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

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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 Sammelmethode (Bodenfallen, Klopfen an Ästen und Handaufsammelungen 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).

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 QuES-SA 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.

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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 (Larivière & 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

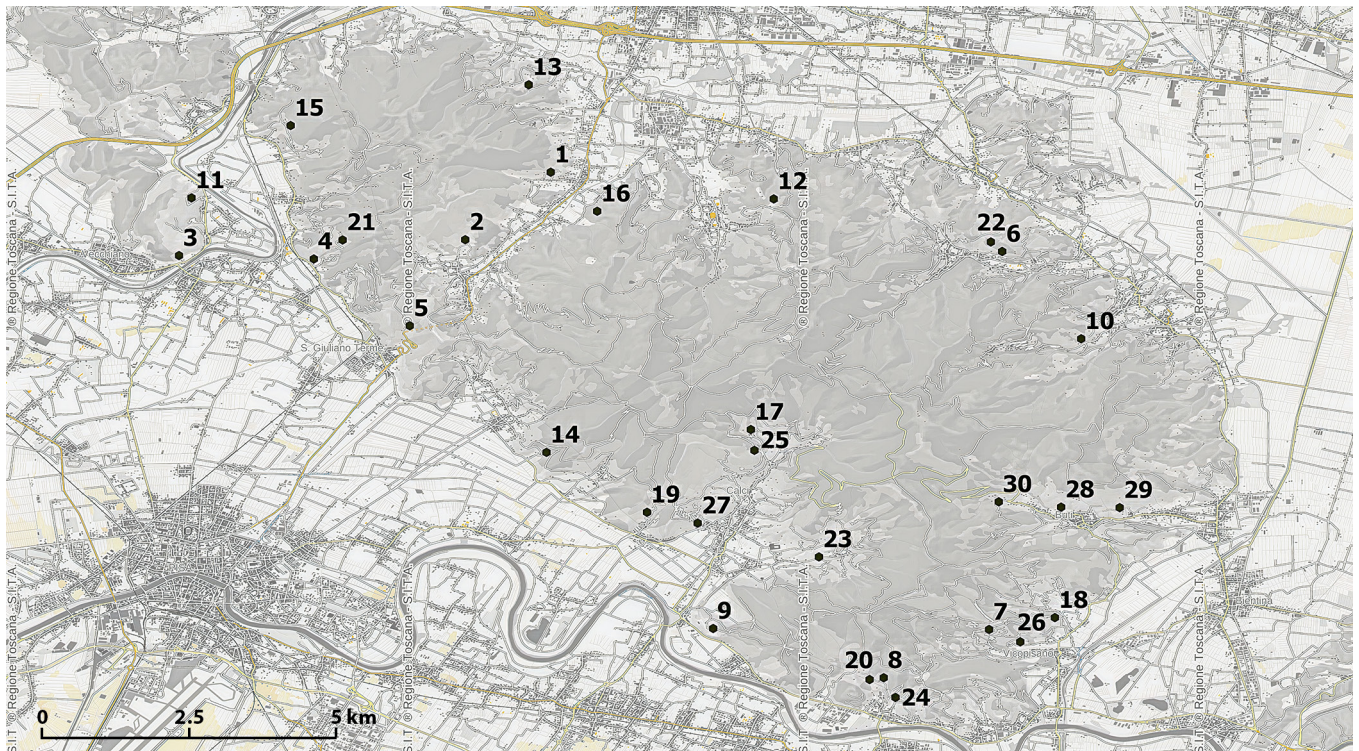


Fig. 1: Map of the sites sampled in 2010 (6), 2013 (12) and 2014 (18) in the Monte Pisano area. The city of Pisa is in the lower left of the map. Detailed information (coordinates, altitude, year and microhabitats) for each site is reported in Tab.1.

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 Palearctic 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 *Pimosa rupicola* (1 male; ALWA: West Alpine-Apenninic), *Eratigena vomeroi* (1 female and 1 male; APPS: South Apenninic), *Dysdera* cf. *andreinii* (1 female APPE: Apenninic) and *Cybaeodes marinae* (1 female and 1 male; APPE: Apenninic), *Gonatium biimpressum* and *Zodarium vicinum* (15 females and 3 males and 26 females and 19 males; TYRR: Tyrrhenian) and *Ozyptila salustri* Wunderlich, 2011 (3 males; APPC: Central Apenninic) (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 Apenninic; 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 = Palearctic; SCO = Sub-cosmopolite; SIE = Sibero-European; SEU = South European; TEM = Turano-European-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		
<i>Agelena labyrinthica</i> (Clerck, 1757)	1	PAL
<i>Eratigena fuesslini</i> (Pavesi, 1873)	5	EUR
<i>Eratigena vomeroi</i> (Brignoli, 1977)	2	APPS

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

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

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

Species	A	B
Zodaridae		
<i>Zodarion elegans</i> (Simon, 1873)	13	SEU
<i>Zodarion italicum</i> (Canestrini, 1868)	1	EUR
<i>Zodarion pusio</i> Simon, 1914	7	MED
<i>Zodarion vicinum</i> 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			
<i>Eratigena fuesslini</i>	3	0	3
<i>Eratigena vomeroi</i>	2	0	2
Araneidae			
<i>Agalenatea redii</i>	0	3	3
<i>Araneus angulatus</i>	0	13	13
<i>Araneus diadematus</i>	0	37	37
<i>Araneus marmoreus</i>	0	2	2
<i>Araneus sturmi</i>	0	1	1
<i>Cyclosa</i> cf. <i>oculata</i>	0	1	1
<i>Cyclosa conica</i>	0	3	3
<i>Cyrtarachne ixoides</i>	0	6	6
<i>Cyrtophora citricola</i>	0	16	16
<i>Mangora acalypha</i>	0	25	25
<i>Neoscona adianta</i>	0	2	2
<i>Zilla diodia</i>	0	1	1
<i>Zygiella x-notata</i>	0	77	77
Clubionidae			
<i>Clubiona brevipes</i>	0	1	1
Dictynidae			
<i>Argenna subnigra</i>	1	0	1
<i>Dictyna arundinacea</i>	0	1	1
Dysderidae			
<i>Dysdera</i> cf. <i>andreinii</i>	1	0	1
<i>Dysdera crocata</i>	27	0	27
<i>Dysdera erythrina</i>	1	0	1
<i>Harpactea arguta</i>	27	0	27
Filistatidae			
<i>Filistata insidiatrix</i>	1	0	1
Gnaphosidae			
<i>Aphantaulax cincta</i>	4	0	4
<i>Civizelotes dentatidens</i>	2	0	2
<i>Drassodes lapidosus</i>	1	0	1
<i>Gnaphosa alacris</i>	6	0	6
<i>Gnaphosa lucifuga</i>	11	0	11
<i>Haplodrassus dalmatensis</i>	27	0	27
<i>Haplodrassus macellinus</i>	1	0	1
<i>Leptodrassus femineus</i>	1	0	1
<i>Marinarozelotes barbatus</i>	28	0	28
<i>Micaria alborvittata</i>	3	0	3

Species	A	B	C	Species	A	B	C
<i>Micaria coarctata</i>	1	0	1	<i>Heliophanus tribulosus</i>	0	14	14
<i>Nomisia exornata</i>	45	0	45	<i>Icius hamatus</i>	0	12	12
<i>Setaphis carmeli</i>	16	0	16	<i>Leptorchestes berolinensis</i>	1	1	2
<i>Zelotes fulvaster</i>	2	0	2	<i>Macaroeris nidicolens</i>	0	10	10
<i>Zelotes hermani</i>	9	0	9	<i>Philaeus chrysops</i>	0	1	1
<i>Zelotes oblongus</i>	14	0	14	<i>Phlegma bresnieri</i>	5	0	5
<i>Zelotes paroculus</i>	7	0	7	<i>Pseudicius encarpatus</i>	0	1	1
<i>Zelotes tenuis</i>	46	0	46	<i>Salticus mandibularis</i>	0	1	1
Linyphiidae				<i>Salticus mutabilis</i>	0	5	5
<i>Agyneta rurestris</i>	4	3	7	<i>Salticus zebraneus</i>	0	4	4
<i>Cresmatoneta mutinensis</i>	0	1	1	Scytodidae			
<i>Diplocephalus graecus</i>	5	0	5	<i>Scytodes thoracica</i>	156	0	156
<i>Erigone autumnalis</i>	5	2	7	Sparassidae			
<i>Erigone dentipalpis</i>	2	0	2	<i>Olios argelasius</i>	1	7	8
<i>Frontinellina frutetorum</i>	0	1496	1496	Tetragnathidae			
<i>Gonatium biimpressum</i>	0	2	2	<i>Metellina segmentata</i>	0	2	2
<i>Linyphia triangularis</i>	0	10	10	<i>Pachygnatha degeeri</i>	1	0	1
<i>Palliduphantes cf. pallidus</i>	0	1	1	Theridiidae			
<i>Palliduphantes istrianus</i>	150	0	150	<i>Argyrodes argyrodes</i>	0	26	26
<i>Styloctetor romanus</i>	1	0	1	<i>Asagena italica</i>	9	0	9
<i>Tenuiphantes herbicola</i>	1	0	1	<i>Crustulina guttata</i>	7	0	7
<i>Tenuiphantes tenuis</i>	20	2	22	<i>Episinus cf. angulatus</i>	0	1	1
<i>Trichoncus affinis</i>	2	1	3	<i>Euryopsis episinoides</i>	3	2	5
<i>Trichoncus hackmani</i>	0	1	1	<i>Euryopsis laeta</i>	9	0	9
<i>Trichoncus sordidus</i>	8	0	8	<i>Heterotheridion nigrovariegatum</i>	0	10	10
<i>Walckenaeria antica</i>	1	0	1	<i>Kochiura aulica</i>	0	35	35
Liocranidae				<i>Lasaeola convexa</i>	0	5	5
<i>Agraeina lineata</i>	3	0	3	<i>Parasteatoda lunata</i>	0	3	3
<i>Agroeca proxima</i>	2	0	2	<i>Parasteatoda tepidariorum</i>	0	4	4
<i>Cybaeodes marinae</i>	1	0	1	<i>Phoroncidia paradoxa</i>	0	1	1
Lycosidae				<i>Platnickina tinctoria</i>	0	9	9
<i>Alopecosa albofasciata</i>	364	0	364	<i>Rhomphaea nasica</i>	0	5	5
<i>Arctosa personata</i>	13	0	13	<i>Robertus mediterraneus</i>	1	0	1
<i>Hogna radiata</i>	26	0	26	<i>Seatoda paykulliana</i>	1	0	1
<i>Trochosa ruricola</i>	76	0	76	<i>Theridion pinastri</i>	0	1	1
Miturgidae				<i>Theridion varians</i>	0	3	3
<i>Zora silvestris</i>	1	0	1	Thomisidae			
Oonopidae				<i>Bassaniodes bufo</i>	3	0	3
<i>Silhouettella loricatula</i>	3	0	3	<i>Bassaniodes robustus</i>	1	0	1
Oxyopidae				<i>Misumena vatia</i>	0	1	1
<i>Oxyopes lineatus</i>	0	6	6	<i>Ozyptila confluens</i>	5	0	5
Philodromidae				<i>Ozyptila pullata</i>	1	0	1
<i>Philodromus cf. rufus</i>	0	1	1	<i>Ozyptila salustri</i>	0	3	3
<i>Philodromus lividus</i>	0	5	5	<i>Ozyptila sanctuaria</i>	1	0	1
<i>Philodromus longipalpis</i>	0	3	3	<i>Runcinia grammica</i>	0	19	19
<i>Pulchellodromus bistigma</i>	1	0	1	<i>Synema globosum</i>	0	21	21
<i>Thanatus atratus</i>	1	0	1	<i>Thomisus onustus</i>	0	1	1
Phrurolithidae				<i>Xysticus kochi</i>	6	0	6
<i>Liophrurillus flavitarsis</i>	11	0	11	Uloboridae			
<i>Phrurolithus festivus</i>	3	0	3	<i>Hyptiotes paradoxus</i>	0	1	1
Salticidae				Zodariidae			
<i>Chalcoscirtus infimus</i>	2	0	2	<i>Zodarion elegans</i>	7	0	7
<i>Euophrys frontalis</i>	7	0	7	<i>Zodarion italicum</i>	1	0	1
<i>Euophrys herbigrada</i>	43	0	43	<i>Zodarion pusio</i>	7	0	7
<i>Evarcha jucunda</i>	0	2	2	<i>Zodarion vicinum</i>	21	0	21
<i>Heliophanus cupreus</i>	1	0	1	Total number of specimens	1294	1934	3228
<i>Heliophanus kochii</i>	3	0	3	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			
<i>Agelena labyrinthica</i>	0	1	1
<i>Eratigena fuesslini</i>	2	0	2
<i>Tegenaria hasperi</i>	1	0	1
Araneidae			
<i>Araneus angulatus</i>	0	2	2
<i>Araneus diadematus</i>	0	8	8
<i>Araneus marmoreus</i>	0	1	1
<i>Araniella cucurbitina</i>	0	3	3
<i>Argiope bruennichi</i>	0	1	1
<i>Cyclosa conica</i>	0	7	7
<i>Cyrtophora citricola</i>	0	2	2
<i>Gibbaranea bituberculata</i>	0	1	1
<i>Hypsosinga sanguinea</i>	0	1	1
<i>Mangora acalypha</i>	0	6	6
<i>Neoscona adianta</i>	0	1	1
<i>Zilla diodia</i>	0	1	1
<i>Zygiella x-notata</i>	0	1	1
Clubionidae			
<i>Clubiona brevipes</i>	0	1	1
Dictynidae			
<i>Brigittea civica</i>	0	1	1
Dysderidae			
<i>Harpactea arguta</i>	1	0	1
Gnaphosidae			
<i>Gnaphosa alacris</i>	1	0	1
<i>Haplodrassus macellinus</i>	1	0	1
<i>Micaria albovittata</i>	1	0	1
<i>Nomisio exornata</i>	1	0	1
<i>Setaphis carmeli</i>	1	0	1
<i>Trachyzelotes pedestris</i>	2	0	2
<i>Zelotes aeneus</i>	1	0	1
<i>Zelotes hermani</i>	4	0	4
<i>Zelotes oblongus</i>	1	0	1
<i>Zelotes paroculus</i>	2	0	2
<i>Zelotes tenuis</i>	4	0	4
Linyphiidae			
<i>Frontinellina frutetorum</i>	0	21	21
<i>Gonatium biimpressum</i>	1	15	16
<i>Linyphia triangularis</i>	0	14	14
<i>Styloctetor romanus</i>	2	0	2
<i>Tapinocyba praecox</i>	1	0	1
<i>Tenuiphantes herbicola</i>	3	0	3
<i>Tenuiphantes tenuis</i>	1	0	1
<i>Trichoncus hackmani</i>	1	0	1
<i>Trichoncus sordidus</i>	13	0	13
<i>Walckenaeria antica</i>	1	0	1
Lycosidae			
<i>Alopecosa albofasciata</i>	1	0	1
<i>Arctosa personata</i>	1	0	1
<i>Hogna radiata</i>	14	0	14
Mimetidae			
<i>Mimetus laevigatus</i>	0	1	1
Philodromidae			

Species	A	B	C
<i>Philodromus lividus</i>	0	1	1
<i>Philodromus longipalpis</i>	0	2	2
Pimoidae			
<i>Pimoa rupicola</i>	1	0	1
Salticidae			
<i>Chalcoscirtus infimus</i>	3	0	3
<i>Euophrys frontalis</i>	4	0	4
<i>Euophrys petrensis</i>	1	0	1
<i>Evarcha jucunda</i>	2	1	3
<i>Heliophanus tribulosus</i>	0	1	1
<i>Pellenes geniculatus</i>	2	0	2
<i>Saitis barbipes</i>	1	0	1
Scytodidae			
<i>Scytodes thoracica</i>	38	0	38
Sparassidae			
<i>Olios argelasius</i>	1	0	1
Tetragnathidae			
<i>Metellina segmentata</i>	0	2	2
<i>Pachygnatha degeeri</i>	1	0	1
Theridiidae			
<i>Argyrodes argyrodes</i>	0	2	2
<i>Asagena italica</i>	2	0	2
<i>Platnickina tincta</i>	0	3	3
<i>Euryopsis episinoides</i>	1	0	1
<i>Rhomphaea nasica</i>	0	2	2
<i>Theridion pinastri</i>	0	1	1
<i>Theridion varians</i>	0	1	1
Thomisidae			
<i>Bassaniodes robustus</i>	1	0	1
<i>Ozyptila confluens</i>	4	0	4
<i>Runcinia grammica</i>	0	1	1
<i>Synema globosum</i>	0	4	4
Titanoecidae			
<i>Nurscia albomaculata</i>	3	0	3
Zodaridae			
<i>Zodarion vicinum</i>	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			
<i>Aculepeira armida</i>	0	1	1
<i>Agalenatea redii</i>	0	1	1
<i>Araneus diadematus</i>	0	1	1
<i>Cyrtophora citricola</i>	0	11	11
<i>Zygiella x-notata</i>	0	4	4
Dictynidae			
<i>Brigittea civica</i>	0	1	1
Gnaphosidae			
<i>Gnaphosa alacris</i>	1	0	1
<i>Gnaphosa lucifuga</i>	3	0	3
<i>Nomisio exornata</i>	1	0	1

Species	A	B	C
Linyphiidae			
<i>Erigone autumnalis</i>	1	0	1
<i>Frontinellina frutetorum</i>	0	38	38
<i>Trichoncus sordidus</i>	2	0	2
Lycosidae			
<i>Hogna radiata</i>	4	0	4
Oecobiidae			
<i>Oecobius maculatus</i>	1	0	1
Oxyopidae			
<i>Oxyopes lineatus</i>	1	0	1
Salticidae			
<i>Aelurillus v-insignitus</i>	1	0	1
<i>Chalcoscirtus infimus</i>	1	0	1
<i>Euophrys herbigrada</i>	1	0	1
<i>Heliophanus tribulosus</i>	0	6	6
<i>Pellenes geniculatus</i>	2	0	2
Sparassidae			
<i>Olios argelasius</i>	9	0	9
Tetragnathidae			
<i>Metellina segmentata</i>	0	2	2
Theridiidae			
<i>Argyrodes argyroides</i>	0	7	7
<i>Kochiura aulica</i>	0	22	22
<i>Platnickina tincta</i>	0	2	2
Thomisidae			
<i>Bassaniodes bufo</i>	2	0	2
<i>Runcinia grammica</i>	0	3	3
<i>Synema globosum</i>	0	3	3
Zodaridae			
<i>Zodarion elegans</i>	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.

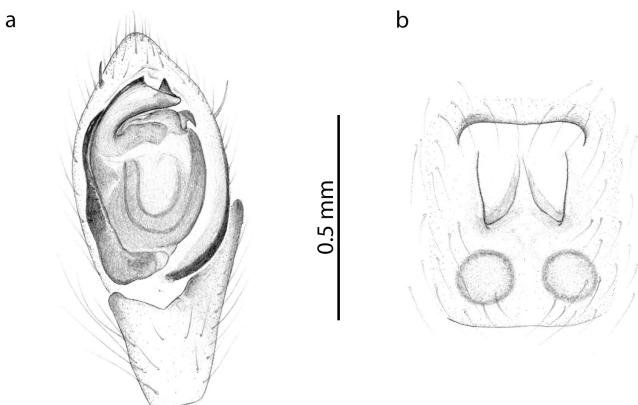


Fig. 2: *Zelotes fulvaster*. **a.** male palp, ventral view; **b.** epigyne, ventral view

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. biimpresum*, 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 from 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*, *Phlegma 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.

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