

Preliminary List of Phallales (Phallomycetidae, Basidiomycota) in Thailand

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Abstract. A total of 18 species (8 genera, 3 families), including one potentially new species, belonging to the order Phallales in Thailand were confirmed by a fieldwork in July, 2009 as well as herbarium and literature searches. This preliminary list will be used to study biogeographical patterns of Phallales.

Key words: distribution, fungi, mushrooms, stinkhorns, taxonomy.

Introduction

The order Phallales was originally described by Fischer (1900) to accommodate taxa commonly referred to as stinkhorns (family Phallaceae) and lattice stinkhorns (family Clathraceae). Both of these families produce epigeous fruit bodies with spongy structures, which allow them to grow rapidly when they absorb water from surrounding environment. Most notably, their spore mass (gleba) becomes slimy and emits distinct odor to attract small insects, especially flies, and their spores are dispersed by those insects (Fulton, 1889).

Cunningham (1931) included Claustulaceae, which does not have stinkhorn-like fruit bodies, in the order Phallales. This family is characterized by having sequestrate or truffle-like fruit bodies, and the gleba is enclosed by peridium and never exposed to the air (Curtis, 1926). Subsequent studies also revealed that more sequestrate or truffle-like taxa, such as *Protuberia* (Malloch, 1989), *Gelopellis* (Beaton & Malajczuk, 1986), and *Phallobata* (Castellano & Beever, 1994) are closely related to stinkhorn taxa (Hosaka *et al.*, 2006).

Molecular phylogenetic studies clearly demonstrated that stinkhorns are closely related to morphologically and ecologically distinct

taxa, such as earthstars (Geastrales), coral and club fungi (Gomphales) (Humpert *et al.*, 2001; Hosaka *et al.*, 2006). Currently, Phallales is recognized as a well-supported monophyletic group with six well-supported subclades within it (Hosaka *et al.*, 2006). It is noteworthy that three basal clades within Phallales were all characterized by truffle-like taxa, indicating that stinkhorn-like fruit bodies are derived from truffle-like morphologies in Phallales (Hosaka *et al.*, 2006). Hosaka *et al.* (2006) also discussed the possibility that spore dispersal of Phallales, including truffle-like taxa, is entirely dependent on arthropods.

For many species of stinkhorns, the center of diversity lies in tropical regions of the world (Dring, 1980). The presence of many endemic taxa in tropical regions, such as Africa (Dring, 1964, 1980; Dring & Rose, 1977), West Indies (Dennis, 1953), Central America (Miller *et al.*, 1991), and Yunnan, China (Zang & Petersen, 1989) is consistent with the hypothesis that the origins of many, if not all, species of stinkhorns are tropical areas. In fact, some widely distributed stinkhorn taxa in North America, such as *Clathrus archeri* (Arora & Burk, 1982) and *Pseudocolus fusiformis* (Blanton, 1976; Burk, 1976; Coker & Rebell, 1949) are believed to have been transferred from other parts of the world, possibly tropics.

This paper is a result of biogeographic studies of subclass Phallomycetidae. Thailand is located in tropical region of Southeast Asia, and understanding its stinkhorn flora will surely clarify distributional patterns and biogeographical history of stinkhorns. So far, no comprehensive list of Phallales in Thailand is available. The list provided here is based solely on a ten-day survey and therefore should be considered preliminary. There is no doubt that future survey will reveal richer stinkhorn flora from Thailand.

Materials and Methods

Fieldwork was conducted by the author in the year of 2009 (July 12–17). The main collecting sites were located in Nakhon Ratchasima and Kanchanaburi Provinces. Specimens collected in Thailand by the author were deposited at the fungal herbarium of the National Museum of Nature and Science, Tsukuba, Japan (TNS). In addition to dried materials, small fragments (glebal tissues) of freshly collected samples were soaked in DMSO buffer (Seutin *et al.*, 1991) with an addition of 100 mM Tris-HCl (pH 8.0) and 0.1 M sodium sulfite (Na_2SO_3) under 4°C, following the procedures of Hosaka (2009) and Hosaka and Castellano (2008). These samples are available upon request to the author for future DNA studies. I have also surveyed for additional specimens of Phallales from Thailand housed at the BIOTEC Bangkok Herbarium (BBH) for this study. If no specimen was available, collecting records were retrieved by the literature survey.

List of the Species

A total of 18 species (8 genera, 3 families) that belong to the order Phallales from Thailand were recognized based on field collecting, herbarium and literature surveys. Short comments on identification and distribution, and literature records from Thailand are given for

each species. For two species that have been collected by the author (*Phallus* sp. and *Clathrus delicatus*), photographs of habitat and fruit bodies are also provided.

Subclass **Phallomycetidae** Hosaka, Castellano et Spatafora, *Mycologia* 98: 955, 2006.

Order **Phallales** Fischer in Engler & Prantl, *Die Natürlichen Pflanzenfamilien*, 1: 276, 1900, “Phallineae”.

Family **Phallaceae** Fries, *Systema Mycologicum*, 2: 281, 1823, “Phalloideae”.

Mutinus bambusinus (Zoll.) E.Fisch., *Ann. Jard. Bot. Buitenzorg* 6: 30, 1886.

Synonyms: *Mutinus boninensis* Lloyd, *Mycol. Writ.*, 2: 402, 1908; *Jansia boninensis* (Fisch.) Lloyd, *Syn. known phalloids*. 32, 1909

Records from Thailand:

Chandrasrikul *et al.*, *Diversity of mushrooms and macrofungi in Thailand*. 295, 2008.

Ellingsen, *Nord. J. Bot.*, 2: 283, 1982.

Specimen examined: THAILAND, Surat Thani, Khao Sok National Park, 12 September 1993, leg. R.J. Bandoni (BBH147).

Remarks. This species has also been reported from Japan, Micronesia (Imazeki & Hongo, 1989, Katsumoto, 2010), Taiwan (Fan *et al.*, 1994; Wang *et al.*, 1999), Africa (Dring, 1964), and Hawaii (Hemmes & Desjardin, 2002). The species was not found during the fieldwork in Thailand by the author in 2009.

Mutinus caninus (Huds.) Fr., *Summa veg. Scand.*, Section Post. (Stockholm): 434, 1849.

Records from Thailand:

Chandrasrikul *et al.*, *Diversity of mushrooms and macrofungi in Thailand*. 295, 2008.

Soytong *et al.*, *Songklanakarin J. Sci. Tech.*, 16: 301–306, 1994.

Remarks. This species has also been reported from Japan (Imazeki & Hongo, 1986; Katsumoto, 2010), China (Liu, 1986), Europe and North America (Liu, 1986). The species was not found during the fieldwork in Thailand by the author in 2009.

Phallus duplicatus Bosc, Mag. Gesell. naturf. Freunde, Berlin, 5: 86, 1811.

Synonym: *Dictyophora duplicata* (Bosc) E. Fisch., in Berlese, De Toni & Fischer, Syll. fung. (Abellini) 7: 6, 1888.

Records from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Soytong *et al.*, Songklanakarin J. Sci. Tech. 16: 301–306, 1994.

Remarks. This species has also been reported from Japan (Imazeki & Hongo, 1989, Katsumoto, 2010), Europe, North America, and China (Liu, 1986; Fan *et al.*, 1994). The species was not found during the fieldwork in Thailand by the author in 2009.

Phallus impudicus L: Pers., Syn. Meth. Fung., 242, 1801.

Record from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Remarks. This species has been reported worldwide, including Japan (Imazeki & Hongo, 1986; Katsumoto, 2010), China (Liu, 1986; Fan *et al.*, 1994), Taiwan (Hosaka, 2010), Myanmar (Thaung, 2007), South Africa, Europe, North and South America (Liu, 1986). Although the species has been reported from Thailand by Chandrasrikul *et al.* (2008), the photograph seems to indicate that the Thai material is distinct from *P. impudicus* s.s. DNA studies are necessary to confirm it.

Phallus indusiatus Vent: Pers., Syn. Meth. Fung., 244, 1801.

Synonyms: *Dictyophora phalloidea* Desv., J. de Bot., 2: 92, 1809; *Dictyophora indusiata* (Vent.) Desv. in Seaver & Chardón, J. Bot., Paris, 2: 92, 1809.

Records from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008. Ellingsen, Nord. J. Bot. 2: 284, 1982.

Soytong *et al.*, Songklanakarin J. Sci. Tech. 16: 301–306, 1994.

Specimens examined: THAILAND, Nakhon Ratchasima, Khao Yai National Park, 12 July 1998, leg. T. W. Flegel (BBH1629); Phetchabun, Nam Nao National Park, 19 September 1994, leg. R.J. Bandoni (BBH396).

Remarks. This species has also been reported from Japan, China, North America, Australia (Imazeki & Hongo, 1989, Katsumoto, 2010), Taiwan (Sawada, 1961; Liu, 1984; Wang *et al.*, 1999), Myanmar (Thaung, 2007), South America, India, Sri Lanka (Liu, 1984), West Indies (Dennis, 1953) and Africa (Dring, 1964). The species was not found during the fieldwork in Thailand by the author in 2009.

Phallus merulinus (Berk.) Cooke, Grevillea, 11(no. 58): 57, 1882.

Synonyms: *Dictyophora merulia* Berk., Intellectual Observer, 9: 404, 1866; *Dictyophora irpicina* Pat., Bull. Soc. Mycol. Fr., 14: 190, 1898; *Phallus irpicinus* (Pat.) Lloyd, Mycol. Notes, 26: 331, 1907.

Record from Thailand:

Reid, Kew Bull. 31: 657, 1977.

Remarks. This species has also been reported from Trinidad and Tobago, India, Singapore (Reid, 1977), Philippines (Kobayasi, 1965), China (Liu, 1986), Sri Lanka (Petch, 1908) and Indonesia (Boedijn, 1932). The species was not found during the fieldwork in Thailand by the author in 2009.

Phallus multicolor (Berk. & Broome) Cooke, Grevillea, 11(no. 58): 57, 1882.

Synonym: *Dictyophora multicolor* Berk. & Broome, Trans. Linn. Soc. London, Bot., Ser., 2 2: 65, 1882.

Record from Thailand:

Soytong *et al.*, Songklanakarin J. Sci. Tech. 16: 301–306, 1994.

Remarks. This species has also been reported from Australia, China, Indonesia, Sri Lanka, Malaysia, Papua New Guinea, Taiwan, Zaire (Liu, 1984), Trinidad and Tobago (Reid, 1977), and Hawaii (Hemmes & Desjardin, 2002). The species was not found during the

fieldwork in Thailand by the author in 2009.

Phallus rubicundus (Bosc) Fr., Syst. Myc., 2: 284, 1823.

Records from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Ellingsen, Nord. J. Bot. 2: 284, 1982.

Specimen examined: THAILAND, Bangkok, Kings Park, 20 August 1995, leg. R.J & A. A. Bandoni (BBH722).

Remarks. This species has also been reported from Japan (Imazeki & Hongo, 1986; Katsumoto, 2010), Taiwan (Liu, 1986), Australia, China, India, West Indies, North America (Liu, 1984), Myanmar (Thaung, 2007),

Hawaii (Hemmes & Desjardin, 2002), and Africa (Cunningham, 1944; Dring & Rose, 1977). The species was not found during the fieldwork in Thailand by the author in 2009.

Phallus rugulosus (E. Fisch.) Kuntze, Rev. Gen. P., 2: 865, 1891.

Record from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Remarks. Some authors considered this species as synonym of *P. rubicundus* (Cunningham, 1944; Liu, 1984), but is treated here as separate species. The species has also been reported from Japan (Katsumoto, 2010) and Taiwan (Wang *et al.*, 1999; Hosaka, 2009), but

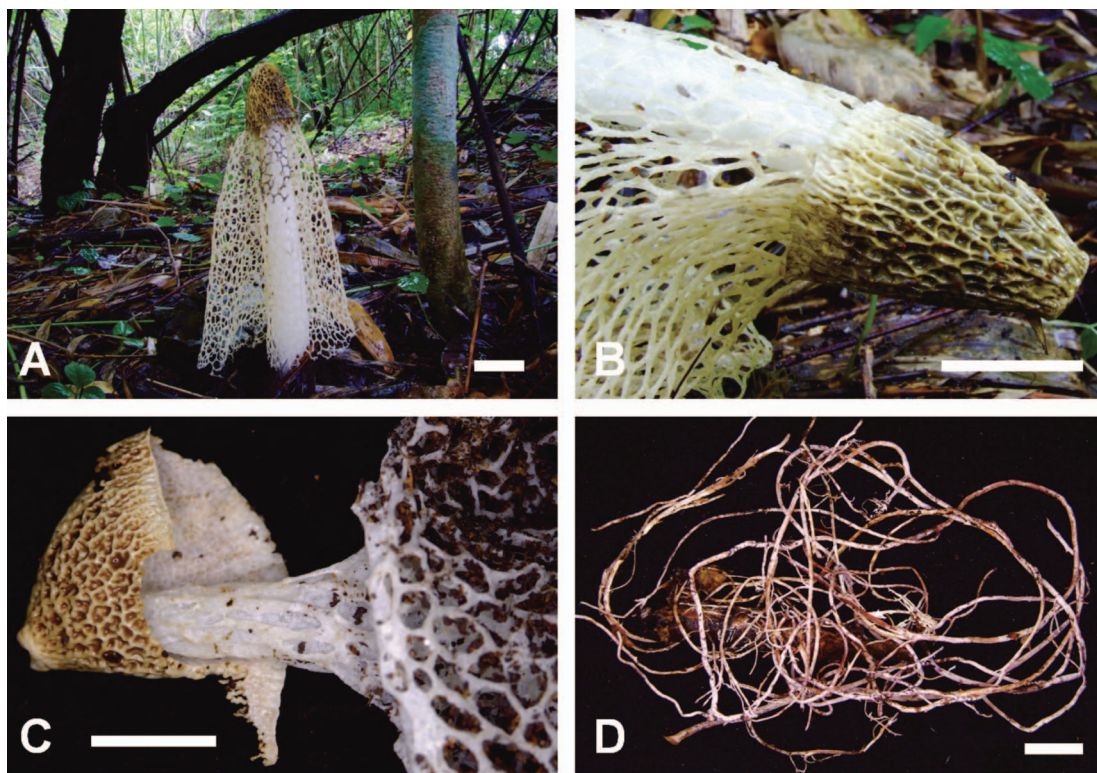


Fig. 1. Habitat and basidiomata of *Phallus* sp. A. Habitat and a basidioma of *Phallus* sp. in Thailand (KH-TH09-097). Note yellowish, reticulated pileus and long indusium with very pale yellowish tint. B. Pileus and upper part of indusium of *Phallus* sp. from Thailand (KH-TH09-097). Note numerous flies attaching to the surface of pileus and indusium. C. Pileus and upper part of indusium of *Phallus* sp. from Thailand (KH-TH09-070). Note yellowish, reticulated pileus and indusium without yellowish tint. D. Rhizomorphs of *Phallus* sp. (KH-TH09-070). Note reddish to purplish tint on the surface. Bars = 1 cm.

was not found during the fieldwork in Thailand by the author in 2009.

Phallus sp. [Fig. 1: A, B, C, D]

Specimens examined: THAILAND, Kanchanaburi, near Pha Dad Waterfall, 15 July 2009, leg. K. Hosaka (KH-TH09-070, TNS); Kanchanaburi, Sai Yok National Park, 17 July, 2009, leg. T. Orihara (KH-TH09-097, TNS).

Remarks. The specimens from 2009 were collected from dense bamboo stands with broadleaf trees, including Dipterocarpaceae. The materials are similar to *Phallus luteus* (Liou & L. Hwang) T. Kasuya and *P. multicolor* with the yellowish tint of pileus. However, it differs from *P. lutea* in having much paler (Fig. 1A, B) to completely white indusium (Fig. 1C). It is different from *P. multicolor* in having a long indusium that extends toward the base of fruit body (Fig. 1A). Future molecular studies may reveal that the materials from Thailand represent distinct species.

Family **Clathraceae** Chevallier,
Flore Générale des Environs de Paris
1: 120, 1826.

Anthurus brownii J.M. Mend., Philipp. J. Sci., C, Bot. 53(2): 207, 1934.

Records from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Soytong *et al.*, Songklanakarin J. Sci. Tech. 16: 301–306, 1994 (as *Anthurus* sp.).

Specimens examined: THAILAND, Bangkok, 25 May 2003 (BBH12283); Bangkok, 10 June 2003 (BBH12284).

Remarks. This species has also been reported from Philippines (Dring, 1980). Although the genus is sometimes treated as a synonym of *Pseudocolus* (Dring, 1980; Liu, 1984), it is distinct from *Pseudocolus* in having six arms that regularly become free at the tip (Dring, 1986). The species was not found during the fieldwork in Thailand by the author in 2009.

Aseroë arachnoidea E. Fischer, Denkschr. Schweiz. Ges. Nat. 32: 76, 1890.

Records from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Dring, Kew Bulletin 35: 86, 1980.

Remarks. This species has also been reported from Africa (Dring, 1964, 1980), Taiwan (Sawada, 1961; Dring, 1980; Liu, 1984; Wang *et al.*, 1999; Hosaka, 2009), Japan, China, Indonesia, Sri Lanka, Malaysia, and New Zealand (Imazeki & Hongo, 1989; Katsumoto, 2010). The species was not found during the fieldwork in Thailand by the author in 2009.

Clathrus crispatus E. Fischer, Denkschr. Schweiz. Ges. Nat. 33: 24, 1893.

Record from Thailand:

Dring, Kew Bulletin 35: 24, 1980.

Remarks. This species has also been reported from Taiwan (Dring, 1980; Wang *et al.*, 1999), Sri Lanka, India, Papua New Guinea, and Indonesia (Dring, 1980). The species was not found during the fieldwork in Thailand by the author in 2009.

Clathrus delicatus Berk. & Broome, J. Linn. Soc., Bot. 14: 77, 1875. [Fig. 2: A, B, C, D]

Synonym: *Clathrella delicate* (Berk. & Broome) E. Fischer, Denkschr. Schweiz. Ges. Nat. 36: 37, 1900.

Record from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Specimen examined: THAILAND, Kanchanaburi, Pha Dad Waterfall, 15 July 2009, leg. K. Hosaka (KH-TH09-046, TNS); Kanchanaburi, Forest Park, 16 July 2009, leg. Y. Ando (KH-TH09-091, TNS).

Remarks. This species has also been reported from Sri Lanka and India (Dring, 1980). The specimens from 2009 were collected from open stands of Dipterocarpaceae. This species is very peculiar in having tiny (less than 2 cm high) fruit bodies with white, delicate receptacle (Fig. 2B, C). The overall morphology is

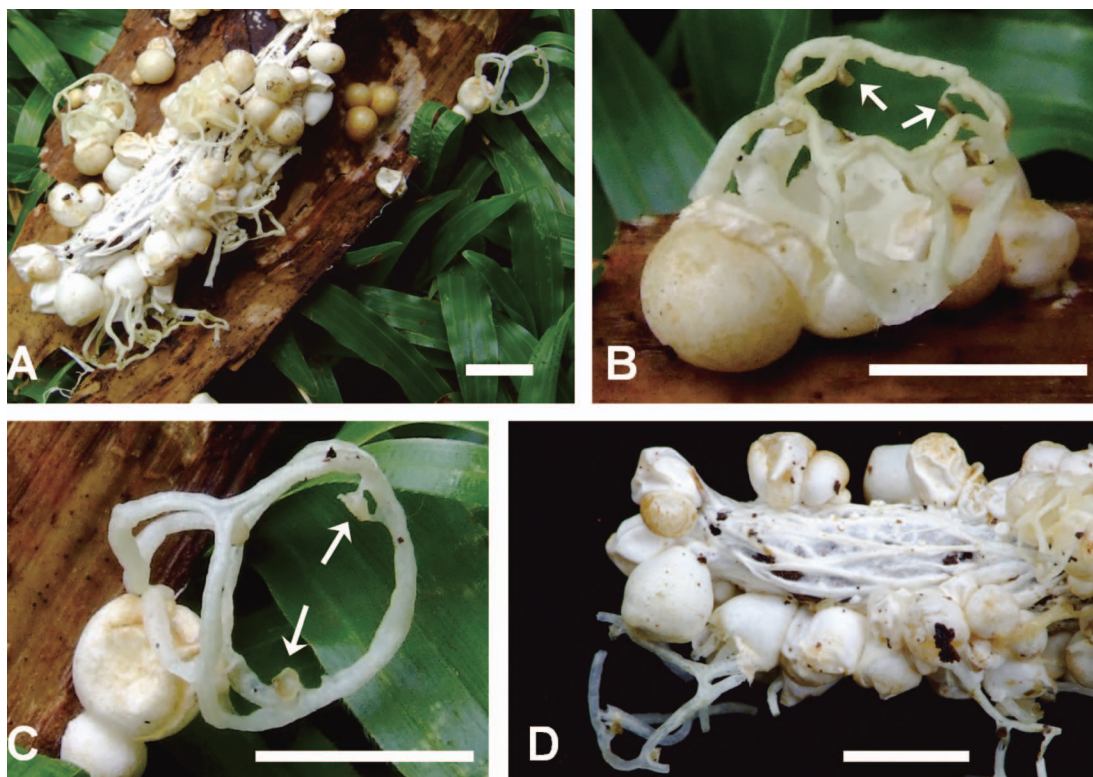


Fig. 2. Habitat and basidiomata of *Clathrus delicatus*. A. Habitat and basidiomata of *Clathrus delicatus* in Thailand (KH-TH09-091). Note dense clusters of basidiomata on plant debris. B, C. Mature, expanded basidiomata of *C. delicatus* (KH-TH09-091). Note glebiferous organs on restricted areas of receptacle (arrows). D. Mature and immature basidiomata of *C. delicatus* (KH-TH09-091). Note thick, white rhizomorphs covering the woody debris. Bars = 1 cm.

similar to *Ileodictyon* Tul. ex M. Raoul, but differs in having gleba produced on a “special glebiferous organs like three-legged stools” (Fig. 2B, C). Some species of *Clathrus*, such as *C. chrysomycelinus* Möller and *C. oahuensis* Dring, possess similar glebiferous structures (Dring, 1980), but their phylogenetic affinities are totally unknown. Future molecular studies are necessary to confirm their close relationships.

Clathrus ruber P. Micheli ex Pers., Syn. meth. fung. (Göttingen) 2: 241, 1801.

Record from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Remarks. This species has also been reported from Japan (Katsumoto, 2010), China, Sri

Lanka, New Zealand, Zaire, North and South America (Liu, 1984), and the Mediterranean area (Dring, 1980). It is speculated that the current distribution of the species in North America is due to anthropogenic introduction from the other areas (Burk, 1976). The species was not found during the fieldwork in Thailand by the author in 2009.

Colus hirudinosus Cavalier & Séchier, Annl. Sci. Nat., Bot., sér. 2 3: 251, 1835.

Synonym: *Clathrus hirudinosus* (Cav. & Sech.) Tulasne in Bory de St Vincent & Durieu de Maisonneuve, Explor. Scient. D’Algerie, Sciences Physique, Bot. 435, 1849.

Record from Thailand:

Chandrasrikul *et al.*, Diversity of mushrooms and macrofungi in Thailand. 295, 2008.

Remarks. This species has also been reported from Europe (France, Spain, and Switzerland), Africa (Algeria and Nigeria), Jamaica, and Asia (countries not specified) (Dring, 1980). The species was not found during the fieldwork in Thailand by the author in 2009.

Linderia columnata (Bosc) Cunn., Proc. Linn. Soc. N. S. Wales 56: 193, 1931.

Synonyms: *Linderiella columnata* (Bosc) Cunn., N. Z. J. Sci. Tech. 23: 171, 1942; *Clathrus columnatus* Bosc, Mag. Gesell. Nat. Freunde 5: 85, 1811; *Laternea columnata* Nees et Henry, Syst. Der Pilze 2: 96, 1858.

Record from Thailand:

Ellingsen, Nord. J. Bot. 2: 284, 1982.

Remarks. This species has also been reported from Japan (Katsumoto, 2010), China (Liu, 1984), North and South America (Dring, 1980), Hawaii, New Zealand, Australia (Dring, 1980; Liu, 1984), and Africa (Dring, 1980; Reid, 1977). The species was not found during the fieldwork in Thailand by the author in 2009.

Family *Lysuraceae* Corda,

Icones Fungorum 5: 28, 1842, "Lysuroideae".

Lysurus periphragmoides (Klotzsch) Dring, Kew Bull. 35: 70, 1980.

Synonyms: *Simblum periphragmoides* Klotzsch, Botanical Miscellany 2: 164, 1831; *Simblum gracile* Berk., in Lloyd, Syn. phall., 65, 1909; *Simblum sphaerocephalum*

Record from Thailand:

Soytong *et al.*, Songklanakarin J. Sci. Tech. 16: 301–306, 1994 (as *S. sphaerocephalum*).

Remarks. This species is distributed in pan-tropical regions of the world, including China, Taiwan, Japan, Australasia, Africa, North and South America (Dring, 1980; Fan *et al.*, 1994; Katsumoto, 2010; Liu, 1984; Sawada, 1961; Wang, 1999). The genus has traditionally been treated as a member of Clathraceae, but phylogenetic analyses clearly demonstrated that Lysuraceae is more closely related to

Phallaceae than it is to Clathraceae (Hosaka *et al.*, 2006). The species was not found during the fieldwork in Thailand by the author in 2009.

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タイ産のスッポントケ目（スッポントケ亜綱，担子菌門）（予報）

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