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Updated and annotated review of Tetranychidae occurring in mainland Portugal, the Azores, and Madeira Archipelagos

Pedro Naves^{a,b}, Filomena Nóbrega^a, Philippe Auger^c

^a Instituto Nacional de Investigação Agrária e Veterinária, I.P. (INIAV), Av. da República, Quinta do Marquês, 2780-157 Oeiras, Portugal.

^b GREEN-IT Bioresources for Sustainability, ITQB NOVA, Portugal.

^c CBGP, INRAE, CIRAD, IRD, Montpellier SupAgro, Univ Montpellier, Montpellier, France.

Original research

ABSTRACT

Data on the diversity, distribution, and main hosts of spider mites (Acari: Tetranychidae) are scarce in the Iberian Peninsula, particularly for Portugal, where only 21 species are recorded on the mainland and in the Azores and Madeira archipelagos. Moreover, the scientific information is mainly available in national publications, and difficult to access for international researchers. In this paper, we review the literature dealing with spider mites in mainland Portugal and the archipelagos of the Azores and Madeira, compiling and synthesizing the most relevant information on their distribution, hosts and pest potential. Further information was obtained by verifying slides in the acarological collection of the Instituto Nacional de Investigação Agrária e Veterinária (INIAV), the most important national collection, and by verifying mites collected on different plant hosts during the period 2018-2020. In total, we found records for 28 spider mite species in Portugal, comprising nine Bryobiinae and 19 Tetranychinae, and including new national records for *Stigmaeopsis nanjingensis* and *Eotetranychus tiliarium*. Additionally, we record a new exotic mite species for the mainland, *Eotetranychus lewisi*, which was found in two localities in the Algarve District on leaves of *Euphorbia pulcherrima*. This is the first record for continental Europe of an established population in outdoor conditions of this regulated quarantine pest. We also comment on the presence of seven species not reported by international taxonomic databases but already recorded from Portugal: *Aplonobia histricina*, *Eotetranychus rubiphilus*, *Schizonobia sycophanta*, *Tetranychus kanzawai* and *Tetranychopsis horridus* (at a national level), and *Oligonychus perseae* and *Panonychus citri* (for the mainland). New host records are given for *Bryobia praetiosa*, *Petrobia (Tetranychina) harti*, *S. sycophanta*, *E. coryli*, *E. rubiphilus*, *Tetranychus kanzawai*, *Tetranychus lintearius*, *Tetranychus ludeni* and *Tetranychus turkestanii*.

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Corresponding author

Pedro Naves: pedro.naves@iniav.pt

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Introduction

The family Tetranychidae contains some of the most injurious plant-feeding mites, including several pests of agricultural importance. In Portugal, mites associated with agricultural crops have been studied for more than 60 years, initially by M. M. Carmona and subsequently by M. A. Ferreira (Ferreira 2011), whilst information on tetranychids of non-agricultural plants is scarce and irregular.

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Bolland *et al.* (1998) listed 15 species of Tetranychidae for Portugal, while Carmona and Dias (1996) reported 19 species of spider mites for mainland Portugal, the Azores and Madeira archipelagos (referred as “Portugal” for the remainder of this paper), with two additional species [*Tetranychus hydrangeae* Pritchard & Baker 1955 and *Tetranychus cinnabarinus* (Boisduval 1867)] which are currently synonyms of *Tetranychus kanzawai* Kishida 1927 and *Tetranychus urticae* Koch 1835, respectively. Subsequent manuscripts, book chapters, academic theses and meeting abstracts were mainly published in national publications with limited distribution, making the information on the Portuguese tetranychid fauna difficult to access for international researchers. Consequently, this knowledge has been poorly disseminated, so that some species known to be present for Portugal are not recorded in international reference taxonomic databases, such as Spider Mites Web (Migeon and Dorkeld 2020) and Fauna Europaea (Bolland 2020).

Our objective is to complete the information on the diversity of Tetranychidae mites in Portugal, by compiling an updated list of the species known to occur in the country and synthesizing the most relevant information on their national distribution, main hosts, and damages. These data are reinforced by new regional and national records of recently collected spider mite species.

Material and methods

To register all the species of mites known to occur in Portugal (including the mainland, the Azores and Madeira archipelagos), we gathered available information from national and international published records, including research produced outside the traditional publishing and distribution channels such as reports, academic theses, national and regional meetings and conferences, and government documents.

We also consulted the Acarological collection of the Instituto Nacional de Investigação Agrária e Veterinária (INIAV, former Estação Agronómica Nacional), the most important national collection which comprises more than 9000 samples of phytophagous and predatory mites, collected uninterrupted since 1959 from cultivated and spontaneous plants (Ferreira 2011). In addition, mites recently collected by the senior author (PN) over a three-year period (2018-2020) in several locations in mainland Portugal, were also included in this assessment, when considered relevant.

For the nine Islands of the Azores archipelago, we used the following abbreviations: COR – Corvo; FLO – Flores; FAI – Faial; PIC – Pico; GRA – Graciosa; SJG – São Jorge; TER – Terceira; SMG – São Miguel, and SMR – Santa Maria.

The morphological identification of *Eotetranychus lewisi* (McGregor) was complemented with molecular analyses. Total DNA from the whole body of six individuals (four females and two males, kept in alcohol 70%) was extracted using the DNeasy Blood & Tissue Kit (Qiagen, Hilden, Germany) and two genomic regions were polymerase chain reaction (PCR) amplified and sequenced: the complete segment of the second internal transcribed spacer (ITS2) region of nuclear ribosomal DNA and a partial region of the cytochrome c oxidase subunit I (COI) gene of mitochondrial DNA. Primers ITS2-F (5'GTCACATCTGTCTGAGAGTTGAGA3') and the degenerate ITS2-R (5'GTARCCTCACCTRMCTCTGAGATC3') (Ben David *et al.* 2007; Mirza *et al.* 2020) and primers COI-F (5'TTYGAYCCWAGAGGAGGAGG3') and COI-R (5'AAACCTARAAAATGTTGWGG3') (Matsuda *et al.* 2013) were used for the PCR. PCR reactions were performed in a 50 µl final volume using the AccuStart II Taq DNA Polymerase kit (Quanta Biosciences) and the PCR cycling conditions as reported previously by Mirza *et al.* (2020). PCR products were cleaned with ExoSAP reagent (Thermo Fisher Scientific) and directly sequenced in both directions using the same primers at INIAV Sequencing Laboratory (Lisbon, Portugal) on a DNA analyser ABI PRISM 3730xl (Applied Biosystems). Sequences were compared with those available in the GenBank database using the BLAST homology search.

For the taxonomic nomenclature of plants, we followed the criteria of Flora Iberica (Castroviejo, 2012).

Results

Overall, we record 28 spider mite species for Portugal, including nine Bryobiinae and 19 Tetranychinae (Table 1).

We present and discuss the species alphabetically by subfamily, tribe, genus, and species, reviewing their distribution, most important host plants and damage potential, and reporting new mite-plant associations, when applicable. An exhaustive list of bibliographic references for all species is provided in Table 1, while in the text are mentioned only the references considered most relevant.

Bryobiinae Berlese, 1913

The Bryobiinae is represented by five genera and nine species in mainland Portugal, with two species in Madeira Island and none from the Azores archipelago (Table 1).

Tribe Bryobiini Berlese, 1913

Genus *Bryobia* Koch, 1936

Bryobia kissophila Eyndhoven, 1955

Bryobia kissophila has only one record from southern Portugal (Algarve) on *Hedera helix*, in a general study of intraspecific clonal diversity of populations from Europe and other continents (Ros *et al.* 2008) and has not been recorded subsequently.

Bryobia praetiosa Koch, 1836

The polyphagous *B. praetiosa* has been collected on numerous plant species of several families, including weed plants in greenhouses, at different locations (Carmona 1970; Pina *et al.* 2012). This is a common species in the INIAV acarological collection, having been collected on new host plant species which are presented in Table 1.

Bryobia rubrioculus (Scheuten, 1857)

First reported in Portugal in 1960, *B. rubrioculus* is quite polyphagous and has been found associated with *Pyrus* and *Malus* cultivars (Carmona 1960), *Ulmus* sp. (Carmona and Dias 1980), and occasionally with blackberry (*Rubus ulmifolius*), but without damaging the plants (Ferreira 2016a). Sobreiro (1993), considered *B. rubrioculus* one of the most important pest mites in pear orchards, but other authors reported a significant decline of its populations since the 1960s, when it was more abundant and occasionally caused damage to fruit orchards (Carmona and Dias 1980; Carmona 1992). *B. rubrioculus* is also reported from Madeira Island on *Ficus* sp. (Carmona 1992) and is found in the INIAV acarological collection.

Bryobia ulicis Eyndhoven, 1959

Bryobia ulicis was reported by Eyndhoven and Vacante (1985) from several locations in southern Portugal on *Ulex europaeus*. Nevertheless, the host reported by these authors is probably incorrect because *U. europaeus* does not occur on or near the locations where the mites were collected (Flora-On 2020), whilst other native *Ulex* species are common and widespread in the collection regions mentioned by the authors. There are no records of this species in the INIAV acarological collection, but in 2019 we collected two females on *U. europaeus* in the centre of Portugal (Table 2), suggesting more widespread national distribution.

Tribe Hystrichonychini Pritchard and Baker, 1955

Genus *Aplonobia* Womersley, 1940

Aplonobia histricina (Berlese, 1910)

This species was reported on the catalogue of Carmona and Dias (1996), collected in the Algarve, southern Portugal, this being the sole record on the INIAV acarological collection.

Table 1 Review of spider mite (Tetranychidae) species and new host records in mainland Portugal, the Azores and Madeira archipelagos, discerning the source of information.

Sub-family	Tribe	Genus	Species*	Mainland	Azores	Madeira	New host records (species/family/reference)
Bryobiinae	Bryobiini	<i>Bryobia</i>	<i>B. kissophila</i>	52			
			<i>B. praetiosa</i>	8, 15, 49, 56			<i>Anagallis arvensis</i> (Primulaceae), <i>Cardamine hirsuta</i> (Brassicaceae), <i>Lotus subbiflorus</i> (Fabaceae) (56)
			<i>B. rubrioculus</i>	5, 14, 15, 26, 48, 55, 56		13, 56	
			<i>B. ulicis</i>	23, 57			
	Hystrichonychini	<i>Aplonobia</i>	<i>A. histricina</i>	15, 56, 57			
		<i>Tetranychopsis</i>	<i>T. horridus</i>	15, 56			
		<i>Schizonobia</i>	<i>S. sycophanta</i>	15, 53, 54, 56			<i>Conyza sumatrensis</i> (Asteraceae); <i>Vitis vinifera</i> (Vitaceae) (56)
	Petrobiini	<i>Petrobia</i>	<i>P. apicalis</i>	8, 15, 56			
			<i>P. harti</i>	8, 14, 15, 49, 56		9, 56	<i>Digitaria sanguinalis</i> (Poaceae) (56)
Tetranychinae	Eurytetranychini	<i>Eurytetranychus</i>	<i>E. buxi</i>	14, 15, 56, 57			
		<i>Eutetranychus</i>	<i>E. banksi</i> †	18, 36, 56			
	Tetranychini	<i>Amphitettranychus</i>	<i>A. viennensis</i>	6, 14, 15, 32, 55, 56			
		<i>Eotetranychus</i>	<i>E. coryli</i>	7, 14, 15, 56			<i>Malus sylvestris</i> , <i>Prunus domestica</i> (Rosaceae) (7, 15)
			<i>E. lewisi</i> †	57		13, 15, 21, 56	
			<i>E. rubiphilus</i>	33, 49, 56			<i>C. hirsuta</i> (Brassicaceae), <i>Rubus brigitinus</i> , <i>Rubus henriquesii</i> , <i>Rubus radula</i> , <i>Rubus vigoii</i> (Rosaceae) (56)
			<i>E. tiliarium</i>	56, 57			
		<i>Oligonychus</i>	<i>O. bicolor</i>	14, 15, 56			
			<i>O. perseae</i> †	34, 56, 57		28, 56	
		<i>Panonychus</i>	<i>P. citri</i>	15, 29, 39, 48, 56	3, 20, 56		
			<i>P. ulmi</i>	1, 5, 10, 11, 14, 15, 16, 17, 19, 22, 25, 30, 40, 41, 42, 43, 45, 55, 56	3, 38	9, 15, 56	
		<i>Schizotetranychus</i>	<i>S. asparagi</i>	8, 14, 15, 56			
		<i>Stigmaeopsis</i>	<i>S. nanjingensis</i> †	57			
		<i>Tetranychus</i>	<i>T. evansi</i> †	2, 15, 31, 35, 48, 53, 54, 56		35, 44, 56	
			<i>T. kanzawai</i> †	15, 30, 56			<i>Mentha suaveolens</i> (Lamiaceae) (56)
			<i>T. lintearius</i>	37, 46, 57			<i>Ulex airensis</i> , <i>Ulex australis</i> , <i>Ulex densus</i> (57)
			<i>T. ludeni</i>	5, 14, 15, 26, 27, 30, 48, 54, 56	3, 20	13, 15	<i>Amaranthus retroflexus</i> (Amaranthaceae), <i>C. sumatrensis</i> (Compositae), <i>Mentha cervina</i> , <i>Mentha pulegium</i> (Lamiaceae), <i>Chondrilla juncea</i> , <i>Sonchus oleraceus</i> (Asteraceae), <i>Echinochloa crus-galli</i> (Poaceae), <i>Urtica urens</i> (Urticaceae) (56)
			<i>T. turkestanii</i>	6, 14, 15, 26, 27, 31, 47, 56			<i>A. arvensis</i> (Primulaceae), <i>Xanthium strumarium</i> (Asteraceae) (56)
			<i>T. urticae</i>	4, 5, 8, 9, 12, 14, 15, 16, 24, 26, 27, 30, 31, 45, 47, 48, 49, 50, 51, 54, 55, 56	3, 20	9, 15, 56	

*New national records are highlighted in bold; *E. lewisi* is a new record for the mainland; †exotic species for Portugal

Source: 1 – Amaro 1980; 2 – Bolland and Vala 2000; 3 – Borges et al. 2010; 4 – Brites et al. 2019; 5 – Carmona 1960; 6 – Carmona 1964; 7 – Carmona 1966; 8 – Carmona 1970; 9 – Carmona 1973a; 10 – Carmona 1973b; 11 – Carmona 1975; 12 – Carmona 1988; 13 – Carmona 1992; 14 – Carmona and Dias 1980; 15 – Carmona and Dias 1996; 16 – Carmona and Ferreira 1989; 17 – Carvalho 1971; 18 – Carvalho et al. 1999; 19 – Costa 2006; 20 – Costa-Comelles et al. 1993; 21 – EPPO 2020; 22 – Espinha et al. 1999; 23 – Eyndhoven et al. 1985; 24 – Ferreira 1980; 25 – Ferreira 1985; 26 – Ferreira 2016a; 27 – Ferreira 2016b; 28 – Ferreira et al. 2006; 29 – Ferreira and Carmona 1990; 30 – Ferreira and Carmona 1994; 31 – Ferreira and Carmona 1995; 32 – Ferreira and Carmona 1997; 33 – Ferreira et al. 2015; 34 – Ferreira et al. 2007; 35 – Ferreira and Sousa 2011; 36 – Gonçalves et al. 2002; 37 – Ireson et al. 2003; 38 – Lopes et al. 2009; 39 – Maltez 1985; 40 – Maltez 1988; 41 – Maltez 1994; 42 – Maltez 1997; 43 – Maltez and Carmona 1980; 44 – Migeon et al. 2009; 45 – Neves 2012; 46 – Norambuena et al. 2007; 47 – Pereira 2004; 48 – Pereira et al. 2006; 49 – Pina et al. 2012; 50 – Rodrigues 2012; 51 – Rodrigues et al. 2018; 52 – Ros et al. 2008; 53 – Santos 2011; 54 – Santos and Ferreira 2016; 55 – Sobreiro 1993; 56 – INIAV acarological collection; 57 – Naves et al., this manuscript.

Nevertheless, recent samplings by the first author revealed *A. histricina* to be common in urban and peri-urban areas in Lisbon District, in association with *Oxalis pes-caprae* (Table 2). The Portuguese record is the second for Europe, after a previous one from Italy (Migeon and Dorkeld 2020).

Genus *Tetranychopsis* Canestrini, 1889

Tetranychopsis horridus (Canestrini & Fanzago, 1876)

Tetranychopsis horridus is the unique species of this genus present on the mainland and was reported from northern Portugal on hazel (*Corylus avellana*), without causing significant damage (Carmona and Dias 1996). It is present in the INIAV acarological collection.

Table 2 New locations for spider mites collected by the senior author in mainland Portugal.

Mite species	Plant host	County	Location/Parish	Geographic coordinates	Altitude (meters above sea level)	Date of collection (month-year)
<i>Bryobia ulicis</i>	<i>Ulex europaeus</i>	Alcobaça	Ribafria (Benedita)	39°42'30.59"N 8°99'03.23"W	189	08-2019
<i>Aplonobia histricina</i>	<i>Oxalis pes-caprae</i>	Cascais	Abóboda	38°43'3.11"N 9°19'57.73"W	108	11-2019
	<i>Oxalis pes-caprae</i>	Cascais	Alcabideche	38°43'51"N 9°25'58"W	105	12-2020
	<i>Oxalis pes-caprae</i>	Oeiras	Qta Marquês (Oeiras)	38°41'47.24"N 9°19'12.03"W	44	04-2019
<i>Eotetranychus lewisi</i>	<i>Euphorbia pulcherrima</i>	Portimão, Loulé	na	na	na	05-2019, 11-2019, 10-2020
<i>Eotetranychus tiliarium</i>	<i>Tilia argentea</i>	Lisboa	Lumiar	38°46'27.73"N 9°9'28.38"W	93	10-2019
	<i>Tilia</i> sp.	Lisboa	Sete Rios	38°44'35.00"N 9°10'10.52"W	65	10-2019
<i>Eurytetranychus buxi</i>	<i>Buxus sempervirens</i>	Alcobaça	Ribafria (Benedita)	39°24'56"N 8°59'39"W	230	07-2020
	<i>Buxus sempervirens</i>	Lisboa	Lisboa	39°43'41"N 9°09'10"W	76	09-2019
<i>Oligonychus perseae</i>	<i>Persea americana</i>	Óbidos	na	na	na	09-2020
<i>Stigmaeopsis nanjingensis</i>	<i>Phyllostachys nigra</i>	Lisboa	Benfica	38°45'0.93"N 9°12'1.51"W	81	04-2018
	<i>Phyllostachys</i> sp.	Oeiras	Parque dos Poetas	38°42'6.11"N 9°18'13.41"W	80	05-2018
	<i>Phyllostachys</i> sp.	Viseu	Quinta da Cruz (Viseu)	40°39'19.69"N 7°56'6.07"W	390	05-2018
<i>Tetranychus lintearius</i>	<i>Ulex airensis</i>	Mafra	Urzal	38°56'27.41"N 9°22'28.64"W	122	06-2020
	<i>Ulex australis</i>	Alcáçer do Sal	Alcáçer do Sal	38°23'17.34"N 8°29'22.74"W	64	04-2019
	<i>Ulex australis</i>	Grândola	Troia	38°28'4.97"N 8°52'14.53"W	15	08-2020
	<i>Ulex densus</i>	Sintra	Varge Mondar	38°45'16.67"N 9°19'42.04"W	105	05-2020
	<i>Ulex densus</i>	Cascais	Abóboda	38°43'10.43"N 9°19'41.29"W	101	07-2019

na - data not available

Genus *Schizonobia* Womersley, 1940

***Schizonobia sycophanta* Womersley, 1940**

Schizonobia sycophanta has a restricted distribution in the Palearctic, having previously only been reported from the Netherlands (Migeon and Dorkeld 2020). In Portugal, it was collected on *Echium plantagineum* growing in vineyards in the Setúbal region (Santos 2011). Furthermore, in the INIAV collection there are specimens collected from leaves and trunk of *Vitis vinifera* in different locations of southern Portugal, and from *Conyza sumatrensis* (labelled as *C. albida*), which are new hosts for this mite (Table 1).

Tribe Petrobiini Reck, 1952

Genus *Petrobia* Murray, 1877

***Petrobia (Petrobia) apicalis* Banks, 1917**

Petrobia (Petrobia) apicalis is a probable exotic of Nearctic origin and was reported by Carmona (1970) on unidentified *Poaceae* weeds in Cascais, near Lisbon, with the slides included in the INIAV acarological collection. The species has not been reported subsequently.

***Petrobia (Tetranychina) harti* (Ewing, 1909)**

The oxalis spider mite, *P. (Tetranychina) harti*, appears to be common and widespread on the mainland, associated mainly with different *Oxalis* species, but also with *Pennisetum longistylum*, *Citrus grandis* and strawberries (*Fragaria* spp.) (Carmona 1970; Carmona and Dias 1980), being also common on weeds in greenhouses (Pina *et al.* 2012). The INIAV collection contains several specimens, mostly collected from *Oxalis corniculata* but also from *Digitaria sanguinalis*, which is a new host for this mite (Table 1). The oxalis spider mite is also reported from Madeira Island, on *O. pes-caprae* (Carmona, 1973a).

Tetranychinae Berlese, 1913

The Tetranychinae includes nine genera and 19 species on mainland Portugal, with six species on Madeira Island and four on the Azores archipelago (Table 1).

Tribe Eurytetranychini Reck, 1950

Genus *Eurytetranychus* Oudemans, 1931

***Eurytetranychus buxi* (Garman, 1935)**

This species has been found on *Buxus sempervirens* in the mainland (Carmona and Dias 1980), being present in the INIAV collection. Despite the absence of additional published records, this mite was recently found by the first author in public and private gardens in the centre and south of mainland Portugal, along with its host plant (Table 2).

Genus *Eutetranychus* Banks, 1917

***Eutetranychus banksi* (McGregor, 1914)**

This exotic species is known as the Texas citrus mite and was reported in the Algarve region (southern Portugal) in 1999 causing significant damage to citrus (Carvalho *et al.* 1999). It is considered a local key-pest by citrus farmers (Gonçalves *et al.* 2002) and is very abundant in citrus orchards in southern Portugal (Naves, personal observations). It is frequent in the INIAV acarological collection, mainly reported from *Citrus* and occasionally from almond, *Prunus dulcis*, in southern Portugal.

Tribe Tetranychini Reck, 1950

Genus *Amphitetranychus* Oudemans, 1931

Amphitetranychus viennensis (Zacher, 1920)

The polyphagous and globally widespread species, *A. viennensis*, was first reported by Carmona in 1964 (as *Tetranychus viennensis*) on *Malus sylvestris*, *Prunus persica*, *Pyrus communis*, and subsequently on other Rosaceae (Carmona and Dias 1980). Despite being considered an important pest in apple orchards (Sobreiro 1993), its populations have been systematically declining since the 1960s (Carmona and Dias 1980), and less than 1% of peach (*P. persica*) orchards were infested in a study conducted in the south and centre of Portugal (Ferreira and Carmona 1997). *A. viennensis* is, consequently, represented by a small number of specimens in the INIAV acarological collection.

Genus *Eotetranychus* Oudemans, 1931

Eotetranychus coryli Reck, 1950

Eotetranychus coryli was reported from several locations in mainland Portugal in 1966 (Carmona 1966), this being one of the first reports in Europe. Its main host is *Corylus avellana* (Carmona 1966; Carmona and Dias 1980), although it has also been collected on *Castanea sativa*, *M. sylvestris* and *Prunus domestica* in north-eastern Portugal (Carmona 1966), the last two plant species being new hosts for this mite (Table 1). Present in the INIAV collection.

Eotetranychus lewisi (McGregor, 1943)

The Lewis spider mite, *E. lewisi* was reported by Carmona (1992) on plants of poinsettia *Euphorbia pulcherrima* and on *Vitis* sp. in Funchal, Madeira Island, included in the INIAV collection. After this finding there are few additional references to this species in Madeira, but from 2017 onwards *E. lewisi* was again detected in poinsettia plants growing wild and in gardens (EPPO, 2020).

The Lewis spider mite is regulated as an A1 quarantine pest for the EU (Annex II - Part A: Pests not known to occur in the Union territory) (EU 2019) and has the potential to establish in large parts of the EU territory (EFSA 2017). In Europe, *E. lewisi* has been reported from Norway, Germany, the UK (EFSA 2017) and Poland (Labanowski 2009), mostly from imported plants kept in glasshouses, but it was successfully eradicated in all the outbreaks (EFSA 2017). A new outbreak was recently reported from nurseries producing poinsettias under greenhouses in Germany, with eradication ongoing (EPPO, 2020).

In continental Portugal, the Lewis spider mite was recently identified from samples collected by the national plant health authority, DGAV - Direção-Geral de Alimentação e Veterinária, in two localities in the Algarve District (Portimão and Loulé county), in 2019 and 2020. Identified specimens were found on leaves of *E. pulcherrima* grown in gardens, confirming high preference for this plant host (Andrews and Poe 1980; Goff 1986; Carmona 1992; Ho and Shih 2004; Ho 2007). Examined leaves of *E. pulcherrima* contained abundant numbers of eggs, immature stages and adults of both sexes, this being the first record for mainland Portugal and continental Europe of an established population in outdoor conditions.

Molecular analysis endorsed the morphological identification: BLAST analysis of the sequences of ITS2 region (447 bp) were 99,76% and 99,55% identical to the only two *E. lewisi* sequences (JF774172 and EU007694, respectively) available in the GenBank. The new sequences were deposited to GenBank database (NCBI) under the accession numbers MW524100 to MW524105. For the COI region (530 bp), the BLAST analysis showed that this primer combination amplified mtDNA of the mite, but in the absence of COI region sequences for this species in the GenBank, it is not possible to determine homology. The sequences were deposited to GenBank database (NCBI) under the accession numbers MW538643 to MW538648. Voucher specimens mounted in slides are deposited in the INIAV acarological collection, reference numbers SV-19-00673, SV-19-02071 and SV-20-01735.

***Eotetranychus rubiphilus* Reck, 1948**

Eotetranychus rubiphilus was reported in 2011 on blackberries (*Rubus* sp.) in a greenhouse in Odemira, southern Portugal (Pina *et al.* 2012), causing damage mainly to the Karaka Black cultivar (Ferreira *et al.* 2015). In the INIAV collection, there are specimens collected during the last decade on several *Rubus* species, which are new hosts for this mite (Table 1). It is the most important phytophagous mite affecting blackberries, particularly in greenhouses, although it has not been found on some species, such as *Rubus sampaioanus* (Ferreira, 2016a). Additionally, *E. rubiphilus* has been collected in Odemira (Beja District) on *V. vinifera*, supporting the suggestion of Migeon *et al.* (2007) that its occurrence on grapevines could be more widespread than assumed previously.

***Eotetranychus tiliarium* (Hermann, 1804)**

Eotetranychus tiliarium is here reported for the first time for continental Portugal and was collected in 2019 on young and adult lime (*Tilia* sp.) trees in the city of Lisbon (Table 2). Moreover, slides of this species collected on *Tilia* sp. in Guimarães (northern Portugal) were present in the INIAV acarological collection since 2010, suggesting a more widespread national distribution of this mite.

Genus *Oligonychus* Berlese, 1886

***Oligonychus bicolor* (Banks, 1894)**

In Portugal, *O. bicolor* is mainly associated with oaks (*Quercus* spp.) (Carmona and Dias, 1980; 1996), but also occasionally found on chestnut (*C. sativa*) in the North and centre of the mainland, without causing damage (Carmona and Dias 1996). It is present in the INIAV acarological collection.

***Oligonychus perseae* Tuttle, Baker & Abbatiello, 1976**

The Persea mite, *O. perseae*, was detected on Madeira Island in 2005 associated with avocado (*Persea americana*), grapes (*V. vinifera*), European plum (*P. domestica*) and the ornamentals *Wisteria sinensis* and *Bauhinia variegata* (Ferreira *et al.* 2006). In 2006, it was found in the Algarve (mainland Portugal), associated mainly with avocado (Hass, Reed and Bacon cultivars), but also with carob trees (*Ceratonia siliqua*), Sweet cherry (*Prunus avium*), Persimmon (*Diospyros kaki*), common Walnut (*Juglans regia*) and grapes (Ferreira *et al.* 2007), being included in the INIAV collection. In 2020, *O. perseae* was found causing significant damage to avocado in the Óbidos region, centre Portugal, suggesting a significant northern extension of its known distribution range.

Genus *Panonychus* Yokoyama, 1929

***Panonychus citri* (McGregor, 1916)**

The citrus red mite, *P. citri*, was detected in 1984 on the mainland with widespread and abundant populations on citrus, a few years after its detection in neighbouring Spain (Maltez 1985). This species is more common in the centre and south of continental Portugal (Ferreira and Carmona 1990; Carmona and Dias 1996; Pereira *et al.* 2006), usually near the coast, where its hosts are more often planted, and temperatures are not so extreme. It is also a common species in the Azores (Costa-Comelles *et al.* 1993), where it was found on four Islands - FAI, PIC, TER and SMG (Borges *et al.* 2010). There are several slides in the INIAV acarological collection.

***Panonychus ulmi* (Koch, 1836)**

The European red mite, *P. ulmi*, is widespread and abundant on mainland Portugal (Carmona 1960; Carvalho 1971; Amaro 1980), on Madeira island (Carmona 1973a; Carmona and Dias 1996) and on the Azorean Islands of PIC and TER (Borges *et al.* 2010).

It is considered the most important phytophagous mite on fruit orchards and a key-pest of apple (and occasionally pear) agrosystems in the mainland (Amaro 1980; Carmona and Dias 1980; Maltez and Carmona 1980; Sobreiro 1993; Espinha *et al.* 1999; Costa 2006) and the Azores (Lopes *et al.* 2009). Damage has also been reported on grapes (Carmona 1973b; Carmona and Dias 1980; Carmona and Ferreira 1989) and occasionally on beans (Ferreira and Carmona 1994) and tomato (Neves 2012), with up to nine (Maltez 1994) or ten (Sobreiro 1993) annual generations possible. It is frequent in the INIAV acarological collection.

Genus *Schizotetranychus* Trägrådh, 1915

***Schizotetranychus asparagi* (Oudemans, 1928)**

This species was reported on the mainland on the ornamental fern, *Asparagus setaceus*, and on *Asparagus officinalis* (Carmona 1970; Carmona and Dias 1980), with the slides included in the INIAV acarological collection. There are no additional recent reports.

Genus *Stigmaeopsis* Banks, 1917

***Stigmaeopsis nanjingensis* (Ma & Yuan, 1980)**

This species is a new record for the Portuguese tetranychid fauna. It was detected in public gardens on *Phyllostachys nigra* in Lisbon, and on *Phyllostachys* sp. in Oeiras and Viseu (Table 2), suggesting a widespread national distribution on its bamboo hosts, which are popular ornamental plants in private and public gardens. Populations were abundant and protected by a dense web nest on the under surface of the leaves, causing conspicuous whitish-yellow spots on the upper side of leaves and negatively affecting the aesthetic value of the plants.

Genus *Tetranychus* Dufour, 1832

***Tetranychus evansi* Baker & Pritchard, 1960**

The tomato spider mite, *T. evansi*, is an important pest of solanaceous crops and was detected in continental Portugal in 1991 (the first report in Europe), 60 km northeast of Lisbon and causing severe damage to tomato (Ferreira and Carmona 1995). A few years later, it was again reported as a new addition to the Portuguese tetranychid fauna by Bolland and Vala (2000). The tomato spider mite is now widespread from Minho to the Algarve, being more frequent in the centre and south of the mainland except for mountainous interior regions where low temperatures during winter seem to limit its presence. It is also found on Madeira Island (Migeon *et al.* 2009; Ferreira and Sousa 2011). This polyphagous mite has been found locally, associated with 39 different plant species belonging to 14 families, in particular to Asteraceae and Solanaceae (Ferreira and Sousa 2011). Its most important local cultivated host is tomato (*Solanum lycopersicum*), on which severe damage was observed (Carmona and Dias 1996). The widespread black nightshade, *Solanum nigrum*, is a common wild host for this mite (Ferreira and Sousa 2011; Santos 2011), and many specimens collected from this plant are present in the INIAV acarological collection.

***Tetranychus kanzawai* Kishida, 1927**

Another exotic species, the Kanzawa spider mite, *T. kanzawai*, was reported in 1994 by Ferreira and Carmona (as *T. hydrangeae*), being more common in the north and centre of the country, where it is mostly associated with bean (*Phaseolus* spp.) (Carmona and Dias 1996). There is one record of this species on *Mentha suaveolens*, a new host plant, in the INIAV acarological collection (Table 1).

***Tetranychus lintearius* Dufour, 1832**

Tetranychus lintearius is a specialist of the genus *Ulex* (Fabaceae) and has been locally reported from *U. europaeus* (Ireson *et al.* 2003; Norambuena *et al.* 2007). Despite being absent from the

INIAV acarological collection, this mite is quite common and widespread in mainland Portugal. In the last three years, it has been found associated with *U. europaeus*, *Ulex minor*, and other new *Ulex* host species: *Ulex airensis*, *Ulex australis*, and *Ulex densus* (Tables 1 and 2).

***Tetranychus ludeni* Zacher, 1913**

The red mite, *T. ludeni*, is widespread in the centre and south of mainland Portugal (Carmona 1960; Carmona and Dias 1980). It is also common on the Azores archipelago, namely on FAI, PIC and SMG (Costa-Comelles *et al.* 1993; Borges *et al.* 2010), and on Madeira Island, where it attacks local banana plantations causing damage to the fruits (Carmona 1992; Carmona and Dias 1996). This polyphagous mite can be found on several important agricultural crops, but particularly on bean, *P. vulgaris* (Carmona and Dias 1980; Ferreira and Carmona 1994). Specimens of *T. ludeni* are very frequent in the INIAV acarological collection, with new plant hosts presented in Table 1.

***Tetranychus turkestani* (Ugarov & Nikolskii, 1937)**

The strawberry spider mite, *T. turkestani*, is a major pest of crops and has been found on cultivated and non-cultivated plants (Carmona 1964; Carmona and Dias 1980), including tomato (Ferreira and Carmona, 1995), strawberries (*Fragaria* spp.) and corn (*Zea mays*) (Carmona and Dias 1980, as *T. atlanticus*; Pereira 2004), but also in vineyards and on fruit trees. In the INIAV acarological collection there are additional samples from weeds in agricultural fields, including new hosts for this species (Table 1). It is present all over the mainland and appears to be more frequent in the north and centre (Carmona and Dias 1996).

***Tetranychus urticae* Koch, 1835**

The two-spotted spider mite, *T. urticae*, particularly the red form formerly known as *T. cinnabarinus* (Auger *et al.* 2013) and *T. telarius* (Smith and Baker, 1968) is locally widespread and quite common (Carmona 1960; 1973a; Carmona and Dias 1980; Ferreira 1980; Ferreira and Carmona 1995). The mite is present all over the mainland (Carmona and Dias 1980), and also found on Madeira (Carmona 1973a; Carmona and Dias 1996) and on three Azorean Islands (FAI, TER and SMG) (Costa-Comelles *et al.* 1993; Borges *et al.* 2010).

The two-spotted spider mite is associated with a wide range of hosts, including wild and ornamental plants and agricultural crops, being quite common on grapes and fruit trees, where it causes damage (Carmona 1988; Carmona and Ferreira 1989; Sobreiro 1993; Carmona and Dias 1996; Brites *et al.* 2019). Other common hosts include bean (Ferreira 1980; Ferreira and Carmona 1994), corn (Pereira 2004), tomato (Ferreira and Carmona 1995) and raspberries (*Rubus idaeus*), particularly in greenhouses (Ferreira 2016b). The number of annual generations varies from six to twelve, according to the region and local climatic conditions (Rodrigues 2012). According to Neves (2012), populations usually increase after application of wide-spectrum pesticides, which probably disrupt natural control by predatory phytoseiid mites (Rodrigues 2012). It is the most common species in the INIAV acarological collection, associated with multiple plant hosts but mainly with tomato, strawberry, and vineyards.

Discussion

Overall, we compiled a total of 28 species of tetranychids for the Portuguese fauna, including several species which have been previously reported but are generally overlooked in international taxonomic databases (*A. histricina*, *E. rubiphilus*, *O. perseae*, *P. citri*, *S. sycophanta*, *T. horridus*, *T. kanzawai*), two species which constitute new national records (*E. tiliarium*, *S. nanjingensis*) and one new record for the mainland (*E. lewisi*). Four and eight species occur on the Azores archipelago and Madeira Island, respectively. Spider mites have not been reported from Porto Santo, the second inhabited Island of the Madeira Archipelago and this could be

due to the absence of sampling and/or to lower availability of suitable host plants in the small, semi-desert ecosystem on the island.

The number of tetranychid mites recorded from Portugal is not remarkably high when comparing with other European countries with similar dimensions, with 37 species recorded for Hungary (Kontschán and Ripka 2017) and 44 for Serbia (Marić *et al.* 2018, 2021), which probably reflects the differences in the dominant vegetation communities, in sampling effort, and in the number of local taxonomic specialists.

It is worth noting the considerable component of non-indigenous species (at least six species, with *A. histricina*, *P. apicalis* and *P. citri* also of probable exotic origin), which correspond to 21% of the tetranychid fauna and highlight the ease with which spider mites are transported and introduced in international trade of mite-infested agricultural and ornamental plants (Navajas *et al.* 2010). The Mediterranean climate prevailing in most of mainland Portugal provides suitable climatic conditions for plant and mite species of temperate climates, but also for the establishment of species of tropical or sub-tropical origin, such as the recently detected *S. nanjingensis* and *E. lewisi*, among others.

Some species are locally important agricultural pests, namely *E. banksi* and *P. citri* on citrus, *P. ulmi* on fruit orchards, *T. evansi* on tomato and *T. urticae* mainly on grapes, tomato, and strawberries, while *E. rubiphilus* and *O. perseae* also exhibit high populations on their main hosts. The recently detected Lewis mite, *E. lewisi*, is a polyphagous pest which can attack several economically important crops in Portugal and in the EU, including *Citrus*, *Carica*, *Euphorbia*, *Fragaria*, *Ficus*, *Olea*, *Prunus*, *Rubus* and *Vitis* (EFSA 2017; EPPO 2021), and should be monitored as a potentially harmful species with its distribution, population levels, main hosts, possible impact, and damages to crops evaluated.

Mite sampling and published studies in Portugal are historically biased towards the species of highest agricultural importance, particularly of the genera *Eotetranychus*, *Oligonychus*, *Panonychus* and *Tetranychus*, whilst most species affecting non-cultivated plants are known from isolated or infrequent records and have not been regularly collected/reported, including *A. histricina*, *B. ulicis*, *B. kissophila*, *P. apicalis*, *T. lintearius* and *S. asparagi*. Nevertheless, this does not necessarily mean they are rare or have restricted distributions, considering the examples of *A. histricina*, *B. ulicis*, *E. buxi* and *T. lintearius* with few records but recently found to be abundant and/or widespread.

It would be interesting to evaluate the presence and impact of *E. buxi* on wild specimens of its host, *B. sempervirens*, which has small and confined natural populations on river gorges and rocky ravines in northern Portugal, being classified as a nationally endangered species (Carapeto *et al.* 2020). Additional sampling of wild vegetation, particularly plant species having limited geographical distribution, may reveal the presence of other tetranychids, particularly Bryobiinae. Furthermore, a few species present in neighbouring Spain, such as *Eutetranychus orientalis* (Klein 1936), *Eotetranychus carpini* (Oudemans, 1905), *Eotetranychus aceri* Reck, 1948, *Oligonychus ununguis* (Jacobi 1905) and *Neotetranychus rubi* Trägårdh 1915 (Migeon and Dorkeld 2020), may be expected to be detected in the future, considering their current distribution and the availability and abundance of their plant hosts in Portugal.

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