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Additions to the calicioid flora of Japan and Korea, with the descriptions of two new species

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Two new species of calicioid fungi are described, *Phaeocalicium triseptatum* Tibell and *Sphinctrina intermedia* Tibell. While *P. triseptatum* is only known from Hokkaido, Japan, *S. intermedia* is known from Hokkaido and Korea. *Sphinctrina leucopoda* as reported from Korea in the literature is misidentified *S. intermedia*. The genus *Microcalicium* is reported as new to Japan with one species, *M. arenarium*. *Phaeocalicium flabelliforme* is reported as new to Asia (Japan). *Chaenothecopsis savonica* is reported as new to Japan and *Sphinctrina tubaeformis* as new to Hokkaido.

Publications on calicioid lichens and fungi in Japan were summarized by Tibell and Thor (2003), and those from Korea by Thor *et al*. (2005, 2008). In total, 50 species are reported from Japan and 9 from Korea. In 2010, A. Frisch and G. Thor participated in an inventory of the biodiversity in Shiretoko National Park, Hokkaido, Japan. Calicioid lichens and fungi are rare in the area, but two new species of calicioid fungi were collected and are described below. Three additional species, *Chaenothecopsis savonica*, *Microcalicium arenarium* and *Phaeocalicium flabelliforme*, were collected and are reported as new to Japan. The unigeneric Microcaliciaceae is nested within the Ostropomycetidae (Lecanoromycetes) (Prieto *et al*. 2013), while *Phaeocalicium* and *Sphinctrina* belong to the Mycocaliciaceae and Sphinctrinaceae in Mycocaliciales, respectively (Tibell & Wedin 2000, Lumbsch & Huhndorf 2010).

Chaenothecopsis savonica (Räsänen) Tibell

For a morphological description, *see* Tibell (1999). The species is new to Japan but it is widely distributed in cool-temperate and temperate areas of the northern hemisphere (continental Europe, Asia, North America) and it also occurs in Australasia and South America (Tibell 1999).

Specimen examined: **Japan**. Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Mt. Rausu along trail from Iwaobetsu hot-spring hotel (Onsen) to summit, on wood of an old *Quercus crispula* (syn. *Q. mongolica*) in oldgrowth mixed montane forest, alt.

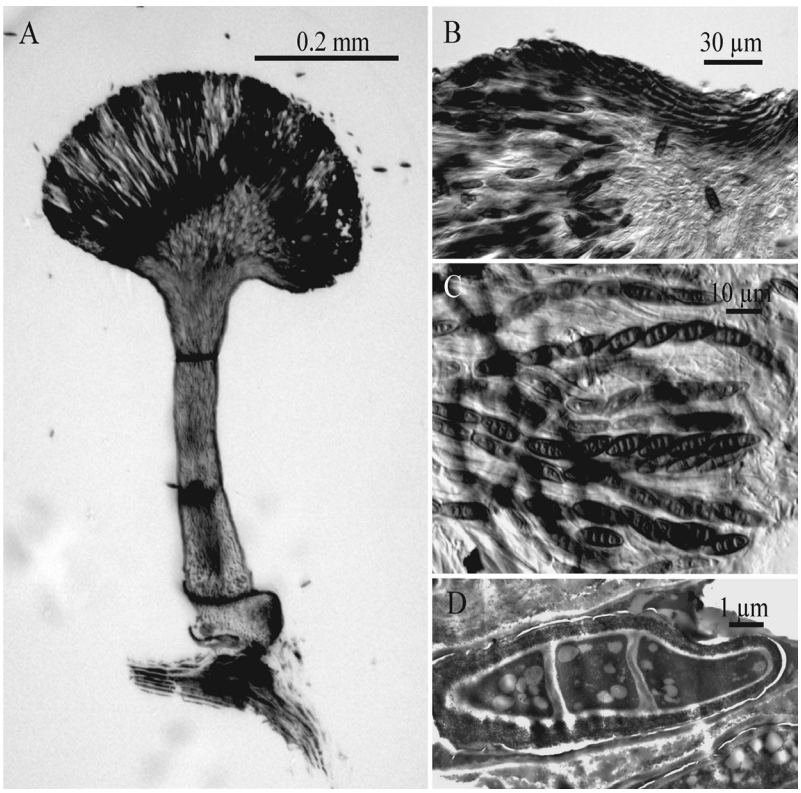

Fig. 1. *Phaeocalicium triseptatum* (from the holotype). — **A**: Longitudinal section of mature apothecium. — **B**: Excipulum consisting of periclinally arranged hyphae. — **C**: 3-septate spores in mature asci. — **D**: TEM picture of a mature spore.

600 m, 44°06.000´N, 145°06.300´E, 10 July 2010 *A. Frisch 10/Jp 140* (UPS).

Microcalicium arenarium (Hampe *ex* A. Massal.) Tibell

For a morphological description, *see* Tibell (1999). The genus is new to Japan. The species is widely distributed in both the northern and southern hemispheres, being known from Europe, Asia, North America, Australasia and southernmost South America (Tibell 1999).

Specimen examined: **Japan**. Hokkaido, Ishikari Prov., Higashikawa-cho, 140 km NE Sapporo, W slope of Mt. Asahidake, along the trail from the ropeway station down to the village Asahidake Onsen, montane forest dominated by *Picea* sp., in cavity at base of *Picea* sp., alt. ca. 1200 m, 43°39.904´N, 142°48.5639´E, 20 July 2010 *G. Thor 25825* (UPS).

Phaeocalicium flabelliforme Tibell

For a morphological description, *see* Tibell (1999). New to Asia. The species was reported previously only from thin *Betula* twigs in Sweden (Tibell 1999), and further also from Norway (Hermansson 2005) and North America (Selva & Tibell 1999). The discovery in Hokkaido considerably expands the known range of this species and also the range of host trees. The Japanese specimens were collected from smooth bark of *Alnus maximowiczii* and *Sorbus* sp.

Specimens examined: **Japan**. Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Shiretoko Peninsula ca. 10 km NE Utoro town, along the trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, oldgrowth subalpine forest dominated by *Betula ermannii*, on *Alnus maximowiczii*, alt. 833 m, 44.09256°N, 145.10961°E, 13 July 2010 *G. Thor 24299* (UPS); oldgrowth subalpine forest dominated by *Betula ermannii*, on *Sorbus* sp., alt. 1000 m, 44.09°N, 145.12°E, 17 July 2010 *G. Thor 25606* (UPS).

Phaeocalicium triseptatum Tibell, *sp. nova* (Fig. 1)

Mycobank accession number: MB 804935.

Saprophyticum vel parasiticum in Betula. Ascomata 0.61–0.85 mm alta, capitulo nigro, stipite pallidiori, olivaceofusco, nitido. Capitulum ascomatorum juvenium obconicum, maturum valde complanatum, 0.28–0.44 mm latum, 0.12–0.18 mm crassum, epruinosum. Epithecium fuscum. Hypothecium obconicum. Excipulum fuscum vel rubrofuscum, 17–23 µm crassum, ubi rubrofuscum K+ rubrum. Stipes 0.06–0.08 mm diametro, K–, hyphis 2–3 µm diametro, periclinaliter ordinatis, paulo intertextis, pallidis constans. Asci anguste cylindrici, 85–104 × 2.5–3.5 µm, sporis uniseriatis ordinatis. Apex asci valde crassuss, ascoplasme horizontaliter abscisso. Sporae semper 3-septatae, fuscae, ellipsoidales, 12–14 × 4–5 µm, per microscopium laeves vel pagina minutissimo verrusosa visae. Septa sporae pallida.

TYPE: Japan. Hokkaido, Kitami Prov., Shari-gun, Sharicho, Shiretoko National Park, NW slope of Shiretoko Peninsula ca. 10 km NE Utoro town, along the trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, oldgrowth subalpine forest dominated by *Betula ermannii* but also with, for example, *Acer tschonoskii*, *Alnus maximowiczii*, *Pinus pumila*, *Prunus nipponica* and *Sorbus* spp., on *Betula ermannii*, alt. 1198 m a.s.l., 44.08406°N, 145.12316°E, 17 July 2010 *G. Thor 25411* (holotype UPS: L280; isotype TNS).

ETYMOLOGY: One of the distinct features of the species is the constantly 3-septate spores.

Thallus saprobic or parasitic on *Betula ermannii*. *Ascomata* 0.61–0.85 mm high, with blackish capitulum and paler, olivaceous brown, shiny stalk. Capitulum of young ascomata obconical, but in mature ascomata strongly flattened and 0.28–0.44 mm wide, and 0.12–0.18 mm thick, epruinose. Epithecium brown, sclerotized, 23–26 µm thick. Hypothecium obconical, ca. 100 µm high, hyaline, consisting of more or less elongated cylindrical cells. Excipulum medium brown or with a reddish tinge, 17–23 µm thick, consisting of periclinally arranged, strongly intertwined, but at base more anticlinally arranged, sclerotized hyphae 2–3 µm diam. Excipulum K– or very weakly intensified red. Stalk 0.06–0.08 mm diam., K–, consisting of periclinally arranged, slightly intertwined pale hyphae, 2–3 µm diam. *Asci* narrowly cylindrical, 85–104 × 2.5–3.5 µm, with uniseriately arranged spores. Ascus apex strongly thickened with the ascus plasma cut off horizontally. *Spores* consistently medium brown, ellipsoidal, 3-septate, 12–14 × 4–5 µm, appearing smooth under light microscope or with a very minutely verrucose surface; spore septa appearing pale.

Phaeocalicium triseptatum is so far known only from *Betula ermannii and Alnus viridis* in Shiretoko National Park, Hokkaido, Japan. It is characterized by the 3-septate spores, the strongly flattened capitula, the pale stalk contrasting against the darker capitulum, the weak K+ reaction of the excipulum, and the occurrence on *Betula*. It was found both on stems and thin twigs (*Thor 25452* & *24620*). When occurring on stems, it was found in lichen-free areas on smooth bark of large *Betula* trees. Thus, lichen-free areas on smooth bark on large *Betula* trees indicated the occurrence of the species. *Betula ermannii* occurs from sea level to the alpine region at ca. 1300 m a.s.l. on the NW slope of Shiretoko Peninsula. However, *P. triseptatum* was only found from ca. 1000 m upwards to 1200 m, and is apparently a subalpine species. In Shiretoko, the only other *Phaeocalicium* found was *P. flabelliforme* (*see* above). However, while *P. triseptatum* was restricted to *B. ermannii*, *P. flabelliforme* was found on *Alnus maximowiczii* and on *Sorbus* sp. (*see* above). An ITS sequence was obtained from the holotype (GenBank KJ865747). It was quite different from two other sequences of *Phaeocalicium* available, *viz*. *P. interruptum* and *P. populneum*.

It is notable that there are a number of species in *Phaeocalicium* occurring on bark and twigs of *Betula* in cool to cool temperate areas of the northern hemisphere. They grow as saprobes or possibly weak parasites and several of them have flattened capitula. Only one *Phaeocalicium* species, *P. compressulum*, has previously been reported from Japan (Tibell & Thor 2003).

Phaeocalicium triseptatum is similar to some other *Phaeocalicium* species, and it might be mistaken for *P. matthewsianum* (Selva & Tibell 1999), another species occurring on *Betula* in which the spores at maturity are 3-septate, but differing in ascoma morphology and spore structure and ontogeny. The ascomata are larger in *P. triseptatum*, and the excipulum in *P. triseptatum* is K– or very pale reddish, whereas there is a strong K+ reaction in *P. matthewsianum*. In *P. matthewsianum* the spores remain non-septate

for a long time and the two secondary septa are formed very late or not at all, and their contrast is low so that they are actually easily overlooked (figs. 30–35 in Selva & Tibell 1999). In *P. triseptatum* all three septa are formed early during spore development and are of equal contrast and quite striking in the mature spore (Fig. 1). *Phaeocalicium triseptatum* differs from *P. flabelliforme* (1-septate or rarely 2-septate spores; asci 76–96 × 4.5–5.5 μm; Tibell 1999), in the consistently 3-septate spores and longer asci. With its flattened ascomata it is also similar to *P. compressulum*, which, however, differs in having smaller ascomata (0.25–0.34 mm high), shorter asci (61–74 μm long), and shorter spores (9.5–11.0 μm long) which are non-septate (Tibell & Thor 2003). In addition, *P. compressulum* has a distinctive ornamentation of the spore wall observable under the light microscope (Tibell & Thor 2003). *Phaeocalicium interruptum*, reported from Finland, Norway and Sweden, differs in having campanulate, non-flattened capitula and usually non-septate or 1-septate spores (Tibell 1999). *Phaeocalicium betulinum* also has strongly flattened capitula, but differs in having non-septate spores (Tibell 1999).

Additional specimens examined (paratypes): **Japan**. Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Shiretoko Peninsula ca. 10 km NE Utoro town, along the trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, oldgrowth subalpine forest dominated by *Betula ermannii*, on *B. ermannii*, alt. 1061 m, 44.08839°N, 145.11891°E, 14 July 2010 *G. Thor 24620* (UPS); oldgrowth subalpine forest dominated by *Betula ermannii*, on *B. ermannii*, alt. 1220 m, 44.08376°N, 145.12332°E, 17 July 2010 *G. Thor 25415* (UPS); on *B. ermannii*, alt. 1220 m, 44.08376°N, 145.12332°E, 17 July 2010 *G. Thor 25452* (UPS); on *B. ermannii*, alt. 1238 m, 44.08353°N, 145.12321°E, 17 July 2010 *G. Thor 25464* (UPS); on *B. ermannii*, alt. 1238 m, 44.08353°N, 145.12321°E, 17 July 2010 *G. Thor 25475* (UPS); on twigs of *Alnus viridis* in subalpine forest, alt. 750–850 m, 44°05.400–800´N, 145°06.400–800´E, 14 July 2010 *Frisch 10/Jp162* (UPS).

Sphinctrina intermedia Tibell, *sp. nova* (Fig. 2)

Mycobank accession number: MB 804936.

Ascomata 0.2–0.3 mm alta, in thallo ascomatisque Pertusariae evolvantia; primo gongylodia, dein distincte stipitatia, nigra. Capitulum 0.11–0.15 mm diametro, sphaericum, regulare, laeve, coracinum. Excipulum porphyreum, sclerotricum. Stipes niger, partes rufi ascomatorum K+ rubri. Asci 37–43 × 3.0–4.5 μm. Sporae fuscae, globosae, 4.5–5.5 μm diametro, ad cubiformes, 5.0–5.5 × 5.0–7.5 μm, ornamento minutissimo plicarum rimarumve irregularium per microscopium visibilibus. Tunica sporae distincta.

Type: Japan. Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Shiretoko Peninsula ca. 7 km NE Utoro village, N of the narrow road to Iwaobetsu hot-spring hotel (Onsen). Oldgrowth lowland forest with, for example, *Abies sachalinensis*, *Acer mono*, *Betula ermannii*, *Cercidiphyllum japonicum*, *Fraxinus mandshurica*, *Kalopanax pictus*, *Magnolia kobus*, *M. obovata*, *Padus ssiori*, *Picea glehnii*, *Quercus crispula* (syn. *Q. mongolica*) and *Tilia maximowicziana*. On *Padus ssiori*, alt. 74 m a.s.l., 44.09991°N, 145.05798°E, 18 July 2010 *G. Thor 25696* (holotype UPS: L281; isotype TNS).

Etymology: This species is intermediate in many respects between *Sphinctrina leucopoda* and *S. turbinata*.

Ascomata 0.2–0.3 mm high, first knob-like, later with a distinct stalk, scattered over thallus and ascomata of *Pertusaria* spp. Apothecia 1.7–2.6 times as long as width of capitulum, black. Capitulum 0.11–0.15 mm diam., spherical, regular and smooth, shining black. Excipulum in section brown, with a reddish tinge, sclerotized, consisting of 4–6 layers of elongated to irregular cells, 3–4 μm diam. Stalk black, consisting of largely periclinally arranged cells with strongly gelatinized walls, 3–4 μm diam. Reddish parts of the ascoma K+ intensified red. *Asci* 37–43 × 3.0–4.5 μm. *Spores* dark brown, globose, simple, 4.5–5.5 μm diam. to cuboid, 5.0–5.5 × 5.0–7.5 μm, with a very minute ornamentation of irregular folds or cracks visible under light microscope. Spore coat thick and distinct in water-mounts of semi-mature spores.

The species is lichenicolous on both atranorin and usnic acid producing fertile *Pertusaria* spp. It has so far not been found on sorediate or isidiate *Pertusaria* species. *Sphinctrina intermedia* is in many respects intermediate between *S. leucopoda* and *S. turbinata*. It differs from *S. leucopoda* in having black stalks and a red, K+ intensified pigment in the excipulum, and from *S. turbinata* in having distinctly stalked

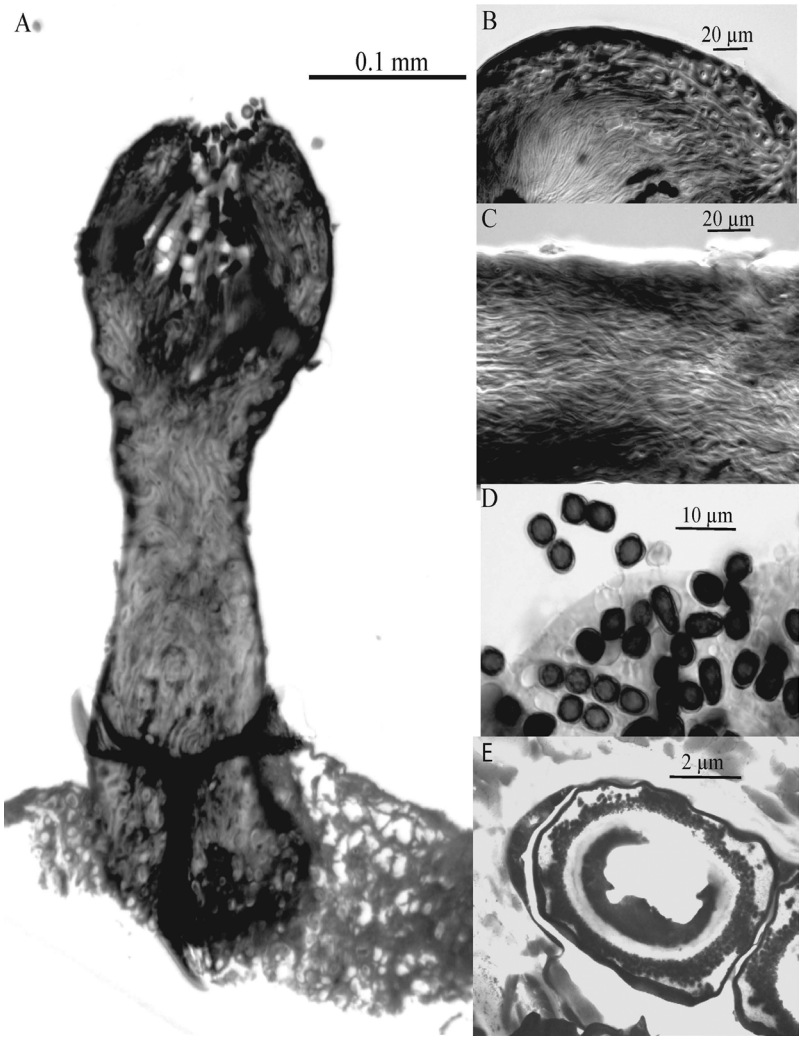

Fig. 2. *Sphinctrina intermedia* (from the holotype). — **A**: Longitudinal section of mature apothecium. — **B**: Excipulum consisting of intertwined hyphae. — **C**: Longitudinal section of the stalk. — **D**: LM picture of spores. Note the distinctive gelatinous coat surrounding the spores, and their weak ornamentation. — **E**: TEM picture of a mature spore. Note the uneven melanization of the spore wall and its uneven outer surface.

ascomata as well as shorter asci and smaller spores (37–43 × 3.0–4.5 µm and 5.0–5.5 × 5–7.5 µm in *S. intermedia* versus 40–51 × 5–7 µm and 5.0–7.0 × 4.5–7.0 µm in *S. turbinata*). *Sphinctrina intermedia* is widely distributed in Shiretoko, being found at altitudes from 50 m to 600 m a.s.l. Specimens earlier reported as *S. leucopoda* and *S. turbinata*, at least from Asia, should be re-examined since they may belong to *S. intermedia*. Two specimens in herbarium UPS, *Thor 14214* (as *S. turbinata* in Tibell & Thor 2003) and *Thor 20555* (as *S. leucopoda* in Thor *et al*. 2008), were re-checked and are indeed *S. intermedia*. As *Thor 20555* is the only collection of *S. leucopoda* reported from Korea, this species should be replaced by *S. intermedia* in the check-lists of Korean lichens. The only other *Sphinctrina* found in Shiretoko is *S. tubaeformis* (new to Hokkaido), but this species is easily distinguished by the ellipsoidal spores with pointed ends. *S. intermedia*, *S. leucopoda* and *S. turbinata* all have spherical to subspherical spores. An ITS (GenBank KJ871615) sequence was obtained from the holotype. It was distinctly different from the ITS sequences of both *S. leucopoda* and *S. turbinata*.

Additional specimens examined of *S. intermedia* (paratypes): **Korea**. Gangwon-do Prov.: Yangyang-gun, Sermyun, Osaeck-ri, Sorak-san National Park, the southern part of the massif Sorak Mts, the south slope of Mt. Dachong, along the trail from the shelter ca. 500 m WNW the top of Mt. Dachong to the village at Hangyeryong Pass, ca.

3–5 km SW the shelter, on exposed dead *Betula* in deciduous forest with scattered coniferous trees and siliceous rocky outcrops, alt. 1400–1350 m a.s.l., 20 October 2006 *G. Thor 20555* (UPS). **Japan**. Hokkaido, Kitami Prov., Esashi-gun, Hamatombetsu-cho, 9 km S of Hamatombetsu town, just S of narrow gravel road, open mixed deciduous forest with undergrowth of *Sasa* near the stream Usota-gawa, on *Quercus crispula* (syn. *Q. mongolica*), 4 June 1995 *G. Thor 14214* (UPS); Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Shiretoko Peninsula ca. 10 km NE Utoro town, along the trail from Iwaobetsu hot-spring hotel (Onsen) to Mt. Rausu-dake, oldgrowth montane forest dominated by *Abies sachalinensis* and *Quercus crispula* (syn. *Q. mongolica*), on *A. sachalinensis*, alt. 395 m a.s.l., 44.1065°N, 145.09207°E, 10 July 2010 *G. Thor 23675* & *A. Frisch* (UPS); on *Quercus crispula* in oldgrowth mixed montane forest, alt. 600 m a.s.l., 44°06.000´N, 145°06.300´E, 10 July 2010 *Frisch 10/Jp136, 138* & *139* (UPS); oldgrowth montane forest dominated by *Quercus crispula*, on *Q. crispula*, alt. 573 m a.s.l., 44.10328°N, 145.09908°E, 14 July 2010 *Frisch 10/Jp 752b* (UPS); oldgrowth montane forest dominated by *Quercus crispula*, on *Q. crispula*, alt. 573 m a.s.l., 44.10328°N, 145.09908°E, 2010 *Frisch 10/Jp 766* (UPS); ca. 7 km NE Utoro town, S of the narrow road to Iwaobetsu hot-spring hotel (Onsen), oldgrowth lowland forest with e.g. *Abies sachalinensis*, *Acer mono*, *Betula ermannii*, *Cercidiphyllum japonicum*, *Fraxinus mandschurica*, *Kalopanax pictus*, *Magnolia kobus*, *M. obovata*, *Padus ssiori*, *Picea glehnii*, *Quercus crispula*, and *Tilia maximowicziana*, on *Abies sachalinensis*, alt. 79 m a.s.l., 44.10122°N, 145.06217°E, 16 July 2010 *A. Frisch 10/Jp 896b* (UPS); on *Tilia maximowicziana*, alt. 74 m a.s.l., 44.09991°N, 145.0572°E, 18 July 2010 *A. Frisch 10/Jp 1125b* (UPS).

Additional specimens examined of *S. tubaeformis*. **Japan**. Hokkaido, Kitami Prov., Shari-gun, Shari-cho, Shiretoko National Park, NW slope of Shiretoko Peninsula ca. 7 km NE Utoro town, N of the narrow road to Iwaobetsu hot-spring hotel (Onsen), oldgrowth lowland forest dominated by *Abies sachalinensis* and *Quercus crispula*, on *Acer mono*, alt. 249 m a.s.l., 44.11123°N, 145.08503°E, 15 July 2010 *G. Thor 24976* (UPS); oldgrowth lowland forest dominated by *Abies sachalinensis* and *Quercus crispula*, on *A. sachalinensis*, alt. 227 m a.s.l., 44.10974°N, 145.08220°E, 11 July 2010 *A. Frisch 10/Jp 326b* (UPS).

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