Ophiostomatoid Fungi from Imported Wood in Taiwan

Han-Yun Li[(1)], Hsiao-Wei Kao[(2)] and Chi-Yu Chen[(1*)]

1. Department of Plant Pathology, National Chung Hsing University, 250, Kuo Kuang Rd., Taichung 402, Taiwan.
2. Department of Life Sciences, National Chung Hsing University, 250, Kuo Kuang Rd., Taichung 402, Taiwan.
** Corresponding author. Tel: 886-4-22840780 ext. 312; Fax: 886-4-22877585; Email: chiyu86@dragon.nchu.edu.tw*

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ABSTRACT: Imported wood is a potential route for exotic fungi to be introduced into Taiwan. For those fungi occurring on wood, ophiostomatoid fungi are the most important. The aim of this study is to survey ophiostomatoid fungi on wood imported into Taiwan. Four species were acquired. They are *Ophiostoma floccosum*, *O. pluriannulatum*, *O. quercus*, and *Leptographium bistatum*. Among them, *Ophiostoma floccosum* and *O. pluriannulatum* have not been reported occurring in Taiwan. Descriptions and illustrations of these fungi were provided.

KEY WORD: Ophiostomatoid fungi, *Ophiostoma*, *Leptographium*.

INTRODUCTION

Ophiostomatoid fungi, including species of *Ophiostoma* and their anamorphs, are known for their decoloration of sapwood, which can lead to substantial losses in lumber value (Seifert, 1993). Most ophiostomatoid fungi are weak pathogens; however a few species are seriously pathogenic. Accordingly, they are responsible for considerable economic losses in wood products, and for ecological impacts in forests. For these reasons, ophiostomatoid fungi are considered as the most important group of fungi by forest pathologists.

The growth of international trade significantly increases the likelihood of introducing exotic organisms. Imported wood, especially in raw log, is particularly a high-risk pathway for introductions of detrimental forest pathogens. Historical examples show that importation of non-indigenous wood has led to the introduction of exotic tree pathogens, causing devastating ecological damage. Dutch elm disease, caused by *Ophiostoma ulmi* and its allied, which are members of ophiostomatoid fungi, is one of the most notable examples, and accounted for the death of 40 million urban elms in the United States (Schumann, 1991). To develop appropriate quarantine strategies to prevent the introduction of exotic fungi, there is a need to systematically survey the fungi that are potentially present on imported wood. The aim of this work was to identify ophiostomatoid fungi, especially of *Ophiostoma* and *Leptographium* species, from imported wood. Fungal identification was carried out by morphological and molecular methods. Four species have been found. Among them, *Ophiostoma floccosum* and *Ophiostoma pluriannulatum* have not previously been reported in Taiwan native forest.

MATERIALS AND METHODS

Fungal isolation

Wood materials were obtained from Taichung harbor where logs and lumbers are imported from a wide range of locations. Wood samples were removed from exposed surface of logs and lumbers. They were surface sterilized by soaking in 75 % alcohol for 1 min followed by rinsing twice in sterile water, and then placed on amended selective medium (malt extract 20g, agar 20g, 1L distilled water, cycloheximide 500 ppm, streptomycin 400 ppm) (Jacobs and Wingfield, 2001).

All isolates obtained are maintained in Mycology Lab., National Taichung University, with a number following the letters "OP" to represent each isolate.

Morphological studies

Cultures used for identification were grown on 2% potato dextrose agar. Measurements and observations were made on fungal structures mounted in water. Terms applied to describe and measure structures of *Ophiostoma* and *Leptographium* followed the usage of Harrington et al. (2001) and Jacobs and Wingfield (2001) respectively.

Molecular studies

DNA extraction was carried out following Sambrook and Russel (2001). For *Ophiostoma* species, ITS region was amplified by using the primers ITS1-F (Gardes and Bruns, 1993) and ITS4 (White et al., 1990), while for *Leptographium* species, ITS2 region and partial LSU rDNA were amplified by using the primers ITS3 (White et al., 1990) and LR3 (Vilgalys and Hester, 1990). PCR amplification was performed by using in a 50 μL PCR reaction mixture, consisting of 5 μL of DNA solution, 1 μL of each primer, 10 μL of 5X PCR Plus Master Mix (GeneMark Technology Co., Ltd., Taiwan), and 33 μL dH_2O. The PCR conditions were as follows: 94 ºC for 2 minutes, followed by 35 cycles at the same temperature, with each cycle containing 30 seconds, then 30 seconds at

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55 ºC and 30 seconds at 72 ºC. The final extension step was 10 minutes at 72 ºC. Amplification products were purified using Micro-Elute DNA Clean (GeneMark Technology Co., Ltd., Taiwan). Sequencing was performed on an ABIPRISM 377 DNA sequencer at the Biotechnology Center of National Chung Hsing University. Homology comparisons with sequences of related species deposited at GenBank were conducted by using the Basic Local Alignment Search Tool (BLAST) provided by National Center for Biotechnology Information (NCBI).

Isolates that were used in the molecular studies were as follows. *Ophiostoma floccosum* OP14 (BCRC34387)(TNM F22129); *O. pluriannulatum* OP10 (BCRC34386)(TNM F22128); *O. pluriannulatum* OP31 (BCRC34390)(TNM F22132); *O. pluriannulatum* OP54 (BRCR34392)(TNM F22134); *O. quercus* OP22 (BCRC34388)(TNM F22130); *O. quercus* OP29 (BCRC34389)(TNM F22131); *O. quercus* OP34 (BCRC34391)(TNM F22133); *Lptographium bistatum* OP145 (BCRC34399)(TNM F22148). In addition to being deposited at Mycology Lab. of National Taichung University, living and dried cultures of these isolates were respectively deposited at Bioresource Collection and Research Center (BCRC), Hsinchu, and National Museum of Natural Science (TNM), Taichung.

RESULTS

A total of 72 isolates of ophiostomatoid fungi were obtained. They can be attributed to four species. Descriptions and illustrations of each species are presented as below. The results of molecular studies on sequence comparisons are presented under the heading of note of each species diagnosis. Discussions are also involved in the note.

Ophiostoma floccosum Math.-Käärik, Svensk bot. Tidskr. 45: 219, 1951. Fig. 1

Ceratocystis floccosa (Math.-Käärik) Hunt, Lloydia, 19: 36, 1956.

Colonies on 2% PDA, 40-47 mm diam. in 13 days at 24℃, flat, powdery slimy due to the production of slimy spores, yellow to pale brown concentric ring indicating the emergence of synnemata which produce the very coloration, margin effuse, entire, reverse brown to dark brown.

Pesotum anamorph: Synnemata single to caespitose, erect, simple or branched, (110-)225-470(-520) μm long, 10-70 μm wide at the base, brown at the base, becoming subhyaline toward the apex, with constituent conidiophores splaying out and penicillately branching at the apex. Conidiogenous cells integrated or discrete, inconspicuously sympodial, cylindrical, hyaline, 14-17 μm long, (1-)1.5-2 μm wide. Conidia holoblastic, hyaline, 1-celled, ellipsoidal to ovoid, oblong to cylindrical, smooth, thin-walled, 4-5 × 1.5-2 μm, aggregated in slimy heads.

Sporothrix anamorph: Conidiophores micronematous to macronematous, hyaline, simple or sometimes loosely branched. Conidiogenous cells cylindrical, (5-)15-32 × 2-2.5(-5) μm, integrated, terminal or intercalary, or discrete and lateral on undifferentiated hyphae, sympodial, denticulate, denticles aggregating on swollen heads or distantly distributed. Conidia holoblastic, hyaline, 1-celled, smooth, varying in shape and size from elliptical to fusiform, with a truncate base, (3-)5-8 × (2-)3-4 μm.

Specimen examined: TAICHUNG COUNTY: Taichung Harbor, imported wood from New Zealand, April 2006, H.Y. Lee, OP14.

Note: *Ophiostoma floccosum* has long been considered to be a morphological variant of *O. piceae*, and was synonymized with *O. piceae* by Upadhyay (1981) in his monographic treatment of *Ophiostoma*-related species. Harrington et al. (2001) recognized the differences between *O. floccosum* and *O. piceae*, and then re-introduced this species. In *O. floccosum*, synnemata are apparently red brown, and conidial masses on synnemata are yellow, whereas in *O. piceae*, synnemata are dark brown and conidial masses on synnemata are white. The sexual structures, perithecia and ascospores were not observed in this study.

Surprisingly, there is only one isolate of *O. floccosum* acquired in this study where totally 72 ophiostomatoids were obtained. This species has been reported in many countries (Harrington et al., 2001). However, judging from the studies of Kim et al. (2005) and Thwaites et al. (2005), this species is common in New Zealand. It is likely that this species only sporadically occurs in countries other than New Zealand. None of the materials of this study is from New Zealand. This may account for the rarity of this species in this study.

The isolate OP14 shows 99% ITS sequence homology with those sequences of *O. floccosum* deposited at Genbank. The identification of this isolate is further ascertained.

Ophiostoma pluriannulatum (Hedgc.) Sydow, H. & Sydow, P., Annales Mycologici. 17(1): 43, 1919. Fig. 2

Ceratostomella pluriannulata Hedgc., Mo. Bot. Gard. Ann. Rept. 17: 72, 1906.
Ceratocystis pluriannulata (Hedgc.) C. Moreau, Rev. Mycol., Paris 17 (Suppl. Colon. no. 1): 22, 1952.

Colonies on 2% PDA, fast growing, 36-49 mm diam. in 10 days at 24℃, aerial mycelium abundant, cottony, surface white, margin entire, reverse white, or black at the central area due to the development of perithecia. With

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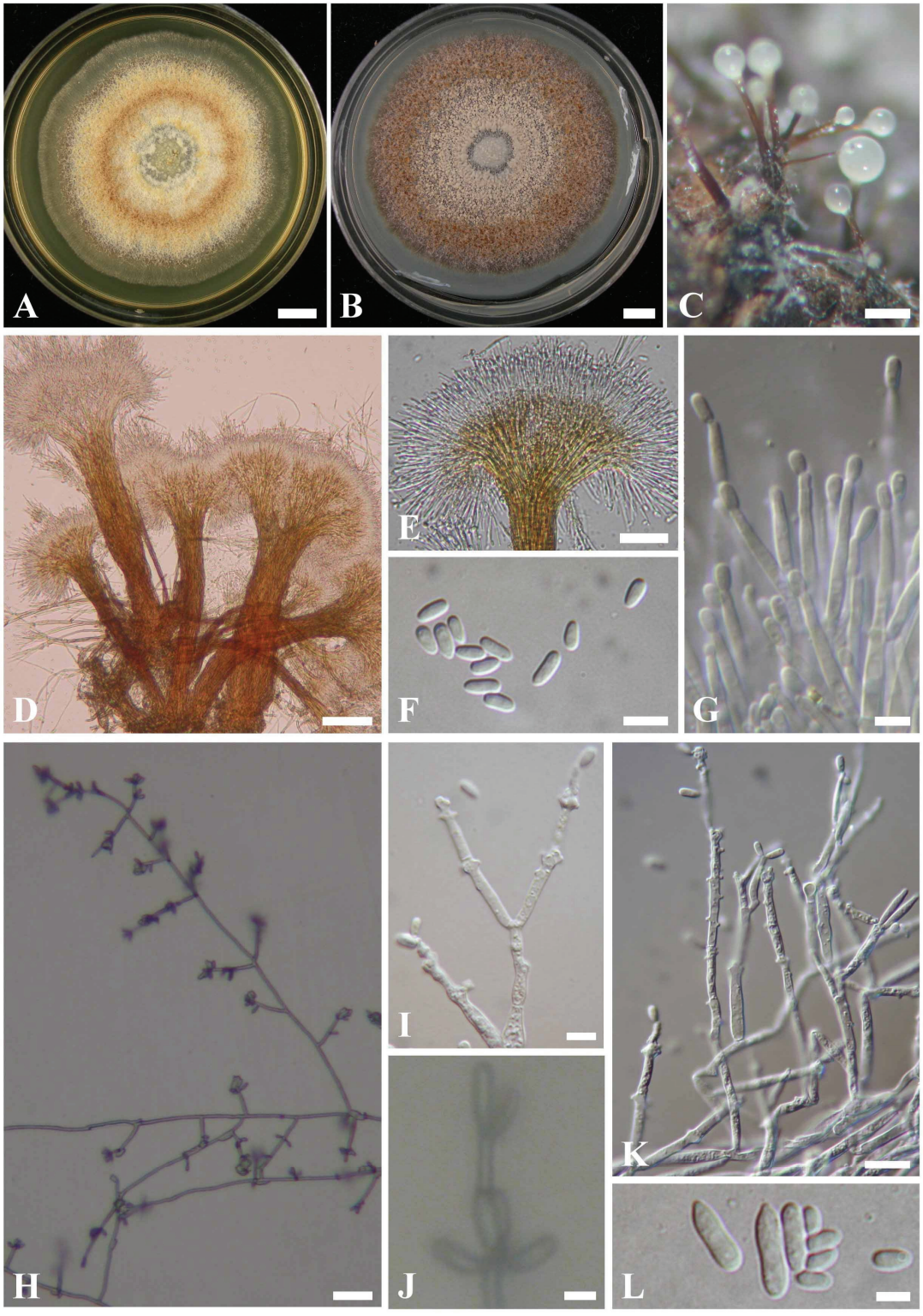


Fig. 1. ***Ophiostoma floccosum.*** **A: Colony on MEA. B: Colony on PDA. C-G:** ***Pesotum*** **form. C-E: Synnemata. F: Conidia. G: Conidiogenous cells and conidia. H-L:** ***Sporothrix*** **form. H-K: Conidiophores and conidia. L: Conidia with truncate base. Bars: A-B = 1 cm. C = 200 µm. D = 100 µm. E = 50 µm. F, G, I, L = 5 µm. H = 20 µm. J, K = 10 µm.**

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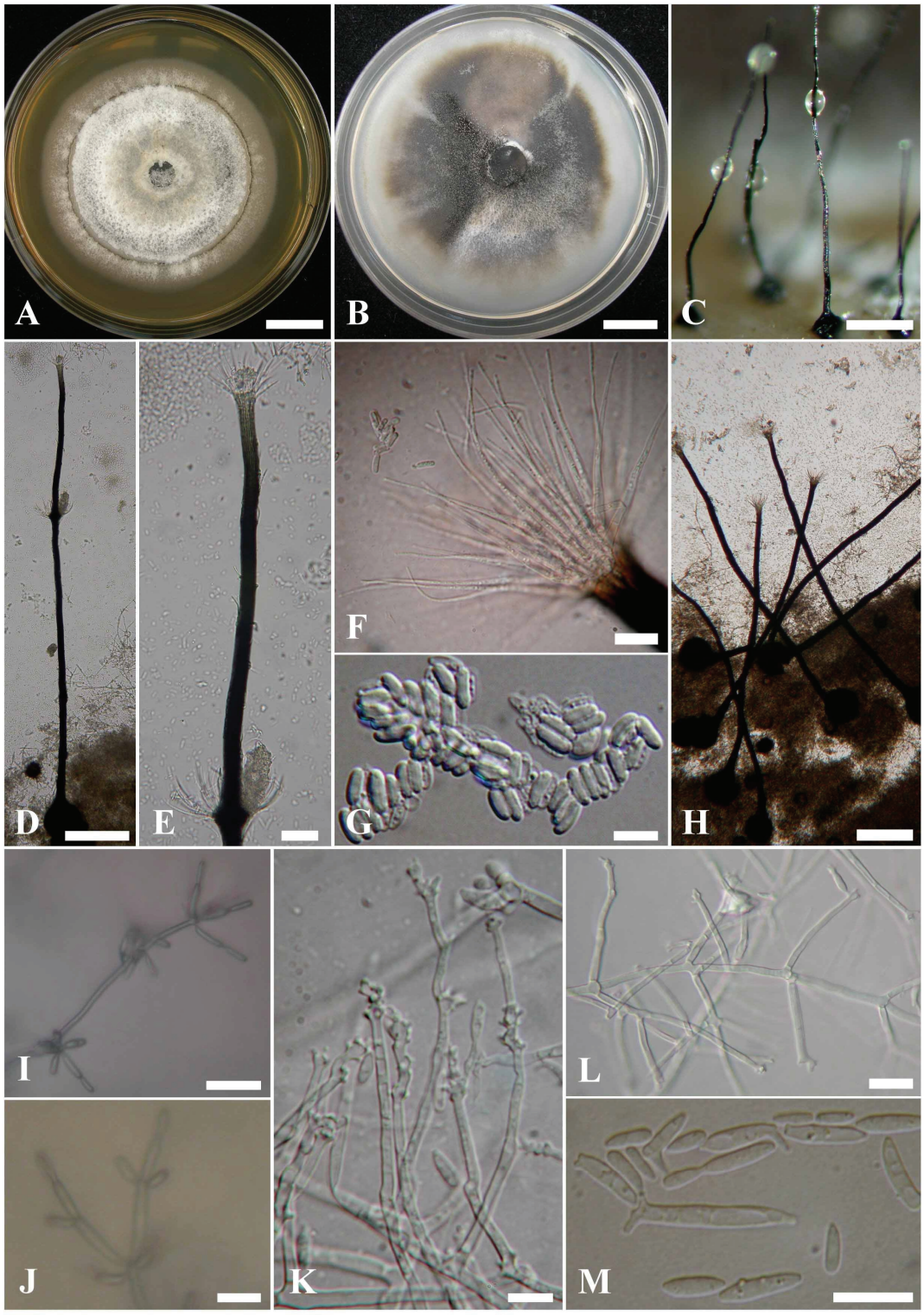


Fig. 2. ***Ophiostoma pluriannulatum.*** **A: Colony on MEA. B: Colony on PDA. C-E, H: Perithecia. C: ascospore accumulating into droplets along the neck. D-E: neck of perithecia, showing whorls of ostiolar hyphae on the top and along the neck. F, H: Ostiolar hyphae on the top of neck. G: Ascospores. I-M:** ***Sporothrix*** **form, conidiophore and conidia. Bars: A-B = 1cm. C, D, H = 200 µm. E = 50 µm. F, I, L = 20 µm. G = 5 µm. J, K, M = 10 µm.**

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age, aerial mycelium becoming compressing to the agar surface, exposing the underlying grayish background, which suggests the presence of perithecia. The gray to black pigmentation in the agar medium is indicative of the emergence of perithecia.

Perithecia: developing on superficial mycelium or partly immersed in the agar, the base globose, 110-170 µm in diameter, with a long neck, the neck composed of dark brown, parallel, laterally fused, smooth hyphal filaments, cylindrical, tapering toward the apex, (550-)1180-1670(-2040) µm long, 35-45 µm wide at the base, 20-30 µm wide at the apex. Ostiolar region composed of divergent, hyaline, smooth hyphae, (20-)42.5-65 µm long. The neck may develop by percurrent extension through the first forming ostiolar region with remnants of divergent hyphae. Ascospores hyaline, 1-celled, ellipsoid to allantoid, 3-5(-5.5) × 1-1.5 µm, collecting in a hyaline or pale yellow glistening droplet at the apex of neck, without sheath.

Sporothrix anamorph: Conidiophores mircronematous, hyaline, cylindrical, simple or loosely branched, smooth. Conidiogenous cells, (5-)25-42(-55) × 2-3 µm, arising terminal, intercalary or laterally from undifferentiated hyphae, denticulate, sympodially proliferating. Conidia holoblastic, hyaline, 1-celled, simple or in branched chains, varying in shape, from clavate to cylindrical, (4-)7-11(-21) × (1.5)2-4 µm.

Specimens examined: All materials were collected in Taichung Harbor from imported wood by H.Y. Lee. **U.S.A.**: Pennsylvania, on walnut, May 2006, OP26; Pennsylvania, on red oak logs, OP39; unknown state, on walnut, April 2006, OP17; unknown state, on unknown host April 2006, OP04; *ibid*. OP10; unknown state, on hard maple, May 2006, OP31; New Hampshire, on *Acer saccharum*, May 2006, OP32; unknown state, on *Nyssa aquatic*, May 2006, OP33; Virginia, on *Acer* sp., July 2006, OP54. **CANADA**: on *Acer* sp., May 2006, OP40. **NEW ZEALAND**: on unknown host, April 2006, OP13. **GUYANA**: on round logs, August 2006, OP63.

Note: Whether *O. pluriannulatum* is homothallic or heterothallic was not reported in previous literature. The isolates acquired in this study are liable to produce perithecia, ie. sexual state, in culture. Cultures from single spore isolations can produce perithecia. It suggests that *O. pluriannulatum* is homothallic. The colony of this species appears white at first, and then turns black with age. The black pigment is due to the coming out of perithecia, which are black in color. The proliferating neck is characteristic for this species. A whorl of the remnant of ostiolar hyphae can usually be observed along the neck, suggesting the previous proliferation of the neck.

The isolates OP10, OP31 and OP54 show 99% to 100% ITS sequence homology with those sequences of *O. pluriannulatum* deposited at Genbank. The identifications of these isolates are further ascertained.

Ophiostoma quercus (Georgév.) Nannf., in Melin & Nannf., Svensk Skogsvårdsförening Tidskr., Hafte 32: 408, 1934. Figs. 3 & 4

Ceratostomella quercus Georgév., C. r. hebd. Séanc. Acad. Scad. Sci., Paris 183: 759, 1926.
Ceratocystis querci (Georgév.) Moreau, Rev. Myco., Paris 17 (Suppl. Colon. no. 1): 22, 1952.
For other synonyms see Harrington et al. (2001)

Colonies on 2% PDA, 36-39 mm diam. in 10 days at 24 ℃, varying in appearance, aerial mycelium sparse to abundant, margin entire, reverse pale to dark brown. For colonies with abundant aerial mycelium, cottony, white, with yellow to orange background, whose pigment arises from the spore mass of synnemata covered in mycelium. For colonies with sparse aerial mycelium, spore mass of synnemata appearing as cream-yellow droplets on agar surface, which are scattered or in vague concentric rings. Nut-like smell present.

Perithecia: developing on superficial mycelium or partly immersed in the agar, the bses globose, 77-192 µm in diameter, with a long neck, the neck composed of dark brown, parallel, laterally fused, smooth hyphal filaments, cylindrical, tapering toward the apex, 470-1060(-1450) µm long, (15-)20-40(-60) µm wide at the base, 12-20 µm wide at the apex. Ostiolar region composed of divergent, hyaline, smooth hyphae, (12-)17-28 µm long. Ascospores hyaline, 1-celled, ellipsoid to allantoid, 4-5 × 1.5-2 µm, collecting in a hyaline or pale yellow glistening droplet at the apex of neck, sheath absent.

Pesotum anamorph: Synnemata single to caespitose, erect, simple or occasionally branched, (117-)220-918(-1230) µm long, (10-)31-60(-70) µm wide at the base, dark brown at the base, becoming hyaline toward the apex, with constituent conidiophores splaying out and penicillately branching at the apex. Conidiogenous cells integrated or discrete, inconspicuously cylindrical sympodial giving the phialidic appearance, hyaline, 13-17 µm long, (1-)1.5-2 µm wide. Conidia holoblastic, hyaline, 1-celled, ellipsoidal to ovoid, oblong, smooth, 3-7 × 1.5-3 µm, aggregated in slimy heads.

Sporothrix anamorph: Conidiophores micronematous to macronematous, scattered, hyaline, cylindrical, simple or loosely branched, smooth. Conidiogenous cells cylindrical, (3-)11-31 × 2-5 µm, integrated and terminal on conidiophores, or discrete and lateral on undifferentiated hypae, apical conidium forming part sympodial, slightly swollen of up to 5 µm in width, bearing denticles. Conidia holoblastic, hyaline, smooth- and thin-walled, varying in shape and size from clavate to fusiform, slightly truncate at the base, 1-celled, conidia of first occassionally rarely 1-septate, (3-)6-8(-15) × (1.5-)3-5 µm.

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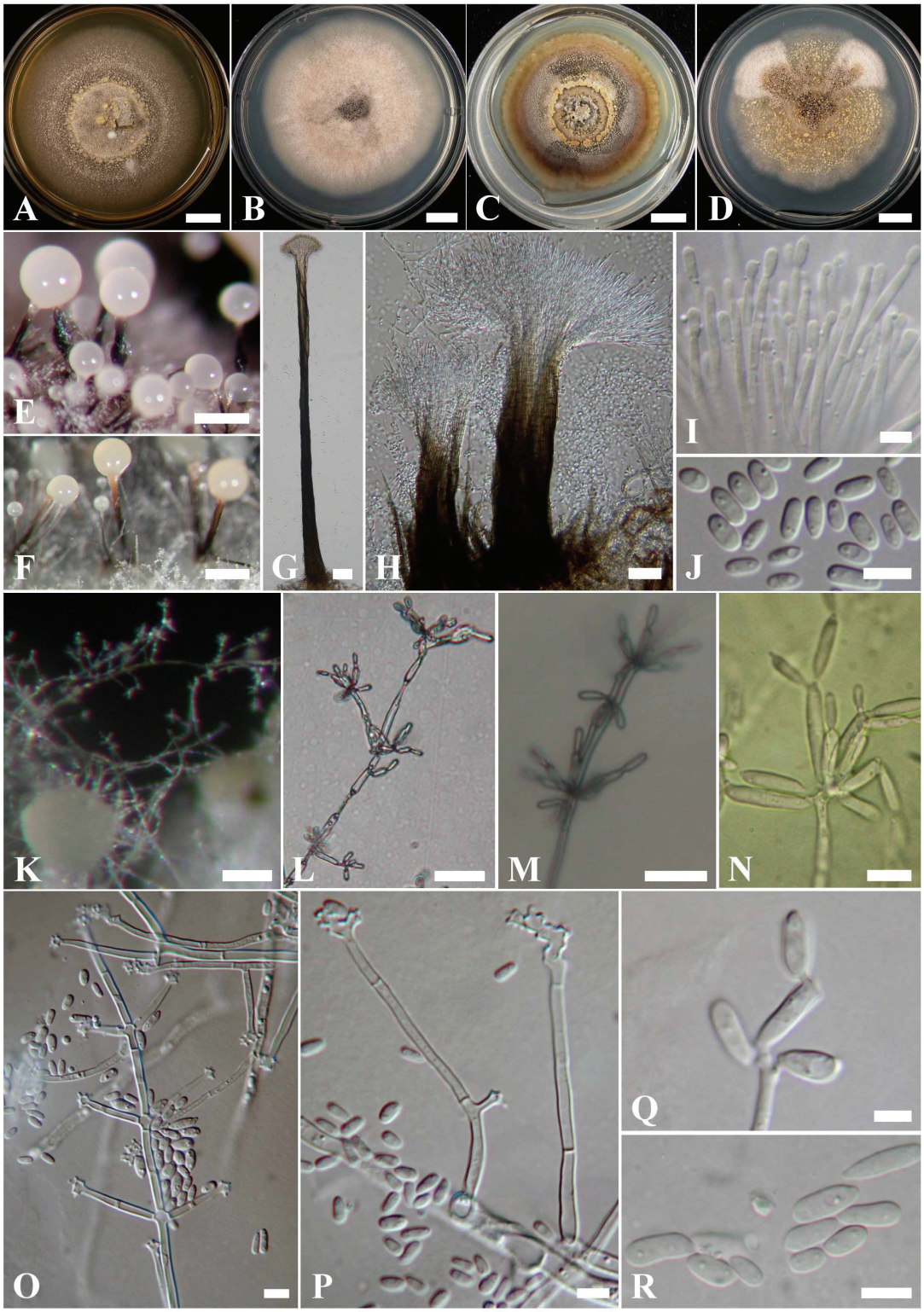


Fig. 3. ***Ophiostoma quercus*****. A-D: The various forms of colonies on PDA. E-J:** ***Pesotum*** **form. E-H: Synnemata. I: Conidiogenous cells and conidia. J: Conidia. K-R:** ***Sporothrix*** **form, conidiophores and conidia. Bars: A-D = 1 cm. E-F = 200 µm. G = 50 µm. H, L-M = 20 µm. I-J, K = 100 µm. N-P = 10 µm. Q-R = 5 µm.**

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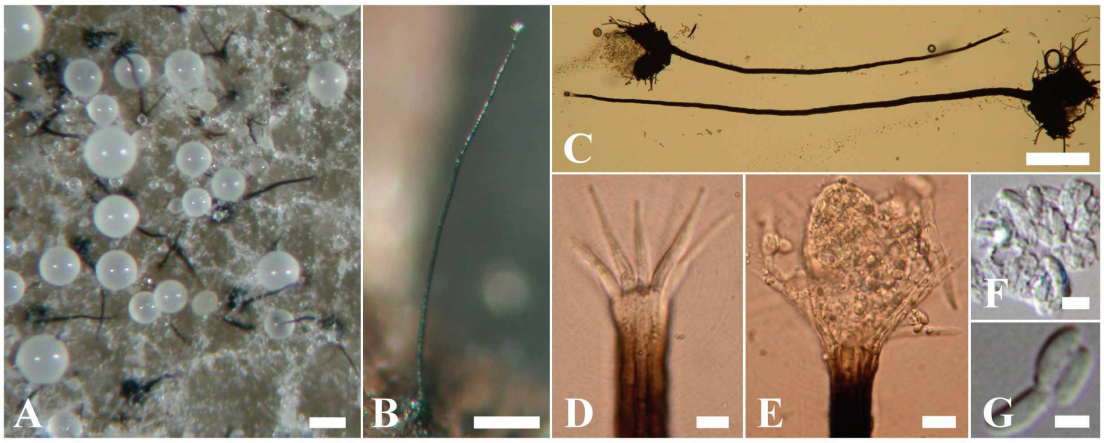


Fig. 4. *Ophiostoma quercus*. A-C: Perithecia. D-E: Neck of perithecia, showing the divergent ostiolar hyphae. F-G: Ascospores. Bars: A-C = 200 µm. D-E = 10 µm. F-G = 2 µm.

Specimens examined: Fifty two isolates were obtained. All materials were collected in Taichung Harbor from imported wood by H.Y. Lee. See table 1.

Note: *O. quercus* was not reported in Taiwan until the year 2003 (Lin et al., 2003), in which this species was considered as one of the causing agent of the mass wilt of China fir at that period of time. Currently it is known that this species is widespread in Taiwan. *O. quercus* and a closely related species *O. piceae* are ubiquitous in the world, but they are hardly distinguishable. Harrington et al. (2001) made a clearly account for their distinction mainly based on temperature endurance and phylogenetic analysis. *O. quercus* can grow at 32 ºC, while *O. piceae* can not. On wood imported into Taiwan, *O. quercus* appears to be dominant, however *O. piceae* has not even been found. The reasonable explanation of the absence of *O. piceae* is that *O. piceae* is reported mainly occurring on coniferous trees, while only hardwood trees are involved in this study. *O. quercus* is heterothallic, ie. sexual state (production of perithecia) can only appear when two compatible strains are mated. The sexual state occasionally appears directly on wood materials, suggesting that mating occurs in nature.

The isolates OP22, OP29 and OP34 show 99% to 100% ITS sequence homology with those sequences of *O. quercus* deposited at Genbank. The identifications of these isolates are further ascertained.

Leptographium bistatum J.-J. Kim & G.-H. Kim, in Kim, Lim, Wingfield, Breuil & Kim, Mycol. Res. 108 (6): 701. 2004. Fig. 5

For detail description, see Li et al. (2009).

Colonies on 2% PDA olivaceous dark brown, reverse dark to olivaceous.

Leptographium anamorph: Conidiophores 100–1000 µm long including conidiogenous cells. Conidiogenous apparatus (24-)45-71(-92) µm long, with 2 to 3 series of penicillate branches. Conidiogenous cells annelidic, (7-)9-12(-16) × 1-1.5 µm, 3-4 per terminal branch. Conidia hyaline, 1-celled, oblong to ovoid, 4-5 × 1.5-2 µm.

Sporothrix anamorph: Conidiophores simple or loosely branched. Conidiogenous cells cylindrical, (11-)15-18(-27) × (1.5-)2-4 µm, sympodial, denticulate. Conidia hyaline, 1-celled, simple or in branched chains, clavate to cylindrical, (3-)8-17 × 2-4(-5) µm.

Hyalorhinocladiella-like anamorph: Conidiophores fluexous or erect. Conidiogenous cells annelidic, discrete, with 3–5 in a whorl, cylindrical, 10-15 × 2 µm. Conidia hyaline, oblong to ovoid, 4-5 × 1-1.5 µm.

Specimen examined: All materials were collected in Taichung Harbor from imported wood by H.Y. Lee. **U.S.A.**: on red oak logs, May 2007, OP171. **CAMEROON**: on unkown hardwood, April 2006, OP11. **GUYANA**: on *Manilkara bidentata*, August 2006, OP72; on *Mora excelsa*, June 2006, OP59. **MALAYSIA**: on unknown host, March 2007, OP145; on sarawak round logs, December 2007, OP169. **UNKNOWN COUNTRY**: on unknown host, April 2006, OP08; *ibid*. OP15.

Note: This species was first described on lumbers exported from New Zealand to Korea (Kim et al., 2004), and was thought to be limited distribution. Very recently, a second report of this species is from Taiwan (Li et al., 2009). The current study largely expands the distribution of this species and suggests that it seems to be widespread in different continents, and many countries including America, Cameroon, Guyana, Malaysia, New Zealand, and Taiwan. Kim et al. (2004) assumed that this species is Korea origin, but their assumption is doubtful.

The sequence of ITS2 and partial LSU rDNA of isolate OP145 shows 100% homology with those sequences of *Leptographium bistatum* deposited at Genbank. The identification of this isolate is further ascertained.

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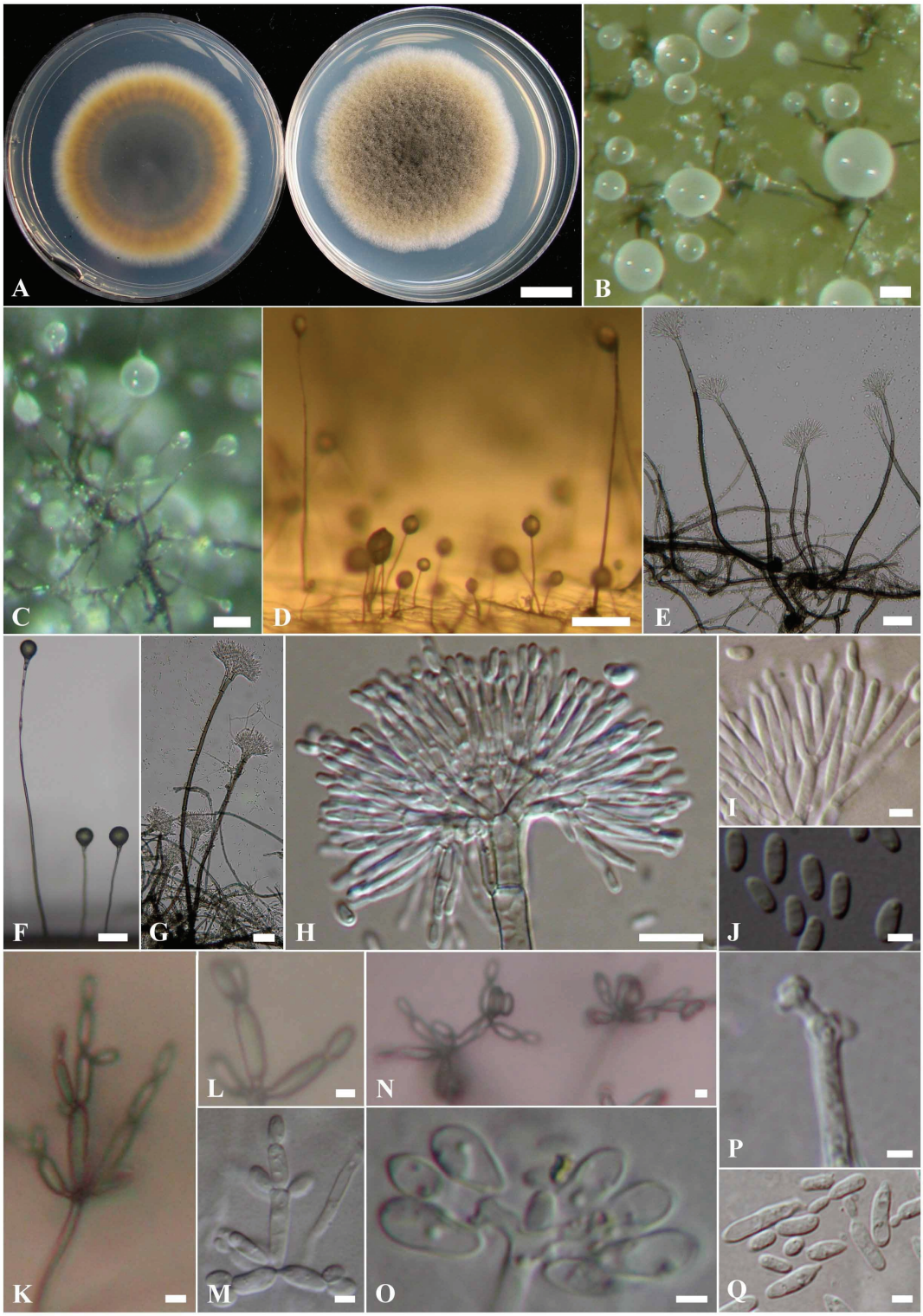


Fig. 5. ***Leptographium bistatum*****. A: Colony on PDA, reverse plate at left hand. B-J:** ***Leptographium*** **form. B-D, F: Conidiophores with apical conidial masses. E, G-H: Conidiophores and apical conidiogenous apparatus. I: Conidiogenous cells and conidia. J: Conidia. K-Q:** ***Sporothrix*** **form, conidiophores and conidia. Bars: A = 1 cm. B-C = 100 µm. F = 100 µm. D = 200 µm. E and G = 50 µm. H = 20 µm. I-Q = 2 µm.**

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Table 1. Host, its exportation country, and date of sampling for each isolate of *Ophiostoma quercus*.

No.	country	Date	Host
OP01	Indonesia	2006/4	N/A
OP03	USA	2006/4	N/A
OP05	USA	2006/4	N/A
OP06	USA	2006/4	N/A
OP09	USA	2006/4	*Quercus rubra*
OP12	Cameroon	2006/4	N/A
OP16	N/A	2006/4	N/A
OP18	N/A	2006/4	*Juglans* sp.
OP21	USA	2006/5	*Acer saccharum*
OP22	USA	2006/5	*Acer saccharum*
OP23	USA	2006/5	*Betula alleghaniensis*
OP24	USA	2006/5	*Betula alleghaniensis*
OP28	USA	2006/5	*Quercus* sp.
OP29	USA	2006/5	*Quercus* sp.
OP34	USA	2006/5	*Acer saccharum*
OP35	USA	2006/5	*Acer saccharum*
OP36	USA	2006/5	*Acer saccharum*
OP37	USA	2006/5	*Acer saccharum*
OP38	USA	2006/5	*Juglans* sp.
OP41	USA	2006/5	*Prunus* sp.
OP42	Germany	2006/5	*Fagus sylvatica*
OP43	USA	2006/5	*Nyssa aquatica*
OP44	Canada	2006/5	*Acer* sp.
OP45	Germany	2006/5	*Fagus sylvatica*
OP46	USA	2006/5	*Acer saccharum*
OP47	USA	2006/5	*Acer saccharum*
OP51	USA	2006/8	*Quercus* sp.
OP52	USA	2006/8	*Quercus* sp.
OP53	USA	2006/7	*Acer saccharum*
OP65	USA	2006/6	*Quercus* sp.
OP66	USA	2006/6	*Populus* sp.
OP67	USA	2006/6	*Populus* sp.
OP68	USA	2006/8	*Nyssa aquatica*
OP74	Congo	2006/6	African round logs
OP90	USA	2006/5	*Quercus* sp.
OP91	Canada	2006/8	*Chamaecyparis* sp.
OP93	Germany	2006/10	*Fagus sylvatica*
OP94	USA	2006/11	*Quercus rubra*
OP95	Malaysia	2006/10	African round logs
OP96	Germany	2006/10	*Fagus sylvatica*
OP97	N/A	2006/11	*Quercus* sp.
OP98	Congo	2006/11	N/A
OP100	Malaysia	2006/10	African round logs
OP102	N/A	2006/11	N/A
OP103	USA	2006/11	*Quercus rubra*
OP104	Malaysia	2006/10	African round logs
OP144	Malaysia	2007/3	N/A
OP146	USA	2007/4	*Quercus* sp.
OP147	Philippines	2007/4	White teak
OP148	USA	2006/11	*Quercus* sp.
OP149	Malaysia	2007/1	Sarawak round logs
OP153	Malaysia	2007/6	*Shorea* sp.

DISCUSSION

During this study, it has been found that ophiostomatoid fungi occur in imported wood very frequently. This may pose a potential threat for the exotic fungi to be introduced into Taiwan through importation. Among the four ophiostomatoid species identified in imported wood, *O. floccosum* and *O. pluriannulatum* have not been reported occurring in Taiwan. Fortunately, all these four species never are seriously pathogenic. Instead, they are opportunistic weak pathogens, mainly infecting fresh cut wood and causing sapstain (blue stain), which is the problem that only concerns countries that export wood. Accordingly these species are not considered as the quarantine required fungi in Taiwan. It is supposed that the imported wood should harbor more ophiostomatoid fungi than we have acquired. However, some species occur only on relatively uncolonized wood and apparently disappear after 3-6 months as other fungi colonize the wood (Seifert, 1993). The imported wood are all experienced a long sea journey during shipment. Therefore, some ophiostomatoid species may be outcompeted by other saprophytic fungi.

Many unidentified *Sporothrix* species were isolated during this study. They are *Ophiostoma*-related and can also been considered to be ophiostomatoid fungi. However, this group of fungi is very intractable, and is variable in morphology. A comprehensive worldwide revision of this genus is required. It is out of the scope of this study.

ACKNOWLEDGEMENT

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臺灣大學學術期刊資料庫

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臺灣進口木材中之長喙殼菌類真菌

李涵葯[(1)]、高孝偉[(2)]、陳啟予[(1*)]

1. 國立中興大學植物病理學系，40224 台中市國光路 250 號，臺灣。
2. 國立中興大學生命科學系，40224 台中市國光路 250 號，臺灣。
* 通信作者。*Tel: 886-4-22840780 ext 312; Fax: 886-4-22877585; Email: chiyu86@dragon.nchu.edu.tw*

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摘要：進口木材潛藏著將外來真菌引進臺灣之風險，而長喙殼菌類為木材中重要真菌之一，本研究即是探討潛藏於進口木材中長喙殼菌類真菌之種類。共發現有四種，為 *Ophiostoma floccosum*、*O. pluriannulatum*、*O. quercus* 及 *Leptographium bistatum*，其中 *O. floccosum* 及 *O. pluriannulatum* 在臺灣森林中尚未被發現。

關鍵詞：長喙殼菌類真菌、*Ophiostoma*、*Leptographium*。

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