

New species and new combinations in the lichen genera *Fissurina* and *Hemithecium* from India

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Abstract: In continuation of our ongoing revisionary studies on the lichen family *Graphidaceae* from India, a treatment of 25 species of the lichen genera *Fissurina* and *Hemithecium* from India is presented. In our earlier work on the lichen genus *Fissurina*, 16 species were reported from India. In the present study, 17 additional species of *Fissurina* from India are recognized. Nine species, viz. *Fissurina andamanensis*, *F. disposita*, *F. immersa*, *F. indica*, *F. microcarpa*, *F. nicobarensis*, *F. simplex*, *F. sporolata*, and *F. submonospora*, are described as new to science. Seven species, viz. *Fissurina canlaonensis*, *F. cingalina*, *F. comparimuralis*, *F. monospora*, *F. nitidescens*, *F. rubiginosa*, and *F. subnitidula*, are recorded for the first time from India. One species, *Fissurina* sp. 1, is recorded but not formally described as new due to scanty material. Eight species in the lichen genus *Hemithecium*, including three new species, viz. *H. kodayarensis*, *H. longilirellatum*, *H. verrucosum*, and five new combinations, viz. *Hemithecium andamanicum*, *H. flabellatum*, *H. flavoalbum*, *H. flexile*, and *H. norlabiatum*, are also recognized in the present work. A revised key for the identification of all 33 species of *Fissurina* and 26 species of *Hemithecium* so far known from India is provided.

Key words: *Graphidaceae*, lichenized ascomycetes, taxonomy

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Introduction

The lichen genus *Fissurina* Fée was established by Fée (1824) for the species with fissurine, lirelline ascumata and ovoid ascospores with a halo. The name *Fissurina* was used by Vainio (1921) at the subgeneric level or for sections of the genus *Graphis* by Redinger (1935) and Zahlbruckner (1923). It was Kalb & Hafellner (1992) who described a species in *Fissurina* as *F. quadrispora* Kalb & Hafellner and thus resurrected the name *Fissurina* at the generic level. Although the distinction of *Fissurina* from *Graphis* was recognized by Aptroot *et al.* (in Hawksworth 1994), stating that *Fissurina* seems to be a natural group which merits reintroduction, no systematic conclusions were drawn at that time. Eriksson & Hawksworth (1998), in “Outline of the ascomycetes”, listed *Fissurina*

as a synonym of *Graphis* following the system of Müll. Arg. (1880, 1882) with spore-based genera. Later *Fissurina* was reintroduced by Staiger & Kalb (1999), and in phylogenetic studies (Staiger *et al.* 2006; Mangold *et al.* 2008) it stands distinct amongst the known genera within *Graphidaceae* (including the *Thelotrema*aceae).

The genus *Hemithecium* Trevis. was reintroduced by Staiger (2002) for taxa with non-carbonized and convergent, often crenate, exciples. It was variable as to secondary chemistry, such as presence of the stictic acid complex, hymenium inspersion and ascospore type (spores hyaline and I+ blue-violet or brown and I+ reddish brown). Although chemistry and inspersion of hymenia may vary in other genera as well, the ascospore colour and iodine reaction are a constant character in most other graphidacean genera. Therefore, Staiger (2002) proposed a subgeneric division of *Hemithecium* based on ascospore coloration with subgenus *Hemithecium* with hyaline ascospores and subgenus *Leucogramma* Staiger with

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brown ascospores. Recently the genus *Pallidogramme* Staiger *et al.* was introduced to accommodate the species in *Hemithecium* subgenus *Leucogramma* Staiger (Lücking *et al.* 2008).

Materials and Methods

About 2000 specimens of lirelline *Graphidaceae*, mainly from the South Western Ghats, Eastern Himalaya, Western Himalaya, and the Andaman and Nicobar Islands of India, were studied from the AMH herbarium.

The species of *Fissurina* and *Hemithecium* were identified by comparison with types and protologues, or based on descriptions and photographs in recent treatments (e.g. Staiger & Kalb 1999; Staiger 2002; Archer 2006, 2007, 2009; Makhija & Adawadkar 2007). Specimens are deposited in the Ajrekar Mycological Herbarium (AMH).

Sections of thalli and ascomata were mounted in water, 10% KOH (K), Lugol's solution (I), and lactophenol cotton-blue (LPCB). All measurements were made on material mounted in water. Secondary products were identified by thin-layer chromatography using standardized methods (Culberson & Kristinsson 1970; Culberson 1972; White & James 1985) using the solvent systems benzene-dioxane-acetic acid (180:45:5), hexane-diethylether-formic acid (130:80:20) and toluene-ethyl acetate-formic acid (139:83:8). The specimens were also examined under UV light (365 nm).

Taxonomy

The lichen genus *Fissurina* Fée

The lichen genus *Fissurina*, is widespread in tropical areas, and characterized by the following features: ascocarps fissurine; exciples poorly developed, non-carbonized or weakly carbonized; paraphyses tips warty or not; periphysoids present or absent; asci 1–8-spored; hyaline, ascospores rounded, usually

thick-walled, trans-septate or muriform, often with a halo.

The similar genus *Acanthothecis* Clem., with warty paraphyses and periphysoids, can be differentiated from *Fissurina* by the ascospores without a thick jelly-like spore wall and with cylindrical spore locules. *Graphis* Adans. can be separated from *Fissurina* by its carbonized, well-developed exciple (labia) and ascospores without a halo.

After the comprehensive revisionary study of *Graphidaceae* by Staiger (2002), many lichenologists reinvestigated this family and several changes have been made. As a result many species were added to *Fissurina*. Noteworthy contributions include the publications recording several species by Staiger (2002), Nakanishi *et al.* (2003), Staiger & Kalb (2004), Archer (2006, 2007, 2009), Makhija & Adawadkar (2007), Lendemer (2007), Lumbsch *et al.* (2011), and Lücking *et al.* (2011).

In an earlier publication (Makhija & Adawadkar 2007), 16 species of *Fissurina* with hyaline, trans-septate ascospores were described. Further studies on the family *Graphidaceae* have revealed the occurrence of 17 additional species, of which nine are new to science, and seven are new records to India. One species is not formally described as new due to scanty material and remains unnamed. Staiger (2002) distinguished five lirella types for the identification of the ascomatal structures: *dumastii*-type, *comparilis*-type, *incrustans*-type, *globulifera*-type and *subcontexta*-type, based on their transition and formation of fruit bodies; the same types have been used in the present treatment.

Key to the species of *Fissurina* from India

- | | | |
|------|---|-------------------------------|
| 1 | Ascospores muriform | 2 |
| | Ascospores trans-septate. | 16 |
| 2(1) | Ascospores >150 µm long; ascomata 0.5–1.0 mm long, simple, round; asci 1-spored; ascospores 95–200 × 40–50 µm; no lichen substances present | |
| | | F. monospora C. Knight |
| | Ascospores <150 µm long | 3 |

- 3(2) Ascospores usually >100 µm long 4
 Ascospores usually <100 µm long 5
- 4(3) Ascomata, 0.5–1.0 mm long, simple to branched; asci 1-spored; ascospores 70–100 (–130) × 20–50 µm; no lichen substances present
 **F. submonospora B. O. Sharma et al.**
 Ascomata 0.1–0.4 mm long, simple to branched, asci 1-spored; ascospores 87–125 × 25–37 µm; stictic acid present
 **F. microcarpa B. O. Sharma et al.**
- 5(3) Ascospores usually > 40 µm long 6
 Ascospores <40 µm long. 8
- 6(5) Lichen substances present; ascomata 0.5–1.5 mm long, simple, straight to curved, asci 1–4-spored; ascospores 70–78 × 20–25 µm; stictic, hypostictic acids present **F. simplex B. O. Sharma et al.**
 Lichen substances absent 7
- 7(6) Ascomata 1.5–3.0 mm long, simple to rarely branched; asci 8-spored; ascospores 42.5–57.5 × 17.5–25.0 µm; no lichen substances present
 **F. sporolata B. O. Sharma et al.**
 Ascomata simple to branched; ascospores muriform, 32–42 × 12–20 µm; no lichen substances present. **F. indica B. O. Sharma et al.**
- 8(5) Ascospores <20 µm long. 9
 Ascospores >20 µm long. 14
- 9(8) Hypothecium very thick, up to 40 µm; psoromic acid present; ascomata 1–3 mm long; asci 8-spored; ascospores 3-trans-septate, occasionally with 1 vertical septum, 9–14 × 4–6 µm **F. globulifica (Nyl.) Staiger**
 Hypothecium thin, less than 40 µm thick; norstictic acid present or no substances 10
- 10(9) Norstictic acid present 11
 Lichen substances absent 12
- 11(10) Ascomata branched, intermingled, short, up to 0.5–1.0 mm long of *incrustans*-type; ascospores submuriform, 7.5–12.5 × 5.0–7.5 µm; norstictic acid present.
 **Fissurina sp. 1**
 Ascomata simple, 0.2–1.5 mm long of *dumastii*-type; ascospores submuriform, 12–13 × 3–5 µm; norstictic acid present
 **F. immersa B. O. Sharma et al.**
- 12(10) Ascomata more than 5 mm long; ascomata 1–10 mm long, asteroidly branched, very rarely simple, semi-emergent; ascospores submuriform, 10–15 × 6–7 µm
 **F. nicobarensis B. O. Sharma et al.**
 Ascomata <5 mm long. 13
- 13(12) Ascomata 0.5–2.0 mm long, simple, immersed; ascospores muriform, 10–18 × 5–10 µm, with a halo of *c.* 2.5–5 µm **F. nitidescens (Nyl.) Nyl.**
 Ascomata 0.2–0.5 mm long, branched, very close to each other, immersed to slightly raised; ascospores submuriform, 10–12 × 5–6 µm
 **F. disposita B. O. Sharma et al.**
- 14(8) Ascomata <1 mm long, simple to branched; ascospores muriform, 17–30 × 10–15 µm; no lichen substances present **F. rubiginosa (Fée) Staiger**
 Ascomata >1 mm long. 15

- 15(14) Ascospores submuriform, with 5–6 transverse septa and 1–2 longitudinal septa, 20–25 × 5–10 μm; no lichen substances present . . . **F. comparimuralis** Staiger
 Ascospores muriform, with 7–9 transverse septa and 2–3 longitudinal septa, 27–35 × 10–18 μm; no lichen substances present . . . **F. cingalina** (Nyl.) Staiger
- 16(1) Thallus saxicolous; warty, cracked; ascomata 1–3 mm long; 17–25 × 6–8 μm, stictic acid present in the thallus **F. saxicola** Makhija & Adaw.
 Thallus corticolous. 17
- 17(16) Thalline margin with swollen tissue 18
 Thalline margin without swollen tissue 20
- 18(17) Lichen substances present; ascomata short, 0.5–1.0 mm long, unbranched, of *subcontexta*-type; ascospores 18–28(–35) × 10–12 μm; stictic acid present in the thallus **F. cf triticea** (Nyl.) Staiger
 Lichen substances absent 19
- 19(18) Ascomata 0.5–2.5 mm long, simple to branched, of *subcontexta*-type; exciple yellowish brown; ascospores 11–16 × 4–5 μm, with a conspicuous, 3–5 μm thick halo **F. capsulata** Makhija & Adaw.
 Ascomata very long, thin, ribbon-like, intricate and anastomosed, of *subcontexta*-type; exciple bright reddish orange to dark red; ascospores 8–16 × 3–4 μm, without a conspicuous thick halo . . . **F. taeniocarpoides** Makhija & Adaw.
- 20(17) Ascomata > 10 mm (8–13 mm) long; ascospores trans-septate, 8–16 (–21) × 3–4 (–6) μm; no lichen substances present . . . **F. longiramea** Makhija & Adaw.
 Ascomata less than 10 mm long. 21
- 21(20) Ascospores >20 μm long. 22
 Ascospores <20 μm long. 26
- 22(21) Ascomata up to 5 mm long 23
 Ascomata >5 mm long. 24
- 23(22) Ascomata 0.5–3.5 mm long; ascospores 15–25 × 8–14 μm; stictic acid present in the thallus **F. canlaonensis** (Vain.) Staiger
 Ascomata 1–5 mm long; ascospores 12–25 × 8–10 μm; no lichen substances present **F. insidiosa** C. Knight & Mitt.
- 24(22) Lichen substances absent; ascomata 3–7 mm long; ascospores 60–70 μm.
 **F. dumastii** Fée
 Lichen substances present 25
- 25(24) Ascomata 1–6 mm long; ascospores 14–21 × 3–5 μm; protocetraric and fumarprotocetraric acids present **F. karnatakensis** Makhija & Adaw.
 Ascomata 1–6 mm long; ascospores 20–27 × 7–10 μm; salazinic acid present
 **F. andamanensis** B. O. Sharma *et al.*
- 26(21) Ascomata >2 mm long. 27
 Ascomata <2 mm long. 29
- 27(26) Salazinic acid present; ascomata 0.5–4.0 mm long, simple to branched; ascospores 10–12 × 4–6 μm. **F. dumastioides** var. **salazinic** Makhija & Adaw.
 Salazinic acid absent 28

- 28(27) Ascomata 2–4 mm long; ascospores 16–19 × 8–10 μm, stictic and constictic acid present **F. khasiana Makhija & Adaw.**
 Ascomata 0.5–3.5 mm long; ascospores 10–12 × 4–6 μm, stictic acid present
 **F. dumastoides (Fink) Staiger**
- 29(26) Lichen substances present 30
 Lichen substances absent 31
- 30(29) Thallus distinctly verrucose; ascomata 0.2–0.3 mm long; ascospores 7–12 × 3–4 μm; protocetraric and fumarprotocetraric acids present.
 **F. verrucosa Makhija & Adaw.**
 Thallus smooth; ascomata 0.2–0.4 mm long; ascospores 13–15 × 4–5 μm, stictic acid present **F. inquinata C. Knight & Mitt.**
- 31(29) Ascomata more than 1 mm long; ascomata 0.5–1.5 mm long; ascospores 10–13 × 5–7 μm. **F. subnitidula (Nyl.) Staiger**
 Ascomata up to 1 mm long 32
- 32(31) Ascomata of *comparilis*-type; ascospores 13–16 × 3–5 μm . **F. rugosa C. Knight**
 Ascomata of *dumastii*-type; ascospores 14–18 × 6–8 μm
 **F. coarctata Makhija & Adaw.**

The Species

Fissurina andamanensis B. O. Sharma, Khadilkar & Makhija sp. nov.

Mycobank No.: MB561853

Species *F. dumastioideis* var. *salazinicici* similis ob acidum salazinicum continentem et ascosporas majores differt.

Typus: India, Andaman Islands, Middle Andaman, Betapur Range, Pitcher Nala, 26 December 1985, M. B. Nagarkar & P. K. Sethy 85.2462 (AMH—holotypus).

(Figs 1A & 2A)

Thallus corticolous, yellowish brown, glossy, cracked, slightly verrucose.

Ascomata lirelline, fissurine, 1–6 mm long, simple to irregularly branched, concolorous with the thallus, immersed to semi-emergent, curved, thin, slender, with acute to subacute ends, structure of *dumastii*-type. *Disc* slit-like, epruinose. *Exciple* entire, dark blackish brown, orange-brown to non-carbonized, thin at the base, convergent, covered by the thalline margin up to the top, with a distinct, reddish orange proso-plectenchymatous upper corticiform layer. *Hymenium* hyaline, clear, 100–112 μm high, I–, KI–. *Hypothecium* light orange-brown, 12–14 μm high. *Paraphyses* simple. *Periphys-*

oids short, indistinctly warty at the tips. *Asci* 8-spored. *Ascospores* hyaline, 3-trans-septate, 20–27 × 7–10 μm, with a thin halo, I–, KI–.

Chemistry. Salazinic acid present.

Remarks. The occurrence of salazinic acid is rather rare amongst *Fissurina* species and so far it is known only in *F. dumastioideis* (Fink) Staiger var. *salazinicica* Makhija & Adawadkar. This can easily be differentiated from *F. andamanensis* in having smaller ascospores, 10–12 × 4–6 μm. The new species also resembles *Fissurina rufula* (Mont.) Staiger, and *F. cf. triticea* (Nyl.) Staiger in having similar ascomatal structure, but differs in having salazinic acid. *Fissurina rufula* has no lichen substances while *F. triticea* contains stictic acid. *Fissurina elaiocarpa* (A. W. Archer) A. W. Archer also has similar ascomatal structure but has muriform ascospores.

The species has been collected from the evergreen forest of Middle Andaman, where the vegetation is typically tropical.

Additional specimen examined. **India:** Andaman Islands: Middle Andaman, Betapur Range, Pitcher Nala, 1985, M. B. Nagarkar & P. K. Sethy 85.1854 (AMH).

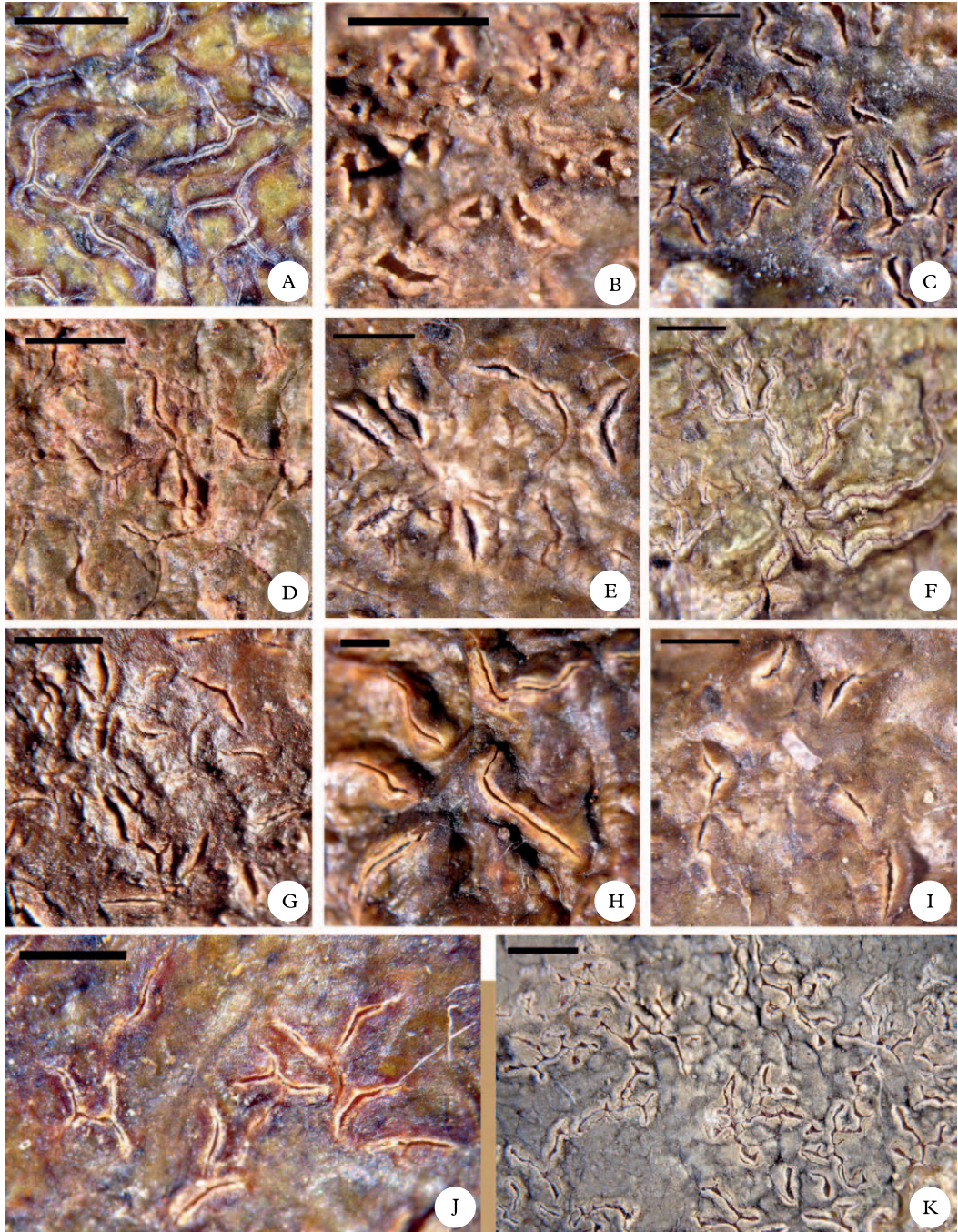


FIG. 1. *Fissurina* species, habitus. A, *F. andamanensis* (85.2462—holotype, AMH); B, *F. disposita* (77.1062—holotype, AMH); C, *F. immersa* (80.92—holotype, AMH); D, *F. indica* (76.67—holotype, AMH); E, *F. microcarpa* (83.382—holotype, AMH); F, *F. nicobarensis* (87.132—holotype, AMH); G, *F. simplex* (81.775—holotype, AMH); H, *F. sporolata* (80.510—holotype, AMH); I, *F. submonospora* (83.187—holotype, AMH); J, *F. rubiginosa* (83.40, AMH); K, *Fissurina* sp. 1 (83.228, AMH), Scales: A–J = 1 mm. 139 × 180 mm. In colour online.

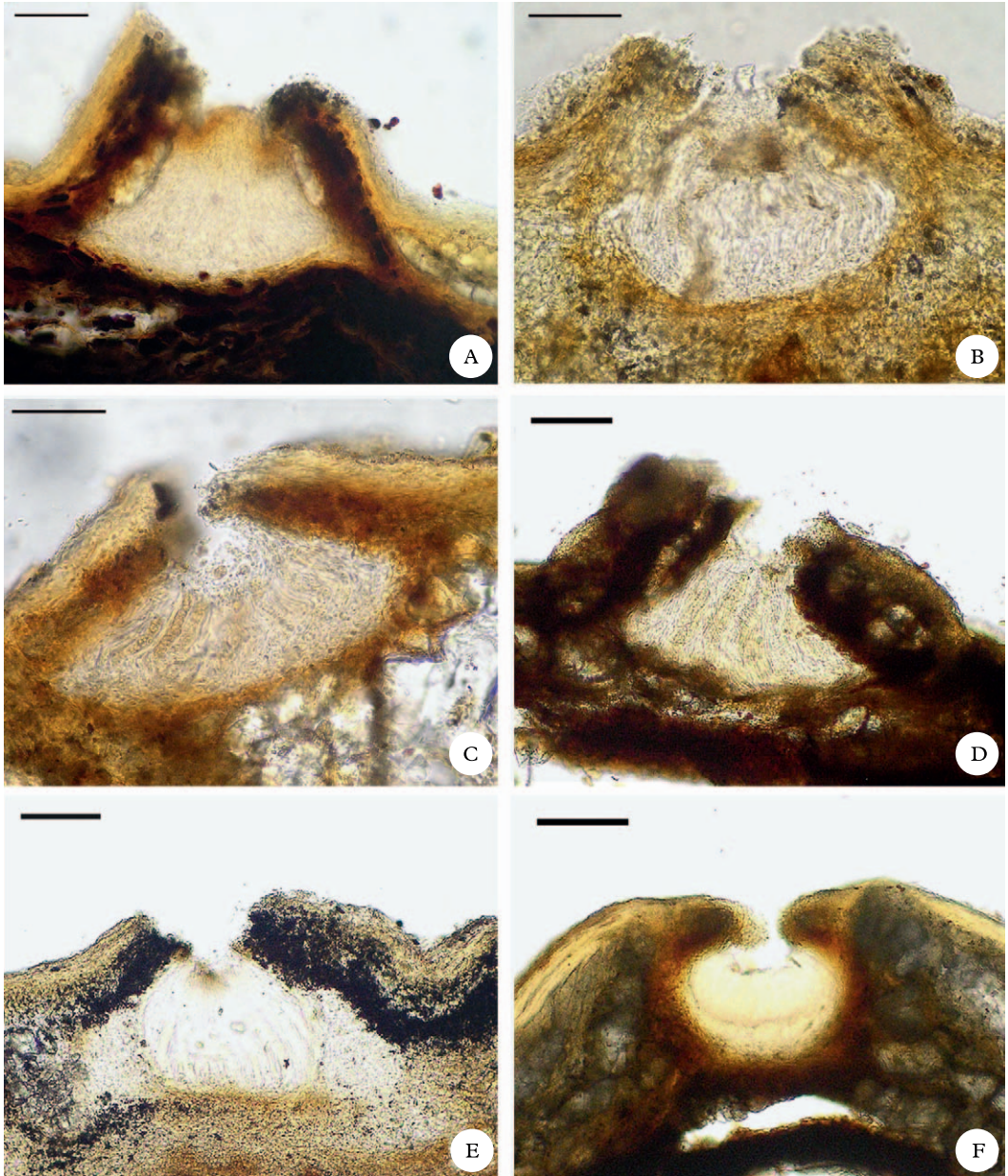


FIG. 2. *Fissurina* species, sections of ascocarps. A, *F. andamanensis* (85.2462—holotype, AMH); B, *F. disposita* (77.1062—holotype, AMH); C, *F. immersa* (80.92—holotype, AMH); D, *F. indica* (76.67—holotype, AMH); E, *F. microcarpa* (83.382—holotype, AMH); F, *F. nicobarensis* (87.132—holotype, AMH). Scales: A–C = 50 µm; D–F = 100 µm. In colour online.

Fissurina canlaonensis (Vain.) Staiger

Biblioth. Lichenol. **82**: 161 (2002).—*Graphis canlaonensis* Vain. *Ann. Acad. Sci. Fenn., ser. A*, **15** (6): 261 (1921).

Thallus corticolous, orange-brown, cracked, uneven, glossy, delimited by black hypothallus.

Ascomata lirelline, 0.5–1.0 mm long, slender, simple, very rarely branched, curved, immersed, terminally acute, structure of *subcontexta*-type. *Disc* slit-like, epruinose. *Exciple* entire, non-carbonized, orange-brown, present at the base, converging at the apical region, covered by the thalline margin up to the top, with a distinct upper corticiform layer, studded with crystals. *Hymenium* hyaline, sometimes with light yellow tinge, clear, 112–162 μm high, I–, KI–. *Hypothecium* indistinct. *Paraphyses* simple with branched tips. *Periphysoids* absent. *Asci* 8-spored. *Ascospores* hyaline, 3–4-trans-septate, 10–17 \times 4–9 μm , with a 2.5–5.0 μm thick halo, I–, KI–.

Chemistry. Stictic, and constictic acids (sometimes) present.

Remarks. *Fissurina canlaonensis* has been collected from the moist deciduous forest in the Andaman Islands and is reported here for the first time from India. The species was earlier reported from the Philippines.

The specimens referred under *Graphis canlaonensis* Vain. (Patwardhan & Kulkarni 1976) were later identified as *Fissurina dumastioides* Makhija & Adawadkar (Makhija & Adawadkar 2007) and *Graphis canlaonensis* was erroneously reported from India.

Specimens examined. **India:** Andaman Islands: North Andaman, Tugapur Range, Pathar Tikari, moist deciduous forest, 1985, P. G. Patwardhan & M. B. Nagarkar 85.2599, 85.2683 (AMH).

Fissurina cingalina (Nyl.) Staiger

Biblioth. Lichenol. 85: 128 (2002).—*Graphis cingalina* Nyl. *Acta Soc. Sci. Fenn.*, 26(10): 21 (1900).

Thallus corticolous, greenish grey, cracked, smooth, glossy, delimited by black hypothallus.

Ascomata lirelline, 1–4 mm long, branched, light brown, immersed, terminally acute, structure of *dumastii*-type. *Disc* slit-like, epruinose. *Exciple* entire, non-carbonized, orange, convergent, present at the base, covered by the thalline margin up to the top with a 10–12 μm thick, orange-brown upper corticiform layer studded with crystals. *Hymenium* hyaline, clear, 100–125 μm

high, I–, KI–. *Hypothecium* indistinct, hyaline, 10–12 μm . *Paraphyses* simple. *Periphysoids* absent. *Asci* 8-spored. *Ascospores* hyaline, muriform, 7–9-trans-septate and 2–3 vertical septa, 27–35 \times 10–18 μm , with a 2.5–5.0 μm thick halo, I–, KI–.

Chemistry. No lichen compounds present.

Remarks. This species has been recorded from the moist deciduous and semi-evergreen forests of Kerala, Tamil Nadu and Maharashtra in India. It was previously known from Sri Lanka, Venezuela and Brazil and has now been reported for the first time from India.

Specimens examined. **India:** Kerala: Munnar-Kumily road, 30 km, Cardamom hills, 1976, P. G. Patwardhan & A. V. Prabhu 76.739, 76.740. Maharashtra: Mahabaleshwar, Dhobi Ghat, 1974, M. B. Nagarkar, 74.640; Amboli, 1974, C. R. Kulkarni & A. V. Prabhu 74.1427; Shirgaonkar Point, 2000, U. V. Makhija 00.496. Tamil Nadu: Kodaikanal, Silver Cascade, 1975, P. G. Patwardhan & A. V. Prabhu 75.109; Naduvattum, Nilgiri hills, in Shola forest, elev. approx. 5000 ft., 1978, P. G. Patwardhan 78.105; Kollimalai, 1985, P. G. Patwardhan & M. B. Nagarkar 85.1531, 85.1536, 85.1537, 85.1539, 85.1572, 85.1609, 85.1633, 85.1647 (AMH).

Fissurina comparimuralis Staiger

Biblioth. Lichenol. 85: 134 (2002).

Thallus corticolous, brown, cracked, verrucose, slightly glossy, delimited by thin black hypothallus.

Ascomata lirelline, 1–4 mm long, slender, all over the thallus, flexuous, simple to irregularly branched, curved, immersed, terminally acute, structure of *comparilis*-type; thalline margin slightly raised. *Disc* slit-like, immersed. *Exciple* entire, non-carbonized, orange, convergent, present at the base, covered by the thalline margin up to the top, with a distinct prosoplectenchymatous upper corticiform layer studded with crystals. *Hymenium* hyaline, clear, 87–112 μm high, I–, KI–. *Hypothecium* indistinct. *Paraphyses* simple. *Periphysoids* short. *Asci* 8-spored. *Ascospores* hyaline, submuriform, 5–6 transverse and 1–2 longitudinal septa, 20–25 \times 5–10 μm , with 1–2 μm thick halo, I+ weak blue.

Chemistry. No lichen compounds present.

Remarks. *Fissurina comparimuralis* was previously known from Brazil and is now reported for the first time from India. The species has been collected from the evergreen forest of Kerala in the Western Ghats of India.

Specimens examined. **India:** Kerala: Thekadi, 1973, P. G. Patwardhan & M. B. Nagarkar 73.2460 (AMH).

***Fissurina disposita* B. O. Sharma, Khadilkar & Makhija sp. nov.**

Mycobank No.: MB561854

Similaris *F. egenae* et *F. nitidescens* ob structuram ascomatium et ascoporas minores et submuriformes differt.

Typus: India, Meghalaya, Mawsmi, near Cherrapunji, 28 October 1977, P. G. Patwardhan & M. B. Nagarkar 77.1062 (AMH—holotypus).

(Figs 1B & 2B)

Thallus corticolous, brown, verrucose, cracked, flaking, glossy.

Ascomata lirelline, 0.2–0.5 mm long, immersed to slightly raised arising as the swelling which then cracks and gapes, branched, present all over the thallus, crowded, terminally acute, structure of *comparilis*-type. *Disc* creamish, sunken, epruinose. *Exciple* entire, non-carbonized, light brown, present at the base. *Hymenium* hyaline, clear, 62–75 µm high, I–, KI–. *Paraphyses* simple. *Periphysoids* short. *Asci* 8-spored. *Ascospores* hyaline, submuriform, 3–4 transverse and 1–2 longitudinal septa, 10–12 × 5–6 µm, I–, KI–.

Chemistry. No lichen substances present.

Remarks. *Fissurina disposita* differs from the most closely allied *F. egenae* (Nyl.) and *F. nitidescens* (Nyl.) Nyl. in having smaller ascospores of 10–12 × 5–6 µm. *Fissurina egenae* has 15–23 × 7–10 µm large, muriform ascospores. *Fissurina cingalina* (Nyl.) Staiger and *F. columbina* (Tuck.) Staiger also lack lichen substances, but they have much larger ascospores, 20–32 × 9–17 µm in *F. cingalina*, and 20–30 × 10–15 µm in *F. columbina*.

Fissurina disposita has been collected from the subtropical forest of Mawsmi near Cherrapunji and from the shola forest of Karnataka. The sholas are sheltered depressions in the landscape.

Additional specimens examined. **India:** Karnataka: Baba Budangiri road, in shola forest, 1980, P. G. Patwardhan & M. B. Nagarkar 80.42, 80.46, 80.47, 80.48 (AMH).

***Fissurina immersa* B. O. Sharma, Khadilkar & Makhija sp. nov.**

Mycobank No.: MB561855

Similaris *F. inabensis* sed differt ascoporis minoribus et acido norstictico continente.

Typus: India, Karnataka, Mudigiri, 26 January 1980, P. G. Patwardhan 80.92 (AMH—holotypus).

(Figs 1C & 2C)

Thallus corticolous, brown, uneven, finely cracked, glossy, delimited by the black hypothalloidal region at the periphery.

Ascomata lirelline, concolorous with the thallus, immersed to slightly raised arising as swelling which then cracks and gapes, simple to very rarely branched, 0.2–1.5 mm long, straight to curved, terminally acute, structure of *dumastii*-type. *Disc* sunken, slit-like, epruinose. *Exciple* entire, non-carbonized, present at the base, orange-brown, covered by the slightly raised thalline margin with a distinct prosoplectenchymatous corticiform layer. *Hymenium* hyaline, clear, 50–75 µm high, I–, KI–. *Paraphyses* thin, simple with indistinct warty tips. *Periphysoids* short, indistinctly warty at the tips. *Asci* 8-spored. *Ascospores* hyaline, submuriform, 3–4 transverse and 1 vertical septa, 12–13 × 3–5 µm, I+ weak blue.

Chemistry. Norstictic acid present.

Remarks. *Fissurina immersa* belongs in a group of species having *dumastii* type ascomata and is clearly distinguished from the other species of this group in having short lirellae, submuriform ascospores and norstictic acid in the thallus.

Fissurina inabensis (Vain.) Nakan. & Kashiw., a species from Japan having submuriform ascospores and somewhat similar ascomatal structure, can be differentiated from the present new species in having larger ascospores, 21–30 × 10–14 µm, and stictic acid. *Fissurina elaiocarpa* (A. W. Archer)

A. W. Archer, with similar ascomatal structure and muriform ascospores, has large ascospores, 21–28 μm long.

Fissurina immersa has been collected from the evergreen forest of Karnataka.

Additional specimen examined. India: Karnataka: Mudigiri, 1980, P. G. Patwardhan 80.635 (AMH).

***Fissurina indica* B. O. Sharma, Khadilkar & Makhija sp. nov.**

Mycobank No.: MB561856

Similis *Fissurinae cingalinae* sed ascosporis majoribus differt.

Typus: India, Kerala, Wynad forest, on Gudalur-Nilambur Road, 20 January 1976, P. G. Patwardhan & A. V. Prabhu 76.67 (AMH—holotypus).

(Figs 1D & 2D)

Thallus corticolous, greenish, cracked, verrucose, glossy, delimited by black hypothaloidal region at the periphery.

Ascomata small, 0.2–0.4 mm long, concolorous with the thallus, immersed, simple to branched, acute ends, structure of *dumastii*-type, present all over the thallus. *Disc* slit-like. *Exciple* entire, non-carbonized, orange-brown, convergent, indistinctly present at the base, covered by the distinct thalline margin up to the top with a prosoplectenchymatous corticiform layer, studded with crystals. *Hymenium* hyaline, clear, 137–162 μm high, I–, KI–. *Hypothecium* indistinct, hyaline. *Paraphyses* simple. *Periphysoids* short, indistinct. *Asci* 6–8-spored. *Ascospores* hyaline, muriform, multilocular, 32–42 \times 12–20 μm , with an indistinct halo, I–, KI–.

Chemistry. No lichen substances present.

Remarks. The new species can be distinguished from other species having no lichen substances, viz. *Fissurina cingalina* (Nyl.) Staiger, *F. columbina* (Tuck.) Staiger and *F. marginata* Staiger, by its larger ascospores.

Additional specimens examined. India: Assam: Maniknagar, 1977, P. G. Patwardhan & M. B. Nagarkar 77.1220; Darugiri Reserved forest, 1978, M. B. Nagarkar 78.356. Kerala: Cardamom hills, Devicolam, 5 km on Kumily road, 1976, P. G. Patwardhan & A. V.

Prabhu 76.750; Munnar-Kumily road, on 78 km from Cardamom hills, 1976, C. R. Kulkarni 76.842; Paranthal, near Trivendrum, 1976, P. G. Patwardhan & A. V. Prabhu 76.878, 76.903 (AMH).

***Fissurina microcarpa* B. O. Sharma, Khadilkar & Makhija sp. nov.**

Mycobank No.: MB561857

Similis *Fissurinae undulatae* sed ascosporis majoribus differt.

Typus: India, Tamil Nadu, Upper Kodayar, 24 January 1983, P. G. Patwardhan 83.382 (AMH—holotypus).

(Figs 1E & 2E)

Thallus corticolous, brownish, cracked, warty, glossy.

Ascomata lirelline, all over the thallus, short, 0.1–0.4 mm long, immersed to slightly raised arising as swelling which then cracks and gapes, simple to branched, concolorous with the thallus, terminally acute, structure of *dumastii*-type. *Disc* slit-like. *Exciple* entire, non-carbonized, indistinct at the base, orange-brown, covered with the thalline margin up to the top with a distinct corticiform layer. *Hymenium* hyaline, clear, 112–150 μm high, I–, KI–. *Hypothecium* light yellow, 10–15 μm . *Paraphyses* simple. *Periphysoids* short, indistinctly warty at the tips. *Asci* 1-spored. *Ascospores* hyaline, muriform, multilocular, 87–125 \times 25–37 μm , with a 5–8 μm thick halo, I–, KI–.

Chemistry. Stictic acid present.

Remarks. *Fissurina microcarpa* is morphologically somewhat similar to *F. submonospora* (described below). However, *Fissurina submonospora* has no lichen compounds in the thallus. *Fissurina undulata* (Müll. Arg.) M. Nakan. & Kashiw., a species from Japan, also has stictic acid and monosporate asci but that species has smaller ascospores, 30–38 \times 15–18 μm .

Additional specimens examined. India: Karnataka: Shringeri, 2 km from Shringeri-Balehonur road, 1974, C. R. Kulkarni 74.3221, 74.3627. Tamil Nadu: Upper Kodayar, 1983, P. G. Patwardhan 83.571 (AMH).

Fissurina monospora C. Knight

Transact. New Zealand Instit. 15: 354 (1883).

Thallus corticolous, brown, cracked, verrucose, glossy, delimited by the black hypothallus.

Ascomata lirelline, 0.5–1.0 mm long, simple, round, immersed, terminally obtuse or rounded. *Disc* narrow to broad, epruinose, sunken. *Exciple* entire, non-carbonized, orange-brown, rudimentary at the base, covered by the crystal-studded thalline margin up to the top, with orange-brown corticiform layer. *Hymenium* hyaline, clear, laterally I–, 90–125 µm high. *Hypothecium* light yellow, 8–10 µm. *Paraphyses* simple. *Asci* 1-spored. *Periphysoids* short, not warty at the tips. *Ascospores* hyaline, muriform, 95–200 × 40–50 µm, with an indistinct halo, I+ weakly blue.

Chemistry. No lichen substances present in the thallus.

Remarks. *Fissurina monospora* is known from New Zealand and has now been reported for the first time from Karnataka in the Western Ghats of India.

Specimens examined. India: Karnataka: Balehonur-Shringeri road, 1974, P. G. Patwardhan & M. B. Nagarkar 74.3168; South Canara, Koppa forest, 5 km from Koppa on Shimoga road, 1976, C. R. Kulkarni 76.1076, 76.1178 (AMH).

Fissurina nicobarensis B. O. Sharma, Khadilkar & Makhija sp. nov.

Mycobank No.: MB561858

Similis *Fissurinae globulifcae* sed lirellis longioribus et acidis deficientibus differt.

Typus: India, Nicobar Islands, Great Nicobar, Campbell Bay to Laful Bay, 2 January 1987, P. K. Sethy & P. G. Patwardhan 87.132 (AMH—holotypus).

(Figs 1F & 2F)

Thallus corticolous, yellowish brown, glossy, warty, delimited by black hypothaloidal region.

Ascomata lirelline, 1–10 mm long, branched, concolorous with the thallus, semi-emergent, terminally acute, structure

of *globulifca*-type. *Disc* creamish, narrow to slightly broad, epruinose. *Exciple* entire, non-carbonized, orange-brown, convergent, thin at base, covered by the thalline margin up to the top, with a distinct, prosoplectenchymatous upper corticiform layer, studded with crystals. *Hymenium* hyaline, clear, 62–87 µm high, I–, KI–. *Hypothecium* distinct, light yellow, 10–15 µm thick. *Paraphyses* simple, long. *Periphysoids* short, thin, without warts. *Asci* 8-spored. *Ascospores* hyaline, submuriform, ellipsoid, 10–15 × 6–7 µm, with a thin halo, I+ weak violet.

Chemistry. No lichen substances present.

Remarks. The new species shows the *globulifca*-type of ascomatal structure. *Fissurina globulifca* (Nyl.) Staiger, with similar ascomatal structure, differs by having short lirellae of c. 1–3 mm long and containing psoromic acid.

Fissurina albocinerea (Vain.) Staiger and *F. instabilis* (Nyl.) Nyl. also have a similar ascomatal structure. They differ because *F. albocinerea* has 4-locular, trans-septate ascospores and *F. instabilis* has muriform ascospores and psoromic acid.

Fissurina nicobarensis has been collected in tropical rainforest from the Great Nicobar Island.

Additional specimens examined. India: Nicobar Islands: Great Nicobar, Campell Bay to Laful Bay, 1986, P. G. Patwardhan & P. K. Sethy 86.856; *ibid.*, 1987, P. K. Sethy & P. G. Patwardhan 87.216 (AMH).

Fissurina nitidescens (Nyl.) Nyl.

Lichenes Japoniae: 108 (1890)—*Graphis nitidescens* Nyl. In Tuckerman, *N. Amer. Lich.*, 2: 123 (1888).

Thallus corticolous, light yellow, cracked, uneven, glossy.

Ascomata lirelline, 0.5–2 mm long, brown, simple, straight, immersed, terminally acute, structure of *dumastii*-type. *Disc* narrow to broad, brown, epruinose. *Exciple* entire, non-carbonized, orange, convergent, present below, covered by the raised thalline margin up to the top, with a thin corticiform layer, studded with crystals. *Hymenium* hyaline, clear, 87–100 µm high, I–, KI–. *Hypothecium*

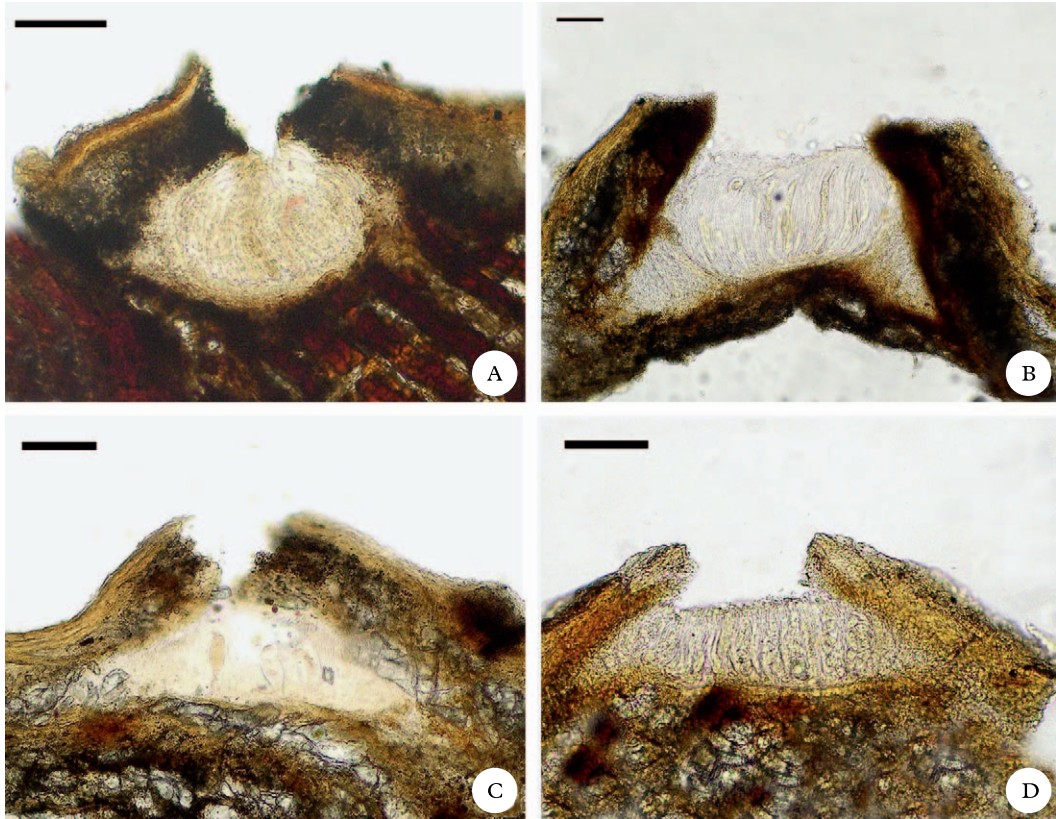


FIG. 3. *Fissurina* species, sections of ascocarps. A, *F. simplex* (81.775—holotype, AMH); B, *F. sporolata* (80.510—holotype, AMH); C, *F. submonospora* (83.187—holotype, AMH); D, *F. rubiginosa* (83.40, AMH). Scales: A–D = 100 μ m. In colour online.

indistinct. *Paraphyses* simple. *Periphysoids* absent or indistinct. *Asci* 8-spored. *Ascospores* hyaline, muriform, 10–18 \times 5–10 μ m, with a halo of c. 2.5–5 μ m, I–.

Chemistry. No lichen substances present.

Remarks. *Fissurina nitidescens* is known from Africa, Australia, USA and Brazil and has now been reported for the first time from India.

Specimens examined. **India:** Karnataka: Ganga Mulla, to Nagartirtha, on the way to Kudremukh, 1981, P. G. Patwardhan & D. W. Rane 81.77. Kerala: Wyanad, 1973, C. R. Kulkarni & P. D. Badhe 73.2810 (AMH).

Fissurina rubiginosa (Fée) Staiger

Biblioth. Lichenol. 85: 148 (2002).—*Graphis rubiginosa* Fée, *Essai Sur les Cryptogames des écorces exotiques officielles*: 47 (1825).

(Figs 1J & 3D)

Thallus corticolous, greyish brown, cracked, rough, verrucose, slightly glossy.

Ascomata lirelline, very short, 0.4–0.6 mm, brownish, concolorous with the thallus, simple to branched, thin, immersed, terminally acute, structure of *dumastii*-type. *Disc* very narrow, not visible. *Exciple* entire, non-carbonized, convergent, present at the base,

covered by the thalline margin up to the top, with a distinct yellowish upper corticiform layer, studded with crystals. *Hymenium* hyaline, clear, 100–120 μm high, I–, KI–. *Hypothecium* indistinct. *Paraphyses* simple. *Periphysoids* short, indistinctly warty at the tips. *Asci* 8-spored. *Ascospores* hyaline, muriform, round to elongate, 17–30 \times 10–15 μm , with a 3–5 μm thick halo, I–.

Chemistry. No lichen substances present.

Remarks. *Fissurina rubiginosa* is well differentiated from *F. elaiocarpa* (A. W. Archer) A. W. Archer and *F. incrustans* Fée by having minute lirellae. Both species have muriform ascospores and no lichen compounds but have large ascocata, 1–6 (–8) mm long in *Fissurina elaiocarpa* and 1–4 mm long in *F. incrustans*. *Fissurina coarctata* Makhija & Adawadkar is also comparable with *F. rubiginosa* in its short, crowded lirellae and chemistry, but it has trans-septate ascospores.

Fissurina rubiginosa is known from French-Guayana and the USA and has now been reported for the first time from India.

Specimen examined. **India:** Tamil Nadu: Chitteri, 1983, P. G. Patwardhan 83.40 (AMH).

***Fissurina simplex* B. O. Sharma, Khadilkar & Makhija sp. nov.**

MycoBank No.: MB561859

Fissurina simplex distincte differt inter omnibus *Fissurinae* speciebus ob praesentiam acidi stictici et ascosporas majores.

Typus: India, Kerala, Silent valley, 31 December 1981, P. K. Sethy & S. P. Kekre 81.775 (AMH—holotypus).

(Figs 1G & 3A)

Thallus corticolous, brown, cracked, glossy, verrucose, delimited by a black hypothalloidal region at the periphery.

Ascocata lirelline, 0.5–1.5 mm long, simple, straight, sometimes curved, concolorous with the thallus, immersed to slightly raised arising as a swelling which then cracks and gapes, terminally acute, structure of *subcontexta*-type. **Disc** narrow, sunken, epur-

inose. **Exciple** entire, non-carbonized, present at the base, convergent, orange-brown, often arising as fissures in swollen thalline margins (slightly ‘puffed’), covered by the distinct orange-brown corticiform layer of 10–12 μm , studded with crystals. **Hymenium** hyaline, clear, 120–150 μm high, I–, KI–. **Hypothecium** indistinct. **Paraphyses** simple. **Periphysoids** short. **Asci** 1–4-spored. **Ascospores** hyaline, muriform, 70–78 \times 20–25 μm , with a thin halo, I–.

Chemistry. Stictic and hypostictic acids present.

Remarks. The new species *Fissurina simplex* can be distinguished easily from all other species by the presence of stictic acid, its swollen thalline margin, 1–4-spored asci and large muriform ascospores. *Fissurina abdita* (A. W. Archer) A. W. Archer and *F. undulata* (Müll. Arg.) M. Nakan. & Kashiw also produce stictic acid, however, they have smaller muriform or submuriform ascospores in the range of 21–35 μm . *Fissurina quadrispora* Kalb & Hafellner, the only other species known to have 4-spored asci, differs from the new species in having 3-trans-septate ascospores and a different chemistry with psoromic and conpsoromic acids in the thallus. *Fissurina inabensis* (Vain.) Nakan & Kashiw. differs from the new species in having small, submuriform ascospores, 21–30 \times 10–15 μm .

Fissurina simplex has been collected from the evergreen forest of Kerala and from the moist deciduous forest of Karnataka.

Additional specimens examined. **India:** Karnataka: Anmod Ghat, 8 km from Anmod check post, Anmod-Goa road, 1974, P. G. Patwardhan & C. R. Kulkarni 74.2455, 74.3628. Kerala: Silent Valley, 1981, P. K. Sethy & S. P. Kekre 81.773 (AMH).

***Fissurina sporolata* B. O. Sharma, Khadilkar & Makhija sp. nov.**

MycoBank No.: MB561860

Fissurina sporolata, a *Fissurinae* speciebus typo subcontexta similibus ascosporis muriformibus majoribusque differt.

Typus: India, Karnataka, Hebri, 30 December 1980, P. G. Patwardhan & M. B. Nagarkar 80.510 (AMH—holotypus).

(Figs 1H & 3B)

Thallus corticolous, brown, finely cracked, glossy, warty, rough.

Ascomata lirelline, 1.5–3.0 mm long, simple to rarely branched, concolorous with the thallus, immersed, terminally acute, structure of *subcontexta*-type. *Disc* narrow, epuriose. *Exciple* entire, non-carbonized, orange-brown, very thin at the base, convergent, often arising as fissures in swollen thalline margins ('puffed'), covered by the raised thalline margin up to top, with a distinct upper corticiform layer. *Hymenium* hyaline, clear, 225–250 µm high, I–, KI–. *Hypothecium* hyaline, 20–25 µm high. *Paraphyses* simple. *Periphysoids* short, slightly warty at the tips. *Asci* 8-spored. *Ascospores* hyaline, muriform, ellipsoidal, multilocular, 42–57 × 17–25 µm, with a 5–7 µm thick halo, I+ blue tinge.

Chemistry. No lichen substances present.

Remarks. *Fissurina marginata* Staiger, the only other species with *subcontexta*-type of ascomatal structure, muriform ascospores and no lichen substances, differs by its smaller ascospores, 22–32 × 13–15 µm. The other species having *subcontexta*-type of ascomatal structure are *Fissurina alboscripta* (Coppins & P. James) Staiger, *F. canlaonensis* (Vain.) Staiger, *F. crassilabra* Mont. & Bosch., *F. rufula* (Mont.) Staiger, *F. subcontexta* (Nyl.) Nyl. and *F. triticea* (Nyl.) Staiger; these all have trans-septate ascospores.

Fissurina sporolata was found growing on a roadside tree trunk in the moist deciduous forest of Hebri in Karnataka, state of India.

Additional specimen examined. **India:** Karnataka: Hebri, 1980, P. G. Patwardhan & M. B. Nagarkar 80.634 (AMH).

Fissurina submonospora B. O. Sharma, Khadilkar & Makhija sp. nov.

MycoBank No.: MB561861

Similis *Fissurinae monosporae* sed ascosporis majoribus differt.

Typus: India, Tamil Nadu, Upper Kodayar, 24 January 1983, P. G. Patwardhan & P. K. Sethy 83.187 (AMH—holotypus).

(Figs 1I & 3C)

Thallus corticolous, brownish grey to dark brown, cracked, uneven, warty, glossy, delimited by the black hypothalloid region at the periphery.

Ascomata lirelline, short, 0.5–1.0 mm long, simple to branched, immersed, concolorous with the thallus, structure of *dumastii*-type. *Disc* slit-like. *Exciple* entire, non-carbonized, absent or indistinct at the base, orange-brown, convergent, covered by the thalline margin up to the top, with prosoptenchymatous upper corticiform layer, studded with crystals. *Hymenium* hyaline, clear, 125–150 µm high. *Hypothecium* indistinct. *Paraphyses* simple. *Periphysoids* short, indistinctly warty at the tips. *Asci* 1-spored. *Ascospores* hyaline, muriform, 10–15 transverse and 4–5 longitudinal septa, 70–100 (–130) × 20–50 µm, with 2.5–10.0 µm thick halo, I+ weakly blue.

Chemistry. No lichen compounds present.

Remarks. *Fissurina monospora* is morphologically similar but has larger ascospores, 185–200 × 65 µm. *Fissurina undulata* (Müll. Arg.) M. Nakan. & Kashiw. from Japan, also with 1-spored asci, differs in having smaller ascospores, 30–38 µm. Another species, *Fissurina microcarpa* (described above), also has monosporate asci and muriform ascospores but that species contains stictic acid.

The species grows in the moist evergreen forests of the Western Ghats of India.

Additional specimens examined. **India:** Karnataka: Anmod ghat, 3 km from Anmod check post, Anmod-Goa road, 1974, A. V. Prabhu & M. B. Nagarkar 74.2518; Jog falls-Sagar road, 6 km from Sagar, 1974, M. B. Nagarkar & P. G. Patwardhan 74.2844. **Kerala:** Cardamom hills, Devicolam-Kumily Road, on 98 km, 1976, C. R. Kulkarni 76.816; Silent Valley, 1981, P. G. Patwardhan & U. V. Makhija 81.870, 81.872; *ibid.*, 1982, P. G. Patwardhan & M. B. Nagarkar 82.81. **Tamil Nadu:** Upper Kodayar, 1983, P. G. Patwardhan & P. K. Sethy 83.248, 83.261, 83.265; Agasthy hills, on Kakachi

road, in moist evergreen forest, elev. approx. 1400 ft., 1984, P. G. Patwardhan & P. K. Sethy 84.61 (AMH).

Fissurina subnitidula (Nyl.) Staiger

Biblioth. Lichenol. **85**: 153 (2002)—*Graphis subnitidula* Nyl. In Tuckerman, *N. Amer. Lich.*, **2**: 123 (1888).

Thallus corticolous, yellowish brown to brown, cracked, verrucose, slightly glossy, delimited by a distinct black hypothallus.

Ascomata lirelline, 0.5–1.0 mm long, concolorous with the thallus, simple, all over the thallus, curved, immersed to semi-emergent, terminally acute to obtuse, structure of *dumastii*-type. *Disc* narrow to broad, brown, epruinose. *Exciple* entire, non-carbonized, brown, convergent, indistinct at the base, covered with the thalline margin up to the top with thin pseudocortex, and studded with crystals. *Hymenium* hyaline, clear, 50–75 µm high, I–, K–. *Hypothecium* indistinct. *Paraphyses* simple with branched tips. *Periphysoids* absent. *Asci* 8-spored. *Ascospores* hyaline, 3-trans-septate, 10–15 × 5–7 µm with a 2.5–5.0 µm thick halo, I–.

Chemistry. No lichen compounds present.

Remarks. *Fissurina subnitidula* was previously known from Africa and has now been reported for the first time from India. It has been collected from the moist deciduous forest of Karnataka.

Specimens examined. India: Karnataka: Kumtha-Sirsi road, Devimane Ghat, rainforest, 1977, C. R. Kulkarni 77.113; Hosar Ghat, 1981, S. P. Kekre & M. B. Nagarkar 81.658, 81.701, 81.703 (AMH).

Fissurina sp. 1

(Figs 1K & 4A)

Thallus yellowish grey, cracked, slightly glossy, rough.

Ascomata lirelline, up to 0.5–1.0 mm long, immersed to slightly raised arising as the swelling which then cracks and gapes, intermingled, branched, creamish, irregularly curved, terminally obtuse, structure of *incrustans*-type. *Disc* sunken, creamish, epruinose. *Exciple* non-carbonized, entire, pre-

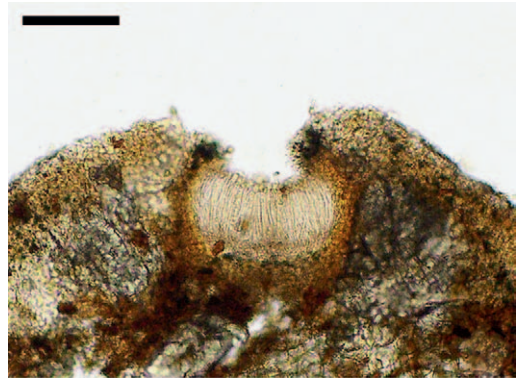


FIG. 4. *Fissurina* sp. 1 (83.228, AMH), section of ascocarp. Scale = 50 µm. In colour online.

sent at the base, orange-brown, convergent, covered by the thalline margin with thin, hyaline corticiform layer up to the top, studded with crystals. *Hymenium* hyaline, clear, 70–100 µm high, I–, KI–. *Hypothecium* indistinct. *Paraphyses* simple. *Periphysoids* short, sometimes warty at the tips. *Asci* 8-spored. *Ascospores* hyaline, submuriform, transversely 3–4-septate and vertically 1-septate, ellipsoidal, 7–12 × 5–7 µm, I+ blue-violet.

Chemistry. Norstictic acid present.

Remarks. *Fissurina* sp. 1, having *incrustans*-type of ascomatal structure, is distinguishable from *F. incrustans* Fée by the presence of norstictic acid and smaller ascospores; *F. incrustans* has rather larger ascospores, 15–25 (–28) × 7–10 (–13) µm, and does not produce any lichen compounds.

This material appears to be a new species but we reserve a final decision until we have had the opportunity to study more material.

Specimen examined. India: Tamil Nadu: Upper Kodayar, 1983, P. G. Patwardhan & P. K. Sethy 83.228 (AMH).

The lichen genus *Hemithecium* Trevis.

After the reintroduction of the genus *Hemithecium* Trevis. by Staiger (2002), the genus is so far represented by about 41 species worldwide, including 19 species from

the Indian subcontinent (Staiger 2002; Nakanishi *et al.* 2003; Adawadkar & Makhija 2005; Makhija & Adawadkar 2005; Makhija *et al.* 2005; Archer 2006, 2009; Chitale *et al.* 2009; Jagadeesh & Sinha 2009). The genus can be distinguished from the other genera of lirelline *Graphidaceae* by well-developed, convergent, non-carbonized and distinctly striate exciples,

1–8-spored asci, and hyaline, transversely septate or muriform ascospores, turning I+ blue or blue-violet.

As a result of our studies, three additional new species of *Hemithecium* have been discovered and five new combinations are proposed. A key for the identification of all 26 species of *Hemithecium* so far known from India is also provided.

Key to Indian *Hemithecium* species

- 1 Ascospores >100 µm in length 2
Ascospores <100 µm in length 8
- 2(1) Ascospores muriform 3
Ascospores trans-septate. 7
- 3(2) Lichen substances absent; ascomata strongly raised, simple to rarely branched,
1–7 mm long; exciple woody brown, 4–5 striate; asci 1–2-spored; ascospores
150–200 × 60–75 µm. **H. multistriatum (Müll. Arg.) Chitale & Makhija**
Lichen substances present 4
- 4(3) Salazinic acid present 5
Salazinic acid absent 6
- 5(4) Ascomata emergent, 1–9 mm long; exciple non-carbonized, 4–5 striate; ascospores
130–200 × 35–60 µm; only salazinic acid present
. **H. salacinilabiatum (Patw. & C. R. Kulk.) Chitale & Makhija**
Ascomata semi-emergent, 2–10 mm long; exciple non-carbonized, 2–3 striate;
ascospores 112–145 × 37–52 µm; salazinic and protocetraric acids present . . .
. **H. longilirellatum B. O. Sharma & Khadilkar**
- 6(4) Ascomata emergent, short, up to 1–10 mm long; exciple non-carbonized, striate;
ascospores 112–209 × 30–66 µm; stictic acid present
. **H. stictilabiatum (Patw. & C. R. Kulk.) Chitale & Makhija**
Ascomata semi-emergent, 0.5–5 mm long; exciple non-carbonized, internally
striate; ascospores 87–225 × 22–40 µm; norstictic acid present
. **H. norlabiatum (Patw. & C. R. Kulk.) B. O. Sharma & Khadilkar**
- 7(2) Ascomata 6–15 mm long, semi-emergent to distinctly emergent; simple to branched;
non-carbonized exciple, with subverrucose margin, heavily crenate; 10–25-trans-
septate ascospores, (45–)52–122 × 8–12 µm; constictic, norstictic and stictic
acids present
. **H. nagalandicum (Kr.P. Singh & G. P. Sinha) Adaw. & Makhija**
Ascomata 2–9(–12) mm long, semi-emergent to distinctly emergent; sparsely
branched; exciple dark blackish brown or slightly carbonized at the tips, 3–4 striate;
13–21-trans-septate ascospores, 49–112 × 7–14 µm; constictic, norstictic and
stictic acids present **H. amboliense Makhija & Dube**

2012	New <i>Fissurina</i> and <i>Hemithecium</i> species from India—Sharma et al.	355
8(1)	Ascospores <50 µm long.	9
	Ascospores >50 µm long.	20
9 (8)	Ascospores muriform	10
	Ascospores trans-septate.	14
10(9)	Lichen substances absent; ascomata immersed, simple, short, 1–2 mm long; exciple non-carbonized, entire; ascospores muriform, 16–20 × 5–7 µm.	
	. . . . . H. flavoalbum (Makhija et al.) B. O. Sharma & Khadilkar	
	Lichen substances present.	11
11(10)	Ascospores > 30 µm long	12
	Ascospores < 30 µm long	13
12(11)	Ascomata 1–8 mm long, simple to irregularly branched; exciple internally striate; ascospores 30–47 × 10–12 µm; stictic acid present	
	. . . . . H. kodayarensis B. O. Sharma & Khadilkar	
	Ascomata 1–20 mm long, simple to irregularly branched, flexuose; exciple indistinctly striate; ascospores muriform to submuriform, 20–40 × 10–15 µm; norstictic, stictic and constictic acids present.	
	. . . . . H. flexile (Makhija et al.) B. O. Sharma & Khadilkar	
13(11)	Ascomata 1.0–7.5 mm long, simple to irregularly branched, flexuous; exciple entire or with 1–2 striae; ascospores 17–21 × 8–14 µm; constictic, stictic, and norstictic acids present.	
	. . . . . H. microspermum Chitale et al.	
	Ascomata up to 2 cm long, simple to rarely branched; exciple woody brown, fan shaped, indistinctly striate, ascospores muriform, 20–25 × 8–9 µm; stictic, norstictic and constictic acids.	
	. . . . . H. andamanicum B. O. Sharma & Khadilkar	
14(9)	Protocetraric acid present; ascomata 0.5–6.0 mm long, simple to branched, immersed; exciple entire; ascospores 9–12-septate, 29–42 × 4–6 µm; protocetraric, stictic and constictic acids present	
	. . . . . H. fulvescens Adaw. & Makhija	
	Protocetraric acid absent	15
15(14)	Norstictic acid present	16
	Norstictic acid absent	17
16(15)	Ascomata 0.5–1.5 mm long, delicate, simple to radially or irregularly branched; exciple non-striate; ascospores 17–25 × 3–4 µm; stictic, consalazinic and norstictic acids present	
	. . . . . H. pulchellum Makhija & Adaw.	
	Ascomata 0.2–2.0 mm long, simple, triradiate or irregularly branched; exciple entire; ascospores 33–46 × 6–8 µm; norstictic and stictic acids present.	
	. . . . . H. balaghatense Adaw. & Makhija	
17(15)	Stictic acid absent; ascomata 0.5–3.0 mm long, simple to branched, immersed; exciple entire, orange-brown, with internal striae; ascospores 21–29 × 4–5 µm; consalazinic acid, testacein A and testacein B present	
	. . . . . H. staigeriae Adaw. & Makhija	
	Stictic acid present.	18
18(17)	Ascomata >10 mm long; ascomata 1–13 mm long, simple to branched, immersed; exciple entire; ascospores 21–33 × 3–4 µm; constictic and stictic acids present	
	. . . . . H. aphaneomicrosporum Makhija & Adaw.	
	Ascomata <10 mm long, mostly simple.	19

- 19(18) Ascomata 3–7 mm long; exciple non-carbonized, yellowish to woody brown, entire, ascospores 6–7-trans-septate, $16\text{--}21 \times 4\text{--}5 \mu\text{m}$; stictic acid present.
 **H. croceum Makhija & Adaw.**
 Ascomata 1–5 mm long; exciple non-carbonized, brown, entire; ascospores 10–15-trans-septate, $30\text{--}42 \times 7\text{--}10 \mu\text{m}$; stictic and constictic acid present.
 **H. verrucosum B. O. Sharma & Khadilkar**
- 20(8) Ascospores muriform 21
 Ascospores trans-septate. 22
- 21(20) Ascomata 2–6 mm long; exciple yellow to brown, simple to sparsely branched, 3–5 striate; ascospores $50\text{--}71 \times 15\text{--}25 \mu\text{m}$; stictic and constictic acids present
 **H. epixanthum (Mont. & Bosch) Chitale & Makhija**
 Ascomata short, 1–4 mm long; exciple simple to sparsely branched, fan-shaped, woody brown, 5–8 striate; ascospores $42\text{--}63 \times 8\text{--}17 \mu\text{m}$; no lichen substances present
 **H. flabillatum (Makhija *et al.*) B. O. Sharma & Khadilkar**
- 22(20) Salazinic acid present; ascomata 1–4 mm long, immersed to slightly raised; exciple entire, woody brown; ascospores $63\text{--}88 \times 6\text{--}8 \mu\text{m}$; constictic, salazinic, and stictic acids present **H. scariosum Makhija & Adaw.**
 Salazinic acid absent 23
- 23(22) Ascomata immersed in elevated wart-like structures (not in stroma), 0.3–1.5 mm long; exciple entire to striate, non-carbonized; ascospores $21\text{--}53 \times 6\text{--}9 \mu\text{m}$; constictic, norstictic and stictic acids present. **H. consociatum Makhija & Dube**
 Ascomata not in wart-like structures 24
- 24(23) Only norstictic acid present; ascomata 1–9 mm long, concolorous; exciple internally striate, occasionally slightly carbonized at the apex; ascospores $25\text{--}56 \times 7\text{--}8 \mu\text{m}$; only norstictic acid present **H. norsticticum Makhija & Dube**
 Norstictic with other acids present 25
- 25(24) Ascomata 2–7 mm long, simple to dendroidally branched; exciple entire to indistinctly striate; ascospores $30\text{--}40(\text{--}60) \times 6\text{--}9 \mu\text{m}$; constictic, norstictic (trace), and stictic acids present . **H. nakanishianum (Patw. & C. R. Kulk.) Makhija & Dube**
 Ascomata 0.5–10.0 mm long, simple or branched; exciple with 2–4 internal striae; ascospores $25\text{--}67(\text{--}80) \times 11\text{--}12 \mu\text{m}$; constictic, norstictic and stictic acids present. **H. aphanes (Mont. & Bosch) M. Nakan. & Kashiw.**

The Species

Hemithecium andamanicum (Makhija, Adaw. & Patw.) B. O. Sharma & Khadilkar comb. nov.

Mycobank No.: MB561862

Graphina andamanica Makhija, Adaw. & Patw., *Biovigyanam* 18(1): 22 (1992); type: India, Andaman Islands, South Andaman, Chidya Tapu, 15 February 1985, P. K. Sethy & P. G. Patwardhan 85.67 (AMH—holotypus!).

(Fig. 5A)

Remarks. *Hemithecium andamanicum* is characterized by: a greyish to white greyish, smooth, glossy thallus; pale brown, semi-emergent, long, up to 2 cm long, simple to rarely branched, thin ascocarps; proper exciple present below, non-carbonized, woody brown, fan shaped, indistinctly striate, encircled by the thalline margin; hyaline, clear hymenium; 8-spored asci; hyaline, muriform, $20\text{--}25 \times 8\text{--}9 \mu\text{m}$ ascospores; stictic, norstictic and constictic acids in the thallus.

Specimens examined. **India:** *Andaman Islands:* South Andaman, Pongibalu, Kala Pahad, 1985, P. G. Patwardhan & P. K. Sethy 85.1182, 85.1184, 85.1189; Chidya

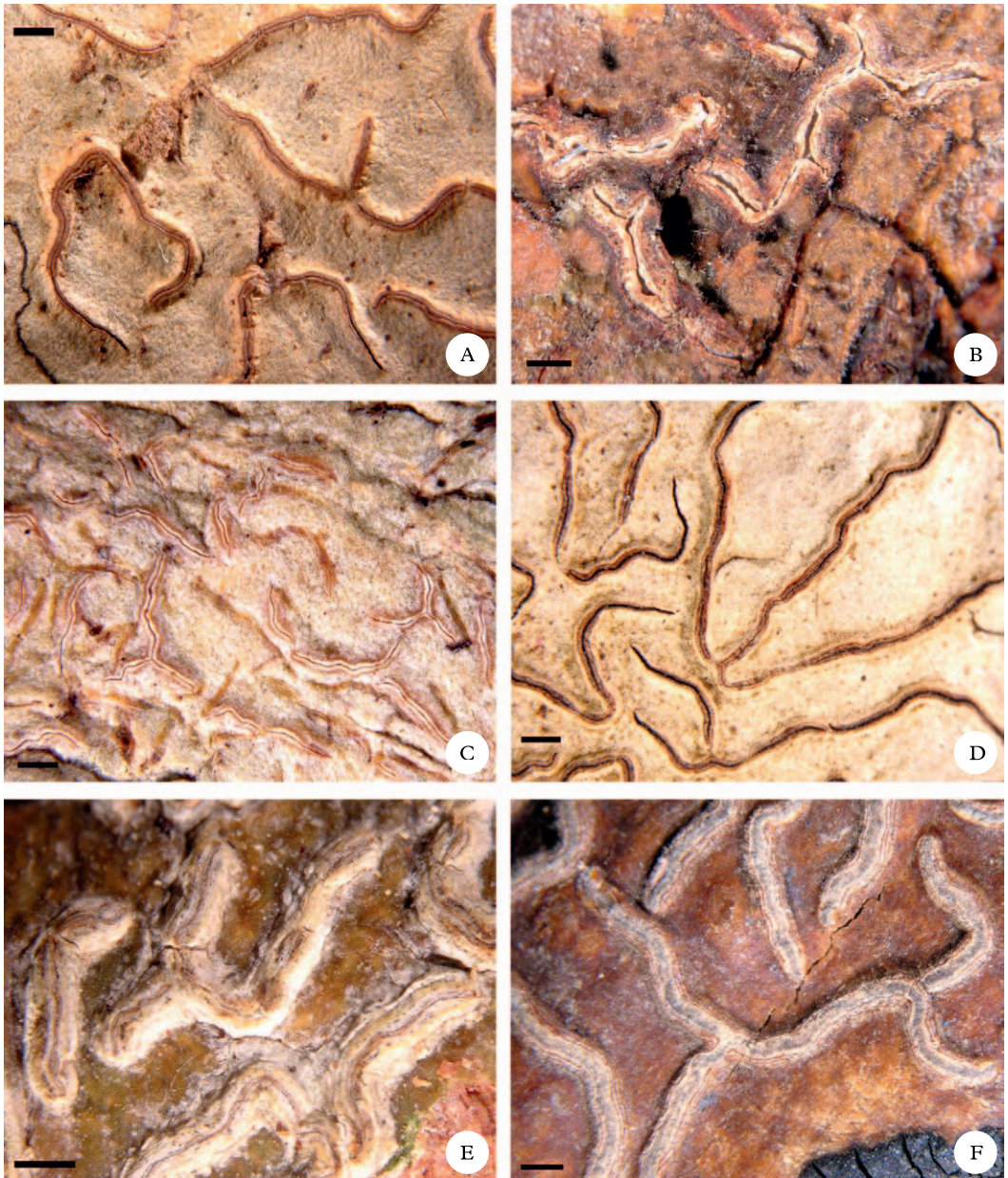


FIG. 5. *Hemithecium* species, habitus. A, *H. andamanicum* (85.67—holotype, AMH); B, *H. flabillatum* (85.2384—holotype, AMH); C, *H. flavoalbum* (85.47—holotype, AMH); D, *H. flexile* (86.364—holotype, AMH); E, *H. kodayarensis* (84.99—holotype, AMH); F, *H. longilirillatum* (85.2771—holotype, AMH). Scales: A–F = 1 mm. In colour online.

Tapu, 1985, P. K. Sethy & P. G. Patwardhan 85.65 (AMH).

Hemithecium flabillatum (Makhija, Adaw. & Patw.) B. O. Sharma & Khadilkar comb. nov.

Mycobank No.: MB561870

Graphina flabillata Makhija, Adaw. & Patw., *Biovigyanam* 18(1): 24 (1992); type: India, Andaman Islands, Middle Andaman, Betapur Range, Pitcher Nala, in evergreen forest, 26 December 1985, P. K. Sethy & P. G. Patwardhan 85.2384 (AMH—holotypus!).

(Fig. 5B)

Remarks. The species is characterized by: a brown, rough, delimited thallus; simple to rarely branched, short, 1–4 mm long ascocarps; white-pruinose disc; fan shaped, non-carbonized, woody brown, striate exciple; hyaline, clear hymenium; 8-spored asci; muriform, $42\text{--}63 \times 8\text{--}17 \mu\text{m}$ ascospores; no lichen substances in the thallus. *Hemithecium rufopallidum* (Vain.) Staiger is closely related to *H. flabillatum*, but differs in having 2–6-spored asci and large ascospores, $50\text{--}86 \times 17\text{--}30 \mu\text{m}$.

Hemithecium flabillatum appears to be endemic to the Andaman Islands of India, where it grows on exposed tree trunks on roadsides.

Specimens examined. India: Andaman Islands: Middle Andaman, Betapur Range, Pitcher Nala, in evergreen forest, 1985, P. G. Patwardhan & P. K. Sethy 85.2384, 85.2385, 85.2401, 85.2411 (AMH).

Hemithecium flavoalbum (Makhija, Adaw. & Patw.) B. O. Sharma & Khadilkar comb. nov.

Mycobank No.: MB561867

Graphina flavoalba Makhija, Adaw. & Patw., *Biovigyanam* 18(1): 24 (1992); type: India, Andaman Islands, South Andaman, Chidya Tapu, 15 February 1985, P. G. Patwardhan 85.47 (AMH—holotypus!).

(Fig. 5C)

Remarks. The species is characterized by: a grey-white, smooth thallus; immersed, simple, short, 1–2 mm long ascocarps; non-carbonized, entire, exciple; hyaline, clear hymenium; 8-spored asci; muriform, $16\text{--}20 \times 5\text{--}7 \mu\text{m}$ ascospores; no lichen substances in the thallus.

Hemithecium flavoalbum was found growing on tree trunks and is known from the type collection only.

Hemithecium flexile (Makhija, Adaw. & Patw.) B. O. Sharma & Khadilkar comb. nov.

Mycobank No.: MB561868

Graphina flexilis Makhija, Adaw. & Patw., *Biovigyanam* 18(1): 25 (1992); type: India, Andaman Islands, North Andaman, Diglipur forest, Millangram in evergreen forest, 3 January 1986, M. B. Nagarkar & P. G. Patwardhan 86.364 (AMH—holotypus!).

(Fig. 5D)

Remarks. This species is characterized by: a greyish white, cracked, smooth, glossy, delimited thallus; lirellae, short to long and up to 1–20 mm long, simple to irregularly branched, flexuose, concolorous with the thallus, semi-emergent to moderately emergent, terminally acute ascocarps; convergent, non-carbonized, woody brown, indistinctly striate exciple; hyaline, clear hymenium; 8-spored asci; muriform to submuriform, hyaline, ascospores $20\text{--}40 \times 10\text{--}15 \mu\text{m}$, and norstictic, stictic and constictic acids in the thallus.

Remarks. The species is found also on the mainland of India in the evergreen forest of the Western Ghats.

Additional specimens examined. India: Andaman Islands: North Andaman, Diglipur Range, kalara, in evergreen forest, 1986, M. B. Nagarkar & P. K. Sethy 86.394, 86.423, 86.443; Tugapur Range, Mayabandar, Pather Tikri, in moist deciduous forest, 1985, M. B. Nagarkar & P. G. Patwardhan 85.2575, 85.2594, 85.2692; *ibid.* P. G. Patwardhan & P. K. Sethy 85.2587; Middle Andaman, Parlobjig Islands, 1985, M. B. Nagarkar & P. K. Sethy 85.2306; Betapur Range, Dhaninala, 1985, M. B. Nagarkar & P. G. Patwardhan 85.2525; South Andaman, Shol Bay, near Wright Myo, 1986, P. K. Sethy & P. G. Patwardhan 86.692. *Karnataka:* Jog-Honawar road, 10 km from Jog, 1974, C. R. Kulkarni 74.2779, 74.2780; Sitanadi, Agumbe-Udipi road, 1974, P. G. Patwardhan & M. B. Nagarkar 74.3054, 74.3055; Khushalnagar, Coorg, 1974, M. B. Nagarkar & A. V. Prabhu 74.3284; Londha-Dharwar road, 5 km from Londha, 1974, A. V. Prabhu & M. B. Nagarkar 74.2540, 74.2541; Devimane Ghat, Sirsi-Kumtha road, 1974, P. G. Patwardhan & M. B. Nagarkar 74.2614. *Kerala:* Anamalai hills, Sholayar,

near dam in the ravine, 1976, C. R. Kulkarni, 76.326; Ponmudi, 1973, P. G. Patwardhan & M. B. Nagarkar 73.2630, 73.2643, 73.2673, 73.2658 (AMH).

***Hemithecium kodayarensis* B. O. Sharma & Khadilkar sp. nov.**

Mycobank No.: MB561863

Similar *Hemithecium nagalandicum*, sed ascoporis minoribus et acido stictico continente differt.

Typus: India, Tamil Nadu, Upper Kodyar, Agasthi Hills, in moist deciduous forest elev. c. 1400 m, 20 February 1984, P. G. Patwardhan & P. K. Sethy 84.99 (AMH—holotypus).

(Figs 5E & 7A)

Thallus crustose, corticolous, epiphloeodal, creamish grey, cracked, smooth, dull to slightly rough, delimited by thin black hypothallus.

Ascomata lirelline, 1–8 mm long, simple to irregularly branched, concolorous with the thallus, emergent, terminally round. *Exciple* convergent, non-carbonized, striate, covered by the raised thalline margin. *Hymenium* hyaline, clear, 100–125 µm in height. *Paraphyses* simple. *Asci* 8-spored. *Ascospores* muriform to submuriform, hyaline 30–47 × 10–12 µm, weakly I+ violet or almost I–.

Chemistry. Stictic acid present.

Remarks. The new species can be differentiated from the externally somewhat similar *Hemithecium nagalandicum* (Kr. P. Singh & G. P. Sinha) Adawadkar & Makhija by its muriform, smaller ascospores and the presence of stictic acid only (*H. nagalandicum* has transversely septate, large ascospores, 52–122 × 8–12 µm and contains norstictic, constictic and stictic acids). *Hemithecium radicolica* (A. W. Archer) A. W. Archer, a species from Australia having only stictic acid and muriform ascospores, 35–40 µm long, differs from the new species by its initially fissurine lirellae and the absence of a proper exciple.

Additional specimens examined. **India:** Tamil Nadu: Upper Kodyar, Agasthi Hills, in moist deciduous forest elev. c. 1400 m, 1984, P. G. Patwardhan & P. K. Sethy 84.137, 84.138 (AMH).

***Hemithecium longilirellatum* B. O. Sharma & Khadilkar sp. nov.**

Mycobank No.: MB561864

Species nova distinctus inter omnibus *Hemithecium* speciebus ob praesentia acidarum salazinicis et protocetraricis.

Typus: India, Andaman Islands, North Andaman, Mayabandar Range, Kaichi Nala, moist deciduous forest, 30 December 1985, P. G. Patwardhan & P. K. Sethy 85.2771 (AMH—holotypus).

(Figs 5F & 7B)

Thallus crustose, corticolous, epiphloeodal, brown, smooth, delimited by a black thin, hypothallus.

Ascomata lirelline, 2–10 mm long, pale brown, simple to branched, irregular, slender, semi-emergent, terminally rounded. *Exciple* non-carbonized, brown, striate, present below, encircled by the thalline margin with pseudocortex and crystals. *Hymenium* hyaline, clear, 150–200 µm high. *Paraphyses* simple. *Asci* 1-spored. *Ascospores* hyaline, muriform, 112.5–145.0 × 37.5–52.5 µm, weakly I+ violet.

Chemistry. Salazinic and protocetraric acids present.

Remarks. *Hemithecium longilirellatum* is characterized by: long, irregularly curved lirellae; striate exciple; 1-spore asci; muriform, large, ascospores; salazinic and protocetraric acids in the thallus.

The new species can be differentiated from the other species of *Hemithecium* having more or less similar morphological features and large, muriform ascospores: *Hemithecium orizaeforme* (Fée) Staiger, *H. chlorocarpum* (Fée) Trevis., *H. salazinilabiatum* (Patw. & C. R. Kulk.) Chitale & Makhija, *H. stictilabiatum* (Patw. & C. R. Kulk.) Chitale & Makhija and *H. multistriatum* (Müll. Arg.) Chitale & Makhija all have differences in their chemistry. *Hemithecium orizaeforme* contains norstictic acid, *H. chlorocarpum* has no lichen substances, *H. salazinilabiatum* has salazinic acid, *H. stictilabiatum* contains stictic acid, and *H. multistriatum* has no lichen acids.

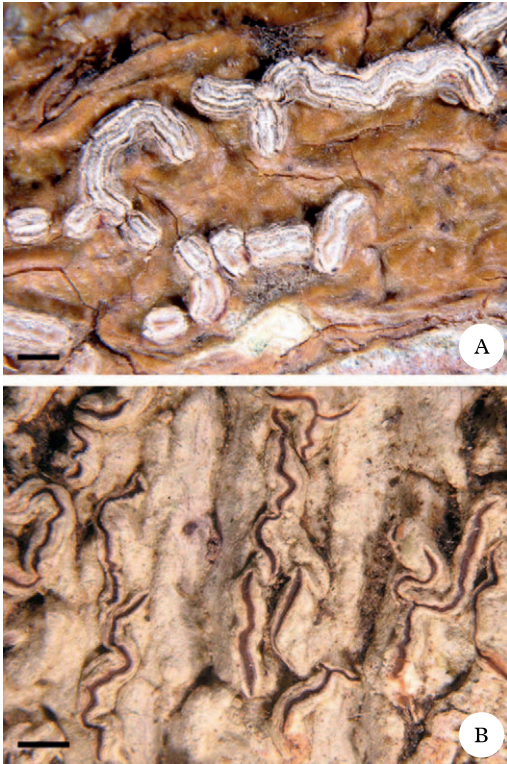


FIG. 6. *Hemithecium* species, habitus. A, *H. norlabiatum* (74.3243—holotype, AMH); B, *H. verrucosum* (04.281—holotype, AMH); Scales A & B = 1mm. In colour online.

The species has been collected in the moist deciduous forest areas of the Andaman Islands.

Additional specimen examined. India: Andaman Islands: North Andaman, Mayabandar Range, Kaichi Nala, moist deciduous forest, 1985, *P. G. Patwardhan & P. K. Sethy* 85.2790 (AMH).

***Hemithecium norlabiatum* (Patw. & C. R. Kulk.) B. O. Sharma & Khadilkar comb. nov.**

Mycobank No.: MB561866

Graphina norlabiata Patw. & C. R. Kulk., *Biovigyanam* 5: 6 (1979); type: India, Karnataka, Agumbe, 2 km on Koppa road, in rainforest, 17 December 1974, *C. R. Kulkarni* 74.3243 (AMH—holotypus!).

(Fig. 6A)

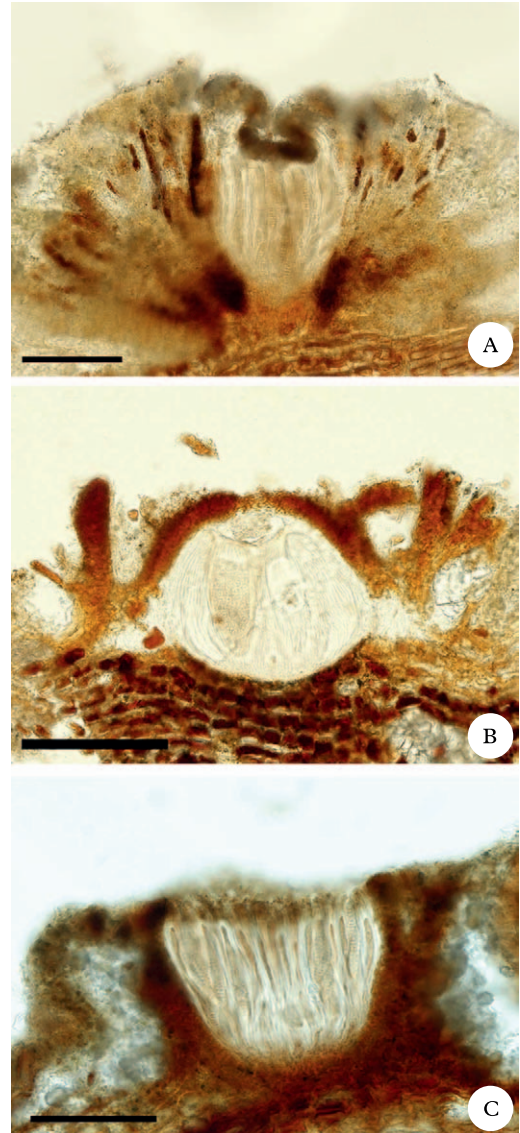


FIG. 7. *Hemithecium*, sections of ascocarps. A, *H. kodayarensis* (84.99—holotype, AMH); B, *H. longilirellatum* (85.2771—holotype, AMH); C, *H. verrucosum* (04.281—holotype, AMH). Scales A–C = 100 µm. In colour online.

Remarks. The species is characterized by: a citrine green to pale olivaceous buff, smooth to uneven, glossy, cracked thallus; 0.5–5.0 mm long, simple, curved, flexuous, semi-emergent, white to dull, pale brownish or concolorous ascocarps; non-carbonized,

brown, indistinctly striate exciple; a hyaline, clear, hymenium; 1–2-spored asci; hyaline, muriform, 87–225 × 22–40 µm ascospores; norstictic acid in the thallus.

Additional specimens examined. India: Karnataka: Devimane Ghat, 1974, *M. B. Nagarkar & A. V. Prabhu* 74.3244; Someshwar, 1982, *P. G. Patwardhan* 82.711; near Agumbe, 1977, *P. G. Patwardhan* 77.411, 77.414, 77.415; Anmod Ghat, 1975, *C. R. Kulkarni & M. B. Nagarkar* 75.564; Hebri, 74.3020, 74.3021, 74.3244. *Kerala:* Silent Valley, 1976, *M. B. Nagarkar* 76.221, 76.222, 76.223, 76.233, 76.234; Chalkudi, 40 kms, 1976, *A. V. Prabhu & M. B. Nagarkar* 76.293; Attapadi, 1976, *M. B. Nagarkar* 76.212, 76.213 (AMH).

***Hemithecium verrucosum* B. O. Sharma & Khadilkar sp. nov.**

Mycobank No.: MB561865

Similis *Hemithecii aphanemicrospori*, sed thallo verruculoso et ascosporis majoribus differt.

Typus: India, Karnataka, Dandeli forest, 5 October 2004, *U. V. Makhija* 04.281 (AMH—holotypus).

(Figs 6B & 7C)

Thallus crustose, corticolous, epiphloeodal, creamish, cracked, warty, verrucose, shiny, delimited with black hypothallus.

Ascomata lirelline 1–5 mm long, simple, rarely branched, emergent, wavy, curved, raised, terminally acute. *Disc* reddish brown, broad, pruinose. *Exciple* brown, entire, non-carbonized, present at the base, covered by the thick thalline margin with pseudocortex. *Hymenium* hyaline, clear, 100–125 µm high. *Paraphyses* simple. *Asci* 8-spored. *Ascospores* transversely septate, 10–15 septa, 30–42 × 7–10 µm, I+ purple.

Chemistry. Stictic and constictic acids present.

Remarks. The new species is characterized by its verruculose thallus, simple, emergent lirellae, trans-septate ascospores, and stictic and constictic acids in the thallus.

The species can be compared with *Hemithecium aphanemicrosporum* Makhija & Adawadkar in having more or less similar exciple characters, transversely septate ascospores and chemistry, but it differs from

the new species in having slightly smaller ascospores, 21–33 × 3–4 µm.

Additional specimens examined. India: Karnataka: Dandeli forest, 2004, *U. V. Makhija* 04.294, 04.265 (AMH).

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