

Anamorphic Morphology in Three Oriental Species of *Microsphaera*

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흰가루病菌 *Microsphaera*屬에서 東洋 3種의 無性世代 形態

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ABSTRACT: Morphological characteristics in the anamorphic states were described in three species of powdery mildew fungi, *Microsphaera akebiae*, *M. picrasmae*, and *M. schizandrae*, which were parasitic on *Akebia quinata*, *Picrasma quassioides*, and *Schizandra chinensis*, respectively. All species were flexuous in foot-cells of conidiophores, producing conidia singly on conidiophores, devoid of fibrosin bodies in conidia, and producing germ tubes on the end of conidia.

KEYWORDS: anamorphic taxonomy, powdery mildews, *Microsphaera akebiae*, *M. picrasmae*, *M. schizandrae*

The classification of powdery mildew fungi is mainly based on the morphological characteristics of the ascocarps, asci, ascospores, and perithecial appendages produced by the teleomorphs. Although importance of anamorphic characteristics on the identification of species has been stressed by many authors (Fresenius, 1852; Tulasne & Tulasne, 1861; de Bary, 1870; Zopf, 1887; Neger, 1902; Braun, 1987), and many attempts have been made to classify species of the powdery mildews basing on their anamorphic features (Ferraris, 1912; Foex, 1912-1925; Sawada, 1914-1959; Bouwens, 1924, 1927; Maurizio, 1927; Jaczewski, 1927; Brundza, 1934; Hirata, 1942, 1955; Golovin, 1960; Yarwood, 1957; Boesewinkel, 1977, 1979, 1980; Hammett, 1977; Braun, 1980, 1982a, 1982b), anamorphic characteristics were generally not included in descriptions of most holomorphic species, or at most inadequately described in a very few species.

During the past few years, the present author has already studied the anamorphic features of

some of the Korean powdery mildews (Shin, 1989-1991; Shin & La, 1989, 1991). In this paper, three more species—*Microsphaera akebiae*, *M. picrasmae*, and *M. schizandrae*, were reported.

Among 20 species of *Microsphaera* collected in Korea by the author (Shin, 1988; Shin, 1992 unpublished), *M. akebiae*, *M. picrasmae*, and *M. schizandrae* were recorded only in the Far East of Asia (Amano, 1986; Otani, 1988) with descriptions of their teleomorphic characteristics (Sawada, 1951; Otani, 1988). The anamorphic features of these species, however, have not been, or only insufficiently described. Therefore, anamorphic characteristics of taxonomic value in these 3 species of *Microsphaera* were studied.

Examination on fresh materials of the 3 species collected by the author was made. In addition, two herbarium materials provided by Mr. J. S. Choi and Prof. R. Y. Zheng were studied by restoring in lactic acid before used (Shin, 1990a).

Notes and Descriptions

Microsphaera akebiae Sawada

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Table 1. Comparative morphological observations on the anamorphic characteristics of *Microsphaera akebiae*.

characters	Sawada(1951)	Shin(1992)
Mycelium		
habitat	amphigenous and on fruits	amphigenous, cauligenous, and on fruits
density	thin	thin
branching	—*	at right angle
appressoria	—	multilobed to moderately lobed
length	—	44-76 μ m
diameter	4.8-5.5 μ m	4.0-6.0(-8.2) μ m
Conidiophores		
measurements	28-36 \times 6-8 μ m (length excluding an immature conidium)	46-90 \times 7.2-8.0 μ m (length including an immature conidium)
foot-cells	straight	slightly to moderately flexuous
basal septum	at the branching point of mycelium	at the branching point of mycelium
Conidia		
measurements	28-41 \times 13-16 μ m	32-46 \times 14.0-16.4 μ m
shape	cylindric	cylindric
fibrosin bodies	absent	absent
conidia production	singly	singly
Germ tubes**		
shape	—	short, straight
position	—	end of conidia
appressoria	—	lobed

* : Not shown in the original description by Sawada(1951).

** : The morphology of germ tubes examined with the author's specimen is in accordance with drawing of Hirata(1955).

The powdery mildew fungus on *Akebia* spp. had been recorded as *M. alni* in Japan(Homma, 1937). Later, Sawada(1951) separated it as a new species *M. akebiae* by its larger perithecial wall-cells and its cylindric conidia from *M. alni* having smaller wall-cells and oval conidia. The fungus was also recorded in Korea(Lee, 1975) and China(Yu & Lai, 1987).

The author collected anamorph of the fungus on *Akebia quinata* Decne. at several different locations of Korea(Kangung, Chunchon, Kwangnung) during the last 3 years. As shown in Table 1, ana-

morphic characteristics of the collections were generally in accordance with the original description of Sawada(1951). Foot-cell of conidiophores, however, one of the most important taxonomic characters, was not straight as described in the original description, but slightly to moderately flexuous in all Korean collections. Furthermore, more of the anamorphic characteristics of the present fungus have not been sufficiently studied and could not be used in taxonomy. Therefore, anamorphic morphology of *M. akebiae* is redescribed as follows:

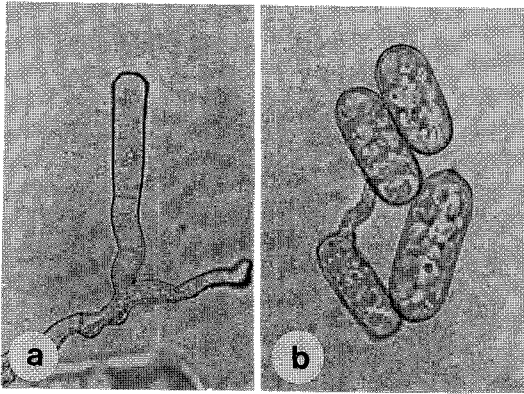


Fig. 1. *Microsphaera akebiae* Sawada: Ⓐ-conidiophore, Ⓑ-conidia.

Oidium state of *Microsphaera akebiae*(Fig. 1).

Amphigenous, cauligenous, also on fruits; mycelium generally thin, but well developed on young shoots in the shade, forming thinly effused white film on both sides of leaves and young shoots, branching at right angle, wavy to straight, $44-76 \times 4-6 \mu\text{m}$, but up to $8.2 \mu\text{m}$ in diameter in conidiogenous cells; appressoria multilobed to moderately lobed, opposite in pairs or single; conidiophores 1 to 2 per mycelial cells, $46-90 \times 7.2-8.0 \mu\text{m}$, slightly to moderately flexuous in foot-cells, producing conidia singly, followed by 1-2 cells, basal septum at the branching point; conidia cylindrical, $32-46 \times 14.0-16.4 \mu\text{m}$ (length/breadth=2.03-3.19), without conspicuous fibrosin bodies, producing germ tubes on the end, germ tubes short or long with lobed appressoria.

Specimens examined: SMK 10063, 10141, 11601, 11619, 11631.(SMK=Mycological herbarium, Department of Horticulture, Kangnung National University, Korea).

잎의 양면, 줄기 그리고 과실을 침해한다. 균층은 일반적으로 얇으나, 그늘에서 어린 줄기에는 잘 발달하고, 잎의 양면과 어린 줄기에 얇게 퍼진다. 균사는 직각 분지하며, 굴곡상 또는 직선상이며, 길이는 $44-76 \mu\text{m}$, 너비는 $4-6 \mu\text{m}$ 이나 분생자경의 모세포에서는 $8.2 \mu\text{m}$ 에 이른다. 부착기는 심한 굴곡상 또는 약한 굴곡상으로서 쌍 또는 단독으로 존재한다. 분생자경은 균사 당 1-2개 형성되고, 길이는 $46-90 \mu\text{m}$, 너비는 $7.2-8.0 \mu\text{m}$ 이며, 기부세포는 약간 또는 보통 굴곡상이며, 분

생포자를 단생한다. 분생포자는 원통상이며, 길이는 $32-46 \mu\text{m}$, 너비는 $14.0-16.4 \mu\text{m}$, 장폭비는 2.03-3.29이며, 뚜렷한 피브로신체를 갖지 않는다. 발아관은 포자의 끝에서 나오고, 짧거나 긴 발아관 끝에 굴곡상의 부착기가 형성된다.

Microsphaera picrasmae Sawada

The powdery mildew fungus of *Microsphaera* sp. on *Picrasma quassioides*(D. Don) Benn. was first recorded as *M.alni* by Homma(1937). Later, Sawada(1951) splitted it as a new species *M. picrasmae* by its smaller elliptic conidia and its 6-spored asci from *M.alni* having much larger conidia and 8-spored asci. The present fungus is confined to Japan and China in its geographical distribution (Amino, 1986).

In Korea, the author was the first one who collected both anamorph and teleomorph of *M. sp.* on *P. quassioides* at two different locations of Kangnung in 1991. Teleomorphic morphology of the collection was in accordance with Japanese(Sawada, 1951; Otani, 1988) and also Chinese description(Yu & Lai, 1987). As shown in Table 2, anamorphic characteristics of the author's collections did not, however, coincide with those of the original description written by Sawada(1951). To confirm my examination of Korean material, a Chinese specimen(HMAS 38629) was also studied. Both Korean and Chinese material had the same morphology in both teleomorph and anamorph. Foot-cell of conidiophores was moderately flexuous rather than straight.

Morphology of foot-cell is one of the most important taxonomic characters for the identification of powdery mildews in their conidial states(Boesewinkel, 1980; Shin, 1988), also that some of the anamorphic characteristics of the present fungus have not been sufficiently studied as they should have been for taxonomic purposes. Therefore, anamorphic morphology of *M. picrasmae* based on the author's collections of *P. quassioides* is redescribed as follows:

Oidium state of *Microsphaera picrasmae*(Fig. 2).

Amphigenous, occasionally cauligenous, especially on distal part of rachis; mycelium generally

Table 2. Comparative morphological observations on the anamorphic characteristics of *Microspphaera picrasmae*.

characters	Sawada(1951)	Shin(1992)
Mycelium		
habitat	amphigenous	amphigenous
density	thin	thin (to thick)
branching	—	at right angle
appressoria	—	moderately lobed to multilobed
length	—	28-52 μ m
diameter	—	2.8-4.8(-8.8) μ m
Conidiophores		
measurements	23-41 \times 6-9 μ m (length excluding an immature conidium)	42-72 \times 6.8-7.6 μ m (length including an immature conidium)
foot-cells	straight	moderately flexuous
basal septum	at the branching point of mycelium	at the branching point of mycelium
Conidia		
measurements	26-38 \times 15-18 μ m	24.0-33.7(-41.8) \times 13.5-17.5 μ m
shape	elliptical to short cylindric	oval to cylindric oval
fibrosin bodies	absent	absent
conidia production	singly	singly
Germ tubes**		
shape	—	short, straight
position	—	end of conidia
appressoria	—	lobed

* : Not shown in the original description by Sawada(1951).

** : The morphology of germ tubes examined with the author's specimen is in accordance with drawing of Hirata(1942).

thin, but well-developed on the upper part of leaves in the shade, forming circular to irregular white patches on the upper part but forming thinly effused with film on the lower part of leaves, branching at right angle, wavy to occasionally geniculate, 28-52 \times 2.8-4.8 μ m, but up to 8.8 μ m in diameter in conidiogenous cells; appressoria moderately lobed to multilobed, opposite in pairs or single; conidiophores 1 to 2 per mycelial cells, (34-42-72 \times 6.8-7.6 μ m, moderately flexuous in foot-cells, producing conidia singly, followed by (1-2) cells, basal septum at the branching point; conidia oval to cylindric oval, 24-33.7(-41.8) \times 13.5-17.5

μ m(length/breadth=1.67-2.74), without conspicuous fibrosin bodies, producing germ tubes on the end, germ tubes short and straight with lobed appressoria.

Specimens examined: SMK 11061, 11287, HMAS 38629.

잎의 양면, 때로는 줄기도 침해하는데, 특히 소엽병의 뒷면을 침해한다. 균총은 일반적으로 얇은데, 그늘에서 잎의 앞면에는 두껍게 형성되며, 잎의 앞면에는 원형 또는 부정형의 흰색으로, 잎의 뒷면에는 얇게 퍼진 흰색으로 나타난다. 균사는 직각 분지하며, 파상이나 때로 결절이 있으며, 길이는 28-52 μ m, 너비는 2.8-4.8 μ m이

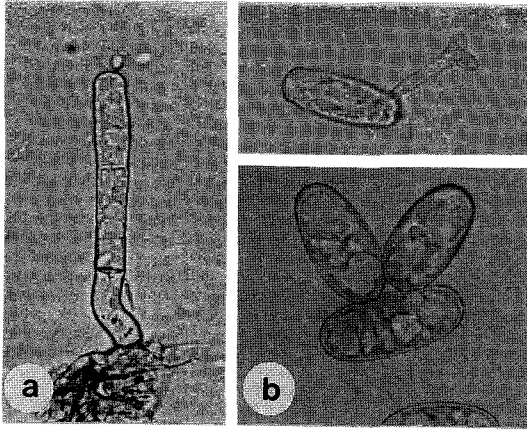


Fig. 2. *Microsphaera picrasmae* Sawada: Ⓐ-conidiophore, ㉔-conidia.

나 분생자정의 모세포인 경우는 $8.8\ \mu\text{m}$ 에 이른다. 부착기는 약간 또는 심한 굴곡상으로 쌍 또는 단독으로 존재한다. 분생자정은 균사 당 1-2개이며, 길이는 $(34-42-72\ \mu\text{m})$ 이고, 너비는 $6.8-7.6\ \mu\text{m}$ 이며, 기부세포는 굴곡상이며, 기부격막은 균사와의 분지점에 있고, 분생포자를 단생한다. 분생포자는 달걀형 내지 원통상 달걀형이며, 길이는 $24-33.7(-42.8)\ \mu\text{m}$, 너비는 $13.5-17.5\ \mu\text{m}$, 장폭비는 $1.67-2.74$ 이며, 뚜렷한 피브로신體를 갖지 않는다. 발아관은 분생포자의 끝에 위치하고, 짧고 직선상으로 그 끝에 굴곡상의 부착기를 형성한다.

Microsphaera schizandrae Sawada

The powdery mildew fungus of *Microsphaera* sp. on *Schizandra chinensis* Baill, and *S. nigra* Maxim. (= *S. repanda* Radlk.) was first recorded as *M. alni* by Homma(1937). Later, Sawada(1951) treated it as a new species *M. schizandrae* by the larger size of perithecial appendages in both diameter and length and also larger ascospores from *M. alni*. Since then, anamorphic characteristics of the fungus have not been reported and regarded as similar to *M. alni* s. str. The present fungus is confined to Japan, Korea, and Far East of USSR in its geographical distribution(Amano, 1986).

The author collected anamorph of *M. schizandrae* on *S. chinensis* in Chinbu in 1991. Another specimen collected in Chinan in 1988 was provided by Mr. J. S. Choi. Examination of these Korean materials revealed that foot-cell of conidiophores was not straight as in *M. alni* but modera-

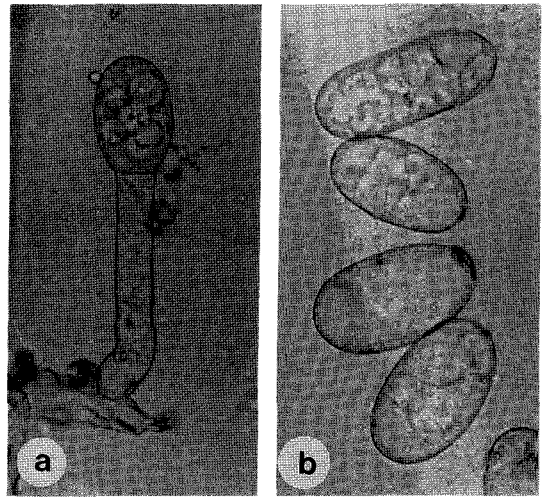


Fig. 3. *Microsphaera schizandrae* Sawada: Ⓐ-conidiophore, ㉔-conidia.

tely flexuous. Some other morphological characteristics of taxonomic value were also studied. Therefore, the present author is the first one who describes anamorphic morphology of *M. schizandrae* as follows:

Oidium state of *Microsphaera schizandrae*(Fig. 3).

Amphigenous, occasionally cauligenous, especially on young shoot and inflorescence; mycelium generally thin, but well developed in the upper part of leaves in the shade, forming circular to irregular white patches on the upper part but forming thinly effused white patches on the lower part of leaves, branching at right angle, straight to wavy, often geniculate, $44-76 \times 4-6\ \mu\text{m}$, but up to $9.2\ \mu\text{m}$ in diameter in conidiogenous cells; appressoria multilobed, opposite in pairs or single; conidiophores 1 to 2 per mycelial cells, $76-117 \times 8.6-9.5\ \mu\text{m}$, moderately flexuous in foot-cells, producing conidia singly, followed by (2-)3 cells, basal septum at the branching point; conidia oval to cylindrical oblong, $33.8-44.1 \times 18.0-24.7\ \mu\text{m}$ (length/breadth=1.48-2.15), without conspicuous fibrosin bodies, producing germ tubes on the end, germ tubes long and geniculate with lobed appressoria.

Specimens examined; SMK 10912, 11930, Dried material collected in Chinan, Korea, on September 15, 1988 by Mr. J. S. Choi.

잎의 양면과 때로는 줄기를 침해하는데, 특히 어린 줄기와 화기를 심하게 침해한다. 균층은 일반적으로 얇고 그늘에서는 잎의 뒷면에 두껍게 형성되기도 하지만, 잎의 앞면에는 원형 또는 부정형의 흰색으로, 잎의 뒷면에는 얇게 퍼진 막상으로 나타난다. 균사는 직각 분지하며, 직선상 내지 파상인데 때로 결절이 있고, 길이는 44-76 μm , 너비는 4-6 μm 인데 분생자경을 형성하는 부분은 9.2 μm 에 이른다. 부착기는 심한 굴곡상이며, 쌍 또는 단독으로 존재한다. 분생자경은 균사당 1-2개이며, 길이는 76-117 μm , 너비는 8.6-9.5 μm , 기부세포는 굴곡상이며, 기부격막은 균사와의 분지점에 위치하며, 분생포자를 단생하며, 그 밑에 (2-)3개의 세포로 구성된다. 분생포자는 달걀형 내지 긴 원통형이며, 길이는 33.8-44.1 μm , 너비는 18.0-24.7 μm , 장폭비는 1.48-2.15이며, 뚜렷한 피브로신體를 갖지 않는다. 발아관은 분생포자의 끝에 형성되며, 길고 결절이 있으며, 그 끝에 부착기를 형성한다.

摘 要

*Microsphaera*屬 흰가루病菌 중에서 아시아의 極東地方에서만 採集되는 *M. akebiae*, *M. picrasmae*, 그리고 *M. schizandrae* 등 3種을 각각 으름, 소태나무 그리고 오미자에서 採集하여 이들이 갖는 無性世代的 形態的 分類特性을 檢鏡하였다. 그 결과, 지금까지 잘못 알려진 形態的 特性을 修正記載하였으며, 報告되지 않았던 몇 가지 分類特性을 追加記載하였다.

이들 3種에서 관찰된 많은 分類特性들은 *Microsphaera*屬에 共通的으로 나타나는 것이었다. 즉, 附着器는 波狀 내지 屈曲狀으로서 雙 또는 單獨으로 存在하였고, 分生子梗은 母細胞 當 1-2個였고, 分生胞子を 單生하였으며, 基部隔膜은 菌絲와의 分枝點에 있었다. 分生胞子は 피브로신體를 含有하지 않았으며, 發芽管은 胞子の 끝에 位置하였다. 그러나 이들 3種은 모두 分生子梗의 基部細胞가 屈曲狀으로서 대부분의 *Microsphaera*屬 흰가루病菌과 달랐으며, 각 種은 分生子梗의 크기와 分生胞子の 크기 및 形態 등으로 서로 有別할 수 있었다. 따라서 이들 흰가루병균을 無性世代에서도 同定할 수 있게 되었다.

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