Tarsonemid mites (Acari, Heterostigmatina) found in association with bark beetles (Insecta, Curculionidae, Scolytinae) in Iran

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Abstract: The authors report on the presence of species of the family Tarsonemidae in association with three bark beetle species (Orthotomicus erosus (Wollaston, 1857), Scolytus scolytus (Fabricius, 1775), and S. multistriatus (Marsham, 1802)) in two provinces in Central and Northern Iran. The following mite species are new for the fauna of Iran: Heterotarsonemus hajekae Smiley and Moser, 1985, H. magowskii Khaustov, 2001, and Tarsonemus crassus (Schaarschmidt, 1959). The genus Heterotarsonemus is newly recorded in Asia. The new record of H. hajekae is the second ever known in the world and H. magowskii is now established as new phoront of the bark beetle host O. erosus. Tarsonemus crassus is recorded outside the Europe for the first time. The taxonomy, identification, relationships with beetle hosts, and biogeography of the newly recorded mite species are briefly discussed.

Key words: Taxonomy, Tarsonemidae, Orthotomicus, Scolytus, host association, Ulmus, Pinus

Bark beetles (Coleoptera: Curculionidae: Scolytinae) are one of the most important pests of woody plants, with immense economic impact, attacking unthrifty, broken, over-mature, dying, or, rarely, even healthy hosts (Wood, 1982). Among bark beetle species, the larger European elm beetle, Scolytus scolytus (Fabricius, 1775), the smaller European elm beetle, S. multistriatus (Marsham, 1802), and the Mediterranean pine engraver beetle, Orthotomicus erosus (Wollaston, 1857), are considered harmful pests of several species of forest and ornamental trees. The first of these species is distributed in Asia and Europe, while the other two are found on most continents (Bright, 2014). All of them are considered destructive pests of forest and ornamental trees in Iran (Abai, 2009). Bark beetles share their microhabitats with many species of mites and other microorganisms. Mites of the family Tarsonemidae are considered important biofactors in association with bark beetles and their communities (Lindquist and Bedard, 1961; Moser, 1985; Lombardero et al., 2003, and others). The feeding habits of tarsonemid associates of bark beetles are mostly unknown (Pseudotarsonemoides, Heterotarsonemus, many Tarsonemus) but some Tarsonemus species are considered fungivores (Lombardero et. al. 2000) while fewer (Iponemus Beer and Nucifora, 1965) feed on eggs of their insect hosts (Lindquist, 1969b).

None of the tarsonemids are known to be true parasites of bark beetles, but many use them as phoretic carriers and sometimes can carry and propagate spores of fungi they are feeding on (Moser, 1985; Lombardero et al., 2003). Tarsonemid fauna associated with scolytines has been well studied in some parts of the world (Lindquist, 1969a, 1969b; Smiley and Moser, 1974; 1985; Moser et al., 1989; Khaustov and Magowski, 2003; Magowski and Khaustov, 2006; Magowski, 2010), but is little known in Iran. To date, only a small number of publications have reported six identified and one unidentified species of Tarsonemidae living in association with bark beetles in Iran (Ostovan and Kamali, 1997; Ahadiyat et al., 2004; Magowski et al., 2007; Magowski, 2010; Arabzadeh et al., 2012). The purpose of the present study was to present new and corrected data on species belonging to the genera Pseudotarsonemoides Vitzthum, 1921, Heterotarsonemus Smiley, 1969, and Tarsonemus Canestrini and Fanzago, 1876 recovered from galleries and individuals of three bark beetle species from Tehran and Guilan provinces in Iran. The taxonomic classification of Tarsonemidae, detailed diagnoses, and descriptions of genera reported herewith can be found in Lindquist (1986). Mite specimens were removed manually from bark samples or insect individuals collected from forests and minor wooded areas during two periods in
Iran. The first sampling was carried out from 1995 to 1997 in various parks and landscapes of two provinces: Tehran (Nārmak: 35°45’N, 51°31’E; Sa’adat Abad: 35°46’N, 51°22’E) and Guilan (Rash: 37°16’N, 49°34’E), and the second sampling was conducted several times between 2006 and 2010 in pine forests in the western region of Tehran Province (Chitgar Park and Peykānshahr, 35°44’ N, 51°12’ E, 1013 m a.s.l.). Mites were mounted on microscopic slides in Hoyer’s medium and subsequently examined with an Olympus BX 50 phase contrast microscope. The material originates from 15 samples. Each sample is represented by collection data differing by at least one characteristic (e.g., collection date) from another. The material collected by H Ostovan is stored permanently at the Department of Entomology, College of Agricultural Sciences, Shiraz Branch, Islamic Azad University (Shiraz, Iran), and that by A Ahadiyat and A Valizadeh at the Department of Entomology, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University (Tehran, Iran) and the Department of Animal Taxonomy and Ecology, A. Mickiewicz University (Poznań, Poland). Collected samples represent three identified and one unidentified bark beetle species and/or their galleries. The identified samples represent three identified and one unidentified species. Three mite specimens could only be identified differing by at least one characteristic (e.g., collection date) from another. The material collected by H Ostovan is stored permanently at the Department of Entomology, College of Agricultural Sciences, Shiraz Branch, Islamic Azad University (Shiraz, Iran), and that by A Ahadiyat and A Valizadeh at the Department of Entomology, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University (Tehran, Iran) and the Department of Animal Taxonomy and Ecology, A. Mickiewicz University (Poznań, Poland). Collected samples represent three identified and one unidentified bark beetle species and/or their galleries. The identified tarsonemid individuals belong to three genera and five species. Three mite specimens could only be identified to genus level: two of the genus Tarsonemus and one Pseudotarsonemoides. A list of mite species in systematic order (with their sampling data transcribed from the original labels) is given below.

Family: Tarsonemidae Canestrini and Fanzago, 1877
Subfamily: Pseudotarsonemoidinae Lindquist, 1986
Tribe: Pseudotarsonemoidini Lindquist, 1986
Genus: Pseudotarsonemoides Vitzthum, 1921

Subfamily: Tarsoneminae Canestrini and Fanzago, 1877
Tribe: Heterotarsonemus Smiley, 1969

Tribe: Tarsonemini Canestrini and Fanzago, 1877
Genus: Tarsonemus (T.) Canestrini and Fanzago, 1876


Identification of the mite material collected in this study has been difficult for multiple reasons. Most importantly, the taxonomy of nearly all tarsonemid species-groups involved is insufficiently understood. The majority of publications originating from the past century contain a number of issues, of which outdated descriptions are the most challenging. A serious effort to sort out the Nearctic fauna of bark beetle tarsonemid associates by Smiley and Moser (1974) was only a partial success. Insufficient insight into some morphological characters resulted in confused diagnoses. Those vague diagnostics and outdated publications (e.g., Vitzthum, 1921; 1923) being the primary source of data make our identification of the Pseudotarsonemoides species less reliable. Furthermore, scarce records on the intraspecific variability in the genus Tarsonemus, particularly for T. crassus and T. fusarii, could render the identifications reported herein uncertain. Suski (1970), describing the male of T. crassus, contributed to amending its diagnostics, and Magowski and Moser (2003) updated its in-group classification, but still little is known of its natural variability. Specimens identified here as T. crassus differ in certain minor morphological characters from the current diagnostic standard. Tarsonemus fusarii,
Table. Tarsonemid mites associated with bark beetles in Iran reported in the present and previous studies. Abbreviations: O. - Orthotomicus, Sc. - Scolytus, T. - Tarsonemus, S. - Schaarschmidtia. P. - Pseudotarsonemoides, H. - Heterotarsonemus. Mite and beetle records lacking species identification are omitted.

<table>
<thead>
<tr>
<th>Mite species</th>
<th>Bark beetle species</th>
<th>Tree host</th>
<th>Relationship between mite and beetle</th>
<th>Province</th>
<th>Reference</th>
<th>Current taxonomic status of a record</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. innumerabilis</em></td>
<td><em>Sc. multistriatus</em></td>
<td>Elm</td>
<td>in galleries, phoretic on beetles</td>
<td>Alborz, Tehran</td>
<td>Ostovan and Kamali (1997), present report</td>
<td>confirmed</td>
</tr>
<tr>
<td></td>
<td><em>Sc. scolytus</em></td>
<td>Elm</td>
<td>in galleries, phoretic on beetles</td>
<td>Guilan, Mazandaran</td>
<td>Ostovan and Kamali (1997)</td>
<td>unconfirmed, probable</td>
</tr>
<tr>
<td><em>H. hajekae</em></td>
<td><em>Sc. multistriatus</em></td>
<td>Elm</td>
<td>in galleries</td>
<td>Tehran</td>
<td>present report</td>
<td>confirmed</td>
</tr>
<tr>
<td><em>H. magowskii</em></td>
<td>O. erosus</td>
<td>Pine</td>
<td>in galleries</td>
<td>Tehran</td>
<td>present report</td>
<td>confirmed</td>
</tr>
<tr>
<td><em>T. (T.) sp. nr. bachmaieri</em></td>
<td><em>Sc. amygdali</em></td>
<td>Fruit trees</td>
<td>-</td>
<td>Alborz, Tehran</td>
<td>Ahadiyat et al. (2004)</td>
<td>confirmed</td>
</tr>
<tr>
<td><em>T. (S.) amygdali</em></td>
<td><em>Sc. amygdali</em></td>
<td>Apricot, plum</td>
<td>in galleries</td>
<td>Tehran</td>
<td>Magowski et al. (2007), Magowski (2010)</td>
<td>confirmed</td>
</tr>
<tr>
<td><em>T. (S.) sp. 1 nr. ips</em></td>
<td><em>Sc. multistriatus</em></td>
<td>Elm</td>
<td>in galleries, phoretic on beetles</td>
<td>Tehran</td>
<td>Ostovan and Kamali (1997)</td>
<td>unconfirmed</td>
</tr>
<tr>
<td><em>T. (S.) sp. 2 nr. ips</em></td>
<td>apple bark beetles</td>
<td>Apple</td>
<td>-</td>
<td>Fars</td>
<td>Arabzadeh et al. (2012)</td>
<td>unconfirmed</td>
</tr>
<tr>
<td><em>T. (T.) pseudolacustris</em></td>
<td><em>Sc. amygdali</em></td>
<td>Fruit trees</td>
<td>-</td>
<td>Alborz, Tehran</td>
<td>Ahadiyat et al. (2004)</td>
<td>confirmed</td>
</tr>
<tr>
<td><em>T. (T.) fusarii</em></td>
<td><em>Sc. multistriatus</em></td>
<td>Elm</td>
<td>in galleries, phoretic on beetle</td>
<td>Tehran</td>
<td>present report</td>
<td>confirmed</td>
</tr>
<tr>
<td><em>T. (T.) subcorticalis</em></td>
<td><em>Sc. multistriatus</em></td>
<td>Elm</td>
<td>in galleries</td>
<td>Tehran</td>
<td>Ostovan and Kamali (1997)</td>
<td>unconfirmed</td>
</tr>
<tr>
<td></td>
<td><em>Sc. scolytus</em></td>
<td>Elm</td>
<td>in galleries</td>
<td>Guilan, Mazandaran</td>
<td>Ostovan and Kamali (1997)</td>
<td>unconfirmed</td>
</tr>
<tr>
<td><em>T. (T.) triarcus</em></td>
<td><em>Sc. multistriatus</em></td>
<td>Elm</td>
<td>in galleries, phoretic on beetles</td>
<td>Tehran</td>
<td>Ostovan and Kamali (1997)</td>
<td>unconfirmed</td>
</tr>
<tr>
<td></td>
<td><em>Sc. scolytus</em></td>
<td>Elm</td>
<td>in galleries</td>
<td>Guilan, Mazandaran</td>
<td>Ostovan and Kamali (1997)</td>
<td>unconfirmed</td>
</tr>
<tr>
<td><em>T. (T.) crassus</em></td>
<td><em>Sc. multistriatus</em></td>
<td>Elm</td>
<td>in galleries, phoretic on beetles</td>
<td>Guilan, Tehran</td>
<td>present report</td>
<td>confirmed</td>
</tr>
<tr>
<td></td>
<td><em>Sc. scolytus</em></td>
<td>Elm</td>
<td>in galleries</td>
<td>Guilan, Tehran</td>
<td>present report</td>
<td>confirmed</td>
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</table>
on the other hand, is a well-known and widespread species (see Kaliszewski and Sell, 1990). Samples from the present collectings reveal some atypical morphological variability with regards to its sejugal apodeme. Unlike T. crassus, T. fusarii is not an obligate associate of bark beetles. As the latter is found in a variety of terrestrial habitats (mostly soils and deteriorating organic substrates) one may speculate that this variability reflects the suboptimal conditions encountered in bark beetles galleries. In his original paper, Khastov (2001) reported H. magowskii phoretic on Hypophloeus pini Panzer, 1799 (Tenebrionidae) and in galleries of Ortotomicus longicollis (Gyllenhall, 1827). Thus, our record adds a new host, namely O. erosus. We observed a relatively high density of H. magowskii moving within the sawdust in galleries, whose individuals could occasionally be seen upon uropodine mites (probably of the genus Tri-chouropoda); however, this association may be accidental (see Camerik, 2010a). Our finding of T. crassus represents the first extra-European record, associated with same beetle host as in Europe. This association appears more stringent and host-specific in nature and perhaps obligate (Camerik, 2010b). The multitude of situations where T. fusarii is found suggests that the notion of "host affiliation" related to this species and bark beetles cannot be safely applied, even though some sparse records (e.g., Khastov and Magowski, 2003) of co-existence with Scolytinae are known. Of the two species, namely T. crassus and T. fusarii, reported as phoretic in this study, the phoresy of the latter is questionable as a natural aptitude.

The present knowledge on identities of reported Iranian species of tarsonemids co-occurring with bark beetles is summarized in the Table. It is conceivable that identifications of four recorded species should be re-examined in the light of recent taxonomic literature. Both Iranian records of "T. ips" (referred to in the Table as spp. nr. ips 1 and 2) in Ostovan and Kamali (1997) and Arabzadeh et al. (2012), respectively, were published prior to or un-awares of the revision of the subgenus Schaarschmidtia by Magowski (2010), and so the vital diagnostics of this compound group could have not been applied. As originally T. ips is known to be associated almost exclusively with pines in North and Central America (Magowski, 2010), it is unlikely that two recorded populations found on elm or apple trees in Iran would represent that, or even one and the same species. Similarly, two other species of the T. minimax group (T. triarcus and T. subcorticalis) were recorded in Iran before the work by Magowski and Moser (2003). While T. triarcus seems to be an exclusively North American species, the identity of Eurasian populations of T. subcorticalis remains uncertain, as similarly has been realized in the case of two other closely allied Crimean populations of T. nr. endophleous Lindquist, 1969 spp. 1 and 2 by Khastov and Magowski (2003). Apart from T. fusarii, another two species, namely T. nr. bachiamaeri and T. pseudolacustris (Table), are not regular associates of bark beetles. An indiscriminative method of material collecting (by examination of twigs and bark from trees occupied with bark beetles) provided an impression of a more intimate association, which may not be true.

Before the present study, six identified and one unidentified species of the family Tarsonemidae had been reported to be associated with bark beetles in Iran (Ostovan and Kamali, 1997; Ahadiyat et al., 2004; Magowski et al., 2007; Magowski, 2010; Arabzadeh et al., 2012 – see Table), making it the most species-rich mite family in this habitat context (Ahadiyat, personal observations) in this country. Three tarsonemid species were reported in association with S. amygdali Guerin-Meneville 1847, four with S. multistriatus and three with S. scolytus (Table). The results of our study increased the number of identified tarsonemid species to nine. It has also brought the total of the genus Tarsonemus species up to six, making it the most diverse genus among Acari associates of bark beetles in Iran. Among all the studied species of bark beetles, S. multistriatus appears the most suitable host, apparently presenting a set of optimal microhabitats for six identified species of Tarsonemidae. Pseudotarsonemoides innumerabilis is the only species (among those reported herewith) found in four provinces of Iran.

Nearly all tarsonemid species presented herewith (except for T. fusarii and P. innumerabilis) are new to the Iranian fauna. Heterotarsonemus magowskii and H. hajekae are both reported worldwide for the second time; moreover, H. magowskii is the first extra-European record and H. hajekae the first extra-American record. Consequently, both Heterotarsonemus species represent first records from Iran and, in a wider context, from Asia.

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