

## Enumeration of Species of Graphidaceae from Vanuatu

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Although species of the family Graphidaceae are very common in Vanuatu, only four of them have been reported (Elix and McCarthy 1998, Nakanishi *et al.* 2002). The present paper reports 25 species of the family found in Vanuatu as a result of taxonomic study for the collection made by Kashiwadani and Moon in 2001. Information of chemical substances is given for all species reported and a key to species of the family in the present area is provided.

### Materials and Methods

The present study is based on 92 specimens of the family Graphidaceae collected from Vanuatu in 2000 by Kashiwadani and Moon. The collection was made from the islands of Espiritu Santo, Efate and Tanna. Specimens reported in the present paper are kept in the herbarium of the National Science Museum, Tokyo (TNS). Chemical and morphological characters are obtained from type collections and newly collected specimens by us. Chemical substances were studied by means of thin-layer chromatography (Culberson and Johnson 1982) and HPLC. Sections of apothecia and thalli were cut by hand-razor and observed in lactophenol cotton-blue solution.

### Explanation of collection sites

The abbreviations of collection sites are listed below.

Efate-Port Vila: Shefa Prov. Efate, ca. 7 km ESE of Port Vila. Plantation of *Cocos nucifera*, elevation about 10 m. October 20, 2000.

Efate-Erakor: Shefa Prov. Efate, Erakor Island. Tree (*Ficus indica*)-lined street, elevation about 5 m. October 21, 2000.

Efate-Iririki: Shefa Prov. Efate, Iririki Island. Open grove along the coast, mixed with *Ficus*, *Gyrocarpus*, *Hibiscus* and *Terminaria*, elevation about 5 m. October 19, 2000.

Efate-Mele Maat: Shefa Prov. Mele Maat, ca. 8 km NW of Port Vila. Plantation of *Cocos nucifera*, mixed with *Hibiscus* and *Cassia*, elevation about 5 m. October 20, 2000.

Santo-Butmas, Sanma Prov. Espiritu Santo, Butmas. Lauch with scattered remaining trees such as *Artocarpus*, *Myristica*, *Pipturus* mixed with *Citrus*, elevation about 520 m. October 24, 2000.

Santo-Luganville: Sanma Prov. Espiritu Santo, ca. 7 km SW of Luganville. Plantation of *Cocos nucifera*, elevation about 15 m. October 26, 2000.

Santo-Matantas: Sanma Prov. Espiritu Santo, Matantas. On bark of *Cunninghamia asiatica* along the coast, elevation about 3 m. October 28, 2000.

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- Santo-Matevulu: Sanma Prov. Espiritu Santo, Matevulu Blue Hole. Plantation of *Cocos nucifera*, elevation about 20 m. October 27, 2000.
- Santo-Neavu: Sanma Prov. Espiritu Santo, ca. 2 km E of Neavu. On bark of *Garuga floribunda* and *Artocarpus*, elevation about 15 m. October 26, 2000.
- Santo-NCK: Sanma Prov. Espiritu Santo, ca. 500 m W of NCK plantation. Plantation of *Cocos nucifera* mixed with *Pterocarpus*, elevation about 40 m. October 27, 2000.
- Santo-Palon: Sanma Prov. Espiritu Santo, Palon. On bark of *Dysoxylum amoroides*, elevation about 170 m. October 24, 2000.
- Santo-Surunda: Sanma Prov. Espiritu Santo, Surunda. On bark of *Garuga floribunda*, elevation about 10 m. October 27, 2000.
- Tanna-Lenakel: Tafea Prov. Tanna, ca. 4 km S of Lenakel (Tanna Beach Resort). On bark of *Hibiscus* sp., elevation about 5 m. November 3, 2000.
- Tanna-Imanaka: Tafea Prov. Tanna, ca. 5 km E of Imanaka. On bark of *Elatostachys falcata*; elevation about 250 m. November 4, 2000.
- Tanna-Manuapen: Tafea Prov. Tanna, ca. 5 km WSW of Manuapen. On bark of *Glochidion namilo*, elevation about 340 m. November 2, 2000.
- Tanna-Fetukai: Tafea Prov. Tanna, Fetukai. On bark of *Erythrina* sp., elevation about 350 m. November 4, 2000.

**List of Species (species with an asterisk is a new record for Vanuatu)**

***Graphina cleistoblephara* (Nyl.) Zahlbr.\***

Chemical substance: norstictic acid.

Specimen examined. Tanna-Manuapen, Kashiwadani 43353.

***Graphina erythrella* (Mont. & v.d.Bosch) Zahlbr.\***

Chemical substance: norstictic acid.

Specimen examined. Santo-Butmas, Kashiwadani 43205.

***Graphina hieroglyphica* (Pers.) M.Nakan., comb. nov.\***

Basionym. *Opegrapha hieroglyphica* Pers., in *Annal. Wetter. Gesellsch.* 2: 16. 1811. Type collection: St. Domingo—holotype in L!

Chemical substances: norstictic and stictic acids.

Specimens examined. Efate-Iririki Moon 5523; Tanna-Manuapen Kashiwadani 43359 and 43400.

Since Acharius (1814) treated this species under *Graphis*, it has been erroneously placed in the genus. However, the type specimen of *Opegrapha hieroglyphica* has colorless muriform spores and should be placed under *Graphina*.

The characteristic features for this species are, the grayish blue thallus covered with powdery crystals, the exciples carbonized laterally, the 1-spored asci, the colorless muriform spores 85–100 × 25–30 μm in size and the presence of norstictic and stictic acids.

It might be confused with *G. pallido-ochracea* (Kremp.) Zahlbr., a species reported from Indonesia (Type collection: Sarawak, O. Becari 79—holotype in M!), which differs in having larger spores (120–125 × 30–33 μm in size) and in the absence of norstictic acid.

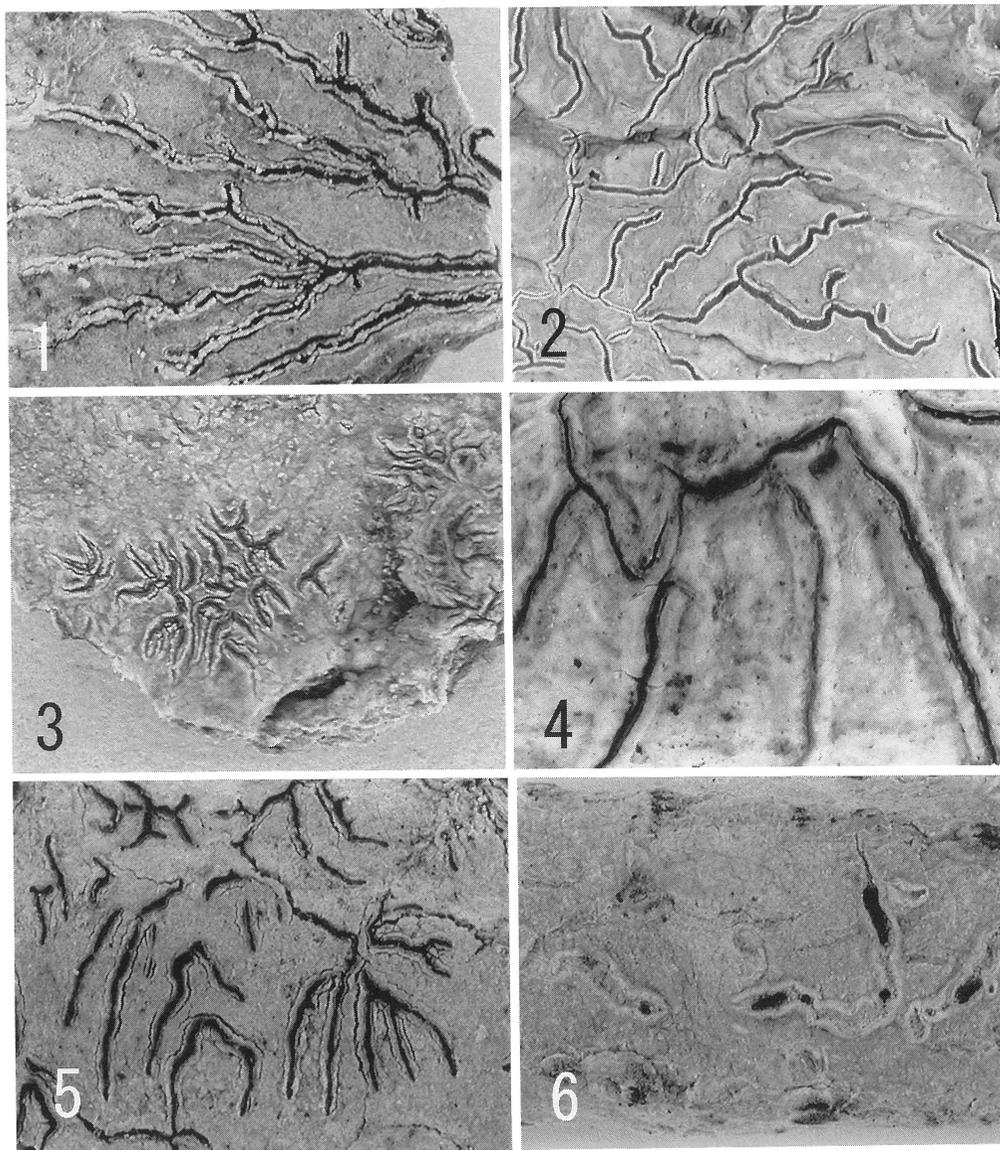


Fig. 1. Species of Graphidaceae: 1, *Graphina hieroglyphica* (Kashiwadani 43359); 2, *G. intortula* (Kashiwadani 43306); 3, *Graphis ceylanica* (Kashiwadani 43111); 4, *G. longiramea* (Kashiwadani 43204); 5, *G. malacoderma* (Kashiwadani 43428); 6, *Phaeographina ochracea* (Kashiwadani 43194). Scale bar = 1 mm.

In the present area, it is rather common on barks of *Acacia*, *Erythrina* and *Hibiscus*. This is the second record for the species.

Specimens examined. Efate-Iririki Moon 5523; Tanna-Manuapen, Kashiwadani 43359 and 43400.

***Graphina intortula*** (Stirt.) Zahlbr.\*, Cat. Lich. Univ. 2: 411. 1924.

Basionym: *Graphis intortula* Stirt., Proc. Philosoph. Soc. Glasgow 13: 186. 1881. Type collection: India, Assam, A. Watt s. n. —holotype in BM! [TLC: salazinic acid]

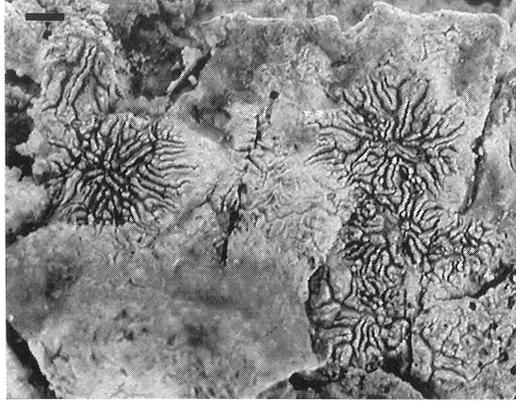


Fig. 2. *Phaeographis heterochroa* (Kashiwadani 43290). Scale bar = 1 mm.

*Graphis eugeniae* Vain., Ann. Acad. Sci. Fenn., ser. A, 15: 262. 1921. Type collection: Philippines, Luzon, Subprov. Corsogon, Irosin, Elmer 14912 [TLC: salazinic acid] - lectotype in TUR, designated here, syn. nov.

*Graphina subcrispa* Horik. & M.Nakan., J. Sci. Hiroshima Univ., Ser. B, Div. 2 (Bot), 2: 97. 1996. Type collection: Japan, Kyushu, Pref. Kagoshima, Tanegashima Island, Minato, S. Okamoto 1920—holotype in HIRO [TLC: salazinic acid], syn. nov.

Vainio (1921) described *Graphis eugeniae* from the Philippines basing on three syntype specimens collected in the islands. They are quite identical morphologically and chemically as cited below and one specimen from Irosin (Elmer 14912) is designated here as the lectotype. The lectotype specimen has slender and commonly branched ascocarps to 10 mm long, red brown discs, divergent pale yellow exciple open at base, submuriform ascospores of  $10\text{--}12 \times 5\text{--}6 \mu\text{m}$  in size and contains salazinic acid. Therefore, *G. eugeniae* is reduced to a synonym of *G. intortula*.

*G. subcrispa*, a species described from Japan, also has the same diagnostic characters with the type of *G. intortula* and can be reduced to a synonym of *G. intortula*.

In the present area it was found only at one locality where it grows on bark of *Hibiscus*.

Specimen examined. Santo-Matevulu, Kashiwadani 43306.

#### **Graphina junghuhnii** (Mont. & v.d.Bosch) Müll.Arg.\*

Chemical substance: stictic acid.

Specimens examined. Santo-Matevulu, Kashiwadani 43304 and 43305; Santo-Butmas, Kashiwadani 43203, 43213 and 43218; Tanna-Imanaka, Kashiwadani 43404 and 43405.

#### **Graphina subserpentina** (Nyl.) Müll.Arg.\*

This species is characterized by the powdery thallus, the lirelliform conspicuous apothecia, the labia thinly but completely covered with thallus, the exciple carbonized laterally and basally, the 1-spored asci, the muriform ascospores  $90\text{--}110 \times 28\text{--}35 \mu\text{m}$  in size and the presence of norstictic acid.

This is one of the most common species of Graphidaceae in Vanuatu, having been found on trunk base where it often forms big colonies up to 1 m wide.

Chemical substance: norstictic acid.

Specimens examined. Efate-Port Vila, Kashiwadani 43123; Santo-Palon, Kashiwadani 43228 and Moon 5575; Santo-Neavu, Kashiwadani 43297, 43302 and Moon 5593. Santo-Luganville, Kashiwadani 43231, 43236, 43249, 43251, 43254 and 43256; Santo-NCK, Kashiwadani 43315, 43328 and Moon 5615; Santo-Surunda, Kashiwadani 43271 and 43282; Santo-Matantas, Kashiwadani 43330, 43332, 43334 and 43335.

**Graphis assimilis** Nyl.

*Graphis assimilis* was described from Colombia (Type collection: Nova Granata, H-NYL 7134!) by Nylander (1868). It is widely distributed in warm temperate to tropical areas surrounding the Pacific Ocean. When Nakanishi (1966) revised Japanese species of *Graphis*, he treated the present species as a synonym of *G. intricata* Fée. However, *G. assimilis* can be distinguished from the latter by the sessile ascocarps having open discs and the exciples more or less open at the base.

Chemical substances: norstictic and stictic acids.

Specimen examined: Tanna-Lenakel, Kashiwadani 43379.

**Graphis brevicarpa** M.Nakan., Kashiw. & K.H.Moon

Chemical substance: norstictic acid.

See Nakanishi *et al.* (2002).

**Graphis ceylanica** Zahlbr.\*

*Graphis ceylanica* is a nom nov. given to a later homonym, *G. irradicans* Nyl. (type collection: Ceylon, Point de Galle, E. Almquist, 1879, H-NYL 7900-isotype!) (non Fée), by Zahlbruckner in 1926. Its occurrence has never been reported from elsewhere excepting type locality.

Two specimens cited below are quite identical with an isotype preserved in H-NYL. They all have raised ascocarps covered with thallus near the top of lips, often and distinctly furrowed discs covered with white pruina, carbonized exciples nearly closed at the base and spores  $18-20 \times 5-6 \mu\text{m}$  in size and produce stictic acid. Thus, these two specimens are reported here as *G. ceylanica*, though the exciples are rather opened at the base and spores are a little smaller ( $11-23 \times 5-6 \mu\text{m}$ ).

*G. ceylanica* is very close to *G. bougainvillei* Zahlbr., a species reported from the Solomon Islands, which differs in having exciples open at base and by the larger spores of  $21-28 \times 9-10 \mu\text{m}$ .

Chemical substance: stictic acid.

Specimens examined: Santo-Luganville, Kashiwadani 43240; Efate-Iririki, Kashiwadani 43111.

**Graphis caesiella** Vain.\*

Chemical substances: norstictic and stictic acids.

Specimen examined: Efate-Mele Maat, Kashiwadani 43118.

**Graphis glaucescens** Fée\*

Chemical substance: no lichen substance.

Specimens examined: Santo-Sarunda, Kashiwadani 43283; Santo-Matantas, Kashiwadani 43342.

**Graphis insidiosa** (Knight & Mitt) J.D.Hooker\*

This species is easily distinguished from other species of *Graphis* in Vanuatu by the fissurine

apothecia with non-carbonated exciples, the 4-loculate ascocarps and by the absence of chemical substance.

It has a wide distribution in tropical to temperate areas including Australia, Dominica, New Caledonia, New Zealand and U.S.A. (Archer 2001, Wirth and Hale 1978). New to Vanuatu.

Chemical substance: no lichen substance.

Specimens examined: Santo-Surunda, Kashiwadani 43287 and 43292; Santo-NCK, Kashiwadani 43325; Tanna-Imanaka, Kashiwadani 43401.

**Graphis longiramea** Müll.Arg.\*

Chemical substance: stictic acid.

Specimen examined: Santo-Butmas, Kashiwadani 43204.

**Graphis malacoderma** Vain.\*

*Graphis malacoderma* was described by Vainio (1921) from the Philippines (Type collection: Philippines, Luzon Prov, Laguna, San Antonio, 1912, M. Ramos 16677—holotype in H!). Since then it has never been reported and this is the second report for the species.

*G. malacoderma* is characterized by the powdery white gray thallus, the barely carbonized and narrow (less than 13  $\mu\text{m}$  thick) exciples, the 8–10-loculated spores, 35–38  $\times$  7–8  $\mu\text{m}$  in size and the presence of stictic acid.

*G. malacoderma* resembles *G. hypolepta* Nyl., a species reported from Colombia (Type collection: Bogota, Lindig 715, 2400 m—holotype in H!) which differs in having smaller spores (21–32  $\times$  8–9  $\mu\text{m}$  in size) with 6–8 locules.

Chemical substance: stictic acid.

Specimens examined: Santo-Butmas, Kashiwadani 43219; Tanna-Fetukai, Kashiwadani 43419, 43420 and 43428.

**Graphis subassimilis** Müll.Arg.\*

Chemical substance: stictic acid.

Specimens examined. Tanna-Lenakel, Kashiwadani 43391; Tanna-Imanaka, Kashiwadani 43407.

**Graphis tenellula** Vain.\*

Chemical substance: norstictic acid.

Specimen examined: Efate-Erakor, Kashiwadani 43156.

**Phaeographina albogranulifera** M.Nakan., Kashiw. & K.H.Moon

Chemical substances: norstictic and protocetraric acids.

See Nakanishi *et al.* (2002).

**Phaeographina caesioradians** (Leight.) Redinger\*

Chemical substance: no chemical substance.

Specimens examined: Santo-Surunda, Kashiwadani 43275; Santo-Luganville, Kashiwadani 43241; Tanna-Fetukai, Kashiwadani 43418.

**Phaeographina montagnei** (v.d.Bosch) Müll.Arg.\*

Chemical substance: unidentified substance.

Specimen examined. Santo-Butmas, Kashiwadani 43206.

**Phaeographina ochracea** (Hepp in Zoll.) Müll.Arg.\*

This species was first reported from Java by Hepp (1854) as *Graphis ochracea* Hepp (Type collection: Java, H. Zollinger 738—holotype in PC). Since then no record has been made for the species. In present survey, however, it was found on bark of *Myristica fatua* at elevation about 520 m.

*P. ochracea* is easily distinguished from other species of *Phaeographina* in Vanuatu by the lirelliform prominent apothecia with open discs, the non-carbonized exciples, 1-spored asci, muriform ascospores of  $80\text{--}100 \times 18\text{--}25 \mu\text{m}$  and the presence of stictic and constictic acids.

Chemical substances: stictic and constictic acids.

Specimen examined. Santo-Butmas, Kashiwadani 43194.

**Phaeographina vanuatuensis** M.Nakan., Kashiw. & K.H.Moon

Chemical substance: stictic acid.

See Nakanishi *et al.* (2002).

**Phaeographis dendroides** (Leight.) Müll.Arg.\*

Chemical substance: stictic acid.

Specimens examined. Efate-Erakor, Kashiwadani 43179 and 43185; Santo-Surunda, Kashiwadani 43276.

**Phaeographis heterochroa** Zarlbr.\*

*Phaeographis heterochroa* is characterized by the intricately branched and substellate apothecia to 0.2 mm in diam., the non-carbonized exciples, the 4-celled brown spores  $14\text{--}17 \times 5\text{--}6 \mu\text{m}$  in size and the presence of norstictic acid.

Since Zahlbruckner (1930) described this species from China (Type collection: China, Fujian, Mt. Guschan, Chung 402—holotype in W!) no record has been made for the species. In present survey, we found a specimen of this species at Espiritu Santo Island where it grows on bark of *Spondias dulcis* at elevation about 10 m. This is the second record for the species.

It might be confused with *P. pruinosa* M.Nakan., a species reported from Japan, which differs in having apothecia with heavily pruinose discs and smaller ascospores ( $15\text{--}20 \times 7 \mu\text{m}$  in size).

Chemical substance: norstictic acid.

Specimen examined. Santo-Surunda, Kashiwadani 43290.

**Phaeographis exaltata** (Mont.) Müll.Arg.\*

Chemical substances: norstictic and stictic acids.

Specimens examined. Santo-Surunda, Kashiwadani 43270, 43277 and 43243; Santo-Luganville, Kashiwadani 43242; Tanna-Imanaka, Kashiwadani 43398.

**Sarcographa macrohydrina** M.Nakan., Kashiw. & K.H.Moon

Chemical substance: stictic acids.

See Nakanishi *et al.* (2002).

### Key to the species for lichen family Graphidaceae in Vanuatu

|   |                                 |
|---|---------------------------------|
| 1. Spores transversely septate (not muriform) .....   | 2                               |
| 1. Spores muriform .....  | 15                              |
| 2. Spores colorless .....   | 3                               |
| 2. Spores brown to dark brown .....   | 12                              |
| 3. Exciples carbonized, black at least in part .....  | 4                               |
| 3. Exciples not carbonized totally, hyaline .....   | 11                              |
| 4. Exciples carbonized apically.....  | <i>Graphis glaucescens</i>      |
| 4. Exciples carbonized laterally .....  | 5                               |
| 5. Exciples open; spores more than 50 $\mu\text{m}$ .....   | <i>Graphis longiramea</i>       |
| 5. Exciples closed; spores less than 50 $\mu\text{m}$ long .....  | 6                               |
| 6. Ascocarps covered with thalline margin nearly to the top.....  | <i>Graphis brevicarpa</i>       |
| 6. Ascocarps covered with thalline margin only at the base.....   | 7                               |
| 7. Ascocarps distinctly pruinose .....  | 8                               |
| 7. Ascocarps epruinose.....   | 9                               |
| 8. Stictic acid present .....   | <i>Graphis ceylanica</i>        |
| 8. Stictic acid absent, norstictic acid present .....   | <i>Graphis caesiella</i>        |
| 9. Stictic acid present.....  | <i>Graphis subassimilis</i>     |
| 9. Stictic acid absent, norstictic acid present .....   | 10                              |
| 10. Ascocarps prominent, rarely branched, short, 0.5–1.2 mm long .....  | <i>Graphis tenellula</i>        |
| 10. Ascocarps emergent, generally branched, elongate up to 5.0 mm .....   | <i>Graphis assimilis</i>        |
| 11. Disc open, reddish brown, pruinose; spores 8–10 loculate, 31–65 $\mu\text{m}$ long.....                         | <i>Graphis malacoderma</i>      |
| 11. Disc fissurine; spores 4-loculate, 15–24 $\mu\text{m}$ long.....  | <i>Graphis insidiosa</i>        |
| 12. Ascocarps somewhat emergent, dendritically branched; exciples not carbonized; norstictic acid present .....     | <i>Phaeographis heterochroa</i> |
| 12. Ascocarps sessile, prominent, often stromatoid; exciples entirely black, closed, much thickened below .....     | 13                              |
| 13. Disc conspicuously cracked.....   | <i>Sarcographa macrohydrina</i> |
| 13. Disc without cracks.....  | 14                              |
| 14. Disc thickly pruinose; spores 25–30 $\mu\text{m}$ long .....  | <i>Phaeographis dendroides</i>  |
| 14. Disc thinly pruinose; spores 19–27 $\mu\text{m}$ long .....   | <i>Phaeographis exaltata</i>    |
| 15. Exciples carbonized at least in part .....  | 16                              |
| 15. Exciples totally not carbonized .....   | 18                              |
| 16. Exciples carbonized laterally and basally, closed and thickened below; disc and hymenium with red pigment ..... | <i>Phaeographina montagnei</i>  |
| 16. Exciples carbonized laterally .....   | 17                              |
| 17. Ascocarps sessile, oval, very short, 1–1.5mm long .....   | <i>Graphina cleistoblephara</i> |
| 17. Ascocarps emergent, slender, 4–6 mm long .....  | <i>Graphina subserpentina</i>   |
| 18. Spores colorless.....   | 19                              |
| 18. Spores brown to dark brown .....  | 22                              |

|  |                                      |
|--|--------------------------------------|
| 19. Spores less than 80 $\mu\text{m}$ long .....   | 20                                   |
| 19. Spores more than 80 $\mu\text{m}$ long .....   | 21                                   |
| 20. Spores 36–62 $\mu\text{m}$ long; norstictic acid present .....   | <i>Graphina erythrella</i>           |
| 20. Spores less than 15 $\mu\text{m}$ long .....   | <i>Graphina intortula</i>            |
| 21. Ascocarps immersed; norstictic and stictic acids present .....   | <i>Graphina hieroglyphica</i>        |
| 21. Ascocarps sessile; stictic acid present .....  | <i>Graphina junghuhnii</i>           |
| 22. Spores up to 36 $\mu\text{m}$ long .....   | <i>Phaeographina caesioradians</i>   |
| 22. Spores more than 80 $\mu\text{m}$ long .....   | 23                                   |
| 23. Salazinic acid present; spores 90–130 $\mu\text{m}$ long .....   | <i>Phaeographina ochracea</i>        |
| 23. Salazinic acid absent, norstictic or stictic acid present .....  | 24                                   |
| 24. Ascocarps crowd, much flexional, dendritically branched; norstictic and protoceraric acids present ..... | <i>Phaeographina albogranulifera</i> |
| 24. Ascocarps mostly simple, sparingly branched; stictic acid present .....                                  | <i>Phaeograpina vanuatuensis</i>     |

### Summary

Twenty-five species of the family Graphidaceae are reported from Vanuatu. *Graphina cleistoblephara* (Nyl.) Zahlbr., *G. erythrella* (Mont. & v.d.Bosch) Zahlbr., *G. hieroglyphica* (Pers.) M. Nakan., *G. intortula* (Stirt.) Zahlbr., *G. junghuhnii* (Mont. & v.d.Bosch) Müll.Arg., *G. subserpentina* (Nyl.) Müll. Arg., *Graphis ceylanica* Zahlbr., *G. caesiella* Vain., *G. glaucescens* Fée, *G. insidiosa* (Knight & Mitt) J.D.Hooker, *G. longiramea* Müll.Arg., *G. malacoderma* Vain., *G. subassimilis* Müll.Arg., *G. tenellula* Vain., *Phaeographina caesioradians* (Leight.) Redinger, *P. montagnei* (v.d.Bosch) Müll.Arg., *P. ochracea* (Hepp) Müll.Arg., *Phaeographis dendroides* (Leight.) Müll.Arg., *P. heterochroa* Zahlbr. and *P. exaltata* (Mont.) Müll.Arg. are new records for Vanuatu. A new combination is made for *Graphina hieroglyphica* (Pers.) M.Nakan. *Graphis eugenize* Vain. and *G. subscripata* Horik. & M.Nakan. are reduced to synonyms of *Graphina intortula*.

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