A PRELIMINARY REPORT ON MITES (ACARI) ASSOCIATED WITH THE SMALL SPRUCE BARK BEETLE *IPS AMITINUS* (COLEOPTERA: CURCULIONIDAE: SCOLYTINAE) IN WESTERN SIBERIA

Alexander A. Khaustov^{1*} and Ivan A. Kerchev^{1,2}

¹X-BIO Institute, Tyumen State University, Tyumen, Russia

²Institute of Monitoring of Climatic and Ecological Systems, Tomsk, Russia

*corresponding author; e-mail: alex1973khaustov@gmail.com

ABSTRACT: The small spruce bark beetle *Ips amitinus* has recently been found in two West Siberian regions: Tomsk and Kemerovo. Here, we collected and identified the mites associated with *I. amitinus* that naturally colonized branches and twigs of Siberian pine, *Pinus sibirica*, in Western Siberia, Russia. Five mites species were revealed: *Dendrolaelaps quadrisetus* (Digamasellidae), *Proctolaelaps hystricoides* (Melicharidae), *Iponemus leionotum* and *I. asiaticus* (Tarsonemidae), as well as *Ereynetes* (*Huntereynetes*) sp. (Ereynetidae). Interestingly, phoresy of two species of *Iponemus* was observed on one host beetle. Three of the five species are known predators and parasitoids of eggs or larvae of bark beetles and could be targeted for biological control of *I. amitinus* in Russia.

KEY WORDS: Acarina, phoresy, SEM photographs, small spruce beetle, parasitoids, predators.

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INTRODUCTION

Bark beetles (Coleoptera: Curculionidae, Scolytinae) are one of the most important components of forest communities (Harvey *et al.* 2013; Raffa *et al.* 2015). Their role in the ecosystem consists of eliminating weakened trees, thereby accelerating the carbon cycle (Ayres *et al.* 2000; Petrov and Dostovalov 2015) and regulating forest structure and processes (Goheen and Hansen 1993). Bark beetles excavate galleries in the inner bark and phloem of the host plants, creating environmental niches for a rather diverse group of organisms: fungi, bacteria, invertebrates and protozoa (Biederman *et al.* 2019).

Mites are known to associate with various bark beetles (Coleoptera: Curculionidae, Scolytinae) (Lindquist 1970; Hofstetter *et al.* 2013). They include predators, preying on bark beetle eggs and larvae, nematodes and other mites that inhabit bark beetle galleries. This group of mites also includes myco- and saprophagous mites, as well as parasitoids of bark beetle eggs and other beetle instars (Hofstetter *et al.* 2015). Most mites that inhabit bark beetle galleries use adult beetles for phoresy (Lindquist 1970). The association of mite communities to particular bark beetle species has only been studied in the context of a few cases associated with economically important pests. They include: *Dendroctonus frontalis* in North and Central America (Moser and Roton 1971; Kinn and Swanson 1976; Stephen and Kinn 1980; Hofstetter 2011; Klepzig and Hofstetter 2011); *Ips typographus*, *I. sexdentatus*, *Pytyocteines* spp, *Scolytus multistriatus*, *S. pygmaeus* in Europe (Lieutier 1978; Moser

and Bogenschütz 1984; Moser *et al.* 1989; Pernek *et al.* 2008, 2012; Takov *et al.* 2009; Gwiazdowicz *et al.* 2011, 2012, 2015; Vrabec *et al.* 2012; Moraza *et al.* 2013; Penttinen *et al.* 2013; Čejka and Holuša 2014); and *Ips typographus japonicus* in Japan (Moser *et al.* 1997). In Western Siberia, only mite communities associated with *Pityogenes chalcographus* and *Ips typographus* have been studied (Khaustov *et al.* 2016, 2018).

Small spruce bark beetle *Ips amitinus* (Eichhoff, 1872), which originated from a glacial conifer refugia in the Central European Highlands, first appeared in Northern Europe at the beginning of 1900s (Økland *et al.* 2019). This beetle's range expansion was first documented in Estonia in the 1930s. By 1951, the species was recorded in southwestern Finland (Voolma *et al.* 2004; Økland *et al.* 2019). In the Leningrad Region of Russia, this bark beetle was first recorded in 1976 (Mandelstam 1999). Recent expansion of the *I. amitinus* range has been rapid and has likely reached the northernmost conifer stands of the Pasvik Nature Reserve, located in the Murmansk Region of European Russia (Shcherbakov *et al.* 2013). Such an unexpected invasion of this species into an area so far from its native habitat has highlighted that the economic importance of *I. amitinus* as a forest pest has been underestimated. In 2019, this beetle was recorded in two West Siberian regions—Tomsk and Kemerovo—where it was responsible for substantial economic losses associated with the killing of approximately one thousand hectares of Siberian pine stands (Kerchev *et al.* 2019).

Very little is known about mites associated with *Ips amitinus*. Lindquist (1969) reported phoresy of *Iponemus gaebleri gaebleri* (Schaarschmidt, 1959) (Tarsonemidae) in Poland. Khaustov (1999) recorded *Aethyophenax ipidarius* (Redikortzev, 1947) on *I. amitinus* in the Leningrad Region of Russia. Kielczewski and Wisniewski (1978, 1983) found *Siculobata (Paraleius) leontonycha* (Berlese, 1910) and *Trichouropoda polytricha* (Vitzthum, 1923) (Trematuridae) in the galleries of *I. amitinus* in Poland.

Our objective was to document the mites associated with *Ips amitinus* from Siberian pine in the Tomsk Region of Western Siberia, Russia.

MATERIALS AND METHODS

Branches and twigs of the Siberian pine, *Pinus sibirica*, containing overwintering bark beetles *Ips amitinus* (Eichhoff, 1871), were collected from several pure Siberian pine stand localities in the vicinity of the settlements of Bazoy (55°44'N, 83°22'E) and Luchanovo (56°21'N, 85°03'E), Tomsk Region, Russia, between January 23 and February 6, 2020. The samples were placed into plastic bags and kept at room temperature in the laboratory. About 200 beetles that were leaving the branches and twigs were collected with an aspirator, after which they were placed into vials containing 96% ethanol. Thereafter, the alcohol sediments from the vials were inspected for phoretic mites. Bark beetle surfaces and their subelytral cavities were also inspected. Galleries of *Ips amitinus* were examined in some samples. For these purposes, the bark containing beetle galleries was removed and examined with a microscope (Discovery V8, Carl Zeiss stereomicroscope). The mites were imaged with a scanning electron microscope (SEM; TESCAN Mira3 LMU SEM microscope). For SEM microscopy, live beetles with phoretic mites were scanned without coating. Additional photomicrographs were taken with a digital camera (Hitachi KP-HD20A, Japan). The mites were mounted in Hoyer's medium for light-microscopy. The morphology of mites was studied using the Carl Zeiss Axio Imager A2 microscope with phase contrast and DIC illumination. The studied material was then deposited in the mite collection of the Tyumen State University Museum of Zoology, Tyumen, Russia.

RESULTS

Order **Mesostigmata**
Family **Digamasellidae**

***Dendrolaelaps (Ipidodendrolaelaps) quadrisetus* (Berlese, 1920)**

(Fig. 1)

This species is known from the Palaearctic (widely distributed in Europe; known from Algeria, Asian Russia and Japan), Nearctic (USA, Canada, Mexico) and the Neotropics (Guatemala) (Shcherbak 1980; Hirschmann and Wiśniewski 1982; Chaires-Grijalva *et al.* 2013; Knee *et al.* 2013; Khaustov *et al.* 2018). These mites were found to be associated with many species of pine bark beetles, inhabiting various coniferous trees (Khaustov *et al.* 2018). In Russia, this species is known from Arkhangelsk Region, Primorye Territory (Shcherbak 1980) and Western Siberia (Khaustov *et al.* 2018). This species is a predator of eggs and immature stages of bark beetles (Kinn 1967). Khaustov *et al.* (2018) observed deutonymphs of *D. quadrisetus* feeding on *Ips typographus* eggs. Most likely, this feeding is necessary for the deutonymphs' normal development and molting into the adult stage. Deutonymphs of *D. quadrisetus* are usually phoretic on the elytral declivity (Figs. 1A) or under the elytra of bark beetles (Fig. 3). Deutonymphs of *D. quadrisetus* are similar to those of *D. quadrisetosimilis* (Fig. 2D–F), differing in the lack of delicate striation on dorsal shields (Figs. 1C, D).

Dendrolaelaps quadrisetus was the most abundant mite species in our samples. This article presents the first record of phoresy of *D. quadrisetus* on *I. amitinus*.

Material examined. More than 100 deutonymphs phoretic mostly under elytra of *I. amitinus*, and some found in galleries under the bark of *Pinus sibirica*.

Family **Melicharidae**

***Proctolaelaps hystricoides* Lindquist and Hunter, 1965**

This species inhabits galleries of subcortical insects and it is phoretic on various bark beetles in Canada and the USA (Lindquist and Hunter 1965). It has also been recorded from Iran (Kazemi and Rajaei 2013) and Croatia (Pernek *et al.* 2008). In Asian Russia, this species was found to be associated with *Pityogenes chalcographus*, *Polygraphus proximus*, *Hylurgops glabratus*, *Ips subelongatus* and *I. typographus* (Trach and Khaustov 2017).

Material examined. Three *Proctolaelaps hystricoides* females were collected in the galleries of *I. amitinus* under the bark of *Pinus sibirica*.

Fig 1. SEM photographs of mites phoretic on *Ips amitinus*. A—general view of elytral declivity with three species of phoretic mites: *Iponemus asiaticus* (I. a), *Iponemus leionotum* (I. l) and *Dendrolaelaps quadrisetus* (the large mite in the center); B—deutonymph of *Dendrolaelaps quadrisetus* (B–D), general view; C—anterior half of idiosoma in dorsal view; D—posterior half of idiosoma in dorsal view.

Order **Trombidiformes**
Suborder **Prostigmata**
Family **Tarsonemidae**

***Iponemus leionotum* Lindquist, 1969**

(Figs. 1A, 2A, B)

This species is known from China, Hungary, Italy and Russia (Western Caucasus) (Lindquist

1969). Phoretic females usually attach to the elytral declivity of bark beetles (Fig. 1A). Although its main host is *Ips sexdentatus*, it also known as an associate of *I. acuminatus*. In Western Siberia, it was collected from *I. sexdentatus* and *I. duplicatus* (Khaustov *et al.* 2017). This species is characterized by setae c_1 being longer than c_2 , very small dimples on the dorsal shields and the presence of longitudinal striation only on the laterad setae d (Fig. 2B).

Fig. 2. SEM photographs of *Iponemus* phoretic females: A—*I. leionotum*, general view; B—left half of tergite D of *I. leionotum*; C—*I. asiaticus*, general view; D—left half of tergite D of *I. asiaticus*.

Ips amitinus is a newly discovered phoretic host of *I. leionotum*. Few *I. leionotum* were observed with a maximum quantity of one female per beetle.

Material examined. Ten *I. leionotum* females on elytral declivity of *I. amitinus*. None were observed in galleries of *I. amitinus* under the bark of *Pinus sibirica*.

Iponemus asiaticus Lindquist, 1969

(Figs. 1A, 2C, D)

This species is known from Asian Russia, China, Poland and Japan (Lindquist 1969). Its main host is *Ips subelongatus*, but it is also known as an associate of *Ips cembrae*, *I. hauseri* and *I. duplicatus* (Lindquist 1969). Similar to *I. leionotum*, only females are phoretic and typically found on the elytral declivity of bark beetles (Fig. 1A). This species is characterized by subequal setae c_1 and

Fig. 3. Photomicrograph of detached elytron of *Ips amitinus* with phoretic deutonymphs of *Dendrolaelaps quadrisetus*: A—general view; B—distal part of elytron.

c_2 , large dimples on the dorsal shields and the presence of longitudinal striation on only the laterad setae *d* (Fig. 2D).

Ips amitinus is a new phoretic host of *I. asiaticus*. In our samples, it was more abundant than *I. leionotum*: maximum of three females per beetle were found.

Material examined. More than 50 *I. leionotum* females on elytral declivity of about 100 *I. amitinus* beetles.

Family Ereynetidae

Ereynetes (*Huntereynetes*) sp.

This species has been reported as *Ereynetes scutulalis* Hunter, 1964, *E. near scutulalis* and *E. propescutulalis* Hunter and Rosario, 1989 from several localities in Europe in associations with various bark beetles (Moser *et al.* 1989; Pernek *et al.* 2008; Penttinen *et al.* 2013). In western Siberia, it was found in association with *Ips typographus* (Khaustov *et al.* 2018).

This species has no specific attachment site on the beetle host; it actively moves around the beetle's body during phoresy. In our samples, it was the rarest species.

Material examined. Two *Ereynetes* females in alcohol sediments containing *I. amitinus*.

DISCUSSION

The mite community associated with *Ips amitinus* collected in the bark beetle invasion area has

no specificity to this particular beetle species. The mite species are known to widely distribute and associate with many bark beetle species. However, the presence of two different species of *Iponemus* on a single host beetle is a very rare phenomenon. Previously, it was reported only for *I. gaebleri* and *I. leionotum*, phoretic on *Ips duplicatus* in Western Siberia (Khaustov *et al.* 2017). Undoubtedly, *I. leionotum* and *I. asiaticus* switched from their main hosts (*Ips sexdentatus* and *I. subelongatus*, respectively) to *I. amitinus*. Because *Ips amitinus*, *I. sexdentatus* and *I. subelongatus* attack Siberian pines (*Pinus sibirica*) in western Siberia (Stark 1952; Kerchev *et al.* 2019), their galleries may intersect. Therefore, mites can freely move through the galleries from one bark beetle species to another.

Through the use of electron microscopy, we were able to establish that the mites of two species of the genus *Iponemus* were located on different parts of a bark beetle declivity: *Iponemus leionotum* attached to the lower part, and *I. asiaticus*—to the upper (Fig. 1A). Three of the five species of mites found on *Ips amitinus* could have a direct effect on bark beetle survival and population growth. In particular, *Iponemus leionotum* and *I. asiaticus* are parasitoids of bark beetle eggs, while *Dendrolaelaps quadrisetus* is a specialized predator of bark beetle eggs and juvenile instars. These findings create the basis for using the above mites to biologically control the invasive bark beetle *Ips amitinus*.

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