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FULL PAPER

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Taxonomic studies of nectrioid fungi in Japan. III. The genus *Cosmospora*

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Abstract Seven species of the genus *Cosmospora* collected in Japan are reported in this article. Among them, *Cosmospora japonica* is described as a new species. *Cosmospora henanensis*, *C. rishbethii*, and *C. triqua*, all of which are known only from their type localities, are added to the Japanese mycobiota. The other species, *C. chaetopsinae-catenulatae*, *C. diminuta*, and *C. peponum*, are new records for Japan. Additional distribution records are given for *Cosmospora* species hitherto known in Japan.

Key words Hypocreales · Nectriaceae · New species · Systematics · Taxonomy

Introduction

The genus *Cosmospora* was established by Rabenhorst in 1862 based on *Cosmospora coccinea* Rabenh., although the name was not widely adopted. Most species of *Cosmospora* have been classified as species in the *Nectria episphaeria* group (Saccardo 1883; Booth 1959; Samuels 1976; Rossman 1983) or *Nectria* subgenus *Dialonectria* (Cooke 1884; Samuels et al. 1991). Details of the taxonomic history of *Cosmospora* are given in Samuels et al. (1991) as *Nectria* subgenus *Dialonectria*. Rossman et al. (1999) recognized this group as the genus *Cosmospora* (Nectriaceae) based on a combination of characteristics including perithecial morphology and anamorph. Rossman et al. (1999) distinguished the genus *Cosmospora* from other nectrioid genera by the following combination of characters: perithecia solitary to gregarious, small (usually less than 300 μm in diameter), collapsing laterally when dry, orange to red or dark red, usually KOH+, rarely KOH–, with thin ascomatal wall (less than 20 μm thick); asci cylindrical to narrowly clavate, 8-spored; ascospores ellipsoid to fusiform, usually spinulose to tuberculate and often yellow-brown. Anamorphs of *Cosmospora* are distributed among seven genera (*Chaetopsina* Rambelli, *Cylindrocladiella* Boesew., *Fusarium* Link, *Stilbella* Lindau, *Verticillium* Nees, *Volutella* Fr., and *Acremonium* Link s. lat.) (Samuels et al. 1991; Rossman et al. 1999). Rossman et al. (1999) included 49 species in *Cosmospora*. *Cosmospora henanensis* Nong & Zhuang (anamorph: *Acremonium*-like) (Nong and Zhuang 2005) and *C. matuoi* Hosoya & Tubaki (*Fusarium matuoi* Hosoya & Tubaki) (Hosoya and Tubaki 2004), both from Asia, have been added.

Classically, anamorph and teleomorph taxonomies have been independent of each other, despite the fact that, especially in the Nectriaceae, the ascomycetes are pleomorphic, including one or more anamorph genera in the life cycle of a single ascomycete species. The combination of teleomorph and anamorph data has led to a more refined definition of ascomycete taxa. Many anamorphs of the Hypocreales are characteristic of their corresponding teleomorph genera (Samuels and Seifert 1987; O'Donnell 1996; Rossman 2000; Kirk et al. 2001). Although phylogenetic analysis has supported genera in the nectrioid fungi that are defined on the basis of combined anamorph and teleomorph data (e.g., Schoch et al. 2000; Mantiri et al. 2001; Rossman et al. 2001; Schroers 2001), most genera of the Nectriaceae have not been subjected to phylogenetic analysis. Among these is *Cosmospora*, which has been linked to seven anamorph genera (*Acremonium*, *Chaetopsina*, *Cylindrocladiella*, *Fusarium*, *Stilbella*, *Verticillium*, and *Volutella*), as was mentioned earlier. The main characteristic of *Cosmospora*, the rather simple, red perithecia, does not present sufficient phenotypic information to allow a distinction at the generic level among the species that have seemingly different anamorphs, but the diversity in anamorphs strongly suggests that *Cosmospora* is polyphyletic.

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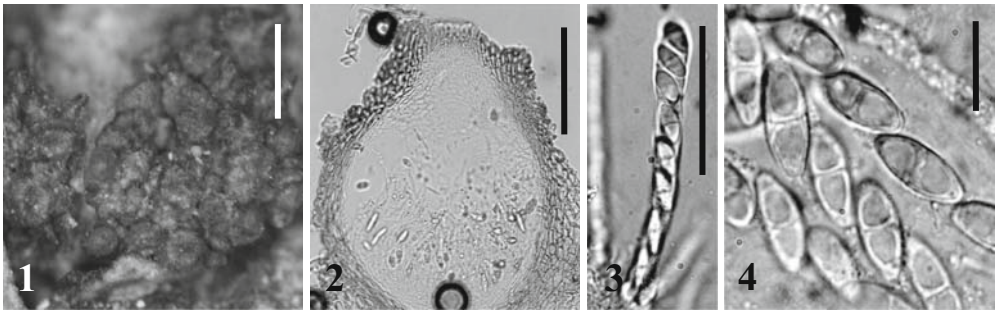


Figs. 1–4. *Cosmospora japonica* (TFM FPH-7962). **1** Perithecia on natural substratum. **2** Median section of perithecium. **3** Ascus with eight, uniseriate ascospores. **4** Ascospores. *Bars* **1** 500 µm; **2** 100 µm; **3** 50 µm; **4** 10 µm

The aim of this series of articles has been to review information on the Japanese species of nectrioid fungi that are poorly known (Hirooka and Kobayashi 2007a,b). In this third report, we describe and illustrate species of genus *Cosmospora*. Moreover, additional localities of species of *Cosmospora* known to occur in Japan are given.

Materials and methods

Materials examined

Fresh specimens of the teleomorph and anamorph of the *Cosmospora* and the single ascospore isolates were collected for the present study. All specimens were kept at TFM, Herbarium of Forest Mycology and Pathology of Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Ibaraki, Japan.

Isolation

Single ascospore cultures were obtained according to the methods of Hirooka and Kobayashi (2007a). These cultures were preserved at MAFF, National Institute of Agrobiological Sciences (NIAS), Tsukuba, Ibaraki, Japan.

Morphological observation

Observation of teleomorph followed Hirooka and Kobayashi (2007a). Colonies on oatmeal agar (OA; Kirk et al. 2001) and potato dextrose agar (PDA; Kirk et al. 2001) grown for 10 days at 25°C in the dark were evaluated for growth rates and colony color. Colors were designated according to Kornerup and Wanscher (1978). For observation of the anamorph, cultures on OA, PDA, synthetic low nutrient agar (SNA; Kirk et al. 2001), and SNA under permanent black light (BLB; Nirenberg 1990) were used.

Descriptions

Cosmospora Rabenh. Fungi Europaei Exsiccati no. 459, 1862.

Type species: *Cosmospora coccinea* Rabenh.

1. ***Cosmospora japonica*** Hirooka, Tak. Kobay. & Samuels, sp. nov. Figs. 1–4, 5a–c

Stromata corticalia, erumpentia, contextu "textura epidermoidea" vel "textura angularis" composita. Perithecia ad stromate superficialia, gregaria, ovalia vel pyriformia, 185–320 µm alta, 180–290 µm diametro, aurantiaca vel rubella. Asci unitunicati, leviter clavati, 77–110 × 6–12 µm, octospori. Ascosporae monostichae vel irregulariter distichae, inaequaliter 1-septatae, ellipsoideae vel fusiformes, flavescente brunneae, 12–20 × 4–7 µm, laeves.

Etymology: *japon* + *-ica*; indicates the collected place of the type material.

Holotypus: On bark of fallen twigs, Siroyama-cho, Ichisigun, Mie Pref., August 25, 2004, by Y. Hirooka (Y.H.) (teleomorph: TFM FPH-7962).

Anamorph: Unknown.

Mycelium not visible around perithecia or host. Stromata abundantly formed in epidermal layer of outer bark, orange, erumpent through the epidermis, "textura epidermoidea" to "textura angularis." Perithecia densely gregarious in groups of 10–50, with conspicuous basal stroma, ovate to pyriform, (185–)252–290(–320) µm high, (180–)194–261(–290) µm diameter, with obtuse apex, collapsing laterally when dry, orange to red, purple in KOH and yellow in LA (lactic acid), slightly warted; perithecial warts orange to red, angular to subglobose, (3–)7–11 µm high; cells of perithecial warts angular to subglobose, (3–)6–8(–10) µm diameter, with unevenly thickened walls. Perithecial walls (17–)22–31(–35) µm wide, composed of about 5 layers of subglobose cells, innermost 2 layers becoming increasingly flattened and compressed toward the perithecial locule. Asci narrowly clavate, (77–)87–110 × (6–)8–10(–12) µm, apex with inconspicuous refractive ring, containing 8 spores in one or irregularly two rows. Ascospores ellipsoid to fusiform, unequally 2-celled, rarely septum submedian, (12)–14–17(–20) × (4–)5–6(–7) µm, 16 × 5.5 µm in average, smooth, yellowish-brown.

Culture not obtained. Ascospores did not germinate on OA, PDA, SNA incubated in darkness, or SNA incubated in BLB light.

Specimens examined: On black stroma on bark of fallen twigs, Akiu-cho, Taihaku-ku, Sendai-shi, Miyagi Pref., August 4, 2004, by Y. Hirooka (Y.H.) (TFM FPH-7963); on black stroma on bark of fallen twigs, Hikawa valley, Yamanashi-shi, Yamanashi Pref., September 26, 2004,

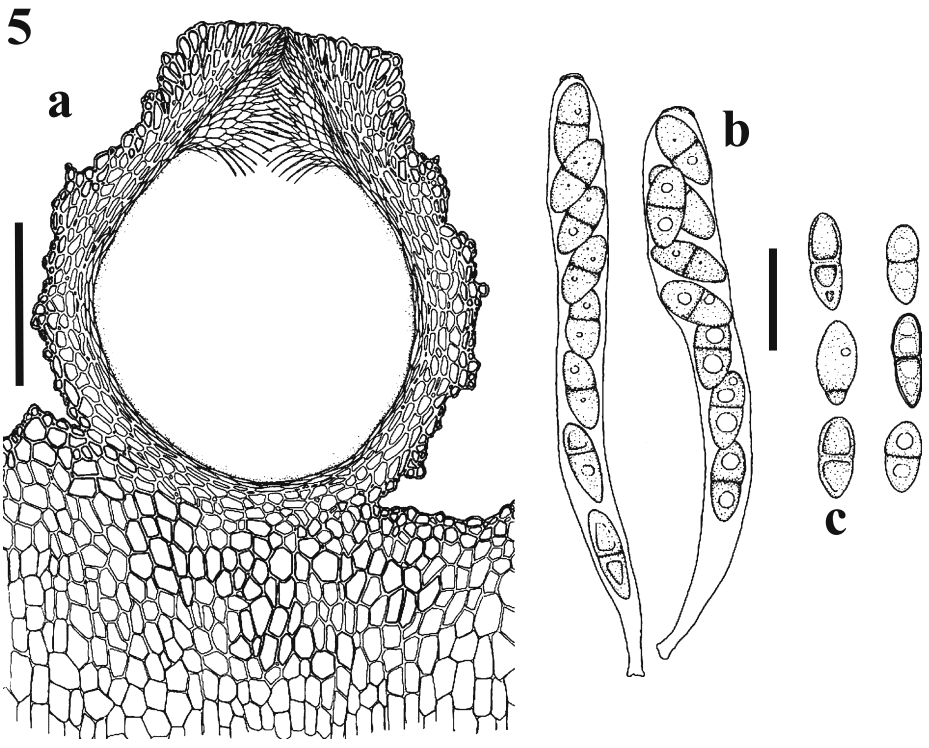


Fig. 5. Schematic figures of *Cosmospora japonica* on natural substratum (TFM FPH-7962). **a** Median section of perithecium. **b** Asci with uniseriate or biseriate ascospores. **c** Ascospores. *Bars* **a** 100 µm; **b**, **c** 20 µm

by T. Tokiwa (T.T.) & Y.H. (TFM FPH-7964); on black stroma on bark of fallen tree, Hikawa valley, Yamanashi-shi, Yamanashi Pref., September 26, 2004, by T.T. & Y.H. (TFM FPH-7965); on black stroma on bark of fallen twigs, Kotohirayama, Kotohira-cho, Nakatado-gun, Kagawa Pref., November 10, 1991, by S. Mitani (TF M FPH-7966); on black stroma on bark of fallen twigs, Minakami-cho, Tone-gun, Gunma Pref., September 18, 2005, by T. Hosoya (T.H.) (TFM FPH-7967).

Note: *Cosmospora japonica* is placed in the genus *Cosmospora* because it has minute red perithecia usually gregarious in groups, positive KOH and LA, collapsing laterally when dry, thin perithecial wall, and light pigmented ascospores. *Cosmospora japonica* is somewhat difficult to identify because several species have ascospores of the same size, and its anamorph is not known. However, the combined characters of slightly warted perithecial wall (Figs. 1, 2, 5a) and unequally 2-celled and smooth ascospores (Figs. 4, 5c) are not found in any known species of *Cosmospora*.

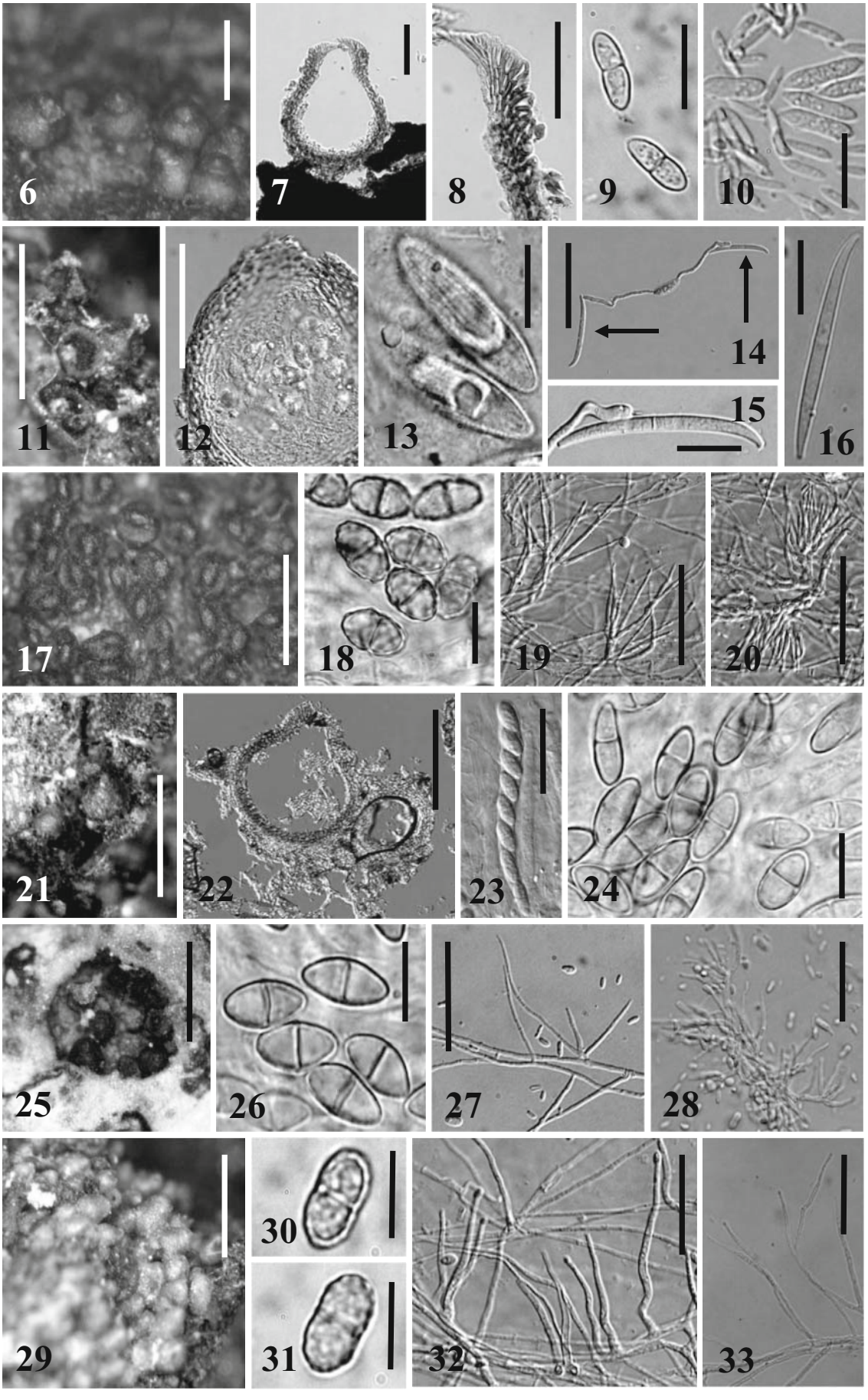
According to the key in Rossman et al. (1999) and Samuels et al. (1991), the important characteristic feature in the species of *Cosmospora* is size of ascospores. Among these taxa, *C. stilbosporae* (Tul. & C. Tul.) Rossman & Samuels (*Fusarium expansum* Schltdl.) and *C. ganymede* (Lowen & Minter) Rossman & Samuels (*Fusarium* sp.) somewhat resemble *C. japonica*. However, *C. japonica* differs from *C. stilbosporae* in having a slightly warted perithecial wall (smooth in *C. stilbosporae*), thinner perithecial wall (35–45 µm in *C. stilbosporae*), and smooth ascospores (spinulose in *C. stilbosporae*), and from *C. ganymede* in having a slightly warted perithecial wall (smooth to scaly in *C. ganymede*), thick perithecial wall (35–45 µm in *C. ganymede*), and smooth ascospores (spinulose in *C. ganymede*). For these reasons, the fungus is described as a new species.

2. ***Cosmospora chaetopsinae-catenulatae*** (Samuels) Rossman & Samuels in Rossman, Samuels, Rogerson & Lowen, Stud. Mycol. 42: 119, 1999. Figs. 6–9, 34a–c

≡ *Nectria chaetopsinae-catenulatae* Samuels, Mycotaxon 22: 28, 1985.

Anamorph: *Chaetopsina catenulata* Samuels, Mycotaxon 22: 28, 1985. Fig. 10

Mycelium sometimes visible around perithecia or host. Stromata thin, spreading over black stroma of unidentified fungi on bark, "textura epidermoidea" to "textura angularis." Perithecia solitary or gregarious, superficial on the stroma, pyriform to slightly flask-shaped, narrowly constricted just below the papilla, (210–)230–350(–450) µm high, 170–280(–330) µm diameter, collapsing laterally when dry, reddish-orange with red papilla, uniformly dark red in KOH and yellow in LA, smooth to scaly with a flat disk (55–)70–140(–175) µm high, 100–150(–220) µm wide. Perithecial walls 25–31(–37) µm wide, composed of 4–5 layers of subglobose cells, the innermost 1 or 2 layers becoming increasingly flattened and compressed toward the perithecial locule. Asci clavate, (40–)50–83(–87) × (5–)8–11(–14) µm, apex with inconspicuous refractive ring, containing 8 biseriate ascospores. Ascospores ellipsoid to fusiform,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(7–)9–13(–19) × (3–4 – 5 µm, equally 2-celled, hyaline, smooth. Anamorph not observed in nature.

Colonies on PDA in the dark 25–32 mm after 10 days at 25°C, cottony with abundant aerial mycelium, whitish-yellow to yellowish-green; reverse greenish-yellow in the center and yellowish-white at the margin (MAFF 240004), greenish-brown in the center and yellowish-green at the margin (MAFF 240005); no distinctive odor. Colonies on OA in the dark 29–36 mm after 10 days at 25°C, with abundant cottony aerial mycelium arising from the entire colony, white to yellowish-white; reverse yellowish-green in the center, yellowish-white at the margin (MAFF 240004), pale green to pale brown in the center, yellowish-green at the margin (MAFF 240005); no distinctive odor. Sporulation on OA in the dark within 1–2 weeks in aerial mycelium and conidiophores arising directly from the agar surface. Conidiophores unbranched monophialidic, or loosely to densely branched, verticillium-like, (63–)82–151(–180) µm long, 4–6 µm wide at the base. Conidiogenous cells in whorls of 2–5, cylindrical, phialidic, (12–)26–35(–44) × 3–4 µm, with a collarette. Conidia held end to end in chains, hyaline, smooth, oblong to fusiform, with a hilum at each end, 0–1-septate; (6–)9–12(–14) × (1.5–)2–3 µm, 8.2 × 2.2 µm in average (0-septate), (11–)12–16(–20) × 3–4 µm, 15.5 × 3.3 µm in average (1-septate). Chlamydospores formed in mycelium, globose, terminal or intercalary in hyphae, hyaline, smooth, (7–)9–10(–12) µm diameter. Perithecia not produced in culture.

Specimens and isolates examined: On black stroma of unidentified fungi on bark, Shikanoshima, Higashi-ku, Fukuoka-shi, Fukuoka Pref., March 31, 2004, by Y.H. (teleomorph: TFM FPH-7827, culture: MAFF 240004); on black stroma of unidentified fungus on bark, Kannonji, Dazaifu-shi, Fukuoka Pref., April 1, 2004, by Y.H. (teleomorph: TFM FPH-7828; anamorph: FPH-7829; culture: MAFF 240005).

Note: *Cosmospora chaetopsinae-catenulatae* (anamorph: *Chaetopsina catenulata*) is characterized by formation of an apical disk on the perithecia, and catenulate, 0–1-septate conidia (Samuels 1985) (Figs. 6–8, 10, 34a) arising from setiform, KOH+ conidiophores. The teleomorph of these specimens agrees well with the description of *C. chaetopsinae-catenulatae* provided by Samuels (1985; as *Nectria chaetopsinae-catenulatae*). The *Chaetopsina* anamorph was not observed on our specimens, and its distinctive setiform conidiophores did not form in culture, but some conidiophores and hyphae were pale reddish-brown. Our cultures were consistent with the cultures described for *C. chaetopsinae-catenulatae* (Samuels 1985).

Five species of *Cosmospora* with *Chaetopsina* anamorph are known (Rossman et al. 1999). In Japan, *Chaetopsina fulva* Rambelli have been recorded (Tubaki and Saito 1969; Aoki et al. 1990; Tokumasu 1996; Okada et al. 1997; Iwamoto and Tokumasu 2001). Its teleomorph has not been discovered. In this article, we report the first occurrence of the teleomorph of a *Chaetopsina* species in Japan.

3. ***Cosmospora diminuta*** (Berk.) Rossman & Samuels in Rossman, Samuels, Rogerson & Lowen, Stud. Mycol. 42: 120, 1999. Figs. 11–13, 35a–c

≡ *Nectria diploa* Berk. & M.A. Curtis var. *diminuta* Berk., Grevillea 4: 46, 1875.

≡ *Nectria diminuta* (Berk.) Sacc., Syll. Fung. 2: 498, 1883.

= *Dialonectria gigaspora* Cooke & Massee, in Cooke, Grevillea 17: 42, 1888.

≡ *Nectriella gigaspora* (Cooke & Massee) Sacc., Syll. Fung. 9: 942, 1891.

≡ *Pseudonectria gigaspora* (Berk.) Petch, Ann. Roy. Bot. Gard. (Peradeniya) 7: 122, 1920.

Anamorph: *Fusarium* sp. Figs. 14–16

Mycelium not visible around perithecia or host. Stromata formed on ostiolar area of other fungi, "textura intricata." Perithecia superficial, solitary to caespitose in groups of about 5, ovate to pyriform, (140–)160–191 (–200) µm high, 120–163(–174) µm diameter, with subacute apex, collapsing laterally when dry, pale red to red, purple in KOH and yellow in LA, smooth. Perithecial walls 15–20(–25) µm wide, composed of about 5 layers of subglobose cells, the innermost 1 or 2 layers, becoming increasingly flattened and compressed toward the perithecial locule. Asci clavate, (47–)62–85 × 10–12 µm, without apical ring, 8-spored, ascospores biseriate. Ascospores ellipsoid to fusiform, at first 1-septate, ultimately 2-septate, (22.5–)29–31(–34) × (7.5–)9–11(–12.5) µm, smooth to finally each striation composed of spinules, hyaline, yellowish brown at maturity.

Figs. 6–33. *Cosmospora* species from Japan. **6–10** *C. chaetopsinae-catenulatae* (anamorph: *Chaetopsina catenulata*) (TFM FPH-7828, MAFF 240005). **6** Perithecia on natural substratum. **7** Median section through perithecium on black stroma of unidentified fungi. **8** Median section of perithecial apex. **9** Ascospores. **10** Conidia on oatmeal agar (OA). **11–16** *C. diminuta* (*Fusarium* sp.) (**11**, **12**, **13**, TFM FPH-7855; **14–16**, TFM FPH-7857). **11** Perithecia on natural substratum. **12** Median section of perithecium. **13** Ascospores with striations formed of spinulae arranged in lines. **14** Germ tube and conidia (*arrows*) from ascospore on synthetic low nutrient agar (SNA). **15** Close-up of conidiogenous cell and conidia on SNA. **16** Conidia from nature. **17–20** *C. henanensis* (anamorph: *Acremonium*-like) (TFM FPH-7819, MAFF 240000). **17** Perithecia on natural substratum. **18** Ascospores. **19** Primary conidiophores on OA. **20** Secondary conidiophores on OA. **21–24** *C. peponum* (TFM FPH-7968). **21** Perithecia on natural substratum. **22** Median section of perithecia. **23** Ascus with eight uniseriate ascospores. **24** Ascospores. **25–28** *C. rishbethii* (*Acremonium*-like) (TFM FPH-7821, MAFF 240001). **25** Perithecia on natural substratum. **26** Ascospores. **27** Primary conidiophores on OA. **28** Secondary conidiophores on OA. **29–33** *C. triqua* (*Acremonium*-like) (TFM FPH-7823, MAFF 240002). **29** Perithecia on natural substratum. **30** Ascospore in optical section. **31** Ascospore in surface view. **32** Short conidiophores on OA. **33** Long conidiophores on OA. *Bars* **6**, **11**, **17**, **21**, **25**, **29** 500 µm; **7**, **8**, **14** 50 µm; **9**, **13**, **15**, **16**, **18**, **24**, **26**, **30**, **31** 10 µm; **10**, **19**, **20**, **23**, **27**, **28**, **32**, **33** 30 µm; **12**, **22** 100 µm

Figs. 34–39. Schematic figures and line drawings of *Cosmospora* species from Japan. **34a–c** *C. chaetopsinae-catenulatae* (TFM FPH-7828). **a** Median section of perithecium. **b** Ascus with biseriate ascospores. **c** Ascospores. **35a–c** *C. diminuta* (TFM FPH-7857). **a** Median section of perithecium. **b** Ascus with biseriate ascospores. **c** Ascospores. **36a–c** *C. henanensis* (TFM FPH-7819). **a** Median section of perithecium. **b** Asci with uniseriate ascospores. **c** Ascospores. **37a–c** *C. peponum* (TFM FPH-7968). **a** Median section of perithecium. **b** Ascus with uniseriate ascospores. **c** Ascospores. **38a–c** *C. rishbethii* (TFM FPH-7821). **a** Median section of perithecium. **b** Ascus with uniseriate or biseriate ascospores. **c** Ascospores. **39a–c** *C. triqua* (TFM FPH-7823). **a** Median section of perithecium. **b** Ascus with uniseriate ascospores. **c** Ascospores. *Bars* **34–39 a** 100 µm; **b**, **c** 20 µm

Culture not obtained. Only one conidium formed on the head of germ tube from ascospore in OA, PDA, SNA and SNA under BLB light. Germ tube from ascospore 73–97 µm long and 4–5 µm diameter, hyaline, smooth. Conidiogenous cell long cylindrical, monophialidic, 11–20 × 3.5–5 µm. Conidia cylindrical to slightly fusiform with a hooked and acute apical cell and indistinct basal foot cell, straight to slightly curved, 1-septate, 38–50 × 4–5 µm, not germinating on OA, PDA, SNA and SNA under BLB light. Chlamydospores absent.

Specimens examined: On pycnidia of *Stagonospora* sp. on dead twigs of *Aucuba japonica* Thunb. (Japanese name: Aoki), Koishikawa Bot. Gard., The University of Tokyo, Hakusan, Bunkyo-ku, Tokyo, August 13, 2002, by Y.H. (teleomorph: TFM FPH-7855); on pycnidia of unidentified fungus on dead twigs of *Fagus* sp., Higashiyamato park, Higashiyamato-shi, Tokyo, October 20, 2003, by T.T. & Y.H. (teleomorph: TFM FPH-7856); on fruit body of unknown ascomycetes on dead twigs, Tonbo park, Shimanto-shi, Kochi Pref., August 6, 2003, by Y.H. (teleomorph: TFM FPH-7857).

Note: *Cosmospora diminuta* (anamorph: *Fusarium* sp.) is newly added to the Japanese mycobiota. Morphological characteristics of the Japanese specimens agree well with published description of *C. diminuta* (Rossman et al. 1999; Samuels et al. 2006). Samuels et al. (2006) described a *Fusarium* anamorph for *C. diminuta*, which occurs on stromata of other ascomycetes in the United States. In our specimens, *Fusarium*-like conidia of *C. diminuta* were produced on each tip of germ tubes from the ascospores grown on SNA (Figs. 14–16). These conidia, however, did not germinate and the culture died. However, conidial characters of *C. diminuta* were morphologically identified as *Fusarium* sp. based on acute apical cell and a basal foot cell.

Twenty species of *Cosmospora* are known to have *Fusarium* anamorph (Rossman et al. 1999; Hosoya and Tubaki 2004; Samuels et al. 2006). They are mycoparasitic or entomopathogens.

4. ***Cosmospora henanensis*** Y. Nong & W.Y. Zhuang, Fungal Diversity 19: 96, 2005. Figs. 17, 18, 36a–c

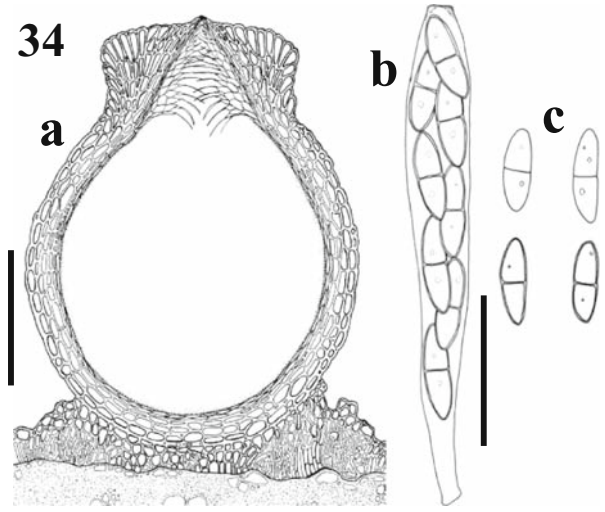
Anamorph: *Acremonium*-like. Figs. 19, 20

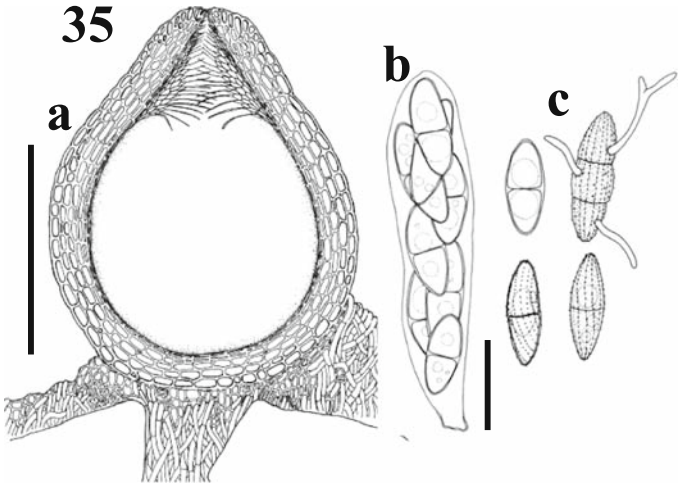
Mycelium not visible around perithecia or host. Stromata abundantly formed on the stroma of Xylariaceae, "textura epidermoidea" to "textura globulosa." Perithecia gregarious, superficial, broadly pyriform to subglobose with slightly acute to round apex, 220–256(–270) µm high, (160–)183–200 µm diameter, collapsing laterally when dry, red to dark red, purple in KOH, yellow in LA, smooth to scaly. Perithecial wall (18–)23–28(–30) µm wide, composed of about 6 layers of subglobose cells, the innermost 1 or 2 layers becoming increasingly flattened and compressed toward the perithecial locule. Asci narrowly clavate, (90–)98–103(–110) × (7–)8–9(–10) µm, apex with a refractive ring, 8-spored, ascospores uniseriate. Ascospores narrowly ellipsoid, equally 2-celled, (8–)10–12 × (5–)6–7(–8) µm, tuberculate, hyaline to pale yellowish-brown.

Colonies on PDA in the dark 13–18 mm after 10 days at 25°C, cottony with white to yellowish-white aerial mycelium restricted to center or margin; reverse yellowish-white in the center and white at the margin; odor sometime putrid. Colonies on OA in the dark 15–23 mm after 10 days at 25°C, lanuginose with pale white to pale yellowish-white aerial mycelium; reverse hyaline to pale yellowish-white; odor sometimes putrid. Sporulation on OA in the dark within 2–3 weeks in aerial mycelium arising directly from the agar surface. On OA in the dark, conidia formed abundantly at the tips of conidiophores. Conidiophores dimorphic. Primary conidiophores unbranched, becoming loosely to densely branched, sometimes verticillate, generally 1–3 branched, 32–44(–50) µm long, 2–3 µm wide at base, 1–2 µm wide near aperture; conidiogenous cells long cylindrical, 28–31(–34) long, 1.5–2.5 µm wide at base, without apical thickening and collarette. Secondary conidiophores unbranched, becoming loosely to densely branched, generally with 1–6 branched, up to (13–)28–38(–42) µm long, 2–2.5 µm wide at base, 1–2 µm wide near aperture; conidiogenous cells cylindrical, (13–)15–22(–27) long, 1.5–2.5 µm wide at base, without apical thickenings or collarette. Conidia aggregated in slimy heads, hyaline, typically ellipsoidal to oblong with rounded ends, slightly curved to straight, 4–8(–10) × 1.5–2.5 µm. Perithecia not produced in culture.

Specimen and isolate examined: On stroma of Xylariaceae, Yamakawa-cho, Ashigarakami-gun, Kanagawa Pref., October 31, 2004, by Y.H. (teleomorph: TFM FPH-7819; anamorph: FPH-7820; culture: MAFF 240000).

Note: Our collection differs form the original description of the anamorph of *C. henanensis*. Conidiophores were described to be simple or sparsely branched, whereas they were densely branched in the current collection (Figs. 19, 20). However, we identify this Japanese collection as *C. henanensis* primarily on the characters of the perithecia, which agree well with the original description of this species.


34
a
b
c


35
a
b
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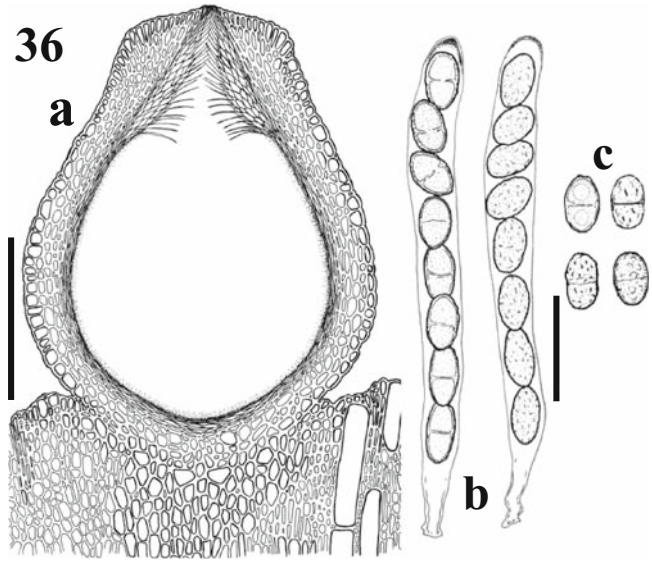
36
a
b
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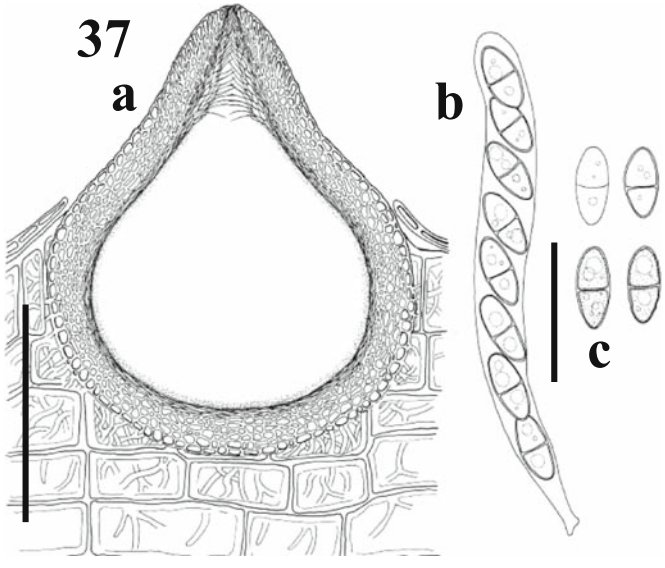
37
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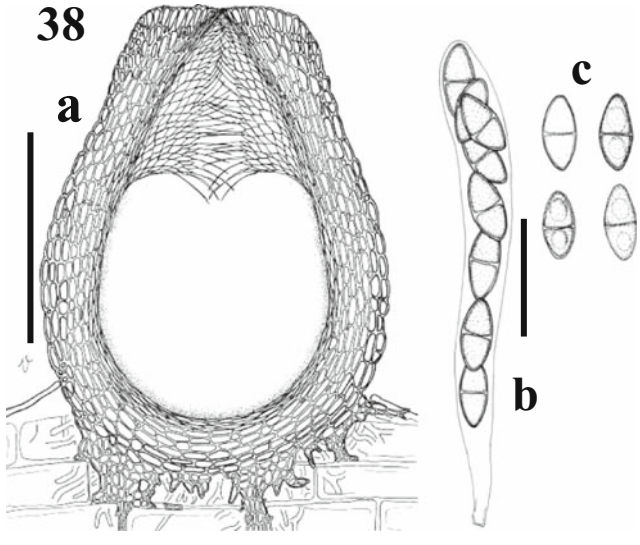
38
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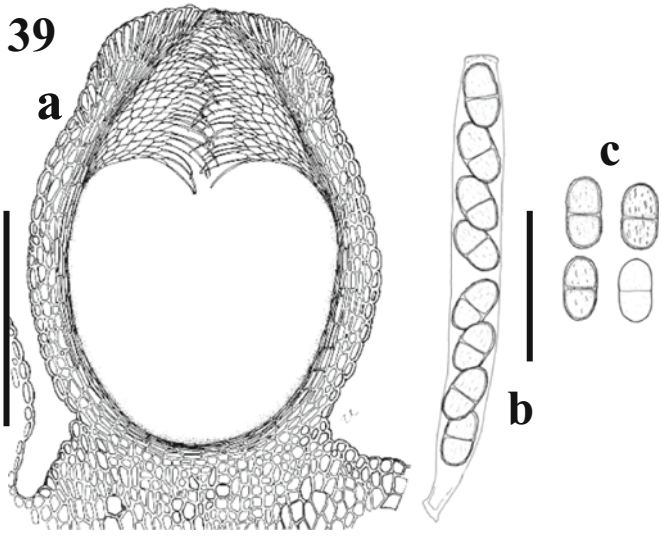
39
a
b
c

Cosmospora henanensis has been known only from the type specimen, collected in China (Nong and Zhuang 2005).

Twelve species of *Cosmospora* with *Acremonium*-like anamorphs are known (Samuels et al. 1991; Rossman et al. 1999; Nong and Zhuang 2005).

5. ***Cosmospora peponum*** (Berk. & M.A. Curtis) Rossman & Samuels in Rossman, Samuels, Rogerson & Lowen, Stud. Mycol. 42: 124, 1999. Figs. 21–24, 37a–c

≡ *Nectria peponum* Berk. & M.A. Curtis in Berkeley, Grevillea 4: 16, 1875.
= *Nectria brassicae* Ellis & Sacc., in Saccardo, Michelia 2: 374, 1881.
≡ *Dialonectria brassicae* (Ellis & Sacc.) Cooke, Grevillea 12: 110, 1884.
= *Nectria peponum* Berk. & M.A. Curtis var. *aurelia* Berk., Grevillea 4: 16, 1874.

Anamorph: *Fusarium* (Booth 1959).

Perithecia superficial with base immersed in substratum, solitary to caespitose in groups of about 5, pyriform, 172–238(–250) µm high, (150–)172–180(–200) µm diameter, with acute apex, collapsing laterally when dry, red to dark red, pale purple in KOH and yellow in LA, smooth to scaly, nonstromatic. Perithecial walls (15–)17–23(–27.5) µm wide, composed of about 6 layers of subglobose to angular cells, the innermost 1 or 2 layers becoming increasingly flattened and compressed toward the perithecial locule. Asci narrowly clavate, 62–78(–82) × 5–8(–11) µm, apex without a ring, 8-spored, ascospores uniseriate. Ascospores ellipsoid to fusiform, equally 2-celled (10–)11–13(–15) × (4–)5–6 µm, smooth, hyaline, becoming yellowish-brown at maturity.

Colonies on PDA in the dark 10–15 mm after 10 days at 25°C, cottony with aerial mycelium, white to yellowish-white; reverse yellowish-white to yellow; distinctive odor lacking. Colonies on OA, PDA, SNA, and SNA under BLB light remaining sterile.

Specimen and isolate examined: On dead twigs or twig blight of *Melastoma tetramerum* Hayata (Japanese name: Munin-nobotan), Mt. Chuo, Chichijima, Ogasawara-mura, Tokyo (Bonin Islands), April 4, 2002, by Y. Ono (teleomorph: TFM FPH 7968; culture: MAFF 240342).

Note: *Cosmospora peponum* is newly added to the Japanese mycobiota; it is especially characterized by nonstromatic perithecia (Figs. 21, 22, 37a). Morphological characteristics of the teleomorph of the Japanese specimen agree well with the description of *C. peponum* by Samuels et al. (1991; as *Nectria peponum*). The anamorph of *C. peponum* was described and illustrated as *Fusarium*-like by Booth (1959), but the culture from the Japanese collection remained sterile.

Our Japanese specimen was collected not only on dead twigs but also on twig blight lesion of *Melastoma tetramerum*, an endemic species in the Bonin Islands. However, pathogenicity of *C. peponum* on twigs of *M. tetramerum* has not been confirmed.

6. ***Cosmospora rishbethii*** (C. Booth) Rossman & Samuels in Rossman, Samuels, Rogerson & Lowen, Stud. Mycol. 42: 124, 1999. Figs. 25, 26, 38a–c

≡ *Nectria rishbethii* C. Booth, Mycol. Pap. 73: 92, 1959.

Anamorph: *Acremonium*-like. Figs. 27, 28

Mycelium not visible around perithecia or host. Stromata formed on the bark, "textura intricata." Perithecia solitary or gregarious in groups of 5–10, immersed in crack of bark with inconspicuous stroma, subglobose to pyriform with obtusely conical apex, 150–170(–240) µm high, 100–144 (–200) µm diameter, collapsing when dry, red to dark red, dark red in KOH, yellow in LA, slightly rough. Perithecial wall (17–)20–26(–35) µm wide, composed of about 8 layers of subglobose cells, the innermost 1–2 layers becoming increasingly flattened and compressed toward the perithecial locule. Asci cylindrical to clavate, (60–)71–81(–100) × (7–)10–15(–18) µm, apex without apical ring, 8-spored, ascospores uni- or biseriate. Ascospores ellipsoid to fusiform, (8–)9–11(–12.5) × 4–5 µm, equally 2-celled, smooth to finally slightly verrucose, hyaline to light brown.

Colonies on PDA in the dark 15–23 mm after 10 days at 25°C, slimy with aerial mycelium, white to whitish-yellow, with aerial mycelium restricted to center or margin; reverse pale ochraceous in the center and white at the margin; odor pungent. Colonies on OA in the dark 17–28 mm after 10 days at 25°C, lanuginose, aerial mycelium hyaline to pale white, restricted to center or margin; reverse hyaline to pale white to pale ochraceous; odor sometimes pungent. Sporulation on OA in the dark within 1–2 weeks in aerial mycelium. Conidiophores dimorphic. Primary conidiophores unbranched, (20–)25–34(–62) µm long, 1.5–3 µm wide at base, 1–1.5 µm wide near aperture; conidiogenous cells long cylindrical, 18–30(–40) × 1.5–2.5 µm wide at base. Secondary conidiophores unbranched, becoming loosely to densely branched, generally with 1–5 branched, up to 18–26(–35) µm long, 2–3.5 µm wide at base, 1–2 µm wide near aperture; conidiogenous cells cylindrical, (8–)10–12(–15) × 1.5 µm wide at base. Hyphae having secondary conidiophores growing upward to form the short stalks of synnemata. Conidia aggregated in slimy heads, hyaline, typically oval to reniform with round ends, slightly curved to straight, (2.5–)3–4(–5) × 1–3 µm, mostly 3.8 × 1.6 µm in average. Perithecia not produced in culture.

Specimen and isolate examined: On *Ficus microcarpa* L.f. (Japanese name: Gajumaru), Tamagusuku-son, Shimajiri-gun, Okinawa Pref. (Okinawa Islands), January 19, 2003, by Y.H. (TFM FPH-7821; anamorph: TFM FPH-7822; culture: MAFF 240001).

Note: *Cosmospora rishbethii* (anamorph: *Acremonium*-like) was recorded as *Nectria rishbethii* in England on bark (*Pinus sylvestris* L.) for the first time (Booth 1959); the species has not been recorded since then. The morphological characteristics of our specimen agree well with Booth's (1959) description of *C. rishbethii*. The anamorph of the Japanese collection differs from Booth's description in having longer conidiogenous cells (10–26 µm long in Booth's

Table 1. Distribution of *Cosmospora* species previously known in Japan

Species of *Cosmospora*	Locality[a]	References for the Japanese species
Cosmospora aurantiicola (*Fusarium larvarum*)[b]	No locality data, **Tokyo**	Booth 1971
C. diploa (*F. coccidicola*)	Shizuoka	Shirai and Miyake 1917; Hara 1932; Booth 1971
C. episphaeria (*F. aquaeductuum*)	Tottori	Tsuneda 1982
C. flammea (*F. coccophilum*)	**Niigata, Yamaguchi, Nara,** Tokyo, **Ibaraki, Okinawa, Kanagawa** (2)[c]**, Toyama,** Yamagata, Fukushima	Miyabe and Sawada 1913; Aoki 1974; Sato 1986
C. matuoi (*F. matuoi*)	Yamagata, Tokyo	Matuo and Kobayashi 1960; Hosoya and Tubaki 2004
C. vilior (*Acremonium berkeleyanum*)	Hokkaido, **Kumamoto**	Saho 1967; Saho and Takahashi 1973

[a]The names of localities shown in bold font indicate newly recorded localities of hitherto known Japanese species
[b]Anamorphic name in parentheses
[c]Number of specimens

description). Gams (1971) also described the anamorph of this fungus. He described only long conidiogenous cells. In our isolate, long and short conidiogenous cells were observed as primary and secondary conidiogenous cells (Schroers 2001), respectively (Figs. 27, 28).

7. ***Cosmospora triqua*** (Samuels) Rossman & Samuels in Rossman, Samuels, Rogerson & Lowen, Stud. Mycol. 42: 125, 1999. Figs. 29–31, 39a–c

≡ *Nectria triqua* Samuels, Mycol. Pap. 164: 40, 1991.

Anamorph: *Acremonium*-like. Figs. 32, 33

Mycelium not visible around perithecia or host. Stromata formed on the stroma of a Diaporthaceous fungus, "textura globulosa." Perithecia gregarious, superficial, pyriform, apex slightly acute to round, (130–)160–188(–227) µm high, (120–)131–148(–180) µm diameter, collapsing when dry, yellowish-red to red, purple in KOH, yellow in LA, smooth to scaly. Perithecial walls 15–16(–17.5) µm wide, composed of about 4–6 layers of subglobose cells, the innermost 1–2 layers becoming increasingly flattened and compressed toward the perithecial locule. Asci narrowly clavate, (50–)61–67.5 × 7–8.5 µm, apex with a refractive ring, 8-spored, ascospores uniseriate. Ascospores broadly ellipsoid, evenly 2-celled, (6–)7–9(–9.5) × (3.7–)4–5 µm, tuberculate, yellowish-brown.

Colonies on PDA in the dark 17–25 mm after 10 days at 25°C, slimy to cottony with white to yellowish-white aerial mycelium, restricted to center or margin; reverse yellowish-white in the center and white at the margin; odor putrid. Colonies on OA in the dark 19–26 mm after 10 days at 25°C, lanuginose with aerial mycelium white; reverse hyaline to pale yellowish-white; odor sometime putrid. Sporulation on OA in the dark within 2–3 weeks in aerial mycelium. Conidiophores of two types. Short conidiophores unbranched or loosely to densely branched to 4 times, sometimes verticillate, (36–)43–50(–65) µm long, 1.5–2(–3) µm wide at base, 1.5–2 µm wide near aperture; conidiogenous cells long cylindrical, (12.5–)19–30 long, 1.5–2.5 µm wide at base. Long conidiophores loosely to densely branched, generally 1–4 branched, (82–)87–107 µm long, 2–2.5 µm wide at base, 1–2 µm wide near aperture; conidiogenous cells cylindrical, 34–41(–47) long, 1.5–2.5 µm wide at base. Hyphae bearing long conidiophores growing upward to form the stalks of the synnemata. Conidia aggregated in slimy heads, hyaline, typically oblong to allantoid with a round end, slightly curved to straight, (2–)4–5 × 1–2 µm. Perithecia not produced in culture.

Specimen and isolate examined: On perithecia of diaporthaceous fungus, Chinen-son, Shimajiri-gun, Okinawa Pref. (Okinawa Islands), January 19, 2003, by Y.H. (TFM FPH-7823; anamorph: TFM FPH-7824; culture: MAFF 240002).

Note: *Cosmospora triqua* (anamorph: *Acremonium*-like) is reported for the first time for Japan. This species has been known only from its type collection on a member of the Diatrypaceae in French Guiana (Samuels et al. 1991; Rossman et al. 1999). Macroscopic and microscopic characteristics of Japanese specimens closely match the protologue of *C. triqua* (*Acremonium* sp.) (Samuels et al. 1991), except for its long conidiophores (82–107 µm long) (Fig. 33) on OA when mature.

Distribution of *Cosmospora* species previously known in Japan

In Japan, six species of *Cosmospora* have been recorded (Miyabe and Sawada 1913; Shirai and Miyake 1917; Hara 1932; Matuo and Kobayashi 1960; Saho 1967; Booth 1971; Saho and Takahashi 1973; Aoki 1974; Tsuneda 1982; Sato 1986; Hosoya and Tubaki 2004). Based on the published reports and the authors' collections, three *Cosmospora* species were found to be new for Japan (Table 1). All known entomopathogenic *Cosmospora* species have *Fusarium* anamorphs (Rossman et al. 1999). We have observed *Fusarium* anamorphs in the entomopathogenic *C. aurantiicola* (Berk. & Broome) Rossman & Samuels (anamorph: *Fusarium larvarum* Fuckel) and *C. flammea* (Tul. & C. Tul.) Rossman & Samuels [*F. coccophilum* (Desm.) Wollenw. & Reinking]; both were observed on several species of scale insects.

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