

## Trans-septate species of *Acanthothecis* and *Fissurina* from India

Urmila MAKHIJA and Bharati ADAWADKAR

**Abstract:** Eighteen species in the lichen genera *Acanthothecis* Clem. and *Fissurina* Fée (*Graphidaceae*) with colourless, trans-septate ascospores are recorded from India. Eight new species, namely *Acanthothecis collateralis*, *Fissurina capsulata*, *F. coarctata*, *F. karnatakensis*, *F. khasiana*, *F. longiramea*, *F. taeniocarpoides* and *F. verrucosa*, and a new variety, *F. dumastioides* var. *salazimica*, are described. *Fissurina saxicola* ad int., clearly distinguished from the other species is recorded, but is not formally described as new to science as the material is scanty. *Acanthothecis consocians*, *F. globulifera*, *F. insidiosa* and *F. rugosa* are reported for the first time from India. A key for the trans-septate species of *Acanthothecis* and *Fissurina* in India is provided.

**Key words:** Ascomycetes, *Graphidaceae*, lichenized fungi, taxonomy

### Introduction

The family *Graphidaceae* with 918 species worldwide (Kirk *et al.* 2001), is one of the largest groups of crustose lichens and is widely distributed mainly in the tropical regions. Several lichenologists have contributed to the knowledge of the family. Noteworthy contributions include the publications recording several species from Ceylon (Leighton 1869), the Philippines, Siam (Vainio 1921*a, b*), Thailand (Nakanishi *et al.* 2001), India (Awasthi 2000), Japan and adjacent areas (Nakanishi 1966; Nakanishi & Harada 1999; Nakanishi *et al.* 2002, 2003), Brazil (Redinger 1935), Mexico (Wirth & Hale 1963), Dominica (Wirth & Hale 1978), Guiana (Sipman 1994) and from Australia (Archer 2001*a, b, c*, 2004).

The family in India, represented mainly by the genera *Graphina* (60 species), *Graphis* (74 species), *Phaeographina* (25 species), and *Phaeographis* (32 species) (Awasthi 1991, 2000), is still inadequately studied and many of the taxa recorded are in need of revision. Several taxa have been recorded in many scattered publications (Awasthi &

Singh K. 1975; Awasthi & Singh S. 1977; Patwardhan & Kulkarni 1976, 1979; Kulkarni 1977; Nagarkar & Patwardhan 1982; Singh 1984; Singh & Sinha 1994; Makhija *et al.* 1992*a, b*), but there has never been a comprehensive treatment of the members of the family in India.

Against this background, we are currently undertaking a detailed survey of *Graphidaceae*. The revision of the genus *Graphis* Adans. *sensu* Müller Arg. (1880, 1882) from India, revealed the occurrence of 145 species from this area but following Staiger (2002) many have been subsequently treated in different genera (Adawadkar & Makhija 2004, 2005; Makhija & Adawadkar 2005*a, b*; Makhija *et al.* 2005). Species with spiny periphysoids and/or periphyses, previously described under *Graphis*, have now been placed in the genera *Acanthothecis* Clem. and *Fissurina* Fée (Staiger & Kalb 1999; Staiger 2002). Consequently, a number of South-East Asian species have been transferred to the genus *Fissurina*; namely *F. flavicans* (Kashiw.) M. Nakan. & Kashiw., *F. fujisanensis* (Kashiw. & M. Nakan.) M. Nakan. & Kashiw., *F. inabensis* (Vain.) M. Nakan. & Kashiw., *F. rufula* (Mont.) Staiger, *F. subtropica* (M. Nakan.) M. Nakan. & Kashiw., and *F. undulata*

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(Müll. Arg.) M. Nakan. & Kashiw. (Nakanishi *et al.* 2003).

Eleven *Graphis* species transferred to the genus *Fissurina* have previously been recorded from India, namely *G. canlaonensis* Vain., *G. batavana* Zahlbr., *G. dumastii* (Fée) Spreng., *G. dumastioides* Fink, *G. furfuracea* Leight., *G. homichlodes* Redinger, *G. implexula* Stirton, *G. inquinata* (C. Knight & Mitt.) J. D. Hooker, *G. karstenii* Zahlbr., *G. subnitidula* Nyl. in Tuck., and *G. triticea* Nyl. (Awasthi, 1991, 2000; Makhija *et al.* 1992a). In a previous paper we have recorded one species of *Acanthothecis*, *A. nivalis*, from India (Makhija & Adawadkar 2003).

In the present study we recognize three species in the genus *Acanthothecis* and fifteen species and a variety having colourless, trans-septate ascospores in *Fissurina* from India.

**Materials and Methods**

Sections of thalli and the ascomata were mounted in water, 10% KOH (K), Lugol's solution (L), and lactophenol cotton-blue (LPCB). All measurements were made on material mounted in water. The iodine reaction of the hymenium was studied in Lugol's iodine solution after pretreatment with K(KI). The secondary products of the specimens were identified by thin-layer chromatography using methods standardized for lichen products (Culberson & Kristinsson 1970; Culberson 1972; White & James 1985) using solvent systems benzene-dioxane-acetic acid (180:45:5), hexane-diethylether-formic acid (130:100:20) and toluene-ethyl acetate-formic acid (139:83:8). All chromatograms were observed under UV light (365 nm).

Morphological and chemical data, based on the re-examination of type or authentic material of several taxa in the *Graphidaceae* together with photographs of type specimens provided by the late Dr Mason Hale during his several visits to our laboratory at ARI have been available to us. This data has been used for the identification of species.

**Key to *Acanthothecis* and *Fissurina* species in India**

- 1 Ascospores hyaline, oblong and without thick, jelly-like outer spore wall; spore locules cylindrical . . . . . 2
- Ascospores hyaline, ovoid, ellipsoid or globose, with ± thick, jelly-like outer spore wall; spore locules lens shaped, or globose . . . . . 4
- 2(1) Lichen substances absent; ascomata indistinct, whitish, lirelline, branched, slightly raised, thin; exciple non-striate, pale brown, non-carbonized, present at the base; ascospores 5–6-trans-septate, 14–20 × 3–4 µm . . **Acanthothecis consocians**
- Lichen substances present . . . . . 3
- 3(2) Ascomata blackish, distinct, immersed to raised, 0.2–1.2 mm long, 2–5 lirellae placed side by side, more or less parallel to each other; exciple non-striate, blackish brown to carbonized at the tips, present at the base; periphysoids short, with slightly elongate warty tips; ascospores 3-trans-septate, 16–21 × 3–4 µm; norstictic acid present . . . . . **Acanthothecis collateralis**
- Ascomata white, mealy, raised, 2–8 mm long; exciple non-carbonized; periphysoids with 24–32 µm long, warty tips; ascospores 4–7-trans-septate, 8–16 × 3–4 µm; psoromic acid present . . . . . **Acanthothecis nivalis**
- 4(1) Thallus saxicolous. Thallus warty, cracked; ascomata concolorous with the thallus, immersed, 1–3 mm long; exciple non-striate, non-carbonized; present at the base; ascospores 3-trans-septate, 17–25 × 6–8 µm; stictic acid present . . . . . **Fissurina saxicola**
- Thallus corticolous . . . . . 5
- 5(4) Lichen substances absent . . . . . 6
- Lichen substances present . . . . . 13

- 6(5) Ascospores hyaline, or rarely brownish afterwards, thallus greenish brown, verrucose; ascomata concolorous, 0.5–1 mm long, simple to rarely branched; disc very narrow; ascospores 3-trans-septate,  $13\text{--}16 \times 3\text{--}5 \mu\text{m}$  . . . ***Fissurina rugosa***  
Ascospores always hyaline . . . . . 7
- 7(6) Hypothecium very thick, up to 40  $\mu\text{m}$ ; thallus brownish, glossy; ascomata scattered, 1–3 mm long, concolorous, immersed, simple to branched; exciple non-carbonized, non-striate, globose, present at base; hypothecium yellowish, 36–42  $\mu\text{m}$  thick; ascospores 3-trans-septate, occasionally with 1 vertical septum,  $9\text{--}14 \times 4\text{--}6 \mu\text{m}$  . . . . . ***Fissurina globulifica***  
Hypothecium not more than 20  $\mu\text{m}$  thick . . . . . 8
- 8(7) Thalline margin with swollen tissue (“puff”) . . . . . 9  
Thalline margin without swollen tissue (“puff”) . . . . . 11
- 9(8) Ascomata intricate, anastomosed; thallus stramineous or greenish; ascomata concolorous with the thallus, ribbon like, very long; exciple non-striate, non-carbonized, reddish, indistinctly present at base, swollen on the inner sides and flattened at the top, leaving hardly any space; ascospores 3-trans-septate,  $8\text{--}16 \times 3\text{--}4 \mu\text{m}$  in size . . . . . ***Fissurina taeniocarpoides***  
Ascomata simple or branched, not anastomosed; exciple not flattened at the top . . . . . 10
- 10(9) Thallus dull green, uneven; ascomata 0.5–2.5 mm long, simple to branched; exciple non-striate, round at the apical region, present below; ascospores 3-trans-septate,  $11\text{--}16 \times 4\text{--}5 \mu\text{m}$ , with a conspicuous, 3–5  $\mu\text{m}$  thick halo . . . . . ***Fissurina capsulata***  
Thallus yellowish green, rugose; ascomata concolorous, 1–5 mm long, mostly unbranched, emergent; exciple non-striate, indistinct at the base, non carbonized; ascospores 3-trans-septate,  $12\text{--}25 \times 8\text{--}10 \mu\text{m}$  . . . . . ***Fissurina insidiosa***
- 11(8) Ascomata minute, less than 1 mm long, crowded, concolorous with the thallus, unbranched, straight, immersed to slightly raised; exciple non-striate, indistinct at the base; ascospores 3-trans-septate,  $14\text{--}18 \times 6\text{--}8 \mu\text{m}$  . . . . . ***Fissurina coarctata***  
Ascomata more than 3 mm long . . . . . 12
- 12(11) Ascomata 8–13 mm long, concolorous with the thallus, flexuose, immersed to slightly raised; exciple non-striate, present at the base, orange-yellow to brownish; ascospores 3-trans-septate,  $8\text{--}16\text{--}(21) \times 3\text{--}4\text{--}(6) \mu\text{m}$  . . . . . ***Fissurina longiramea***  
Ascomata 3–7 mm long, concolorous with the thallus, simple to branched; exciple absent below, convergent; ascospores 3-trans-septate,  $10\text{--}14 \times 4\text{--}5 \mu\text{m}$  . . . . . ***Fissurina dumastii***
- 13(5) Thalline margin with swollen tissue (“puff”); thallus olivaceous green; ascomata short, 0.5–1 mm long, unbranched; exciple indistinct at base; ascospores 3-trans-septate,  $16\text{--}24 \times 10\text{--}12 \mu\text{m}$ ; stictic acid present . . . ***Fissurina triticea***  
Thalline margin without swollen tissue (“puff”) . . . . . 14
- 14(13) Ascomatal structure “dumastii type” (Staiger, 2002) . . . . . 15  
Ascomatal structure “comparilis type” (Staiger, 2002) . . . . . 16

- 15(14) Ascomata 0.5–3.5 mm long, simple to branched; ascospores 3-trans-septate, 10–12 × 4–6 µm; stictic acid present . . . . . **Fissurina dumastioides**  
 Ascomata 0.5–4 mm long, simple to branched; ascospores 3-trans-septate, 11–14 × 4–6 µm; stictic and salazinic acids present . . . . .  
 . . . . . **Fissurina dumastioides var. salazinic**
- 16(14) Protocetraric and fumarprotocetraric acids present . . . . . 17  
 Protocetraric and fumarprotocetraric acids absent . . . . . 18
- 17(16) Thallus smooth; ascomata concolorous, large, 1–6 mm long, simple to irregularly branched; exciple non-striate; ascospores 3-trans-septate, 14–21 × 3–4 µm . . . . . **Fissurina karnatakensis**  
 Thallus distinctly verrucose; ascomata concolorous, minute, 0.2–0.3 mm long, simple to branched, in scattered groups; exciple non-striate or with 2 striae; ascospores 3-trans-septate, 7–12 × 3–4 µm . . . . . **Fissurina verrucosa**
- 18(16) Thallus yellowish orange; ascomata minute, simple, concolorous, 0.2–0.4 mm long, in groups of several lirellae; exciple dark brown, slightly carbonized at the tips, non-striate, present at the base; ascospores 3-trans-septate, 13–15 × 4–5 µm; stictic acid present . . . . . **Fissurina inquinata**  
 Thallus greenish grey, smooth; ascomata large, not in groups, black, 2–4 mm long, simple to irregularly branched; exciple brownish at the tips, present at the base; ascospores 3-trans-septate, 16–19 × 8–10 µm; stictic and constrictic acids present . . . . . **Fissurina khasiana**

### The Species

#### ***Acanthothecis collateralis* Makhija & Adawadkar sp. nov.**

*Acanthothecis collateralis* distincte differt inter omnibus *Acanthothecis* specibus ob ascomata lirellina, collateraliter (± parallele) disposita, a specibus nobis notis bene distincta.

Typus: India, Andaman Islands, South Andaman, Baratang Island, Lorojig, 19 February 1985, P. G. Patwardhan, 85.259 (AMH—holotypus).

(Figs 1A, 2A & E)

*Thallus* corticolous, creamy, off-white, smooth, finely cracked, delimited by thin, light to slightly darkened hypothallus.

*Ascomata* lirelline, 0.2–1.2 mm long, mostly simple, very rarely branched, immersed to raised, in groups of 2–5 lirellae arranged side by side, more or less parallel to each other, bordered by whitish rim, narrow, with obtuse ends. *Disc* narrow, reddish brown to black, pruinose. *Exciple* brown, non-striate, present at the base, convergent, covered by a thalline margin up to the top, apically carbonized or not. *Hymenium* hyaline, not interspersed, 84–100 µm high and

117–126 µm broad, I–, KI–. *Hypothecium* hyaline, thin. *Paraphyses* simple, long, thin, filiform. *Periphysoids* short, with slightly elongate, warty tips. *Asci* cylindrical, 8-spored, 42–50 × 8–10 µm. *Ascospores* 3-trans-septate, oblong, 16–21 × 3–4 µm, I–, KI–.

*Chemistry.* K+ yellow red, C–, KC–, P+ orange; UV–; norstictic and stictic (trace) acids present.

*Remarks.* *Acanthothecis collateralis* contains norstictic and stictic acids in its thallus. Other species containing norstictic acid, namely *A. africana* Staiger & Kalb, *A. aurantiaca* (Müll. Arg.) Staiger & Kalb, *A. farinosa* ad int. (Staiger 2002) and *A. silvicola* (Redinger) Staiger & Kalb, all have ascospores with more than 4 locules. *Acanthothecis rosea* (Vain.) Staiger & Kalb, a species from Dominica is the only other species of *Acanthothecis* which has 4-locular ascospores. However, in this species the ascocarps are coloured rose pink, oblong, large, up to 10 mm long with brown

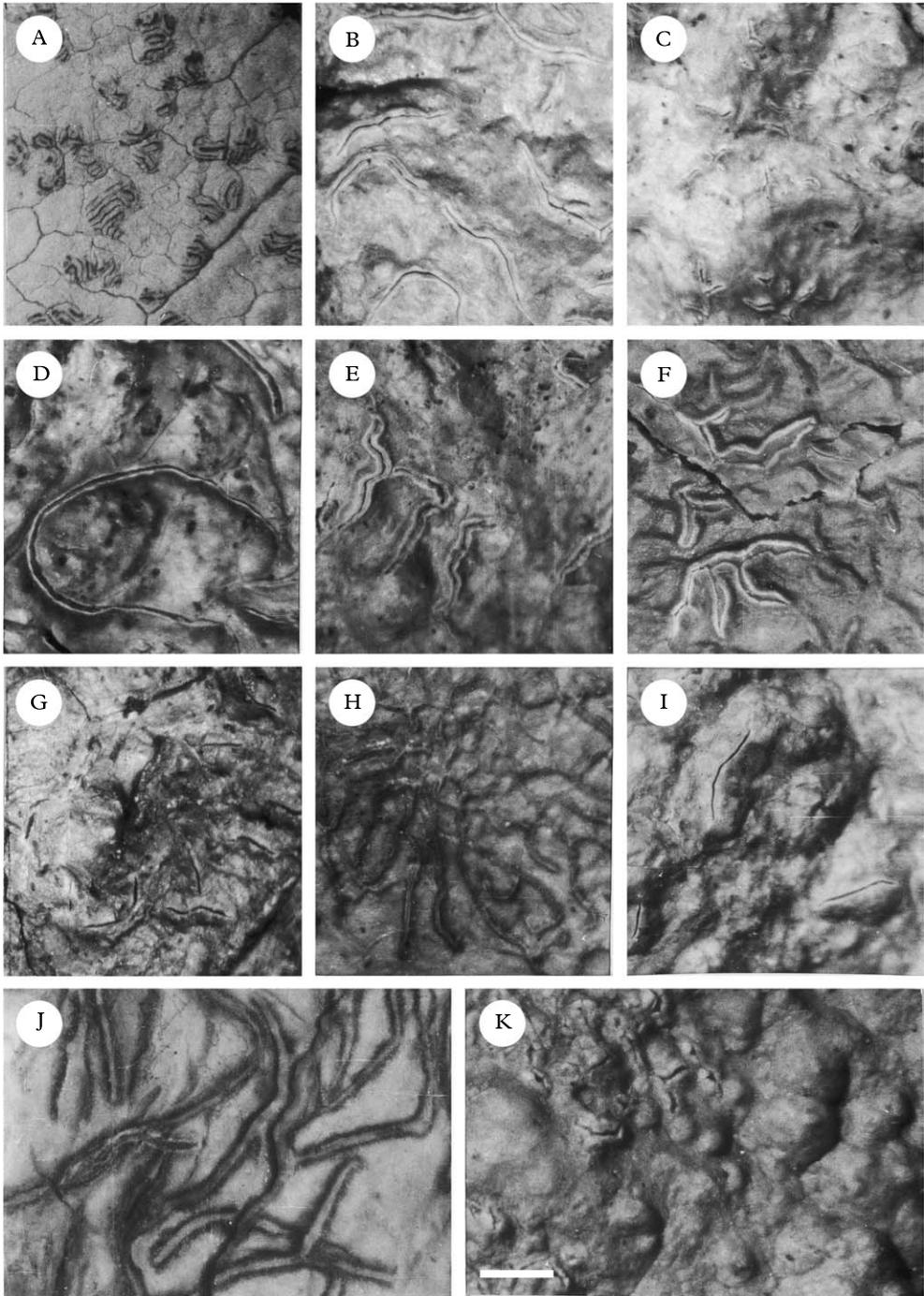


FIG. 1. *Acanthothecis* and *Fissurina* species, habitus. A, *A. collateralis* (holotype); B, *F. capsulata* (holotype); C, *F. coarctata* (holotype); D, *F. dumastioides* var. *salazimica* (holotype); E, *F. globulifica* (87.5); F, *F. karnatakensis* (holotype); G, *F. khasiana* (holotype); H, *F. longiramea* (holotype); I, *F. saxicola* (76.691); J, *F. taeniocarpoides* (holotype); K, *F. verrucosa* (holotype). All specimens in AMH. Scale: A–K=1 mm.

ascospores and the species contains the pigment isohypocrelline.

The new species can easily be distinguished by the 2–4(–5) ascomata arranged side by side, more or less in parallel fashion in groups all over the thallus and by its colourless, 4-locular ascospores.

The species appears to be a rare endemic from India and has been collected only once in the tropical rain forest in the Andaman Islands where it grows on exposed tree trunks.

*Specimen examined.* **India:** Andaman Islands: Baratang Island, Lorojig, 1985, *P. G. Patwardhan* 85.458A (AMH).

### ***Acanthothecis consocians* (Nyl.) Staiger & Kalb**

*Mycotaxon* 73: 97 (1999).

*Graphis consocians* Nyl., *Bull. Soc. Linn. Normand.*, sér. 2, 2: 116 (1868).

*Thallus* corticolous, pale white, effuse, epruinose.

*Ascomata* lirelline, white, very thin, delicate, slightly raised above the thallus, simple to branched, slender, 3–6 mm long and 0.25 mm broad with acute to subacute ends. *Disc* narrow, light brown, pruinose. *Exciple* brown, non-striate, present at the base, convergent, covered by a thalline margin up to the top. *Hymenium* hyaline, not interspersed, 80–90 µm high and 80–115 µm broad, I–, KI–. *Hypothecium* hyaline. *Paraphyses* simple, long, thin, filiform, septate, with warty tips. *Periphysoids* short, with slightly elongate warty tips. *Asci* 8-spored, 42–71 × 8–10 µm. *Ascospores* 5–6-trans-septate, ellipsoidal, 14–20 × 3–4 µm, I–, KI–.

*Chemistry.* K–, C–, KC–, P–; UV–; no lichen substances present.

*Remarks.* Staiger and Kalb (1999) reported the occurrence of psoromic acid in this species. According to an annotation by Nakanishi on the holotype from New Caledonia (H-NYL), it lacks any lichen substances as do the specimens studied here.

*Acanthothecis consocians* appears to be a rare species. In India it has been collected in evergreen forests where it grows on exposed tree trunks in two localities, one in the Andaman Islands and the other in the foothills of the Himalayas in Assam.

Previously known from New Caledonia and Papua New Guinea, *Acanthothecis consocians* is reported here for the first time from India.

*Specimens examined.* **India:** Middle Andaman: Pitcher Nala, Betapur Range, in tropical evergreen forest, 1985, *P. G. Patwardhan* 85.2362 (AMH). Assam: Maniknagar, evergreen forest, 1977, *M. B. Nagarkar* 77.1197 (AMH).

### ***Acanthothecis nivalis* Makhija & Adawadkar**

*Mycotaxon* 88: 139 (2003): type: India, Andaman Islands, North Andaman, Mayabandar Range, Kaichi Nala, in moist deciduous forest, 30 Jan. 1985, *M. B. Nagarkar* & *P. K. Sethy* 85.2804 (AMH—holotype)!

*Thallus* corticolous, brown, irregularly cracked, epruinose, delimited with a distinct, black hypothalloidal region at the periphery, studded with numerous colourless crystals.

*Ascomata* white, mealy, lirelline, raised above the thallus, simple to branched, slender, 2–8 mm long and 0.25 mm broad, with acute ends, disc not visible when dry but when wet appears brown, very narrow, slit like. *Excipulum* non-carbonized, pale orange brown, non-striate to striate, convergent. *Hymenium* 58–63 µm high, not interspersed, I–, KI–. *Paraphyses* 1 µm thick, tips hyaline, distinctly warty. *Periphysoids* emerging out of the inner side and the edge of the proper exciple covering the disc, distinctly warty, 24–32 µm long. *Ascospores* 8-spored ascus, hyaline, trans-septate 4–7-septate, 8–16 × 3–4 µm, I–, KI–.

*Chemistry:* K–, C–, KC–, P+ yellow red, UV–. Psoromic acid present.

*Remarks.* *Acanthothecis nivalis* can easily be identified by its pure white, effuse, raised lirellate, slender, branched ascomata, 2–8 mm long and up to 0.25 mm broad with

a non-carbonized exciple, its 4–7-trans-septate ascospores,  $8\text{--}16 \times 3\text{--}4 \mu\text{m}$ , and by the presence of psoromic acid in the thallus.

This species was collected from tree trunks in the moist deciduous forest of North Andaman and from the evergreen forest of Middle Andaman where the vegetation is typically tropical dominated by *Dipterocarpaceae* and rich in *Pleurocarpus* and *Mesua ferea*. The corticolous, pyrenocarpous, graphidaceous lichens and thelotremes predominate in the lichen flora of these islands.

*Specimen examined. India: Middle Andaman:* Betapur Range, Pitcher Nala, in evergreen forest, 1985, P. G. Patwardhan & P. K. Sethy, 85.2372 (AMH).

### **Fissurina capsulata Makhija & Adawadkar sp. nov.**

Structura propria ascomatis ut in stirpe *Fissurina subcontexta* sed species nova distincta inter omnibus *Fissurina* specibus ob ascosporeae strato gelatinoso,  $3\text{--}5 \mu\text{m}$  crasso, vulgo inaequaliter indutae.

Typus: India, Tamil Nadu, Kodaikanal, near Daisy Bank, 25 January 1975, P. G. Patwardhan & A. V. Prabhu 75.373 (AMH—holotypus).

(Figs 1B, 2B & F)

*Thallus* corticolous, pale green or dull green, uneven, cracked.

*Ascomata* lirelline,  $0.5\text{--}2.5 \text{ mm}$  long, simple to branched, concolorous with the thallus, immersed to slightly raised, acute to subacute ends. *Disc* narrow to moderately broad, epruinose. *Exciple* complete, present below, non-striate, non-carbonized, yellowish brown, convergent, covered by a thalline exciple up to the top, round at the apical region, with swollen “puff”, interspersed with crystals. *Hymenium* hyaline, not interspersed,  $63\text{--}71 \mu\text{m}$  high, I–, KI–. *Hypothecium* distinct, thin, pale,  $6\text{--}8 \mu\text{m}$  high. *Paraphyses* simple, long, thin with warty tips. *Periphysoids* short to moderately elongate,  $4\text{--}6 \mu\text{m}$  long, with warty tips. *Asci* 8-spored,  $60\text{--}70 \times 8\text{--}10 \mu\text{m}$ . *Ascospores* hyaline, always 3-trans-septate, ellipsoidal, I– to sometimes reddish violet, KI+ reddish violet,  $11\text{--}16 \times 4\text{--}5 \mu\text{m}$ , with a large, conspicuous,  $3\text{--}5 \mu\text{m}$  thick halo; halo is narrow at one end and thick at the other end.

*Chemistry.* Thallus K–, C–, KC–, P–; UV–; no lichen substances present.

*Remarks.* The structure of the ascomata of this new species has an obvious affinity with *F. subcontexta* (Nyl.) Nyl., but it differs in the size of lirellae and the ascospore characters. *Fissurina subcontexta* has longer lirellae,  $2\text{--}10 \text{ mm}$  in length, and ascospores with a regular halo,  $1\text{--}2 \mu\text{m}$  thick (Staiger 2002), while *F. capsulata* has short lirellae, only up to  $2.5 \text{ mm}$  long, and ascospores with a very conspicuous halo,  $3\text{--}5 \mu\text{m}$  thick. Moreover the halo is narrow at one end and thick at the other end.

Other species with similar ascomatal structure, *Fissurina marginata* Staiger, and *F. rufula* (Mont.) Staiger, also lack lichen substances. While *F. marginata* has muriform ascospores, the trans-septate *F. rufula* has longer ascomata,  $1\text{--}12 \text{ mm}$  long, and larger ascospores,  $22\text{--}24 \times 10\text{--}13 \mu\text{m}$ .

Other species which have a similar ascomatal structure viz. *Fissurina alboscripta* (Coppins & P. James) Staiger, *F. canlaonensis*, *F. crassilabra* Mont. & Bosch, and *F. cf. triticea* (Nyl.) Staiger, all differ by producing various lichen substances such as psoromic, 2'-O-methylpsoromic, subpsoromic, and stictic acids.

*Specimen examined. India: Tamil Nadu:* Kodaikanal, near Daisy Bank, 1975, P. G. Patwardhan & A. V. Prabhu 75.379 (AMH).

### **Fissurina coarctata Makhija & Adawadkar sp. nov.**

*Fissurinae subnitidulae* (Nyl.) Staiger similis species nova sed ascosporis maioribus differt.

Typus: India, Andaman Islands, Middle Andaman, Dhaninala, Betapur Range, 26 December 1985, M. B. Nagarkar & P. G. Patwardhan 85.2468 (AMH—holotypus).

(Figs 1C, 2C & G)

*Thallus* corticolous, yellowish brown to olive green, thick, verrucose.

*Ascomata* short lirellate, up to  $1 \text{ mm}$  long (rarely up to  $2 \text{ mm}$ ), crowded, all over the thallus, simple, unbranched, straight, immersed to slightly raised, arising as a swelling

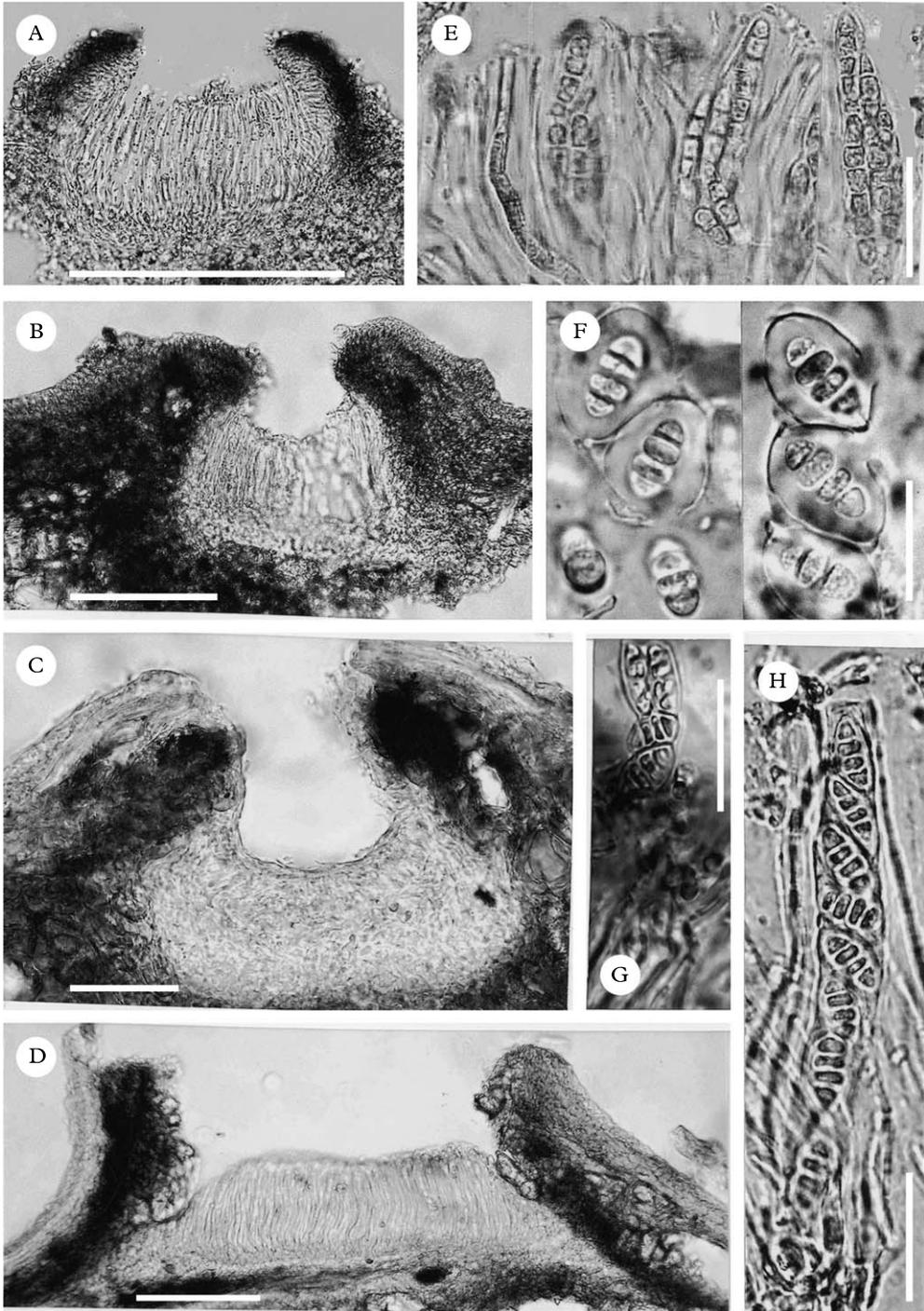


FIG. 2. *Acanthothecis* and *Fissurina* species, vertical sections of ascomata (A–D) and ascospores (E–H). A & E, *A. collateralis* (holotype); B & F, *F. capsulata* (holotype); C & G, *F. coarctata* (holotype); D & H, *F. dumastioides* var. *salazimica* (holotype). All specimens in AMH. Scales: A–D=100  $\mu$ m; E–H=20  $\mu$ m.

which then cracks and gapes, pale brown to concolorous with the thallus, terminally obtuse to acute. *Disc* very narrow, sunken, usually not visible but brown when visible. *Exciple* thick, indistinct at the base, converging at the apical portion and broad at the base, non-striate, non-carbonized, covered by the thalline margin up to the top with a distinct prosoplectenchymatous corticiform layer, studded with crystals. *Hymenium* hyaline, not inspersed, 60–80  $\mu\text{m}$  high, I–, KI–. *Hypothecium* indistinct. *Paraphyses* simple, unbranched, thin, septate, sparsely branched, shortly spiny at the short tips. *Periphysoids* short, indistinct. *Asci* 8-spored, 60–75  $\times$  8–10  $\mu\text{m}$ . *Ascospores* hyaline, oval, always 3-trans-septate, 14–18  $\times$  6–8  $\mu\text{m}$ , with a thin halo, I–, KI–.

**Chemistry.** Thallus K–, C–, KC–, P–; UV–; no lichen substances present.

**Remarks.** This new species with its “*dumastii* type” (Staiger 2002) ascomata resembles *F. subnitidula* somewhat in its external morphology, but differs in having larger ascospores. The ascospores of *Fissurina subnitidula* are 10–13  $\times$  5–6  $\mu\text{m}$ , with a halo (Staiger 2002).

*Fissurina coarctata* also resembles *F. dumastii* Fée in ascomatal structure but differs in having very short, mostly less than 1 mm long, densely crowded, always simple, unbranched lirellae. *Fissurina dumastii* has simple to branched lirellae 1–5 mm long. Furthermore *F. dumastii* has an unidentified substance in its thallus (Staiger & Kalb 1999).

Specimens with larger ascospores from the Andaman Islands previously recorded as *Graphis subnitidula* (Makhija *et al.* 1992a) have now been placed in this new species.

This species is endemic to India where it grows on exposed tree trunks on road sides. It seems to be rather common and occurs in tropical rain forests and also in moist deciduous forests.

**Specimens examined.** **India:** Middle Andaman: Dhani-nala, Betapur Range, 1985, M. B. Nagarkar & P. K. Sethy 85.2469, 85.2503 (AMH); Long Island, on the way to Lalaji, P. K. Sethy & P. G. Patwardhan 85.2080

(AMH). South Andaman: Baratang Island, Wrafter’s Creek, 1985, P. K. Sethy & P. G. Patwardhan 85.509, 85.554, 85.561. Karnataka: Devimane ghat, Sirsi-Kumtha road, 1974, A. V. Prabhu & M. B. Nagarkar 74.2668 (AMH) [this specimen was earlier recorded as *G. dumastii* (Patwardhan & Kulkarni 1976)]. Meghalaya: Mohmtheid-Cherapunji road, 1977, P. G. Patwardhan & M. B. Nagarkar 77.1017 (AMH).

### **Fissurina dumastii Fée**

*Essai sur les cryptogames des écorces exotiques officinales.* (59) (1825).

*Thallus* corticolous, brown, uneven, slightly glossy.

*Ascomata* lirelline, 3–7 mm long, simple to branched, concolorous with the thallus, immersed to raised due to raised thalline exciple, terminally acute to subacute. *Disc* narrow to moderately broad, epruinose. *Exciple* non-striate, non-carbonized, orange brown, absent at the base, convergent to divergent, covered by a crystal studded thalline exciple covered up to the top with a distinct corticiform layer. *Hymenium* hyaline, not inspersed, 84–92  $\mu\text{m}$  high, I–, KI–.

*Hypothecium* indistinct, thin, pale, 16–21  $\mu\text{m}$  high. *Paraphyses* simple, long, thin, with warty tips. *Periphysoids* short, thin, branched, distinctly warty. *Asci* 8-spored, 60–70  $\times$  8–10  $\mu\text{m}$ . *Ascospores* hyaline, always 3-trans-septate, ellipsoidal, 10–14  $\times$  4–5  $\mu\text{m}$ , with a thin halo, I–, KI–.

**Chemistry.** Thallus K–, C–, KC–, P–; UV–; no lichen substances present.

**Remarks.** *Fissurina dumastii* is a pantropical species. In India it appears to be restricted to the Nicobar Islands and has been collected in the beach forest in the warm and humid climate of these islands. This species was previously reported as *Graphis dumastii* from the state of Karnataka in India (Patwardhan & Kulkarni 1976). A re-examination of these mainland specimens has shown that they do not belong to *F. dumastii*.

**Specimens examined.** **India:** Great Nicobar: Campbell Bay to Laful Bay, beach forest, 1987, P. K. Sethy & P. G. Patwardhan 87.50, 87.103 87.139 (AMH).

**Fissurina dumastioides (Fink) Staiger**

*Biblioth. Lichenol.* **85**: 161 (2002).

*Graphis dumastioides* Fink, *Mycologia* **19**: 213 (1927).

*Thallus* corticolous, crustose, grey-green, stramineous, rough, rugose, thick, cracked.

*Ascomata* lirelline, 0.5–3.5 mm long, simple to branched, visible as fissures in the thallus, immersed, flexuose, ends obtuse to acute. *Disc* very narrow, sunken. *Exciple* non-striate, non-carbonized, present at the base, converging at the apical portion, covered by the thalline margin up to the top, with a distinct prosoplectenchymatous upper corticiform layer, studded with crystals. *Hymenium* hyaline, not inspersioned, 95–110 µm high, I–, KI–. *Hypothecium* indistinct. *Paraphyses* simple, unbranched to sparsely branched, thin, septate, spiny at the tips. *Periphysoids* indistinct. *Asci* cylindrical, 8-spored, 50–90 × 8–10 µm. *Ascospores* oval, hyaline, always 3-trans-septate, 10–12 × 4–6 µm, with a 1–2 µm thick halo, I–, KI–.

*Chemistry.* Thallus K+ yellow, C–, KC–, P+ orange, UV–; stictic acid present.

*Remarks.* *Fissurina dumastioides*, the stictic acid equivalent of *Fissurina dumastii*, appears to be rather common in the rain forests in the Andaman and Nicobar islands.

The specimens from Kerala were earlier recorded erroneously as *Graphis canlaonensis* (Patwardhan & Kulkarni 1976).

Specimens examined. **India:** *North Andaman:* Tugapur Range, Pathar Tikri, in moist deciduous forest, 1985, P. K. Sethy 85.2640 (AMH); Lamia Bay from Kalipur, S.E. of Aerial Bay, in mixed forest, 1986, P. G. Patwardhan & M. B. Nagarkar 86.474, 86.476, 86.520, 86.523 (AMH). *Middle Andaman:* Betapur Range, Pitcher Nala, evergreen forest, 1985, P. G. Patwardhan & P. K. Sethy 85.2317, 85.2377 (AMH). *South Andaman:* Baratang Island, Bishnu Nala, 1985, M. B. Nagarkar & P. G. Patwardhan 85.673, 85.685, 85.705 (AMH); Baludera Mangrove forest, 1985, P. G. Patwardhan 85.814, Alexandria Island, Wandoor, 1985, P. G. Patwardhan & P. K. Sethy 85.1120, 85.1134 (AMH). *Little Andaman:* Krishna Nala, Netaji Nagar, 1985, P. G. Patwardhan 85.912 (AMH). *Karnataka:* Udupi-Agumbe road, 1977, P. G. Patwardhan 77.494 (AMH). *Kerala:* Anamali hills, Walparai forest, 1976, M. B. Nagarkar 76.409 (AMH); Cardamom

hills, 5 km from Devicoloam on Kumily road, 1976, C. R. Kulkarni 76.698 (AMH). *Nicobar Island:* Kamorta, 1987, P. G. Patwardhan & P. K. Sethy 87.244, 87.328 (AMH). *Great Nicobar:* Campbell Bay to Laful Bay, beach forest, 1987, P. G. Patwardhan 87.27 (AMH). *Tamil Nadu:* Kodaikanal, 1975, P. G. Patwardhan 75.200 (AMH).

**Fissurina dumastioides (Fink) Staiger var. salazinica Makhija & Adawadkar var. nov.**

Similis *Fissurina dumastioides* sed acidum sticticum et salazinicum continens.

Typus: India, Andaman Islands, Middle Andaman, Betapur Range, Pitcher Nala, 26 December 1985, M. B. Nagarkar & P. K. Sethy 85.2461 (AMH—holotypus).

(Figs 1D, 2D & H)

This specimen differs from *Fissurina dumastioides* in having salazinic acid in addition to stictic acid in its thallus. However, we do not wish to describe it as a new species based on a single, small specimen and hence it has been described here as a variety of *Fissurina dumastioides*.

It was found on a tree trunk on the road side in the evergreen forest on Betapur Range of Andaman Islands.

**Fissurina globulifica (Nyl.) Staiger**

*Biblioth. Lichenol.* **85**: 137 (2002).

*Graphis globulifica* Nyl., *Bull. Soc. Linn. Normandie, sér. 2*, **2**: 117 (1868).

(Fig. 1E)

*Thallus* corticolous, brownish green, thick, rough, uneven.

*Ascomata* lirelline, short, 1–3 mm long, simple to branched, concolorous with the thallus, immersed to slightly raised, irregular, with subacute to round ends. *Disc* narrow, not visible, epruinose. *Exciple* non-striate, non-carbonized, orange-brown, indistinctly present below, convergent, covered by a thalline exciple up to the top with corticiform layer studded with crystals. *Hymenium* hyaline, not inspersioned, 75–84 µm high and 168–176 µm broad, I–, KI–. *Hypothecium* distinct, very thick, 40–42 µm high; pale yellow. *Paraphyses* simple, long,

thin, spiny at the tips. *Periphysoids* short, globose at the tip,  $\pm$  warty. *Asci* 8-spored,  $67\text{--}79 \times 6\text{--}8 \mu\text{m}$ . *Ascospores* mostly 3-trans-septate, occasionally with 1 vertical septum, ellipsoidal,  $9\text{--}14 \times 4\text{--}6 \mu\text{m}$ , with thin halo, I –, KI –.

**Chemistry.** Thallus K –, C –, KC –, P –; UV –; no lichen substances present.

**Remarks.** The specimen studied is characterized by a “*globulifica*-type” (Staiger 2002) ascomatal structure. The other three species having this ascomatal type, *Fissurina albocinerea* (Vain.) Staiger, *F. globulifica* and *F. instabilis* (Nyl.) Nyl., all have distinctly muriform ascospores and psoromic acid in their thalli.

*Fissurina globulifica* has previously been reported from Australia, the Philippines and New Caledonia and is characterized by globose always muriform ascospores (Staiger 2002) and produces psoromic acid. The specimen from India has an obvious affinity with *F. globulifica* but differs in having mostly 3-trans-septate ellipsoidal ascospores occasionally with 1-vertical septum with regular orientation of locules, and does not produce psoromic acid. Thus, our specimen may well merit recognition as a separate species but with such limited material we feel that such a decision would be premature.

The species was collected on an exposed tree-trunk in a primary beach forest.

**Specimen examined.** **India:** Nicobar Islands: Campbell Bay to Laful Bay, beach forest, 1987, P. K. Sethy & M. B. Nagarkar 87.5 (AMH).

### **Fissurina inquinata C. Knight & Mitt.**

*Trans. Linn. Soc. London* 23: 102, 1860.

**Thallus** corticolous, pale yellowish green to yellowish orange, smooth, uneven.

**Ascomata** concolorous with the thallus, simple, very short, 0.2–0.4 mm long, immersed, in groups of several lirellae, individually distinct. **Disc** slit like, narrow. **Exciple** non-striate, present at the base, apically carbonized. **Hymenium** hyaline, not

inspersed, 100–150  $\mu\text{m}$  high, I –, KI –. **Paraphyses** simple, thin, spiny at the tips. **Periphysoids** short, indistinct. **Asci** 8-spored,  $60\text{--}70 \times 4\text{--}6 \mu\text{m}$ . **Ascospores** 3-trans-septate,  $13\text{--}15 \times 4\text{--}5 \mu\text{m}$ , I –, KI –.

**Chemistry.** Thallus K+ yellow, C –, KC –, P+ orange; UV –; stictic acid present.

**Remarks.** In the fissurine alliance, *Fissurina inquinata* is clearly differentiated from other species by its thick thallus, non-gapeing ascomata and the apically carbonized exciple.

This species has been collected in the tropical rain forests of the Andaman Islands.

**Specimens examined.** **India:** South Andaman: Wimberliganj, Kalatang, 1985, P. G. Patwardhan 85.107, 85.115 (AMH); Wandoor, Alexandria Island, 1985, P. G. Patwardhan 85.1152 (AMH); Baratang Island, Lorojig, 1985, P. G. Patwardhan 85.289 (AMH).

### **Fissurina insidiosa C. Knight & Mitt.**

*Trans. Linn. Soc. London* 23: 102, 1860.

**Thallus** corticolous, yellowish green, smooth, rugose, thick, cracked, uneven.

**Ascomata** lirelline, concolorous with the thallus, 1–5 mm long, mostly simple, raised, scattered all over the thallus, distinct. **Disc** very narrow, pale brown, epruinose. **Exciple** smooth, non-striate, pale to barely darkened, non-carbonized, indistinct at the base, converging at the apical region and broad at the base, covered by a poorly developed prosoplectenchymatous upper layer studded with crystals, usually raised, swollen (“puff”) at the apical region. **Hymenium** hyaline, not inspersed, 100–160  $\mu\text{m}$  high, I –, KI –. **Hypothecium** not distinct. **Paraphyses** simple, unbranched, thin, septate, warty at the tips. **Periphysoids** short, indistinctly warty. **Asci** cylindrical, 8-spored,  $60\text{--}75 \times 6\text{--}8 \mu\text{m}$ . **Ascospores** ovoid, always 3-trans-septate,  $12\text{--}25 \times 8\text{--}10 \mu\text{m}$ , with a  $<1 \mu\text{m}$  halo, I –, KI –.

**Chemistry.** Thallus K –, C –, KC –, P –; UV –; no lichen substances present.

*Remarks.* *Fissurina insidiosa* has “subcontexta-type” (Staiger 2002) ascomata. It is most similar to *F. triticea* (Nyl.) Staiger from which it differs in lacking stictic acid, and by having lower ascomata with a less elaborate exciple, and by a less prominent prosoplectenchymatous cortex.

Large patches of *Fissurina insidiosa* have been collected in moist deciduous forests in India. The species was previously known from Dominica, Florida and New Zealand.

*Specimens examined.* **India:** North Andaman: Tugapur Range, Pathar Tikri, in moist deciduous forest, 1985, M. B. Nagarkar & P. G. Patwardhan 85.2647 (AMH). Middle Andaman: Betapur Range, Pitcher Nala, 1985, M. B. Nagarkar & P. K. Sethy 85.2437 (AMH). Little Andaman: Vivekanandapuram, 1985, P. G. Patwardhan 85.974 (AMH). Tamil Nadu: Agasthi hills, Upper Kodayar, 1983, P. G. Patwardhan 83.224, 83.225, 83.226, 83.227, 83.238; Kollimalai, 1985, M. B. Nagarkar & P. G. Patwardhan 85.1558, 85.1559 (AMH).

### ***Fissurina karnatakensis* Makhija & Adawadkar sp. nov.**

Species nova *Fissurinae verrucosae* similis ob continentem acido protocetrarico et fumarprotocetrarico sed ascosporis maioribus differt.

Typus: India, Karnataka, Peercod-Hiriyadka, elev. approx. 200 ft, 27 January 1980, P. G. Patwardhan & M. B. Nagarkar 80.224 (AMH—holotypus).

(Figs 1F, 3A & E)

*Thallus* corticolous, brown, smooth to uneven, cracked, slightly glossy, delimited with a thin, black hypothalloidal region at the periphery.

*Ascomata* lirelline, concolorous, immersed, simple to branched, 1–6 mm long and 0.25 mm broad, terminally acute to subacute. *Disc* not visible, very narrow, slit like. *Thalline margin* often separated by a narrow slit from the proper exciple. *Exciple* non-striate, present at the base, non-carbonized, pale orange-brown, covered by a distinct corticiform layer. *Hymenium* 105–113  $\mu\text{m}$  high, not interspersed, I–, KI–. *Paraphyses* c. 1  $\mu\text{m}$  thick, tips hyaline, distinctly warty. *Periphysoids* short to moderately long, distinctly warty. *Asci* 8-spored. *Ascospores* transversely 3-septate, 14–21  $\times$  3–

5  $\mu\text{m}$ , with a 1–1.6  $\mu\text{m}$  thick halo, I–, KI–.

*Chemistry.* K+ yellow, C–, KC–, P+ rust-red, UV–, protocetraric and fumarprotocetraric acids present.

*Remarks.* The occurrence of protocetraric acid is rather rare in the *Graphidaceae* and has been reported so far in *Acanthothecis abaphoides* (Nyl.) Staiger, *A. clavulifera* (Vain.) Staiger & Kalb, *A. hololeucoides* (Nyl.) Staiger & Kalb, *A. subabaphoides* ad int. (Staiger 2002), *Graphis candidata* Nyl., *G. chinophora* Redinger (Staiger & Kalb 1999), *Graphina laevigata* (Müll. Arg.) Archer, *Graphina pertenella* (Stirt.) Shirley (Archer 1999) and *Carbacanthographis subalbotecta* Staiger & Kalb (Staiger 2002).

*Fissurina karnatakensis* shows the “comparilis-type” (Staiger 2002) ascomatal structure and has fumarprotocetraric and protocetraric acid in its thallus. The new species *F. verrucosa*, described below, is the only other species of *Fissurina* having protocetraric and fumarprotocetraric acids in its thallus but this species has an exciple often with 2 striae, smaller ascospores (7–12  $\mu\text{m}$  long) and a verrucose thallus.

The species was found growing on a tree trunk in exposed conditions on a road side in moist forest. The state of Karnataka has many endemic lichen species.

*Specimen examined.* **India:** Karnataka: Hiriyadka, Udupi to Hebri road, moist forest, elev. approx. 150 ft, 1978, P. G. Patwardhan 78.45 (AMH).

### ***Fissurina khasiana* Makhija & Adawadkar sp. nov.**

Similis *Fissurinae inquinatae* sed ascomata minutissima in maculis pallidioribus congregata et excipulo apicaliter nigro differt et similis *F. triticeae* sed excipulo valde tumido et ascosporis maioribus differt.

Typus: India, upper Shillong, Khasi hills, near Satmile, 2 December 1978, M. B. Nagarkar 78.251 (AMH—holotypus).

(Figs 1G, 3B & F)

*Thallus* greyish green, smooth, cracked, pruinose.

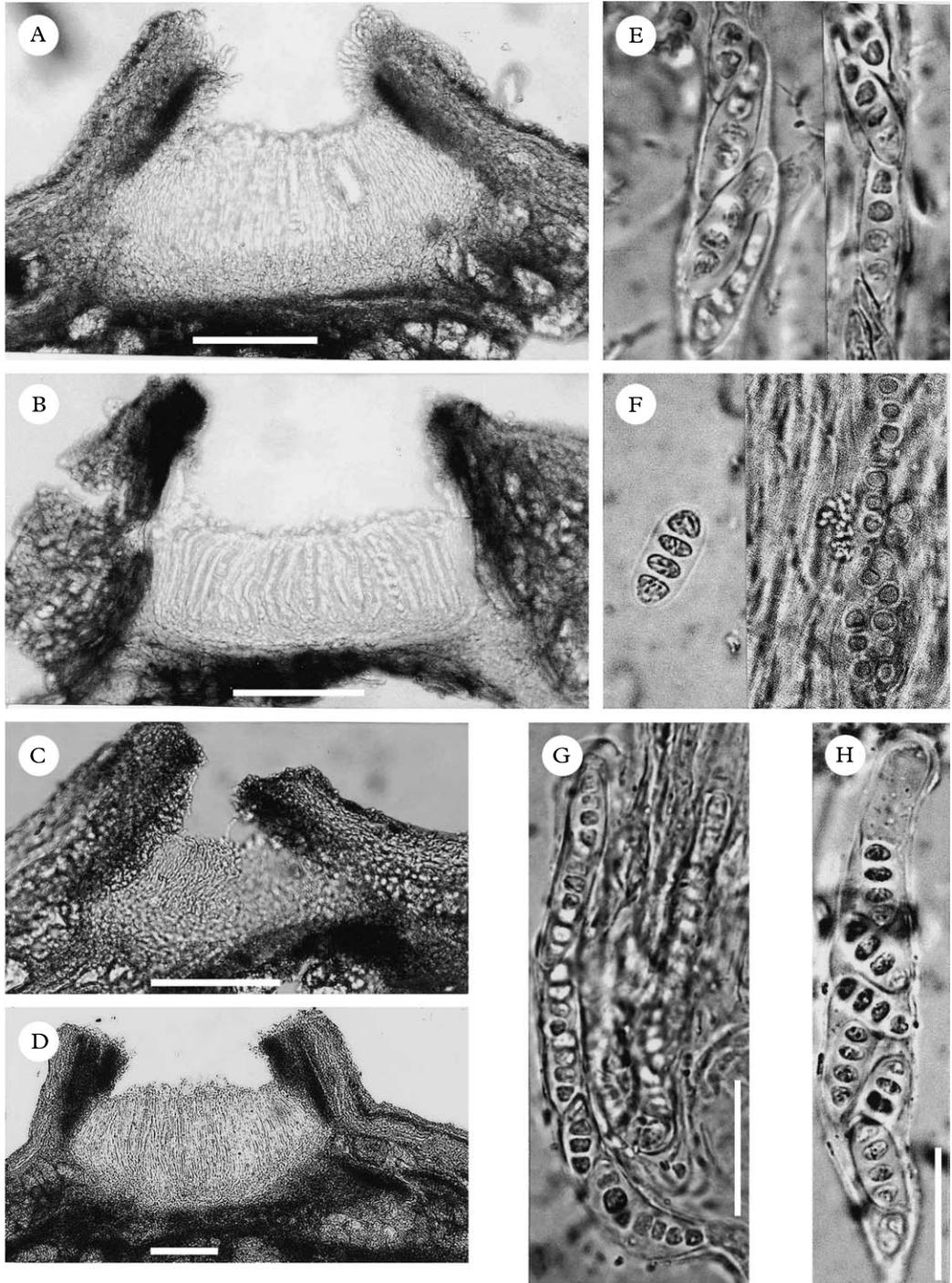


FIG. 3. *Fissurina* species, vertical sections of ascomata (A–D) and ascospores (E–H), A & E, *F. karnatakensis* (holotype); B & F, *F. khasiana* (holotype); C & G, *F. longiramea* (holotype); D & H, *F. verrucosa* (holotype). All specimens in AMH. Scales: A–D=100  $\mu$ m; E–H=20  $\mu$ m (E & F same scale bar as G & H).

*Ascomata* lirelline, 2–4 mm long and 0.1 mm broad, simple to irregularly branched, immersed, terminally acute to subacute. *Disc* narrow, black, indistinct. *Exciple* present at the base, non-striate, non-carbonized, round, somewhat puffed, mostly convergent to slightly divergent, covered by a thalline margin up to the top. *Hymenium* hyaline, not interspersed, 80–100 µm high, I–, KI–. *Hypothecium* hyaline. *Paraphyses* simple, long, thin, with slightly elongate, warty tips. *Periphysoids* short, mostly smooth to rarely warty at the tips. *Asci* cylindrical, 6–8-spored, 50–60 × 6–8 µm. *Ascospores* 3-trans-septate, ellipsoidal, 16–19 × 8–10 µm, with a 1.6–2 µm thick halo, I–, KI–.

*Chemistry.* Thallus K+ yellow red, C–, KC–, P+ orange; UV–; constictic and stictic acids present.

*Remarks.* The type specimen was previously reported as *Graphis inquinata* from India (Nagarkar & Patwardhan 1982). It was collected from the evergreen forest of upper Shillong in the Khasi hills and hence the name *Fissurina khasiana*.

The ascomatal structure of the new species is of the “*comparilis*-type”. The other species in this group, *Fissurina comparilis* (Nyl.) Nyl., *F. comparimuralis* Staiger, *F. humilis* (Vainio) Staiger and *F. tachygrapha* (Nyl.) Staiger, all lack lichen substances in the thallus while *F. inquinata* contains only stictic acid and has many, very small ascomata, 0.2–0.4 mm long, grouped into whitish patches, and 3–4-trans-septate ascospores. The new species has longer ascomata, 2–4 mm long, scattered all over the thallus and not confined to patches or in groups, consistently 3-trans-septate ascospores, and contains both stictic and constictic acids in its thallus.

The ascomatal structure of the new species is rather intermediate between *Fissurina inquinata* and *F. triticea*. *Fissurina inquinata* has little “puffing” and the exciple is carbonized, whilst *Fissurina triticea* has strongly “puffed” ascomata and a non-carbonized exciple. The new species thus

differs from both these species in having little “puffing” and a non-carbonized exciple. Moreover *Fissurina triticea* has larger and more rounded ascospores of 15–20 × 10–15 µm in size.

### ***Fissurina longiramea* Makhija & Adawadkar sp. nov.**

Similis *Fissurinae dumastii* Fée et *F. subnitidulae* (Nyl.) Staiger ob structuram ascomatis sed lirellis longioribus (8–13 mm longae) differt.

Typus: India, Andaman Island, Middle Andaman, Betapur Range, Pitcher Nala, 26 December 1985, P. G. Patwardhan & M. B. Nagarkar 85.2440 (AMH—holotypus).

(Figs 1H, 3C & G)

*Thallus* corticolous, pale brown, greenish yellow, rough, slightly glossy, thick, cracked, delimited by a thin, black hypothallus.

*Ascomata* lirelline, 8–13 mm long, simple, radiating, or dichotomously branched, concolorous with the thallus, scattered, flexuose, immersed to slightly raised, with acute to obtuse ends. *Disc* narrow, slit-like, dark brown, pruinose. *Exciple* present below, non-striate, broad at the apex and flattened at the basal region, non-carbonized, orange-yellow to brownish, dark orange-red when wet, convergent, covered by a thalline exciple with a distinct, yellowish corticiform layer up to the top. *Hymenium* hyaline, 142–155 µm high, sometimes interspersed with crystals, I–, KI–. *Hypothecium* indistinct, thin, hyaline to pale yellowish. *Paraphyses* simple, long, thick, unbranched, warty at the tips. *Periphysoids* short to moderately long, warty at the tips. *Asci* 8-spored, 95–110 × 10–12 µm. *Ascospores* always 3-trans-septate, ellipsoidal, 8–16(–21) × 3–4(–6) µm, with a 1–2 µm thick halo, I–, KI–.

*Chemistry.* Thallus K–, C–, KC–, P–; UV–; no lichen substances present.

*Remarks.* This new species lacking lichen substances resembles *Fissurina dumastii* and *F. subnitidula* in respect of the ascomatal structure. However, it differs from both these species, especially in having much larger lirellae (8–13 mm long). *Fissurina*

*dumastii* has lirellae up to 7 mm long while in *F. subnitidula* the ascomata are 0.3–0.5 (–1) mm long with smaller ascospores [8–10 × 5 µm according to Wirth & Hale (1978) and 10–13 × 5–6 µm with a halo according to Staiger (2002)].

The other species with trans-septate ascospores, namely *Fissurina columbina* (Tuck.) Staiger, *F. quadrispora* Kalb and *F. dumastioides*, produce various lichen substances and have much larger ascospores, while *F. glauca* (Müll. Arg.) Staiger, an Australian species, has smaller ascomata, 1–3 mm long.

This species has been collected in tropical rain forest and was found associated with *Pyrenula arthonioides*.

*Specimens examined. India: North Andaman:* Inter-view Island, Mayabandar Range, moist deciduous forest, 1985, P. G. Patwardhan 85.2911 (AMH). *Middle Andaman:* Long Island, on the way to Lalaji, moist deciduous forest, 1985, P. K. Sethy & M. B. Nagarkar 85.2070, 85.2071 (AMH); Betapur Range, Pitcher Nala, 1985, M. B. Nagarkar & P. G. Patwardhan 85.2539, 85.2441 (AMH). *Little Andaman:* Vivekanadapuram, 1985, M. B. Nagarkar 85.974 (AMH). *Karnataka:* Hiriyadka, Udupi to Hebri road, in moist rain forest, c. 150 ft, 1978, M. B. Nagarkar, 78.48 (AMH). *Nicobar Islands:* Kamorta, 1987, P. G. Patwardhan & M. B. Nagarkar 87.3, 87.37, 87.41, 87.247, 87.248, 87.298 (AMH). *Great Nicobar:* Campbell Bay to Laful Bay, 1987, P. G. Patwardhan 86.63, 87.53, 87.125 (AMH).

### *Fissurina rugosa* C. Knight

*Trans. Proc. New Zealand Inst.* 16: 404 (1884).

*Thallus* corticolous, dull greenish brown, uneven, verrucose, delimited with a thin black hypothalloidal region at the periphery.

*Ascomata* lirelline, short, 0.5–1 mm long, concolorous with the thallus, immersed, simple to rarely branched, irregular, terminally acute to subacute. *Disc* not visible, very narrow, slit like. *Exciple* indistinct at the base, non-striate, non-carbonized, pale orange brown to dark brown at the tip, convergent. *Hymenium* 50–92 µm high, not interspersed, I –, KI –. *Paraphyses* 1 µm thick, with smooth to indistinctly warty tips. *Periphysoids* emerging out of the inner side and the edge of the proper exciple covering the disc, distinctly warty, short. *Asci* 8-spored,

63–71 µm long. *Ascospores* hyaline to rarely brown at maturity when old, 3-trans-septate, 13–16 × 3–5 µm, surrounded by a 1–2 µm thick halo, I –, KI –.

*Chemistry.* Thallus K –, C –, KC –, P –, UV –; no lichen substances present.

*Remarks.* *Fissurina rugosa* has “*comparilis-type*” (Staiger 2002) ascomata. This species previously known only from New Zealand is reported here for the first time from India. It was collected from moist deciduous forest at an altitude of c. 400 m. This species has been identified from the original description.

*Specimen examined. India: Tamil Nadu:* Agasthi hills, Upper Kodayar, in moist deciduous forest, elev. c. 400 m, 1984, P. G. Patwardhan & M. B. Nagarkar 84.98B (AMH).

### *Fissurina saxicola* ad int.

(Figs 1I, 4A & B)

*Thallus* saxicolous, dull brown, closely attached, warty, cracked.

*Ascomata* lirelline, few, 1–3 mm long, simple, concolorous, arising as fissures in swollen thalline margins, curved, with acute to subacute ends. *Disc* narrow or slightly broader. *Exciple* indistinctly present below, non-striate, non-carbonized, convergent, covered by a thalline margin, swollen (puff-like) at the apices, crystal-studded, with a distinct, prosoplectenchymatous corticiform layer. *Hymenium* hyaline, not interspersed, 150–178 µm high, I –, KI –. *Hypothecium* indistinct, thin, pale. *Paraphyses* simple, long, thin with warty tips. *Periphysoids* short, with warty tips. *Asci* 8-spored, 60–70 × 8–10 µm. *Ascospores* always 3-trans-septate, ellipsoidal, 17–25 × 6–8 µm, with a 1.6 µm thick halo, I –, KI –.

*Chemistry.* Thallus K+ yellow, C –, KC –, P+ orange; UV –; stictic acid present.

*Remarks.* This new species has the ascomatal structure of the “*subcontexta-type*”

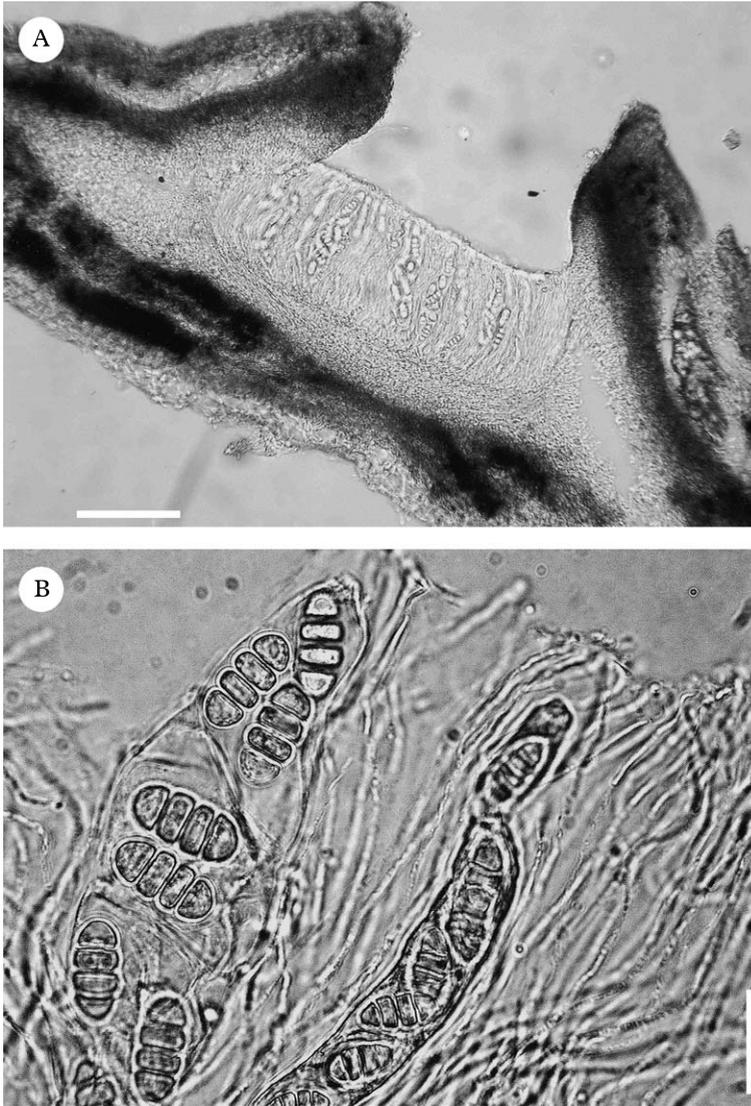


FIG. 4. *Fissurina saxicola* (76.691, AMH); A, vertical section of ascoma; B, ascospores. Scales: A=100  $\mu$ m; B=20  $\mu$ m.

(Staiger 2002). *Fissurina canlaonensis*, a corticolous species from the Philippines, appears to be close to this new species, but it has a yellowish exciple with a red pigment. *Graphis howeana* Archer (= *Fissurina howeana*), a saxicolous species from Australia, has inconspicuous, immersed, fissurine ascomata lacking a proper exciple, and small ascospores (14–16  $\mu$ m long), but lacks lichen compounds.

*Fissurina saxicola* can be clearly distinguished from all other *Fissurina* species by virtue of its saxicolous habit. It is true that facultative transitions to acidic rocks are rather common both in the tropics and extra tropics, but the occurrence of saxicolous species, in fact, is extremely rare in the family *Graphidaceae* and therefore we feel that the present species represents a clearly differentiated taxon. Since we have seen only

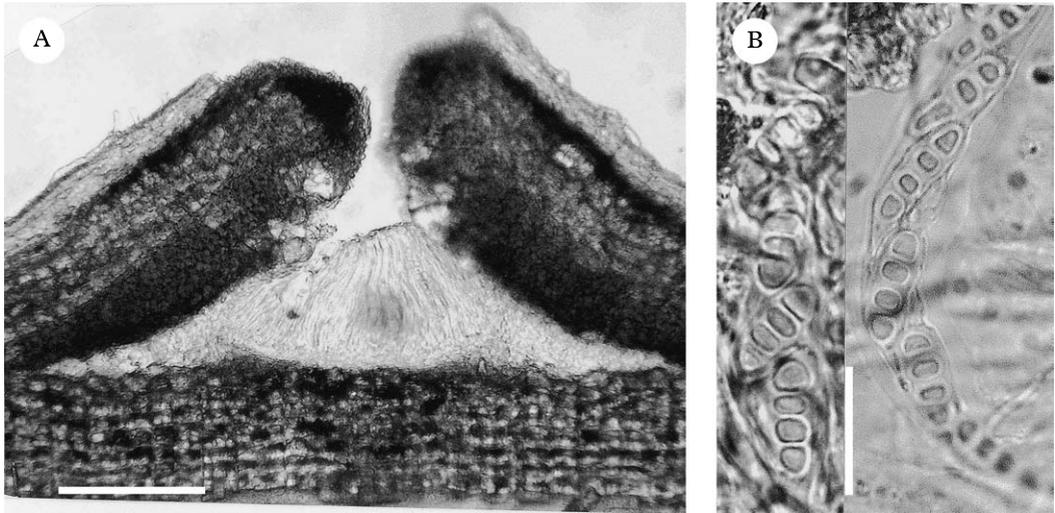


FIG. 5. *Fissurina taeniocarpoides* (87.123-holotype, AMH); A, vertical section of ascoma; B, ascospores. Scales: A=100  $\mu$ m; B=20  $\mu$ m.

a single specimen it would be premature to state that it is an exclusively saxicolous species. Therefore it has not been formally recorded as a new species.

This species was collected on exposed rock on the road side.

*Specimen examined.* **India:** Kerala: Cardamom hills, Devicolam, 5 km from Devicolam on Kumily road, 1976, *M. B. Nagarkar* 76.691 (AMH).

### ***Fissurina taeniocarpoides* Makhija & Adawadkar sp. nov.**

Inter specibus *Fissurina* distincte differt lirellis longis, taeniformibus intricatis, apice crasso inflatis, excipulo externe et in sectione rubescente. Similis *F. rufula* sed differt ascosporis maioribus et excipulo striato.

*Typus:* India, Nicobar Island, Great Nicobar, Campbell Bay to Laful Bay, beach forest, 2 January 1987, *P. G. Patwardhan* & *P. K. Sethy* 87.123 (AMH—holotypus).

(Figs 1J, 5A & B)

*Thallus* corticolous, stramineous yellow to brownish green, smooth to rough, cracked, delimited by thin, black hypothallus.

*Ascomata* lirelline, thin, flat, ribbon like, bordered with distinct dark orange-red coloured margins, immersed to slightly raised, often arising as fissures in swollen thalline

margins (strongly “puffed”), barely revealing the disc, straight to curved, simple to branched, intricate and anastomosed, with acute to subacute ends. *Disc* very narrow, slit like. *Exciple* non-carbonized, bright reddish orange to dark red, indistinct or absent below, flattened at the apical region so as to give a flat ribbon-like appearance to the lirellae when seen externally, convergent, covered by a thalline exciple to the top, crystal-studded, with a distinct, prosoplectenchymatous corticiform layer. *Hymenium* hyaline, not inspersed, 84–92  $\mu$ m high, I – , KI – . *Hypothecium* indistinct, thin, pale. *Paraphyses* simple, long, thin, warty at the tips. *Periphysoids* short, not clearly visible. *Asci* 8-spored, 63–71  $\times$  8–10  $\mu$ m. *Ascospores* always 3-trans-septate, ellipsoidal, 8–16  $\times$  3–4  $\mu$ m, with a thick halo <1  $\mu$ m, I – , KI – .

*Chemistry.* Thallus K – , C – , KC – , P – ; UV – ; no lichen substances present.

*Remarks.* *Fissurina taeniocarpoides* can be distinguished from all other species of this genus by the stramineous colour of its thallus, its concolorous, long, flat, intricately branched ascomata with distinct dark orange-red margins, often arising in fissures

in swollen thalline margins (strongly “puffed”) and barely revealing the disc, and by its reddish orange to dark red exciple with a flattened apical region.

*Fissurina taeniocarpoides* closely resembles *F. rufula* in respect of the colour of the exciple and lack of lichen substances but that species has much larger ascospores  $22\text{--}24 \times 10\text{--}13 \mu\text{m}$ . Moreover in *Fissurina rufula* the exciple is striate (Harris 1995; Staiger 2002).

The new species also comes very close to *Fissurina subcontexta* but the morphology of ascomata in that species is very variable in that the lips are closed or slightly open, the apex may or may not be carbonized, and at the base is slightly open or sometimes closed (Archer 1999). The major difference is that in *F. subcontexta* the exciple is not flattened at the apical region. Moreover the ascomata in *Fissurina taeniocarpoides* are much longer, although being intricate cannot be measured while in *F. subcontexta* the ascomata are 4–10 mm long.

We have placed all the specimens from India which were earlier recorded as *Graphis bataviana* (syn. of *Graphis karstenii*) (Patwardhan & Kulkarni 1976; Makhija *et al.* 1992a) here.

*Fissurina taeniocarpoides* is so far known only from India where it grows on exposed tree-trunks and branches. Although it is more abundant in the Andaman and Nicobar Islands, where the vegetation is typically tropical, it has also been collected in montane forests at various localities on the mainland.

*Specimens examined. India: North Andaman:* Interview Island, Mayabander Range, 1985, *M. B. Nagarkar* 85.2861, 85.2912, 85.2908 (AMH). *Middle Andaman:* Betapur Range, Dhaninala, 1985, *P. K. Sethy* 85.2477, 85.2478, 85.2520, 85.2521 (AMH); Long Island, on the way to Lalaji, 1985, *P. K. Sethy* 85.2062, 85.2083 (AMH); Elphiston Bay, Long Island Range, on beach forest, 1985, *P. G. Patwardhan* 85.2215 (AMH). *South Andaman:* Kalatang, Wimberliganj, 1985, *P. G. Patwardhan* 85.176 (AMH); Tarmugli Island, Wandoor, 1985, *M. B. Nagarkar* 85.1970, 85.1928 (AMH). *Karnataka:* Agumbe, 2 km from Agumbe to Udupi road, 1974, *M. B. Nagarkar* 74.2965, 74.2878 (AMH); Rippon Peth, Tirthhalli road, 13 km to Tirthhalli, 1974, *C. R. Kulkarni* 74.2876 (AMH); Agumbe to Shringeri road, 1977, *M. B. Nagarkar* 77.442 (AMH).

*Kerala:* Anamalai hills, Silent Valley, 1976, *C. R. Kulkarni* 76.227, 76.246, 76.248, 76.260, 76.399 (AMH); Attapadi, Chalgudi to Palghat road, 76.170 (AMH). *Nicobar Islands:* Great Nicobar, Campbell Bay to Laful Bay, beach forest, 87.42; Kamorta, 1987, *P. G. Patwardhan* 87.329 (AMH). *Tamil Nadu:* Singhalamtheri, app. 1100 m, Tirunelveli dist., in moist evergreen forest, 84.76; Nilgiri hills, Coonoor, Sim’s Park, 1999, *U. V. Makhija* 99.35 (AMH).

### *Fissurina triticea* (Nyl.) Staiger

*Biblioth. Lichenol.* 85: 156 (2002).

*Graphis triticea* Nyl., *Acta Soc. Sci. Fenn.* 7: 470 (1863).

*Thallus* corticolous, olivaceous green or citrine green, continuous, smooth to warty, thick.

*Ascomata* lirelline, semi-emergent, concolorous with the thallus to pale amber brown, simple, curved to flexuose, unbranched, short, 0.5–1 mm long, terminally subacute. *Disc* narrow, slit like, invisible. *Exciple* non-striate, non-carbonized, indistinctly present at the base, covered by concolorous to slightly paler thalline margin, with swollen tissue (“puffed”). *Hymenium* hyaline, 150–200  $\mu\text{m}$  high, I–, KI–. *Hypothecium* indistinct. *Paraphyses* thin, simple, occasionally warty at the tips. *Peri-physoids* short, indistinct. *Asci* 8-spored, 90–105  $\times$  10–12  $\mu\text{m}$ . *Ascospores* always 3-trans-septate, hyaline, 16–24  $\times$  10–12  $\mu\text{m}$ , I+ reddish, KI+ reddish.

*Chemistry.* Thallus K+ yellow, C–, KC–, P+ orange; UV–; stictic acid present.

*Remarks.* The structure of the ascomata in this species is of the “*subcontexta*-type” (Staiger 2002). *Fissurina triticea* is easily distinguished from the closely allied *F. insidiosa* by its thick thallus, non-carbonized exciple and by having stictic acid in the thallus.

*Specimens examined. India: Karnataka:* 3 km to Hebri, 1977, *P. G. Patwardhan* 77.498 (AMH). *Kerala:* Cardamom hills, Devicolam forest, 1976, *C. R. Kulkarni* 76.698, Anamalai hills, 1976, *C. R. Kulkarni* 76.409 (AMH).

### **Fissurina verrucosa Makhija & Adawadkar sp. nov.**

Species nova *Fissurinae karnatakensis* similis ob continentem acido protocetrarico et fumarprotocetrarico sed thallo verrucoso et ascosporis minoribus differt.

Typus: India, Karnataka, Devimane Ghat, Sirsi to Kumtha road, 12 December 1974, C. R. Kulkarni 74.2636 (AMH—holotypus).

(Figs 1K, 3D & H)

*Thallus* corticolous, yellowish brown, minutely cracked, slightly glossy, uneven, verrucose.

*Ascomata* lirelline, very short, 0.2–0.3 mm long, simple to branched, branches short, concolorous with the thallus, in scattered patches, immersed, thalline exciple raised, gapeing. *Disc* narrow to broad, visible when gapeing. *Exciple* indistinctly present below, non-striate or with 2 striae, non-carbonized, convergent, covered by a thalline exciple up to the top, crystal studded, with a distinct, prosoplectenchymatous corticiform layer. *Hymenium* hyaline, not interspersed, 26–138 µm high, I –, KI –. *Hypothecium* indistinct, thin, pale, hyaline, 21–29 µm high. *Paraphyses* simple, long, thin, with distinctly warty tips. *Periphysoids* distinct with warty edges, 13–16 µm long. *Asci* 8-spored, 105–113 × 10–14 µm. *Ascospores* always 3-trans-septate, ellipsoidal, 7–12 × 3–4 µm, with 1.6–2 µm thick halo, I –, KI –.

*Chemistry.* Thallus K –, C –, KC –, P+ rust-red; UV –; protocetraric (trace) and fumarprotocetraric acids present.

*Remarks.* The present species has the “*comparilis*-type” (Staiger 2002) ascomatal structure and can easily be distinguished by its verrucose thallus and presence of protocetraric and fumarprotocetraric acids in its thallus (see also *Fissurina karnatakensis* for details).

According to Staiger (2002) the other species with “*comparilis*-type” ascomata are: *Fissurina comparilis*, *F. comparimuralis*, *F. humilis*, *F. inquinata*, and *F. tachygrapha*. Only *Fissurina inquinata* has stictic acid in its thallus, while the remaining species have

no lichen substances and have much larger ascospores. Moreover *F. comparimuralis* has muriform ascospores. The present species can therefore be clearly distinguished from all other species of this group, particularly by its smaller ascospores and the presence of fumarprotocetraric and protocetraric acids in its thallus.

This lichen was found on an exposed tree-trunk on the road side in a montane forest.

*Specimen examined.* **India:** Karnataka: Devimane Ghat, Siris-Kumtha road, 1974, C. R. Kulkarni 74.2639, previously reported as *G. dumastii* (AMH).

### **Excluded Species**

Three species which were recorded as *Graphis furfuracea*, *G. homichlodes*, and *G. implexula* from the Indian subcontinent by Awasthi (1991, 2000) have been excluded from the present treatment.

#### **Graphis furfuracea Leighton**

*Trans. Linn. Soc. London* 25: 454 (1866).

Awasthi (1965, 1991) recorded *Graphis furfuracea* from Sri Lanka. But no specimens corresponding to *G. furfuracea* have yet been seen among the Indian *Graphis* specimens examined.

#### **Graphis homichlodes Redgr.**

*Ark. Bot.* 27A: 61 (1935).

The occurrence of *Graphis homichlodes* was recorded from India by Awasthi (1991, 2000). We have neither seen any specimen under this name, nor have we any specimens in our collections which match this species.

#### **Graphis implexula Stirt.**

*Proc. Phil. Soc. Glasgow.* 13: 186 (1882).

Stirton (1881) described this species from India based on a specimen collected by A. Watt from Assam [Assam, leg. A. Watt, BM (!)]. We have studied this specimen and

observed only paraphyses; no asci or ascospores were seen, possibly having been abraded or eaten by mites. No other specimen of this taxon is available at BM or GLAM so that its nature is not clear.

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