Spiders (Araneae) of olive groves and adjacent semi-natural habitats from central Italy

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doi: 10.30963/aramit6001

Abstract. In the Monte Pisano area (Tuscany, central Italy), spiders were collected within two research projects during three years (2010, 2013, 2014). Olive groves and adjacent semi-natural habitats (wood and Mediterranean garrigue) were investigated with three sampling methods (pitfall trapping, beating at branches and hand collection in the canopy). A total of 148 species was identified. The ground spider (Gnaphosidae) *Zelotes fulvaster* (Simon, 1878) was recorded for the first time in Italy.

Keywords: canopy, epigeon, Mediterranean garrigue, Monte Pisano, wood, *Zelotes fulvaster*

Zusammenfassung. Spinnen (Araneae) aus Olivenhainen und benachbarten naturnahen Lebensräumen in Mittelitalien. In der Region Monte Pisano (Toskana, Mittelitalien) wurden in drei Jahren (2010, 2013, 2014) Spinnen mit drei Sammelmethoden (Bodenfallen, Klopfen an Ästen und Handaufsammlungen in den Kronen) erfasst. In zwei Forschungsprojekten wurden Olivenhaine und benachbarte naturnahe Lebensräume (kleine Wälder und mediterrane Garrigue) untersucht. Insgesamt wurden 148 Arten bestimmt, darunter die Plattbauchspinne (Gnaphosidae) *Zelotes fulvaster* (Simon, 1878) als Erstnachweis für Italien.

Riassunto. Ragni (Araneae) degli oliveti e degli habitat semi-naturali limitrofi in Italia centrale. Esemplari di ragni sono stati raccolti in oliveti e in habitat semi-naturali a essi adiacenti (bosco e gariga mediterranea) nell'ambito di due progetti di ricerca svolti sul Monte Pisano (Toscana, Italia centrale) negli anni 2010, 2013 e 2014. Tre diversi metodi di campionamento sono stati utilizzati (trappole a caduta, scuotimento dei rami e raccolta a mano sulla chioma) e sono state identificate 148 specie, tra cui *Zelotes fulvaster* (Simon, 1878) (Gnaphosidae), segnalato per la prima volta in Italia.

Spiders are widespread predators found in every terrestrial habitat, from the coast to the tops of mountains (Nyffeler & Birkhofer 2017). Italy, a country with a mosaic of landscapes, is extremely rich in spider species within the European Union (Nentwig et al. 2019). Italy also has a high rate of endemism due to climatic, topographic and geological differences (European Environment Agency 2018). The latest version of the Italian spider checklist documents 1674 species (Pantini & Isaia 2019). The number of recently described new species shows that the knowledge of Italian spiders is still incomplete, especially in the central and southern part of the peninsula (Pantini pers. comm., May 2018). In order to facilitate conservation policies, research on Italian spiders should be encouraged (Franc 2000, Milano et al. 2017) – knowledge advancing through revisions, new descriptions and considering new national records or, at a closer scale, regional records.

In addition, spiders are still understated regarding their role in ecosystems, utility as indicators or potential role in reducing herbivores (Lang 2003, Symondson et al. 2002) like other soil-surface dwelling predators such as ground beetles (Carabidae). Moreover, due to the diversity in their behaviour, spiders seem to act in complimentary ways on different life stages of pests (Sunderland & Samu 2000). Despite some recent results, data on biological control mediated by spiders in Italy is still a work in progress. Increasing study of ecological dynamics in agroecosystems could stimulate new sustainable pest control approaches in annual crops, as well as in perennials such as olive groves (Benhadi-Marín et al. 2017).

Olive groves play an important role in the economics of Italy, especially for regions such as Tuscany. The present article presents faunistic data originating from several different projects carried out in the Monte Pisano area. The studies aimed at improving awareness about the effect of management and the influence of landscape features on biological control by spiders against the olive fruit fly *Bactrocera oleae* (Rossi, 1790) (Picchi et al. 2016, 2020).

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Academic editor: Petr Dolejš

submitted 6.8.2019, accepted 4.7.2020, online 25.9.2020

Material and methods

The research projects were carried out in the years 2010, 2013 and 2014 in the mountain formation of Monte Pisano (about 16000 ha; Bertacchi et al. 2004), between the cities of Pisa and Lucca in the north-west of Tuscany (Italy, highest peak 916 m a.s.l.; Fig. 1), and used different sampling techniques in olive groves and adjacent semi-natural habitats. This area is well suited for olive oil production, in which orchards are traditionally managed with low input practices and where they can be arranged in rain-fed terraces. The climate is typically Mediterranean, with a mean annual temperature of 14.3°C with a dry and hot summer (Niccolai & Marchi 2005, Peel et al. 2007) and average annual precipitation of 1107 mm. Olive groves are placed in hilly landscapes, interspersed in patches of woods and Mediterranean garrigue.

Woods surrounding the olive groves were mainly formed from pine trees (*Pinus pinaster* Aiton), chestnuts (*Castanea sativa* Mill.) and oak species (mainly *Quercus ilex* L. and *Q. pubescens* Wild.), with associated understory vegetation, whereas Mediterranean garrigue was constituted mainly by shrubs and herbs typical of xerothermic habitats (Polunin & Walters 1985).

In 2010, six sites were sampled. Only ground-dwelling spiders in the olive groves were collected. At each of the six sites, eight pitfall traps with ethylene glycol were set in a transect. Traps were collected three times during summer, from 13. May to 15. Jul., and emptied every three weeks.

The case studies of 2013 and 2014 were part of the QuESSA pan-European project (Holland et al. 2014). In addition, the adjacent semi-natural woods or shrublands were studied in their interior (in 2013) and at their edges with the olive groves (2013 and 2014).

In 2013, twelve olive groves bordering woody areas were studied (including some samplings in Mediterranean garrigue patches whose results are included here) and eighteen in 2014 next to patches of woods, shrublands or another olive orchard.

Among the sites examined in 2014, five sampling sites were the same as in the previous year and one organic field was the same as in 2010.

In 2013, olive groves and adjacent semi-natural habitats were both sampled using pitfall traps with ethylene glycol for four days in three sampling periods in summer starting on 28. Jun., 20. Jul. and 20. Sep., all according to the protocol of the QuESSA project. Pitfall traps were placed pairwise, in two transects in each habitat, one transect was placed at the centre of the habitat, the other one at the edge.

In 2014, spiders were sampled four times from the canopy of olive trees starting from the edge towards the interior part at four distances, using two techniques: hand collecting of spiders, searching for 8 minutes in the branches and leaves, and a beating technique, both up to 1.5–2.0 m high. For each sampling point, four branches, one in each cardinal direction were beaten ten times and spiders were collected. Four samplings were done from summer to autumn (23. Jun., 22. Jul.,15. Sept. and 15. Oct.) in the daytime, following the life cycle phases of the olive fruit fly (Picchi et al. 2016). In addition, one more sampling point with the same approach as in Picchi et al. (2016) was selected at the margin of the olive groves, inside the adjacent semi-natural habitats (Picchi et al. 2020).

Spiders were mostly identified by the author; part of the spiders sampled in 2010 were identified by Marco Isaia while spiders of uncertain identity collected during the QuESSA project of 2013 were identified by Paolo Pantini. Spiders were identified using Italian and European keys (Roberts 1987, Trotta 2005), the online keys of Nentwig et al. (2019), and comparison with genital images by Oger (2019). Names follow current nomenclature in the World Spider Catalog (2020). Juveniles were assigned to a species only when they had clear characteristics or when an extremely high percentage of the adults of the respective genus were of only one species (Larrivée & Buddle 2009). Individuals of the same species were pooled according to their habitat preference. Whenever possible, other individuals were identified to family level, but have not been considered in the lists proposed here. In addition, the lists indicate the microhabitat preference of the spiders if collected on the ground or in the canopy. Moreover, the chorotype (Tab. 2) was assigned to each species (Pantini & Isaia 2018).

Spiders are preserved in 70% alcohol and were deposited in the Department of Life Sciences and Systems Biology of the University of Turin, at the Natural Science Museum "E. Caffi" of Bergamo, and the Biolabs-Institute of Life Science of Sant'Anna School of Advanced Studies (Pisa). The new species record for Italy, *Zelotes fulvaster* (Simon, 1878), was identified by Paolo Pantini from the Natural Science Museum "E. Caffi" of Bergamo, where specimens of one female and one male are now stored.

Tab. 1: List of the sites sampled with coordinates and altitude (m a.s.l.). The table contains detailed information for each site: the microhabitat sampled (Ground: species collected by pitfall traps; canopy: species collected by hand or beating technique, the year of sampling (2010, 2013 and 2014) and the type of habitat (OL = olive groves; WA = woods; GA = Mediterranean garrigue)

Number	Latitude	Longitude	Altitude (m a.s.l.)	Sampling/Year/Microhabitat
1	43.80092	10.47663	95	Canopy 2014 OL + GA
2	43.78670	10.45860	151	Canopy 2014 OL + GA
3	43.78335	10.39824	36	Canopy 2014 OL + GA
4	43.78264	10.42667	42	Canopy 2014 OL
5	43.76854	10.44690	109	Canopy 2014 OL + GA
6	43.78422	10.57183	181	Canopy 2014 OL
7	43.70452	10.56907	216	Canopy 2014 OL
8	43.69435	10.54685	122	Canopy 2014 OL + GA
9	43.70472	10.51089	56	Canopy 2014 OL + GA
10	43.76580	10.58849	184	Canopy 2014 OL + WA
11	43.79551	10.40088	90	Ground 2013 OL + GA; Canopy 2014 OL
12	43.79529	10.52366	229	Ground 2013 OL + WA; Canopy 2014 OL + WA
13	43.81936	10.47199	147	Ground 2013 OL + WA; Canopy 2014 OL + WA
14	43.74186	10.47574	65	Ground 2013 OL + WA; Canopy 2014 OL + WA
15	43.81076	10.42178	155	Ground 2013 OL + WA; Canopy 2014 OL + WA
16	43.79269	10.48643	88	Ground 2013 OL + WA
17	43,74667	10.51883	267	Ground 2013 OL + WA
18	43.70702	10.58295	74	Ground 2013 OL + WA
19	43.72923	10.49694	117	Ground 2013 OL + WA
20	43.69396	10.54387	74	Ground 2013 OL + GA + WA
21	43.78663	10.43274	238	Ground 2013 OL + WA
22	43.78621	10.56945	236	Ground 2013 OL + WA
23	43.71982	10.53319	111	Ground 2010 OL; Canopy 2014 OL
24	43.69019	10.54933	34	Ground 2010 OL
25	43,74228	10.51958	216	Ground 2010 OL
26	43.70192	10.57565	56	Ground 2010 OL
27	43,72694	10.50762	62	Ground 2010 OL
28	43.73032	10.58426	187	Ground 2010 OL
29	43.73020	10.59661	89	Canopy 2014 OL
30	43.73144	10.57111	230	Canopy 2014 OL + WA

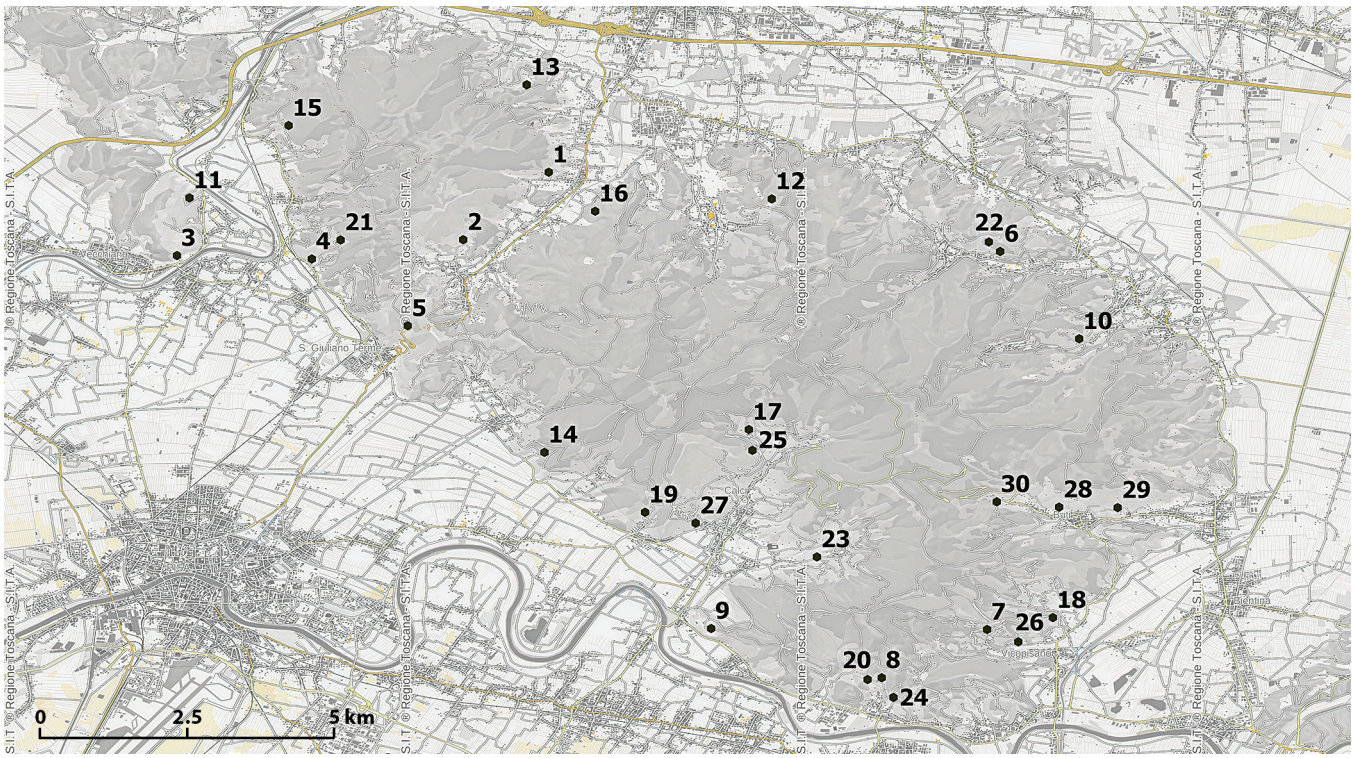

Fig. 1: Map of the sites sampled in 2010 (6), 2013 (12) and 2014 (18) in the Monte Pisano area. The city of Pisa is in the lower left of the map. Detailed information (coordinates, altitude, year and microhabitats) for each site is reported in Tab.1.

Results

A total of 30 sites (Tab. 1, Fig. 1; QGIS Development Team 2019) was sampled during the three years of research in the Monte Pisano area, from which 6083 spiders were collected, 3623 identified to species level, including all adults. The specimens belong to 148 species in 27 families (Tab. 2): spiders from the Monte Pisano thus represent about 9% of the Italian araneofauna, and include seven Italian endemics. There were 129 species (3228 individuals, 76 species sampled at the ground and 60 from the canopy; Tab. 3) found inside the olive groves, including the new report of *Zelotes fulvaster*.

In the woods, 71 species were collected (257 individuals, 41 species from the ground and 32 from the canopy; Tab. 4) and 29 species in the Mediterranean garrigue (138 individuals, 14 from the canopy and 15 from the ground; Tab. 5). The spider assemblages of these olive landscapes consist mainly of Linyphiidae, contributing 50.7% of the total species number. Indeed, Linyphiidae is the most abundant family in canopies in all habitats and among the linyphiids found, *Frontinellina frutetorum* was the dominant species. It comprised 84.9% of the specimens belonging to this family. Tabs 3, 4 and 5 show that considering only the most numerous families in olive groves, woods and garrigue, Araneidae were collected only in canopies, while Gnaphosidae, Lycosidae and Zodariidae were collected exclusively on the ground.

Considering species richness, the highest number of species in olive groves belonged to Theridiidae and Gnaphosidae with 18 species, in woods to Araneidae (13 species), and in the Mediterranean garrigue Salticidae and Araneidae (5 species). However, the highest number of specimens was observed for *Scytodes thoracica* on the ground of the woods and *Olios argelasius* in the Mediterranean garrigue.

In addition to these results, three more families were sampled with 14 species identified to genus level, but these are not included in the tables. Species belonged to 26 chorotypes (Tab. 2), the most represented being the Palaearctic type (21%, 31 species). Furthermore, Mediterranean species constituted 15.5% (23 species). Eight species have a European chorotype (5.4%) and one species, *Erigone autumnalis*, is an introduced species from North and Central America (Pesarini 1996).

Seven species (4.7%) are endemic to central Italy, namely *Pimoa rupicola* (1 male; ALWA: West Alpine-Apenninic), *Eratigena vomeroi* (1 female and 1 male; APPS: South Apenninic), *Dysdera* cf. *andreinii* (1 female APPE: Apeninnic) and *Cybaeodes marinae* (1 female and 1 male: APPE: Apenninic), *Gonatium biimpressum* and *Zodarion vicinum* (15 females and 3 males and 26 females and 19 males; TYRR: Tyrrhenian) and *Ozyptila salustri* Wunderlich, 2011 (3 males; APPC: Central Apeninic) (acronyms see caption Tab. 2).

Tab. 2: List of spider species (alphabetical order) collected in the case studies of 2010, 2013 and 2014 in olive groves and adjacent semi-natural habitats. For each species, the number of specimens and chorotype are reported (AIM = Afrotropico-Indo-Mediterranean; AFM = Afrotropico-Mediterranean; ALWA = West Alpine-Apenninic; APPC = Central Appenninic; APPE = Apenninic; APPS = South Apenninic; ASE = Asiatic-European; CAE = Centralasiatic-European; CAM = Centralasiatic-Mediterranean; COS = Cosmopolite; EUM = Europeo-Mediterranean; EUR = European; MED = Mediterranean; OLA = Holartic; PAL = Palaearctic; SCO = Sub-cosmopolite; SIE = Sibero-European; SEU = South European; TEM = Turano-Europeo-Mediterranean; TUE = Turano-European; TUM = Turano-Mediterranean; TYRR = Tyrrhenian; WME = W-Mediterranean; WEU = W-European; INT = introduced; chorotype according to Stoch & Vigna Taglianti 2006)
A = Total number of specimens; B = Chorotypes

Species	A	B
Agelenidae		
Agelena labyrinthica (Clerck, 1757)	1	PAL
Eratigena fuesslini (Pavesi, 1873)	5	EUR
Eratigena vomeroi (Brignoli, 1977)	2	APPS

Species	A	B
Tegenaria hasperi Chyzer, 1897	1	SEU
Araneidae		
Aculepeira armida (Audouin, 1826)	1	ASE
Agalenatea redii (Scopoli, 1763)	4	PAL
Araneus angulatus Clerck, 1757	15	PAL
Araneus diadematus Clerck, 1757	46	OLA
Araneus marmoreus Clerck, 1757	3	OLA
Araneus sturmi (Hahn, 1831)	1	PAL
Araniella cucurbitina (Clerck, 1757)	3	PAL
Argiope bruennichi (Scopoli, 1772)	1	PAL
Cyclosa cf. *oculata* (Walckenaer, 1802)	1	ASE
Cyclosa conica (Pallas, 1772)	10	OLA
Cyrtarachne ixoides (Simon, 1870)	6	MED
Cyrtophora citricola (Forsskål, 1775)	29	AIM
Gibbaranea bituberculata (Walckenaer, 1802)	1	PAL
Hypsosinga sanguinea (C. L. Koch, 1844)	1	PAL
Mangora acalypha (Walckenaer, 1802)	31	PAL
Neoscona adianta (Walckenaer, 1802)	3	PAL
Zilla diodia (Walckenaer, 1802)	2	SIE
Zygiella x-notata (Clerck, 1757)	82	OLA
Clubionidae		
Clubiona brevipes Blackwall, 1841	2	PAL
Dictynidae		
Argenna subnigra (O. Pickard-Cambridge, 1861)	1	EUR
Brigittea civica (Lucas, 1850)	2	OLA
Dictyna arundinacea (Linnaeus, 1758)	1	OLA
Dysderidae		
Dysdera cf. *andreinii* Caporiacco, 1928	1	APPE
Dysdera crocata C. L. Koch, 1838	27	COS
Dysdera erythrina (Walckenaer, 1802)	1	EUR
Harpactea arguta (Simon, 1907)	28	SEU
Filistatidae		
Filistata insidiatrix (Forsskål, 1775)	1	MED
Gnaphosidae		
Aphantaulax cincta (L. Koch, 1866)	4	EUM
Civizelotes dentatidens (Simon, 1914)	2	PAL
Drassodes lapidosus (Walckenaer, 1802)	1	MED
Gnaphosa alacris Simon, 1878	8	PAL
Gnaphosa lucifuga (Walckenaer, 1802)	14	PAL
Haplodrassus dalmatensis (L. Koch, 1866)	27	MED
Haplodrassus macellinus (Thorell, 1871)	2	WME
Leptodrassus femineus (Simon, 1873)	1	PAL
Marinarozelotes barbatus (L. Koch, 1866)	28	EUR
Micaria albovittata (Lucas, 1846)	4	CAM
Micaria coarctata (Lucas, 1846)	1	TUE
Nomisia exornata (C. L. Koch, 1839)	47	MED
Setaphis carmeli (O. Pickard-Cambridge, 1872)	17	OLA
Trachyzelotes pedestris (C. L. Koch, 1837)	2	EUR
Zelotes aeneus (Simon, 1878)	1	WME
Zelotes fulvaster (Simon, 1878)	2	MED
Zelotes hermani (Chyzer, 1897)	13	SIE
Zelotes oblongus (C. L. Koch, 1833)	15	SEU
Zelotes paroculus Simon, 1914	9	WEU
Zelotes tenuis (L. Koch, 1866)	50	OLA
Linyphiidae		
Agyneta rurestris (C. L. Koch, 1836)	7	PAL

Species	A	B
Cresmatoneta mutinensis (Canestrini, 1868)	1	ASE
Diplocephalus graecus (O. Pickard-Cambridge, 1873)	5	MED
Erigone autumnalis Emerton, 1882	8	INT
Erigone dentipalpis (Wider, 1834)	2	OLA
Frontinellina frutetorum (C. L. Koch, 1834)	1561	SIE
Gonatium biimpressum Simon, 1884	18	TYRR
Linyphia triangularis (Clerck, 1757)	24	PAL
Palliduphantes cf. *pallidus* (O. Pickard-Cambridge, 1871)	1	EUR
Palliduphantes istrianus (Kulczyński, 1914)	150	SEU
Styloctetor romanus (O. Pickard-Cambridge, 1873	3	ASE
Tapinocyba praecox (O. Pickard-Cambridge, 1873)	1	EUR
Tenuiphantes herbicola (Simon, 1884)	4	MED
Tenuiphantes tenuis (Blackwall, 1852)	23	TUE
Trichoncus affinis Kulczyński, 1894	3	EUR
Trichoncus hackmani Millidge, 1955	2	EUR
Trichoncus sordidus Simon, 1884	23	SEU
Walckenaeria antica (Wider, 1834)	2	ASE
Liocranidae		
Agraecina lineata (Simon, 1878)	3	WME
Agroeca proxima (O. Pickard-Cambridge, 1871)	2	SIE
Cybaeodes marinae Di Franco, 1989	1	APPE
Lycosidae		
Alopecosa albofasciata (Brullé, 1832)	365	TUM
Arctosa personata (L. Koch, 1872)	14	MED
Hogna radiata (Latreille, 1817)	44	CAE
Trochosa ruricola (De Geer, 1778)	76	OLA
Mimetidae		
Mimetus laevigatus (Keyserling, 1863)	1	CAM
Miturgidae		
Zora silvestris Kulczyński, 1897	1	CAE
Oecobiidae		
Oecobius maculatus Simon, 1870	1	TUM
Oonopidae		
Silhouettella loricatula (Roewer, 1942)	3	TEM
Oxyopidae		
Oxyopes lineatus Latreille, 1806	7	TUE
Philodromidae		
Philodromus cf. *rufus* Walckenaer, 1826	1	MED
Philodromus lividus Simon, 1875	6	OLA
Philodromus longipalpis Simon, 1870	5	MED
Pulchellodromus bistigma (Simon, 1870)	1	MED
Thanatus atratus Simon, 1875	1	PAL
Phrurolithidae		
Liophrurillus flavitarsis (Lucas, 1846)	11	WME
Phrurolithus festivus (C. L. Koch, 1835)	3	PAL
Pimoidae		
Pimoa rupicola (Simon, 1884)	1	ALWA
Salticidae		
Aelurillus v-insignitus (Clerck, 1757)	1	PAL
Chalcoscirtus infimus (Simon, 1868)	6	TUE
Euophrys frontalis (Walckenaer, 1802)	11	PAL
Euophrys herbigrada (Simon, 1871)	44	EUR
Euophrys petrensis (C. L. Koch, 1837)	1	TEM
Evarcha jucunda (Lucas, 1846)	5	MED
Heliophanus cupreus (Walckenaer, 1802)	1	SIE

Species	A	B
Heliophanus kochii Simon, 1868	3	EUM
Heliophanus tribulosus Simon, 1868	21	SIE
Icius hamatus (C. L. Koch, 1846)	12	MED
Leptorchestes berolinensis (C. L. Koch, 1846	2	EUM
Macaroeris nidicolens (Walckenaer, 1802)	10	SEU
Pellenes geniculatus (Simon, 1868)	4	CAM
Philaeus chrysops (Poda, 1761)	1	PAL
Phlegra bresnieri (Lucas, 1846)	5	AFM
Pseudicius encarpatus (Walckenaer, 1802)	1	EUR
Saitis barbipes (Simon, 1868)	1	MED
Salticus mandibularis (Simon, 1868)	1	MED
Salticus mutabilis Lucas, 1846	5	TUE
Salticus zebraneus (C. L. Koch, 1837)	4	PAL
Scytodidae		
Scytodes thoracica (Latreille, 1802)	194	OLA
Sparassidae		
Olios argelasius (Walckenaer, 1806)	18	MED
Tetragnathidae		
Metellina segmentata (Clerck, 1757)	6	OLA
Pachygnatha degeeri Sundevall, 1830	2	PAL
Theridiidae		
Argyrodes argyrodes (Walckenaer, 1841)	35	MED
Asagena italica (Knoflach, 1996)	11	PAL
Crustulina guttata (Wider, 1834)	7	SIE
Episinus cf. *angulatus* (Blackwall, 1836)	1	MED
Euryopis episinoides (Walckenaer, 1847)	6	TEM
Euryopis laeta (Westring, 1861)	9	PAL
Heterotheridion nigrovariegatum (Simon, 1873)	10	TUM
Kochiura aulica (C. L. Koch, 1838)	57	SEU
Lasaeola convexa (Blackwall, 1870)	5	PAL
Parasteatoda lunata (Clerck, 1757)	3	COS
Parasteatoda tepidariorum (C. L. Koch, 1841)	4	WME
Phoroncidia paradoxa (Lucas, 1846)	1	OLA
Platnickina tincta (Walckenaer, 1802)	14	MED
Rhomphaea nasica (Simon, 1873)	7	MED
Robertus mediterraneus Eskov, 1987	1	WME
Steatoda paykulliana (Walckenaer, 1806)	1	CAE
Theridion pinastri L. Koch, 1872	2	PAL
Theridion varians Hahn, 1833	4	OLA
Thomisidae		
Bassaniodes bufo (Dufour, 1820)	5	MED
Bassaniodes robustus (Hahn, 1832)	2	CAE
Misumena vatia (Clerck, 1757)	1	OLA
Ozyptila confluens (C. L. Koch, 1845)	9	SEU
Ozyptila pullata (Thorell, 1875)	1	EUR
Ozyptila salustri Wunderlich, 2011	3	APPC
Ozyptila sanctuaria (O. Pickard-Cambridge, 1871)	1	EUR
Runcinia grammica (C. L. Koch, 1837)	23	SCO
Synema globosum (Fabricius, 1775)	28	PAL
Thomisus onustus Walckenaer, 1805	1	PAL
Xysticus kochi Thorell, 1872	6	SIE
Titanoecidae		
Nurscia albomaculata (Lucas, 1846)	3	TUE
Uloboridae		
Hyptiotes paradoxus (C. L. Koch, 1834)	1	PAL
Zodaridae		
Zodarion elegans (Simon, 1873)	13	SEU
Zodarion italicum (Canestrini, 1868)	1	EUR
Zodarion pusio Simon, 1914	7	MED
Zodarion vicinum Denis, 1935	35	TYRR
Total number of specimens	**3623**	
Species number	**148**	

Tab. 3: List of spider species (alphabetical order) collected in the case studies of 2010, 2013 and 2014 in olive groves (OL). For each species the number of specimens per microhabitat type is reported (Ground: species collected by pitfall traps; canopy: species collected by hand or beating) and the total number of specimens
A = OL_Ground; B = OL_Canopy; C = Total OL

Species	A	B	C
Agelenidae			
Eratigena fuesslini	3	0	3
Eratigena vomeroi	2	0	2
Araneidae			
Agalenatea redii	0	3	3
Araneus angulatus	0	13	13
Araneus diadematus	0	37	37
Araneus marmoreus	0	2	2
Araneus sturmi	0	1	1
Cyclosa cf. *oculata*	0	1	1
Cyclosa conica	0	3	3
Cyrtarachne ixoides	0	6	6
Cyrtophora citricola	0	16	16
Mangora acalypha	0	25	25
Neoscona adianta	0	2	2
Zilla diodia	0	1	1
Zygiella x-notata	0	77	77
Clubionidae			
Clubiona brevipes	0	1	1
Dictynidae			
Argenna subnigra	1	0	1
Dictyna arundinacea	0	1	1
Dysderidae			
Dysdera cf. *andreinii*	1	0	1
Dysdera crocata	27	0	27
Dysdera erythrina	1	0	1
Harpactea arguta	27	0	27
Filistatidae			
Filistata insidiatrix	1	0	1
Gnaphosidae			
Aphantaulax cincta	4	0	4
Civizelotes dentatidens	2	0	2
Drassodes lapidosus	1	0	1
Gnaphosa alacris	6	0	6
Gnaphosa lucifuga	11	0	11
Haplodrassus dalmatensis	27	0	27
Haplodrassus macellinus	1	0	1
Leptodrassus femineus	1	0	1
Marinarozelotes barbatus	28	0	28
Micaria albovittata	3	0	3

Species	A	B	C
Micaria coarctata	1	0	1
Nomisia exornata	45	0	45
Setaphis carmeli	16	0	16
Zelotes fulvaster	2	0	2
Zelotes hermani	9	0	9
Zelotes oblongus	14	0	14
Zelotes paroculus	7	0	7
Zelotes tenuis	46	0	46
Linyphiidae			
Agyneta rurestris	4	3	7
Cresmatoneta mutinensis	0	1	1
Diplocephalus graecus	5	0	5
Erigone autumnalis	5	2	7
Erigone dentipalpis	2	0	2
Frontinellina frutetorum	0	1496	1496
Gonatium biimpressum	0	2	2
Linyphia triangularis	0	10	10
Palliduphantes cf. *pallidus*	0	1	1
Palliduphantes istrianus	150	0	150
Styloctetor romanus	1	0	1
Tenuiphantes herbicola	1	0	1
Tenuiphantes tenuis	20	2	22
Trichoncus affinis	2	1	3
Trichoncus hackmani	0	1	1
Trichoncus sordidus	8	0	8
Walckenaeria antica	1	0	1
Liocranidae			
Agraecina lineata	3	0	3
Agroeca proxima	2	0	2
Cybaeodes marinae	1	0	1
Lycosidae			
Alopecosa albofasciata	364	0	364
Arctosa personata	13	0	13
Hogna radiata	26	0	26
Trochosa ruricola	76	0	76
Miturgidae			
Zora silvestris	1	0	1
Oonopidae			
Silhouettella loricatula	3	0	3
Oxyopidae			
Oxyopes lineatus	0	6	6
Philodromidae			
Philodromus cf. *rufus*	0	1	1
Philodromus lividus	0	5	5
Philodromus longipalpis	0	3	3
Pulchellodromus bistigma	1	0	1
Thanatus atratus	1	0	1
Phrurolithidae			
Liophrurillus flavitarsis	11	0	11
Phrurolithus festivus	3	0	3
Salticidae			
Chalcoscirtus infimus	2	0	2
Euophrys frontalis	7	0	7
Euophrys herbigrada	43	0	43
Evarcha jucunda	0	2	2
Heliophanus cupreus	1	0	1
Heliophanus kochii	3	0	3
Heliophanus tribulosus	0	14	14
Icius hamatus	0	12	12
Leptorchestes berolinensis	1	1	2
Macaroeris nidicolens	0	10	10
Philaeus chrysops	0	1	1
Phlegra bresnieri	5	0	5
Pseudicius encarpatus	0	1	1
Salticus mandibularis	0	1	1
Salticus mutabilis	0	5	5
Salticus zebraneus	0	4	4
Scytodidae			
Scytodes thoracica	156	0	156
Sparassidae			
Olios argelasius	1	7	8
Tetragnathidae			
Metellina segmentata	0	2	2
Pachygnatha degeeri	1	0	1
Theridiidae			
Argyrodes argyrodes	0	26	26
Asagena italica	9	0	9
Crustulina guttata	7	0	7
Episinus cf. *angulatus*	0	1	1
Euryopis episinoides	3	2	5
Euryopis laeta	9	0	9
Heterotheridion nigrovariegatum	0	10	10
Kochiura aulica	0	35	35
Lasaeola convexa	0	5	5
Parasteatoda lunata	0	3	3
Parasteatoda tepidariorum	0	4	4
Phoroncidia paradoxa	0	1	1
Platnickina tincta	0	9	9
Rhomphaea nasica	0	5	5
Robertus mediterraneus	1	0	1
Steatoda paykulliana	1	0	1
Theridion pinastri	0	1	1
Theridion varians	0	3	3
Thomisidae			
Bassaniodes bufo	3	0	3
Bassaniodes robustus	1	0	1
Misumena vatia	0	1	1
Ozyptila confluens	5	0	5
Ozyptila pullata	1	0	1
Ozyptila salustri	0	3	3
Ozyptila sanctuaria	1	0	1
Runcinia grammica	0	19	19
Synema globosum	0	21	21
Thomisus onustus	0	1	1
Xysticus kochi	6	0	6
Uloboridae			
Hyptiotes paradoxus	0	1	1
Zodaridae			
Zodarion elegans	7	0	7
Zodarion italicum	1	0	1
Zodarion pusio	7	0	7
Zodarion vicinum	21	0	21
Total number of specimens	**1294**	**1934**	**3228**
Species number	**76**	**60**	**129**

Tab. 4: List of spider species (alphabetical order) collected in the case studies of 2013 and 2014 in woods (WA). For each species the number of specimens per microhabitat type is reported (Ground: species collected by pitfall traps; canopy: species collected by hand or beating) and the total number of specimens
A = WA _Ground; B = WA_Canopy; C = Total WA

Species	A	B	C
Agelenidae			
Agelena labyrinthica	0	1	1
Eratigena fuesslini	2	0	2
Tegenaria hasperi	1	0	1
Araneidae			
Araneus angulatus	0	2	2
Araneus diadematus	0	8	8
Araneus marmoreus	0	1	1
Araniella cucurbitina	0	3	3
Argiope bruennichi	0	1	1
Cyclosa conica	0	7	7
Cyrtophora citricola	0	2	2
Gibbaranea bituberculata	0	1	1
Hypsosinga sanguinea	0	1	1
Mangora acalypha	0	6	6
Neoscona adianta	0	1	1
Zilla diodia	0	1	1
Zygiella x-notata	0	1	1
Clubionidae			
Clubiona brevipes	0	1	1
Dictynidae			
Brigittea civica	0	1	1
Dysderidae			
Harpactea arguta	1	0	1
Gnaphosidae			
Gnaphosa alacris	1	0	1
Haplodrassus macellinus	1	0	1
Micaria albovittata	1	0	1
Nomisia exornata	1	0	1
Setaphis carmeli	1	0	1
Trachyzelotes pedestris	2	0	2
Zelotes aeneus	1	0	1
Zelotes hermani	4	0	4
Zelotes oblongus	1	0	1
Zelotes paroculus	2	0	2
Zelotes tenuis	4	0	4
Linyphiidae			
Frontinellina frutetorum	0	21	21
Gonatium biimpressum	1	15	16
Linyphia triangularis	0	14	14
Styloctetor romanus	2	0	2
Tapinocyba praecox	1	0	1
Tenuiphantes herbicola	3	0	3
Tenuiphantes tenuis	1	0	1
Trichoncus hackmani	1	0	1
Trichoncus sordidus	13	0	13
Walckenaeria antica	1	0	1
Lycosidae			
Alopecosa albofasciata	1	0	1
Arctosa personata	1	0	1
Hogna radiata	14	0	14
Mimetidae			
Mimetus laevigatus	0	1	1
Philodromidae			
Philodromus lividus	0	1	1
Philodromus longipalpis	0	2	2
Pimoidae			
Pimoa rupicola	1	0	1
Salticidae			
Chalcoscirtus infimus	3	0	3
Euophrys frontalis	4	0	4
Euophrys petrensis	1	0	1
Evarcha jucunda	2	1	3
Heliophanus tribulosus	0	1	1
Pellenes geniculatus	2	0	2
Saitis barbipes	1	0	1
Scytodidae			
Scytodes thoracica	38	0	38
Sparassidae			
Olios argelasius	1	0	1
Tetragnathidae			
Metellina segmentata	0	2	2
Pachygnatha degeeri	1	0	1
Theridiidae			
Argyrodes argyrodes	0	2	2
Asagena italica	2	0	2
Platnickina tincta	0	3	3
Euryopis episinoides	1	0	1
Rhomphaea nasica	0	2	2
Theridion pinastri	0	1	1
Theridion varians	0	1	1
Thomisidae			
Bassaniodes robustus	1	0	1
Ozyptila confluens	4	0	4
Runcinia grammica	0	1	1
Synema globosum	0	4	4
Titanoecidae			
Nurscia albomaculata	3	0	3
Zodaridae			
Zodarion vicinum	14	0	14
Total number of specimens	**141**	**110**	**251**
Species number	**41**	**32**	**71**

Tab. 5: List of spider species (alphabetical order) collected in the case studies of 2013 and 2014 in the Mediterranean garrigue (GA). For each species the number of specimens per microhabitat type is reported (Ground: species collected by pitfall traps; canopy: species collected by hand or beating) and the total number of specimens
A = GA_Ground; B = GA_Canopy; C = Total GA

Species	A	B	C
Araneidae			
Aculepeira armida	0	1	1
Agalenatea redii	0	1	1
Araneus diadematus	0	1	1
Cyrtophora citricola	0	11	11
Zygiella x-notata	0	4	4
Dictynidae			
Brigittea civica	0	1	1
Gnaphosidae			
Gnaphosa alacris	1	0	1
Gnaphosa lucifuga	3	0	3
Nomisia exornata	1	0	1

Species	A	B	C
Linyphiidae			
Erigone autumnalis	1	0	1
Frontinellina frutetorum	0	38	38
Trichoncus sordidus	2	0	2
Lycosidae			
Hogna radiata	4	0	4
Oecobiidae			
Oecobius maculatus	1	0	1
Oxyopidae			
Oxyopes lineatus	1	0	1
Salticidae			
Aelurillus v-insignitus	1	0	1
Chalcoscirtus infimus	1	0	1
Euophrys herbigrada	1	0	1
Heliophanus tribulosus	0	6	6
Pellenes geniculatus	2	0	2
Sparassidae			
Olios argelasius	9	0	9
Tetragnathidae			
Metellina segmentata	0	2	2
Theridiidae			
Argyrodes argyrodes	0	7	7
Kochiura aulica	0	22	22
Platnickina tincta	0	2	2
Thomisidae			
Bassaniodes bufo	2	0	2
Runcinia grammica	0	3	3
Synema globosum	0	3	3
Zodariidae			
Zodarion elegans	6	0	6
Total number of specimens	**36**	**102**	**138**
Species number	**15**	**14**	**29**

Zelotes fulvaster (Simon, 1878) (Gnaphosidae) (Fig. 2a-b)
Material examined. ITALY: Tuscany, Monte Pisano, olive groves: Avane (Pisa), 43.79444°N, 10.39905°E, 117 m a.s.l., 1 ♀, pitfall trap (20.–24. Sep. 2013); Pozzuolo (Lucca), 43.81887°N, 10.47096°E, 135 m a.s.l., 1 ♂, pitfall trap (20.–24. Jul. 2013); leg. M. S. Picchi, det. P. Pantini.
Distribution. France, Bulgaria, North Macedonia, Greece, Iran (Jézéquel 1962, Komnenov 2014, Nentwig et al. 2019, Senglet et al. 2011), new record for Italy.
Chorotype. Mediterranean.

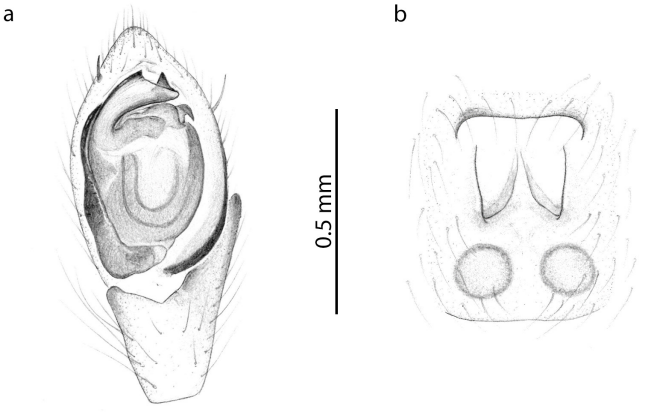

Fig. 2: *Zelotes fulvaster*. **a.** male palp, ventral view; **b.** epigyne, ventral view

Discussion

Olive groves of Central Italy, along with adjacent woods and garrigue, host a considerable number of spider species both on the ground and in the canopies, including a number of endemic species. Moreover, in two olive groves *Zelotes fulvaster*, a new record for Italy, was collected (see above). Hitherto the distribution of this species of the *Zelotes tenuis*-group was confirmed in the southern part of the Balkans (Greece and Macedonia), in Corsica (France) and, outside Europe, in Iran (Senglet et al. 2011). Since this is a new species report for Italy, its known distribution range is extended here to the West-Mediterranean part of Southern Europe, consistent with its Mediterranean chorotype. Previous reports of this species come from xeric habitats (Komnenov 2014) and this preference for arid habitats partially matches the microclimate of olive orchards.

Pimoa rupicola is a troglobiotic species with some reports from central Apennine regions (Mammola et al. 2016), where it was found in pitfall traps in a wood, contrary to *G. biimpressum*, of which more specimens were found in the foliage of the forest trees, whereas *D.* cf. *andreinii* and *E. vomeroi* were collected at the ground level of olive orchards. *Cybaeodes marinae* has been sampled with pitfall traps on the ground of one olive orchard. This night-active species is typical of Mediterranean woods and it is probably related to a warm and dry environment (Di Franco 1989). Three endemic species were described form Tuscany: *Zodarion vicinum* was originally described by Denis (1935) from individuals collected on the island of Giglio (Tuscany), whereas *D. andreinii* was described by di Caporiacco (1928) from the island of Capraia (Tuscany). *Ozyptila salustri* was described based on samples collected in Grosseto (Tuscany) by Wunderlich (2011).

Considering the chorotype profiles, it is suggested here that besides common species (11% OLA: 16 species and 21% PAL: 31 species), the Mediterranean chorotype is represented by a high number of species (15.6%: 23 species). This is an expected result since Tuscany is typically associated with Mediterranean climatic conditions and vegetation associations. Generally, species in traditional olive landscapes are mesophilic species, often associated with garrigue or sunny localities (Gaymard & Lecigne 2018), e.g. *Kochiura aulica* (canopy) and *Nomisia exornata* (ground).

The most abundant species in olive canopies was the linyphiid *Frontinellina frutetorum*, also observed by Gaymard & Lecigne (2018) in mesophile woods. In fact, this species was numerous in the samples from woods and garrigue next to olive groves, despite previous analyses highlighting a lower number of *F. frutetorum* in garrigue-dominant landscapes (Picchi et al. 2016), probably due to the risk of desiccation (Pekár 2013). Likewise, *Frontinellina frutetorum* was dominant among 48 species in Iranian olive groves (Ghavami 2006).

On the ground, among olive trees sampled in 2010, the most abundant spider was the lycosid *Alopecosa albofasciata*, already known to be common in olive groves (Thaler et al. 2000), in grass and in the garrigue. It has been regularly found in open sunny and arid places (Lugetti & Tongiorgi 1969). These results suggest that olive groves qualify as a mesophile habitat with species typical of drier habitats.

Considering species numbers in olive landscapes, Gnaphosidae and Salticidae were represented by 20 species each.

Gnaphosids are common in all Mediterranean areas (Cardoso et al. 2007). The present results confirm those from the other studies (Cárdenas et al. 2012, Dinis et al. 2015).

Jumping spiders are one of the richest families in dry shrubland, and most species collected were usually associated to garrigue. Nyffeler & Sunderland (2003) suggested that jumping spiders usually have a higher abundance in warmer regions because at low temperatures they are less active and their hunting efficiency is lower. Salticids were also one of the most abundant families found by Morris et al. (1999) in olive groves of Spain.

Olive groves provide spiders with more habitats for overwintering and food resources than the annual crops, therefore spiders are less dependent on adjacent non-crop and semi-natural vegetation (Picchi et al. 2016). In fact, olive groves have higher stability and are structurally and vegetationally more diverse (Maloney et al. 2003, Öberg et al. 2008) than annual crops and thus provide a high diversity of niches (Arambourg 1986), including for instance dry-stone walls and stones on the ground (Benhadi-Marín et al. 2018) that influence the occurrence of spiders (Samu et al. 1999).

Such a hypothesis was also supposed for vineyards by D'Alberto et al. (2012). They suggested there were only weak relationships between woody vegetation and the abundance of spiders in vineyards at all spatial scales and that this could be due to differences in the crop structure. Remarkably, perennials (type of crop) have a greater structural and compositional complexity than annuals (Lefebvre et al. 2016). At the same time, other authors showed the importance of vineyards for the conservation of endangered or rare species of spiders (Košulic & Hula 2013, 2014, Košulič et al. 2014). The same conclusion could be applied to olive groves in the light of the presence of endemic species.

In olive groves of other Mediterranean countries, the species richness was similar. In research conducted in Spain 142 species of spiders were collected (Cárdenas & Barrientos 2011) with 33 species in common to Monte Pisano's area, while in southern Portugal 144 spider species were sampled (Sousa da Silva 2013) and 36 species were shared with the present study. In the northern part of Portugal, knowledge of the spider assemblages of olive groves increased recently (Benhadi-Marín et al. 2018, 2020) – the authors found 24 species common to the list of spiders in Monte Pisano's olive groves. Considering these three countries, European olive groves share 12 species, and among them, many have a Mediterranean chorotype such as *Icius hamatus*, *Drassodes lapidosus* and *Nomisia exornata*. Moreover, they share other species typical of xerothermic habitats such as *Gnaphosa alacris*, *Phlegra bresnieri* and *Hogna radiata*. The other common species of olive groves were *Araniella cucurbitina*, *Mangora acalypha*, *Neoscona adianta*, *Setaphis carmeli*, *Alopecosa albofasciata* and *Synema globosum*.

In Italy, spiders of olive groves were rarely analysed and, as far as I am aware, little data is available for both the ground and canopy of these habitats. In the study of Lasinio & Zapparoli (1993) spiders were abundant and constituted a high percentage of sampled arthropods. Thaler & Zapparoli (1993) observed 70 species of ground-dwelling spiders compare to 76 species in Tuscan olive grounds: 32 species were shared with the present study, among them all of the wolf spider species. Pantaleoni et al. (2001) reported 18 families and 40 genera of spiders. Theridiidae, were the most abundant family. Four species are common to all case studies considered in this paper: *A. albofasciata* (TUM), *D. lapidosus* (MED), *H. radiata* (CAE) and *S. globosum* (PAL).

In conclusion, olive groves host rich spider assemblages, with both common European species and species with a Mediterranean geographical distribution, and even endemics. Although it is a perennial agroecosystem with periodic human intervention, olive groves appear to represent a stable and elaborate crop able to host many spider species. Application for environmentally friendly solutions to pest control issues through conservation biological control and conservation aims should encourage the study of this group of predators.

Acknowledgements

Species lists in this article were defined during several years of research in different institutes and the author wishes to thank all the colleagues involved, as well as farmers and partners. I am grateful to Paolo Pantini for his help in the identification of uncertain spiders, Elena Pelizzoli for the drawings of the genitalia of *Z. fulvaster*, Marco Isaia as supervisor of my M.Sc. project and for the identification of species collected in 2010. I acknowledge Camilla Moonen, Martin H. Entling and Ruggero Petacchi as supervisors of the Ph.D. project. Thanks to Elena Tondini, Alice Caselli and Piergiorgio Di Pompeo for their useful suggestions. The case studies of 2013 and 2014 are part of the QuESSA Project and received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under the grant agreement Nº311879.

References

Arambourg Y 1986 Entomologie oleicole. Conseil Oleicole International, Madrid. 360 pp.

Benhadi-Marín J, Pereira JA, Barrientos JA, Sousa JP & Santos SAP 2018 Stones on the ground in olive groves promote the presence of spiders (Araneae). – European Journal of Entomology 115: 372-379 – doi: 10.14411/EJE.2018.037

Benhadi-Marín J, Pereira JA, Bento A, Sousa P & Santos SAP 2017 Biodiversity of spiders in agroecosystems: from community structure to conservation biological control of pest. In: Santos SAP (ed.) Natural enemies: identification, protection strategies and ecological impacts. Nova, New York. pp. 43-109

Benhadi-Marín J, Pereira JA, Sousa JP & Santos SAP 2020 Distribution of the spider community in the olive grove agroecosystem (Portugal): potential bioindicators. – Agricultural and Forest Entomology 22: 10-19 – doi: 10.1111/afe.12352

Bertacchi A, Sani A & Tomei PE 2004 La vegetazione del Monte Pisano. Felici Editore, Pisa. 56 pp.

Caporiacco L di 1928 Aracnidi della Capraja. – Bollettino della Società Entomologica Italiana 60: 124-127

Cárdenas M & Barrientos J 2011 Arañas del olivar andaluz (Arachnida; Araneae). Aspectos faunísticos. Spiders from Andalusian olive groves (Arachnida; Araneae). Faunistic aspects. – Zoologica baetica 22: 99-136

Cárdenas M, Castro J & Campos M 2012 Short-term response of soil spiders to cover-crop removal in an organic olive orchard in a Mediterranean setting. – Journal of Insect Science 12: 1-18 – doi: 10.1673/031.012.6101

Cardoso P, Silva I, De Oliveira NG & Serrano ARM 2007 Seasonality of spiders (Araneae) in Mediterranean ecosystems and its implications in the optimum sampling period. – Ecological Entomology 32: 516-526 – doi: 10.1111/j.1365-2311.2007.00894.x

D'Alberto CF, Hoffmann AA & Thomson LJ 2012 Limited benefits of non-crop vegetation on spiders in Australian vineyards: regional or crop differences? – BioControl 57: 541-552 – doi: 10.1007/s10526-011-9435-x

Decae A & Huber S 2017 Description of a new *Nemesia* species from Sardinia that constructs a remarkable star-shaped trapdoor (Araneae: Mygalomorphae: Nemesiidae). – Arachnology 17: 188-194 – doi: 10.13156/arac.2017.17.4.188

Denis J 1935 Les Araignées du genre *Zodarion* Walck. appartenant à la faune d'Italie. – Memorie della Società Entomologica Italiana 14: 65-83

Dinis AM, Pereira JA, Pimenta MC, Oliveira J, Benhadi-Marín J & Santos SAP 2015 Suppression of *Bactrocera oleae* (Diptera: Tephritidae) pupae by soil arthropods in the olive grove. – Journal of Applied Entomology 140: 677-687 – doi: 10.1111/jen.12291

European Environment Agency 2018 Biodiversity Information System for Europe. – Internet: https://biodiversity.europa.eu/countries/italy (10. Mar. 2018)

Franc V 2000 Spiders (Araneae) on the red lists of European countries. – Ekológia (Bratislava) 19, Suppl. 4: 23-28

Di Franco F 1988 *Cybaeodes marinae*; nuova specie di Gnaphosidae (Arachnida, Araneae) d'Italia. – Animalia 15: 25-36

Gaymard M & Lecigne S 2018 Contribution à la connaissance de l'aranéofaune (Araneae) du Gard et en particulier du massif des Gorges du Gardon (Occitanie, France). – Bulletin de l'Association Française d'Arachnologie 1: 2-39

Ghavami S 2006 Abundance of spiders (Arachnida: Araneae) in olive orchards in northern part of Iran. – Pakistan Journal of Biological Sciences 9: 795-799 – doi: 10.3923/pjbs.2006.795.799

Holland J, Jeanneret P, Herzog F, Moonen AC, Rossing W, Werf WV, Kiss J, Helden MV, Paracchini ML, Cresswell J, Pointereau P, Heijne B, Veromann E, Antichi D, Entling M & Balázs B 2014 The QuESSA. Project: quantification of ecological services for sustainable agriculture. – IOBC/WPRS Bulletin 100: 55-58 – doi: 10.13140/2.1.3108.1923

Jézéquel JF 1962 Contribution a l'étude des *Zelotes* femelles (Araneidea, Labidognatha, Gnaphosidae) de la faune française (2e note). – Bulletin du Museum National d'Histoire Naturelle de Paris (2) 33: 594-610

Komnenov M 2014 Spider fauna of the Osogovo Mt. Range, Northeastern Macedonia. – Fauna Balkana 2: 1-267

Košulic O & Hula V 2014 Rare and remarkable spiders (Araneae) from vineyard terraces in Pálava region (South Moravia, Czech Republic). – Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis 61: 663-676 – doi: 10.11118/actaun201361030663

Košulič O & Hula V 2014 A faunistic study on spiders (Araneae) from vineyard terraces in the municipalities of Morkůvky and Mutěnice (South Moravia, Czech Republic). – Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis 62: 137-154 – doi: 10.11118/actaun201462010137

Košulič O, Michalko R & Hula V 2014 Recent artificial vineyard terraces as a refuge for rare and endangered spiders in a modern agricultural landscape. – Ecological Engineering 68: 133-142 – doi: 10.1016/j.ecoleng.2014.03.030

Lang A 2003 Intraguild interference and biocontrol effects of generalist predators in a winter wheat field. – Oecologia 134: 144-153 – doi: 10.1007/s00442-002-1091-5

Larrivée M & Buddle CM 2009 Diversity of canopy and understorey spiders in north-temperate hardwood forests. – Agricultural and Forest Entomology 11: 225-237 – doi: 10.1111/j.1461-9563.2008.00421.x

Lasinio PJ & Zapparoli M 1993 First data on the soil arthropod community in an olive grove in central Italy. In: Coleman DC, Foissner W & Paoletti MG (eds.) Soil biota, nutrient cycling and farming systems. Lewis Publishers, Boca Raton. pp. 113-121

Lefebvre M, Franck P, Toubon J-F, Bouvier J-C & Lavigne C 2016 The impact of landscape composition on the occurrence of a canopy dwelling spider depends on orchard management. – Agriculture, Ecosystems & Environment 215: 20-29 – doi: 10.1016/j.agee.2015.09.003

Lugetti G & Tongiorgi P 1969 Ricerche sul genere *Alopecosa* Simon (Araneae-Lycosidae). – Atti della Società Toscana di Scienze Naturali (B) 76: 1-100

Maloney D, Drummond F & Alford R 2003 Spider predation in agroecosystems: can spiders effectively control pest populations? – The University of Maine: department of Biological Sciences Technical Bulletin 190: 1-32

Mammola S, Hormiga G, Arnedo MA & Isaia M 2016 Unexpected diversity in the relictual European spiders of the genus *Pimoa* (Araneae: Pimoidae). – Invertebrate Systematics 30: 566-587 – doi: 10.1071/IS16017

Milano F, Pantini P, Mammola S & Isaia M 2017 La conservazione dell'araneofauna in Italia e in Europa. – Atti Accademia Nazionale Italiana di Entomologia: 91-103

Morris TI, Campos M, Kidd NAC, Jervis MA & Symondson WOC 1999 Dynamics of the predatory arthropod community in Spanish olive grove. – Agricultural and Forest Entomology 1: 219-228 – doi: 10.1046/j.1461-9563.1999.00030.x

Nentwig W, Blick T, Gloor D, Hänggi A & Kropf C 2019 Araneae – Spiders of Europe, version 07.2019. – Internet: https://araneae.unibe.ch/ (27. Jul. 2019) – doi: 10.24436/1

Niccolai M & Marchi S 2005 Il clima della Toscana. In: RaFT 2005: Rapporto sullo stato delle foreste in Toscana 205. pp. 16-22

Nyffeler M & Birkhofer K 2017 An estimated 400–800 million tons of prey are annually killed by the global spider community – The Science of Nature 104: 30 – doi: 10.1007/s00114-017-1440-1

Nyffeler M & Sunderland KD 2003 Composition, abundance and pest control potential of spider communities in agroecosystems: a comparison of European and US studies. – Agriculture, Ecosystems & Environment 95: 579-612 – doi: 10.1016/S0167-8809(02)00181-0

Öberg S, Mayr S & Dauber J 2008 Landscape effects on recolonisation patterns of spiders in arable fields. – Agriculture, Ecosystems and Environment 123: 211-218 – doi: 10.1016/j.agee.2007.06.005

Oger P 2019 Les araignées de Belgique et de France.– Internet: https://arachno.piwigo.com/ (9. Sep. 2018)

Pantaleoni RA, Lentini A & Delrio G 2001 Lacewings in Sardinian olive groves. In: McEwen P, New T & Whittington A (eds.) Lacewings in the crop environment. Cambridge University Press, New York. pp. 435-446 – doi: 10.1017/CBO9780511666117.027

Pantini P & Isaia M 2019 Araneae.it: the online catalog of Italian spiders with addenda on other arachnid orders occurring in Italy (Arachnida: Araneae, Opiliones, Palpigradi, Pseudoscorpionida, Scorpiones, Solifugae). – Fragmenta entomologica 51: 127-152 – Internet: http://www.araneae.it (5. Nov. 2019)

Pantini P & Mazzoleni F 2018 I Ragni di Calabria. – Rivista del Museo Civico di Scienza Naturali „Enrico Caffi" 31: 1-70

Peel MC, Grieser J, Beck C, Rudolf B & Rubel F 2007 Updated world map of the Koppen-Geiger climate classification. – Meteorologische Zeitschrift 11: 1633-1644 – doi: 10.1127/0941-2948/2006/0130

Pekár S 2013 Side effect of synthetic pesticides on spiders. In: Nentwig W (ed.) Spider ecophysiology. Springer Verlag, Berlin, Heidelberg. pp. 415-427 – doi: 10.1007/978-3-642-33989-9_31

Pesarini C 1996 Note su alcuni Erigonidae italiani, con descrizione di una nuova specie (Araneae). – Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano 135: 413-429

Picchi MS, Bocci G, Petacchi R & Entling MH 2016 Effects of local and landscape factors on spiders and olive fruit flies. – Agriculture, Ecosystems & Environment 222: 138-147 – doi: 10.1016/j.agee.2016.01.045

Picchi MS, Bocci G, Petacchi R & Entling MH 2020 Taxonomic and functional differentiation of spiders in habitats in traditional olive producing landscapes in Italy. – European Journal of Entomology 117:18-26 – doi: 10.14411/eje.2020.002

Polunin O & Walters M 1985 A guide to the vegetation of Britain and Europe. Oxford, New York. 238 pp.

QGIS Development Team 2019 QGIS Geographic Information System. Open Source Geospatial Foundation Project. – Internet: https://www.qgis.org/it/site/ (24. Jul. 2019)

Roberts MJ 1987 The spiders of Great Britain and Ireland, Volume 2. Harley Books, Colchester. 204 pp.

Samu F, Sunderland KD & Szinetár C 1999 Scale-dependent dispersal and distribution patterns of spiders in agricultural systems: a review. – Journal of Arachnology 27: 325-332 – doi: 10.2307/3706004

Senglet A 2011 New species in the *Zelotes tenuis*-group and new or little known species in other *Zelotes* groups (Gnaphosidae, Araneae). – Revue suisse de zoologie 118: 513-559 – doi: 10.5962/bhl.part.117816

Sousa da Silva A 2013 Diversidade de Aranhas nos diferentes sistemas de cultivo de olival no Alentejo (Portugal). Dissertation, Instituto Politécnico de Beja. 100 pp.

Stoch F & Vigna Taglianti A 2006 The chorotypes of the Italian fauna. In: Ruffo S & Stoch F (eds) Checklist e distribuzione della fauna italiana. – Memorie del Museo Civico di Storia Naturale di Verona (2A) 17: 25-28

Sunderland K & Samu F 2000 Effects of agricultural diversification on the abundance, distribution, and pest control potential of spiders. – Entomologia Experimentalis et Applicata 95: 1-13 – doi: 10.1046/j.1570-7458.2000.00635.x

Symondson WOC, Sunderland KD & Greenstone MH 2002 Can generalist predators be effective biocontrol agents? – Plant Science 47: 561-594 – doi: 10.1146/annurev.ento.47.091201.145240

Thaler K, Buchar J & Knoflach B 2000 Notes on wolf spiders from Greece (Araneae, Lycosidae). – Linzer Biologische Beiträge 32: 1071-1091

Thaler K & Zapparoli M 1993 Epigeic spiders in an olive-grove in Central Italy (Araneae). – Redia 86: 307-316

Trotta A 2005 Introduzione al ragni italiani (Arachnida Araneae). – Memorie della Società Entomologica Italiana 83: 3-178

World Spider Catalog 2020 World spider catalog. Version 21.5. Natural History Museum, Bern. – Internet: https://wsc.nmbe.ch (30. Aug. 2020) – doi: 10.24436/2

Wunderlich J 2011 On extant West-Palaearctic (mainly Southern European) spiders (Araneae) of various families, with new descriptions. – Beitrage zur Araneologie 6: 158-338