APPENDIX A

Chemical Reagent

During the fungal examination from *Pandanus* and *Dracaena* specimens, various chemical reagents were used in the present study. Indian ink, potassium hydroxide (KOH), lactogleceral and Melzer's reagent were prepared as following.

Indian ink was used infrequently, but was found to be useful when observing gelatinous appendages of ascospores that appeared in some species.

Potassium Hydroxide 3%, 5% and 10% was routinely used in the rehydration of ascomycetes, especially the apothecial ascomycetes.

Lactogleceral was used routinely in the preparation of semipermanent slides instead of lactophenol. It was prepared as following formula:

Lactic acid	10	ml
Gleceral	10	ml
Water	10	ml

Melzer's reagent was used in the examination of ascomycetes. Frequently colour-change reactions occur in Melzer's reagent. The amyloid reaction (blue) of apical pore is often of taxonomic importance.

Chloral hydrate	100	g
Potassium Iodide	5	g
Iodine	1.5	g
Distilled water	100	ml

Media

Potato dextrose agar (PDA)

Potatoes	200	g
Glucose	20	g
Agar	15	g
Distilled water	1	l

½ PDA was used for culture collection and sporulation of fungal isolates.

Potatoes	100	g
Glucose	10	g
Agar	15	g
Distilled water	1	l

Water agar (WA)

Agar	15	g
Distilled water	1	l

APPENDIX B

Average temperature of Thailand in each month during 1995-2004

Month	Average temperature of Thailand in each month during 1995-2004 (°C)									
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
January	25.4	24.8	24.5	26.7	25.6	25.6	26.3	25.2	25.2	25.6
February	26.2	25.6	26.5	28.0	26.7	25.9	27.0	27.1	27.0	26.1
March	28.7	28.5	28.1	29.7	28.7	27.9	27.6	28.5	28.0	28.9
April	30.0	28.9	28.5	30.6	28.4	28.4	30.2	29.6	29.8	30.0
May	29.0	28.5	29.5	30.2	27.7	28.3	28.3	28.7	29.3	28.8
June	28.7	28.2	29.1	29.1	27.9	27.8	28.1	28.6	28.4	28.0
July	27.7	27.8	28.0	28.5	28.0	27.8	28.1	28.4	27.9	27.8
August	27.5	27.6	27.9	28.1	27.6	27.7	28.0	27.6	28.1	27.9
September	27.3	27.1	27.5	27.6	27.4	27.2	27.7	27.3	27.4	27.4
October	27.1	26.9	27.5	27.3	26.8	27.2	27.2	27.3	27.1	27.2
November	25.9	26.2	26.8	26.2	26.0	25.7	25.1	26.6	26.9	27.0
December	24.2	24.1	26.4	25.2	23.0	25.8	25.4	26.5	24.9	24.7
Average	**27.3**	**27.0**	**27.5**	**28.1**	**27.0**	**27.1**	**27.4**	**27.6**	**27.5**	**27.5**

Cool dry (Nov.-Jan.) = 24.7-27.0 (2.3)

Hot dry (Mar.-May) = 27.7-30.2 (2.5)

Hot wet (Jul.-Sep.) = 27.1-28.4 (1.3)

From

ที่มา: กรมอุตุนิยมวิทยา กระทรวงเทคโนโลยีสารสนเทศและการสื่อสาร

Average relative humidity of Thailand in each month during 1995-2004

Month	Average relative humidity of Thailand in each month during 1995-2004 (%)									
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
January	70	71	71	72	72	73	75	72	72	72
February	67	68	70	70	70	71	70	71	71	71
March	68	69	70	65	70	71	77	71	74	68
April	70	75	73	69	78	78	72	71	72	70
May	77	80	73	74	82	80	80	79	76	78
June	79	81	74	78	80	82	80	80	79	80
July	81	81	79	81	79	81	80	79	82	80
August	84	82	80	82	81	81	81	82	81	81
September	84	85	83	83	83	83	83	83	84	83
October	82	82	82	81	83	83	84	81	81	77
November	78	80	77	79	80	76	75	79	75	72
December	71	73	73	74	70	74	74	78	69	68
Average	**76**	**77**	**75**	**76**	**77**	**78**	**78**	**77**	**76**	**75**

Cool dry (Nov.-Jan.) = (69-80)

Hot dry (Mar.-May) = (65-80)

Hot wet (Jul.-Sep.) = (79-85)

From

ที่มา: กรมอุตุนิยมวิทยา กระทรวงเทคโนโลยีสารสนเทศและการสื่อสาร

Average rainfall of Thailand in each month during 1995-2004

Month	Average rainfall of Thailand in each month during 1995-2004 (mm)									
	1995	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
January	15.7	13.9	4.8	11.8	43.8	19.8	58.5	7.1	12.7	24.6
February	9.6	33.4	27.2	19.0	65.3	48.4	11.3	12.7	21.2	39.3
March	37.7	29.5	45.3	16.5	71.3	68.4	163.5	50.4	100.7	24.6
April	54.5	141.6	82.8	44.7	177.3	181.0	57.9	77.2	50.2	66.9
May	168.8	163.3	118.5	166.0	250.4	214.3	229.1	212.2	144.3	204.0
June	180.3	193.1	124.5	199.3	165.1	233.6	192.1	170.8	188.0	221.2
July	259.1	185.6	225.8	189.0	195.3	181.0	177.0	160.0	205.5	236.9
August	332.2	223.4	270.1	236.9	195.6	250.9	243.6	266.7	223.0	203.8
September	283.8	311.5	236.1	247.5	235.9	217.2	220.4	276.1	271.5	236.3
October	167.4	199.0	163.1	193.0	242.5	196.1	230.2	142.7	191.9	105.0
November	141.4	141.5	77.0	120.5	110.7	136.9	66.3	140.3	62.5	55.4
December	36.0	98.5	57.1	61.2	76.4	65.4	57.4	91.7	54.4	20.3
Overall rainfall	1,686.5	1,734.3	1,432.3	1,505.4	1,829.6	1,813.0	1,707.3	1,607.9	1,525.9	1,438.3

Cool dry (Nov.-Jan.) = (7-142)

Hot dry (Mar.-May) = (30-250)

Hot wet (Jul.-Sep.) = (160-332)

From

ที่มา: กรมอุตุนิยมวิทยา กระทรวงเทคโนโลยีสารสนเทศและการสื่อสาร

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Certificates

Thongkantha S. 14-19 March 2005. GBIF & EASIANET Proposed Collection/Names/ Images digitization workshop. Centre for Research in Fungal Diversity Department of Ecology & Biodiversity, The University of Hong Kong, Hong Kong.

Thongkantha S. 17-22 March 2004. Molecular Phylogenetics Workshop. Department of Ecology & Biodiversity, The University of Hong Kong, Hong Kong.

Thongkantha S. 7-27 July 2003. Workshop on Mycology at the Mushroom Research Centre, Chiang Mai, Thailand.

Publications

Thongkantha S., Lumyong S., Lumyong P., Whitton S.R., McKenzie E.H.C. and Hyde K.D. (2003). Microfungi on the Pandanaceae: *Linocarpon lammiae* sp. nov., *L. siamiensis* sp. nov. and *L. suthepensis* sp. nov., and a key to species from the Pandanaceae. *Mycologia* 95: 360-367. (For this study).

Thongkantha S., Bussaban B., Lumyong P., McKenzie E.H.C., Hyde K.D. and Lumyong S. (2006). Taxonomy and phylogeny of *Myrothecium* and *Solheimia* analysed from ITS ribosomal DNA sequences. *Fungal Diversity* (in press). (For this study).

Thongkantha S., Jeewon R., Dhanasekaran V., Lumyong S., McKenzie E.H.C. and Hyde K.D. (2006). Molecular Phylogeny of Magnaporthaceae (Sordariomycetes): Implication on taxonomy and phylogenetic placement. *Mycologia* (in press). (For this study).

Lumyong, S., **Thongkantha, S.**, Lumyong, P. & Tomita, F. (2000). Endophytic fungi from 13 bamboo species in Thailand. Biotechnology for Sustainable Utilization of Biological Resources in the Tropics 14, 96-101.

Posters

Thongkantha S., Jeewon R., Lumyong S., McKenzie E.H.C. and Hyde K.D. 2004. Molecular systematics of the Magnaporthaceae and allied genera based on cladistic analyses of partial SSU and LSU rDNA gene sequence. (For this study).

Thongkantha S., Lumyong P., Hyde K.D. and Lumyong S. 2002. Endophytic fungi of native herbaceous plants (*Eupatorium odoradum* and *Euphobia thymifolia*) at Doi Suthep Pui National Park, Thailand. Extended Abstracts in the 3rd Asia-Pacific Mycological Congress on Biodiversity and Biotechnology (AMC 2002), Yunnan University, Kunming, Yunnan, Chaina. p. 155. (For this study).

Thongkantha S. and Chantawanukun P. 2000. Selection of Thermotolerance Bacteria Producing Glucose Oxidase. Extended Abstracts in the 26th Congress on Science and Technology of Thailand, Queen Sirikit National Convention Center, Bangkok. p. 350.

Thongklam S., **Thongkantha S.**, and Sardsus U. 2000. Diversity of *Boletus* in Huay Kok Ma; Doi Suthep-Pui National Park, Chiangmai Province. Extended Abstracts in the 26th Congress on Science and Technology of Thailand, Queen Sirikit National Convention Center, Bangkok. p. 398.

Thongkantha S. and Lumyong S. 1997. Isolation and Screening for Mannanase Production by Endophytic Fungi Isolated from Bamboo. Programme and Abstracts in the 9th Annual Meeting of the Thai Society for Biotechnology and the 2nd JSPS-NRCT-DOST-LIPI_VICC Seminar, Biotechnology: An Essential Tool for Future Development. Suranaree University of Technology, Nakhon Ratchasima. P. 118.

Lumyong S. and **Thongkantha S.** 1997. Endophytic Fungi of Some Species in Fagaceae Family from Doi Suthep Pui. Programme and Abstracts in the 23rd Congress on Science and Technology of Thailand, The Lotus Hotel Pang Suan Kaew, Chiang Mai. P. 898-899.

Mycologia, 95(2), 2003, pp. 360–367.

Microfungi on the *Pandanaceae*: *Linocarpon lammiae* sp. nov., *L. siamensis* sp. nov. and *L. suthepensis* sp. nov. are described with a key to *Linocarpon* species from the *Pandanaceae*

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Abstract: *Linocarpon* species are reported from *Pandanaceae* in Australia, Brunei, Hong Kong, Nepal, New Zealand, Philippines, Seychelles, Thailand and Vanuatu. *Linocarpon lammiae* sp. nov. were collected on decaying leaves of *Pandanus tectorius* in Hong Kong. *Linocarpon siamensis* sp. nov. and *L. suthepensis* sp. nov. were collected from decaying leaves of *P. penetrans* in Thailand. These taxa are described, illustrated and compared with *Linocarpon* species with similar ascospore morphology and dimensions. Included are a synoptic table, which compares the new species to similar known species, and a dichotomous key to species of *Linocarpon* known from members of the *Pandanaceae*.

Key words: new species, *Pandanus*, saprophytic fungi, systematics

INTRODUCTION

Linocarpon Syd. & P. Syd. was introduced with the single species *L. pandani* (Syd. & P. Syd.) Syd. & P. Syd. and is characterized by solitary ascomata beneath a circular, raised, typically black, shiny, dome-shaped clypeus and having a central, raised, black, often shiny ostiolar papilla. Ascomata sometimes are gregarious, with overlapping clypeal stromata. Ascospores are typically filiform or cylindrical, elongate, hyaline, smooth and arranged in a single overlapping fascicle. In addition, the ascospores typically have numerous refringent septum-like bands; these are caused by a single row of closely packed guttules. Appendages of varying morphologies often occur at one or both ends of the ascospores. The asci are cylindrical to clavate, truncate or rounded at the apex, and have a small, often refractive, J-apical ring (Hyde 1992).

Species of *Linocarpon* are distinguished among each other primarily through ascospore morphology and ascospore dimensions. Ascospore shape, the presence or absence of a gelatinous appendage and the morphology of appendages are of primary importance (Hyde 1992, 1997, Dulymamode et al 1998, Poonyth et al 2000). *Linocarpon* ascospores are aseptate, and might lack appendages, have a single appendage or have bipolar appendages.

In a review of scolecosporous genera of ascomycetes, Walker (1980) discussed the current taxonomic status of species referred to *Linocarpon* and accepted five species, while *L. appendiculatum* K.D. Hyde, *L. nipae* (Henn.) K.D. Hyde and *L. pandani* were recorded from mangrove palm *Nypa fruticans* by Hyde (1988). Hyde (1992) revised *Linocarpon*, accepting 10 species, and introduced *L. bipolaris* K.D. Hyde as well as *L. longisporum* K.D. Hyde. After this revision, other species were added; *L. hamasporum* (Ellis & Everh.) M.E. Barr (Barr 1993); 11 new species and one new combination and key to all 23 accepted species (Hyde 1997); four new species (Dulymamode et al 1998); *L. angustatum* K.D. Hyde & Alias (Hyde and Alias 1999); and four new species (Fröhlich and Hyde 2000).

Nine species of *Linocarpon* have been described from pandanaceous substrates: *L. appendisporum* K.D. Hyde; *L. breve* K.D. Hyde; *L. falciformisporum* K.D. Hyde; *L. fasciatum* Dulymamode; P.F. Cannon & Peerally; *L. pandani*, *L. pandanicola* K.D. Hyde; *L. spathulatum* Dulymamode; P.F. Cannon & Peerally; *L. sulcatum* Dulymamode, P.F. Cannon & Peerally from *Pandanus* spp.; and *L. freycinetiae* (Rehm) K.D. Hyde from *Freycinetia* sp. (Hyde 1992, 1997, Dulymamode et al 1998). Two other species, *L. livistonae* (Henn.) K.D. Hyde and *L. elaeidis* Petr., previously known from palms, also have been reported from *Pandanus*

Accepted for publication August 31, 2002.
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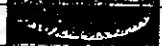
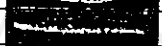
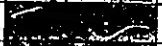
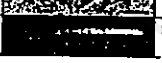
TABLE I. Synopsis of ascospore and appendages of *Linocarpon* spp. for comparison with new taxa

Linocarpon spp.	Host	Ascospore size (µm)	Ascospore shape	Appendage form
L. alpiniae K.D. Hyde	*Alpinia* sp.	56–64 × 3.5–4.5		minute drop, at both ends
L. appendisporum K.D. Hyde	*Pandanus* sp.	60–76 × 2.8–4		mucilage which spread in water, at both ends
L. breve K.D. Hyde	*Pandanus* sp.	34–45 × 2.2–2.6		collar-like, at both ends
L. clavatum K.D. Hyde	*Pinanga* sp. and *Eugeissona* sp.	41–51 × 4–5.5		mucilaginous appendage, at one end
L. falciformisporum K.D. Hyde	*Pandanus* sp.	33–42 × 2.5–4.5		veil-like, at one end
L. lammiae Whitton *et al.*	*P. tectorius*	53–76 × 4.5–7		absent
L. pandanicola K.D. Hyde	*Pandanus* sp.	72–100 × 2.6–3.2		small pad, at both ends
L. siamensis Thongkantha	*P. penetrans*	59–71 × 3.1–3.3		cap-like or a pad-like, at both ends
L. suthepensis Thongkantha	*P. penetrans*	18.5–30.8 × 2.3–3.1		arrow-like, at one end
L. zingiberacicola K.D. Hyde	Unidentified Zingiberaceae	102–120 × 2.4–3		mucilage, at both ends

Scale bar = 10 µm

spp. (Hyde 1997, Dulymamode et al 1998). This research reports on seven species of *Linocarpon*, all on *Pandanaceae*, three of which are introduced as new to science.

MATERIALS AND METHODS

Specimens of *Pandanaceae* were collected in Australia, Brunei, Hong Kong, Nepal, New Zealand, Philippines, Seychelles, Thailand and Vanuatu. Samples were cut into short lengths and put in snap-lock plastic bags or plastic airtight boxes with wet tissue and incubated at room temperature (~25 C) to induce ascomata development. Care was taken not to put too many leaves in each container. All material was examined within a day and up to a month of collection. Material from fresh specimens were mounted in water, as in previous studies, and observed under differential interference microscopy. Measurements were made from discharged ascospores.

TAXONOMY

Linocarpon Syd. & P. Syd., Ann. Mycol. 15: 210. 1917.

Type species: *Linocarpon pandani* (Syd. & P. Syd.) Syd. & P. Syd., Ann. Mycol. 15: 210. 1917.

≡ *Linospora pandani* Syd. & P. Syd., Ann. Mycol. 11: 60. 1913.

Linocarpon falciformisporum K.D. Hyde, Bot. J. Linn. Soc. 123: 123. 1997.

Asci 79–105 µm long, 9–11 µm wide at the widest point. Ascospores 27.5–36 × 3–5 µm.

Habitat/Distribution. Known to inhabit decaying leaves of *Pandanus* sp. and *P. nepalensis*. Indonesia (Hyde 1997), Nepal (current specimen).

Specimen examined. NEPAL, Pokhara, in forest around Lake Phewa, on decaying leaves of *Pandanus nepalensis*, 1 Oct 1997, *S.R. Whitton* HKU(M) 12710.

Notes. Linocarpon falciformisporum is unique, being easily recognized by its short, cylindrical ascospores and a veil-like appendage at one end of the ascospore (Hyde 1997, figure in TABLE I). The current specimen has ascospores that are slightly shorter than those reported by Hyde (1997) for *L. falciformisporum* (33–42 × 2.5–4.5 µm), but this variation is small and is not thought to be of taxonomic significance.

Linocarpon freycinetiae (Rehm) K.D. Hyde, Bot. J. Linn. Soc. 123: 126. 1997.

Asci 72–101 µm long, 7.5–10.5 µm wide at the widest point. Ascospores 32–40 × 2–2.8 µm.

Habitat/Distribution. Known to inhabit decaying leaves of *Freycinetia* sp. Philippines (Hyde 1997, current specimen).

Specimen examined. PHILIPPINES, Luzon Island, Quezon Region, Los Baños, Mount Makiling, Baranggay Bagang Silang, on decaying leaves of *Freycinetia* sp., 22 Oct 1996, *S.R. Whitton* HKU(M) 4985.

Notes. Linocarpon freycinetiae, described from *Freycinetia* from the Philippines, is characterized by short acicular ascospores. The current specimen differs from the holotype (Hyde 1997) in having slightly longer ascospores (32–40 × 2–2.8 µm vs. 28–32 × 2.5–

3 µm) and a distinct mucilaginous pad at the base of the ascospore. The mucilaginous appendage might not have preserved well in the old material. These differences are not significant enough to warrant specific recognition. *Linocarpon freycinetiae* is similar to *L. falciformisporum* in respect to ascospore size but differs in having slightly smaller ascospores (28–32 × 2.5–3 µm vs. 33–42 × 2.5–4.5 µm) and lacks the distinctive veil-like appendage found in freshly examined material of *L. falciformisporum* (Hyde 1997).

Linocarpon lammiae Whitton, K.D. Hyde et McKenzie, sp. nov. FIGS. 1–11

Ascomata tholiformia, 400–675 µm diam, lenticularia. Paraphyses 5–7 µm diam. latae, cylindricae, hyalinae, septatae. Asci 97–133 µm longi, 13.5–26 µm lati, octospori, clavati, apicibus rotundatibus vel truncati. Ascosporae 53–76 × 4.5–7 µm, hyalinae, aseptatae, appendicibus destituti.

Etymology. Lammiae, referring to the type locality, Lamma Island, Hong Kong.

Ascomata forming beneath black (sometimes non-pigmented), raised, circular, shiny, dome-shaped areas (pseudostromata) on the host surface, 400–675 µm diam, with a central, raised, black, shiny papilla, solitary or gregarious; pseudostromata pigmentation variable, sometimes black and shiny, sometimes non-pigmented; in some pseudostromata, the pigmentation is well defined with distinct edges, in others pigmentation is variable or indistinct. Ascomata 420–485 µm wide, 190–202 µm high, lenticular, immersed beneath pseudostromata. Ostiole central, surrounded by a dense area of black, stromatized tissue, which is surrounded by short, hyaline, thin-walled, septate, obtuse periphysoids. Peridium 4–14 µm thick, comprising 2–4 layers of thin-walled, brown to pale brown, flattened, elongate cells. Paraphyses 3–7 µm diam., irregularly cylindrical, flexuous, hyaline, smooth, septate, with a broadly rounded apex. Asci 97–133 µm long, 13.5–26 µm wide, 8-spored, clavate, tapering to a rounded or truncate apex, tapering below to a narrow, obtuse base, thin-walled, with a refractive, J-cylindrical apical ring. Ascospores 53–76 µm long, 4.5–7 µm wide, arranged in a single, overlapping fascicle, acicular, with a broadly rounded apex, tapering to an acute base, smooth, hyaline, aseptate, typically slightly curved, without visible gelatinous appendages.

Habitat/Distribution. Known to inhabit decaying leaves of *Pandanus tectorius*. Australia, Hong Kong.

Specimens examined. AUSTRALIA, QUEENSLAND, Brisbane, on decaying leaves of *Pandanus tectorius*, 5 Jan 1997, *J.G. Wright* HOLOTYPE: HKU(M) 12707. HONG KONG, Lamma Island, Hung Shing Ye Beach, on decaying leaves of *P. tectorius*, 24 July 1997, *S.R. Whitton* HKU(M) 12706.

Notes. Linocarpon lammiae is characterized by relatively short, acicular ascospores that have a broadly rounded apex, taper to an acute base, and have no gelatinous appendages (in fresh material). Other species of *Linocarpon* with short spores are *L. freycinetiae*, *L. clavatum* K.D. Hyde, *L. falciformisporum*, *L. breve*, *L. palmetto* (Ellis & Everh.) M.E. Barr and *L. spathulatum*. *Linocarpon palmetto* has filiform ascospores (50–56 × 2.5–3.5 µm) and is a pathogen causing necrotic regions on leaves of *Sabal palmetto*. The ascospores of *L. breve* (34–45 × 2.2–2.6 µm), *L. falciformisporum* (33–42 × 2.5–4.5 µm) and *L. freycinetiae* (28–32 × 2.5–3 µm) are filiform/cylindrical and shorter than those of *L. lammiae* (Hyde 1997). In addition, *L. falciformisporum* has a veil-like appendage at one end of the ascospore. In *L. clavatum* the ascospores are widest at the center, rounded at the apex, truncate and appendaged at the base, and shorter (41–51 × 4–5.5 µm) than those of *L. lammiae*. *Linocarpon spathulatum* has similarly shaped ascospores to those of *L. lammiae*, but they typically are slightly longer (66–89 × 4–6 µm versus 53–76 × 4.5–7 µm) and the base has a distinct gelatinous cap (Dulymamode et al 1998). Based on ascospore morphology and dimensions, these specimens require specific recognition (see key).

Linocarpon pandani (Syd. & P. Syd.) Syd. & P. Syd., Ann. Mycol. 15: 210. 1917.

≡ *Linospora pandani* Syd. & P. Syd., Ann. Mycol. 11: 60. 1913.

Asci 85–150 µm long, 7–13 µm wide at the widest point. Ascospores 57–96 × 2–4 µm.

Habitat/Distribution. Known to inhabit decaying leaves of *Freycinetia banksii*, *Miscanthus* sp., *Pandanus* sp., *P. copelandii*, *P. furcatus*, *P. laevis*, *P. monticola*, *P. seychellarum*, *P. simplex*, *P. tectorius*. Australia (current specimens), Brunei (current specimen), Hong Kong (current specimens), New Zealand (current specimen), Philippines (Hyde 1992, current specimens), Seychelles (current specimen), Taiwan (Hyde 1992), Vanuatu (current specimen).

Specimens examined. AUSTRALIA, NORTH QUEENSLAND, next to the road to Branston Beach from Cairns, on decaying leaves of *Pandanus tectorius*, 16 June 1996, *S.R. Whitton* HKU(M) 4977; HKU(M) 4996; 17 June 1996, HKU(M) 4978; North Queensland, Lacey Creek State Forest Park, on decaying leaves of *P. monticola*, 17 June 1996, *S.R. Whitton* HKU(M) 4979; HKU(M) 4982; North Queensland, in forest next to Lake Barrine, on decaying leaves of *P. monticola*, 18 June 1996, *S.R. Whitton* HKU(M) 4999. BRUNEI DARUSSALAM, Bandar Seri Begawan, in the mangroves at the mouth of Sungai Brunei, on decaying leaves of *Pandanus* sp., 28 Oct 1995, *S.R. Whitton* HKU(M) 12711. HONG KONG, Hong Kong Island, Mount Austin, on decaying leaves of *P. furcatus*, 7 June 1995, *S.R. Whitton* HKU(M) 4995; Hong Kong Island, The Peak, on decaying leaves of *P. furcatus*, 8 Aug 1995, *S.R. Whitton* HKU(M) 4997; Lamma Island, near Lamma Island Youth Hostel, on

FIG. 1. *Linocarpon lammiae* (from holotype). 1. Longitudinal section through an ascoma. 2–5. Ascospores. 6–7. Appearance of pseudostromata in situ. 8–11. Asci. Scale bars: 1 = 100 μm; 2–5 = 10 μm; 6–7 = 500 μm; 8–10 = 20 μm.

decaying leaves of *P. tectorius*, 28 Jan 1997, *S.R. Whitton* HKU(M) 5000; Lamma Island, Hung Shing Yhe Beach, on decaying leaves of *P. tectorius*, 24 July 1997, *S.R. Whitton* HKU(M) 14118; Hong Kong Island, Pokfulam, off Hatton Road in bush above Hong Kong University, on decaying leaves of *P. furcatus*, 7 Aug 1997, *S.R. Whitton* HKU(M) 12712. NEW ZEALAND, North Island, northern Hawke Bay, White Pine Bush, on decaying leaves of *Freycinetia banksii*, 30 Apr 1997, *S.R. Whitton* HKU(M) 12709. PHILIPPINES, Luzon Island, Quezon Region, Sinoloan, Baranggay Magsaysay U. P. Site, on decaying leaves of *Pandanus* sp., 21 Oct 1996, *S.R. Whitton* HKU(M) 4990; HKU(M) 4991; HKU(M) 4992; Luzon Island, Quezon Region, Baranggay Papalong Infanta, on decaying leaves of *P. copelandii*, 22 Oct 1996,

S.R. Whitton HKU(M) 4988; HKU(M) 4989; HKU(M) 4993; Luzon Island, Quezon Region, Laguna, Baranggay Bakas Luisiana, on decaying leaves of *P. simplex*, 23 Oct 1996, *S.R. Whitton* HKU(M) 4986; HKU(M) 4987; Luzon Island, Quezon Region, Laguna, Baranggay Balaho Cavinti, on decaying leaves of *P. simplex*, 23 Oct 1996, *S.R. Whitton* HKU(M) 4994. SEYCHELLES, Mahe Island, La Reserve, on decaying leaves of *P. seychellarum*, 31 July 1996, *K.D. Hyde* HKU(M) 4984. VANUATU, Espiritu Santo Island, South Santo, on decaying leaves of *Pandanus* sp., 31 Oct 1996, *E.H.C. McKenzie* HKU(M) 4985.

Notes. Linocarpon pandani is characterized by long, narrow ascospores (62–80 × 2–4 μm) that have distinctive septum-like bands (closely packed guttules) and no mucilaginous appendages. *Linocarpon pandanicola* is similar to *L. pandani* in morphology and ascospore dimensions (72–100 × 2.6–3.2 μm). The major morphological character distinguishing these two species is the presence of mucilaginous appendages in *L. pandanicola* (Hyde 1992, 1997). Many of these specimens have ascospores longer than that reported by Hyde (1992) for *L. pandani*, but due to the lack of mucilaginous appendages it is considered more appropriate to place them in *L. pandani* than *L. pandanicola*.

Linocarpon pandanicola K.D. Hyde, Bot. J. Linn. Soc. 123: 129. 1997.

Asci 100–136 μm long, 8–9 μm wide at the widest point. Ascospores 74–90 × 2–3 μm.

Habitat/Distribution. Known to inhabit decaying leaves of *Pandanus* sp., *P. furcatus* and decaying petioles of *Mauritia flexuosa*. Brunei Darussalam (current specimen), Ecuador (Fröhlich & Hyde 2000), Hong Kong (current specimen), Indonesia (Hyde 1997).

Specimens examined. BRUNEI DARUSSALAM, Temburong, Batu Apoi Forest Reserve, Kuala Belalong Field Studies Centre, alongside Esu Stream, on decaying leaves of *Pandanus* sp., 25 Oct 1995, *S.R. Whitton* HKU(M) 4981. HONG KONG, New Territories, Tai Po Kau Country Park, on decaying leaves of *P. furcatus*, 1995, *S.R. Whitton* HKU(M) 4980.

Notes. Linocarpon pandanicola is characterized by long, narrow ascospores (72–100 × 2.6–3.2 μm) with small mucilaginous pads at each end (Hyde 1997). *Linocarpon pandani* is similar to *L. pandanicola* but differs by having slightly shorter ascospores and no mucilaginous appendages (Hyde 1992, 1997). Both specimens collected in this study have mucilaginous appendages and thus are identified as *L. pandanicola*.

Linocarpon siamensis Thongkantha, sp. nov.
FIGS. 12–21

Ascomata tholiformia, 575–825 × 650–875 μm. Paraphyses 3.1–12.3 μm latae, hyalinae, septatae, apicibus rotundati. Asci 100–156 × 7.7–9.3 μm, octospori, cylindrici, apice rotundato vel truncato. Ascosporae 59–71 × 3.1–3.3 μm, fasciculatae, multiseriatae, filiformes, hyalinae, e multis zonis praeditae, appendiculatae.

Etymology. In reference to Siam (Thailand), where the specimens were collected.

Ascomata forming beneath black, raised, circular, shiny, dome-shaped areas (pseudostromata) on the host surface, 575–825 × 650–875 μm, with a minute central black dot, solitary. Pseudostromata pigmentation variable, sometimes being black and shiny, sometimes non-pigmented. Ascomata 850–950 μm wide, 140–240 μm high, hemispherical, with a flattened base. Ostiole central, raised. Peridium thin, comprising a few layers of brown-walled, compressed cells. Paraphyses 3–12 μm at the widest point, filamentous, smooth, septate, apex broadly rounded or obtuse, flexuous, hyaline, tapering toward the apex, surrounded by a gelatinous matrix. Asci 100–156 × 7.7–9.3 μm, 8-spored, cylindrical, pedicellate, rounded or truncate apex, with a J- ring. Ascospores 59–71 × 3.1–3.3 μm ($\bar{x}$ = 67.3 × 3.15 μm, n = 20), arranged in a single overlapping fascicle, filiform, hyaline, often slightly curved or straight, containing numerous refringent, septum-like bands, gelatinous cap-like or pad-like appendages at both ends (FIGS. 18–21).

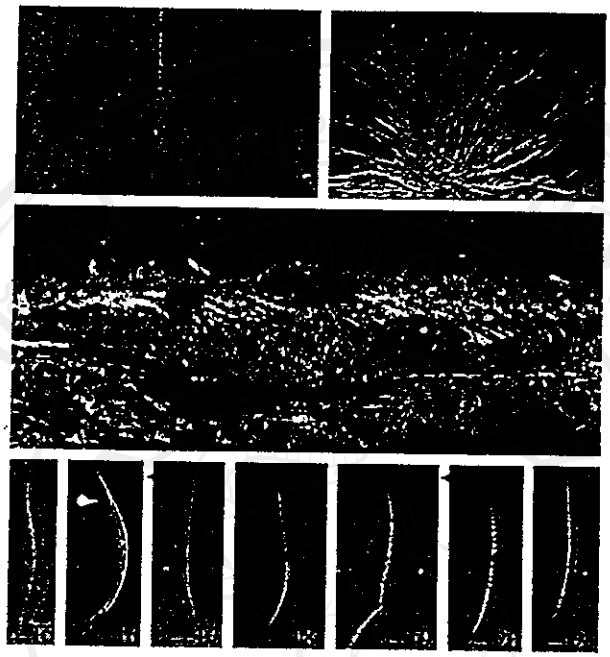
Habitat/Distribution. Known to inhabit decaying leaves of *Pandanus penetrans*, Thailand.

Specimens examined. THAILAND, Chiang Mai, Doi Suthep-Pui National Park, on decaying leaves of *Pandanus penetrans*, 21 July 2001, *S. Thongkantha PQ 010*, HOLOTYPE: PDD 74300; 31 July 2001, *S. Thongkantha PQ 010/1* PDD 74301.

Notes. Linocarpon siamensis is characterized by filiform ascospores, with pad-like appendages at both ends. A similar species, *L. appendisporum*, is differentiated from *L. siamensis* by the morphology of the mucilaginous appendages and ascospore shape. In *L. appendisporum* the spore ends are truncate, while in *L. siamensis* they taper to a point (Hyde, 1997). *Linocarpon alpiniae* K.D. Hyde, *L. clavatum* K.D. Hyde and *L. falciformisporum* have ascospores shaped similarly to those of *L. siamensis* but are shorter and slightly wider (*L. alpiniae* 56–64 × 3.5–4.5 μm, *L. clavatum* 33–42 × 2.5–4.5 μm, *L. falciformisporum* 41–45 × 4–5.5 μm), and the latter two have a minute mucilaginous appendage, evident at only one end of the ascospore (TABLE I). *Linocapon alpinae*, which is most similar to *L. siamensis*, was observed as fresh material by Hyde (1997), and ascospores are narrower and taper to apiculate processes that lack appendages.

Linocarpon suthepensis Thongkantha, sp. nov.
FIGS. 22–31

Ascomata tholiformia, 300–485 μm diam, lenticularia. Paraphyses 4.6–7.7 μm latae, hyalinae, septatae. Asci 77–92.5



FIGS. 12–21. *Linocarpon siamensis* (from holotype). 12. Appearance of pseudostromata on host surface. 13. Paraphyses and asci. 14. Longitudinal section of ascoma. 15–17. Asci. 18–21. Ascospores. Note the bipolar appendages (arrowed). Scale bars: 12, 14 = 200 μm; 13 = 20 μm; 15–17 = 20 μm; 18–21 = 10 μm.

× 6.1–7.7 μm, octospori, cylindrici, pedicellati, apicibus rotundati. Ascosporae 18.5–30.8 × 2.3–3.1 μm, fasciculatae multiseriatae, filiformes, hyalinae, rectae vel parvae curvatae, fasciatibus refringentibus, e multis zonis praeditae, appendiculatae.

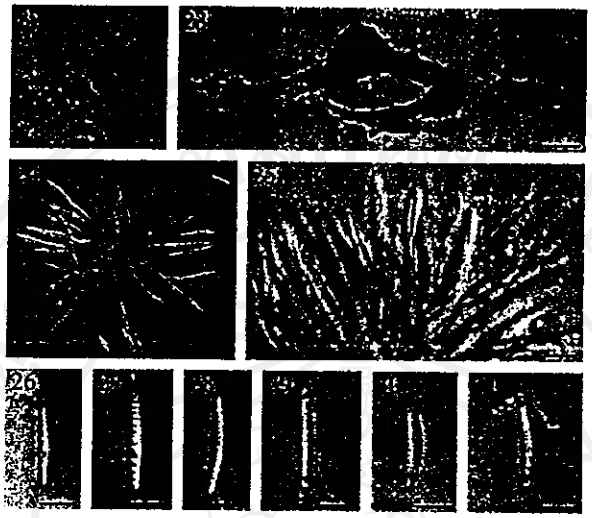
Etymology. In reference to Doi Suthep Pui National Park, where the specimens were collected.

Ascomata forming beneath black, slightly raised, circular, grayish-black areas, 300–485 μm diam (pseudostromata) on the host surface, with pronounced black papilla, typically gregarious. Ascomata 500–650 μm wide, 162–280 μm high, lenticular, black, developing deep inside leaf tissues. Ostiole central, raised. Peridium thin, comprising a few layers of brown-walled compressed cells. Paraphyses 4.6–7.7 μm at the widest point, filamentous, smooth, septate, obtuse, flexuous, hyaline, tapering toward the apex. Asci 77–92.5 × 6.1–7.7 μm, 8-spored, cylindrical, pedicellate, apex rounded or truncate, with a J- apical ring. Ascospores 18.5–30.8 × 2.3–3.1 μm ($\bar{x}$ = 25.5 × 3 μm, n = 20), multiseriate, cylindrical, hyaline, straight or slightly curved, often containing numerous refringent septum-like bands, with a basal, arrow-like appendage.

Habitat/Distribution. Known to inhabit decaying leaves of *Pandanus penetrans*, Thailand.

Specimens examined. THAILAND: Chiang Mai, Doi Suthep Pui National Park, in rainforest, on dead leaves of *Pandanus penetrans*, 21 July 2001, *S. Thongkantha PQ 011*, HOLOTYPE: PDD 74602; 31 July 2001, *S. Thongkantha PQ 011/1* PDD 74416.

Notes. Linocarpon suthepensis is characterized by short ascospores that have a rounded apex, with an arrow-like appendage at the base. Other species of *Linocarpon* with short ascospores and an appendage at only one end are *L. clavatum* and *L. falciformisporum*. *Linocarpon suthepensis* differs in having shorter ascospores (*L. clavatum* 33–42 × 2.5–4.5 μm, *L. falciformisporum* 41–45 × 4–5.5 μm) and for *Linocarpon* species, a unique appendage morphology. Appendages of *L. clavatum* and *L. falciformisporum* are mucilaginous and veil-like, respectively. Ascospores of



FIGS. 22–31. *Linocarpon suthepensis* (from holotype). 22. Appearance of pseudostromata on host surface. 23. Section of ascoma. 24. Asci and paraphyses. 25. Asci with J-apical ring. 26–31. Ascospores. Note the apical appendages. Scale bars: 22 = 200 μm; 23 = 100 μm; 24 = 20 μm; 25–31 = 10 μm.

L. suthepensis are shorter than *L. appendisporum* (60–76 μm) and *L. breve* (34–45 μm), which have appendages at both ends of the ascospores (TABLE I).

KEY TO SPECIES OF *LINOCARPON* KNOWN FROM THE PANDANACEAE

1. Ascospores swollen toward the apex, tapering to a narrow base 2
1. Ascospores cylindrical or filiform 4
2. Ascospores 76–107 × 3–4 μm; basal appendage of ascospores 3–4.5 × 1–1.5 μm; asci 92–170 × 12–20 μm, cylindrical ..... *L. sulcatum*
2. Ascospores wider than 4 μm 3
3. Ascospores 66–89 × 4–6 μm, with short (6 × 2 μm) gelatinous appendage at base; asci 110–170 × 12–16 μm, cylindrical ..... *L. spathulatum*
3. Ascospores 53–76 × 4.5–7 μm, without appendages; asci 97–133 × 13.5–26 μm, clavate ..... *L. lammiae*
4. Ascospores <60 μm long 5
4. Ascospores >60 μm long 8
5. Appendages absent, ascospores 28–32 × 2.5–3 μm; asci 54–82 × 7–10 μm, cylindric-clavate ..... *L. freycinetiae*
5. Ascospores with appendages 6
6. Appendage at each end collar-like, ascospores 34–45 × 2.2–2.6 μm; asci 104–158 × 4.5–6 μm, cylindrical ..... *L. breve*
6. Ascospore appendages only at basal end 7
7. Ascospores 35–42 × 2.5–4.5 μm; appendage mucilaginous, becoming sickle-shaped or veil-like in water; asci 112–140 × 8–10 μm, cylindrical ..... *L. falciformisporum*
7. Ascospores 18.5–31 × 2.3–3.1 μm; appendage arrow-like; asci 77–92.5 × 6.1–7.7 μm, cylindrical ..... *L. suthepensis*
8. Ascospore appendages absent 9
8. Ascospore appendages present 10
9. Ascospores 62–80 × 2–4 μm; asci 100–140 × 8–10 μm, cylindrical ..... *L. pandani*
9. Ascospores 84–110 × 2.5–3.5 μm; asci 110–178 × 8–14 μm, cylindrical ..... *L. fasciatum*
10. Ascospore appendages basal 11
10. Ascospore appendages bipolar 12
11. Ascospores 70–104 × 1.6–2.3 μm; appendage mucilaginous; asci 100–140 × 6–12 μm, cylindrical .... *L. livistonae*
11. Ascospores 72–97 × 3–4 μm; appendage mucilaginous; asci 116–148 × 9–13 μm, cylindrical ..... *L. elaeidis*
12. Ascospore 72–100 × 2.6–3.2 μm; appendages pad-like; asci 160–190 × 8–10 μm, cylindrical ... *L. pandanicola*
12. Ascospores typically shorter 13
13. Ascospores 59–71 × 3.1–3.3 μm; appendages pad-like; asci 100–156 × 7.7–9.3 μm, cylindrical ..... *L. siamensis*
13. Ascospores 60–76 × 2.7–4 μm, appendages gelatinous, spreading in water; asci 100–150 × 8–10 μm, cylindrical ..... *L. appendisporum*

ACKNOWLEDGMENTS

K.D. Hyde thanks The Institute of Science and Technology Development of Chiang Mai University for financing his visit to Chiang Mai University. B. Bussaban and I. Promputtha are thanked for help in collecting samples. S.R. Whitton thanks the University of Hong Kong for the award of a postgraduate studentship. We thank W.H. Ho, C. Pearce and T. Umali for organizing collection trips in Brunei, Australia and the Philippines, respectively. Landcare Research is

thanked for providing research facilities for S.R. Whitton in May 1996.

LITERATURE CITED

Barr ME. 1993. Redisposition of Ellis taxa: a correction. Mycotaxon 48:537.

Dulymamode R, Cannon PF, Peerally A. 1998. Fungi from Mauritius: *Linocarpon* species on *Pandanus*. Mycol Res 102:1331–1337.

Fröhlich J, Hyde KD. 2000. Palm Microfungi. Fungal Diversity Research Series 3, Fungal Diversity Press, Hong Kong, 380 p.

Hyde KD. 1988. The genus *Linocarpon* from the mangrove palm *Nypa fruticans*. Trans Mycol Soc Japan 29:339–350.

———. 1992. Fungi from palms. I. The genus *Linocarpon*, a revision. Sydowia 44:32–54.

———. 1997. Additions to the genus *Linocarpon* (Ascomycetes: Hyponectriaceae). Bot J Linn Soc 123:109–131.

———, Alias SA. 1999. *Linocarpon angustatum* sp. nov., and *Neolinocarpon nypicola* sp. nov. from petioles of *Nypa fruticans*, and a list of fungi from aerial parts of this host. Mycoscience 40:145–150.

Poonyth AD, Hyde KD, Wong SW, Peerally A. 2000. Ultrastructure of asci and ascospore appendages in *Linocarpon appendiculatum* and *L. nipae*. Bot Mar 43:213–221.

Walker J. 1980. *Gaeumannomyces*, *Linocarpon*, *Ophiobolus* and several other genera of scolecospored ascomycetes and *Phialophora* conidial states, with a note on hyphopodia. Mycotaxon 11:1–129.