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New combinations in the family *Graphidaceae* (lichenized Ascomycota: *Ostropales*) from India

The lichen family *Graphidaceae* is widely distributed in the tropical and subtropical regions of the world. Prior to 2002, the schematic generic concepts based on apothecial and ascospore types first established by Müller Argoviensis (1880*a*, *b*) were followed to describe and classify species of the family. Staiger (2002) provided a new systematic revision based on structure of the thallus and exciple, type of hymenium and ascospore, and secondary chemistry. Later, Frisch *et al.* (2006), Mangold *et al.* (2009), Nelsen *et al.* (2010), Lücking *et al.* (2011, 2012, 2013), Rivas Plata *et al.* (2010, 2012*a*, *b*, 2013), Cáceres *et al.* (2012, 2014), Parnmen *et al.* (2012, 2013), Sipman *et al.* (2012), Kraichak *et al.* (2014) and Mercado-Diaz *et al*. (2014) established many new genera in the family based on molecular data. These changes have resulted in the transfer of many species from earlier established genera, such as *Graphis*, *Phaeographis*, *Graphina* and *Phaeographina*, to other genera. As such, *Graphina* is now a synonym of *Graphis* (Staiger 2002) and *Phaeographina* an illegitimate name (Lücking *et al*. 2007). These changes in the generic concept of the family have necessitated the rearrangement of a number of Indian taxa.

In an earlier publication, Singh & Swarnlatha (2009) made eight new combinations. As a result of our continuing study on Indian *Graphidaceae* and examination of more type specimens preserved at Agarkar Research Institute, Pune, India (AMH), Botanical Survey of India, Allahabad (BSA), Botanische Staatssammlung München (M), British Museum of Natural History, London (BM), and the National Botanical Research Institute, Lucknow, India (LWG), we further propose six new combinations, namely *Diorygma aeolum*, *D. spilotum*, *Kalbographa hypoglaucoides*, *Pallidogramme awasthii*, *P. divaricoides* and *Phaeographis firmula*. In addition, *Diorygma megasporum*, *Phaeographis albolabiata* and *Acanthothecis subconsocians* are synonymized with *Diorygma aeolum*, *Nitidochapsa leprieurii* and *Pallidogramme divaricoides*, respectively.

Type specimens deposited in AMH, BM and LWG-LWU herbaria were examined morphologically, anatomically and chemically. Morphological characters of thalli (reproductive structures, colour, size and shape) were examined using a Nikon SMZ 1500 stereomicroscope. Thin hand-cut sections of thalli and ascomata, mounted in an aqueous solution of KOH, were examined. All anatomical measurements were made in water mounts and examined using a Nikon Eclipse 50i compound microscope. Ascospores were stained with Lugol's solution to check the amyloid reaction and measured in water. Secondary metabolites were identified by thin-layer chromatography (TLC) using solvent A (180 toluene: 45 dioxane: 5 acetic acid), following Orange *et al.* (2001).

New Combinations

Diorygma aeolum (Stirt.) Pushpi Singh & Kr. P. Singh comb. nov.

MycoBank No.: MB 819997

Graphis aeola Stirt., *Proc. Roy. Soc. Glasgow* **11:** 316 (1879).—*Graphina aeola* (Stirt.) Zahlbr., *Cat. Lich. Univ.* **2:** 394 (1923); type: India, Tamil Nadu, 'Nelghiri' (Nilgiri hills), *G. Watt* (BM 001097383!—lectotype).

Diorygma megasporum Kalb, Staiger & Elix, *Symb. Bot. Upsal.* **34**(1)**:** 160 (2004); type: Myanmar, Yomah, Khaboung Pass, 2000 ft, 21.01.1868, *S. Kurz*, s. n (M 0102172!—holotype).

(Fig. 1A)

Thallus corticolous, whitish to pale grey, ecorticate, basal layer not carbonaceous.

Apothecia lirelliform, immersed, irregularly branched; *disc* closed to slit-like, ±pruinose; *exciple* uncarbonized, convergent to slightly divergent; *hymenium* not inspersed, weakly to distinctly I+ blue in lateral parts; *asci*

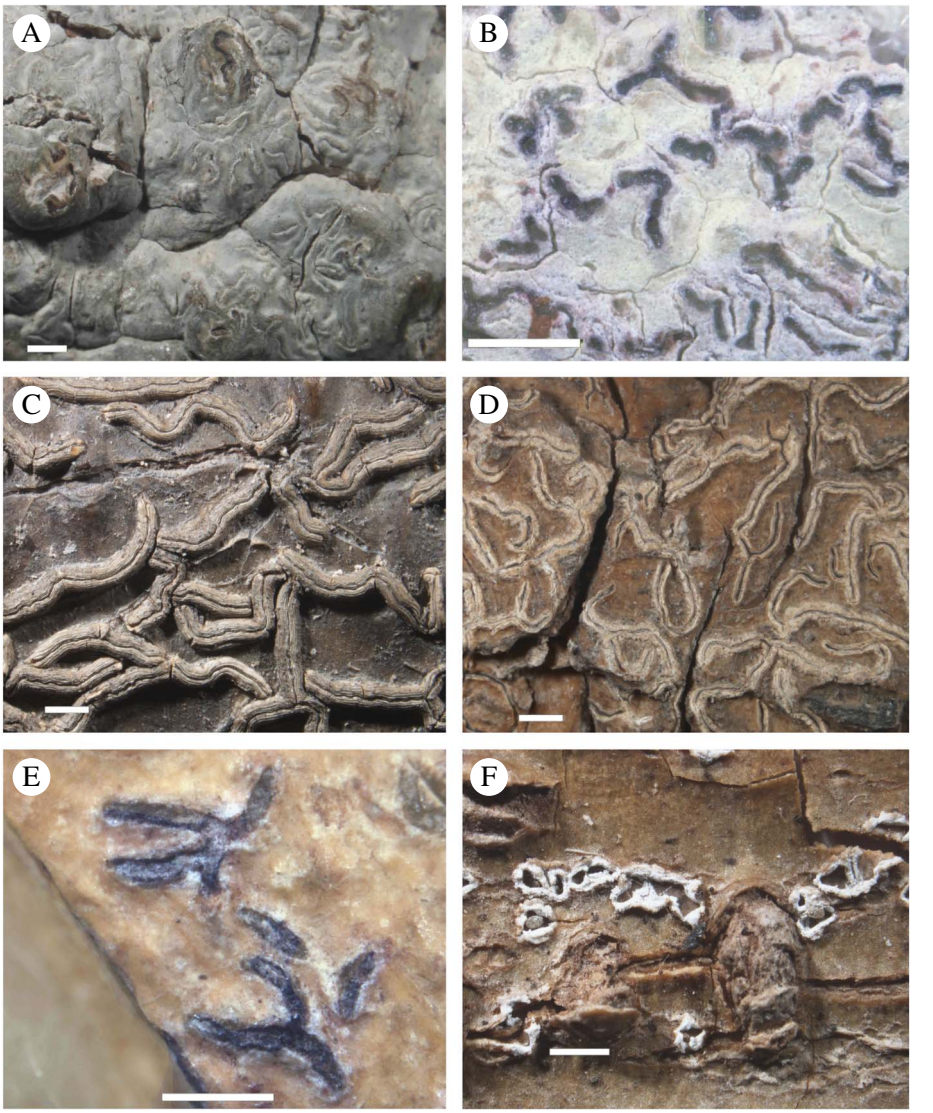

FIG. 1. Habits of species studied. A, *Diorygma aeolum* (lectotype); B, *Diorygma spilotum* (lectotype); C, *Pallidogramme awasthii* (holotype); D, *Pallidogramme divaricoides* (holotype); E, *Phaeographis firmula* (lectotype); F, *Nitidochapsa leprieurii* (holotype of *Phaeographis albolabiata*). Scales = 1 mm. In colour online.

4–6-spored; *ascospores* colourless, ellipsoidal, muriform with all locules of equal size, (76–) 90–120 × 26–40 µm, I+ violet; stictic acid (major) and constictic acid (minor) present.

Notes. Examination of the type material of *Graphis aeola*, borrowed from BM, revealed that it belongs to the genus *Diorygma*. The type of *Diorygma megasporum* Kalb *et al*., borrowed from M, originates from Myanmar (Burma) and not from India as reported earlier (Kalb *et al.* 2004). It agrees with that of *D. aeolum* in morphology, anatomy, the 4–6-spored asci, ascospore size and chemistry. Therefore, *D. megasporum* is synonymized with *D. aeolum*. Morphologically,

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Diorygma aeolum resembles *D. junghuhnii* (Mont. & Bosch) Zahlbr. which has 1-spored asci and norstictic acid. In chemistry, it also closely resembles *D. albovirescens* Makhija *et al.*, which has smaller, 66–99 × 12–36 µm ascospores (Makhija *et al.* 2009). So far, *D. aeolum* is known from India and Myanmar and widely distributed in hilly regions.

Diorygma spilotum (Stirt.) Pushpi Singh & Kr. P. Singh comb. nov.

MycoBank No.: MB 819998

Graphis spilota Stirt., *Proc. Roy. Soc. Glasgow* **13:** 187 (1881).—*Graphina spilota* (Stirt.) Zahlbr., *Cat. Lich. Univ.* **2:** 425 (1923); type: India, Assam, 1879, *A. Watt*, s. n. (BM 001097478! —lectotype).

(Fig. 1B)

Thallus corticolous, pale or creamish to whitish-greyish, ecorticate, basal layer not carbonaceous.

Apothecia lirelliform, simple, immersed, brownish black; *disc* exposed, brownish, epruinose; *exciple* uncarbonized, divergent; *hymenium* not inspersed, laterally weak I+ blue; *asci* 1-spored; *ascospores* colourless, muriform with all locules ± of equal size, 90–110(–140) × 30–45 µm, I− or I+ faintly violet; wall thickening I−; norstictic acid present.

Notes. Examination of the type material of *Graphis spilota*, borrowed from BM, revealed that it belongs to the genus *Diorygma*. In its chemistry and 1-spored asci, *D. spilotum* resembles *Diorygma junghuhnii* (Mont. & Bosch) Kalb *et al.*, *D. tuberculosum* (Stirt.) Kalb *et al.* and *D. soozanum* (Zahlbr.) M. Nakan. & Kashiw. *Diorygma junghuhnii* differs by its erumpent to prominent lirellae and completely I+ blue hymenium, while *D. tuberculosum* differs by its lirellae being distinctly raised from the thallus surface and its peripheral ascospore locules being distinctly smaller than central ones. *Diorygma soozanum* is distinguished by its erumpent lirellae with a thick whitish pruinose disc (Kalb *et al.* 2004). The species is endemic to India and so far known only from the type locality.

Kalbographa hypoglaucoides (Kr. P. Singh & D. D. Awasthi) Kr. P. Singh & Pushpi Singh comb. nov.

MycoBank No.: MB 819999

Phaeographis hypoglaucoides Kr. P. Singh & D. D. Awasthi, *Bull. Bot. Surv. India* **21**(1–4)**:** 109 (1979); type: India, Tamil Nadu, Palni Hills, on way to Thandikuddi, alt. 1350 m, *D. D. Awasthi & K. P. Singh* 70.459 (LWG-LWU!—holotype).

(Fig. 2 A–C)

Thallus saxicolous, grey to brown, smooth to cracked; cortex indistinct.

Apothecia lirelliform, immersed, simple to bifurcate; *disc* exposed, plane to slightly concave, black, covered by faintly whitish pruina; *exciple* uncarbonized; *hymenium* not inspersed; *asci* 8-spored; *ascospores* brown, ovoid-ellipsoid, thin-walled, 3-septate, 10–13 × 5·0–7·5 µm, I−; no lichen substances present.

Notes. Examination of the type material of *Phaeographis hypoglaucoides*, from LWG-LWU, revealed that it belongs to the genus *Kalbographa*. So far, four species of *Kalbographa* are known, *viz*. *K. caracasana* (Müll. Arg.) Lücking, *K. lobata* Lücking, *K. lueckingii* Kalb and *K. miniata* Lücking. All are characterized by their corticolous habit, in addition to submuriform ascospores in *K. caracasana*, *K. lobata* and *K. miniata* (Lücking 2007). The remaining species, *K. lueckingii*, produces 5(–6)-septate, 18–23 µm long ascospores, and norstictic and connorstictic acids as secondary substances (Kalb *et al.* 2009). *Kalbographa* should not be confused with *Phaeographopsis*, which also has the same type of ascospores but differs in having an ecorticate thallus and a pseudomazaedium.

Pallidogramme awasthii (Patw. & C. R. Kulk.) Kr. P. Singh & Pushpi Singh comb. nov.

MycoBank No.: MB 820010

Phaeographina awasthii Patw. & C. R. Kulk., *Norw. J. Bot.* **26:** 49 (1979); type: India, Kerala, Idukki District,

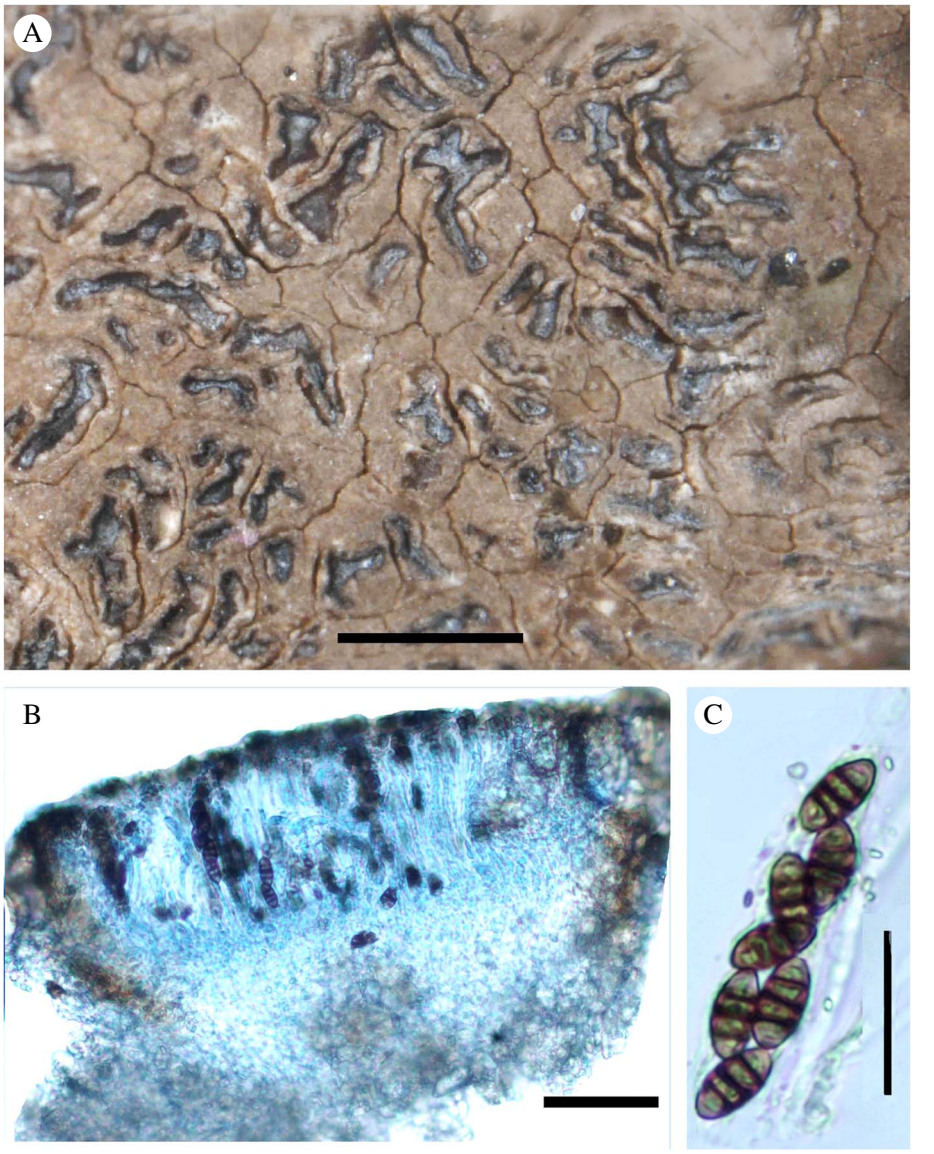

FIG. 2. *Kalbographa hypoglaucoides* (holotype). A, habit; B, cross-section of apothecia; C, mature ascospores. Scales: A = 1 mm; B = 100 µm; C = 20 µm. In colour online.

Anamalai Hills, near Munnar, Chinnar, *C. R. Kulkarni* & *A. V. Prabhu* 76.462 (AMH!—holotype).

(Fig. 1C)

Thallus corticolous, brown, glossy, smooth, corticate.

Apothecia lirelliform, emergent to prominent, ashy white to dull brownish, simple to flexuous; *disc* narrow slit-like; *exciple* uncarbonized, brownish, striate; *hymenium* inspersed; *asci* 8-spored; *ascospores* brown, muriform, 80–105 × 20–30 µm, I+ reddish brown; lichen substances absent.

Notes. Examination of the type material of *Phaeographina awasthii*, from LWG-LWU,

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revealed that it belongs to the genus *Pallidogramme*. In morphology, it closely resembles *Pallidogramme bengalense* B. O. Sharma & Khadilkar which has smaller, 50–80 × 12–20 µm ascospores (Sharma & Khadilkar 2011). It also resembles *P. chlorocarpoides* (Nyl.) Staiger *et al.* and *P. chrysenteron* (Mont.) Staiger *et al.*, but *P. chlorocarpoides* is distinguished by its 2–4-spored asci and presence of stictic and constictic acids, while *P. chrysenteron* differs by having 6–8-spored asci and smaller (33–65 × 10–15 µm; *vide* Staiger 2002) ascospores, and also by the production of stictic and constictic acids. *Pallidogramme awasthii* is endemic to India and distributed in the states of Karnataka, Kerala and West Bengal.

Pallidogramme divaricoides (Räsänen) Pushpi Singh & Kr. P. Singh comb. nov.

MycoBank No.: MB 820017

Phaeographis divaricoides Räsänen, *Arch. Soc. Zool. Bot. Fenn. Vanamo* **5:** 31 (1951); type: India, E. Himalayas, Sikkim State, Gangtok, alt. 2100 m, *D. D. Awasthi* 219 (LWG-AWAS!—isotype).

Acanthothecis subconsocians Pooja Gupta & G. P. Sinha, *J. New Biol. Rep.* **4**(2)**:** 98 (2015); type: India, Sikkim, East District, Pangthang-Rokshe, alt. *c.* 1900 m, 2006, *G. P. Sinha* 3621 (BSA!—holotype).

(Fig. 1D)

Thallus corticolous, brownish, glossy, smooth, corticate.

Apothecia lirelliform, emergent to prominent, dull brownish, divaricately branched; *disc* closed to narrow, brownish, epruinose; *exciple* uncarbonized, brownish, striate; *hymenium* inspersed; *ascospores* hyaline to brown, (5–)7–9-septate, 20–35 × 7–10 µm, I+ reddish brown; no lichen substances present.

Notes. Examination of the type material of *Phaeographis divaricoides*, from LWG-LWU, revealed that it belongs to the genus *Pallidogramme*. Only two other *Pallidogramme* species with transversely septate ascospores, *viz*. *P. indica* A. Dube & Makhija and *P. undulatolirellata* A. Dube & Makhija, occur in India. Both species can be distinguished from *P. divaricoides* by their clear hymenia, larger ascospores and presence of secondary metabolites (Chitale *et al.* 2009). The type of *Acanthothecis subconsocians* Pooja Gupta & G. P. Sinha, preserved at BSA, agrees with that of *Pallidogramme divaricoides* in morphology, anatomy, ascospore size and chemistry. Thus, the two taxa are conspecific and *P. divaricoides* is the correct name. In India, *P. divaricoides* is widely distributed in Arunachal Pradesh, Nagaland, Sikkim and hilly areas of West Bengal.

Additional specimens examined. **India:** *Arunachal Pradesh*: West Kameng District, Simipam forest, alt. 1500–1250 m, *K. P. Singh* 9904C (BSA). *Sikkim*: North Sikkim District, Tangla Br., alt. 1689 m, *G. Swarnlatha* 5903C (BSA). *West Bengal*: Darjeeling District, Takdah Tea Estate, near Char mile, *V. K. Singh* 2313 (BSA).

Phaeographis firmula (Stirt.) Pushpi Singh & Kr. P. Singh comb. nov.

MycoBank No.: MB 820019

Graphis firmula Stirt., *Proc. Roy. Soc. Glasgow* **13:** 186 (1881).—*Phaeographina firmula* (Stirt.) Zahlbr., *Cat. Lich. Univ.* **2:** 438 (1923); type: Assam, *A. Watt* (BM 001106502!—lectotype).

(Fig. 1E)

Thallus corticolous, smooth, shiny, brownish, corticate.

Apothecia lirelliform, immersed, simple to trifurcate; *disc* exposed, epruinose; labia entire; *exciple* apically pale brown to brown; *hymenium* clear; *asci* 8-spored; *ascospores* brown, muriform, 18–26 × 8–12 µm; no lichen substances present.

Notes. Examination of the type material of *Graphis firmula*, from BM, revealed that it belongs to the genus *Phaeographis*. It closely resembles *P. noralboradians* (Patw. & C. R. Kulk.) Makhija & Chitale which has a densely pruinose disc and norstictic acid as a secondary substance (Makhija *et al.* 2014). In ascospore characters it resembles *Phaeographis schizolomoides* Poengs. & Kalb, but the latter species differs in the inspersed

hymenium and the norstictic acid chemistry. The species is endemic to India.

Nitidochapsa leprieurii (Mont.) Parnmen, Lücking & Lumbsch

Bryologist **116**(2)**:** 129 (2013).—*Stictis leprieurii* Mont., *Ann. Sci. Nat., Bot., sér. 4* **3:** 97 (1855).—*Chapsa leprieurii* (Mont.) Frisch, *Biblioth. Lichenol.* **92:** 105 (2006); type: French Guiana, Cayenne, *Leprieur* 804 (PC— lectotype; G—isolectotype).

Phaeographis albolabiata Patw. & C. R. Kulk., *Norw. J. Bot.* **26**(1)**:** 48 (1979); type: India, Kerala, Anamalai Hills, Sholayar Forest, *C. R. Kulkarni* 76.229 (AMH!—holotype).

(Fig. 1F)

Notes. Patwardhan & Kulkarni (1979) described *Phaeographis albolabiata* Patw. & C. R. Kulk. as a new species from India. We have examined the type (AMH!) and confirmed that it agrees with *Nitidochapsa leprieurii* in morphology, anatomy and chemistry. The former is therefore synonymized here.

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