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Powdery Mildews and Their Causal Fungi on Some Spice and Medicinal Plants

By

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Summary : Taxomic examinations of five powdery mildew fungi found on two new host plants in Japan, rosemary (*Rosmarinus officinalis,* fam. Labiatae) and downy thorn apple (*Datura metel,* fam. Solanaceae), and on blue gum (*Eucalyptus globulus,* fam. Myrtaceae) on which the causal fungus is still indeterminate in Japan, were carried out.

Between two anamorphic types found on blue gum, the fungus of Euoidium type was identified to be *Oidium* state of *Sphaerotheca aphanis* var. *aphanis*. Another one, Pseudoidium type was regarded as a new *Oidium* species, *O. eucalypti-globuli*. The fungus of Euoidium type on downy thorn apple was identified with the anamorphic state of *Erysiphe orontii,* but it was not able to specify that of Pseudoidium type.

The anamorph on rosemary morphologically agreed well with that of *Erysiphe galeopsidis* observed on various plants of the Labiatae.

Key Words : powdery mildew, blue gum, downy thorn apple, rosemary, *Oidium eucalypti-globuli*

Introduction

Five powdery mildew fungi were found on three plants, *viz.* rosemary (*Rosmarinus officinalis* L. family Labiatae), downy thorn apple (*Datura metel* L., fam. Solanaceae) and blue gum (*Eucalyptus globulus* LABIL, fam. Myrtaceae). Among them, rosemary and downy thorn apple are new hosts of the fungi in Japan, and the taxonomic position of the causal fungus on blue gum has not been determined in our country. The identification of these powdery mildew fungi was conducted in the study.

Materials and Methods

1. The fungi and their host plants

① *Oidium* sp. (a) on blue gum (Locality and date collected : Seijo, Setagaya-ku, Tokyo, 10 Nov. 2001) (TUAMH 6129).

② *Oidium* sp. (b) on blue gum (Locality and date collected : The same place and date as ① *Oidiump* sp.(a), TUAMH6129).

③ *Oidium* sp. on rosemary (Localities and dates collected : Nunobiki Herb Park, Kobe-shi, Hyogo Pref., 28 Oct. 2001 (TUAMH6102); Tokyo Univ. of Agric., Atsugi-shi, Kanagawa Pref., 11 Dec. 2001) (TUAMH6112).

④ *Oidium* sp. (a) on downy thorn apple (Locality and date collected : Tokyo Univ. of Agric., Atsugi-shi, Kanagawa Pref., 3 Dec. 2001) (TUAMH6109).

⑤ *Oidium* sp. (b) on downy thorn apple (Locality and date collected : the same place and date as ④ *Oidium* sp. (a), TUAMH6109).

In addition to the above five materials, many other fungous herbaria on different plants of families Labiatae and Solanaceae (Table 2, 3) were tested for comparison.

2. The observations of the causal fungi

The observations of the mycelial state on the affected plants and causal fungi conformed to the ones described by TANDA and SUGA (2002)[1].

Results and Discussion

I. Two powdery mildew fungi on blue gum

Recently, powdery mildew was found on seedlings of blue gum which were planted in pots at a nursery. Through microscopic observation of the causal fungi, their anamorphic states were discriminated between Euoidium and Pseudoidium types.

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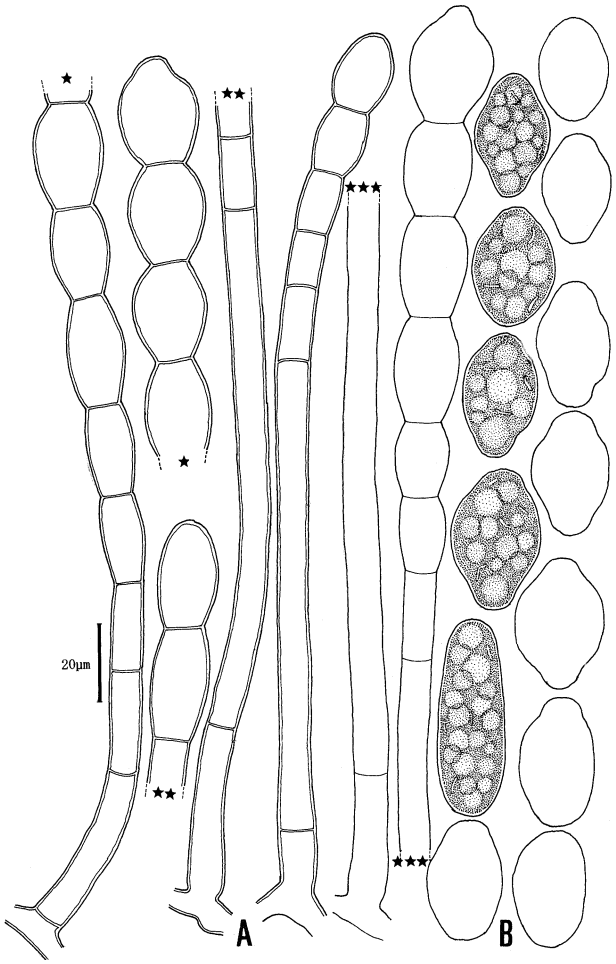

Fig. 1 Anamorph of *Sphaerotheca aphanis* (WALLR.) BRAUN var. *aphanis* on *Eucalyptus globulus* (A : Conidia and conidiophores ; B : Mature conidia)

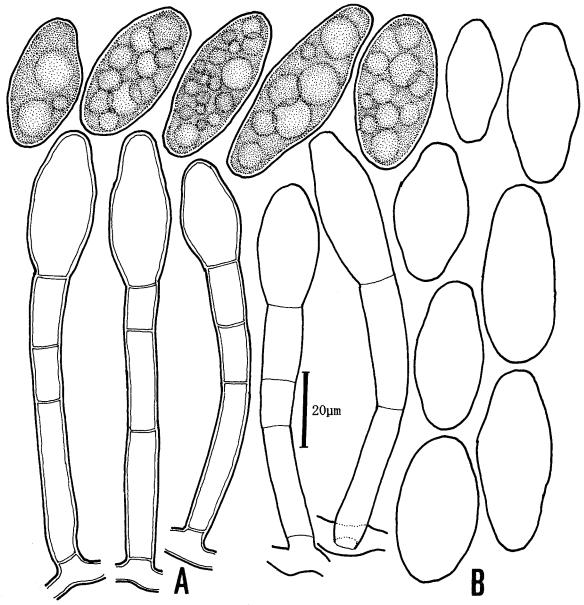

Fig. 2 *Oidium eucalypti-globuli* TANDA on *Eucalyptus globulus* (A : Conidia and conidiophores ; B : Mature conidia)

Though a powdery mildew on different *Eucalyptus* plants including blue gum has been reported in Japan, its taxonomic position has not been elucidated (TERASHITA, 1955)[2]. The present fungus corresponding to the Euoidium type agreed well with the anamorph of *Sphaerotheca aphanis* (WALLR.) BRAUN var. *aphanis* which has been reported on various *Eucalyptus* plants from several other countries.

The other one belonging to Pseudoidium type is highly distinct in the appearance of the conidia and conidiophores, and there is no allied fungus hitherto known on *Eucalyptus* and other genera of Myrtaceae. Therefore, it should be considered as a new, independent species of the genus *Oidium*.

1. Two causal fungi

i. *Sphaerotheca aphanis* (WALLR.) BRAUN var. *aphanis* (Fig. 1 ; Table 1 ; Photo 1・A, D, E).

Mycelia amphigenous, external appearance very similar to those of *Oidium eucalypti-globuli* which is described later, but evidently dense ; conidiophores erect, branching from hyphae on the surfaces of the leaves, 2- or 3-septate, straight or remarkably curved near the middle, 90–320×9–11 (av. 191.9±24.9×10.1±0.23) μm, foot-cells slender cylindric, 30–135×9–11 (av. 62.8±13.5×10.0±0.24) μm ; conidia catenulate, usually lemon shaped to doliform, often ellipsoidal, rarely oblong, vacuolate, fibrosin-bodies evidently present, 25–33 (–51)×16–21 (–24) (av. 31.4±0.94×19.2±0.39) μm, length/width (l/w) ratio. 1.3–1.8 (–2.8) (av. 1.65±0.056).

ii. *Oidium eucalypti-globuli* TANDA, sp. nov. (Fig. 2 ; Table 1 ; Photo 1・A～C).

Mycelium amphigenum in foliis, pelliculas albas rotundas vel irregulariter, frequenter occupans tota superficiem ; conidiophora recta ver interdum leviter curvata, (1–) 2 septata, cellulis ad basim cylindracea, 27–41×(6–) 8 (–9) μm ; conidia singularia, doriformes vel ellipsoidea, vacuolata, 32–46 (–52)×(15–) 18–22 μm.

Holotypus : in foliis vivis *Eucalypti globuli* LABILL (blue gum). Seijo, Setagaya-ku, Tokyo, Japan, 10 Nov. 2001, leg. S. TANDA (TUAMH6129). The type material of the fungus is kept in the Mycological Herbarium of the Tokyo University of Agriculture, Setagaya, Tokyo, Japan (TUAMH).

Mycelia amphigenous, conspicuous on the upper surface of the leaves, developing whitish powdery, round to irregular patches, margin obscure, often covering the whole surface of the leaves ; conidiophores erect, branching from hyphae on the surfaces of the leaves,

Table 1 Morphological characteristics of anamorph of powdery mildew fungi on *Eucalyptus* and other myrtaceous plants

Fungus	Host plant (Genus)	Conidium				Size of foot-cell (μm)	Investigator
		Forming manner	Shape	Fibrosin-body	Size (μm)		
Oidium eucalypti-globuli	*Eucalyptus*	solitary	doriform, elliptic	absent	32-46(-52)×(15-)18-22	27-41×(6-)8(-9)	The authors
Sphaerotheca aphanis	〃	catenulate	lemon-shaped, doliform, elliptic	present	25-33(-51)×16-21(-24)	30-135×9-11	〃
〃	*Eucalyptus* and genera of Rosoceae	〃	elliptic to doliform	〃	23-44×15-26	50-160×8-13.5	BRAUN (1987)[4]
Erysiphe orontii	*Eucalyptus* and many families	〃	elliptic-ovoid to doliform-subcylindric	absent	25-40×15-23	40-100×10-13	〃
? Oidium eucalypti	*Eucalyptus*	unclear	unclear	unclear	22-27×14-18	12-13 in length*	GRASSO (1948)[6]
O. sp.	〃	〃	elliptic to doliform(?)	〃	22-30×12-16	unclear	TERASHITA (1955)[2]
Uncinula australis	*Eugenia*	solitary	unclear	absent	28-32×12-14	unclear	BRAUN (1987)[4]

*conidiophores

Table 2 Dimension of conidia and foot-cells of conidiophore of *Erysiphe galeopsidis* on various plants of fam. Labiatae

Host plant	TUAMH*	Occurring location of leaf	Conidium		Size of foot-sell (mean) μm
			Size (mean) μm	Length/Width (mean)	
Rosmarinus officinalis	6102	Upper surface	(27-)31-36(-38)×(14-)17-21 (33.1±0.49×18.4±0.34)	1.5-1.9(-2.4) (1.80±0.043)	57-135×12-15 (82.9±8.2 ×12.9±0.35)
Glechoma hederaceae var. *grandis*	5201	Do.	25-35(-40)×14-18 (32.0±0.73×15.7±0.25)	1.7-2.5(-2.7) (2.05±0.054)	33-74 ×11-12 (50.1±0.58×11.3±0.33)
Chelonopsis moschata	2088	Do.	24-32(-39)×17-22 (28.3±0.92×18.4±0.40)	1.3-2.2 (1.52±0.094)	26-46 × 9-10 (37.5±4.2 × 9.3±0.25)
Lamium album var. *arbatum*	3492	Do.	(24-)28-32(-42)×15-20 (30.5±0.91×18.0±0.39)	1.5-1.8(-2.8) (1.79±0.061)	37-51 × 9-10 (41.3±3.3 × 9.5±0.29)
L. amplexicaule	5093	Do.	24-35(-37)×15-20 (30.0±0.62×17.6±0.28)	1.3-2.1(-2.4) (1.71±0.050)	26-48 × 9-11 (35.6±2.3 × 9.6±0.24)
L. purpureum	5092	Do.	23-30(-32)×14-20 (27.7±0.43×17.4±0.32)	1.3-2.0 (1.61±0.041)	20-50 × 9-12 (32.7±2.8 ×10.2±0.36)
Mentha viridis	5063	Do.	27-37(-41)×(14-)17-23 (32.2±0.63×19.7±0.44)	1.3-2.5 (1.66±0.057)	37-70 × 9-13 (55.2±3.3 ×11.6±0.41)
Do.	Do.	Under surface	Ca. same size as dimension on upper surface		65-172× 9-13 (112.3±11.6×11.4±0.38)
Stachys japonica var. *intermedia*	2175	Upper surface	(22-)29-37(-44)×(13-)16-18 (33.7±1.2×16.2±0.41)	1.3-2.6(-2.8) (2.11±0.082)	38-47 × 9-11 (42.5±2.1 × 9.8±0.48)

*TUAMH: Mycological Herbarium of Tokyo University of Agriculture.

usually 2-, rarely 1-septate, straight or slightly curved, 57–74×8–10 (av. 66.3±1.8×8.9±0.26) μm, foot-cells cylindric, 27–41×(6–)8(–9) (av. 34.1±1.6×7.8±0.28) μm; conidia solitary, doriform or ellipsoidal, vacuolate, fibrosin-body absent, 32–46 (–52)×(15–) 18–22 (av. 39.1±0.95×19.0±0.32) μm, l/w ratio 1.7–2.3 (–2.6) (av. 2.06±0.044).

2. Taxonomic consideration of the two fungi

Sphaerotheca aphanis var. *aphanis* [syn. : *S. alchemillae* (STEIN.) ERIKKSS., *S. macularis* (WALLR. : FR.) LIND, and *S. pannosa* (WALLR. : FR.) LÉV.] and *Erysiphe orontii* CAST., of which the anamorphs are Euoidium type, have been recorded on different *Eucalyptus* species from other countries (AMANO, 1986[3] ; BRAUN, 1987)[4]. However, no Pseudoidium type on the plant of the same genus was found in any reliable references. Unfortunately we were unable to find the description of detailed anamorphic character of *Oidium eucalypti* ROSTR reported on *Eucalyptus* plants from Europe (SACCARDO, 1931[5] ; GRASSO, 1948)[6]. TERASHITA (1955)[2] did not mention the formation manner of conidia and their fibrosin-body. Both the conidia and conidiophores of *Oidium* sp. found on five *Eucalyptus* spp. in Japan are evidently smaller than those of the present *Oidium* fungus (Table 1).

The hitherto known species on *Eucalyptus* plants are

distinguished from *O. eucalypti-globuli* by the following features : the anamorph of *S. aphanis* var. *aphanis* [conidia catenulate, smaller (25–33 (–51) μm long), fibrosin-bodies present in them, foot-cells of the conidiophores very long (30–135 μm)], the anamorph of *E. orontii* [conidia catenulate, foot-cells very long (40–100 μm)], and *O. eucalypti* [conidia smaller (22–27×14–18 μm), foot-cells short (12–13 μm long)].

The conidia of *Uncinula australis* Speg. on the genus *Eugenia* (fam. Myrtaceae) are Pseudoidium type (Braun, 1987)[4], but the taxon is easily distinguishable from *O. eucalypti-globuli* owing to the small conidia.

II. Powdery mildew and its causal fungus on rosemary

Rosemary is an evergreen shrub native to the Mediterranean, which introduced into Japan early in the 19 th century. No record of powdery mildew on this plant was found in any Japanese references although it is extensively planted throughout the country.

In October and December 2001, the disease was found on the plant in Hyogo and Kanagawa Prefectures. Though the observation was continued to the spring, no ascocarp of the causal fungus was detected. Therefore, the taxonomic position of the fungus was determind with morphologic characters of its anamorph and affinity to the host plant as follows.

1. The anamorph of *Erysiphe galeopsidis* DC. on rosemary (Fig. 3 ; Table 2 ; Photo 2・F)

Mycelia amphigenous, also cauligenous, developing irregular, white, dense powdery patches, often covering the whole surface of the leaves and young treetops ; conidiophores erect, branching from hyphae on the surfaces of the leaves and branches, 2–3 (–4)-septate, straight or loosely curved, 125–173×12–15 (av. 141.4±8.6×12.9±0.35) μm , foot-cells cylindric, 57–135 (av. 82.9±8.2) μm long, the width same as those of conidiophores ; conidia catenulate, ellipsoidal, often doliform, vacuolate, fibrosin-body absent, (27–) 31–36 (–38)×(14–) 17–21 (av. 33.1±0.49×18.4±0.34) μm, l/w ratio 1.5–1.9 (–2.4) (av. 1.80±0.043).

2. Taxonomic consideration of the fungus

Two powdery mildew fungi, *Leveillula taurica* (Lév.) Arnaud and *E. galeopsidis* have been reported on the rosemary from foreign countries (Amano, 1986[3] ; Braun, 1987[4]). The anamorph of Japanese fungus is applicable undoubtedly to that of the latter taxon.

We have examined the anamorph of *E. galeopsidis* collected from seven species of the Labiatae with the fungus on the rosemary (Table 2). Among them, the conidia on *Lamium album* L. var. *barbatum* (Sieb. et Zucc.) Franch. et Savat., *L. amplexicaule* L., *Mentha viridis* L., *Stachys japonica* Miq. var. *intermedia* (Kudo) Ohwi and *Glechoma hederaceae* L. var. *grandis* (A. Gray) Kudo. had considerable resemblance to those of the rosemary fungus although the foot-cells of their conidiophores were rather short. The foot-cell of some powdery mildew fungi is markedly variable in the length ; e.g. usually the foot-cells of *E. galeopsidis* on under surface of the leaf of *M. viridis* are far longer than those on upper surface (Table 2). So we accepted the long foot-cells of rosemary fungus as a modification brought about by an envionmental condition.

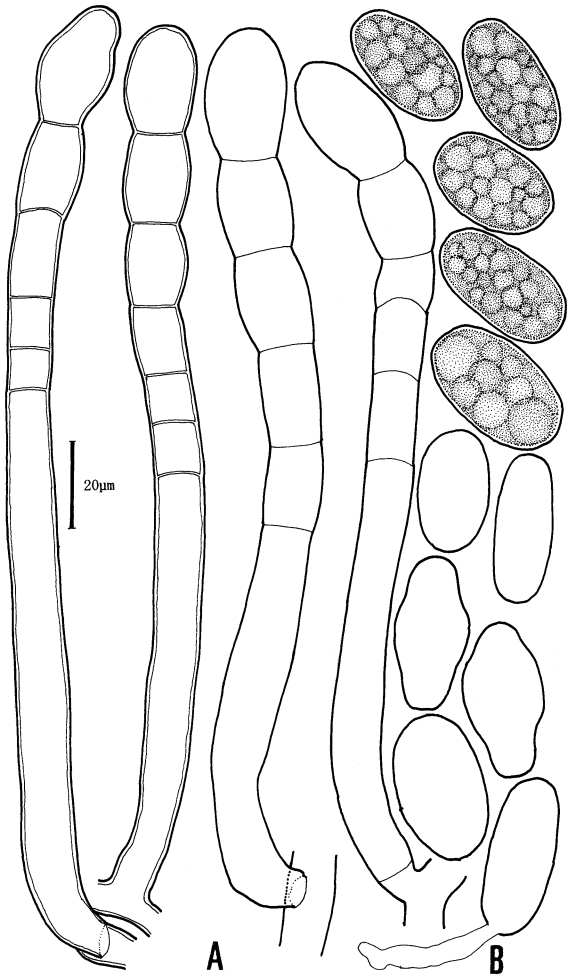

Fig. 3 Anamorph of *Erysiphe galeopsidis* DC. on *Rosmarinus officinalis* (A : Conidia and conidiophores ; B : Mature conidia)

III. Two powdery mildew fungi on downy thorn apple

In late autumn, a powdery mildew was found on the leaves of downy thorn apple, which was planted in the sample garden of medicinal and spice plants of the university. The disease was not so serious, and ascocarp of the causal fungus was not found on any affect-

ed leaves up to early winter.

Two conidial types, *viz.* the solitary and catenulate conidia were distinguishable on the separate leaves of one plant. One of them, the fungus having solitary conidia (Pseudoidium type) agreed well with those of *Oidium* sp. on common thorn apple (*Datura stramonium* L. var. *tatula* (L.) TORR.) which has been recorded by SATO *et al.* (1996)[7]. The another one, the catenulate conidia (Euoidium type) resembled closely those of *Erysiphe orontii* CAST. obtained from Chinese-lantern (*Physalis alkekengi* L. var. *franchetii* (MAST.) HORT.) and a few other solanaceous genera.

1. Two causal fungi

i. *Oidium* sp. (Fig. 4).

Mycelia amphigenous, external appearances resembling closely those of *E. orontii* ; conidiophores erect, branching from hyphae, slightly curved, 1- or 2-septate, 57–80×10–12 (av. 68.4±2.3×10.6±0.24) μm, foot-cells cylindric, somewhat slender, 28–40×9–12 (av. 34.6±1.0×10.3±0.33) μm ; conidia solitary, ellipsoidal to ovoid, often doliform, vacuolate, 27–42×14–21 (av. 34.2±0.84×17.4±0.41) μm, l/w ratio 1.5–2.3 (–2.5) (av. 1.95±0.095).

ii. The anamorph of *Erysiphe orontii* CAST. (Fig. 5 ; Table 3 ; Photo 2·G, H).

Mycelia amphigenous, developing thin, grayish white, round to irregular patches, margins obscure ; conidiophores erect, branching from hyphae creeping on the surfaces of the leaves, straight or loosely curved, usually 1-, rarely 2-septate or aseptate, 65–102×12–13 (av. 81.1±4.0×12.6±0.18) μm, foot-cells cylindric, 43-73×12-13 (av. 58.4±4.1×12.6±0.18) μm ; conidia catenu-

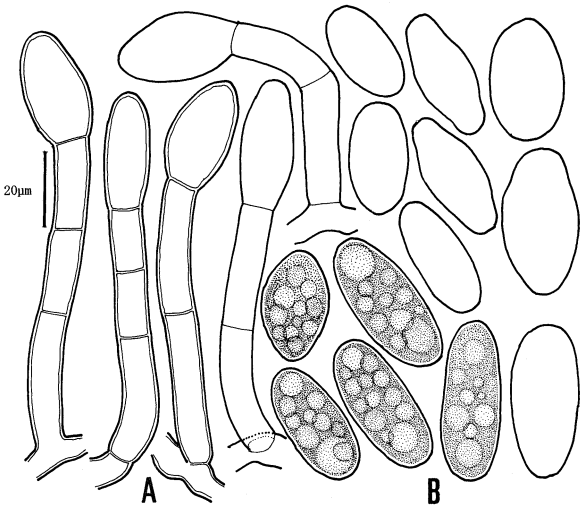

Fig. 4 *Oidium* sp. on *Datula metel* (A : Conidia and conidiophores ; B : Mature conidia)

Table 3 Dimension of anamorphs of two powdery mildew fungi (*Erysiphe orontii* and *Oidium* sp.) on *Datula* and other solanaceous plants

Fungus	Conidial formation	Host plant (Solanaceae)	TUAMH	Conidium		Size of foot-cell of conidiophore(mean) μm	Investigator
				Size(mean) μm	Length/width (mean)		
E. orontii	Catenate	*Datula metel*	6109	(28-)31-36(-39)×18-22 (33.6±0.47×20.6±0.22)	1.4-1.9 (1.63±0.033)	43-73×12-13 (58.4±4.1×12.6±0.18)	The authors
〃	〃	*Physaliastrum japonicum*	0085	28-35×13-20 (30.1±0.67×16.3±0.72)	1.4-2.0(-2.6) (1.84±0.091)	57-75×9-10 (65.5±4.2×9.8±0.25)	Do.
〃	〃	*Physalis alkekengi*	3567	25-34(-42)×14-18 (32.0±1.0×16.4±0.29)	1.4-2.1(-3.1) (1.98±0.083)	45-73×9-10 (54.0±6.5×9.5±0.29)	Do.
〃	〃	*Solanum mammosum*	5065	(24-)28-41(-45)×15-24 (35.0±0.51×18.7±0.24)	1.3-2.4(-2.7) (1.89±0.037)	30-77×7-13 (43.8±0.33×11.4±0.24)	Do.
O. sp.	Solitary	*Datula metel*	6109	27-42×14-21 (34.2±0.84×17.4±0.41)	1.5-2.3(-2.5) (1.95±0.095)	28-40×9-12 (34.6±1.0×10.3±0.33)	Do.
〃	〃	*D. stramonium* var. *tatula*		29-44×(13-)16-21	unentered	(28-)34-52×8-10	SATO *et al.* (1996)[7]
〃	〃	*Solanum aculeatissimum*	2062	29-43×15-23 (33.8±0.46×19.2±0.23)			The authors
〃	〃	*S. carolinensis*	3968	(28-)32-44×14-19 (36.1±1.2×16.6±0.35)	1.6-2.4(-2.9) (2.19±0.15)	46-56×8-9 (51.3±2.5×8.8±0.25)	Do.
〃	〃	*S. lycopersicum*	0039	(26-)32-41(-45)×15-21(-23) (37.0±0.91×18.5±0.37)	1.5-2.4(-2.6) (2.03±0.065)	31-52×8-9 (39.2±2.1×8.4±0.18)	Do.
〃	〃	*S. americanum*	5728	27-37(-44)×(17-)19-23 (33.6±0.77×20.4±0.26)	1.3-1.9(-2.1) (1.66±0.041)	31-62×9-10 (41.8±3.7×9.3±0.17)	Do.

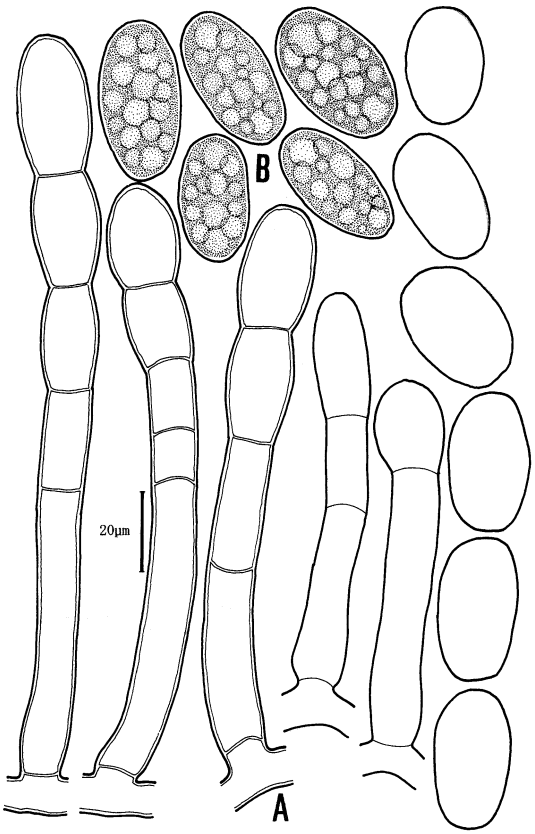

Fig. 5 Anamorph of *Erysiphe orontii* CAST. on *Datura metel* (A : Conidia and conidiophores ; B : Mature conidia)

late, ellipsoidal to ovoid, vacuolate, fibrosin-body absent, (28–) 31–36 (–39)×18–22 (av. 33.6±0.47×20.6±0.22) μm, l/w ratio 1.4–1.9 (av. 1.63±0.033).

2. Taxonomic consideration of the two fungi

Erysiphe cichoracearum DC. has been described on downy thorn apple from India (AMANO, 1986)[3]. BRAUN (1987)[4] has listed *Datula* as a host of *E. orontii* and included *E. cichoracearum* among the synonyms of *E. orontii*. As compared with the foot-cells of the conidiophore of *E. orontii* described by BRAUN, although those of the present fungus of Euoidium type are more or less short, other morphological characteristics agreed mutually.

The conidia of *Oidium* sp. were not only solitary but also the conidiophores were rather short and more slender than those of *E. orintii*. Moreover, there were some morphological differences between the conidial shape of both the fungi on downy thorn apple.

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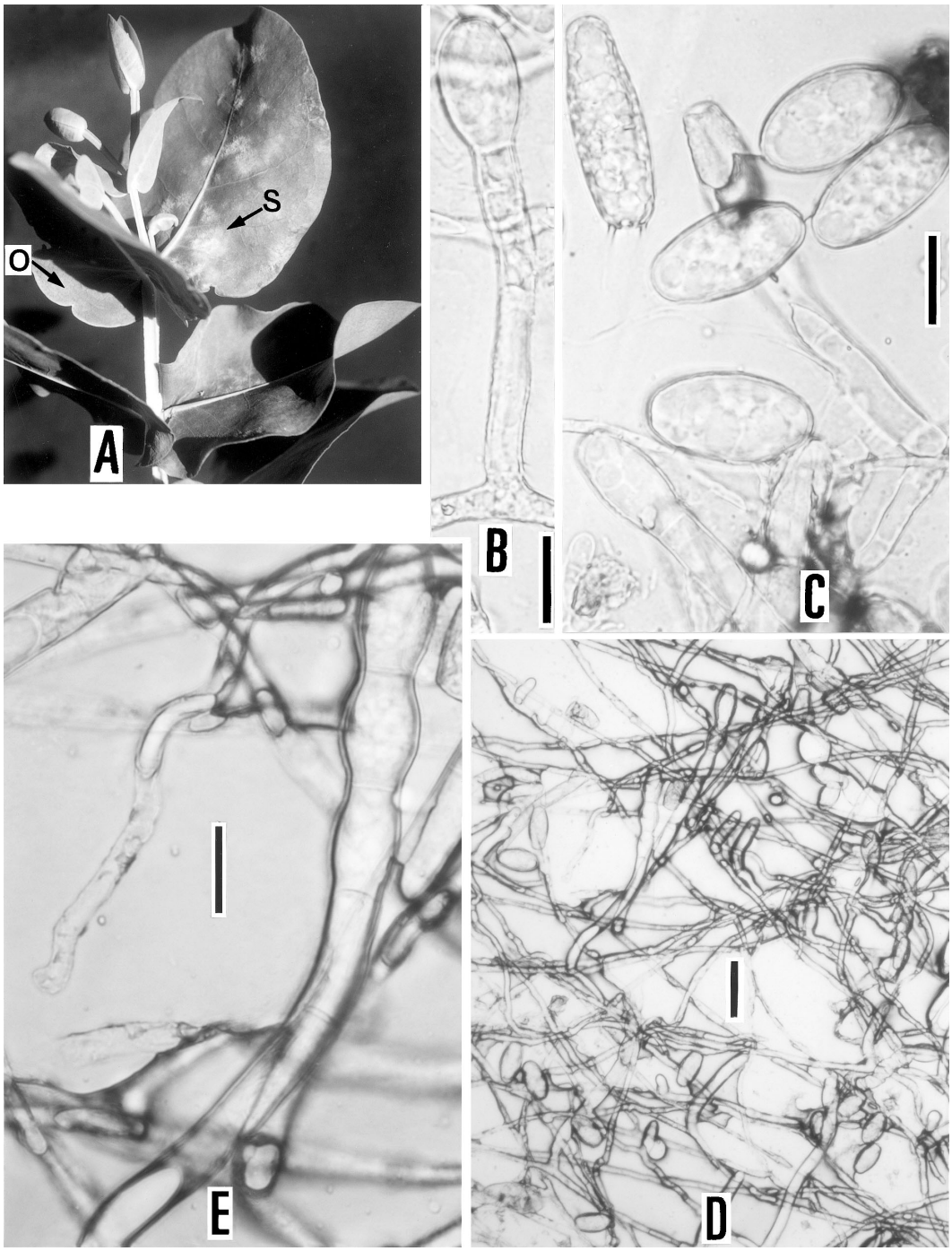

Photo 1 Two powdery mildews and their causal fungi occurred on *Eucalyptus globulus* (A : Mycelial patches of *Oidium eucalypti-globuli* (O) and *Sphaerotheca aphanis* var. *aphanis* (S); B: Conidium and conidiophore of *O. eucalypti-globuli*; C: Mature conidia of *O. eucalypti-globuli*; D: Anamorph of *S. aphanis* var. *aphanis*; E: Conidia and conidiophore of *S. aphanis* var. *aphanis*). Bars B, C, E 20 μm ; D 40 μm

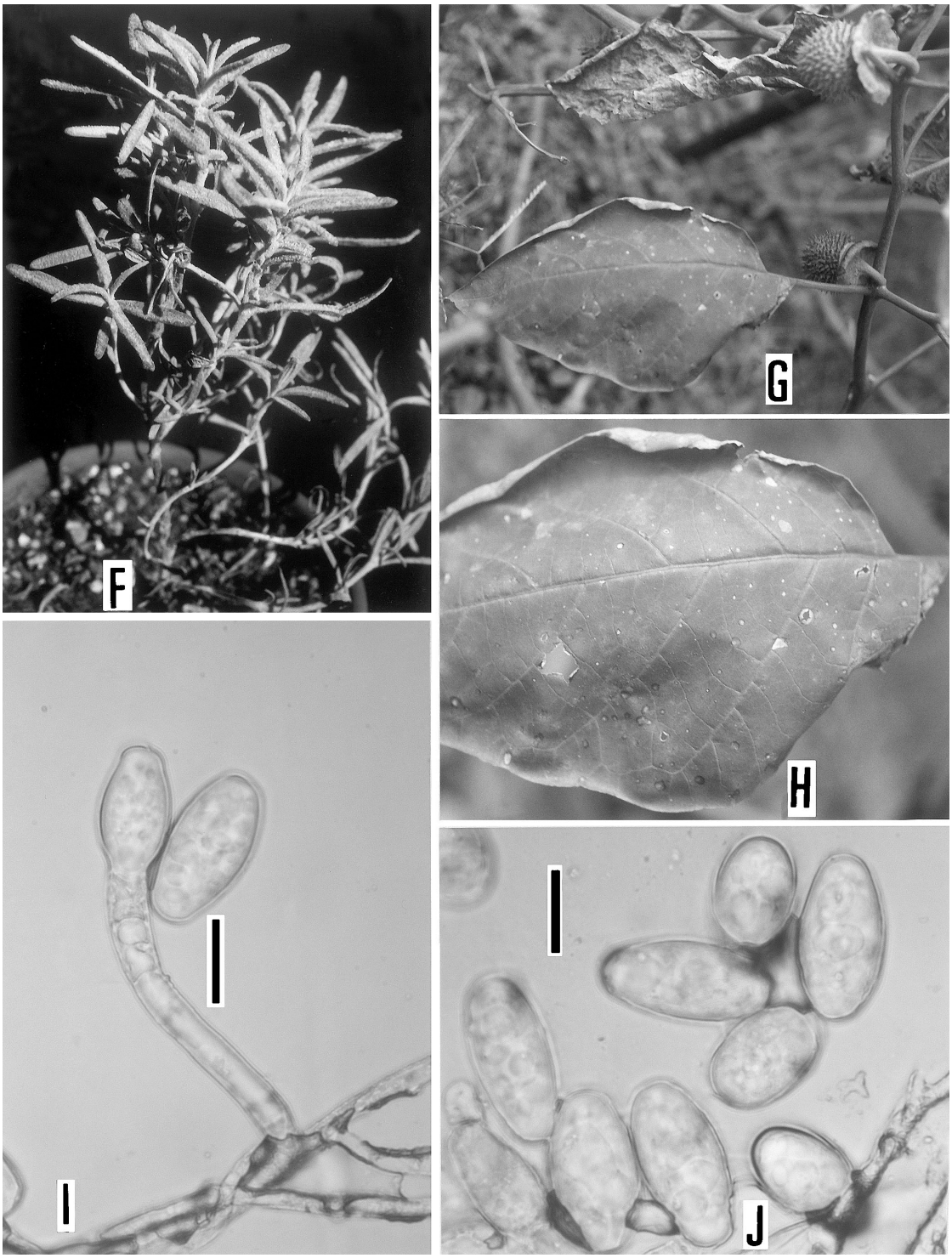

Photo 2 Powdery mildews and their causal fungi on two plants (F : Diseased plant of *Rosmarinus officinalis* ; G, H : Diseased leaf of *Datura metel* by *Oidium* sp., I : Conidia and conidiophore of *Oidium* sp. on *D. metel* ; J : Mature conidia of *O.* sp.). Bars I, J 20μm

2 種の香料植物と薬料植物 1 種に発生したうどんこ病とその病原菌

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要約：ローズマリー（シソ科）とチョウセンアサガオ（ナス科）にわが国では未記録のうどんこ病の発生がみられた。さらに，ユーカリノキ（フトモモ科）に未同定菌による同病の発生が観察されたので，それらの菌の同定を試みた。3 宿主植物上の菌はすべてアナモルフのみであったが，ユーカリノキとチョウセンアサガオでは分生子の形成状態で容易に識別できる Euoidium **型と** Pseudoidium **型の 2 菌が認められた。**

形態的特徴よりユーカリノキ上の Euoidium **型菌は** *Sphaerotheca aphanis* var. *aphanis* **と同定され，** Pseudoidium **型菌は新種とみなされ，** *Oidium eucalypti-globuli* **と命名された。ローズマリー上のアナモルフは** Euoidium **型で，他のシソ科植物に発生する** *Erysiphe galeopsidis* **の分生子時代によく一致した。チョウセンアサガオ上の** Euoidium **型菌は** *Erysiphe orontii* **のアナモルフと判定されたが，** Pseudoidium **型菌の所属は特定できなかった。**

キーワード：うどんこ病，ユーカリノキ，チョウセンアサガオ，ローズマリー， *Oidium eucalypti-globuli*

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