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Article

Oribatid mites (Acari: Oribatida) associated with bark beetles (Coleoptera: Curculionidae: Scolytinae) in Iran, with a review on *Paraleius leontonychus* (Berlese) and a list of bark beetles in association with this species

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Abstract

During investigations on mites associated with fruit and pine tree bark beetles in Alborz and Tehran Provinces, six species of oribatid mites, belonging to five families, were found during 2001–2002 and 2006–2010 and identified. The species and their families are as follows: *Paraleius leontonychus* (Hemileiidae), *Oribatula* (*Zygoribatula*) *skrjabini, Oribatula* sp. (Oribatulidae), *Scheloribates* sp. nr. *fusifer* (Scheloribatidae), *Tectocepheus velatus* (Tectocepheidae) and *Xenillus* sp. (Xenillidae). This is likely the first report of *O.* (*Z.*) *skrjabini* in association with bark beetles. In this paper, the ecological aspects and behavioral relationships with all related bark beetle species and distribution of *P. leontonychus* are reviewed and discussed, as well as notes on the other oribatid species collected from galleries of scolytines in Iran are provided.

Key words: Alborz; Bark beetles; fauna; Oribatida; *Orthotomicus erosus*; *Scolytus amygdali*; Tehran.

Introduction

Many species of bark beetles of the subfamily Scolytinae (Coleoptera: Curculionidae) are important pests of fruit, ornamental and forest trees. These destructive pests and their galleries provide diverse habitats for many mite species of different groups with various food habits and behaviors (Moser 1975; Moser *et al*. 2005; Pernek *et al*. 2008). More than 100 mite species live within bark beetle habitats and play important roles in their communities (Hofstetter *et al*. 2014). Although oribatid mites are occasionally found in scolytine galleries (Kinn 1971), the specific species are still mainly unknown. A literature review shows that bark beetle-associated Oribatida have been studied only in a few cases and in some countries (Kinn 1971; Kiełczewski and Wiśniewski 1978; Norton 1980; Moser *et al*. 2005; Pernek *et al*. 2008, 2012; Knee *et al*. 2013; Penttinen *et al*. 2013).

The almond bark beetle, *Scolytus amygdali* Guérin-Méneville, 1847 and the Mediterranean pine engraver beetle, *Orthotomicus erosus* (Wollaston, 1857) are considered as important and the most important xylophagous pests of fruit and pine trees in Iran, respectively (Radjabi 1991; Abaii 2000), causing severe damages to their tree hosts (Ahadiyat and Ostovan 2006; Ahadiyat, personal observations). The main objective of this research is to recognize oribatid mite species in bark beetle galleries from unmanaged orchards and from some natural forests in Alborz and Tehran Provinces.

Material and methods

The majority of samples were collected from early December 2001 to November 2002 in damaged fruit tree orchards in different parts of Karaj region (Alborz Province), and Shahriyār (Tehran Province) and from January 2006 to June 2010 in different pine forests of Peykān-shahr and Garmsār regions of Tehran Province. In all samplings, the localities were selected among severely bark beetle-damaged orchards and forests. All damaged trees were recognized by the beetle entrance and exit holes. Infested tree bark and branches were transferred into the laboratory, and mite specimens were extracted using Berlese-Tullgren funnels, then preserved in 70–75% ethanol. Mites were cleared in lactophenol or lactic acid, then mounted on microscope slides using Hoyer's medium. All measurements are given in micrometers (μm). The materials examined are partly deposited at the Department of Plant Protection, Shiraz University and partly at the Acarological Collection of the Department of Entomology (ACDE), College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran.

Results and discussion

A total of six species of oribatid mites, belonging to five families, were collected from galleries of two bark beetle species and identified. A list of the species with information of each species, are presented as follows:

1. *Paraleius leontonychus* (Berlese, 1910) (Hemileiidae)

Oribella leontonycha Berlese, 1910
Liebstadia leontonycha (Berlese, 1910): Vitzthum, 1926
Paraleius leontonycha (Berlese, 1910): Travé, 1960
Siculobata leontonycha (Berlese, 1910): Weigmann, 2006

Diagnostic characters

Body length 353–374 × 184–221, light brown in color. Rostrum extended to form a narrow point. All prodorsal setae long, barbed, reaching the rostrum and beyond, interlamellar seta the longest. Sensillus short, with a thick oval and club-like head, the head and stalk about equal in length, covered with spinules. Notogaster with 10 pairs of smooth setae and 4 pairs of sacculi. 3–4 pairs of genital setae, 1 pair of aggenital, 2 pairs of anal, and 3 pairs of adanal setae. In the present material, two females and two males had 3 pairs of genital setae, one male and one female had 4 pairs, one male had 3 setae on the right genital plate and 4 setae on the left, and one female bore 4 setae on the right genital plate and 3 setae on the left. Legs with 3 claws (tridactylous), paired lateral claws fine and thin, empodial claw very thick and strongly hooked.

Table 1. *Paraleius* mite associations with species of bark beetles and not-related to the scolytid beetles, and their plant hosts, dates of occurrence and world distribution (in all cases, mites belong to *P. leontonychus*, except for those with an asterisk which belong to *Paraleius* sp.).

Common name	Bark beetle species	Tree host or collecting method	Occurrence in month	Association	Region	Relative abundance	Reference
_	*Cryphalus abietis* (Ratzeburg, 1837)[1]	Forest trees	October	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
Southern pine beetle	*Dendroctonus frontalis* (Zimmermann, 1868)	*Pinus taeda* Linnaeus, 1753	February, April, December	Beetle galleries	USA (Louisiana)	Infrequent	Moser and Roton (1971)*
		Pinus oocarpa Schiede ex Schlechtendal, 1838	January-March	Beetle galleries	Honduras	Not indicated	Moser *et al*. (1974)*
		_	_	Phoretic	USA (Louisiana)	Infrequent	Norton (1980)
		_	_	Phoretic	USA (Louisiana, Mississippi, Alabama)	Infrequent	Hofstetter *et al*. (2014)
		_	_	Phoretic	USA (Arizona)	Infrequent	Hofstetter *et al*. (2014)*
Spruce beetle	*D. obesus* (Mannerheim, 1843)	Not indicated	Not indicated	Not indicated	USA (Alaska)	Infrequent	Moser and Roton (1971)*
Douglas-fir beetle	*D. pseudotsugae* Hopkins, 1905	Not indicated	Not indicated	Not indicated	USA (Idaho)	Infrequent	Moser and Roton (1971)*
Eastern larch beetle	*D. simplex* LeConte, 1868	Not indicated	Not indicated	Not indicated	Canada (Alberta)	Infrequent	Moser and Roton (1971)*
Black turpentine	*D. terebrans* (Olivier, 1795)	Not indicated	Not indicated	Not indicated	Not indicated	Infrequent	Moser and Roton (1971)*
_	*Dryocoetes affaber* LeConte, 1876	_	_	Phoretic	USA (Alaska)	Infrequent	Norton (1980)
_	*D. autographus* (Ratzeburg, 1837)	Forest trees	March, July	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
Western balsam bark beetle	*D. confusus* Swaine, 1912	_	_	Phoretic	USA (Arizona)	Infrequent	Hofstetter *et al*. (2014)
Douglas fir root bark	*Hylastes nigrinus* LeConte, 1868	_	_	Phoretic	USA (Oregon)	Infrequent	Norton (1980)
_	*H. salebrosus* Eichhoff, 1868,	_	_	Phoretic	USA (Louisiana)	Infrequent	Norton (1980)
Lesser spruce shoot beetle	*Hylurgops palliatus* (Gyllenhal, 1813)	Forest trees	June	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)

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Table 1. Continued.

Common name	Bark beetle species	Tree host or collecting method	Occurrence in month	Association	Region	Relative abundance	Reference
Small spruce bark beetle	*Ips amitinus* (Eichhoff, 1871)[1]	Forest trees	May	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
Six-toothed bark beetle	*Ips sexdentatus* (Böerner, 1767)	Pine/ Berlese funnel	January-December	Beetle galleries	France	Infrequent	Lieutier (1978)
		Pinus pinaster Aiton, 1789	October	Found in funnel traps	Spain	Infrequent	Fernández *et al*. (2013)
Spruce bark beetle	*I. typographus* (Linnaeus, 1758)	Forest trees	July, August	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
		Spruce/ Berlese funnel	May-November	Beetle galleries	France	Most abundant	Lieutier (1978)
		Traps in various localities	Not indicated	Not indicated exactly	Germany	Infrequent	Moser and Bogenschütz (1984)
		Traps in a coniferous forest	May-June	Phoretic	Sweden	Infrequent	Moser *et al*. (1989a)
		Traps in a coniferous forest	May-June	Not indicated exactly	Sweden	Infrequent	Moser *et al*. (1989b)
		Traps in *Picea abies* forests	May	Most probably phoretic	Austria	Not indicated	Knapp *et al*. (2009); Krisper (December 2011, pers. commu.)
		Pheromone traps in forests	Not specified clearly	Phoretic	Finland	Relatively most common	Penttinen *et al*. (2013)
	I. typographus japonicus Niijima, 1909	Traps	May-July	Phoretic	Japan	Almost common	Moser *et al*. (1997)
Lesser larch bark beetle	*Orthotomicus laricis* (Fabricius, 1792)	*Picea abies* (Linnaeus, 1753) Karsten, 1881 (Syn.: *P. excelsa* Link.)	May ?	Beetle galleries	Unknown	?	Vitzthum (1926)
Mediterranean pine engraver beetle	*O. erosus*	Pine	Not indicated	Beetle galleries	Iran	_	Ahadiyat and Akrami (2013)
		Pinus eldarica	January, September	Beetle galleries	Iran	Infrequent	This paper
Six-toothed spruce bark beetle	*Pityogenes chalcographus* (Linnaeus, 1761)	Forest trees	February, May	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
		Traps in *Picea abies* forests	May	Most probably Phoretic	Austria	Not indicated	Knapp *et al*. (2009); Krisper (December 2011, pers. commu.)

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Table 1. Continued.

Common name	Bark beetle species	Tree host or collecting method	Occurrence in month	Association	Region	Relative abundance	Reference
Silver fir bark beetle	*Pityokteines curvidens* (Germar, 1824)	*Abies alba* Miller, 1768	November-December	Phoretic	Croatia	Occasionally	Pernek *et al*. (2008)
		Traps in mixed *Abies alba* and *Fagetum* sp. forests	April	Phoretic	Croatia	Most abundant	Pernek *et al*. (2012)
Fir bark beetle	*P. spinidens* (Reitter, 1894)	*Abies alba*	November-December	Phoretic	Croatia	Occasionally	Pernek *et al*. (2008)
		_	_	Phoretic	Croatia	Not indicated	Pernek (2010)
European fir engraver beetle	*P. vorontzowi* (Jacobson, 1895)	*Abies alba*	November-December	Phoretic	Croatia	Occasionally	Pernek *et al*. (2008)
Smaller European elm bark beetle	*Scolytus multistriatus* (Marsham, 1802)	Forest trees	July	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
Lesser pine-shoot beetle	*Tomicus minor* (Hartig, 1834)	Forest trees	May-June	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
Common pine shot beetle	*T. piniperda* (Linnaeus, 1758)	Forest trees	March-April	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
Not indicated	Not indicated	Beech	Not indicated	Beetle galleries?	Germany?	Not indicated	Travé (1960)
Not indicated	Not indicated	Not indicated	Not indicated	Not indicated	Honduras	?	Moser and Roton (1971)[2]*
Undetermined species	?	Forest trees	August	Beetle galleries	Poland	Not indicated	Kiełczewski and Wiśniewski (1978)
Nine species	Not indicated	Trees of parks, forests and reservations	Not indicated	Beetle galleries	Poland	Not indicated	Kiełczewski *et al.* (1983)
Not related to species of bark beetles		Trap in beech forest	July	_	Germany	Infrequent	Wunderle *et al*. (1990)
		Under decaying oak bark	January	_	Germany	Infrequent	Wunderle *et al*. (1990)
		Under decaying beech bark	October	_	Germany	Infrequent	Wunderle *et al*. (1990)

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Table 1. Continued.

Common name	Bark beetle species	Tree host or collecting method	Occurrence in month	Association	Region	Relative abundance	Reference
Not related to species of bark		Dead branch on the ground	January	_	Germany	Infrequent	Wunderle *et al*. (1990)
		Beech wood	April	_	Germany	Infrequent	Wunderle *et al*. (1990)
		Rotten wood under the bark of walnut	?	_	Germany?	?	Strenzke (1952) (Cited in Wunderle *et al*., 1990)[3]

1. In Kiełczewski and Wiśniewski (1978), names of the genera of the indicated bark beetles have not been mentioned, but literature reviews related to bark beetles showed that their genera seem to be *Cryphalus* Erichson, 1836, and *Ips* De Geer, 1775, respectively.
2. Although Moser and Roton (1971) have not presented any information regarding the unnamed species of *Paraleius* in Honduras, it seems that all details of this row are as the same as that one, which have been prepared by Moser *et al*. (1974).
3. We could not find the article written by Sternzke (1952). " ? " means that we could not understand the related situation.

Material examined

6 females and 2 males, Alborz Research Station of the Research Institute of Forests and Rangelands (RIFR), south of Karaj, Alborz Province, latitude: N 35° 45', longitude: E 50° 57', altitude: 1320 m a.s.l., galleries of *Orthotomicus erosus*, *Pinus brutia* var. *eldarica*, 3 September 2007, Ali Ahadiyat; Chitgar Park, Peykān-shahr, Tehran Province, latitude: N 35° 44', longitude: E 51° 12', altitude: 1013 m a.s.l., galleries of *O. erosus*, *P. brutia* var. *eldarica*, 23 January 2010, Ahmad Valizadeh.

The individuals of this species are deposited at the Plant Protection Department of Shiraz University, and at the ACDE, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran.

Ecological aspects

Paraleius leontonychus was found in low abundances in the beetle galleries, and did not phoretically attach to the adult bark beetles. It was found in two seasons (summer and winter). Also, our observations showed that this mite is found in localities in altitudes ranging between 1013–1320 m a.s.l., which indicates that it can at least live in mid-land areas. This species was first reported from Iran by Ahadiyat and Akrami (2013).

Paraleius Travé, 1960 is found or lives on the bark of trees or shrubs, as some lichens and mosses. The species *P. leontonychus* is an arboreal mite, which is only found in association with forest tree bark beetles, and seems not to be found with fruit tree scolytines (Table 1; Ahadiyat *et al*. 2004). Also, among the most destructive bark beetles genera (*Dendroctonus* Erichson, 1836, *Ips* De Geer, 1775 and *Scolytus* Geoffroy, 1762), *P. leontonychus* has been reported only once related to the genus *Scolytus*. In this case, Kiełczewski and Wiśniewski (1978) recorded it in galleries of *S. multistriatus* (Marsham, 1802) just in one locality out of six. *Paraleius leontonychus* has not been recorded in other studies on mites of *Scolytus* beetles elsewhere e.g. Hajek and Dahlsten 1985 [*S. multistriatus*], Ahadiyat *et al*. 2004 [*S. amygdali*], Moser *et al*. 2005 [*S. multistriatus* and *S. pygmaeus* (Fabricius, 1787)] and Moser *et al*. 2010 [*S. multistriatus*, *S. pygmaeus* and *S. scolytus* (Fabricius, 1775)]. Therefore, it is likely that this mite does not prefer to live in *Scolytus* beetle galleries, which probably provide unsuitable shelter and trophic sources.

Other than most articles, which have reported this oribatid species in association with bark beetles, Wunderle *et al*. (1990) found it from other habitats not in bark beetle galleries, but related to tree structures, including beech wood, under decaying beech and oak trees, and from a dead branch on the ground in southwest Germany in all seasons, and considered them as typical microhabitats of this oribatid (Table 1).

Distribution

Paraleius leontonychus has been recorded on tree bark or in association with several genera and species of bark beetles especially in North and Central America, and Europe, with various temperatures, such as: Honduras, Iran, Spain and USA (Arizona and Louisiana) with high or relatively high temperatures, and Canada (Alberta), European countries and USA (Alaska) with low temperatures.

It is distributed, associated with bark beetles, in three ecozones of the world, namely Nearctic, Neotropic and Palaearctic regions, in three continents, including Asia (Iran, Japan), Europe (Austria, Croatia, Finland, France, Germany, Poland, Spain, Sweden) and North and Central America (Canada, USA, Honduras). Karppinen *et al*.

(1986) listed it from Turkmenistan in their checklist of oribatid mites of northern Palaearctic region arid lands, such as steppes, semi-desert and sand deserts. However, there is not any record of *P. leontonychus* in relationship to bark beetles in other ecozones, such as Afrotropic, Australasia, Indo-Malaya, Oceania and Antarctic (Table 1).

Association with bark beetles

The first record of this oribatid species associated with bark beetles was published by Vitzthum (1926), who found it on the lesser larch bark beetle, *Orthotomicus laricis* (Fabricius, 1792) attacking the Norway spruce, *Picea abies* (Linnaeus, 1753) Karsten, 1881. Travé (1960) found it in dead beech wood from which the bark could be easily removed and in which there were numerous galleries of xylophagous beetles. Moser and Roton (1971) found an unnamed new species of this oribatid genus in North and Central American countries, in boring dust of a tree stump associated with five species of bark beetle of the genus *Dendroctonus*. The unnamed species was twice recorded in association with the southern pine beetle in Honduras and the USA by Moser *et al*. (1974) and Hofstetter *et al*. (2014), respectively. Kiełczewski and Wiśniewski (1978) and Kiełczewski *et al*. (1983) found *P. leontonychus* related to 10 and nine bark beetle species, respectively, in Poland, but none of the genus *Orthotomicus*. Moser and Bogenschütz (1984) and Moser *et al*. (1989) reported this oribatid species associated with the spruce bark beetle, *Ips typographus* (Linnaeus, 1758), respectively in south Germany and Sweden. Other findings are summarized in Table 1.

The occurrence of *P. leontonychus* and its association with scolytine beetles are discussed here (see also Table 1). *Paraleius leontonychus* has been found in association with 11 genera, 24 species and one subspecies of bark beetles as follows: *Cryphalus* Erichson, 1836 (1 species), *Dendroctonus* (5 spp.), *Dryocoetes* Eichhoff, 1864 (3 spp.), *Hylastes* Erichson, 1836 (2 spp.), *Hylurgops* LeConte, 1876 (1 sp.), *Ips* (3 spp. and 1 subspecies), *Orthotomicus* Ferrari, 1867 (2 spp.), *Pityogenes* Bedel, 1888 (1 sp.), *Pityokteines* Fuchs, 1911 (3 spp.), *Scolytus* (1 sp.), and *Tomicus* Latreille, 1802–1803 (2 spp.). The taxonomic position of these scolytine beetles is presented in Table 2. Most of the taxa belong to the tribe Ipini Bedel, 1888 with four genera, nine species and one subspecies. Considering Tables 1 and 2, it is easily supposed that this species is not monospecific and is common in association with bark beetle species. This viewpoint had been previously presented elsewhere by Norton (1980) and Moser and Bogenschütz (1984). This non-specific trait may be the reason for its relatively wide distribution in the Northern Hemisphere. Among the scolytine species, *Dendroctonus* with five species and *Pityokteines* with three species are the most diverse which the mite can live in association with (Tables 1, 2).

Seasonal activities

This mite was found in two seasons, summer and winter, in Tehran region, while Moser and Roton (1971) have reported an unnamed species of *Paraleius* associated with *Dendroctonus* spp. in three seasons other than summer, in Louisiana. Kiełczewski and Wiśniewski (1978) have found adult stages of *P. leontonychus* in association with several species of bark beetles (listed in Table 1) in Poland in all seasons. Lieutier (1978) found it in three seasons (spring, summer and autumn) and believed it overwinters in soil, not galleries of bark beetles. Knapp *et al*. (2009) reported it in spring in Austria (Krisper, personal communications, 2011). The diversity of bark

beetles (Table 2) together with the arboreal and subcortical habitats probably provide suitable conditions for the species to live, feed, and reproduce several probable generations in bark beetle galleries in all seasons. For making an accurate assessment of seasonal activities and biology of this mite in the galleries of each related bark beetle, more collecting is needed.

Table 2. Species diversity of bark beetles related to *Paraleius leontonychus* based on their taxa.

Tribe	Genus	Species or subspecies
Cryphalini Lindemann, 1876	*Cryphalus* Erichson, 1836	*C. abietis* (Ratzeburg, 1837)
Dryocoetini Lindemann, 1876	*Dryocoetes* Eichhoff, 1864	*D. affaber* LeConte, 1876
		D. autographus (Ratzeburg, 1837)
		D. confusus Swaine, 1912
Hylastini LeConte, 1876	*Hylastes* Erichson, 1836	*H. nigrinus* LeConte, 1868
		H. salebrosus Eichhoff, 1868,
	Hylurgops LeConte, 1876	*H. palliatus* (Gyllenhal, 1813)
Ipini Bedel, 1888	*Ips* De Geer, 1775	*I. amitinus* (Eichhoff, 1871)
		I. sexdentatus (Böerner, 1767)
		I. typographus (Linnaeus, 1758)
		I. typographus japonicus Niijima, 1909
	Orthotomicus Ferrari, 1867	*O. laricis* (Fabricius, 1792)
		O. erosus (Wollaston, 1857)
	Pityogenes Bedel, 1888	*P. chalcographus* (Linnaeus, 1761)
	Pityokteines Fuchs, 1911	*P. curvidens* (Germar, 1824)
		P. spinidens (Reitter, 1894)
		P. vorontzowi (Jacobson, 1895)
Scolytini Latreille, 1807	*Scolytus* Geoffroy, 1762	*S. multistriatus* (Marsham, 1802)
Tomicini Thomson, 1859	*Dendroctonus* Erichson, 1836	*D. frontalis* (Zimmermann, 1868)
		D. obesus (Mannerheim, 1843)
		D. pseudotsugae Hopkins, 1905
		D. simplex LeConte, 1868
		D. terebrans (Olivier, 1795)
	Tomicus Latreille, 1802–1803	*T. minor* (Hartig, 1834)
		T. piniperda (Linnaeus, 1758)

Abundance

Paraleius leontonychus was found in low population abundance (only eight specimens) in galleries of *O. erosus* during more than 20 samplings from beetle galleries (Ahadiyat, unpublished data). Literature reviews gave us different results concerning the mite abundance in galleries or on bodies of the beetles. Norton (1980) recorded it in low abundance phoretically adhered to four species of bark beetles, and Moser and Bogenschütz (1984) did not collect it as the phoretic stage on *I. typographus*, but found it in low abundance in the alcohol sediments. Also, Moser *et al*. (1989, 1997) found a few individuals of *P. leontonychus* in alcohol sediments related to *I. typographus*. Pernek *et al*. (2008) observed that this mite occurs phoretically on three

species of *Pityokteines*, although a few specimens had also been found in the alcohol sediments. The similar scarce and infrequent relative abundances of *P. leontonychus* in association with *I. sexdentatus* (Böerner, 1767), *Dendroctonus frontalis* (Zimmermann, 1868) and *Dryocoetes confuses* Swaine, 1912 have been observed by Fernández *et al*. (2013) (*I.s.*) and Hofstetter *et al*. (2014) (*D.f.* and *D.c.*). Lieutier (1978) obtained different results: he found the mites, both not phoretic, in low abundance, in galleries of *I. sexdentatus* and in high abundance in galleries of *I. typographus*. In that research, this species had high frequency in galleries of *I. typographus* around August till October, and then overwintered in soil in late October and early November. In two recent studies, Pernek *et al*. (2012) found it as the most frequent phoretic species of *P. curvidens*, and Penttinen *et al*. (2013) stated that it has been relatively common and considered it among the dominant species associated with *I. typographus*. The results confirm that in many cases this species is found in low abundances and would not be considered as a common mite species in association with bark beetles.

Phoretic relationship

Although during the current research, no phoretic specimens of this oribatid species were observed on the adult stage of *O. erosus*, this mite has had phoretic behavior in associations with some species of bark beetles at least in some cases reported. For instance, Norton (1980) indicated adult stages of *P. leontonychus* attached to three genera of bark beetles, namely *Dendroctonus*, *Dryocoetes* and *Hylastes*, in the United States of America. Also, Pernek *et al*. (2008) recorded phoretic females of this species attached to some body parts of fir bark beetles of *Pityokteines* spp. in Croatia, e.g. on the coxa of *P. curvidens* (Germar, 1824), on the ventral thorax and the leg of *P. spinidens* (Reitter, 1894), and on the ventral thorax of *P. vorontzowi* (Jacobson, 1895). Pernek *et al*. (2012) found adults of this mite on the elytra declivity and under the elytra (as female stage) and on legs (as males) of both sexes of *P. curvidens* caught in pheromone traps. Therefore, it is concluded that this mite could be a regular phoretic associate of bark beetles. The precise mechanisms by which the mite attached to bark beetles are unknown, but Pernek *et al.* (2012) mentioned that it presumably adheres by the chelicerae, while the strong hook-like claw on leg I [as drawn by Wunderle *et al*. (1990)] shows that it would be considered as the main structure by which this species can be adhered to the body of its phoronts (Fig. 1). Penttinen *et al*. (2013) supported this result. Pérez-Iñigo (1993) believes that by the modified claws, it can hold on to xylophagus beetle setae and be phoretic on them. Consequently, phoretic behavior of *P. leontonychus* has been observed on all species of two genera *Hylastes* and *Pityokteines*. In other words, the mite has only been found as phoretic, but not in galleries of these genera. Concerning the scolytine *D. frontalis*, and probably *I. typographus* and *P. chalcographus*, not only has it phoretic behavior, but can also be found in the galleries (Table 1).

Food habits

Feeding behaviors of this species is completely unknown. Hofstetter *et al*. (2014) mentioned that its feeding behavior was not clear, when they had found it in association with *D. frontalis*. Kinn (1971) believes that the oribatid mites found with bark beetles probably feed upon fungi, algae and other organic matter. *Paraleius leontonychus* has been observed carrying some fungal species which were found in bark beetle galleries, although it may have small role in their transportations. In two studies, it carried fungal spores: Moser *et al*. (1989) recognized ascospores of three different species of blue-

stain fungi, including *Ophiostoma bicolor* Davidson and Wells, 1955, *O. europhioides* (Wright and Cain), *O. polonicum* Siemaszko, 1939, hyperphoretically attached to this mite (all with less than 30 ascospores per mite specimen) in the galleries of *I. typographus*, and Moser *et al*. (1997) found only one, two and four specimens of *P. leontonychus* carrying spores of *Pyxidiophora* spp., *Ophiostoma bicolor* and unidentified spores, respectively, in Japan. Therefore, it is likely that at least some fungi species are food sources for *P. leontonychus*. Pernek *et al*. (2008) mentioned that it is probably a detritivore species, while Lieutier (1978) and Penttinen *et al*. (2013) confirmed that it is a fungivorous or detritivorous species and feeds on fungi and decaying wooden galleries, like most species of Oribatida.

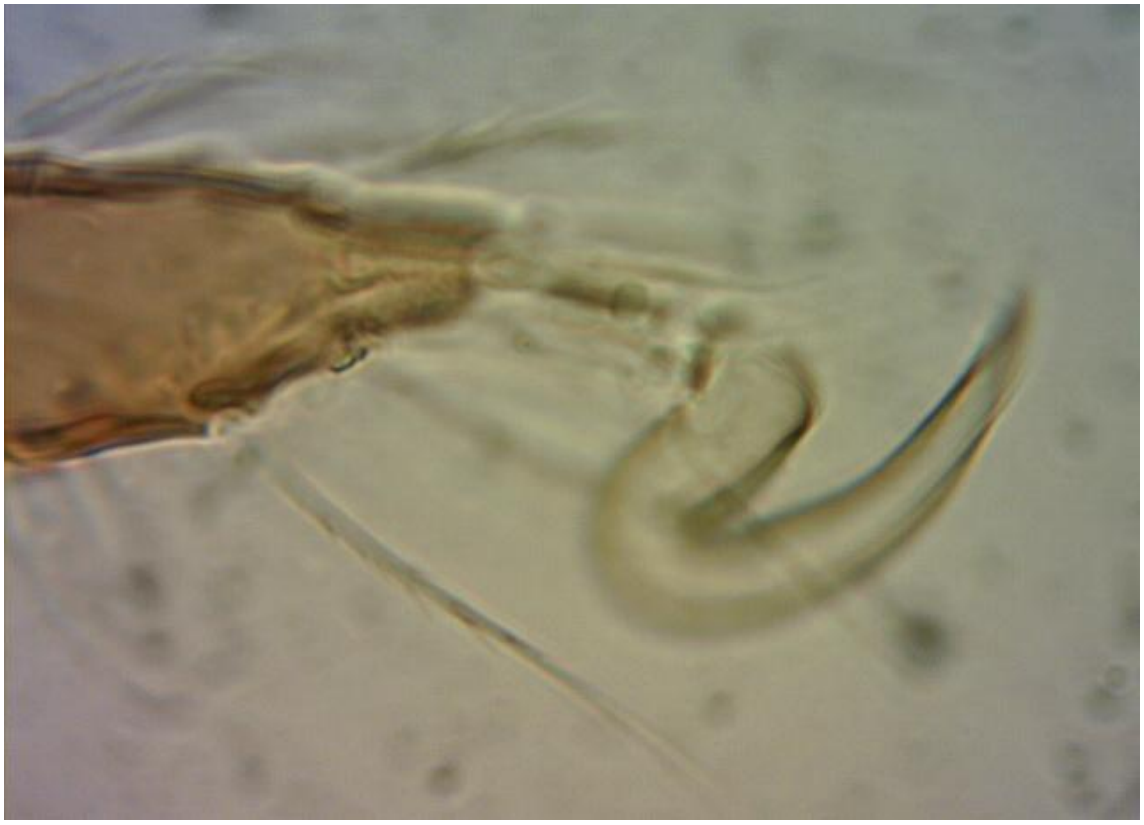

Figure 1. *Paraleius leontonychus* (female) – claw on leg I (1000×).

2. *Oribatula* (*Zygoribatula*) *skrjabini* (Bulanova-Zachvatkina, 1967) (Oribatulidae)

Material examined

1 ♂, Chitgar Park, Peykān-shahr, Tehran Province, latitude: N 35° 44', longitude: E 51° 12', altitude: 1013 m a.s.l., galleries of *Orthotomicus erosus*, *Pinus brutia* var. *eldarica*, 21 April 2006, Ali Ahadiyat.

This species is likely reported for the first time in association with bark beetles, because we could not find any information about it in many related publications reviewed. Kiełczewski and Wiśniewski (1978) found adult stages of two other species of this genus, *O.* (*Z.*) *exilis* (Nicolet, 1855) and *O.* (*Z.*) *glabra* (Michael, 1890)[1], in

[1] These species were named *Zygoribatula exilis* (Nicolet, 1855) and *Z. propinquus* (Oudemans, 1902) in the above mentioned article.

association with five and two determined bark beetle species, respectively, in different types of forests in Poland. Penttinen *et al*. (2013) also found *O. exilis* with *Ips typographus* in Finland.

3. *Oribatula* sp. (Oribatulidae)

Material examined

1 female, Shahriyār, Tehran Province, latitude: N 35° 39', longitude: E 51° 3', altitude: 997 m a.s.l., *Scolytus amygdali* gallery, apricot (*Prunus armeniaca* Linnaeus, 1753), late April 2002, Ali Ahadiyat.

This species was found in very low abundances in spring. This is probably a fungivorous species, because of the oval and multi-cellular spores which were found within its body. Kiełczewski and Wiśniewski (1978) found adult specimens of *Oribatula tibialis* (Nicolet, 1855) in galleries of *Orthotomicus* sp. in Poland. Moser and Roton (1971), Moser *et al*. (1974) and Moser and Bogenschütz (1984) found other species of the family Oribatulidae associated with several species of *Dendroctonus* and *Ips* in the USA (Louisiana), Honduras and south Germany, respectively.

4. *Scheloribates* sp. nr. *fusifer* Berlese, 1908 (Scheloribatidae)

Material examined

1 female, Vahidiyeh, Shahriyār, Tehran Province, latitude: N 35° 39', longitude: E 51° 3', altitude: 997 m a.s.l., *Scolytus amygdali* gallery, plum (*Prunus domestica* Linnaeus, 1753), 24 February 2002, Ali Ahadiyat.

The species was found in very low abundances in winter. Moser and Roton (1971) found *Scheloribates* sp. in low frequencies in winter, within galleries of *Ips avulsus* (Eichhoff, 1868) and *I. calligraphus* (Germar, 1824) in infested trees in Lousiana, USA. Also, Moser *et al*. (1974) reported an unknown species of this genus from *D. frontalis* galleries, in Honduras. Another species of this genus of mite, called *S. latipes* (C. L. Koch, 1844), was reported in galleries of nine determined bark beetle species in Poland (Kiełczewski and Wiśniewski 1978; Kiełczewski *et al*. 1983). Kiełczewski and Wiśniewski (1978) and Lieutier (1978) found it in three seasons, spring, summer and autumn, in association with about eight genera and one species of bark beetles, respectively, none of them belonged to the genus *Scolytus*.

5. *Tectocepheus velatus* (Michael, 1880) (Tectocepheidae)

Material examined

1 female, Vahidiyeh, Shahriyār, Tehran Province, latitude: N 35° 39', longitude: E 51° 3', altitude: 997 m a.s.l., *Scolytus amygdali* gallery, apricot (*Prunus armeniaca*), late April 2002, Ali Ahadiyat.

This species was found in very low abundances in winter. Kiełczewski and Wiśniewski (1978) found its adult specimens in galleries of an undetermined bark beetle species in autumn in Poland. This cosmopolitan species has been variously considered as a mycophagous, herbofungivorous or particle-feeding saprophagous and mycophagous mite (Norton and Behan-Pelletier 2009), and is found in very different biotopes (Kiełczewski and Wiśniewski 1978). Norton (1980) reported another species of

Tectocepheus Berlese, 1896, called *T. sarekensis* Trägårdh, 1910, phoretically attached to the coxa of the bark beetle *D. frontalis*.

6. *Xenillus* sp. (Xenillidae)

Material examined:

1 female, Chitgar Park, Peykān-shahr, Tehran Province, latitude: N 35° 44', longitude: E 51° 12', altitude 1013 m a.s.l., galleries of *Orthotomicus erosus*, *P. brutia* var. *eldarica*, 21 April 2006, Ali Ahadiyat.

The genus *Xenillus* Robineau-Desvoidy, 1839, is distributed in Holarctic, Oriental and Neotropical (Subías, 2004, online version 2015).

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کنه‌های اریباتید (Acari: Oribatidae) مرتبط با سوسک‌های پوستخوار (Coleoptera: Curculionidae: Scolytinae) ایران، همراه با مروری بر گونهٔ *Paraleius leontonychus* (Berlese) و فهرست سوسک‌های پوستخوار مرتبط با این گونه

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چکیده

طی بررسی کنه‌های مرتبط با سوسک‌های پوستخوار درختان میوه و کاج در استان‌های البرز و تهران در سال‌های ۱۳۸۰-۱۳۸۱ و ۱۳۸۵-۱۳۸۹، شش گونه کنهٔ اریباتید متعلق به پنج خانواده به شرح زیر شناسایی شد: *Paraleius leontonychus* (Hemileiidae) ، *Oribatula* (*Zygoribatula*) *skrjabini* ، *Scheloribates* sp. nr. *fusifer* (Scheloribatidae) ، *Oribatula* sp. (Oribatulidae) ، *Tectocepheus velatus* (Tectocepheidae) و *Xenillus* sp. (Xenillidae). گزارش *Oribatula* (*Zygoribatula*) *skrjabini* در ارتباط با سوسک‌های پوستخوار به احتمال زیاد جدید است. در مقالهٔ حاضر، جنبه‌های بوم‌شناختی و ارتباطات رفتاری با تمام گونه‌های سوسک‌های پوستخوار مرتبط و پراکندگی *Paraleius leontonychus* مرور و مورد بحث قرار گرفته است، همچنین اطلاعاتی از سایر اریباتیدهای جمع‌آوری شده از دالان‌های سوسک‌های پوست زیرخانوادهٔ Scolytinae در ایران ارایه شده است.

واژگان کلیدی: البرز؛ سوسک‌های پوستخوار؛ فون؛ نهان‌استیگمایان؛ *Orthotomicus erosus* ؛ *Scolytus amygdali* ؛ تهران.

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