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ORIGINAL PAPER

Phoretic mites of three bark beetles (*Pityokteines* spp.) on Silver fir

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Abstract The species composition and abundance of phoretic mites of the bark beetles *Pityokteines curvidens*, *P. spinidens,* and *P. vorontzowi* on Silver fir (*Abies alba*) were investigated in 2003 at two locations (Trakoscan and Litoric) in Croatia. Stem sections and branches from *A. alba* trees infested by *Pityokteines* ssp. were collected and incubated in rearing cages. Bark beetles emerging from the stem sections and branches were examined for photetic mites. A total of ten mite species were documented for the first time as associates of *Pityokteines* spp. on *A. alba.* These included *Dendrolaelaps quadrisetus*, *Ereynetes scutulis*, *Histiostoma piceae*, *Paraleius leontonychus*, *Pleuronectocelaeno japonica*, *Proctolaelaps hystricoides*, *Schizostethus simulatrix*, *Tarsonemus minimax*, *Trichouropoda lamellose,* and *Uroobovella ipidis*. *T. minimax* was the most frequent phoretic mite of all the three scolytines and *U. ipidis* was also common, whereas, the other mite species occurred less frequently. The species spectrum and relative abundance of mite associates were similar for all three *Pityokteines* species. Another species, *Pleuronectocelaeno barbara* was commonly found phoretic on *P. curvidens,* captured in pheromone traps in 2005 at the location Litoric. Furthermore, two previously collected mite specimens from Switzerland, phoretic on *P. curvidens*, were identified as *Nanacarus* sp. and *Bonomia* sp. The records from Croatia and Switzerland in the present study increase the number of known mite associates of *Pityokteines* spp. from one previously documented species to 14 species. None of the phoretic mites found in the survey in Croatia appear to have the potential to be used for biological control of *Pityokteines* spp., although the feeding habits are unknown for many species recorded.

Keywords *Abies alba* · Acarina · Scolytinae · Forest pests

Introduction

Four bark beetle species of the genus *Pityokteines* (Coleoptera, Curculionidae, Scolytinae) occur in the Palaearctic region (Pfeffer 1995; Knizek 1998). Among these, *P. curvidens* (Germar), *P. spinidens* (Reitter), and *P. vorontzowi* (Jakobson) commonly occur in Europe where they infest Silver fir (*Abies alba* Mill.) and occasionally other conifers (Schwerdtfeger 1981; Pfeffer 1995). *P. curvidens* and *P. spinidens* usually breed in the lower trunk of Silver fir trees, while *P. vorontzowi* usually occupies only the upper part of the crown (Pernek 2005). The three *Pityokteines* species have been reported as an important factor in Silver fir decline (widely known as "Tannensterben" in German-speaking countries) in some parts of Europe, a syndrome caused by a variety of abiotic and biotic factors (Schwerdtfeger 1981). *P. curvidens*, *P. spinidens*, and

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P. vorontzowi are commonly found in Croatia and have been associated with increased levels of Silver fir mortality since the beginning of 2000 (Pernek 2005).

Bark beetles are known to be associated with diverse guilds of arthropods of which phoretic mites are amongst the best-known associates (Kinn 1983; Moser and Macias-Samano 2000; Klepzig et al. 2001; Lombardero et al. 2003; Moser et al. 2005). Phoretic mites use bark beetles for transportation to new, suitable habitats and their ecological roles are diverse (Lindquist 1969). It is of particular practical interest that some phoretic mites act as predators and parasitoids of bark beetles and their immature stages, especially egg and early larval stages (Moser 1975; Moser et al. 1978). They are thus potential agents for biological control of scolytine forest pests (Kinn 1983), although there is presently no successful example of any biological control program against bark beetles using phoretic mites.

Mites phoretic on bark beetles can also be involved in complex symbiotic interactions with bark beetles and fungi, especially ophiostomatoid fungi belonging to the genera *Ceratocystis*, *Ceratocystiopsis*, *Ophiostoma*, *Grosmannia* and related genera of anamorphic fungi (Wingfield et al. 1993; Kirisits 2004; Zipfel et al. 2006) and their host trees (Klepzig et al. 2001; Hofstetter et al. 2005). The occurrence of hyperphoretic fungal spores (both conidia and ascospores) on phoretic mites of bark beetles suggests that they can to some extent be involved in the transmission of fungi to their host trees, including ophiostomatoid fungi and especially also tree pathogens (Moser et al. 1989b, 1997, 2005). Phoretic females of some species in the minimax group of *Tarsonemus* even possess so-called sporothecae, specialized integumental, pocket-like structures, in which ascospores and conidia of ophiostomatoid fungi are deposited and transported (Moser 1985; Bridges and Moser 1986).

Increased local populations of *P. curvidens*, *P. spinidens* and *P. vorontzowi* have been recently noted in conifer forests in various parts of Croatia, resulting in high damage levels on Silver fir (Pernek 2005). This increase in importance of *Pityokteines* species as forest pests of *A. alba* in Croatia prompted a research on the biology of these bark beetles species, their natural enemies (Pernek 2005) and also on their mite associates. The purpose of this study was to investigate the species spectrum and abundance of phoretic mites associated with *P. curvidens*, *P. spinidens,* and *P. vorontzowi* in natural Silver fir stands in Croatia. Previously unpublished records of two phoretic mites of *P. curvidens* in Switzerland are also reported.

Materials and methods

Bark beetle specimens and respective bark and wood samples included in this study of phoretic mites of *Pityokteines* spp. originated from natural Silver fir stands (at two locations in Croatia: one in the Pannonic biogeographic region (Trakoscan, 400 m a.s.l., 46°05(′28″ N and 15°56′55″ E) and the other one in the Dinaric biogeographic region (Litoric, 550 m a.s.l., 45°27′00″ N and 15°04′06″ E). On 6 October 2003, one stem section (37 cm in length and 36 cm in diameter) and four branches (1 m long) were cut from the trunk of a Silver fir tree infested by *Pityokteines* spp. in Trakoscan. In Litoric, sampling was conducted on 20 October 2003. Here, another stem section (46 cm in length and 34 cm in diameter) and four branches (1 m long) were taken from a bark beetle infested Silver fir tree. Bolts and branches were collected when broods were in the pupal stage. The sampled material was incubated in separate rearing cages at 23(±2)°C and under a 16L:8D photoperiod. All bark beetles emerging from the stem sections and branches were collected daily from the cage screens during the entire emergence period.

A total of 192 beetles belonging to the three *Pityokteines* species were randomly chosen and placed into vials with 70% ethanol (Table 1). Bark beetle specimens belonging to different species and originating from different localities were placed in separate vials. The beetles were then transferred to lactophenol for clearing. Their accompanying mites were counted and plucked from their bodies. Mites were tallied separately according to whether they were: (1) still attached to the beetle, (2) separated from the beetles in lactophenol, or (3) separated from the beetles in alcohol.

The identification of two mite specimens phoretic on *P. curvidens*, collected by B. Forster (see acknowledgments) in Switzerland and sent to J. C. Moser for determination, was also included in this study, as they represent hitherto unpublished records. Voucher specimens (slides) of all mite species detected in this study are stored in the collections of the authors (M. Pernek and J. C. Moser), and in other collections of mite taxonomists (H. Klompen and E. E. Lindquist; see acknowledgments).

Results and discussion

A total of 504 individuals of *P. spinidens* emerged from 8 November to 10 December 2003 from the collected stem sections incubated in separate rearing cages at Trakoscan, while 512 specimens of *P. spinidens* and 55 indviduals of *P. curvidens* emerged from 25 November to 13 December 2003 from the stem sections collected at Litoric (Table 1). From the branches collected at Trakoscan, 231 individuals of *P. vorontzowi* emerged from 23 November to 2 December 2003, and 416 specimens of this scolytine species emerged from 25 November to 6 December 2003 from the branches collected at Litoric (Table 1).

Table 1 Overview about the number of *Pityokteines spinidens, P. curvidens*, and *P. vorontzowi* emerging from the stem sections and branches collected in 2003 at the two Croatian localities Litoric and Trakoscan and incubated in breeding cages in the laboratory, the number of beetles investigated for the presence of phoretic mites, and number and percentage of investigated beetles carrying phoretic mites

Observations	*Pityokteines spinidens*		*Pityokteines vorontzowi*		*Pityokteines curvidens*	Total
	Litoric	Trakoscan	Litoric	Trakoscan	Litoric	
Total number of bark beetles emerging from stem sections/branches incubated in the laboratory	512	504	416	231	55	1,718
Number of beetles sampled for identification of phoretic mites	56	21	53	20	42	192
Number of sampled beetles carrying mites	34	11	28	11	30	114
Sampled beetles carrying mites (%)	60.7	52.4	52.8	55.0	71.4	59.4

The percentages of fir bark beetles carrying mites on their bodies ranged from about 52 to 71%, depending on the *Pityokteines* species and the collection site (Table 1). The overall average of insects carrying mites was about 60%. These values considerably underestimate the actual portion of individuals carrying phoretic mites. This is suggested by the large number of mites that fell-off the beetles, as indicated by their presence in the alcohol and lactophenol sediments (Tables 2, 3, 4, 5, 6).

Ten phoretic mite species are documented here for the first time as associates of fir bark beetles in the genus *Pityokteines* in Croatia (Tables 2, 3, 4, 5, 6). Overall, *Tarsonemus minimax* (Vitzthum) (Fig. 1g) and *Uroobovella ipidis* (Vitzthum) (Fig. 1f) were relatively common, whereas, *Dendrolaelaps quadrisetus* (Berlese) (Fig. 1d), *Paraleius leontonychus* (Berlese) (Fig. 1j), and *Histiostoma piceae* (Scheucher) (Fig 1h) occurred occasionally. *Trichouropoda lamellosa* (Hirschmann) (Fig. 1e), *Proctolaelaps hystricoides* (Lindquist and Hunter) (Fig. 1c), *Schizostethus simulatrix* (Athias–Henriot) (Fig. 1b), *Ereynetes scutulis* (Hunter) (Fig. 1i), and *Pleuronectocelaeno japonica* (Kinn) (Fig. 1a) were rare. In addition, *Pleuronectocelaeno barbara*

Table 2 Species spectrum and abundance of mites phoretic on 42 individuals of *Pityokteines curvidens* at the locality Litoric

Mite species	Phoretic stage	On beetles	Location on beetle	Lactophenol sediments	Alcohol sediments	Totals
Pleuronectocelaeno japonica	Female	2	Under elytra	0	0	2
Schizostethus simulatrix	Deutonymph	0		0	1	1
Dendrolaelaps quadrisetus	Deutonymph	10	Under elytra	2	1	13
Trichouropoda lamellose	Deutonymph	1	Elytral declivity	0	2	3
Uroobovella ipidis	Deutonymph	18	Coxa, elytral declivity, and ventral thorax	12	0	30
Tarsonemus minimax	Female	28	Elytral declivity, under elytral, and ventral thorax	60	128	216
Histiostoma piceae	Deutonymph	4	Under elytra	6	2	12
Paraleius leontonychus	Female	1	Coxa	1	4	6
Total		64		81	138	283

Table 3 Species spectrum and abundance of phoretic mites on 56 individuals of *Pityokteines spinidens* at the locality Litoric

Mite species	Phoretic stage	On beetles	Location on beetle	Lactophenol sediments	Alcohol sediments	Totals
Dendrolaelaps quadrisetus	Deutonymph	8	Under elytra	0	0	8
Uroobovella ipidis	Deutonymph	32	Ventral thorax, elytral declivity, coxa, and dorsal thorax	0	0	32
Tarsonemus minimax	Female	29	Under elytra and ventral thorax	0	6	35
Histiostoma piceae	Deutonymph	9	Under elytra	0	2	11
Paraleius leontonychus	Female	4	Ventral thorax and leg	0	0	4
Total		82		0	8	90

Table 4 Species spectrum and abundance of phoretic mites on 21 individuals of *Pityokteines spinidens* at the locality Trakoscan

Mite species	Phoretic stage	On beetles	Location on beetle	Lactophenol sediments	Alcohol sediments	Totals
Proctolaelaps hystricoides	Female	0		1	1	2
Dendrolaelaps quadrisetus	Deutonymph	4	Under elytra	0	0	4
Trichouropoda lamellose	Deutonymph	0		1	0	1
Uroobovella ipidis	Deutonymph	5	Under elytra, elytral declivity, and coxa	15	2	22
Tarsonemus minimax	Female	28	Under elytra and ventral thorax	63	356	447
Histiostoma piceae	Deutonymph	4	Under elytra	3	0	7
Ereynetes scutulis	Female	0		0	1	1
Paraleius leontonychus	Female	0		1	7	8
Total		41		84	367	492

Table 5 Species spectrum and abundance of phoretic mites on 53 individuals of *Pityokteines vorontzowi* at the locality Litoric

Mite species	Phoretic stage	On beetles	Location on beetle	Lactophenol sediments	Alcohol sediments	Totals
Proctolaelaps hystricoides	Female	0		0	1	1
Dendrolaelaps quadrisetus	Deutonymph	4	Under elytra	0	0	4
Uroobovella ipidis	Deutonymph	29	Under elytra, elytral declivity, and coax	19	0	48
Tarsonemus minimax	Female	64	Under elytra and ventral thorax	86	159	309
Histiostoma piceae	Deutonymph	1	Under elytra	1	0	2
Ereynetes scutulis	Female	0		1	3	4
Paraleius leontonychus	Female	1	Ventral thorax	2	5	8
Total		99		109	168	376

Table 6 Species spectrum and abundance of phoretic mites on 20 individuals of *Pityokteines vorontzowi* at the locality Trakoscan

Mite species	Phoretic stage	On beetle	Location on beetle	Lactophenol sediments	Alcohol sediments	Totals
Dendrolaelaps quadrisetus	Deutonymph	5	Under elytra	1	0	6
Uroobovella ipidis	Deutonymph	8	Ventral thorax, elytral declivity, coax, and dorsal thorax	3	1	12
Tarsonemus minimax	Female	1	Under elytra and ventral thorax	10	52	63
Histiostoma piceae	Deutonymph	1	Under elytra	0	0	1
Paraleius leontonychus	Female	0	Ventral thorax and leg	0	3	3
Total		15		14	56	85

(Athias–Henriot) was commonly found phoretic on *P. curvidens* collected from pheromone traps installed in 2005 in a Silver fir stand in Litoric, while further specimens of *P. japonica* could not be detected (M. Pernek and J. C. Moser, unpublished data). With *P. barbara*, which was not found on *Pityokteines* beetles emerging from the logs in 2003 (Tables 2, 3, 4, 5, 6), the number of known mite associates of *Pityokteines* spp. in Croatia increased from 10 to 11 species (Tables 2, 3, 4, 5, 6). Mites were either phoretic on *Pityokteines* spp. as females (*P. hystricoides*, *P. japonica*, *T. minimax, E. scutulis, P. leontonychus*) or as deutonymphs (*S. simulatrix*, *D. quadrisetus*, *T. lamellosa*, *U. ipidis*, *H. piceae*) (Tables 2, 3, 4, 5, 6).

The most abundant mite species on all of the three bark beetle species was *T. minimax* which comprised 39–90% of all mite individuals per collection, depending on the *Pityokteines* species and the site where samples were collected (Tables 2, 3, 4, 5, 6). The species spectrum and relative abundance of phoretic mites were similar for all the three *Pityokteines* species, especially regarding the most common species, *T. minimax* and *U. ipidis* (Tables 2, 3, 4, 5, 6). The differences in the assemblages and the abundance of phoretic mites between *Pityokteines* species and between different sampling localities thus refer mainly to those mite species that were generally rare (*P. hystricoides*, *S. simulatrix*, *T. lamellosa*, *H. piceae*, *E. scutulis*). Care should be taken in interpreting the results of this study, as only a single tree at each of the two study sites were sampled. However, previous experience in a number of phoretic mite bark beetle systems has shown that intensive sampling of a single tree will reveal most or all of the common mite species, although many of the uncommon associates may be missed (Moser and Roton 1971; Moser and Bogenschütz 1984; Moser et al. 1989a, 1997).

The two mite specimens from *P. curvidens*, collected by B. Forster in Switzerland, were identfied as *Nanacarus* sp. (Fig. 1k) and *Bonomia* sp. (Fig. 1l), respectively. Another phoretic mite recorded from *P. curvidens*, again in Switzerland, is *Pyemotes dryas* (Vitzthum) (Nierhaus-Wunderwald 1997). The three mite species from Switzerland were, however, not found in the present survey in Croatia. Summarizing the previous record from Switzerland (Nierhaus-Wunderwald 1997) and those from Croatia and Switzerland made in the present study, the known assemblage of phoretic mites of *Pityokteines* spp. on *A. alba* consists of 14 species.

Phoretic mites from *Pityokteines curvidens*

A total of 42 individuals of *P. curvidens* from Litoric, consisting of 23 males (55%) and 19 females (45%), were collected after their emergence from logs, and examined for mites. Eight mite species, *P. japonica*, *S. simulatrix*, *D. quadrisetus*, *T. lamellosa*, *U. ipidis*, *T. minimax*, *H. piceae*, and *P. leontonychus* were detected among the

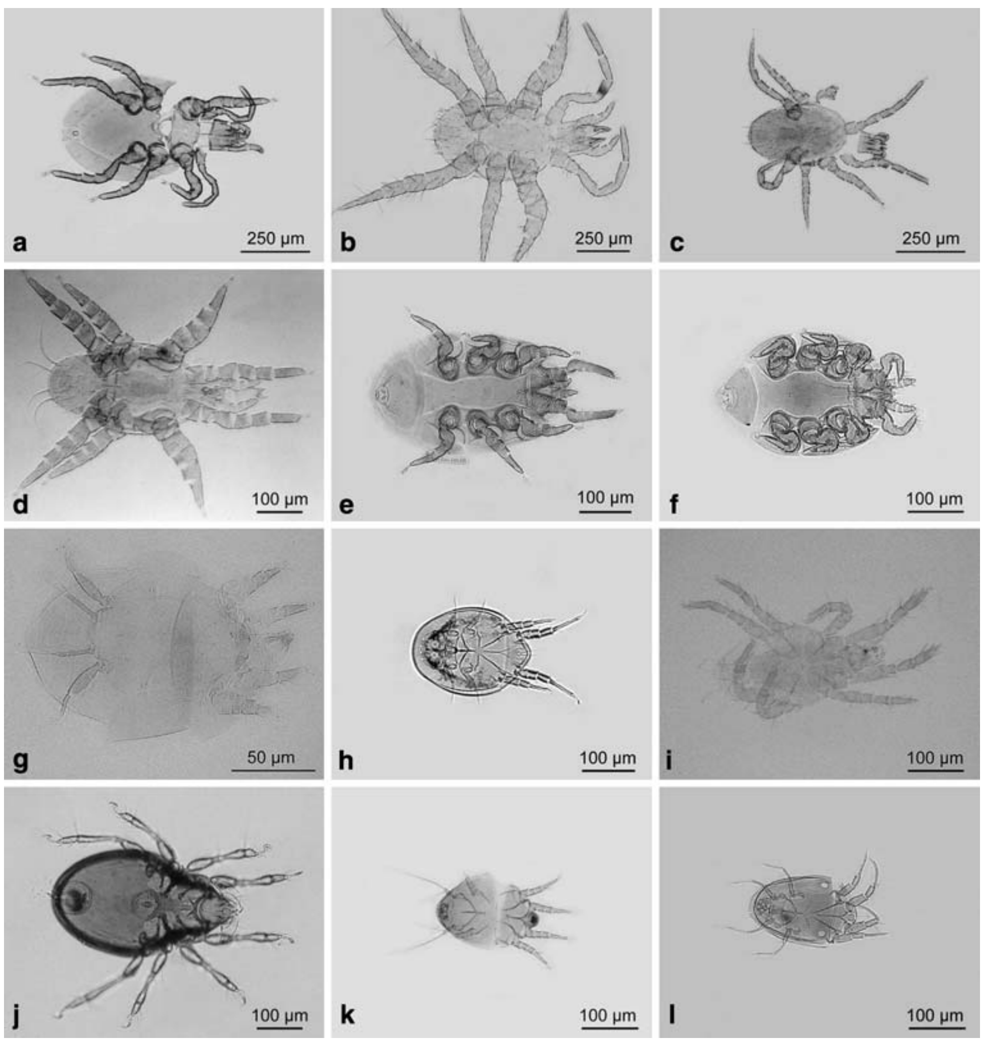

Fig. 1 Phoretic mites from *Pityokteines* spp. in Croatia: **a** *Pleuronectocelaeno japonica*, **b** *Schizostethus simulatrix*, **c** *Proctolaelaps hystricoides*, **d** *Dendrolaelaps quadrisetus*, **e** *Trichouropoda lamellosa*, **f** *Uroobovella ipidis*, **g** *Tarsonemus minimax*, **h** *Histiostoma piceae*, **i** *Ereynetes scutulis*, **j** *Paraleius leontonychus*, and from Switzerland: **k** *Nanacarus* sp., **l** *Bonomia* sp.

283 mite individuals examined (Table 2). Two mite species, *P. japonica* and *S. simulatrix*, were detected only on this *Pityokteines* species. The discovery of *P. japonica* in Europe is puzzling and raises questions concerning the hosts, ecological niches, and geographic distribution of this species. Kinn (1991) and Moser et al. (1997) found this mite phoretic on the spruce bark beetle *Ips typographus japonicus* (Niijima) in Japan. However, in all collections of *Ips typographus* L. in Europe only phoretic individuals of *P. barbara* where detected, while *P. japonica* never occurred (Moser and Bogenschütz 1984; Moser et al. 1989a). Hence, based on the differences in phoretic hosts and geographic distribution, it is possible that the populations of *P. japonica* on *P. curvidens* in Croatia and on *I. typographus japonicus* in Japan may be morphologically identical, but genetically and ecologically separate sibling species.

Phoretic mites from *Pityokteines spinidens*

A total of 77 individuals of *P. spinidens* (21 from Trakoscan, 56 from Litoric), consisting of 36 males (47%) and 41 females (53%), were collected after their emergence from logs and examined for mites. Five mite species, *D. quadrisetus*, *U. ipidis*, *T. minimax*, *H. piceae,* and *P. leontonychus*, were detected among the 90 mite individuals from the location Litoric (Table 3). Eight mite species were detected among the 492 mite individuals sampled from the location Trakoscan (Table 4). These included all the species recorded from *P. spinidens* at Litoric and additionally also *P. hystricoides*, *T. lamellose,* and *E. scutulis*.

Phoretic mites from *Pityokteines vorontzowi*

A total of 73 individuals of *P. vorontzowi* (20 from Trakoscan, 53 from Litoric), consisting of 40 males (55%) and 33 females (45%), were collected after their emergence from branches and examined for mites. Seven mite species, *P. hystricoides*, *D. quadrisetus*, *U. ipidis*, *T. minimax*, *H. piceae*, *E. scutulis,* and *P. leontonychus*, were detected among the 376 mite individuals from Litoric (Table 5). Five species were detected from the 85 mite individuals from Trakoscan (Table 6). These included all mite species recorded from *P. vorontzowi* at Litoric, except *P. hystricoides* and *E. scutulis* (Table 6).

Location of phoretic mites on *Pityokteines* beetles (Tables 2, 3, 4, 5, 6)

Locations of the different mite species on the bark beetle bodies varied widely. Some species were consistently detected on certain locations. Individuals of *P. leontonychus* were seen on the thorax or legs, while those of *P. japonica* occurred only under the elytra. *D. quadrisetus* and *H. piceae* were found under the elytra and *T. lamellosa* on the elytral declivity. *U. ipidis* occurred on various locations, including under the elytra, on the elytral declivity, and the ventral thorax. Although numerous individuals of the most abundant species, *T. minimax*, were present under the elytra, the most common locations of this mite likely were somewhere on the beetle's body surface. Most individuals of this mite species fell-off from the beetles, which is more likely to occur when they are carried on the beetle's body surface, where attachment of the mite to the insect is relatively weak. Locations of *E. scutulis*, *P. hystricoides* and *S. simulatrix* could not be assessed, because of that all individuals of these species were collected from lactophenol or alcohol sediments.

Ecological roles of the phoretic mites on *Pityokteines* spp.

The ecological roles of most of the phoretic mites associated with *Pityokteines* spp. are poorly known. However, based on the knowledge of other bark beetle–mite–fungal systems and previous records of the biology of these mites in the scientific literature, it is justified to assume that their biology and ecology are diverse (Moser et al. 1995; Klepzig et al. 2001; Lombardero et al. 2003). *H. picea*, like most members of this genus may occur in liquid, "soupy" substrates, and may be a filter feeder of bacteria and yeasts (Oconnor 1984). *D. quadrisetus* and *T. lamellosa* prey on nematodes (Kinn 1967, 1987). Likewise, *P. japonica* and *P. barbara* may also feed on nematodes (Kinn 1971). No records exist about the feeding habits of *U. ipidis*. The anal opening of *P. hystricoides* is enlarged, suggesting that it may feed on fungal spores. *S. simulatrix*, like *S. lyriformis* (Moser 1975), may prey on subcortical arthropods, as it is a member of the predatory mite family *Parasitidae*. Most oribatids are detritivores (Jacot 1934; Walter and Proctor 1999), and *P. leontonychus* is probably no exception to the general trophic pattern of this group of mites. Similar to other *Tarsonemus* species, *T. minimax* may feed on fungal mycelia and spores (Oconnor 1984; Lombardero et al. 2003). *E. scutulis* is phoretic on many scolytines on conifers and it preferably inhabits drier and older subcortical galleries. Although no feeding preferences of *E. scutulis* have so far been observed, Walter and Proctor (1999) noted that *Ereynetes macquariensis* (Fain), at least, may feed on small mites, eggs, and immature stages of larger arthropods or on nematodes. Only *S. simulatrix*, as it is a member of the predatory mite family *Parasitidae* and probably *E. scutulis* could have some potential for biological control of *Pityokteines* bark beetle pests, but they were very rarely recorded in the present survey. However, further field and laboratory studies are required to precisely assess the feeding habits of the phoretic mites of *Pityokteines* spp. and their potential use as biocontrol agents against fir bark beetles.

Hyperphoretic fungal spores on phoretic mites of *Pityokteines* spp.

Hyperphoretic fungal spores were attached to the body surfaces of many individuals of phoretic mites of *Pityokteines* spp. with the exception of specimens of *P. japonica, S. simulatrix, E. scutulus,* and *P. leontonychus*, which generally occurred rarely. These spores appeared to be conidia of several fungi and were of various sizes and shapes. None could be unambiguously assigned to individual fungal species, except for large, four-celled, *Alternaria*-like conidia.

The assemblages of ophiostomatoid fungi associated with any of the three *Pityokteines* species has thus-far not been studied (Kirisits 2004). Examination of 20 gallery systems of *P. spinidens* on a Silver fir tree in Litoric in April 2004 for sexual and asexual stages of ophiostomatoid fungi resulted in the isolation of six ophiostomatoid species. Based on morphology, they were tentatively identified as *Ceratocystiopsis minuta* (Siemaszko) H. P. Upadhyay and W. B. Kendrick, *Ceratocystiopsis* cf. *alba*, *Graphium* cf. *fimbriisporum*, *Ophiostoma* cf. *cucullatum*, *Ophiostoma piceae sensu lato,* and a *Pesotum* species (T. Kirisits, unpublished data). None of the spores found on the body surfaces of mites phoretic on *Pityokteines* spp. were identified as ascospores of *Ceratocystis, Ceratocystiopsis*, *Grosmannia*, *Ophiostoma,* or any asexual ophiostomatoid species commonly associated with conifer bark beetles, including the six taxa mentioned above as associates of *P. spinidens*.

Ascospores and conidia of ophiostomatoid fungi, especially *Ophiostoma* and *Ceratocystiopsis* species are often transported in sporothecae by phoretic females of some species in the minimax group of *Tarsonemus*, such as *Tarsonemus krantzi* (Smiley and Moser), and *Tarsomeus crassus* (Schaarschmidt) (Moser 1985; Bridges and Moser 1986; J. Moser, unpublished). It is enigmatic, why *T. minimax* does not transport spores of ophiostomatoid fungi, even though this mite is clearly a member of the "minimax group" of *Tarsonemus* (Magowski and Moser 2003) and possesses similar morphological adaptations (two paired, "pocket-like" structures under tergite 1) as other *Tarsonemus* species that could fully function as sporothecae (Moser 1985; Bridges and Moser 1986; Magowski and Moser 2003).

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