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Morphology and ecology of *Schizosthetus simulatrix* (Acari, Mesostigmata) associated with galleries of bark beetles (Scolytidae)

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The deutonymphal stage and adults of *Schizosthetus simulatrix* Athias-Henriot, 1982 (Acari, Mesostigmata, Parasitidae), originally known from Canary Islands and Portugal, has been illustrated and described or redescribed, respectively. The subadults of *S. simulatrix* have not previously been described. This very specialised subcorticolous species lives in galleries of xylophagous insects under bark of coniferous trees. This phoretic mite uses these various xylophages to distribute to new suitable habitats. Aside from the specimens from Slovakia presented in the paper, some phoretic deutonymphs of *S. simulatrix* (previously described from France, Germany and Sweden as *Vulgarogamasus* sp. in associations with scolytids) and *S. lyriformis* (McGraw et Farrier, 1969) have been reexamined. The differential diagnosis of the *S. simulatrix* deutonymph has been revised.

Key words: Acari, Mesostigmata, *Schizosthetus simulatrix*, morphology, ecology, association, Scolytidae.

Introduction

Mesostigmatic mites live in various habitats, and some of them are adapted to life in subcortical galleries of xylophagous insects. Many mesostigs exclusively inhabit decaying wood matter and subcorticolous habitats, e.g. species within the genera *Dendrolaelaps* Halbert, 1915, *Proctolaelaps* Berlese, 1923, *Trichouropoda* Berlese, 1916, *Uroobovella* Berlese, 1905, etc. (KINN, 1971; MOSER & ROTON, 1971; HIRSCHMANN & WIŚNIEWSKI, 1982; KIEŁCZEWSKI & WIŚNIEWSKI, 1983; KIEŁCZEWSKI et al., 1983; KACZMAREK & MICHALSKI, 1994). Specialised lignicolous and subcorticolous species of the Mesostigmata are often rare or missing, and the family Parasitidae Oudemans, 1901 which includes large and moveable predators is no exception.

Several subcorticolous mite species of the subfamily Parasitinae Oudemans, 1901 are known. *Eugamasus lyriformis* McGraw et Farrier, 1969 was first described from the USA, but was also found in Canada, Mexico, Guatemala and Honduras. McGRAW & FARRIER (1969) found it under the bark of coniferous trees (*Pinus* spp., *Larix* sp.). This species occurs in the galleries of several bark beetles belonging to the genera *Dendroctonus* Erichson, 1836 and *Ips* De

Geer, 1775. TIKHOMIROV (1977) subsequently included this species in the genus *Parasitus* Latreille, 1795 and the subgenus *Vulgarogamasus* Tikhomirov, 1969. In 1982, the species was erected as the type species of a new genus *Schizosthetus* Athias-Henriot, 1982 and two related species with similar ecology, *Schizosthetus simulatrix* Athias-Henriot, 1982 from both Canary Islands and Portugal, and *S. vicarius* Athias-Henriot, 1982 from USA, were described (ATHIAS-HENRIOT 1982). AL-ATAWI (2001) revised the genus *Schizosthetus*, including all developmental stages, and redescription of its type species *S. lyriformis*.

TIKHOMIROV (1977) identified adult specimens (probably *S. simulatrix*) from N Russia (Arkhangelsk env.) as *Parasitus (Vulgarogamasus) lyriformis*. Although identification based on the illustration of sterno-genital area of female is impossible, the description of femoral apophysis of the second pair of legs in male shows very similar characters as in *S. simulatrix*. The present distribution of *S. simulatrix* in Europe also suggests that this species probably reaches the N parts of Russia.

Papers dealing with the mites associated with *Ips typographus* (L., 1758) in Europe contribute some information on findings of deutonymphs of subfamily Parasitinae [papers of LIEUTIER (1978) from France, MOSER & BOGENSCHÜTZ (1984) from Germany and MOSER et al. (1989) from Sweden]. The examined deutonymphs were presented in mentioned papers as *Vulgarogamasus* sp. The paper of MOSER & BOGENSCHÜTZ (1984) involves also a rough illustration of a deutonymph stated as *Vulgarogamasus* sp. In present study, some Moser's deutonymphs of this European species (*S. simulatrix*) were reexamined and compared with the deutonymphs and adults collected in Slovakia (*S. simulatrix*) and USA (*S. lyriformis*). AL-ATAWI (2001) also reexamined some of these Moser's deutonymphs, but he found no morphological differences between deutonymphs of *S. simulatrix* and *S. lyriformis*. In revision of the genus *Schizosthetus* he partly redrew some characters of adults (tectum, cheliceral brush, sterno-genital and metapodal area of female, male femur II and tarsus II) and briefly redescribed the adults. Until now the deutonymphal stages of *S. simulatrix* were not particularly figured and described.

As stated above, systematic status of subcorticolous mite representatives within the subfamily Parasitinae is still not clear. In our opinion, the differential diagnosis of the genus *Schizosthetus* (ATHIAS-HENRIOT, 1982; AL-ATAWI, 2001) includes characters generally compatible with the diagnosis of the genus *Vulgarogamasus* according to e.g. TIKHOMIROV (1969) or HYATT (1980), with an exception of sternal shield in the female. On the other hand, the genus *Schizosthetus* includes species with similar and specific habitat requirements.

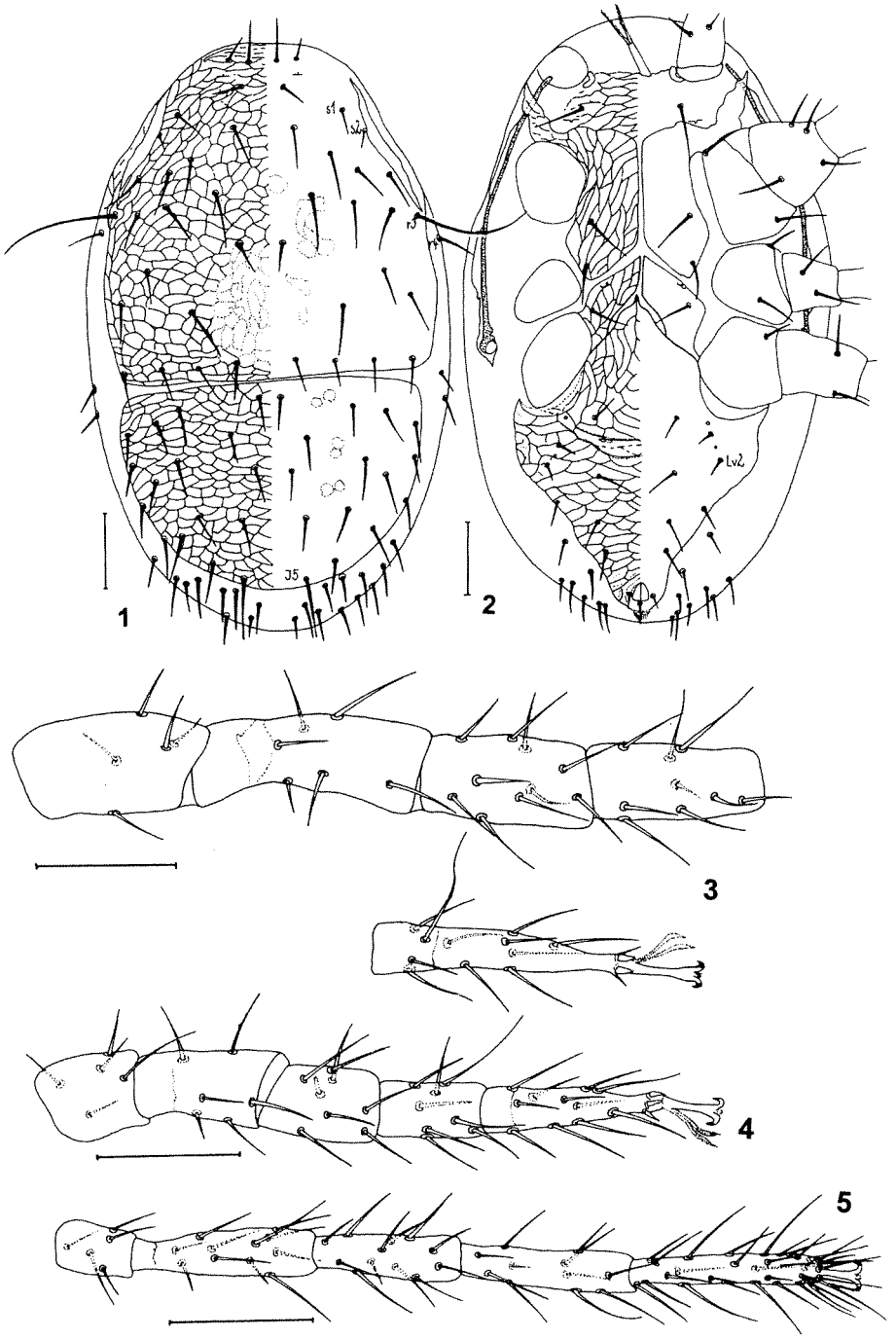
Schizosthetus simulatrix Athias-Henriot, 1982

Description. Female (Figs 1–5, 7–8, 10–13). Length of idiosoma 740–935 μm Shape oval.

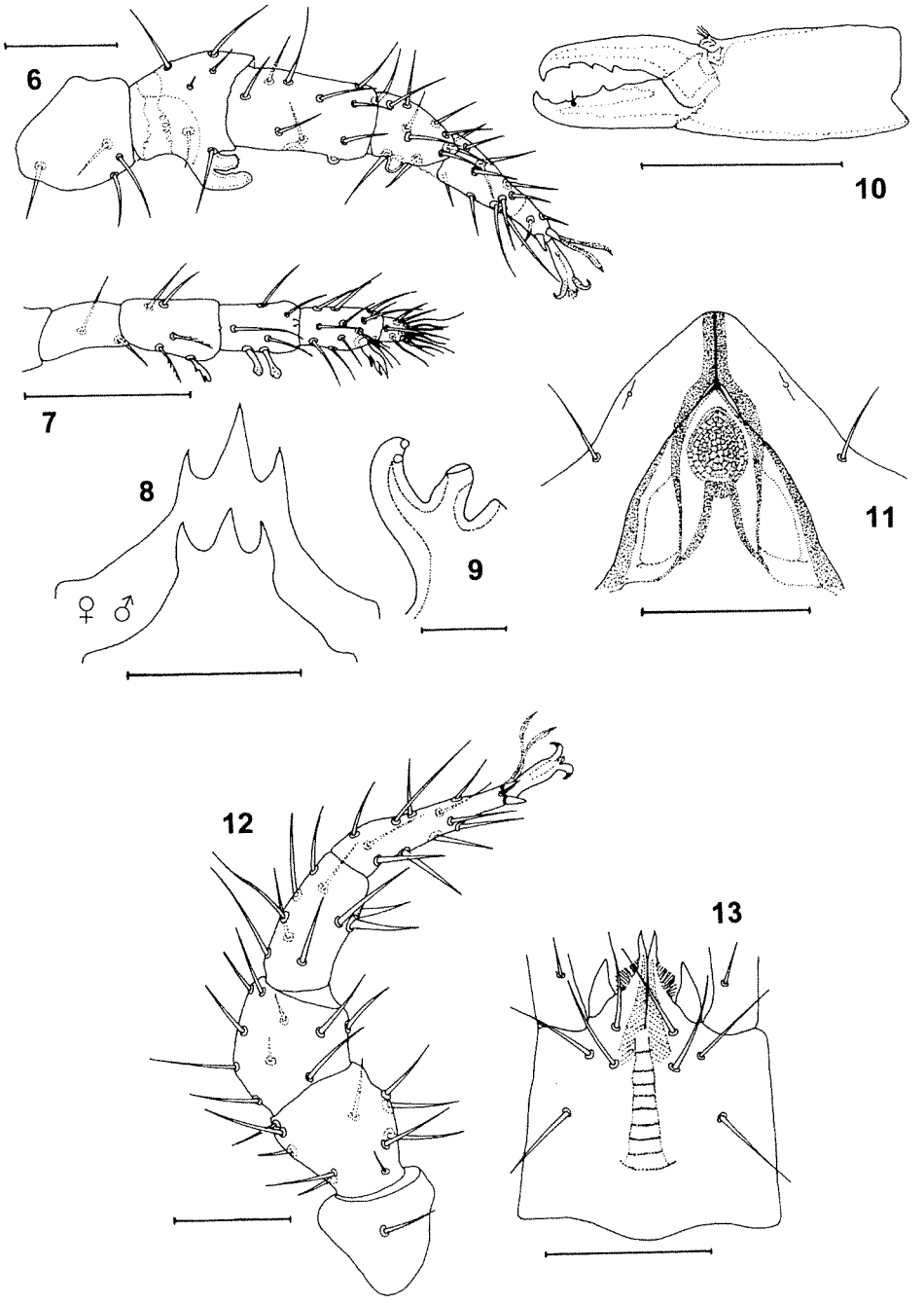
Dorsum (Fig. 1). The dorsal shields are sclerotized and entirely reticulated. Podonotal shield (430–490 μm long) bears 21 pairs of simple, needle-shaped setae. Setae r3 are the longest, s1 and s2 are the shortest, r4 are off the shield [chaetotactic pattern followed the concept of LINDQUIST & EVANS (1965)]. Relatively small opisthonotal shield (245–335 μm long) bears generally 15 pairs of simple, needle-shaped setae, but in some specimens additional seta or pair of setae are present. Setae J5 are the longest.

Venter (Fig. 2). The tritosternum has a narrow base and pilose laciniae. All ventral setae are simple and needle-shaped. The ventral shields are entirely reticulated, but the anterior part of sternal shield shows distinctly weaker sclerotization. This area bears one pair of small presternal sclerites and sternal setae I. Sternal setae I and II are slightly longer and well separated. Sternal shield is very deeply indented posteriorly. This strip-shaped indentation reaches anteriorly almost the sternal setae I and longitudinally divides the sternal shield into two parts. Metasternal shields subtriangular with one pair of sternal setae IV, genital shield broad and pointed anteriorly. The endogynium is oval (Fig. 11). Fairly symmetrical and relatively shorter ventrianal shield is slightly undulated in outline. It bears 7 pairs of opisthogastric setae and 3 shorter anal setae. Posteriorly free peritrematal shield, is not fused with ventrianal shield. The peritreme anteriorly extends to coxa I and posteriorly to coxa IV. Stigmae are situated near the lateral margin of coxae IV. Legs I–IV are shown in detail in Figs 3–5 and 12, respectively.

Gnathosoma (Figs 7–8, 10 and 13). Pedipalp is shown in detail in Fig. 7: apotele of palp tibia 3-tined; setae al_1 and al_2 of palp genu entire, spatulate; seta al of palp femur multifid. Apical part of tectum comprises a stout central prong and a pair of shorter, slightly divergent lateral prongs (Fig. 8). Moveable digit of chelicerae with 3 teeth (Fig. 10). Ventral side of hypostome is shown in detail in Fig. 13: corniculi short, entire; coxal se-



Figs 1–5. Female of *Schizosthetus simulatrix*: 1 – idiosoma (dorsal view); 2 – idiosoma (ventral view); 3 – leg IV; 4 – leg III; 5 – leg I. Scale 50 μm (Figs 3–5), 100 μm (Figs 1, 2).



Figs 6–13. *Schizosthetus simulatrix*: 6 – leg II (male); 7 – pedipalp (female); 8 – tecta; 9 – apophyses of leg II (male); 10 – chelicera (female); 11 – endogynium (female); 12 – leg II (female); 13 – hypostome of female (ventral view). Scale 25 μm (Fig. 9), 50 μm (Figs 7, 8, 10–12), 100 μm (Figs 6, 13).

tae simple and needle-like; 9 deutosternal rows of microdenticles well developed.

Male (Figs 6, 8–9, 14–15). Length of idiosoma 645–810 μm. Shape oval.

Dorsum (Fig. 14). Sclerotized dorsal shields are entirely reticulated and separated at the level of 2/3 of idiosoma length by an undulated transverse suture. Entire podonotal region bears 22–23 pairs of setae (r6 setae in some specimens are out of shield) very similar in form and length, except setae r3 which are the longest. Setae r4 on shield. The opisthonotal region bears 24–26 pairs of setae similar to the majority of those on the podonotum. All dorsal setae are simple and needle-like.

Venter (Fig. 15). Tritosternum has a shorter and wider base as compared to female. It is flanked by a pair of small presternal shields. Sclerotized and reticulated holoventral shield bears 13–14 pairs of simple and needle-like setae. The genital lamina is weakly sclerotized. Peritremes, posteriorly connected to holoventral shield are similarly formed as in female. Bifurcated apophysal protuberance on femur of legs II (Fig. 6) is stout and heavily sclerotized. The inner spur is shorter and obtusely rounded apically whilst the outer one is longer, slim and slightly pointed apically (Fig. 9). The shape of tectum is similar as in female, but the central prong is distinctly shorter.

Deutonymph (Figs 16–17). Length of idiosoma 660–700 μm. Shape oval.

Dorsum (Fig. 16). The dorsal shields are sclerotized and entirely reticulated. Podonotal shield (365–395 μm long) bears 20 pairs of simple and needle-shaped setae. Setae r3 are the longest, s1 are the shortest, s2 and r4 are off the shield. Relatively small opisthonotal shield (195–220 μm long) bears 12 pairs of simple and needle-shaped setae. Distinctly prolonged setae J5 are 2–2.5 times longer than the other opisthonotal setae.

Venter (Fig. 17). The tritosternum has a narrow base and pilose laciniae. All ventral setae are simple and needle-shaped. A pair of small presternal shields is present. Entirely reticulated drop-like sternal shield (300–320 μm long) bears 4 pairs of sternal setae. Rounded and reticulated anal shield bears anus and 3 short anal setae posteriorly. A pair of small reticulated metapodal shields is present. There are 3 pairs of microgranulated sclerites on ventral region. The peritreme extends to coxa I anteriorly and coxa IV posteriorly. Stigma situated close to anterior margin of the opening for coxa IV. The tectum is trispinate as in female, but prongs are slimmer.

Material examined. Slovakia – Borská nížina lowland, found under bark of old pine (*Pinus sylvestris*): Záhorská Ves env. (7667 = grid reference number of Databank of the Fauna of Slovakia), 4.VIII.1999, 3 ♀♀; Jakubov env. (7567), 27.IX.1999, 16 ♀♀, 7 ♂♂ and 4 dns (deutonymphs). Malá Fatra Mts, pheromone trap, associated with scolytids (non det.): Martin, Podstráne env. (6879), 23.VI.1993, 1 dn. The examined material (coll. and det. P. Mašán) is deposited at the Institute of Zoology (Slovak Academy of Sciences) in Bratislava (Slovakia) in the first junior author's collection. Germany – pheromone trap, associated with *Ips typographus*: Freiburg env., 19.VI.1980, 1 dn; Kappel env., 10.VI.1980, 1 dn (coll. H. Bogenschütz, det. J. C. Moser as *Vulgarogamasus* sp.). Sweden – pheromone trap, associated with *I. typographus*: Uppsala env., 8.VI.1983, 2 dns (coll. J. R. Regnander, det. J. C. Moser as *Vulgarogamasus* sp.). France – under bark of *Pinus sylvestris*, associated with *Ips sexdentatus* (Boerner, 1776): Orleans env., May, 1986, 4 dns (coll. F. Lieutier, det. J. C. Moser as *Vulgarogamasus* sp.).

The reexamined material is deposited at the Southern Research Station of USDA Forest Service in Pineville (Louisiana, USA) in the second junior author's collection. The material of *S. lyriformis* collected in USA (1 ♀, 1 ♂ and 2 dns) was also available for this study to the differential diagnosis of *S. simulatrix*.

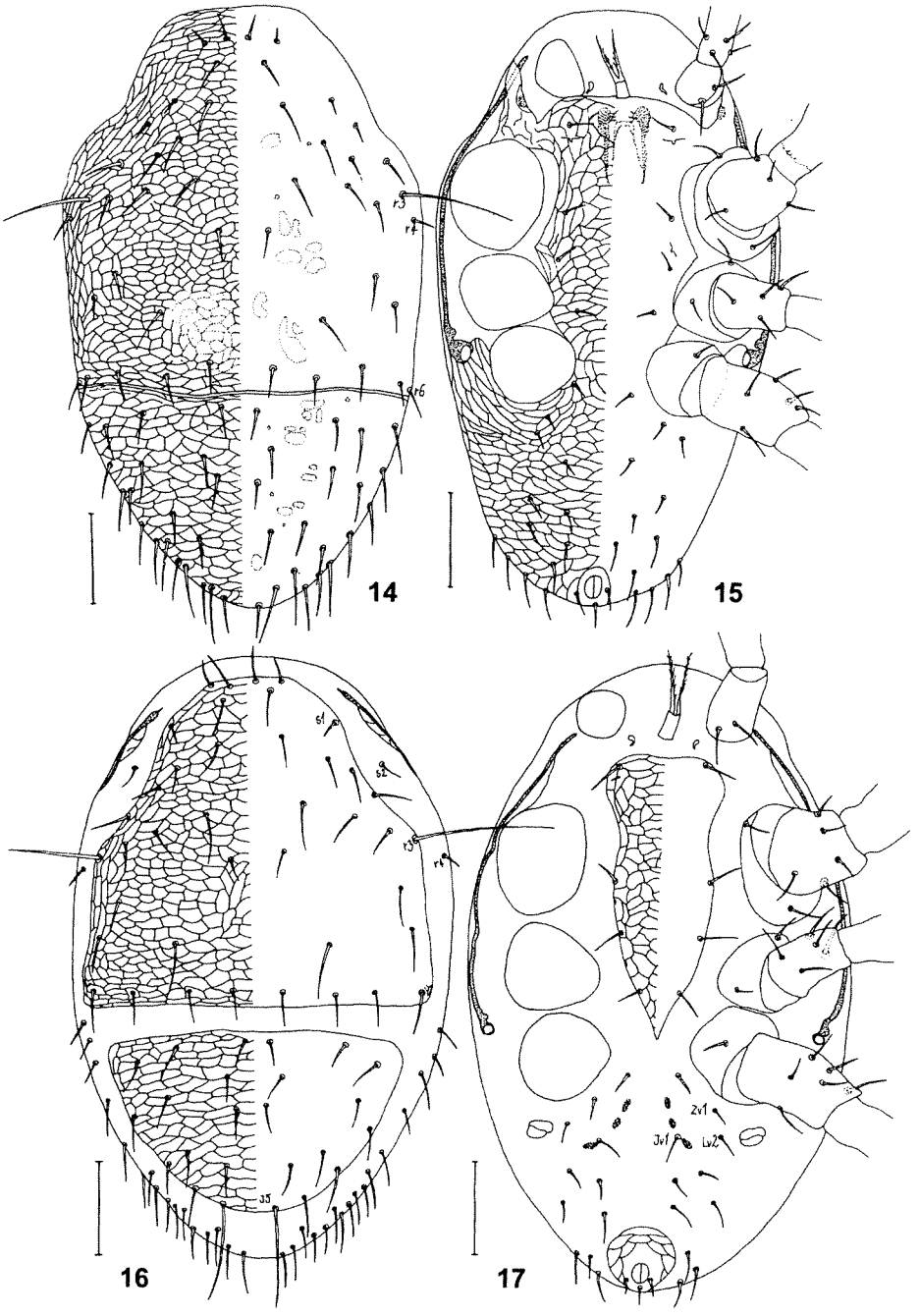
Taxonomical notes. Although ATHIAS-HENRIOT (1982) and AL-ATAWI (2001) examined deutonymphs, the relevant descriptions and illustrations of deutonymphal stage were missing. Only deutonymphs were phoretic on the scolytids taken from the pheromone traps (see introduction). Since the material from Slovakia includes both adults and deutonymphs, the reexamination and the exact identification of deutonymphs (without adults) from France (LIEUTIER, 1978), Germany (MOSER & BOGENSCHÜTZ, 1984) and Sweden (MOSER et al., 1989) were possible.

Differential diagnosis. Differential diagnosis of the species known from subcorticolous habitats is presented in the identification keys (see below). Females of individual species are easily distinguished except for the relatively uniform deutonymphs.

Key to *Schizosthetus* species, females

1 (2) Opisthonotal shield polytrichous: about 30 pairs of setae present; podonotal shield with 22 pairs of setae (setae r4 on shield); ventrianal setae Lv2 absent; peritrematal shield posteriorly free, not fused with ventrianal shield ..... ***Schizosthetus vicarius*** Athias-Henriot, 1982

2 (1) Opisthonotal shield oligotrichous: 15–16 pairs of setae present; podonotal shield with 21



Figs 14–17. *Schizosthetus simulatrix*: 14 –idiosoma of male (dorsal view); 15 – idiosoma of male (ventral view); *Schizosthetus simulatrix*: 16 – idiosoma of deutonymph (dorsal view); 17 – idiosoma of deutonymph (ventral view). Scale 100 μm.

pairs of setae (setae r4 out of shield); ventrianal setae Lv2 present.....3

3 (4) Peritrematal shield posteriorly fused with ventrianal shield; venter with 9 pairs of opisthogastric setae ..... ***Schizosthetus lyriformis*** (McGraw et Farrier, 1969)

4 (3) The peritrematal shield posteriorly free, not fused with ventrianal shield; venter with 7 pairs of opisthogastric setae (Lv2 present) ***Schizosthetus simulatrix*** Athias-Henriot, 1982

Key to *Schizosthetus* species, males

1 (2) Two apophysal spurs of femur II on separate bases and both almost equally sized, inner spur distinctly slimmer than outer one..... ..... ***Schizosthetus lyriformis***

2 (1) Two apophysal spurs of femur II on common base, inner spur distinctly shorter than outer one.....3

3 (4) Common base of apophysal spurs very short; inner spur short, medially both spurs with circumferential furrow on surface..... ..... ***Schizosthetus vicarious***

4 (3) Common base of apophysal spurs long, inner spur long, both spurs with smooth surface medially (Fig. 9)..... ..... ***Schizosthetus simulatrix***

Key to *Schizosthetus* species, deutonymphs

1 (2) Three pairs of small oval sclerites on ventrianal membrane separated equally; sclerites of the first pair placed between setae Zv1; sclerites of the third pair connected with the bases of setae Jv1..... ..... ***Schizosthetus simulatrix***

2 (1) Two pairs of small oval sclerites on ventrianal membrane more separated; sclerites of the second pair placed between setae Zv1, sclerites of the third pair not connected with the bases of setae Jv1, but placed between setae Jv1 and Lv2..... ..... ***Schizosthetus lyriformis***

Notes on distribution and ecology. Little is known concerning the ecological demands and distribution of *S. simulatrix*. The only information available appeared in original taxonomic paper of ATHIAS-HENRIOT (1982), when the several type specimens were located under the bark of *Pinus canariensis* and *P. pinaster* from two localities in the West Mediterranean region. New findings cited by AL-ATAWI (2001) and in present study enlarged the originally known W European area of geographic distribution of *S. simulatrix* (Canary Islands, Portugal, France) through C Europe (Germany, Slovakia) to N Europe (Sweden). If the identity of species mentioned by TIKHOMIROV (1977) from N Russia is confirmed, the distribution area will be considerably enlarged to the East. This species is able to adapt to environmental conditions including various temperature and climate extremes. Hence, *S. simulatrix* is a species with wide ecological potency and plasticity. The geographic distribution of *S. simulatrix* will probably include large part of the Palearctic. However, despite the many Polish records of mites in subcorticolous habitats, information on the occurrence of *S. simulatrix* from Poland (BŁASZAK & MADEJ, 1997) is still missing.

In Slovakia, *S. simulatrix* was found in different types of coniferous forest, including the pine forest of Borská nížina lowland (150 m a.s.l.) and the spruce forest of Malá Fatra Mts (570 m a.s.l.). The greatest abundance of this species was registered under the bark of dead and fallen trunks of *Pinus sylvestris*. Mites occurred mostly in galleries with larvae of bark beetles (the individuals were collected by wet paintbrush into a test tube). Its abundance under the bark of infested and dead pine trunks was very high, but living trees were rarely inhabited.

Due to their small body size, mites have remarkably restricted their ability to disperse and find appropriate (optimal) living substrates. That is why they have developed the phoresy as original life strategy. This strategy has substantially increased their vagility. Phoresy in many species enables a poised specialization to temporarily and spatially limited microhabitats, e.g. subcorticolous merocoenoses (ATHIAS-BINCHE 1984). Thus, phoretic mites are dependent on phoresy carriers (phoronts), e.g. on arthropods able to fly and topically associate with similar habitats. Generally, ecological requirements of phoretics can be deduced from the ecological demands of phoronts.

Schizosthetus simulatrix has not been found as phoretic on any host until recent. However, the findings in alcohol sediments of pheromone traps confirm its phoretic activity on scolytid beetles (mainly on *I. typographus*). A very common phenomenon in coprophilous mites of the subfamily Parasitinae is their releasing from the host phoronts after the immersion into alcohol. We suppose, that *S. simulatrix* utilises a wider range of cambiophagous and xylophagous phoretic hosts (e.g. Buprestidae, Cerambycidae, Cucujidae, Curculionidae, Elateridae, Lucanidae, Lymexylonidae,

etc.) that only accidentally appear in traps baited with the bark beetle pheromones.

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