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Sphaerellothecium phaeorrhizae and *Zwackhiomyces sipmanii* spp. nov. on *Phaeorrhiza sareptana* from north-eastern Asia, with a key to the species of *Sphaerellothecium*

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Abstract: The lichenicolous fungi *Sphaerellothecium phaeorrhizae* and *Zwackhiomyces sipmanii* on *Phaeorrhiza sareptana* var. *sphaerocarpa* in Eastern Siberia (Russia) are described as new to science. A key to the known species of *Sphaerellothecium* is presented.

Key words: *Sphaerellothecium*, *Zwackhiomyces,* new species, *Phaeorrhiza,* Siberia, lichenicolous fungi

Introduction

The genus *Phaeorrhiza* has rarely been recognized as hosting lichenicolous fungi. To date, the following species have been reported from it: *Charonectria amabilis* Lowen & D. Hawksw., described from North America (Alberta) on *Phaeorrhiza sareptana* var. *sphaerocarpa* (ROSSMAN et al. 1999); *Lecanographa rinodinae* (Vězda) R. Sant., described from Slovakia on *P. nimbosa* (VĚZDA 1969) and later reported from Austria and Norway (HAFELLNER 1994, SANTESSON et al. 2004); *Arthonia epiphyscia* Nyl., supposed to be confined to species of *Physcia* s. str. (GRUBE & MATZER 1997), has been reported on *P. nimbosa* by ALSTRUP & HAWKSWORTH (1990); *Cercidospora punctillata* (Nyl.) R. Sant. s. l. was found on *P. nimbosa* in Russia on Franz Josef Land (ZHURBENKO & SANTESSON 1996); and *Intralichen lichenum* (Diederich) D. Hawksw. & M.S. Cole was reported from *P. nimbosa* from Greenland (HANSEN 2001).

During lichenological explorations of the Sakha-Yakutiya Republic and the Magadan Region of Russia, the second author collected new species of *Sphaerellothecium* and *Zwackhiomyces* on *Phaeorrhiza sareptana* var. *sphaerocarpa*, and the aim of this paper is to describe both. As many

Sphaerellothecium species have only recently been described, and as no comprehensive key for them exists, a first key to the species of *Sphaerellothecium* is given.

Material and Methods

All specimens examined are deposited in the mycological herbarium of the V. L. Komarov Botanical Institute in St.-Petersburg (LE), and some duplicates in the private collection of P. Diederich. Herbarium specimens were examined and measured under a binocular microscope Leica MZ 7.5 (magnification up to 50×) and photographed using a Nikon Coolpix 4500. Hand-made sections of perithecia were studied in water, 5% KOH, Lugol's reagent (without [I] or with [K/I] pre-treatment with KOH), Congo red or lactophenol cotton blue. Microscopic drawings were prepared using a drawing tube, and photographs of sections were prepared using a Zeiss Photomikroskop III with a Canon PowerShot G5.

The Species

Sphaerellothecium phaeorrhizae Diederich & Zhurb., sp. nov.

> *Sphaerellothecium* species lichenicola insignis mycelio hyalino ad brunneo immerso in hostis thallo, peritheciis partim immersis ad superficialibus 50-100 µm diam., hamathecio paraphysoidibus ramosis et anastomosantibus, ascis 8-sporis 34-48 × 9-12(-15) µm, ascosporis hyalinis 1-septatis levibus 9-11.5 × 4-5(-5.5) µm.

Type: RUSSIA. Eastern Siberia, Sakha-Yakutiya Republic: Moma District, 54 km N-NNW of Tyubelyakh, 65°51' N, 143°01' E, 250 m, right bank of Indigirka River, open slope with steppe-like vegetation over limestone, on *Phaeorrhiza sareptana* var. *sphaerocarpa*, 20. VII. 1992, M. Zhurbenko 92436 [LE 232603 holotype; hb Diederich isotype].

(Figs 1, 3 A–C)

Mycelium immersed in the host thallus and not visible macroscopically, colourless or brownish, usually visible just around the ascomata in microscopical section, short-celled, torulose, 3.5-6 µm thick.

Ascomata perithecioid, partly immersed to almost completely superficial, blackish, subspherical, with a roughened surface caused by external roundish cells, 50-100 µm in diam. *Ascoma wall* laterally dark brown, 10-30 µm thick, basally pale to medium brown, up to 30 µm thick, cells in section roundish to ellipsoid, 6-10 × 3-6 µm. *Hamathecium* of branched and anastomosed interascal paraphysoids (sensu ROUX & TRIEBEL 1994). Centrum I- and K/I-. *Asci* elongate ellipsoid to claviform, wall apically strongly thickened, with a distinct ocular chamber, wall K/I–, epiplasma K/I+ orange to reddish, 8-spored, 34-48 × 9-12(-15) µm. *Ascospores* hyaline, 1-septate, not or slightly constricted at the septum, upper cell slightly broader, each cell with one large guttule, smooth-walled, without a distinct perispore, 9-11.5 × 4-5(-5.5) µm. *Conidiomata* unknown.

Host: *Phaeorrhiza sareptana* var. *sphaerocarpa* (thallus), commensalistic.

Distribution: Known only from the boreal zone of north-eastern Russia.

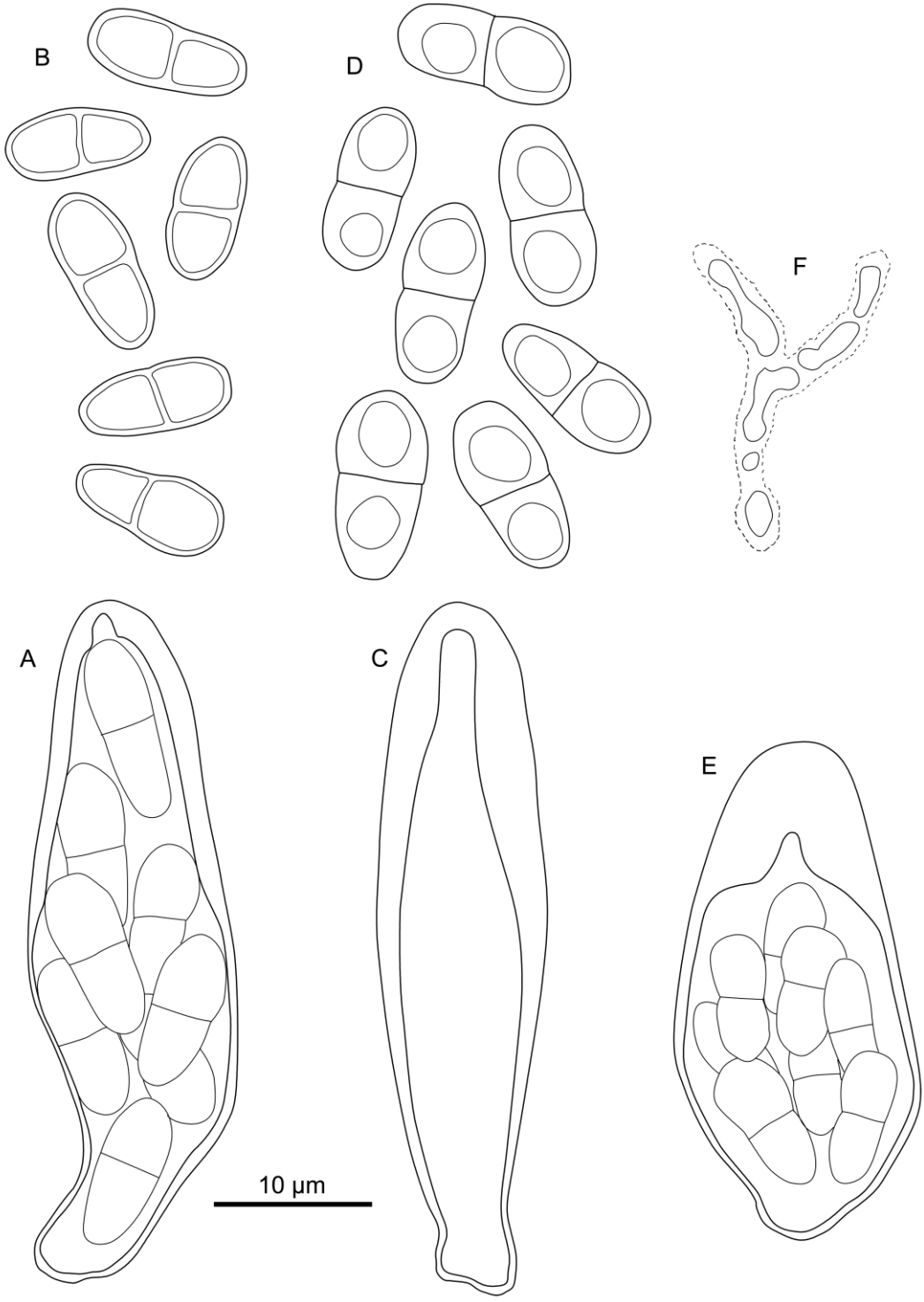

Fig. 1. *Sphaerellothecium phaeorrhizae*. A-B (holotype), ascus and ascospores (in water). C-D (*Zhurbenko* 92434), ascus and ascospores (in Congo red; wall of ascospores not represented). E-F (*Zhurbenko* 92435), ascus and interascal filament (in Lugol after pre-treatment with KOH).

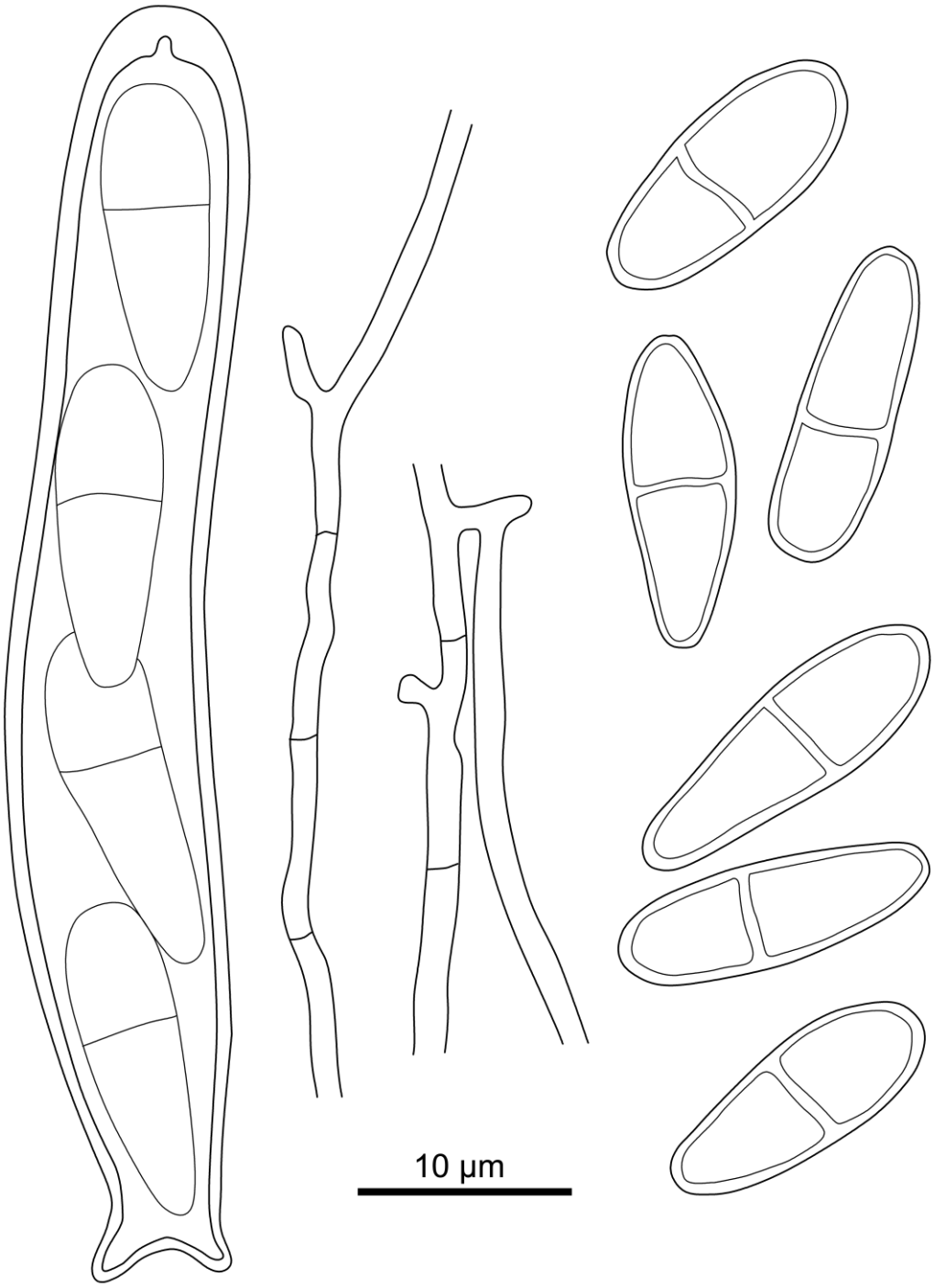

Fig. 2. *Zwackhiomyces sipmanii* (holotype), ascus, paraphyses and ascospores in water.

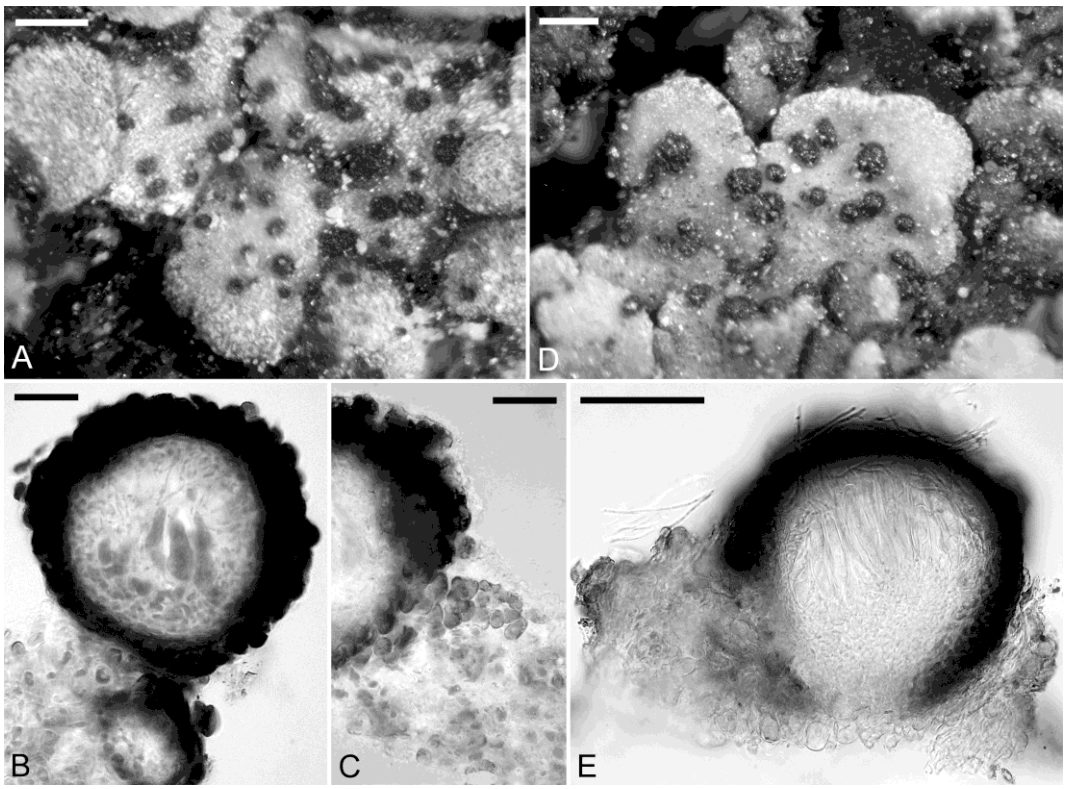

Fig. 3. A-C, *Sphaerellothecium phaeorrhizae* (holotype), A. ascomata on host thallus, B. section through ascoma showing interascal filaments (in lactophenol cotton blue), C. section through ascoma showing brown vegetative hyphae developed around ascoma (in lactophenol cotton blue). D-E, *Zwackhiomyces sipmanii* (holotype), D. ascomata on host thallus, E. section through ascoma (in water). Scale bars: A & D = 200 μm, B-C = 20 μm, E = 50 μm.

Additional specimens examined (all on thallus of *Phaeorrhiza sareptana* var. *sphaerocarpa*): **Russia.** Eastern Siberia, Sakha-Yakutiya Republic**:** Khangalass District, 165 km SW of Yakutsk, between Sinsk and Tit-Ary, right bank of Lena River, 61°04' N, 127°29' E, 150 m, SW exposed slope of calcareous cliffs with steppe-like vegetation, 4. VII. 1992, Zhurbenko 92435 [LE 232651]. Oimyakon District, 36 km N of Ust'-Nera, right bank of Indigirka River, 64°54' N, 143°18' E, 500 m, steep sandy slope of river terrace with open *Larix* forest, 14. VII. 1992, Zhurbenko 92438 [LE 232581].—Moma District, near Tyubelyakh, right bank of Indigirka River, 65°19' N, 143°15' E, 800 m, exposed slope with steppe-like vegetation on a mountain summit, 16. VII. 1992, Zhurbenko 92434, 92298 [LE 232675]. Same locality as type, Zhurbenko 92295 [LE 232715]. Indigirka River between Ust'-Nera and Moma rapids, open river terrace with steppe-like vegetation, 16. VI. 1976, Makarova [LE 232552]; ibid., 27. VI. 1976, Makarova [LE 232605].

Observations: Because of the absence of the dark superficial net of vegetative hyphae, this species could easily be mistaken for a species of *Stigmidium*. However, it clearly differs from *Stigmidium* s. str. by the presence of branched and anastomosed interascal filaments. The only other known *Sphaerellothecium* species developing over the host thallus and lacking the superficial net of

vegetative hyphae, *S. cinerascens* Etayo & Diederich and *S. parietinarium* (Linds.) Hafellner & V. John, are both distinguished by dark brown ascospores.
The new species should also be compared with species of the so-called *Stigmidium psorae* (Anzi) Hafellner group. Species of that group also possess distinct interascal filaments, but they are distinguished by their colourless vegetative hyphae and ascomata that are frequently colourless below (e.g. CALATAYUD & TRIEBEL 2003). The three species recognized by these authors have larger ascomata and larger ascospores than the new *Sphaerellothecium phaeorrhizae*.

***Zwackhiomyces sipmanii* Diederich & Zhurb., sp. nov.**

> *Zwackhiomyces* species lichenicola insignis peritheciis semi-immersis ad superficialibus globosis (50-)85-150 µm diam., ascis 4(-6)-sporis 45-62 × 5-7.5 µm, ascosporis 1-septatis levibus 12.5-16 × 4-5.5 µm.

Type: RUSSIA. Eastern Siberia, Magadan Region: 10 km E of Susuman, 62°50' N, 148°25' E, 700 m, S-exposed slope with steppe-like vegetation by the Ust'-Nera–Magadan road, on *Phaeorrhiza sareptana* var. *sphaerocarpa*, 26. VII. 1992, M. Zhurbenko 92437 [LE 232693 holotype; hb Diederich isotype].

(Figs 2, 3 D–E)

Ascomata perithecioid, half-immersed when young, becoming superficial, black, spherical, (50-)85-150 µm wide; wall olivaceous-brown, K–, 20-25 µm thick, pale brown in the immersed parts, pigment extracellular; centrum not inspersed, K/I–; paraphyses present, linear, branched or anastomosed, 1.5-1.7 µm thick; asci ± cylindrical, K/I–, wall apically thickened, 4(-6)-spored, 45-62 × 5-7.5 µm; ascospores 1(-2)-seriate, hyaline, 1-septate, smooth-walled, 12.5-16 × 4-5.5 µm. *Conidiomata:* unknown.

Host: Phaeorrhiza sareptana var. *sphaerocarpa* (thallus), commensalistic.

Distribution: Known only from the type locality in the boreal zone of north-eastern Russia.

Observations: A key to the species of *Zwackhiomyces* has recently been published by CALATAYUD et al. (2007), who obviously did not have access to HAWKSWORTH & ITURRIAGA (2006) while preparing the key, it becomes necessary to replace the name *Z. cladoniae* (C.W. Dodge) Diederich by *Z. diederichii* D. Hawksw. & Iturr. (couplet 22), and to add to the key the genuine *Z. cladoniae*, a species with particularly large ascomata, 300-425 µm diam., known from *Cladonia cervicornis* subsp. *mawsonii*. When comparing the new species *Z. sipmanii* with the known *Zwackhiomyces* species on crustose lichens (couplets 2-16 in the key), four species must be considered: *Z. martinatianus* (Arnold) Triebel & Grube is distinguished by its sunken, more or less gall-inducing ascomata on *Porpidia*; *Z. lithoiceae* (B. de Lesd.) Hafellner & V. John has larger ascospores, 15-20 × 5-7.5 µm and grows on *Verrucaria nigrescens* s. lat.; *Z. immersae* (Arnold) Grube & Triebel also has larger ascospores, 13.5-20.5 × 5-7 µm and grows on *Clauzadea* species; *Z. argentinae* D. Hawksw. & V. Atienza has slightly

broader ascospores, 14-16 × 5-6 µm, 8-spored asci and grows on *Acarospora*. When comparing *Z. sipmanii* with the species on macrolichens (couplets 17-22 in the key), three species must be checked: *Z. coepulonus* (Norm.) Grube & R. Sant. has distinctly larger ascospores, 15-21 × 5.5-8.5 µm, and grows on *Xanthoria* and *Caloplaca*; *Z. diederichii* (in the key as "*cladoniae*", see above) has immersed to semi-immersed ascomata and distinctly shorter ascospores, 10-12.5 × 3.5-4 µm, and is confined to *Cladonia*; *Z. euplocinus* Hafellner, Grube & R. S. Egan has larger ascomata, 140–170 µm, slightly larger ascospores, 14-17 × 4-6 µm, and is known from *Speerschneidera euploca*.

It is a great pleasure for us to dedicate the new species to our friend Harrie Sipman on the occasion of his 64th birthday.

Key to the known species of *Sphaerellothecium*

The hosts indicated in this key are those of the type specimen and of other reliable reports, and do not include the entire list from which some species have been reported. Unusual hosts normally suggest the presence of an undescribed species.

1 Infected thallus blackish over large areas, sometimes with a visible net of dark hyphae; on *Parmelia* s. str. ..... ***S. parmeliae*** Diederich & Etayo
1' Infected parts of thallus not entirely blackish **2**

2 Vegetative mycelium macroscopically not visible, immersed, colourless or brownish **3**
2' Vegetative mycelium dark brown, macroscopically visible **5**

3 Ascospores hyaline, 9-11.5 × 4-5(-5.5) µm; on *Phaeorrhiza sareptana* var. *sphaerocarpa* ..... ***S. phaeorrhizae*** Diederich & Zhurb.
3' Ascospores dark brown **4**

4 Ascospores 9-11.5 × 3-4 µm; on *Cladonia parasitica* .... ***S. cinerascens*** Etayo & Diederich
4' Ascospores (10.5-)11-13(-14) × (4-)4.5-5.5(-6) µm; on *Xanthoria* ..... ***S. parietinarium*** (Linds.) Hafellner & V. John

5 Ascomata developing in the host apothecia; vegetative hyphae immersed in the hymenium and often in the surrounding areas of the host..... **6**
5' Ascomata developing on the host thallus; vegetative hyphae forming a distinct, more or less superficial net **7**

6 Ascospores 10-13 × 4-5 µm, at first hyaline, then pale to medium brown; conidia 2-3 × 0.5-1 µm; on the disc of the apothecia of *Lecanora bicincta*, *L. cenisia* var. *atrynea*, *L. rupicola* subsp. *subplanata* and *L. swartzii* .... ***S. atryneae*** (Arnold) Cl. Roux & Triebel
6' Ascospores 11.5-15 × 4-5.5 µm, hyaline, rarely becoming pale brownish when mature; conidia 3-4.5 × 0.5-1 µm; on the disc and the thalline margine, sometimes also the thallus of *Lecanora carpinea*, *L. leptyrodes* and *L. subcarpinea* ..... ***S. propinquellum*** (Nyl.) Cl. Roux & Triebel

7 On *Buellia* sp.; ascomata (20-)30-55 µm diam.; asci and ascospores unknown ..... ***S. buelliae*** (C. W. Dodge) D. Hawksw. & Iturr.
7' Not on *Buellia* **8**

8 Ascospores 1-3(-5)-septate **9**
8' Ascospores 1(-3)-septate **10**

9 Ascospores 1-3-septate, hyaline, then dark brown, (12.5-)13.5-17(-22) × (3.5-)5-7(-7.5) µm; ascomata 40-100 µm diam.; on *Ochrolechia*, *Pertusaria* and *Varicellaria* ..... ***S. araneosum*** (Arnold) Zopf
9' Ascospores (1-)3(-5)-septate, hyaline, then often pale olive-brown, (10-)11.5-14.5(-15) × (3.5-)4-5 µm; ascomata 30-60 µm diam.; on *Arthrorhaphis alpina* ..... ***S. soechtingii*** Zhurb. & Alstrup

10 Ascospores 5-6.5 µm broad **11**
10' Ascospores 3-5 µm broad **13**

11 Ascospores hyaline, 8-12 × 5 µm; ascomata 30-60 µm diam.; on *Cladonia* subgen. *Cladina* ..... ***S. cladoniicola*** E. S. Hansen & Alstrup
11' Ascospores (medium to) dark brown **12**

12 Ascospores (9-)9.5-10.5(-12) × (4.5-)5-5.5(-6) µm; asci 19-22 × 13-15 µm; ascomata 40-60(-70) µm diam.; on *Immersaria* and *Lecidea* ..... ***S. abditum*** Triebel
12' Ascospores (10-)11.5-14(-16) × (4.5-)5-6.5(-8) µm; asci 22-28(-33) × 15-19 µm; ascomata (40-)50-70(-80) µm diam.; on *Calvitimela*, *Protoparmelia*, *Rhizocarpon*, *Rhizoplaca* and *Sporastatia* ..... ***S. contextum*** Triebel

13 Ascospores becoming dark brown when mature **14**
13' Ascospores colourless, rarely becoming pale brown **15**

14 Ascospores (6.5-)7.5-8(-8.5) × 3-3.5 µm; asci 16-20 × 8-9 µm; ascomata 25-35(-40) µm diam.; on *Teloschistes* ..... ***S. subtile*** Triebel & Rambold
14' Ascospores 11-13 × 3.5-5 µm; asci 26-30 × 10-14 µm; ascomata 40-60 µm diam.; on *Baeomyces rufus* ..... ***S. conioides*** (Nyl.) Cl. Roux & Diederich

15 Ascomata 60-80 µm diam.; ascospores 9-13 × 3-5 µm; on *Sphaerophorus* .... ***S. minutum*** Hafellner
15' Ascomata 20-60 µm diam.; ascospores similarly sized or smaller **16**

16 Ascospores 8-12 × 5 µm; mycelium composed not only of single, but often of a few parallel, adglutinated hyphae; on *Cladonia* subgen. *Cladina* .... ***S. cladoniicola*** E. S. Hansen & Alstrup
16' Ascospores narrower, 3-4.5 µm broad; mycelium usually composed of single hyphae **17**

17 Ascospores (7-)9-12.5(-14) × (2.5-)3-4.5(-5) µm; on *Cladonia* subgen. *Cladonia* ..... ***S. cladoniae*** (Alstrup & Zhurb.) Hafellner

17' Ascospores 7-10 µm long.....**18**

18 Ascomata 30-45(-60) µm diam.; ascospores 7.7-10 × (2.5-)3-4 µm; asci 17-27 × 9-13 µm; on *Heterodermia*.....***S. gallowayi*** Diederich

18' Ascomata 40-60 µm diam.; ascospores c. 7 × 4 µm; 22-26 × 13-15 µm; on *Acarospora schleicheri*.....***S. gowardii*** Alstrup & M. S. Cole

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