

## Addition to the myxomycete biota of Vietnam

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**Abstract.** During the study of materials from Vietnam collected in 2011–2019 and stored in the herbarium of the Komarov Botanical Institute of the Russian Academy of Sciences (LE) we identified specimens of 15 species and four varieties of myxomycetes, which have not been previously reported for the country. Among them, *Licea verrucispora*, *Paradiacheopsis fimbriata*, *Perichaena areolata*, *P. luteola*, *Physarum dictyosporum*, *Reticularia splendens*, *Stemonaria gracilis* are reported for the first time in Southeast Asia. The data on their localities, habitats, substrate, and distribution are provided.

**Keywords:** Amoebozoa, Myxomycetes, fungi-like protists, slime molds, tropical forests, Vietnam.

## Дополнение к биоте миксомицетов Вьетнама

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**Резюме.** В результате изучения материалов из Вьетнама, собранных в 2011–2019 гг. и хранящихся в гербарии БИН РАН (LE), были выявлены образцы 15 видов и четырех разновидностей миксомицетов, которые ранее не приводились для страны. Среди них *Licea verrucispora*, *Paradiacheopsis fimbriata*, *Perichaena areolata*, *P. luteola*, *Physarum dictyosporum*, *Reticularia splendens*, *Stemonaria gracilis* впервые выявлены в Юго-Восточной Азии. Приводятся сведения о местонахождениях, местообитаниях и субстратной приуроченности, а также сведения о распространении выявленных таксонов.

**Ключевые слова:** Amoebozoa, Мухомycetes, грибообразные протисты, слизевики, тропические леса, Вьетнам.

The Socialist Republic of Vietnam is located on the Southeast Asian Indochinese Peninsula. The country has an S-shaped outline and stretches over 3200 km from the North to the South. The total land area of Vietnam is approximately 325360 km<sup>2</sup> (Averyanov *et al.*, 2003).

The first records of myxomycetes from Vietnam reported by van Hooff (2009), who registered 23 myxomycete species in the country. Beginning in 2010 and continuing until present time, Yu. K. Novozhilov and his colleagues, carried out research of myxomycetes and accumulated data from the lowland and mountain forests of Vietnam (Novozhilov *et al.*, 2017a, 2020; Fedorova *et al.*, 2020, 2021). To date, Loi *et al.* (2023)

have published a systematic review of myxomycetes in Vietnam, which includes 173 species. However, this paper does not cite the finding of *Licea eleanorae* Ing, which was published by Fedorova *et al.* (2021). Thus, 174 species of myxomycetes are known from Vietnam up to 2023.

As a result of studying materials stored in the Herbarium of the Komarov Botanical Institute of the Russian Academy of Sciences (LE), some species and varieties of myxomycetes that were not previously published for Vietnam have been found.

## Materials and Methods

Herbarium collections of myxomycetes were obtained during expeditions organized by T. H. G. Pham and Yu. K. Novozhilov to national parks and nature reserves of Vietnam in 2011–2019: Binh Chau-Phuoc Buu Nature Reserve (10°28′–37′N, 107°24′–36′E) in the Ba Ria-Vung Tau Province, Bu Gia Map National Park (12°05′–18′N, 107°03′–14′E) in Binh Phuoc Province, Kon Ka Kinh National Park (14°09′–30′N, 108°15′–27′E) in Gia Lai Province, Phia Oac-Phia Den Nature Reserve (22°32′–40′N, 105°49′–57′E) in Cao Bang Province, Xuan Son National Park (21°03′–12′N, 104°51′–105°01′E) in Phu Tho Province, Yok Don National Park (12°05′–13°01′N, 107°03′–05′E) in Dak Lak Province.

The specimens were examined by A. D. Luptakova and Yu. K. Novozhilov using Zeiss Axio Imager A1 light microscope (LM) with differential interference contrast (DIC), Stemi 2000 dissecting microscope (DM), Zeiss motorized stereomicroscope ZEISS Axio Zoom.V16, and JSM-6390 LA scanning electron microscope (SEM) at the Core Facility Center of the Komarov Botanical Institute of the Russian Academy of Sciences. For microscopy, the sporocarps were preserved as permanent slides in polyvinyl-lactophenol. The microscopic measurements were made using Zeiss Zen 3.2 software (Carl Zeiss Microscopy GmbH, free license, blue edition). The average spore diameter (including spore ornamentation) was calculated from 30 spores measured for each collection. The specimens for scanning electron microscopy were mounted on copper stubs with a double-sided tape and sputter-coated with gold.

The specimens of myxomycete sporocarps were identified to the lowest possible taxonomic level according to Martin and Alexopoulos (1969) and various original descriptions from the literature (Farr, 1976; Poulain *et al.*, 2011) applying a morphospecies concept. Nomenclature follows Lado (2005–2024).

## Results

In the studied collections of myxomycetes, we found 15 species and four varieties that had not been previously published for Vietnam. The taxa in the annotated list are arranged in the alphabetical order. Each species is accompanied with the list of localities, habitat types and substrates. Localities were georeferenced with a portable GPS device (WGS 84 mapping data, precision 3–10 m).

In the annotated species list presented below the following symbols and abbreviations are used: \* – species new to Vietnam; \*\* – species new to Southeast Asia; mc – indicates that the specimen was obtained using the moist chambers.

\**Arcyria affinis* Rostaf. — Phia Oac-Phia Den Nature Reserve, 500 m W from the road DT212, at the bottom of the deep valley, 22°35'12.7"N, 105°52'10.5"E, dense mountain forest with tree-ferns, on decayed wood, 10 XI 2019, *Novozhilov, O. N. Shchepin*, det. *Novozhilov*, LE 326248.

Sporocarps stipitate, with deep calyculus and wide-meshed red and very elastic capillitium expanding into a long plume up to 10 mm, which is connected only to the central part of the calyculus and gets easily blown away. The threads of capillitium ornamented with warts, spines, half-rings, and rings, which may form sometimes reticulum. Spores globose, ornamented with small warts collected in groups, 6–7 µm in diam., reddish in mass; light yellow by transmitted light.

In Southeast Asia, this species was known from the Philippines (*dela Cruz et al.*, 2014).

\**A. pomiformis* (Leers) Rostaf. — Binh Chau-Phuoc Buu Nature Reserve, opened dipterocarp forest on the top of the hill, 10°31'39.5"N, 107°29'15.1"E, dry dipterocarp coast forest, on large scaly bark of *Dipterocarpus* sp., 7 VIII 2015, *Novozhilov*, mc, LE 305703; *ibid.*, xerophilic coniferous coastal forest near sea sandy shore, 10°29'27.8"N, 107°27'40.0"E, dry dipterocarp coast forest, on fissured bark of *Casuarina* sp., 5 IX 2015, *Novozhilov*, mc, LE 305434.

Sporocarps stipitate, 1.5–2 mm in height. Sporotheca subglobose, 0.9–1.2 mm in diam. Spores globose, slightly warty, with scattered groups of more conspicuous warts, 7–8 µm in diam., grayish-yellow in mass, colorless by transmitted light.

In Southeast Asia, this species is also known from the Philippines (*Kuhn et al.*, 2013; *Dagamac et al.*, 2015), Myanmar (*Ko Ko et al.*, 2013), and Singapore (*Rosing et al.*, 2011).

\**A. virescens* G. Lister — Bu Gia Map National Park, valley of the Dak Soi river, passing across the Dak Soi river, 12°12'19.1"N, 107°12'16.4"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on finally decayed log, 22 V 2011, *E. S. Popov*, det. *Novozhilov*, LE 291714 (Fig. 1A); *ibid.*, in the depression near the dried stream, 12°10'59.1"N, 107°11'49.3"E, secondary forest with bamboo and Dipterocarpaceae, on strongly decayed log of bamboo, 29 XI 2017, *Novozhilov*, LE 317412 (Fig. 1B).

Sporocarps have a small funnel-shaped calyculus reticulate and spinose within; elastic greenish or yellowish capillitium, free from the cup and expanding into a long plume about 6 mm (Fig. 1A). The threads of capillitium ornamented with scattered groups of prominent, sharp-edged transverse ridges 3–5 µm high, arranged in an open spiral, the remaining surface obscurely reticulate and roughened with delicate spines. Spores yellowish green in mass, 7–9 µm in diam., nearly smooth (Fig. 1B).

In Southeast Asia, this species is also known from Singapore, Malaysia (*Lado, Wrigley de Basanta*, 2018), and the Philippines (*Dagamac, dela Cruz*, 2015).

*Ceratiomyxa fruticulosa* (O. F. Müll.) T. Macbr. var. *flexuosa* (Lister) G. Lister — Bu Gia Map National Park, 500 m towards SW from the station, 12°11'26.9"N, 107°12'14.6"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on decayed wood, 29 X 2018, *Novozhilov*, LE 317706; *ibid.*, 650 m towards SE from the station, near the rivulet, 12°11'25.3"N, 107°12'37.5"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on decayed wood, 25 X 2019, *Novozhilov, O. N. Shchepin*, det. *Novozhilov*, LE 326419 (Fig. 1C).

In Vietnam, *Ceratiomyxa fruticulosa* was reported from Bu Gia Map National Park, Cuc Phuong National Park (*Tran et al.*, 2014), Cat Tien National Park (*Tran et al.*, 2014; *Novozhilov et al.*, 2017a), Vinh Cuu Nature Reserve (*Novozhilov et al.*, 2017a), Bidoup Nui Ba National Park, Chu Yang Sin National Park (*Novozhilov et al.*, 2020).

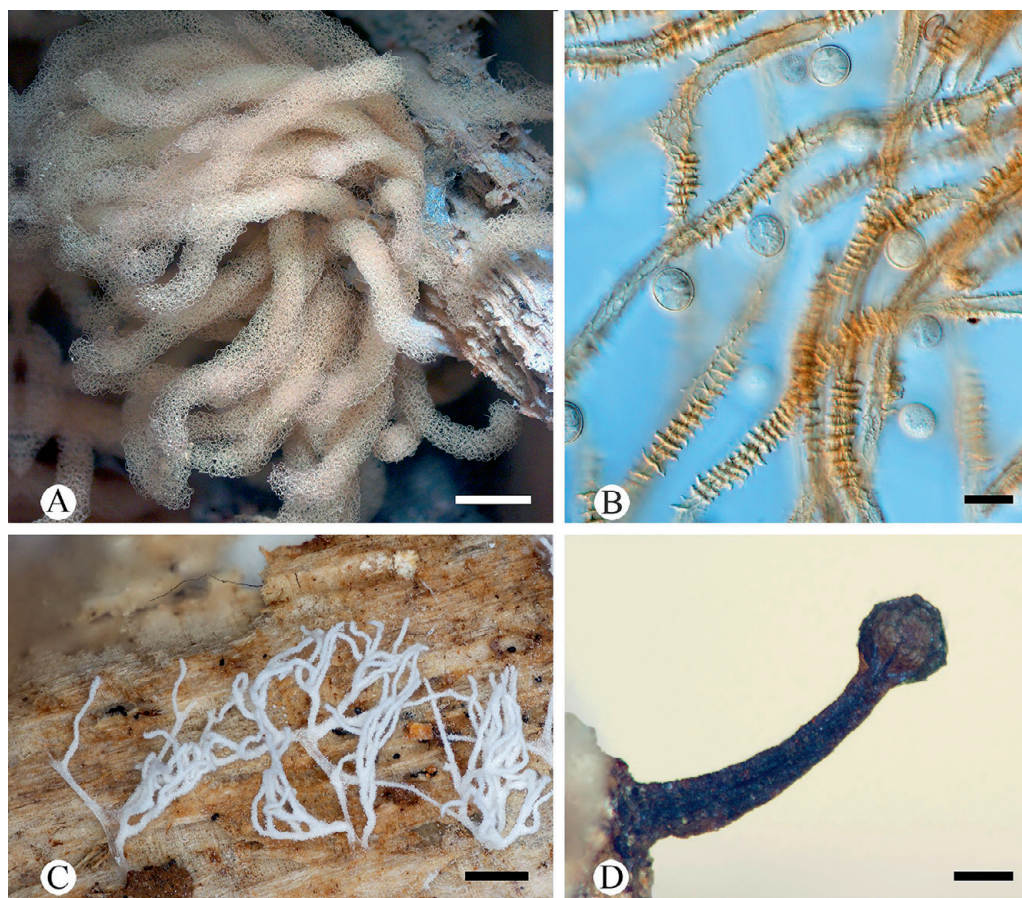


Fig. 1. Myxomycete taxa new to Vietnam.

- A, B – *Arcyria virescens*: A – sporocarps as seen by dissecting microscope (LE 291714, DM);  
 B – spores and capillitium threads as seen by differential interference contrast (LE 317412, DIC);  
 C – *Ceratiomyxa fruticulosa* var. *flexuosa* (LE 326419), sporocarps (DM);  
 D – *Licea verrucispora* (LE 305714), sporocarp (DM).  
 Scale bars: A – 2 mm; B – 10  $\mu$ m; C – 0.5 mm; D – 0.1 mm.

Sporocarps 2–4 mm in height. Spores smooth, oval, 6–7  $\times$  10–13  $\mu$ m, white in mass, colorless by transmitted light. *Ceratiomyxa fruticulosa* sporocarps are 1–2 mm in total height, they may remain unbranched or may branch and form anastomose (Martin, Alexopoulos, 1969; Cavalcanti et al., 2008). However, *C. fruticulosa* var. *flexuosa* differs from type variety by sporocarps 2–5 mm high, elongated, slender, white, profusely branching but not anastomosing (Lister, Lister, 1911).

In Southeast Asia, this variety has not previously been reported, but it is known from Europe (Nannenga-Bremekamp, 1961; Gmoshinskiy et al., 2020), Asia (Gmoshinskiy et al., 2020; Harakon, Takahashi, 2020), Africa (Doidge, 1950), North America [Olive, 1897, as *Ceratiomyxa mucida* (Pers.) J. Schröt. var. *flexuosa* Lister], South America (Yamamoto et al., 2000), and Australia (Cheesman, Lister, 1915).

***Collaria arcyrionema*** (Rostaf.) Nann.-Bremek. ex Lado var. ***japonica*** (Meyl.) Nann.-Bremek. et Y. Yamam. ( $\equiv$  *Lamproderma arcyrionema* Rostaf. var. *japonicum* Meyl.) – Binh

Chau-Phuoc Buu Nature Reserve, xerophilic deciduous tropical dense forest on sandy soil on border with dunes near road, 10°29'35.4"N, 107°27'37.6"E, dry dipterocarp coast forest, on fissured bark, 5 IX 2015, *Novozhilov*, mc, LE 305432.

In Vietnam, *Collaria arcyronema* was reported from Bu Gia Map National Park, Cuc Phuong National Park (Tran *et al.*, 2014), Cat Tien National Park (Tran *et al.*, 2014; Novozhilov *et al.*, 2017a), Thai Nguyen City (Redeña-Santos *et al.*, 2017), Vinh Cuu Nature Reserve (Novozhilov *et al.*, 2017a), and Bidoup Nui Ba National Park (Novozhilov *et al.*, 2020).

Sporocarps stipitate, erect, 1–2 mm in height. Sporotheca globose 0.4–0.5 mm in diam., peridium silvery gray or iridescent bronze. Spores globose, minutely punctate, 8–9 µm in diam., black in mass, violet-gray by transmitted light.

The type of *Collaria arcyronema* var. *japonica* has unusually lax and slender capillitium and dark spores 8–9 µm in diam. (Yamamoto, Nannenga-Bremekamp, 1995). According to Kowalski (1975), Meylan (1935) differentiated it from *Lamproderma arcyronema* by its larger sporocarps, laxer capillitium and larger spores. Kowalski's observations on the type showed that the sizes are all typical for *L. arcyronema*, but the capillitium is only slightly laxer than in the typical variety. However, Yamamoto and Nannenga-Bremekamp (1995) believed that this variety could stand because its capillitium appears different under the microscope.

In Southeast Asia, this variety has not previously been reported. It is known only from Japan (Yamamoto, Nannenga-Bremekamp, 1995).

**Comatricha pulchella** (C. Bab.) Rostaf. var. **fusca** (Lister) G. Lister — Binh Chau-Phuoc Buu Nature Reserve, xerophilic deciduous tropical opened forest on sandy soil with many stones and rocks, 10°30'27.8"N, 107°29'49.7"E, dry dipterocarp coast forest, on leaf litter, 5 IX 2015, *Novozhilov*, mc, LE 305673; *ibid.*, dense swamp forest with *Melaleuca cajuputi* Banks *et al.* is situated around dried lake, 10°32'44.6"N, 107°29'17.8"E, dry dipterocarp coast forest, on leaf litter of *M. cajuputi*, 5 IX 2015, *Novozhilov*, mc, LE 305657, LE 305658.

In Vietnam, *Comatricha pulchella* was reported from Red River Delta [van Hooff, 2009, as *Comatricha cf. brachypus* (Meyl.) Meyl.], Thai Nguyen City (Redeña-Santos *et al.*, 2017), Vinh Cuu Nature Reserve (Novozhilov *et al.*, 2017a), Bidoup Nui Ba National Park (Novozhilov *et al.*, 2020), and Phia Oac National Park (Fedorova *et al.*, 2020).

Sporocarps stipitate, 0.8–1.6 mm in height. Sporotheca oval, 0.5 mm in diam. Spores minutely and evenly warted, 6–8 µm in diam., brown in mass, pale greyish-brown by transmitted light. Sporangia of this variety differ by more rigid purplish-brown capillitium, and pale greyish-brown spores than in the type variety (Lister, Lister, 1911).

In Southeast Asia, this variety has not previously been reported, but it is known from Europe (Neubert, Baumann, 1986; Johannesen, Vetlesen, 2020; etc.), Asia (Matsumoto, 2004), North America (Brooks, 1942), and Australia (Fraser, 1933).

\***Erionema aureum** Penz. — Kon Ka Kinh National Park, 8 km NNE of Dak Jieng village, basin of Ayun river, 14°12'12.2"N, 108°19'08.9"E, middle mountain valley polydominant forest with dominance of Euphorbiaceae, Myrtaceae, Moraceae, Duabangaceae, Lauraceae, Fagaceae, and Meliaceae, on finally decayed log, 17 V 2016, *E. S. Popov*, det. *Novozhilov*, LE 307864.

Plasmodiocarps pendent on slender strands, branched and anastomosing to form a 3-dimensional network, capillitium elastic, consisting of numerous colorless tubules with mostly elastic junction, and a small number of lime nodes (Farr, 1976). Spores black in mass, purple-brown by transmitted light, 7–8 µm in diam., minutely warted. This species was placed by García-Martín *et al.* (2023) in subclade 6-VI along with *Fuligo* and *Physarella*. However, since the relationships with most other subclades within the "Clade 6", and especially with "*Fuligo* + *Physarella*", are unresolved, the authors refrain from directly accepting *Erionema* as an independent genus.

In Southeast Asia, this species is also known from Brunei (Ing, Spooner, 1998), Malaysia (Sanderson, 1922), the Philippines (Macabago *et al.*, 2020), Singapore (Rosing *et al.*, 2011), and Thailand (Reynolds, Alexopoulos, 1971).

\***Licea pseudoconica** T. E. Brooks et H. W. Keller – Binh Chau-Phuoc Buu Nature Reserve, mixed dense deciduous coastal forest, 10°29'50.4"N, 107°27'50.1"E, dry dipterocarp coast forest, on fissured bark, 19 VIII 2015, *Novozhilov*, mc, LE 305642; *ibid.*, 21 VIII 2015, *Novozhilov*, mc, LE 305690; *ibid.*, 24 VIII 2015, *Novozhilov*, mc, LE 305643; *ibid.*, "savanna" forest with scattered *Melaleuca cajuputi* trees on sandy soil, 10°32'25.7"N, 107°28'15.0"E, dry dipterocarp coast forest, on large scaly bark of *Dipterocarpus* sp., 5 IX 2015, *Novozhilov*, mc, LE 305654.

Sporocarps sessile, subglobose to more or less conical, 50–90 µm in diam. Peridium light brown to black. Spores dark brown in mass, olivaceous-brown by transmitted light, 10–11 µm in diam., smooth, with a thin, pale area.

In Southeast Asia, this species is also known from Indonesia (Gilert, Neuendorf, 1991).

\*\***L. verrucispora** D. Wrigley et Lado – Binh Chau-Phuoc Buu Nature Reserve, xerophilic deciduous tropical dense forest on sandy soil on border with dunes near road, 10°29'35.4"N, 107°27'37.6"E, dry dipterocarp coast forest, on litter of twigs, 5 IX 2015, *Novozhilov*, mc, LE 305442; Bu Gia Map National Park, near the ranger station №2, 12°11'51.0"N, 107°12'19.0"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on fissured bark, 1 VII 2015, *Novozhilov*, mc, LE 305714 (Fig. 1D).

Sporocarps stipitate, 250–500(700) µm in height. Sporotheca dark ochraceous-brown, shiny, subglobose, 100–200 µm in diam. Stalk 150–350(500) µm in height, dark, straight, subcylindrical, rugose (Fig. 1D). Peridium single, membranous, grey, densely warted. Dehiscence irregular. Spores globose, 10–12(13) µm in diam., pale yellow to greyish yellow, minutely and irregularly warted, spore wall is unevenly thickened.

This species was reported only from India (Wrigley de Basanta, Lado, 2005) and the Primorye Territory of Russia (*Novozhilov et al.*, 2017b).

\***Oligonema affine** (de Bary) García-Cunch. et al. (= *Trichia affinis* de Bary) – Phia Oac-Phia Den Nature Reserve, 150 m towards E from the abandoned French mine settlement, near the creek, 22°36'26.4"N, 105°52'17.3"E, closed lower montane evergreen tropical monsoon broad-leaved forest, on decayed wood, 5 X 2019, *Novozhilov*, O. N. *Shchepin*, det. *Novozhilov*, LE 326163; *ibid.*, 300 m towards W from the road DT212, 22°36'10.6"N, 105°52'57.5"E, closed submontane evergreen tropical monsoon broad-leaved forest, on decayed wood, 6 X 2019, *Novozhilov*, O. N. *Shchepin*, det. *Novozhilov*, LE 326177; *ibid.*, 500 m W from the road DT212, at the bottom of the deep valley, 22°35'12.7"N, 105°52'10.5"E, dense mountain forest with tree-ferns, on decayed wood, 10 XI 2019, *Novozhilov*, O. N. *Shchepin*, det. *Novozhilov*, LE 326251.

Sporocarps sessile, bright yellow to ochraceous-yellow, 0.8–1 mm in diam. Elaters of capillitium short-ended, 6–7 µm in diam., with smooth spirals. Spores bright yellow in mass, pale yellow by transmitted light, 13–15 µm in diam., covered by incomplete, large-meshed reticulum.

In Southeast Asia, this species is also known from Malaysia (Sanderson, 1922) and Thailand (Siwasin, Ing, 1982; Ko Ko *et al.*, 2010).

\*\***Paradiacheopsis fimbriata** (G. Lister et Cran) Hertel ex Nann.-Bremek. var. **penicillata** (Nann.-Bremek. et Y. Yamam.) Y. Yamam. – Binh Chau-Phuoc Buu Nature Reserve, "savanna" forest with scattered *Melaleuca cajuputi* trees on sandy soil, 10°32'25.7"N, 107°28'15.0"E, dry dipterocarp coast forest, on large scaly bark of *Dipterocarpus* sp., 5 IX 2015, *Novozhilov*, mc, LE 305652, LE 305655.

Sporocarps stipitate, 0.5–1.5 mm in height. Sporotheca globose, 0.1–0.4 mm in diam. Stalk black, slender, 0.4–1 mm long. Columella reaches to about the center of the sporotheca. Capillitium scanty, consists of purplish brown threads, slender at the base and with expanded tips. Spores dark reddish brown in mass, dark lilac-grey by transmitted light, 7–9  $\mu\text{m}$  in diam., minutely and densely warted.

The scanty capillitium, with the enlarged tips to the branches, a few or no anastomoses and the large dark spores closely and minutely spinulose (10)11–12(14)  $\mu\text{m}$  in diam. are the marks of *Paradiacheopsis fimbriata* (Martin, Alexopoulos, 1969). *Paradiacheopsis fimbriata* var. *penicillata* differs by less pronounced club-shaped thickenings at the tips of capillitium and smaller spores 7.0–8.5  $\mu\text{m}$  in diam. minutely and densely warty (Nannenga-Bremekamp, Yamamoto, 1983; Yamamoto, 1998).

In Southeast Asia, this species and variety have not previously been reported. This variety is known from Europe (Johannesen, Vetlesen, 2020), Asia (Yamamoto, 1999), North America (Snell *et al.*, 2003), and South America (Schnittler *et al.*, 2002).

**\*\*Perichaena areolata** Rammeloo — Binh Chau-Phuoc Buu Nature Reserve, xerophilic deciduous tropical dense forest on sandy soil near small river, 10°30'21.1"N, 107°29'49.1"E, dry dipterocarp coast forest, on fissured bark, 5 IX 2015, *Novozhilov*, mc, LE 307285.

Sporocarps sessile, globose or ellipsoidal, 0.4–0.8 mm in diam. Peridium double, cinnamon, with polygonal areoles. Spores globose, pale yellow in mass, yellowish by transmitted light, 10–12  $\mu\text{m}$  in diam., minutely warted.

In Southeast Asia, this species has not previously been reported. This species is only known from Rwanda (Rammeloo, 1981) and Ethiopia (Dagamac *et al.*, 2017).

**\*\*P. luteola** (Kowalski) Gilert — Binh Chau-Phuoc Buu Nature Reserve, xerophilic deciduous tropical opened forest on sandy soil with many stones and rocks, 10°30'27.8"N, 107°29'49.7"E, dry dipterocarp coast forest, on weathered dung of cow, 5 IX 2015, *Novozhilov*, mc, LE 305660; *ibid.*, "savanna" forest with scattered *Melaleuca cajuputi* trees on sandy soil, 10°32'25.7"N, 107°28'15.0"E, dry dipterocarp coast forest, on weathered dung of cow, 5 IX 2015, *Novozhilov*, mc, LE 305647; *ibid.*, dense swamp forest with *M. cajuputi* is situated around dried lake, 10°32'44.6"N, 107°29'17.8"E, dry dipterocarp coast forest, on weathered dung of cow, 5 IX 2015, *Novozhilov*, mc, LE 307288.

Sporocarps sessile, globose, 0.1–0.5 mm in diam., olive shiny with a bright yellow spore mass that looks as a dense globe within the sporotheca when observed with DM. Peridium with smooth inner surface. Capillitium yellow, composed of a network of branched and anastomosed tubules 1–4  $\mu\text{m}$  in diam., with a few free ends that are weakly attached to the peridium (Novozhilov *et al.*, 2009). Spores globose, yellow in mass, light greyish-yellow by transmitted light, 11–12  $\mu\text{m}$  in diam., spinulose.

This species is a strictly coprophilous myxomycete that is widespread throughout the world (Calaça *et al.*, 2020), but has not previously been reported in tropical regions.

**P. vermicularis** (Schwein.) Rostaf. var. **microsperma** Y. Yamam. et Nann.-Bremek. [= *Gulielmina vermicularis* (Schwein.) García-Cunch. *et al.*] — Phia Oac-Phia Den Nature Reserve, 600 m towards E from the road DT212, 22°35'29.7"N, 105°53'24.3"E, submontane polidominant tropical forest with wild banana plantation, on bark of living trees and shrubs, lianas, *Musa acuminata* Colla, 9 X 2019, *Novozhilov*, O. N. *Shchepin*, det. *Novozhilov*, LE 326219, LE 326226; *ibid.*, wild banana plantation, 22°35'25.9"N, 105°53'22.6"E, submontane polidominant tropical forest with wild banana plantation, on air litter of *M. acuminata*, 9 X 2019, *Novozhilov*, O. N. *Shchepin*, det. *Novozhilov*, LE 326238.

In Vietnam, *Perichaena vermicularis* was reported from Red River Delta (van Hooff, 2009), Cat Tien National Park (Tran *et al.*, 2014; Novozhilov *et al.*, 2017a), Cuc Phuong National

Park (Tran *et al.*, 2014), Thai Nguyen City (Redeña-Santos *et al.*, 2017; Nguyen *et al.*, 2019), Vinh Cuu Nature Reserve (Novozhilov *et al.*, 2017a), Ba Vi National Park, and Da Nang city (Nguyen *et al.*, 2019).

Plasmodiocarps pulvinate to elongated. Peridium dark ochraceous, thin, consisting of two layers, dehiscence irregular. Capillitium abundant, the threads 2–2.5 µm in diam., minutely spinulose. Spores yellow in mass, pale yellow by transmitted light, 8.5–10.5 µm in diam., minutely roughened. According to Yamamoto and Nannenga-Bremekamp (1995) the variety differs by its smaller spores which are 7.5–9.2 µm in diam., as in the *G. vermicularis* var. *vermicularis* they are 10–14 µm in diam.

In Southeast Asia, this variety has not previously been reported, but it is known from Japan (Yamamoto, Nannenga-Bremekamp, 1995) and Taiwan (Liu *et al.*, 2007).

**\*\*Physarum dictyosporum** G. W. Martin – Yok Don National Park, 40 km towards NW from Buon Ma Thuot city, 12°56'52.8"N, 107°47'29.3"E, open tropical deciduous forest on hills is dominated by *Dipterocarpus obtusifolius* Teijsm. ex Miq., *D. tuberculatus* Roxb., and *Shorea siamensis* Miq. (Dipterocarpaceae), on leaf litter of *Dipterocarpus* sp., 9 I 2015, Novozhilov, mc, LE 300067 (Fig. 2A–D).

Plasmodiocarps and few pulvinate sporangia scattered and sinuous, up to 5 mm long, 0.3–0.5 mm in diam. (Fig. 2A); peridium double, consisting of a smooth calcareous white outer layer and a membranous, translucent inner layer; capillitium consisting of angular, irregular, white nodes massed in the center as a pseudocolumella, and hyaline connecting filaments; spore mass black (Fig. 2A); spores yellow-brownish by transmitted light, globose or slightly oval, 11–14 µm in diam., including ornamentation, prominently banded-reticulate with irregular large 3–5 meshes across the hemisphere; the bands form a border ca. 1.5–2 µm high in optical section (Fig. 2B, C); in SEM coarse verrucae 0.2–0.5 µm high are visible on the upper edges of the bands (Fig. 2D).

This species was previously recorded in the North and South America (Martin, 1962; Martin, Alexopoulos, 1969; Farr, 1976), India (Ranade *et al.*, 2012), Madagascar (Wrigley de Basanta *et al.*, 2013), Taiwan (Liu *et al.*, 2013), Seychelles Islands (Krivomaz *et al.*, 2020), and Turkey (Eroğlu, 2021).

**\*\*Reticularia splendens** Morgan – Phia Oac-Phia Den Nature Reserve, 200 m towards W from the road DT212, 22°35'41.4"N, 105°52'46.3"E, closed submontane evergreen tropical monsoon broad-leaved forest, on decayed wood of bamboo, 13 XI 2018, Novozhilov, LE 317770 (Fig. 2F); *ibid.*, 200 m towards W from the road DT212, 22°34'28.7"N, 105°52'17.9"E, pine plantation with *Pinus massoniana*, on decayed wood of *Pinus* sp., 10 XII 2019, Novozhilov, O. N. Shchepin, det. Novozhilov, LE 326276 (Fig. 2E).

Aethalium pulvinate. Cortex of aethalium reddish-brown. Pseudocapillitium membranous, dense, honey-comb-like, remaining attached to the cortex (Fig. 2E). Spores brown in mass, pale brownish yellow by transmitted light, 7–9 µm in diam., banded-reticulate over two-thirds of the surface (Fig. 2F).

This species was known from Europe, Asia, North America, South America, and Australia (*Reticularia...*, 2023).

**\*\*Stemonaria gracilis** Nann.-Bremek. et Y. Yamam. – Bu Gia Map National Park, 480 m towards E from the station, near the rivulet, 12°11'29.1"N, 107°12'34.9"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on decayed wood, 27 X 2018, Novozhilov, LE 317692.

Sporocarps in the small groups, 3–3.5 mm tall, stalks about 1/3 of the total height. Capillitium dark brown, forming a rather dense internal net of threads with membranous expansions. Spores globose, pale brown by transmitted light, 9–10 µm in diam., the ornamentation consists



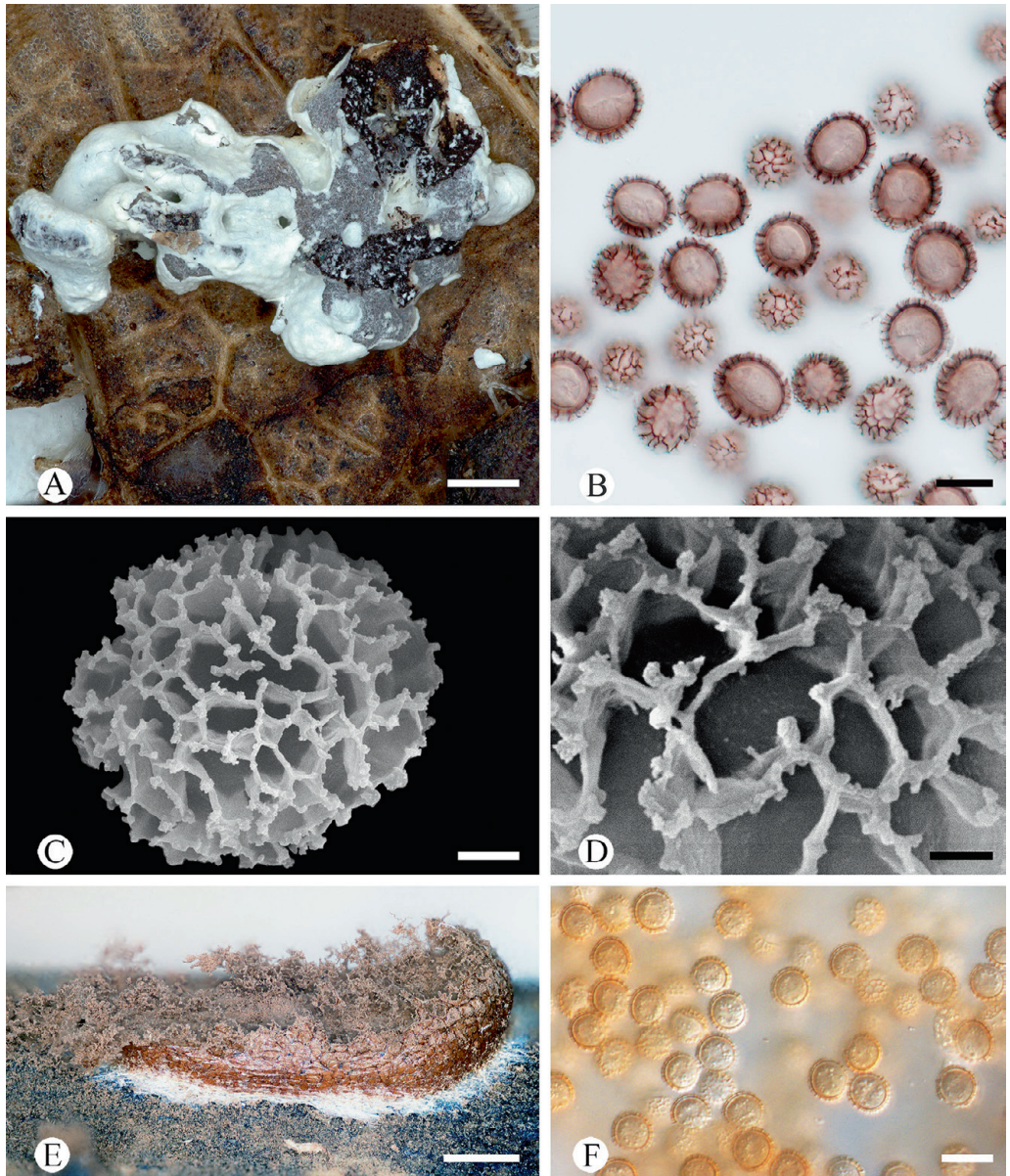


Fig. 2. Rare myxomycete species for Southeast Asia from Vietnam.

A, B, C, D – *Physarum dictyosporum* (LE 300067): A – plasmodiocarp as seen by dissecting microscope (DM); B – spores as seen by differential interference contrast (DIC); C – spore as seen by scanning electron microscope (SEM); D – spore ornamentation (SEM); E, F – *Reticularia splendens*: E – opened aethalium (LE 317770, DM); F – spores (LE 326276, DIC).

Scale bars: A – 0.5 mm; B, F – 10  $\mu$ m; C – 2  $\mu$ m; D – 1  $\mu$ m; E – 1 mm.

of free spinules about 1 µm high, arranged in rows, which form a small meshed reticulum. The characters or morphology of the specimen corresponds to the protologue of this species by Nannenga-Bremekamp et al. (1984).

This species was known from Japan (Nannenga-Bremekamp et al., 1984), Costa Rica (Rojas et al., 2018), Peru (Lado et al., 2016), and Russia (Bortnikov et al., 2020).

\***Stemonaria longa** (Peck) Nann.-Bremek. et al. — Xuan Son National Park, the environs of Lap village, 30 km towards SW from Thanh Son city, 21°07'39.4"N, 104°56'34.0"E, submontane primary tropical forest on limestone mountain (karst), on finally decayed log, 9 VI 2014, A. V. Alexandrova, det. Novozhilov, LE 299974; Bu Gia Map National Park, in the depression near the dried stream, 12°11'33.9"N, 107°11'27.7"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on decayed log, 24 XI 2017, Novozhilov, LE 317360; *ibid.*, in the depression near the dried stream, 12°11'33.5"N, 107°12'31.1"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on finally decayed log, 30 XI 2017, Novozhilov, LE 317447; *ibid.*, 200 m towards W from the station, 12°11'32.4"N, 107°12'18.4"E, submontane polidominant tropical forest with Dipterocarpaceae, Lythraceae, Rubiaceae, Theaceae, Lauraceae, and Arecaceae, on decayed wood, 26 X 2018, Novozhilov, LE 317683.

Sporocarps in dense clusters, stipitate. Sporotheca long-cylindrical, 10–20 mm in total length, drooping. Capillitium consisting of dichotomously, free ending branches. Columella slender, ending near the apex of the sporotheca. Spores black in mass, dark brown by transmitted light, 7.5–9 µm in diam., verrucose-reticulate.

In Southeast Asia, this species is also known from Cambodia (Ko Ko et al., 2015), Myanmar (Ko Ko et al., 2013), Singapore (Rosing et al., 2011), Thailand (Reynolds, Alexopoulos, 1971, as *Comatricha longa* Peck), and Malaysia (Sanderson, 1922).

\***Tubifera ferruginosa** (Batsch) J. F. Gmel. — Kon Ka Kinh National Park, 8 km NNE of Dak Jieng village, basin of Ayun river, 14°12'12.2"N, 108°19'08.9"E, middle mountain valley polydominant forest with dominance of Euphorbiaceae, Myrtaceae, Moraceae, Duabangaceae, Lauraceae, Fagaceae, and Meliaceae, on finally decayed log, 17 V 2016, E. S. Popov, det. Novozhilov, LE 307873.

Pseudoaethalium solitary, 17 mm in total extent. Sporotheca-like units crowded together, the individual units cylindrical, with free hemispherical to obtusely conical tips and blunt or papillate apices, up to 0.4 mm in diam. Peridium membranous, thin, reddish brown. Spores rustbrown in mass, pallid by transmitted light, 6–8 µm in diam., finely reticulate over about three-quarters of the surface. Unmatured fructification in the field was pink salmon. The characters or morphology of the specimen corresponds to the description of this morphospecies (Leontyev et al., 2015).

In Southeast Asia, this species was known from Cambodia [Patouillard, 1923, as *Tubulina ferruginosa* (Batsch) T. Macbr.], Malaysia (Sanderson, 1922), and the Philippines (Alfaro et al., 2014).

## Discussion

This study reports 15 species and four variation found in Vietnam for the first time and seven taxa registered as new for Southeast Asia. Some of the reported species, such as *Arcyria affinis*, *A. pomiformis*, *Oligonema affine*, *Reticularia splendens*, *Stemonaria longa*, *Tubifera ferruginosa*, are widespread in the world (GBIF..., 2024). In contrast, we found some rare species in the world, such as *Licea verrucispora*, *Perichaena areolata*, *Physarum dictyosporum*, and *Stemonaria gracilis*. The finds of *Tubifera ferruginosa*

and *Reticularia splendens*, whose distribution is apparently centered in boreal and temperate regions of Europe, Asia, and North America (Martin, Alexopoulos, 1969), is most interesting.

The typical tropical species of the genus *Tubifera* J. F. Gmel. is *T. microsperma* (Berk. et M. A. Curtis) Lado. found recently in Vietnam (Novozhilov *et al.*, 2017a), whereas *T. ferruginosa* is common in boreal and temperate forests, where it tends to develop in wet depressions, on the strongly decomposed wood of conifers and deciduous trees, which may be entirely covered by bryophytes (Leontyev *et al.*, 2015). Apparently, this species, as well as *Lamproderma columbinum* (Pers.) Rostaf., *Barbeyella minutissima* Meyl., and *Diderma tigrinum* (Schrad.) Prikhodko *et al.*, appear to be rare in tropical forests of Vietnam (Novozhilov *et al.*, 2020; Stephenson *et al.*, 2019). Our findings show that abovementioned species may penetrate into the tropical zone and may overcome abiotic barriers to invasion by colonizing coarse woody debris in montane forests of Vietnam. However, it should be emphasized that the taxonomic boundaries of *Tubifera ferruginosa* found in Vietnam still need to be clarified. Recently it has been shown that the species complex *T. ferruginosa* s. l. represents about seven separate species (Leontyev *et al.*, 2019). In addition, three species clusters have unclear morphological distinctions (Leontyev *et al.*, 2015; Lloyd *et al.*, 2019) and molecular genetic analysis is required to distinguish them. In this regard we postpone the final decision about distribution of *T. ferruginosa* in Vietnam.

Thus, the list of myxomycete species of Vietnam includes 189 species. However, for an underrepresented and highly understudied different regions of Vietnam, need more efforts to reveal real species diversity of myxomycetes in this country.

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