

## Contributions to the genus *Synarthonia* (lichenized Ascomycota, Arthoniaceae)

Siljo JOSEPH and Gopal Prasad SINHA

**Abstract:** The type specimens of *Synarthonia bicolor* and *S. stigmatidialis* were examined, leading the authors to revise their descriptions as well as the generic description. Also, two new species of *Synarthonia*, viz. *S. psoromica* and *S. sikkimensis* are described from India. *Synarthonia psoromica*, collected from the Nilgiri Hills of Tamil Nadu, is characterized by immersed synascomata and the presence of psoromic acid. *Synarthonia sikkimensis*, collected from Sikkim-Himalaya, is characterized by the sorediate thallus with a rhizomorph-like prothallus. These distinguishing characters are observed for the first time in *Synarthonia*. After considering the protologue of the recently described *S. sarcographoides*, a comprehensive account of this genus is made. In addition, a world key to all known species of *Synarthonia* is provided.

**Key words:** Arthoniales, India, lichen, new species, taxonomy

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### Introduction

The genus *Synarthonia* Müll. Arg. is characterized by solitary ascomata, becoming mono- to pluri-carpocentral synascomata embedded in a slightly elevated to immersed pseudostroma, with a thin white thalline margin and *Arthonia*-type asci with transversely septate (macrocephalic) or muriform ascospores. The genus, represented by only two species (Müller Argoviensis 1891, 1895) viz. *S. bicolor* Müll. Arg. and *S. stigmatidialis* Müll. Arg., remained unfamiliar to most lichenologists until the discovery of an allied new genus *Synarthothelium* (Sparrius 2009). Recently, Menezes *et al.* (2013) added another species, *S. sarcographoides* Aptroot *et al.* from Brazil. Out of the three species, only *S. bicolor* is known from India (Jagadeesh Ram & Sinha 2009).

During the course of studies on specimens of the family *Arthoniaceae*, types of *S. bicolor* and *S. stigmatidialis* were examined. Study of the types and protologue of *S. sarcographoides* Aptroot *et al.* revealed some additional information about the genus. These studies

also led to the discovery of two new species, *S. psoromica* and *S. sikkimensis* from India. The taxonomic significance of these findings is discussed here.

### Material and Methods

The specimens examined are housed in BSA and G herbaria. Morphological details were examined using a Nikon SMZ 1500 stereomicroscope. Anatomical details were studied using a Nikon Eclipse 50i compound microscope. Hand-cut sections of thalli and ascomata mounted in distilled water, KOH solution (K), and lactophenol cotton blue (LPCB) were studied. The amyloid reactions were tested in Lugol's iodine solution without (I) or with pretreatment with KOH (KI). All measurements were made on material mounted in distilled water and drawings were made with the help of an Ernst Leitz Wetzlar (Germany) microscope (in  $\times 10$ ) with sections mounted in distilled water. The length, breadth, and length/breadth ratio ( $l/b$ ) of ascospores are given as:  $(\text{min})-(\bar{x}-SD)-(\bar{x}+SD)$  ( $-\text{max}$ ), where 'min' and 'max' are the extreme values,  $\bar{x}$  the arithmetic mean, and SD the corresponding standard deviation, followed by the number of measurements ( $n$ ). The chemistry was studied by spot tests and thin-layer chromatography following Orange *et al.* (2001).

### Taxonomic Treatment

#### *Synarthonia* Müll. Arg.

*Bull. Soc. R. Bot. Belg.* 30: 85 (1891).

Type species: *Synarthonia bicolor* Müll. Arg.

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*Thallus* corticolous, crustose, endophloeodal to epiphloeodal, smooth, cracked to rimose-like, smooth to verruculose, sorediate or esorediate, ecarticate. *Prothallus* white fibrous-like or rhizomorph-like, pale brownish to dark brown when in contact with other lichen species. *Photobiont* trentepohlioid, in short chains or single-celled, cells globose to ellipsoid.

*Ascomata* solitary when young, later becoming mono- to pluri-carpocentral synascomata embedded in a slightly elevated to immersed pseudostroma, with a thin white thalline margin, without algal cells; *disc* thinly white or greyish pruinose to epruinose, pale brown to dark brown when pruina removed. *Excipulum* hyaline to pale brownish or straw-coloured, composed of brown pigmented or hyaline conglutinated hyphae, non-carbonized. *Epitecium* pale brownish, formed by densely branched and anastomosing tips of paraphysoids, with some greyish gelatinous material and hyaline crystals. *Hymenium* hyaline, not inspersed, rarely inspersed with some hyaline granular crystals. *Paraphysoids* branched and anastomosing, apices thickened, with or without brown pigment. *Hypothecium* hyaline to pale brownish. *Asci* 8-spored, *Arthonia*-type, without KI+ blue ring structures. *Ascospores* hyaline or brownish, transversely septate (macrocephalic) or muriform, with or without thin epispore.

*Pycnidia* not seen.

*Chemistry.* Including psoromic acid and lichexanthone.

*Notes.* The ascomata of *Synarthonia* are solitary when young, with a well-developed white thalline margin especially in *S. bicolor*, or poorly developed to inconspicuous white thalline margin in all other species examined. Ascomata are later grouped to form mono-carpocentral synascomata, as observed in *S. bicolor* and the newly described *S. sikkimensis*. Finally, they become pluri-carpocentral synascomata, appearing as ascomata developed in a pseudostroma. The type of *S. bicolor* (c. 1 cm<sup>2</sup>), with only a few ascomata, has mono-carpocentral

synascomata. Other specimens of *S. bicolor* examined have distinct solitary to mono-carpocentral ascomata in the peripheral part of the thallus, turning into pluri-carpocentral synascomata in the central part.

*Synarthothelium* is another genus having mono- to pluri-carpocentral synascomata with a thalline margin similar to *Synarthonia*, but with *Arthothelium*-type asci and ascospores more than 40 µm long. *Synarthonia* superficially resembles some species of *Synnesia*, due to its synascomata and thinly white pruinose discs, but can be easily distinguished by its non-carbonized hypothecium, *Arthonia*-type asci and macrocephalic, transversely septate or muriform ascospores.

Study of the protologue of the recently amended genus *Reichlingia* Diederich & Scheid (Frisch *et al.* 2014), where ascomata are divided and individual hymenia separated by deep or incomplete fissures, and ascomata are densely covered by coarse white pruina, shows its morphological similarity with *Synarthonia*. In *Synarthonia* there are also some deep fissures separating individual ascomata in synascomata, with the fissures sometimes crossing the level of the hypothecium (Fig. 1B & F). The drawing by Müller Argoviensis of a cross-section of the ascomata of *S. stigmatidialis* associated with the holotype shows a fissure separating the individual ascomata (Fig. 3B). We have not seen any type specimens of *Reichlingia* species. Further studies may show that *Reichlingia* may be a synonym of *Synarthonia*.

### ***Synarthonia bicolor* Müll. Arg.**

*Bull. Soc. R. Bot. Belg.* 30: 86 (1891); type: Costa Rica, San José, 1890, *Pittier* 5292 (G00110644—holotype!).

(Figs 1A & B, 2A & B; 3A, C & D)

*Thallus* corticolous, crustose, white to whitish grey, some areas yellowish to brownish (in type), smooth, 50–80 µm thick; calcium oxalate crystals absent. *Border line* dark brown, c. 0.2 mm wide. *Algal cells* 8–15 × 6–10 µm.

*Ascomata* solitary when young, with a well-developed white thalline margin lacking algal

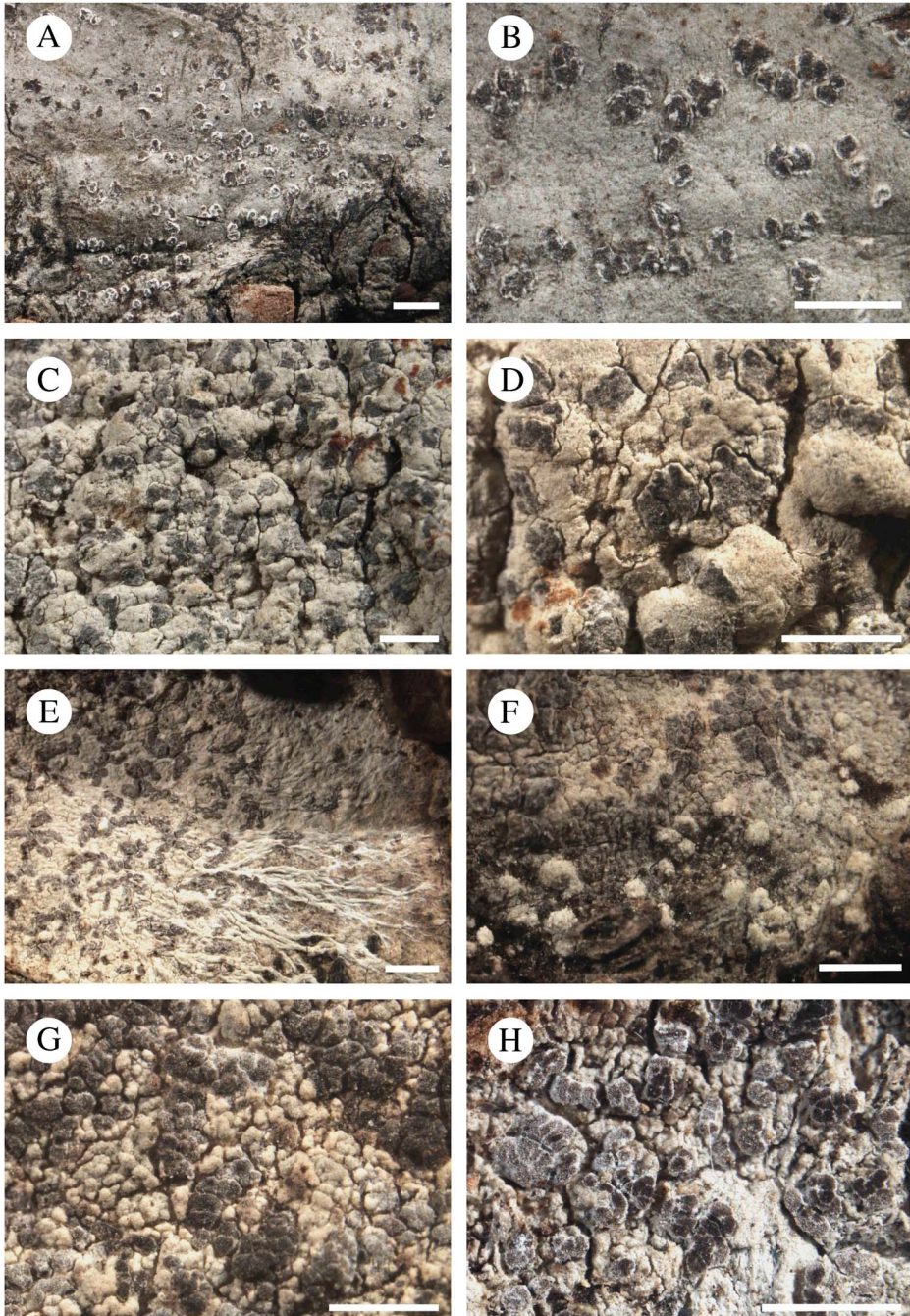


FIG. 1. A & B, habits of *Synarthonia bicolor* (Jagadeesh 1016A); C & D, habits of *S. psoromica* (holotype); E–G, *S. sikkimensis* (holotype); E, rhizomorph-like prothallus; F, thallus with marginal soredia; G, centre of thallus. H, habit of *S. stigmatidialis* (holotype). Scales: A–H = 2 mm. In colour online.



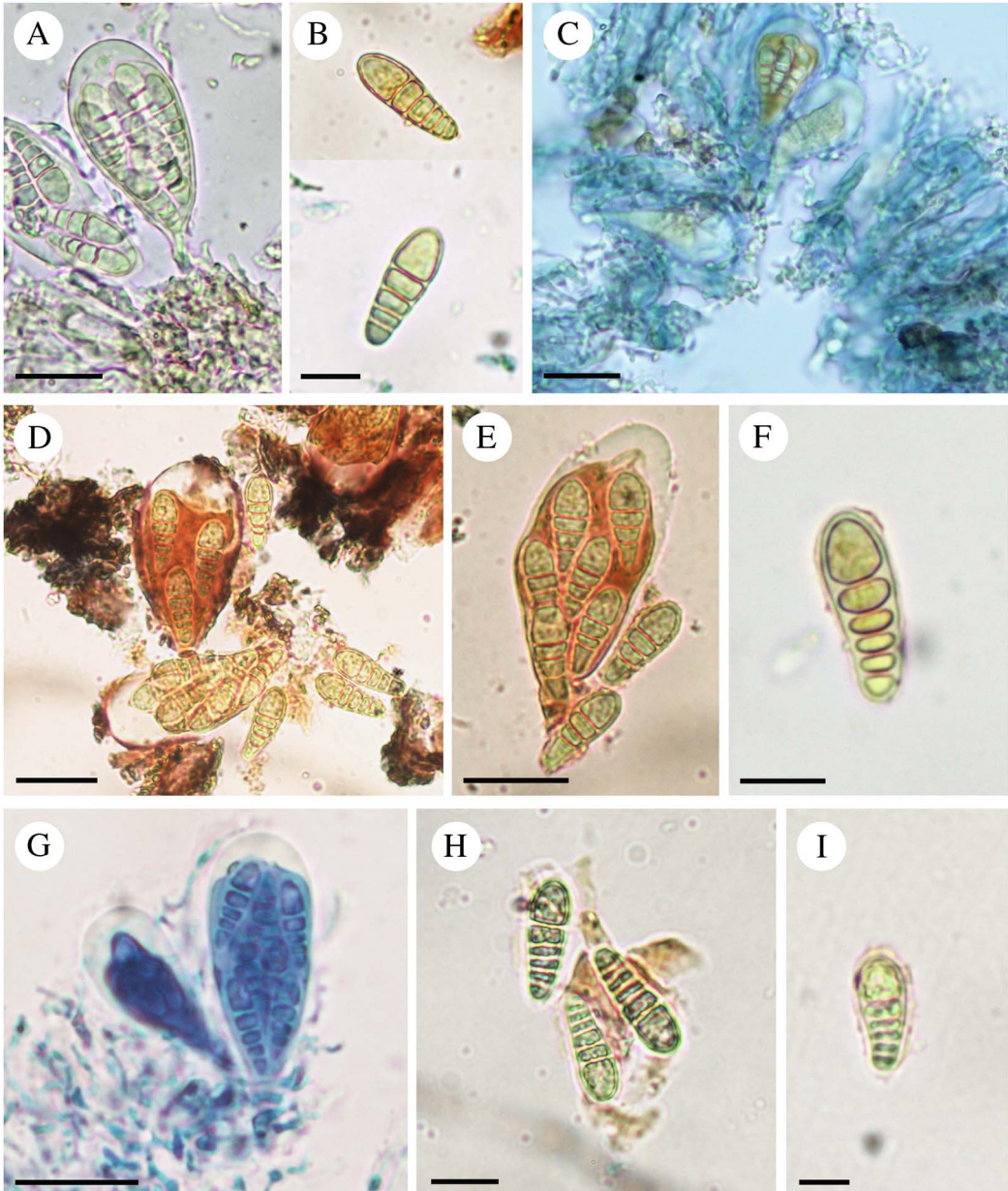


FIG. 2. A & B, *Synarthonia bicolor*; A, ascus (Jagadeesh 754B); B, ascospores (holotype). C, asci and paraphyses of *S. psoromica* (holotype); D–F, *S. sikkimensis* (holotype); D, asci; E, ascus with 3-septate ascospores; F, an ascospore with thin episporium. G–I, *S. stigmatidialis* (holotype); G, asci; H, ascospores; I, an ascospore with thin episporium. A, in water; B, D–F, H & I, in Lugol's iodine solution; C, in KI; G, in LPCB. Scales: A, C, D, E & G = 20  $\mu\text{m}$ ; B, F, H & I = 10  $\mu\text{m}$ . In colour online.

cells, turning into mono-carpocentral synascomata and finally becoming pluri-carpocentral synascomata forming a pseudostromatic

structure, with a hardly visible white thalline margin, individual ascumata irregular to lirellate or rounded; disc pale brownish to

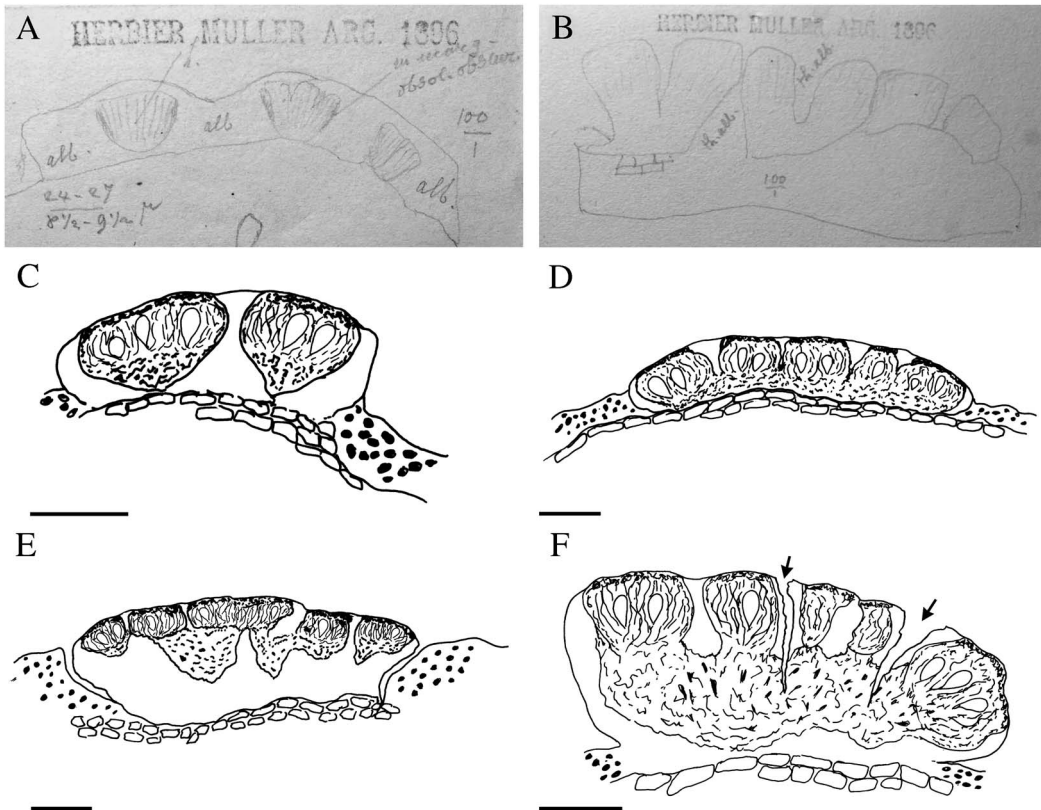


FIG. 3. A & B, drawings of cross-section of synascomata by Müller Argoviensis associated with holotype; A, *Synarthonia bicolor*; B, *S. stigmatidialis*. C & D, *S. bicolor* (Jagadeesh 1016A); C, section showing monocarpocentral synascomata; D, section showing pluricarpocentral synascomata. E, synascomata cross-section of *S. psoromica* (holotype); F, synascomata cross-section of *S. sikkimensis* (holotype), arrow showing deep fissures separating individual ascomata. Scales: C–F = 100  $\mu$ m.

brownish, epruinose or rarely white pruinose. *Excipulum* hyaline to pale brownish, 10–15  $\mu$ m thick, K–. *Epitecium* brownish to somewhat greyish, with some gelatinous material and hyaline crystals, 10–25  $\mu$ m thick, K+ olivaceous. *Hymenium* hyaline, clear, rarely with some minute crystals, 35–80  $\mu$ m high, I+ directly red, KI+ blue. *Paraphysoids* richly branched and anastomosing up to the tip, 1.0–1.5  $\mu$ m wide; apices slightly thickened, 2.0–2.5  $\mu$ m wide, brown pigmented. *Hypothecium* hyaline to pale yellowish, 18–44  $\mu$ m thick, K–, I+ red, KI+ blue. *Asci* 8-spored, *Arthomia*-type, 43–72  $\times$  18–27  $\mu$ m. *Ascospores* hyaline, pale brownish at maturity, old spores  $\pm$  warty and with shrivelled surface, (3–)4–5-septate,

macrocephalic, (17.2–)20.0–24.0(–26.8)  $\times$  (5.0–)7.0–8.5(–9.2)  $\mu$ m ( $n = 50$ ),  $l/b = (2.4–)2.6–3.0(–3.5)$   $\mu$ m, epispore not seen.

*Chemistry*. Thallus K–, C–, P–, UV+ yellow. TLC: lichexanthone present.

*Notes*. The ascomata of *S. bicolor* are mainly epruinose, especially in the type specimen, and rarely with some sparse minute hyaline crystals in the hymenium. The width of ascospores in the protologue is 8.5–9.5  $\mu$ m, according to Sparrius (2009) it is 4–5  $\mu$ m, whilst the present study shows the width to be (5.0–)7.0–8.5(–9.2)  $\mu$ m. It is the only species with a UV+ yellow thallus and lichexanthone as a secondary metabolite.

*Specimens examined.* **India:** West Bengal: Sundarbans Biosphere Reserve, on *Excoecaria agallocha* L., 2004, Jagadeesh 754B (BSA); Haldibari, on *Excoecaria agallocha* L., 2004, Jagadeesh 957 (BSA); Maya dwip, Sundarbans National Park, on *Excoecaria agallocha* L., 2004, Jagadeesh 1016A (BSA).

**Synarthonia psoromica** S. Joseph & G. P. Sinha sp. nov.

Mycobank No.: MB811393

*Synarthonia psoromica* is characterized by immersed synascomata, 3-septate ascospores and a thallus with psoromic acid as a secondary metabolite.

Type: India, Tamil Nadu, Nilgiris, Armbi Forest, on bark of *Rapanea wightiana* (Wall. ex A. DC.) Mez, 11°25'09.5"N, 76°41'13.2"E, 2410 m, 6 December 2012, S. Joseph 8140 (BSA—holotype & isotype).

(Figs 1C & D, 2C & 3E)

*Thallus* corticolous, rimose in appearance, whitish, c. 100 µm thick; calcium oxalate crystals absent. *Prothallus* pale brownish, fibrous-like. *Algal cells* 11–16 × 9–14 µm.

*Ascomata* grouped in a slightly immersed pseudostroma, pluri-carpocentral synascomata, usually separated from the thallus by a narrow slit, with an inconspicuous to thin thalline margin, individual ascomata rounded to slightly elongated; *disc* thinly white pruinose. *Excipulum* hyaline to pale brownish, 10–20 µm thick, K– or K+ slightly olivaceous. *Epithecium* pale brownish, 13–20 µm thick, with some hyaline to pale brownish crystals, K+ olivaceous. *Hymenium* hyaline, not inspersed, 40–70 µm high, I+ red, KI+ pale blue. *Paraphysoids* richly branched and anastomosing up to apices, 1.0–1.8 µm wide, apices slightly thickened, 2.0–2.5 µm wide, not pigmented. *Hypothecium* hyaline to pale yellowish, with some brownish hyphal inclusions, 15–60 µm thick, I+ blue, KI+ deep blue. *Asci* 8-spored, *Arthonia*-type, 34–50 × 15–20 µm. *Ascospores* hyaline, brownish at maturity, (2–)3-septate, (12.5–)13.0–14.7 (–15.8) × (4.0–)4.4–5.2 (–5.5) µm ( $n = 30$ ), l/b = (2.4–)2.6–3.0 (–3.4) µm, macrocephalic, epispore not seen.

*Chemistry.* Thallus K–, C–, P+ yellow, UV–. TLC: psoromic acid present.

*Notes.* *Synarthonia psoromica* is easily distinguished from other known species by its synascomata embedded in a slightly immersed pseudostroma, an I+ red hymenium, smaller and less septate (2–3-septate) ascospores and the presence of psoromic acid.

**Synarthonia sarcographoides**  
*Aptroot et al.*

In Menezes *et al.*, *Lichenologist* 45: 616 (2013); type: not seen.

The species recently described from north-east Brazil (Menezes *et al.* 2013) can be distinguished from other *Synarthonia* species by its brown, broadly ellipsoid, 7 × 1–2-septate, muriform ascospores, 20–22 × 11.0–12.5 µm.

**Synarthonia sikkimensis** S. Joseph & G. P. Sinha sp. nov.

Mycobank No.: MB811394

Similar to *S. stigmatidialis* but differs by the sorediate thallus, rhizomorph-like prothallus and larger ascospores [(17.0–)19.0–23.0 (–25.7) × (5.5–)6.5–7.5 (–8.6) µm].

Type: India, Sikkim, Lachung-Dombang, near Yakche, bridge area, 27°43'35.5"N, 88°45'17.9"E, 3040 m, 20 March 2012, G. P. Sinha & S. Joseph 7192 (BSA—holotype).

(Figs 1E–G, 2D–F, 3F)

*Thallus* corticolous, crustose, rimose-like, smooth to verrucose, 100–180 µm thick, centrally with some pustule-like structures, becoming sorediate at margins; calcium oxalate crystals absent. *Prothallus* rhizomorph-like, pale brownish when in contact with other lichens. *Algal cells* 10–17 × 7–14 µm.

*Ascomata* solitary along thallus margin, elongated to lirellate, centrally grouped in slightly elevated pseudostroma, pluri-carpocentral synascomata, with a thin white margin, individual ascomata rounded to slightly elongated; *disc* thinly white pruinose. *Epithecium* pale brownish, 10–20 µm thick,

K+ slightly greenish. *Hymenium* hyaline, not interspersed, 50–80 µm high, I+ blue turning red or I+ red with blue streaks, KI+ blue. *Paraphysoids* richly branched and anastomosing, 0.8–1.5 µm wide, with more branching network at the epithecium, apices thickened, 2.0–2.8 µm wide, brown pigmented. *Hypothecium* hyaline to pale brownish, with some brownish hyphal inclusions, 20–40 µm thick, K+ greenish, I+ blue turning red or I+ red with blue streaks, KI+ blue. *Asci* 8-spored, *Arthonia*-type, 45–55 × 16–25 µm. *Ascospores* hyaline, brown granular and warty at maturity, 3–5-septate, macrocephalic, (17.0–)19.0–23.0(–25.7) × (5.5–)6.5–7.5(–8.6) µm ( $n = 50$ ),  $l/b = (2.5–)2.7–3.3(–3.5)$  µm, rarely with thin episporium, 0.4–0.6 µm.

**Chemistry.** Thallus K–, C–, P–, UV–. TLC: no substances detected.

**Notes.** This is the only known species of *Synarthonia* having a sorediate thallus. It has small pustules usually located in the central part of the thallus which turn into marginal soredia. *Synarthonia sikkimensis* is close to *S. stigmatidialis* but has soredia, a well-developed rhizomorph-like prothallus and larger ascospores.

### ***Synarthonia stigmatidialis* Müll. Arg.**

*Hedwigia* 34: 145 (1895); type: Mexico, San Luis Potosí, 1890, *f. M. Eckfeldt* 245 (G00110645—holotype!).

(Figs: 1H; 2G–I; 3B)

*Thallus* corticolous, rimose, whitish. *Prothallus* fibrous-like. *Algal cells* 9–13 × 8–11 µm.

*Ascomata* grouped in pseudostroma, pluricarpocentral synascomata, with an inconspicuous to thin white margin, individual ascomata rounded to short lirellate; *disc* thinly white pruinose. *Excipulum* poorly developed, hyaline to pale brownish, 7–15 µm thick, K– or K+ slightly olivaceous. *Epithecium* greyish to brownish, 13–20 µm thick. *Hymenium* hyaline, not interspersed, 40–70 µm high, I+ blue, KI+ deep blue. *Paraphysoids* richly branched and anastomosing, 0.7–1.7 µm thick, apices thickened, 2.0–2.8 µm wide, brown pigmented. *Hypothecium* hyaline, 13–40 µm thick, I+ blue, KI+ deep blue. *Asci* 8-spored, *Arthonia*-type, 40–45 × 16–20 µm. *Ascospores* hyaline, (3–)4(–5)-septate, (12.0–)14.5–19.0(–22.0) × (4.8–)5.4–6.6(–7.0) µm ( $n = 30$ ),  $l/b = (2.0–)2.5–3.2(–3.9)$  µm, macrocephalic, rarely with thin episporium, *c.* 0.5 µm.

**Chemistry.** Thallus K–, C–, P–, UV–. TLC: not conducted.

**Notes.** In the protologue and Sparrius (2009), ascospore size is recorded as 15–17 × 4.0–5.5 µm, but it has been found that the size is more variable: (12.0–)14.5–19.0(–22.0) × (4.8–)5.4–6.6(–7.0) µm. For the first time in this species, the I reactions of ascomatal tissue and chemical tests were confirmed, which will help to distinguish the species from others. The species is currently known only from the type locality.

### **World key to the species of *Synarthonia***

- 1 Thallus sorediate . . . . . **S. sikkimensis** S. Joseph & G. P. Sinha  
Thallus esorediate. . . . . 2
- 2(1) Ascospores muriform . . . . . **S. sarcographoides** Aptroot *et al.*  
Ascospores transversely septate. . . . . 3
- 3(2) Thallus P+ yellow, ascospores 3-septate. . . . .  
. . . . . **S. psoromica** S. Joseph & G. P. Sinha  
Thallus P–, ascospores more than 3-septate . . . . . 4
- 4(3) Thallus UV+ yellow, hymenium I+ red . . . . . **S. bicolor** Müll. Arg.  
Thallus UV–, hymenium I+ blue . . . . . **S. stigmatidialis** Müll. Arg.



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