

Ascospore formation and morphology in two species of the genus *Erysiphe* remaining immature on the living host plant

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Erysiphe cumminsiana and *E. galeopsidis*, which have immature asci in the current season, have been recorded from Japan, but the ascospores of both fungi have not been described. In the present experiments, some observations before and after overwintering were made on the cleistothecia of *E. cumminsiana* on three species of *Cacalia* and two species of *Ligularia*, and *E. galeopsidis* on *Geranium thunbergii*. After overwintering, the former fungus developed six to eight, rarely four spores in an ascus and the latter fungus always four spores in an ascus. Their teleomorphic characteristics including those of ascospores are also described.

Key Words—ascospore development; *Cacalia*; *Erysiphe cumminsiana*; *Erysiphe galeopsidis*; *Geranium thunbergii*.

Introduction

Two species of the genus *Erysiphe* which hardly develop ascospores in the asci before overwintering are known in Japan. One of them, *Erysiphe cumminsiana* Braun, occurs on several genera of the family Compositae, including *Cacalia*, but its ascospores have not been described (Braun, 1983, 1987; Otani, 1988). In the present experiments, genuine spores were found in the cleistothecia that had overwintered on two species of *Cacalia*.

Two powdery mildew fungi, *Sphaerotheca fugax* Penzig et Saccardo [*S. humuli* (DC.) Burr.] and *Erysiphe galeopsidis* DC. have been recorded on *Geranium thunbergii* Seib. et Zucc. (Homma, 1937; Amano, 1986; Otani, 1988). Braun (1987) illustrated a cleistothecium of *E. galeopsidis* on the leaves of *G. thunbergii* without comment, which have been sent from the present author to him. So far as I know, no morphological characteristics of the *Erysiphe* fungus on *G. thunbergii* have been described, except for Braun's illustration (Braun, 1987).

In late autumn, 1986, I collected a few leaves of *G. thunbergii* having some cleistothecia of *Erysiphe* in a suburb of Tokyo. Since ascospores were not found in the cleistothecia on living leaves, overwintered cleistothecia were examined in spring of the next year, when fully matured ascospores were recognized in most asci.

I. *Erysiphe cumminsiana* on *Cacalia* and *Ligularia*

Erysiphe cumminsiana has been recorded on the plants of the genera *Cacalia* and *Ligularia* from Japan, and on *Eupatorium*, *Heliopsis* and *Senecio* from the U.S.A. (Braun, 1987). Since the fungus does not form ascospores in the current year, it was first regarded as *E. galeopsidis*, which is mostly found on a number of genera of the Labiatae (Salmon, 1905; Hirata, 1956; Takamatsu

et al., 1978; Amano, 1986). However, Braun (1983) examined in detail the anamorph and teleomorph of an *Erysiphe* fungus on *Senecio sesamanni* Sch.-Bip., and he found some discriminative differences in the cleistothecial size and characteristics of the appendages of the cleistothecium between *Senecio* fungus and *E. galeopsidis*. He denominated the former fungus as a new taxon, *E. cumminsiana*, but its ascospore is not described from anywhere the fungus has been recorded.

I obtained cleistothecia of *Erysiphe* on *Cacalia delphiniifolia* Sieb. et Zucc., *C. nipponica* Miq., *C. tebakensis* Makino, *Ligularia fischeri* Turcz. and *L. stenocephala* Matsum. et Koidz. in different localities of Japan. Although *Erysiphe polygoni* DC. or its anamorph has also been recorded on these plants (Homma, 1937; Hirata et al., 1964; Nomura, 1974; Otani, 1988), in the present observations on these materials, no ascus containing ascospores was recognized in the current season.

In the present experiments, a few leaves of *C. delphiniifolia* (TUAMH3542) and *C. nipponica* (TUAMH-3601) bearing numerous cleistothecia were each enclosed in a bag of cotton gauze. At the beginning of December, the bags were fastened to the trunk of a shrub at about 30 cm above the ground and left under natural conditions until the next spring. In late March, four to eight genuine ascospores were observed in almost all asci of these cleistothecia. The teleomorphic characteristics and those of ascospores of the fungus are as follows:

Erysiphe cumminsiana Braun on *Cacalia* and *Ligularia* (Fam. Compositae). Figs. 1, 2

Mycelia amphigenous or on petioles, usually developing round, whitish, persistent patches on the upper surface of the leaves, evanescent on the under surface; cleistothecia scattered or subgregarious, depressed globose, dark brown, 83–198 μm diam, wall cells irregularly polygonal, 7–18 \times 7–14 μm ; appendages produced 40–

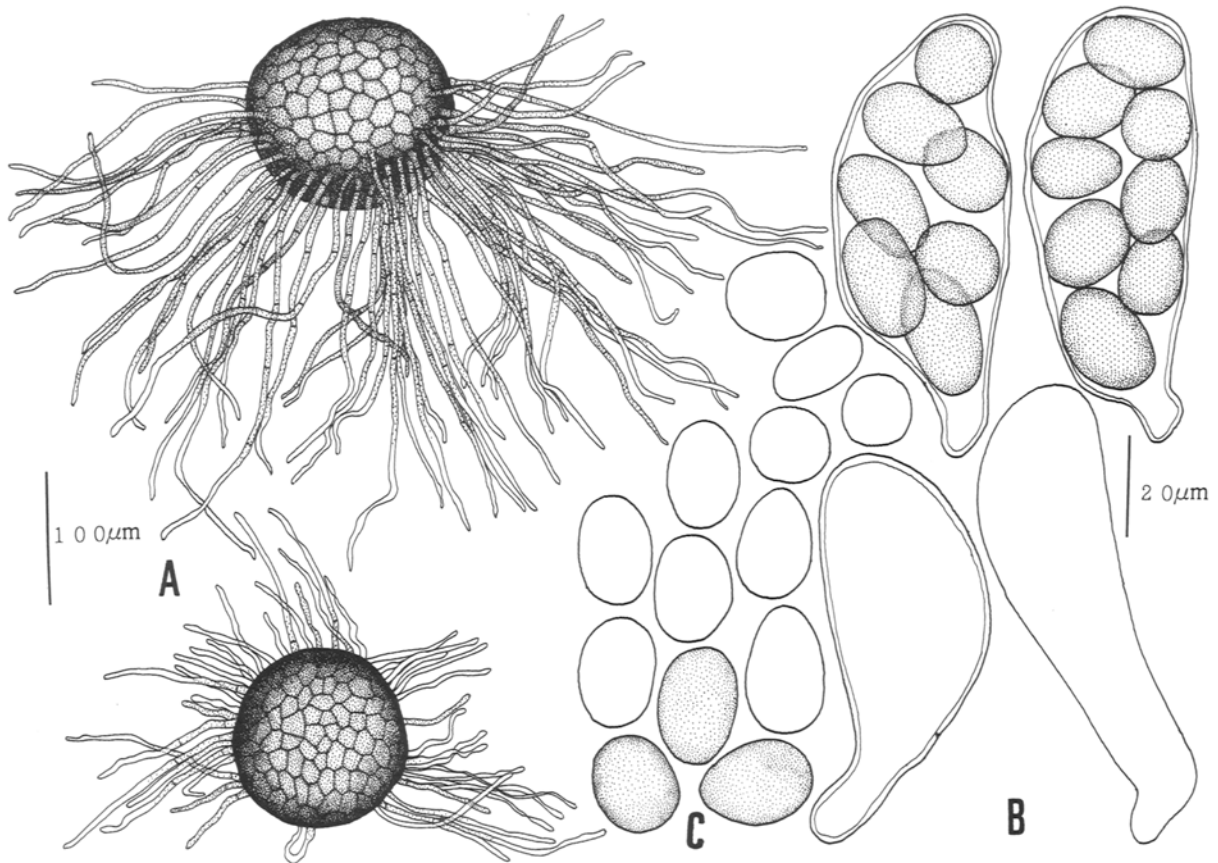


Fig. 1. *Erysiphe cumminsiana* on *Cacalia nipponica*. A. Cleistothecia; B. Asci; C. Ascospores.

60 in the lower half part of the cleistothecium, simple, straight or curved, throughout light brown to brown, light-end upward, 2-5-septate inconspicuously, 360-468 μm long, 3.2-6.3 μm wide near the base; asci 5-13, ovate or oblong, pedicellate, 51-94 \times 22-40 μm ; ascospores immature on the living host plants, after overwintering (4-) 6-8-spores developed in an ascus of the cleistothecium, globose to subglobose, ovate or ellipsoidal, light yellow, 13-26 \times 10-17 μm .

Hosts and localities: 1) *Cacalia delphinifolia* Sieb. et Zucc. (momijigasa), Mt. Kiyosumi, Chiba Pref., 24 Oct. 1967. TUAMH0015 (teleomorph); Itsukaichi-machi, Tokyo, 5 Nov. 1967. TUAMH0016 (teleom.), K. Kurihara; Mt. Mitake, Tokyo, 19 Sep. 1978. TUAMH0855 (anamorph), M. Yoshimura; Mt. Takao, Tokyo, 30 Oct. 1976. TUAMH0907 (teleom.), M. Yoshimura; Kurabuchi-mura, Gunma Pref., 15 Oct. 1980. TUAMH1741 (teleom.), S. Totsuka; Okutama-machi, Tokyo, 22 Sep. 1982. TUAMH2056 (teleom.), K. Takahashi; Kiyokawamura, Kanagawa Pref., 21 Oct. 1984. TUAMH2491 (teleom.); Hadano-shi, Kanagawa Pref., 3 Nov. 1984 (anam.); Hakone-machi, Kanagawa Pref., 2 Nov. 1984. TUAMH2732 (teleom.), S. Mochizuki; Mt. Unzen, Nagasaki Pref., 9 Nov. 1984. TUAMH2979 (anam.), K. Kōmoto; Agatsuma-machi, Gunma Pref., 11 Oct. 1984. TUAMH3030 (teleom.), M. Koike; Fujinomiya-shi, Shizuoka Pref., 24 Aug. 1985. TUAMH3127 (anam.); Okuta-

ma-machi, Tokyo, 5 Nov. 1985 (teleom.); Ōme-shi, Tokyo, 9 Nov. TUAMH3257 (teleom.); Sakae-mura, Nagano Pref., 10 Oct. 1986. TUAMH3542 (teleom.); Mt. Tanzawa, Kanagawa Pref., 19 Oct. 1986. TUAMH3550 (anam.); Matsuida-machi, Gunma Pref., 20 Oct. 1986. TUAMH3692 (teleom.), H. Horikoshi; Matsuda-machi, Kanagawa Pref., 20 Oct. 1987. (anam.), M. Horie; Kiyokawa-mura, Kanagawa Pref., 22 Oct. 1987 (teleom.), M. Horie; Isehara-shi, Kanagawa Pref., 30 Oct. 1987. TUAMH4062 (teleom.), M. Horie; Yamakita-machi, Kanagawa Pref., 6 Nov. 1987 (teleom.), M. Horie.

2) *C. nipponica* Miq. (tsukushi-kōmori), Wanizuka Park, Miyazaki Pref., 16 Nov. 1986. TUAMH3601 (teleom.).

3) *C. tebakoensis* Makino (tebako-momijigasa), Tabayama-mura, Yamanashi Pref., 27 Oct. 1974. TUAMH0185 (anam.), T. Iwamochi; Okutama-machi, Tokyo, 7 Oct. 1981. 1847 (teleom.), H. Kanō.

4) *Ligularia fischeri* Turcz. (o-takarakō), Tateiwamura, Fukushima Pref., 30 Sep. 1988. TUAMH4188 (teleom.).

5) *L. stenocephala* Matsum. et Koidz. (me-takararakō), Masutomi-spa, Yamanashi Pref., 4 Oct. 1980. TUAMH1572 (anam.), H. Shibata; Okutama-machi, Tokyo, 10 Sep. 1981. TUAMH1884 (teleom.); Masutomi-spa, Yamanashi Pref., 9 Oct. 1983. TUAMH2227 (teleom.).

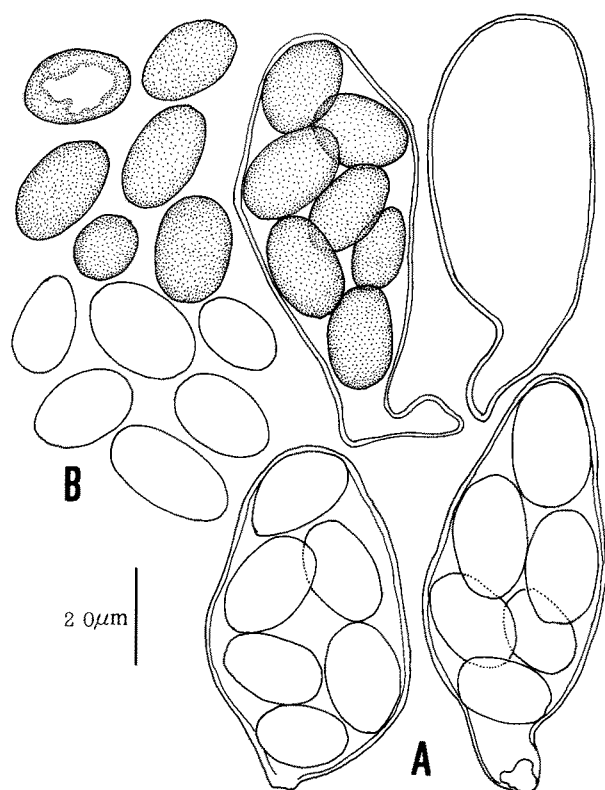


Fig. 2. *Erysiphe cumminsiana* on *C. delphiniifolia*. A. Asci; B. Ascospores.

Remarks: The cleistothecia on *C. delphiniifolia* and *L. fischeri* were somewhat larger than those from the other three plants, and those on *C. tebakoensis* were the smallest among all the plants examined (Table 1). However, their shape, and the morphology of the appendages and asci substantially resembled one another. Moreover, these morphological characteristics also matched the original description of *E. cumminsiana* (Braun, 1983).

The asci immediately after collecting are always immature, thin-walled, light yellow, with inconspicuous

pedicels, and usually small. In contrast to the immature asci, the overwintered ones on the two plants increased markedly in size, and the pedicels extended obviously. Six to eight, rarely up to four, ascospores were formed in an ascus, and they were light yellow, globose to ellipsoidal. These characteristics of ascospores closely resemble those of *E. galeopsidis* described by Braun (1987), though their number is somewhat larger than that of *E. galeopsidis*.

II. *Erysiphe galeopsidis* on *Geranium thunbergii*

Although *E. galeopsidis* usually occurs on plants of many genera of the family Labiatae, it has also been recorded on some species of the genus *Geranium* of the family Geraniaceae throughout the world (Braun, 1987). In Japan, ascospores of *E. galeopsidis* have not been recorded on either family. Since ascospores were not found in the cleistothecia on living leaves of *G. thunbergii*, a few leaves bearing cleistothecia were overwintered under outdoor conditions by the same procedures as were used for the examination of *E. cumminsiana*.

As a result, ascospores were found in most asci in late March of the following year. The morphological characteristics of the teleomorph including the ascospores and the anamorph are as follows.

Erysiphe galeopsidis DC. on *Geranium thunbergii* (Fam. Geraniaceae). Fig. 3

Mycelia amphigenous, cauligenous, also on petioles, usually persistent, developing whitish, powdery patches on the whole surface; conidiophores straight, cylindrical, foot-cells 34-58 × 9-14 μm, 44.6 ± 4.2 × 11.0 ± 0.84 μm on average; conidia catenulate, ovate to oblong, 23-31 × 14-18 μm, 27.4 ± 0.57 × 16.0 ± 0.25 μm on average; cleistothecia scattered or subgregarious, depressed globose, dark brown, diam (90-)108-155 μm, 128.8 ± 1.8 μm on average, wall cells irregularly polygonal, 11-29 × 7-14 μm, 18.0 ± 2.1 × 11.2 ± 1.1 μm on average; appendages produced 12-34, 27.3 ± 4.8 on average, from the lower half, simple, rarely bifurcate, mycelioid, usually flexuous or curved, rarely straight, thinwalled throughout, hyaline or obscurely light brown towards the base, uniform or irregular in width, length 126-342 μm,

Table 1. Dimensions of cleistothecial structures of *Erysiphe comminsiana* on different host plants.

Host plant	THAMH	Diam. of cleistothecium (μm)	Ascospore		Ascus	
			Number	Size (μm)	Number	Size (μm)
<i>Cacalia delphiniifolia</i>	3542	83-188 (150.8 ± 3.3)	12-13 (12.5 ± 0.50)	67-90 × 29-40 (83.6 ± 1.6 × 32.8 ± 1.1)	6-7 (6.7 ± 0.14)	13-26 × 10-16 (19.9 ± 0.53 × 13.7 ± 0.23)
<i>C. nipponica</i>	3601	97-198 (123.8 ± 3.1)	9-13 (11.0 ± 1.2)	72-94 × 25-40 (82.4 ± 1.5 × 31.3 ± 1.0)	4-8 (6.3 ± 1.2)	14-23 × 10-17 (19.5 ± 0.41 × 14.2 ± 0.31)
<i>C. tebakoensis</i>	1847	99-130 (115.9 ± 2.3)	ca. 7	ca. 54 × 25*		
<i>Ligularia fischeri</i>	4188	97-171 (143.8 ± 3.8)	9-10	ca. 53 × 24*		
<i>L. stenocephala</i>	1884	99-155 (130.0 ± 2.3)	5- 6	ca. 53 × 25*		

(): average. *Asci were examined before overwintering.

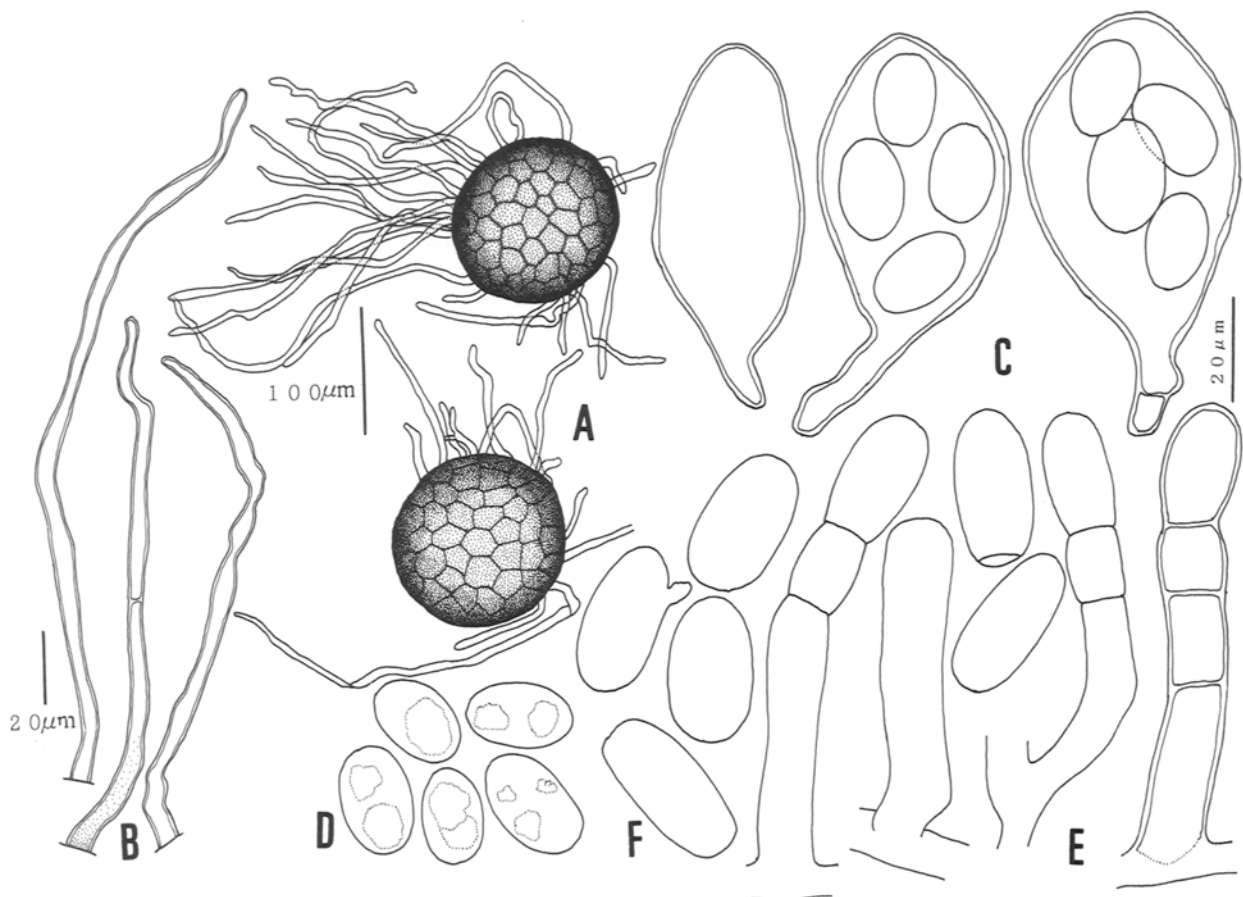


Fig. 3. *Erysiphe galeopsidis* on *Geranium thunbergii*. A. Cleistothecia; B. Appendages; C. Asci and ascospores; D. Ascospores; E. Conidia and conidiophores; F. Conidia.

258.4±24.1 μm on average, width near the base 5.1–6.3 μm, 5.42±0.15 μm on average, aseptate or 1-2-septate; asci 6–12, 8.3±0.67 on average, ellipsoidal or ovate, pedicellate, light brown, 36–68×18–32 μm, 54.3±1.3×25.3±0.55 μm on average in the cleistothecium before overwintering, 70–81×28–42 μm, 76.7±3.4×36.0±4.2 μm on average in the cleistothecium after overwintering; after overwintering always 4 ascospores developed in the asci, ascospores ellipsoidal, hyaline, 18–21×10–16 μm, 19.7±0.63×12.9±0.82 μm on average.

Locality and date collected: Mt. Jinba, Hachiōji-shi, Tokyo, 4 Nov. 1986. TUAMH3560 (anamorph & tele-morph).

Remarks: Compared with *E. galeopsidis* on the plants of the Labiatae, the appendages of the cleistothecium of the present fungus are pale or hyaline, and the septa are fewer. All the asci examined contained four ascospores. Although ascospores of *E. galeopsidis* are not described in most monographs of powdery mildew fungi by different authors, Braun (1987) noted that overwintered asci possess (2-)3-6(-8) spores. On the other hand, Homma (1937) stated that two spores are developed in an ascus in the following year, referring to reports by foreign investigators.

Braun (1987) reexamined a collection on *Geranium sibiricum* L. from Japan and found that the cleistothecia as well as the anamorph perfectly agree with *E. galeopsidis*. However, he stated that "the status of *E. galeopsidis* on various host species of the Geraniaceae is uncertain. Maybe this fungus represents a different species." Certainly the appendages of the fungus on *G. thunbergii* are hyaline or obscurely light brown toward the base. In contrast, the appendages of *E. galeopsidis* on the Labiatae are dark brown throughout or hyaline at the only apex. Such characteristics of the appendages resemble rather those of *E. cumminsiana*. However, the colouration may change as the cleistothecium matures, though no examination has been made on the appendage of the overwintered cleistothecium. So the present fungus is traditionally included in the form of *E. galeopsidis*.

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