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Eriophyoid studies in Turkey: review and perspectives

EVSEL DENIZHAN[1], WIKTORIA SZYDŁO[2] and ANNA SKORACKA[2]

[1]Department of Plant Protection, University of Yüzüncü Yil, Agricultural Faculty, 65080 Van, Turkey
[2]Adam Mickiewicz University, Institute of Environmental Biology, Department of Animal Taxonomy and Ecology, Umultowska 89, 60-687 Poznań, Poland
Corresponding author: Wiktoria Szydło, wiktoria.szydlo@amu.edu.pl

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Abstract: Although the geographical location and botanical history of Turkey make the country a perfect place for a potentially rich diversity of eriophyoid mites, little is known about the Turkish eriophyoid fauna. The current paper is a brief review of the existing records of eriophyoid mites found so far in Turkey, with additional information on 6 grass-associated eriophyoid species recorded recently. The 134 eriophyoid species collected in Turkey come from only ca. 1.2% of all Turkish plant species. The role of collecting ecological and molecular data and studying economically significant eriophyoid mites species in this area is particularly stressed.

Keywords: Eriophyoidea, new records, faunistic, Turkey

INTRODUCTION

The superfamily Eriophyoidea is one of the largest groups of plant-feeding arthropods, which includes plant parasites of great economic significance (Lindquist et al. 1996). Their special importance is due to their potential influence on crops, orchards, and forests all over the world. They are in fact major pests causing significant economic losses in agriculturally important plants (Duso et al. 2010). They can cause various plant deformations and abnormalities, e.g. discolouration and curling of leaves, galls on various organs, bud proliferation, and fruit swelling (Petanović & Kiełkiewicz 2010), and therefore can reduce the quality of yields (Westphal & Manson 1996). Apart from the direct negative effects of eriophyoid mites feeding on their host plants, quite frequently they are the major vectors of plant viruses (Oldfield & Proeseler 1996). Eriophyoid mites can be potentially used as biological control agents of weeds and some species have already been efficiently applied and recommended for biological control programs of weeds (Smith et al. 2010).

The diversity of eriophyoid mites is best known in temperate regions of the world (Amrine et al. 2003). In spite of this, Turkey is among the regions whose erio-

phyoid mite fauna has not been sufficiently explored and described. Till 1999 only 62 eriophyoid mite species were recorded in Turkey, and only few studies published before 2005 discussed eriophyoid species occurring on economically important and ornamental plants (e.g. Denizhan et al. 2006). The scarcity of information seems to be inexplicable since the geographical location and botanical history of Turkey make it a perfect place for a potentially rich diversity of eriophyoid mites. The area under scrutiny is unique because it comprises parts of 3 important phytogeographical regions: Euro-Siberian, Mediterranean, and Irano-Turanian. The Turkish flora is exceptionally rich and diversified. Anatolia forms a natural bridge between southern Europe and the flora of south-western Asia, and has probably served as a migration route, especially in the process of penetration of Asiatic elements into southern Europe. Many cultivated plants (crops, fruit trees, and ornamentals) as well as weeds found in Europe, appear to originate from Anatolia and adjacent areas (Davis 1965–1985; Davis et al. 1988; Güner et al. 2000). Turkey covers partially the original region of the Fertile Crescent, a place historically recognised as the cradle of the agricultural civilization in Eurasia (Badr et al. 2000; Lev-Yadun et al. 2000) and, not surprisingly, it is the geographic centre of genetic diversity of wheat (Dvorak et al. 2011).

Some faunistic surveys attempting to gather the knowledge on eriophyoid fauna have been carried out in Turkey. A full list of eriophyoid taxa found in Turkey is provided in a recently updated catalogue (Denizhan et al. submitted). Recently, the second author has investigated the area of Lake Van basin in Turkey. The survey resulted in new records of grass-associated eriophyoid species. The major aim of this paper is to provide a synthetic description of the current state of research on the eriophyoid fauna of Turkey on the basis of the updated catalogue (Denizhan et al. submitted), with additional information on new records of grass-associated taxa, and to stress the issues that still need to be investigated.

MATERIALS AND METHODS

The literature regarding the eriophyoid mite fauna of Turkey was briefly reviewed (Düzgüneş 1977; Ecevit 1981; Alaoğlu 1984; Şekeroğlu & Özgür 1984; Madanlar & Öncüer 1994; Özman 1999, de Lillo et al. 2003; Denizhan et al. 2006; Denizhan 2007, 2011; Denizhan & Çobanoğlu 2010a, b; Denizhan et al. submitted). The faunistic study was carried out from 2009 to 2011 in Lake Van basin. The sampling and taxonomic analysis were done according to the classical methods (de Lillo et al. 2010). The collected plants were examined under a stereomicroscope and the specimens collected from the plants were mounted according to Keifer (1975). The specimens were examined with a Leica DM 1000 microscope. The classification followed the system outlined in Amrine et al. (2003). The taxonomical verifications were based on Amrine et al. (2003) and other published descriptions of species. The host plants were identified by Dr. Fevzi Özgökçe (Department of Biology, Yüzüncü Yıl University). The taxonomic verification of plant taxa was based on Simpson (2010), and the verification of invasive and noxious plant status was based on CABI (2013).

RESULTS

Six grass-associated eriophyoid species were found in the area of Lake Van basin. One of them, namely *Abacarus hystrix* (Nalepa, 1896), has already been recorded in Turkey. However, in the present survey we recorded additional host plants for this mite species: *Hordeum violaceum* Boiss. & Hohen., *Triticum aestivum* L., *Elymus hispidus* (Opiz) Melderis, and *Agropyron cristatum* (L.) Gaertn. The wheat curl mite, *Aceria tosichella* (Keifer, 1969), was expected to be found in Turkey (Denizhan et al. submitted), and the present survey confirmed its presence and recorded the following grass host plants: *T. aestivum*, *Hordeum murinum* L., *H. geniculatum* All., *H. giganteum* (Vahl) Raspail, *H. violaceum*, *Secale ciliatoglume* (Boiss.) Grossh., *Aegilops cylindrica* Host, *Bromus tomentellus* Boiss., *B. arvensis* L., *Agropyron cristatum* (L.) Gaertn. subsp. *inconum* (Nab) Medler, and *E. hispidus* subsp. *barbulatus* (Schur) Melderis. Other eriophyoid species recorded are: *Abacarus lolii* Skoracka, 2009, found on *Eremopyrum orientale* (L.) Jaub. & Spach; *A. longilobus* Skoracka, 2002, found on *Bromus erectus* Hudson and *Dactylis glomerata* L.; *Aculodes dubius* (Nalepa, 1891), found on *T. aestivum*; and *Aculodes holcusi* Skoracka, 2004, found on *A. cylindrica* and *H. violaceum*.

Güner et al. (2000) report about 9300 species of vascular plants from Turkey. However, the presence of eriophyoid mites was confirmed only on about 1.2% of Turkish plant species, i.e. at least 116 plant species (some of eriophyoid records originated from plants that were not identified to species) belonging to 79 plant genera (for the list of the plant species, see the Appendix 1). So far 134 eriophyoid species have been found in Turkey, and Turkey is the type locality for 16 of them.

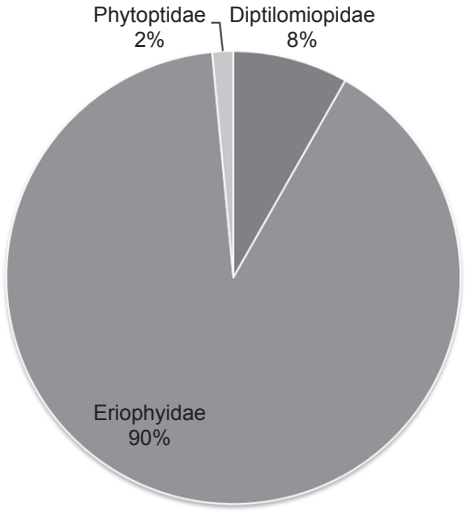

Fig. 1. Percentage contributions of the families to which eriophyoid species found in Turkey belong

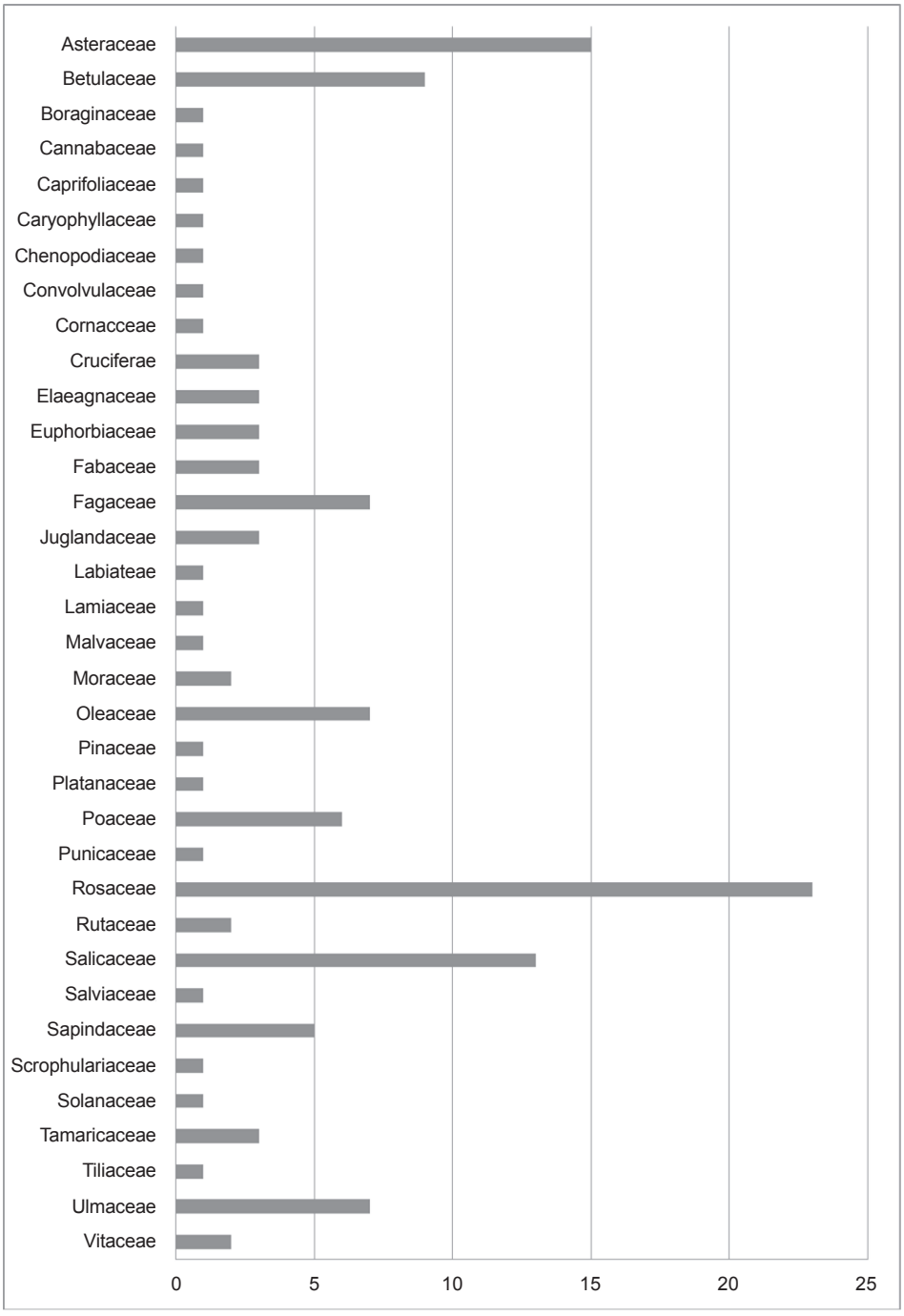

Fig. 2. Number of eriophyoid species found on plant species belonging to respective plant families

Most of the collected eriophyoid species belong to the family Eriophyidae (90%). The Diptilomiopidae represent only 8% of the recorded taxa, and the lowest number of eriophyoid species represents the family Phytoptidae (2%) (Fig. 1). The recorded eriophyoid species belong to 33 eriophyoid genera (listed in Appendix 2).

Most of the eriophyoid species were highly host-specific (94 species, 70%), observed on only one plant species. The eriophyoid mites were found on plants from 35 families. The plant families with the highest number of eriophyoid species recorded, were: Rosaceae (23 eriophyoid species, henceforth ES), Asteraceae (15 ES), Salicaceae (13 ES), and Betulaceae (9 ES) (Fig. 2). Many of the investigated host plants infested by eriophyoid mites are important as ornamental and crop plants (32% and 39%, respectively), both categories including herbaceous and woody plants, but a similar number of plant species in the study are wild herbaceous plants (29%). About 10% of plant species on which eriophyoid mites were recorded are noxious or invasive, native to Eurasia and introduced e.g. to North America.

As many as 96 eriophyoid species (81.4%) recorded in Turkey cause damages to their host plants, and 41% of eriophyoid species were found to cause galls (including erinea). Additionally, 52% of eriophyoid species were recorded as vagrants on plants, and only 7%, as refugee-seeking.

DISCUSSION AND CONCLUSIONS

The significance of the 9300 species of vascular plants listed from Turkey is quite evident when this number is compared with the flora of Europe, containing roughly 11 500 plant species but distributed over a 13-fold larger area. The Turkish flora comprises a relatively high number of endemics, as nearly ⅓ of Turkish plant species are endemic (Davis et al. 1988). However, only for 1.2% of the Turkish flora the occurrence of eriophyoid mites has been confirmed. It seems that surveys reporting about the Turkish eriophyoid fauna are highly insufficient. Furthermore, some of the eriophyoid species recorded so far have a great potential as pests of crops and ornamental plants, e.g. *Aculops lycopersici* (Tryon, 1917), and *Aculus schlechtendali* (Nalepa, 1890) (Duso et al. 2010). In some cases, they are considered as potential agents for biological control of weeds, e.g. the newly discovered *Metaculus lepidifolii* Monfreda et de Lillo, 2012, that can cause distortions of rosettes and flowers of perennial pepperweed (*Lepidium latifolium* L.), a noxious weed in North America (Monfreda & de Lillo 2012). All studies on the Turkish eriophyoid fauna conducted hitherto present faunistic and taxonomical approaches and therefore further research should definitely involve ecological and molecular data. Finally, the agricultural role of eriophyoid mites, both negative as pests and positive as biological control agents, obviously requires experimental studies.

This clearly shows that there is a need to continue the studies on eriophyoid mites in Turkey, which may result in further development of proper strategies of pest management and biological control of weeds. Revision of the eriophyoid fauna of Turkey has resulted in compiling a list of eriophyoid species (Denizhan et al. submitted). Some of them may be useful as biological control agents of plant species, some are invasive in other parts of the world, and some others are potential pests.

The Turkish region can also be an extremely data-rich environment for research, particularly on the wheat curl mite *A. tosichella*. This mite species is a pest of crops worldwide, especially of *T. aestivum* (Styer & Nault 1996; Harvey et al. 2002; Navia et al. 2013). As the only vector of plant viruses, such as Wheat Streak Mosaic Virus (WSMV) (Slykhuis 1955), Triticum Mosaic Virus (TriMV) (Seifers et al. 2009) and Wheat Mosaic Virus (WMoV) (also known as High Plains Virus, HPV) (Seifers et al. 1997), the wheat curl mite draws attention of many scientists all over the world these days. The main scientific problem is the wheat curl mite's genetic diversity, most likely driven by its host specificity (Siriwetwiwat 2006; Carew et al. 2009; Skoracka et al. 2012). As wheat ancestors, ancient wheat cultivars and weeds associated with them can be found there, so the wheat curl mite may have originated in this area. Considering the presence of Wheat Streak Mosaic Virus in that region (Rabenstein et al. 2002; Ilbağı et al. 2005), the wheat curl mite may be very common there. Therefore, further research on genetic variation and host specificity of the wheat curl mite in this region can largely contribute to its phylogeny reconstruction and establishment of its taxonomic status.

As has been shown, Turkey is an extremely attractive region for faunistic surveys on the diversity of eriophyoid mites as well as ecological and evolutionary research. Since only a small part of the Turkish flora has been investigated so far in search for eriophyoid mites in just few locations, their vast diversity probably still remains obscure. As eriophyoid mites are of high economic significance, more attention should be paid to research on local crops and ornamental plants. Results of the studies of the eriophyoid fauna published for the last 3 decades (intensified in 2005) open promising perspectives for exploring the eriophyoid mite diversity and encourage further investigations.

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APPENDICES

Appendix 1. Plant species recorded as hosts for eriophyoid mites in Turkey:

Acer semenovii Rgl. et Herd, *Acer heldreichii* subsp. *trautvetteri* (Medw.) A.E.Murray, *Acer negundo* L., *Acer pseudoplatanus* L., *Achillea millefolium* L., *Acroptilon repens* (L.) D.C., *Aegilops cylindrica* Host, *Aesculus* × *carnea* Hayne, *Agropyron cristatum* (L.) Gaertn., *Alcea rosea* L., *Alnus glutinosa* (L.) Gaertn, *Anchusa* sp. L., *Anthemis tinctoria* L., *Bromus arvensis* L., *Bromus erectus* Hudson, *Bromus tomentellus* Boiss., *Camellia sinensis* (L.) Kuntze, *Cardaria draba* (L.) Desv., *Carpinus betulus* L., *Celtis* sp., *Centaurea depressa* M.Bieb., *Centaurea solstitialis* L., *Centaurea squarrosa* Willd., *Chondrilla juncea* L., *Cichorium intybus* L., *Cirsium arvense* (L.) Scop., *Cirsium vulgare* (Savi) Ten., *Citrus* sp. *Convolvulus betonicifolius* Mill., *Cornus kousa* Buerger ex Hance, *Corylus avellana* L., *Cotoneaster horizontalis* Decne, *Cotoneaster salicifolius* Franch, *Crataegus monogyna* Jacq., *Crupina* sp., *Cydonia oblonga* Mill., *Dactylis glomerata* L., *Dianthus chinensis* L., *Elaeagnus angustifolia* L., *Elymus hispidus* (Opiz) Melderis, *Eremopyrum orientale* (L.) Jaub. & Spach, *Euphorbia helioscopia* L., *Euphorbia nicaeensis* All., *Euphorbia peplus* L., *Ficus carica* L., *Fraxinus angustifolia* Vahl subsp. *syriaca* (Boiss.) Yalt., *Fraxinus excelsior* L., *Fraxinus ornus* L., *Glycyrrhiza glabra* L., *Hedysarum* sp., *Hippophae rhamnoides* L., *Hordeum geniculatum* All., *Hordeum giganteum*, (Vahl) Raspail, *Hordeum murinum* L., *Hordeum violaceum* Boiss. & Hohen., *Isatis tinctoria* L., *Juglans regia* L., *Lepidium latifolium* L., *Ligustrum vulgare* L., *Lolium* sp., *Malus communis* L., *Malus domestica* Borkh., *Malus floribunda* Siebold ex Van Houtte, *Malus pumila* Mill., *Malus sylvestris* Mill., *Marrubium alysson* L., *Mespilus germanica* L., *Olea europaea* L., *Pinus nigra* J. F. Arnold, *Platanus orientalis* L., *Populus alba* L., *Populus nigra* L., *Populus tremula* L., *Prunus armeniaca* L., *Prunus avium* (L.) L., *Prunus cerasifera* Ehrh., *Prunus cerasus* L., *Prunus domestica* L., *Prunus dulcis* (Mill.) D. A.W ebb, *Prunus mahaleb* L., *Punica granatum* L., *Pyrus communis* L., *Quercus imbricata* Michx., *Quercus cerris* L., *Quercus macrolepis* Kotschy, *Quercus robur* L., *Rosa* sp., *Rubus* sp., *Rubus vitifolius* Cham. & Schlecht., *Salix babylonica* L., *Salix caprea* L., *Salix matsudana* Koidz., *Salix alba* L., *Salix purpurea* L., *Salsola australis* R. Br., *Salsola kali* L., *Salviae* sp., *Secale ciliatoglume* (Boiss.) Grossh., *Solanum lycopersicum* var. *lycopersicum* L., *Sorbus aucuparia* L., *Sorbus domestica* L., *Syringa vulgaris* L., *Tamarix parviflora* DC, *Tamarix smyrnensis* Bunge, *Tanacetum vulgare* L., *Tanecetum unifoliorum* Sch.Bip., *Tilia tomentosa* Moench, *Trigonella* sp., *Triticum aestivum* L., *Tussilago farfara* L., *Ulmus procera* Salisb., *Ulmus laevis* Pall., *Ulmus minor* Mill., *Verbascum* sp., *Viburnum* sp., *Vitex agnus–castus* L., *Vitis vinifera* L.

Appendix 2. Genera of eriophyoid mites found in Turkey:

Abacarus, *Acalitus*, *Aceria*, *Aculodes*, *Aculops*, *Aculus*, *Anthocoptes*, *Boczekiana*, *Brevulacus*, *Calacarus*, *Calepitrimerus*, *Cecidophyes*, *Cecidophyopsis*, *Colomerus*, *Coptophylla*, *Diptacus*, *Epitrimerus*, *Eriophyes*, *Glyptacus*, *Metaculus*, *Paraphytoptus*, *Phyllocoptes*, *Phyllocoptruta*, *Phytoptus*, *Platyphytoptus*, *Reckella*, *Rhyncaphytoptus*, *Shevtchenkella, Stenacis*, *Tegolophus*, *Tegonotus*, *Tetra*, *Vasates*