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Notes on Species of Graphidaceae (Ascomycotina) from Eastern Asia with Three New Species

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Abstract. Three new species of the lichen family Graphidaceae are described from Eastern Asia: *Graphis kurokawae* M.Nakan., Kashiw. & K.H.Moon, *Leiorreuma taiwanense* M.Nakan., Kashiw. & K.H.Moon and *Phaeographis fumarprotocetrarica* M.Nakan., Kashiw. & K.H.Moon. *Graphis epiphloea* Zahlbr. and *Graphina japonica* var. *major* Zahlbr. described from Taiwan are reduced to synonyms of *Graphis awaënsis* Vain. and *G. streblocarpa* (Bél.) Nyl., respectively.
Key words: taxonomy, lichen, *Graphis kurokawae*, *Leiorreuma taiwanense*, *Phaeographis fumarprotocetrarica*, Graphidaceae, Eastern Asia.

Species of the family Graphidaceae is one of the most common crustose lichens in tropical and subtropical areas in the world. Although a comprehensive study for delimitation of the family was made by Staiger (2002), species in the family in Eastern Asia have not been taxonomically revised well. During our lichenological field works in Taiwan and Indonesia, through a research project "Biodiversity inventory in the Western Pacific region" supported by the National Museum of Nature and Science, Kashiwadani and Moon made an extensive collection of lichens. As a result of the taxonomic studies of specimens belonging to the Graphidaceae, three species were described as new to science. Additional notes for rare species, *Graphis awaënsis* Vain. and *G. streblocarpa* (Bél.) Nyl. were given in the present paper.

Materials and Methods

The present study is based on ca. 100 specimens of the family Graphidaceae collected in 2003 and 2006 by Kashiwadani and Moon in Taiwan and Indonesia. Other specimens collected in Japan and Thailand and preserved in TNS were also used for the present study. Specimens reported in the present paper are kept in the herbarium of the National Museum of Nature and Science (=National Science Museum, Tokyo, TNS), unless otherwise stated. Chemical substances were studied by means of thin-layer chromatography (Culberson & Johnson, 1982) and HPLC. Sections of apothecia and thalli were cut by hand-razor and mounted in lacto-phenol cotton-blue or GAW solutions.

Species

Graphis awaënsis Vain., Bot. Mag. Tokyo 38: 72. 1921. (Figs. 1A & 2A)

Type collection: Japan, Prov. Awa, Mt. Kiyosumi, on bark, July 25, 1918, E. Ochiai s.n. (A. Yasuda 251) — holotype in H-Vain. 27183 (TUR!); isotype in TNS! TLC: stictic acid (major) and norstictic acid (trace).

Graphis epiphloea Zahlbr., Fedde, Repert. 31: 210. 1933. Type collection: Taiwan, Toryoen, Mt.

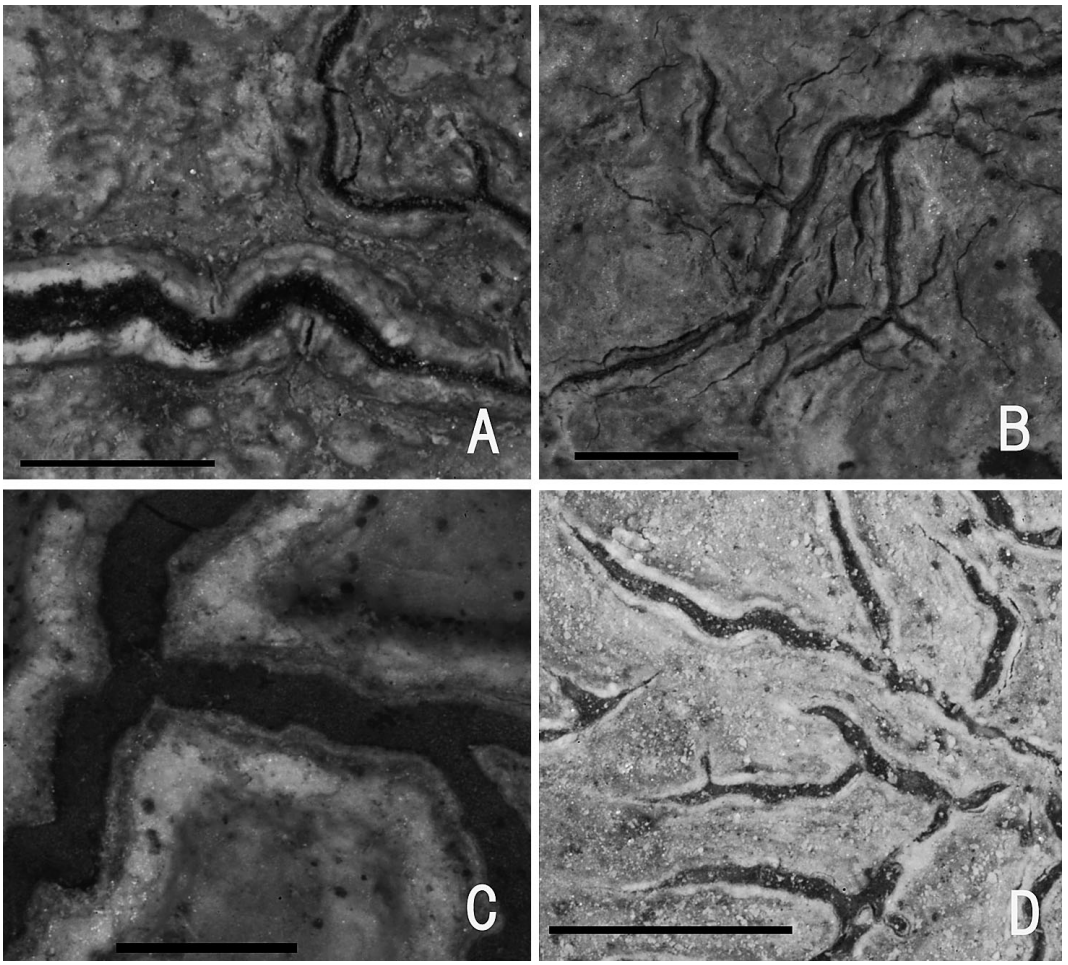

Fig. 1. Surface view of apothecia. A, *Graphis awaënsis* Vain. (S. Kurokawa 7308, TNS). B, *Graphis kurokawae* M.Nakan., Kashiw. & K.H.Moon, part of holotype (K.H. Moon 10011, TNS). C, *Leiorreuma taiwanense* M.Nakan., Kashiw. & K.H.Moon, part of holotype (H. Kashiwadani 35675, TNS). D, *Phaeographis fumarprotocetrarica* M.Nakan., Kashiw. & K.H.Moon, part of holotype (H. Kashiwadani 47937, TNS). (Scale bars = 1 mm in figs A, C & D; = 0.5 mm in fig. B; = 1 mm in figs. A, B, C & D)

Ari-san, December 24, 1925, Y. Asahina F354–holotype in W!; isotype in TNS!, syn. nov. TLC: stictic acid (major) and norstictic acid (trace).

Graphis awaënsis is characterized by the corticolous or saxicolous habit, the thin off-white thallus, the moderately branched subsessile apothecia (Fig. 1A), the convergent exciples carbonized laterally (Fig. 2A), transversely septate colorless ascospores with 12–20 locules and 50–75×10–12 μm in size and the presence of stictic (major) and norstictic acids (trace or -).

Zahlbruckner (1933) described *Graphis epiphloea* based on a specimen collected in Taiwan. The type specimen is well fertile and coincide well with the holotype of *G. awaënsis* morphologically and chemically. Thus, it is reduced to a synonym of *G. awaënsis*.

As reported by Nakanishi (1966), this species grows both on bark and rock. However, the corticolous specimens seem to be more common than the saxicolous one in Japan. It has been reported from Japan and Taiwan and the northern most locality for this species is Mt. Kiyosumi, Prov. Awa (Pref. Chiba), central Japan.

Representative specimens examined. Japan. Tokyo Metrop.: Sato-Mt. Oyama, Mikura Island, on decayed wood, elevation 350 m, July 14, 1981, M. Higuchi 10281 (TNS). Ryukyu Islands: Mt. Omoto-dake, Ishigaki Island, on rock, August 23, 1973, S. Kurokawa 73081 (TNS). Taiwan. Taichung Co.: Hashian-shan, Hopen Hsiang, on rock, elevation 800–900 m, March 6, 2003, K.H. Moon 10013 (TNS).

Graphis kurokawae M.Nakan., Kashiw. & K.H.Moon, sp. nov. (Figs. 1B, 2B, 3A & 4A)

Thallus et ascoparpus ut in *Graphis streblocarpa* sed excipulis propris tantum apicis carbonaceis differt. Acidum sticticum et acidum norsticticum continentibus.

Thallus saxicolous, continuous, smooth, pale fawn, subnitid. Apothecia lirelliform, black, immersed, scattered, slightly raised, sparingly branched, nearly completely covered with a thalline margin, showing very slender black line at the surface view, up to 3 mm long, 0.5–0.6 mm wide; disc pale brown, sunken and usually not visible in the surface view; exciple carbonized only at the upper half, never carbonized at the bottom, 22–25 μm thick at sides, 8–12 μm thick

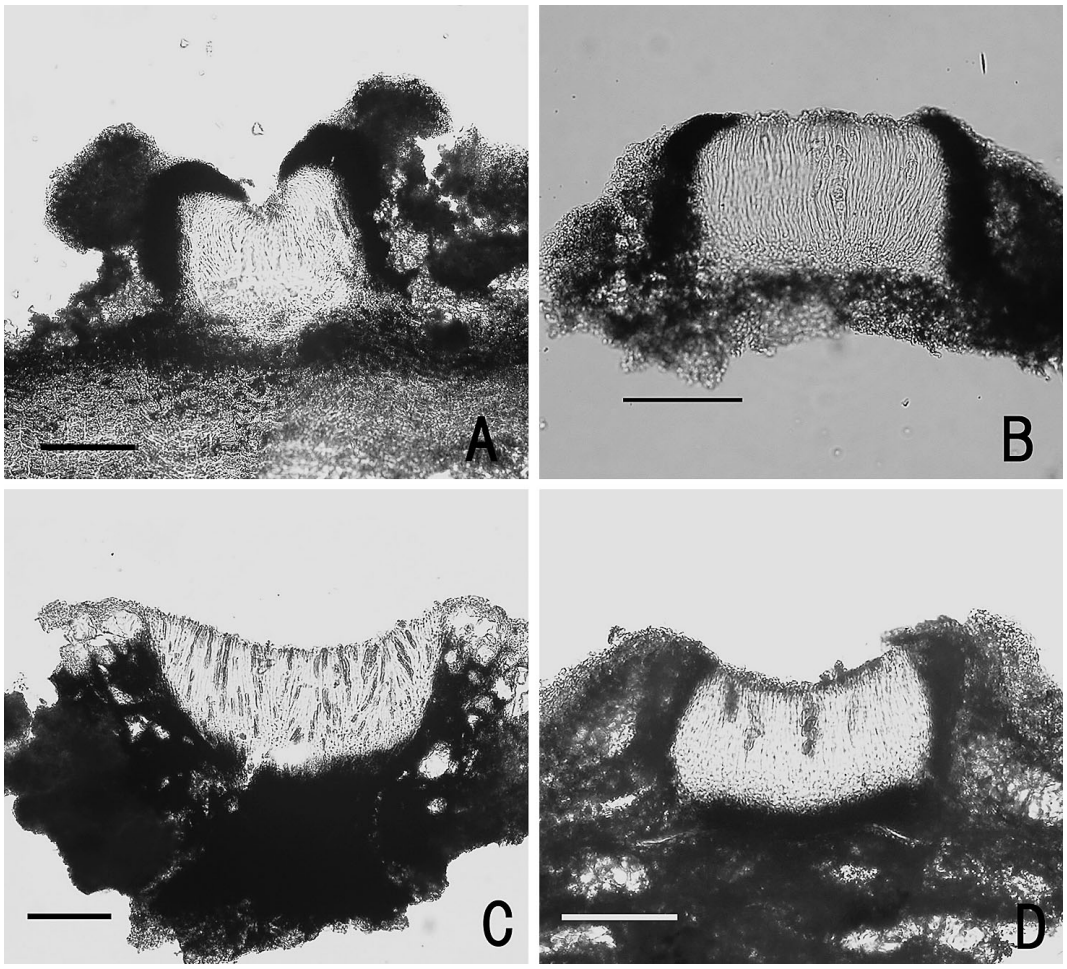

Fig. 2. Cross section of apothecia. A, *Graphis awaënsis* Vain. (S. Kurokawa 7308, TNS). B, *Graphis kurokawae* M.Nakan., Kashiw. & K.H.Moon (K.H. Moon 10011, TNS). C, *Leiorreuma taiwanense* M.Nakan., Kashiw. & K.H.Moon (H. Kashiwadani 35675, TNS). D, *Phaeographis fumarprotocetrarica* M.Nakan., Kashiw. & K.H.Moon (H. Kashiwadani 47937, TNS). (Scale bars = 100 μm)

at bottom; hymenium 100–120 μm high. Asci 4-spored, spores colorless, submuriform (9–12/2–3 locules), (42–)50–70(–82) μm.

Type collection: Taiwan. Taichung Co.: Guguan Hot Spring, Hopen Hsiang (24°19′N, 121°01′E), on rock, elevation 800–900 m, March 6, 2003, K.H. Moon 10011–holotype in TNS. TLC: stictic acid (major) and norstictic acid (minor).

Graphis kurokawae resembles *G. streblocarpa* (Bél.) Nyl. in having similar ascocarps covered with thallus (Fig. 1B), submuriform ascospores (Fig. 3A) and in producing stictic acid as major chemical substance. However, it can be clearly distinguished from the latter by the proper exciples carbonized only at the upper half (Figs. 2B, 4A); the proper exciples are thick and totally carbonized from the top to the bottom in *G. streblocarpa*. It might be confused with *Graphina filiformis* Zahlbr., a species described from China (type collection: Kushaku, corticola, Faurie 156, W!), which also differs in having thickly carbonized exciples as in *G. streblocarpa*.

This species has been known only from two localities in Taiwan.

Specimens examined. Taiwan. Taichung Co.: (the same locality with the type), K.H. Moon 10012 (TNS); Tekki, Hoping-gun, on rock, elevation about 1450 m, March 4, 1991, H. Kashiwadani 48236 (TNS)

Graphis streblocarpa (Bél.) Nyl., Flora 49: 133. 1866.

Basionym: *Opegrapha streblocarpa* Bél., Voy. Indies. Or., Botanique II, Cryptogamie: 134. 1834. Type collection: India, dans les forets du Bengale, C. Bélanger s.n.–holotype in G!. TLC: stictic acid.

Graphina japonica var. *major* Zahlbr., Fedde, Repert. 31: 212. 1933. Type collection: Taiwan, Rengechi, December 30–31, 1925, Y. Asahina F338–lectotype designated here, W!; isotype in TNS!, syn. nov. TLC: stictic acid and norstictic acid.

Graphis streblocarpa is a well-known species for Japanese lichenologists under the name of

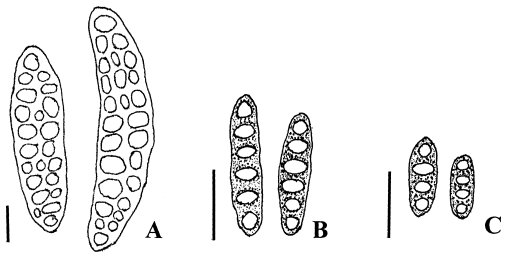

Fig. 3. Ascospores of holotypes. A, *Graphis kurokawae* M.Nakan., Kashiw. & K.H.Moon. B, *Leiorreuma taiwanense* M.Nakan., Kashiw. & K.H.Moon. C, *Phaeographis fumarprotocetrarica* M.Nakan., Kashiw. & K.H.Moon (Scale bars=100 μm)

Graphina japonica M.Nakan. (Type collection: Japan, Shikoku, Prov. Tosa, M. Miyoshi 23–holotype in G!, isotype in TNS!) or *G. fissofurcata* (Leight.) Müll.Arg. [Type collection: Ceylon (Sri Lanka), Nuwara Eliya, G.H.K. Thwaites CL 75–lectotype in BM!]. The latter two species were treated under *Graphis streblocarpa* by Archer (2006). *G. streblocarpa* is characterized by the lirellae covered with thick thalline margins, the laterally carbonized exciples which are convergent and open at the base, the colorless submuriform ascospores, 57–80×15–21 μm in size and the presence of stictic acid as major chemical substance.

Zahlbruckner (1933) described *Graphina japonica* var. *major* Zahlbr. on the basis of two specimens collected in Taiwan (Y. Asahina 338 and 339, W and TNS). These two specimens were collected in the same area and are identical each other. Therefore, one of them (Y. Asahina 338) indicated as TYPUS on a label was designated here as the lectotype. When Zahlbruckner described *G. japonica* var. *major*, he stressed in his description that it was characterized by the 1–2-spored asci and larger spores (118–122×30–32 μm in size). However, careful examination of the type specimen reveals that most asci have 4-spores which are 55–75×18–20 μm in size and only rarely 2-spored asci containing larger spores up to 105×23 μm in length are found. The spore characters found in the lectotype of var. *major*

can be considered as a minor variation within *G. streblocarpa*.

Graphis streblocarpa resembles *G. awaënsis* in having similar ascocarps, the convergent proper exciples, the exciples carbonized laterally and opened at the base and in producing stictic acid as major chemical substance. However, it is readily distinguished from the latter species by the muriform ascospores rather than the transversely septated ones of *G. awaënsis*.

This species has been reported from Australia, Ceylon, India, Indonesia, Japan, Java, the Philippines and Tanzania (Archer, 2006; Nakanishi, 1966). The distribution now includes Taiwan and Thailand.

Representative specimens examined. Japan. Izu Islands: Mt. Mihara-yama, Hachijo Island, on bark, September 9, 1976, H. Kashiwadani 13607 (TNS). Honshu. Prov. Mikawa: Chiiwa Gorge, Horai-cho, Minamishitara-gun, on rock, elevation 250 m, October 19, 2003, K.H. Moon 6132 (TNS). Prov. Ise: Mt. Kamiji, Ise-city, on bark of *Quercus glauca*, July 29, 1978, H. Kashiwadani (no. 14639, TNS) & C. Chuma. Prov. Kii: Mitogawa, Kozagawa-cho, Higashimuro-gun, on bark, August 2, 1978, H. Kashiwadani 14667 (TNS). Shikoku. Prov. Tosa (Pref. Kochi): Nogawa, Kitagawa-mura, Aki-gun, on bark, August 12, 1931, F. Fujikawa s.n. (TNS); Kitagawa, Higashitusnomura, Takaoka-gun, on rocks, elevation 350 m, March 26, 1983, H. Kashiwadani 19820 (TNS). Kyushu. Prov. Hyuga (Pref. Miyazaki): Kiyomizugane, Minou, Saito-city, on rock, elevation 70 m, April 7, 2004, Y. Umezu s.n. (TNS); Sano Shrine, Takaharu-cho, Nishimorokata-gun, on bark of Distylium racemosum, elevation 270 m, March 9, 2001, Y. Ohmura (no. 4594) & S. Kurogi (TNS); the same locality, on rock, Y. Ohmura (no. 4588) & S. Kurogi (TNS).

Taiwan. Taipei Co.: Yang-Ming-San, on bark, January 11, 1964, S. Kurokawa 701 (TNS). Nantou Co.: Lakeside of Sun Moon, on bark, January 28, 1964, S. Kurokawa 1295 (TNS). Kaohsiung Co.: en route from Ryuhkuei to Shanping, on bark, elevation 400–700 m, February 6, 1965, S. Kurokawa 2685 (TNS).

Indonesia. West Java: Cibodas Botanical Garden, Cianjur, on rock, elevation about 1400 m, September 13, 2006, H. Kashiwadani 48028 (TNS).

Thailand. Prov. Chieng Mai: Doi Sutep, on bark, elevation 1000–1676 m, February 16, 1964, S. Kurokawa 1623 (TNS).

Leiorreuma taiwanense M.Nakan., Kashiw. & K.H.Moon, sp. nov. (Figs. 1C, 2C, 3B & 4B)

Thallus ut in *Leiorreuma nornotaticum* sed sporis minoribus et excipulis thalloidum crasse denigratis differt. Acidum hypoprotocetraricum et acidum 4′-O-demethylnotaticum continentibus.

Thallus corticolous, continuous, smooth, pale olive green, shiny. Apothecia lirelliform, prominent, sessile, sparingly branched, tips of branching tapering, nearly completely covered with a thalline margin, ocher yellow at the upper half, pale olive green at lower half; up to 15 mm long; disc black, more or less convex and canaliculate, slightly covered with gray white pruina, more or less concave; proper exciples thin, dark brown,

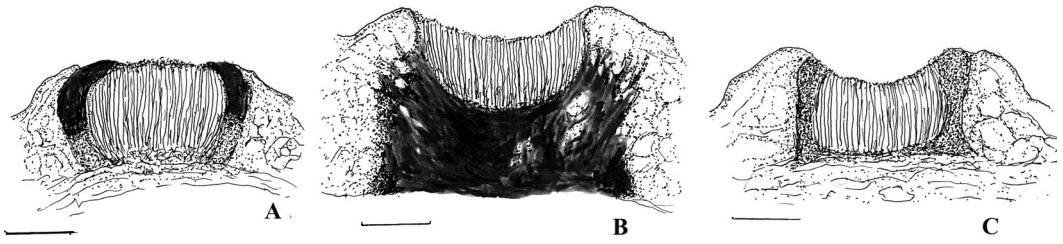

Fig. 4. Cross section of apothecia of holotypes. A, *Graphis kurokawae* M.Nakan., Kashiw. & K.H.Moon. B, *Leiorreuma taiwanense* M.Nakan., Kashiw. & K.H.Moon. C, *Phaeographis fumarprotocetrarica* M.Nakan., Kashiw. & K.H.Moon. (Scale bars = 100 μm)

8–12 μm thick; thalloid exciples completely carbonized at both sides (60–100 μm thick) and at the base (150–200 μm thick) (Fig. 4B); hymenium J-, 100–120 μm high. Ascospores 8 per ascus, pale brown, elongate ellipsoid, transversely septate with 6 locules, 17–20×6–7 μm.

Type collection: Taiwan. Taitung Co. (Taitung Hsien). Tian Chi, Lanyu Island, on bark, elevation about 300 m, October 24, 1989, H. Kashiwadani 35675–holotype in TNS. TLC: hypoprotocetraric acid (major) and 4′-O-demethylnotatic acid (minor).

Leiorreuma taiwanense is unique in having prominent ascocarps covered with thallus nearly up to the top of the labia (Fig. 1C), the completely carbonized exciples at both sides and at the base (Figs. 2C, 4B), the 8-spored asci with pale brown ascospores with 6 locules (Fig. 3B) and the presence of hypoprotocetraric acid (major) and 4′-O-demethylnotatic acid.

Leiorreuma taiwanense might be confused with *L. nornotaticum* (A.W. Archer & Elix) A.W. Archer, a species reported from Australia, because they both have prominent ascocarps and produce the same chemical substances, though 4′-O-demethylnotatic acid is a main chemical substance in the latter species (Archer & Elix, 1999). However, it can be distinguished from the latter by the thickly carbonized exciples at both sides and by the smaller spores; exciples are thinly carbonized laterally and spores are larger (21–25 μm in *L. nornotaticum*). In addition, *L. taiwanense* has apothecia with acute tips and apparently canaliculate discs, whereas *L. nornotaticum* has apothecia with round tips and flat disc. It might be confused with *L. exaltatum* (Mont. & v.d. Bosh) Staiger, a species widely distributed in temperate and tropical regions in the world. However, it is clearly distinguished from the latter by the presence of depsidones.

The new species is known only from two localities in southern Taiwan.

Specimens examined. Taiwan. Prov. Taitung: the same locality with the type, H. Kashiwadani 35674 (TNS). Prov. Pingtung: Keitoku, ca 7 km NE of Mudang along R 199, Mudan Hisang. On bark, elevationa about 200 m, March 7, 2004, H. Kashiwadani 46704b (TNS).

Phaeographis fumarprotocetrarica M.Nakan., Kashiw. & K.H.Moon, sp. nov.

(Figs. 1D, 2D, 3C & 4C)

Thallus ut in *Phaeographis hypoglauca* sed excipulis propriis pallidis et acidum fumarprotocetraricum continentibus differt.

Thallus saxicolous, continuous, smooth, yellowish brown, dull. Apothecia lirelliform, inconspicuous, immersed, sparingly branched, nearly completely covered with a thalline margin, up to 3 mm long, 0.2–0.25 mm wide; disc open, dark brown; proper exciple thin, pale brown, 30–40 μm thick; hymenium 100–110 μm high. Asci 8 spored; spores dark brown, ellipsoid, with 4 locules, 11–15×6–7 μm in size.

Type collection: Japan. Prov. Ryukyu: ca. 5 km NW of Ohtomi, Taketomi-cho, Iriomote-jima, Yaeyama Islands, on rock (sand stone) along Nakama-gawa, elevation about 30 m, February 9, 1995, H. Kashiwadani 47937–holotype in TNS.

Chemistry: fumarprotocetraric acid.

Notes: This new species is unique in having fumarprotocetraric acid as a chemical substance in the family Graphidaceae. This species very much resembles *Graphis hypoglauca* Kremp., a species from China and *G. hypoglaucoides* K.P.Singh & D.D.Awasthi, a species from India, in having similar brown ascocarps with 4 locules (Fig. 3C). However, it can be distinguished from them by the non-carbonized exciple at the base (Figs. 2D, 4C) and by the presence of fumarprotocetraric acid.

At present this species is known from Iriomote Island, Japan and Taiwan.

Specimens examined. Japan. Prov. Ryukyu: ca. 6 km NW of Ohtomi, Taketomi-cho, Iriomote-jima, Yaeyama Islands, on rock (sand stone) along Nakama-gawa, elevation about 30 m, February 9, 1995, H. Kashiwadani 47938 (TNS). Taiwan. Taipei Co.: Shrmen, Shrmen-gun, on rock (sand stone) along river, elevation about 10 m, March 11, 2005, H. Kashiwadani 48303 (TNS).

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3新種を含む東アジア産モジゴケ科について

文　光喜・中西　稔・柏谷博之

東アジア産の標本をもとに*Graphis kurokawae* M.Nakan., Kashiw. & K.H.Moon, *Leiorreuma taiwanense* M.Nakan., Kashiw. & K.H.Moon, *Phaeographis fumarprotocetrarica* M.Nakan., Kashiw. & K.H.Moonの三新種を記載した．台湾から報告されていた*Graphis epiphloea* Zahlbr.は*Graphis awaënsis* Vain.のシノニムとなった．また，*Graphina japonica* var. *major* Zahlbr.は*G. streblocarpa* (Bél.) Nyl.のシノニ ムとなった.