

STUDIES IN PLANT PATHOGENIC FUNGI-II
On some powdery mildews (Erysiphales) recently recorded from the
Netherlands

M.E. NOORDELOOS & W.M. LOERAKKER

*Plant Protection Service, Wageningen**

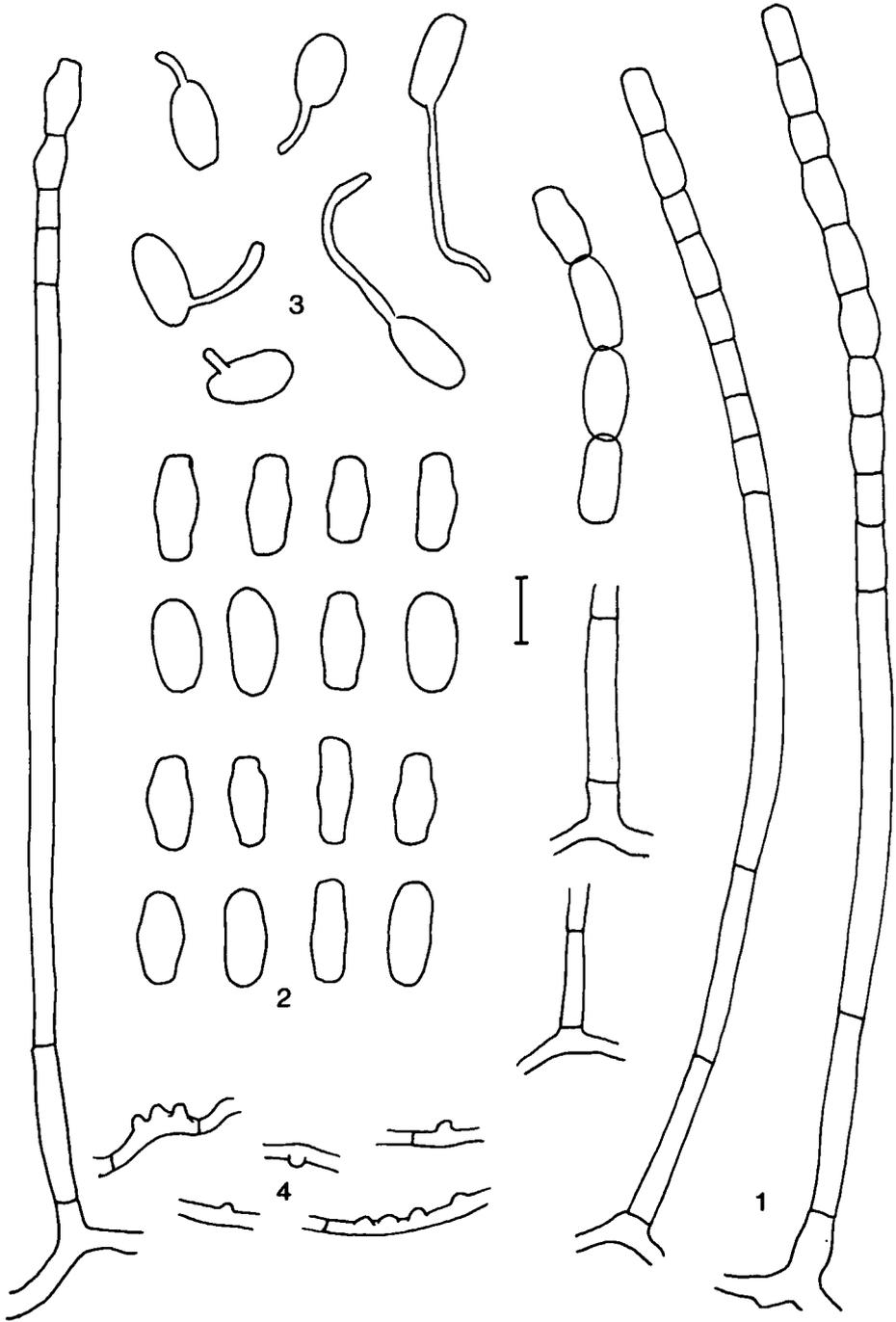
Full descriptions and notes on their pathogenous properties are given of the anamorphs of four powdery mildews recently recorded as new from the Netherlands. Two are described as new species, viz. *Oidium longipes* on *Solanum melongena* and *O. limnanthis* on *Limnanthes alba*. *Oidium lycopersicum* Cooke & Massee is redescribed on account of the study of the holotype and recently collected material, and an *Oidium* sp. occurring on *Chrysanthemum morifolium* is critically compared with the existing descriptions of *Oidium chrysanthemi* Rabenh. and *O. helichrysi* Boesewinkel.

Powdery mildews form a serious threat to our crops and ornamentals because of their ability to spread easily and to produce vast numbers of conidia. To the taxonomist confronted with the need of naming them they offer big problems. Traditionally powdery mildews have been classified on characters of the teleomorph and on their host plants. Unfortunately many diseases are caused by the anamorphic state of these fungi, belonging to the hyphomycetous genera *Oidium*, *Oidiopsis*, *Ovulariopsis*, and *Streptopodium*.

With the classical works on Erysiphales by Blumer (1933), Hirata (1966), and Yarwood (1957) it usually was impossible to name such an anamorphic state. In recent years, however, the works of Boesewinkel (1977, 1979a, b, 1980) and Braun (1980, 1981a, b, 1982a-c) have contributed much to our knowledge of the powdery mildews, especially to their anamorphs and to the anamorph-teleomorph relation. Both authors introduced new characters and presented a broad and more natural species-concept. They clearly demonstrated that many species of powdery mildews have a wider host-range than generally accepted, although these usually are confined to certain genera within one or more plant-families. Within such a polyphagous species several host-specific races may occur. Boesewinkel (1977, 1980) provided provisional keys to the anamorphic states of Erysiphales.

With help of these keys and the recent monograph of Braun (1987) an attempt has been made to tackle some of the taxonomic and diagnostic problems in connection with species of powdery mildew that have recently been encountered in the Netherlands, also making use of notes and drawings by W.M. Loerakker. Since the knowledge of the anamorphic states of Erysiphales is still far from complete, it was decided to publish full descriptions of some of these *Oidium* stages in order to contribute to a better understanding of the diagnostic problems involved and the variability within each species.

* Address: P.O. Box 9102, 6700 HC Wageningen, Netherlands.



I. A NEW POWDERY MILDEW ON EGG-PLANTS (*SOLANUM MELONGENA* L.)

In the spring of 1987 a few nurseries in the Netherlands were confronted with an unknown powdery mildew on egg-plants grown under glass. The disease started with chlorotic leaf spots up to 20 mm across on the upper side of the leaves that became necrotic after a while, gradually intergrading. The beige-brown leaves of the plants were eventually overgrown by an expanding mycelial mat.

The powdery mildew appeared to be an *Oidium* with a rather distinctive set of characters that could not be named with the literature mentioned above. Therefore it is described here as a new species.

***Oidium longipes* Noordel. & Loerakk., spec. nov. — Figs. 1–4**

Mycelium in epiphyllis effusum sed tenue, albus vel griseus. Hyphis sterilis repentibus 3–7 μm latis, hyalinis. Hyphopodiis distinctis, mammiformibus, alternatis, sparsis vel confertis. Conidiophoris ex hyphis sterilibus oriundis, uni- vel biseptatis, typi Euoidii, rectis, interdum ramosibus, cylindraceis, cellulis basalibus 45–80 \times 7–11.5 μm , cellulis secundis longissimis, (60–)95–300 \times 9–14 μm vel statura cellularum basalium, tum cellulis tertiis ac 300 μm longis. Conidiis catenatis, 26–38 \times 13–18.5(–19) μm , doliformibus vel ellipsoideis corpusculis fibrosinis conspicuis carentibus. Tubis germinativis 11.5–34.5(–64.5) \times 3.4–4.2 μm , filiformibus, ad apicem conidorum oriundos. Habitat in foliis vivis *Solani melongena* L. 'Dobrix'.

Holotypus: 'J. Hoogstrate s.n., 13.II.1987, Klazienaveen, prov. Drenthe, Netherlands' (L).

Mycelium on upper side of the leaves and on the petioles, white or mouse-gray. Hyphae 3–7 μm wide, repent, thin-walled, hyaline or sometimes minutely encrusted with colourless grains. Appressoria spread or crowded, single or in sequence, nipple-shaped, never lobed. Conidiophores 165–300 μm long, of the Euoidium-type; foot-cell cylindrical, 45–80 \times 7–11.5 μm , basal septum at a distance of 4.5–25 μm from point of branching; secondary cell usually (very) long: (60–)95–300 \times 9–14 μm or about the same dimension as the first, then always a long third cell present, up to 300 μm long; often some additional sterile cells present poorly distinguishable from immature conidia. Conidia in chains, 26–38 \times 13–18.5(–19) μm , $Q = (1.6\text{--})1.8\text{--}2.8$, doliform or (sub-)cylindrical, without conspicuous fibrosin-bodies. Germ-tubes 11.5–35(–65) \times 3.5–4 μm , almost terminal, filiform without distinct appressoria.

HABITAT. — On leaves of *Solanum melongena* L. 'Dobrix'.

COLLECTIONS EXAMINED. — NETHERLANDS: prov. Drenthe: Klazienaveen, 13 Febr. 1987, J. Hoogstrate (holotype, L); ditto, 12 March 1987, J. Hoogstrate (PD 2871); prov. Zuid-Holland: Bleiswijk, 4 March 1987, K. Peeters (PD 470); Naaldwijk, 4 Febr. 1987, R. Simonse (PD 2854); ditto, 20 March 1987, R. Simonse (PD 473).

The diagnostic features of *Oidium longipes* are the long conidiophores with strongly elongated secondary or tertiary foot-cell, nipple-shaped appressoria, doliform conidia with unbranched germ-tubes, absence of fibrosin-bodies, and placement of the basal septum. This set of morphological characters place *O. longipes* in the group of *Oidium* species that belong to *Erysiphe* subsect. *Depressa* (Braun, 1981b), a rather small group of taxa with long foot-cells and doliform conidia. The *Oidium*-state of *Erysiphe depressa* (Wallr.) Schlecht. is similar in having a long secondary foot-cell, but differs by having more voluminous conidia and

Figs. 1–4. *Oidium longipes*. — 1. Conidiophores. — 2. Conidia. — 3. Germinating conidia. — 4. Appressoria. (Bar = 20 μm ; all figs. from holotype and del. W.M. Loerakker.)

it occurs only on members of the Asteraceae. The remaining species in subsect. *Depressa* differ by having a long primary foot-cell, conidial characteristics, and host family.

Oidium helichrysi Boesewinkel, of which no teleomorph is known, probably also belongs to the same group with a large primary foot-cell and larger conidia than in *O. longipes*.

There are several species of powdery mildew that occur on *Solanum*, viz. *Erysiphe orontii* Cast. (= *E. cichoracearum* DC. pro parte); *Leveillula taurica* (Lév.) G. Arn., and *Sphaerotheca fusca* (Fr.) Blumer. All these species have an anamorph that is definitively different from ours. *Oidium melongena* Zaprometov, described from egg-plant in Tashkent, USSR, differs from *O. longipes* by having a violaceous-gray mycelium and elongate conidia, $45 \times 11\text{--}15 \mu\text{m}$, on account of which it has been excluded from the Erysiphales (Braun, 1987).

The diseased egg-plants have been destroyed and the rest of the crop was treated chemically; *O. longipes* has not been recorded since. Therefore we are convinced that the disease has been eradicated effectively.

Oidium longipes is morphologically distinct from the *Oidium* from tomato that occurred at the same time in the same area (see below). Moreover, inoculation experiments have proved that *O. longipes* is not pathogenic for tomato.

II. A REDESCRIPTION OF *OIDIUM LYCOPERSICUM* COOKE & MASS.

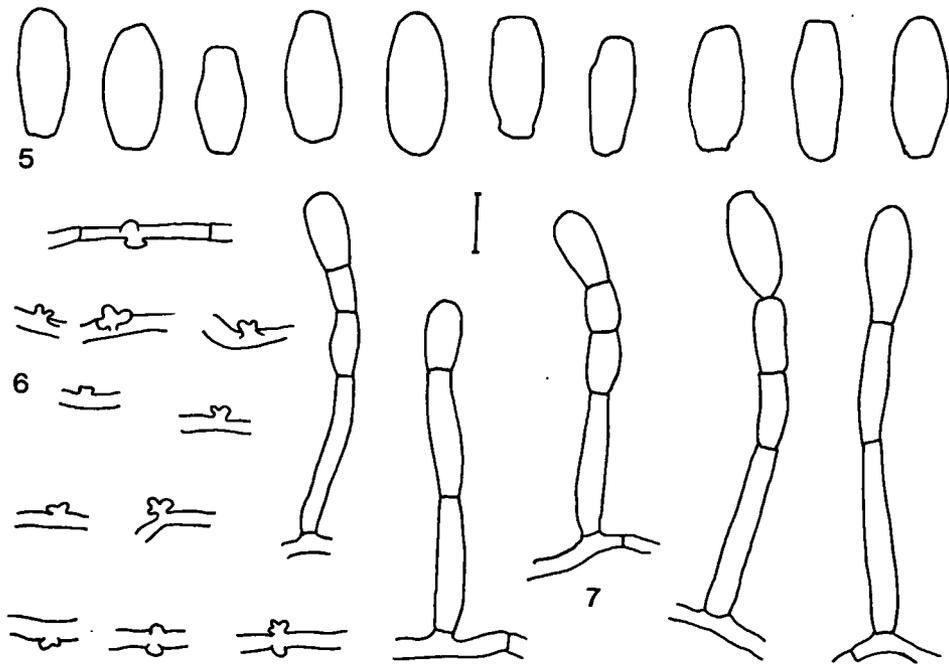
Tomato, *Lycopersicon esculentum* (L.) Mill, is an economically important vegetable that is grown in almost all parts of the world. In tropical and subtropical regions it is a field crop, whereas in the temperate parts of the world it usually is cultivated in glasshouses.

There are many records of the occurrence of powdery mildews on tomato. A wide-spread and common powdery mildew is the polyphagous species *Erysiphe orontii* Cast. (also known as *E. cichoracearum* DC. pro parte and *E. polyphaga* Hammarl., see Braun, 1987). Its anamorphic state *Oidium* produces conidia in chains. *Erysiphe orontii* is recorded from both tropical and temperate regions (Wicks & Clare, 1981; Price, 1981). *Leveillula taurica* (Lév.) G. Arn. is another powdery mildew that attacks tomato plants, mainly in tropical regions (Price l.c.). It is morphologically distinct from *E. orontii* on account of the conidiogenesis, that places its anamorph in the form genus *Oidiopsis* Scalia.

A recent outbreak of powdery mildew on tomato in western Europe made clear that a third powdery mildew was involved. Morphological studies and analysis of the holotype revealed that it is identical with *Oidium lycopersicum* Cooke & Mass., a species described from Australia in 1888. A modern redescription of this taxon is given here, based on material collected in the Netherlands.

Oidium lycopersicum Cooke & Mass. in Grevillea 14: 114. 1888. — Figs. 5–7

Mycelium white, thin, arachnoid, covering the upperside, rarely also the underside of the leaves, and the stems. Hyphae hyaline, thin, $5\text{--}7.5 \mu\text{m}$ wide, septate; appressoria distinct, opposite or spread, lobed rarely nipple-shaped. Conidiophores 2–3 septate, erect, $(55\text{--})67\text{--}104 \mu\text{m}$ long, $7\text{--}11.5 \mu\text{m}$ wide, foot-cell $37\text{--}76 \mu\text{m}$ long, straight, cylindrical, sometimes inflated in the middle and constricted at base; second cell $(11.5\text{--})16\text{--}30(\text{--}37.5) \mu\text{m}$ long; third cell $(11.5\text{--})16\text{--}30(\text{--}37.5) \mu\text{m}$ long. Conidia single, $(17.5\text{--})28\text{--}45(\text{--}50) \times 13\text{--}19.5(\text{--}21.0)$



Figs. 5–7. *Oidium lycopersicum*. — 5. Conidia. — 6. Appressoria. — 7. Conidiophores. (Bar = 20 μm all figs. del. W.M. Loerakker.)

μm ; Q = 1.8–2.8(–3.1), doliform or ellipsoid, sometimes in pseudo-chains of 3 to 8 conidia in high moisture; fibrosin-bodies absent; germ-tube simple, cylindrical, not broadened at apex, originating from one end or on one side of the conidium.

HABITAT & DISTRIBUTION. — On leaves of *Lycopersicon esculentum* (L.) Mill in glass-houses.

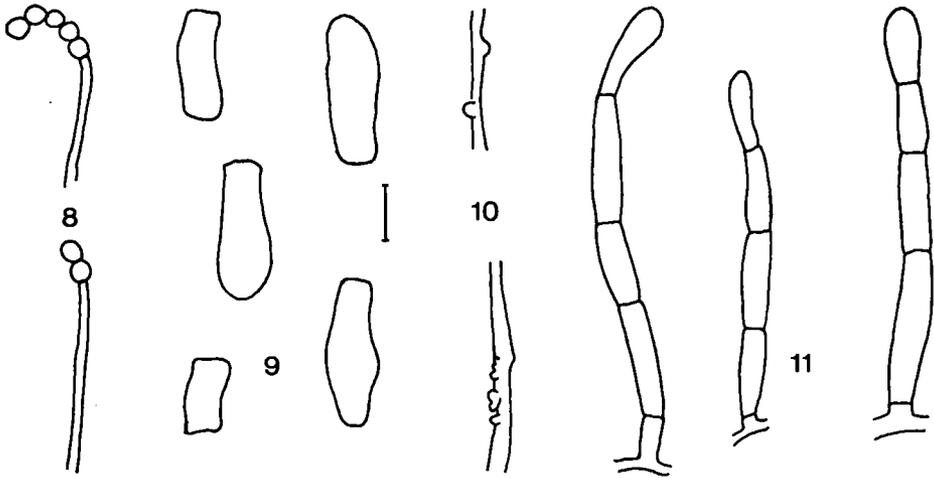
COLLECTIONS EXAMINED. — NETHERLANDS: prov. Zuid-Holland: Honselersdijk, 26 Aug. 1986, M.P. Simonse; Naaldwijk, 9 Febr. 1987, M.P. Simonse (on *L.e.* 'Counter'); ditto, 6 April 1987, M.P. Simonse (on *L.e.* 'Dombito'); prov. Gelderland: Wageningen, I.V.T., March 1988, G. Pet.

Study of the holotype.

Australia, at the upper Yarra, March 1888, on *Solanum lycopersicum* (K) — Figs. 8–11.

The holotype consists of a dried young tomato shoot glued on a herbarium sheet. The stem and leaves are covered by various moulds. Some of them could be identified as belonging to the hyphomycete genera *Cladosporium* and *Fulvia*. Also some hyphae, conidiophores and conidia of an *Oidium*-species could be detected with the following characteristics:

Hyphae 6–9 μm wide, hyaline, with nipple-shaped or weakly lobed appressoria; conidiophores about 150–200 μm long and 8–18 μm wide; conidia subcylindrical to subdoliform, 20–45 \times 12–18 μm .



Figs. 8–11. *Oidium lycopersicum*. — 8. Secondary mould. — 9. Conidia. — 10. Appressoria. — 11. Conidiophores. (Bar = 20 μ m; all figs. from holotype.)

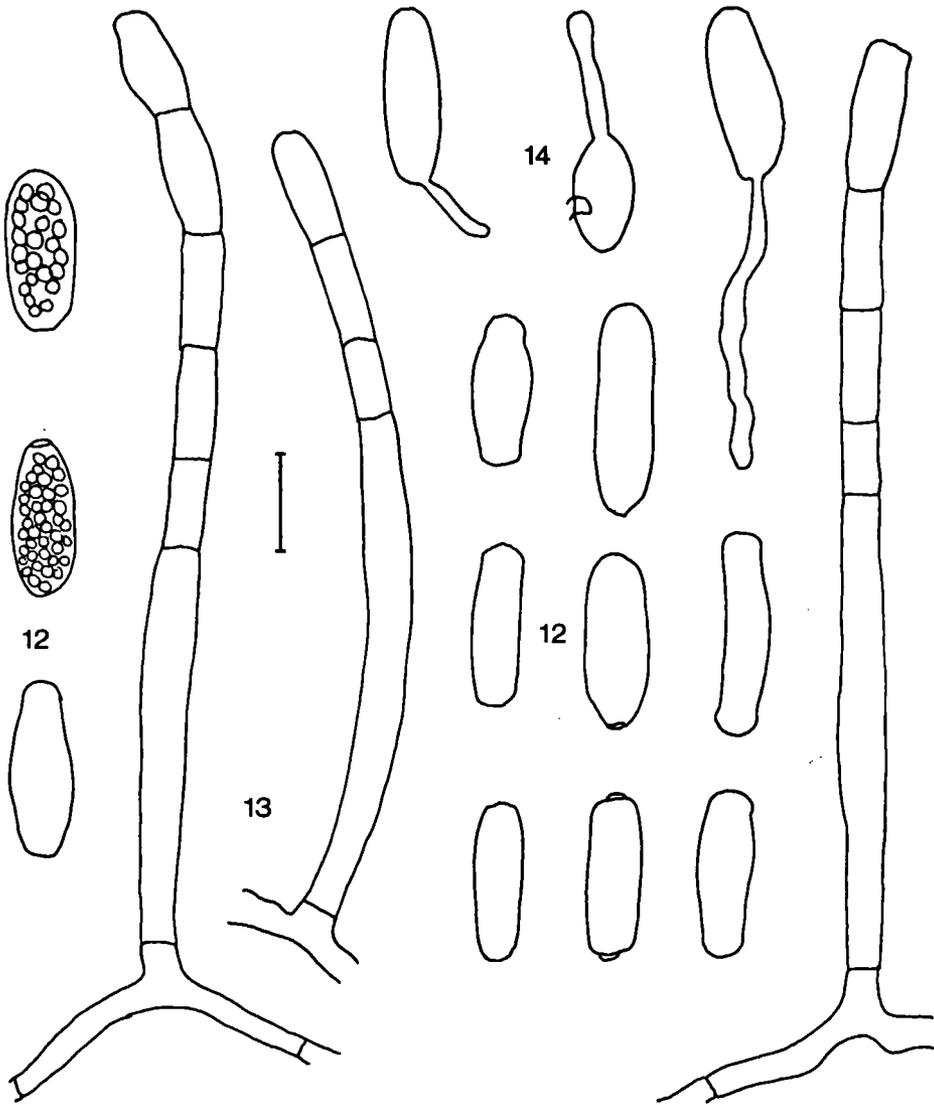
Due to the bad state of the material it proved to be impossible to determine the nature of the conidiogenesis. It is certain, however, that the anamorph of *Leveillula taurica* is not involved, since size and shape of conidiophores and conidia are definitively of an *Oidium* state. These characters fit reasonably well with our observations on the powdery mildew that occurred in the Netherlands, and we do not hesitate to use the name *Oidium lycopersicum* for it.

Braun excluded *Oidium lycopersicum* from the Erysiphales on account of the description by Cooke & Massee and the notes on the herbarium sheet. It is clear that Cooke & Massee erroneously drew and described a secondary mould on the type material. I was able to find similar structures (Fig. 8). However, since also an *Oidium* sp. is present on the same material, it seems reasonable to use the name *O. lycopersicum* for it, and to exclude part of the protologue denoting the secondary mould, viz. the sentence 'conidiis subglobosis, concatenatis, hyalinis, 8–9 μ m diam.'

Not much is known about the geographical distribution of *Oidium lycopersicum*. It is difficult to get a good picture since many records of powdery mildews in phytopathological literature do not contain information on the morphology of the fungus. A recent record of *Erysiphe polygoni* from the United Kingdom (Anonymous, 1987) most probably refers to *Oidium lycopersicum*. Unpublished records that reached us by personal communication give also indications that similar attacks of powdery mildew on tomato occurred in Belgium, France, and West Germany.

III. AN OIDIUM ON CHRYSANTHEMUM

A recent attack of powdery mildew in a culture of *Chrysanthemum* under glass proved to be an *Oidium* species with the following characteristics (Figs. 12–14):



Figs. 12–14. *Oidium* cf. *chrysanthemi*. — 12. Conidia. — 13. Conidiophores. — 14. Germinating conidia. (Bar = 20 μ m; all figs. del. W.M. Loerakker.)

Mycelium white, amphigenous. Hyphae hyalinous, 4.5–9.5 μ m wide; appressoria inconspicuous. Conidiophores 160–260 μ m long, straight, unbranched, producing conidia in chains. Foot-cell 100–180(–200) \times 12–17.5 μ m, cylindrical, straight or slightly wider in the middle or at the top, with basal septum (4.5–)11.5–16(–23) μ m away from branching point of the mycelium, followed by 2–3 short cells, 18.5–37 \times 11–15 μ m. Conidia (35–)46–68 \times

14–26 μm , $Q = 1.7\text{--}3.6$, variably shaped subcylindrical to doliform, often strongly vacuolized without fibrosin-bodies. Germ-tubes 20–122 \times 3.5–5.3 μm , filiform, without appressorium, usually at apex of conidia.

HABITAT & DISTRIBUTION. — On leaves of *Chrysanthemum morifolium* 'Spider'.

COLLECTION EXAMINED. — NETHERLANDS: prov. Noord-Holland, Aalsmeer, 23 March 1987, J. Amsing.

This *Oidium* is, like *O. longipes*, characterized by having relatively long foot-cells and is therefore close to the anamorph of *Erysiphe depressa* (Wallr.) Schlecht. that is known from various Asteraceae (Braun, 1987: 265). It differs, however, by the indistinct appressoria and larger conidia. Boesewinkel (1979a: 38–39) gives a full description of *O. chrysanthemi* Rabenh. that is known to occur on *Chrysanthemum morifolium*. Our collection fits this description only partially. In Boesewinkel's material the foot-cells are shorter (75–130(–140) \times 12.5(–15) μm), and the germ-tubes have distinct appressoria. The size and shape of the conidia, however, are very similar. In some respects our collection is intermediate between *O. chrysanthemi* and *O. helichrysi* Boesewinkel (Boesewinkel l.c.: 39–40) especially when the size of the foot-cells and conidia is taken into account. It is clear that more material is needed to evaluate the differences between the two taxa.

The diseased plants have been destroyed. Inoculation tests have proved that the *Oidium* from *Chrysanthemum* does not affect *Senecio vulgaris* nor *Lycopersicon esculentum* nor *Cichorium intybus*.

IV. A NEW OIDIUM ON LIMNANTHES ALBA BENTH.

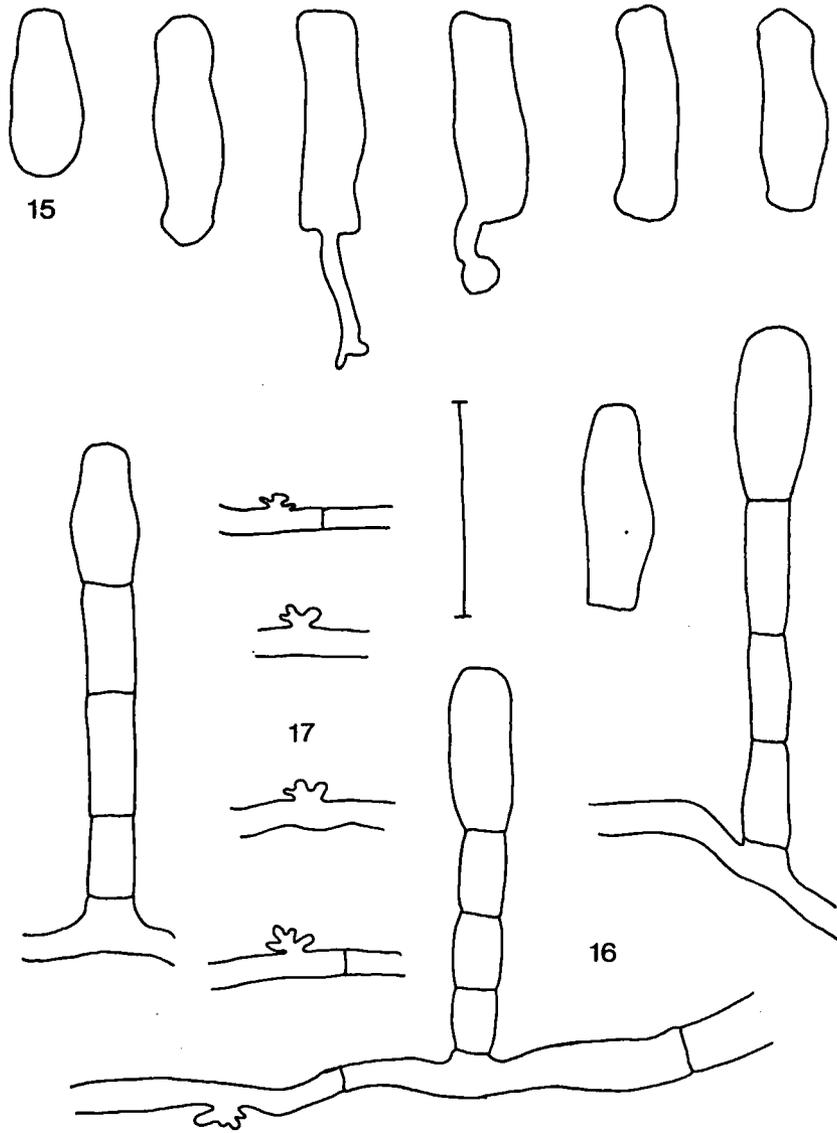
The genus *Limnanthes* is a small group of annuals that belong to the monotypic family Limnanthaceae in the likewise monotypic order Limnanthales (Lanjouw & al., 1968). Recently the genus attracted more attention because of the potential as an oil-seed crop of some of its species. The Foundation for Agricultural Plant Breeding (SVP) at Wageningen is therefore involved in a project on *Limnanthes*. In their experimental fields an attack of a powdery mildew occurred that was caused by an unknown species of *Oidium*:

Oidium limnanthis Noordel., *spec. nov.* — Figs. 15–17

Mycelium albus, floccosus. Hyphis 7–12 μm latis, hyalinis, tenuipatiatis. Hyphopodiis distinctis, multilobatis. Conidiophoris typi Pseudoidii, 50–80 \times 9–11.5 μm ; cellulis basalibus 22–30 \times 7–9 μm . Conidiis cylindraceutis, 40–53 \times 13.5–18 μm , corpusculis fibrosinis carentibus. Tubis germinativis hyphopodiis lobatis ad apicem conidiorum oriundis. Habitat in foliis, caulibus, pedunculis et calycibus vivis *Limnanthes albae* Benth.

Holotypus: 'M. Doorgeest s.n.', 19.IV.1988, S. V. P., Wageningen, Netherlands' (L).

Mycelium white, floccose, on both sides of the leaves, stems, peduncles and calyx of the flowers. Hyphae 7–12 μm wide, thin-walled, colourless. Appressoria moderately lobed to multilobed, numerous, usually single. Conidiophores of the *Pseudoidium*-type, 50–80 \times 9–11.5 μm , foot-cell 22–30 \times 7–9 μm , straight, cylindrical. Conidia 40–53 \times 13.5–18 μm , $Q = 2.3\text{--}3.7$, average $Q = 2.9$, cylindrical, without fibrosin-bodies. Germ-tubes straight with a lobed terminal appressorium, usually born at the apex of the conidia.



Figs. 15-17. *Oidium limnanthis*. — 15. Conidia. — 16. Conidiophores — 17. Appressoria. (Bar = 20 μ m; all figs. from holotype.)

COLLECTION EXAMINED. — NETHERLANDS: prov. Gelderland: Wageningen, S.V.P., 19 April 1988, *M. Doorgeest* (holotype, L).

No records are known of the occurrence of a powdery mildew on *Limnanthes*. The slender conidia and multilobed appressoria are fairly distinctive, and therefore it is described as a new species. The anamorphic state of *Erysiphe cruciferarum* Opiz ex Junell comes close, but has less slender conidia, unlobed or moderately lobed appressoria and a different host-plant range.

The diseased plants have been destroyed.

ACKNOWLEDGEMENTS

The director of the Herbarium, Royal Botanic Gardens, Kew, is gratefully acknowledged for the loan of the holotype of *Oidium lycopersicum*. My colleagues of the Plant Protection Service, H. A. van Kesteren and Maria E. C. Hamers greatly improved the manuscript of this paper, for which I would like to express my sincere thanks.

REFERENCES

- ANONYMOUS. (1987). 'New' tomato fungus identified on South Coast nursery. *In* *Grower* 107(7): 5.
- BLUMER, S. (1933). Die Erysiphaceen Mitteleuropas unter besonderer Berücksichtigung der Schweiz. *In* *Beitr. Krypt.-Fl. Schweiz* 7(1): 1–483.
- BOESEWINKEL, H.J. (1977). Identification of Erysiphaceae by conidial characteristics. *In* *Rev. Mycol.* 41: 493–507.
- (1979a). Erysiphaceae of New Zealand. *In* *Sydowia* 32: 13–56.
- (1979b). Observations on the host range of powdery mildews. *In* *Phytopath. Z.* 94: 241–248.
- (1980). The morphology of the imperfect states of powdery mildews (Erysiphaceae). *In* *Bot. Rev.* 46(2): 167–224.
- BRAUN, U. (1980). Morphological studies in the genus *Oidium*. *In* *Flora* 170: 77–90.
- (1981a). Miscellaneous notes on the Erysiphaceae (II). *In* *Feddes Repertorium* 92(7-8): 499–513.
- (1981b). Taxonomic studies in the genus *Erysiphe* I. Generic delimitation and position in the system of the Erysiphaceae. *In* *Nova Hedwigia* 34: 679–719.
- (1982a). Morphological studies in the genus *Oidium* (II). *In* *Zentbl. Mikrobiol.* 137: 138–152.
- (1982b). Morphological studies in the genus *Oidium* (III). *In* *Zentbl. Mikrobiol.* 137: 314–324.
- (1982c). Taxonomic notes on some powdery mildews. *In* *Mycotaxon* 15: 138–154.
- (1987). A monograph of the Erysiphales (powdery mildews). *Beih. Nova Hedwigia* 89.
- HIRATA, K. (1966). Host range and geographical distribution of the powdery mildews. *Fac. Agric. Niigata Univ., Niigata*.
- LANJOUW, J. & al. (1968). Compendium van de Pteridophyta en Spermatophyta. Utrecht.
- PRICE, T.V. (1981). Powdery mildew of tomato in Australia. *In* *Australas. Pl. Path.* 10: 38–40.
- WICKS, T.J. & CLARE, B.G. (1981). Powdery mildew on tomato. *In* *Australas. Pl. Path.* 10: 36.
- YARWOOD, C.E. (1957). Powdery mildews. *In* *Bot. Rev.* 13: 235–301.