

Coemansia furcata sp. nov. and its distribution in Japan and Taiwan*

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Coemansia furcata, isolated from forest soils of Japan and Taiwan, is described and illustrated. This species is characterised by its sporangiophore branching and relatively large sporocladia. Its distribution in soils of Japan and Taiwan is discussed.

Key Words—*Coemansia formosensis*; *Coemansia furcata*; distribution; Kickxellales; new species.

Since van Tieghem and Le Monnier (1873) established the genus *Coemansia* (Kickxellaceae, Kickxellales, Zygomycetes), 16 taxa (15 species and 1 variety) have been described in the genus (Linder, 1943; Benjamin, 1958; Mehrotra and Kakkar, 1970; Chien, 1971). Taxonomic studies on the genus were conducted by Linder (1943) and Benjamin (1958, 1959). No species have been described in *Coemansia* since *C. nantahalensis* Chien (1971), though Kirk (1993) predicted the existence of morphologically diversified members of the Kickxellales in the tropics.

Miura (1978) and Udagawa (1978) found that *Coemansia aciculifera* Linder and *Coemansia* spp. were widely distributed in forest soils of Japan. No research has been done to determine the distribution of the new species of *Coemansia* in Japan and Taiwan.

During a floristic survey on Kickxellales of Japan, the senior author obtained several isolates of an unidentified *Coemansia* from various forest soils. As the result of a taxonomic investigation, these isolates were combined with Chien's isolates of *Coemansia* from Taiwan [*C. formosensis*, '*formosanensis*' Chien (1969), nomen nudum]. Here, we describe these isolates as a new species of *Coemansia* and discuss the distribution of the species in Japan and Taiwan.

Materials and Methods

The isolates were incubated on half-strength malt extract-yeast extract agar medium (1/2 ME-YE agar; Benjamin, 1958) at 20°C. Slides were prepared of the 10-day colonies mounted in lactic acid-cotton blue (cotton blue, 0.5 g; 90% lactic acid, 1l). They were observed by

an optical microscope (Microphoto, Nikon) using an oil immersion lens, and the sizes of individual features were measured with an ocular micrometer. One hundred measurements were done for each morphological feature. Microsoft Excel (Microsoft Corp.) was used for statistical analysis.

To investigate its distribution, soil samples were collected in more than 1000 locations in Japan and Taiwan. Samples were collected in sterile plastic bags aseptically. These samples were processed by the soil plate method (Warcup, 1950) using 10% carrot extract agar medium and/or the shrimp baiting method (Degawa and Tokumasu, 1997). The plates and moist chambers were incubated at room temperature for at least four weeks.

Species description

Coemansia furcata Kurihara, Tokumasu & C.-Y. Chien, sp. nov. Figs. 1–11

Coloniae in 1/2 ME-YE agar luteolae, post 10 dies ad 20°C 52.4 mm diam attingentes. Hyphae vegetativae hyalinae, septatae, 1.8–10.0 µm latae, frequenter gangligerae. Sporangiophora erecta, septata, 7.5–15.3 µm lata, simplicia vel infra furcata, in partibus fertilibus furcata et sporocladia ferentia. Sporocladia asperula, ex stipitibus 10.4–28.0 × 4.2–7.7 µm evolventia, 7–13-cellularia, praeter stipites 30.8–55.8 × 5.4–7.4 µm; cellula apicalis sterilis et recurvata, 3.7–12.4 × 1.4–4.2 µm. Pseudophialides lageniformes, e cellulis fertilibus sporocladii lateraliter orientes, latrorsae, 4.7–6.3 × 1.3–2.5 µm. Sporangiola monospora, incolorata, cylindrica, cum latere alio convexo alio leviter concavo, 10.2–17.5 × 2.4–3.2 µm. Sporangiosporae cylindricae, 8.3–12.9 × 1.6–2.8 µm, ad apicem minute cacuminales.

Zygosporae globosae vel oblongae, aliquando anomalae, incoloratae, pachydermae, laevigatae, 21.5–

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74.9 μm diam, muri 0.9–12.5 μm crassi, globulos hyalinos aliquot vel multum (interdum plus quam 100) 2.9–26.2 μm diam continentes, homothallicae.

Holotypus: TNM F10612, colonia exsiccata e cultura ex solo silvae *Cyclobalanopsis morii* et *Liquidambar formosana*, Lishan, Taichung Pref., in Formosa, a H. Indoh leg. et a C.-Y. Chien isolata in 1 Jun., 1966.

Colonies on 1/2 ME-YE agar pale yellow. Vegetative hyphae colourless, septate, 1.8–10.0 μm wide, often with gangliform swellings. Sporangiphores erect, septate, 7.5–15.3 μm wide, unbranched or furcate below, furcate in the fertile part bearing sporocladia, intersporocladial distance 0.3–15.7 μm . Sporocladia asperulate, with stalks of 10.4–28.0 \times 4.2–7.7 μm , composed of 7–13 cells excluding the stalks, 30.8–55.8 \times 5.4–7.4 μm , the apical cell sterile and recurved, 3.7–12.4 \times 1.4–4.2 μm . Pseudophialides flask-shaped, 4.7–6.3 \times 1.3–2.5 μm , sitting laterally in transverse rows on the fertile cells of sporocladia. Sporangiola monosporic, colourless, cylindrical, 10.2–17.5 \times 2.4–3.2 μm , in lateral view one side convex, the other slightly concave. Sporangiospores cylindrical, slightly pointed at the apex, 8.3–12.9 \times 1.6–2.8 μm .

Zygospores globose to oblong, sometimes anomalous, colourless, thick walled, smooth, 21.5–74.9 μm in diameter, wall 0.9–12.5 μm thick, containing several to many (sometimes more than 100) hyaline globules of 2.9–26.2 μm in diameter, formed on the surface or buried in the agar medium, homothallic.

Colony diameter on 1/2 ME-YE agar reached 52.4 mm at 20°C for 10 days.

Holotype: TNM F10612, a dried specimen from the culture of ATCC 24540=CBS 102833=FIRDI 33645=F66-124-1, isolated from soil of a *Cyclobalanopsis morii*-*Liquidambar formosana* forest in Lishan, Taichung Pref., Taiwan, collected by H. Indoh, isolated by C.-Y. Chien, 1 June, 1966, Dried specimen is deposited in the National Museum of Natural Science of Taiwan,

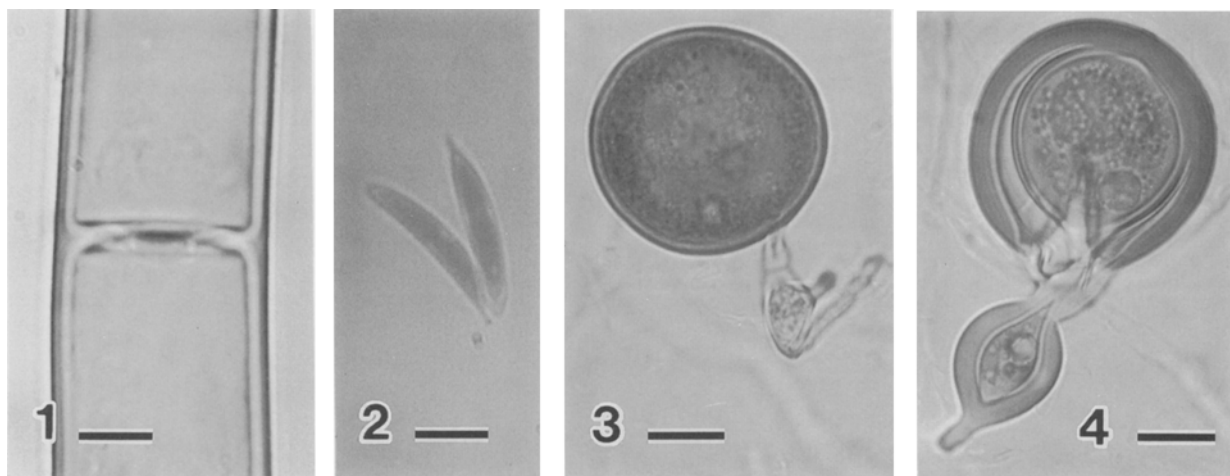
Taichung, Taiwan. Living cultures deposited in the American Type Cultural Collection (ATCC 24540) in the USA, Centraalbureau voor Schimmelcultures (CBS 102833) in the Netherlands, Cultural Collection Research Center, Food Industry Research and Development Institute (FIRDI 33645), Hsinchu, Taiwan, and the Mycological Laboratory, Institute of Biological Sciences, National Taiwan Normal University (F66-124-1), Taipei, Taiwan.

Other isolates examined: KK0003, Mt. Yuwan, Amami Island, Uken, Kagoshima Pref., from soil of a *Symplocos confusa*-*Symplocos prunifolia* forest, collected by R. Machida, isolated by Y. Kurihara, Mar. 1996. KK0006, Sugadaira, Sanada, Nagano Pref., from soil of a *Pinus densiflora* forest, collected and isolated by Y. Kurihara, 23 July, 1996.

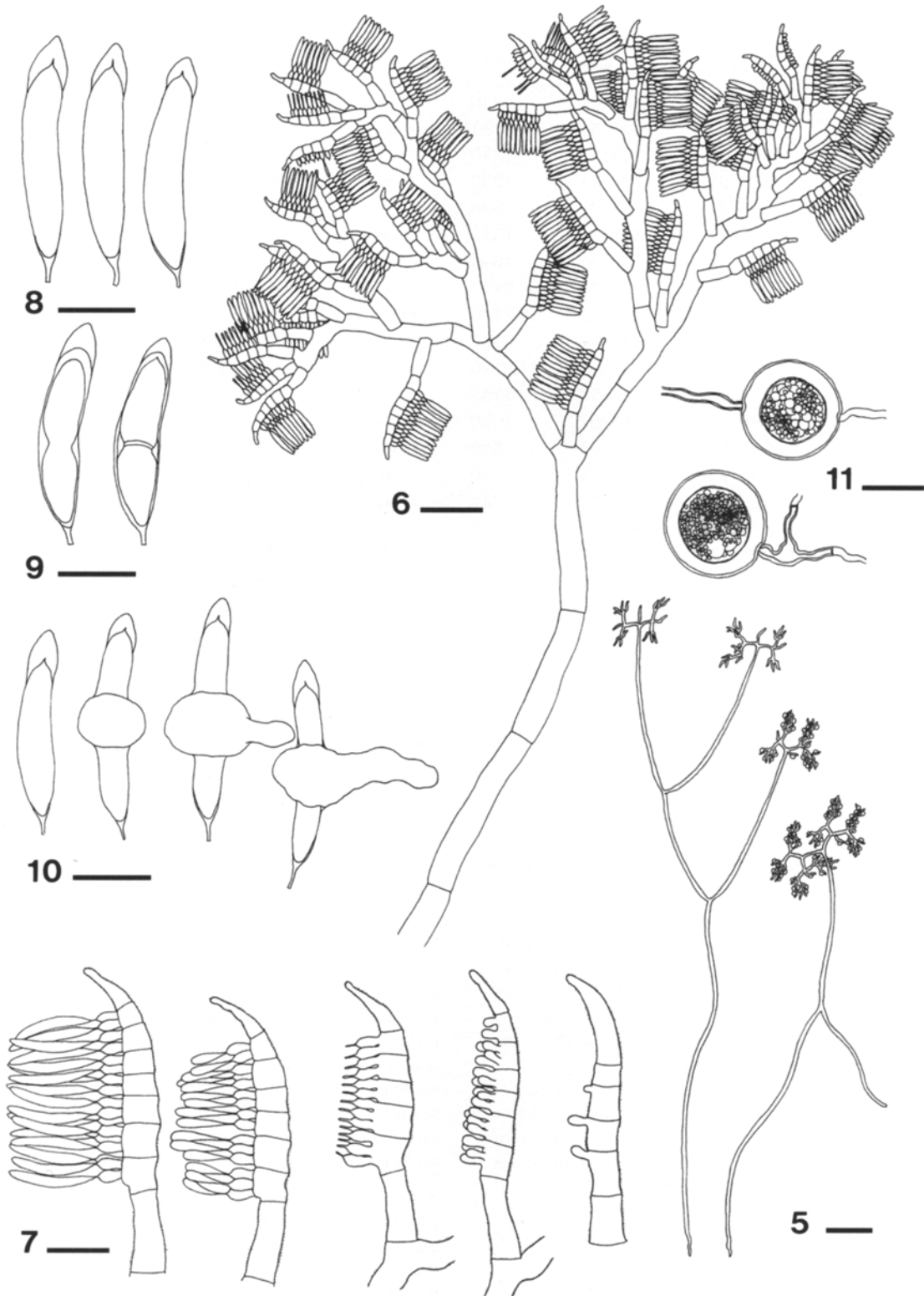
Notes *Coemansia furcata* resembles *C. aciculifera* Linder var. *suhagensis* B. R. Mehrotra & Kakkar in branching dichotomously in the upper part of the sporangiophore. It is, however, clearly distinguished from the latter species in its higher and wider sporangiophore and sporocladium, and slightly wide, elongate cylindrical sporangiole.

In 1969, Chien reported this fungus from Taiwan as *Coemansia formosensis* (as '*formosanensis*')—nomen nudum, but he has not published it formally since that time. *Coemansia furcata* has been reported in the literature as *C. formosanensis* (Chien, 1969) or *C. formosensis* (Chien, 1994), but these names were never validly described. Through this survey, we recognised that this species is widely distributed both in Taiwan and Japan. Therefore, we named it *Coemansia furcata* based on the branching habit of the sporangiophore.

Benjamin (1958) pointed out that the shape of sporangiospores of *Coemansia* spp. and *Kickxella alabastrina* Coemans change in lactic acid under optical microscopic observation, namely, the appearance of annular



Figs. 1–4. *Coemansia furcata*. 1. Septum of the sporangiophore. Bar=5 μm . 2. Two sporangiola with sporangiospores in lactic acid-cotton blue; the sporangiospores are deformed. Bar=5 μm . 3. Young zygospore. Bar=25 μm . 4. Mature Zygospore. Bar=25 μm .



Figs. 5–11. *Coemansia furcata*. 5. Habit sketch of sporangiophores, The left structure often seen in old cultures. Bar=150 μ m. 6. Upper part of sporangiophore. Bar=30 μ m. 7. Five sporocladia showing successive stages in producing pseudophialides and sporangia. Bar=10 μ m. 8. Three sporangia with sporangiospores in water. Bar=5 μ m. 9. Two sporangia with sporangiospores in lactic acid-cotton blue; the sporangiospores are deformed. Bar=5 μ m. 10. Successive stages in germination of sporangiospore in water. Bar=5 μ m. 11. Zygospores. Bar=20 μ m.

Table 1. Localities and forest types of isolates of *C. furcata* in Japan and Taiwan.

locality	location		altitude (m) ^{a)}	forest type ^{b)}	dominant species ^{a)}
	north lat.	east long.			
Japan					
Shari	44° 07'	145° 05'	245	ev, co	<i>Abies sachalinensis</i>
Sendai	38° 14'	140° 51'	90	ev, co	<i>Abies firma</i>
Sugadaira 1	36° 31'	138° 21'	1340	ev, co	<i>Pinus densiflora</i>
Sugadaira 2	36° 31'	138° 21'	1330	ev, co	<i>P. densiflora</i>
Sugadaira 3	36° 31'	138° 21'	1320	ev, co	<i>P. densiflora</i>
Sugadaira 4	36° 31'	138° 21'	1310	de, bl	<i>Quercus crispula</i>
Kawakami	35° 55'	138° 30'	1500	de, bl	<i>Acer sieboldianum</i> , <i>Acer japonicum</i>
Inabu	35° 11'	137° 35'	1180	de, bl	<i>Fagus crenata</i>
Yasu	35° 02'	136° 02'	120	ev & de, bl	<i>Castanopsis cuspidata</i> , <i>Quercus serrata</i>
Kyoto 1	35° 01'	135° 47'	80	de & ev, bl	<i>Q. serrata</i> , <i>Camellia japonica</i>
Kyoto 2	35° 01'	135° 47'	70	ev, bl	<i>C. cuspidata</i>
Amagi 1	34° 50'	138° 57'	1143	de, bl	<i>F. crenata</i> , <i>Stewartia monadelphica</i>
Amagi 2	34° 50'	138° 57'	1050	de, bl	<i>F. crenata</i>
Amagi 3	34° 50'	138° 56'	840	ev, co	<i>Cryptomeria japonica</i> (plantation)
Hagi	34° 25'	131° 23'	30	ev, bl	—
Tanabe	33° 41'	135° 22'	0–24	ev, bl	—
TosaYamada	33° 35'	133° 44'	210	ev, co	<i>C. japonica</i> (plantation)
Aya	32° 02'	131° 12'	350	ev, bl	<i>Quercus</i> spp., <i>Cinnamomum japonicum</i>
Takabaru	31° 52'	130° 58'	360	ev, bl	<i>Quercus</i> spp., Lauraceae spp.
Amami I. 1	28° 17'	129° 19'	650	ev, bl	<i>Symplocos confusa</i> , <i>Symplocos prunifolia</i>
Amami I. 2	28° 17'	129° 19'	650	ev, bl	<i>S. confusa</i> , <i>S. prunifolia</i>
Ishigaki I.	24° 24'	124° 10'	—	ev, bl	—
Taiwan					
Wulai	24° 50'	121° 31'	—	ev, bl	<i>Lithocarpus amygdalifolius</i> , <i>Limlia uraiana</i>
Shilanshan	24° 36'	121° 31'	—	ev, bl	<i>Liquidambar formosana</i> , <i>L. uraiana</i>
Lishan	24° 17'	121° 14'	—	ev, bl	<i>Cyclobalanopsis morii</i> , <i>L. formosana</i>
Wuseh	24° 03'	121° 07'	—	ev, bl	<i>Pasania shinsuiensis</i>
Chitou	23° 41'	120° 40'	—	ev, bl	<i>Pasania nantouensis</i>
Alishan	23° 31'	120° 46'	—	ev, bl	<i>Pasania ternaticupula</i>

a) —: unidentified, b) ev: evergreen, de: deciduous, bl: broad-leaved, co: coniferous.

thickening. A similar alteration also occurred in this species. This suggests that the species has a similar annular thickening of the inner complex of the sporangiospore wall, as shown in *C. aciculifera* (Young, 1973), *C. mojavensis* R. K. Benj. (Young, 1990) and *K. alabastrina* (Young, 1974) by ultrastructural studies.

In water, sporangiola measure $13.7 \pm 0.107 \times 2.9 \pm 0.02 \mu\text{m}$, and sporangiospores $11.1 \pm 0.089 \times 2.5 \pm 0.02 \mu\text{m}$. The results of dispersion analysing of the one-way layout (Sokal and Rohlf, 1973) showed clear differences in width of sporangiola ($H=48.102$, $P<0.001$; $z=6.937$, $P<0.00003$), length ($H=8.901$, $P<0.01$; $z=2.983$, $P<0.00014$) and width ($H=105.765$, $P<0.001$; $z=10.284$, $P<0.00003$) of sporangiospores in lactic acid-cotton blue to those in water. In contrast, no significant difference was recognised in the length of sporangiola ($H=0.682$, $P>0.05$; $z=-0.826$, $P>0.05$). Therefore, it is necessary to pay attention to this point when we compare the size of various parts of *Coemansia* species.

Distribution

Coemansia furcata was recorded from many forest soils collected in Taiwan and Japan. This species was apparently widely distributed in various types of forests both in the warm and cool temperate regions (Table 1). As shown in Table 1, the dominant species of tree of the forest also varied. This supports Udagawa (1978), who stated that *Coemansia* species were commonly distributed in forest soils of Japan.

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