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Serge Kreiter, Martial Douin, Marie Stephane Tixier. New records of phytoseiid mites (Acari: Mesostigmata) from Madeira Island. *Acarologia*, 2021, 61 (2), pp.217-240. 10.24349/acarologia/20214428 . hal-03187655

HAL Id: hal-03187655

<https://hal.science/hal-03187655>

Submitted on 1 Apr 2021

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Acarologia

A quarterly journal of acarology, since 1959
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Subscriptions: Year 2021 (Volume 61): 450 €

<http://www1.montpellier.inra.fr/CBGP/acarologia/subscribe.php>

Previous volumes (2010-2020): 250 € / year (4 issues)

Acarologia, CBGP, CS 30016, 34988 MONTFERRIER-sur-LEZ Cedex, France



ISSN 0044-586X (print), ISSN 2107-7207 (electronic)

The digitalization of Acarologia papers prior to 2000 was supported by Agropolis Fondation under the reference ID 1500-024 through the « Investissements d'avenir » programme (Labex Agro: ANR-10-LABX-0001-01)



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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.

Received 05 March 2021

Accepted 30 March 2021

Published 01 April 2021

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Academic editor

Faraji, Farid

DOI

10.24349/acarologia/20214428

ISSN 0044-586X (print)

ISSN 2107-7207 (electronic)

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How to cite this article Kreiter S. *et al.* (2021), New records of phytoseiid mites (Acari: Mesostigmata) from Madeira Island. *Acarologia* 61(2): 217-240; DOI 10.24349/acarologia/20214428

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), *Neoseiulella 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 all examined and identified using a phase and interferential contrast microscope (DMLB, Leica Microsystems 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); **gensl** = genital shield length; **gensw *st5*** = genital shield width at level of setae *st5*; **gensw post. cor.** = genital shield width at level of posterior corners; **lisl** = primary or largest inguinal sigilla (= “metapodal plate”) length; **lisw** = primary or largest inguinal sigilla (= “metapodal plate”) width; **sisl** = 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; **scl**: calyx total length; **scw** = calyx widest width; **Fdl** = fixed digit length; **Mdl** = 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

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) (this study)	Madeira Island 2011 (10)	Characters	Madeira Island (1) (this study)	Madeira Island 2011 (10)
Dsl	340	327 (321 – 340)	st1-st1	55	–
Dsw	175	168 (161 – 174)	st2-st2	62	62 (59 – 63)
j1	23	24 (23 – 27)	st3-st3	79	–
j3	51	51 (49 – 52)	st1-st3	62	65 (63 – 67)
j4	48	48 (45 – 50)	st4-st4	90	–
j5	50	50 (49 – 52)	Gensl	130	–
j6	55	57 (54 – 59)	Gensw st5	68	–
J2	58	55 (50 – 58)	Gensw post. corn.	78	–
J5	12	11 (9 – 13)	st5-st5	60	60 (58 – 63)
z2	50	50 (47 – 54)	Lisl	33	–
z4	58	57 (54 – 59)	Lsiw	3	–
z5	43	45 (41 – 49)	Vsl	125	120 (115 – 122)
Z1	53	54 (50 – 58)	vsw ZV2	90	86 (81 – 92)
Z4	63	67 (65 – 70)	Vsw anus	60	–
Z5	73	70 (65 – 76)	gv3 – gv3	15	–
s4	65	62 (59 – 68)	JV5	50	48 (47 – 50)
S2	59	57 (50 – 61)	StIV	54	47 (45 – 50)
S4	34	32 (29 – 36)	scl	18	18
S5	28	27 (25 – 29)	scw	7	–
r3	35	32 (29 – 36)	Fdl	24	24 (23 – 25)
RI	33	30 (27 – 32)	No teeth Fdl	4	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. Knisley and Swift (1971) and Kazak *et al.* (2002) showed its ability to develop feeding on *Tetranychus urticae* Koch. Sengonca and Drescher (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 schlehtendali* (Nalepa), adults of *Quadraspidiotus perniciosus* (Comstock), and on apple and cherry pollens (Knisley and Swift 1971). Adults of *Agistemus fleschneri* Summers, and winter eggs of *P. ulmi* were not fed (Knisley 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, 2004b: 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 giganticus Gupta 1981: 33 (synonymy according to Gupta 1986).

Amblyseius (*Amblyseialus*) *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 annum* 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.), chilli 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 *Persea indica* Sprengel (Lauraceae), 23/V/2019; **Portela** (670 m aasl, 32°44'50" N, 16°49'33" W), 2 ♀♀ and 1 imm. on *Ocotea foetens* (Aiton) Baillon (Lauraceae), 3 ♀♀ on *Laurus azorica* (Seubert) Franco (Lauraceae), 5 ♀♀ on *Nephrolepis 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°40'18" N, 17°4'00" 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 and *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°38'57" N, 16°56'36" W), 1 ♀ and 1 ♂ on *Markhamia lutea* (Benth) Schumann (Bignoniaceae), 14/V/2019; **Funchal**, Botanical garden (350 m aasl, 32°39'46" N, 16°53'38" W), 1 ♂ and 1 imm. on *Montanoa 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* (Benth) Kuntze (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 south 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 (Vantornhout *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 Abbatiello. 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 aasl, 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.

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) (this study)	Canary Island (10)	Characters	Madeira Island (1) (this study)	Canary Island (10)
Dsl	380	381 (340 – 420)	<i>st1-st1</i>	59	–
Dsw	208	183 (170 – 200)	<i>st2-st2</i>	65	–
<i>j1</i>	Not visible	31 (30 – 36)	<i>st3-st3</i>	78	–
<i>j3</i>	40	41 (39 – 46)	<i>st1-st3</i>	80	–
<i>j4</i>	22	23 (20 – 25)	<i>st4-st4</i>	81	–
<i>j5</i>	22	23 (22 – 25)	Gensl	138	110 (90 – 129)*
<i>j6</i>	30	31 (28 – 33)	Gensw st5	66	54 (48 – 60)*
<i>J2</i>	38	35 (30 – 41)	<i>st5 – st5</i>	60	–
<i>J5</i>	38	35 (31 – 41)	Gensw post. corn.	70	73 (66 – 77)
<i>z2</i>	20	20 (15 – 24)	Lisl	29	29 (24 – 30)
<i>z3</i>	38	39 (36 – 45)	Lisw	5	6 (5 – 7)*
<i>z4</i>	36	34 (27 – 38)	sisl	10	–
<i>z5</i>	22	22 (20 – 25)	Vsl	130	128 (108 – 138)
<i>Z1</i>	35	33 (28 – 40)	Vsw ZV2	97	90 (83 – 99)
<i>Z4</i>	70	62 (54 – 68)	Vsw anus	88	–
<i>Z5</i>	88	82 (72 – 90)	<i>gv3 – gv3</i>	60	57 (51 – 59)
<i>s4</i>	45	47 (42 – 50)	JV5	65	–
<i>s6</i>	47	50 (47 – 53)	SgeIV	35	34 (30 – 37)
<i>S2</i>	53	52 (48 – 54)	StiIV	32	31 (27 – 35)
<i>S4</i>	46	41 (34 – 50)	StIV	60	55 (49 – 62)
<i>S5</i>	34	31 (28 – 35)	Scl	20	–
<i>r3</i>	35	33 (30 – 35)	Scw	8	–
<i>RI</i>	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-Estevéz (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)
z2	22	23	20	24 (22 – 25)	22 (17 – 28)
z3	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 st5	53	–	–	–	–
Gensw post. corn.	58	50	–	–	–
Lisl	23	–	–	–	–
Lisw	4	–	–	–	–
sisl	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)
gv3 – gv3	18	–	–	–	–
JV5	38	46	–	39 (37 – 40)	–
StIV	23	50?	23	25 – 26	24 (22 – 26)
ScI	16	16	11	9	11 (10 – 13)
Sew	8	9	–	8	–
Fdl	23	–	–	31	21 (20 – 22)
No teeth Fd	not visible	4	–	4	4
Mdl	23	–	–	34	24 (21 – 25)
No teeth Md	not visible	3	–	2	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).

Table 4 Character measurements of an adult male of *Typhlodromus (Anthoseius) capparidis* collected in this study (localities followed by the number of specimens measured between brackets).

Characters	Grande Comore Island (1) (this study)	Characters	Grande Comore Island (1) (this study)
Dsl	230	Rl	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	SgeIV	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 exhilarates, 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) Parlatores (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 more 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 record 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

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)	Characters	Madeira Island (1) (this study)	Morocco (15)
Dsl	333	330	st1 – st1	50	–
Dsw	185	176	st2 – st2	63	–
j1	23	27 (21 – 33)	st3 – st3	73	–
j3	33	27 (21 – 33)	st1 – st3	65	–
j4	15	15 (11 – 19)	st4 – st4	90	–
j5	14	14 (10 – 18)	Gensl	125	–
j6	16	16 (12 – 20)	st5 – st5	66	–
J2	18	19 (14 – 23)	Gensw st5	71	–
J5	6	4 (2–8)	Gensw post. corn.	76	–
z2	18	17 (13 – 21)	Lisl	28	–
z3	Broken	19 (14 – 23)	Lisw	4	–
z4	24	19 (14 – 23)	sisl	15	–
z5	16	17 (13 – 21)	sisw	2	–
Z4	30	42 (34 – 50)	Vsl	120	–
Z5	63	62 (52 – 72)	Vsw ZV2	105	–
s4	27	24 (19 – 29)	Vsw anus	83	–
s6	29	29 (23 – 35)	JV5	38	–
S2	30	32 (25 – 39)	SgeIV	20	24 (19 – 29)
S4	28	32 (25 – 39)	StiIV	21	27 (21 – 33)
r3	24	25 (19 – 31)	StIV	38	46 (36 – 55)
RI	20	25 (19 – 31)	Scl	Not well visible	20
			Scw	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**, Sacrada familia (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. on *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.) rhenanoides*, *T. (Typhlodromus) 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 Baumann (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. (Typhlodromus) exhilaratus*, *T. (T.) moroccoensis* 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) (this study)	Morocco (15)	Portugal paratype (1)	Characters	Madeira Island (1) (this study)	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)	23
z3	28	24 (20 – 27)	27	Lisw	4	5 (4 – 6)	2
z4	27	24 (20 – 27)	25	sisl	15	13 (12 – 14)	–
z5	16	17 (15 – 18)	–	sisw	2	3 (2 – 3)	–
Z4	43	44 (40 – 50)	41	Vsl	138	106 (100 – 110)	122
Z5	80	67 (60 – 75)	59	Vsw ZV2	121	101 (95 – 105)	100
s4	35	30 (25 – 35)	32	Vsw anus	85	83 (75 – 90)	87
s6	37	33 (30 – 37)	35	JV5	51	55 (48 – 60)	52
S2	38	36 (32 – 42)	37	SgeIV	27	27 (25 – 28)	–
S4	36	36 (30 – 42)	37	StiIV	31	31 (28 – 33)	–
r3	33	25 (20 – 25)	26	StIV	53	50 (42 – 55)	–
RI	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	3
				Mdl	28	25	24
				No teeth Md	1	1	1

Sources of measurements – Morocco: Tixier *et al.* (2016); Portugal: Chant & Yoshida-Shaul (1987) after Dosse (1961); –: not provided.

Three species previously reported by Carmona (1973) were not found in subsequent studies by Papadoulis and Kapaxidi (2011) and Ferragut and Baumann (2020) as well as in this study. 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 of *A. largoensis* by Carmona (1973) represents probably a misidentification, though those specimens were not available for study. Just like the former authors, *A. herbicolus* 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. herbicolus* might be the reason. Three characters allow to distinguish the two species as highlighted by Döker *et al.* (2020):

- calyx of spermatheca trumpet-shaped for *A. herbicolus* vs. calyx of the spermatheca tubular for *A. largoensis*;
- atrium of spermatheca wider than the base of calyx for *A. herbicolus* vs. atrium of spermatheca as wide as the basis of calyx for *A. largoensis*;
- movable digit of chelicera with four teeth in *A. herbicolus* vs. movable digit of chelicera with three teeth in *A. largoensis*.

Döker *et al.* (2020) stated the possible misidentification of *A. herbicolus* 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. herbicolus* 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. herbicolus*, *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.

Acknowledgements

Thanks are due to the wife of the senior author, Marie Kreiter, for material helps and patience during this study. Many thanks also to our colleagues and friends, Professor Francisco “Paco” Ferragut from University of Valencia, and Eric Pierre from INRAE CBGP for valuable discussion concerning Madeira Island biodiversity and taxonomic topic on species found.

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