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Taxonomic Paper

Contribution to the knowledge of the arthropods community inhabiting the winter-flooded meadows (marcite) of northern Italy

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Abstract

Background

Flooded semi-natural grasslands are endangered ecosystems throughout Europe. In Italy, amongst flooded meadows, one special type called "*marcita*" is strongly threatened. It is a stable flooded grassland used to produce green forage even during winter months due to the thermal properties of water coming from springs and fountains that prevent the soil from freezing. To date, some research has been carried out to investigate the role of the *marcita* for ornithological and herpetological communities. However, no comprehensive data on invertebrates inhabiting this particular biotope available. The aim of this study was to characterise the terrestrial entomological community of these typical winter-flooded meadows in northern Italy and, in particular, in six *marcita* fields located in the Ticino Valley Regional Park. We collected data on species richness and diversity of Carabidae, Staphylinidae, Araneae, Lepidoptera and Orthoptera inhabiting *marcita* during the summers of 2014 and 2015 and data on overwintering Coleoptera during the winter of 2014-2015. Amongst the collected species, we identified those highly linked to this habitat.

New information

We found a total of 47 ground beetle species, 35 rove beetle species, 29 spider species, one Lucanidae, 16 butterfly species and 24 grasshopper and cricket species. Most of the species were collected during the summers of 2014 and 2015, while some others were also, or exclusively, overwintering (17 ground beetles, four rove beetles and one Lucanidae) and were collected during the winter of 2014-2015.

Marcita fields hosted specialised species and species typical of hygrophilous habitats, amongst which are included the butterfly *Lycaena dispar*, the ground beetle *Dolichus halensis* and the grasshopper *Chrysochraon dispar*. This study represents the first contribution to the knowledge of terrestrial arthropod communities associated with this particular type of winter-irrigated meadow in Europe and confirms the importance of this biotope for invertebrate conservation in agricultural landscapes.

Keywords

arthropods community, threatened habitat, *Lycaena dispar*, *Dolichus halensis*, *Chrysochraon dispar*

Introduction

Flooded semi-natural grasslands are highly productive biotopes that support characteristic animal species communities (Prach et al. 1996). Until the early twentieth century, they were widely distributed throughout Europe: in Germany, Belgium, Switzerland and Sweden (Leibundgut and Kohn 2014), in addition to Italy. Later, they fell into disuse and gradually disappeared from the landscape. The main causes of their decline, both in extent and quality, are mechanisation and intensive agriculture which led to a change in land use over the last 50 years (Saarinen et al. 2003, Van Buskirk and Willi 2004). Intensive practices for semi-natural water meadows include higher fertiliser and herbicide applications and the use of modern mowing techniques (Van Buskirk and Willi 2004). This results in eutrophic, structurally poor and homogeneous meadows with negative impacts on diversity, species composition and ecosystem processes (Hans et al. 2020).

In northern Italy and, in particular, in the Po Plain, a typical winter-flooded meadow, the so called “*marcita*” (pronunciation: maarcheeta), is still present, but highly threatened. The *marcita* is a traditional agricultural practice used to produce green forage for domestic animals throughout the year. This agriculture system exploits the thermal properties of water coming from springs and fountains to prevent soil from freezing during periods of intense cold and, due to a network of canals skilfully controlled through sluice gates and earth ridges, a thin layer of water flows smoothly and continuously over the ground during the winter months, allowing a perennial growth of the vegetation (Tomaselli 1960, Ferrari and Lavezzi 1995).

This masterpiece of hydraulic engineering is due to water regimentations that Cistercian monks began in the late thirteenth century by reclaiming the marshes that occupied a large part of the Po Plain. The *marcita* spread consistently from the end of the XVIII century, when modern agriculture brought the development of a more capillary irrigation network (Brown and Redondi 2016).

In the past, the socio-economic role of the *marcita* has been extremely high; farmers could annually carry out 7-8 cuts of green forage, with 3-4 of them collected during the winter. However, since the second World War, the changing agronomic and zootechnical requirements made the *marcita* economically disadvantageous, leading to its progressive conversion into more profitable crops, such as corn, wheat or barley (Gomarasca 2002, Origgi and Guarisco 1992). Therefore, this traditional practice, which, for centuries, was one of the typical and supporting elements of the rural economy of the Po Plain, has now remained as a relict in an agricultural landscape mainly dominated by monocultures (Gomarasca 2002). Today, it survives mainly thanks to the subsidies paid to farmers by some park authorities.

Beyond the importance of the *marcita* as a mixture of cultivation, artwork and historical-cultural elements to preserve, in the last few years, its naturalistic and environmental value has also been recognised (Bove et al. 2017). Indeed, the *marcita*, inserted in a context of intensive agriculture, increases landscape diversity and its aesthetic value. Due to its floristic composition, partly made up of leguminous plants, it has the ability to use atmospheric nitrogen, which reduces or eliminates the need for external inputs, such as fertilisers, agrochemicals and fossil fuels (Bove et al. 2017). Moreover, regulating the water cycle, the *marcita* protects soil from erosion and leaching of nutrients (Bove et al. 2017). The low anthropic pressure, together with the presence of water and vegetation during cold months, allows this habitat to host a rich biodiversity, acting as a refuge and feeding and resting sites for different animal species of conservation interest, especially during the winter season (e.g. amphibians - Gentilli et al. 1997; birds - Casale 2015 and Casale et al. 2016).

Even if some research has been carried out to investigate the role of the *marcita* for ornithological and herpetological communities, to date in Italy, no comprehensive data on invertebrates inhabiting this particular biotope are available. Beyond the conservation interest on their own, many arthropods may play key roles in the maintenance of this ecosystem functioning, feeding on soil invertebrates (Wise et al. 1999), serving as prey for small mammals, amphibians and birds (Holland et al. 2007, Rodríguez and Bustamante 2008) and being natural enemies of crop pests and weeds (Ichihara et al. 2014, Symondson et al. 2002).

Ground beetles (Coleoptera, Carabidae), rove beetles (Coleoptera, Staphylinidae), spiders (Araneae), butterflies (Lepidoptera), grasshoppers and crickets (Orthoptera) are amongst the most common, well-studied and species-rich groups of arthropods in agricultural landscapes and are often used as environmental indicators of human impacts and habitat quality (Báldi and Kisbenedek 1997, Wise et al. 1999, Holland and Luff 2000, Bubová et al. 2015, Marc et al. 1999, Courtney et al. 1982).

The aim of the study was to characterise the terrestrial entomological community of the typical winter-flooded meadows of northern Italy. We quantified species richness and diversity of Carabidae, Staphylinidae, Araneae, Lepidoptera and Orthoptera inhabiting the *marcita* and identified those species highly linked to this habitat.

Materials and methods

Study area

The study was conducted in the Ticino Valley Regional Park, in north-western Italy. The Park crosses the most urbanised area of the country and represents an important ecological corridor connecting the Alps to the Po Plain. It is the largest natural area of the entire Po Valley (about 97 km^2) and encompasses a mosaic of ecosystems, such as riparian woods, patches of primary floodplain forests, large river habitats and wetlands. Amongst the flooded grasslands, the *marcita* extends for a total surface of about 500 ha fragmented into several fields (Bove et al. 2016).

Six *marcita* fields inside the Park were investigated in 2014 and 2015 for invertebrate assemblages (Fig. 1, Table 1). The fields were mainly named as the near farmhouse or village: Casterno in the Municipality of Robecco sul Naviglio and Tre Colombaie, Sforzesca, Amerio 1, Amerio 2 and Garlaschè in the Municipality of Vigevano.

Table 1.

Coordinates (latitude and longitude in datum WGS84) of the six investigated *Marcita* fields and their altitude.

marcita	**Latitude / Longitude**	**Altitude (m a.s.l.)**
Tre Colombaie	45.309175, 8.818740	110
Cascina Grande	45.422929, 8.865366	110
Sforzesca	45.284550, 8.901501	90
Garlaschè	8.899698, 45.292460	85
Amerio 1	45.280201, 8.900642	80
Amerio 2	45.278269, 8.897209	95

Data collection

Ground beetles, rove beetles and spiders were sampled in Sforzesca, Tre Colombaie and Casterno fields from April to October 2014. Six pitfall traps were installed at 10 m intervals along a 50 m linear transect in each field, totalling 18 traps in the whole study area. Once a month, the traps were set, filled with 50 ml of wine vinegar and a drop of detergent, covered with a 10 cm×10 cm wooden roof to prevent flooding and remained active in the field for 10 days. The 10 days of sampling was slightly different amongst the three *marcita*

within each month because, during summer, farmers take turns in irrigating the fields. As a consequence, the traps were kept active for 10 days in each field and month, making sure with farmers that irrigation would not take place during those days.

Coleoptera (ground beetles, rove beetles and Lucanidae) were also sampled during November and December 2014 in all six *marcita* fields by actively and opportunistically searching for overwintering species in suitable natural and artificial places along the banks, such as dead woods, barks, stones, wooden boards and earthen banks. Beetles and spiders were preserved in hermetic bottles containing 70% ethanol solution and transported to the laboratory for identification.

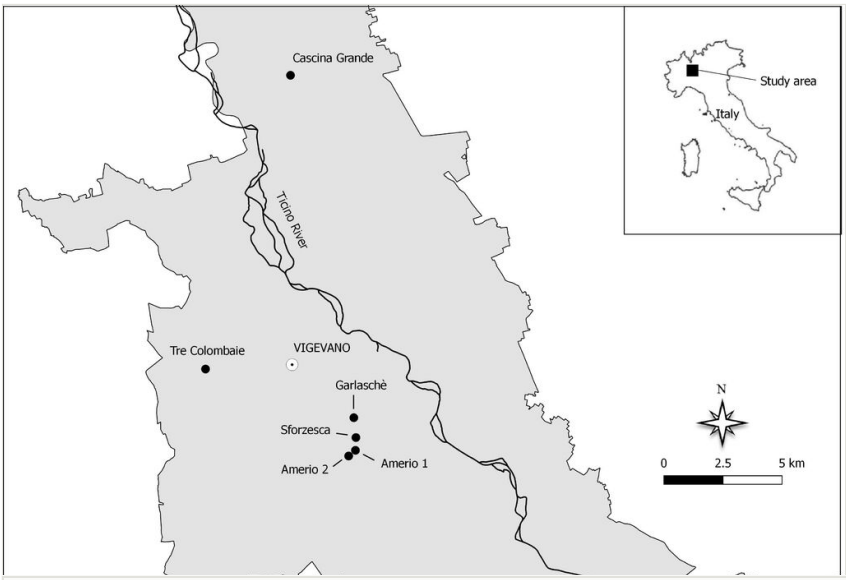

Figure 1. doi

The six *marcita* fields in north-western Italy. In grey, the boundaries of the Ticino Valley Regional Park (Lombardy area) and, in black, the Ticino River.

Butterflies were sampled in Sforzesca, Tre Colombaie and Casterno fields from April to October 2014. A two-hour long visual census was carried out every two weeks along a 100 m linear transect for a total of 14 sampling dates. Individuals were captured with an entomological net, photographed and then released. During 2015, the butterfly *Lycaena dispar* was opportunistically searched for in all six *marcita* fields.

Grasshoppers and crickets were sampled in all six *marcita* fields from May to September 2015. A two-hour long visual census was carried out monthly along a 100 m linear transect for a total of seven sampling dates. Individuals were sampled by the casual positioning of a transparent plexiglas cylinder, 1 m high and about 30 cm in diameter and by manual collection; specimens were preserved in hermetic bottles containing ethyl acetate and sawdust, placed in a refrigerated bag and transported to the laboratory for identification.

All taxa were identified to the species level by experts (see Acknowledgements) and following the nomenclature of: "Fauna Europaea web project" (De Jong et al. 2014) for ground beetles, rove beetles and butterflies; (World Spider Catalog 2020) for spiders; Massa et al. (2012) for grasshoppers and crickets.

In order to assess the role of *marcita* as a refuge for sensitive species, we selected ground beetles and grasshoppers and crickets as model groups of predatory and herbivorous species. These two groups are well studied (Hůrka 1996, Homburg et al. 2013, Reinhardt et al. 2005, Massa et al. 2012) and information on their ecology and morphology at species level is more exhaustive compared to others taxa. Ground beetles and grasshoppers and crickets were grouped, based on their morpho-ecological features, focusing on their dispersal capability, adult diet and habitat specificity. Specialised species, such as apterous and predatory ones, are known to be spread throughout permanent, undisturbed habitats (Reinhardt et al. 2005, Gobbi and Fontaneto 2008) and their persistence in agricultural landscapes could be highly enhanced by habitat patches with low anthropic pressure (Cardarelli and Bogliani 2014, Giuliano and Bogliani 2018).

For ground beetles, data on wing development and adult diet were derived from Hůrka (1996), Brandmayr et al. (2005), Homburg et al. (2013) and, when not available from literature, from specialist knowledge. The species have been classified as brachypterous (with reduced wings, not suitable for flight), macropterous (with developed wings, suitable for flight) and dimorphic (with both brachypterous and macropterous individuals) and therefore, respectively, with low, high and medium dispersal ability (Brandmayr et al. 2005). As for diet, species were classified as predators, omnivorous and phytophagous. Wing development and diet provide useful information on the level of disturbance and stability of the environment, with wingless and strictly predatory species negatively affected by human impacts (Ribera et al. 2001, Gobbi and Fontaneto 2008). Conversely, mobile, omnivorous species are expected to perform better in disturbed and fragmented habitats due to their major dispersal ability and capacity to use different food resources.

For grasshoppers and crickets, we collected information on dispersal capabilities and habitat specificity. These features are considered important factors in determining species sensitivity to habitat loss and human disturbance, with sedentary and habitat specialist taxa often more susceptible to local extinction events (Reinhardt et al. 2005). Dispersal capabilities were measured using the Mobility Index developed by Reinhardt et al. (2005). Each species was classified into one of three broad mobility classes: sedentary, intermediate dispersers and mobile species. All apterous and brachypterous orthopterans were classified as sedentary, while readily-flying species were assigned as mobile. Furthermore, for species with wing dimorphism (i.e characterised by a solitary or gregarious phase), we considered the most common form observed in the collected sample. Concerning habitat specificity, each species was assessed according to its moisture preferences, following the procedure reported by Reinhardt et al. (2005). We assigned orthopteran species to one of three broad classes: habitat specialists, medium specialised species and generalists. Xerothermophilous and hygrophilous species were classified as habitat specialists, while orthopterans with broad ecological requirements were considered as generalists. The species not treated by Reinhardt et al. (2005) and

Marini et al. (2010) were assigned to mobility and habitat specificity classes according to their wing development and their habitat requirements, by gathering this information from Baur et al. (2006) and Massa et al. (2012).

Araneae

Family Gnaphosidae

Micaria pulicaria Sundevall, 1831

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed in Europe, Turkey, Caucasus, Russia, Central Asia, Mongolia and China (World Spider Catalog 2020). It can be found in mainland Italy and Sardinia (Pantini and Isaia 2019).

Notes: It is a widespread species that occurs, at ground level, in a wide variety of locations exposed to the sun: under stones and other debris, at the base of tufts of grass and in leaf litter (Roberts 1995). It is a diurnal hunter and a specialised predator (Isaia et al. 2007)

Zelotes longipes Koch, 1866

Distribution: It is distributed in Europe, Turkey, Caucasus, Russia (Europe to Far East), Central Asia, Mongolia and China (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019).

Notes: It is widespread in Europe. Lives in dry heathlands, under stones and amongst moss and other vegetation at the base of heather. Adults occur at spring and summer (Roberts 1995). It is a night hunter (Isaia et al. 2007)

Family Linyphiidae

Araeoncus humilis Blackwall, 1841

Distribution: Palaearctic species (Isaia et al. 2007). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019); in Lombardy, it is reported only in the Province of Bergamo (Isaia et al. 2007).

Notes: It is a fairly widespread species, found in a variety of habitats including moss, grass, straw, litter and bark. It is sometimes found in coastal algae litter and sewage filter beds. Adults occur in all seasons (Harvey et al. 2002). It is a weaver spider of simple webs on the ground (Isaia et al. 2007).

Bathyphantes gracilis Blackwall, 1841

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed in North America, Europe, northern Africa, Turkey, Caucasus, Russia (Europe to Far East), Kazakhstan, China, Korea and Japan (World Spider Catalog 2020). It can be found in mainland Italy and Sardinia (Pantini and Isaia 2019).

Notes: This ubiquitous spider is common in grasslands and undergrowth of all kinds, including heathlands, woodlands and marshy habitats. Adults can be found at all times of the year, but mostly in the summer and autumn (Harvey et al. 2002). It is a weaver spider of simple webs on the ground (Isaia et al. 2007).

Ceratinella brevipes Westring, 1851

Distribution: Sibirico-Europea species (Isaia et al. 2007). It is distributed in Europe, Caucasus andJapan (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019) and, in Lombardy, it is reported only in the Province of Bergamo (Isaia et al. 2007).

Notes: It is found in a variety of situations: in moss and litter layers in various habitats. Adults have been recorded almost year-round, but most frequently from late spring to mid-summer (Harvey et al. 2002). It is a weaver spider of simple webs on the ground (Isaia et al. 2007).

Diplostyla concolor Wider, 1834

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed in North America, Europe, Turkey, Caucasus and Russia (World Spider Catalog 2020). It can be found in mainland Italy and Sardinia (Pantini and Isaia 2019).

Notes: It is found in a wide variety of situations, usually at a ground level. The conditions can range from the relative dryness of chalk lowlands to the dampness of marshes. Adults of both sexes are commonly recorded throughout the year (Harvey et al. 2002). It is a weaver spider of simple webs on the ground (Isaia et al. 2007).

Erigone dentipalpis Wider, 1834

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed in Europe, Turkey, Caucasus, Russia and China (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is widespread in a range of habitats: particularly in low vegetation, meadows and litter. Adults can be found all throughout the year, with peak numbers in summer (Harvey et al. 2002). It is a weaver spider of simple webs on the ground (Isaia et al. 2007).

Gnathonarium dentatum Wider, 1834

Distribution: Palaearctic species (Isaia et al. 2007). It is distributed in Europe, North Africa, Turkey, Caucasus, Russia to Central Asia, China, Korea and Japan (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is a wetlands inhabitant frequently found at ground level amongst marsh plants. This species readily colonises disturbed wetland sites and may be found, often in high numbers, in flooded poolside grasslands. Mature specimens of both sexes are present throughout the year (Harvey et al. 2002). It is a weaver spider of simple webs on the ground (Pantini and Isaia 2019).

Mermessus trilobatus Emerton, 1882

Distribution: It is a North American species. It was introduced to Azores and Europe (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019).

Notes: It is found in meadows, in litter layer of forests, in humid areas and sandy beaches (Harvey et al. 2002).

Microlinyphia pusilla Sundevall, 1830

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed in North America, Europe, North Africa, Turkey, Caucasus, Russia, China, Mongolia and Japan (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is found in low vegetation and meadows, both dry and wet. It is a "domed" web weaver spider (Isaia et al. 2007).

Neriene clathrata Sundevall, 1830)

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed in North America, Europe, North Africa, Caucasus, Russia (Europe to Far East), Central Asia, China, Korea and Japan (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It occurs on low vegetations and bushes, in a variety of habitats. Adults mature from spring to late autumn (Harvey et al. 2002). It is a "domed" web weaver spider (Isaia et al. 2007).

Oedothorax apicatus Blackwall, 1850

Distribution: Palaearctic species (Isaia et al. 2007). It is distributed in Europe, Turkey, Caucasus, Russia to Central Asia and China (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019).

Notes: It is a widespread species in many open habitats, such as disturbed grasslands, agricultural fields and river pebbles. It is found mainly in low vegetation and in litter. It is a mainly nocturnal active species, which has a low resistance to drying and low temperatures. It is a weaver spider of simple webs on the ground (Isaia et al. 2007). Adults of both sexes have been recorded throughout the year, most often between late spring and mid-summer. Individuals can either overwinter as immature individual or as eggs, depending on the time of reproduction (Harvey et al. 2002).

Palliduphantes pallidus O. Pickard-Cambridge, 1871

Distribution: European species (Isaia et al. 2007). It can be found in mainland Italy (Pantini and Isaia 2019).

Notes: It is a troglophile species (Isaia et al. 2007). It is found in a wide variety of habitats, including short grasslands, under stones, moss and litter, on abandoned urban land, in cavities within hollow trees and on dune systems. Adults of both sexes were found throughout the year, with the highest numbers from early to mid-summer (Harvey et al. 2002). It is a "domed" web weaver spider (Isaia et al. 2007).

Prinerigone vagans Audouin, 1826

Distribution: Palaearctic species (Isaia et al. 2007). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019); in Lombardy, it is reported only in the Province of Pavia (Isaia et al. 2007).

Notes: It is a hygrophilous species (Isaia et al. 2007). It lives in humid places, including wet grassy meadows, lake shores, gravel pits, sewage filter beds, swamps and in bedding. Adults have been found at most times of the year, but mainly from early to mid-summer and autumn. (Harvey et al. 2002). It is a weaver spider of simple webs on the ground (Isaia et al. 2007).

Family Lycosidae

Alopecosa pulverulenta Clerck, 1757

Distribution: Palaearctic species (Isaia et al. 2007). It is distributed in Europe, Turkey, Caucasus, Russia, Kazakhstan, China, Korea and Japan (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is a nocturnal hunter that is especially found in debris. It is a widespread species in open areas of moorland, in grasslands and cultivated land (Isaia et al. 2007).

Arctosa leopardus Sundevall, 1833

Distribution: Asiatic-European species (Isaia et al. 2007). It is distributed in Europe, Turkey, Caucasus and Russia to Central Asia (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It lives amongst moss and debris in swampy areas. It is a nocturnal hunter whether it weaves tubular webs or runs outdoors (Isaia et al. 2007).

Pardosa agrestis Westring, 1861

Distribution: Palaearctic species (Isaia et al. 2007). It is distributed in Europe, Caucasus, Russia, Central Asia and China (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019).

Notes: It occurs mainly on poorly vegetated clay soils, in clay pits, mudflats and on the banks of estuaries (Roberts 1995). It is a diurnal hunter (Isaia et al. 2007)

Pardosa cribrata Simon, 1876

Distribution: Mediterrean species (Isaia et al. 2007). Southern Europe, Algeria and Iraq (World Spider Catalog 2020). It can be found in mainland Italy and Sardinia (Pantini and Isaia 2019); in Lombardy, it is reported only in the Province of Cremona (Isaia et al. 2007).

Notes: It is a hygrophilous species that hunts during the day in low vegetation and detritus (Isaia et al. 2007).

Pardosa prativaga L. Koch, 1870

Distribution: Sibiric-European species (Isaia et al. 2007). It is distributed in Europe and Russia (World Spider Catalog 2020). It can be found in mainland Italy and Sardinia (Pantini and Isaia 2019).

Notes: It is a diurnal hunter species that lives in low vegetation, meadows and debris (Isaia et al. 2007).

Pardosa proxima s.l. C. L. Koch, 1847

Distribution: Sibiric-European species (Isaia et al. 2007). It is distributed in Macaronesia, northern Africa, southern Europe, Russia, Central Asia and China (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is a diurnal hunter species that lives in low vegetation, meadows and debris (Isaia et al. 2007).

Pirata tenuitarsis Simon, 1876

Distribution: European species (Isaia et al. 2007). It is distributed from Europe to Mongolia (World Spider Catalog 2020). It can be found in mainland Italy and Sardinia (Pantini and Isaia 2019

Notes: It occurs in acid bogs, with most records from *Sphagnum* bogs, often in the vicinity of bog pools and wet heathland (Dawson et al. 2020).

Piratula hygrophila Thorell, 1872

Distribution: It is distributed in Europe, Turkey, Caucasus and Russia to Central Asia (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019).

Notes: Lives in humid and shady habitats: in forests, in peat bogs or on the soil of the riparian zone (Bazelet and Samways 2011, Roberts 1995).

Trochosa ruricola De Geer, 1778

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed from Europe to China, Japan and Korea. Introduced to North America, Cuba, Puerto Rico and Bermuda (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily.

Notes: It lives under stones and detritus and amongst moss in a variety of damp habitats (Roberts 1995).

Family Tetragnathidae

Pachygnatha clercki Sundevall, 1823

Distribution: Holoarctic species (Isaia et al. 2007). It is distributed in North America, Europe, Caucasus, Russia, Central Asia, China, Korea and Japan (World Spider Catalog 2020). It can be found in mainland Italy and Sardinia (Pantini and Isaia 2019).

Notes: It is a hygrophilous species that lives in low vegetation, meadows and litter. It is a night hunter (Isaia et al. 2007).

Pachygnatha degeeri Sundevall, 1830

Distribution: Palearctic species (Isaia et al. 2007). It is distributed in Europe, Turkey, Caucasus, Russia to Central Asia and China (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is a hygrophilous species that lives in low vegetation, meadows and litter. It is a night hunter (Isaia et al. 2007).

Family Thomisidae

Ozyptila sanctuaria O. Pickard-Cambridge, 1871

Distribution: European species (Isaia et al. 2007). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is a xerophilous species that lives in the undergrowth, on tufts of grass, sometimes on chalk or marl. It is a night stalker (Roberts 1995, Isaia et al. 2007).

Ozyptila simplex O. Pickard-Cambridge, 1862

Distribution: Sibiric-European species (Isaia et al. 2007). It is distributed in Europe and Turkey (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019); in Lombardy, it is reported only in the Province of Pavia (Isaia et al. 2007).

Notes: It lives amongst the bases of plants and in detritus, usually in sandy habitats. It is sometimes found higher up on low vegetations (Roberts 1995). It is a night stalker (Isaia et al. 2007).

Xysticus gallicus Simon, 1875

Distribution: Sibiric-European species (Isaia et al. 2007). It is distributed in Europe, Turkey, Caucasus and Iran (World Spider Catalog 2020). It can be found in mainland Italy (Pantini and Isaia 2019); in Lombardy, it is reported only in the Provinces of Bergamo and Sondrio (Isaia et al. 2007).

Notes: It lives in the low vegetation in the pine forests or in the rocky moors, under stones and in detritus from the plains to the alpine areas (Harvey et al. 2002). It is a night stalker (Isaia et al. 2007).

Xysticus kochi Thorell, 1872

Distribution: Sibiric-European species (Isaia et al. 2007). It is distributed in Europe, from the Mediterranean area to Central Asia (World Spider Catalog 2020). It can be found in mainland Italy, Sardinia and Sicily (Pantini and Isaia 2019).

Notes: It is common to find it in low vegetation, on bushes and in the undergrowth. The species prefers warm, dry conditions, provided by open and sparsely-vegetated habitats, such as ruderal habitats, dunes and vegetated pebbles. Adults of both sexes are found mainly in May and June, but females can sometimes survive until autumn (Harvey et al. 2002). It is a night stalker (Isaia et al. 2007).

Coleoptera

Family Carabidae

Agonum (*Olisares*) *emarginatum* Gyllenhal, 1827

Distribution: European species (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterus. Lives on edges of waters and swamps with vegetation, in floodplain forests, on saline habitats; lowlands and hills (Hůrka 1996).

Agonum (*Agonum*) *muelleri* Herbst, 1784

Distribution: Holoarctic species ranging eastwards to W Siberia (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterus. Eurytopic species of mostly unshaded habitats: edges of waters with vegetation, swamps, meadows, fields and ruderal habitats; from lowlands to mountains, mostly in hills (Hůrka 1996).

Agonum (*Olisares*) *sexpunctatum* Linnaeus, 1758

Distribution: Siberic-European. It can be found in mainland Italy and Sardinia; doubtfully present in Sicily (Vigna Taglianti 2010, Vigna Taglianti 2005).

Notes: Macropterus. Lives in moderately moist to wet, unshaded habitats: meadows, pastures, water margins with vegetation, moist forest clearings; from lowlands to mountains, mostly in foothills (Hůrka 1996).

Amara (*Amara*) *aenea* DeGeer, 1774

Distribution: Palearctic species, introduced into North America (Hůrka 1996). It is widespread throughout Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterus. Eurytopic species of open habitats: fields, steppe and ruderals; from lowlands to mountains (Hůrka 1996).

Amara (*Amara*) *familiaris* Duftschmid, 1812

Distribution: Palearctic species, ranging central Siberia and north Mongolia, introduced into North America (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterus. Eurytopic: fields, ruderals; from lowlands to mountains (Hůrka 1996).

Amara (*Zezea*) *fulvipes* Audinet-Serville, 1821

Distribution: Southern Europe, south of Central Europe and Asia Minor (Hůrka 1996). It can be found in mainland Italy, Sardinia included (Vigna Taglianti 2005).

Notes: Lives in dry, unshaded habitats, steppe and fields; from lowlands to hills (Hůrka 1996).

Amara (*Amara*) *similata* Gyllenhal, 1810

Distribution: Transpalearctic species, ranging eastwards to Kamchatka (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterus. Lives in dry to moderately moist, unshaded habitats: fields, meadows, ruderals; from lowlands to mountains, mostly in hills (Hůrka 1996).

Anchomenus (*Anchomenus*) *dorsalis* Pontoppidan, 1763

Distribution: West Palearctic species, ranging eastwards to Middle Asia (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterus. Lives in unshaded, dry to moderately moist habitats; fields, steppe, pastures, edges of small woods; from lowlands to mountains, often gregariously (Hůrka 1996).

Anisodactylus (*Anisodactylus*) *binotatus* Fabricius, 1787

Distribution: West Palearctic species, ranging eastwards to Middle Asia (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterus. Eurytopic species: meadows, water margins with vegetation, fields and ruderals; from lowlands to mountains (Hůrka 1996).

Anisodactylus (*Pseudanisodactylus*) *signatus* Panzer, 1796

Distribution: Transpalearctic species (Hůrka 1996). It can be found in northern Italy (Vigna Taglianti 2005).

Notes: Macropterus. Lives in moderately dry to moist, unshaded habitats, mainly on sandy, loamy ground: grassy water edges, sand pits, fields, saline habitats; from lowlands to foothills (Hůrka 1996).

Badister (*Badister*) *bullatus* Schrank, 1798

Distribution: Circumpolar and Paleartic species (Hůrka 1996). It can be found in mainland Italy and Sicily; doubtfully present in Sardinia (Vigna Taglianti 2005, Vigna Taglianti 2010).

Notes: Macropterus. Lives in dry to wet habitats, indifferent to shade: steppe, meadows, overgrown edges of water and swamps; from lowlands to mountain, mostly in hills (Hůrka 1996).

Bembidion (*Bembidion*) *quadrimaculatum* Linnaeus, 1760

Distribution: Holoarctic species (Hůrka 1996). It can be found in mainland Italy and Sicily (Vigna Taglianti 2005).

Notes: Macropterus. Lives in both drier and moist, unshaded or partly shaded habitats: fields, meadows, even far from water; from lowlands to mountains (Hůrka 1996).

Brachinus (*Brachinus*) *elegans* Chaudoir, 1842

Distribution: Mediterranean species (Vigna Taglianti 2005). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: It frequently lives in open formations of the western alpine valleys. It is present in damp meadows, but occasionally we can find it in biotopes characterised by relative xericity (Bisio 2011).

Brachinus (*Brachynidius*) *sclopeta* Fabricius, 1792

Distribution: European and Mediterranean species (Anderson 2005, Vigna Taglianti 2005). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Species widely widespread in the plains (Bisio 2011).

Calathus (*Calathus*) *fuscipes* Goeze, 1777

Distribution: West Palearctic species, introduced in North America (Hůrka 1996). It can be found in mainland Italy and Sicily; doubtfully present in Sardinia (Vigna Taglianti 2005, Vigna Taglianti 2010).

Notes: Brachypterus, rarely macropterous. Lives in unshaded, rather dry habitats: meadows, fields, balks and steppes; from lowlands to mountains. (Hůrka 1996).

Calathus (*Neocalathus*) *melanocephalus* Linnaeus, 1758

Distribution: Palearctic species, probably introduced into North America (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Brachypterus, less frequently macropterous. Lives mainly in unshaded or moderately-shaded habitats: fields, steppe; from lowlands to mountains (Hůrka 1996).

Calosoma (*Campalita*) *auropunctatum* Herbst, 1784

Distribution: Europe, Asia Minor, Syria and Egypt (Hůrka 1996). In can be found in northern Italy (Vigna Taglianti 2005).

Notes: Lives in fields and steppe in lowlands (Hůrka 1996).

Carabus (*Carabus*) *granulatus* Linnaeus, 1758

Distribution: Transpalearctic species, distributed from Pyrenees and Great Britain as far east as Sakhalin and Japan. Introduced in North America (Hůrka 1996). It can be found in mainland Italy; it is widespread in the northen part (Vigna Taglianti 2005, Ruffo and Stoch 2005).

Notes: Brachypterous individuals dominate, but both macropterous and apterous specimens occurs. It is an hygrophilous, eurytopic species of both unshaded and shaded habitats; from lowlands to mountains (Hůrka 1996).

Chlaeniellus nitidulus Schrank, 1781

Distribution: European species (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterous. Lives on unshaded, overgrown edges of waters, in meadows and clay pits; from lowlands to foothills, more often in hills (Hůrka 1996).

Clivina (*Clivina*) *fossor* Linnaeus, 1758

Distribution: Holarctic species, in Palearctic Region eastwards to Kamchatka and NE China (Hůrka 1996). It can be found in mainland Italy and Sicily; doubtfully present in Sardinia (Vigna Taglianti 2005).

Notes: Both brachypterous and macropterous. Lives on moist, unshaded or slightly shaded habitats: meadows and water shores; from lowlands to mountains (Hůrka 1996).

Diachromus germanus Linnaeus, 1758

Distribution: West Palearctic species (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives mostly in moist, unshaded habitats: water edges with vegetation, meadows along waters, saline habitats, overgrown bottoms of drained ponds; from lowlands to foothills (Hůrka 1996).

Dolichus halensis Schaller, 1783

Distribution: Palearctic species, reaching southern Kuril Islands, Japan and South China (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterous. Lives on dry to moderately dry, unshaded habitats: fields; from lowlands to hills (Hůrka 1996).

Egadroma marginatus Dejean, 1829

Distribution: It is a typically Mediterranean species, widespread in warm regions of the Western Palearctic (Chittaro and Marggi 2015). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: It is generally described as riparian and swamp-dwelling species. It occurs near freshwater, particularly irrigation canals and swamps Chittaro and Marggi 2015).

Harpalus (*Harpalus*) *affinis* Schrank, 1781

Distribution: Transpalearctic species, introduced in North America (Hůrka 1996). It can be found in mainland Italy; doubtfully present in Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives in dry to moderately moist, unshaded habitats: fields, meadows and ruderals; from lowlands to mountains (Hůrka 1996).

Harpalus (*Harpalus*) *distinguendus* Duftschmid, 1812

Distribution: Transpalearctic species, ranging from the Azores and NW Africa to Far East (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Live in dry to moderately moist, unshaded habitats: fields, steppes and ruderals; from lowlands to hills (Hůrka 1996).

Harpalus (*Harpalus*) *oblitus* Dejean, 1829

Distribution: South-western Palearctic Region, from north-western Africa and Iberian Peninsula to south-western Siberia and south-eastern Kazakhstan (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2010, Vigna Taglianti 2005).

Notes: Macropterous. Lives in moderately dry, unshaded habitats: vineyards, balks and steppes; it can be found in lowlands (Hůrka 1996).

Harpalus (*Harpalus*) *serripes* Quensel in Schonherr, 1806

Distribution: West Palearctic species, reaching Caucasus and Middle Asia (Hůrka 1996). It can be found in mainland Italy and Sicily; doubtfully present in Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives in very dry to moderately dry, unshaded habitats: steppe, fields and quarries; from lowlands to foothills (Hůrka 1996).

Limodromus (*Platynus*) *assimilis* Paykull, 1790

Distribution: Transpalearctic species, distributed eastwards to Sakhalin and Japan (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterous. Lives indifferent to moisture or very moist habitats, to entirely shaded: forests, parks and shaded water edges; from lowlands to mountains, often in hills (Hůrka 1996).

Limodromus (*Platynus*) *krynickii* Sperk, 1835

Distribution: West Palearctic species (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterous. It is a hygrophilous species of shaded borders of waters with rich vegetation in floodplain forests; it can be found in lowlands (Hůrka 1996).

Metallina (*Metallina*) *properans* Stephens, 1828

Distribution: Palearctic species introduced in North America (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterous, rarely brachypterous. It lives in unshaded, drier or moist habitats: meadows, grassy, loamy edges of water; from lowlands to foothills (Hůrka 1996).

Microlestes minutulus Goeze, 1777

Distribution: Palearctic species introduced into North America and India (Hůrka 1996). It can be found in mainland Italy; doubtfully present in Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous, rarely brachypterous. Lives indifferent to shade: steppe and forests; from lowlands to mountains, often in hills (Hůrka 1996).

Panagaeus (*Panagaeus*) *cruxmajor* Linnaeus, 1758

Distribution: Palearctic species (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives in moist, unshaded habitats: meadows near waters and grassy water edges; from lowlands to hills (Hůrka 1996).

Paranchus albipes Fabricius, 1796

Distribution: Europe, North Africa and Asia Minor, introduced into North America (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Often lives on gravelly habitats, gravelly sandy, gravelly loamy to stony water edges, largely tolerating pollution; from lowlands to mountains. Indifferent to shade (Hůrka 1996).

Parophonus (*Ophonomimus*) *hirsutulus* Dejean, 1829

Distribution: Turanic-Mediterranean (Pilon et al. 2013). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. It is a hygrophilous species, lives in open habitats (Pilon et al. 2013).

Parophonus (*Parophonus*) *maculicornis* Duftschmid, 1812

Distribution: South-western part of the Paleartic Region, eastwards to Caucasus and Syria (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives indifferent in the shade: steppe, vineyards and floodplain groves; it can be found in lowlands (Hůrka 1996).

Poecilus (*Poecilus*) *cupreus* Linnaeus, 1758

Distribution: West Palearctic species, reaching Central Siberia and Middle Asia (Hůrka 1996). It is widespread throughout Italy, Sicily and Sardinia included (Ruffo and Stoch 2005, Vigna Taglianti 2005).

Notes: Macropterous. Lives in unshaded habitats: fields, steppes and water edges; from lowlands to mountains (Hůrka 1996).

Poecilus (*Poecilus*) *versicolor* Sturm, 1824

Distribution: Palearctic species (Hůrka 1996). It can be found in mainland Italy; it is widespread in northern parts (Ruffo and Stoch 2005, Vigna Taglianti 2005).

Notes: Macropterous. Lives in unshaded habitats: meadows, pastures, fields, water edges with vegetation and forest clearings; from lowlands to mountains, mostly in hills (Hůrka 1996).

Pseudoophonus (*Pseudoophonus*) *griseus* Panzer, 1796

Distribution: Transpalearctic species (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives in dry to indifferent, unshaded habitats: fields, meadows, ruderals and often on sandy soil; from lowlands to mountains (Hůrka 1996).

Pseudoophonus (*Pseudoophonus*) *rufipes* De Geer, 1774

Distribution: Palearctic species introduced into North America (Hůrka 1996). It is widespread throughout Italy, Sicily and Sardinia included (Vigna Taglianti 2005).

Notes: Macropterous. Lives in dry to moderately moist, preferably unshaded habitats: fields, meadows, ruderals and forest edges; from lowlands to mountains (Hůrka 1996).

Pterostichus (*Melanius*) *aterrimus* Herbst, 1784

Distribution: West Palearctic species (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterous. Lives on borders of swamps amongst soaking wet vegetation; it can be found in lowlands (Hůrka 1996).

Pterostichus (*Morphnosoma*) *melanarius* Illiger, 1798

Distribution: Eurosiberian species, introduced ino North America (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Brachypterous, rarely macropterous. It is a very eurytopic species of fields, meadows, gardens, as well as forests; from lowlands to mountains (Hůrka 1996).

Pterostichus (*Platysma*) *niger* Schaller, 1783

Distribution: Palearctic species (Hůrka 1996). It can be found in mainland Italy and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives in moist habitats, indifferent to shade: meadows, forests, water margins with vegetation; from lowlands to mountains, frequently in hills (Hůrka 1996).

Pterostichus (*Phonias*) *strenuus* Panzer, 1796

Distribution: Eurosiberian species (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Brachypterous, more frequently macropterous. Prefers moist habitats, indifferent to shade: floodplain forests, meadows near water, margins of waters with vegetation and forest clearings; from lowlands to mountains (Hůrka 1996).

Pterostichus (*Argutor*) *vernalis* Panzer, 1796

Distribution: Palearctic species (Hůrka 1996). It can be found in mainland Italy (Vigna Taglianti 2005).

Notes: Macropterous. Lives in moist to wet habitats, indifferent to shade: grassy water shores, moist meadows, floodplain forests and gardens; from lowlands to mountains (Hůrka 1996).

Sphaerotachys hoemorrhoidalis Ponza, 1805

Distribution: Mediterranean and Caucasian species (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives on marshy borders of irrigation canal; it can be found in lowlands (Hůrka 1996).

Stenolophus (*Stenolophus*) *teutonus* Schrank, 1781

Distribution: West Palearctic species (Hůrka 1996). It can be found in mainland Italy, Sicily and Sardinia (Vigna Taglianti 2005).

Notes: Macropterous. Lives on unshaded, overgrown edges of waters; from lowlands to foothills (Hůrka 1996).

Family Lucanidae

Dorcus parallelipipedus Linnaeus, 1785

Conservation status: Least Concern for Italian (Audisio et al. 2014) and European assessments (Clix et al. 2018).

Distribution: West Palearctic species (Bartolozzi and Sprecher-Uebersax 2006).

Notes: It has a larval biology linked to the presence of rotting wood in deciduous and sometimes coniferous forests (Boucher 2014, Franciscolo 1997).

Family Staphilinidae

Aleochara (*Coprochara*) *bipustulata* Linnaeus, 1760

Distribution: Palearctic species (Maus 1998). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives in open habitats. In particular, adults can be found in rotting *Brassica* and other vegetation and it is associated with carrion and dung (Andreassen 2013).

Anotylus rugosus Fabricius, 1775

Distribution: Palearctic species (Majka and Klimaszewski 2012). Widespread in Italy, but absent in Sicily (Ruffo and Stoch 2005).

Notes: Frequently found on dung, carrion and other decomposing organic matter (Majka and Klimaszewski 2012).

Arpedium quadrum Gravenhorst, 1806

Distribution: Europe and Russian species (ITIS Species 2000 2020). The presence of this species is reported only for northern Italy including: Friuli Venezia Giulia, Veneto, Trentino-Alto Adige, Lombardia, Val d'Aosta, Piemonte, Liguria and Emilia-Romagna (Ruffo and Stoch 2005).

Notes: Lives on banks, riverbanks, marshy areas (*Phragmitetum*, *Caricetum*), wetlands, damaged marshy areas, rural settlements, sandy small areas and wetlands near source (Zanetti et al. 2016).

Astrapaeus ulmi Rossi, 1790

Distribution: Europe (except in the northern part) and it reaches western Turkey (Pietrykowska-Tudruj et al. 2014). Its occurrence is patchy and it is generally considered a rare species (Assing and Schülke 2012). In Italy, the species is present along the peninsula, in Sicily and in Sardinia (Ruffo and Stoch 2005).

Notes: As a thermophilus species, inhabits xerothermic habitats with moderately moist soil. Many authors collected the adults in open grassy sites with some layers of humus, under heaps of rotting plants or stones and often in riverside areas covered with low vegetation (Pietrykowska-Tudruj et al. 2014).

Atheta (*Atheta*) *aeneicollis* Sharp, 1869

Distribution: West Palearctic species (Sushko 2016): Europe, Canary Islands, western North Africa, Cyprus, Israel and Syria (Zanetti et al. 2016). In Italy, the species is widespread (Ruffo and Stoch 2005).

Notes: Lives on banks, forests (floodplain, hill and mountains), reforestation areas (*Picea*, *Pinus*), pebbly shores, lakeshores, pastures, wetlands, clearings, meadows, margin of pastures with trees, gorges, hill bushes, historical gardens, vineyards, lakeshore with *Phragmitetum*, rural settlements, riverbanks, floodplains, uncultivated areas, orchards, marshy areas (*Phragmitetum, Caricetum*), vegetable crops, subalpine bushes (*Alnus*) and corn crops (Zanetti et al. 2016).

Atheta fungii Gravenhorst, 1806

Distribution: Under the name *Atheta fungii*, considered a widespread Palaearctic species, a very difficult complex of taxa is included (Zanetti et al. 2016, Sushko 2016). In Italy, the species is widespread (Ruffo and Stoch 2005).

Notes: Lives on banks, pastures, forests (floodplain, hill and mountains), reforestation areas (*Picea, Pinus*), gardens, wetlands, subalpine bushes (*Pinus mugo*), peat bogs, meadow, parks, margin of pastures with trees, subalpine grasslands, waterfalls, historical gardens, uncultivated areas, marshy areas (*Phragmitetum*, *Caricetum*), riverbanks, floodplains, orchards, vegetable crops, rural settlements and rows of trees (*Quercus*) (Zanetti et al. 2016).

Atheta (*Dimetrotina*) *laticollis* Stephens, 1832

Distribution: European species (ITIS Species 2000 2020). In Italy, the species is widespread (Ruffo and Stoch 2005).

Notes: Lives in clearing, hill forests, lakeshores, pastures, wetlands, subalpine bushes (*Pinus mugo*), reforestation areas (*Pinus nigra*), mountain forests (*Fagus*), banks, parks, damaged hill forests, rural settlements, riverbanks, gardens, marshy areas (*Phragmitetum*, *Caricetum*) and uncultivated areas (Zanetti et al. 2016).

Atheta (*Atheta*) *triangulum* Kraatz, 1856

Distribution: Palearctic species (Lupi et al. 2006). In Italy, the species is widespread (Ruffo and Stoch 2005).

Notes: It is a saprophilous species widespread from the plains to middle altitude elevations (1000 m). It is a very common predator and it is found mostly in decaying vegetable matter (Lupi et al. 2006).

Carpelimus (*Taenosoma*) *corticinus* Gravenhorst, 1806

Distribution: Cosmopolitan species (ITIS Species 2000 2020). In Italy, the species is widespread (Ruffo and Stoch 2005).

Notes: Lives on banks, pebbly shores, cirques, coppiced mixed forests, wetlands, hill forests, parks, mountain forests (*Fagus*), pastures, *Phragmitetum*, riverbanks, floodplain forests, marshy areas (*Phragmitetum*, *Caricetum*), damaged marshy areas, gardens, uncultivated areas, vegetable crops and wetlands near source (Zanetti et al. 2016).

Cordalia obscura Gravenhorst, 1802

Distribution: Europe, north Asia (excluding China), Caucaso and North America (Pace 2005, Majka and Klimaszewski 2012). In Italy, the species is widespread (Ruffo and Stoch 2005).

Notes: Common in decaying plant material and also found on carrion and dung. It is found in the nest of several birds species (Majka and Klimaszewski 2012).

Dinaraea angustula Gyllenhal, 1810

Conservation status: Least Concern for Italian assessment (Audisio et al. 2014).

Distribution: Europe, Turkey and North America (ITIS Species 2000 2020). The species is present only in the Italian pensinsula (absent in the Islands) (Ruffo and Stoch 2005).

Notes: Lives in parks, banks, wetlands, floodplains, orchards, marshy areas (*Phragmitetum*, *Caricetum*), damaged marshy areas, vegetable crops, rural settlements, permanent meadows, wetlands near source and vineyards (Zanetti et al. 2016).

Drusilla (*Drusilla*) *canaliculata* Fabricius, 1787

Distribution: Palearctic species (Majka and Klimaszewski 2012): Central-southern Europe, Russia (European, Siberia, Far East), Ukraine, Armenia, Georgia, Turkey, Azerbaijan, Israel, Iran, Kazakhstan, Kyrgyzstan, Korea, Japan and Nepal; introduced into Canada (ITIS Species 2000 2020, Pace 2005). In Italy, the species is currently known only for the peninsula (Ruffo and Stoch 2005).

Notes: Found in open areas under vegetation, stone, mosses and decomposing materials. A very eurytopic species adapted to a wide range of ground conditions: it can be found on dry, heathy and sandy soils; on damp loam and in humic soils; in wet soil and *Sphagnum*. Often found in proximity of ants (Majka and Klimaszewski 2012).

Euryalea murina Erichson, 1839

Distribution: European species (ITIS Species 2000 2020). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives in banks of stream, pastures, hill forests, parks, coppiced mixed forests, uncultivated areas, marshy areas (*Phragmitetum*, *Caricetum*), permanent meadows, wetlands near source (Zanetti et al. 2016).

Falagria sulcatula Gravenhorst, 1806

Distribution: Holoarctic species (ITIS Species 2000 2020). Widespread in Italy, but absent in Sicily (Ruffo and Stoch 2005).

Notes: Lives in banks, wetlands, orchards, vegetable crops, marshy areas (*Phragmitetum*, *Caricetum*) and permanent meadows (Zanetti et al. 2016).

Falagrioma thoracica Stephens, 1832

Distribution: Palearctic species (ITIS Species 2000 2020). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives in banks, hill forests (*Quercus ilex*), vineyards, mountain forests (*Abies*), historical gardens, mixed forests, floodplain forests, marshy areas (*Phragmitetum*, *Caricetum*), wetlands, parks, permanent meadows and wetlands near source (Zanetti et al. 2016).

Ochthephilum brevipenne Mulsant & Rey, 1861

Distribution: Mediterranean species, from south-western France and north-western Africa to Greece and Ukraine (including Italy and Switzerland) (ITIS Species 2000 2020, Zanetti et al. 2016).

Notes: Lives in banks, coppiced mixed forests, marshy areas (*Phragmitetum*, *Caricetum*), permanent meadows, lakeshore with *Phragmitetum*, orchards and wetlands (Zanetti et al. 2016).

Ocypus (*Matidus*) *brunnipes* Fabricius, 1781

Distribution: Palearctic species (ITIS Species 2000 2020). The species is present only in the Italian pensinsula (absents in the Islands) (Ruffo and Stoch 2005).

Notes: Lives amongst the stones, mosses and plant remains (Fernàndez and Masò 2010).

Ocypus (*Ocypus*) *olens* O.F.Müller, 1764

Distribution: Euro-Mediterranean species (ITIS Species 2000 2020). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives on lakeshore, mountain forests (*Abies*), vineyards, dry meadows, hill forests (*Carpinus*), margin of pastures with trees, coppiced mixed forests, mixed forests, hill bushes, wetlands, floodplain forests, floodplains, banks, riverbanks, marshy areas (*Phragmitetum*, *Caricetum*), orchards, sandy small areas, vegetable crops, wetlands near source and cellars (Zanetti et al. 2016).

Omalium caesum Gravenhorst, 1806

Distribution: Holoarctic species (Sushko 2016). The species is widespread in the Italian pensinsula, while absent in the Islands (Ruffo and Stoch 2005, Zanetti et al. 2016).

Notes: It occurs in open bogs with *Carex* sp. and *Eriophorum vaginatum* (Sushko 2016).

Omalium oxyacanthae Gravenhorst, 1806

Distribution: Holoarctic species (ITIS Species 2000 2020). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives in coppiced mixed forests, wetlands, floodplain, marshy areas (*Phragmitetum*, *Caricetum*), sandy small areas, uncultivated areas and wetlands near source (Zanetti et al. 2016).

Oxypoda (*Oxypoda*) *opaca* Gravenhorst, 1802

Distribution: Palearctic species (ITIS Species 2000 2020). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives in banks, reforestation areas (*Pinus nigra*), forests (hill and mountain), meadows, wetlands, disused quarries, pastures, parks, marshy areas (*Phragmitetum*, *Caricetum*), riverbanks, orchards, gardens, uncultivated areas, corn crops and wetlands near source (Zanetti et al. 2016).

Paederus (*Heteropaederus*) *fuscipes* Curtis, 1826

Distribution: Africa, Asian and European species (Smetana 2004). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives in banks, coppiced mixed forests, subalpine bushes (*Rhododendron*), peat bogs, parks, cultivated riverbanks, permanent meadows, lakeshore with *Phragmitetum*, marshy areas (*Phragmitetum*, *Caricetum*), wetlands, floodplain forests,

damaged marshy areas, rural settlements, uncultivated areas, riverbanks, wetlands near source and vineyards (Zanetti et al. 2016).

Philonthus (*Philonthus*) *carbonarius* Gravenhorst, 1802

Distribution: Siberian-European species (Sushko 2016). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Widespread, but not abundant in open bogs (Sushko 2016).

Philonthus (*Philonthus*) *cognatus* Stephens, 1832

Distribution: Holoarctic species (Sushko 2016). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: It is a widespread species that lives in all bog habitats (Sushko 2016).

Philonthus (*Philonthus*) *succicola* C.G.Thomson, 1860

Distribution: Palearctic species. Widespread in Italy but absent in Sardinia (Ruffo and Stoch 2005).

Notes: Lives on putrefying matter and dung (Schmidt 2006).

Platystethus (*Craetopycrus*) *burlei* Brisout de Barneville, 1862

Distribution: European species (ITIS Species 2000 2020). Widespread in Italy, but absent in Sardinia (Ruffo and Stoch 2005).

Platystethus (*Craetopycrus*) *nitens* C. Sahlberg, 1832

Distribution: Palearctic species (ITIS Species 2000 2020). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives on banks, pebbly shores, gorge with rocks, forests (hill and mountain), reforestation areas (*Picea, Pinus*), fountains, pastures, lakeshores, wetlands, cirques, subalpine bushes (*Rhododendron*, *Dryas*, *Pinus mugo*), peat bogs, screes, parks, coppiced mixed forests, dry meadows, marshy areas (*Phragmitetum*, *Caricetum*), rural settlements, riverbanks, vegetable crops, uncultivated areas, corn crops and wetlands near source (Zanetti et al. 2016).

Proteinus ovalis Stephens, 1834

Distribution: European species (ITIS Species 2000 2020). In Italy, it is widespread (Ruffo and Stoch 2005).

Notes: Lives forests (floodplain, mountain and hill)) , banks, screes, reforestation areas (*Picea, Pinus*), pastures, banks of stream, parks, subalpine bushes (*Pinus mugo*, *Alnus*), disused quarries, dry meadows, margin of pastures with trees, subalpine grasslands, tumbled limestones, row of trees (*Quercus*), caves, meadows, hill bushes, historical gardens, vineyards, wetlands, lakeshore with *Phragmitetum*, floodplains, riverbanks, marshy areas (*Phragmitetum*, *Caricetum*), damaged marshy areas, orchards, sandy small areas, vegetable crops, permanent meadows and wetlands near source (Zanetti et al. 2016).

Quedius cruentus Olivier, 1795

Conservation status: Least Concern for Italian assessment (Audisio et al. 2014).

Distribution: Palearctic species (Zanetti 2007). In Italy, it is present along the peninsula and in Sicily (Ruffo and Stoch 2005).

Notes: Lives in the rotting wood of several broad-leaved species (Zanetti 2007).

Quedius (*Raphirus*) *nitipennis* Stephens, 1833

Distribution: Palearctic species (ITIS Species 2000 2020). Widespread in Italy but absent in Sardinia (Ruffo and Stoch 2005).

Notes: Lives in pastures, peat bogs, mountain forests (*Fagus*), meadows, banks, wetlands, uncultivated areas, marshy areas (*Phragmitetum*, *Caricetum*) and rural settlements (Zanetti et al. 2016).

Rugilus (*Rugilus*) *orbiculatus* Paykull, 1789

Distribution: Holoarctic species (ITIS Species 2000 2020). Widespread in Italy but absent in Sardinia where it is replaced by the subspecies *Rugilus orbiculatus sardous* (Ruffo and Stoch 2005).

Notes: Lives in olive groves, banks, clearings, coppiced mixed forests, rural settlements, vineyards, parks, wetlands, riverbanks, marshy areas (*Phragmitetum*, *Caricetum*), sandy small areas, uncultivated areas, wetlands and marshy areas near source (Zanetti et al. 2016).

Tachinus (*Tachinus*) *corticinus* Gravenhorst, 1802

Distribution: Europe, Russia, south to Turkey and the Caucasus, east to Japan (Majka and Klimaszewski 2012). The presence of this species is reported only for northern Italy including: Friuli Venezia Giulia, Veneto, Trentino-Alto Adige, Lombardia, Val d'Aosta, Piemonte, Liguria and Emilia-Romagna (Ruffo and Stoch 2005).

Notes: Lives in both lowlands and mountain areas, mainly in moist mixed and deciduous forests. It can be found under fallen leaves, in mosses, in compost and

rotting hay and straw, and in mountains under stones in moist places (Majka and Klimaszewski 2012).

Xantholinus (*Xantholinus*) *linearis* Olivier, 1795

Distribution: Palearctic species (Majka and Klimaszewski 2012). Widespread in Italy, but absent in Sardinia (Ruffo and Stoch 2005).

Notes: Found in many kinds of decaying organic matter such as animal dung, compost piles and decaying vegetation; also in leaf litter and debris and amongst low vegetation in moist habitats; often around gardens and farmhouses (Majka and Klimaszewski 2012).

Xantholinus (*Xantholinus*) *longiventris* Heer, 1839

Distribution: Holoarctic species (ITIS Species 2000 2020). Widespread in Italy, but absent in Sardinia (Ruffo and Stoch 2005).

Notes: Lives on banks, clearings, meadows, dry meadows, coppiced mixed forests, lakeshore with *Phragmitetum*, wetlands, riverbanks, floodplains, floodplain forests, marshy areas (*Phragmitetum*, *Caricetum*), orchards, parks, vineyards, damaged marshy areas, vegetable crops, permanent meadows, rural backyards, rural settlements and uncultivated areas (Zanetti et al. 2016).

Lepidoptera

Family Carabidae

Loxostege sticticalis Linnaeus, 1761

Distribution: Holoarctic species (Fabiano 2017).

Notes: It is a migratory pest that causes serious economic damage every year. Seems to be polyphagous in its larval stage, but it has been reported to have obvious hostplant selection for many crops (sugar beet, potato and soybean) and pastures (Wei et al. 2017).

Pyrausta despicata Scopoli, 1763

Distribution: Holoarctic species (Fabiano 2017).

Notes: Euryecious and heliophilous species. The larvae feed on various species of *Plantago* spp., *Antennaria* spp. and *Salvia* spp. (Fabiano 2017).

Family Geometrida

Idaea deversaria Herrich-Schäffer, 1847

Distribution: European and Central Asian species. It can be found in mainland Italy, Sardinia and Sicily (Flamigni and Bastia 1998).

Notes: Common from the foothills up to about 1400 m. In the hills, it flies from early June to the first ten days of July, in the mountains throughout the month of July (Flamigni and Bastia 1998).

Timandra comae Schmidt, 1931

Distribution: From North Africa across Europe to East Asia (Wagner 2020).

Notes: Inhabits many habitats in which the larval host plants (*Rumex* spp.) occurs, such as woodlands clearings and edges, extensively-managed meadows and pastures or shores and wetlands. Has 2-3 (in the south also 4) generations from May to September. The caterpillar overwinters. It is observed quite frequently on leaves and fruit stands (Wagner 2020).

Family Lycaenidae

Lycaena dispar Haworth, 1802

Conservation status: Least Concern for Italian (Balletto et al. 2015) and European assessments (Van Swaay et al. 2010); Near-Threatened for Global assessment (Gimenez 1996).

Distribution: It is distributed in Europe and north Turkey (Tolman and Lewington 2008). It can be found in northern and central Italy. It is present in the Po Valley and in the wetlands of northern Tuscany. The population of Lazio (Paludi Pontine) became extinct during the first half of the 1900s (Villa et al. 2009, IUCN, 2020 2020).

Notes: Hygrophilous species, it lives in humid meadows from the plain up to 500m a.s.l. Trivoltine species, with generations in April-May, June-July, August-September (Paolucci 2013, Villa et al. 2009).

Lycaena phlaeas Linnaeus, 1761

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessments (Van Swaay et al. 2010).

Distribution: It is distributed in Canary Islands, North and east-central Africa, Europe, temperate Asia, Japan and northeast America (Tolman and Lewington 2008). It can be found in mainland Italy, Sardinia and Sicily (IUCN, 2020 2020, Villa et al. 2009).

Notes: Eurycora species widespread and locally common, it frequents flowery meadows, open hedges, grasslands with scattered patches, pastures, moors and grassy banks, from the plain up to 2000 m a.s.l. Trivoltine species with generations in April-May, June-July, August-September (Paolucci 2013, Villa et al. 2009).

Family Noctuidae

Autographa gamma Linnaeus, 1758

Distribution: Holarctic species (Plepys et al. 2002).

Notes: It is one of the largest migratory moths in the world. It is common and often abundant. Polyvoltine, flies almost all year round both at night and during the day. It frequents a great variety of environments because its larvae feed on many different herbaceous species (Sterry and Mackay 2005).

Rivula sericealis Scopoli, 1763

Distribution: European species (Shaw 2012).

Notes: It is a small, partly plurivoltine noctuid moth. It is generally occurring in a wide variety of grassy sites, perhaps most commonly in somewhat sheltered situations. The larvae feed on various grasses and it is also recorded from sedges. The adults are long-lived and there is then a succession of at least partial additional generations, such that adults are on flights more or less continuously from late May well into September, with summer generation larvae in various stages of growth from June until the third instar larvae start to enter diapause in the autumn (Shaw 2012).

Family Nymphalidae

Aglais io Linnaeus, 1758

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessments (Van Swaay et al. 2010).

Distribution: It is distributed in most of Europe south to northern half of Iberian peninsula, Sierra Nevada, north and central Greece, European Turkey and Mediterranean Islands. (Tolman and Lewington 2008). It can be found in mainland Italy, Sardinia and Sicily (Villa et al. 2009).

Notes: Eurycora species, it lives in open and sunny places, in the woods, wooded banks, humid meadows, uncultivated fields and disturbed ground, rocky gullies sheltered with bushes and small trees at the upper limit of the altitude. It is spread from the plain at 2500 m a.s.l. Univoltine species flies in June-July (Paolucci 2013, Villa et al. 2009).

Vanessa cardui Linnaeus, 1758

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessments (Van Swaay et al. 2010).

Distribution: It is distributed in Europe and North Africa (Sterry and Mackay 2005). It can be found in mainland Italy, Sardinia and Sicily (Villa et al. 2009).

Notes: Migratory species widely distributed in many different environments, from the plains to 2500 m a.s.l. Migratory individuals arriving in Italy have two generations in June-July and September-October (Paolucci 2013, Villa et al. 2009).

Family Pieridae

Colias alfacariensis Ribbe, 1905

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessments (Van Swaay et al. 2010).

Distribution: It is distributed in south and central Europe and Turkey (Tolman and Lewington 2008). It can be found in mainland Italy, Sardinia and Sicily (Villa et al. 2009).

Notes: Thermophilic migratory species, it is found in arid grasslands, stony grasslands and rocky slopes from the plain at 1900 m a.s.l. Trivoltine species with generations in April-May, June-July and August-September (Paolucci 2013, Villa et al. 2009).

Colias crocea Fourcroy, 1785

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessments (Van Swaay et al. 2010).

Distribution: It is distributed in North Africa, central and south Europe, Middle East, Turkey, Iran, central-west Asia, central and south Urals (Tolman and Lewington 2008). It can be found in mainland Italy, Sardinia and Sicily (Villa et al. 2009).

Notes: Eurycora and migratory species, it lives in open environments such as prairies, alpine pastures and cultivated areas, from the plain to 2000 m a.s.l. Trivoltine species with generations in April-May, June-July and August-September (Paolucci 2013, Villa et al. 2009).

Pieris rapae Linnaeus, 1758

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessment (Van Swaay et al. 2010).

Distribution: European species (Sterry and Mackay 2005). It can be found in mainland Italy, Sardinia and Sicily (Villa et al. 2009).

Notes: Eurycora and migratory species very widespread in every environment from the plain to 2300m a.s.l., especially in prairies, cultivated areas and arid meadows. It has four generations in March-April, June, August and September-October (Paolucci 2013, Villa et al. 2009).

Family Satyridae

Coenonympha pamphilus Linnaeus, 1758

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessments (Van Swaay et al. 2010).

Distribution: It is distributed in North Africa, Europe, Turkey, Middle East and west Mongolia (Tolman and Lewington 2008). It can be found in mainland Italy, Sardinia and Sicily (Villa et al. 2009).

Notes: Widespread in a wide range of habitats, often in arid and flower-rich meadows, mountain pastures and rugged fields from the plain to 2100 m a.s.l. It is also found in peatlands and wet meadows. Bivoltine species with generations in April-May, July-August, sometimes a third in October (Paolucci 2013, Tolman and Lewington 2008, Villa et al. 2009).

Maniola jurtina Linnaeus, 1758

Conservation status: Least Concern for Italian (Balletto et al. 2015), Mediterranean (Numa et al. 2016) and European assessments (Van Swaay et al. 2010).

Distribution: It is distributed in Canary Islands, northwest Africa, Europe, Turkey, north Iran, Kazakhstan, central and south Urals to west Siberia (Tolman and Lewington 2008). It can be found in mainland Italy, Sardinia and Sicily (Villa et al. 2009).

Notes: Widely distributed, often abundant; it is common to all types of pasture, such as flowery meadows, grassy slopes, neglected cultivated areas; it is also found along open hedges and wooded edges from the plain to 1500 m a.s.l. Univoltine species flies in June-July (Paolucci 2013, Tolman and Lewington 2008, Villa et al. 2009).

Orthoptera

Family Acrididae

Acrida ungarica subsp. *mediterranea* Herbst, 1786

Conservation status: Least Concern for European (Hochkirch et al. 2016) and Global assessments (Hochkirch et al. 2016a).

Distribution: Mediterranean area and Africa (Fontana et al. 2002). In Italy, it is widespread in the whole of the country (Sicily and Sardinia included), with some discontinuity in northern Italy (Baroni et al. 2018, Iorio et al. 2019, Massa et al. 2012).

Notes: It is a thermophilous species, living in all kinds of dry habitats, wet grassland, dunes and wasteland. The adults can be found in summer and autumn (Fontana et al. 2002, Massa et al. 2012).

Aiolopus strepens subsp. *strepens* Latreille, 1804

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Europe and northern Africa to the Caucasus and Middle East (Fontana et al. 2002). Widespread all over in Italy (Sicily and Sardinia included), also on many small islands (Massa et al. 2012, Iorio et al. 2019).

Notes: It is a thermophilous species (Fontana et al. 2002), living in habitats with sparse vegetation like dry grassland, roadside verges and forest clearings. Adults can be found throughout the year, even during warm days in winter, while the highest densities occur in autumn (Massa et al. 2012).

Aiolopus thalassinus subsp. *thalassinus* Fabricius, 1781

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Europe, Africa and Asia (Fontana et al. 2002). In Italy, it is widespread in the whole country (Sicily and Sardinia included), but often discontinuously (Baroni et al. 2018, Iorio et al. 2019, Massa et al. 2012).

Notes: It is a hygrophilous species, often living in brackish habitats (Fontana et al. 2002). In Italy, it seems to be in decline (Iorio et al. 2019, Massa et al. 2012).

Calliptamus italicus subsp. *italicus* Linnaeus, 1758

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Widely distributed from Europe to Afghanistan (Massa et al. 2012). In Italy, it is widespread over the whole country (Sicily and Sardinia included), but especially in the northern part (Iorio et al. 2019, Massa et al. 2012). It should be typical of the Po Plain (Massa et al. 2012).

Notes: It lives in all kinds of dry open, often rocky habitats, with sparse vegetation. They can build up high population densities and it is one of the most harmful species to agriculture in Italy (Massa et al. 2012).

Chorthippus (*Glyptobothrus*) *brunneus* subsp. *brunneus* Thunberg, 1815

Conservation status: Least Concern for European (Hochkirch et al. 2016) and Global assessments (Bushell and Hochkirch 2014).

Distribution: From the Balkan Peninsula and north-eastern Italy (Massa et al. 2012). In Italy, it is widespread all over the country. It is only absent in Sicily (Massa et al. 2012, Iorio et al. 2019).

Notes: It lives in open habitats with sparse vegetation, like wasteland, mountain slope, forest clearings and roadside verges. The adults can be found from May to October (Massa et al. 2012).

Chorthippus (*Chorthippus*) *dorsatus* subsp. *dorsatus* Zetterstedt, 1821

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: From Europe to Siberia (Massa et al. 2012). In Italy, it is widespread in the north and central mainland; the southernmost records are from the south of Abruzzo. There is one record from Sardinia (Iorio et al. 2019, Massa et al. 2012).

Notes: It lives from sea level to the mountains, in dry to moist grassy habitats. It can build large populations. The adults can be found in summer and autumn (Massa et al. 2012).

Chrysochraon dispar subsp. *dispar* Germar, 1834

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Central Europe, Middle East to Siberia (Massa et al. 2012). The actual status of the species in Italy has to be re-evaluated. It is known to be present in the

north-eastern area of the country, in mountain areas of Veneto and Friuli-Venezia Giulia (Iorio et al. 2019, Massa et al. 2012).

Notes: It lives in moist grassland with high vegetation, in marshy and swampy areas (Massa et al. 2012).

Euchorthippus declivus Brisout de Barneville, 1848

Conservation status: Least Concern for European (Hochkirch et al. 2016) and Global assessments (Hochkirch et al. 2016b).

Distribution: From Europe to Ukraine (Fontana et al. 2002). In Italy, it is widespread throughout the mainland, with a few records in Sardinia (Iorio et al. 2019, Massa et al. 2012).

Notes: It is a xerothermophilus species. It lives in dry, stony and sunny meadows, in clearings and at the edge of the woods. Sometimes, it behaves like a hygrophilous species and inhabits fresh and wet meadows and swampy areas. The adults can be found from July to September (Fontana et al. 2002).

Locusta migratoria subsp. *cinerascens* Linnaeus, 1758

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Southern Europe, Mediterranean area, Africa and Asia (Fontana et al. 2002). In Italy, it is widespread in the whole country (Sicily and Sardinia included), but recently, it is much scarcer in the north (Iorio et al. 2019, Massa et al. 2012).

Notes: Lives in wet habitats with high grasses and herbs and sandy soil. Adults can be found in summer and autumn (Fontana et al. 2002, Massa et al. 2012).

Mecostethus parapleurus subsp. *parapleurus* Hagenbach, 1822

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Central and eastern Europe, widespread from Asia to Siberia. In Italy, it is widespread in the northern part, but rare in the Alpine arc (Iorio et al. 2019, Massa et al. 2012).

Notes: The species is typical of wet grassland, where it lives in the high vegetation. The adults can be found from June to October. In Italy, it seems to be in decline (Massa et al. 2012).

Oedipoda caerulescens subsp. *caerulescens* Linnaeus, 1758

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Europe, North Africa, Middle East and Asia to China (Massa et al. 2012). In Italy, it is widespread in the whole country. It is absent from Sardinia (Iorio et al. 2019, Massa et al. 2012).

Notes: It lives on bare ground in a wide variety of dry, open habitats like grassland, slopes, roadside verges and forest clearings. The adults can be found in summer and autumn (Massa et al. 2012).

Omocestus (*Omocestus*) *rufipes* Zetterstedt, 1821

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Wide distribution, from Europe and North Africa (Fontana et al. 2002). In Italy, it is widespread over the whole country (Sicily and Sardinia included) (Iorio et al. 2019, Massa et al. 2012).

Notes: It lives from the sea level to 2300 m in the mountains, in grasslands, wasteland, forest clearings, urban and agricultural habitats. This species has two generations in one year and can be found from May to November. It is one of the few species living in the Padanian Plain, in cultivated fields, too (Fontana et al. 2002, Massa et al. 2012).

Pezotettix giornae Rossi, 1794

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: It is distributed in south Europe, North Africa as far east as Caucasus (Fontana et al. 2002). In Italy, it is widespread in the whole country (Sicily and Sardinia included), also on several small islands (Iorio et al. 2019, Massa et al. 2012).

Notes: It is a thermophilus species and lives in many different open habitats. It lives in meadow environments, preferably mesoxerophilous; it can frequent mountain stony and arid stony environments. The adults appear from June to October, but it is frequent to observe them in autumn during the mating season (Fontana et al. 2002, Massa et al. 2012).

Pseudochorthippus parallelus subsp. *parallelus* Zetterstedt, 1821

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: It is distributed from Europe to Siberia. In Italy, it is widespread in the Alps and Apennines. From Sardinia, there is a doubtful record (Fontana et al. 2002).

Notes: It is a mesohygrophilus to hygrophilus montane species. The adults can be found in summer and autumn in dry to moist grassland (Fontana et al. 2002).

Family Tetrigidae

Tetrix subulata Linnaeus, 1758

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Widely distributed species in Eurasia and North America (Fontana et al. 2002). In Italy, it is recorded in many localities in the mainland, while with single records in Sicily and Sardinia (Iorio et al. 2019, Massa et al. 2012).

Notes: It is a meso-hygrophilous or hygrophilous species and lives from the coast up to 1700 m a.s.l. More frequent in lowland areas, submontane up to 1000 m a.s.l. It often forms abundant populations, located in fresh and humid habitats. It is an early species that overwinters as a nymph or adult insect (Fontana et al. 2002).

Tetrix tenuicornis Sahlberg, 1893

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Central and east Europe and Middle East. In Italy, it is widespread in the north-eastern regions, scarce in the north-west and with some records in the central Apennines (Iorio et al. 2019, Massa et al. 2012).

Notes: It is a small meso-hygrophilous species. It is common from the coast to submontane habitats, up to 1100 m a.s.l (Fontana et al. 2002). It forms abundant population in the slightly moist parts of dry grassland, along irrigation canals or in irrigated meadows. The adult can be found throughout the year, even if the species probably winters as a nymph (Massa et al. 2012).

Family Tettigonidae

Platycleis grisea subsp. *grisea* Fabricius, 1781

Distribution: Central, southern and eastern Europe to southern Russia. In Italy, it is widespread over the whole country, most abundant in the northern regions. In Sicily, it is known only from Etna (Iorio et al. 2019, Massa et al. 2012).

Notes: It is a widespread species. It lives from sea level to high up in the mountains, in dry open habitats, mostly in patches with dense vegetation. The adults can be found in summer and autumn (Massa et al. 2012).

Roeseliana azami subsp. *azami* Finot, 1892

Conservation status: Vulnerable for European (Hochkirch et al. 2016), Mediterranean and Global assessments (Braud et al. 2016).

Distribution: Endemic species of southern France, recently reported in Italy (Bardiani and Buzzetti 2009). A review of the genus is underway (Iorio et al. 2019).

Notes: In France, it lives in wet meadows and along the edges of streams. In Italy, it is reported as a mountain and hygrophilous species. It lives in wet grasslands, in dense vegetation. The adults can be found in summer and autumn (Massa et al. 2012).

Ruspolia nitidula Scopoli, 1786

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Widespread species, from central-southern Europe to Palearctic Asia and Africa (Fontana et al. 2002). In Italy, it is widespread all over the country (Sicily and Sardinia included) (Iorio et al. 2019, Massa et al. 2012).

Notes: Meso-hygrophilous or hygrophilous species, it inhabits all kinds of open habitats with a high rate of humidity and dense vegetation. It is frequent in agricultural fields, grasslands, banks of rivers, lakes and canals and also in brackish wetlands. It also lives in urban environments (Fontana et al. 2002, Massa et al. 2012).

Tettigonia viridissima Linnaeus, 1758

Conservation status: Least Concern for European assessment (Hochkirch et al. 2016).

Distribution: Holopaleartic species, widespread in Europe and north-western Africa. In Italy, it is widespread in the whole country (Siciliy and Sardinia included) (Iorio et al. 2019, Massa et al. 2012).

Notes: Mesophilic species with a wide ecological value. It lives from sea level up to higher elevations. It can be found among the tall grasses of the meadows, on bushes and on the crown of trees. It feeds on various insects and larvae and vegetarian nutrition is limited. Adults can be found in summer and autumn (Massa et al. 2012).

Analysis

Data analysis

Statistical analysis was conducted exclusively on ground beetles, rove beetles and spiders sampled by pitfall traps because only these taxa had a sufficient amount of quantitative data available. For spiders and beetles, immature specimens and larvae, respectively, were not considered in the analysis because, for many of them, it was not possible to determine the species. For the other groups, only descriptive tables have been prepared.

To examine whether trap locations were sufficiently spaced to be independent replicates, we tested our data for autocorrelation by performing a Mantel test, based on Pearson's product-moment correlation (permutations: 9999) between Bray-Curtis distances in assemblage composition and the geographical distances of samples collected. We found that spatial correlation in assemblages between samples was low (Person's $r = 0.43$) and not significant ($p \geq 0.05$). Therefore, we assumed all sampling plots as statistically independent (inter-sample distance ≥ 10 m). From hereafter, each trap is called a plot and each field (with six plots) a site.

The mean number of species and individuals per plot was calculated and the difference in species richness amongst sites was evaluated with the Kruskal–Wallis non-parametric analysis of variance. Differences amongst individual factor levels was tested by Wilcoxon pairwise rank sum tests.

Differences in species richness amongst sites was also evaluated by computing a sample size-based rarefaction curve using the software iNEXT (interpolation/extrapolation) R package (Hsieh et al. 2016). iNEXT focuses on three measures of Hill numbers (Hill 1973) of order q: species richness (q = 0: the relative abundances of species are not considered and, therefore, the value obtained is equal to that of species richness), Shannon diversity (q = 1: the index weighs the species, based on their frequency and the result is the exponential version of the Shannon Index) and Simpson diversity (q = 2: the abundant species have a higher weight and the result is the inverse of the Simpson concentration).

For each diversity measure, iNEXT uses the observed sample of abundance data to compute diversity estimates, calculated via the functions ChaoRichness for q = 0, ChaoShannon for q = 1 and ChaoSimpson for q = 2; (see Chao et al. 2014 for the formulae of these asymptotic estimators). The 95% confidence intervals associated with the estimates are also calculated and a sample-size-based rarefaction and extrapolation (R/E) curve is plotted.

In order to verify differences in species composition amongst the *marcita* fields, we performed a PERMANOVA (permutational multivariate analysis of variance) analysis, using Primer 6+ statistical software with the PERMANOVA + add-on package (Anderson et al. 2006, Clarke and Gorley 2006). The analysis was conducted on a Bray–Curtis similarity matrix in which abundance raw data were standardised by dividing the number of individuals of each species collected in each plot by the total number of individuals

collected in that plot. These data were then square-root transformed to underestimate the contribution of the more abundant species (Clarke 1993, Bray and Curtis 1957). Pairwise post-hoc tests to compare similarities in species composition amongst sites were performed under 9999 permutations (for further details, see Anderson 2005). Whenever the sample size was too small once divided into factors, PERMANOVA's Monte Carlo test, which uses chi-square variables, combined with eigenvalues to construct the asymptotic permutation, was used.

We also used the Bray–Curtis similarity matrix in a distance-based Redundancy Analysis – dbRDA (Anderson and Cribble 1998, Ramette and Tiedje 2007) to display differences in species composition amongst all samples and the contribution of individual species to these differences. The contribution of each species in determining the dissimilarity between pairs of *marcita* fields was measured using the SIMPER test (Anderson et al. 2006, Clarke and Gorley 2006) which provides a percentage measurement of this contribution according to a decreasing dissimilarity order.

Results

During the whole sampling period we found a total of 47 ground beetle species, 35 rove beetle species, 29 spider species, one Lucanidae, 16 butterfly species and 24 grasshopper and cricket species. Specifically, between April and October 2014, we found a total of 4449 ground beetles belonging to 41 species (Table 2); 1698 spiders belonging to 29 species (Table 3); 589 rove beetles belonging to 34 species (Table 4); 45 butterflies belonging to 16 species (Table 5). During the winter 2014/2015, we collected 618 overwintering beetles belonging to 22 species divided as follows: 17 ground beetle species, four rove beetle species and one species belonging to Lucanidae (Table 6).

Table 2.

List of ground beetle species collected in the three *marcita* fields of the study area during the summer of 2014. For each species, information is reported for wing development WD (M = Macropterous, winged species; D = dimorphic, a species that can be either winged or not winged; B = Brachypterous, species without wings or reduced ones) and diet D (P = Predator, OM = Omnivorous, PHY = Phytophagous).

Species	WD	D	Field			Total
			Casterno	Sforzesca	Tre Colombaie	
Agonum (*Olisares*) *emarginatum* (Gyllenhal, 1827)	M	P	1	1	0	2
Agonum (*Agonum*) *muelleri* (Herbst, 1784)	M	P	2	0	0	2
Amara (*Amara*) *aenea* (DeGeer, 1774)	M	OM	4	84	20	108
Amara (*Amara*) *familiaris* (Duftschmid, 1812)	M	OM	0	0	2	2
Amara (*Zezea*) *fulvipes* (Audinet-Serville, 1821)	M	OM	20	2	0	22
Amara (*Amara*) *similata* (Gyllenhal, 1810)	M	OM	0	1	0	1

Species	WD	D	Field			Total
			Casterno	Sforzesca	Tre Colombaie	
Anchomenus (*Anchomenus*) *dorsalis* (Pontoppidan, 1763)	M	P	5	9	6	20
Anchomenus (*Anchomenus*) *binotatus* (Fabricius, 1787)	M	OM	82	15	48	145
Anisodactylus (*Pseudanisodactylus*) *signatus* (Panzer, 1796)	M	OM	2	0	4	6
Bembidion (*Bembidion*) *quadrimaculatum* (Linnaeus, 1760)	M	OM	1	0	0	1
Brachinus (*Brachinus*) *elegans* (Chaudoir, 1842)	M	P	1	41	2	44
Brachinus (*Brachynidius*) *sclopeta* (Fabricius, 1792)	M	P	0	21	0	21
Calathus (*Calathus*) *fuscipes* (Goeze, 1777)	M	P	0	4	1	5
Calathus (*Neocalathus*) *melanocephalus* (Linnaeus, 1758)	B	P	0	1	2	3
Calosoma (*Campalita*) *auropunctatum* (Herbst, 1784)	M	P	0	6	1	7
Carabus (*Carabus*) *granulatus* (Linnaeus, 1758)	D	P	14	91	7	112
Chlaenius (*Chlaeniellus*) *nitidulus* (Schrank, 1781)	M	P	35	0	2	37
Clivina (*Clivina*) *fossor* (Linnaeus, 1758)	M	P	8	6	9	23
Diachromus germanus (Linnaeus, 1758)	M	PHY	0	140	1	141
Dolichus halensis (Schaller, 1783)	M	P	0	2	0	2
Egodroma marginatus (Dejean, 1829)	M	P	0	0	1	1
Harpalus (*Harpalus*) *affinis* (Schrank, 1781)	M	P	16	84	497	597
Harpalus (*Harpalus*) *distinguendus* (Duftschmid, 1812)	M	OM	2	5	50	57
Harpalus (*Harpalus*) *oblitus* (Dejean, 1829)	M	OM	0	4	1	5
Harpalus (*Harpalus*) *serripes* (Quensel in Schonherr, 1806)	M	OM	0	0	1	1
Metallina (*Metallina*) *properans* (Stephens, 1828)	M	OM	196	51	383	630
Microlestes minutulus (Goeze, 1777)	B	P	0	0	2	2
Panagaeus (*Panagaeus*) *cruxmajor* (Linnaeus, 1758)	M	P	6	0	0	6
Parophonus (*Ophonomimus*) *hirsutulus* (Dejean, 1829)	M	P	0	1	9	10
Parophonus (*Parophonus*) *maculicornis* (Duftschmid, 1812)	M	OM	0	1	0	1
Poecilus (*Poecilus*) *cupreus* (Linnaeus, 1758)	M	OM	22	203	81	306
Poecilus (*Poecilus*) *versicolor* (Sturm, 1824)	M	OM	2	11	12	25
Pseudoophonus (*Pseudoophonus*) *griseus* (Panzer, 1796)	M	P	0	9	70	79
Pseudoophonus (*Pseudoophonus*) *rufipes* (De Geer, 1774)	M	OM	76	883	915	1874
Pterostichus (*Melanius*) *aterrimus* (Herbst, 1784)	M	OM	0	0	1	1

Species	WD	D	Field			Total
			Casterno	Sforzesca	Tre Colombaie	
Pterostichus (*Morphnosoma*) *melanarius* (Illiger, 1798)	M	P	0	19	12	31
Pterostichus (*Platysma*) *niger* (Schaller, 1783)	M	P	0	1	1	2
Pterostichus (*Phonias*) *strenuus* (Panzer, 1796)	M	P	25	19	1	45
Pterostichus (*Argutor*) *vernalis* (Panzer, 1796)	M	P	6	10	2	18
Sphaerotachys hoemorrhoidalis (Ponza, 1805)	M	P	1	0	0	1
Stenolophus (*Stenolophus*) *teutonus* (Schrank, 1781)	M	OM	6	36	10	52
TOTAL			534	1758	2157	4449

Table 3.

List of spiders collected in the three *marcita* fields of the study area during the summer of 2014.

Family	Species	Field			Total
		Casterno	Tre Colombaie	Sforzesca	
Gnaphosidae	*Micaria pulicaria* (Sundevall, 1831)	1	0	0	1
Gnaphosidae	*Zelotes longipes* (Koch, 1866)	0	1	1	2
Linyphiidae	*Araeoncus humilis* (Blackwall, 1841)	1	6	0	7
Linyphiidae	*Bathyphantes gracilis* (Blackwall, 1841)	3	3	6	12
Linyphiidae	*Ceratinella brevipes* (Westring, 1851)	2	0	0	2
Linyphiidae	*Diplostyla concolor* (Wider, 1834)	1	7	0	8
Linyphiidae	*Erigone dentipalpis* (Wider, 1834)	11	23	36	70
Linyphiidae	*Gnathonarium dentatum* (Wider, 1834)	4	14	14	32
Linyphiidae	*Mermessus trilobatus* (Emerton, 1882)	2	3	0	5
Linyphiidae	*Microlinyphia pusilla* (Sundevall, 1830)	1	0	0	1
Linyphiidae	*Neriene clathrata* (Sundevall, 1830)	1	0	0	1
Linyphiidae	*Oedothorax apicatus* (Blackwall, 1850)	95	56	75	226
Linyphiidae	*Palliduphantes pallidus* (O. Pickard-Cambridge, 1871)	0	1	0	1
Linyphiidae	*Prinerigone vagans* (Audouin, 1826)	2	12	5	19
Lycosidae	*Alopecosa pulverulenta* (Clerck, 1757)	0	1	1	2
Lycosidae	*Arctosa leopardus* (Sundevall, 1833)	92	43	53	188
Lycosidae	*Pardosa agrestis* (Westring, 1861)	1	0	0	1

Family	Species	Field			Total
		Casterno	Tre Colombaie	Sforzesca	
Lycosidae	*Pardosa cribrata* (Simon, 1876)	1	0	5	6
Lycosidae	*Pardosa prativaga* (L. Koch, 1870)	12	13	21	46
Lycosidae	*Pardosa proxima* s.l.* (C. L. Koch, 1847)	205	303	223	731
Lycosidae	*Pirata tenuitarsis* (Simon, 1876)	1	0	0	1
Lycosidae	*Piratula hygrophila* (Thorell, 1872)	3	0	0	3
Lycosidae	*Trochosa ruricola* (De Geer, 1778)	37	8	9	48
Tetragnathidae	*Pachygnatha clercki* (Sundevall, 1823)	1	2	6	9
Tetragnathidae	*Pachygnatha degeeri* (Sundevall, 1830)	240	4	7	251
Thomisidae	*Ozyptila sanctuaria* (O. Pickard-Cambridge, 1871)	0	1	0	1
Thomisidae	*Ozyptila simplex* (O. Pickard-Cambridge, 1862)	9	1	0	10
Thomisidae	*Xysticus gallicus* (Simon, 1875)	2	0	0	2
Thomisidae	*Xysticus kochi* (Thorell, 1872)	6	0	0	6
Total		**734**	**502**	**462**	**1698**

*taxonomic identification of this species is prior to the new classification from Pantini and Isaia (2019) Isaia et al. (2018)

Table 4.

List of rove beetle species collected in the three *marcita* fields of the study area during the summer of 2014.

Species	Field			Total
	Casterno	Sforzesca	Tre Colombaie	
Aleochara (*Coprophara*) *bipustulata* (Linnaeus, 1760)	8	0	0	8
Anotylus rugosus (Fabricius, 1775)	2	0	0	2
Arpedium quadrum (Gravenhorst, 1806)	1	0	0	1
Astrapaeus ulmi (Rossi, 1790)	0	0	1	1
Atheta (*Atheta*) *aeneicollis* (Sharp, 1869)	50	3	76	129
Atheta fungi (Gravenhorst, 1806)	0	13	0	13
Atheta (*Dimetrotina*) *laticollis* (Stephens, 1832)	0	6	0	6
Atheta (*Atheta*) *triangulum* (Kraatz, 1856)	0	7	0	7
Carpelimus (*Taenosoma*) *corticinus* (Gravenhorst, 1806)	0	1	0	1

Species	Field			Total
	Casterno	Sforzesca	Tre Colombaie	
Cordalia obscura (Gravenhorst, 1802)	0	4	0	4
Dinaraea angustula (Gyllenhal, 1810)	0	4	0	4
Drusilla (*Drusilla*) *canaliculata* (Fabricius, 1787)	6	0	0	6
Euryalea murina (Erichson, 1839)	5	0	0	5
Falagria sulcatula (Gravenhorst, 1806)	1	0	0	1
Falagrioma thoracica (Stephens, 1832)	0	0	1	1
Gabrius sp. (Stephens, 1829)	0	0	1	1
Ochthephilum brevipenne (Mulsant & Rey, 1861)	0	0	1	1
Ocypus (*Matidus*) *brunnipes* (Fabricius, 1781)	1	0	0	1
Ocypus (*Ocypus*) *olens* (O.F.Müller, 1764)	2	3	5	10
Omalium caesum (Gravenhorst, 1806)	6	1	6	13
Omalium oxyacanthae (Gravenhorst, 1806)	0	3	4	7
Oxypoda (*Oxypoda*) *opaca* (Gravenhorst, 1802)	1	4	3	8
Paederus (*Heteropaederus*) *fuscipes* (Curtis, 1826)	10	7	38	55
Philonthus (*Philonthus*) *carbonarius* (Gravenhorst, 1802)	6	70	96	172
Philonthus (*Philonthus*) *cognatus* (Stephens, 1832)	1	73	3	77
Philonthus (*Philonthus*) *succicola* (C.G.Thomson, 1860)	0	1	2	3
Platystethus (*Craetopycrus*) *burlei* (Brisout de Barneville, 1862)	0	0	1	1
Platystethus (*Craetopycrus*) *nitens* (C. Sahlberg, 1832)	0	0	1	1
Proteinus ovalis (Stephens, 1834)	0	0	2	2
Quedius nitipennis (Stephens, 1833)	1	0	1	2
Rugilus (*Rugilus*) *orbiculatus* (Paykull, 1789)	0	1	3	4
Tachinus (*Tachinus*) *corticinus* (Gravenhorst, 1802)	0	7	1	8
Xantholinus (*Xantholinus*) *linearis* (Olivier, 1795)	0	0	1	1
Xantholinus (*Xantholinus*) *longiventris* (Heer, 1839)	23	1	9	33
TOTAL	**124**	**209**	**256**	**589**

Table 5.

List of butterflies collected in the three *marcita* fields of the study area during the summer of 2014.

Family	**Species**	**Field**			**Total**
		Casterno	**Tre Colombaie**	**Sforzesca**	
Carabidae	*Loxostege sticticalis* (Linnaeus, 1761)	1	0	0	1
Carabidae	*Pyrausta despicata* (Scopoli, 1763)	0	1	0	1
Geometridae	*Idaea deversaria* (Herrich-Schäffer, 1847)	1	2	0	3
Geometridae	*Timandra comae* (Schmidt, 1931)	0	1	1	2
Hesperiidae	*Pyrgus* sp. (Hübner, 1819)	0	1	0	1
Lycaenidae	*Lycaena dispar* (Haworth, 1802)	1	1	2*	4
Lycaenidae	*Lycaena phlaeas* (Linnaeus, 1761)	0	0	1	1
Noctuidae	*Autographa gamma* (Linnaeus, 1758)	0	2	0	2
Noctuidae	*Rivula sericealis* (Scopoli, 1763)	1	1	0	2
Nymphalidae	*Inachis io* (Linnaeus, 1758)	0	0	4	4
Nymphalidae	*Vanessa cardui* (Linnaeus, 1758)	0	1	0	1
Pieridae	*Colias alfacariensis* (Ribbe, 1905)	1	0	0	1
Pieridae	*Colias crocea* (Fourcroy, 1785)	1	3	1	5
Pieridae	*Pieris rapae* (Linnaeus, 1758)	2	1	5	8
Satyridae	*Coenonympha pamphilus* (Linnaeus, 1758)	3	3	1	7
Satyridae	*Maniola jurtina* (Linnaeus, 1758)	1	0	1	2
Total		**12**	**17**	**16**	**45**

*the species was also collected once in 2015 at the field “Amerio 2"

Table 6.

List of the overwintering beetles collected in the six *marcita* fields of the study area during the winter of 2014-2015. For ground beetles species, information is reported for the wing development WD (M = Macropterous, winged species; D = dimorphic, a species that can be either winged or not winged; B = Brachypterous, species without wings or reduced ones) and diet D (P = Predator, OM = Omnivorous).

Family	Species	WD	D	Field						Total
				Casterno	Tre Colombaie	Sforzesca	Amerio1	Amerio2	Garlaschè	
Carabidae	*Agonum* (*Olisares*) *emarginatum* (Gyllenhal, 1827)	M	P	0	1	0	0	0	0	1
Carabidae	*Agonum* (*Olisares*) *sexpunctatum* (Linnaeus, 1758)	M	P	3	0	0	0	0	0	3
Carabidae	*Anchomenus* (*Anchomenus*) *dorsalis* (Pontoppidan, 1763)	M	P	24	0	0	0	0	0	24
Carabidae	*Anisodactylus* (*Anisodactylus*) *binotatus* (Fabricius, 1787)	M	OM	2	0	0	0	0	0	2
Carabidae	*Badister* (*Badister*) *bullatus* (Schrank, 1798)	M	P	0	3	0	0	0	0	3
Carabidae	*Carabus* (*Carabus*) *granulatus* (Linnaeus, 1758)	D	P	21	7	15	11	3	6	63
Carabidae	*Limodromus* (*Limodromus*) *assimilis* (Paykull, 1790)	M	P	0	0	0	0	3	0	3
Carabidae	*Limodromus* (*Limodromus*) *krynickii* (Sperk, 1835)	M		1	0	9	0	0	0	10

Family	Species	WD	D	Field						Total
				Caste-rno	Tre Colom-baie	Sfor-zesca	Ame-rio1	Ame-rio2	Garla-schè	
Carabidae	*Panagaeus* (*Panagaeus*) *cruxmajor* (Linnaeus, 1758)	M	P	39	0	0	0	0	0	39
Carabidae	*Paranchus albipes* (Fabricius, 1796)	M		15	1	0	0	0	0	16
Carabidae	*Parophonus* (*Ophonomimus*) *hirsutulus* Dejean, 1829)	M	OM	1	0	0	0	0	0	1
Carabidae	*Pseudoophonus* (*Pseudoophonus*) *griseus* (Panzer, 1796)	M	OM	1	0	0	0	0	0	1
Carabidae	*Pseudoophonus* (*Pseudoophonus*) *rufipes* (De Geer, 1774)	M	OM	0	0	0	0	0	1	1
Carabidae	*Pterostichus* (*Melanius*) *aterrimus* (Herbst, 1784)	M	P	0	1	0	0	0	0	1
Carabidae	*Pterostichus* (*Phonias*) *strenuus* (Panzer, 1796)	M	P	0	0	0	0	0	2	2
Carabidae	*Pterostichus* (*Argutor*) *vernalis* (Panzer, 1796)	M	P	0	0	20	0	0	0	20
Carabidae	*Stenolophus* (*Stenolophus*) *teutonus* (Schrank, 1781)	M	OM	2	0	2	0	10	0	14

Family	Species	WD	D	Field						Total
				Caste-rno	Tre Colom-baie	Sfor-zesca	Ame-rio1	Ame-rio2	Garla-schè	
Lucanidae	*Dorcus parallelepipedus* (Linnaeus, 1785)			0	2	0	0	0	0	2
Staphilinidae	*Ocypus* (*Ocypus*) *olens* (O.F.Müller, 1764)		P	0	2	0	0	0	0	2
Staphilinidae	*Paederus* (*Heteropaederus*) *fuscipes* (Curtis, 1826)		P	400	7	0	0	0	1	408
Staphilinidae	*Quedius cruentus* (Olivier, 1795)			0	1	0	0	0	0	1
Staphilinidae	*Quedius* (*Raphirus*) *nitipennis* (Stephens, 1833)			1	0	0	0	0	0	1
Total				**510**	**14**	**124**	**11**	**28**	**12**	**618**

Between May and September 2015, we found a total of 262 grasshoppers and crickets belonging to 24 species (Table 7) and we confirmed the presence of *Lycaena dispar* at the "Amerio 2" field in the Sforzesca area.

Table 7.

List of grasshoppers and crickets collected in the six *marcita* fields of the study area during summer 2015. For each species, information is reported about the mobility class (Mob) and the habitat specificity class (HS). Mobility classes are: 1 = Sedentary; 2 = Intermediate dispersers; 3 = Mobile species. Habitat specificity classes are: 1 = Generalists; 2 = Medium specialised species; 3 = Specialists (* indicates hygrophilous species).

Family	Species	Mob	HS	Field						Total
				Amerio 1	Amerio 2	Cas-terno	Gar-laschè	Sforzesca	Tre Colom-baie	
Acrididae	*Acrida ungarica mediterranea* (Herbst, 1786)	2	1					1		1

Acrididae	*Aiolopus strepens strepens* (Latreille, 1804)	3	2						1	1
Acrididae	*Aiolopus thalassinus thalassinus* (Fabricius, 1781)	3	2	8	1	9	12	8	10	48
Acrididae	*Calliptamus italicus italicus* (Linnaeus, 1758)	2	2	1		2	1	4		8
Acrididae	*Chorthippus* (*Glyptobothrus*) *brunneus brunneus* (Thunberg, 1815)	2	1			3			11	14
Acrididae	*Chorthippus* (*Chorthippus*) *dorsatus dorsatus* (Zetterstedt, 1821)	3	1		1	2		2		5
Acrididae	*Chorthippus* sp. (Fieber, 1852)					2			5	7
Acrididae	*Chrysocharon dispar dispar** (Germar, 1834)	2	2				1			1
Acrididae	*Euchorthippus declivus* (Brisout de Barneville, 1848)	3	2		8	1	2	7	19	37
Acrididae	*Glyptobothrus* sp. (Fieber, 1852)			3	1	2	2	4	1	13
Acrididae	*Locusta migratoria cinerascens* (Linnaeus, 1758)	3	2	1			1	1	3	6
Acrididae	*Mecostethus parapleurus parapleurus* (Hagenbach, 1822)	2	2	5	3	2			1	11
Acrididae	*Oedipoda caerulescens caerulescens* (Linnaeus, 1758)	3	2	1						1
Acrididae	*Omocestus* (*Omocestus*) *rufipes* (Zetterstedt, 1821)	2	2	6		2	1	2	6	17
Acrididae	*Pezotettix giornae* (Rossi, 1794)	3	1						1	1

Acrididae	*Pseudochorthippus parallelus parallelus* (Zetterstedt, 1821)	3	3	12	5	15	2	10	11	55
Tetrigidae	*Tetrix subulata* (Linnaeus, 1758)	3	3			1	1	1	1	4
Tetrigidae	*Tetrix tenuicornis* (Sahlberg, 1893)	2	3			1				1
Tetrigidae	*Tetrix* sp. (Latreille, 1802)					1				1
Tettigonidae	*Platycleis grisea grisea* (Fabricius, 1781)	2	1					1		1
Tettigonidae	*Roeseliana azami azami** (Finot, 1892)	1	2	1						1
Tettigonidae	*Ruspolia nitidula* (Scopoli, 1786)	3	3	3	2	4	6	4	7	26
Tettigonidae	*Tettigonia viridissima* (Linnaeus, 1758)	3	3				1			1
Tettigonidae	*Tettigonia* sp. (Linnaeus, 1758)						1			1
Total				**41**	**21**	**47**	**31**	**45**	**77**	**26**

Table 8.

Species richness and diversity of ground beetles during summer 2014. The Table shows the observed diversity, the asymptotic estimates (Estimator), the estimated bootstrap S.E. and 95% confidence intervals (LCL and UCL) for Hill numbers of order q (0: Species richness, 1: Shannon diversity and 2: Simpson diversity).

Sites	**Observed diversity**		**Estimator**	**S.E.**	**LCL**	**UCL**
Casterno	Species richness	24	27.119	3.652	24.505	43.269
	Shannon diversity	8.56	8.793	0.477	8.56	9.728
	Simpson diversity	5.248	5.29	0.353	5.248	5.981
Tre Colombaie	Species richness	31	36.331	4.927	32.143	55.87
	Shannon diversity	5.544	5.595	0.137	5.544	5.863
	Simpson diversity	3.727	3.732	0.086	3.727	3.901
Sforzesca	Species richness	29	37.995	10.168	30.519	82.248
	Shannon diversity	6.753	6.829	0.239	6.753	7.297
	Simpson diversity	3.451	3.455	0.129	3.451	3.708

Ground beetle richness and abundance

During the summer of 2014, carabid assemblage in the whole study area was dominated by macropterous individuals (4331 out of 117, for a total of 38 species), both omnivorous and predators (Table 2). We found only two brachypterous species, *Calathus* (*Neocalathus*) *melanocephalus* and *Microlestes minutulus*, both predators, for a total of five individuals and one dimorphic species, *Carabus* (*Carabus*) *granulatus* (n = 112), which is also a predator. Amongst the collected ground beetles, we found only one phytophagus species: *Diachromus germanus.* The most abundant species was *Pseudoophonus* (*Pseudoophonus*) *rufipes* with more than 1000 specimens, followed by *Metallina* (*Metallina*) *properans* and *Harpalus* (*Harpalus*) *affinis* with more than 500 specimens (Table 2).

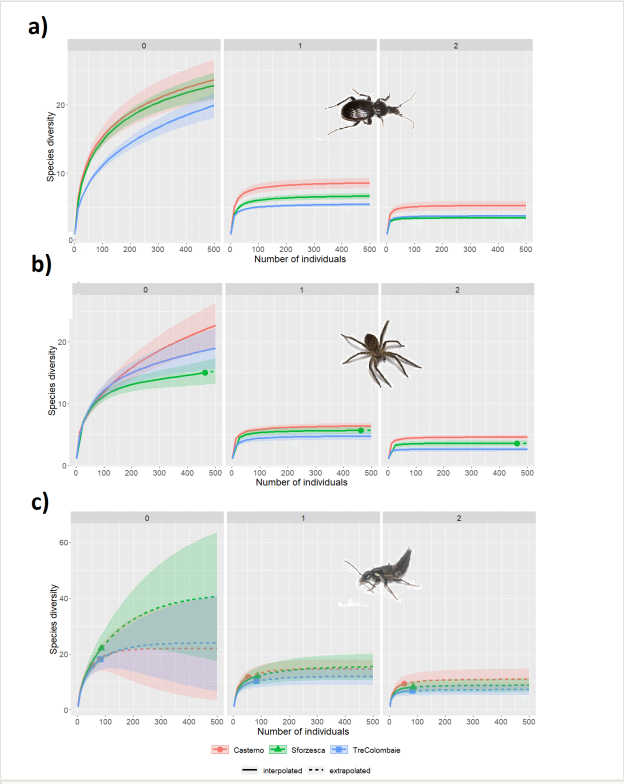

Figure 2. doi

Rarefaction curves showing the diversity of a) ground beetles; b) spiders; c) rove beetles, in the three *marcita* fields when the order q was set at q = 0 (species richness), q=1 (exponential Shannon index) and q=2 (Simpson index).

Ground beetle species richness differed significantly amongst the three *marcita* fields (Kruskal-Wallis chi-squared = 8.68, df = 2, p-value = 0.013). The field with the highest number of species was Tre Colombaie, followed by Sforzesca and Casterno (Table 8). Although Casterno resulted in the field with the lowest number of species (Wilcoxon rank sum test: Casterno vs. Tre Colombaie, p = 0.024; Casterno vs. Sforzesca p = 0.036), it

showed a more equitable species abundance compared to the other two fields. Therefore, as shown in Fig. 2, Casterno is the field with the highest Shannon and Simpson diversity.

The PERMANOVA test revealed differences in species composition amongst the fields (Table 9). In particular, Casterno was significantly different from Sforzesca and Tre Colombaie (Table 10) showing a low frequency of some species, such as *Pseudoophonus* (*Pseudoophonus*) *rufipes* and *Harpalus* (*Harpalus*) *affinis*, that were otherwise significantly abundant in the other two fields (Table 2). Species composition differed also between Sforzesca and Tre Colombaie (Table 10). The species that contributed the most to the dissimilarity between the two fields was *Harpalus* (*Harpalus*) *affinis*, which was clearly more abundant in Tre Colombaie (Table 11).

Table 9.

Results from permutational multivariate analysis of variance for differences in species composition amongst the fields, based on a Bray-Curtis resemblance matrix with *P*-values obtained by 9999 permutations.

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Ground beetles	2	13709	6854.4	12.635	**0.0001**	9906
Spiders	2	5442.8	2721.4	4.926	**0.001**	9998
Rove beetles	2	15186	7593.1	5.1917	**0.0001**	9920

SS, sum of squares; MS, mean sum of squares; Pseudo-*F*, *F* value by permutation. Bold indicates statistical significance at $P < 0.05$.

Table 10.

Results from permutational multivariate analysis of variance pairwise tests for differences in species composition between pairs of fields.

Taxa	Fields	t	Unique perm	P(MC)
Ground beetles	Casterno, Tre colombaie	3.3453	424	**0.001**
	Casterno, Sforzesca	3.5711	413	**0.001**
	Tre colombaie, Sforzesca	3.9663	409	**0.001**
Spiders	Casterno, Tre Colombaie	2.5317	400	**0.002**
	Casterno, Sforzesca	2.4161	413	**0.004**
	Tre Colombaie, Sforzesca	1.4634	409	0.06
Rove beetles	Casterno, Tre Colombaie	1.4314	407	0.082
	Casterno, Sforzesca	2.4808	407	**0.003**
	Tre Colombaie, Sforzesca	2.2146	409	**0.008**

The significantly different species composition is indicated by bold *p*-values obtained by permutation.

Table 11.

Results from SIMPER analysis for differences in species composition amongst the three *marcita* fields. This analysis shows which species contribute the most to dissimilarity between pairs of fields and provides a percentage of this contribution in a decreasing dissimilarity order.

Taxa	**Species**	**% Dissimilarity**	**Average abundance**		**CONTRIB%**	**CUM%**
			Casterno	**Sforzesca**		
Ground Beetles	*Pseudoophonus* (*Pseudoophonus*) *rufipes* (De Geer, 1774)	64.19	3.39	12.3	19.1	19.1
	Harpalus (*Harpalus*) *affinis* (Schrank, 1781)		1.1	9.04	17.1	36.2
Spiders	*Pachygnatha degeeri* (Sundevall, 1830)	44.42	6.2	0.87	21.7	21.7
	Oedothorax apicatus (Blackwall, 1850)		3.37	3.36	8.39	30.09
Rove Beetles	*Philonthus* (*Philonthus*) *cognatus* (Stephens, 1832)	81.20	0.17	3.04	15.77	15.77
	Philonthus (*Philonthus*) *carbonarius* (Gravenhorst, 1802)		0.80	3.30	13.64	29.41
			Tre Colombaie	**Sforzesca**		
Ground Beetle	*Harpalus* (*Harpalus*) *affinis* (Schrank, 1781)	43.32	9.04	3.44	11.99	11.99
	Metallina (*Metallina*) *properans* (Stephens, 1828)		7.93	2.76	10.95	22.93
Spiders	*Erigone dentipalpis* (Wider, 1834)	33.83	1.54	2.15	9.14	9.14
	Pardosa proxima s.l* (C. L. Koch, 1847)		7.09	6.01	8.31	17.44
Rove Beetles	*Philonthus* (*Philonthus*) *cognatus* (Stephens, 1832)	61.95	0.40	3.04	15.54	15.54
	Atheta (*Atheta*) *aeneicollis* (Sharp, 1869)		2.89	0.29	15.34	30.88
			Casterno	**Tre Colombaie**		

Taxa	Species	% Dissimilarity	Average abundance		CONTRIB%	CUM%
			Casterno	Sforzesca		
Ground Beetle	*Pseudoophonus* (*Pseudoophonus*) *rufipes* (De Geer, 1774)	58.75	3.39	12.3	19.1	19.1
	Harpalus (*Harpalus*) *affinis* (Schrank, 1781)		1.1	9.04	17.1	36.2
Spiders	*Pachygnatha degeeri* (Sundevall, 1830)	46.39	6.2	0.57	21.42	21.42
	Oedothorax apicatus (Blackwall, 1850)		3.37	3.01	7.61	29.03
Rove Beetles	*Philonthus* (*Philonthus*) *carbonarius* (Gravenhorst, 1802)	63.99	0.80	3.91	19.94	19.94
	Atheta (*Atheta*) *aeneicollis* (Sharp, 1869)		2.21	2.89	15.08	35.03

Ordinations with db-RDA confirm differences in species composition amongst the three communities (Fig. 3). In particular, the first axis explains 45% of the total variance and clearly separates Casterno from Sforzesca and Tre Colombaie ground beetle communities. The second axis, with 23% of the total variance explained, separates Sforzesca from Tre Colombaie communities. In the cloud of species projected in the db-RDA graph, also less frequent species are present. Amongst them, those collected only on one occasion are: *Harpalus* (*Harpalus*) *serripes* and *Pterostichus* (*Melanius*) *aterrimus* in the Tre Colombaie field, *Bembidion* (*Bembidion*) *quadrimaculatum*, *Sphaerotachys hoemorrhoidalis* and *Stenolophus* (*Egodroma*) *marginatus* in the Casterno field, *Parophonus* (*Parophonus*) *maculicornis* and *Amara* (*Amara*) *similata* in the Sforzesca field.

Spider richness and abundance

The whole spider community analysed has 1698 specimens with a slightly unbalanced sex ratio in favour of males (1019 vs. 763 females). *Pardosa proxima* (Lycodidae) was the most abundant species with 731 specimens mainly sampled in Tre Colombaie (Table 3), followed by *Pachygnatha degeeri* (Tetragnathidae), with 251 specimens mainly sampled in Casterno, *Oedothorax apicatus* (Linyphiidae) with 226 specimens equally distributed amongst the fields and *Arctosa leopardus* (Lycosidae) with 188 specimens mainly sampled in Casterno (Table 3).

Spider richness ranged from 25 species in Casterno to 19 and 15 species in Tre Colombaie and Sforzesca, respectively (Table 12). The higher diversity value of the Casterno community remains constant as the order q changes (Fig. 2). Conversely, Tre Colombaie and Sforzesca showed, respectively, a decrease and an increase in the diversity value as the order q increased. The mean species richness did not differ

significantly amongst the three *marcita* fields (Kruskal-Wallis chi-squared = 5.48, df = 2, p-value = 0.065). However, the higher number of species, found in Casterno, makes this value very close to significance.

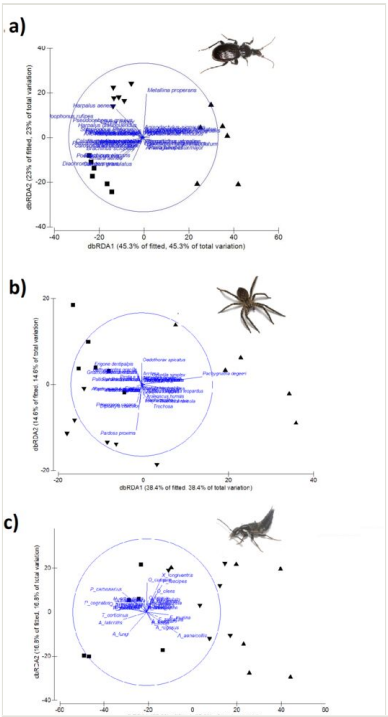

Figure 3. doi

Distance-based redundancy analysis (dbRDA) ordination plot of ground beetle, spiders and rove beetle assemblages in the three *marcita* fields (Casterno: triangle; Tre Colombaie: inverted triangle; Sforzesca: square)

Table 12.

Species richness and diversity of spiders during summer 2014. The Table shows the observed diversity, the asymptotic estimates (Estimator), the estimated bootstrap S.E. and 95% confidence intervals (LCL and UCL) for Hill numbers of order q (0: Species richness, 1: Shannon diversity and 2: Simpson diversity).

Sites	Observed diversity		Estimator	s.e.	LCL	UCL
Casterno	Species richness	26	36.111	9.006	28.261	71.221
	Shannon diversity	6.42	6.591	0.309	6.42	7.197
	Simpson diversity	4.542	4.565	0.183	4.542	4.924
Tre Colombaie	Species richness	19	31.475	17.106	20.662	112.652
	Shannon diversity	4.697	4.838	0.327	4.697	5.48

Sites	Observed diversity		Estimator	s.e.	LCL	UCL
	Simpson diversity	2.571	2.579	0.17	2.571	2.912
Sforzesca	Species richness	15	17.994	4.532	15.352	40.431
	Shannon diversity	5.611	5.723	0.312	5.611	6.334
	Simpson diversity	3.538	3.557	0.227	3.538	4.002

Species composition differed significantly amongst the fields (Table 9). Similarly to ground beetles, spider species sampled in Casterno were also very different from those sampled in Tre Colombaie and Sforzesca (Table 10). Casterno is characterised by the presence of a very abundant species, the Tetragnathidae *Pachygnatha degeeri*, which is almost completely absent in the other two fields. This species contributes to 21.4% of the dissimilarity between Casterno and Tre Colombaie and 21.7% of the dissimilarity between Casterno and Sforzesca (Table 11). Conversely, species composition of Tre Colombaie and Sforzesca were similar.

Ordinations with db-RDA confirm differences in species composition amongst the three communities also highlighting the species that contribute most to this difference (Fig. 3). The first axis explains 38.4% of the variance (53% total variance from the first two axis) and clearly separates Casterno from Sforzesca and Tre Colombaie spider communities. The second axis, with 14.6% of total variance explained, separates Sforzesca from Tre Colombaie communities. In the cloud of species projected in the db-RDA graph,10 species sampled exclusively in Casterno and three species sampled exclusively in Tre Colombaie are also shown (Table 3).

Rove beetle richness and abundance

During summer 2014, rove beetle richness ranged from 21 species in Tre Colombaie to 18 and 16 species in Sforzesca and Casterno, respectively (Table 13). Although there was a high number of species in Tre Colombaie, the mean species richness did not differ significantly amongst the three *marcita* fields (Kruskal-Wallis chi-squared = 1.21, df = 2, p-value = 0.545). Moreover, rove beetle communities from Casterno and Sforzesca fields showed very similar values of Shannon and Simpson indices (Table 13, Fig. 2).

Table 13.

Species richness and diversity of rove beetles during summer 2014. The Table shows the observed diversity, the asymptotic estimates (Estimator), the estimated bootstrap S.E. and 95% confidence intervals (LCL and UCL) for Hill numbers of order q (0: Species richness, 1: Shannon diversity and 2: Simpson diversity).

Sites	Observed diversity		Estimator	s.e.	LCL	UCL
Casterno	Species richness	16	24.927	10.095	17.507	68.87
	Shannon diversity	7.345	8.142	0.915	7.345	9.936

Sites	Observed diversity		Estimator	s.e.	LCL	UCL
	Simpson diversity	4.604	4.743	0.662	4.604	6.039
Tre Colombaie	Species richness	21	41.171	20.111	24.959	123.771
	Shannon diversity	5.947	6.424	0.616	5.947	7.63
	Simpson diversity	3.924	3.97	0.253	3.924	4.466
Sforzesca	Species richness	18	27.948	10.229	19.883	70.563
	Shannon diversity	7.009	7.522	0.786	7.009	9.062
	Simpson diversity	4.339	4.415	0.436	4.339	5.27

Philonthus (*Philonthus*) *carbonarius* was the most abundant species with 172 specimens sampled mainly in Tre Colombaie and Sforzesca. The second most abundant species, *Atheta* (*Atheta*) *aeneicollis*, with 129 specimens, was sampled mainly in Tre Colombaie and Casterno (Table 4).

The PERMANOVA test revealed differences in species composition amongst the three fields (Tables 9, 10). Ordinations with db-RDA confirmed differences in species composition amongst the three communities (Fig. 3) and the first axis, explaining 39.1% of the total variance, clearly separated Sforzesca from Casterno and Tre Colombaie rove beetle communities. In the cloud projected in the db-RDA graph, the species that characterises each community is clearly visible. The species that contributed the most to dissimilarity between fields was *Philonthus* (*Philonthus*) *cognatus*, contributing to 15.5% of the dissimilarity between Sforzesca and Tre Colombaie and 15.8% of the dissimilarity between Sforzesca and Casterno (Table 11).

Butterfly richness and abundance

Amongst butterfly families, the most representative one was that of Pieridae with three species (Table 5). The most abundant species belonging to this family was *Pieris rapae*, which is found mainly in Sforzesca. All the other families had two species with the exception of Hesperiidae with only one member. Tre Colombaie was the most diversified field with at least one species per family and four exclusive species: *Pyrausta despicata*, *Pyrgus* sp., *Autographa gamma* and *Vanessa cardui*, while Sforzesca was the leastdiversified one with only five families out of eight. However, this was the only field where two Lycaenidae are present: *Lycaena dispar* (also sampled in the other two fields) and *Lycaena phlaeas* (Table 5). Finally, the species *Colias alfacariensis* and *Loxostege sticticalis* were found exclusively in Casterno.

Overwintering beetle richness and abundance

The largest number of collected species during winter 2014-2015 belongs to the ground beetle family (Carabidae) (Table 6). Carabidae was also the most abundant family found in Casterno and Tre Colombaie. Within this family, *Carabus* (*Carabus*) *granulatus*,

Panagaeus (*Panagaeus*) *cruxmajor* and *Anchomenus* (*Anchomenus*) *dorsalis* were the most abundant species with 63, 39 and 24 specimens, respectively (Table 6).

Staphilinidae was the most abundant family found in Sforzesca. Amongst rove beetles (four species), the most abundant was *Paederus* (*Heteropaederus*) *fuscipes* with 408 specimens, almost all collected in Casterno (Table 6).

The other collected family has only one representative: *Dorcus parallelepipedus* (Lucanidae) with only two specimens found exclusively in Tre Colombaie.

Grasshopper and Cricket richness and abundance

Amongst the grasshoppers and crickets, the most representative family was Acrididae with a number of species much higher than the other families (Table 7). The most abundant species were the Acrididae *Pseudochorthippus parallelus* with 55 specimens and *Aiolopus thalassinus* with 48 specimens (Table 7).

Concerning ecological traits, the orthopteran assemblage was dominated by highly mobile species (11 out of 20 identified species), followed by eight intermediate dispersers species and one sedentary species, *Roeseliana azami*. Medium specialised species represent a large proportion of the community observed in the winter-irrigated meadows investigated (n = 10), while habitat specialist (n = 5) and generalist (n = 5) orthopterans were less common.

Discussion

Ground beetle community

Most of the beetle individuals sampled in *marcita* fields during the summer of 2014 were macropterous (i.e. with high dispersal ability) and omnivorous, adapted to living in periodically-disturbed sites, such as watercourses or grasslands (Rainio and Niemelä 2003). In perturbed habitats, species face an elevated risk of local extinction and the ability to relocate by flight to new favourable patches when resource availability suddenly changes is essential to survival (Ribera et al. 2001, Gobbi and Fontaneto 2008). Moreover, omnivorous species, due to their wide trophic niche breadth and great resilience to reductions in food supply, better persist in stochastic environments (Purtauf et al. 2004, Schweiger et al. 2005).

However, we also found two brachypterous, *Calathus* (*Neocalathus*) *melanocephalus* and *Microlestes minutulus*, one dimorphic, *Carabus* (*Carabus*) *granulatus* and a conspicuous number of predatory species (23 out of 41, constituting 56% of the collected individuals). The presence of these species confirms that traditional agricultural habitats, such as *marcita*, could contribute to the persistence of individuals with low dispersal ability and also of strictly predatory species in intensive agroecosystems (Brandmayr et al. 2005, Cardarelli and Bogliani 2014).

Even if we did not find any endemism, we recorded the presence of *Dolichus halensis*, that has been identified as a focal species of wet meadows of the Po Plain (Bogliani et al. 2007). We also unfortunately confirmed the disappearance from the investigated *marcita* fields of *Carabus* (*Limnocarabus*) *clatratus antonellii*, documented as closely associated with this biotope (Bucciarelli 1963) and extinct in the Ticino Park for over 30 years, despite the apparent persistence of the habitat that was considered suitable.

Casterno was the field with the lowest number of species, but with the highest Shannon and Simpson diversity. All the species found in Casterno were equitably distributed showing this site to have more stable environmental conditions (Death 1996) compared to the other two investigated fields. Contrarily, Sforzesca and Tre Colombaie communities are characterised by few and abundant species resulting in communities that are very different from those of Casterno. In particular, the PERMANOVA highlighted the presence of two very abundant species, *Pseudoophonus* (*Pseudoophonus*) *rufipes* and *Harpalus* (*Harpalus*) *affinis*, which, respectively, characterise Sforzesca and Tre Colombaie fields. Both these species are clearly dominant within the family Carabidae occurring in agro-ecosystems and are widely considered generalist species with a broad ecological valence (Porhajašová et al. 2014).

Spider community

Collected spiders were all very common and quite frequent (Nentwig et al. 2020), with the only exception being *Ceratinella brevipes*, a rare, detrital species that lives both in woodlands and grasslands (Hansen 2010). Half of the species was linked to wet environments, but only two of them can be considered stenohygrophilous: *Gnathonarium dentatum* (Linyphiidae) and *Pirata tenuitarsis* (Lycosidae) (Hansen 2010).

Both Linyphiidae and Lycosidae were very abundant in this study. Linyphiidae are the most abundant spiders in temperate regions (Samiayyan 2014) and this is probably the main reason why they were so frequently captured in our samples. Moreover, the use of pitfall traps can partially explain the abundance of Lycosidae, as this family includes species living and hunting on the ground and so easily interceptable by pitfall traps (Green 1999). Both these families are also typical of highly dynamic ecosystems, especially those disturbed by frequent flooding (Buchholz and Schröder 2013), as *marcita*. Many Lycosidae, such as *Arctosa leopardus* and *Pardosa proxima* s.l., recorded in high numbers in our fields, are specialised for living in wet habitats with temporal flooding, while Linyphiidae are able to rapidly recolonise disturbed areas and survive flooding through ballooning (Hayashi et al. 2015, Holland et al. 2007).

Most of the collected individuals were males. Indeed, males, because of their mate-searching behaviour (Lang 2000, Collins et al. 1996), are more mobile and, therefore, more easily intercepted by traps.

Concerning the spider community in the three *marcita*, Casterno resulted in being significantly different from the other two fields. In Casterno, spiders species, belonging to Lycosidae and Linyphiidae, were almost double those found in Tre Colombaie and

Sforzesca, making this field the richest in species. Moreover, rarefaction curves showed higher species diversity and a more equitable distribution of the species abundance in Casterno compared to the other two fields where few, very abundant species were found. PERMANOVA and db-RDA also showed how Casterno hosted a well-characterised community that greatly differs from those of the other two fields. Casterno was the only field to host the rare *Ceratinella brevipes* and the stenohygrophilous *Pirata tenuitarsis*. Moreover, in this field, some hygrophilous species, such as *Pachygnatha degeeri*, *Arctosa leopardus* and *Trochosa ruricola*, were very abundant.

On the other hand, analyses showed a very poor spider community in Sforzesca and Tre Colombaie. Most of the species collected in the two fields, including the exclusive captures, such as *Palliduphantes pallidus* and *Ozyptila sanctuaria*, were less related to wet environments and, therefore, in general, less indicative of this type of habitat.

Rove beetle community

All the rove beetles sampled during the summer of 2014 were good flyers of open habitat, with wide distribution and ecological value. The only exception was *Ocypus* (*Matidus*) *brunnipes*, a flightless species that inhabits both forested and open disturbed areas (Deichsel 2006). Only *Ochthephilum brevipenne* was exclusively linked to wet habitat, as it is usually found in ponds, along watercourses, in marshy meadows and near the seashore (Bordoni et al. 2006). All other species can be found also in less humid habitats and one species, the uncommon *Astrapaeus ulmi*, is thermophilous and mainly lives in xerothermic plant communities (Wojas 2011).

Most of the species were predators, linked to meadows or non-cropped areas (Zanetti et al. 2016). Amongst them, *Ocypus* (*Ocypus*) *olens*, recorded in all studied fields even if in low number, is known to be a species sensitive to agricultural practices (Daccordi and Zanetti 1989), highlighting the lower pressure to which this traditional agricultural habitat undergoes with respect to conventional, intensive crops. According to what was found for ground beetles, *marcita* may act as a refuge from detrimental agronomic practices for more sensitive species (Bordoni et al. 2006, Wojas 2011).

The number of rove beetle species was very similar amongst the three *marcita*. Most of the species were shared between fields and, according to the rarefaction curves, species abundance of the three communites are equally distributed. db-RBDA showed a less clear distinction amongst the rove beetles of the three fields compared to what was observed for spiders. However, PERMANOVA analyisis revealed the existence of a different species composition amongst the three *marcita* fields. About 20% of the species was found exclusively in one of the three fields. In particular, the flightless *Ocypus* (*Matidus*) *brunnipes* was collected only in Casterno, while the hygrophilous *Ochthephilum brevipenne* and the thermophilous *Astrapaeus ulmi* were exclusively found in Tre Colombaie. Again, Casterno seems to host species more typical of humid and well-preserved habitat compared to those more common and generalist collected in Tre Colombaie and Sforzesca. Amongst the commonest species shared between Sforzesca and Tre

Colombaie, there is *Philonthus* (*Philonthus*) *carbonarius*, a species related to anthropogenic habitats (Lupi et al. 2006).

Butterfly community

Most of the sampled species are included in the European and Italian IUCN Red List as "Least Concern" (Balletto et al. 2015, Bonelli et al. 2018, Van Swaay et al. 2010). Particularly important is the presence of *Lycaena dispar* in all the investigated sites. This butterfly is the only globally-recognised one as "Near Threatened" in our study area (Gimenez 1996). The species is an indicator of the importance of *marcita* as a humid habitat in the Ticino Valley Regional Park and, again, the important role that this traditional agricultural habitat may have in preserving specialised, sensitive species. Indeed, *Lycaena dispar* is of great conservation interest as it is included in Annexes II and IV of the Habitats Directive 92/43/CEE and listed in Appendix II of the Berne Convention. It is typical of lowland humid areas, such as meadows, canals and river banks with slow courses. It is in decline in most of its range due to degradation and destruction of its environment, which is threatened mainly by conversion to other uses of open wetlands. Amongst the conservation strategies suggested by the IUCN for the conservation of this species, there are, first and foremost, the protection of reproductive sites avoiding excessive off-season mowing and radical cleaning of ditches and canal banks (Thomas et al. 2011). The importance of *Lycaena dispar* presence in the area and of the maintenance of *marcita* fields is also highlighted by local studies. *Lycaena dispar* has been identified as a focal species of wet meadows of the Po Plain and described as “rare, localized, of conservation interest and indicator of the habitat” (Bogliani et al. 2007).

Grasshopper and cricket community

The orthopterans of the *marcita* fields, as well as for the other investigated taxa, reflected the high dynamism of this biotope, characterised during the summer by the succession of flooded and dry phases. Indeed, most of the sampled species had a high dispersal capacity, a typical feature of arthropods adapted to temporary and perturbed habitats (Ribera et al. 2001Dziock et al. 2011).

Orthopteran communities composed of a significant percentage of mobile species were also described for rice agro-ecosystems in the western Po Plain, (Giuliano and Bogliani 2018). Moreover, as in rice agro-ecosystems, *marcita* hosted some thermophilous species probably favoured by the presence of xerothermic micro-habitats, such as bare banks, mown levees and unpaved country roads surrounding the fields. During the summer, the alternation of flooded and dry phases could favour the co-existence of thermophilous and hygrophilous elements.

According to the IUCN European Red List of Orthopterans (Hochkirch et al. 2016), most of the species observed in the winter-flooded meadows are considered of least conservation concern. Amongst them, three species, *Euchorthippus declivus*, *Chorthippus Bunneus* and *Acrida ungarica*, were globally assessed as "Least Concern" (Hochkirch et al. 2016). However, it is important to remark on the presence of the hygrophilous *Roeseliana azami*,

assessed as "Vulnerable" in Mediterranian regions, in Europe and throughout the world (Braud et al. 2016) and of *Mecostethus parapleurus* and *Chrysochraon dispar*. *Mecostethus parapleurus* is typical of humid environments, such as swamps, water meadows and peat bogs and is threatened and rare in the Italian territory (Tami et al. 2005, Baroni 2015). *Chrysochraon dispar* is a hygrophilous and stenotherm species inhabiting marshes, swamps, wet meadows and brackish biotopes (Nadig 1986). It is a rare and protected species in France, Germany, Austria and Switzerland (Detzel 1998). In Italy, the degree of threat for this species is still unknown, but it is probably at risk of extinction (Tami et al. 2005). Currently, *Chrysochraon dispar* has been found only in Trentino and Alta Val Venosta, with the subspecies *C. dispar dispar* (but here could already be extinct), while in Veneto, in Friuli-Venezia Giulia and in Venice Lagoon, with the subspecies *C. dispar giganteus* (Tami et al. 2005). In the Lombardy Region, the species was recently found in the Ticino Valley Regional Park (Roberto Scherini, pers comm). The maintenance and, where possible, the re-naturalisation of wet areas is considered essential to guarantee the species survival (Tami et al. 2005).

Again, as already pointed out for the other investigated taxa, the presence of extensively-managed habitats in agro-ecosystems, such as *marcita*, may also provide refuge to species more sensitive to human disturbance (Giuliano et al. 2018).

Overall arthropod community in the investigated fields

Overall, the winter-flooded meadow system of our study area hosted a rich and diverse entomofauna with indicator species of a hygrophilous environment, such as the butterfly *Lycaena dispar*, the ground beetle *Dolichus halensis* and the grasshopper *Chrysochraon dispar*. However, the arthropod communities of the investigated fields differed from each other in terms of site specificity, species richness and species composition.

In particular, Casterno field stands out for having a high number of exclusive species in all taxa, including two spiders of high conservation value, such as *Ceratinella brevipes* and *Pirata tenuitarsis*. Tre Colombaie field is undoubtedly the richest both for the presence of a large number of species in all taxa and to host exclusive, “priority” species, that are also indicators of a wet environment, such as *Dolichus halensis*. Sforzesca field, although neither stands out for species richness nor for the presence of exclusive species, also hosts specialised species and species of conservation relevance, such as the butterfly *Lycaena dispar*, the two brachypterous ground beetles *Calathus melanocephalus* and *Microlestes minutulus* and the stenohygrophilous spider *Gnathonarium dentatum*. However, these are also species found in the other two fields, so they do not give Sforzesca a uniqueness.

There are no differences in the agronomic management of the three *marcita* fields. In all of them, the winter flooding has been practised for at least five years and mowing has been carried out 3-4 times during the summer season. The only field that has been periodically fertilised is Casterno, but taking into account the high degree of diversity found in the three *marcita*, fertilisation is probably not a determining factor influencing the biodiversity. Likely, the differences amongst sites is found in the landscape diversity, as the mosaic of habitat

surrounding the field (e.g. hedgerows, old isolated trees, small woodlots) could determine the facility with which specialised species could colonise the *marcita* fields at first and then after disturbing events, such as the periodic mowing and flooding.

On the other hand, the practice of winter flooding could be considered crucial to guaranteeing the presence of species of wet habitats. In fact, amongst the *marcita* investigated in 2015, the only one to be completely devoid of hygrophilous species was the Amerio 1 which, until 2013, was subjected to total abandonment and in which the winter flooding was carried out exclusively during the winter 2014-2015. The situation was slightly better in Amerio 2, where the meadow management resumed a year earlier than Amerio 1 and lasted until 2016. This certainly favoured the presence of *Lycaena dispar*.

The only field investigated in 2015, in which a winter flooding was comparable to that of Casterno, Sforzesca and Tre Colombaie was carried out, was at “Garlaschè” field. It is the only one in which *Chrysochraon dispar*, a rare and strongly indicative species of wet environments, has been observed.

Conclusion

This study represents the first comprehensive contribution to the knowledge of terrestrial arthropod communities associated with the winter-irrigated meadows, the so-called *marcita*, in Europe. Our investigation showed that *marcita* fields hosted specialised species (e.g. brachypterous, predators) and species typical of hygrophilous habitats. This result confirms the importance of *marcita* for invertebrate conservation, as already stated for other taxa, such as amphibians and birds (Casale 2015, Casale et al. 2016, Gentilli et al. 1997). It also highlights the importance for biodiversity conservation, to preserve traditional and extensive crops as refuge habitats in highly intensive and exploited agroecosystems, such as that of the fertile Po Plain in Italy (Casale et al. 2017).

Moreover, *marcita* plays a significant role in terms of the ecosystem services provided: they may be a source of bio-controllers through their important bulk of predatory species detected amongst carabids, rove beetles and spiders, that could move to surrounding fields, contributing to limit crop pests (Nyffeler and Sunderland 2003, Symondson et al. 2002). Pest regulation has been demonstrated to be strengthened by complementarity amongst natural enemies, guaranteed by a various guild of natural enemies (Dainese et al. 2017).

Finally, *marcita* has an undeniable aesthetic value, as they are considered a “Rural traditional landscape of Italy” by MIPAAF (Bove et al. 2017), contributing to increasing the landscape beauty of the area.

Since the late eighties, the Ticino Valley Regional Park is making a huge effort in terms of incentives to farmers to preserve and restore these winter-flooded meadows (Casale et al. 2016), together with events to bring back the cultural and historical value of this crop to the attention of local people. A plan to support the re-activation of a sustainable production chain, aiming to re-introduce this high-quality forage in the local zootechnical practices

(Bove et al. 2016) and sensitise the consumers on the quality of dairy products obtained from green forage (Elgersma et al. 2006) would certainly help to increase the attraction of this crop amongst farmers.

Obviously, the work to be done is still demanding. A more synergic conservation effort amongst local and regional managing bodies is desirable to restore, where possible, this precious habitat and to retain the biodiversity linked to it.

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