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Survey of Freshwater Hyphomycetes in Yakushima Island, Southern Japan

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Abstract Fungal spores collected from streams in Yakushima Island are examined and reported with illustrations. Thirty two taxa of 22 genera were recognized, and their differences in occurrence in relation to hitherto known Japanese stream spora were noted.
Key words: aquatic hyphomycetes, freshwater hyphomycetes, fungal diversity, Ingoldian fungi, local mycobiota.

Introduction

In spite of the past explorations of mycobiota in Yakushima Island (literature cited in Hosoya and Tanaka, 2007), there have been no records of aquatic hyphomycetes. Aquatic hyphomycetes were first found in Europe and are known for their characteristic morphology of the spores (Ingold, 1942). Later, the more highly diverse morphology of aquatic hyphomycetes in subtropical and tropical areas caught attention of many mycologists (e. g., Goh, 1997; Marvanová, 1997). At present, more than 500 species are known from freshwater habitats (Tsui and Hyde, 2003). They are involved in the degradation of dead plant material and animal parts in freshwater ecosystems (Wong *et al.*, 1998).

Spores of aquatic hyphomycetes are caught in water foam in streams, and can be analyzed by fixed samples. Miura (1974) compared stream spora from three representative areas in Japan, and noted few overlap of mycobiota between a northern area (Rebun Island) and a southern area (Yaeyama Islands). Because of the diverse vegetation, a diverse aquatic mycobiota is expected in Yakushima Island. During the exploratory visit to Yakushima in 2005 (Taxonomic research for plants and fungi in areas with remarkable biodiversity in Japan), the authors collected water foam samples to contribute to elucidation of mycobiota in aquatic habitats. In the present paper, a list is provided with taxonomic notes.

Materials and Methods

Five sites along major rivers and water falls in Yakushima Island were explored and 8 samples were obtained (Fig. 1, Table 1). Water foam was scooped up with an aluminum spoon, and immediately fixed on site by formalin with cotton blue stain. For examination, a drop of fixed sample was applied onto a slide glass, and water-soluble resin "Neo-shigaral" (Shiga konchu-fukyu-sha, Tokyo) was applied and mixed with the sample for solidification. The prepared slides were examined by a compound microscope for identification.

Results and Discussion

In total, 32 taxa (including six unidentified and 10 not identified to specific rank) belonging to 22

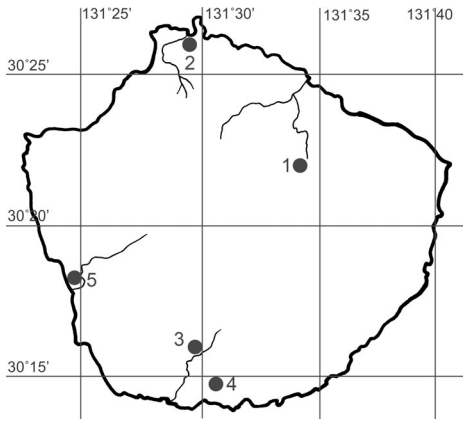

Fig. 1. Map of Yakushima Island showing collection sites by solid circles.
Numbers represent site numbers shown in Table 1.

genera were recognized (Figs. 2–4, Table 2). No clear differences were observed in samples at the same site, and the mycobiota at the given site seemed to be stable during the observed period.

The biodiversity and the numbers of stream spora differed from site to site, *Triscelophorus* spp. and *Triramulispora* sp. being the most frequently occurring members from all sites. Samples from Shiratani-unsui-kyo (Site 1), where the stream was running through deep forest, were rich in diversity, while those in rocky stream in Nunobiki-no-taki (Site 2) and Yudomari-gawa river (Site 5) were not.

Tubaki and Sugino (1982) studied stream spora in Mt. Tsukuba through the year, and identified 19 genera, 27 species. Miura (1967, 1974) found 33 spore types from Sugadaira based on multiple sampling around the year. In compari-

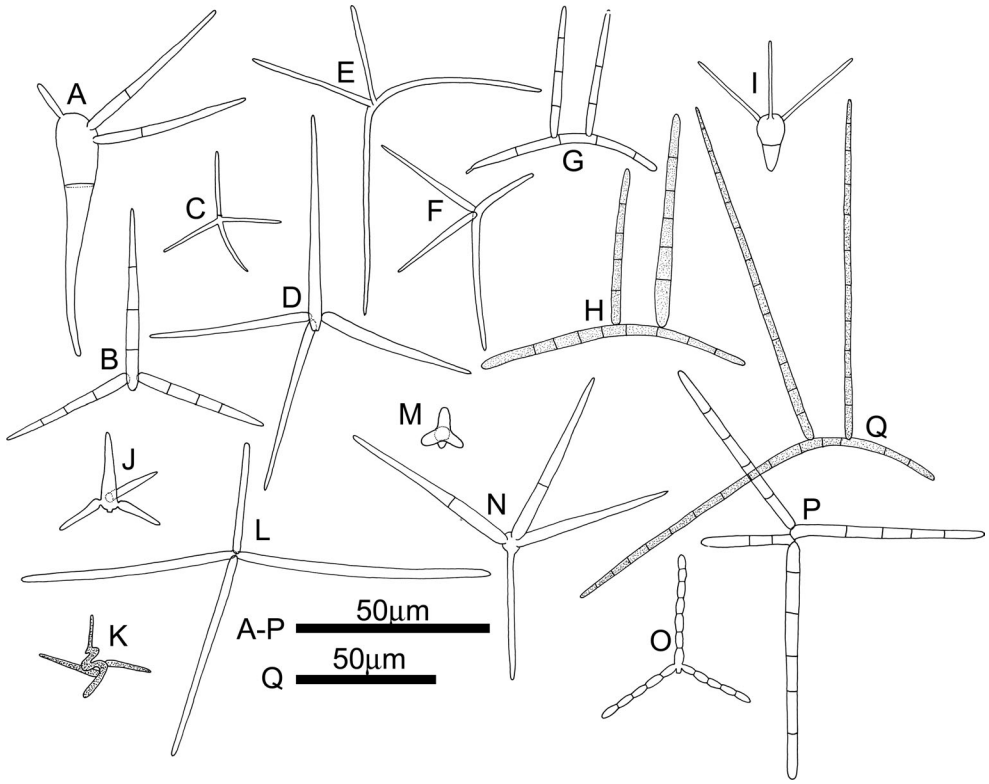

Fig. 2. Representatives of stream spora in Yakushima Island (mainly tetra-radiating spores). A, *Culicidospora gravida*; B, *Triscelophorus* sp. 1; C, *Alatospora* sp. 1; D, *Triscelophorus* sp. 2; E, *Tetrachaetum elegans* (?); F, *Alatospora* sp. 2; G, *Tricladium splendens*; H, *Tricladiospora brunnea*; I, *Clavariopsis aquatica*; J, *Triscelophorus* sp. 3; K, unidentified 1; L, unidentified 2; M, unidentified 3; N, *Flabellospora tetracladia*; O, *Trisulcosporium acerinum*; P, *Fontanospora eccentrica*; Q, *Tricladiosproa* sp.

Table 1. Collection sites in Yakushima Island.

Site no.	Site	Elevation (m)	Date	No. of samples
1	Shiratani-unsui-kyo	620	2005-X-18, 19	3
2	Nunobiki-no-taki	20	2005-X-19	1
3	Upstream of Yudomari River	250	2005-X-20	1
4	Sarugawa Gajumaru Park	110	2005-X-21	1
5	Oko-no-taki	150	2005-X-21	2

Table 2. Stream spora of Yakushima Island.

	Site*				
	1	2	3	4	5
Alatospora sp. 1 (Fig. 2C)	+			+	
Alatospora sp. 2 (Fig. 2F)	+				
Anguillospora crassa Ingold (Fig. 3E)	++			+	
Anguillospora sp. (Fig. 4B)	+				
Campylospora parvula Kuzuha (?) (Fig. 4J)	+				
Clavariopsis aquatica De Wild. (Fig. 2I)					+
Clasterosporium flexum (Matsush.) B. Sutton et R. T. A. Cook (Fig. 3B)	++		+		
Condylospora spumigena Nawawi (Fig. 3F)	+				
Culicidospora gravida R.H. Petersen (Fig. 2A)	+				
Dendrospora sp. (Fig. 4A)	+				
Entomophthora sp. (Fig. 4E)	+				
Fontanospora eccentrica (R. H. Petersen) Dyko (Fig. 2P)	+				
Flabellospora tetracladia Nawawi (Fig. 2N)	+				
Lateriramulosa uniinflata Matsush. (Fig. 4I)	+				
Lunulospora cymbiformis K. Miura (Fig. 4G)	+				
Obelispora sp. (Fig. 4C)	+				
Tetrachaetum elegans Ingold (Fig. 2E)	+			+	
Tetraploa aristata Berk. et Broome (Fig. 4H)		+	+		
Tricladiospora brunnea (Nawawi) Nawawi et Kuthub. (Figs. 2H, 2Q)	++				
Tricladium splendens Ingold (Fig. 2G)	+				
Triramulispora sp. (Fig. 4F)	+	+	++	+	++
Triscelophorus sp. 1 (Fig. 2B)	+	+	+		+
Triscelophorus sp. 2 (Fig. 2D)	++	+	++	++	++
Triscelophorus sp. 3 (Fig. 2J)	+		+	++	+
Trisulcosporium acerinum H. J. Huds. et B. Sutton (Fig. 2O)	+				
Wiesneriomyces laurinus (Tassi) P. M. Kirk (Fig. 3A)	+				
unidentified 1 (Figs. 2K, 4K)	+				
unidentified 2 (Fig. 2L)	++				
unidentified 3 (Fig. 2M)	+			+	
unidentified 4 (Fig. 3C)	+		+	+	
unidentified 5 (Fig. 3D)	+				
unidentified 6 (Fig. 4D)	+				

* Site numbers represent those in Table 1.
Number of + shows abundance of spores.

son to these data, the biodiversity of stream spora in Yakushima Island seems to be similar to or more diverse than that of central Honshu in Japan.

Spores typically observed in a subtropical area (e.g., *Tricladiospora brunnea* and *Obelispora* sp.; Goh, 1997) were also frequently observed, while some of the common fungi in temperate zones were not observed (e.g., *Heliscus*, *Lemoniera*; Miura, 1974).

Among the 36 specifically identified fungi with hyaline, thin-walled, radiately branched spores listed by Miura (1974), only five species were found in the present study: two (*Clavariopsis aquatica* and *Lateriramulosa uniinflata*) were known to be distributed widely, two (*Culicidospora gravida* and *Tricladium splendens*) were found from northern areas, and *Flabellospora tetracladia* was thought to be a subtropical element.

Dematiaceous spores that characterize subtropical stream spora (Goh, 1997; Marvanová, 1997), and others characteristic to subtropical regions were frequently observed. Spores of *Beltrainia* and *Sporoschisma*, coniophores of other dematiaceous fungi, and aseptate fusiform dematiaceous spores were also often encountered.

Among the stream spora observed, the followings were noteworthy. Unidentified 1 (Figs. 2K, 4K) superficially resembles *Laterilamulosa* in the complex main axis, but differs in having dematiaceous color and more filamentous, apparent central body. Unidentified 2 (Fig. 2L) is similar to *Articulospora* in the radiating branch connected at a point, but differs in the longer branches. Unidentified 4 (Fig. 3C) is similar to *Lunulospora* with crescent-shaped spores, but lacks vestige of attachment to the sporophore. This shape of conidia was encountered multiple times at two sites and the spore shape seemed to be stable. Unidentified 5 (Fig. 3D) resembles *Flagellospora penicilloides*, but differs in having more than one septa while *F. penicilloides* usually have one septum. Unidentified 6 (Fig. 4D) differs from known taxa in having a main axis strongly curved at one end. This fungus is cited as "fungus imperfectus non nominatus" (Matsushima, 1975: 206). *Triramulispora* sp. (Fig. 4F) was found in all the samples. It is characterized by the four radiating acicular arms, arising from two different levels; two arising from the upper level extending upward, and two arising from the lower level, extending below, shorter than the rest. The configuration of the spore arms seems to be close to *Triscelophorus*, but differs from *Triscelophorus* in the arms of this fungus occurring from the different levels.

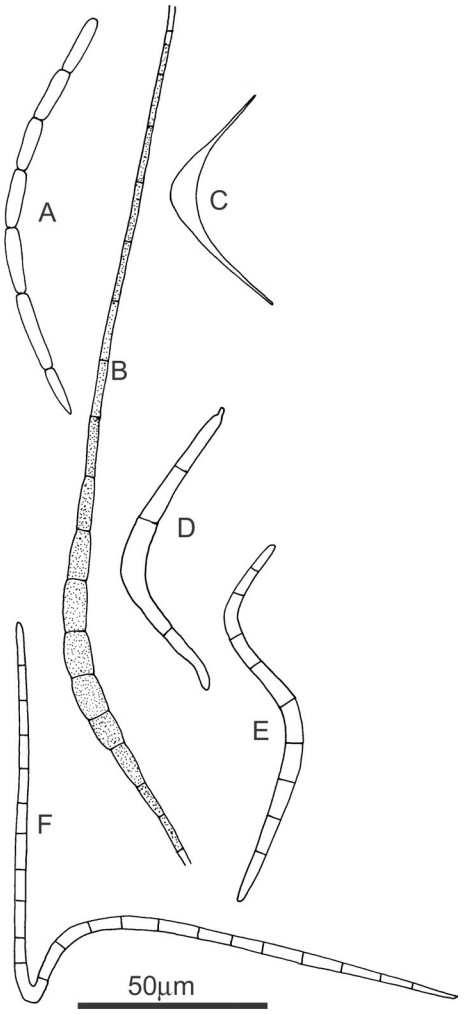

Fig. 3. Representatives of stream spora in Yakushima Island (mainly sigmoid to filiform spores). A, *Wiesneriomyces laurinus*; B, *Clasterosporium flexum*; C, unidentified 4; D, unidentified 5; E, *Anguillospora crassa*; F, *Condylospora spumigena*.

Although the spore morphology of *Clasterosporium fllexum* was relatively consistent with Matsushima (1975), it varied considerably, having a various elongation of the apical extention up to 600 μm, possibly due to adaptations to streams.

This is the first report to apply water soluble resin to a study of aquatic hyphomycetes. Although application of resin interferes transparency of the sample, the conformation of the stream

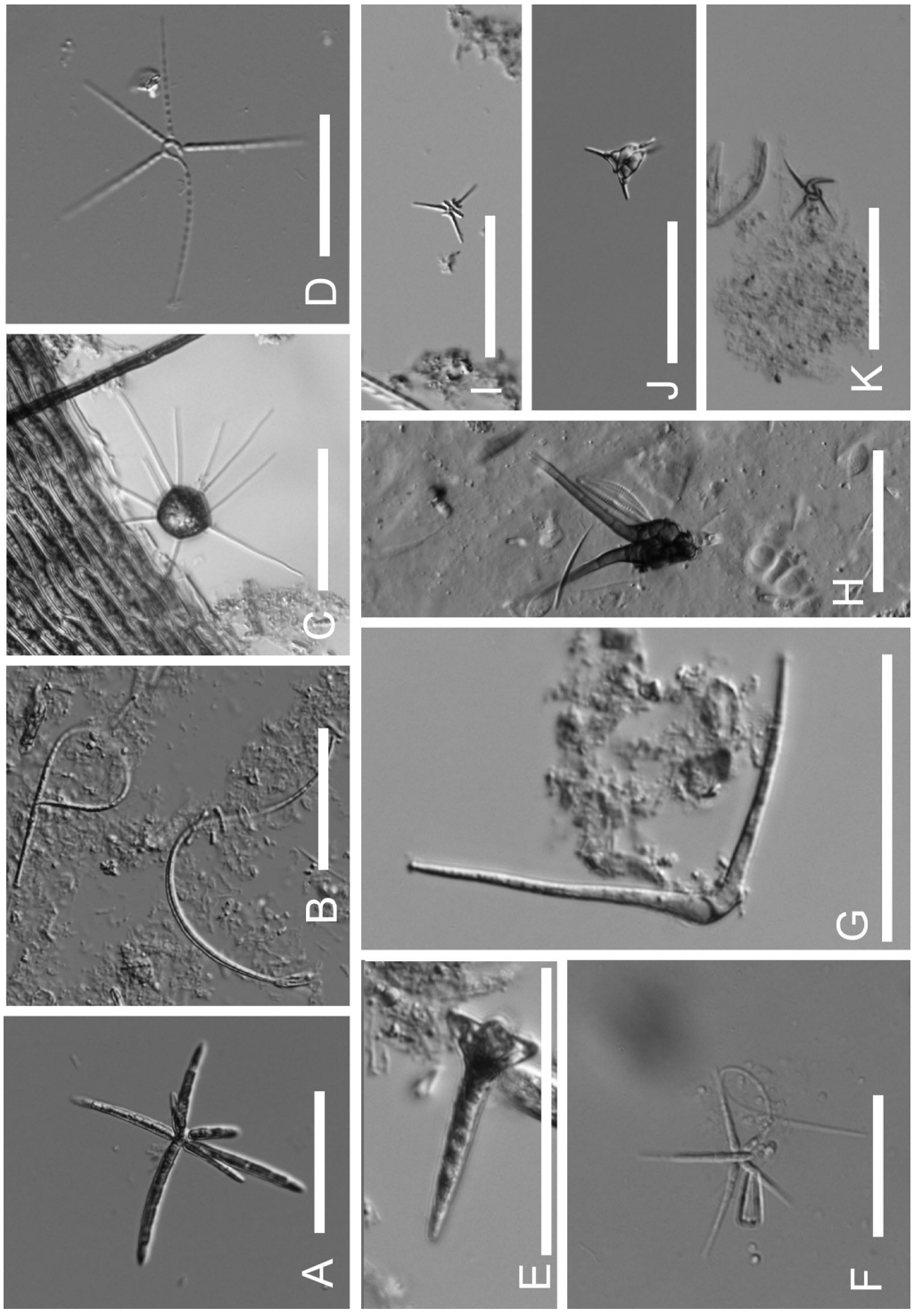

Fig. 4. Representatives of stream spora in Yakushima Island. A, *Dendrospora* sp.; B, *Anguillospora* sp.; C, *Obelispora* sp.; D, unidentified 6; E, *Entomophthora* sp.; F, *Triramullispora* sp.; G, *Lunulospora cymbiformis*; H, *Tetraploa aristata*; I, *Lateriramulosa uniinflata*; J, *Campylospora parvula* (?); K, unidentified 1.

spora can be maintained in more natural manner than temporal slide preparation with volatile mounting fluid. One year after the preparation, the spores maintained without morphological damage.

Seasonal fluctuation of the strem spora has been pointed out (e.g., Ingold, 1942; Nilsson, 1964; Iqbal and Webster, 1973), and more samples are required for quantitative analysis of stream spora of Yakushima.

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