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New records of phytoseiid mites (Acari: Mesostigmata) from Madeira Island

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Original research

ABSTRACT

Madeira is the largest of the four islands constituting Madeira Archipelago in the North Atlantic Ocean. It is located at 400 km from the Northern Canary Islands, at 500 km from Morocco and between 900 and 1000 km from South Portugal and Spain. So far, nineteen species of the mite family Phytoseiidae had been reported from this island. We report in this paper the results of a survey conducted in May 2019 in Madeira Island, in which 15 species have been found, six being new for the Island fauna.

Keywords survey; collection; taxonomy; systematics; predatory mites

Introduction

Species of the family Phytoseiidae are all predators of phytophagous mites and small insects like thrips and whiteflies, both on crops and wild vegetation. Several species are biological control agents of pest organisms in both open and protected crops all around the world (McMurtry and Croft 1997; McMurtry et al. 2013; Knapp et al. 2018).

This family is widespread around the world, present on all continents except Antarctica, and consists of about 2,500 valid species, dispatched in 94 genera and three subfamilies (Demite et al. 2021).

Biodiversity surveys in poorly investigated areas is still an urgent need and might result in the discovery of additional species potentially useful for biological control as well as in getting more information on the biodiversity of these areas in the context of global climatic changes (Kreiter et al. 2018a, b, c, 2020a, b, c, d, 2021a, b, c; Ferragut and Baumann 2019, 2020, 2021; Döker et al. 2020; Kreiter and Abo-Shnaf 2020a, b; Fang et al. 2020; Demite et al. 2021; Toldi et al. 2021).

In these perspectives, the most interesting areas are probably those with a high level of biodiversity. Macaronesia is renowned for its biodiversity, with extraordinary high levels of species diversity and endemism in both the terrestrial and marine realms and constitutes a biodiversity hotspot (Kondraskov et al. 2015). Those areas, being called hotspots, were defined by Myers (1988) in order to identify the most immediately important areas for biodiversity conservation. The common characteristics of these hotspots are that they hold high endemism levels and have lost at least 70% of their original natural vegetation (Myers et al. 2000).

Located in the Atlantic Ocean at around 500 km away from the western coast of Morocco, about 400 km from the Northern Islands of the Canary Archipelago in the so-called Macaronesia region, Madeira Island is one of the four main islands constituting Madeira Archipelago, with Porto Santo and the two main Desertas Islands, Deserta Grande and Bugio, the largest of the four ones, with more than 740 km² on a total of 801. This Archipelago was a historical crossing point just like Canary Archipelago, with ships stopping at departure towards Africa or South America or ships returning to Europe full of Tropical plants. Both native and imported species are thus expected to be present.
Nineteen phytoseiid species are known from this island (Demite et al. 2021). Carmona (1962) recorded firstly Iphiseius degenerans (Berlese). Then, she recorded additional four species: Amblyseius largoensis (Muma), Euseius hibisci (Chant), Typhlodromus (Anthoseius) rhenanus (Oudemans) and Typhlodromus (Typhlodromus) pyri Scheuten (Carmona, 1973). Papadoulis and Kapaxidi (2011) added five other species, namely: E. stipulatus (Athias-Henriot), Neoseiella canariensis (Ferragut and Peña-Estévez), Neoseiulus madeirensis Papadoulis and Kapaxidi, T. (A.) rhenanoides Athias-Henriot and T. (T.) phialatus Athias-Henriot. Recently, Ferragut and Baumann (2020) described three new phytoseiid species of the subfamily Amblyseiinae from the Island: N. laetus Ferragut, N. uncinatus Ferragut and Chelaseius longicervix Ferragut, and the unknown male of N. madeirensis. They mentioned also six additional species of Amblyseiinae reported for the first time from the Madeira Archipelago, namely: N. californicus (McGregor), Kampimodromus aberrans (Oudemans), Phytoseiulus persimilis Athias-Henriot, A. herbicolus (Chant), E. machadoi Ferragut and Peña-Estévez and E. scutalis (Athias-Henriot).

Therefore, the number of the recorded species is of 19 for Madeira Island, prior to this study.

The objective of this paper is to report the phytoseiid species found in a survey conducted by the senior author in May 2019 in Madeira Island.

Material and methods

The survey took place in Madeira Island from 13th to 23rd of May, 2019. Plant inhabiting mites were collected from cultivated and wild plants in all parts of the island.

Mites were directly collected from leaves with a fine brush with or without a pocket lens (large leaves and herbaceous plants) or by beating the plants (mainly shrubs and trees with very small or spiny leaves) and collecting the mites in a black plastic rectangular saucer 45 x 30 cm (Ref. STR 45, BHR, 71370 Saint-Germain-du-Plain, France). Collected mites were then transferred into small plastic vials containing 1.5 ml of 70% ethanol by using a fine brush. A total of 116 Phytoseiidae in 29 samples were collected and the percentage of some species have been calculated by dividing the number for those species by the total number of phytoseiids or the number in which the species is present by the total number of samples.

The mites were then slide-mounted in Hoyer’s medium (Walter and Krantz 2009), the slides were dried at 45-50°C for at least two weeks and then examined and identified using a phase and interferential contrast microscope (DMLB, Leica Microsystèmes SAS, Nanterre, France). Characters of specimens were measured using a graded eyepiece (Leica, see above).

Chant and McMurtry’s (1994, 2007) concepts of the taxonomy of the family Phytoseiidae for identification and the world catalogue database of Demite et al. (2014, 2021) for distribution and information on descriptions and re-descriptions were used.

The setal nomenclature system adopted was that of Lindquist & Evans (1965) and Lindquist (1994) as adapted by Rowell et al. (1978) and Chant & Yoshida-Shaul (1989) for the dorsal surface and by Chant & Yoshida-Shaul (1991) for the ventral surface. Pore (= solenostome) and poroid (= lyrifissure) notations are that of Athias-Henriot (1975). Macrosetal notation (Sge = genual macroseta; Sti = tibial macroseta; St = tarsal macroseta) is that of Muma and Denmark (1970). Types of spermatheca or insemination apparatus are those proposed by Denmark and Evans (2011). Numbers of teeth on the fixed and movable cheliceral digits do not include the respective apical tooth. Setae not referred to in results section should be considered as absent.

All measurements are given in micrometres (µm) and presented with the mean followed by the range in parenthesis (data concerning our specimens are in bold). Classification of plants follows the APG IV classification of 2016 (ex. Byng et al. 2018).

Specimens of each species are deposited in the mite collections of Montpellier SupAgro conserved in UMR CBGP INRAE/IRD/CIRAD/Institut Agro (SupAgro)/University of Montpellier.
The following abbreviations are used in this paper for morphological characters: 

- **dsl** = dorsal shield length just above J1 to just below J5 in the middle line; 
- **dsw** = dorsal shield width at the level of s4; 
- **Z4 ser., Z5 ser.** = Z4, Z5 serrated (if Z4 and Z5 without ser. = not serrated); 
- **gns1** = genital shield length; 
- **gns w st5** = genital shield width at level of setae st5; 
- **gns w post. cor.** = genital shield width at level of posterior corners; 
- **lis1** = primary or largest inguinal sigilla (= “metapodal plate”) length; 
- **lis w** = primary or largest inguinal sigilla (= “metapodal plate”) width; 
- **sis1** = secondary or smallest inguinal sigilla (= “metapodal plate”) length; 
- **vsl** = ventrianal shield length; 
- **gv3 – gv3** = distance between centers of solenostomes gv3 on the ventrianal shield; 
- **vsw ZV2 & vsw anus** = ventrianal shield width at ZV2 level and at paranal setae level; 
- **sc1** = calyx total length; 
- **scw** = calyx widest width; 
- **Fd1** = fixed digit length; 
- **Md1** = movable digit length; 
- **Nb teeth Fd** = number of teeth on the fixed digit; 
- **Nb teeth Md** = number of teeth on the movable digit; 
- **Shaft** = length of the shaft of spermatodactyl; 
- **toe** = length of the toe; 
- **BCA** = Biological control agent; 
- **aasl** = altitude above sea level; 
- **imm.** = immature.

The following abbreviations are used in this paper for institutions: 

- **CBGP** = Centre de Biologie pour la Gestion des Populations; 
- **CIRAD** = Centre International de Recherche Agronomique pour le Développement; 
- **IA** = Institut Agro; 
- **INRAE** = Institut National de Recherche pour l’Agriculture, l’Alimentation et l’Environnement; 
- **IRD** = Institut de Recherche pour le Développement; 
- **MSA** = Montpellier SupAgro, France; 
- **UMR** = Unité Mixte de Recherche.

### Results and Discussion

A total of fifteen species had been found during this study presented hereafter. Six species are presented with new measurements compared to only few references already available in the literature.

**Subfamily Amblyseiinae Muma**

Amblyseiinae Muma 1961: 273.

**Tribe Neoseiulini Chant & McMurtry**

Neoseiulini Chant & McMurtry 2003a: 6.

**Genus Neoseiulus Hughes**

Neoseiulus Hughes 1948: 141.

**Neoseiulus madeirensis Papadoulis & Kapaxidi**

Neoseiulus madeirensis Papadoulis & Kapaxidi 2011: 119.

Neoseiulus madeirensis belongs to the cucumeris species group of Neoseiulus, as the dorsocentral setae are not short relatively to dorsolateral setae. It belongs to the cucumeris species subgroup as the spermatheca does not have a stalk between calyx and atrium, the atrium is undifferentiated or nodular and joined directly to calyx (Chant and McMurtry 2003a).

This species was already recorded in Madeira Island as it was collected and described by Papadoulis and Kapaxidi (2011) from specimens collected on Lantana sp. in the Botanical Garden of Funchal in Madeira Island. Its biology is totally unknown.

**World distribution:** Madeira Island.

**Specimens examined:** a single specimen (1 ♀) collected during this study. **Ribeira Brava,** Dazkarizeh Guesthouse (475 m aasl, 32°40′5″ N, 17°2′55″ W), 1 ♀ on Hibiscus tiliaceus L. (Malvaceae), 21/V/2019.

**Remarks:** measurements of morphological characters and traits of the *N. madeirensis* female specimen from Madeira Island (Table 1) are very close to measurements of specimens
considered in the original description by Papadoulis and Kapaxidi (2011). We have added some measurements of some important characters not documented before as it is only the second record of that species from Madeira Island. Our specimen was collected at Ribeira Brava, at only 20 km from the botanical garden of Funchal from where the species has been described.

**Neoseiulus teke (Pritchard & Baker)**

*Amblyseius (Amblyseius) teke* Pritchard & Baker 1962: 239.

*Amblyseius teke*, Meyer & Rodrigues 1966: 30, Moraes et al. 1989a: 83, 1989b: 97.

*Neoseiulus teke*, Moraes et al. 1986: 98, 2004b: 147, Chant & McMurtry 2003a: 37, 2007: 31.

*Amblyseius (Amblyseius) bibens* Blommers 1973: 111 (synonymy according to Ueckermann & Loots 1988).

*Neoseiulus teke* belongs to the *barkeri* species group and the *womersleyi* species subgroup (Chant and McMurtry 2003a). This species is reported from sub-Saharan Africa often associated with *Mononychellus tanajoa* (Bondar), the cassava green mite (CGM) (Mutisya et al. 2017). It has been studied for its potential as BCA against the CGM. Nwilene and Nachman (1996) studied its reproduction characteristics on *M. tanajoa*. It was more efficient than *I. degenerans*, but seems not efficient enough in field conditions (Nwilene and Nachman 1996). This is the first report of this species from Madeira Island. The Madeira population might have originated from Madeira Island 2011 (10).

### Table 1
Character measurements of an adult female of *Neoseiulus madeirensis* collected in this study with those obtained from previous studies (localities followed by the number of specimens measured between brackets).

| Characters | Madeira Island (1) | Madeira Island 2011 (10) |
|------------|-------------------|--------------------------|
| Dsl        | 340               | 327 (321 – 340)          |
| Dsw        | 175               | 168 (161 – 174)          |
| j1         | 23                | 24 (23 – 27)             |
| j3         | 51                | 51 (49 – 52)             |
| j4         | 48                | 48 (45 – 50)             |
| j5         | 50                | 50 (49 – 52)             |
| j6         | 55                | 57 (54 – 59)             |
| J2         | 58                | 55 (50 – 58)             |
| J5         | 12                | 11 (9 – 13)              |
| z2         | 50                | 50 (47 – 54)             |
| z4         | 58                | 57 (54 – 59)             |
| z5         | 43                | 45 (41 – 49)             |
| Z1         | 53                | 54 (50 – 58)             |
| Z4         | 63                | 67 (65 – 70)             |
| Z5         | 73                | 70 (65 – 76)             |
| s4         | 65                | 62 (59 – 68)             |
| S2         | 59                | 57 (50 – 61)             |
| S4         | 34                | 32 (29 – 36)             |
| S5         | 28                | 27 (25 – 29)             |
| r3         | 35                | 32 (29 – 36)             |
| R1         | 33                | 30 (27 – 32)             |

| Characters | Madeira Island (1) | Madeira Island 2011 (10) |
|------------|-------------------|--------------------------|
| st1-st1    | 55                | –                        |
| st2-st2    | 62                | 62 (59 – 63)             |
| st3-st3    | 79                | –                        |
| st1-st3    | 62                | 65 (63 – 67)             |
| st4-st4    | 90                | –                        |
| Gensl      | 130               | –                        |
| Gensw st5  | 68                | –                        |
| Gensw post. corn. | 78 | – |
| st5-st5    | 60                | 60 (58 – 63)             |
| Lisl       | 33                | –                        |
| Lsiw       | 3                 | –                        |
| Vsl        | 125               | 120 (115 – 122)          |
| vsw ZV2    | 90                | 86 (81 – 92)             |
| Vsw anus   | 60                | –                        |
| gv3 – gv3  | 15                | –                        |
| JV5        | 50                | 48 (47 – 50)             |
| StIV       | 54                | 47 (45 – 50)             |
| scl        | 18                | 18                       |
| scw        | 7                 | –                        |
| Fdl        | 24                | 24 (23 – 25)             |
| No teeth Fdl | 4 | – |
| Mdl        | 26                | 26 (25 – 27)             |
| No teeth Mdl | Not visible | 3 |

**Sources of measurements – Madeira Island 2011**: Papadoulis & Kapaxidi (2011); – : not provided.
from Ethiopian Region through commercial exchanges. It was collected in the Botanical garden at Funchal, where most of the plants have African origin.

**World distribution:** Burundi, DR Congo, Ghana, Kenya, Malawi, Mayotte Island, Mohéli Island, Mozambique, La Réunion Island, Rwanda, Sierra Leone, South Africa, Tanzania, Zimbabwe.

**Specimens examined:** a single specimen (1 ♀) collected during this study. **Funchal,** Botanical garden (350 m aasl, 32°39′46″ N, 16°53′38″ W), 1 ♀ on *Montanoa bipinnatifida* (Kunth) Koch (Asteraceae), 14/V/2019.

**Remarks:** measurements of morphological characters and traits of the *N. teke* female specimen from Madeira Island are very close to measurements of specimens from La Réunion (Quilici et al. 2000; Kreiter et al. 2020d), Mayotte (Kreiter et al. 2020a), Mohéli (Kreiter et al. 2021b) and Grande Comore (Kreiter et al. submitted) Islands.

**Neoseiulus umbraticus** (Chant)

*Typhlodromus umbraticus* Chant 1956: 26.

*Typhlodromus (Typhlodromus) umbraticus*, Beglyarov 1958: 107.

*Amblyseius umbraticus*, Athias-Henriot 1959: 138.

*Typhlodromus (Amblyseius) umbraticus*, Chant 1959: 75.

*Amblyseius (Typhlodromopsis) umbraticus*, Muma 1961: 287.

*Amblyseius (Amblyseius) umbraticus*, Wainstein & Vartapetov 1973: 103.

*Amblyseius (Neoseiulus) umbraticus*, Karg 1991: 23.

*Neoseiulus umbraticus*, Moraes et al. 1986: 99, 2004: 149, Chant & McMurtry 2003a: 23, 2007: 31.

Similar to the morphological characters already mentioned for *N. madeirensis*, this species is also belonging to the *cucumeris* species group of *Neoseiulus* and to the *cucumeris* species subgroup (Chant and McMurtry 2003a).

Very few studies exist on its biology. Kniisle and Swift (1971) and Kazak et al. (2002) showed its ability to develop feeding on *Tetranychus urticae* Koch. Sengonca and Dresher (2001) studied the ability of this species to feed and develop on *Thrips tabaci* Lindeman and concluded that this food alters its biological parameters in comparison to *T. urticae*. It seems that *N. umbraticus* able to develop and reproduce also on *Panonychus ulmi* (Koch), *Calvolia lordi* (Nesbitt), *Aculus schlechtendali* (Nalepa), adults of *Quadraspidiotus perniciosus* (Comstock), and on apple and cherry pollens (Kniisle and Swift 1971). Adults of *Agistemus fleschneri* Summers, and winter eggs of *P. ulmi* were not fed (Kniisle and Swift 1971).

This is the first report of this species from Madeira Island.

**World distribution:** Armenia, Azerbaijan, Azores, Belarus, Caucasus Region, Denmark, England, France, Georgia, Germany, Hungary, Iran, Italy, Jamaica, Latvia, Mexico, Moldova, Montenegro, Morocco, Norway, Poland, Russia, Slovakia, Spain, Switzerland, Turkey, Ukraine, USA.

**Specimens examined:** 13 specimens (9 ♀♀, 2 ♂♂ and 2 imm.) collected during this study. **Encumeada** (709 m aasl, 32°44′36″ N, 17°1′31″ W), 9 ♀♀, 2 ♂♂ and 2 imm. on an endemic plant of Madeira Island, the so-called Star of Madeira, *Echium candicans* L. f. (Boraginaceae), 20/V/2019.

**Remarks:** the description and measurements of morphological characters and traits of the adult females collected agree with those provided by Chant and Yoshida-Shaul (1982) for specimens from England, by Ferragut et al. (2010) for specimens from Spain and by Tixier et al. (2016) for specimens from Morocco.

**Tribe Amblyseiini Muma**

Amblyseiinae Muma 1961: 273 and Amblyseiini Muma, Wainstein 1962: 26.
Subtribe Amblyseiina Muma

Amblyseiina Muma, Chant & McMurtry 2004a: 179.

Genus Amblyseius Berlese

Amblyseius Berlese 1914: 143.

Amblyseius herbicolus (Chant)

Typhlodromus (Amblyseius) herbicolus Chant 1959: 84.
Amblyseius (Amblyseius) herbicolus, Muma 1961: 287.
Typhlodromus herbicolus, Hirschmann 1962: 23.
Amblyseius herbicolus, Moraes et al. 1986: 14, 1989a: 79, 2004a: 27, Chant & McMurtry 2004a: 208, 2007: 78.
Amblyseius impactus Chaudhri 1968: 553 (synonymy according to Daneshvar & Denmark 1982).
Typhlodromus (Amblyseius) amitae Bhattacharyya 1968: 677 (synonymy according to Denmark & Muma 1989).
Amblyseius deleoni Muma & Denmark 1970: 68 (synonymy according to Daneshvar & Denmark 1982).
Amblyseius giganteus Gupta 1981: 33 (synonymy according to Gupta 1986).
Amblyseius (Amblyseiatrus) thermophilus Karg 1991: 12 (synonymy according to El-Banhawy & Knapp 2011).

This species belongs to the largoensis species group as setae J2 and Z1 are present, setae Z4 are minute and the ventrianal shield of the female is vase-shaped. It belongs to the largoensis species subgroup as setae Z4 are long, spermatheca has the calyx elongate and the female ventrianal shield is entire (Chant and McMurtry 2004).

Amblyseius herbicolus is widespread in all tropical and subtropical regions of the world. It is the second most abundant phytoseiid mites on Coffea arabica L. in Brazil, associated with Brevipalpus phoenicis (Geijskes), vector of the coffee ring spot virus and it was found to be an efficient predator of that species (Reis et al. 2007). Amblyseius herbicolus is also found associated with the broad mite, Polyphagotarsonemus latus (Banks), in crops such as chili pepper (Capsicum annuum L.) in Brazil and has also be proposed as a good potential for controlling this pest. Rodriguez-Cruz et al. (2013) had studied biological, reproductive and life table parameters of A. herbicolus on three different diets: the broad mite, castor bean pollen (Ricinus communis L.) and sun hemp pollen (Crotalaria juncea L.). The predator was able to develop and reproduce on all these three diets. However, its intrinsic rate of natural increase was the highest on broad mites and castor bean pollen. Feeding on alternative food such as pollen can facilitate the predator’s mass rearing and maintains its population on crops when prey is absent or scarce. Many polyphagous generalist phytoseiid mites are important natural enemies because they can feed on plant provided pollen and various prey species, and thus persist in crops even in the absence of target pests (McMurtry et al. 2013). Hence, populations of these predators can be established in a crop by providing alternative food, thus increasing biological control. Alternative food affects P. latus control on chilli pepper plants by predatory mites (Duarte et al. 2015). Amblyseius herbicolus had high oviposition and population growth rates when fed with cattail pollen (Typha latifolia L.), chili pepper pollen and bee-collected pollen, and a low rate on the alternative prey (Tetranychus urticae Koch). Supplementing pepper plants with pollen resulted in better control of broad mite populations (Duarte et al. 2015). Release of A. herbicolus on young plants with weekly addition of honeybee pollen or cattail pollen until plants produce flowers seems a viable strategy to sustain populations of this predator (Duarte et al. 2015). This is the second report of that species from Madeira Island after the recent record of Ferragut and Baumann (2020).
World distribution: Anjouan Island, Argentina, Australia, Azores, Benin, Brazil, Burundi, Canary Islands, China, Colombia, Grande Comore Island, Costa Rica, Dominican Republic, DR Congo, El Salvador, Ghana, Guadeloupe Island, Guatemala, Hawaii, Honduras, India, Iran, Kenya, Les Saintes, Madagascar Island, Malawi, Malaysia, Martinique Island, Mauritius Island, Mohéli Island, New Caledonia Island, Papua New Guinea, Peru, Philippines, Portugal, Puerto Rico, Réunion Island, Rodrigues Island, Rwanda, Senegal, Singapore, South Africa, Spain, Taiwan, Thailand, Turkey, USA, Venezuela, West Indies.

Specimens examined: 25 specimens (20 ♀♀ and 5 imm.) collected during this study.

Funchal, Botanical garden (350 m aasl, 32°39′46″ N, 16°53′38″ W), 1 ♀ on Montanoa bipinnatifida (Kunth) Koch (Asteraceae), 14/V/2019; Monte, Botanical garden of Monte Palace (943 m aasl, 32°40′27″ N, 16°54′10″ W), 1 imm. on Fuchsia boliviana Carrière (Onagraceae) and 1 ♀ on Plectranthus ciliatus Meyer (Lamiaceae), 16/V/2019; Ribeira Brava, Dazkarizeh Guesthouse (475 m aasl, 32°40′5″ N, 17°2′55″ W), 1 ♀ on Gossypium hirsutum L. (Malvaceae), 20/V/2019; Same location, 3 ♀♀ and 1 imm. on Ocotea foetens (Aiton) Baillon (Lauraceae), 23/V/2019; Portela (670 m aasl, 32°44′50″ N, 16°49′33″ W), 2 ♀♀ and 1 imm. on Nephrolepsis exaltata (L.) Shott (Dryopteridaceae) and 4 ♀♀ and 2 imm. Erica scoparia L. (Ericaceae), 23/V/2019.

Remarks: morphological and morphometric characters and all measurements fit well with those provided in Kreiter and Abo-Shnaf (2020a, b) and Kreiter et al. (2021a, b) for specimens of the Indian Ocean. Amblyseius herbicolus was previously recorded in many countries of the world and especially in French West Indies (Moraes et al. 2000, Kreiter et al. 2006). It is also reported recently from Vietnam (Kreiter et al. 2020c), Rodrigues and Mauritius Islands (Kreiter and Abo-Shnaf 2020a, b) but only from females, like in Ferragut and Baumann (2020) and this study.

We agree with the opinion of Ferragut and Baumann (2020), as the report of A. largoensis by Carmona (1973) could represent a misidentification. The same conclusion was drawn by Döker et al. (2020) for specimens of both species in Turkey. However, Carmona’s specimens were not available for examination by the former authors. Just like the former authors, we found that A. herbicolus was one of the most abundant phytoseiid species (35.3% of all the phytoseiids collected for them and 21% for us) and frequent (19% of samples for them and 31% for us) in material collected in the Madeira archipelago. Moreover, many confusions were made in the literature between A. largoensis and A. herbicolus, these two species being separate by only three characters: the shape of the calyx of spermatheca (McMurtry and Moraes 1984; Döker et al. 2020), the size of atrium compared to the base of calyx and the number of teeth on the movable digit (Döker et al. 2020).

Tribe Euseiini Chant & McMurtry
Euseiini Chant & McMurtry 2005: 191.

Subtribe Euseiina Chant & McMurtry
Euseiina Chant & McMurtry 2005: 209.

Genus Euseius Wainstein

Amblyseius (Amblyseius) section Euseius Wainstein 1962: 15, Euseius De Leon 1966: 86.

Euseius scutalis (Athias-Henriot)

Typhlodromus scutalis Athias-Henriot 1958a: 183.
Amblyseius scutalis Athias-Henriot 1960a: 297.
Amblyseius (Typhlodromalus) scutalis, Muma 1961: 288.
Amblyseius (Amblyseius) scutalis, Ueckermann & Loots 1988: 109.

Euseius scutalis, Moraes et al. 1986: 52, 2004b: 82, Chant & McMurtry 2005: 216, 2007: 123.

The 200 species of the genus Euseius are considered as Type IV species that are pollen feeding generalists predators (McMurtry and Croft 1997; McMurtry et al. 2013). Euseius scutalis can be reared on pollen and was recorded as a predator of Panonychus citri (McGregor) in citrus orchards (McMurtry 1977; Kasap and Sekeroglu 2004); it is also reported as a biological control agent of Bemisia tabaci (Gennadius) (Nomikou et al. 2003). Euseius scutalis was observed in high numbers on olive trees in late spring (Chatti et al. 2017). The biology of E. scutalis, however, remains poorly known. This species was recently recorded from Madeira Island by Ferragut and Baumann (2020). Recorded from Maghreb and South of Spain (Kreiter et al. 2004, Ferragut and Baumann 2020), it was probably introduced in the Madeira Island by commercial exchanges with Morocco.

**World distribution:** Algeria, Canary Islands, Cape Verde, Ghana, Egypt, Greece, India, Iran, Israel, Italy, Jordan, Lebanon, Morocco, Pakistan, South Africa, Spain, Turkey.

**Specimens examined:** 4 specimens (2 ♀♀, 1 ♂ and 1 imm.) collected during this study.

**Punta do Sol,** City center (249 m aasl, 32°40′ W), 2 ♀♀, 1 ♂ and 1 imm. on *Rosa canina* L. (Rosaceae), 18/V/2019.

**Remarks:** this species is very common in Maghreb and South of Spain (Kreiter et al. 2004, Ferragut and Baumann 2020). It is also widespread in the Tunisian orchards (Kreiter et al. 2010, Sahraoui et al. 2012).

**Euseius stipulatus** (Athias-Henriot)

Amblyseius stipulatus Athias-Henriot 1960a: 294.

Typhlodromus stipulatus, Hirschmann 1962.

Amblyseius (Amblyseius) stipulatus, Ueckermann & Loots 1988: 110.

Euseius stipulatus (Athias-Henriot), Ferragut et al. 1985: 225, Moraes et al. 1986: 55, 2004: 84, Chant & McMurtry 2005: 216, 2007: 123.

This species was described from Algeria (Athias-Henriot 1960). It is mainly known from the south of the Western Palearctic region. *Euseius stipulatus* is a common species reported from many plants, including cultivated plants such as peach, avocado and vines. It is especially abundant in citrus orchards (Ragusa 1977, Ferragut et al. 1983, Papaioannou-Souliotis et al. 1994, Ragusa 2006, Kreiter et al. 2010, Sahraoui et al. 2012). Several studies have shown its ability to feed on pollen but also on pests such as *T. urticae* and *P. citri* or eriophyid mites (Ferragut et al. 1992, Santaballa et al. 1994, Abad-Moyano et al. 2009, Pina et al. 2012). *Euseius stipulatus* was already recorded in Madeira Island by Papadoulis and Kapaxidi (2011) and Ferragut and Baumann (2020).

**World distribution:** Algeria, Azores, Canary Islands, France, Greece, Hungary, Iran, Italy, Madeira Island, Montenegro, Morocco, Peru, Portugal, Spain, Syria, Tunisia, Turkey, USA.

**Specimens examined:** 26 specimens (12 ♀♀, 8 ♂♂ and 6 imm.) in total.

**Funchal,** Garden São Martinho (141 m aasl, 32°38′18″ N, 17°4′00″ W), 1 ♀ and 1 ♂ on *Markhamia lutea* (Bentham) Schumann (Bignonaceae), 14/V/2019; **Funchal,** Botanical garden (350 m aasl, 32°39′46″ N, 16°53′38″ W), 1 ♂ and 1 imm. on *Montana bipinnatifida* (Kunth) Koch (Asteraceae), 2 ♀♀ and 1 imm. on *Morus alba* L. (Moraceae) and 5 ♀♀, 2 ♂♂ and 2 imm. on *Ricinus communis* L. (Euphorbiaceae), 14/V/2019; **Monte,** Tropical garden of Monte Palace (943 m aasl, 32°40′27″ N, 16°54′10″ W), 1 ♀ on *Fuchsia boliviana* Carrière (Onagraceae), 16/V/2019; **Punta do Sol,** City center (249 m aasl, 32°40′18″ N, 17°4′00″ W), 1 ♀ on *Rosa canina* L. (Rosaceae), 18/V/2019; **Arco de Calheta,** City center (249 m aasl, 32°40′18″ N, 17°4′00″ W), 2 ♀♀, 2 ♂♂ and 2 imm. on *Brachychiton acerifolius* (Cunningham and Don) Macarthur and Moore (Malvaceae), 18/V/2018; **Ribeira Brava,** Dazkarizeh Guesthouse (475 m aasl, 32°40′5″ N, 17°2′55″ W), 1 ♀ on *Tipuana tipu* (Bentham) Kurtz (Fabaceae), 21/V/2019; **Quinta da Serra** (802 m aasl, 32°40′5″ N, 17°2′55″ W), 1 ♀ on *Ocotea foetens* (Aiton) Baillon (Lauraceae), 21/V/2019.
Remarks: the features and measurements of the adult female and male specimens collected in this study agree with those provided by Ferragut and Escudero (1997) and by Ferragut et al. (2010) for specimens from Spain. This is the most abundant (22% of the total number of phytoseiids collected) and frequent species (31% of total samples, just like for *A. herbicolus* which is similarly abundant) herein collected. As emphasized by Ferragut and Baumann (2020), the report of *E. hibisci* by Carmona (1973) should be considered a misidentification, as already suggested by Papadoulis & Kapaxidi (2011). Ferragut has examined specimens labelled as “*Amblyseius hibisci*” sent by M.M. Carmona and they were, in fact, *E. stipulatus*. *Euseius hibisci* must be removed from the species list reported in Madeira.

Genus *Iphiseius* Berlese

*Iphiseius* Berlese 1916: 33, Chant & McMurtry 2005a: 217, 2007: 123.

**Iphiseius degenerans** (Berlese)

*Seius degenerans* Berlese 1889: 9.
*Amblyseius* (*Iphiseius*) *degenerans*, Muma 1961: 288.
*Typhlodromus degenerans*, Hirschmann 1962: 2.
*Iphiseius* (*Iphiseius*) *degenerans*, Pritchard & Baker 1962: 299.
*Amblyseius* *degenerans*, Zaher 1986: 99, Northcraft 1987: 521, Papadoulis & Emmanouel 1991: 36.
*Iphiseius degenerans*, Berlese 1921: 95, Evans 1954: 518, Moraes *et al.* 1986: 61, 2004b: 92, Chant & McMurtry, 2005: 215, 2007: 125.
*Iphiseius martigellus* El-Badry 1968: 325 (synonymy according to Chant & McMurtry 2005).

The biological characteristics of this Mediterranean species have been well documented because of its use in controlling thrips on various cultivated plants in greenhouses. *Iphiseius degenerans* is a commercially available biological control agent of thrips and spider mites in greenhouse crops. It is able to feed on a variety of foods, but thrips’ larvae and sweet pepper pollen are unfavourable food for immature development. This could compromise the establishment of this biological control agent when used against thrips in sweet pepper crops. According to the classification by McMurtry *et al.* (2013), *I. degenerans* is a type-IV polliniphagous predator.

It is one of the most common native phytoseiid mite species on cassava in southern Africa (Zannou *et al.* 2005) and feeds on *M. tanajoa* (Nwilene and Nachman 1996), a widely distributed neotropical mite pest of cassava in Africa, insect larvae and pollen of many plants (Vantomhout *et al.* 2005). Another study concluded that *I. degenerans* can be considered a suitable biological control candidate based on its preference for *Eutetranychus orientalis* (Klein) in the Mediterranean region (Fantinou *et al.* 2012). *Iphiseius degenerans* preys on *Oligonychus perseae* Tuttle, Baker and Abbatteillo. Although *I. degenerans* contribution to *O. perseae* biocontrol can be limited, it needs to be assessed, also taking into account the importance of alternative food source (e.g. Castor oil pollen) for predator population growth (Zappala *et al.* 2015). This species was already known from Madeira Island, first mentioned by Carmona (1962) and then by Ferragut and Baumann (2020).

**World distribution:** numerous countries in Northern and Southern Africa, in Mediterranean area (Cyprus, Greece, Italy, Portugal), in Near East or Middle East (Egypt, Israel, Lebanon, Saudi Arabia, Syria, Turkey, Yemen), in Europe (Georgia), in South America (Brazil) and in North America (USA in California, Florida, Georgia, New Hampshire). Also Grande Comore Island (Kreiter *et al.* 2018b and Kreiter *et al.* submitted).

Specimens examined: 4 specimens (2 ♀♀, 1 ♂ and 1 imm.) collected during this study.

**Porto da Cruz,** Rum distillery (15 m asl, 32°48’18”N, 16°49’46”W), 2 ♀♀, 1 ♂ and 1 imm. on *Acalypha wilkesiana* Müller Argoviensis (Euphorbiaceae), 18/V/2019.
Remarks: measurements of the 2 ♀♀ and 1 ♂ fit well with measurements of specimens reported in the literature from close countries and with those concerning the specimens previously collected in Grande Comore in Moroni (Kreiter et al. 2018b).

Subfamily Typhlodrominae Wainstein
Typhlodromini Wainstein 1962: 26 and Typhlodrominae Chant & McMurtry 1994: 235.

Tribe Typhlodromini Wainstein
Typhlodromini Wainstein 1962: 26.

Genus Neoseiulella Muma
Neoseiulella Muma 1961: 295.

Neoseiulella canariensis Ferragut & Peña-Estevez
Neoseiulella canariensis Ferragut & Peña-Estevez 2003: 159-161, Moraes et al. 2004: 292, Moraza & Peña-Estevez 2006: 59, Chant & McMurtry 2007: 147.

This species belongs to the tiliarum species group of the genus Neoseiulella as setae JV3 are present and chelicerae have only few teeth. Neoseiulella canariensis was only known from the Macaronesia Region, from the Canary Islands (Ferragut and Peña-Estevez 2003, 2007) from where this species was described on various plants belonging to 15 botanical families and then from Madeira Island (Papadoulis and Kapaxidi 2011). Its biology is totally unknown.

World distribution: Canary Islands, Madeira Island.

Specimens examined: a single specimen (1 ♀) collected during this study. Risco (1040 m aasl, 32°47′56″ N, 17°11′8″ W), 1♀ on Persea indica Sprengel (Lauraceae), 23/V/2019.

Remarks: morphological and morphometric characters and all measurements of our specimens (Table 2) fit well with measurements of Ferragut and Peña-Estevez (2003) completed by Kanouh et al. (2012), except for the 20% larger dimensions of the genital shield. We have added in the table 2 measurements of some important characters not documented before as it is only the second record of that species from Madeira Island.

Genus Typhlodromus Scheuten
Typhlodromus Scheuten 1857: 111.

Subgenus Anthoseius De Leon
Typhlodromus (Anthoseius) De Leon 1959: 258, van der Merwe 1968: 20, Karg 1982: 194, Chant & McMurtry 1994: 250, 2007: 149.

Typhlodromus (Anthoseius) capparidis van der Merwe
Typhlodromus (Anthoseius) capparidis van der Merwe 1968: 26, Ueckermann & Loots 1988: 16, Moraes et al. 2004: 315, Chant & McMurtry 2007: 152, Ueckermann et al. 2008: 25, El-Banhawy & Knapp 2011: 53. Amblydromella capparidis, Moraes et al. 1986: 157. Amblydromella (Aphanoseia) capparidis, Denmark & Welbourn 2002: 308.

This species belongs to the bergi species group (Chant and McMurtry 1994). The biology of that species is totally unknown. This is the first report of this species outside the African continent.

World distribution: Kenya, South Africa.
Specimens examined: two specimens (1 ♀ and 1 ♂) collected during this study. **Funchal,** Botanical garden (350 m aasl, 32°39′46″ N, 16°53′38″ W), 1 ♀ on *Thumbergia grandiflora* Roxburgh (Acanthaceae), 14/V/2019; **Monte,** Botanical garden of Monte Palace (943 m aasl, 32°40′27″ N, 16°54′10″ W), 1 ♂ on *Fuchsia boliviana* Carrière (Onagraceae), 16/V/2019.

**Remarks:** morphological and morphometric characters and all measurements of our specimens (Table 3) fit well with measurements of the original description and other measurements of the literature, especially with those for specimens of South Africa (van der Merwe 1968, Ueckermann *et al.* 2008). The male of this species is apparently already known and mentioned in the paper of El-Banhawy *et al.* (2011) but it was not illustrated. Therefore, we do not describe and only measurements of the male specimen are given here (Table 4).

**Typhlodromus (Anthoseius) rhenanoides** Athias-Henriot

*Typhlodromus rhenanoides* Athias-Henriot 1960b: 85.

*Neoseiulus rhenanoides*, Schuster & Pritchard 1963: 205.

*Anthoseius rhenanoides*, Charlet & McMurtry 1977: 186.

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**Table 2** Character measurements of an adult female of *Neoseiulella canariensis* collected in this study compared to those in previous studies (localities followed by the number of specimens measured between brackets).

| Characters | Madeira Island (1) | Canary Island (10) | Characters | Madeira Island (1) | Canary Island (10) |
|------------|-------------------|-------------------|------------|-------------------|-------------------|
|            | (this study)       |                    |            | (this study)       |                    |
| Dsl        | 380               | 381 (340 – 420)    | st1-st1    | 59                 | –                 |
| Dsw        | 208               | 183 (170 – 200)    | st2-st2    | 65                 | –                 |
| j1         | Not visible       | 31 (30 – 36)       | st3-st3    | 78                 | –                 |
| j3         | 40                | 41 (39 – 46)       | st1-st3    | 80                 | –                 |
| j4         | 22                | 23 (20 – 25)       | st4-st4    | 81                 | –                 |
| j5         | 22                | 23 (22 – 25)       | Gensl      | 138                | 110 (90 – 129)*   |
| j6         | 30                | 31 (28 – 33)       | Gensw st5  | 66                 | 54 (48 – 60)*     |
| J2         | 38                | 35 (30 – 41)       | st5 – st5  | 60                 | –                 |
| J5         | 38                | 35 (31 – 41)       | Gensw post. corn. | 70 | 73 (66 – 77) |
| z2         | 20                | 20 (15 – 24)       | Lisl       | 29                 | 29 (24 – 30)      |
| z3         | 38                | 39 (36 – 45)       | Lisw       | 5                  | 6 (5 – 7)*        |
| z4         | 36                | 34 (27 – 38)       | sisl       | 10                 | –                 |
| z5         | 22                | 22 (20 – 25)       | VsV        | 130                | 128 (108 – 138)   |
| Z1         | 35                | 33 (28 – 40)       | Vsv ZV2    | 97                 | 90 (83 – 99)      |
| Z4         | 70                | 62 (54 – 68)       | Vsv anus   | 88                 | –                 |
| Z5         | 88                | 82 (72 - 90)       | gv3 – gv3  | 60                 | 57 (51 – 59)      |
| s4         | 45                | 47 (42 – 50)       | JV5        | 65                 | –                 |
| s6         | 47                | 50 (47 – 53)       | SgelIV     | 35                 | 34 (30 – 37)      |
| S2         | 53                | 52 (48 – 54)       | StilV      | 32                 | 31 (27 – 35)      |
| S4         | 46                | 41 (34 – 50)       | StlV       | 60                 | 55 (49 – 62)      |
| S5         | 34                | 31 (28 – 35)       | Sel        | 20                 | –                 |
| r3         | 35                | 33 (30 - 35)       | Scw        | 8                  | –                 |
| Rl         | 34                | 31 (27 – 35)       | Fdl        | 36                 | –                 |
|            |                   |                    | No teeth Fd | 6                  | 6                 |
|            |                   |                    | Mdl        | 35                 | –                 |
|            |                   |                    | No teeth Md | 2                  | 2                 |

* In bold right column: additional measurements from Kanouh *et al.* (2012).

**Sources of measurements – Canary Island:** Ferragut & Pena-Estevez (2003); – : not provided.
Table 3 Character measurements of an adult female of *Typhlodromus (Anthoseius) capparidis* collected in this study (localities followed by the number of specimens measured between brackets).

| Characters | Madeira Island (1) (this study) | Kenya (1) | Holotype | South Africa 1 (6) | South Africa 2 (7) |
|------------|---------------------------------|-----------|----------|-------------------|-------------------|
| Dsl        | 295                             | 260       | 302      | 304 (300 – 313)   | 309 (289 – 323)   |
| Dsw        | 150                             | 130       | 148      | 165 (165 – 180)   | 171 (148 – 184)   |
| j1         | 20                              | 12        | 21       | 24 (22 – 25)      | 20 (16 – 22)      |
| j3         | 26                              | 25        | 23       | 27 (27 – 30)      | 26 (22 – 31)      |
| j4         | 20                              | 16        | 16       | 20 (19 – 22)      | 19 (15 – 25)      |
| j5         | 22                              | 18        | 18       | 20 (19 – 22)      | 20 (16 – 28)      |
| j6         | 25                              | 26        | 25       | 25 (24 – 25)      | 24 (17 – 31)      |
| J2         | 30                              | 30        | 28       | 32 (30 – 33)      | 30 (26 – 42)      |
| J5         | 11                              | 8         | 10       | 13                | 11 (10 – 15)      |
| j3         | 22                              | 23        | 20       | 24 (22 – 25)      | 22 (17 – 28)      |
| j5         | 28                              | 25        | 20       | 27 (27 – 30)      | 26 (20 – 33)      |
| z4         | 28                              | 35        | 26       | 27 (27 – 30)      | 28 (24 – 35)      |
| z5         | 23                              | 23        | 20       | 24 (22 – 25)      | 22 (19 – 27)      |
| Z4         | 38                              | 40        | 41       | 43 (42 – 46)      | 39 (30 – 44)      |
| Z5         | 50                              | 48        | 52       | 56 (56 – 60)      | 50 (45 – 58)      |
| s4         | 30                              | 28        | 28       | 32 (30 – 33)      | 30 (24 – 36)      |
| s6         | 33                              | 25        | 31       | 34 (34 – 36)      | 33 (24 – 39)      |
| S2         | 35                              | 35        | 33       | 38 (37 – 39)      | 35 (28 – 41)      |
| S4         | 35                              | 30        | 33       | 40 (9 – 41)       | 36 (28 – 44)      |
| S5         | 35                              | 26        | 35       | 40 (9 – 41)       | 34 (30 – 37)      |
| r3         | 28                              | 25        | 23       | 30 (28 – 31)      | 27 (24 – 31)      |
| R1         | 28                              | 25        | 27       | 30 (28 – 31)      | 27 (23 – 34)      |
| st1 – st1  | 45                              | –         | –        | –                 | –                 |
| st2 – st2  | 48                              | –         | 50       | 56 (56 – 58)      | 49 (44 – 52)      |
| st3 – st3  | 59                              | –         | –        | –                 | –                 |
| st1 – st3  | 59                              | –         | 55       | 76 (74 – 80)      | 57 (54 – 62)      |
| st4 – st4  | 70                              | –         | –        | –                 | –                 |
| Gensl      | 103                             | –         | –        | –                 | –                 |
| st5 – st5  | 49                              | –         | 51       | 58 (56 – 60)      | 49 (43 – 54)      |
| Gensw      | 53                              | –         | –        | –                 | –                 |
| Gensw post. corn. | 58                  | 50        | –        | –                 | –                 |
| Lisl       | 23                              | –         | –        | –                 | –                 |
| Lisw       | 4                               | –         | –        | –                 | –                 |
| sis1       | 8                               | –         | –        | –                 | –                 |
| Vsl        | 98                              | 83        | 109      | 98 (97 – 100)     | 103 (94 – 111)    |
| Vsw ZV2    | 76                              | 58        | 74       | 76 (74 – 80)      | 78 (73 – 85)      |
| Vsw anus   | 68                              | –         | 72       | –                 | 75 (70 – 83)      |
| gw3 – gw3  | 18                              | –         | –        | –                 | –                 |
| JV5        | 38                              | 46        | –        | 39 (37 – 40)      | –                 |
| SiIV       | 23                              | 50?       | 23       | 25 – 26           | 24 (22 – 26)      |
| Scl        | 16                              | 16        | 11       | 9                 | 11 (10 – 13)      |
| Scw        | 8                               | 9         | –        | 8                 | –                 |
| Fdl        | 23                              | –         | –        | 31                | 21 (20 – 22)      |
| No teeth Fd| not visible                     | 4         | –        | 4                 | –                 |
| Mdl        | 23                              | –         | –        | 34                | 24 (21 – 25)      |
| No teeth Md| not visible                     | 3         | –        | 2                 | –                 |

Sources of measurements – Kenya: El-Banhawy & Knapp (2011); South Africa 1: van der Merwe (1968); Holotype & South Africa 2: Ueckermann et al. (2008); --: not provided.
Amblydromella rhenanoides, Moraes et al. 1986: 174.
Amblydromella (Aphanoseia) rhenanoides, Denmark & Welbourn 2002: 308.
Typhlodromus (Anthoseius) rhenanoides, Moraes et al. 2004: 347, Chant & McMurtry 2007: 155.

This species belongs to the rhenanus species group (Chant and McMurtry 1994).
It is mainly reported from the Mediterranean basin. It has been recorded on many uncultivated plants and sometimes on some orchards such as peach, plum, olive, citrus and vineyards (Ragusa 1977, 2006, Papaioannou – Souliotis et al. 1994, Ragusa and Tsolakis 2001). Its biology is totally unknown and nothing is known with regard to its ability to control pests. This species was reported from Morocco by McMurtry & Bonfour (1989) on Cupressus sp. and then by Tixier et al. (2016). It is also present in Spain (Ferragut et al. 2010) and in Portugal (Espinha 1995) and was already mentioned by Papadoulis and Kapaxidi (2011) from Madeira Island.

Specimens examined: six specimens (3 ♀♀ and 3 imm.) collected during this study. Pico das Urzes, in the bush (1172 m aasl, 32°44′3″ N, 17°3′43″ W), 1 ♀ on Rubus grandifolius Lowe (Rosaceae), 19/V/2019; Risco (1040 m aasl, 32°47′56″ N, 17°11′8″ W), 2 ♀♀ and 1 imm. on Erica madeirensis (Ericaceae) and 2 imm. on Prunus pumila L. (Rosaceae), 23/V/2019.

World distribution: Algeria, Canary Islands, France, Greece, Hawaii, Italy, Les Saintes, Madeira Islands, Morocco, Portugal, Spain, Tunisia, USA.

Remarks: morphological and morphometric characters and all measurements of our specimens fit well measurements of Tixier et al. (2016, 2019).

| Characters | Grande Comore Island (1) (this study) | Characters | Grande Comore Island (1) (this study) |
|------------|--------------------------------------|------------|--------------------------------------|
| Dsl        | 230                                  | R1         | 23                                   |
| Dsw        | 120                                  | st1-st1    | 38                                   |
| j1         | 15                                   | st2-st2    | 46                                   |
| j3         | 23                                   | st3-st3    | 46                                   |
| j4         | 14                                   | st1-st5    | 99                                   |
| j5         | 18                                   | st4-st4    | 40                                   |
| j6         | 18                                   | st5-st5    | 31                                   |
| J2         | 22                                   | Vsl        | 95                                   |
| J5         | 10                                   | Vsw ZV2    | 118                                  |
| z2         | 18                                   | Vsw anus   | 63                                   |
| z3         | 19                                   | gV3 - gV3  | 13                                   |
| z4         | 24                                   | JV5        | 18                                   |
| z5         | 18                                   | SgelIV     | 20                                   |
| Z4         | 23                                   | Fdl        | 20                                   |
| Z5         | 33                                   | No teeth Fd| Not visible                          |
| s4         | 25                                   | Mdl        | 20                                   |
| s6         | 25                                   | No teeth Md| Not visible                          |
| S2         | 28                                   | Shaft      | 18                                   |
| S4         | 26                                   | Branch     | 6                                    |
| S5         | 28                                   |            |                                       |
| r3         | 24                                   |            |                                       |

This species was drawn and described but no measurements are available in the literature.
Typhlodromus (Typhlodromus) exhilaratus Ragusa

Typhlodromus exhilaratus Ragusa 1977: 380.
Typhlodromus exhilaratus ex hilarates, Chant & Yoshida-Shaul 1987: 1795.
Typhlodromus exhilaratus americanus, Chant & Yoshida-Shaul 1987: 1795.
Typhlodromus (Typhlodromus) exhilaratus, Mores et al. 2004: 371, Chant & McMurtry 2007: 157.

Typhlodromus (T.) exhilaratus has been wrongly considered as a synonym of T. tiliae Oudemans by Denmark (1992). This species has been mainly reported in the Mediterranean basin. It is quite common in some vineyards in France and Italy (Tixier et al., 2006; Castagnoli et al., 2002). Liguori and Guidi (1990) have shown its ability to feed on the main mite pest in South European vineyards, Eotetranychus carpini (Oudemans). Typhlodromus (T.) exhilaratus is known from Morocco, it was reported by Tixier et al. (2003) from vineyards in the region of Meknes but it is also observed on various plants and locations (Tixier et al. 2016). This is the first record of that species in Madeira Island.

Specimens examined: 20 specimens (19 ♀♀ and 1 ♂) collected during this study. Canical, Quinta do Lorde (20 m aasl, 32°44’36” N, 16°42’20” W), 17 ♀♀ and 1 ♂ on Chamaecyparis lawsonia (Murray) Parlattere (Cupressaceae), 17/V/2019; Punta do Sol, City center (249 m aasl, 32°40’18” N, 17°4’00” W), 1 ♀ on Rosa canina L. (Rosaceae), 18/V/2019; Portela (670 m aasl, 32°44’50” N, 16°49’33” W), 1 ♀ on Laurus azorica (Seubert) Franco (Lauraceae), 23/V/2019.

Previous records: Austria, Cyprus, Egypt (Abo-Shnaf & Moraes, 2014), France, Greece, Hungary, Israel, Italy, Morocco, Tunisia, USA.

Remarks: morphological and morphometric characters and all measurements of our specimens fit well with measurements of the re-description of Chant and Yoshida-Shaul (1987). This species is the third most abundant (17%) after E. stipulatus (22%) and A. herbicolus (21%) but it is not very frequent (only 10% of the total samples against 31% for E. stipulatus and 31% for A. herbicolus).

Typhlodromus (Typhlodromus) moroccoensis Denmark

Typhlodromus moroccoensis Denmark 1992a: 16.
Typhlodromus (Typhlodromus) moroccoensis, Moraes et al. 2004: 366, Chant & McMurtry 2007: 157, Tixier et al. 2010: 170, Ferragut & Ueckermann 2012: 1742, Tixier et al. 2016: 528.

Typhlodromus (T.) moroccoensis Denmark (reported once from Morocco on Prunus sp.) (Denmark 1992) is the only species with T. (T.) setubali within the sub-genus Typhlodromus (Typhlodromus) bearing six setae on genu II. Nothing is known about the biology of this species. This is the first recorded of that species in Madeira Island.

World distribution: Morocco.

Specimens examined: a single specimen (1 ♀) collected during this study. Risco (1040 m aasl, 32°47’56” N, 17°11’8” W), 1 ♀ on Persea indica Sprengel (Lauraceae), 23/V/2019.

Remarks: the measurements of the adult females collected (Table 5) agree with those provided by Denmark (1992) for specimens from Morocco as reported by Tixier et al. (2016). Typhlodromus (T.) setubali and T. (T.) moroccoensis are morphologically close and Tixier et al. (2016) indicated that further analyses would be required to determine if T. (T.) moroccoensis is valid or synonym. But comparisons provided in tables 5 and 6, show some differences especially the number of teeth on the fixed digit and spermatheca shape.

Typhlodromus (Typhlodromus) phialatus Athias-Henriot

Typhlodromus phialatus Athias-Henriot 1960b: 100.
Typhlodromus (Typhlodromus) phialatus, Moraes et al. 2004: 366, Chant & McMurtry 2007: 157.
This species is mainly known from the Western Palearctic region and is very common in the Mediterranean basin. It has been reported from many plants and some orchards such as vineyards, apple, almond, pear but essentially on citrus (Ferragut et al. 1983; Papaioannou-Souliotis et al. 1994; Espinha et al. 1995; Kreiter et al. 2000; Sahraoui et al. 2012). Some studies have been carried out on the biology of this species (Meszaros et al. 2007) and some publications reported that it could limit the development of mite pests in citrus orchards. This species was reported from Morocco by McMurtry and Bounfour (1989) on citrus, weeds and Argania spinosa (L.) Skeels and is present in Canary Island. It was first mentioned by Papadoulis and Kapaxidi (2011) from Madeira Island. The report here confirms the occurrence of this species in the island.

**World distribution:** Algeria, Canary Islands, Cyprus, England, France, Greece, Hungary, Israel, Italy, Jordan, Madeira islands, Moldova, Morocco, Norway, Portugal, Russia, Serbia-Montenegro, Spain, Tunisia, Ukraine.

**Specimens examined:** a single specimen (1 ♀) collected during this study. **Risco** (1040 m aasl, 32°47′56″ N, 17°11′8″ W), 1 ♀ on the Macaronesian endemic Laurus novocanariensis Martinez, Lousa, Pietro, Dias, Costa and Aguiar (Lauraceae).

**Remarks:** the measurements of the adult females collected agree with those provided by Ferragut et al. (2010) for specimens from Spain and by Tixier et al. (2019) for specimens from Morocco.

### Table 5 Character measurements of an adult female of *Typhlodromus (Typhlodromus) moroccoensis* collected in this study (localities followed by the number of specimens measured between brackets).

| Characters | Madeira Island (1) (this study) | Morocco (15) |
|------------|---------------------------------|--------------|
| Dsl        | 333                             | 330          |
| Dsw        | 185                             | 176          |
| j1         | 23                              | 27 (21 – 33) |
| j3         | 33                              | 27 (21 – 33) |
| j4         | 15                              | 15 (11 – 19) |
| j5         | 14                              | 14 (10 – 18) |
| j6         | 16                              | 16 (12 – 20) |
| J2         | 18                              | 19 (14 – 23) |
| J5         | 6                               | 4 (2 – 8)    |
| Z2         | 18                              | 17 (13 – 21) |
| Z3         | Broken                          | 19 (14 – 23) |
| z4         | 24                              | 19 (14 – 23) |
| z5         | 16                              | 17 (13 – 21) |
| Z4         | 30                              | 42 (34 – 50) |
| Z5         | 63                              | 62 (52 – 72) |
| s4         | 27                              | 24 (19 – 29) |
| s6         | 29                              | 29 (23 – 35) |
| S2         | 30                              | 32 (25 – 39) |
| S4         | 28                              | 32 (25 – 39) |
| r3         | 24                              | 25 (19 – 31) |
| R1         | 20                              | 25 (19 – 31) |

| Characters | Madeira Island (1) (this study) | Morocco (15) |
|------------|---------------------------------|--------------|
| st1 – st1  | 50                              | –            |
| st2 – st2  | 63                              | –            |
| st3 – st3  | 73                              | –            |
| st1 – st3  | 65                              | –            |
| st4 – st4  | 90                              | –            |
| Gensl      | 125                             | –            |
| st5 – st5  | 66                              | –            |
| Gensw st5  | 71                              | –            |
| Gensw post. corn. | 76 | – |
| Lisl       | 28                              | –            |
| Lisw       | 4                               | –            |
| sisl       | 15                              | –            |
| sisw       | 2                               | –            |
| Vsl        | 120                             | –            |
| VsV2       | 105                             | –            |
| Vsw anus   | 83                              | –            |
| JV5        | 38                              | –            |
| SgelIV     | 20                              | 24 (19 – 29) |
| StIV       | 21                              | 27 (21 – 33) |
| StIV       | 38                              | 46 (36 – 55) |
| Scel       | Not well visible                | 20           |
| Scew       | Not well visible                | –            |
| Fdl        | 23                              | –            |
| No teeth Fd| 4                               | 4            |
| Mdl        | 24                              | –            |
| No teeth Md| 1                               | 1            |

**Sources of measurements – Morocco:** Denmark (1992) in Tixier et al. (2016) as proposed by Tixier (2012); –: not provided.
France.

**Typhlodromus (Typhlodromus) pyri Scheuten**

*Typhlodromus pyri* Scheuten 1857: 104, Moraes *et al.* 1986: 246.  
*Typhlodromus (Typhlodromus) pyri*, Chant 1959: 64.  
*Typhlodromus (Typhlodromus) pyri*, Moraes *et al.* 2004: 367, Chant & McMurtry 2007: 157.

This species is cosmopolitan but it is one of the most common and dominant species in vineyards and orchards in the western part of Europe. It has been introduced in various countries such as Australia, New Zealand and the USA for biological control purposes. It has been reported on a wide range of plants, essentially on cultivated and uncultivated shrubs and trees. This species is an efficient predator of red and yellow spider mites, and eriophyid mites mainly in orchards and vineyards as well as the grape thrips *Drepanothrips reuteri* (Uzel) in France (Serrano *et al.* 2004).

**World distribution:** Australia, Austria, Azerbaijan, Belarus, Belgium, Canada, Chile, Croatia, Czechoslovakia, Czech Republic, Denmark, Egypt, England, Finland, France, Germany, Greece, Hungary, Italy, Madeira Island, Moldova, Montenegro, Netherlands, New Zealand, Northern Ireland, Norway, Poland, Portugal, Russia, Saudi Arabia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, USA.

**Specimens examined:** 13 specimens (11 ♀♀, 2 imm.) collected during this study.

**Encumeada** (709 m aasl, 32°44′36″ N, 17°1′31″ W), 1 ♀ on an endemic plant of Madeira Island, the so-called Star of Madeira, *Echium candicans* L. f. (Boraginaceae), 20/V/2019; **Pico das Urzes**, in the bush (1172 m aasl, 32°44′3″ N, 17°3′43″ W), 2 ♀♀ on *Rubus grandifolius* Lowe (Rosaceae), 19/V/2019; **São Paulo**, Sacradafamilia (705 m aasl, 32°40′11″ N, 17°3′45″ W), 8 ♀♀ and 1 imm. *Woodwardia radicans* (L.) Smith (Blechnaceae), 21/V/2019; **Quinta da Serra** (802 m aasl, 32°40′5″ N, 17°2′55″ W), 1 imm. *Ocotea foetens* (Aiton) Baillon (Lauraceae), 21/V/2019.

**Remarks:** The measurements of the adult females collected agree with those provided by Ferragut *et al.* (2010) for specimens from Spain and by Tixier *et al.* (2019) for specimens from France. This species is the fourth most abundant (11%) after *E. stipulatus* (22%), *A. herbicolus* (21%) and *T. (T.) exhilaratus* (17%) but it is slightly more frequent than the later species [14% of the total samples against only 10% for *T. (T.) exhilaratus*].

**Typhlodromus (Typhlodromus) setubali Dosse**

*Typhlodromus setubali* Dosse 1961: 313.  
*Typhlodromus (Typhlodromus) setubali*, Moraes *et al.* 2004: 369, Chant & McMurtry 2007: 157.  
*Typhlodromus laurentii* Ragusa & Swirski 1978: 213 (synonymy according to Chant & Yoshida-Shaul 1987).

This species is mainly known from the South of the Mediterranean basin, and it is not very common. It has been reported in Portugal and Spain by Dosse (1961) and in Moroccan crops by Tixier *et al.* (2003, 2016) and Kreiter specifically from Oulmès region (unpub. data). Its biology has been recently studied (Ouassat and Allam 2020 and Allam *et al.* unpub. data) with specimens collected on apple in Oulmès region of Morocco (Ouassat 2017, Ouassat and Allam 2019). It seems an efficient predator of *P. ulmi*. It was already observed in Morocco by McMurtry & Bounfour (1989) on *Olea europea* L., *Cupressus* sp. and *Cynodon dactylon* Richard. This is the first record of that species in Madeira Island.

**Specimens examined:** a single specimen (1 ♀) collected during this study. **Risco** (1040 m aasl, 32°47′56″ N, 17°11′8″ W), 1 ♀ on *Erica madeirensis* (Ericaceae) and 1 ♀ on *Persea indica* Sprengel (Lauraceae), 23/V/2019.

**Previous records:** Azerbaijan, Cyprus, Egypt, France, Greece, Iran, Israel, Jordan, Syria, Turkey.
Remarks: morphological and morphometric characters and all measurements of our specimens (Table 6) fit well with measurements of the re-description of Chant and Yoshida-Shaul (1987) for specimens from Portugal and measurement of specimens from Morocco (Tixier et al. 2016).

Conclusion

The results of a survey, made in May 2019 in Madeira Island are presented in this paper. Fifteen species are documented here: 7 Amblyseiinae and 8 Typhlodrominae, have been collected, namely: Neoseiulus madeirensis, N. teke, N. umbraticus, Amblyseius herbicolus, Euseius scutalis, E. stipulatus, Iphiseius degenerans, Neoseiulella canariensis, Typhlodromus (Anthoseius) capparidis, T. (A.) rhenoides, T. (T.) exhilaratus, T. (T.) moroccoensis, T. (T.) phialatus, T. (T.) pyri and T. (T.) setubali. This is interesting to mention that Papadoulis and Kapaxidi (2011) recorded two species of Amblyseiinae and three species of Typhlodrominae and Ferragut and Baummann (2020) recorded 12 species all belonging to the subfamily Amblyseiinae. No Phytoseiinae has been found until now, and the presence of any members of Phytoseiinae in Madeira remain as mystery.

Six species, namely: Neoseiulus teke, N. umbraticus, Typhlodromus (Anthoseius) capparidis, T. (T.) exhilaratus, T. (T.) moroccoensis, T. (T.) phialatus, T. (T.) pyri and T. (T.) setubali are reported for the first time from Madeira Island. So the number of species recorded after this study is now of 24.

Table 6 Character measurements of an adult female of *Typhlodromus (Typhlodromus) setubali* collected in this study (localities followed by the number of specimens measured between brackets).

| Characters | Madeira Island (1) | Morocco (15) | Portugal paratype (1) | Characters | Madeira Island (1) | Morocco (15) | Portugal paratype (1) |
|------------|-------------------|--------------|-----------------------|------------|-------------------|--------------|-----------------------|
| Dsl        | 383               | 326 (320 – 335) | 321                   | st1 – st1  | 59                | –            |
| Dsw        | 203               | 161 (157 – 165) | 179                   | st2 – st2  | 69                | 59 (55 – 70)  |
| j1         | 33                | 24 (22 – 25)    | 25                    | st3 – st3  | 84                | –            |
| j3         | 35                | 30 (25 – 30)    | 31                    | st1 – st3  | 70                | 61 (50 – 65)  |
| j4         | 18                | 16 (15 – 18)    | 18                    | st4 – st4  | 100               | –            |
| j5         | 18                | 16 (15 – 18)    | –                     | Gensl      | 138               | –            |
| j6         | 20                | 19 (15 – 23)    | 22                    | st5 – st5  | 72                | 61 (55 – 68)  |
| J2         | 23                | 22 (20 – 25)    | 20                    | Gensw st5  | 78                | –            |
| J5         | 6                 | 5 (5 – 8)       | 5                     | Gensw post. corn. | 83 | – |
| z2         | 23                | 17 (15 – 18)    | 21                    | Lisl       | 29                | 25 (22 – 26)  |
| z3         | 28                | 24 (20 – 27)    | 27                    | Lisw       | 4                 | 5 (4 – 6)    |
| z4         | 27                | 24 (20 – 27)    | 25                    | sid        | 15                | 13 (12 – 14)  |
| z5         | 16                | 17 (15 – 18)    | –                     | sisw       | 2                 | 3 (2 – 3)    |
| Z4         | 43                | 44 (40 – 50)    | 41                    | Vds        | 138               | 106 (100 – 110) |
| Z5         | 80                | 67 (60 – 75)    | 59                    | Vsw ZV2    | 121               | 101 (95 – 105) |
| s4         | 35                | 30 (25 – 35)    | 32                    | Vsw anus   | 85                | 83 (75 – 90)  |
| s6         | 37                | 33 (30 – 37)    | 35                    | JV5        | 51                | 55 (48 – 60)  |
| S2         | 38                | 36 (32 – 42)    | 37                    | SgeIV      | 27                | 27 (25 – 28)  |
| S4         | 36                | 36 (30 – 42)    | 37                    | St1V       | 31                | 31 (28 – 33)  |
| r3         | 33                | 25 (20 – 25)    | 26                    | St1V       | 53                | 50 (42 – 55)  |
| R1         | 31                | 23 (18 – 25)    | 26                    | Scl Not well visible | 18 (17 – 19) | 16 | |
|            |                   |               |                       | Scw Not well visible | 10 (9 – 10) | – |
|            |                   |               |                       | Fdl        | 28                | 22 |
|            |                   |               |                       | No teeth Fd | 3           | 3   |
|            |                   |               |                       | Mdl        | 28                | 25 |
|            |                   |               |                       | No teeth Md | 1           | 1   |

Sources of measurements – Morocco: Tixier et al. (2016); Portugal: Chant & Yoshida-Shaul (1987) after Dosse (1961); –: not provided.
ThreespeciespreviouslyreportedbyCarmona(1973)werenotfoundinsubsequentstudies
byPapadoulisandKapaxidi(2011)andFerragutandBaumann(2020)aswellasinthisstudy.
Those species are, Amblyseius largoensis, Euseius hibisci and T. (A.) rhenanus. Similar to
the conclusion by Ferragut and Baumann (2020), we think that the report ofA. largoensis by
Carmona (1973) represents probably a misidentification, though those specimens were not
availableforstudy. Just like the former authors, A. hericolus was the most abundant (18% of
all the phytoseiids collected) and frequent (31% of samples) in our material from the Madeira
archipelago. As reported in the literature (Döker et al. 2020, Ferragut and Baumann 2020),
confusions between A. largoensis and A. hericolus might be the reason. Three characters
allow todistinguishthesetwospeciesashighlightedbyDökeret al. (2020):

- calyx of spermatheca trumpet-shaped for A. hericolus vs. calyx of the spermatheca tubu-
lar for A. largoensis;
- atrium of spermatheca wider than the base of calyx for A. hericolus vs. atrium of sper-
matheca as wide as the basis of calyx for A. largoensis;
- movable digit of chelicera with four teeth in A. hericolus vs. movable digit of chelicera
with three teeth in A. largoensis.

Döker et al. (2020) stated the possible misidentification of A. hericolus as A. largoensis
and Ferragut and Baumann (2020) highlighted the same hypothesis for specimens from
Madeira. The species A. largoensis was not listed in Carmona (1962 and 1973), Papadoulis
and Kapaxidi (2011), Ferragut and Baumann (2020) and in the present paper. We thus assumed
that specimens of A. hericolus might also get misidentified as belonging to the species A.
largoensis by Carmona (1973) and that the occurrence of the species A. largoensis have to be
confirmed.

Concerning E. hibisci, Carmona (1973) reported E. hibisci in Madeira Islands, a species
usually reported from the American continent. Just like Papadoulis and Kapaxidi (2011), we
think that as E. hibisci closely resembles to E. stipulatus, it is possible that the above-mentioned
record was not E. hibisci but actually E. stipulatus, which is the main Euseius species in
Mediterranean region.

And finally, T. (A.) rhenanus which is very close to several species of Typhlodromus
(Anthoseius), was often misidentified, and a misidentification might have been also happened
in Madeira reports.

On three surveys conducted after the two of Carmona (1962, 1973), none of these three
species were recovered.

The Phytoseiidae fauna of Madeira is essentially composed of West Palearctic species with
some African species.

Among the 15 species recorded in this study, at least seven species [N. teke, A. hericolus,
E. stipulatus, I. degenerans, T. (T.) exhilaratus, T. (T) setubali and T. (T) pyri] are already
known as biological control agents (BCAs), some having been experimented and some others
sold in several places of the world.

In addition to the intrinsic value of phytoseiid mite biodiversity in such environments,
demonstration of the natural occurrence of efficient BCAs in an isolated island such as Madeira
Island is of great agricultural, commercial and strategic interests for the country.

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