016			X	X		X		X		Angelini, 2020	
<i>Athica</i> sp. Geoffroy, 1762	P	Baviera & Biondi, 2015			X	X	X					Angelini, 2020	
<i>Aphthona</i> sp. Chevrolat, 1836	P	Fornasari, 2004			X	X						Angelini, 2020	
<i>Apteropeda orbiculata</i> (Marsham, 1802)	P	Pollini, 2013								X		Angelini, 2020	
Bruchinae	P	Pollini, 2013			X	X	X	X	X	X		Angelini, 2020	
<i>Cassida</i> (<i>Cassida</i>) <i>prasina</i> Illiger, 1798	P	Boniotti, 2020; Bidolini, 1974					X					Angelini, 2020	
<i>Cassida</i> (<i>Cassida</i>) <i>rubiginosa</i> O.F. Muller, 1776	P	Boniotti, 2020					X					Angelini, 2020	
<i>Cassida sanguinolenta</i> Muller, 1776	P	Boniotti, 2020					X					Angelini, 2020	
<i>Cassida</i> sp. Linnaeus, 1758	P	Boniotti, 2020					X					Angelini, 2020	
<i>Chaetocnema</i> sp. Stephens, 1831	P	Boniotti, 2020			X	X	X	X				Angelini, 2020	
<i>Chrysolina</i> (<i>Synerga</i>) <i>herbacea</i> (Duftschmid, 1825)	P	Boniotti, 2020			X							Angelini, 2020	
<i>Chrysolina</i> (<i>Chalcoidea</i>) <i>interstincta</i> (Suffrian, 1851)	P	Boniotti, 2020				X	X					Angelini, 2020	
<i>Chrysolina rossia</i> (Illiger, 1802)	P	Boniotti, 2020				X	X					Angelini, 2020	
<i>Crepidodera aurea</i> (Geoffroy, 1785)	P	Boniotti, 2020					X					Angelini, 2020	
<i>Cryptocephalus</i> sp. O. F. Muller, 1764	P	Boniotti, 2020				X	X	X				Angelini, 2020	
<i>Derocrepis sodalis</i> (Kutschera, 1860)	P	Boniotti, 2020				X			X	X		Angelini, 2020	
<i>Exosoma lusitanicum</i> (Linnaeus, 1767)	P	Boniotti, 2020			X	X	X					Angelini, 2020	
<i>Galeruca</i> (<i>Galeruca</i>) <i>littoralis</i> (Fabricius, 1787)	P	Boniotti, 2020			X	X	X	X			C		
<i>Galeruca</i> (<i>Galeruca</i>) <i>pomona</i> subsp. <i>pomona</i> (Scopoli, 1763)	P	Boniotti, 2020			X	X	X	X				Angelini, 2020	
<i>Galeruca</i> (<i>Galeruca</i>) <i>tanacetii</i> (Linnaeus, 1758)	P	Boniotti, 2020			X	X	X	X				Angelini, 2020	
<i>Galerucella lineola</i> (Fabricius, 1781)	P	Boniotti, 2020					X		X			Angelini, 2020	
Halticinae	P	Boniotti, 2020			X	X						Angelini, 2020	
<i>Hispa atra</i> Linnaeus, 1767	P	Boniotti, 2020				X		X				Angelini, 2020	
<i>Leptinotarsa decemlineata</i> (Say, 1824)	P	Boniotti, 2020			X							Angelini, 2020	
<i>Longitarsus</i> sp. Berthold, 1827	P	Boniotti, 2020			X	X	X	X				Angelini, 2020	
<i>Luperus</i> sp. Geoffroy, 1762	P	Boniotti, 2020								X		Angelini, 2020	
<i>Mantura</i> (<i>Mantura</i>) <i>obtusata</i> (Gyllenhal, 1813)	P	Boniotti, 2020			X							Angelini, 2020	
<i>Neocrepidodera ferruginea</i> (Scopoli, 1763)	P	Boniotti, 2020				X						Angelini, 2020	
<i>Neocrepidodera impressa</i> (Fabricius, 1801)	P	Boniotti, 2020				X						Angelini, 2020	
<i>Pachybrachis</i> sp. Dejean, 1836	P	Boniotti, 2020				X						Angelini, 2020	
<i>Psylliodes</i> (<i>Psylliodes</i>) <i>chrysocephala</i> (Linnaeus, 1758)	P	Boniotti, 2020			X	X						Angelini, 2020	
<i>Psylliodes</i> sp. Berthold, 1827	P	Boniotti, 2020			X	X	X	X	X			Angelini, 2020	
<i>Phyllotreta cruciferae</i> (Goeze, 1777)	P	Boniotti, 2020			X							Angelini, 2020	
<i>Phyllotreta</i> sp. Chevrolat, 1837	P	Boniotti, 2020			X	X						Angelini, 2020	
<i>Phyllotreta undulata</i> Kutschera, 1860	P	Boniotti, 2020							X			Angelini, 2020	
Cleridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Opilo mollis</i> (Linnaeus, 1758)	Z/SX	Audisio et al., 2014	LC					X		X		Angelini, 2020	
<i>Thanasimus formicarius</i> (Linnaeus, 1758)	Z/SX	Audisio et al., 2014	LC			X				X		Angelini, 2020	
<i>Trichodes alvearius</i> (Fabricius, 1792)	Z/FV	Felicioni, 2014			X	X	X		X			Angelini, 2020	
<i>Trichodes apiarius</i> (Linnaeus, 1758)	Z/FV	Felicioni, 2014				X		X				Angelini, 2020	
<i>Trichodes leucospideus</i> (Olivier, 1795)	Z/FV	Felicioni, 2014			X			X				Angelini, 2020	

Coccinellidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Adalia (Adalia) bipunctata</i> (Linnaeus, 1758)	Z	Pervez, 2005							X			Angelini, 2020	
<i>Adalia (Adalia) decempunctata</i> (Linnaeus, 1758)	Z	Dixon, 1959							X	X		Angelini, 2020	
<i>Calvia quatuordecimguttata</i> Linnaeus, 1758	Z	Pollini, 2013			X	X		X	X	X		Angelini, 2020	
<i>Ceratomegilla (Ceratomegilla) undecimnotata</i> Schneider, D. H., 1792	Z	Skouras et al., 2021				X						Angelini, 2020	
<i>Coccinella (Coccinella) septempunctata</i> Linnaeus, 1758	Z	Ali & Rizvi, 2007			X	X	X	X	X			Angelini, 2020	
<i>Coccinella (Spilota) undecimpunctata</i> Linnaeus, 1758	Z	Zhu & Park, 2005					X					Angelini, 2020	
<i>Coccinula quatuordecimpustulata</i> (Linnaeus, 1758)	Z	Pollini, 2013			X			X	X			Angelini, 2020	
<i>Exochomus (Exochomus) quadripustulatus</i> Linnaeus, 1758	Z	Radwan & Lovei, 1983						X				Angelini, 2020	
<i>Hippodamia (Hippodamia) variegata</i> Goeze, 1777	Z	Franzmann, 2002			X	X	X					Angelini, 2020	
<i>Hyperaspis</i> sp. Chevrolat, 1836	Z	Pollini, 2013			X							Angelini, 2020	
<i>Myrrha octodecimguttata</i> (Linnaeus, 1758)	Z	Ulgenturk et al., 2013							X	X		Angelini, 2020	
<i>Propylea quatuordecimpunctata</i> (Linnaeus, 1758)	Z	Obrycki & Orr, 1990			X	X	X		X	X		Angelini, 2020	
<i>Psyllobora vigintiduopunctata</i> (Linnaeus, 1758)	Z	Karataraki et al., 2015			X	X	X	X				Angelini, 2020	
<i>Scymnus (Scymnus) frontalis</i> (Fabricius, 1787)	Z	Naranjo et al., 1990					X					Angelini, 2020	
<i>Scymnus</i> sp. Kugelann, 1794	Z	Pollini, 2013			X	X	X	X	X	X		Angelini, 2020	
<i>Subcoccinella vigintiquatuor punctata</i>	P	Pollini, 2013			X	X						Angelini, 2020	
Cryptophagidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Cryptophagus</i> sp. Herbst, 1792	MY	Duff, 2020			X	X	X	X	X	X		Angelini, 2020	
<i>Pteryngium crenulatum</i> (Erichson, 1846)	MY/SX	Audisio et al., 2014	LC						X			Angelini, 2020	
<i>Sternodea baudii</i> Reitter, 1875	MY/SX	Audisio et al., 2014	LC						X	X		Angelini, 2020	
Cucujidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Cucujus cinaberinus</i> (Scopoli, 1763)	Z/SX	Audisio et al., 2014	VU	NT							X	Angelini, 2020	
<i>Pediacus dermestoides</i> (Fabricius, 1792)	Z/SX	Audisio et al., 2014	NT	DD					X	X		Angelini, 2020	
Curculionidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Bothynoderes affinis</i> (Schrank, 1781)	P	Tshova et al., 2019			X						C	Angelini, 2020	
<i>Coniocleonus (Plagiographus) pseudobliquus</i> (G. Muller, 1921)	P	Duff, 2016						X				Angelini, 2020	
<i>Hylastes angustatus</i> (Herbst, 1793)	SX	Audisio et al., 2014	LC						X			Angelini, 2020	
<i>Hylastes ater</i> (Paykull, 1800)	SX	Audisio et al., 2014	LC						X	X		Angelini, 2020	
<i>Hylastes attenuatus</i> Erichson, 1836	SX	Audisio et al., 2014	LC						X	X		Angelini, 2020	
<i>Hylastes</i> sp. Erichson, 1836	SX	Audisio et al., 2014							X	X		Angelini, 2020	
<i>Lixus</i> sp. J.C.Fabricius, 1802	P	Pollini, 2013					X					Angelini, 2020	
<i>Phyllobius (Subphyllobius) viridaeris</i> (Laicharting, 1781)	P	Pollini, 2013					X					Angelini, 2020	
<i>Pityogenes</i> sp. Bedel, 1888	P	Pollini, 2013								X		Angelini, 2020	
Scolytinae	P	Pollini, 2013								X		Angelini, 2020	
<i>Orthotomicus</i> sp. Ferrari, 1867	P	Pollini, 2013							X			Angelini, 2020	
<i>Tomicus minor</i> (Hartig, 1834)	XY/SX	Audisio et al., 2014	LC							X		Angelini, 2020	
Cybocephalidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Cybocephalus politus</i> Gyllenhal, 1813	Z	Lupi, 2003					X				C		
<i>Cybocephalus</i> sp. Erichson, 1844	Z	Lupi, 2003					X					Angelini, 2020	
Dasytidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Aplocnemus (Aplocnemus) nigricornis</i> (Fabricius, 1792)	Z/SX	Audisio et al., 2014	LC				X		X	X		Angelini, 2020	
<i>Aplocnemus</i> sp. Stephens, 1830	Z/SX	Audisio et al., 2014								X		Angelini, 2020	
<i>Danacea</i> sp. Laporte de Castelnau, 1836	Z/FV	Duff, 2020			X	X	X	X	X	X		Angelini, 2020	
<i>Dasytes</i> sp. Paykull, 1799	Z/FV	Duff, 2020			X			X	X	X		Angelini, 2020	
<i>Divales bipustulatus</i> (Fabricius, 1781)	Z/FV	Duff, 2020			X	X	X	X		X		Angelini, 2020	
<i>Enicopus (Enicopus) pilosus</i> (Scopoli, 1763)	Z/FV	Duff, 2020				X						Angelini, 2020	
<i>Psylothrix</i> sp. Kuster, 1858	Z/FV	Duff, 2020			X							Angelini, 2020	
<i>Psilothrix viridicoerulea</i> (Geoffroy, 1785)	FV	Badenes-Pérez et al., 2017			X	X	X			X		Angelini, 2020	

Dermestidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Anthrenus (Florilinus) signatus</i> Erichson, 1846	S/FV	Holloway & Pinniger, 2020			X		X					Angelini, 2020	
<i>Anthrenus</i> sp. Geoffroy, 1762	S/FV	Holloway & Pinniger, 2020							X			Angelini, 2020	
<i>Ctesias serra</i> (Fabricius, 1792)	S	Audisio et al., 2014	LC						X			Angelini, 2020	
<i>Dermestes erichsoni</i> (Ganglbauer, 1903)	SS	Pollini, 2013							X			Angelini, 2020	
<i>Dermestes (Dermestinus) frischi</i> Kugelann, 1792	SS	Bonacci et al., 2017					X					Angelini, 2020	
<i>Dermestes (Dermestes) lanarius</i> Linnaeus, 1758	SS	Matuszewski et al., 2013			X		X					Angelini, 2020	
<i>Dermestes (Dermestes) lardarius</i> Linnaeus, 1758	SS	Bonacci et al., 2017						X	X			Angelini, 2020	
<i>Dermestes murinus</i> Linnaeus, 1758	SS	Bonacci et al., 2017			X	X		X				Angelini, 2020	
<i>Dermestes (Dermestinus) mustelinus</i> Erichson, 1846	SS	Bonacci et al., 2017			X	X	X	X	X			Angelini, 2020	
<i>Dermestes (Montandonia) olivieri</i> Lepesme, 1939	SS	Bonacci et al., 2017			X	X	X	X				Angelini, 2020	
<i>Dermestes</i> sp. Linnaeus, 1758	SS	Pollini, 2013			X	X		X		X		Angelini, 2020	
Drillidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Drilus flavescens</i> Olivier, 1790	Z	Duff, 2020									X	Angelini, 2020	
Dynastidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Pentodon bidens</i> (Pallas, 1771)	P	Temreshev et al., 2019									X	Angelini, 2020	
Elateridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Agriotes</i> sp. Eschscholtz, 1829	P	Pollini, 2013							X			Angelini, 2020	
<i>Agrypnus murinus</i> (Linnaeus, 1758)	P	Detter & Beran, 2000			X			X	X			Angelini, 2020	
<i>Ampedus (Ampedus) sinuatus</i> Germar, 1844	Z/SX	Audisio et al., 2014	VU	LC					X	X		Angelini, 2020	
<i>Ampedus</i> sp. Dejean, 1833	Z/SX	Audisio et al., 2014								X		Angelini, 2020	
<i>Athous (Athous) ineptus</i> Candèze, 1860	P	Baviera & Platia, 2018							X			Angelini, 2020	
<i>Athous</i> sp. Eschscholtz, 1829	P	Baviera & Platia, 2018							X			Angelini, 2020	
<i>Cardiophorus (Cardiophorus) collaris/italicus</i>	ZS	Baviera & Platia, 2018					X	X	X			Angelini, 2020	
<i>Cardiophorus (Cardiophorus) italicus</i> Platia & Bartolozzi, 1988	ZS	Baviera & Platia, 2018							X			Angelini, 2020	
<i>Cardiophorus</i> sp. Eschscholtz, 1829	ZS	Baviera & Platia, 2018			X		X		X	X		Angelini, 2020	
<i>Cidnopus pilosus</i> (Leske, 1785)	ZS	Baviera & Platia, 2018								X		Angelini, 2020	
<i>Cidnopus pseudopilosus</i> Platia & Gudenzi, 1985	P	Baviera & Platia, 2018							X	X		Angelini, 2020	
<i>Ctenicera cuprea</i> (Fabricius, 1775)	P	Duff, 2020						X		X		Angelini, 2020	
<i>Ctenicera pectinicornis</i> (Linnaeus, 1758)	P	Duff, 2020						X	X			Angelini, 2020	
<i>Dicronychus cinereus</i> (Herbst, 1784)	?	Piccini et al., 2023								X		Angelini, 2020	
<i>Drasterius bimaculatus</i> (Rossi, 1790)	Z	Baviera & Platia, 2018			X	X						Angelini, 2020	
<i>Hemicrepidius hirtus</i> (Herbst, 1784)	ZS	Baviera & Platia, 2018					X		X			Angelini, 2020	
<i>Idiotarmon quadrivittatus</i> (Ragusa, 1893)	?	Baviera & Platia, 2018										Angelini, 2020	
<i>Melanotus (Melanotus) castanipes</i> (Paykull, 1800)	Z/SX	Audisio et al., 2014	LC	LC						X		Angelini, 2020	
<i>Melanotus crassicolis</i> (Erichson, 1841)	Z	Baviera & Platia, 2018							X			Angelini, 2020	
<i>Nothodes parvulus</i> (Panzer, 1799)	?								X	X		Angelini, 2020	
<i>Pheletes quercus</i> (Olivier, 1790)	?				X				X			Angelini, 2020	
Endomychidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Lycoperdina bovistae</i> (Fabricius, 1792)	MY/SX	Audisio et al., 2014	LC					X		X		Angelini, 2020	
Erotylidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Dacne rufifrons</i> (Fabricius, 1775)	MY/SX	Audisio et al., 2014	NT	DD						X	C		
<i>Triplax lacordairii</i> Crotch, 1870	MY/SX	Audisio et al., 2014	NT	EN					X	X		Angelini, 2020	
<i>Triplax marseuli</i> Bedel, 1864	MY/SX	Audisio et al., 2014	NT	DD					X	X		Angelini, 2020	
<i>Triplax rufipes</i> (Fabricius, 1787)	MY/SX	Audisio et al., 2014	LC	LC					X		C		
<i>Triplax</i> sp. Herbst, 1793	MY/SX	Audisio et al., 2014							X	X		Angelini, 2020	

Geotrupidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Anoplotrupes stercorosus</i> (Scriba, 1791)	CP	Weithmann et al., 2020								X		Angelini, 2020	
<i>Geotrupes spinigier</i>	CP	Milander et al., 1977						X				Angelini, 2020	
Histeridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Gnathoncus</i> sp. Jacquelin du Val, 1858	S	Duff, 2012				X						Angelini, 2020	
<i>Hister quadrimaculatus</i> Linnaeus, 1758	S	Duff, 2012			X	X	X	X				Angelini, 2020	
<i>Hypocaccus (Hypocaccus) rugifrons</i> (Paykull, 1798)	S	Duff, 2012			X							Angelini, 2020	
<i>Pachylister (Pachylister) inaequalis</i> (A. G. Olivier, 1789)	S	Baviera & Vienna, 2019						X				Angelini, 2020	
<i>Onthophilus punctatus</i> (O. F. Muller, 1776)	S	Baviera & Vienna, 2019						X				Angelini, 2020	
<i>Saprinus (Saprinus) semistriatus</i> (Scriba, 1790)	Z	Szelezec et al, 2018				X						Angelini, 2020	
<i>Saprinus</i> sp. Erichson, 1834	Z	Szelezec et al, 2018							X	X		Angelini, 2020	
Hydrophilidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Anacaena globulus</i> (Paykull, 1798)	CP	Duff, 2012					X					Angelini, 2020	
<i>Sphaeridium bipustulatum</i> Fabricius, 1781	CP	Duff, 2012					X					Angelini, 2020	
<i>Sphaeridium lunatum</i> Fabricius, 1792	CP	Otronen & Hanski, 1983						X				Angelini, 2020	
Lampyridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Lampyris brutia</i> Costa, 1882	Z	Pollini, 2013				X			X	X		Angelini, 2020	
<i>Lampyris</i> sp. Geoffroy, 1762	Z	Pollini, 2013			X	X	X	X	X	X		Angelini, 2020	
Latridiidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	?						X					Angelini, 2020	
Leioidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
Chlovinae	MY	Duff, 2012			X				X	X		Angelini, 2020	
<i>Anemadus</i> sp. Reitter, 1885	MY	Duff, 2012							X			Angelini, 2020	
<i>Leiodes badia</i> (Sturm, 1807)	MY	Duff, 2012			X							Angelini, 2020	
<i>Leiodes</i> sp. Latreille, 1797	MY	Duff, 2012			X					X		Angelini, 2020	
Lycidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Lygistopterus anorachilus</i> Ragusa, 1838	MY/SX	Audisio et al., 2014	NT						X	X		Angelini, 2020	
Malachiidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	?				X	X	X	X	X	X		Angelini, 2020	
Melandryidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Rushia parreyssi</i> (Mulsant, 1856)	MY/SX	Audisio et al., 2014	NT							X		Angelini, 2020	
<i>Cerocoma (Cerocoma) schaefferi</i> (Linnaeus, 1758)	P	Turco & Bologna, 2011				X	X					Angelini, 2020	
<i>Meloe</i> sp. Linnaeus, 1758	PAR	Pan & Bologna, 2014			X							Angelini, 2020	
<i>Mylabris (Eumylabris) fabricii</i> Soumacov, 1924	PAR/FV	Pan & Bologna, 2014					X					Angelini, 2020	
<i>Mylabris (Mylabris) variabilis</i> (Pallas, 1781)	PAR/FV	Pan & Bologna, 2014					X					Angelini, 2020	
Melolonthidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Amadotrogus quercanus</i> (Burmeister, 1855)	P	Chinery, 2010							X			Angelini, 2020	
<i>Firminus baudii</i> (Brenske, 1886)	P	Chinery, 2010			X	X	X	X		X		Angelini, 2020	
<i>Firminus ciliatus vexillis</i> (Reitter, 1902)	P	Chinery, 2010						X				Angelini, 2020	
<i>Rhizotrogus aestivus</i> (Olivier, 1789)	P	Chinery, 2010					X	X				Angelini, 2020	
<i>Rhizotrogus marginipes</i> Mulsant, 1842	P	Chinery, 2010						X			C	Angelini, 2020	
Mordellidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Mordella</i> sp. Linnaeus, 1758	P/FV	Duff, 2020			X	X	X	X	X	X		Angelini, 2020	
<i>Mordellistena</i> sp. Costa, 1854	P/FV	Duff, 2020			X	X	X	X	X			Angelini, 2020	
Mycteridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Mycterus (Mycterus) curculioides</i> (Fabricius, 1781)	P	Duff, 2020				X	X	X				Angelini, 2020	
<i>Mycterus (Eutryptes) tibialis</i> Kuster, 1850	P	Duff, 2020				X						Angelini, 2020	

Nitidulidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Carpophilus hemipterus</i> (Linnaeus, 1758)	S	Pollini, 2013					X	X				Angelini, 2020	
<i>Epuraea</i> sp. Erichson, 1864	S	Pollini, 2013					X		X			Angelini, 2020	
<i>Glischrochilus quadrisignatus</i> (Say, 1835)	MY/SX	Audisio et al., 2014	NT		X		X	X	X	X	C		
<i>Haptoncus ocularis</i> (Fairmaire, 1849)	S	Lason et al., 2023			X		X	X	X	X		Angelini, 2020	
<i>Haptoncus</i> sp. (Fairmaire, 1849)	S	Lason et al., 2023						X	X	X		Angelini, 2020	
<i>Ipidia binotata</i> Reitter, 1875	MY/SX	Audisio et al., 2014	VU		X					X		Angelini, 2020	
Meligitinae	FV	Pollini, 2013			X	X	X	X	X	X		Angelini, 2020	
<i>Nitidula flavomaculata</i> Rossi, 1790	S	Bonacci et al., 2021								X		Angelini, 2020	
<i>Urophorus humeralis</i> (Fabricius, 1798)	P	Vincent & Lindgren, 1972			X							Angelini, 2020	
<i>Pityophagus ferrugineus</i> (Linnaeus, 1758)	Z/SX	Audisio et al., 2014	LC						X	X		Angelini, 2020	
<i>Soronia grisea</i> (Linnaeus, 1758)	SX	Audisio et al., 2014	LC						X	X		Angelini, 2020	
<i>Thalycra fervida</i> (Olivier, 1790)	MY	Duff, 2020						X	X	X		Angelini, 2020	
<i>Xenostrogylus</i> sp. Wollaston, 1854	MY	Lee & Lee, 2020					X					Angelini, 2020	
Oedemeridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Chrysanthia viridissima</i> (Linnaeus, 1758)	FV	Atanassova & Silvilov, 2014			X	X	X	X	X	X		Angelini, 2020	
<i>Nacerdes (Xanthochroa) carniolica</i> (Gistel, 1834)	S/FV	Poloni, 2019					X	X		X		Angelini, 2020	
<i>Oedemera (Oedemera) atrata</i> W. Schmidt, 1846	P/FV	Duff, 2020				X		X				Angelini, 2020	
<i>Oedemera femorata</i> (Scopoli, 1763)	P/FV	Atanassova & Silvilov, 2014				X				X		Angelini, 2020	
<i>Oedemera (Oedemera) flavipennis</i> W. Schmidt, 1846	P/FV	Duff, 2020			X	X	X	X	X			Angelini, 2020	
<i>Oedemera flavipes</i> (Fabricius, 1792)	P/FV	Atanassova & Silvilov, 2014			X	X	X	X	X	X		Angelini, 2020	
<i>Oedemera lurida/crassipes</i>	P/FV	Atanassova & Silvilov, 2014			X	X	X	X	X			Angelini, 2020	
<i>Oedemera (Oedemera) nobilis</i> (Scopoli, 1763)	P/FV	Ferreiro, 2017			X	X	X	X	X			Angelini, 2020	
<i>Oedemera podagrariae</i> (Linnaeus, 1767)	P/FV	Atanassova & Silvilov, 2014			X	X						Angelini, 2020	
<i>Oedemera (Oedemera) pthysica</i> (Scopoli, 1763)	P/FV	Atanassova & Silvilov, 2014			X			X				Angelini, 2020	
<i>Oedemera (Oedemera) simplex</i> (Linnaeus, 1767)	P/FV	Atanassova & Silvilov, 2014			X	X	X					Angelini, 2020	
<i>Oedemera</i> sp. Olivier, 1789	P/FV	Duff, 2020			X							Angelini, 2020	
Phalacridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	?							X				Angelini, 2020	
<i>Olibrus</i> sp. Erichson, 1845	FV	Duff, 2020			X	X	X	X	X	X		Angelini, 2020	
Salpingidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Rabocerus foveolatus</i> (Ljungh, 1823)	Z	Duff, 2020							X			Angelini, 2020	
Scarabaeidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Amidorus obscurus</i> ssp. <i>Obscurus</i> (Fabricius, 1792)	CP	Tocco et al., 2011						X				Angelini, 2020	
<i>Amphimallon pseudomajale</i> Sabatinelli, 1976	P	Pollini, 2013			X	X		X				Angelini, 2020	
<i>Amphimallon ochraceum</i> (Knoch, 1801)	P	Pollini, 2013			X							Angelini, 2020	
<i>Caccobius schreberi</i> (Linnaeus, 1767)	P	Aronton et al., 2012						X				Angelini, 2020	
<i>Chilothorax distinctus</i> (O. F. Muller, 1776)	CP	Dellacasa et al., 2001			X							Angelini, 2020	
<i>Chilothorax paykulli</i> (Bedel, 1907)	CP	Dellacasa et al., 2001			X		X	X				Angelini, 2020	
<i>Colobopterus erraticus</i> (Linnaeus, 1758)	CP	Duff, 2020						X				Angelini, 2020	
<i>Coprinorhynchus scrutator</i> (Herbst, 1789)	CP	Palestrini & Barbero, 1994						X				Angelini, 2020	
<i>Esymus merdarius</i> (Fabricius, 1775)	CP	Dellacasa & Kirgiz, 2002			X	X	X	X				Angelini, 2020	
<i>Esymus pusillus</i> subsp. <i>pusillus</i> (Herbst, 1789)	CP	Dellacasa & Kirgiz, 2002			X							Angelini, 2020	
<i>Euonicellus fulvus</i> (Goeze, 1777)	CP	Cosandey et al., 2022				X		X				Angelini, 2020	
<i>Euonthophagus gibbosus</i> (Scriba, 1790)	CP	Duff, 2020						X				Angelini, 2020	
<i>Liothorax niger</i> (Illiger, 1798)	S	Dellacasa et al., 2007						X				Angelini, 2020	
<i>Mycetoporus</i> sp. Mannerheim, 1830	CP	Duff, 2020								X		Angelini, 2020	
<i>Nimbus obliteratus</i> (Panzer, 1823)	CP	Dellacasa et al., 2001							X			Angelini, 2020	
<i>Onthophagus (Palaeonthophagus) coenobita</i> (Herbst, 1783)	CP	Cosandey et al., 2022						X				Angelini, 2020	
<i>Onthophagus illyricus</i> (Scopoli, 1763)	CP	Cosandey et al., 2022				X						Angelini, 2020	
<i>Onthophagus (Palaeonthophagus) fracticornis</i> (Preyssler, 1790)	CP	Cosandey et al., 2022						X		X		Angelini, 2020	
<i>Onthophagus (Palaeonthophagus) semicornis</i> (Panzer, 1798)	S	Duff, 2020					X	X				Angelini, 2020	
<i>Onthophagus (Onthophagus) taurus</i> (Schreber, 1759)	S	Rounds & Floate, 2012						X	X			Angelini, 2020	
<i>Onthophagus (Palaeonthophagus) vacca</i> Linnaeus, 1767	S	Sowing, 1996						X				Angelini, 2020	
<i>Pseudacrossus suffertus</i> (A. Schmidt, 1916)	S	Dellacasa & Kirgiz, 2002			X			X				Angelini, 2020	
<i>Sigorus porcus</i> (Fabricius, 1792)	S	Turner & Anderson, 2020						X				Angelini, 2020	
<i>Trichonotulus scrofa</i> (Fabricius, 1787)	S	Gavrilovic & Curcic, 2010						X				Angelini, 2020	
Scirtidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Elodes</i> sp. Latreille, 1796	S	Duff, 2020							X			Angelini, 2020	

Scolyidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
Ipinae										X		Angelini, 2020	
Scraptiidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Anaspis</i> sp. Geoffroy, 1762	FV	Duff, 2020			X	X	X	X	X	X		Angelini, 2020	
n.d.	FV							X	X	X		Angelini, 2020	
<i>Trotomma (Trotomma) pubescens</i> Kiesenwetter, 1851	FV	Duff, 2020					X					Angelini, 2020	
Silphidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Nicrophorus vespilloides</i> Herbst, 1783	N	von Hoermann et al., 2013						X				Angelini, 2020	
<i>Silpha olivieri</i> Bedel, 1887	N	Dekeirsschieter et al., 2011						X				Angelini, 2020	
Silvanidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Oryzaephilus surinamensis</i> (Linnaeus, 1758)	P	Hashem et al., 2021					X		X			Angelini, 2020	
Staphilinidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
Aleocharinae	Z	Ozgen & Mamay, 2022			X	X	X	X	X	X		Angelini, 2020	
<i>Anisotoma castanea</i> (Herbst, 1792)	MY/SX	Audisio et al., 2014	LC								X	Angelini, 2020	
<i>Bolitobius castaneus</i> (Stephens, 1832)	Z	Eugen & Nitzu, 2009									X	Angelini, 2020	
<i>Boreaphilus velox</i> (Heer, 1839)	Z	Lupi et al., 2006							X	X		Angelini, 2020	
<i>Carphacis striatus</i> (Olivier, 1795)	Z	Nikitsky & Schigel, 2004							X	X		Angelini, 2020	
<i>Eusphalerum</i> sp. Kraatz, 1857	FV	Rivest et al., 2024							X	X		Angelini, 2020	
<i>Gyrophypnus angustatus</i> Stephens, 1833	Z	Steenberg et al., 1995				X		X				Angelini, 2020	
<i>Gyrophypnus punctulatus</i> (Paykull, 1789)	Z	Steenberg et al., 1995						X	X			Angelini, 2020	
<i>Lordithon lunulatus</i> (Linnaeus, 1760)	Z	Lunde et al., 2023						X	X	X		Angelini, 2020	
<i>Ocypus (Pseudocypus) fulvipennis</i> Erichson, 1840	Z	Staniec et al., 2009			X	X	X	X	X			Angelini, 2020	
<i>Ocypus (Matidus) italicus</i> (Aragona, 1830)	Z	Bonacci et al., 2006					X	X		X		Angelini, 2020	
<i>Ocypus (Ocypus) olens</i> (O. Muller, 1764)	Z	Lupi et al., 2006			X	X	X	X	X			Angelini, 2020	
<i>Ocypus (Pseudocypus) sericeicollis</i> (Menetries, 1832)	Z	Bonacci et al., 2006			X	X	X	X	X			Angelini, 2020	
<i>Othius laeviusculus</i> Stephens, 1833	Z	Sunderland, 1975			X	X	X	X	X			Angelini, 2020	
Omaliniinae MacLeay, 1825	Z	Dettner & Reissenweber, 1991			X	X						Angelini, 2020	
<i>Ontholestes murinus</i> (Linnaeus, 1758)	Z	Dekeirsschieter et al., 2013						X				Angelini, 2020	
<i>Oxytelus (Oxytelus) piceus</i> (Linnaeus, 1767)	Z	Lu & Zhou, 2012						X				Angelini, 2020	
<i>Phyllodrepa salicis</i> (Gyllenhal, 1810)	Z/SX	Audisio et al., 2014	VU						X	X		Angelini, 2020	
<i>Philonthus</i> sp. Stephens, 1829	Z	Betz & Mumm, 2001			X	X		X		X		Angelini, 2020	
<i>Platydracus stercorarius</i> (Oliviero, 1795)	Z	Lupi et al., 2006			X					X		Angelini, 2020	
<i>Platystethus nitens</i> (Sahlberg, 1832)	SS	Lupi et al., 2006						X				Angelini, 2020	
<i>Quedius (Microsaurus) latinus</i> Gridelli, 1938	Z	Hansen et al., 2022							X	X		Angelini, 2020	
<i>Quedius (Raphirus) semiobscurus</i> (Marshall, 1802)	Z	Hansen et al., 2022			X	X	X	X	X	X		Angelini, 2020	
<i>Quedius</i> sp. Stephens, 1829	Z	Hansen et al., 2022			X	X	X	X	X	X		Angelini, 2020	
<i>Scaphium immaculatum</i> (Olivier, 1790)	MY/SX	Audisio et al., 2014	NT					X				Angelini, 2020	
<i>Stenus</i> sp. Latreille, 1797	Z	Betz, 2006									X	Angelini, 2020	
<i>Tachinus humeralis</i> Gravenhorst, 1802	Z	Lutska & Serenko, 2020			X				X			Angelini, 2020	
<i>Tachinus</i> sp. Gravenhorst, 1802	Z	Lutska & Serenko, 2020			X				X	X		Angelini, 2020	
<i>Tachyporus</i> sp. Gravenhorst, 1802	Z	Lutska & Serenko, 2020					X					Angelini, 2020	
<i>Tasgius (Rayachiela) morsitans</i> (Rossi, 1790)	Z	Lutska & Serenko, 2020				X			X	X		Angelini, 2020	
<i>Tasgius pedator</i> (Gravenhorst, 1802)	Z	Lutska & Serenko, 2020			X							Angelini, 2020	
<i>Xantholinus (Typhlotinus) appennincola</i> Steel, 1946	Z	Lupi et al., 2006				X		X				Angelini, 2020	
<i>Xantholinus (Polydonthallus) elegans</i> (Olivier, 1795)	Z	Lupi et al., 2006				X	X	X				Angelini, 2020	
<i>Xantholinus</i> sp. Dejean, 1821	Z	Lupi et al., 2006				X						Angelini, 2020	
Tenebrionidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Blaps gibba</i> Laporte de Castelnau, 1840	S	Amari et al., 2021			X	X	X	X		X		Angelini, 2020	
<i>Diaperis boleti</i> (Linnaeus, 1758)	MY/SX	Audisio et al., 2014	LC								X	Angelini, 2020	
<i>Enoplopus dentipes</i> (Rossi, 1790)	SX	Audisio et al., 2014	LC			X	X	X		X		Angelini, 2020	
<i>Gonocephalum granulatum</i> (Fabricius, 1791)	Z	Perera-Fernández et al., 2023			X	X	X	X	X	X		Angelini, 2020	
<i>Helops (Helops) caruleus caeruleus</i> (Linnaeus, 1758)	SX	Audisio et al., 2014	LC								X	Angelini, 2020	
<i>Isomira</i> sp. Mulsant, 1856	Z	Perera-Fernández et al., 2023			X		X	X	X	X		Angelini, 2020	
<i>Lagria</i> sp. Fabricius, 1775	Z	Perera-Fernández et al., 2023									X	Angelini, 2020	
<i>Nalassus dryadophilus</i> (Mulsant, 1854)	SX	Audisio et al., 2014	LC						X	X		Angelini, 2020	
<i>Omophlus lepturoides</i> (Fabricius, 1787)	P	Wilson & Graham, 1983					X					Angelini, 2020	
<i>Omophlus picipes</i> (Fabricius, 1792)	P	Wilson & Graham, 1983			X	X	X	X				Angelini, 2020	
<i>Omophlus</i> sp. Solier, 1835	P	Wilson & Graham, 1983				X						Angelini, 2020	
<i>Opatrum</i> sp. Fabricius, 1775	P	Pollini, 2013					X	X				Angelini, 2020	
<i>Pedinus meridianus</i> Mulsant & Rey, 1853	?				X	X	X	X	X			Angelini, 2020	

Throscidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Trixagus</i> sp. Kugelann, 1794	?						X	X		X	X		Angelini, 2020
Trogidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Trox (Trox) niger</i> Rossi, 1792	?				X								Angelini, 2020
Trogossitidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Grynocaris oblonga</i> (Linnaeus, 1757)	Z/SX	Audisio et al., 2014	NT								X		Angelini, 2020
Zoopheridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Corticus celtis</i> Germar, 1824	SX	Audisio et al., 2014	LC								X		Angelini, 2020
<i>Endophloeus markovichianus</i> (Piller&Mitterpacher, 1783)	SX	Audisio et al., 2014	NT							X			Angelini, 2020
<i>Pycnomerus italicus</i> (Ganglbauer, 1899)	SX	Audisio et al., 2014	EN								X		Angelini, 2020

Diptera

Asilidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Machimus cyanopus</i> (Loew, 1849)	Z	Pollini, 2013						X			C		
<i>Machimus</i> sp. Loew, 1849	Z	Pollini, 2013			X	X	X	X	X	X			www.gibf.org
n.d.	Z	Pollini, 2013			X	X	X		X				www.gibf.org
<i>Stichopogon</i> sp. Loew, 1847	Z	Pollini, 2013			X								www.gibf.org
Aulacigasteridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Aulacigaster leucopeza</i> (Meigen, 1830)	P				X	X	X	X	X	X	C		
Bibionidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Biblio hortulanus</i> (Linnaeus, 1758)	P/FV	Pollini, 2013; Weiner, 2016				X	X	X	X	X			Heanni, 2009
<i>Biblio marci</i> (Linnaeus, 1758)	P/FV	Pollini, 2013; Weiner, 2016				X	X	X	X				Heanni, 2009
<i>Biblio</i> sp. Geoffroy, 1762	P/FV	Pollini, 2013; Weiner, 2016			X	X	X	X	X	X			Heanni, 2009
<i>Dilophus femoratus</i> Meigen, 1804	P/FV	Pollini, 2013; Weiner, 2016			X	X	X	X	X		C		
Bombyliidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Amictus</i> sp. Wiedemann, 1817	POL	Pollini, 2013			X		X	X					www.gibf.org
<i>Bombylius minor</i> (Linnaeus, 1758)	POL	Pollini, 2013			X	X	X	X					Bezzi, 1895
<i>Lomatia</i> sp. Meigen, 1822	POL	Pollini, 2013			X	X	X	X		X			www.gibf.org
n.d.	POL	Pollini, 2013					X	X					www.gibf.org
<i>Usia</i> sp. Latreille, 1802	POL	Pollini, 2013			X	X							Bezzi, 1895
<i>Villa</i> sp. Liroy, 1864	POL	Pollini, 2013			X	X	X	X	X				www.gibf.org

Calliphoridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Angioneura cyrtoneurina</i> (Zetterstedt, 1859)	PAR	Andrews & Sivell, 2019								X	S	
<i>Bellardia</i> sp. Robineau-Desvoidy, 1863	PAR/FV	Falk, 2016; Falk 2017				X						www.gibf.org
<i>Bellardia viarum</i> (Robineau-Desvoidy, 1830)	PAR/FV	Falk, 2016; Falk 2017			X		X					C
<i>Bellardia vulgaris</i> (Robineau-Desvoidy, 1830)	PAR/FV	Falk, 2016; Falk 2017			X	X	X	X	X			Bezzi, 1895
<i>Calliphora rohndendorfi</i> (Grunin, 1966)	?	Pezzi, 2024				X						Pezzi et al., 2024
<i>Calliphora vicina</i> Robineau-Desvoidy, 1830	N/FV	Bonacci et al., 2009; Howlett, 2011			X	X	X	X	X	X		Bonacci et al. 2011
<i>Calliphora vomitoria</i> (Linnaeus, 1758)	N/FV	Greco et al., 2014; Currah & Ockendon, 2008			X	X	X	X	X	X		Bonacci et al. 2021
<i>Chrysomya albiceps</i> Wiedemann, 1819	Z/FV/N	Barbosa et al., 2021; Cook et al., 2020				X	X	X				Greco et al., 2014
<i>Cynomya mortuorum</i> (Linnaeus, 1761)	SS/FV	Braet et al., 2015; Weiner, 2016			X		X					S
<i>Eurychaeta muscaria</i> (Meigen, 1826)	PAR	Coupland & Barker, 2004			X	X		X	X			C
<i>Lucilia ampullacea</i> Villeneuve, 1922	N/FV	Vannin et al., 2008; Choi & Joung, 2015				X		X		X		Bonacci et al., 2010; Greco et al., 2014
<i>Lucilia caesar</i> (Linnaeus, 1758)	SS/FV	Pezzi et al., 2021; Weiner, 2016			X	X		X		X		Bonacci et al., 2010; Greco et al., 2014
<i>Lucilia sericata</i> Meigen, 1826	SS/FV	Pezzi et al., 2022; Weiner, 2016			X	X						Bonacci et al., 2010; Greco et al., 2014
<i>Melinda gentilis</i> Robineau-Desvoidy, 1830	PAR/FV	Falk, 2016; Weiner, 2016			X		X			X		C
<i>Melinda viridicyanea</i> (Robineau-Desvoidy, 1830)	PAR/FV	Falk, 2016; Weiner, 2016			X	X	X	X	X	X		C
<i>Onesia floralis</i> Robineau-Desvoidy, 1830	PAR/FV	Rognes, 1991; Weiner, 2016			X	X	X	X	X	X		C
<i>Protocalliphora azurea</i> (Fallen, 1817)	PAR/FV	Falk, 2016; Weiner, 2016			X		X					Mencicino et al., 2023
<i>Stomorhina lunata</i> (Fabricius, 1805)	PAR/FV	Falk, 2016; Marques et al., 2007			X	X	X	X	X	X		C
Chironomidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.								X				www.gibf.org
Chloropidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Chlorops</i> sp. Meigen, 1803	P	Nartshuk, 2011			X	X	X	X	X	X		www.gibf.org
n.d.	P	Nartshuk, 2011			X	X	X		X	X		www.gibf.org
Conopidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Leopoldius</i> sp. Rondani, 1843	PAR/FV	Raw, 1968						X				www.gibf.org
n.d.	PAR/FV				X	X	X					www.gibf.org
<i>Sicus</i> sp. Scopoli, 1763	PAR/FV	Plowright & Lavery, 2003; Falk, 2017								X		Bezzi, 1895
<i>Threcophora</i> sp. Rondani, 1845	PAR/FV	Smith, 2009				X						www.gibf.org
<i>Zodion</i> sp. Latreille, 1796	PAR/FV	Camras, 1944; Falk, 2017			X	X						www.gibf.org
Dolichopodidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Dolichopus</i> sp. Latreille, 1796	Z	Qian et al., 2023			X	X			X			www.gibf.org
n.d.	Z				X	X	X	X	X	X		www.gibf.org
<i>Neurigona suturalis</i> Fallem, 1823	Z	libro ditteri			X	X	X		X	X		C
Drosophilidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Drosophila</i> sp. Fallen, 1823	S	Rohlf's & Kurschner, 2010			X	X	X	X	X	X		www.gibf.org
<i>Drosophila sukuii</i> Matsumura, 1931	P	Cini et al., 2012			X	X	X	X	X	X		Bonelli et al., 2022
<i>Leucophenga (Leucophenga) maculata</i> (Dufour, 1839)	MY	Ozbel Catal et al., 2021			X	X	X	X	X	X		C
n.d.					X		X	X	X	X		www.gibf.org
Dryomyzidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Dryomyza flaveola</i> (Fabricius, 1794)	S	Mathis & Sueyoshi, 2011					X	X	X	X		C
Empididae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Empis (Empis) pennipes</i> Linnaeus, 1758	S/FV	Watson & Dallwitz, 2003			X	X	X		X	X		Bezzi, 1895
n.d.					X	X	X	X	X	X		www.gibf.org
Fanniidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Fannia canicularis</i> (Linnaeus, 1761)	S/FV	Kang et al., 2023; Falk, 2017			X	X		X	X	X		Bezzi, 1895
<i>Fannia lineata</i> (Stein, 1895)	S/FV	Grzywacz & Prado e Castro, 2012			X		X	X	X	X		Bezzi, 1895
<i>Fannia</i> sp. Robineau-Desvoidy, 1830	S/FV	Kang et al., 2023; Falk, 2017			X				X	X		Bezzi, 1895

Helomyzidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Suillia affinis</i> (Meigen, 1830)	MY	Rohacek & Sevcik, 2013			X	X	X	X	X	X		Lo Giudice & Woznica, 2013
<i>Suillia bicolor</i> (Zetterstedt, 1830)	MY	Rohacek & Sevcik, 2013			X		X	X	X	X		Lo Giudice & Woznica, 2013
<i>Suillia flava</i> (Meigen, 1830)	MY	Rohacek & Sevcik, 2013			X	X	X	X	X	X	C	
<i>Suillia flavifrons</i> (Zetterstedt, 1838)	MY	Rohacek & Sevcik, 2013			X		X	X	X	X	S	
<i>Suillia laevifrons</i> (Loew, 1862)	MY	Rohacek & Sevcik, 2013				X	X	X	X	X		Lo Giudice & Woznica, 2013
<i>Suillia notata</i> (Meigen, 1830)	MY	Rohacek & Sevcik, 2013				X	X	X	X	X		Lo Giudice & Woznica, 2013
<i>Suillia</i> sp. Robineau-Desvoidy, 1830	MY	Rohacek & Sevcik, 2013			X	X	X	X	X	X		Lo Giudice & Woznica, 2013
<i>Suillia variegata</i> (Loew, 1862)	MY	Rohacek & Sevcik, 2013			X	X	X	X	X	X		Lo Giudice & Woznica, 2013
Hybotidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	Z				X	X		X	X	X		www.gibf.org
Lauzanidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Lyciella</i> sp. Collin, 1948	S/FV	Semelbauer & Kozánek, 2014;					X	X	X	X		www.gibf.org
<i>Minettia fasciata</i> (Fallen, 1820)	S/FV	Karimi et al., 2018; Merz, 2004			X	X	X	X	X		C	
<i>Minettia</i> sp. Robineau-Desvoidy, 1830	S/FV	Karimi et al., 2018; Merz, 2004			X	X		X	X	X		www.gibf.org
<i>Sapromyza quadripunctata</i> (Gimmerthal, 1842)	S/FV	Semelbauer & Kozánek, 2014			X						C	
Lonchaedidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Lonchaea</i> sp. Fallen, 1820	S	MacGowan et al., 2007			X	X	X	X	X	X		www.gibf.org

Muscidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Coenosia intermedia</i> (Fallén, 1825)	S	Gregor et al., 2016				X					S	
<i>Coenosia</i> sp. Meigen, 1826	S	Gregor et al., 2016			X	X	X	X	X	X		www.gibf.org
<i>Coenosia tigrina</i> (Fabricius, 1775)	S/FV	Gregor et al., 2016; Falk, 2017			X	X	X	X	X	X	C	
<i>Dasyphora albofasciata</i> (Macquart, 1839)	CP	Gregor et al., 2016			X	X	X	X	X	X		Bezzi, 1895
<i>Eudasyphora cianella</i> (Meigen, 1826)	CP/FV	Gregor et al., 2016; Falk, 2017						X				Bezzi, 1895
<i>Eudasyphora cyanicolor</i> (Zetterstedt, 1845)	CP/FV	Gregor et al., 2016; Falk, 2017			X	X	X	X	X	X		Bezzi, 1895
<i>Graphomya maculata</i> (Scopoli, 1763)	Z/FV/N	Gregor et al., 2016; Falk, 2017			X							Bezzi, 1895
<i>Haematobosca stimulans</i> (Meigen, 1824)	CP/Z	Gregor et al., 2016							X	X		Medicino et al., 2023
<i>Helina celsa</i> (Harris, 1780)	S	Gregor et al., 2016				X					C	
<i>Helina confinis</i> (Fallén, 1825)	S	Gregor et al., 2016							X	X	C	
<i>Helina cothurnata</i> (Rondani, 1866)	S	Gregor et al., 2016					X				C	
<i>Helina impuncta</i> (Fallén, 1825)	S/FV	Gregor et al., 2016; Weiner, 2016			X	X		X	X	X	C	
<i>Helina quadrinotata</i> (Meigen, 1826)	S	Gregor et al., 2016			X	X			X	X	S	
<i>Helina reversio</i> (Harris, 1780)	S/FV	Gregor et al., 2016; Weiner, 2016			X	X	X	X	X	X	C	
<i>Helina setigera</i> (Pokorný, 1887)	S	Gregor et al., 2016						X			S	
<i>Helina</i> sp. Robineau-Desvoidy, 1830	S	Gregor et al., 2016			X	X	X	X	X	X		www.gibf.org
<i>Hydrotaea albipuncta</i> (Zetterstedt, 1845)	CP/FV	Gregor et al., 2016; Weiner, 2016						X			S	
<i>Hydrotaea ignava</i> (Harris, 1780)	S	Gregor et al., 2016					X					www.gibf.org
<i>Hydrotaea</i> sp. Robineau-Desvoidy, 1830	S	Gregor et al., 2016						X				www.gibf.org
<i>Hydrotaea meridionalis</i> Porchinsky, 1882	S	Gregor et al., 2016							X		C	
<i>Mesembrina meridiana</i> (Linnaeus, 1758)	CP/FV	Gregor et al., 2016; Falk, 2017			X	X	X	X				Bezzi, 1895
<i>Morellia simplex</i> (Loew, 1857)	CP/FV	Gregor et al., 2016; Falk, 2017			X		X					Bezzi, 1895
<i>Musca autumnalis</i> De Geer, 1776	CP/FV	Gregor et al., 2016; Falk, 2017			X	X	X	X		X		Medicino et al., 2023
<i>Musca domestica</i> Linnaeus, 1758	S/FV	Gregor et al., 2016; Falk, 2017			X	X	X	X	X	X		Bonacci et al., 2011
<i>Muscina levida</i> (Harris, 1780)	S	Gregor et al., 2016; Weiner, 2016			X	X	X	X	X	X		Bonacci et al., 2011
<i>Muscina prolapsa</i> (Harris, 1780)	S	Gregor et al., 2016; Falk, 2017			X	X	X	X	X	X		Bonacci et al., 2011
<i>Muscina stabulans</i> (Fallén, 1817)	S	Gregor et al., 2016				X	X	X	X	X		Bonacci et al., 2011
<i>Neomyia cornicina</i> (Fabricius, 1781)	CP/FV	Gregor et al., 2016; Weiner, 2016			X	X	X	X	X	X	C	
<i>Neomyia viridescens</i> (Robineau-Desvoidy, 1830)	S/FV	Gregor et al., 2016; Falk, 2017				X			X	X	S	
<i>Phaonia angelicae</i> (Scopoli, 1763)	FV	Gregor et al., 2016; Falk, 2017			X	X	X	X	X	X		Medicino et al., 2023
<i>Phaonia errans</i> (Meigen, 1826)	S	Gregor et al., 2016; Falk, 2017			X	X		X	X	X		Medicino et al., 2023
<i>Phaonia incana</i> (Wiedemann, 1817)	S	Gregor et al., 2016; Falk, 2017			X	X	X	X	X	X	S	
<i>Phaonia mediterranea</i> Hannig, 1963	S	Gregor et al., 2016			X	X		X	X	X	C	
<i>Phaonia pallida</i> (Fabricius, 1787)	MY/FV	Gregor et al., 2016; Falk, 2017				X	X		X	X	C	
<i>Phaonia rufipalpis</i> (Macquart, 1835)	S/FV	Gregor et al., 2016						X			S	
<i>Phaonia fuscata</i> (Fallén, 1823)	S	Gregor et al., 2016			X	X	X	X	X	X		Bezzi, 1895
<i>Phaonia</i> sp. Robineau-Desvoidy, 1830	S	Gregor et al., 2016			X	X		X	X			Bezzi, 1895
<i>Phaonia subventa</i> (Harris, 1780)	S/FV	Gregor et al., 2016; King et al., 2013			X	X	X	X	X	X		Bonacci et al., 2021
<i>Phaonia trimaculata</i> (Bouché, 1834)	S	Gregor et al., 2016			X	X	X	X	X	X	C	
<i>Phaonia tuguriorum</i> (Scopoli, 1763)	S/FV	Gregor et al., 2016; Falk, 2017			X	X	X	X	X	X	C	
<i>Polietes meridionalis</i> Peris & Llorente, 1963	S/FV	Gregor et al., 2016; Pont & Falk, 2013			X	X	X	X	X	X		Bonacci et al., 2021
<i>Stomoxys calcitrans</i> (Linnaeus, 1758)	EMA	Gregor et al., 2016			X	X	X	X	X			Bezzi, 1895
<i>Thricops simplex</i> (Wiedemann, 1817)	S	Gregor et al., 2016			X				X	X		Medicino et al., 2023
<i>Thricops semicinereus</i> (Wiedemann, 1817)	S/FV	Gregor et al., 2016; Weiner, 2016				X	X			X	C	

Mycetophilidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	MY	Oliveira & Amorim, 2016			X	X	X	X	X	X		www.gibf.org

Pallopteridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Palloptera muliebris</i> (Harris, 1780)	MY	Yaran, 2019						X			C	

Platystomatidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Platystoma gemmationis</i> (Rondani, 1869)	S	Greco & Bonacci, 2012			X	X	X	X	X	X		Greco et al., 2012
<i>Platystoma lugubre</i> (Robineau-Desvoidy, 1830)	S	Greco & Bonacci, 2012			X	X	X	X	X			Greco et al., 2012
<i>Platystoma</i> sp. Meigen, 1803	S	Greco & Bonacci, 2012			X	X	X	X	X	X		www.gibf.org
Phoridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Anevrina</i> sp. Lioy, 1864	S	Penev et al., 2004							X			www.gibf.org
<i>Megaselia</i> sp. Rondani, 1856	S	Zhang et al., 2024			X	X	X	X	X	X		www.gibf.org
n.d.	S					X			X	X		www.gibf.org
Pipunculidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Pipunculus</i> sp. Latreille, 1802	PAR/FV	Pollini, 2013			X	X	X			X		www.gibf.org
Pollenidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Pollenia griseotomentosa</i> (Jacentkovsky, 1944)	PAR/FV	Falk, 2016; Falk 2017			X	X	X	X	X		C	
<i>Pollenia rudis</i> (Fabricius, 1794)	PAR/FV	Falk, 2016; Falk 2017			X	X	X	X	X	X		Bezzi, 1895
<i>Pollenia</i> sp. Robineau-Desvoidy, 1830	PAR/FV	Falk, 2016; Falk 2017				X						www.gibf.org
Psillidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Loxocera aristata</i> (Panzer, 1801)	P	Buck & Marshall, 2006				X				X		S
Rhagionidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Rhagio</i> sp. Fabricius, 1775	EMA/FV	Weiner, 2016			X	X	X	X	X	X		www.gibf.org
Rhinophoridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.							X	X		X		www.gibf.org
<i>Paykullia</i> sp. Robineau-Desvoidy, 1830	PAR/FV	Ziegler, 2008					X		X	X		www.gibf.org
<i>Phyto</i> sp. Robineau-Desvoidy, 1830	PAR/FV	Ziegler, 2008			X	X				X		www.gibf.org
<i>Rhinophora lepida</i> (Meigen, 1824)	PAR/FV	Ziegler, 2008; Falk, 2017			X	X	X	X	X	X	S	
<i>Stevenia</i> sp. Robineau-Desvoidy, 1830	PAR/FV	Ziegler, 2008			X		X	X	X			www.gibf.org

Sarcophagidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Angiometopa falleni</i> Pape, 1986	SS	Buenaventura et al., 2020			X	X	X					C	
<i>Miltogramma</i> sp.	SS/FV	Buenaventura et al., 2020; Falk, 2017			X		X					www.gibf.org	
<i>Pterella grisea</i> Meigen, 1824	?						X					C	
<i>Oebalia cylindrica</i> (Fallen, 1810)	SS	Richet et al., 2011				X						C	
<i>Ravinia pernix</i> (Harris, 1780)	SS/FV	Weiner, 2016			X	X	X	X				Bezzi, 1895	
<i>Sarcophaga (Bercaea) africa</i> (Wiedemann, 1824)	SS	Richet et al., 2011					X	X				Whitmore et al., 2016	
<i>Sarcophaga (Helicophagella) agnata</i> Rondani, 1860	SS	Richet et al., 2011				X	X	X	X			C	
<i>Sarcophaga (Helicophagella)</i> sp. Enderlein, 1928	SS	Richet et al., 2011			X		X					www.gibf.org	
<i>Sarcophaga (Parasarcophaga) albiceps</i> Meigen, 1826	SS	Richet et al., 2011			X		X	X				Whitmore et al., 2016	
<i>Sarcophaga (Discachaeta) amita</i> Rondani, 1860	SS	Richet et al., 2011					X					C	
<i>Sarcophaga (Robineauella) caeruleascens</i> Zetterstedt, 1838	SS	Richet et al., 2011			X	X	X	X	X			Whitmore et al., 2016	
<i>Sarcophaga (Liopygia) crassipalpis</i> Macquart, 1839	SS	Richet et al., 2011				X						Whitmore et al., 2016	
<i>Sarcophaga (Helicophagella) crassimargo</i> Pandelle, 1896	SS/FV	Richet et al., 2011; Falk, 2017						X	X			C	
<i>Sarcophaga (Sarcophaga) croatica/variegata</i>	SS	Richet et al., 2011			X	X	X	X	X	X			
<i>Sarcophaga (Heteronychia) filia</i> Rondani, 1860	SS	Richet et al., 2011				X	X	X		X		C	
<i>Sarcophaga (Heteronychia) haemorrhoea</i> Meigen, 1826	SS/FV	Richet et al., 2011; Falk, 2017			X	X	X	X		X		Whitmore et al., 2016	
<i>Sarcophaga (Heteronychia) sp. Brauer & Bergenstamm</i> , 1889	SS	Richet et al., 2011					X					www.gibf.org	
<i>Sarcophaga (Liosarcophaga) sp. Enderlein</i> , 1928	SS	Richet et al., 2011			X		X					www.gibf.org	
<i>Sarcophaga (Thyrsocnema) incistilobata</i> Pandelle, 1896	SS/FV	Richet et al., 2011; Weiner, 2016			X	X	X	X				C	
<i>Sarcophaga (Thyrsocnema) kentejana</i> (Rohdendorf, 1937)	SS	Richet et al., 2011			X	X	X	X	X	X		S	
<i>Sarcophaga (Thyrsocnema) sp. Enderlein</i> , 1928	SS	Richet et al., 2011			X	X		X	X	X		www.gibf.org	
<i>Sarcophaga (Helicophagella) melanura</i> Meigen, 1826	SS/FV	Richet et al., 2011; Weiner, 2016			17	X	X	X	X	X		Whitmore et al., 2016	
<i>Sarcophaga (Helicophagella) novercoides</i> Bottcher, 1913	SS	Richet et al., 2011						X				C	
<i>Sarcophaga (Myorhina) nigriventris</i> (Meigen, 1826)	SS/FV	Richet et al., 2011; Falk, 2017					X					Whitmore et al., 2016	
<i>Sarcophaga (Liosarcophaga) portschinskyi</i> (Rohdendorf, 1937)	SS	Richet et al., 2011			X	X	X	X				Whitmore et al., 2016	
<i>Sarcophaga (Pandelleana) protuberans</i> Pandelle, 1896	SS	Richet et al., 2011								X		C	
<i>Sarcophaga (Sarcotachinella) sinuata</i> Meigen, 1826	SS	Richet et al., 2011			X							C	
<i>Sarcophaga (Myorhina) socrus</i> Rondani, 1860	SS	Richet et al., 2011						X				Whitmore et al., 2016	
<i>Sarcophaga (Sarcophaga) sp. Meigen</i> , 1826	SS	Richet et al., 2011			X	X	X	X	X	X		www.gibf.org	
<i>Sarcophaga (Sarcophaga) subvicina</i> Rohdendorf, 1937	SS/FV	Richet et al., 2011; Falk, 2017				X	X			X		Whitmore et al., 2016	
<i>Sarcophaga (Heteronychia) vicina</i> Macquart, 1835	SS	Richet et al., 2011			X	X	X	X				C	
<i>Sarcophila latifrons</i> (Fallen, 1817)	SS	Richet et al., 2011			X	X	X	X	X	X		C	
<i>Wohlfartia magnifica</i> (Schiner, 1862)	SS	Bonacci et al., 2013				X	X	X	X			Bonacci et al., 2017	
Scathophagidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Scathophaga</i> sp. Meigen, 1803	CP	Webb et al., 2007			X	X		X	X	X		www.gibf.org	
<i>Scathophaga stercoraria</i> (Linnaeus, 1758)	CP	Webb et al., 2007			X	X	X	X	X			Bezzi, 1895	
Sciariidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	MY	Pollini, 2013			X	X	X	X	X	X		www.gibf.org	
Sciomyzidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Coremacera marginata</i> (Fabricius, 1775)	PAR	Sivell & Sivell, 2021					X					www.gibf.org	
<i>Coremacera</i> sp. Rondani, 1856	PAR	Sivell & Sivell, 2021						X		X		www.gibf.org	
n.d.					X	X			X	X			
Sepsidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Sepsis</i> sp. Fallen, 1810	S	Pont & Meier, 2002			X	X	X	X	X	X		www.gibf.org	
<i>Sepsis thoracica</i> (Robineau-Desvoidy, 1830)	S	Pont & Meier, 2002							X			C	

Stratiomyidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Chloromyia formosa</i> (Scopoli, 1763)	S/FV	Nartshuk, 2007			X	X	X	X	X	X		Mason, 2013
<i>Microchrysa polita</i> (Linnaeus, 1758)	S/FV	Nartshuk, 2007			X		X		X	X	C	
Syrphidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Arctophila superbiens</i> (Muller, 1776)	POL									X	C	
<i>Brachypalpoides lentus</i> Meigen, 1822	POL									X	C	
<i>Cheilosia</i> sp. Meigen, 1822	POL	van Veen, 2010			X	X		X		X		Bezzi, 1895
<i>Cheilosia vulpina</i> (Meigen, 1822)	POL	van Veen, 2010		LC				X			C	
<i>Chrysotoxum festivum</i> (Linnaeus, 1758)	POL	van Veen, 2010			X							Bezzi, 1895
<i>Chrysotoxum elegans</i> Loew, 1841	POL	van Veen, 2010		NT		X						van Der Goot., 1969
<i>Chrysotoxum intermedium</i> (Meigen, 1822)	POL	van Veen, 2010		LC	X		X			X		Costa, 1863
<i>Chrysotoxum octomaculatum</i> Curtis, 1837	POL	van Veen, 2010		NT	X			X				van Der Goot., 1969
<i>Chrysotoxum</i> sp. Meigen, 1803	POL	van Veen, 2010					X					www.gibf.org
<i>Dasyrphus</i> sp. Enderlein, 1938	POL	van Veen, 2010			X		X					www.gibf.org
<i>Epistrophe</i> sp. Walker, 1852	POL	van Veen, 2010			X		X		X			www.gibf.org
<i>Episyrphus (Meliscaeva) auricollis</i> (Meigen, 1822)	POL	van Veen, 2010						X			C	
<i>Episyrphus balteatus</i> (De Geer, 1776)	POL	van Veen, 2010		LC	X		X	X	X	X		Bezzi, 1895
<i>Episyrphus</i> sp. Matsumura & Adachi, 1917	POL	van Veen, 2010								X		Bezzi, 1895
<i>Eristalis arbustorum</i> (Linnaeus, 1758)	POL	van Veen, 2010		LC	X							Bezzi, 1895
<i>Eristalis jugorum</i> Egger, 1925	POL	van Veen, 2010		LC	X						C	
<i>Eristalis pertinax</i> (Scopoli, 1763)	POL	van Veen, 2010		LC				X				van Der Goot., 1969; Mason et al., 2006
<i>Eristalis</i> sp. Latreille, 1804	POL	van Veen, 2010			X	X	X	X		X		van Der Goot., 1969; Mason et al., 2006
<i>Eristalis tenax</i> (Linnaeus, 1758)	SS/POL	van Veen, 2010		LC	X		X	X				Mason et al., 2006; Mendicino et al., 2023
<i>Eumerus flavitarsis</i> Zetterstedt, 1843	POL	van Veen, 2010		LC				X			C	
<i>Eumerus</i> sp. Meigen, 1822	POL	van Veen, 2010			X	X	X	X	X	X		Bezzi, 1895
<i>Eupeodes corollae</i> (Fabricius, 1794)	POL	van Veen, 2010		LC	X	X	X	X	X	X		Bezzi, 1895
<i>Eupeodes latifasciatus</i> (Macquart, 1829)	POL	van Veen, 2010		LC			X		X	X		van Der Goot., 1969
<i>Eupeodes luniger</i> (Meigen, 1822)	POL	van Veen, 2010		LC	X	X	X	X	X	X		coll. Mus. Verona 1989
<i>Melanostoma mellinum</i> (Linnaeus, 1758)	Z/POL	van Veen, 2010		LC					X	X		Bezzi, 1895
<i>Mallota fuciformis</i> (Fabricius, 1794)	S/POL	van Veen, 2010			X							Bezzi, 1895
<i>Merodon aberrans</i> Shamon, 1927	POL	van Veen, 2010		LC	X		X					Bezzi, 1895
<i>Merodon aeneus</i> Meigen, 1822	POL	van Veen, 2010			X	X	X	X				Bezzi, 1895
<i>Merodon albifrons</i> Meigen, 1822	POL	van Veen, 2010		LC	X		X	X				Bezzi, 1895
<i>Merodon avidus</i> (Rossi, 1790)	POL	van Veen, 2010		LC	X	X	X	X		X		Bezzi, 1895
<i>Merodon equestris</i> (Fabricius, 1794)	POL	van Veen, 2010		LC			X				C	
<i>Merodon rufus</i> Meigen, 1838	POL	van Veen, 2010		LC		X			X		C	
<i>Merodon</i> sp. Meigen, 1803	POL	van Veen, 2010			X	X	X	X				Bezzi, 1895
<i>Myathropa florea</i> (Linnaeus, 1758)	POL	van Veen, 2010		LC						X		bezzi, 1895; Mason et al., 2006
<i>Pelecocera</i> sp. Meigen, 1822	POL	van Veen, 2010			X							www.gibf.org
<i>Platycheirus angustatus</i> (Zetterstedt, 1842)	POL	van Veen, 2010		LC			X	X		X		Bezzi, 1895
<i>Sphaerophoria rupepelli</i> (Wiedmann, 1830)	POL	van Veen, 2010		LC				X				Bezzi, 1895
<i>Sericomyia silentis</i> (Harris, 1776)	POL	van Veen, 2010		LC	X							Bezzi, 1895
<i>Sphaerophoria scripta</i> (Linnaeus, 1758)	POL	van Veen, 2010		LC	X	X	X	X	X	X		costa, 1863; van der got, 1969
<i>Sphaerophoria</i> sp. Le Peletier & Serville, 1828	POL	van Veen, 2010			X	X		X		X		Bezzi, 1895
<i>Syrphus</i> sp. Fabricius, 1775	POL	van Veen, 2010				X	X		X	X		van der got, 1969; Coll. Mus. Firenze
<i>Syrphus vitripennis</i> Meigen, 1822	POL	van Veen, 2010		LC						X	C	
<i>Tropidia fasciata</i> Meigen, 1822	POL	van Veen, 2010		LC	X	X		X			C	
<i>Tropidia</i> sp. Meigen, 1822	POL	van Veen, 2010			X			X		X		Bezzi, 1895
<i>Xylota</i> sp. Meigen, 1822	POL	van Veen, 2010					X			X		Bezzi, 1895
Tabanidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Chrysops (Chrysops) caecutiens</i> (Linnaeus, 1758)	POL/EM A	Southwick, 2020			X	X	X		X	X	C	
<i>Chrysops viduatus</i> (Fabricius, 1794)	POL/EM A	Southwick, 2020			X		X				C	
<i>Haematopoda italica</i> Meigen, 1804	POL/EM A	Krcmar & Maric, 2006			X	X			X		C	
<i>Haematopoda</i> sp. Meigen, 1803	POL/EM A	Krcmar & Maric, 2006					X	X	X			www.gibf.org
<i>Hybomitra montana</i> (Meigen, 1820)	POL/EM A	Krcmar & Maric, 2006							X	X		Mendicino et al., 2023
<i>Tabanus rectus</i> Low, 1858	POL/EM A	Krcmar & Maric, 2006			X		X			X	C	
<i>Tabanus</i> sp. Linnaeus, 1758	POL/EM A	Krcmar & Maric, 2006			X				X	X		www.gibf.org
<i>Tabanus tergestinus</i> Egger, 1859	POL/EM A	Krcmar & Maric, 2006			X		X	X			C	

Tachinidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Bithia modesta</i> (Meigen, 1824)	PAR/FV	Muckstein et al., 2007								X	C	
<i>Bithia</i> sp. Robineau-Desvoidy	PAR/FV	Muckstein et al., 2007					X					www.gibf.org
<i>Cistogaster globosa</i> (Fabricius, 1775)	PAR/FV	Raper & Smith, 2002						X				Bezzi, 1985
<i>Clausicella</i> sp. Rondani, 1856	PAR/FV	Scaramozzino et al., 2020						X				www.gibf.org
<i>Cylindromyia intermedia</i> (Meigen, 1824)	PAR/FV	Ziegler, 2016			X			X			C	
<i>Cylindromyia</i> sp. Meigen, 1803	PAR/FV	Ziegler, 2016						X				www.gibf.org
<i>Cyzenis albicans</i> (Fallen, 1810)	PAR/FV	Eskinton et al., 2021			X	X	X	X		X		Mason et al., 2006
<i>Dexiosoma caninum</i> (Fabricius, 1781)	PAR/FV	Piper, 2021					X					Mason et al., 2006
<i>Dufouria chalybeata</i> (Meigen, 1824)	PAR/FV	Atay, 2018								X	C	
<i>Dufouria nigrita</i> (Fallen, 1810)	PAR/FV	Atay, 2018					X	X			C	
<i>Eriothrix moniticola</i> (Egger, 1856)	PAR/FV	Cerretti & Tschorsnig, 2012			X	X	X	X				C
<i>Eriothrix rufomaculata</i> (DeGeer, 1776)	PAR/FV	Cerretti & Tschorsnig, 2012			X			X				C
<i>Estheria microcera</i> (Robineau-Desvoidy, 1830)	PAR/FV	Cerretti & Tschorsnig, 2012						X				C
<i>Estheria petiolata</i> (Bonsdorff, 1866)	PAR/FV	Cerretti & Tschorsnig, 2012					X					C
<i>Estheria</i> sp. Robineau-Desvoidy, 1830	PAR/FV	Cerretti & Tschorsnig, 2012							X			Cerretti, 2010
<i>Gonia bimaculata</i> Wiedemann, 1819	PAR/FV	Baronio & Schnal, 1980			X		X	X				Cerretti & Tschorsnig, 2010
<i>Gonia picea</i> (Robineau-Desvoidy, 1830)	PAR/FV	Baronio & Schnal, 1980				X						C
<i>Gonia vacua</i> Meigen, 1826	PAR/FV	Baronio & Schnal, 1980			X							C
<i>Gymnosoma nitens</i> Meigen, 1824	PAR/FV	Cerretti & Tschorsnig, 2010						X				C
<i>Gymnosoma</i> sp. Meigen, 1803	PAR/FV	Cerretti & Tschorsnig, 2010						X				www.gibf.org
<i>Kirbya moerens</i> (Meigen, 1830)	PAR/FV	Karagoz et al., 2009			X	X	X	X				C
<i>Microphthalma europea</i> Egger, 1860	PAR/FV									X		C
<i>Nowickia</i> sp. Wachtl, 1894	FV	Cerretti & Tschorsnig, 2010								X		www.gibf.org
<i>Nowickia strobili</i> (Rondani, 1865)	FV	Cerretti & Tschorsnig, 2010			X	X	X	X	X	X		C
<i>Peleteria</i> sp. Robineau-Desvoidy, 1830	PAR/FV	Foerster & Doetzer, 2002			X							www.gibf.org
<i>Peleteria rubescens</i> (Robineau-Desvoidy, 1830)	PAR/FV	Foerster & Doetzer, 2002				X	X					www.gibf.org
<i>Smidtia</i> sp. Robineau-Desvoidy, 1830	PAR/FV	Haupt & Haupt, 2002						X				www.gibf.org
<i>Tachina casta</i> (Rondani, 1859)	PAR/FV	Haupt & Haupt, 2002			X	X		X		X		Bezzi, 1895
<i>Tachina fera</i> (Linnaeus, 1761)	PAR/FV	Haupt & Haupt, 2002			X	X	X			X		Bezzi, 1895
<i>Tachina magnicornis</i> (Zetterstedt, 1844)	PAR/FV	Haupt & Haupt, 2002			X	X		X	X	X		C
<i>Tachina</i> sp. Meigen, 1803	PAR/FV	Haupt & Haupt, 2002						X				www.gibf.org
<i>Wegneria</i> sp. Diakonoff, 1951	PAR/FV	Cerretti & Tschorsnig, 2010			X	X						www.gibf.org
Tephritidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Carpomya schineri</i> (Loew, 1856)	P/FV	Korneyex et al., 2017			X							C
<i>Chaetorellia</i> sp. Hendel, 1927	P/FV	Pollini, 2013			X	X	X					www.gibf.org
<i>Tephris</i> sp. Ragonot, 1891	P/FV	Kutur, 2005			X	X	X	X	X	X		www.gibf.org
Therevidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Thereva</i> sp. Latreille, 1797	Z/FV	van Herk et al., 2014						X	X			www.gibf.org
<i>Thereva valida</i> Loew, 1847	Z/FV	van Herk et al., 2014						X				C
Tipulidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Nephrotoma</i> sp. Meigen, 1803	P	Hofsvang, 2010				X			X			www.gibf.org
<i>Tipula</i> sp. Linnaeus, 1758	S	Lantsov, 2003			X	X	X	X	X	X		www.gibf.org
Uliididae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Herina</i> sp. Robineau-Desvoidy, 1830	S	Tuccia et al., 2021			X	X				X		www.gibf.org
<i>Otites</i> sp. Latreille, 1804	S	Tuccia et al., 2021			X	X	X	X	X	X		www.gibf.org
<i>Physiphora alcaeae</i> (Preyssl, 1791)	S	Tuccia et al., 2021					X	X	X	X		Bezzi, 1895

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Andrenidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Andrena afzeliella</i> (Kirby, 1802)	POL	Danforth et al., 2019			X					X	C	
<i>Andrena agilissima</i> (Scopoli, 1770)	POL	Comba, 2019		DD					X			Comba, 2019
<i>Andrena barbareae</i> Panzer, 1805)	POL	Comba, 2019		DD			X			X	S	
<i>Andrena bicolor</i> Fabricius, 1775	POL	Comba, 2019		LC						X		Comba, 2019
<i>Andrena cinerea</i> Brulle, 1832	POL	Comba, 2019		DD	X	X	X					Comba, 2019
<i>Andrena combinata</i> (Christ, 1791)	POL	Comba, 2019		DD						X		Comba, 2019
<i>Andrena curvungula</i> Thomson, 1870	POL	Comba, 2019		DD		X			X		S	
<i>Andrena dorsata</i> (Kirby, 1802)	POL	Comba, 2019		DD		X			X	X		Comba, 2019
<i>Andrena flavipes</i> Panzer, 1799	POL	Comba, 2019		LC	X	X	X	X	X	X		Comba, 2019
<i>Andrena fucata</i> Smith, 1847	POL	Comba, 2019				X				X	S	
<i>Andrena fulva</i> (Muller, 1766)	POL	Comba, 2019		DD			X				C	
<i>Andrena fulvago</i> (Christ, 1791)	POL	Comba, 2019		DD						X		Comba, 2019
<i>Andrena fulvata</i> E. Stockhert, 1930	POL	Comba, 2019		DD					X		S	
<i>Andrena fulvitaris</i> Brullè, 1832	POL	Comba, 2019		LC	X	X	X		X			Comba, 2019
<i>Andrena fumida</i> Perez, 1895	POL	Comba, 2019		DD						X	C	
<i>Andrena gelrae</i> van der Vecht, 1927	POL	Comba, 2019		DD						X	C	
<i>Andrena gravida</i> Imhoff, 1832	POL	Comba, 2019		DD	X	X	X	X	X		S	
<i>Andrena helvola</i> (Linnaeus, 1758)	POL	Comba, 2019		DD					X			Comba, 2019
<i>Andrena humilis</i> Imhoff, 1832	POL	Comba, 2019		DD	X							Comba, 2019
<i>Andrena (Chlorandrena) kamarti</i> Schmiedeknecht, 1900	POL	Comba, 2019		DD						X	P	
<i>Andrena labiata</i> Fabricius, 1781	POL	Comba, 2019		DD		X		X		X		Comba, 2019
<i>Andrena minutuloides</i> Perkins, 1914	POL	Comba, 2019		DD	X	X			X	X	C	
<i>Andrena minutula</i> (Kirby, 1802)	POL	Comba, 2019		DD	X				X	X		Comba, 2019
<i>Andrena (Melandrena) morio</i> Brullè, 1832	POL	Comba, 2019		DD	X	X	X					Comba, 2019
<i>Andrena nigroaenea</i> (Kirby, 1802)	POL	Comba, 2019		LC	X		X			X		Comba, 2019
<i>Andrena ovata</i> Schenck, 1853	POL	Comba, 2019								X	C	
<i>Andrena pilipes</i> Fabricius, 1781	POL	Comba, 2019		LC		X						Comba, 2019
<i>Andrena polita</i> Smith, 1847	POL	Comba, 2019		LC		X	X	X			C	
<i>Andrena</i> sp. Fabricius, 1775	POL	Comba, 2019				X		X				Comba, 2019
<i>Andrena thoracica</i> (Fabricius, 1775)	POL	Comba, 2019		DD	X		X					Comba, 2019
<i>Andrena tomora</i> Warncke, 1975	POL	Comba, 2019		DD	X	X				X		Wood et al., 2023
<i>Andrena trimmerana</i> (Kirby, 1802)	POL	Comba, 2019		DD	X		X		X	X	C	
<i>Andrena wilkella</i> (Kirby, 1802)	POL	Comba, 2019		DD		X			X		C	
<i>Panurgus calcaratus</i> (Scopoli, 1763)	POL	Comba, 2019		LC	X	X	X	X	X	X		Comba, 2019

Apidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Amegilla quadrifasciata</i> (Villers, 1789)	POL	Comba, 2019		LC			X					Comba, 2019
<i>Anthophora balnearum</i> Lepeletier, 1841	POL	Comba, 2019		LC		X					S	
<i>Anthophora bimaculata</i> (Panzer, 1801)	POL	Comba, 2019		LC		X	X					Comba, 2019
<i>Anthophora plumipes</i> Pallas, 1772	POL	Comba, 2019		LC						X		Comba, 2019
<i>Anthophora retusa</i> (Linnaeus, 1758)	POL	Comba, 2019		LC		X		X			C	
<i>Anthophora</i> sp. Latreille, 1803	POL	Comba, 2019				X						Comba, 2019
<i>Apis mellifera</i> Linnaeus, 1758	POL	Comba, 2019		DD	X	X	X	X	X	X		Comba, 2019
<i>Bombus hortorum</i> (Linnaeus, 1758)	POL	Comba, 2019		LC					X	X		Comba, 2019
<i>Bombus lapidarius</i> Linnaeus, 1758	POL	Comba, 2019		LC			X		X	X		Comba, 2019
<i>Bombus</i> sp. Latreille, 1802	POL	Comba, 2019	LC	LC						X		Comba, 2019
<i>Bombus pascuorum melleofacies</i> Vogt, 1909	POL	Comba, 2019		LC	X	X		X	X	X		Comba, 2019
<i>Bombus pratorum</i> (Linnaeus, 1761)	POL	Comba, 2019		LC	X		X	X	X	X		Comba, 2019
<i>Bombus ruderatus</i> (Fabricius, 1775)	POL	Comba, 2019		LC			X		X	X		Comba, 2019
<i>Bombus rupestris</i> (Fabricius, 1793)	POL	Comba, 2019		LC			X					Comba, 2019
<i>Bombus sylavurum</i> Linnaeus, 1761	POL	Comba, 2019		LC			X					Comba, 2019
<i>Bombus terrestris</i> (Linnaeus, 1758)	POL	Comba, 2019		LC	X	X	X	X	X	X		Comba, 2019
<i>Bombus vestalis</i> (Fourcroy, 1785)	POL	Comba, 2019		LC	X	X	X	X	X	X		Comba, 2019
<i>Ceratina cucurbitina</i> (Rossi, 1792)	POL	Comba, 2019		LC	X	X	X	X	X	X		Comba, 2019
<i>Eucera albofasciata</i> Friese, 1895	POL	Comba, 2019		DD	X						P	
<i>Eucera cineraria</i> Eversmann, 1852	POL	Comba, 2019		LC			X					Comba, 2019
<i>Eucera longicornis</i> (Linnaeus, 1758)	POL	Comba, 2019		LC			X			X		Comba, 2019
<i>Eucera nigrifacies</i> Lepeletier, 1841	POL	Comba, 2019		LC			X	X			C	
<i>Eucera pannonica</i> Mocsáry, 1878	POL	Comba, 2019		DD			X			X	C	
<i>Habropoda tarsata</i> (Spinola, 1838)	POL	Comba, 2019		LC						X		Comba, 2019
<i>Melecta festiva</i> Liefstinck, 1980	CLEP/POL	Comba, 2019		DD							S	
<i>Melecta</i> sp. Latreille, 1802	CLEP/POL	Comba, 2019				X		X	X			Comba, 2019
<i>Nomada armata</i> Herrich-Schäffer, 1839	CLEP/POL	Comba, 2019		NT						X	C	
<i>Nomada castellana</i> Dusmet, 1913	CLEP/POL	Comba, 2020		LC							S	
<i>Nomada fucata</i> Panzer, 1798	CLEP/POL	Comba, 2019		LC			X					Comba, 2019
<i>Nomada mutabilis</i> Morawitz, 1870	CLEP/POL	Comba, 2019		LC		X					S	
<i>Nomada panzeri</i> gr.	CLEP/POL	Comba, 2019		LC						X	C	
<i>Nomada pleurosticta</i> Herrich-Schäffer, 1839	CLEP/POL	Comba, 2019		NT		X					S	
<i>Nomada signata</i> Jurine, 187	CLEP/POL	Comba, 2019		LC						X	C	
<i>Nomada</i> sp. Scopoli, 1770	CLEP/POL	Comba, 2019					X					Comba, 2019
<i>Tetralonia malvae</i> (Rossi, 1790)	POL	Comba, 2019		LC			X		X		C	
<i>Tetraloniella dentata</i> (Germar, 1839)	POL	Comba, 2019		LC			X					Comba, 2019
<i>Xylocopa iris</i> (Christ, 1791)	POL	Comba, 2019		LC			X					Comba, 2019
<i>Xylocopa valga</i> (Gerstaecker, 1872)	POL	Comba, 2019		LC				X				Comba, 2019
<i>Xylocopa violacea</i> (Linnaeus, 1758)	POL	Comba, 2019		LC	X	X	X	X	X			Comba, 2019
Braconidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	CLEP/POL	Loni et al., 2016			X	X	X	X	X	X		www.gibf.org
Chalcididae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	PAR	Pollini, 2013				X	X	X		X		www.gibf.org
Chrysididae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Chrysis</i> sp. Linnaeus, 1761	PAR/FV	Pollini, 2013			X	X	X	X	X	X		www.gibf.org
<i>Elampus</i> sp. Spinola, 1806	PAR/FV	Pollini, 2013				X						www.gibf.org
n.d.	PAR/FV	Pollini, 2013				X	X	X	X	X		www.gibf.org
Crabronidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Argogorytes</i> sp. Ashmead, 1899	Z/FV	Pagliano & Negrisola, 2005			X		X					www.gibf.org
<i>Astata</i> sp. Latreille, 1796	Z/FV	Pagliano & Negrisola, 2005					X					www.gibf.org
<i>Cerceris</i> sp. Latreille, 1802	Z/FV	Pagliano & Negrisola, 2005				X		X		X		www.gibf.org
<i>Ectemnius massiliensis</i> (Kohl, 1883)	Z/FV	Pagliano & Negrisola, 2005								X	C	
<i>Ectemnius</i> sp. Dahlbom, 1845	Z/FV	Pagliano & Negrisola, 2005			X							www.gibf.org
<i>Gorytes</i> sp. Latreille, 1804	Z/FV	Pagliano & Negrisola, 2005						X				www.gibf.org
<i>Lindenius</i> sp. Lepeletier & Brullé, 1835	Z/FV	Pagliano & Negrisola, 2005				X	X			X		www.gibf.org
n.d.					X	X	X	X	X	X		www.gibf.org
<i>Oxybelus</i> sp. Latreille, 1796	Z/FV	Pagliano & Negrisola, 2005			X	X	X					www.gibf.org
<i>Oxybelus subspinosus</i> Klug, 1835	Z/FV	Pagliano & Negrisola, 2005			X	X	X	X			C	

Colletidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Colletes mlokoszewiczi</i> Radoszkowski, 1891	POL	Comba, 2019		LC	X	X	X					Comba, 2019
<i>Colletes similis</i> Schenck, 1853	POL	Comba, 2019		LC		X					C	
<i>Hylaeus brevicornis</i> Nylander, 1852	POL	Comba, 2019		LC	X	X		X				Comba, 2019
<i>Hylaeus clypearis</i> (Schenck, 1853)	POL	Comba, 2019		LC	X	X	X	X				Comba, 2019
<i>Hylaeus communis</i> Nylander, 1852	POL	Comba, 2019		LC	X	X		X	X	X		Comba, 2019
<i>Hylaeus dilatatus</i> (Kirby, 1802)	POL	Comba, 2019		LC	X						S	
<i>Hylaeus hyalinatus montebovensis</i> (Pittioni, 1950)	POL	Comba, 2019		LC	X						C	
<i>Hylaeus kahri</i> Forster, 1871	POL	Comba, 2019		DD						X	S	
<i>Hylaeus imparilis</i> Forster, 1871	POL	Comba, 2019		LC		X	X					Comba, 2019
<i>Hylaeus incongruus</i> Forster, 1871	POL	Comba, 2019		DD				X		X	S	
<i>Hylaeus sinuatus</i> (Schenck, 1853)	POL	Comba, 2019		LC			X					Comba, 2019
<i>Hylaeus taeniolatus</i> Forster, 1871	POL	Comba, 2019		LC	X							Comba, 2019
Cynipoidea												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Brachymeria femorata</i> (Panzer, 1801)	PAR	El-Salam, 2020				X					S	
n.d.	P	Pollini, 2013			X		X	X	X	X		www.gibf.org
Diapriidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	PAR	Bellow et al., 1999			X	X	X	X	X	X		www.gibf.org
Evaniidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	PAR	Pollini, 2013			X		X	X	X	X		www.gibf.org
Formicidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Camponotus (Tanaemyrmex) aethiops</i> (Latreille, 1798)	ZS	Lebas et al., 2016			X	X	X	X	X			www.gibf.org
<i>Camponotus (Myrmentoma) gestroi</i> Emery, 1878	ZS	Lebas et al., 2016				X	X	X	X		C	
<i>Camponotus micans</i> (Nylander, 1856)	ZS	Lebas et al., 2016			X	X	X	X	X			www.gibf.org
<i>Camponotus</i> sp. Mayr 1861	ZS	Lebas et al., 2016			X	X	X			X		www.gibf.org
<i>Camponotus vagus</i> (mettere qui le ultime mincans in genere)	ZS	Lebas et al., 2016				X		X	X			www.gibf.org
<i>Cardiocondyla</i> sp. Emery, 1869	ZS	Lebas et al., 2016			X	X		X	X	X		www.gibf.org
<i>Formica (Serviformica) cinerea</i> Mayr, 1853	ZS	Lebas et al., 2016				X	X	X	X			www.gibf.org
<i>Formica cunicularia</i> Latreille, 1798	ZS	Lebas et al., 2016					X					Lebas et al., 2019
<i>Formica (Serviformica) fusca</i> Linnaeus, 1758	ZS	Lebas et al., 2016			X	X	X	X	X			Lebas et al., 2019
<i>Formica gagates</i> Latreille, 1798	ZS	Lebas et al., 2016					X		X			Lebas et al., 2019
<i>Formica (Serviformica) rufibarbis</i> Fabricius, 1793	ZS	Lebas et al., 2016			X	X	X			X		Lebas et al., 2019
<i>Formica (Raptiformica) sanguinea</i> Latreille, 1798	ZS	Lebas et al., 2016			X							Lebas et al., 2019
<i>Lasius alienus</i> Forster, 1850	ZS	Lebas et al., 2016			X	X	X	X	X	X		Lebas et al., 2019
<i>Lasius (Lasius) brunneus</i> (Latreille, 1798)	ZS	Lebas et al., 2016			X	X		X				Lebas et al., 2019
<i>Lasius (Lasius) lasioides</i> (Emery, 1869)	ZS	Lebas et al., 2016			X	X		X	X			Lebas et al., 2019
<i>Lasius</i> sp. Fabricius, 1804 (gruppo alienus)	ZS	Lebas et al., 2016			X	X	X	X		X		Lebas et al., 2019
<i>Messor capitatus</i> (Latreille, 1798)	ZS	Lebas et al., 2016			X	X	X	X	X			Lebas et al., 2019
<i>Messor structor</i> (Latreille, 1798)	ZS	Lebas et al., 2016				X						Lebas et al., 2019
<i>Myrmica sabuleti</i> Meinert, 1861	ZS	Lebas et al., 2016				X				X		Lebas et al., 2019
<i>Myrmica</i> sp. Latreille, 1804	ZS	Lebas et al., 2016						X	X	X		Lebas et al., 2019
<i>Pheidole</i> sp. Westwood, 1839	ZS	Lebas et al., 2016			X	X						Lebas et al., 2019
<i>Tapinoma nigerrimum</i> (Nylander, 1856)	ZS	Lebas et al., 2016			X		X	X				Lebas et al., 2019
<i>Tetramorium</i> sp. Mayr, 1855	ZS	Lebas et al., 2016					X					Lebas et al., 2019

Halictidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Halictus alfenellus</i> Stand, 1909	POL	Comba, 2019		DD						X	P	
<i>Halictus brunnescens</i> (Eversmann, 1852)	POL	Comba, 2019		DD	X		X					Comba, 2019
<i>Halictus eurygnatus</i> Bluthgen, 1931	POL	Comba, 2019		DD	X	X	X					Comba, 2019
<i>Halictus fulvipes</i> (Klug, 1817)	POL	Comba, 2019		LC		X					C	
<i>Halictus maculatus</i> Smith, 1848	POL	Comba, 2019		LC	X	X						Comba, 2019
<i>Halictus scabiosae</i> (Rossi, 1790)	POL	Comba, 2019		LC	X	X	X	X	X	X		Comba, 2019
<i>Halictus sexcinctus</i> (Fabricius, 1775)	POL	Comba, 2019		LC				X				Comba, 2019
<i>Halictus simplex</i> gr.	POL	Comba, 2019				X	X			X	C	
<i>Halictus subauratus</i> (Rossi, 1792)	POL	Comba, 2019		LC	X	X	X	X		X		Comba, 2019
<i>Halictus</i> sp. Latreille, 1804	POL	Comba, 2019			X	X			X			Comba, 2019
<i>Halictus quadricinctus</i> (Fabricius, 1776)	POL	Comba, 2019	DD/LC	NT		X	X	X				Comba, 2019
<i>Lasioglossum aeratum</i> (Kirby, 1802)	POL	Comba, 2019		LC	X	X	X				C	
<i>Lasioglossum alipes</i> (Fabricius, 1781)	POL	Comba, 2019		LC	X	X		X	X	X	C	
<i>Lasioglossum albocinctum</i> (Lucas, 1849)	POL	Comba, 2019		LC	X	X	X	X	X			Comba, 2019
<i>Lasioglossum binaculatum</i> (Dours, 1872)	POL	Comba, 2019		LC	X	X	X	X	X	X		Comba, 2019
<i>Lasioglossum brevicorne</i> (Schenck, 1870)	POL	Comba, 2019	DD/LC	NT	X	X	X	X				Comba, 2019
<i>Lasioglossum calceatum</i> (Scopoli, 1763)	POL	Comba, 2019		LC	X	X		X			C	
<i>Lasioglossum crassepunctatum</i> (Bluthgen, 1923)	POL	Comba, 2019		DD						X		Comba, 2019
<i>Lasioglossum convexiusculum</i> (Schenck, 1853)	POL	Comba, 2019	DD/LC	NT					X		S	
<i>Lasioglossum fulvicorne</i> (Kirby, 1802)	POL	Comba, 2019		LC						X	S	
<i>Lasioglossum glabriusculum</i> (Morawitz, 1872)	POL	Comba, 2019		LC			X					Comba, 2019
<i>Lasioglossum griseolum</i> (Morawitz, 1872)	POL	Comba, 2019		LC	X	X	X	X		X	C	
<i>Lasioglossum (Evyllaesus) immunitum</i> (Vachal, 1895)	POL	Comba, 2019		DD	X				X			Comba, 2019
<i>Lasioglossum interruptum</i> (Panzer, 1798)	POL	Comba, 2019		LC	X	X	X			X		Comba, 2019
<i>Lasioglossum laeve</i> Kirby, 1802	POL	Comba, 2019		EN					X	X	C	
<i>Lasioglossum laevigatum</i> (Kirby, 1802)	POL	Comba, 2019	DD/LC	NT		X	X		X		C	
<i>Lasioglossum laticeps</i> (Schenck, 1869)	POL	Comba, 2019		LC		X	X	X				Comba, 2019
<i>Lasioglossum lativentre</i> (Schenck, 1853)	POL	Comba, 2019		LC	X		X	X		X	C	
<i>Lasioglossum leucopus</i> (Kirby, 1802)	POL	Comba, 2019		LC						X	S	
<i>Lasioglossum leucozonium</i> (Schränk, 1781)	POL	Comba, 2019		LC	X	X	X	X				Comba, 2019
<i>Lasioglossum lineare</i> (Schenck, 1870)	POL	Comba, 2019		DD	X		X				S	
<i>Lasioglossum majus</i> (Nylander, 1852)	POL	Comba, 2019		NT			X					Comba, 2019
<i>Lasioglossum morio</i> (Fabricius, 1793)	POL	Comba, 2019		LC	X	X				X	C	
<i>Lasioglossum nitidiusculum</i> (Kirby, 1802)	POL	Comba, 2019		LC		X						Comba, 2019
<i>Lasioglossum pauperatum</i> (Brullé, 1832)	POL	Comba, 2019		LC	X	X	X			X		Comba, 2019
<i>Lasioglossum pauxillum</i> (Schenck, 1853)	POL	Comba, 2019		LC	X	X	X					Comba, 2019
<i>Lasioglossum punctatissimum</i> (Schenck, 1853)	POL	Comba, 2019		LC	X							Comba, 2019
<i>Lasioglossum pygmaeum</i> (Schenck, 1853)	POL	Comba, 2019	DD/LC	NT	X					X	C	
<i>Lasioglossum</i> sp. Curtis, 1833	POL	Comba, 2019			X	X	X	X				Comba, 2019
<i>Lasioglossum rufitarse</i> (Zetterstedt, 1838)	POL	Comba, 2019		LC			X				C	
<i>Lasioglossum semilucens</i> (Alfken, 1914)	POL	Comba, 2019		LC	X					X	S	
<i>Lasioglossum transitorium</i> (Schenck, 1868)	POL	Comba, 2019		LC	X			X			C	
<i>Lasioglossum tricinctum</i> (Schenck, 1874)	POL	Comba, 2019		DD	X	X	X				C	
<i>Lasioglossum villosulum</i> (Kirby, 1802)	POL	Comba, 2019		LC	X							Comba, 2019
<i>Lasioglossum xanthopus</i> (Kirby, 1802)	POL	Comba, 2019	DD/LC	NT	X		X	X			C	
<i>Seladonia seladonia</i>	POL	Comba, 2019				X						Comba, 2019
<i>Seladonia smaragdula</i> complex	POL	Comba, 2019		LC	X	X	X				C	
<i>Sphecodes ephippius</i> (Linnaeus, 1758)	CLEP/POL	Comba, 2019		LC	X							Comba, 2019
<i>Sphecodes miniatus</i> von Hagens, 1882	CLEP/POL	Comba, 2019		LC	X	X					S	
<i>Sphecodes reticulatus</i> Thomson, 1870	CLEP/POL	Comba, 2019		LC			X				C	
<i>Sphecodes</i> sp. Latreille, 1804	CLEP/POL	Comba, 2019				X	X					Comba, 2019
<i>Sphecodes pseudofasciatus</i> Bluthgen, 1925	CLEP/POL	Comba, 2019		DD						X	S	

Ichneumonidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Enicospilus</i> sp. Stephens, 1835	PAR	Pollini, 2013			X	X	X	X	X	X		www.gibf.org
<i>Gelis</i> sp. Thunberg, 1827	PAR	Pollini, 2013			X	X			X	X		www.gibf.org
<i>Ichneumon</i> sp. Linnaeus, 1758	PAR	Pollini, 2013				X	X			X		www.gibf.org
n.d.	PAR	Pollini, 2013			X	X	X	X	X	X		www.gibf.org

Megachilidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Chelostoma cf. florissomne</i> (Linnaeus, 1758)	POL	Comba, 2019		LC					X			Comba, 2019
<i>Chelostoma grande</i> (Nylander, 1852)	POL	Comba, 2019		DD		X						S
<i>Heriades</i> sp. Spinola, 1808	POL	Comba, 2019				X		X	X			Comba, 2019
<i>Heriades crenulatus</i> (Nylander, 1856)	POL	Comba, 2019		LC				X				C
<i>Heriades (Heriades) truncorum</i> (Linnaeus, 1758)	POL	Comba, 2019		LC	X	X	X	X				Comba, 2019
<i>Hoplitis tridentata</i> (Dufour & Perris, 1840)	POL	Comba, 2019		LC			X					Comba, 2019
<i>Hoplitis scutellaris</i> Morawitz, 1868	POL	Comba, 2019		DD			X	X		X		C
<i>Lithurgus chrysurus</i> (Fonscolombe, 1834)	POL	Comba, 2019		LC		X		X				Comba, 2019
<i>Megachile argentata</i> (Fabricius, 1793)	POL	Comba, 2019		LC		X	X					Comba, 2019
<i>Megachile centuncularis</i> (Linnaeus, 1758)	POL	Comba, 2019		LC	X	X		X				C
<i>Megachile melanopyga</i> Costa, 1863	POL	Comba, 2019		LC			X	X		X		Comba, 2019
<i>Stelis</i> sp. Panzer, 1806	POL	Comba, 2019						X				Comba, 2019
<i>Osmia cephalotes</i> Morawitz, 1870	POL	Comba, 2019		LC			X					C
<i>Osmia cerinthidis</i> Morawitz, 1876	POL	Comba, 2019		LC		X				X		S
<i>Osmia dimidiata</i> Morawitz, 1870	POL	Comba, 2019		LC						X		Comba, 2019
<i>Osmia leaiana</i> (Kirby, 1802)	POL	Comba, 2019		LC				X				Comba, 2019
<i>Osmia (Hoplosmia) ligurica</i> Morawitz, 1868	POL	Comba, 2019		LC	X	X	X	X				C
<i>Osmia niveata</i> (Fabricius, 1804)	POL	Comba, 2019		LC	X							Comba, 2019
Melittidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Dasypoda hirtipes</i> (Fabricius, 1793)	POL	Comba, 2019		LC	X		X	X				Comba, 2019
Mutillidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Cystomutilla ruficeps</i> (Smith, 1855)	PAR	Tu, 2014			X							C
<i>Mutilla</i> sp. Linnaeus, 1758	PAR	Pollini, 2013					X					www.gibf.org
<i>Myrmilla (Myrmilla) calva</i> (Villers, 1789)	PAR	Pollini, 2013				X						C
<i>Myrmilla</i> sp. Wesmäl, 1852	PAR	Pollini, 2013			X	X	X			X		www.gibf.org
n.d.	PAR	Pollini, 2013					X				X	www.gibf.org
<i>Ronisia brutia</i> (Petagna, 1787)	PAR	Pollini, 2013									X	www.gibf.org
Pompilidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Anoplius viaticus</i> (Linnaeus, 1758)	PAR	Pollini, 2013					X		X	X		C
<i>Cryptocheilus</i> Panzer, 1806	PAR	Pollini, 2013			X	X		X	X	X		www.gibf.org
n.d.	PAR	Pollini, 2013			X	X	X	X	X	X		www.gibf.org
Proctotrupidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	PAR	Pollini, 2013								X		www.gibf.org
Pteromalidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	PAR	Pollini, 2013			X	X	X	X	X			www.gibf.org
Scolidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Colpa (Heterelis) quinquecincta</i> (Fabricius, 1793)	PAR/POL	Pollini, 2013				X	X		X			C
<i>Colpa sexmaculata</i> (Fabricius, 1781)	PAR/POL	Pollini, 2013				X						www.gibf.org
<i>Megascolia maculata flavifrons</i> (Fabricius, 1775)	PAR/POL	Pollini, 2013					X					www.gibf.org
<i>Scolia (Discolia) hirta</i> (Schränk, 1781)	PAR/POL	Pollini, 2013			X	X	X		X	X		www.gibf.org
Sphecidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Ammophila</i> sp. W. Kirby, 1798	Z	Pagliano & Negrisolò, 2005								X		www.gibf.org
<i>Ammophila pubescens</i> Curtis, 1836	Z	Pagliano & Negrisolò, 2005					X		X			Negrisolò & Pagliaro, 2005
n.d.	Z	Pagliano & Negrisolò, 2005							X			www.gibf.org
<i>Sphex</i> sp. Linnaeus, 1758	Z	Pagliano & Negrisolò, 2005								X		www.gibf.org

Tenthreniidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Arge</i> sp. Schrank, 1802	P/NE	Lacourt, 2020								X			www.gibf.org
<i>Athalia bicolor</i> Serville, 1823	P/NE	Lacourt, 2020			X				X	X	C		
<i>Athalia circularis</i> (Klug, 1815)	P/NE	Lacourt, 2020			X	X				X	C		
<i>Athalia</i> sp. Leach, 1817	P/NE	Lacourt, 2020			X	X	X		X	X			www.gibf.org
<i>Dolerus</i> sp. Panzer, 1801	P/NE	Lacourt, 2020								X			www.gibf.org
<i>Macrophya (Macrophya) montana</i> (Scopoli, 1763)	P/NE	Lacourt, 2020				X				X	C		www.gibf.org
n.d.	P/NE	Lacourt, 2020			X	X	X		X	X			www.gibf.org
<i>Nematus (Pteronidea) myosotidis</i> (Fabricius, 1804)	P/NE	Lacourt, 2020			X		X	X	X	X	C		
<i>Nematus</i> sp. Panzer, 1801	P/NE	Lacourt, 2020			X			X		X			www.gibf.org
Tiphidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Tiphia</i> sp. Fabricius, 1775	PAR	Strange, 1994			X	X	X	X	X	X			www.gibf.org
Vespidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Ancistrocerus</i> sp. Wesm., 1836	Z/FV	Kyu Kim & Yamane, 2009				X			X	X			www.gibf.org
<i>Dolichovespula media</i> (Retzius, 1783)	ZS/FV	Torniainen & Komonen, 2021					X	X			C		
<i>Eumenes mediterraneus</i> Kriechbaumer, 1879	Z/FV	Selis, 2023					X						www.gibf.org
n.d.					X	X	X						www.gibf.org
<i>Polistes atrimandibularis</i> Zimmermann, 1930	PAR/FV	Fanelli et al., 2005			X		X				C		
<i>Polistes dominula</i> (Christ, 1791)	ZS/FV	Baker & Potter, 2020			X	X	X	X		X			www.gibf.org
<i>Polistes gallicus</i> (Linnaeus, 1767)	ZS/FV	Rusina L. Yu, 2011			X	X	X						www.gibf.org
<i>Polistes nimphus</i> (Christ, 1791)	ZS/FV	Kozyra & Baraniak, 2016			X	X	X	X	X	X			www.gibf.org
<i>Polistes sulcifer</i> Zimmermann, 1930	ZS/FV	Bruschini & Cervo, 2011			X								www.gibf.org
<i>Vespa crabro</i> Linnaeus, 1761	ZS/FV	Pusceddu et al., 2022							X				www.gibf.org
<i>Vespa germanica</i> (Fabricius, 1793)	ZS/FV	Pusceddu et al., 2018				X	X		X	X			www.gibf.org
Xiphydriidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	?					X							www.gibf.org

Hemiptera

Alydidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Alydus calcaratus</i> (Linnaeus, 1758)	Z	Musolin et al., 1999			X	X	X		X			C	
Anthorcoridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	P	Saulich & Musolin, 2009					X	X					www.gibf.org
Aphrophoridae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	P	Smaili et al., 2022			X	X	X	X	X	X			www.gibf.org
Aphidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
n.d.	P	Uygun et al., 2012			X	X	X	X	X	X			www.gibf.org
Cercopidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Cercopis arcuata</i> Fieber, 1775	P	Cirlig et al., 2021								X		C	
<i>Cercopis sanguinolenta</i> (Scopoli, 1763)	P	Biedermann, 2002; Pollini, 2013				X	X	X					www.gibf.org
<i>Haematoloma dorsatum</i> (Ahrens, 1812)	P	Roversi et al., 1989; Pollini, 2013			X	X	X	X	X	X		C	
Cicadellidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Aphrodes</i> sp. Curtis, 1833	P	Schmitz, 1998					X						www.gibf.org
<i>Cicadella viridis</i> (Linnaeus, 1758)	P	Zhang et al., 2023					X						www.gibf.org
<i>Eupelix cuspidata</i> (Fabricius, 1775)	P	Abdollahi et al., 2015			X	X	X			X			www.gibf.org
<i>Ledra aurita</i> (Linnaeus, 1758)	P	Hansen & Fjellstad, 1998			X								www.gibf.org
n.d.	P				X	X	X	X	X	X			www.gibf.org
Coreidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Centrocoris variegatus</i> Kolenati, 1845	P	Ghahari et al., 2012				X						C	
<i>Coriomeris hirticornis</i> (Fabricius, 1794)	P	El Hamouly et al., 2010					X					C	
<i>Coriomeris scabricornis</i> (Panzer, 1809)	P	Heiss et al., 2023					X					C	
<i>Coriomeris</i> sp. Westwood, 1842	P	Heiss et al., 2023			X		X						www.gibf.org
n.d.	P				X	X	X						www.gibf.org
<i>Spathocera lobata</i> (Herrich-Schäffer, 1840)	P	Heiss et al., 2023					X		X			C	
<i>Syromastus rhombeus</i> (Linnaeus, 1767)	P	Heiss et al., 2023				X							www.gibf.org
Cydnidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Canthophorus</i> sp. Mulsant & Rey, 1866	P	Yazici et al., 2014						X		X			www.gibf.org
n.d.	P	Yazici et al., 2014			X			X	X				www.gibf.org
<i>Ochetostethus</i> sp. Fieber, 1860	P	Yazici et al., 2014				X	X	X	X	X			www.gibf.org
Issidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Issus</i> sp. Fabricius, 1803	P	Wang et al., 2016			X	X	X						www.gibf.org
n.d.	P	Wang et al., 2016				X		X					www.gibf.org
Lygaeidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Eremocoris plebejus</i> (Fallen, 1807)	P	Fent et al., 2021			X		X	X	X	X		C	
<i>Eremocoris</i> sp. Fieber, 1860	P	Fent et al., 2021			X								www.gibf.org
<i>Emblethis verbasci</i> (Fabricius 1803)	P	Fent et al., 2021					X					C	
<i>Gastrodes grossipes</i> (De Geer, 1773)	P	Fent et al., 2021							X				www.gibf.org
<i>Lygaeus equestris</i> (Linnaeus, 1758)	P	Fent et al., 2021			X	X	X						www.gibf.org
<i>Melanocoryphus albomaculatus</i> (Goeze, 1778)	P	Fent et al., 2021			X		X	X					www.gibf.org
n.d.	P	Fent et al., 2021			X								www.gibf.org
<i>Raglius confusus</i> (Reuter, 1886)	P	Fent et al., 2021					X						Bonacci et al., 2002
<i>Rhyparochromus vulgaris</i> (Schilling, 1829)	P	Fent et al., 2021				X	X	X	X				www.gibf.org
<i>Xanthochilus saturnius</i> (Rossi, 1790)	P	Fent et al., 2021				X						C	
Membracidae													
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography	
<i>Gargara genistae</i> (Fabricius, 1775)	P	Petrasiunas, 2023			X			X				C	

Miridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Adelphocoris lineolatus</i> (Goeze, 1778)	P	Nikolova, 2018			X	X	X	X	X	X		Tamanini, 1981
<i>Calocoris nemoralis</i> (Fabricius, 1787)	P	Bonacci et al., 2002				X						Bonacci et al., 2002
<i>Calocoris</i> sp. Fieber, 1858	P	Bonacci et al., 2002			X							Tamanini, 1981
<i>Deraeocoris punctum</i> (Rambur, 1839)	P	Helyer et al., 2014				X			X			Bonacci et al., 2002
<i>Deraeocoris (Deraeocoris) ruber</i> (Linnaeus, 1758)	P	Helyer et al., 2014						X				Tamanini, 1981
<i>Deraeocoris</i> sp. Kirschbaum, 1856	P	Helyer et al., 2014							X			Tamanini, 1981
<i>Grypocoris (Lophyromiris) sexguttatus</i> (Fabricius, 1777)	P	Helyer et al., 2014							X		C	
<i>Lygus pratensis</i> (Linnaeus, 1758)	P	Pollini, 2013			X							Tamanini, 1981
n.d.	P				X	X	X	X	X			
Oxycarenidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Metopoplax</i> sp. Fieber, 1860 (ditomoides)	P	Principato et al., 2007					X					www.gibf.org
Pentatomidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Aelia acuminata</i> (Linnaeus, 1758)	P	Lodos N., 2008				X	X	X				www.gibf.org
<i>Aelia rostrata</i> Boheman, 1852	P	Pollini, 2013					X					www.gibf.org
<i>Carpocoris mediterraneus mediterraneus</i> (Tamanini, 1958)	P	Kocakoglu & Candan, 2022				X	X					www.gibf.org
<i>Dolicoris baccharum</i> (Linnaeus, 1758)	P	Pollini, 2013			X	X	X	X		X		Bonacci et al., 2002
<i>Dyroderes umbraculatus</i> (Fabricius, 1775)	P	Lodos & Onder, 1982						X			C	
<i>Eurydema fieberi</i> Schummel, 1837	P	Pollini, 2013				X					C	
<i>Eurydema (Eurydema) oleracea</i> (Linnaeus, 1758)	P	Pollini, 2013			X	X	X					www.gibf.org
<i>Eurydema (Eurydema) ornata</i> (Linnaeus, 1758)	P	Pollini, 2013				X	X	X	X			Bonacci et al., 2002
<i>Eurydema ventralis</i> (Kolenati, 1846)	P	Pollini, 2013					X					Dioli, 1997
<i>Graphosoma lineatum</i> (Linnaeus, 1758)	P	Pollini, 2013				X	X	X				Dioli, 1997
n.d.	P				X	X				X		www.gibf.org
<i>Palomena prasina</i> (Linnaeus, 1761)	P	Pollini, 2013								X		Dioli, 1997
<i>Sciocoris</i> sp. Fallen, 1829	P	Bonacci, 2002			X	X			X			Bonacci et al., 2002
Psyllidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.	P				X	X	X	X	X	X		
Pyrrhocoridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Pyrrhocoris apterus</i> (Linnaeus, 1758)	P	Kristenova et al., 2011					X	X	X	X		www.gibf.org
<i>Pyrrhocoris marginatus</i> (Kolenati, 1845)	P	Awad & Onder, 1997								X	C	
Reduviidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Coranus (Coranus) aegyptius</i> (Fabricius, 1775)	Z	El-Shazly & El-Sebaey, 1997				X	X					Tamanini, 1981
<i>Empicoris</i> sp. Wolff, 1811	Z	Hribar, 2009				X						Tamanini, 1981
<i>Phymata (Phymata) crassipes</i> (Fabricius, 1775)	Z	Virant-Doberlet et al., 2019							X			Tamanini, 1981
<i>Rhynocoris (Rhynocoris) annulatus</i> (Linnaeus, 1758)	Z	Ambrose & Kumar, 2016					X				C	
<i>Rhynocoris</i> sp. Hahn, 1833	Z	Ambrose & Kumar, 2016					X					Tamanini, 1981
<i>Rhynocoris (Rhynocoris) erythropus</i> (Linnaeus, 1767)	Z	El Harche et al., 2023				X	X		X	X		Tamanini, 1981
Rhopalidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Chorosoma schillingii</i> (Schilling, 1829)	P	Gogala et al., 2020			X		X		X		C	
<i>Corizus hyoscyami</i> (Linnaeus, 1758)	P					X						www.gibf.org
n.d.	P				X	X		X		X		www.gibf.org
Rhyparochromidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Xanthochilus saturnius</i> (Rossi, 1790)	P	Lessieur, 2017			X		X	X			C	
Scutelleridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.					X		X					www.gibf.org
<i>Odontoscelis (Odontoscelis) fuliginosa</i> (Linnaeus, 1761)	P	Pollini, 2013				X		X			C	
Stenocephalidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
n.d.							X	X				www.gibf.org
Tettigometridae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Tettigomedia</i> sp. Latreille, 1804	P	Pollini, 2013					X					www.gibf.org
Tingidae												
Genera/Species	Thropic category	Bibliography	IUCN	IUCN Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
<i>Dictyla humuli</i> (Fabricius, 1794)	P	Pollini, 2013					X				C	
n.d.	P	Pollini, 2013					X		X			www.gibf.org
<i>Tingis</i> sp. Fabricius, 1803	P	Pollini, 2013				X	X	X	X	X		www.gibf.org

Others

Dermaptera														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Forficulidae	<i>Forficula</i> sp. Linnaeus, 1758	Z	Pollini, 2013				X	X	X	X	X			www.gibf.org
	n.d.	Z	Pollini, 2013				X	X	X	X	X			www.gibf.org
Dyctyoptera														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Blattellidae	n.d.	S						X		X	X	X		www.gibf.org
	<i>Ectobius (Ectobius) pallidus</i> (Olivier, 1789)	S	Adedara et al., 2022				X		X	X	X	X	C	
Ectobidae	<i>Ectobius</i> sp. Steohens, 1835	S	Adedara et al., 2022					X				X		www.gibf.org
	n.d.	S	Adedara et al., 2022				X			X	X			www.gibf.org
	<i>Phyllodromica marginata</i> (Schreber, 1781)	S	Hristov & Chobanov, 2016						X					www.gibf.org
Lepidoptera														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Arctidae	<i>Amata phegea</i> (Linnaeus, 1758)	P/POL	Tolman & Lewington, 2014					X	X			X	X	www.gibf.org
	<i>Amata</i> sp. Fabricius, 1807	P/POL	Tolman & Lewington, 2014					X	X			X	X	www.gibf.org
Erebidae	n.d.	P/POL	Tolman & Lewington, 2014				X	X	X	X	X	X		www.gibf.org
	n.d.		Tolman & Lewington, 2014				X	X	X	X	X	X		www.gibf.org
Geometridae	n.d.						X	X	X	X	X	X		www.gibf.org
Hesperiidae	<i>Pyrgus armoricanus</i> (Oberthür, 1910)	POL	Tolman & Lewington, 2014	LC	LC				X					www.gibf.org
	<i>Thymelicus lineola</i> (Ochsenheimer, 1808)	POL	Tolman & Lewington, 2014	LC	LC	X	X	X	X					www.gibf.org
Lycaenidae	<i>Thymelicus</i> sp. Hubner, 1819	POL	Tolman & Lewington, 2014						X					www.gibf.org
	<i>Cupido (Cupido) minimus</i> (Fuessly, 1775)	POL	Tolman & Lewington, 2014	LC	LC		X	X	X	X	X	X		www.gibf.org
	n.d.	POL	Tolman & Lewington, 2014				X	X	X	X				www.gibf.org
	<i>Plebejus (Plebejus) argus</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC	X	X	X						www.gibf.org
	<i>Plebejus</i> sp. Kluk, 1780	POL	Tolman & Lewington, 2014						X					www.gibf.org
Noctuidae	<i>Epilecta linogrisea</i> (Denis & Schiffermüller, 1775)	P/POL	Leraut, 2019							X				Scalercio & Di Marco, 2022
	n.d.						X	X	X	X	X	X		www.gibf.org
	<i>Noctua orbona</i> (Hufnagel, 1766)	P/POL	Leraut, 2019					X	X	X	X	X		www.gibf.org
	<i>Noctua pronuba</i> (Linnaeus, 1758)	P/POL	Leraut, 2019					X	X	X	X	X		www.gibf.org
	<i>Trigonophora (Trigonophora) flammea</i> (Esper, 1785)	P/POL	Leraut, 2019				X	X		X		X		www.gibf.org
	<i>Argynnis (Argynnis) paphia</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC				X			X		www.gibf.org
	<i>Coenonympha pamphilus</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC		X							www.gibf.org
	<i>Hipparchia (Hipparchia) fagi</i> (Scopoli, 1763)	POL	Tolman & Lewington, 2014	LC	NT		X	X	X			X		www.gibf.org
	<i>Hipparchia statilinus</i> (Hufnagel, 1766)	POL	Tolman & Lewington, 2014	LC	NT		X		X					www.gibf.org
	<i>Issoria lathonia</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC				X					www.gibf.org
Nymphalidae	<i>Maniola jurtina</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC	X		X	X					www.gibf.org
	<i>Melanargia galathea f. prociada</i>	POL	Tolman & Lewington, 2014	LC	LC	X	X	X	X	X	X	X		www.gibf.org
	<i>Melitaea cinxia</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC				X					www.gibf.org
	<i>Melitaea</i> sp. Fabricius, 1807	POL	Tolman & Lewington, 2014				X		X		X	X		www.gibf.org
	n.d.	POL	Tolman & Lewington, 2014				X	X	X	X	X	X		www.gibf.org
	<i>Pararge aegeria</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC	X	X	X	X	X	X	X		www.gibf.org
	<i>Polygonia c-album</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC	X								www.gibf.org
	<i>Vanessa cardui</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC		X			X				www.gibf.org
	<i>Aporia crataegi</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC	X			X					www.gibf.org
	<i>Colias croceus</i> (Fourcroy, 1785)	POL	Tolman & Lewington, 2014	LC	LC	X	X	X	X	X				www.gibf.org
	<i>Euchloe (Euchloe) ausonia</i> (Hübner, 1804)	POL	Tolman & Lewington, 2014	LC	LC				X	X		X		www.gibf.org
	<i>Pieris rapae</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	LC				X	X				www.gibf.org
Pieridae	<i>Pieris</i> sp. Schrank, 1801	POL	Tolman & Lewington, 2014				X	X	X	X	X	X		www.gibf.org
	<i>Pontia edusa</i> (Fabricius, 1777)	POL	Tolman & Lewington, 2014	LC	LC				X					www.gibf.org
	<i>Parnassius mnemosyne</i> (Linnaeus, 1758)	POL	Tolman & Lewington, 2014	LC	NT		X	X				X		www.gibf.org
Papilionidae	<i>Adscita marnii</i> (Lederer, 1853)	P/POL	Tolman & Lewington, 2014									X		www.gibf.org
	<i>Zygaena</i> sp. Fabricius, 1775	P/POL	Tolman & Lewington, 2014					X	X		X	X		www.gibf.org
Mantoidea														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Mantidae	<i>Mantis religiosa</i> Linnaeus, 1758	Z	Battiston, 2008				X							www.gibf.org
Mecoptera														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Panorpidae	<i>Panorpa</i> sp. Linnaeus, 1758	S	Dvorak et al., 2023				X	X				X		www.gibf.org
Neuroptera														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Chrysopidae	<i>Chrysoperla</i> sp. Steinmann, 1964	Z	Saminathan et al., 1999					X	X					www.gibf.org
	n.d.						X		X	X	X	X		www.gibf.org
Myrmeleonidae	<i>Myrmeleon formicarius</i> Linnaeus, 1767	Z	Saminathan et al., 1999							X				Letardi, 2004
	<i>Myrmeleon</i> sp. Linnaeus, 1767	Z	Saminathan et al., 1999						X					Letardi, 2004

Odonata														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Coenagrionidae	<i>Coenagrion castellani</i> Roberts, 1948	Z	Dijkstra & Schroter, 2021				X							www.gibf.org
	<i>Coenagrion</i> sp. Kirby, 1890	Z	Dijkstra & Schroter, 2021								X			Dijkstra & Schroter, 2021
Platycnemididae	<i>Platycnemis pennipes</i> (Pallas, 1771)	Z	Dijkstra & Schroter, 2021	LC			X							www.gibf.org
Orthoptera														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Acrididae	<i>Ailopus</i> sp. Fieber, 1853	P	Massa et al., 2012						X					www.gibf.org
	<i>Calliptamus italicus</i> (Linnaeus, 1758)	P	Massa et al., 2012						X	X				www.gibf.org
	<i>Calliptamus siciliae</i> Ramme, 1927	P	Massa et al., 2012						X	X				www.gibf.org
	<i>Chorthippus</i> sp. Fieber, 1852	P	Massa et al., 2012				X	X	X	X				www.gibf.org
	<i>Eyprepocnemis plorans</i> (Charpentier, 1825)	P	Massa et al., 2012				X	X	X	X				www.gibf.org
	<i>Oedipoda caerulescens</i> (Linnaeus, 1758)	P	Massa et al., 2012						X	X				www.gibf.org
	<i>Omocestus (Omocestus) rufipes</i> (Zetterstedt, 1821)	P	Massa et al., 2012				X							www.gibf.org
Gryllidae	<i>Stenobothrus lineatus lineatus</i> (Panzer, 1796)	P	Massa et al., 2012					X	X	X				www.gibf.org
	<i>Gryllus campestris</i> Linnaeus, 1758	P	Massa et al., 2012				X	X	X	X		X		www.gibf.org
Tettigoniidae	n.d.	P	Massa et al., 2012				X	X	X	X		X		www.gibf.org
	<i>Dectitus</i> sp. Serville, 1831	P	Massa et al., 2012				X	X	X	X		X		www.gibf.org
Tetrigidae	<i>Tetrix</i> sp. Latreille, 1802	P	Massa et al., 2012				X				X			www.gibf.org
Raphioptera														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Raphidiidae	<i>Raphidia</i> sp. Linnaeus, 1758	Z							X	X	X	X		www.gibf.org
Aranea														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Araneidae	n.d.	Z	Trotta, 2005							X				Trotta, 2005
Dysderidae	n.d.	Z	Trotta, 2005				X	X	X	X	X	X		Trotta, 2005
Eresidae	<i>Eresus</i> sp. Walckenaer, 1805	Z	Trotta, 2005				X	X	X					Trotta, 2005
Gnaphosidae	n.d.	Z	Trotta, 2005								X	X		Trotta, 2005
Lycosidae	n.d.	Z	Trotta, 2005				X	X	X	X	X	X		Trotta, 2005
n.d.	n.d.	Z	Trotta, 2005				X	X	X	X	X	X		Trotta, 2005
Salticidae	n.d.	Z	Trotta, 2005				X	X	X	X	X	X		Trotta, 2005
Thomisidae	n.d.	Z	Trotta, 2005				X	X	X	X	X	X		Trotta, 2005
Scorpiones														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Scorpionidae	n.d.	Z	Gullan & Craston, 2010					X					X	www.gibf.org
Opiliones														
Family	Genera/Species	Thropic category	Bibliography	IUCN	IUCN	Eu	Fbio	Fint	Gecot	Gnat	Pecot	Pnat	NEW	Bibliography
Phalangidae	n.d.	?					X	X	X				X	www.gibf.org

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