

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

S. Thongkantha

S. Lumyong¹

Department of Biology, Faculty of Science, Chiang Mai University, Chiang Mai, Thailand

P. Lumyong

Department of Plant Pathology, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand

S. R. Whitton

E. H. C. McKenzie

Landcare Research, Private Bag 92170, Auckland, New Zealand

K. D. Hyde

Centre for Research in Fungal Diversity, Department of Ecology & Biodiversity, The University of Hong Kong, Pokfulam Road, Hong Kong, China

Abstract: *Linocarpon* species are reported from *Pandanaceae* in Australia, Brunei, Hong Kong, Nepal, New Zealand, Philippines, Seychelles, Thailand and Vanuatu. *Linocarpon lammiiae* 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. Asco-

spores 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.

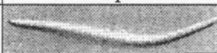

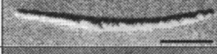




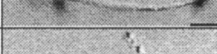


In a review of scolecospore genera of ascomycetes, Walker (1980) discussed the current taxonomic status of species referred to *Linocarpon* and accepted five species, while *L. appendiculatum* K.D. Hyde, *L. nipae* (Henn.) K.D. Hyde and *L. pandani* were recorded from mangrove palm *Nypa fruticans* by 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.

¹ Corresponding author, E-mail: sboi009@chiangmai.ac.th

TABLE I. Synopsis of ascospore and appendages of *Linocarpon* spp. for comparison with new taxa

<i>Linocarpon</i> spp.	Host	Ascospore size (μm)	Ascospore shape	Appendage form
<i>L. alpiniae</i> K.D. Hyde	<i>Alpinia</i> sp.	56-64 \times 3.5-4.5		minute drop, at both ends
<i>L. appendisporum</i> K.D. Hyde	<i>Pandanus</i> sp.	60-76 \times 2.8-4		mucilage which spread in water, at both ends
<i>L. breve</i> K.D. Hyde	<i>Pandanus</i> sp.	34-45 \times 2.2-2.6		collar-like, at both ends
<i>L. clavatum</i> K.D. Hyde	<i>Pinanga</i> sp. and <i>Eugeissona</i> sp.	41-51 \times 4-5.5		mucilaginous appendage, at one end
<i>L. falciiformisporum</i> K.D. Hyde	<i>Pandanus</i> sp.	33-42 \times 2.5-4.5		veil-like, at one end
<i>L. lammiae</i> Whitton et al.	<i>P. tectorius</i>	53-76 \times 4.5-7		absent
<i>L. pandanicola</i> K.D. Hyde	<i>Pandanus</i> sp.	72-100 \times 2.6-3.2		small pad, at both ends
<i>L. siamensis</i> Thongkantha	<i>P. penetrans</i>	59-71 \times 3.1-3.3		cap-like or a pad-like, at both ends
<i>L. suthepensis</i> Thongkantha	<i>P. penetrans</i>	18.5-30.8 \times 2.3-3.1		arrow-like, at one end
<i>L. zingiberacicola</i> K.D. Hyde	Unidentified Zingiberaceae	102-120 \times 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 falciiformisporum 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 \times 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 falciiformisporum* 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. falciiformisporum* (33-42 \times 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 \times 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, Barangay Bagang Silang, on decaying leaves of *Freycinetia* sp., 22 Oct 1996, S.R. Whitton HKU(M) 4983.

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 \times 2-2.8 μm vs. 28-32 \times 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 ($28\text{--}32 \times 2.5\text{--}3 \mu\text{m}$ vs. $33\text{--}42 \times 2.5\text{--}4.5 \mu\text{m}$) and lacks the distinctive veil-like appendage found in freshly examined material of *L. falciformisporum* (Hyde 1997).

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

Ascomata tholiformia, 400–675 μm diam, lenticularia. Paraphyses 3–7 μm diam. latae, cylindricae, hyalinae, septatae. Asci 97–133 μm longi, 13.5–26 μm lati, octospori, clavati, apicibus rotundatibus vel truncati. Ascospores 53–76 \times 4.5–7 μm , hyalinae, aseptatae, appendicibus destituti.

Etymology. *Lammliae*, 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 Yeh Beach, on decaying leaves of *P. tectorius*, 24 July 1997, S.R. Whitton HKU(M) 12706.

Notes. *Linocarpon lammliae* 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 ($50\text{--}56 \times 2.5\text{--}3.5 \mu\text{m}$) and is a pathogen causing necrotic regions on leaves of *Sabal palmetto*. The ascospores of *L. breve* ($34\text{--}45 \times 2.2\text{--}2.6 \mu\text{m}$), *L. falciformisporum* ($33\text{--}42 \times 2.5\text{--}4.5 \mu\text{m}$) and *L. freycinetiae* ($28\text{--}32 \times 2.5\text{--}3 \mu\text{m}$) are filiform/cylindrical and shorter than those of *L. lammliae* (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 ($41\text{--}51 \times 4\text{--}5.5 \mu\text{m}$) than those of *L. lammliae*. *Linocarpon spathulatum* has similarly shaped ascospores to those of *L. lammliae*, but they typically are slightly longer ($66\text{--}89 \times 4\text{--}6 \mu\text{m}$ versus $53\text{--}76 \times 4.5\text{--}7 \mu\text{m}$) 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 \times 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

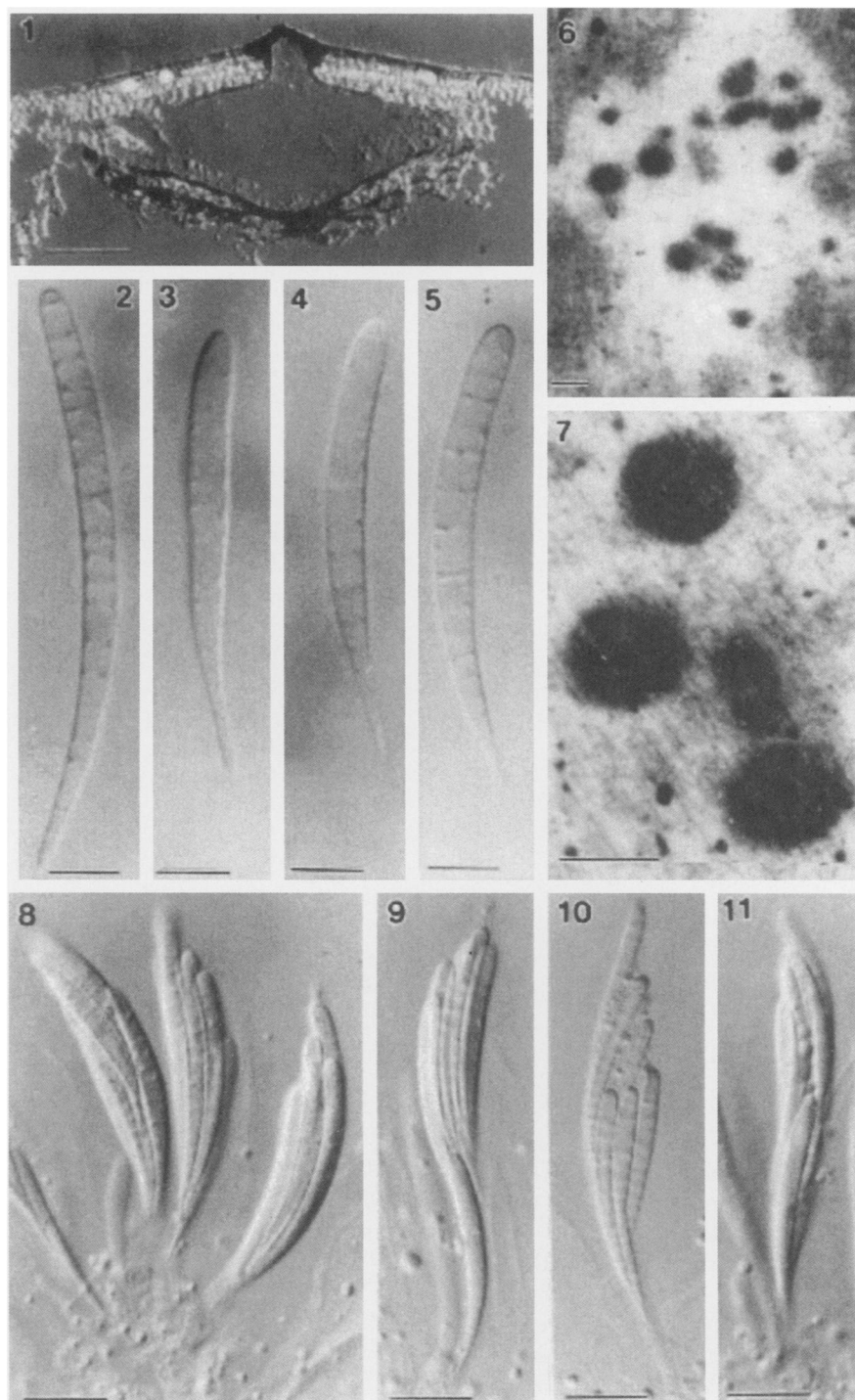


FIG. 1. *Linocarpion lammbiae* (from holotype). 1. Longitudinal section through an ascoma. 2–5. Ascospores. 6–7. Appearance of pseudostromata in situ. 8–11. Asci. Scale bars: 1 = 100 μm ; 2–5 = 10 μm ; 6–7 = 500 μm ; 8–10 = 20 μm .

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 Mag-saysay 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 ($62\text{--}80 \times 2\text{--}4 \mu\text{m}$) 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 ($72\text{--}100 \times 2.6\text{--}3.2 \mu\text{m}$). 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 $100\text{--}136 \mu\text{m}$ long, $8\text{--}9 \mu\text{m}$ wide at the widest point. Ascospores $74\text{--}90 \times 2\text{--}3 \mu\text{m}$.

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 ($72\text{--}100 \times 2.6\text{--}3.2 \mu\text{m}$) 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, $575\text{--}825 \times 650\text{--}875 \mu\text{m}$. Paraphyses $3.1\text{--}12.3 \mu\text{m}$ latae, hyalinae, septatae, apicibus rotun-

dati. Asci $100\text{--}156 \times 7.7\text{--}9.3 \mu\text{m}$, octospori, cylindrici, apice rotundato vel truncato. Ascospores $59\text{--}71 \times 3.1\text{--}3.3 \mu\text{m}$, 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, $575\text{--}825 \times 650\text{--}875 \mu\text{m}$, with a minute central black dot, solitary. Pseudostromata pigmentation variable, sometimes being black and shiny, sometimes non-pigmented. Ascomata $850\text{--}950 \mu\text{m}$ wide, $140\text{--}240 \mu\text{m}$ high, hemispherical, with a flattened base. Ostiole central, raised. Peridium thin, comprising a few layers of brown-walled, compressed cells. Paraphyses $3\text{--}12 \mu\text{m}$ at the widest point, filamentous, smooth, septate, apex broadly rounded or obtuse, flexuous, hyaline, tapering toward the apex, surrounded by a gelatinous matrix. Asci $100\text{--}156 \times 7.7\text{--}9.3 \mu\text{m}$, 8-spored, cylindrical, pedicellate, rounded or truncate apex, with a J-ring. Ascospores $59\text{--}71 \times 3.1\text{--}3.3 \mu\text{m}$ ($\bar{x} = 67.3 \times 3.15 \mu\text{m}$, $n = 20$), 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.

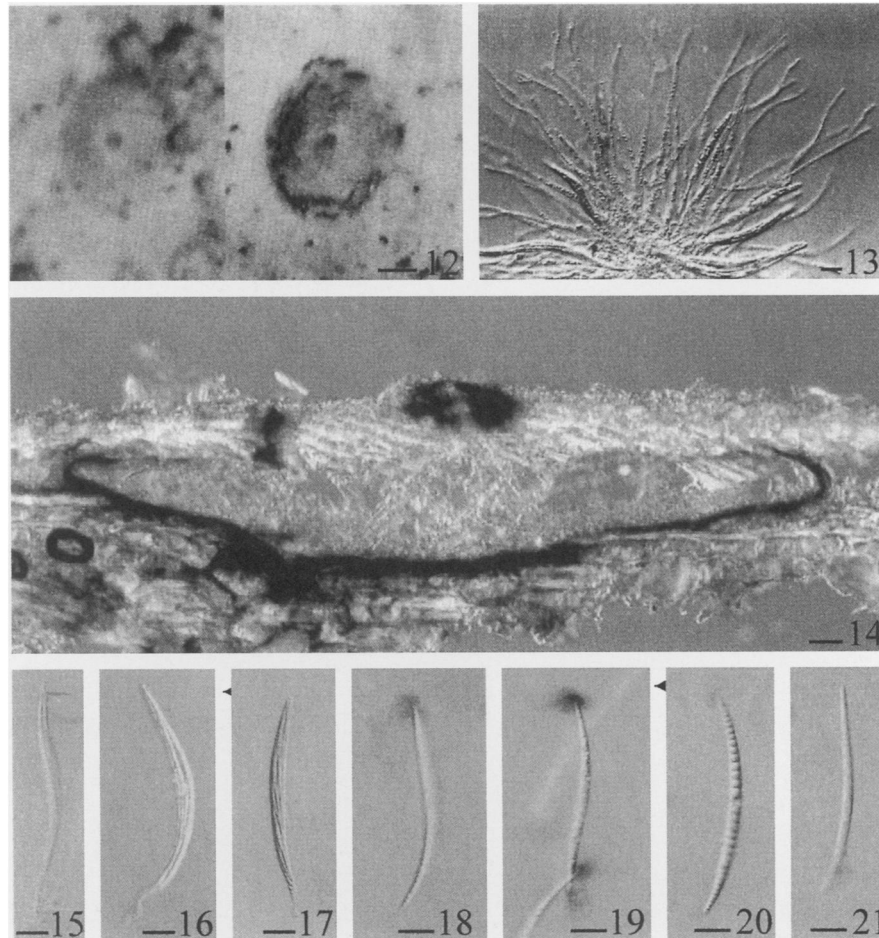
Specimens examined. THAILAND, Chiang Mai, Doi Suthep-Pui National Park, on decaying leaves of *Pandanus penetrans*, 21 July 2001, *S. Thongkantha* PQ 010, HOLOTYPE: PDD 74300; 31 July 2001, *S. Thongkantha* PQ 010/1 PDD 74301.

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* $56\text{--}64 \times 3.5\text{--}4.5 \mu\text{m}$, *L. clavatum* $33\text{--}42 \times 2.5\text{--}4.5 \mu\text{m}$, *L. falciformisporum* $41\text{--}45 \times 4\text{--}5.5 \mu\text{m}$), and the latter two have a minute mucilaginous appendage, evident at only one end of the ascospore (TABLE I). *Linocarpon alpiniae*, 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, $300\text{--}485 \mu\text{m}$ diam, lenticularia. Paraphyses $4.6\text{--}7.7 \mu\text{m}$ latae, hyalinae, septatae. Asci $77\text{--}92.5$



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 .

$\times 6.1\text{--}7.7 \mu\text{m}$, octospori, cylindrici, pedicellati, apicibus rotundati. Ascosporae $18.5\text{--}30.8 \times 2.3\text{--}3.1 \mu\text{m}$, 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.

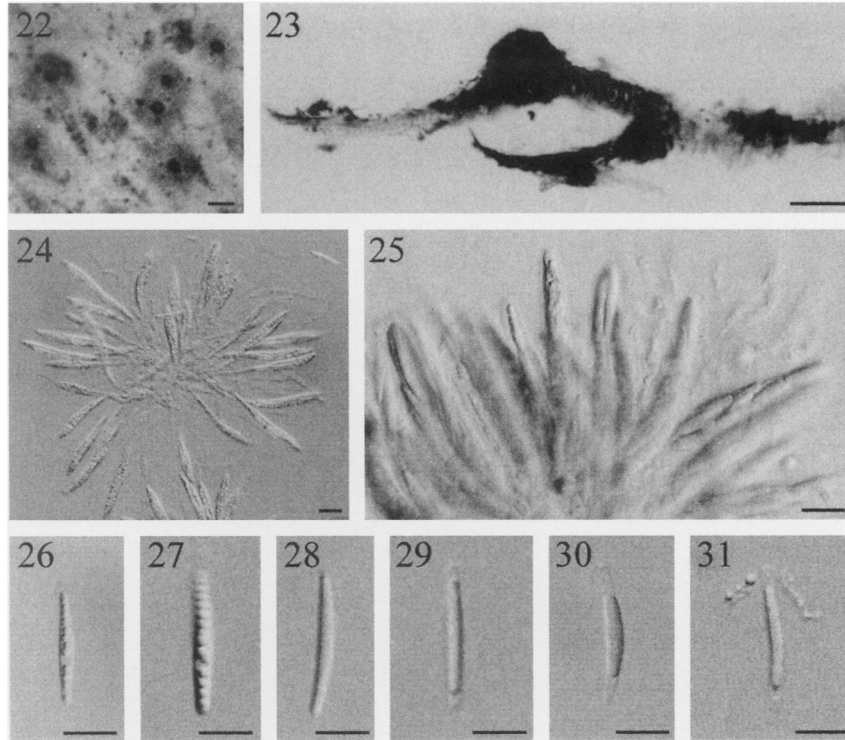
Ascomata forming beneath black, slightly raised, circular, grayish-black areas, $300\text{--}485 \mu\text{m}$ diam (pseudostromata) on the host surface, with pronounced black papilla, typically gregarious. Ascomata $500\text{--}650 \mu\text{m}$ wide, $162\text{--}280 \mu\text{m}$ high, lenticular, black, developing deep inside leaf tissues. Ostiole central, raised. Peridium thin, comprising a few layers of brown-walled compressed cells. Paraphyses $4.6\text{--}7.7 \mu\text{m}$ at the widest point, filamentous, smooth, septate, obtuse, flexuous, hyaline, tapering toward the apex. Asci $77\text{--}92.5 \times 6.1\text{--}7.7 \mu\text{m}$, 8-spored, cylindrical, pedicellate, apex rounded or truncate, with a J- apical ring. Ascospores $18.5\text{--}30.8 \times 2.3\text{--}3.1 \mu\text{m}$ ($\bar{x} = 25.5 \times 3 \mu\text{m}$, $n = 20$), 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* $33\text{--}42 \times 2.5\text{--}4.5 \mu\text{m}$, *L. falciformisporum* $41\text{--}45 \times 4\text{--}5.5 \mu\text{m}$) 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 | 8. Ascospore appendages absent | 9 |
| 1. Ascospores cylindrical or filiform | 4 | 8. Ascospore appendages present | 10 |
| 2. Ascospores 76–107 \times 3–4 μm ; basal appendage of ascospores 3–4.5 \times 1–1.5 μm ; asci 92–170 \times 12–20 μm , cylindrical | | 9. Ascospores 62–80 \times 2–4 μm ; asci 100–140 \times 8–10 μm , cylindrical | <i>L. pandani</i> |
| 2. Ascospores wider than 4 μm | 3 | 9. Ascospores 84–110 \times 2.5–3.5 μm ; asci 110–178 \times 8–14 μm , cylindrical | <i>L. fasciatum</i> |
| 3. Ascospores 66–89 \times 4–6 μm , with short (6 \times 2 μm) gelatinous appendage at base; asci 110–170 \times 12–16 μm , cylindrical | | 10. Ascospore appendages basal | 11 |
| 3. Ascospores 53–76 \times 4.5–7 μm , without appendages; asci 97–133 \times 13.5–26 μm , clavate | | 10. Ascospore appendages bipolar | 12 |
| 4. Ascospores <60 μm long | 5 | 11. Ascospores 70–104 \times 1.6–2.3 μm ; appendage mucilaginous; asci 100–140 \times 6–12 μm , cylindrical | <i>L. livistonae</i> |
| 4. Ascospores >60 μm long | 8 | 11. Ascospores 72–97 \times 3–4 μm ; appendage mucilaginous; asci 116–148 \times 9–13 μm , cylindrical | <i>L. elaeidis</i> |
| 5. Appendages absent, ascospores 28–32 \times 2.5–3 μm ; asci 54–82 \times 7–10 μm , cylindrical-clavate | | 12. Ascospore 72–100 \times 2.6–3.2 μm ; appendages pad-like; asci 160–190 \times 8–10 μm , cylindrical | <i>L. pandanicola</i> |
| 5. Ascospores with appendages | 6 | 12. Ascospores typically shorter | 13 |
| 6. Appendage at each end collar-like, ascospores 34–45 \times 2.2–2.6 μm ; asci 104–138 \times 4.5–6 μm , cylindrical | | 13. Ascospores 59–71 \times 3.1–3.3 μm ; appendages pad-like; asci 100–156 \times 7.7–9.3 μm , cylindrical | <i>L. siamensis</i> |
| 6. Ascospore appendages only at basal end | 7 | 13. Ascospores 60–76 \times 2.7–4 μm , appendages gelatinous, spreading in water; asci 100–150 \times 8–10 μm , cylindrical | <i>L. appendisporum</i> |
| 7. Ascospores 33–42 \times 2.5–4.5 μm ; appendage mucilaginous, becoming sickle-shaped or veil-like in water; asci 112–140 \times 8–10 μm , cylindrical | | | |
| 7. Ascospores 18.5–31 \times 2.3–3.1 μm ; appendage arrow-like; asci 77–92.5 \times 6.1–7.7 μm , cylindrical | | | |

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 post-graduate 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, Peeraly 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, Peeraly 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 *Phialiophora* conidial states, with a note on hyphopodia. *Mycotaxon* 11:1–129.