INTRODUCTION

Mites of the family Phytoseiidae (Mesostigmata) have been extensively studied for their potential as biological control agents of phytophagous mites (McMurtry and Croft, 1997). Several species are currently used for bio-control of mite and insect pests in several crops all over the world (McMurtry and Croft, 1997). About 2,300 phytoseiid species belonging to 90 genera have been described in this family (Chant and McMurtry, 2007). However, the fauna of all countries has not been equally surveyed (Tixier et al., 2012). Until very recently, only few species were reported from Tunisia (Kreiter et al., 2010). For a long time, *Phytoseiulus persimilis* Athias-Henriot was the unique species reported from this country (Gafsa, South of Tunisia) (Rambier, 1972), and many works referring to phytoseiids from Tunisia have been recently initiated (Kreiter et al., 2002, 2004, 2006, 2010). A synthesis of the surveys carried out during 15 years (between 1994 and 2008) in the main crops and surrounding vegetation was reported by Kreiter et al. (2010): 27 species of phytoseiid mites belonging to 14 genera are now recorded. Among them, twelve species were identified on citrus trees (table 1).

Despite these progresses, additional studies are still necessary in order to evaluate properly the diversity of Phytoseiidae species in Tunisian ecosystems, especially in crops in order to exploit their predatory potential for biological control applica-
The present paper aims to better accurately characterize the phytoseiid mite diversity in a wide range of citrus plots, located in different growing areas, sampled on several varieties at different seasons.

**MATERIALS AND METHODS**

A survey of phytoseiid mites was carried out from September 2009 to August 2011, in 46 citrus orchards in the most important productive regions of Tunisia: twenty three orchards are situated in Cap Bon which is the most important citrus productive region (with a surface of about 75% of the total citrus surface), eight orchards in Tunis (Mornag, Sidi Thabet and Ariana), six orchards in Bizerte, seven in the North West (Beja and Jandouba), one orchard in Sousse and one orchard in Kairouan (Figure 1). One hundred and eight samplings have been carried out in the 46 selected orchards: for each sampling, collections were carried out on citrus trees, uncultivated weeds in inter-rows and break winds trees.

Samples of each plant were individually bagged in plastic bags and transported the same day in freezing boxes to the laboratory for mite extraction. Mites were extracted from leaves using a fine hair brush and were preserved in 70% ethanol. They were then mounted on slides using Hoyer’s medium (Gutierrez, 1985) and identified using a phase contrast microscope.

The generic classification of Chant and McMurry (2007) was used for identification. Other more specific literature was used for species determination (Ferragut et al., 2009; Papadoulis et al., 2009).

**Table 1: Phytoseiidae species reported on citrus trees in Tunisia in Kreiter et al. (2010) and those presently recorded.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Sub-family</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euseius scutalis (Athias-Henriot)</td>
<td>Amblyseiinae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Euseius stipulatus (Athias-Henriot)</td>
<td>Amblyseiinae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Graminaseius graminis (Chant)</td>
<td>Amblyseiinae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Iphiseius degenerans (Berlese)</td>
<td>Amblyseiinae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Neoseiulus californicus (McGregor)</td>
<td>Amblyseiinae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Phytoseiulus persimilis (Athias-Henriot)</td>
<td>Amblyseiinae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Proprioseiopsis bordjelaini (Athias-Henriot)</td>
<td>New records</td>
<td></td>
</tr>
<tr>
<td>Phytoseius finitimus (Ribaga)</td>
<td>Phytoseiinae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Paraseiulus talbi (Athias-Henriot)</td>
<td>Typhlodrominae</td>
<td>New records</td>
</tr>
<tr>
<td>Typhlodromus (Anthoseius) foenilis (Oudemans)</td>
<td>Typhlodrominae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Typhlodromus (Anthoseius) pegazzani (Ragusa and Swirski)</td>
<td>Typhlodrominae</td>
<td>New records</td>
</tr>
<tr>
<td>Typhlodromus (Anthoseius) rhenanoides (Athias-Henriot)</td>
<td>Typhlodrominae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Typhlodromus (Anthoseius) rhenanus (Oudemans)</td>
<td>Typhlodrominae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Typhlodromus (Anthoseius) yasminae (Faraji)</td>
<td>Typhlodrominae</td>
<td>New records</td>
</tr>
<tr>
<td>Typhlodromus (Typhlodromus) ernesti (Ragusa and Swirski)</td>
<td>Typhlodrominae</td>
<td>New records</td>
</tr>
<tr>
<td>Typhlodromus (Typhlodromus) exilaratus (Ragusa)</td>
<td>Typhlodrominae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Typhlodromus (Typhlodromus) philatus (Athias-Henriot)</td>
<td>Typhlodrominae</td>
<td>(Kreiter et al. 2010)</td>
</tr>
<tr>
<td>Typhlodromus (Typhlodromus) setubali (Dosse)</td>
<td>Typhlodrominae</td>
<td>New records</td>
</tr>
</tbody>
</table>
RESULTS

A total of 2,759 individuals (adults) of phytoseiid mites were identified from citrus trees and associated uncultivated plants in the 46 Tunisian orchards considered.

Twenty-six phytoseiid species belonging to 10 genera were found, fifteen of them being already known and eleven are new species for Tunisia (Table 2). Among them six were found on citrus trees (Table 1), the others on weeds and conifers. First, we will present the twenty six species presently found in citrus agrosystems. Some biological data are given when available and helpful for biological control applications, the current geographic distribution of species are from Moraes et al. (2004) and Papadoulis et al. (2009). Data on the species previously recorded in Tunisia are from Kreiter et al. (2010). Then, a key of all the species of Phytoseiidae known from Tunisia is provided.

SPECIES OF PHYTOSEIIDAE MITES PRESENTLY OBSERVED IN CITRUS AGROSYSTEMS

Sub-family Amblyseiinae

1. Graminaseius graminis (Chant)


Distribution — Algeria, Armenia, Australia, Azerbaijan, Denmark, England, France, Germany, Greece, Moldova, Morocco, Norway, Poland, Russia, Spain, Turkey, Ukraine, and USA.

Previous records from Tunisia — Cap Bon region – July 2006 on *Citrus* sp. (lemon, navel and orange).
Table 2: Phytoseiidae species presently observed and their geographical distribution in the sampled citrus orchards (the species in bold characters are new for the Tunisian fauna).

<table>
<thead>
<tr>
<th></th>
<th>Bizerte (Azib, Alia, Ras Jbel)</th>
<th>Grand-Tunis (Morneg, Ariana Sidi Thabêt, Khlidia)</th>
<th>Cap bon (Takelsa, Menzel Bouzella, Grombalia, Bouargoub, Slimen, Bni Khalled, Hammamet)</th>
<th>North West (Jandouba-Beja)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E. stipulatus</td>
<td>×</td>
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<tr>
<td>E. scutalis</td>
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<td>×</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. californicus</td>
<td>×</td>
<td>×</td>
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<td>×</td>
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<tr>
<td>N. cucumeris</td>
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<tr>
<td>N. longilaterus</td>
<td>×</td>
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<tr>
<td>N. barkeri</td>
<td>×</td>
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<tr>
<td>N. alpinus (aurescens)</td>
<td>×</td>
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<tr>
<td>N. paspalivorus</td>
<td>×</td>
<td>×</td>
<td></td>
<td></td>
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<tr>
<td>N. bicaudus</td>
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<tr>
<td>P. persimilis</td>
<td>×</td>
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<tr>
<td>I. degenerans</td>
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<tr>
<td>T. phialatus</td>
<td>×</td>
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<tr>
<td>T. exilatus</td>
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<tr>
<td>T. pegazzani</td>
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<tr>
<td>T. ernesti</td>
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<tr>
<td>T. setubali</td>
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<tr>
<td>P. talbii</td>
<td>×</td>
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<td></td>
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<tr>
<td>A. foenelis</td>
<td>×</td>
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<td></td>
<td></td>
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<tr>
<td>A. gasminiae</td>
<td>×</td>
<td>×</td>
<td></td>
<td></td>
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<tr>
<td>A. athenas</td>
<td>×</td>
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<td></td>
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<tr>
<td>A. rhenanoides</td>
<td>×</td>
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<td></td>
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<tr>
<td>A. recki</td>
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<tr>
<td>G. graminis</td>
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<tr>
<td>P. bordjelaini</td>
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<tr>
<td>A. meridionalis</td>
<td></td>
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<td></td>
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<tr>
<td>A. obtusus</td>
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</tr>
</tbody>
</table>

Additional records from Tunisia — Takelsa (Cap Bon): December – 1♀ on *Citrus* sp.; March – 1♀ on *Malva* sp.; June and July – 7♀ on *Hordeum murinum*.

2. *Amblyseius obtusus* (Koch)


Distribution — Algeria, Armenia, Canada, Czech Republic, England, France, Greece, Germany, Hawaii, Hungary, Italy, Moldova, Morocco, Norway, New Zealand, Pakistan, Poland, Russia, Spain, Sweden, Turkey, USA, Ukraine and Venezuela.

Specimens examined — Takelsa (Cap Bon): March – 1♀ on Malva sp.; April – 2♀ and 1♂ on H. murinum. This is the first record of this species in Tunisia.

3. *Amblyseius meridionalis* (Berlese)


Distribution — Algeria, Azerbaijan, Canada, Germany, Greece, Hungary, Italy, Morocco, Poland, Spain, Switzerland and Ukraine.

Specimens examined — Boumhal (Tunis): June 2011 – 1♀ on *Convolvulus* sp. This is the first record of this species in Tunisia.

4. *Proprioseiopsis bordjelaini* (Athias-Henriot)


Distribution — Spain, Canary Islands, Algeria and Morocco.

Specimens examined — Takelsa (Cap Bon), December – 1♀ on *Citrus* sp. This is the first record of this species in Tunisia.

5. *Euseius scutalis* (Athias-Henriot)


Distribution — Algeria, Canary Islands, Cape Verde, Ghana, Egypt, Greece, India, Iran, Israel, Italy, Jordan, Lebanon, Morocco, Pakistan, South Africa, Spain and Turkey.

Previous records from Tunisia — this is a wide spread species in Tunisia, recorded in several orchards (citrus, vineyards, ornamental plants, fruit trees, wild cover).

Additional records from Tunisia — INAT (Tunis) (Institut National Agronomique de Tunisie), June – 1♀ on *Citrus* sp.

Biology — *Euseius scutalis* was described from Algeria by Athias-Henriot (1958). This species can be reared on pollen (Alshammeri, 2011) and was recorded as a predator of *Panonychus citri* (McGregor) in citrus orchards (McMurtry, 1969, 1977; Kasap and Ekerog, 2004). *Euseius scutalis* has also been reported as a biological control agent of *Bemisia tabaci* (Gennadius) (Nomikou et al., 2003; Dale and Donald, 1986).


Distribution — Algeria, Canary Islands (Spain), France, Greece, Italy, Montenegro, Morocco, Portugal, Tunisia, Turkey, and former Yugoslavia

Previous records from Tunisia — recorded in many regions in the Cap Bon, Mateur (North region), Sousse (Sahel region), on *Citrus* sp. and *M. domestica* and in Degache (South), July 2005 on *Olea europea*.

Additional records from Tunisia — Tekelsa (Cap Bon): all the year – 343♀ and 39♂ on *Citrus* sp.; February, April and June – 129♀ and 60♂ on *Acalypha rhomboidea*; March – 2♀ and 3♂ on *Mercurialis annua*; April – 2♀ and 5♂ on *U. dioica*; April, May and June – 9♀ on *Solanum nigrum*; April – 5♂ on *Conyza canadensis*; May and July – 3♀ on *Cupressus* sp.; March – 1♀ on *Chrysanthemum* sp., June – 3♀.
on *H. murinum*, April – 1♂ and 1♂ on *Convulvulus* sp.; March – 3♀ and 4♂ on *Amaranthus retroflexus*; Alia and Ras ejbal (Bizerte): March, April and May – 80♀ and 28♂ on *Citrus* sp.; April – 7♀ and 1♂ on *A. retroflexus*; March – 1♀ on *M. annua*; May – 1♀ on *S. nigrum*; May – 2♀ and 2♂ on *Cupressus* sp.; March – 1♀ on *Nerium oleander*; April – 2♀ and 2♂ on *Malva* sp.; Grombalia (Cap Bon): February, March, April, and June – 96♀ and 13♂ on *Citrus* sp.; April and May – 2♀ and 1♂ on *A. rhomboidea*; April – 2♀ on *Malva* sp.; May – 1♀ on *S. nigrum*; April – 7♀ on *Convulvulus* sp.; Mor nag (Tunis): December, March and April – 2♀ and 9♂ on *Citrus* sp.; March – 2♀ on *M. annua*; April – 1♀ on *U. dioica*; April – 2♀ and 1♂ on *Hedera helix*.

7. *Iphiseius degenerans* (Berlese)


Distribution — Algeria, Benin, Brazil, Burundi, Cape Verde, China (Hong-Kong), Congo, Egypt, Georgia, Greece, Israel, Italy, Kenya, Lebanon, Madeira Islands, Madagascar, Malawi, Morocco, Nigeria, Portugal, Rwanda, South-Africa, Canary Islands, Tanzania, Turkey, Yemen, Zaire and Zim babwe.

Previous records from Tunisia — Sousse (Sahel region): April 2000 on *Citrus* sp. and *Hibiscus syriacus* near citrus orchard; Cap Bon Region: May 2006 on *Citrus* sp. (Thomson, Navel and oranges).

Additional records from Tunisia — Sidi Thabet (Tunis): March – 1♀ on *Citrus* sp.; Alia (Bizerte): March and April – 2♀ and 1♂ on *Citrus* sp.

8. *Neoseiulus barkeri* Hughes


Distribution — Algeria, Australia, Brazil, Canary Islands, Cape Verde, China, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Hawaii, Israel, Italy, Japan, Jordan, Madagascar, Netherlands, Nigeria, Norway, Reunion Island, Russia, South Africa, South Korea, Spain, Sweden, Turkey, Ukraine, United Kingdom, West Bank and Yemen.

Previous records from Tunisia — Beni Khiar (Cap Bon region): October 1995 on *Oxalis* sp. in citrus orchard; Palmeraie Ibn Chabbat (South): July 2000 on *C. dactylifera*; Segdoud: January 2006 on *Ph. dactylifera* cv. Alig.

Additional records from Tunisia — Takelsa (Cap Bon): May – 1♀ on *S. nigrum*; April – 1♀ on *Conyza canadensis*; Alia (Bizerte): July – 1♀ on *C. canadensis*.

Biology — Various studies have shown its ability to control *F. occidentalis* (Rodriguez-Reina et al., 1992), *Thrips tabaci* (Lindeman) (Hansen, 1988; Bonde, 1989; Dsgaard et al., 1992) and *T. urticae* in cucumber (Yuqing and Petitt, 1994). Fan and Petitt (1994) showed that augmentative releases of *N. barkeri* provided control of broad mite [*Polyphagotarsonemus latus* (Banks)] on peppers.

9. *Neoseiulus californicus* (McGregor)


Distribution — Algeria, Argentina, Brazil, Chile, Colombia, Cuba, France, Greece, Guatemala, Italy, Japan, Mexico, Peru, South Korea, Spain, Taiwan, Uruguay, USA (California) and Venezuela.

Previous records from Tunisia — Sousse (Sahel Region): April 2000 on Lycopersicon esculentum in greenhouses; Mateur (North Region): July 2000 on M. domestica; Chekmo oasis (South): June 2005 on Malva sp.; Hammamet, Mraissa, Grombalia, Menzel Bou Zelfa (Cap Bon Region): July 2006 on Citrus sp. (lemon, clementine and maltaise).

Additional records from Tunisia — Grombalia (Cap Bon): July – 1♀ on Citrus sp., April – 6♀ on Malva sp.; Takelsa (Cap bon): December, January, February, March and April – 47♀ and 16♂ on Citrus sp.; May, April – 3♀ on S. nigrum; July – 1♀ on Fubus sp.; April, May – 73♀ and 5♂ on M. annua, August – 1♀ on P. persica; March, April – 76♀ and 1♂ on Malva sp., May – 1♀ on Cupressus sp.; July – 2♀ and 1♂ on Tamarix sp.; July – 1♀ on F. carica; Alia (Bizerte): August – 1♀ on Citrus sp.; March – 1♀ on N. oleander, July – 8♀ and 1♂ on Phaseolus vulgaris; August – 9♀ and 2♂ on S. nigrum; July – 3♂ and 3♂ on A. rhomboides; July – 5♀ and 1♂ on C. canadensis; August – 1♀ and 1♂ Salvia officinalis; August – 6♀ and 1♂ on Malva sp.; August – 5♀ and 1♂ on A. retroflexus; July – 6♀ and 1♂ on Cupressus sp.; March – 13♀ on M. annua; Morneg (Tunis): April – 1♀ on Citrus sp.; August – 1♀ on Convolvulus sp.; August – 1♂ on Malus sp.; April – 1♂ on U. dioica.

Biology — This is a very widespread species (Moraes et al., 2004). Neoseiulus californicus has characteristics of both specialist and generalist predatory mites (Castagnoli and Simoni, 2003). It prefers to feed on Tetanychidae mites (Escudero et al., 2004, 2005; Greco et al., 2005; Katayama et al., 2006; Fraulo et al., 2008; Gomez et al., 2009), but can also consume other mite species like tarsonemid mites [Phytoseius pallidus (Banks)] (Easterbrook et al., 2001), small insects, such as thrips (Rodriguez et al., 1992) and even pollen when the primary prey is unavailable (Rhodes and Liburd, 2005).

10. Neoseiulus cucumeris (Oudemans)


Distribution — Algeria, Armenia, Australia, Austria, Azerbaijan, Belgium, Byelorussia, Canada, Canary Islands, Caucasus Region, Egypt, England, Finland, France, Georgia, Germany, Greece, Hungary, Italy, Iran, Israel, Italy, Mexico, Moldova, Morocco, Netherlands, New Zealand, Norway, Poland, Russia, Spain, Sweden, Switzerland, Tunisia, Ukraine, USA and West Bank.

Previous records from Tunisia — recorded in several palmareas in the south of Tunisia on C. dactylic, Sorghum vulgare, Setaria sp., Digitaria communata and Ph. dactilifera.

Additional records from Tunisia — Sidi Thabet (Tunis): June – 6♀ on Elytrigia repens.

Biology — The biological characteristics of this species have been well documented because of its ability to control thrips on various cultivated plants in greenhouses (McMurtry and Croft, 1997; Mes selink et al., 2005).

11. Neoseiulus bicaudus (Wainstein)


Distribution — Armenia, Azerbaijan, Caucasus Region, France, Georgia, Greece, Hungary, Israel, Italy, Kazakhstan, Moldova, Norway, Russia, Spain, Switzerland, Turkey and USA (Washington).

Specimens examined — Takelsa (Cap Bon): July – 1♀ on Cupressus sp. This is the first record of this species in Tunisia.

12. Neoseiulus longilatus Athias-Henriot


Distribution — Algeria, Israel.
Specimens examined — Manzel Bouzelfa (Cap Bon): August – 1♀ on Convolvulus sp., Sidi Thabêt (Tunis): 1♀ on C. dactylon. This is the first record of this species in Tunisia.

13. Neoseiulus alpinus Athias-Henriot


Distribution — Algeria, Australia, Belgium, Cuba, Czech Republic, England, France, Georgia, Russia, Ukraine, Germany, Greece, Hawaii, Hungary, Italy, Jordan, Norway, Poland, Switzerland, Spain, Turkey and USA (Arizona, California, Washington).

Specimens examined — Mjaz el Bab (Béja): May – 1♀ on M. annua; Takelsa (Cap Bon): 1♀ on S. nigrum, 1♀ on H. murinum. This is the first record of this species in Tunisia.

14. Neoseiulus paspalivorus (De Leon)


Distribution — Guadeloupe, India, Jamaica, Philippines, USA (Florida).

Previous Records in Tunisia — Palmeraie M’Rah Lahouara, on C. dactylon, July 2000.

Additional records from Tunisia — Sidi Thabêt: June 2011 – 1♀ on Chenopodium murale.

Biology — Neoseiulus paspalivorus was found only on coconut and on fruits, in association with A. guereronis (Moraes et al., 2004). This species is a promising candidate for the biological control of the coconut eriophyid (Lawson-Balagbo et al., 2008).

15. Phytoseiulus persimilis Athias-Henriot


Distribution — Algeria, Australia, Canary Islands, Chile, China, Costa Rica, Finland, France, Greece, Guatemala, Hungary, Israel, Italy, Jordan, Lebanon, Lybia, Morocco, New Caledonia, Peru, Reunion Island, South Africa, South Korea, Spain, Tunisia, Turkey, Venezuela and USA (California).

Previous records from Tunisia — Sousse (Sahel region): April 2000 on L. esculentum and Cucumber sativus in greenhouses; Hammamet, Menzel Bouzelfa and Mraïssa (Cap-Bon region): November 1994, October 1995 and July 2001 on Citrus sp. (Thomson, Navel and lemon); Metline (Bizerte region): June 2000 on M. domestica.

Additional records from Tunisia — Grombalia (Cap Bon): February, July, April – 31♀ and 2♂ on Citrus sp.; July – 4♀ on Convolvulus sp.; Takelsa (Cap bon): March, April and July – 1♂ on Citrus sp.; March, July – 7♀ on S. nigrum; March – 2♀ and 1♂ on M. annua; March, August – 30♀ on Malva sp.; July – 1♀ and 1♂ on Cupressus sp.; July – 1♀ on Tamarix sp.; July – 1♀ on Ficus carica; Alia (Bizerte): July – 2♀ on Citrus sp.; July, August – 163♀ on Ph. vulgaris; April, July, August – 101♀ and 3♂ on S. nigrum; July – 1♀ on C. canadensis; July, August – 3♀ on S. officinalis; July, August – 46♀ and 1♂ on Malva sp.; March – 147♀ on M. annua.

Biology — Phytoseiulus persimilis was first collected in Algeria (Athias-Henriot, 1957). It is known mainly from Mediterranean climates around the world (Takahashi and Chant, 1993). Many studies deal with this specialist predator because of its economic importance, especially in the bio-control of T. urticae Koch in greenhouses all over the world (McMurtry and Croft, 1997).
Sub-Family Typhlodrominae

16. Paraseiulus talbii Athias-Henriot


Distribution — Algeria, Armenia, Azerbaijan, China, Cyprus, Caucasus region, Denmark, Egypt, Finland, France, Georgia, Germany, Greece, Hungary, Israel, Italy, Iran, Kazakhstan, Moldova, Netherlands, Slovakia, Spain, Sweden, Switzerland, Turkey and Ukraine.

Specimens examined — INAT (Tunis): June – 3♀ on Citrus sp.; Takelsa (Cap Bon): July – 1♀ on F. carica, August – 1♀ on P. persica; Alia (Bizerte): June – 2♀ and 1♂ on Citrus sp., May – 2♀ on Cupressus sp. This is the first record of this species in Tunisia.

17. Typhlodromus (Anthoseius) athenas

Swirski and Ragusa 1976: 111.

Distribution — Greece, Israel, Italy, Morocco.

Previous records from Tunisia — Gafsa: March 2004 and March 2007 on O. europaea; Segdoud: November 2005, October 2006 and October 2007 on Ph. dactylifera; April 2006 on S. melongena (Kreiter et al. 2010).


18. Typhlodromus (Anthoseius) foenilis

Oudemans


Distribution — Azerbaijan, Belgium, Canada, England, France, Greece, Ireland, Israel, Italy and Norway.

Previous records from Tunisia — Degache: May 2005 on P. granatum; Cap Bon: June 2005 on Citrus sp.


19. Typhlodromus (Anthoseius) rhenanoides

Athias-Henriot


Distribution — Algeria, Canary Islands, France, Hawaii, Italy, Les Saintes, Morocco, Spain and USA (California).

Previous records from Tunisia — Cap Bon region: November 1994 and October 1995 on Citrus sp.; Chekmo oasis (South): June 2005 on Tamarix sp.

Additional records from Tunisia — Takelsa (Cap Bon): October, December, February and July – 9♀ and 3♂ on Citrus sp.; July, August – 71♀ and 15♂ on Cupressus sp.; August – 8♀ on Tamarix sp.; August – 3♀ on Malva sp.; June – 4♀ on S. nigrum., August – 7♀ on Rubus sp.; March – 3♀ and 2♂ on M. annua; March – 1♀ on A. rhomboidea; Morne (Tunis): April – 1♀ on H. helix; April – 1♀ on U. dioica; April – 10♀ and 1♂ on Chenopodium murale; August – 4♀ on Cupressus sp.; Hammamet (Cap Bon): July – 7♀ on Cupressus sp.; Alia (Bizerte): March, April, August...
Specimens examined — Takelsa (Cap Bon): April, May, June – 32♀ and 2♂ on Cupressus sp., August – 1♀ on Tamarix sp., May – 2♂ on Citrus sp.; Nianou (Cap Bon): May – 1♀ and 2♂ on Cupressus sp.; Alia (Bizerte): June, July and August – 11♀ and 1♂ on Cupressus sp.; Morneg (Tunis): August – 1♀ on Cupressus sp. This is the first record of this species in Tunisia.

23. Typhlodromus (Typhlodromus) exhilaratus

Ragusa


Typhlodromus exhilaratus has been considered as a synonym of T. tiliae Oudemans by Denmark (1992).

Distribution — Cyprus, France, Greece, Israel, Italy, Morocco and USA.

Previous records from Tunisia — Sousse (Sahel region): July 2000 on M. domestica; (Cap Bon region): May 2006 on Citrus sp. (maltaise, Thomson and lemon); Gafsa (South): March 2007 on O. europaea.

Additional records from Tunisia — Takelsa (Cap Bon): July – 5♀ on Malva sp.

Biological — Typhlodromus exhilaratus was reported as type III predators (generalist predators, able to develop without prey) (McMurtry and Croft, 1997), its food range includes Tetranychidae, Eriophyidae and pollen (Ragusa, 1979, 1981). Its intrinsic population growth rate (rm) is higher on Eotetranychus carpini (Oudemans) and pollen than on P. ulmi (Castagnoli and Liguori, 1986; Castagnoli et al., 1989).

24. Typhlodromus (Typhlodromus) phialatus

Athias-Henriot


Distribution — Algeria, Cyprus, France, Germany, Hungary, Israel, Italy, Jordan, Moldova, Morocco, Norway, Russia, Spain and Ukraine.

Previous Records from Tunisia — Cap Bon region: June 1994 on Citrus sp., July 1995 in several vineyards, on V. vinifera; September 2006 on Citrus sp.; Monastir (Sahel region): November 1994 on Citrus sp.; Slimane (Cap Bon region) and Sousse (Sahel region): July 2000 on M. domestica.


Biology — This species is known to feed on red spider mites and to consume pollen (Ferragut et al., 1987, 1992).

25. *Typhlodromus (Typhlodromus) setubali* Dosse

*Typhlodromus (Typhlodromus) setubali* Dosse 1961: 313.

Distribution — Germany, Israel, Jordan, Morocco and Spain.

Specimens examined — INAT (Tunis): June – 2♀ on Citrus sp. This is the first record of this species in Tunisia.

26. *Typhlodromus (Typhlodromus) ernesti* Raguza and Swirski


Distribution — Israel, Norway, Russia and Sweden.

Specimens examined — Sidi Thabêt: June 2011 – 1♀ on Citrus sp. (traps). This is the first record of this species in Tunisia.

**Key to the species of Phytoseiid mites of Tunisia**

Thirty eight species belonging to 17 genera are known from Tunisia. Among them, 18 species were identified on citrus trees. In order to facilitate the identification of the Phytoseiidae species reported from Tunisia until now, a dichotomous key comprising these 38 species of Phytoseiidae is provided below.

1. Podonotal region of the dorsal shield (anterior to setae R1) of the female with 5 or 6 pairs of “lateral” setae J3, Z2, Z4 and S4 always present and Z3 and/or S6 present .................................................. 2

1’. Podonotal region of the dorsal shield (anterior to setae R1) of the female with 4 pairs of “lateral” setae J3, Z2, Z4 and S4 present, Z3 and S6 absent .............................................. Amblyseiinae: 3

2 (1). Posterior "lateral" setae Z1, S2, S4 and S5 absent. Setae r3 usually inserted on the dorsal shield .............................................. Phytoseiinae: *Phytoseius finitimus* 2’ (1). At least one of setae Z1, S2, S4 and S5 present. Setae r3 usually inserted on the interscutal soft cuticle (rarely on the shield). . . . . Typhlodominae: 22

3 (1’). Sternal shield with median posterior projection, some forward “migration” of preanal setae ZV2 and/or JV2 .................................................. 4

3’ (1’). Sternal shield without posterior projection, without forward “migration” of preanal setae ZV2 and/or JV2 .................................................. 7

4 (3). Heavily sclerotized and brown body with separate anal shield and subrectangular ventral shield .............................................. *Iphiseius degenerans* 4’ (3). Lightly sclerotised and ventrianal shield entire .............................................. *Euseius*: 5

5 (4’). Cervix of spermatheca thin, long and sinuous (43 μm). Macrosetae of the basitarsus of the leg IV
long (77 µm) Peritreme short, extending to level of z4 or between z2 and z4. \textit{Euseius scutalis} 5′(4′). Cervix of the spermatheca tubular and not sinuous (20-25 µm). Macrosetae of the basitarsus of the leg IV shorter (50-60 µm). Peritreme long, extending to level of j3 or between j3 and z2. 6′ (5′). Cervix of the spermatheca not vase-shape (side walls of the calyx parallel), atrium globular. Dorsum slightly reticulated. \textit{Euseius stipulatus} 6′ (5′). Cervix of spermatheca vase-shaped (side walls of the calyx not parallel) Dorsum more strongly reticulated. \textit{Euseius gallicus} 7 (3′). Setae S4 absent. 8 (7). Setae J2, S2 absent, female ventrianal shield reduced, setae j6 very long: 2-3 times longer than distance between their bases, female ventrianal shield with 1 pair of preanal setae. \textit{Phytoseiulus persimilis} 8′ (7). Setae J2, S2 present, female ventrianal shield elongated with three preanal setae, setae j6 not long. \textit{Kampidromus aberrans} 9 (7′). Z2 present, ventrianal shield reduced. \textit{Typhloseiella isotricha} 9′ (7′). Z2 absent. 10 (9′). Macrosetae usually present only on leg IV (rarely missing on this leg) but sometimes also on leg III. Lateral dorsal setae except Z5 usually subequal. J2, Z1, S2, S4 and S5 always present. 10′ (9′). Macrosetae usually present on legs II, III and IV, and sometimes also on leg I. Lateral dorsal setae often of quite different lengths. J2, Z1, S2, S4 or S5 may be missing. Dorsal shield smooth and sclerotized. 11 (10). Female ventrianal shield reduced and/or markedly wider at anus level, with a marked waist. Movable and fixed cheliceral digits with a larger number of teeth not confined to apical region. \textit{Neoseiulus} 12 (11′). Spermatheca with atrium forked for at least half its length at juncture with major duct, or atrium appearing thick-walled, vacuolated. 12′ (11′). Spermatheca with atrium not deeply forked at juncture with major duct, nor appearing thick-walled, vacuolated. 13 (12). 4 pairs of solenostomes on the dorsal shield. \textit{Neoseiulus barkeri} 13′ (12). 7 pairs of solenostomes on the dorsal shield. \textit{Neoseiulus alpinus} 14 (12′). Female ventrianal shield large, square or rectangular, rounded posteriorly. Dorsal shield with marked "shoulder" at level of seta r3, Z5 serrated. 14′ (12′). Female ventrianal shield pentagonal or with lateral margins slightly rounded. Dorsal shield without marked "shoulder" at level of seta r3. 15 (14). Leg IV without macrosetae. \textit{Neoseiulus mumai} 15′ (14). Setaceous macroseta on basitarsus IV. \textit{Neoseiulus paspalivorus} 16 (14′). Spermatheca bell-shaped. \textit{Neoeoseiulus cucumeris} 16′ (14′). Cervix of the spermatheca cup-shaped and short. 17 (16). Ventrianal shield with preanal pores, Five pairs of prominent crateriform solenostomes on the dorsal shield. \textit{Neoseiulus californicus} 17′ (16). Ventrianal shield without preanal pores, six pairs of solenostomes. \textit{Neoseiulus longilatater} 18 (16′). Ventrianal shield with large prominent crescentic preanal pores close to the central part. Setae Z4 longer than S4, J2 longer than S5. \textit{Neoseiulus californicus} 18′ (16′). Ventrianal shield with small slightly crescent preanal pores, setae Z4 shorter than
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>19 (10').</td>
<td>J2 present; leg IV usually with 3 strong macrosetae, setae z2 and z4 usually short; setae j5, S2 and S4 present; setae j2, S5 and Z1 present/absent.</td>
</tr>
<tr>
<td>19' (10').</td>
<td>J2 absent; legs II-IV with/without macrosetae, setae z2 and/or z4 often longer, setae j3 present.</td>
</tr>
<tr>
<td>20 (19).</td>
<td>Spermatheca with atrium bifurcate/vacuolated at juncture with major duct. Male spermatophoral process T-shaped, with both heel and toe elongate, approximately equal.</td>
</tr>
<tr>
<td>20' (19).</td>
<td>Spermatheca with atrium not bifurcate/vacuolated at the juncture with major duct.</td>
</tr>
<tr>
<td>21 (20').</td>
<td>Fixed digit of chelicerae with more than 7 teeth, spermatheca short cup-shaped with long tubular calyx having annulated stalk.</td>
</tr>
<tr>
<td>21' (20').</td>
<td>Fixed digit of chelicerae with less than 5 teeth, movable digit without tooth, spermatheca with saccular cervix and c-shaped atrium.</td>
</tr>
<tr>
<td>22 (2').</td>
<td>Setae z6 present.</td>
</tr>
<tr>
<td>22' (2').</td>
<td>Setae z6 absent.</td>
</tr>
<tr>
<td>23 (22).</td>
<td>Seta Z3 present.</td>
</tr>
<tr>
<td>23' (22).</td>
<td>Seta Z3 absent, one pair of solenostomes on dorsal shield.</td>
</tr>
<tr>
<td>24 (22').</td>
<td>Both S4 and JV4 present.</td>
</tr>
<tr>
<td>24' (22').</td>
<td>Both setae S4 and JV4 absent.</td>
</tr>
<tr>
<td>25' (24).</td>
<td>Seta Z1 present, seta on dorsal shield slender, setiform, peritreme punctuate, 3 or 4 pairs of preanal setae.</td>
</tr>
<tr>
<td>26 (25).</td>
<td>Setae S5 present.</td>
</tr>
<tr>
<td>26' (25).</td>
<td>Setae S5 absent.</td>
</tr>
<tr>
<td>27 (26).</td>
<td>Presence of 3 pairs (gd2, gd6, gd9) of solenostomes on a strongly reticulated dorsal shield.</td>
</tr>
<tr>
<td>27' (26).</td>
<td>Presence of more than 3 pairs of solenostomes on a less reticulate dorsal shield.</td>
</tr>
<tr>
<td>28 (27').</td>
<td>Ventrianal shield without preanal solenostome.</td>
</tr>
<tr>
<td>28' (27').</td>
<td>Ventrianal shield with preanal solenostome.</td>
</tr>
<tr>
<td>29 (28).</td>
<td>Dorsal shield with 5 pairs of solenostomes.</td>
</tr>
<tr>
<td>29' (28).</td>
<td>Dorsal shield with 4 pairs of solenostomes.</td>
</tr>
<tr>
<td>30 (29).</td>
<td>Movable digit of chelicerae with 2 teeth, spermatheca with cylindrical calyx, ventrianal shield pentagonal in outline and with inconspicuous ornamentation.</td>
</tr>
<tr>
<td>30' (29).</td>
<td>Movable digit of chelicerae with 1 tooth, spermatheca without a neck between atrium and cervix and a long cylindrical major duct.</td>
</tr>
<tr>
<td>31 (28').</td>
<td>Leg IV with a long knobbed macroseta on tarsus.</td>
</tr>
<tr>
<td>31' (28').</td>
<td>Leg IV with macroseta, not knobbed on tarsus.</td>
</tr>
<tr>
<td>32 (30).</td>
<td>Spermatheca with calyx elongate and tubular.</td>
</tr>
</tbody>
</table>
| 32' (30). | Spermatheca with calyx cup-shaped and...
with c-shaped atrium on a short stalk

...Typhlodromus (Anthoseius) yasminae

33 (30'). Macroseta of leg IV short, less than 30 µm.............. Typhlodromus (Anthoseius) rhenanus 33' (30'). Macroseta of leg IV long, 56 (54-60) µm.............. Typhlodromus (Anthoseius) pegazzani

34 (26'). Peritreme extending to about the level of z2. Six setae on the the genu II

...Typhlodromus (Typhlodromus) setubali

34' (26'). Peritreme extending to about the level between j1 and j3. Seven setae on the the genu II

35 (34'). Basitarsus IV with macroseta having blunt tip

...Typhlodromus (Typhlodromus) ernesti

35' (34'). Basitarsus IV with macroseta having bulbous tip

36 (35'). Calix of the spermatheca squared basally, with a short neck

...Typhlodromus (Typhlodromus) exhilaratus

36' (35'). Calix of the spermatheca rounded basally, without neck

...Typhlodromus (Typhlodromus) phialatus

37 (25'). Four large and one small solenostomes on the dorsal shield (gd1, gd2, gd6, gd8, gd9). Ventrianal shield not reduced, with 4 pairs of preanal setae and without pores. Dorsal setae mostly slender and almost of the same medium size. Peritreme short, extending anteriorly between z3 and z4. Cervix of spermatheca saccular. Leg IV without macroseta

...Neoseiulella tiliarum

37' (25'). Six small round solenostomes on the dorsal shield (gd1, gd2, gd5, gd6, gd8, gd9). Ventrianal shield reduced, with 4 pairs of preanal setae and without solenostome. Dorsal setae also slender, but short and not of the same size. Peritreme long, extending anteriorly to z2. Cervix of spermatheca saccular. Leg IV with a macroseta on basitarsus

...Neoseiulella perforata

**DISCUSSION AND CONCLUSION**

Twenty-seven species were known from Tunisia until now (Kreiter *et al.*, 2010), including one new genus and one new species to science found in the South of Tunisia. In this study, twenty six species belonging to 10 genera were found, eleven of them being new for the Tunisian fauna. Among these species, six were found on citrus trees: *Typhlodromus*
(Typhlodromus) setubali, Typhlodromus (Typhlodromus) ernesti, Typhlodromus (Anthoseius) pegazzani, Typhlodromus (Anthoseius) yasminae, Proprioseiopsis bordjelaini and Paraseiulus talbii. Only one of these six species (Paraseiulus talbii) was found in two samples and two different regions (Bizerte and Cap Bon), the other species were found only once (one or two individuals per species) (Table 2). These latter species seem thus to be rare on citrus trees. Two of the 10 newly reported species were also found on Cupressus sp. (conifer planted usually around orchards to break winds) and Tamarix sp.: Neoseiulus bicaudus and Typhlodromus (Anthoseius) yasminae. Three others were also found on weeds: Neoseiulus longilaterus, Neoseiulus alpinus, Amblyseius obtusus and Amblyseius meridionalis; all of them being rare. Only one of the new reported species was present in many samples and several regions (Bizerte, Tunis and Cap Bon), Typhlodromus (Anthoseius) yasminae, but almost on the same plants: Cupressus sp. and Tamarix sp. (on Citrus sp. in only one sample). These new recorded species were found in Cap Bon region, North region (Bizerte), North West (Beja) and in Tunis (Ariana, Sidi Thabet, Morneg and Boumhal) (Table 2). Even the number of citrus plots sampled in the Cap Bon region (23 plots) was higher than of Tunis (8 plots) and Bizerte (6 plots), the global diversity of Phytoseiidae in these three regions is similar (Figure 2).

Euseius stipulatus was the most abundant species on citrus trees (82 %) followed by P. persimilis, N. californicus, A. rhenanoides and T. phialatus which only represented respectively 4 %, 5 %, 3 % and 1 % of the phytoseiids collected from citrus trees. These most abundant phytoseiid species could be helpful in biological pest management programs. Since these most important species are also present in weeds, it is important to know which weed plants are favorable to these phytoseiid species. Additional studies are required to determine the factors that affect the diversity but also the abundance of preys and predators.

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REFERENCES


Koch C.L. 1839 — Deutschlands Crustaceen, Myriapoden und Arachniden — Herrich-Schaeffer: Regensburg, v.5 and 6, fasc.25, t.22; fasc.27, t.6, 13.


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